ICES WGMHSA Report 2007

ICES Advisory Committee on Fishery Management

ICES CM 2007/ACFM:31

Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA)

4 - 13 September 2007

ICES Headquarters

ICES
International Council for the Exploration of the Sea
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International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2007. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA), 4 - 13 September 2007, ICES Headquarters. ICES CM 2007/ACFM:31. 712 pp.

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0 Executive Summary

The Working Group on the Assessment of NEA Mackerel, Horse Mackerel, Sardine and Anchovy (**WGMHSA**) met in ICES Headquarters 4 -13 September, to assess and provide catch options for these four widely distributed pelagic species in the Northeast Atlantic Ocean. The WG reports on the status of **7 stocks** (see Fig. 0.1 for stock definitions), and in case of Sardine it only relates to Subdivision VIIIc and Division IX considered the central areas of distribution of the stock. This year a **benchmark** analytical assessment is available for NEA mackerel and **update** analytical assessments are available for Sardine and Anchovy in Biscay. Due to its depleted state an assessment and management advice for Anchovy in Biscay were provided by STECF in June. **Exploratory analysis** continued on western and southern Horse mackerel stocks and Gulf of Cadiz anchovy. All these assessments are still in a developmental stage, whilst no assessment was possible for North Sea horse mackerel due to lack of coherent data.

Northeast-Atlantic (NEA) Mackerel. This species is distributed in the whole ICES area and currently supports one of the most valuable European fisheries (with around 500 kt annual landings). Mackerel is fished by a variety of fleets (ranging from open boats using hand lines on the Iberian coasts to large freezer trawlers and Refrigerated Sea Water (RSW) vessels in the Northern Area. The stock is historically divided into three components, with the North Sea component considered to be over fished since the late 1970s, and the Western component contributing the vast majority of biomass and catch to the stock. The quality of sampling data remains good. The NEA mackerel assessment was treated as a benchmark, with new inputs to the assessment coming from fishery dependent data and from the 2007 Egg survey. However, further progress was made on the putative effect of different misreporting levels on the assessment, and its interpretation for advice. The WG concludes that the accuracy of landings and estimates of total discards are still inadequate.

Horse Mackerel. For North Sea horse mackerel effort the data exploration again showed inconsistent signals in the catch at age data and a survey index, which may be missing an important component of the stock due to seasonal migration. The WG concluded that more intensive age sampling and a directed survey will need to be available before an analytical assessment can be attempted for this stock. The exploratory analysis for western horse mackerel was refined to incorporate information on age structure into the egg abundance index. This allows in an indirect way the assessment to be scaled. The assessment indicates that the current level of biomass is at or above that in 1982. However large uncertainty surrounds the estimates of stock parameters. The analyses confirms strong recruitment of the 2001 year class however this is not estimated to be the same order of magnitude as the 1982 year class. An exploratory analysis was conducted for southern horse mackerel. The 2 surveys were combined and a clear cohort signal was evident. However previously adopted AMCI required strong conditioning and gave unrealistic results while, XSA used last year showed poor diagnostics. So, this year the data were explored in a Flexible Forward Age-Structured Assessment program (ASAP). SSB appears stable at the 1990s level.

Sardine The recent EU project SARDYN was not conclusive with respecto to the most suitable assessment approaches for the stock. However, provided useful indications on the probability of emigration from the Biscay shelf to the Cantabrian Sea. An update assessment using the single area AMCI model was conducted including some exploration of model settings. The model exploration confirmed that the catchability of the DEPM is close to unity and that the decline of both selection and catchability of the 6+ age group may be related to the biology of the species.

Anchovy is a short-lived species, showing large fluctuations in biomass. This is driven by recruitment which in turn might be driven by a combination of environmental factors. In Bay

of Biscay Anchovy catches consist mainly of 1- and 2-yr old fish. In 2005 there was a failure of the commercial fishery for the Biscay stock, and this prompted much intercessional work since May 2005. After extensive exploration of both the old ICA assessment and new Bayesian biomass based model (BBM) undertaken in 2006 this year the assessment was conducted using the BBM. The prognosis for Bay of Biscay Anchovy is that the stock is still in a depleted state, although recruitment in 2007 shows improvement. The exploratory assessment of Anchovy in Cadiz was simplified this year using only survey indices as tuning fleets. The suitability of a biomass based model to assess this stock is to be investigated intersession ally.

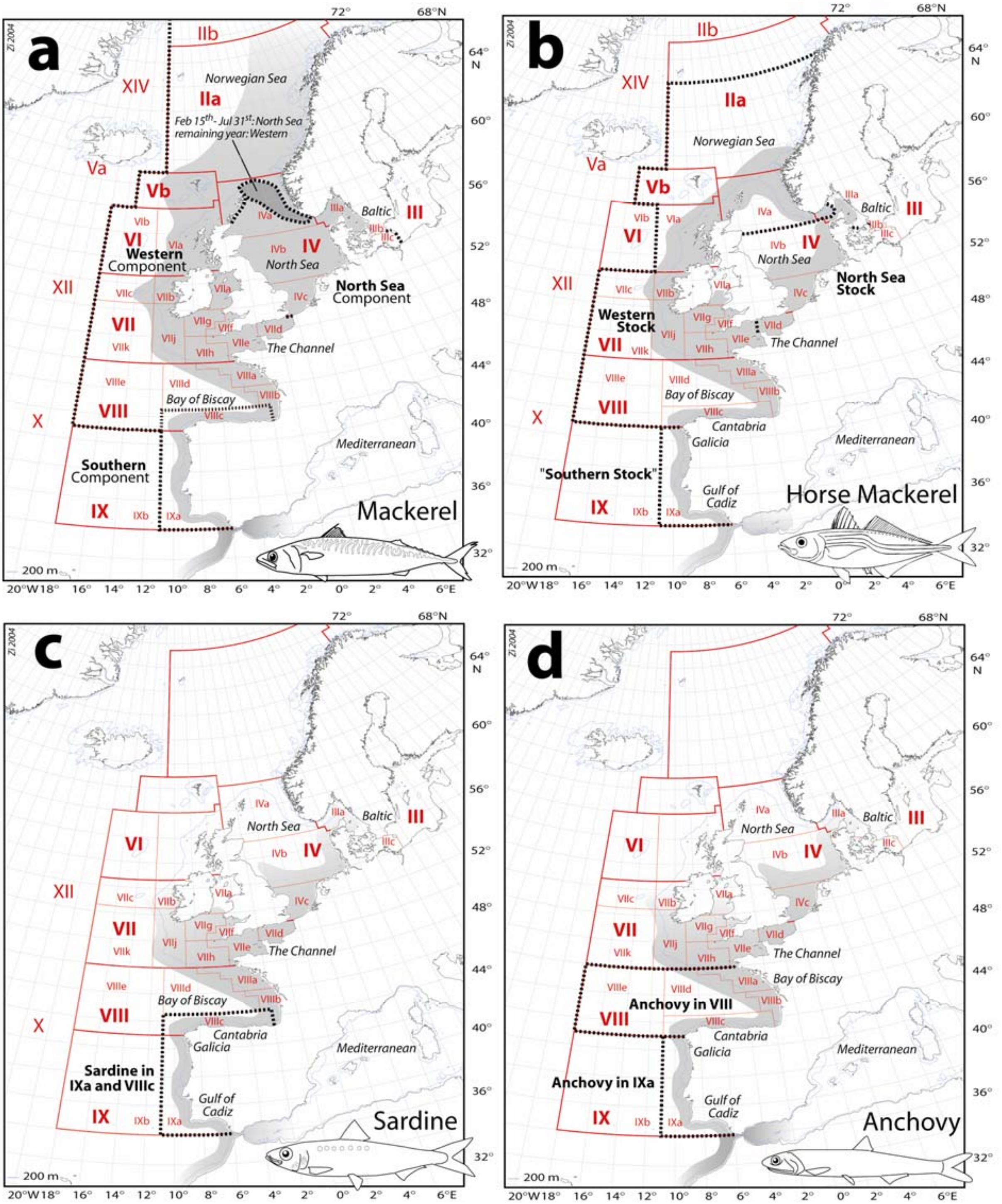


Figure 0.1: Distribution of the four species assessed by the ICES Mackerel, Horse Mackerel, Sardine and Anchovy WG: Stock and component definitions as used by the 2004 WG. Map source: GEBCO, polar projection, 200 m depth contour drawn. a: Northeast Atlantic Mackerel (with North Sea, Western and Southern component), b: Horse Mackerel: North Sea, Western and "Southern" stock, c: Sardine, d: Anchovy: Stock in area VIII and stock in IXa.

1 Introduction

1.1 Terms of Reference

The **Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy** [WGMHSA] met from 4-13 September 2007 in ICES HQ to address the following terms of reference:

a) assess the status of and provide management options for 2008 for:
   - mackerel and sardine in Divisions VIIIc and IXa,
   - western and southern horse mackerel,
   - anchovy in Subarea VIII and anchovy in Division IXa;

b) carry out in-depth exploratory assessments for NEA mackerel;

c) for the stocks mentioned in a) perform the tasks described in C.Res. 2006/2/ACFM01.

WGHMSA will report by 14 September 2007 to the attention of ACFM.

In resolution 2ACFM01 the following general terms of reference are relevant to this working group

1) based on input from e.g. WGRED and for the North Sea NORSEPP, consider existing knowledge on important environmental drivers for stock productivity and management and if such drivers are considered important for management advice incorporate such knowledge into assessment and prediction, and important impacts of fisheries on the ecosystem;

2) Evaluate existing management plans to the extent that they have not yet been evaluated. Develop options for management strategies including target reference points if management has not already agreed strategies or target reference points (or HCRs) and where it is considered relevant review limit reference points (and come forward with new ones where none exist) – following the guidelines from SGMAS (2005, 2006), AGLTA (2005) and AMAWGC (2004, 2005, and 2006); If mixed fisheries are considered important consider the consistence of options for target reference points and management strategies. If the WG is not in a position to perform this evaluation then identify the problems involved and suggest and initiate a process to perform the management evaluation;

3) where mixed catches are an important feature of the fisheries assess the influence of individual fleet activities on the stocks and the technical interactions;

4) update the description of fisheries exploiting the stocks, including major regulatory changes and their potential effects. Comment on the outcome of existing management measures including technical measures, TACs, effort control and management plans. The description of the fisheries should include an enumeration of the number, capacity and effort of vessels prosecuting the fishery by country;

5) where misreporting is considered significant provide qualitative and where possible quantitative information, for example from inspection schemes, on its distribution on fisheries and the methods used to obtain the information; document the nature of the information and its influence on the assessment and predictions;

6) provide for each stock information on discards (its distribution in time and space) and the method used to obtain it. Describe how it has been considered in the assessment;

7) report as prescribed by the Secretariat on a national basis an overview of the sampling of the basic assessment data for the stocks considered;

8) provide specific information on possible deficiencies in the 2006 assessments including, at least, any major inadequacies in the data on landings, effort or

discards; any major inadequacies in research vessel surveys data, and any major difficulties in model formulation; including inadequacies in available software. The consequences of these deficiencies for both the assessment of the status of the stocks and the projection should be clarified.

Term of reference a) is addressed under the respective stocks.

The structure of Section 2 addresses term of reference b, with special consideration given to the results of the International Mackerel Egg Survey.

The Sardine assessment was treated as an update, with new inputs to the assessment coming from both fishery dependent and independent data. The performance of the western horse mackerel assessment model has been further explored, and a management plan for the stock proposed by the pelagic RAC was reviewed, however the production of quantitative short-term advice still remains problematic. A quantitative assessment for North Sea horse mackerel is still not possible due to the lack of coherent catch at age data and a suitable index. An update assessment was performed for Southern Horse mackerel where the surveys were merged. Anchovy in Cadiz was also treated as an exploratory assessment.

Where relevant terms of reference 1-6 are addressed under the respective stocks. An overview of the input data and their shortcomings (addressing terms of reference 8) is given in Section 1.3 which includes comments on the use of Intercatch, and an overview of the assessment methods in Section 1.4. General comments on relevant information on ecological/ environmental studies are addressed in Section 1.9. An overview of recent changes in fishery regulations is presented in Section 1.10 addressing terms of reference 3.

The present report is structured as last year. Specific attention has again been given to the explicit treatment of uncertainties in either the input data or the assessment assumptions.

1.2 Participants

Geert	Aarts	The Netherlands
Pablo	Abaunza	Spain
Johnatan	Beecham	UK (England & Wales)
Sergei	Belikov	Russia
Andy	Campbell	Ireland
Erwan	Duhamel	France
Sarah	Clarke	UK (Scotland)
Leire	Ibaibarriaga (on line)	Spain
Svein	Iversen	Norway
Jan Arge	Jacobsen	Faroe
Ciarán	Kelly	Ireland
Jacques	Massé	France
Alberto	Murta	Portugal
Leif	Nottesdad	Norway
Jan Jaap	Poos	The Netherlands
Fernando	Ramos	Spain
Beatriz	Roel (Chair)	UK (England & Wales)
Begoña	Santos	Spain
John	Simmonds	UK (Scotland)
Alexandra	Silva	Portugal
Dankert	Skagen	Norway
Per	Sparre	Denmark
Andres	Uriarte	Spain
Dimitri	Vasilyev	Russia

1.3 Quality and Adequacy of Fishery and Sampling data

1.3.1 Sampling Data from Commercial Fishery

The working group again carried out a brief review of the sampling data and the level of sampling on the commercial fisheries. Sampling coverage for mackerel continued to increase and now stands at 85%, exceeding the long-term average (82%). Sampling intensity has also increased, reversing the trend noted in the 2006 report. The proportion of the horse mackerel catch sampled has decreased slightly to 72% and there remain divisions where sampling is considered inadequate.

Sardines continue to be well sampled with samples now provided by Portugal, Spain and France. However, to facilitate age-structured assessment, samples should be obtained from all countries with catches of sardines (England & Wales, Ireland and The Netherlands). The EU Data Collection Regulation (DCR) does not require sampling of sardines north of VIIIc.

Anchovy sampling continues at a high level. A short summary of the data, similar to that presented in recent Working Groups is shown in the relevant stock sections. Sampling programmes by EU countries have been partially funded under the EU sampling directive and this has contributed to the improvement in sampling levels. Under the DCR fish in EU countries are to be sampled in the country into which they are landed.

The sampling programmes on the various species are summarised as follows:

Mackerel

YEAR	TOTAL CATCH (WG CATCH)	% CATCH COVERED BY SAMPLING PROGRAMME*	NO. SAMPLES	NO. MEASURED	NO. AGED
1992	760,000	85	920	77,000	11,800
1993	825,000	83	890	80,411	12,922
1994	822,000	80	807	72,541	13,360
1995	755,000	85	1,008	102,383	14,481
1996	563,600	79	1,492	171,830	14,130
1997	569,600	83	1,067	138,845	16,355
1998	666,700	80	1,252	130,011	19,371
1999	608,928	86	1,109	116,978	17,432
2000	667,158	76	1,182	122,769	15,923
2001	677,708	83	1,419	142,517	19,824
2002	717,882	87	1,450	184,101	26,146
2003	617,330	80	1,212	148,501	19,779
2004	611,461	79	1,380	177,812	24,173
2005	543,486	83	1,229	164,593	20,217
2006	472,652	85	1,604	183,767	23,467

***Percentage related to working group catch.**

In 2006, 85% of the total catch was covered by national sampling programmes, a small increase on the figure for the previous year (83%). The corresponding sampling intensity has increased significantly with the highest number of samples on record. Denmark, the Faroe Islands, Norway, Portugal, Russia and Spain all sampled 100% of their catch with Germany, Ireland and Scotland achieving rates over 85%. As in previous years, the Netherlands and England & Wales continue to sample smaller fractions (62% and 13% respectively). The remaining countries (of which France, Iceland, Northern Ireland, Sweden and Poland had significant catches) failed to sample any catches.

The sampling summary of the mackerel catching countries is shown in the following table:

COUNTRY	OFFICIAL	% CATCH	NO.	NO.	NO. AGED
Belgium	3	0	0	0	0
Denmark	24,219	99	20	1,306	790
Faroe Islands	12,067	99	2	216	126
France	14,953	0	0	0	0
Germany	16,608	85	56	25,502	2,478
Guernsey	10	0	0	0	0
Iceland	4,222	0	0	0	0
Ireland	40,664	94	40	7,485	3,142
Jersey	8	0	0	0	0
Lithuania	95	0	0	0	0
Netherlands	24,157	62	49	1,225	1,225
Norway	121,993	100	460	37,907	2,721
Poland	1,368	0	0	0	0
Portugal	2,620	100	245	20,405	1,007
Russia	33,580	100	139	35,330	1,445
Spain	54,136	100	485	34,462	5,025
Sweden	3,209	0	0	0	0
UK (England & Wales)	7,723	13	19	1,861	1,225
UK (Northern Ireland)	8,369	0	0	0	0
UK (Scotland)	79,723	87	89	18,068	4,283
Total	449,728	85	1,604	183,767	23,467

*** Percentage based on Working Group catch**

The following table describes the mackerel sampling levels by relating numbers measured and aged to the size of the catch in each ICES division. Areas where insufficient sampling was carried out include Va (1,741t), VIIIa (8,097t) and VIIId (566t). This was also the case with VIIIa,d in the previous year. No sampling was carried out in areas IIIb and VIIa,c,g , although the corresponding catches were minor.

AREA	OFFICIAL	WG	NO	NO	NO	NO AGED/	NO
IIa	42,376	42,376	196	1,808	39,017	40	920
IIIa	1,381	1,381	47	147	3,405	110	2470
IIIb	1	1	0	0	0	0	0
IVa	190,169	204,481	458	7,564	50,926	40	270
IVb	259	256	6	150	150	580	580
IVc	229	193	1	25	25	110	110
Va	1,741	1,741	0	0	0	0	0
Vb	2,599	2,599	4	63	916	20	350
Via	103,604	94,108	87	4,248	23,589	40	230
VIIa	11	11	0	0	0	0	0
VIIb	14,922	15,503	11	1029	3647	70	240
VIIc	45	45	0	0	0	0	0
VIId	5,520	17,011	14	338	364	60	70
VIIe	597	728	5	125	125	210	210
VIIf	972	972	19	1,225	1,861	1,260	1,920
VIIg	16	16	0	0	0	0	0
VIIh	157	5,324	3	178	348	1,140	2,220
VIIj	17,424	18,397	20	435	4,465	20	260
VIIIa	8,097	7,642	4	100	100	10	10
VIIIb	6,292	6,292	73	1,245	4,116	200	650
VIIIcE	35,793	35,793	271	2,436	18,740	70	520
VIIIcW	7,313	7,313	65	824	5,675	110	780
VIIId	566	824	0	0	0	0	0
IXaN	7,025	7,025	75	520	5,893	70	840
IXaCN	2,620	2,620	245	1,007	20,405	380	7,790
Total	449,728	472,652	1,604	23,467	183,767	50	410

*** Based on official catches**

Horse Mackerel

The following table shows a summary of the overall sampling intensity on horse mackerel catches in recent years:

YEAR	TOTAL	% CATCH COVERED BY	NO.	NO.	NO. AGED
1992	436,500	45	1,803	158,447	5,797
1993	504,190	75	1,178	158,954	7,476
1994	447,153	61	1,453	134,269	6,571
1995	580,000	48	2,041	177,803	5,885
1996	460,200	63	2,498	208,416	4,719
1997	518,900	75	2,572	247,207	6,391
1998	399,700	62	2,539	245,220	6,416
1999	363,033	51	2,158	208,387	7,954
2000	272,496	56	1,610	186,825	5,874
2001	283,331	64	1,502	204,400	8,117
2002	241,336	72	1,768	235,697	8,561
2003	241,830	79	1,568	200,563	12,377
2004	216,361	68	1,672	213,066	16,218
2005	234,876	78	2,315	241,629	15,866
2006	215,277	75	1,627	231,549	12,214

*** Percentage related to Working Group catch**

There was a minor decrease in overall sampling for horse mackerel from 2005 to 2006. The large numbers of measured fish are as usual due to intensive length measurement programs in the southern areas. In 2006, 75% of the horse mackerel measured were from Division IXa.

Countries that carried out sampling were Germany which covered 49% of the catches while Denmark, Ireland, the Netherlands, Norway, Portugal and Spain covered 63%-100% of their catches. France and Lithuania took considerable catches without providing any samples or data to the Working Group. The lack of sampling data for relatively large portions of the horse mackerel catches continues to have a serious effect on the accuracy and reliability of the assessment and the Working Group remain concerned about the low number of fish that are aged. It is the first time Lithuania has reported horse mackerel catches. Their main catches were taken in Sub Divisions IVb,c, VIa, and VIIb,h.

The following table shows the most important horse mackerel catching countries and the summarised details of their sampling programme in 2006:

COUNTRY	OFFICIAL	% CATCH	NO.	NO.	NO. AGED
Belgium	4	0	0	0	0
Denmark	9,696	63	4	205	205
Faroe Islands	1,205	0	0	0	0
France	14,665	0	0	0	0
Germany	12,454	49	53	16,724	1,904
Ireland	28,856	96	40	6,396	2,277
Lithuania	9,206	0	0	0	0
Netherlands	64,416	84	68	1,700	1,700
Norway	27,227	99	36	2,071	194
Portugal	14,606	100	845	156,499	1,809
Spain	23,829	97	581	47,954	4,125
Sweden	491	0	0	0	0
UK (England &Wales)	4,179	0	0	0	0
UK (Northern Ireland)	224	0	0	0	0
UK (Scotland)	770	0	0	0	0
Total (WG catch)	215,277	72	1,627	231,344	12,009

*** Percentage based on Working Group catch**

The following tables have information broken down by horse mackerel stock.

The horse mackerel sampling intensity for the Western stock was as follows:

COUNTRY	OFFICIAL	% CATCH	NO.	NO.	NO. AGED
Denmark	8,353	72	4	205	205
Faroe Islands	1,205	0	0	0	0
France	11,034	0	0	0	0
Germany	10,863	50	35	10,344	1,365
Ireland	26,779	96	38	6,057	2,124
Lithuania	6,829	0	0	0	0
Netherlands	37,130	76	56	1,400	1,400
Norway	27,114	100	36	2,071	194
Spain	13,878	100	399	30,534	3,554
UK (England &Wales)	3,583	0	0	0	0
UK (Northern Ireland)	224	0	0	0	0
UK (Scotland)	469	0	0	0	0
Total (WG catch)	155,094	73	568	50,611	8,842

*** Percentage based on Working Group catch**

The horse mackerel sampling intensity for the North Sea stock (IVb,c, VIId and the eastern part of IIIa) was as follows:

COUNTRY	OFFICIAL	% CATCH	NO.	NO.	NO. AGED
Belgium	4	0	0	0	0
Denmark	1,341	0	0	0	0
France	4,380	0	0	0	0
Germany	1,691	39	18	6,380	539
Ireland	2,077	100	2	339	153
Lithuania	2,377	0	0	0	0
Netherlands	27,284	99	12	300	300
Norway	113	0	0	0	0
Sweden	491	0	0	0	0
UK (England &Wales)	596	0	0	0	0
UK (Scotland)	300	0	0	0	0
Total (WG catch)	35,626	70	32	7,019	992

*** Percentage based on Working Group catch**

The horse mackerel sample intensity is higher than usual and is caused by the Netherlands which has an extensive sampling program and takes 77% of the catches.

The horse mackerel sampling intensity for the Southern stock (areas) was as follows:

COUNTRY	OFFICIAL	% CATCH	NO.	NO.	NO. AGED
Portugal	14,607	100	845	156,499	1,809
Spain	9,950	93	182	17,420	571
Total (WG catch)	24,557	97	1,027	173,919	2,380

*** Percentage based on Working Group catch**

The horse mackerel sampling intensity by division was as follows:

AREA	OFFICIA	WG	NO	NO	NO	NO AGED/	NO
IIa	30	30	0	0	0	0	0
IIIa	634	634	0	0	0	0	0
IIIc	465	465	0	0	0	0	0
IVa	32,078	29,812	38	347	2,410	11	80
IVb	3,009	1,580	0	0	0	0	0
IVc	22,348	6,418	2	50	50	7	7
Va	0	0	0	0	0	0	0
Vb	1	1	0	0	0	0	0
VIa	16,055	15,751	34	1,888	6,603	119	419
VIIa	22	22	0	0	0	0	0
VIIb	29,801	23,944	22	1,046	3,406	43	142
VIIc	633	613	0	0	0	0	0
VIId	9,173	23,868	28	789	6,630	33	277
VIIe	12,322	17,107	24	875	2,810	51	164
VIIf	2	2	0	0	0	0	0
VIIg	76	76	0	0	0	0	0
VIIh	20,608	25,747	10	355	355	14	14
VIIj	9,902	10,530	28	488	2,308	46	219
VIIIa	14,422	18,212	11	342	2.424	18	133
VIIIb	1,922	1,747	40	620	2,241	355	1282
VIIIcE	5,641	5,641	225	2,125	15,910	377	2823
VIIIcW	7,829	7,829	134	809	12,383	103	1581
VIIId	296	693	4	100	100	144	144
IXaN	9,288	9,288	182	571	17,420	61	1875
IXaCN	6,239	6,239	605	1,809	86,765	290	13,906
IXaCS	5,454	5,454	86	0	25,109	0	4,603
IXaS	3,576	3,576	154	0	44,625	0	12,479
Total	211,824	215,277	1,627	12,009	231,549	56	1,075

*** Based on official catches**

Sardine

The following table shows a summary of the overall sampling intensity over recent years on the catches of the sardine stock in VIIIc and IXa.

YEAR	TOTAL	% CATCH COVERED BY	NO.	NO.	NO. AGED
1992	164,000	79	788	66,346	4,086
1993	149,600	96	813	68,225	4,821
1994	162,900	83	748	63,788	4,253
1995	138,200	88	716	59,444	4,991
1996	126,900	90	833	73,220	4,830
1997	134,800	97	796	79,969	5,133
1998	209,422	92	1,372	123,754	12,163
1999	101,302	93	849	91,060	8,399
2000	91,718	94	777	92,517	7,753
2001	110,276	92	874	115,738	8,058
2002	99,673	100	814	96,968	10,231
2003	97,831	100	756	93,102	10,629
2004	91,886	100	932	112,218	9,268
2005	97,345	100	925	116,400	9,753
2006	87,848	100	927	122,185	9,165

- Percentage related to Working Group catch

COUNTRY	OFFICIAL CATCH	% CATCH SAMPLED*	NO. SAMPLES	NO. MEASURED	NO. AGED
Portugal	55,011	100	486	67,724	5,466
Spain	32,837	100	441	54,461	3,699
France	28,844	55.1	40	2,786	1,535
Ireland	9,156	0	0	0	0
The Netherlands	4,523	0	0	0	0
UK (England & Wales)	2,800	0	0	0	0
Germany	325	3.7	6	393	322
Total	133,171	78.1	973	125,364	12,022

*** Percentage based on Working Group catch**

Anchovy

The following table shows a summary of the overall sampling intensity over recent years on the catches of the anchovy stock in divisions VIII and IXa.

YEAR	TOTAL	% CATCH COVERED BY	NO.	NO.	NO. AGED
1992	40,800	92	289	17,112	3,805
1993	39,700	100	323	21,113	6,563
1994	34,600	99	281	17,111	2,923
1995	42,104	83	?	?	?
1996	38,773	93	214	17,800	4,029
1997	27,440	76	258	18,850	5,194
1998	31,617	100	268	15,520	5,181
1999	40,156	100	397	33,778	10,227
2000	39,497	99	209	18,023	4,713
2001	49,247	58	317	28,615	4,683
2002	26,313	94	216	45,909	4,685
2003	15,864	96	205	22,081	5,324
2004	22,200	97	304	22,436	6,553
2005	5,643	98	145	8,918	3,601
2006	6,243	98	89	8,905	4,139

*** Percentage related to Working Group catch**

The sampling programmes for France and Spain in area VIII in 2006 were as follows:

COUNTRY	DIVISIO	OFFICIAL	% CATCH COVERED BY	NO	NO	NO AGED
France	VIIIb	912	100	10	1,220	1,040
Spain	VIIIb	430	100	25	1,572	634
Spain	VIIIc	410	100	13	1,087	696
Total	VIII	1,752	100	48	3,879	2,340

Sampling coverage for anchovy and area VIII appears to be satisfactory.

The sampling programmes for Portugal and Spain in division IXa in 2006 were as follows:

COUNTRY	DIVISIO	OFFICIAL	% CATCH COVERED BY	NO	NO	NO AGED
Portugal	IXa	108	0	0	0	0
Spain	IXa	4,383	100	41	5,026	1,799
Total	IXa	4,491	97.3	41	5,026	1,799

As in 2005, no catches of anchovy in division IXa from Portugal were sampled for length and age in 2006.

1.3.2 Catch Data

Recent working groups have on a number of occasions discussed the accuracy of the catch statistics and the possibility of large scale underreporting or species and area misreporting. These discussions applied particularly to mackerel and horse mackerel in the northern areas. The working group considers that the best estimates of catch it can produce are likely to be an underestimate.

For mackerel and horse mackerel it was concluded that in the southern areas the catch statistics appear to be satisfactory.

For sardines and adult anchovy the WG assumption is that the landings figures are not significantly under reported.

1.3.3 Discards

In pelagic fisheries discarding occurs in a sporadic way compared to demersal fisheries. This is because the nature of pelagic fishing is to pursue schooling fish, creating hauls with low diversity of species and sizes and consequently often extreme fluctuation in discard rates (100% or null discards). Extreme discards occur especially during ´slippage´ events, when the entire catch is released. Mean reasons for ´slipping´ are daily or total quota limitations, illegal size and mixture with unmarketable bycatch. Quantifying such discards at a population level is extremely difficult as they vary considerably between years, seasons, species targeted and geographical region.

Discard estimates of pelagic species from pelagic fisheries and demersal fisheries have been published by several authors. Discard percentages of pelagic species from demersal fisheries were estimated between 3% to 7% (Borges et al., 2005) of the total catch in weight, while from pelagic fisheries were estimated between 3% to 17% (Pierce et al. 2002; Hofstede and Dickey-Collas 2006, Dickey-Collas and van Helmond 2007, Ulleweit & Panten 2007). Slipping estimates has only been published for the Portuguese purse seine fishery targeting sardine, with values at around 70% of the total catch (Stratoudakis et al., 2002) and recently for the Dutch freezer trawler fleet, with values at around 10% in numbers (Dickey-Collas & van Helmond 2007). Nevertheless, the majority of these estimates were associated with very large variances and composition estimates of ´slippages´ are liable to strong biases and are therefore open to criticism.

Detailed information on species composition (including non-commercial species) is available for the Dutch and German freezer trawler fleet (Dickey-Collas & van Helmond 2007, Ulleweit & Panten 2007). In the Dutch data (Dickey-Collas & van Helmond 2007) the most important commercial species discarded is mackerel, accounting for 39% of total pelagic discards. It is important to note that discards of mackerel are also the consequence of fisheries targeted at other species (e.g. horse mackerel and herring targeted fishery). Other important discarded species are herring (18%), horse mackerel (15%) and blue whiting (8%). The most important non-commercial species is boarfish accounting for 5% of the discards. Although larger animals (e.g. sea turtles, cetaceans and birds) are occasionally being caught, population or fleet level estimates are not available (Pierce et al. 2002).

Discard estimates for some countries for mackerel, horse mackerel and sardine were provided to the working group. These data included sampling levels and raised discard estimates, which can be raised by trips or total landings. The exact sampling and raising procedures used are unclear and differ between different datasets, which complicates comparison. In addition, the associated sampling levels are low, and therefore the data should be treated with caution. The necessary steps involved in providing discard data to stock assessments require further research.

Because of the potential importance of significant discards levels on pelagic species assessments the **Working Group again recommends that observers should be placed on board vessels in those areas in which discarding occurs, and existing observer programmes should be continued. Furthermore agreement should be made on sampling methods and raising procedures to allow comparisons and merging of dataset for assessment purposes.**

Mackerel

The Netherlands, Germany and Scotland provided 2006 discard data on mackerel to the working group. Age and length disaggregated data was available from the Scottish fishery in the first quarter in area IVa and VIa (almost 100% of total catches were from these areas), the German freezer trawler fishery in the first and fourth quarter in area IVa, VIa and VII.and the Dutch freezer trawler fishery in all quarters. The estimated mackerel landings of Scotland, Netherlands and Germany represent approximately 40% of the total landings. For 2006 the total mackerel discards estimated for the Dutch, German and Scottish fishery were approximately 7,265t (se = 1,763), 959t and 10,932t, respectively. Discard percentages of the total catch varied between 6 and 20%. It is important to note that such estimates are liable to large levels of imprecision and comparisons between fleets is complicated as a result of different raising methods and sampling procedures used.

Horse Mackerel

In the past discards of juvenile horse mackerel have been thought to constitute a problem. However, in recent years a targeted fishery has developed on juveniles, including 1-year old fish. Therefore discarding of juveniles is now thought to be small. In 2006 the Netherlands and Germany estimated a discard of 764t and 59 t, respectively, accounting for only 1% or less of the national landings. Horse mackerel catches of the Netherlands and Germany represent respectively 28% and 8% of the total catch.

Sardine

A discard programme, sampling purse seine vessels, has started in Portugal. Nevertheless, discard estimates are still not available to the working group. There is some slipping in northern Portugal (division IXa) but mostly in years with high recruitment. During a 12 week lasting study, the sampled fleet (nine vessels) landed 2196 t and released an estimated 4979 t (CV 33.6%) (Stratoudakis & Marcalo 2002). More than 95% of the total catch was sardine.

Both Germany and the Netherlands have provided discard estimates of sardine for the area of VII and VIIIa. However, the German and Dutch catch data is not in the assessment area of sardine.

Anchovy

An onboard observer programme was conducted in 2005 to estimate discards by the Spanish fisheries (trawl, purse seine and artisanal) in the Gulf of Cadiz (see Section 11.2.3 in WGMHSA 2006). Preliminary discard estimates for purse seine vessels show that 10.1% of anchovy catch in numbers and 10.7% in weight is discarded. Such ratios should be, however, considered with caution given the extremely high CV associated to the estimates (CV= 157.2 for discarded catch in weight). There are no recent estimates of discards in the French and Spanish anchovy fishery in the Bay of Biscay. However given the high economic value of anchovy in recent years, discard levels at least in the French fisheries (Jacques Massé pers. comm.) are thought to be very low. In some cases slipping of low sized anchovy occurs, but this often results in the vessel to relocate to other areas.

1.3.4 Age-reading

Reliable age data are an important pre-requisite in the stock assessment process. The accuracy and precision of these data, for the various species, is kept under constant review by the Working Group.

Mackerel

It is now six years since the last age reading workshop and, therefore, **the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine, and Anchovy again recommends that institutes examine their otolith preparation technique for mackerel before a new mackerel otolith exchange be carried out to evaluate the otolith processing techniques of all institutes that are providing age data to this Working Group.**

Horse mackerel

An exchange and a workshop on age reading were carried out in the Netherlands in 2006. Experienced readers and trainees participated in the exchange and in the workshop. All countries providing age reading data to the WGMHSA were represented in both the exchange and the workshop by an experienced reader. Portugal, Germany and the Netherlands provided otolith sets for the exchange. The sets represented different otolith preparation methods and stocks. Two sets consisted of otoliths from the extremely strong 1982 year-class and hence the age is considered to be known (with a certainty of approximately 95%). One set focused on the younger fish which were expected to present problems based on the informal small-scale otolith exchange.

The experienced readers were accustomed to different otolith preparation methods and different growth patterns associated with the different stocks. Generally, the readers had more difficulty if they were reading material they were not accustomed to. Horse mackerel is regarded to be a difficult species to age and this is reflected by the results of the exchange. The agreement between the experienced readers was low, especially for otoliths from the Southern stock. For the sets including the 1982 year-class the agreement with the modal age was higher than with “true” age. Comparison with the “true” ages showed an overall tendency to underestimate the age.

For some sets, the images of the sectioned otoliths were digitised and annotated by the readers participating in the exchange. During the workshop these annotated images were used to discuss differences in interpretation. A great deal of attention was paid to the interpretation of the first annuli, both in young fish as well as in older fish. This point appeared to be the mayor cause of differences in interpretation. In some otoliths split rings or the interpretation of the edge of the otoliths caused problems. All these features were discussed and eventually consensus was reached for all otoliths put up on the screen.

For a small set of the Southern stock otoliths provided by Portugal, images of sectioned otoliths were digitised during the meeting. These images were discussed in the group. In some cases consensus could be reached on how to interpret the otolith, however in other cases it seemed to be impossible to age the otolith. Ageing of the Southern stock otoliths appeared to be less difficult when using broken-burnt material in stead of (images of) sectioned otoliths.

Most of the trainees only participated in the workshop. Comparison of their results for their first reading and the results of the consecutive second age reading showed a tremendous improvement in both accuracy as well as precision.

Sardine

A workshop on sardine age reading took place in June 2005 to discuss the results of an otolith exchange carried out during 2004. The report is available under http://www.ices.dk/reports/acfm/pgccdbs/pil.agewk2005.pdf. The otolith exchange and workshop aimed to evaluate readers' agreement and ageing precision, to assess the extent of ageing difficulties previously identified (identification of the first annual ring and ageing of older individuals) and to propose guidelines for their minimization. The consistency of age readings in time (comparison of the 1980s, 1990s and 2004) and in space (comparison with Mediterranean and northwest African areas) was also explored and the consequences of the assumed birth date for the estimation of growth were discussed. In addition, profiting from the experience of the workshop attendants, biological sampling methodologies (assignment of sexual maturity stages, visceral fat and stomach condition) were listed and discussed and standard protocols have been recommended.

Anchovy

Previous to 2005 different exchanges and workshops took place (Astudillo et al. 1990 & Villamor et al. WD 1996, Garcia 1998, Uriarte 2002).

In 2005 an otolith exchange programme for anchovy from the Bay of Biscay took place followed by a workshop in 2006 (WD Uriarte 2007). For the findings on the 2005 exchange programme refer to the WGMHSA report 2006. The major conclusions of the workshop were:

- The overall level of agreement and precision in anchovy age reading determinations were satisfactory with an average agreement of 92.7 % and a CV of 9.2%. CVs were on average smaller than 15% for any age, although individual CVs for ages or readers might be as high as 30-35%.

- The percentage of agreement of the new readings and the coefficient of determination are similar to those achieved during the 2005 otolith exchange program.

- In the 2006 otolith workshop as in the 2005 exchange program the difficulties become more relevant for the otoliths from the second half of the year (Percentage of agreement of 90.7 % and CV of 14.1%).

- Major difficulties encountered refer to the discrimination between true winter rings from summer and autumn checks: There are marks after the first winter ring which could be interpreted as checks formed during summer or autumn time, C15 or C18, or as additional winter rings. This is hard to be elucidated for fish caught at summer and autumn time when the expected total annual growth is not yet achieved and it is difficult of being assessed. This makes it easy to confound fish of age 1 with older. In these circumstances the strength of the marks observed and their distance to the first winter ring become the criteria which can be applied.

- Spring otoliths, prior to the start of the annual white growth band, are easier to be aged.

- Future research is needed to get to a better discrimination between juveniles and older fishin the second half of the year.

- The next workshop on anchovy otoliths is suggested to take place in 4 years, preceded by a new exchange program.

1.3.5 Biological data

The main problems in relation to other biological data identified by the Working Group are listed by species.

Mackerel

There is inadequate sampling for stock weights during the spawning season. This applies particularly to the North Sea, where insufficient fish were sampled for the 9+ group.

Horse Mackerel

WGMEGS investigated the possibility to apply feeding state and lipid content as proxies for fecundity. Samples were collected during the 2004 egg survey and showed a constant decline in lipid content suggesting that the peak occurred prior to sampling. If lipid content is to be used as an indication of fecundity, sampling should be carried out during the peak period. For this reason samples were collected both prior to and during the 2007 survey. Results will be available and discussed on the next WGMEGS meeting in April 2008.

Sardine

There are no problems with regard to biological data for sardine.

Anchovy

There are no problems with regard to biological data for anchovy.

1.3.6 Quality Control and Data Archiving

Current methods of compiling fisheries assessment data. Information on official, area misreported, unallocated, discarded and sampled catches have again this year been recorded by the national laboratories on the WG-data exchange sheet (MS Excel; for definitions see text table below) and sent to the species co-ordinators. Co-ordinators collate data using the latest version of *sallocl* (Patterson, 1998) which produces a standard output file (*Sam.out*). However only sampled, official, WG catch and discards are available in this file. Efforts were made to use the Intercatch system this year in parallel to the existing system on a trial basis (see Sec.1.3.7 for details).

There are at present no defined criteria on how to allocate samples of catch numbers, mean length and mean weight at age to unsampled catches, but the following general process is implemented by the species co-ordinators. Searches are made for appropriate samples by gear (fleet), area, and quarter, if an exact match is not available the search will move to a neighbouring area, if the fishery extends to this area in the same quarter. More than one sample may be allocated to an unsampled catch, in this case a straight mean or weighted mean of the observations may be used. If there are no samples available the search will move to the closest non-adjacent area by gear (fleet) and quarter, but not in all cases. For example in the case of NEA mackerel samples from the southern area are not allocated to unsampled catches in the western area. It would be very difficult to formulate an absolute definition of allocation of samples to unsampled catches which was generic to all stocks, however full documentation of any allocations made are stored each year in the data archives (see below). It was noted that when samples are allocated the quality of the samples may not be examined (i.e. numbers aged) and that allocations may be made notwithstanding this. The Working Group again encourages national data submitters to provide an indication of what data could be used as representative of their unsampled catches. Definitions of the different catch categories as used by the WGMHSA:

Official Catch	Catches as reported by the official statistics to ICES
Unallocated Catch	Adjustments to the official catches made for any special knowledge about the fishery, such as under- or over-reporting for which there is firm external evidence. (can be negative)
Area misreported Catch	To be used only to adjust official catches which have been reported from the wrong area. (can be negative). For any country the sum of all the area misreported catches should be zero.
Discarded Catch	Catch which is discarded
WG Catch	The sum of the 4 categories above
Sampled Catch	The catch corresponding to the age distribution

Quality of the Input data. Primary responsibility for the accuracy of national biological data lies with the national laboratories that submit such data. Each species co-ordinator is responsible for combining, collating, and interpolating the national data where necessary to produce the input data for the assessments. A number of validation checks are already incorporated in the data submission spreadsheet currently in use, and these are checked by the co-ordinators who in the first instance report anomalies to the laboratory which provided the data.

The working group acknowledges the effort some members have made to provide “corrected” data, which in some cases differ significantly from the officially reported catches. Most of this valuable information is gathered on the basis of personal knowledge of the fishery and good relations between the responsible scientist and the fishermen. The WG is aware of the problem that this knowledge might be lost if the scientist resigns, and asks the national laboratories to ensure continuity in data provision. In addition the working group recognises and would like to highlight the inherent conflict of interest in obtaining details of unallocated catches by country and increasing the transparency of data handling by the Working Group. The Working group is unsure of how this issue is handled in InterCatch, and would appreciate information on such from the secretariat.

Overall, data quality has improved and sampling deficiencies have been reduced compared to earlier years, partly due to the implementation of the EU sampling regulation for commercial catch data. However, some nations have still not or inadequately aged samples. Others have not even submitted any data, so only catch data from Eurostat are available, which are not aggregated quarterly but are yearly catch data per area.. Tab. 1.3.6.1 gives an overview on the availability and format of data provided to the species coordinators. Missing data or a lack of age samples are regarded to be problematic for France, Iceland, Northern Ireland, Poland and Sweden in the case of Mackerel; UK, France, the Faroes, Lithuania (reporting for the first time catches of 9206t) and Sweden in the case of Horse Mackerel; England and Ireland in the case of Sardine, and Portugal in the case of Anchovy. However, under the EU directive for sampling of commercial catch the responsibility lies within the member state where the catch is landed. This would imply for instance that the Netherlands should be sampling French, UK and German mackerel and horse mackerel catches landed into the Netherlands. For sardine in the northern areas in VIIIa and VII some countries provided catch data but the sampling is still poor. This might become problematic if catches in this currently unregulated fishery continue to rise. For anchovy, a complex method of catch sampling based on stratifying by commercial size-categories is used. Although a documented programme such as *sallocl* is not used to combine these data it was felt that such a programme would not improve the quality of this data.

The Working Group documents sampling coverage of the catches in two ways. National sampling effort is tabulated against official catches of the corresponding country (section 1.3.1). Furthermore tables showing total catch in relation to numbers of aged and measured fish by area give a picture of the quality of the overall sampling programme in relation to where the fisheries are taking place. These tables are shown in section 1.3.1 as text tables under Mackerel and Horse Mackerel.

Transparency of data handling by the Working Group and archiving past data. The current practice of data handling by the working group has been the same for a number of years. Data received by the co-ordinators which is not reproduced in the report is available in a folder called “archives” under the working group and year directory structure. This archived data contains the disaggregated dataset, the allocations of samples to unsampled catches, the aggregated dataset and (in some cases) a document describing any problems with the data in that year.

Prior to 1997, most of the data was handled in multiple spreadsheet systems in varying formats. These are now stored in the original format, separately for each stock and catch year. Table 1.3.6.2 gives an overview on data collected up to and including Sept. 2007. It is the intention of the Working group that in the interim period until the proposed standard database is developed (see below) the previous years archived data will be copied over to the current year directory and updated at the working group. Thus the archive for each year will contain the complete dataset available. Further, it should be backed up on Compact Disk/DVD. **The WG recommends again that archives folder should be given access only to designated members of the WGMHSA**, as it contains sensitive data.

The WG continues to ask members to provide any kind of national data reported to previous working groups (official catches, working group catches, catch-at-age and biological sampling data), to fill in missing historical disaggregated data. However, there was little response from the national institutes. **The WG recommends that national institutes increase national efforts to gain historical data, aiming to provide an overview which data are stored where, in which format and for what time frame.** The working Group still sees a need to raise funds (possibly in the framework of a EU-study) for completing the collection of historic data, for verification and transfer into digital format. This is particularly relevant given that for the 2005 mackerel assessment the time series had to be truncated due to poor data in the earliest years.

1.3.7 InterCatch

From the InterCatch website:

“InterCatch is a web-based system, to which fish stock coordinators and national data submitters from the North East Atlantic can have access. In InterCatch national institutes can upload national fish catches per area per time period per fleet etc. The data can be checked at any level. Fish stock coordinators can allocate sampled catch data to unsampled catches and aggregate all catch data. The aggregated output files can then be downloaded to the stock coordinators workstation. The files will be used as input for the stock assessment models.

InterCatch is developed to ease data handling, standardise procedures and calculations, remove errors and document the national data and process done at ICES level. The data in InterCatch are used as a basis for advice to the European Commission, NASCO and NEAFC. InterCatch is part of the ICES quality assurance program. “

Following on from the AMAWGC 2007 report, in which it was decided that all stocks due for assessment in working groups in 2007 should use the InterCatch application in parallel with existing legacy systems for the purposes of comparing the results, stock coordinators at the working group conducted a review of the use of InterCatch.

Primarily due to limited time resources prior to the working group and the significant amount of time required to repeat stock data coordination in InterCatch, several stocks had not been processed by the start of the meeting. However, some progress was made during the meeting and national catch data for four of the stocks assessed during the working group were processed in the traditional way (using the sallocl application) and using InterCatch. The comparisons between the results available from InterCatch and sallocl are presented below for North East Atlantic Mackerel, Sardine, North Sea Horse Mackerel and Southern Horse Mackerel:

Average and maximum discrepancies between InterCatch and sallocl:

	NEA-MAC		**SAR-SOTH**		**HOM-NRTN**		**HOM-SOTH**	
Parameter	Avg. Disc.	Max. Disc.	Avg. Disc.	Max. Disc.	Avg. Disc.	Max. Disc.	Avg. Disc.	Max. Disc.
Caton	0.00%	N/A	0.00%	N/A	0.00%	N/A	0.00%	N/A
Canum	0.04%	0.11%	0.09%	0.28%	0.04%	0.21%	0.00%	0.00%
Weca	0.16%	-1.01%	0.05%	0.13%	0.02%	0.06%	0.00%	0.03%

Good agreement was obtained for the limited number of stocks examined. A proportion of the observed discrepancy can be attributed to the varying accuracy to which the different applications report the results. For stocks where no allocations are required (e.g. Sardine), the sallocl application requires a ‘dummy’ allocation to be made in order for the program to run successfully. While a very small value is used for the allocation, it is likely to have some impact on the results and so will add to discrepancy when compared with the InterCatch results.

While the potential for a system such as InterCatch is recognized, the stock coordinators feel that there are a number of issues that require attention before InterCatch is used as the only means of stock coordination.

- While the sallocl application produces output in a fixed format, it is readily convertible into the data tables that are routinely contained in the report produced by the working group. While InterCatch has the potential to produce reports in a convenient format for the report, this functionality has not been implemented to date. Examples of the outputs required for the working group report include

  1. numbers, weights and lengths at age by country, area and quarter
  2. total samples, numbers measured, numbers aged and the percentage of catch sampled by country and area

- Catch data is traditionally supplied to the stock coordinators as an Excel spreadsheet with a fixed format (the exchange format). Currently, InterCatch uses only a subset of the data provided in the spreadsheet. The additional data (e.g. catch by statistical rectangle) forms a valuable source of information and can also be used for quality control.
- The exchange format provides several checks and balances. Errors are commonly highlighted and corrected prior to the data being processed. InterCatch will need to provide a similar level of validation in the interest of data integrity.
- InterCatch requires inputs in a form that is not readily available from the current data format meaning that data submitters need to (usually manually) create these files. This is not a feasible solution for larger stocks. An application has been developed for conversion of Excel sheets in the exchange format to InterCatch input files.

- Currently the InterCatch system identifies a stock as a collection of data for a particular species in a set of areas/divisions and subdivisions. However, there is no provision for a temporal element. This causes problems for stocks such as Western Horse Mackerel and North Sea Horse Mackerel where catches in quarters 1 and 2 in area IVa are considered part of the North Sea Horse Mackerel and catches in quarters 3 and 4 are assigned to the Western Horse Mackerel stock.
- For large stocks the allocation process can be time consuming.
- Individual institute directors need to provide resources to stock coordinators to carry out tasks associated with InterCatch.

1.4 Checklists for quality of assessments

To further continue the systematic documentation of assessment procedures and quality, checklists as suggested by the HAWG (ICES 2000) were updated for mackerel and anchovy in Biscay and added for horse mackerel and Sardine (Tables 1.4.1-???)

1.5 Comment on update and benchmark assessments

For this year, ICES had scheduled a benchmark assessment for NEA mackerel, an update assessment for Sardine and Anchovy in Biscay, and all other assessments as experimental. It should be noted that the Update assessment for Sardine refers only to VIIIc and IXa. This is for a number of reasons but primarily as this is the only area where sufficient data exist. A brief overview is given below; details are given in the respective sections.

NEA mackerel: Benchmark: Catch and survey data were explored by means of the standard version of ICA, a version of ICA that uses Bayes estimation, AMCI and ISVPA. The performance of ICA is considerate adequate so, the other models were only used for purposes of data exploration. The models appeared sensitive to assumptions regarding terminal selection therefore those were explored extensively. Assumptions regarding the length of the separable period and survey weight were revised. Further exploration of the effect of under reported catches is provided in the report.

North Sea horse mackerel*:* Exploratory: The data are sparse and of variable quality. This year, the IBTS survey was again examined. The analysis of the data reveal that they are insufficient for an age based analytical assessment. Length based assessments based on survey data may still be explored, but the necessary data are not available to the WG. This stock assessment may be more productively explored in SGASAM.

Western horse mackerel: Exploratory. The historic catch data are dominated by the very strong 1982 year class going through the fishery. Catch data was explored by means of a modified SAD assessment which accounts for the age structure in population in the relationship between the egg abundance and the SSB. This has helped to scale the assessment.

Southern horse mackerel*:* Exploratory: The AMCI approach required strong conditioning and gave unrealistic results. XSA was used in 2006 and did not converge. With the surveys combined a clear cohort signal was evident. This was explored along with the catch at age data in an ASAP model.

Sardine: Update assessment: Performed with the AMCI model. The assumptions on selectivity in the plus group were explored. Although much progress has been made with various technical aspects, some remain outstanding with the final assessment and will require further exploration.

Anchovy in VIIIb: Update assessment. Performed by means of a Bayesian biomass based model (BBM). The sensitivity of the Bayesian production model to informative priors, and the effect and consequences of treating both surveys as relative measures of stock abundance were explored.

Anchovy IXa*:* Exploratory: Seasonal separable model applied using acoustic surveys as tuning indices. The results are sensitive to the inclusion of a 2007 acoustic survey, which is only available as a biomass index.

1.6 The ICES stock handbook

As in previous years and due to time constraints, the working group could not begin to create the stock handbook for WGMHSA. Therefore the "static" parts of the report have remained in the body of the report. With the current workload, it is unlikely that the stock handbook can be created during the working group session and thus intersessional work is required to create the handbook.

1.7 Reference points relevant for WGMHSA

No revisions of the reference points have been considered at this meeting. An elaboration on reference points is given in the 2004 years WG report.

1.8 Long term management strategies

1.8.1 On the proposed management plan for Western horse mackerel

Western horse mackerel is a stock for which little information exists to annually evaluate its status using analytical stock assessments. The available data are both the age structured estimates of the catches and the tri-annual egg production estimates. However, this has not lead to accepted analytical stock assessments. The lack of an analytical assessment or forecast precludes the implementation of the implicit EU management strategy (ref to EU policy doc). The implicit strategy is to set TAC one year ahead, based on forecasted population size in an intermediate year, from an assessment in a given year. This TAC does not apply to the stock distribution area.

Given that F, SSB and recruitment are imprecisely estimated, ICES produced precautionary advice on the basis that catches should be constrained below 130,000 t. Advice augmented this by 20,000 t, corresponding to average landings from Division VIIIC, on account of the findings of Abaunza et al. (2003). These TACS are based on a yield per recruitment analysis that excluded the strong 1982 year class.

The Pelagic RAC has put forward a proposal for a management plan to the EU with the request to ask ICES to evaluate this plan. This management plan (Annex 4 to report) was developed in cooperation with an *ad hoc* group of scientists. Several manuscripts and a journal article exists (WD to this WG, Roel and De Oliveira, 2007), describing the rationale underlying the harvest control rule in the management plan. However, none of this work is referred to in the working document describing the proposed management plan. In order to perform a technical evaluation of the management plan, these documents were consulted.

For the numerical simulations to be a valid evaluation of the effectiveness of the harvest control rule (HCR) in the management plan, the recruitment, natural mortality, growth and maturity need to represent the full range of plausible dynamics, and the fishery dynamics need to be adequately represented. Further, it is assumed that the historic dynamics reflects the future dynamics.

The studies underlying the harvest control rule in the proposed management plan consist of a number of numerical simulations. These simulations were based on the 2006 SADVF stock assessment, from which historic stock dynamics were taken. The working group notes that there is a scaling issue with any form of analytical stock assessment on this stock. Uncertainty on the starting values is incorporated in the simulations, but it is unclear whether this fully deals with the problems of scaling in the assessment.

The scaling of the assessment is an issue if a quantitave forecast is to be based on the assessment result. However, because the management plan does not require quantitave forecasts, but is based on a risk evaluation of current SSB in relation to a historic level, the scaling issue may not affect the evaluation of the harvest control rule in terms of risk.

The simulations underlying the risk evaluation of the harvest control rule in the management plan have been tested for robustness on a number of assumptions.

- the amount of fishing in the juvenile area
- Bias in the assessment and implementation (to account for discards and historical TACs overshoot).

However, the working group notes that further robustness testing of error in maturity, and weights is needed for a full evaluation of the management plan.

The WG notes that the risk levels associated with the harvest control rules are sensitive to the accuracy of the catch data. The simulation result presented in the working document assumes that total removals from the stock are accounted for. In particular, the simulated catches are inclusive of discards. If unaccounted removals are made, in addition to the advised catches, then a central assumption of the work is violated. The WG notes that there is provision in the plan that the industry will partake in studies to demonstrate that there are no additional catches above the level of TAC. However, there is no mention of how the accuracy of these studies is ensured.

In case of the normal decision rule, the TAC will be set following the year of the most recent egg production survey. This implies that final egg estimates have to be provided to the body advising or setting the TACs. This TAC is set for three year. Because the TAC is set using the slope of the three previous egg survey estimates, there is a considerable lag between the information used in the rule, and the exploitation level decided in the rule. Although this is intrinsic to the calculation of the risk, this feature of the harvest control rule makes it very inert to abrupt changes in the stock dynamics.

By using only the egg survey estimates in the rule, no additional information is taken into account that may indicate changes in the relation between egg production and stock size. However, the analytical stock assessment method used to derive the stock dynamics indicate that there may have been a change in this relation in the history of the egg surveys. The egg estimates since 1995 correspond well with the catch information, but show a marked difference before. If the change in the correspondence between the stock size and the egg production in the historic period is because of the strong 1982 year class, there is a provision in the management plan to change the rules accordingly.

Results of the study underlying the evaluation of the strategy suggest that taking a larger portion of the TAC in the area occupied by juveniles increases the risk of impaired recruitment. It is important to notice that the management plan does not make provision for independent management for juvenile and adult fisheries.

It should be noted that the plan was evaluated in the absence of the 2007 egg production estimate, and it is not clear whether the inclusion of this information in the management plan would change the outcome of the results.

To conclude, the management plan proposal appears to follow the ICES precautionary approach in the fact that it has a risk of falling below $SSB_{1982} < 5\%$. However, the HCR was parameterized on the basis of the assessment model estimates of the current stock level (based on the 2006 assessment). In that sense, the assumption of a 7% increase in the base line TAC of 150,000 tonnes assumed in the HCR appears as a scaling issue that could be questionable. The outcomes of the evaluations depend strongly on the validity of the assumptions for the future stock dynamics. Also, the perception of risk is conditional on unchanged selectivity of the fishery and accuracy of the catch estimates. In this context, the management plan contains a general provision that the industry will partake in studies to demonstrate there are no additional catches above the TAC.

1.8.2 Special request on mackerel management plan

At the start of 2007 the EU requested ICES to evaluate multi annual plans for NEA mackerel in the form of the current coastal states agreement (which is applied annually). This request also suggested that ICES should examine other approaches on its own initiative. ICES decided to develop the evaluations of potential management plans through consultation with stakeholders in line with the recommendations of SGMAS (ICES 2007a) and appointed a group of scientists to carry out the work.

At a first stakeholder meeting in April 2007the industry expressed the view that catch stability, the maintenance of larger size fish in the stock, and (of course) the avoidance of stock collapse were objectives they would like included in any plan. The scientists outlined the knowledge base and stock dynamics for NEA mackerel. It was concluded from this meeting that an HCR which met the objectives of the industry and was cognisant of the knowledge base and stock dynamics should have the following properties; a multiannual implementation, a moderate exploitation ($F_{0.1}$), and an emphasis on trends in abundance and exploitation.

Following this meeting simulations were undertaken in to explore the trade offs under three strategies. A target TAC strategy and 2 harvest rate strategies, one where a simple harvest rate was applied and a second where an F rule was applied in line with the current coastal states agreement. In all three cases the TAC, the harvest rate or the F was fixed under the condition that the assessed stock was above a trigger point, and reduced proportionally under the condition that the assessed stock was below the trigger point.

The simulations were carried out with a variety of simulation tools, but conditioned with the same stock data and similar S/R assumptions. Options where the HCR was applied annually or every 3rd year were explored. The F-rule requires lower average catches if decisions are made on a tri-annual basis. This is not the case with the other strategies. In all cases, the maximum average catch associated with a low risk and stability in catch is below the recent average from the fishery. However, it is evident from the current assessment that the recent average catches have led to a gradual decline in the stock, and thus are not sustainable.

There are advantages and disadvantages with all strategies. The F-rule and Harvest rate strategy in principle allow a closer adaptation of the TACs to the fluctuations in the state of the stock. In particular, they allow large catches when the stock is large. Likewise, because they adapt closer to the perceived state of the stock, catches become more variable with the F-rule and the harvest rate regime. On the other hand, they are sensitive to the noise in the data.

The fixed TAC regime may result in lower yields than the F-rule or the harvest rate but catches are less variable. A drawback with fixed TAC regimes is that they imply a risk of severe depletion if they are not moderated to effectively to maintain stock productivity. The simulations indicate that if sufficiently strong measures are taken when the stock declines, this risk can be kept small, though these strong measures increase the variability in the fixed TAC regime.

For catch optimisation with all regimes, in order to keep the risk to reduced stock productivity small the trigger biomass below which catches need to be reduced has to be quite high. This implies that the protection rule will be invoked frequently.

For almost all situations higher risks appear to be associated with the F-rule which makes use of the short-term forecast. This suggests that the increased variability introduced by this step outweighs the added information on recruitment included in the projection. Therefore, the use of SSB based harvest rates should be seriously considered as an alternative for the traditional short term forecast to set TACs. The differences in risk and yield between survey and assessment based harvest rates appear to be small. The use of adult stock 1st of January in the intermediate year (estimated from an assessment) might be the best measure of the state of stock to use.

Results from comparing the performance of three-year TAC setting strategy as opposed to annual revisions suggests that the three-year strategies does not necessarily result in a lower yield on average but does result in lower variability for a similar associated risk. The use of some year on year constraint has not been fully explored yet, but appears to be reduce catch and increase risk under all conditions tested.

Technical detail and a more complete discussion of the simulations will be given in a report of the second stakeholder meeting, this report will be available from ICES in late September 2007.

1.9 Relevant information on ecological/environmental studies related to small pelagic species.

WGMHSA reviewed ecological studies and information that impact on advice in detail last year, this section is updated here and links to the newly set up WKEFA are indicated at the end section.

Ecological work currently linked to WGMHSA

There are a number different sources of ecological/environmental information relevant to this WG. Within ICES, recent Working and Study groups that have been specifically set up to investigate ecological or environmental questions include the extinct SGSBSA and SGRESP and their successors WGACEGG and WGLESP. In addition there are eco-region description groups NORSEPP, REGSNS and PGNSP. Specific workshops like WKIMS were set up to provide a framework for the correlation between environmental index and fish distribution at the appropriate scale. More general oceanographic and/or environmental groups are also of interest to this WG, like WGOH, which provides a yearly summary on climatic conditions in the North Atlantic, and WGRED which aimed to provide a description of the different regional ecosystems included in the ICES areas. WGRED report covers nine ecological regions, of which one general area (Oceanic and deep sea area) and four different regions (Norwegian Sea, Faroe Plateau Ecosystem, Celtic Seas and North Sea) are of importance for the assessment of the pelagic species covered by WGMHSA. WGRED attempts to provide the different assessment groups with material to generate a more environmental oriented assessment of the fisheries in the ICES area, as requested by ACFM and finally WKEFA which has looked in detail at environmental links to advice and has specifically used two stocks (Bay of Biscay anchovy and NE Atlantic Sardine) to help draw inferences on the way forward.

Nevertheless, despite the increasing pressure on working groups to consider their allocated stocks within the context of the ecosystem and the effort of the different ecosystem description groups; the impact of ecosystem change and ecosystem vulnerability on the assessments of WGMHSA is still limited. This is due to two factors a the lack of an interaction between the general ecological and oceanographic groups and the assessment groups, which still tend to work in isolation, and some of the difficulties in taking ecological influences and prediction into advice as highlighted in WKEFA. The provision of the data by the ecosystem groups and the summaries they provide are still largely unsuitable for consideration and adoption by assessment working groups. Assessment working groups need information on vulnerabilities and sensitivities of ecoregions to exploitation and indices and mechanisms of changes in productivity. Also it appears that scale is a problem, with oceanographic groups studying changes in the ecosystem at scales larger than the ones useful for assessment. This is the case with main oceanic indices such as NAO that operate on a larger scale then the response of fish behaviour to environmental change.

Although assessment working groups are generally populated by scientists with a "stock assessment" slant, WGMHSA has a history of using and investigating environmental drivers and changes in productivity. These investigations include:

- the upwelling index for Bay of Biscay anchovy recruitment
- the link between the influx of water into the North Sea and horse mackerel catches
- the investigations of the between year egg mortality and fish natural mortality in North East Atlantic mackerel
- the variability of NEA mackerel migration along the western shelf.
- Changes in distribution and variability in number of recruits to NEA mackerel.
- the variability in migrations of sardine in the Iberian area
- fecundity in horse mackerel and proxies for fecundity
- the search for more robust indices of recruitment in all stocks
- initiating work on the interactions of multispecies catches of the fleets that target small pelagics

Apart from these specific issues, other more general ecological issues like the effect of climate change in the different marine communities is to some extent taken into account and being addressed by WGMHSA by monitoring changes in productivity. Northerly shifts on the distribution of different fish communities, as well as changes in spawning seasons, changes in the spawning ground characteristics and migration patterns are continuously being addressed by this group in order to improve the assessment of the different species.

The work on ecological/environmental studies within WGMHSA has fed into and been used by groups such as SGPRISM, SGRESP, SPACC and other GLOBEC groups. Interaction between these groups and WGMHSA is much larger than with the general oceanographic or environmental groups, mainly due to sharing common objectives and scientists of similar profiles. This is reflected by the participation by the membership of WGMHSA of projects such as UNCOVER which looks at the dynamics of stock recovery in variable ecosystems, and RECLAIM which looks at climate effects on the productivity of pelagic and demersal fish stocks. A good example of such work, is the dedicated workshop on identifying mesoscale oceanographic features such as fronts, eddies and upwelling events which operate on the same temporal and spatial scale as the patterns in fisheries population dynamics (WKIMS; ICES CM 2006/OCC:01). The workshop aimed to identify these features and develop numerical indices which can be used for comparison with relative distribution of different life stages of fish communities.

The working group thus recommends improved coordination between assessment working groups and the ecological/oceanographic working groups, with clearly defined deliverables. In particular, with the development of tools and the analysis for

i) the detection and enumeration of environmental variability and changes in productivity

ii) highlighting vulnerabilities of ecosystems to overexploitation and impact on trophic diversity.

Development of the Integration of Environmental Information into Fisheries Management Strategies and Advice, WKEFA and its links to WGMHSA

ICES held a workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA) in 2007. Following a preparatory meeting in February which developed a strategy and identified a number of relevant case studies, the main WKEFA workshop co-sponsored by ICES, EUR-OCEANS, and GLOBEC met from 18-22 June 2007. Fourteen cases studies involving a wide range of demersal and pelagic stocks, as well as some generic stock simulations were presented in detail over the first two days. Pelagic stocks included two sardine stocks, two anchovy stocks, one herring and one sprat stock. Of these Bay of Biscay anchovy and NE Atlantic Sardine are dealt with by this assessment WG. In addition the influence of Atlantic water inflow and its affect on distribution of western horse mackerel was discussed. The main results from the case studies and the demonstrated influence of environmental change on the stocks are summarised in the WKEFA report. WKEFA discussed and formulate generic concepts for improving fisheries management strategies and advice considering interactions under four main aspects,

a) Entries and exits from populations (recruitment, natural mortality and migration)

b) Internal population processes, encompassing a range of aspects associated with growth maturation and reproduction.

c) Location and habitat (including such aspects as vertical and horizontal movement)

d) Multi-species interactions

WKEFA considered that while it has been long accepted that we are providing fisheries advice within the context of a varying environment, the workshop indicated the need to take into account not only stochastic variability but also trends and shifts in the environment in the development of scientific advice. Changes in physical drivers at many scales of space and time act together and this result in changes in habitat. Through complex linkages these changes result in differences in fish location, growth, maturation and reproductive potential. These differences may then influence recruitment and abundance leading to changes in natural mortality due to different species interactions. The workshop concluded that the effects of environmental change on fisheries management are better addressed by separating variability according to the time scale of the changes.

Some aspects such as catastrophic events can only be dealt with though a willingness to remain aware and the collection of information, observing and accounting for unusual events causing migration, mortality or recruitment failure. This is particularly relevant for recruitment of pelagic species.

Some short term changes can be observed, estimated and brought into advice even where the complexity of the drivers is unknown. For example changes in growth and maturation can be brought directly into methods for estimating spawning stocks one or two years ahead and for estimating catch where TACs are required. Combining such information can improve the performance of management but only if the errors in the information are included appropriately. There are a number of instances where environmental drivers have been clearly shown to explain variability in recruitment, such as Bay of Biscay Anchovy, but once in use some have shown problems. This indicates that testing the utility of indicators in management simulations must be a requirement before they are formally applied, including developing implementation frameworks that are informative and robust to errors.

As habitats changes, spatial distributions of fish change, both horizontally and vertically. These changes can interact with surveys, and fisheries leading to the requirement to monitor and account for change in catchability in assessment tuning series. These differences may impact on recruit surveys, such as those for NE Atlantic mackerel. Such changes are explicitly considered in the variable fecundity model included in the SADVF model for western horse mackerel.

Medium term change cannot be predicted in the same way as short term effects. WKEFA considered that the approach needs to follow two avenues. Where explicit relationships exist between stock and the environment the mean of stochastic projections can be modified accordingly. Such situations include average temperature dependence, species interactions and food availability for different exploited stocks. Where no explicit relationships exist or there is no basis for predicting environmental drivers into the future, advice should be based on scenario testing, along the lines of the evaluations of SGMAS management plans.

As a general recommendation the workshop concluded that in the light of climate change, rather than assuming that the mean of a given parameter derived from the (recent) past will best define future we should consider trends and attempt to estimate them. This calls for the development of a number of tools that evaluate estimates of current values and current trends in the presence of noise in both measurement and environment. The workshop concluded with a number of specific recommendations under changes in

- Productivity regimes that require adapting management procedures or procedures robust to regimes.
- Habitat influencing measurement and stock carrying capacity
- Growth and maturation influencing short and medium term advice.
- Recruitment changes due to environmental influence in the short and medium term

Recommendations from WKEFA also include the use of multi-species models primarily for hypothesis testing and testing management procedures.

1.10 Overview on major regulatory mechanism

An overview on the major existing technical measures, TACs, effort control and management plans is given in Table 1.10. The recent changes of regulatory mechanism are listed as follows:

Mackerel

There are no recent changes with one exception regarding the quota assignment to UK and Ireland (see Sec.2.1).

Existing measures are mainly designed to afford maximum protection to the North Sea spawning component as well as to protect juvenile mackerel (see also Sec. 2.1). Within the area of the South West Mackerel Box off Cornwall in southern England only handliners are permitted to target mackerel. This area was set up at a time of high fishing effort in the area in 1981 by Council regulation to protect juvenile mackerel, as the area is a well known nursery. The area of the box was extended to its present size in 1989**.** Additionally, there are various other national measures in operation in some of the mackerel catching countries.

Horse Mackerel

The stock allocations were changed in 2005 following the results of the HOMSIR project (Abaunza et al. 2003b). VIIIc is now belonging to the western stock. However, this is still not expressed in the management areas of the EU TAC regulation.

Sardines and Anchovy in the Gulf of Cadiz

Regarding the purse seine fishery directed towards sardines and anchovy in the Golf of Cadiz recent changes are summarized as follows:

Until 1997 the Spanish purse-seine fleet was performing a voluntary closure of three months (December to February). Since 2004 two complementary sets of management measures affecting directly to the Gulf of Cadiz fishery have been implemented and are still in force. The first one was the new "*Plan for the conservation and sustainable management of the purse-seine fishery in the Gulf of Cadiz National Fishing Ground*". This plan is in force during 12 months since October the 30th and includes a fishery closure of either 45 days (between 17th of November to the 31st of December in 2004 and 2005) or two months (November and December in 2006), which is accompanied by a subsidized tie-up scheme for the purse-seine fleet. The plan also includes additional regulatory measures on the fishing effort (200 fishing days/vessel/year as a maximum) and daily catch quotas per vessel (3000 kg of sardine, 3000 kg of anchovy, 6000 kg of sardine-anchovy mixing but in no case each of these species can exceed 3000 kg). A new regulation approved in October 2006 establishes that up to 10% of the total catch weight could be constituted by fish below the established minimum landing size (10 cm) but fish must always be ≥9 cm.

The second management action in force since 15th of July 2004 is the delimitation of a marine protected area (fishing reserve) in the mouth and surrounding waters of the Guadalquivir river, a zone that plays a fundamental role as nursery area of fish (including anchovy) and crustacean decapods in the Gulf. Fishing in the reserve is only allowed (with pertinent regulatory measures) to gill-nets and trammel-nets, although in those waters outside the riverbed. Neither purse-seine nor bottom trawl fishing is allowed all over this MPA.

Anchovy in the Bay of Biscay

Since July 2005 the fishery on anchovies in the Bay of Biscay (Sub area VIII) is closed following an EU decision. In 2006 5000t were allocated in the TAC regulation which were not to be fished before the 1st March but this again was followed by the closing of the fishery in July 2006 to present. For detailed information refer to section 10.1.

Table 1.3.6.1. Overview of the availability and format of data provided to the species co-ordinators

Catch year 2006.

A. Mackerel

Country*	Data supplied	Data exchange sheet	Aged Samples
Denmark	YES	YES	YES
England&Wales	YES	YES	YES
Faroes	YES	YES	YES
France	YES	YES	NO
Germany	YES	YES	YES
Iceland	NO	-	-
Ireland	YES	YES	YES
Netherlands	YES	YES	YES
Northern Ireland	YES	YES	NO
Norway	YES	YES	YES
Poland	NO	-	-
Portugal	YES	YES	YES
Russia	YES	YES	YES
Scotland	YES	YES	YES
Spain	YES	YES	YES
Sweden	NO	-	-

* Belgium, Guernsey, Jersey and Lithuania not listed (Offical catches below 100t)

B. Horse Mackerel

Country	Data supplied	Data exchange sheet	Aged Samples
Denmark	YES	YES	YES
England&Wales	YES	YES	NO
Faroes	YES	NO	NO
France	NO	-	-
Germany	YES	YES	YES
Ireland	YES	YES	YES
Lithuania	NO	-	-
Netherlands	YES	YES	YES
Northern Ireland	YES	YES	NO
Norway	YES	YES	YES
Portugal	YES	YES	YES
Scotland	YES	YES	NO
Spain	YES	YES	YES
Sweden	NO	-	-

* Belgium not listed (Offical catches below 100t)

C. Sardine

Country	Data supplied	Data exchange sheet	Aged Samples
France	YES	YES	YES
England&Wales	YES	YES	NO
Ireland	YES	YES	NO
Germany	YES	YES	YES
Portugal	YES	YES	YES
Spain	YES	YES	YES
Netherlands	YES	NO	NO

C. Anchovy

Country	Data supplied	Data exchange sheet	Aged Samples
France	YES	YES	YES
Portugal	YES	YES	NO
Spain	YES	YES	YES

Table 1.3.6.2: Available disaggregated data for the WG MHSA per Sept. 2007
X: Multiple spreadsheets(usually xls); W: WG-data national input spreadsheets (xls);
D: Disfad and Alloc-outputs (ascii/txt)

Stock	Catchyear	Format			Comments
		X	W	D	
Horse Mackerel: Western and North Sea					
HOM_NS+W	1991	X			Files from Svein Iversen, April 1999
	1992	X			Files from Svein Iversen, April 1999
	1993	X			Files from Svein Iversen, April 1999
	1994	X			Files from Svein Iversen, April 1999
	1995	X			Files from Svein Iversen, April 1999
	1996	X			Files from Svein Iversen, April 1999
	1997	X	W	D	Files from Svein Iversen, April 1999
	1998		W	D	Files provided by Pablo Abaunza Sept 1999
	1999		W	D	Files provided by Svein Iversen Sept 2000
	2000	X	W	D	Files provided by Svein Iversen Sept 2001
	2001	X	W	D	Files provided by Svein Iversen Sept 2002
	2002	X	W	D	Files provided by Svein Iversen Sept 2003
	2003	X	W	D	Files provided by Svein Iversen Sept 2004
	2004	X	W	D	Files provided by Svein Iversen Sept 2005
	2005	X	W	D	Files provided by Svein Iversen Sept 2006
	2006	X	W	D	Files provided by Svein Iversen Sept 2007
Horse Mackerel: Southern					
HOM_S	1992	X			WG Files on ICES system [Database.92], March 1999
	1996	X			Source?
	1997		(W)	D	WG Files on ICES system [WGFILES\HOM_SOTH], March 1999
	1998		W	D	Files provided by Pablo Abaunza Sept 1999
	1999		W	D	Files provided by Pablo Abaunza Sept 2000
	2000	X	W		Files provided by Pablo Abaunza Sept 2001
	2001	X	W		Files provided by Pablo Abaunza Sept 2002
	2002	X	W		Files provided by Pablo Abaunza Sept 2003 (D incl. in NS+W)
	2003	X	W		Files provided by Pablo Abaunza Sept 2004 (D incl. in NS+W)
	2004	X	W		Files provided by Pablo Abaunza Sept 2005 (D incl. in NS+W)
	2005	X	W		Files provided by Pablo Abaunza Sept 2006 (D incl. in NS+W)
	2006	X	W		Files provided by Pablo Abaunza Sept 2007 (D incl. in NS+W)
North East Atlantic Mackerel					
NEAM	1991	X			North Sea +Western WG Files on ICES system [Database.91], March 1999
	1992	X			North Sea +Western WG Files on ICES system [Database.92], March 1999
	1993	X			North Sea +Western WG Files on ICES system [Database.93], March 1999
	1997		W	D	Files from Ciaran Kelly, April 1999
	1998		W	D	Files from Ciaran Kelly, Sept 1999
	1999		W	D	Files provided by Ciaran Kelly, Sept 2000, revisions Sept 2004
	2000		W	D	Files provided by Ciaran Kelly, Sept 2001, revisions Sept 2004
	2001		W	D	Files provided by Ciaran Kelly, Sept 2002, revisions Sept 2004
	2002		W	D	Files provided by Ciaran Kelly, Sept 2003, revisions Sept 2004
	2003		W	D	Files provided by Leonie Dransfeld, Sept 2004
	2004		W	D	Files provided by Leonie Dransfeld, Sept 2005
	2005		W	D	Files provided by Leonie Dransfeld, Sept 2006
	2006		W	D	Files provided by Andrew Campbell, Sept 2007
Western Mackerel subset					
	1997		(W)	D	Files from Ciaran Kelly, April 1999; (W) contained in NEAM
	1998		(W)	D	Files from Ciaran Kelly, Sept 1999; (W) contained in NEAM
	1999		(W)	D	Files provided by Ciaran Kelly, Sept 2000; (W) contained in NEAM
	2000	X	(W)		Files provided by Guus Eltink, Sept 2001; (W) contained in NEAM
	2001	X	(W)		Files provided by Guus Eltink, Sept 2002; (W) contained in NEAM
Southern Mackerel subset					
	1991	X			WG Files on ICES system [Database.91], March 1999
	1992	X			WG Files on ICES system [Database.92], March 1999
	1993	X			WG Files on ICES system [Database.93], March 1999
	1994	X			WG Files on ICES system [Database.94], March 1999
	1995	X			WG Files on ICES system [Database.95], March 1999
	1996	X			WG Files on ICES system [Database.96], March 1999
	1997	X	(W)		WG Files on ICES system [WGFILES\MAC_SOTH], March 1999
	1998	X	(W)		Files provided by Mane Martins; (W) contained in NEAM
	1999	X	(W)		Files provided by Begoña Villamor, Sept 2000; (W) contained in NEAM
	2000	X	(W)		Files provided by Begoña Villamor, Sept 2001; (W) contained in NEAM
	2001	X	(W)		Files provided by Guus Eltink, Sept 2002; (W) contained in NEAM
Sardine					
	1992	X			WG Files on ICES system [Database.92], March 1999
	1993	X			WG Files on ICES system [Database.93], March 1999
	1995	X			files provided by Pablo Carrera Sept 2001
	1996	X			files provided by Pablo Carrera Sept 2001
	1997		W	D	W for Portugal only, files provided by Pablo Carrera and Kenneth Patterson
	1998		W	D	files provided by Pablo Carrera Sept 1999
	1999		W		files provided by Pablo Carrera Sept 2000
	2000		W	D	files provided by Pablo Carrera Sept 2001
	2001		W	D	files provided by Alexandra Silva, Sept. 2002
	2002		W	D	files provided by Alexandra Silva, Sept. 2003
	2003		W	D	files provided by Alexandra Silva, Sept. 2004
	2004		W	D	files provided by Alexandra Silva, Sept. 2005
	2005		W	D	files provided by Alexandra Silva, Sept. 2006
	2006		W	D	files provided by Alexandra Silva, Sept. 2007
Anchovy					
Anchovy in VIII	1987-95	X			revised data, all in one spreadsheet, provided by Andres Uriarte Sept 1999
	1996	X			file provided by Andres Uriarte Sept 1999
	1997	X	W	D	files provided by Andres Uriarte Sept 1999
	1998	X	W		files provided by Andres Uriarte Sept 1999
	1999	X	W		files provided by Andres Uriarte Sept 2000
	2000	X	W		files provided by Andres Uriarte Sept 2001
	2001	X	W		files provided by Andres Uriarte Sept 2002
	2002	X	W		files provided by Andres Uriarte Sept 2003
	2003	X	W		files provided by Andres Uriarte Sept 2004
	2004	X	W		files provided by Andres Uriarte Sept 2005
	2005	X	W		files provided by Andres Uriarte Sept 2006
	2006	X	W		files provided by Andres Uriarte Sept 2007
Anchovy in IX					
	1992	X			files in WK3-format provided by Begoña Villamor Sept 1999
	1993	X			files in WK3-format provided by Begoña Villamor Sept 1999
	1994	X			files provided by Begoña Villamor Sept 1999
	1995	X			files provided by Begoña Villamor Sept 1999
	1996	X			files provided by Begoña Villamor Sept 1999
	1997	X	W		W for Spain only, files provided by Begoña Villamor Sept 1999
	1998	X	W		W for Spain only, files provided by Begoña Villamor Sept 1999
	1999	X	W		W for Spain only, files provided by Begoña Villamor Sept 2000
	2000	X	W		W for Spain only, files provided by Begoña Villamor Sept 2001
	2001	X	W		W for Spain only, files provided by Fernando Ramos Sept 2002
	2002	X	W		W for Spain only, files provided by Fernando Ramos Sept 2003
	2003	X	W		W for Spain only, files provided by Fernando Ramos Sept 2004
	2004	X	W		W for Spain only, files provided by Fernando Ramos Sept 2005
	2005	X	W		W for Spain only, files provided by Fernando Ramos Sept 2006
	2006	X	W		W for Spain only, files provided by Fernando Ramos Sept 2007

Table 1.4.1. Checklist for North-East Atlantic Mackerel assessments

1. General

step	Item	Considerations
1.1	Stock definition	Assessments are performed for mackerel (Scomber scombrus) over the whole distribution area. Stock components are separated on the basis of catch distribution, which reflects management considerations and different historical information for the components rather than biological evidence: Western component: spawning in Sub-areas and Div. VI, VII, VIIIabde, distributed also in IIa, Vb, XII, XIV; North Sea component: spawning in IV and IIIa (but as the North Sea component is relatively small, most of the catches in IVa and IIIa are considered as belonging to the Western component); Southern component: spawning in VIIIc and IXa. Possible problems with species mixing (S. japonicus) in the Southern part of the area.
1.2	Stock structure	
1.3	Single/multi-species	Single species assessments

2. Data

step	Item	Considerations
2.1	Removals: catch, discarding, misreporting	Catch estimates are based on official landings statistics and are augmented by national information on misreporting and discarding. In the 2006 data the age structure of the discards from one fleet (Scotland) was available. This age structure was not applied to other discarded catches. Discarding is considered a problem in the fishery. Separation of the different mackerel stock components is on the basis of the spatial and temporal distribution of catches (see above). The ICA assessment in 2004 accepted by ACFM shows that the Egg Survey is estimated with a Q of 1.3, suggesting that bias in the catches or at least unaccounted mortality from all sources exceeds bias in the Egg Survey which is itself believed to be an underestimate (of very approximately 40% see Egg Survey below), leading to uncertain estimates of unaccounted mortality which is of the order of an amount equal of the reported catch. This discussed in section 2.2.1 and section 2.8.2.6 of this report.
2.2	Indices of abundance	
	Catch per unit effort	CPUE (at age) information for the Southern area only
	Gear surveys (trawl, longline)	Trawl surveys for juvenile mackerel, which give indications of recruit abundance and distribution. These are currently not used for the assessment, but did accurately predict the weak 2000 year class, and also the strong 2002 year class. The surveys have estimated the 2003 year class as mid range with the 2004 estimate higher than average. The use of these surveys needs further investigation.
	Acoustic surveys	Experimental surveys in 1999 to 2004 by Norway, Scotland, Spain, Portugal and France. Results from the North Sea have been tested in an assessment but not fully evaluated. These are not currently used in the assessment.

Table 1.4.1 (Cont'd)

	Egg surveys	The triennial egg survey for mackerel and horse mackerel currently provides the only fishery independent SSB estimate used in the assessment. The survey has been conducted in the western area since 1977, and in the southern area since 1992. In its present form the survey aims at covering the whole spawning time (January - July) and area (South of Portugal to West of Scotland) for both components since 1995. The most recent survey was carried out in 2007, and used in the assessment in this year. Applied method: Annual Egg Production Method. Similar egg surveys are also carried out on a roughly triennial basis in the North Sea, but these have only a partial spatio-temporal coverage and are not currently used in the assessment An analysis carried out by Portilla for WGMEGS (ICES 2005) indicates that egg mortality which is not currently included in the survey estimates is of the order of 30%, and would lead to a corresponding underestimate of the biomass. Furthermore, an additional study by Mendiola and Alvarez (WD 2005), carried out on mackerel from the southern spawning component, indicated a faster egg development time than that used in the calculation of egg production by the WGMEGS. This was calculated to lead to an underestimate of the egg production by between 7 and 12%. These two studies indicate that the egg production might be underestimated by 40% but these estimates are very uncertain.
	Larvae surveys	None
	Other surveys	Russian aerial surveys have been conducted annually in July since 1997 in international waters in the Norwegian Sea and in part of the Norwegian and Faroese waters (Div. IIa). This gives distribution and biomass estimates, not currently used in the assessment. The aerial surveys now include Norwegian & Faroese participation.

Table 1.4.1 (Cont'd)

2.3	Age, size and sex-structure: catch-at-age, weight-at-age, Maturity-at-age, Size-at-age, age-specific reproductive information	Catch at age: derived from national sampling programmes. Sampling programmes differ largely by country and sometimes by fishery. Sampling procedures applied are either separate length and age sampling or representative age sampling. 85% of the catch was sampled for length and age in 2006 (was 83% for 2005). Total number of samples taken (2006): 1,604; total number of fish aged:23,467; total number of fish measured: 183,767. Weight at age in the stock: Stock weights were available from national sampling programmes in 2006. Western component: based on Dutch and Spanish commercial catch data collected in Divisions VIIh, VIIIa and VIIIb from March to May, and supplemented by samples from the egg survey. Southern component: based on samples taken in VIIIc and IXa in the second quarter. North Sea components: based on the sample catches collected by the Norwegians and Dutch from areas IVa and IVb during 2006. The separate component stock weights were then weighted by the relative proportion of the SSB estimates (from egg surveys) for the respective components (Western / Southern / North Sea from egg surveys in 2005 and 2007 respectively: 81.4% / 8.6% / 10.0%). Weight at age in the catch: derived from the total international catch at age data weighted by catch in numbers. In some countries, weight at age is derived from general length-weight relationships, others use direct measurements. Maturity at age: based on biological samples from commercial and research vessels; weighted maturity ogive according to the SSB biomass in the three components. As there was no new data there was no change in the estimated maturity ogive in 2006 even though the weighting changed between the Western / Southern / North Sea component as described above.
2.4	Tagging information	Used as indicator for the mixing of the Southern and Western components; used to estimate total mortality; for exploratory assessment runs (WINBUGS ICA and AMCI).
2.5	Environmental data	Not currently used but under investigation
2.6	Fishery information	Several scientists involved in the assessment of this stock are familiar with the fishery. Most major mackerel fishing nations have placed observers aboard the fishing vessels. Anecdotal information on the fishery may be used in the judgement of the assessment.

3. Assessment model

step	Item	*Considerations*
3.1	Age, size, length or sex-structured model	Current assessment model: ICA Exploratory analyses: AMCI & ISVPA/TISVPA & WINBUGS ICA
3.2	Spatially explicit or not	No
3.3	Key model parameters: natural mortality, vulnerability, fishing mortality, catchability	Natural mortality: fixed parameter over years and ages (M=0.15) based on tagging data. Selection at age: Reference age 5 for which selection is set at 1. Selection at final age set to 1.5. One period of 12 years of separable constraint (including the egg survey biomass estimates from 1992 onwards). Population in final year: 13 parameters. Population at final age for separable years: 11 parameters. Recruitment for survivors year: Total number of parameters: 46 Total number of observations: 150 Number of observations per parameter: 3.3
	Recruitment	No recruitment relationship fitted.
3.4	Statistical formulation: - what process errors - what observation errors - what likelihood distr.	Model is in the form of maximum log likelihood. Terms are weighted by manually set weights. Index for biomass from egg surveys is given a weight of 30 and each catch at age observation in the separable period is given a weight of 1 except 0-group, which is down-weighted to 0.01 and the 1-group which is down-weighted to 0.1. The survey biomass estimate was treated as relative from 1999 to 2007
3.5	Evaluation of uncertainty: - asymptotic estimates of variance, - likelihood profile - bootstrapping - bayes posteriors	Maximum likelihood estimates of parameters and 95% confidence limits are given. Total variance for the model and model components given, both weighted and unweighted. (weighted is currently incorrectly calculated in the model) Several test statistics given (skewness, kurtosis, partial chi-square). Historic uncertainty analysis based on Monte-Carlo evaluation of the parameter distributions. (this failed this year and was replaced by WINBUGS ICA)
3.6	Retrospective evaluation	Currently retrospective analysis is carried out (in FLICA) because the assumptions concerning the separable period have been very variable over recent years. Historic realisations of assessments are routinely presented and form a direct overview on the changes in the perception of the state of the stock. These are presented for SSB, fishing mortality and recruitment. The quality of the assessment was evaluated by comparing the first estimates of recruitment in a certain year with the second , the third, etc. estimates for that same year from following WG meetings. These figures indicate the precision and bias in successive estimates of recruitment.
3.7	Major deficiencies	selection at final age not well determined, evaluated as 1.5. weighting for catch and survey data set approximately equivalent but not well related to variability in the data area misreporting of catch is a minor problem In the past catches at age have been treated as being not biased, but information from many sources now indicates substantial unaccounted mortality of which an important part may be because catches could be seriously underestimated simpler assessment models currently not evaluated Assessment is over sensitive to recent survey SSBs

4. Prediction model(s) – SHORT TERM

step	Item	Considerations
4.1	Age, size, sex or fleet-structured prediction model	Age-structured model, by fleet and area fished. Because of the uncertainty in levels of catch these should be used only in a relative sense to indicate the direction and relative magnitude of exploitation options.
4.2	Spatially explicit or not	Not
4.3	Key model (input) parameters	Stock weights at age: average from last 3 years Natural mortality at age: average from last 3 years (fixed) Maturity at age: average from last 3 years Catch weights at age: average from last 3 years Proportion of M before spawning: 0.35 Proportion of F before spawning: 0.42 Fishing mortalities by age: From ICA (from 12 year separable model) Numbers at age: from ICA, final year in assessment; ages 2 to 12+ 0-group is GM recruitment whole period except last 3 years 1-group is GM recruitment applying mortality at age 0
4.4	Recruitment	Geometric mean over whole period except last 3 years.
4.5	Evaluation of uncertainty	Uncertainty in model parameters is NOT incorporated, though sometimes a limited number of sensitivity analyses may be performed, usually with regard to recruitment level.
4.6	Evaluation of predictions	Predictions are not evaluated retrospectively (this is tricky to do in terms of catches, but some evaluation in terms of population numbers at age should be done).
4.7	Major Deficiencies	Catches are likely to be underestimated (see above) this leads to a perception that the current assessment gives biased estimates of SSB but provided the bias is sufficiently constant F maybe unbiased and trend in SSB and F will be unbiased SSB estimates from egg surveys are only available every 3 years. Assessment/Prediction mismatch: In particular, stock estimates are based on a separable model, which is then treated in a non-separable way in the short term predictions. Catch options: no unique solution for catches by fleet when management objectives are stated in terms of Fadult and Fjuvenile. No stochasticity/uncertainty reflected in short term predictions. Intermediate year: general problem- whether to use status quo F or a TAC constraint for intermediate year Software: MFDP programme

5. Prediction model(s) – MEDIUM TERM

No medium term projections were carried out this year.

Table 1.4.2. Checklist for assessments of Western Horse Mackerel

1. General

step	Item	Considerations
1.1	Stock definition	Stock caught in divisions IIa, IIIa (western part), IVa, Vb, VIa, VIIa–c, e–k and VIIIa-e
1.2	Stock structure	No sub-populations have been defined.
1.3	Single/multi-species	Single species assessment

2. Data

step	Item	Considerations
2.1	Removals: catch, discarding, fishery induced mortality	Discards are not included but are considered not relevant. Misreporting of juvenile catch taken in VIIe,h and VIId (mostly North Sea stock). Catches outside the area covered by the TAC.
2.2	Indices of abundance	Series of tri-ennial AEPM surveys since 1983 (with a gap in 1986). Acoustic and bottom trawl surveys do not cover the entire distribution of the stock. Not used in the assessment.
	Catch per unit effort	Series of catch per unit effort fromVIIIc. Not used in assessment.
	Gear surveys (trawl, longline)	
	Acoustic surveys	French acoustic spring survey indices available (PELGAS) only covering VIIIa & b.
	Egg surveys	Total egg production estimate used in the assessment as a relative index of SSB.
	Larvae surveys	None.
2.3	Age, size and sex-structure: catch-at-age, weight-at-age, Maturity-at-age, Size-at-age, age-specific reproductive information	A large portion of the catch remains un-sampled. Catch-at-age data has improved in recent years. However, the number of age readings for some of fishing areas is not satisfactory. Proportion mature at-age data have not been provided since 1993. Weight-at-age in the stock data are based on a small sample.
2.4	Tagging information	None.
2.5	Environmental data	The availability of western horse mackerel in the Norwegian NEZ in the third/fourth quarter seems to be linked with the modelled influx of Atlantic water to the North Sea the first quarter (Iversen et.al. 2002).
2.6	Fishery information	Directed trawl fishery operated by Ireland, Denmark, Scotland, England & Wales, The Netherlands, France and Germany. Norway operates a directed purse-seine fishery. Spain operates both purse-seines and trawlers. A varying proportion of the total catch is caught in the area where juveniles are distributed (Divisions VIIa,e,f,g,h and VIIIa,b,d).

3. Assessment model

step	Item	Considerations
3.1	Age, size, length or sex-structured model	Age-structured. A linked separable VPA and ADAPT VPA model (SAD), so that different structural models are applied to the recent and historic periods. The separable component is short (currently 4 years) and applies to the most recent period, while the ADAPT VPA component applies to the historic period. Model estimates from the separable period initiate a historic VPA for the cohorts in the first year of the separable period.
3.2	Spatially explicit or not	No
3.3	Key model parameters: natural mortality, vulnerability, fishing mortality, catchability	Natural mortality is fixed at 0.15, catchability for the AEPM is estimated. The parameters treated as "free" in the model (i.e. those estimated directly) are: (1) Fishing mortality year effects for the final four years for which catch data are available; (2) Fishing mortality age effects (selectivities) for ages 1-10 (except for selectivity at age 7 which is set to 1); (3) scaling parameter for fishing mortality at age 10 relative to the average for ages 7-9 (ignoring the 1982 year-class where applicable); (4) fishing mortality on the 1982 year-class at age 10 in 1992; (5) catchability linking the egg production estimates and the SSB estimates from the model.
	Recruitment	No stock recruitment relationship is assumed.
3.4	Statistical formulation: - what process errors - what observation errors - what likelihood distr.	The estimation is based on maximum likelihood. There are three components to the likelihood that correspond to the egg estimates, catches for the separable period, and catches for the plus-group. The variance of each component is estimated. A penalty term to incorporate information on changes in maturity/g relative to the age-structure of the stock was included in the objective function of the 2006 SAD version.
3.5	Evaluation of uncertainty: - asymptotic estimates of variance, - likelihood profile – bootstrapping - bayes posteriors	Asymptotic estimates of variances by the inverse of the Hessian matrix.
3.6	Retrospective evaluation	Historic retrospective last performed in 2003 showed a consistent retrospective pattern.

4. Prediction model(s) – SHORT TERM

Step	Item	Considerations
4.1	Age, size, sex or fleet-structured prediction model	Given uncertainty in stock numbers and F no short-term predictions were conducted for this stock since 2003 (ICES CM 2004/ACFM:08).
4.2	Spatially explicit or not	N/a
4.3	Key model (input) parameters	N/a.
4.4	Recruitment	N/a
4.5	Evaluation of uncertainty	N/a
4.6	Evaluation of predictions	N/a
4.7	Major deficiencies	N/a

5. Prediction model(s) – MEDIUM TERM

No medium term predictions are conducted.

Table 1.4.3 Checklist for assessments of Southern Horse Mackerel

1. General

step	Item	Considerations
1.1	Stock definition	Stock caught in division IXa.
1.2	Stock structure	This has been defined as a single stock unit in a multidisciplinary stock-identification project.
1.3	Single/multi-species	Single species assessment

2. Data

step	Item	Considerations
2.1	Removals: catch, discarding, fishery induced mortality	Discards are not included but are considered not relevant.
2.2	Indices of abundance	Age-structured abundance indices from a series of bottom-trawl surveys covering the Portuguese and Spanish areas of the stock. The completion of a series of SSB estimates from triennial DEPM surveys (2002, 2005 and 2007) is ongoing (only the 2002 estimate is available at present).
	Catch per unit effort	Series of catch per unit effort from the Marin bottom-trawl fleet. Not used in assessment.
	Gear surveys (trawl, longline)	Annual bottom-trawl surveys covering the whole stock area.
	Acoustic surveys	Portuguese and Spanish acoustic survey indices are not available for this species.
	Egg surveys	SSB estimates available from DEPM egg surveys.
	Larvae surveys	None.
2.3	Age, size and sex-structure: catch-at-age, weight-at-age, Maturity-at-age, Size-at-age, age-specific reproductive information	Most of the catch is covered in the sampling program. Catch-at-age data is based on quarterly age-length keys made for the Portuguese and Spanish areas. Each key is made with around 400 otoliths. Maturity ogive is fixed. It was made in 2003 using data obtained with histological slides. Weight-at-age in the stock is assumed the same as in the catch.
2.4	Tagging information	None.
2.5	Environmental data	The recruitment strength of southern horse mackerel seems to be well correlated with upwelling indices.
2.6	Fishery information	Directed trawl fishery operated Portuguese and Spanish vessels, and also caught as bycatch in the purse-seine and polyvalent fisheries in the waters of both countries. Catches are taken along the whole coastal area, to a depth of 400m. Juveniles are closer to the shore and caught mainly by purse-seiners.

Table 1.4.3 (Cont'd)

3. Assessment model

step	Item	Considerations
3.1	Age, size, length or sex-structured model	Age-structured. A statistical catch-at-age assessment model (ASAP). The optimisation of a complex objective function, based on likelihoods with different sources of information, is made by automatic differentiation.
3.2	Spatially explicit or not	No.
3.3	Key model parameters: natural mortality, vulnerability, fishing mortality, catchability	Natural mortality fixed at 0.15/year. The estimated parameters are: a vector of selectivities-at-age for 1991 and kept fixed during the whole assessment period (12 parameters), F multiplier for the first year (1 parameter), deviations to the F multiplier for each year except the 1st one (16 parameters), a vector of catchabilities-at-age, kept fixed during the whole assessment period (12 parameters), a vector of the recruitment deviations from the mean for each year (16 parameters), a vector of deviations, for each age, from the number at age 0 in the 1st year (11 parameters), the virgin biomass for the stock-recruitment relationship (1 parameter).
	Recruitment	A Beverton-Holt stock recruitment relationship is assumed, but recruitment estimates are allowed to deviate from that relationship.
3.4	Statistical formulation: - what process errors - what observation errors - what likelihood distr.	The estimation is based on maximum likelihood. There are eleven components to the likelihood that correspond to the total catch, catch proportions at age, abundance indices,
3.5	Evaluation of uncertainty: - asymptotic estimates of variance, - likelihood profile – bootstrapping - bayes posteriors	Asymptotic estimates of variances by the inverse of the Hessian matrix.
3.6	Retrospective evaluation	Historic retrospective was performed, showing

4. Prediction model(s) – SHORT TERM

Step	Item	Considerations
4.1	Age, size, sex or fleet-structured prediction model	Age structured model.
4.2	Spatially explicit or not	No
4.3	Key model (input) parameters	Weight-at-age, proportion mature at age, estimates of numbers-at-age, selectivity-at-age, target catch, geometric mean recruitment from 1991 to 2005.
4.4	Recruitment	Was fixed as the geometric mean of the period 1991-2005.
4.5	Evaluation of uncertainty	N/a
4.6	Evaluation of predictions	N/a
4.7	Major deficiencies	N/a

Table 1.4.4 Sardine Check List

Table 1.4.5 Chccklist for the assessment of Anchovy in subarea VIII

1. General

step	Item	Considerations
1.1	Stock definition	The stock is distributed in the Bay of Biscay. It is considered to be isolated from a small population in the English Channel and from the population(s) in the IXa.
1.2	Stock structure	No subpopulations have been defined, although morphometrics and meristic studies suggest some heterogeneity at least in morphotipes.
1.3	Single/multi-species	Single species assessment

2. Data

step	Item	Considerations
2.1	Removals: catch, discarding, fishery induced mortality	Discards are not included but are considered not relevant for the two fleets. The fishing statistics are considered accurate and the fishery is well known.
2.2	Indices of abundance	Spring surveys on adults: Series of DEPM surveys since 1987 (with a gap in 1993). Series of acoustic surveys since 1983 (although not covering all the years). Autumn surveys on Juveniles: An acoustic series was started in 2003 (JUVENA) which is still under testing period.
	Catch per unit effort	Series of catch per unit effort for the French trawlers and Spanish purse seine fleets (although not standardized). They are not used in assessment, nor reflected in the report.
	Gear surveys (trawl, longline, etc.)	Pelagic trawls and in some cases (opportunistically) purse seining.
	Acoustic surveys	French acoustic spring survey indices available since 1989 (PELGAS) (which are used in the assessment). Some previous indices are available since 1983 (before the period of the assessment). A series of Spanish acoustic autumn surveys on juveniles started in 2003 (JUVENA) for estimating the strength of next coming recruitment for improving the management advice but it is still at a testing period of its performance.
	Egg surveys	Daily Egg Production Method (DEPM) applied to estimate the SSB available since 1987 with a gap in 1993. Estimates in 1996, 1999 and 2003 are based on regression models of previous DEPM SSB on daily egg production and spawning area or total egg production.
	Larvae surveys	None.
2.3	Age, size and sex-structure: catch-at-age, weight-at-age, Maturity-at-age, Size-at-age, age-specific reproductive information	Biological sampling of the catches has been generally sufficient, except for 2000 and 2001. An increase of the sampling effort seems useful to have a better knowledge of the age structure of the catches during the second semester in the North of the Bay of Biscay. Age reading is considered accurate. Recent Cross reading exchanges and a workshop between Spain and France were made in 2005 and 2006 respectively.
2.4	Tagging information	None.

Table 1.4.5 (Cont'd)

2.5	Environmental data	Environmental data recorded in the spring surveys encompasses: temperature, salinity, etc. Environmental indices (upwelling, stratification) affecting recruitment are reported (Borja et al. 1996, 1998; Allain et al. 2001) but with poor performance (not used in predictions of the population). Some update is presented in this year's report.
2.6	Fishery information	Two main fisheries: A Spanish purse seine fishery operating mainly in Spring and a French one using mainly pelagic trawling and operating mainly in winter, summer and autumn. A small fleet of French purse seiners fishery operates in the South of the Bay of Biscay (Spring) and in the North (2nd half of the year).

3. Assessment model

step	Item	Considerations
3.1	Age, size, length or sex-structured model	The assessment model up to 2004 has been Integrated Catch-at-age Analysis (ICA). Since 2005, the stock has been assessed using the Bayesian biomass-based model. Both models are age structured. However, whereas ICA used 5 age classes in catches and 2-3 ages in surveys the biomass-based model only distinguishes age 1 biomass from the rest of the population in surveys and just make of that information from surveys (and a first period of the catches up to 15 of May).
3.2	Spatially explicit or not	No
3.3	Key model parameters: natural mortality, vulnerability, fishing mortality, catchability	Both in ICA (former assessment) as in the Bayesian biomass-based model (current one) natural mortality is fixed at 1.2, catchability for the DEPM biomass is set to 1 because it is assumed to be an absolute indicator of Biomass and catchability of the acoustic biomass survey is estimated. Furthermore in the Bayesian biomass-based model DEPM and acoustic surveys assumed to provide unbiased proportion of age 1 biomass estimates. In the Bayesian biomass-based model catches are used as an offset and are not used for tuning (while in ICA fishing mortality was assumed to be separable).
	Recruitment	No stock recruitment relationship is assumed. However, below Blim (21 000 tonnes) the possibility of a good recruitment is assumed to be diminished.
3.4	Statistical formulation: - what process errors - what observation errors - what likelihood distr.	Bayesian biomass-based model: It is set within framework of Bayesian state-space models. Log-normal process errors for recruitment in the first period of the year (until the peak of the spawning season in mid-May) Log-normal observation errors for the total biomass from DEPM and acoustic surveys. Beta observation errors for the proportion of age 1 biomass from DEPM and acoustic surveys. Prior distributions for the catchability of the biomass from the DEPM and acoustic surveys are Log-normal, for the precision of the observation equations of biomass from the DEPM and acoustic surveys are Gamma, for the parameter defining the precision of the proportion of age 1 biomass from the DEPM and acoustic surveys is Normal, for the initial biomass is Normal, for the recruitment is Log-normal and for the parameter defining the precision of the process errors is Gamma. (In past) ICA: Maximum likelihood is used. No process errors are assumed. Observation errors of the DEPM and

		acoustics biomass and numbers at age and of the catch at age are assumed to be log normally distributed. The likelihood functions incorporates weighting factors to translate the validity of the information used into the tuning of the assessment
3.5	Evaluation of uncertainty: - asymptotic estimates of variance, - likelihood profile – bootstrapping - bayes posteriors	Bayesian biomass-based model: Bayesian posterior distributions of the parameters provide direct evaluation of the uncertainty in the assessment. (IN pas ICA: Asymptotic estimates of variances by the inverse of the Hessian matrix.)
3.6	Retrospective evaluation	Not done so far, but the assessment made every year with the BBM is very consistent with assessment in previous years of past series and no retrospective bias is perceived.

4. Prediction model(s) – SHORT TERM

Step	Item	Considerations
4.1	Age, size, sex or fleet-structured prediction model	No unique short term prediction has been conducted for this stock in the last years (2005 - 2007), for the unability to predict recruitment at age 1 next year (which is bulk of the population). Contrary to that predictions for different levels of recruitment are presented this year for illustration purposes of the high level of dependency of any forecast on Recruitment In 2004 as in this year 2007 a stochastic projections based on the Bayesian biomass-based model were presented, just accounting for surviving biomass and the potential new mass of recruits. In the past (from the ICA assessment) deterministic projections used to carried out based on age predictions models and using CEFAS deterministic projections (MFDP). Not any more.
4.2	Spatially explicit or not	No
4.3	Key model (input) parameters	For the BBM stochastic projections: prior distribution of recruitment at age 1 and catch constrain for the assessment year. In this case were based on no catch in the second half of 2007 (given the closure of the fishery) and a range of catches for the first half of 2008.
4.4	Recruitment	A general undetermined level of recruitments (addition of posterior past estimates) and three scenarios additional levels of corresponding recruitment corresponding to low, medium and high levels as inferred from modes from the past posterior estimates of recruitments are essayed for scenario based recruitment forecast of the population and the fishery.
4.5	Evaluation of uncertainty	Current stochastic projections based on the Bayesian biomass-based allowed to incorporate the uncertainty from the current population state (in May 2007) and on the selected recruitment scenario based on the posterior distribution of historical series of recruitment contributing to it..
4.6	Evaluation of predictions	Not properly and not required in the current circumstances of no recruitment indicator for forecast.
4.7	Major deficiencies	

5. Prediction model(s) – MEDIUM TERM

Given the short living of the species, no medium term predictions are conducted.

Table 1.10: Overview on the major existing regulatory mechanism for mackerel, horse mackerel, sardines and anchovy

Species	Technical measure	National/European level	Specification	Note	Source/date of implementation
Mackerel	Catch limitation	European	TAC 2006: 444.000t all areas TAC 2007: 501.000t all areas		EU Reg 41/2006, NEAFC Agreement, Coastal States Agreement
Mackerel	Management plan	European	F=0.15 to 0.20, SSB not under 2.300.000t		1999
Mackerel	Minimum size	European	30cm in the North Sea		EU Reg 850/98 amended 1999, 2000, 2001, 2004
Mackerel	Minimum size	European	20cm in all areas except North Sea	10% undersized allowed	EU Reg 850/98 amended 1999, 2000, 2001, 2004
Mackerel	Catch limitation	European	Within the limits of the quota for the western component (VI,VII, VIIIabde, Vb(EC), IIa(nonEC), XII, XIV), a certain quantity may be taken from IVa but only during the periods 1 January to 15 February and 1 October to 31 December.		EU Reg 41/2006
Mackerel	Area closure	National (UK)	South-West Mackerel Box off Cornwall	except where the weight of the mackerel does not exceed 15 % by liveweight of the total quantities of mackerel and other marine organisms onboard which have been caught in this	EU Reg 850/98 est. 1981
Mackerel/Horse Mackerel	Discard prohibition	National (Nor)	All discarding is prohibited in Norwegian waters		Norwegian Directorate of Fisheries
Horse Mackerel	Bycatch limitation	National (Nor)	In Norwegian waters vessels targetting horse mackerel have to leave the fishing area when the bycatch of mackerel		
Horse mackerel	Catch limitation	European	TAC 2006: 235.000t all areas TAC 2007: 235.000t all areas		EU Reg 41/2006
Horse mackerel	Minimum size	European	15cm	10% undersized allowed	EU Reg 850/98 amended 1999, 2000, 2001, 2004
Sardine	Minimum size	European	11cm	10% undersized allowed	EU Reg 850/98 amended 1999, 2000, 2001, 2004
Sardine/Anchovy	Effort limitations	National (ES)	VIIIc,IXa: minimum vessel tonnage 20GRT, maximum engine power 450hp, max length purse seine 450m, max height purse seine 80m, minimum mesh size 14mm, max number of fishing days/week: 5, fishing prohibited in bays and estuaries		1997
Sardine	Catch limitation	National (ES)	max 7 000 kg/day/boat fish > 15 cm, max 500 kg/day/boat fish between 11 and 15 cm. IXaS Cadiz: in addition max 3 000 kg/day/boat		1997
Sardine/anchovy	Area closure	National (ES)	IXaS Cádiz: no fishing between 1.November and 31.December		2006 (2004 and 2005, 45 days closure)
Sardine/Anchovy	Effort limitations	National (PT)	IXa: max number of fishing days/week: 5, max number of fishing days/year: 180		1997
Sardine/Anchovy	Area closure	National (PT)	no purse-seine fishery north of 39°42'N between 1.February and 31.March	on voluntary basis	1997
Sardine	Catch limitation	National (PT)	around 80 000t/year	split by regional producers organisations	1997
Anchovy	Catch limitation	European	TAC 2006: 8000t in IXa, 5000t in VIII; TAC 2007: 8000t in IXa, 0t in VIII		EU Reg 41/2006
Anchovy	Minimum size	European	12cm except IXa, East of 7°23'48W: 10cm		EU Reg 850/98 amended 1999, 2000, 2001, 2004
Anchovy	Area closure	European	Fishery closed in SA VIII		EU Reg 1037/2005, 1539/2005, 1116/2006
All species	Mesh sizes	European	different specifications acc. to catch compositions		EU Reg 850/98 amended 1999, 2000, 2001, 2004
All species	Mesh openings	European	different specifications acc. to catch compositions		EU Reg 850/98 amended 1999, 2000, 2001, 2004

2 Northeast Atlantic Mackerel

2.1 ICES advice applicable to 2006 and 2007

The internationally agreed TAC's have covered the total distribution area of the Northeast Atlantic mackerel stock since 2001. The advice for this stock includes the three stock components: Southern, Western and North Sea mackerel. In parts of the year these components mix in the distribution area. The advised TAC is split into a Northern (IIa, IIIa,b,d, IV, Vb, VI, VII, VIIIa,b,d,e, XII, XIV) and a Southern (VIIIc, IXa) part on the basis of the catches the previous three years in the respective areas (Fig. 2.1.1). The three components have overlapping distributions and a part of the Southern component is fished in the northern area.

The different agreements cover the total distribution area of Northeast Atlantic mackerel, while each agreement in some cases covers different parts of the same ICES Divisions and Subareas. The agreements also provide flexibility of where the catches can be taken.

The TAC's agreed by the various management authorities (the Coastal States of mackerel and NEAFC) and the advice given by ACFM for 2006 and 2007, as well as the WG catch estimate for 2006 are given in the text table below.

<table>
<tr><th>Agreement</th><th>Areas and Divisions</th><th>TAC in 2006</th><th>TAC in 2007</th><th>Stock compo-nents</th><th>ACFM advice 2006</th><th>ACFM advice 2007</th><th>Areas used for allocations</th><th>Prediction basis</th><th>WG catch in 2006</th></tr>
<tr><td rowspan="2">Coastal states agreement (EU, Faroes, Norway)</td><td rowspan="2">IIa, IIIa, IV, Vb, VI, VII, VIII, XII, XIV</td><td rowspan="2">373,535</td><td rowspan="2">422,551</td><td>North Sea</td><td>Lowest possible level</td><td>Lowest possible level</td><td rowspan="4">IIa, IIIa, IV, Vb, VI, VII, VIIIa,b,d,e, XII, XIV</td><td rowspan="4">Northern</td><td rowspan="4">419,901</td></tr>
<tr><td rowspan="3">Western</td><td rowspan="4">Reduce F in the range 0.15 – 0.20</td><td rowspan="4">Reduce F in the range 0.15 – 0.20</td></tr>
<tr><td>NEAFC agreement</td><td>International waters of IIa, IV, Vb, VI, VII, XII, XIV</td><td>42,289</td><td>47,838</td></tr>
<tr><td>EU-NO agreement[1)]</td><td>IIIa, IVa,b</td><td>1,865</td><td>1,865</td></tr>
<tr><td>EU autonomous[2)]</td><td>VIIIc, IXa</td><td>26,176</td><td>29,611</td><td>Southern</td><td>VIIIc, Ixa</td><td>Southern[3)]</td><td>52,751</td></tr>
<tr><td>Total</td><td></td><td>443,865</td><td>501,865</td><td></td><td>373-487</td><td>390-509</td><td></td><td></td><td>472,652</td></tr>
</table>

1) Fixed quota to Sweden.

2) Includes 3,000 t of the Spanish quota that can be taken in Spanish waters VIIIb.

3) Does not include the 3,000 t of Spanish catches taken in Spanish waters of VIIIb under the southern TAC.

Over recent years improved enforcement has detected some undeclared landings of mackerel from 2001 to 2004 in UK and Ireland. As a consequence the EU introduced a new regulation scheduling payback over the next few years (Commission Regulation 147/2007). For 2007 this figure was 21,168.1 tonnes and this amount of mackerel should be withdrawn from their national quotas in 2007. Thus, to arrive at an expected amount of mackerel in 2007 it is necessary to take the total TAC (501,865 tonnes) adding the estimated discards (17,970 tonnes, Table 2.2.1.1.) and subtracting the UK/Ireland payback (21,168.1 tonnes), giving an expected catch in 2007 of 498,667 tonnes.

The TAC for the Southern area applies to Division VIIIc and IXa, although 3,000 t of this TAC could be taken from Division VIIIb (Spanish waters), which is included in the Northern area. However, these catches (3,000t) have always been included by the Working Group in the provision of catch options for the Northern area.

In addition to the TACs and the national quotas, the following additional management measures are advised as stated by ACFM (2006). These measures are mainly designed to afford maximum protection to the North Sea spawning component while it remains in it's present depleted state while at the same time allowing fishing on the western component while it is present in the North Sea, as well as to protect juvenile mackerel. In detail these measures are: There should be no fishing for mackerel in Divisions IIIa and IVb,c at any time of the year, there should be no fishing for mackerel in Division IVa during the period 15 February – 31 July and the 30 cm minimum landing size at present in force in Subarea IV should be maintained.

However, according to the EU TAC regulation some small quotas are still assigned to IIIa and IVbc. In the same regulation is also stated that within the limits of the quota for the western component (VI, VII, VIIIabde, Vb(EU), IIa (non EU); XII, XIV), a certain quantity of this stock may be caught in IVa but only during the periods 1 January to 15 February and 1 October to 31 December. In all other areas than in the Subarea IV a minimum length of 20cm is required.

Various national measures such as closed seasons and boat quotas are also in operations in most of the major mackerel catching countries.

2.2 The Fishery in 2006

2.2.1 Catch Estimates

The total estimated working group catch for NEA mackerel in 2006 was 472,700t, a reduction of 71,000t over the 2005 figure (543,500t). With the TAC for 2006 set at 443,865t the overshoot is just over 28,500t. The combined fishable TAC as best ascertained by the Working Group (Section 2.1) agreed for 2007 amounts to 501,865t. Of this TAC, the UK and Ireland have agreed not to fish 21,168t

Catches reported in this and previous working group reports are considered to be best estimates. In some cases catch figures are available from processors, and where available discard estimates are included (see 1.3.3 and 2.2.2 for further discard information on mackerel). In most cases catch information comes only from official logbook records of catches. The table below gives a brief overview of the basis for the catch estimates.

Country	**Official Log Book**	**Other Sources**	**Discard information made available to the WG[2]**
Germany	Y (landings)		Y
Norway[1]	Y (catches)		
UK	Y (landings)	Y	Y
Ireland	Y (landings)		
Denmark	Y (landings)	Y (sale slips)	
Faroe[1]	Y (catches)	Y (coast guard)	
Netherlands	Y (landings)	Y	Y
Spain		Y	
Portugal		Y (sale slips)	
France	Y (landings)		
Russia[1]	Y (catches)		
Sweden	Y (landings)		

[1]In the Russian, Norwegian and Faroese fleets discarding is illegal, which means officially landings are equal to catches.
[2]Note that this column represents the countries submitting information on discarding and not the occurrence of discarding itself. For other countries there is no information available.

From this table it can be seen that discard or slipping estimates are not available from many countries, and in most cases figures are only available from the logbooks. The working group considers that the best estimates of catch it can produce are likely to be an underestimate for the following reasons:

- Estimates of discarding due to high-grading or slipping are not available for most countries, and anecdotal information suggests that slipping may be widespread especially in the Q4 fishery in IVa and the Q1 fishery in VIa. Since about 1985 the Japanese market preferred mackerel that weighed more than 600g (G-6 fish) and paid considerably more for such fish. This resulted in slipping of catches when the percentage of G-6 was low. The slipped fish resulted in an extra unknown fishing mortality. Norway therefore introduced a special regulation to prevent the slipping limiting the percentage of G-6 fish. This regulation was in force from 1988-2002. Since then the price has been better for smaller fish and a special regulation was not needed.
- Confidential information suggests substantial under reported catches for which numerical information is not available for most countries.
- Reliance on logbook data from EU countries implies (even with 100% compliance) a precision of 89% from 2004 and 82% previous to this (Council Regulation (EC) No’s 2807/83 & 2287/2003). Given that over reporting of mackerel landings is unlikely for economic reasons, the WG considers that where based on logbook figures, the reported landings may be an underestimate of up to 18% (11% from 2004). Where inspections were not carried out there is a possibility of a 56% under reporting, without there being an obvious illegal record in the logsheets. Without information on the percentage of the landings inspected it is not possible for the working group to evaluate the underestimate in its figures due to this technicality. EU catches represent about 65% of the total estimated NEA mackerel catch.
- The precision in the logbook records from countries outside the EU has not been evaluated.

The total catch estimated by the Working Group to have been taken from the different ICES areas is shown in Table 2.2.1.1. and illustrates the development of the fisheries since 1969.

The total catch recorded from the North Sea (Sub-area IV and Division IIIa) (Table 2.2.1.3) in 2006 was about 206,000t, which is 46,000t less than the catches in 2005. This continues the trend of reducing catches in this area since 2004. Previous to this, the trend had been for increasing catches since 1996. The misreporting of catches taken in this area into VIa was 9,000t, one of the smallest values on record and a reduction from the 2005 figure of 38,000t.

Catches in the Norwegian Sea and area V were 47,000t and were slightly lower that the previous year (54,000t). This is the lowest catch on record for this area and is between half and a third of the catches taken during the nineties. For the first time catches have been reported in area Va. The catch taken in the western area (Sub-area VI, VII and Divisions VIIIa,b,d,e) decreased by approximately 20,000 t to around 167,000 t.

Catches in divisions VIIIc and IXa have continued to increase and are now over 52,000t. The “Prestige” oil spill in 2003 had caused a closure of the fishery in the first quarter of that year and resulted in the lowest catches in the area for the last 10 years. Following a reopening of the fishery, catches have increased and are now similar to levels recorded prior to the oil spill. For two consecutive years, catches in VIIIc and IXa have risen to twice the official TAC for the area (see section 2.1).

The quarterly distributions of the catches since 1990 are shown in the text table below.

YEAR	Q1	Q2	Q3	Q4
1990	28	6	26	40
1991	38	5	25	32
1992	34	5	24	37
1993	29	7	25	39
1994	32	6	28	34
1995	37	8	27	28
1996	37	8	32	23
1997	34	11	33	22
1998	38	12	24	27

YEAR	Q1	Q2	Q3	Q4
1999*	36	9	28	27
2000*	41	4	21	33
2001*	40	6	23	30
2002*	37	5	29	28
2003*	36	5	22	37
2004*	37	6	28	29
2005	46	6	25	23
2006	41	5	18	36

* **Revised for additional unallocated catches**

These catches are shown per statistical rectangle in Figs 2.7 1.1 to 2.7.1.4. and are discussed in more detail in Section 2.7.1. It should be noted that these figures are a combination of official and WG catches and may not indicate the true location of the catches or represent the location of the entire stock. Of the total catch, 41% was taken during the 1st quarter as the shoals migrate from division IVa through area VI to the main spawning areas in area VII. Only a small proportion of the total catch was taken in quarter 2 (5%). The proportion of catch taken during quarter 3 has dropped to 18% (from 25% in 2005). Combined with a 5% drop for quarter 1, there is a significant increase in the proportion of the total catch taken in the fourth quarter (a rise of 13% to 36%).

National catches

The national catches recorded by the various countries for the different areas are given in Tables 2.2.1.2 - 2.2.1.5. As has been stated in previous reports these figures should not be used to study trends in national figures. This is because of the high degree of misreporting and “unallocated” catches recorded in some years due to some countries exceeding their quota. The main mackerel catching countries in recent years continue to be Scotland, Norway, Spain, Ireland, Netherlands and Russia. Significant catches were also taken by Denmark, Germany, France, England & Wales, Northern Ireland and the Faroe Islands (combined catch 84,000t).

The main catches taken in IVa were recorded by Norway (112,000t) and Scotland (41,000t) while substantial catches were also recorded by Denmark (24,000t). The total catch estimated to have been taken from the Western areas (Table 2.2.1.4) was ca. 167,000t. with most of the catches taken by Scotland (50,000t), Ireland (37,000t) and the Netherlands (20,000t). The remainder is taken by Germany (15,000t), France (14,000t) and England (8,000 t) also continue to have important fisheries in this area. The misreported catches from IVa have dropped to 9,000t from the 38,000t reported last year.

2.2.2 Discard Estimates

Discarding of small mackerel has historically been a major problem in the mackerel fishery and was largely responsible for the introduction of the south-west mackerel box. In the years prior to 1994 there was evidence of large-scale discarding and slipping of small mackerel in the fisheries in Division IIa and Sub-area IV, mainly because of the very high prices paid for larger mackerel (>600 g) for the Japanese market. This factor was put forward as a possible reason for the very low abundance of the 1991 year class in the 1993 catches. The difference in prices has decreased since 1994 and discarding has been reduced in these areas.

In some of the horse mackerel directed fisheries e.g. those in Subareas VI and VII mackerel is taken as by-catch. Reports from these fisheries have suggested that discarding may be significant because of the low mackerel quota relative to the high horse mackerel quota - particularly in those fisheries carried out by freezer trawlers in the fourth quarter. The level of discards is greatly influenced by the market price and by quotas.

With a few exceptions, since 1978 estimates of discards were provided to the Working Group for the areas VI, VII/VIIIa,b,d,e and III/IV (see table 2.2.1.1). However, the Working Group considers the estimates for these areas as incomplete. In 2006 discard data for mackerel were provided by three nations: Scotland, the Netherlands and Germany. Total discards amount to approximately 18,000t from the three nations, a slight drop on the previously reported figure (20,000t).

A new analysis of Dutch discard data from their freezer trawler fleet (from 2002 to 2006) was presented to the working group. The analysis suggests that estimates for discards from this fleet should be revised upwards. Previous estimates have indicated discard tonnages of 0-10,000t for this period. The new analysis suggests levels are between 10,000 and 20,000t. Furthermore, the age structure of the discarded differs from the landed catch, with higher proportions at the younger age groups. Countries providing discards estimates should be encouraged to also provide age based information in order that the total stock removal may be more accurately estimated. No discards are available for the areas I/II/Vb and VIIIc/IXa.

The only discard age disaggregated data made available to the group is from Scotland and is data on the Scottish fishery in divisions IVa in the first and fourth quarters and VIa in the first quarter. For quarter 1 in area IV, 91% of the fish discarded were aged 1 or 2. The fourth quarter data from this area shows a different pattern with 83% of the fish discarded aged 4 and 5. For area VIa only quarter 1 data is available. Whilst mostly young fish are discarded (63% age 4 or less), there is still significant discarding of fish up to 7 years old. The percentage length compositions of the Scottish discards for both areas are shown in table 2.4.2.1.

2.2.3 Fleet composition in 2006

Details about vessels operated by the different nations targeting mackerel are given in table 2.2.3.1.

In the Norwegian Sea (Sub-area II) catches are mainly taken by the Norwegian fleet (purse seiners >21 m) and Russian freezer trawlers (55-80 m) that target mackerel, blue whiting and herring at the same time.

The fishery in the North Sea, Skagerrak, and Kattegat (Sub-areas IV and III) is exploited by the Norwegian and Danish purse-seine fleets and pelagic fleets from Scotland, Ireland, Denmark, Faroes and England. Large freezer trawlers (>85m) from the Netherlands, with some operating under the German and English flags, also fish in this area.

To the west of the British Isles (sub-divisions VI, VIIb,c) catches are predominantly taken by the Scottish and Irish pelagic trawl fleet,while sub-divisions VIId-j are also fished by the English fleet and Dutch, French and German freezer trawlers. The Spanish fleet operates in the Bay of Biscay (VIII) and Division IX and consists of demersal trawlers, purse-seiners between 10-32 m and a large artisanal fleet with vessels between 2 and 34 m.

2.2.4 *Scomber* Species Mixing

Scomber sp: Two species of *Scomber* genus, *S. scombrus* and *S. colias,* which previously was sinonimus of *S. japonicus,* are found together and are commercially exploited in the NE Atlantic waters. Recent studies on genetic differentiation showed a strong divergence between *S. japonicus* and *S. colias,* and it has restricted the distribution of *S. japonicus* to Indic-Pacific Oceans and *S. Colias* to Atlantic Ocean (Collette, 1999; 2003).

As in previous years, there were both Spanish and Portuguese fisheries for Spanish mackerel, *Scomber colias* in the south of Division VIIIb, in Division VIIIc and Division IXa. Figure 2.2.4.1 shows the annual landings by ICES Divisions since 1982. The greatest catches came from Division IXa for the whole period. The distribution of catches in Division IXa varies from the minimum value (373 t) in 1983 to the maximum (16,015 t) in 2006. Since 2002, the highest catches correspond to the IXa South area (Table 2.2.4.1).

Table 2.2.4.1 shows the Spanish landings by sub-division in the period 1982-2006. The total Spanish landings of *S. colias* in 2006 were 7,506t, showing an increasing slope trend since 1999, as in the first period of the series (1982-1992). From 1993 to 1998, very high catches were obtained, with the maximum of the whole period (10,903 t) in 1994. More than 95% of the catches were obtained by purse seiners and the main catches were taken in the second half of the year, mainly in autumn (80%), when the *S. scombrus* catches were lowest. *S. colias* is not a target species to the Spanish purse seine fleet in these areas.

Data of monthly landings by gear and area were obtained from fishing vessel owner's associations and fishermen's associations through the existing information network of the IEO and AZTI (Advisory Organisations to Fisheries and Oceanography Administration) in all Cantabrian and Galician ports. In the ports of Cantabria and Northern Galicia (Sub-division VIIIc West) catches of *S. scombrus* and *S. colias* are separated by species, since each of them is important in a certain season of the year. In the ports of Southern Galicia (Sub-division IXa North) the separation of the catch of the two species is not registered at all ports, for which reason the total separation of the catch is based on the monthly percentages of the ports in which they are separated and on the samplings carried out in the ports of this area. There is no problem in the mackerel species identification in the Spanish fishery in Divisions VIIIbc and Subdivision IXa North.

In Subdivision IXa South, the Gulf of Cadiz, there is a small Spanish fishery for mixed mackerel species which had a catch of 239 t of *Scomber colias* in 2006. Every year, a bottom trawl survey is carried out in the Gulf of Cadiz. In 2006, catches of *S. colias* made up on average 51.57 % and *S. scombrus* 48.43 % of the total catch in weight of both species in the survey (M. Millán, pers. comm). From 1992 to 1997 surveys, the catch of *S. scombrus* was scarce or even non-existent (about 1% of the total catch of both species). Since 1998 to 2000, this proportion of the *S. scombrus* has progressively increased, accounting for 61 % in 2000. From 2002 to 2006 the catch of *S. Scombrus* was very scarce, as in the period 1992-1997. This proportion is used to estimate Spanish commercial catches of *S. colias* in this area, however, due to the uncertainties in this proportion rate, the estimated *S. scombrus* catches in the Gulf of Cádiz have never been included in the mackerel catches reported to this Working Group by Spain.

Portuguese landings of *S. colias* from Division IXa (CN, CS and S) in 2006 were 13,031 t, showing a similar level to the last two years. The distribution of the catches is very variable, especially those in subdivision IXa Central-South, with an alternation of increasing and decreasing steep slope trends. During the whole period, catches are higher in the southern areas than in the northern ones (Table 2.2.4.1). These species are landed by all fleets but the purse seiners accounted approximately for 65-70 % of total weight. *S. colias* is not a main target species to the Portuguese fleet.

Landing data are collected from the auction market system and sent to the General Directorate for Fisheries where they are compiled. This includes information on the landings per species by day and vessel. Probably, there is no misidentification of mackerel species in the Portuguese fishery in Division IXa.

Unless stated otherwise, references to mackerel in this report refer to *Scomber scombrus* only. As stated in a paragraph above, the catches from the Gulf of Cadiz have never been included in this report.

2.3 Stock Components

2.3.1 Biological Evidence for Stock Components

No new biological evidence has been presented to assist in stock component definition for mackerel.

2.3.2 Allocation of Catches to Component

Since 1987 all catches taken in the North Sea and Division IIIa have been assumed to belong to the Western stock. This assumption also applies to all the catches taken in the international waters. It has not been possible to calculate the total catch taken from the North Sea stock component separately but it has been assumed to be 10,000 t for a number of years. This is because of the very low stock size and because of the low catches taken from Divisions IVbc. This figure was originally based on a comparison of the age compositions of the spawning stock calculated at the time of the North Sea egg surveys. This assumption has been continued for the catches taken in 2006. An international egg survey carried out in the North Sea during June 1999 again provided a very low index of stock size in the area (<100,000t) (ICES 2002, G: 06)). New egg surveys in the North Sea carried out during June 2002 and 2005 and the SSB adopted at 210,000 t and 220,000 respectively, indicating an increase SSB from 70,000 t in 1999 (See Section 2.5.2). The issue of allocating catches in the North Sea to stock components needs to be revisited in light of the latest surveys which indicate an increase in the proportion of North Sea mackerel in the NEA stock.

Prior to 1995 catches from Divisions VIIIc and IXa were all considered belonging to the southern mackerel stock, although no separate assessment had been carried out on the stock. In 1995 a combined assessment was carried out in which all catches from all areas were combined, i.e. the catches from the southern stock were combined with those from the western stock. The same procedure was carried out by the 1997 - 2006 Working Groups and again by the present Working Group, - the new population unit again being called the Northeast Atlantic mackerel unit.

The TAC for the Southern area applies to Divs.VIIIc and IXa. Since 1990, 3,000 t of this TAC, which has been set at 26,000 t in 2006, have been permitted to be taken from Div.VIIIb in Spanish waters. This area is included in the "Western management area”. These catches (3,000 t) have always been included by the Working Group in the western component and are therefore included in the provision of catch options for the Northern area.

2.4 Biological Data

2.4.1 Catch in Numbers at Age

The 2005 catches in numbers-at-age by quarter for NE Atlantic mackerel (Areas II, III, IV, V, VI, VII, VIII and IX) are shown in Table 2.4.1.1. This catch in numbers relates to a tonnage of 472,652 t, which is the WG estimate of the total catches from the stock in 2006.

Age distributions of catches were provided by Denmark, England & Wales, the Faroe Islands, Ireland, Netherlands, Norway, Portugal, Russia, Scotland, Spain and Germany. There are gaps in the overall sampling for age from countries which take substantial catches, notably France, Northern Ireland and Sweden (amounting to a total catch of over 26,500t) while England & Wales provide aged data for only 12% of their catches. In addition there were insufficient samples to cover Divisions Va, VIIIa and VIIId amounting to a total catch of 10,000t. Minor catches from Divisions IIIb and VIIa,c,g were also not sampled. Catches for which there were no sampling data were converted into numbers-at-age using data from the most appropriate fleets (for further details on sampling quality see Section 1.3).

The percentage catch by numbers-at-age are given in Table 2.4.1.2. In 2005, 2-7 year old fish constituted over 90% of the total. For 2006, this figure has dropped to 83%, primarily due to an increase of the proportion of age 0 and age 1 fish taken (9% of the total in 2006, 3% in 2005%). Of particular note is the very large proportion of age 0 fish taken in area IXaN in quarters 3 and 4 (90% for these quarters and 69% of the annual quantity). Similarly, age 1 fish in VIIIcW represented 74 and 79% of the catch in Q3 and Q4.

Age 0-2 fish also dominate (over 50%) the catches in area VIIc,d,e and f. In these areas mackerel are caught as by-catch in the horse mackerel fishery.

2.4.2 Length Composition by Fleet and Country

Length distributions of the 2006 catches were provided by Denmark, Netherlands, Portugal, Russian, Ireland, Norway, Scotland, Germany, Spain, England & Wales and the Faroe Islands.

The length distributions were available from most of the fishing fleets and account for ca. 90% of the catches. These distributions are only intended to give a very rough indication of the size of mackerel by the various fleets and do not reflect the seasonal variations, which occur in many of the landings. More detailed information on a quarterly basis is available for most of the fleets on the working group files. The length distributions by country and fleet for 2006 catches and discards are shown in Table 2.4.2.1.

2.4.3 Mean Lengths and Weights in the Catches

The mean lengths-at-age in the catch per quarter and ICES division for 2006 for the NE Atlantic mackerel are shown in Table 2.4.3.1. These data continue the long time series and may be useful in investigating changes in relation to stock size. Mean lengths for fish aged 3 and over remained similar to last year. However, mean lengths for juvenile mackerel were approximately 2cm less that reported for 2005.

The mean weights-at-age in the catch per quarter and ICES Division for NE Atlantic mackerel in 2005 are shown in Table 2.4.3.2. As with the lengths, mean weights are reduced for the juvenile fish whilst the weights in the older cohorts are comparable to 2005 data.

2.4.4 Mean Weights in the Stock

For the 2006 western stock there were only a small number of samples of mean weight at age collected from the commercial fishery due to the low level of catch in that quarter. The working group used stock weights based on mean weights-at-age from Dutch and Spanish commercial catch data collected in Divisions VIIh,VIIIa and VIIIb over the period March to May and these were supplemented by samples from the Egg survey used for fecundity evaluations. The two datasets were combined based on the numbers of observations in the samples. Mean weights-at-age for the North Sea component are based on the sample catches collected by the Norwegians and Dutch from areas IVa and IVb during 2006. For the southern component, stock weights are based on samples taken in VIIIc and IXa in the second quarter of the year. The weights for the total stock are combined based on the estimated size of the three areas. For a complete time series on mean weights-at-age in the three components and their relative weighting for the stock weights see the 2004 WHMHSA report (ICES CM 2005/ACFM:8).

DATA SOURCE	NORTH SEA	WESTERN COMPONENT		SOUTHERN COMPONENT	NEA MACKEREL
Age	Catch	Catch	Survey	Catch	
0	0.150	0.066	0.066	0.090	0.076
1	0.220	0.167	0.177	0.198	0.178
2	0.288	0.224	0.214	0.232	0.228
3	0.321	0.303	0.285	0.270	0.297
4	0.372	0.347	0.328	0.353	0.345
5	0.476	0.387	0.367	0.395	0.391
6	0.514	0.417	0.451	0.414	0.436
7	0.573	0.442	0.451	0.441	0.458
8	0.709	0.499	0.499	0.464	0.517
9	0.633	0.516	0.502	0.511	0.523
10	0.671	0.593	0.532	0.532	0.578
11	0.827	0.597	0.581	0.592	0.614
12+	0.150	0.066	0.066	0.090	0.076
No of Samples	607	567	329	16475	
Weighting of stock	0.100	0.814		0.086	

2.4.5 Maturity Ogive

The weighting for the maturity ogive for NEA mackerel is calculated as described above for the stock weights using the egg production from the 2007 international egg survey for the western and southern component and the 2005 North Sea egg survey for the North Sea component. The weighting factors have changed from last year's working group due to the inclusion of the Western and Southern egg production estimates in 2007, but the effect on the overall Maturity ogive is very small. For a complete time series on proportion mature at age (MATPROP) in the three components and their relative weighting in the stock see the 2004 WHMHSA report (ICES CM 2005/ACFM:8).

AGE	NORTH SEA[1]	WESTERN COMPONENT[2]	SOUTHERN COMPONENT[3]	NEA MACKEREL
0	0.00	0.00	0.00	0.00
1	0.00	0.08	0.02	0.07
2	0.37	0.60	0.54	0.57
3	1.00	0.90	0.70	0.89
4	1.00	0.97	1.00	0.98
5	1.00	0.97	1.00	0.98
6	1.00	0.99	1.00	0.99
7	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00
12+	1.00	1.00	1.00	1.00
Weighting of stock	0.100	0.814	0.086	

[1]ICES fisheries assessment database kept constant 1972-recent,

2.4.6 Natural Mortality and Proportion of F and M

The mean time of egg spawning was estimated from the egg survey data (see section 2.5.1) by calculating the average egg production per Julian day over the period of spawning (Figure 2.4.6.1).

From this the fraction of the year before which spawning occurred was calculated for each of the egg survey years (Figure 2.4.6.2).Very little change between years is observed. A mean value was then obtained over all years of 0.35.

It was noticed by inspection of the catch data that there appeared to be a shift in the timing of the effort by the fishery from the last quarter of the year to the first quarter (Figure 2.4.6.2), that indicated the need to investigate the proportion of F before spawning.

Catch numbers were taken by quarter and the quarter 2 data partitioned to give an observed catch before and after time of spawning. Partial Fs were then calculated using the output from the 2006 ICA mackerel assessment and an estimated catch calculated using the catch equation. A proportion of F before spawning was then obtained by age and year and mean values calculated (Table 2.4.6.2).

2.5 Fishery-independent Information

2.5.1 Egg survey estimates of fecundity and spawning biomass in 2007

The ICES Triennial Mackerel and Horse Mackerel Egg Survey was carried out during February - July 2007. It is planned to present the results of the survey at the WGMEGS meeting in April 2008. However, it was agreed at the WGMEGS in Vigo in March 2006 that the WG should aim to provide an estimate of NEA mackerel biomass and western horse mackerel egg production in time for the meeting of the WGMHSA in Copenhagen, September 2008. This required a complete work up of the data from the egg survey itself as well as the histological data on mackerel fecundity and atresia. The results were presented in a document by Alvarez and Burns (WD 2007). The production of useable estimates for both species required considerable commitment from the members of WGMEGS. WGMHSA were both aware and appreciative of this. It has to be noted that this is a preliminary analysis because due to time constraint it has been impossible to look deep into the egg data and only relatively few fecundity data are finalized.

The survey was carried out over six periods with a total of 315 survey days.

Period	Dates
1	Pre 7 March
2	7 March - 8 April
3	9 April – 6 May
4	7 May – 3 June
5	4 June – 24 June
6	25 June – 31 July

The analysis protocols followed those described in the report of WGMEGS (ICES 2000/G:01). Egg counts were converted to stage 1 egg production m^{-2}, using data on the volume of water filtered and on the sampled depth. These values were then converted to egg production $m^{-2}.day^{-1}$ using the development equations and water temperature at 20m depth. Arithmetic means were used where more than one sample per rectangle per period was collected. Daily egg production values were interpolated into unsampled rectangles according to the rules set down in the above report.

Plots of the distribution of egg production for the western area are presented in Figures 2.5.1.1.a-e. Interpolated values are highlighted in red. Overall survey coverage was good for all periods up to and including period 5. Period 6 consisted of one survey with the prime consideration of establishing the southern boundary which was achieved.

Most of the surveys ran and were completed within period give or take a couple of days. The one notable exception to the rule was the AZTI period 2 survey which unfortunately straddled periods 2 and 3. By the time dates were finalised it actually occupied more time in period 3 than period 2. Given the proximity to the start of the surveys the decision was made to retain the survey within period two rather than splitting it between the periods which risked disrupting an otherwise settled survey plan. The large egg production estimate for period 2 compared to period 3 required a special look at the contribution made by these late AZTI stations that were sampled within period 3.

The contribution made by these stations to the total mackerel stage 1 estimate is approximately 5% ($4.9*10^{11}$) and as we can see from figure 2.5.1.1a most of the spawning activity in that period takes place further north in the Celtic sea and West of Ireland. It was therefore assume that the impact of these out of period stations on the overall period 2 mackerel stage 1 estimate is negligible.

The egg distributions in the southern areas for the period 2-4 are shown in Figure 2.5.1.2.a-c. During the meeting data from the west coast of Portugal and Spain were provided, but only a total of 8 stage-I eggs were collected in this area .

Egg production for each survey period was then calculated by raising each value to the rectangle area, summing across the whole period, and raising to the number of days in each period. Egg production in the unsampled periods were then calculated by simple linear interpolation from the adjacent periods. The observed and interpolated periods were then assembled to produce separate western and southern area egg production curves or histograms. The Total Annual Egg Production (TAEP) was then calculated by integration of the histograms. The egg production curves for the western area is presented in Figure 2.5.1.3. The TAEP for the western area was $1.22 *10^{15}$ which is quite similar to that obtained in 2001, $1.21 *10^{15}$, and 2004, $1.20 *10^{15}$. TAEP in the southern area was $0.15 *10^{15}$, compared with $0.28 *10^{15}$ in 2001 and $0.126*10^{15}$ in 2004.

2.5.2 Fecundity and atresia estimation

During the survey 1035 mackerel ovaries were collected for fecundity and atresia from the southern and westen area. So far 299 have been selected to be analysed at this stage. The results form 1998, 2001, 2004 and the preliminary results from 2007 are given in the table below:

Assessment year Parameter	1998	2001	2004	**VERY preliminary 2007**
Number of samples analysed: potential fecundity	96	187	205	**132**
atresia	112	290	348	**73**
Potential fecundity	1206	1097	1127	**1098**
Prevalence of atresia	0.55	0.20	0.28	**0.370**
Geometric mean Relative intensity of atresia	46	40	33	**26**
Number of potential fecundity lost per day	3.37	1.07	1.25	
Number or potential fecundity lost over an individual's spawning season	202	64	75	**77**
Realised fecundity	1002	1033	1052	**1021**
Percentage of potential fecundity lost	17	6	7	**7**

The table gives the combined data from the southern and western areas. The preliminary analysis of the 2007 data indicates a 7% loss of potential fecundity giving a preliminary realised fecundity of 1021

eggs. g^{-1} female. Both the observed loss of potential fecundity and the realised fecundity for 2007 are similar to the respective observations in 2001 and 2004.

Biomass estimates for the western and southern areas

The TAEP was converted to an SSB estimate using information on female fecundity, sex ratio and pre-SSB to SSB correction. Parameters used in the calculation and the SSB for 2007 are given in the table below:

	Western component	Southern component
Total Annual Eggs Production	1.22 * 10^15	0.15 * 10^15
Realised Fecundity (egg g female-1)	1021	1021
Female fraction	0.5	0.5
Pre-spawning Biomass to SSB conversion	1.08	1.08
BIOMASS	Western component	Southern component
Pre-spawning biomass	2,389,814	293,830
SSB (tonnes)	2,580,999	317,336
TOTAL 2007	2,898,335	
SSB (tonnes) 2001	2,530,000	371,300
SSB (tonnes) 2004	2,470,000	280,300

The combined estimated SSB for the southern and western components in 2007 is about 3,000 tons smaller than in 2001 and about 148,000 tons larger than in 2004.

2.5.3 Quality and reliability of the 2007 egg survey in light of previous surveys.

The preliminary estimate of the mackerel egg survey results were provided at the beginning of the WG (Alvarez and Burns, WD 2007). Based on previous years there is good reason to believe that these results will not differ greatly from those obtained when all countries have completed the analysis of fecundity and atresia data. Although in previous years the final figures for fecundity and atresia have varied considerably, they have had little effect on the resulting assessment, and there is no reason to believe that the egg survey estimates of SSB used this year are not reliable and robust to future changes.

The area surveyed this year by all countries encompassed well the limits of the spawning area, with zero values for egg production recorded along most boundaries. The only exception to this is the most northerly boundary of the western area, where eggs were still being recorded at the limit of the survey. The total area covered by the surveys in 2007 was smaller than that of the year previous. (WGMEGS 2007).

2.5.4 Results from the 2005 mackerel egg survey in the North Sea

The results of this survey were given in last year's working group report. The total egg production was $0.155*10^{15}$ eggs corresponding to a SSB of 223,000 tons applying the standard fecundity of 1401 eggs/g/female (Adoff and Iversen, 1983). For the first time since 1982 a fecundity study was carried out in the North Sea in 2005 giving a slightly lower fecundity, 1359 eggs/g/female, corresponding to a SSB of 228,000 tons. The next egg survey in the North Sea is planned to take place in 2008.

Since the last egg survey in the North Sea was in 2005 the Working Group decided not to combine this survey with the 2007 western and southern surveys. The next North Sea survey in 2008 will be closer in time to the 2007 surveys and it might thereby be better to combine these two. The WGMEGS is asked to advice on this item during their next meeting.

2.5.5 Southern component: CPUE from bottom trawl surveys

There are two surveys series: The Spanish September-October survey and the Portuguese October survey. The two sets of Autumn surveys covered Sub-divisions VIIIc East, VIIIc West and IXa North (Spain) from 20-500 m depth, using Baka 44/60 gear and Subdivisions IXa Central North, Central South and South (Portugal), from 20-750 m depth, using a Norwegian Campell Trawl (NCT), that is a trawl net having a 14 m horizontal opening, rollers on the ground-roper and has been fitted with a 20 mm mesh size cod end. The same sampling methodology is used in both surveys but there were differences in the gear design. The Spanish survey used a bottom trawl gear called “Baka” (similar to the gear normally used in these waters by the commercial trawl fleet) aimed at benthic and demersal species, therefore the scope of the survey must be borne in mind, regarding the validity of the abundance indices obtained for pelagic species. In addition, no work is carried out at less than 80 m depth, which results in an incomplete coverage of the whole area of mackerel juvenile distribution. Comparative data analysis of Baka and GOV gears are described in Section 2.7.2.

Table 2.5.5.1 and **Figure 2.5.5.1** show the numbers at age per half hour trawl from the Spanish bottom trawl surveys from 1984 to 2006 in September-October and the numbers at age per hour trawl from the Portuguese bottom trawl autumn surveys from 1986 to 2006. Both are carried out during the fourth quarter when the recruits have entered the area and the adults are very scarce in this area. The historical series of abundance indices from the Spanish trawl surveys indicates that 1992, 1996, 1997, 2000, 2002, 2005 and mainly 2006 were those with the highest values of juvenile presence (0 and 1). The series of the Portuguese October survey shows a very high values of recruitment (age 0) in 1988, 1992, the period 1995 to 1999, 2001 2002 and 2006. See next section 2.5.6 for the use of this information as recruitment index.

2.5.6 Preliminary Analysis of Bottom Trawl Surveys as recruit index.

An extensive investigation of potential use of the 0 group surveys was carried out in 2006. Initially the data were analysed by national survey, by stat rectangle and latitudinal area. The survey series has gaps and changes in survey intensity over time. The best indications of recruitment (compared with the current assessment) were obtained when the stations were treated as identically distributed independent estimates of abundance, and a simple mean of all stations. This suggests that the random error associated with encounter with mackerel is the overriding dominant source of variability, and differences between survey catchability and spatial effects are less important. Table 2.5.6.1 illustrates the time series of mean abundance, the effort expressed as station numbers and the coverage as count of ICES rectangles. The early part of the series is sparsely populated (some surveys are missing) and poorly resolved, (low station numbers). The coverage and effort increase from 1985 to 1989 and then again by 1997 and remains relatively stable subsequently. In addition there is a northern Q1 survey (Table 2.5.6.2) that also catches juveniles, coverage is more limited though more consistent.

A simple regression analysis between the two series of survey estimates of yearclass 1985 to 2006 is illustrated in Figure 2.5.6.1a. Although noisy the results are potentially encouraging, with r^2 of 0.5 and the four largest values appearing in recent years in both surveys. A combined estimate weighted by number of hauls is shown as a simple regression in Figure 2.5.6.1b. The combined survey estimates his higher r^2 than either of the surveys individually. Potential recruit estimates for 2004, 2005 and 2006 are also given in this figure. It can be seen that these values are estimated as highest in the time series, the r^2 is similar at 0.53 but the equation depends heavily on the single large value from 2002. The comparison of recent data from the index and the assessment indicates that high values in the index can indicate high recruitment, and low values are indicators of low recruitment, (see 2000, 2002 and 2003 values in Table 2.5.6.1). However, the regression analysis can easily give values that exceed previously observed recruitment. The survey CVs have been high in the past (around 0.5) though currently lower (around 0.35) this still indicates relatively low precision as a predictor.

An alternative approach presented in 2006 is to consider that the rank of the survey index is a better indicator of the rank of the recruitment. While rank correlation does not improve *per se*, the process more or less resolves large, small and intermediate values without the problems needed in a direct classification to a small number of categories. The process is

$$R_y = ranked[R_{ICA} i][nt[Rank[I_y] * Y_{ICA} / Y_{survey}]$$

Where R_y is recruitment in year y, R_{ICA} is the recruit series (without the last two years) from ICA, Y_{ICA} and Y_{survey} are the number of years in ICA and the survey series.

A scatter plot of the rank index picked recruitment and assessment estimated recruitment is illustrated in Figure 2.5.6.1c, a 1:1 line is included to show the relationship implied. Estimated values for 2004, 2005 and 2006 yearclasses are placed on the plot using the rank pick procedure (on a 1:1 line).

Use of the surveys to predict recruitment

The primary purpose of the analysis of these survey data is to derive the most informative method for predicting recruitment. A retrospective analysis of the methods for deriving 0 and 1 group recruitment described above was given last year. For convenience the main conclusions repeated here. Use of the assessment data directly was clearly the worst decision and has been correctly rejected by the WG. Replacement of both 0 and 1 group by geometric mean has been the least biased method over the last 7 years, but it does not explain any of the variability in recruitment. Replacement of only 0 group gives 20% bias but reduced deviation from the assessed recruitment. The use of replacement of both 0 and 1 group increases the bias by 2% but reduces the variability by a modest 30%. Last year the WG concluded that the next two years would provide a good opportunity to assess the performance of the survey index described above. Since then this years assessment has revised the 2004 yearclass upwards from 1828 to 3430 but this is still not as high as the value 7300 currently estimated by the survey index. The 2005 year class has also been revised upward from 780 to 1879 but again not as high as the 7200 derived from the survey index. The direction of the revision is correct though the magnitude is not sufficient to provide satisfactory validation. Further substantial revision of the 2005 year class is still possible in future years. However, major revision is less likely for the 2004 year ass which is currently estimated as close to the mid range by the assessment and high by the survey index. The survey index for this year estimates the 2006 year class as high at 5300. So currently the use of the geometric mean for 0 and 1 (yearclass 2006 and 2007) is expected to provide the most unbiased predictions, and this practice will be continued at present. Further work with the survey index will be continued to attempt to obtain the best use of this data.

2.5.7 Mortality estimates from tag recaptures

As in previous years, mortality estimates from tag recaptures in the Norwegian tagging program was updated. The detailed methodology has been reported in previous WG reports (see e.g. ICES 2007 (MHSAWG report)) Each year, a number of mackerel (normally about 20 000) have been tagged with internal steel tags on the spawning grounds West of Ireland in May. Recovery is by metal detectors at landing sites and by magnets in fish meal factories.

Mortalities between consecutive tag releases can be derived without knowing the amount of fish screened for tags, hence the whole material of recovered tags could be used. Such estimates only consider the fractional representation of tags from two different releases in subsequent recaptures, within the same year class, and therefore are independent of how the fishery is performed and where and when the fishery takes place, unless that leads to different representation of tags released in two consecutive years within the same year class.

Calculations were done by year class. The age of each released tag could be derived from length and age-length keys at tagging time. Age of recaptured tags was either measured directly if otholiths were available, if not, it was derived from the length at release.

The total mortalities were calculated according to the Jolly-Seber principle as:

$Z(y_i,y_j,a_i) = log\{\Sigma r(y_i,y_k,a_i)/\Sigma r(y_j,y_k,a_j)*R(y_j,a_j)/R(y_i,a_i)\}$

where $R(y_i,a_i)$ is the number of tags that were released in year y_i at age a_i, and $r(y_i,a_i,y_k)$ be the number of such tags that are recaptured in year y_k. .

To obtain measures of the uncertainty of the estimates, bootstrapping was done at two stages of the process:

1) For recaptured tags where age at recapture was not available, each fish was given an age by drawing randomly from the age distribution at length in the age-length key.

2) The raw number of tags $r(y_i,y_k,a_i)$ of each category y_i,y_k,a_i was assumed to be Poisson distributed, and substituted by a random number drawn from a Poisson distribution with the raw estimate as parameter.

Estimated mortalities over one year periods (between subsequent releases) are presented here. No tags were released in 1987, i.e. mortalities for 1986 and 1987 could not be estimated. If calculated for each single age and year, the estimates are very noisy, both due to imprecise age data and to variations between years in the survival of the fish immediately after tagging. Therefore, the results are the average over various age ranges, and presented as 3-year running averages.

The results are shown in Figure 2.5.7.1. The estimated for the late 1980ies is probably unreliable, due to the gap in the releases in 1987. Later, the mortality has remained close or slightly below 0.4, with a dip in the mid 1990'ies and a peak around 1999. For the years after 2000, the results are highly uncertain.

The results are quite similar to those presented last year. The difference in the data is that more recent recaptures, as well as the release data from 2004 have been added. Last year, there appeared to be a very low mortality from 2002 to 2003, with a very high standard deviation. Now, the estimate of this mortality and its standard deviation is more in line with the previous years. The mortality from 2003 to 2004 is also largely in line with the previous years.

There are some strong year effects, probably due to variable mortality in the tagging process, and recent trends can hardly be inferred from these data. The general impression is that Z has fluctuated mostly in the range 0.3 – 0.4, which is slightly below what one would expect from the analytic assessment (mean Z estimated by ICA over the period covered is 0.4)

2.5.8 Biomass estimates from tag recaptures.

In 2005, estimates of stock biomass from tag recaptures in catches with known volume were reported to the group by Antsalo & ald. This study indicated that the spawning biomass has declined gradually over time, but that this trend may have been reversed at the end of the 1990s. Work is in progress to extend this study, but the results are not yet ready.

2.5.9 Acoustic estimates of mackerel biomass

2.5.9.1 Acoustic surveys in the North Sea and Norwegian Sea

NEA mackerel has been measured acoustically by Norway in October-November in the Northern North Sea annually since 1999. The main fishery is concentrated in this area during this season. The results of these surveys have been summarised in a Working Document by Korneliussen & al. presented to the PGAAM in May 2005 but were revised late 2005 (ICES 2006 - MHSAWG report 2006).

The acoustic survey in 2006 showed a different distribution pattern than in previous years from 1999-2005, with a more pronounced distribution of mackerel in the central and western part of the Northern North Sea (Figure 2.5.9.1.1).

The biomass estimates of NEA mackerel in the Northern North Sea where the main fishery has been taking place in October-November have been varying from 351 000 tons in 2004 to 872 000 tons in 2006 (Figure 2.5.9.). This means that the acoustic biomass estimates have been varying by a factor of up to 2.5 the most recent years. Thus, the acoustic abundance estimates are still not reliable enough to be included in the annual assessment of the NEA mackerel. Consequently, the acoustic data should be treated more as exploratory in order to improve the acoustic methodology on the mackerel stock. The biomass estimates cannot be taken as absolute for a number of reasons: The target strength for mackerel, and its relation to mackerel behaviour is poorly known. Mackerel that is scattered without forming distinct schools may not be representatively recorded. In the samples used both for converting integrated acoustic abundance (s_A) to biomass and to obtain age distributions, large fish are likely to be under-represented (Slotte & al, 2007). Obtaining samples by pelagic trawling from research vessel has been problematic, and samples from the commercial purse seine fleet operating in the area at the time of the survey showed a mean length about 5 cm larger than the samples by the research vessel trawl. As in 2003, 2004 and 2005, there was no sharp thermocline in the eastern and central part of the northern North Sea in 2006. Rather, the water was warm in the whole water column. Mackerel was found in the whole water column, while when there is a thermocline, the mackerel is normally found above it.

There exists a fundamental challenge when measuring the NEA mackerel stock in the North Sea in autumn: most of the acoustic estimate comes from very limited number of registrations (see Figure 2.5.9.1.3). In practise, it is the large schools that we happen to find occasionally that matters in the overall abundance estimation.

Ecosystem survey in the Norwegian Sea

The major aim of this coordinated cruise is to map the large-scale oceanic distribution and quantify the abundance, aggregation and feeding ecology of Northeast Atlantic (NEA) mackerel (*Scomber scombrus*), Norwegian spring-spawning herring (*Clupea harengus* L.) and blue whiting (*Micromesistius poutassou*) in relation to their experienced physical and biological environment during summer in the Norwegian Sea and surrounding waters. The fleet included two chartered commercial fishing vessels: M/V *Libas* and M/V *Eros*. These two vessels have adjustable drop keel and highly advanced acoustic instrumentation and commercial sampling devices, making them excellent for large-scale scientific surveys. The vessels covered substantial areas (7395 nmi.) in the Norwegian Sea and surrounding waters between 62°30-75.00ºN and 18°W-20°E.

The geographical coverage during this coordinated cruise was substantial and we managed to include the entire NEA mackerel distribution from 62º00N to 74º00N and from 20º00 E to 18º00 W. Length (n=5451) and age (n=1377) distribution from 92 trawl stations containing NEA mackerel is shown in figure 2.5.9.4. The pelagic trawling should be representative for the true distribution of mackerel, due to large opening (d=1300 m) and high towing speed.

The NEA mackerel was distributed over substantial areas in Coastal, Atlantic and Arctic water masses, as well as frontal coastal and Arctic regions within shallow waters less than 50 meters depth (Figure 2.5.9.5). Mackerel had some preference for the warmer water masses >8ºC, but were also found in colder water masses in the western and northern part of the large distribution area. The mackerel were mainly feeding on *Calanus finmarchicus* and *Limacina retroversa*.

The dominant acoustic registrations and pelagic trawl catches were taken in the central and eastern part of the Norwegian Sea. The largest and oldest mackerel were typically caught in the western and northern part of the Norwegian Sea in the Jan Mayen area and 5 years old individuals dominated the catches (21%), together with 2 years old (20%). 1 year old mackerel contributed with almost 10% of the catches, indicating good recruitment from the 2006 year class. Mackerel was caught as far north as 73°30 N and weights ranging from 100-920 g.

Quantitative analyses of abundance, aggregation and distribution of mackerel concentrations were also performed continuously based on Simrad ER60 raw data using 38 kHz as the primary frequency (in addition to 18, 70, 120 and 200 kHz), for fish species and nautical area scattering coefficient (NASC) allocation. Acoustic detection of species and NASC allocation to mackerel was done based on the multi-frequency response pattern of the acoustic echoes. Judging of the acoustic data was performed daily by two scientists applying the post processing system Large Scale Survey System (LSSS) http://www.marec.no/ . Results on acoustic NASC values for NEA mackerel are shown in Figure 2.5.9.6. An abundance estimation from the acoustic data on NEA mackerel in the Norwegian Sea will be performed on a later stage, after exploring the data in more detail.

We counted > 100 000 individual schools of mackerel and herring with multibeam sonars (Simrad SP70/90 and SH80) onboard Libas and Eros along the cruise tracks. The future aim is to combine concurrent echsounder and sonar registrations for more accurate abundance estimation on NEA mackerel in the Norwegian Sea. Most of the schools were quite small in size with shallow distribution (0-50 m) and the school biomass typically ranged from about 100 kg – 20 tons. Distribution of NEA mackerel in the Norwegian Sea in summer (July) during the period 2002-2007 has shown considerable changes and steadily increased their western and northern distribution area when the species exhibit their most extensive migration pattern throughout the year (Table 2.5.9.1). Changes in northern and western distribution pattern in the Norwegian Sea during late summer could be a useful qualitative indicator on the abundance and health of the NEA mackerel stock. The data clearly show that there has been a significant increase in maximum geographical distribution both into the western and northern part of the Norwegian Sea in 2007 compared to previous years. A larger proportion of the NEA mackerel stock may be using the Norwegian Sea as their primary feeding area in recent years, due to high experienced primary and secondary production and favourable physical conditions with increased temperatures over larger areas in this vast ecosystem.

2.5.9.2 Acoustic estimates of mackerel in the Iberian Peninsula and Bay of Biscay

The IEO acoustic surveys were carried out onboard R/V *Thalassa* in March-April, with the main aim to assess the pelagic fish community off the North Iberian Peninsula (Divisions VIIIc and IXa). Biomass estimates are obtained for the main pelagic fishes in the survey area, including sardine, mackerel, horse mackerel and, whenever it is present in sufficient fishing hauls, anchovy. The methodology for the estimation of mackerel biomass by acoustic methods in the study area has been standardised (Iglesias et al., 2005). The high abundance of this species in the Atlantic-Cantabrian Sea area during these months and their particular behaviour, with schools and aggregations close to the bottom, permits their detection by means of scientific echosound and fishing trawls for the purposes of identification with relative ease. The TS/L relationship used was the same as in the North Sea and as recommended by PGAAM. The use of several frequencies, mainly 38 and 120 kHz, helps in the identification of the echotraces of this species, above all when they are masked by plankton or bubbles. In the all surveys a reading threshold of echograms of -60 dB was chosen.

Mackerel has been measured acoustically by Spain in March-April in the North and Northwest of Iberian Peninsula since 1999. Mackerel are abundant in this area in spring, when they come to the area to spawn. Details are available in the working document on acoustic surveys (Iglesias et al., 2005, WD to WGMHSA 2005). The results of the 2001 to 2007 surveys are presented, leaving the re-evaluation of the 1999 and 2000 surveys pending.

In all years, mackerel are distributed throughout the whole area surveyed (Figure 2.5.9.2.1), and the highest concentrations are found in Division VIIIc (Table 2.5.9.2.1), coinciding with the main spawning ground in the Southern Area (ICES 2005). Mackerel abundance has varied considerably from 2001 to 2007, with higher values in 2002 and 2003 coinciding with a high abundance of juveniles (Table 2.5.9.2.2). Regarding biomass, a maximum was reached in 2002 (1,534,793 t) with a large reduction in 2005 (409,493 t) followed by a further large reduction in 2006 (146,572 t) and 2007 (198,801 t) with respect to 2003 and 2004 (907,814 t and 945,619 t respectively) values. The fall in abundance and biomass registered in the last years (2005-2007), as Figure 2.5.9.2.2 shows, may be partly because the dates on which the survey was carried out were the latest of the whole series (April). Historically, the commercial catches of this species have usually come mainly in March and April, with a peak in the latter of the two months (Villamor et al. 1997; ICES, 2005). Nevertheless, from 2000 onwards, and even more markedly in 2004 - 2006, catches were mainly taken in March (51% in 2004, 60% in 2005 and 51% in 2006), while catches in April fell sharply (by 19% in 2004, 18% in 2005 and 16% in 2006). Another important detected fact is the increase of catches in February and even in January in 2004-2006. This may suggest that in those most recent years, possible temporary shifts in the mackerel migration to the Southern component spawning area has occurred. Their arrival and their post-spawning northward migration seem to be earlier than in previous years, although biological studies are necessary to confirm this. If so, this fact may have had an influence on the detection of the species and on the low estimate of its biomass in 2005-2007 compared with previous years, since the survey was conducted on these dates (April).

Also, as we see in biomass by length class distribution (Figure 2.5.9.2.3), years 2005-2007 show extremely low values. Biomass by age class (Figure 2.5.9.2.4) for the whole Spanish area (VIIIc and IXa North) reflect a strong year class in 2002 (age 1 in 2003) and also in 2001 (age 1 in 2002), albeit less than in 2002, a weak year class in 2000 (age 1 in 2001) and also in 2004 (age 1 in 2005).

The age structure of the surveys is similar to the current perception of the age structure of the Northeast Atlantic mackerel stock, with a poor year class in 2000 while the year classes of 2001 and 2002 appear to be strong (ICES WGMHSA 2006). The similarity between the age structure of the survey and those of the catches used in the assessment indicates that the survey may potentially be a good candidate for use as an independent index of the fishery. On the other hand, it may also be a good candidate to be used as an index of recruitment to age 1, since the survey seems to detect year classes quite well.

The IPIMAR surveys have not so far been used to develop biomass estimates for species other than sardine in Portuguese waters, due to the lack of targeted fishing. In the future it is hoped that attempts will be made to carry out more targeted hauls, with the aim of producing biomass estimates for other species than sardine. However, due to the low mackerel abundance and the tendency to be mixed with other species, it is unlikely that a reliable acoustic abundance index may be obtained for this species.

The IFREMER annual survey in the French Biscay area is targeted at all pelagic fish resources. However, in that area mackerel are widely scattered and mixed in with the plankton and other fish. This lack of aggregation into schools, combined with the low target strength value and the difficulty of acoustic separation means that estimates of biomass are still very difficult to derive. Length distribution and some additional biological data are available, but a quantitative assessment is not possible.

2.5.10 Conclusions to fishery independent data

2.5.10.1 Changes in distribution of mackerel in the Northeast Atlantic

The Spanish fishery in divisions VIIIc (Cantabrian Sea) and VIIIb (Bay of Biscay) has since 2005 started and ended earlier than in the previous years. In the latter period the fishing season has been January/February-April, while in the previous years it started in March and ended in May. This has been confirmed by surveys the last two years when a sharp decline in biomass in April was observed (see Section 2.5.9.2, Figure 2.5.9.2.2). This indicates a temporal shift of about one month in the migration pattern of mackerel in the southern areas and might be linked to a more northern distribution pattern.

French acoustic surveys in divisions VIIIa and VIIIb in May showed both in 2006 and 2007 a significant reduction in adult NEA mackerel within the survey area compared to previous studies, also suggesting a northerly shift in the distribution area in recent years.

During the Norwegian acoustic survey in the Northern North Sea in October-November 2006, adult pre-spawning mackerel showed a more western and partly northern distribution pattern compared to previous years (Figure 2.5.9.1).

Scottish data on 0-group mackerel data from the IBTS survey indicates a strong 2006-year class, although these data are subject to uncertainties.

The mackerel was distributed further to the west in offshore waters and partly to the north during the international egg survey west of the British Isles in 2007 compared to earlier egg surveys.

A Faroese study showed 0-group mackerel caught in December 2006 and 1-group mackerel caught in January and April 2007 in the southwestern part of the Faroe Bank and in the Faroe-Shetland Channel (Jacobsen, WD2007). The 2006 year class mackerel were caught as by-catch in the Faroese commercial blue whiting fishery. This was also confirmed in survey by R/V “Magnus Heinason” south of Faroe Bank early April 2007 when 1-group mackerel was caught. The mean length was 19 cm and mean weight 42 g.

Data from a coordinated ecosystem survey in the Norwegian Sea in July-August 2007 showed a significant increase in the western and northern distribution area of adult mackerel (Figure 2.5.9.1). Furthermore, juvenile mackerel from the 2006 year-class where present for the first time in relatively large quantities up to 66ºN (Figure 2.5.9.5) and constituted about 10% of the sampled specimen (Figure 2.5.9.4).

The Working Group has put forward a hypothesis that an overall northerly shift in the distribution of NEA mackerel has taken place in 2005-2007. There is also a westerly shift in the northern part of the spawning and feeding areas. If such a large-scale change in distribution and migration pattern really have occurred it is assumed this may have substantial consequences for future abundance, spawning, growth and recruitment of the NEA mackerel stock.

The reasons to the observed changes in distribution are likely to be found in recent changes in the hydrographic conditions in the spawning area. It is well-known that there have been large changes in the size and distribution of blue whiting stock since the mid 1990s, especially in the western distribution area (ICES 2007/ACFM:29). Mackerel uses more or less the same areas to spawn, thus it is likely that these large-scale changes in the environment would also affect mackerel. Changes in the oceanic environment in the Porcupine/Rockall/Hatton areas have been shown to be linked toe the strength of the so-called subpolar gyre (Hátún *et al*. 2005). In recent years the area has been dominated by the more warm and saline Eastern North Atlantic Water (origination from the south), thus giving favourable conditions for spawning over a relatively wide area (Hátún *et al*. 2007). However, it remains to be shown whether there is a causal relationship between hydrographic conditions and recruitment of mackerel.

2.5.10.2 Future aspects of mackerel surveys.

The most important information from acoustic surveys up until now relates to abundance, spatial distribution and migration pattern of mackerel. In addition they often also provide information to improve ecological understanding and ecosystem perspectives. Nevertheless, using such information in assessments would require more comprehensive surveys. This is a major challenge both because the distribution area is huge, and because of methodological problems since mackerel often is distributed high in the water beyond the range of echo sounders and mixing with other species in some areas. For the time being the WG from an assessment perspective gives highest priority to the egg surveys. However, due to the pronounced changes in the distribution and migration pattern of mackerel observed recently (2006 and 2007) the WG encourage future surveys to gain more information and to monitor these changes.

2.6 Effort and Catch per Unit Effort

The effort and catch-per-unit- effort from the commercial fleets is only provided for some fleets in the southern area.

Table 2.6.1 and **Figure 2.6.1** show the fishing effort data from Spanish and Portuguese commercial fleets. The table includes Spanish effort of the hand-line fleets from Santoña and Santander (Sub-division VIIIc East) from 1989 to 2006 and from 1990 to 2006 respectively, for which mackerel is the target species from March to May. The Figure also shows the effort of the Aviles and A Coruna trawl fleets (Sub-division VIIIc East and VIIIc West) from 1983 to 2006. The effort of the Aviles trawl fleet is not available since 2004. The Spanish trawl fleet effort corresponds to the total annual effort of the fleet for which demersal species is the main target. The Vigo purse-seine fleet (Sub-division IXa North) from 1983 to 2006 for which mackerel is a by catch is also presented. In 2003, the effort of the Spanish fleets was lower due to the spatial and temporal closure during the first quarter imposed by the presence of oil in the water, due to the catastrophe of the *Prestige* oil spill. The effort of the hand-line fleet showed an increasing trend from 1993 to 1998. Since then, the trend has been variable The effort of the trawl fleets is rather stable during all periods with a smooth decreasing trend especially since 1995. The purse-seine fleet effort fluctuated during available period.

Portuguese Mackerel effort from the trawl fleet (Sub-division IXa Central-North, Central-South and South) during 1988 - 2001 is also included and as in Spain mackerel is a by catch. The effort for this fleet varied between the lowest value (38,719 fishing hours) in 1994 to the highest one (86,020 fishing hours) in 1998. 1992 and 2001 also showed high effort values. Since 2002 the effort data has not been available.

Figure 2.6.2 and **Table 2.6.2** show the CPUE corresponding to the fleets referred to in Table 2.6.1. The CPUE trend of the Spanish hand-line fleets shows an increasing trend, with ups and downs trough the whole series. In 2005 and 2006, the CPUEs of the handline fleets show the highest values of the two series, Santoña and Santander hand-line fleets. The CPUE of the trawl fleets, like the hand-line fleets, presents an increasing general trend. The CPUE for the Aviles trawl fleet has increased since 1995, in particular in 2000 and 2002, but this figure is not reliable because catches of this fleet are estimated since 1994 onwards. For the A Coruña trawl fleet is rather stable during all period until 2004, increasing in 2005 and over all in 2006.

The CPUE of the Portuguese trawl fleet is variable, with a decreasing trend and the maximum value in 1991 and the minimum in 1998. The CPUE of the purse-seine fleet shows fluctuations during the period 1983 to 1995 and since 1996 to 2002 the CPUE of this fleet shows an increasing trend. In 2003 a fall was seen in the CPUE of this fleet, increasing since 2004.

Catch-per-unit-effort, expressed as the numbers fish at each age group, for the hand-line and trawl fleets is shown in **Table 2.6.3**.

2.7 Distribution of mackerel in 2006-2007

2.7.1 Distribution of commercial catches in 2006

The distribution of the mackerel catches taken in 2006 is shown by quarter and rectangle in Figures 2.7.1.1 – 4. These data are based on catches reported by Denmark, the Faroe Islands, Germany, Ireland, Netherlands, Norway, Portugal, Russia, Spain and the UK. In these data the Spanish catches are not based on official data. Not all official catches are included in these data. The total catches reported by rectangle were approximately 449,000 tonnes including Spanish WG data, the total working group catches were 472,652 tonnes. The main data missing from this series are from France, Iceland, Sweden and Poland, who did not supply this data to the WG.

First Quarter 2006 (194,749t)

The distribution of catches in quarter 1 is shown in figure 2.7.1.1. The misreporting between divisions IVa and VIa reported in 2005 is significantly reduced (9kt compared with approximately 40kt) resulting in a more even distribution of catch across areas IVa and VIa. The overall distribution of catches remains similar to previous years with the majority of catches taken along the shelf edge from the Celtic Sea up to the Shetland Isles. It can be concluded that the pattern and timing of the pre-spawning migration remains as previously understood.

In the Southern area, catches continue to be concentrated along the northern coasts of Spain and Portugal. Relative catch levels in the Bay of Biscay are reduced when compared with 2005. Minor catches continue to be taken in the English Channel and down the west coast of Portugal in this quarter.

Second Quarter 2006 (22,324t)

The second quarter distribution of catches is shown in figure 2.7.1.2. The catch in this quarter has continued to decrease and is now down to 5% of the total catch. The principal catch area remains along the northern Iberian coast which has not reduced from 2005 levels. The principal reductions are seen in the Bay of Biscay, Celtic Sea and area IIa.

Third Quarter 2006 (83,925t)

The third quarter distribution of catches is shown in figure 2.7.1.3. Whilst catches have reduced overall, areas IIa and the eastern half (Norwegian coast) of IVa remain the principal mackerel catching areas in the third quarter. There is a notable absence of catch to the north of Scotland and into the North Sea. Activity in the southern North Sea, English Channel and Celtic Sea is also reduced. Southern catches remains as reported in 2005.

Fourth Quarter 2006 (171,654t)

The fourth quarter distribution of catches is shown in figure 2.7.1.4. In contrast to the WG catch which has reduced by approximately 70,000t, quarter 4 catches show a significant increase and now constitute 36% of the total catch, an increase of 13% (approximately 45,000t). The spatial distribution remains similar, with the majority of catch taken between Shetland and southern Norway. Compared to 2005, Norwegian catches in IVa in this quarter are doubled to 84kt (with a corresponding quarter 3 decrease). This is due primarily to the larger Norwegian vessels taking the majority of their quotas in this quarter. There is a slight reduction in the proportion taken in VIa to the north of Scotland whilst catches in VIIh and VIIIa have also reduced. However, this is matches by an increase in catches in VIIb on the west coast of Ireland. Whilst minimal in 2005, no significant catches are recorded in Celtic and Irish Sea and southern North Sea. Catches in the English Channel are similar to 2005 levels. For the Southern areas, there is a noticeable increase in catches in the western part of area VIIIc and the very north of area IXa.

2.7.2 Distribution of juvenile mackerel

Surveys in winter 2006/2007

Data is presented to this WG from 2006/2007 and is shown in Fig.2.7.2.1-6. They are derived from the mean catch rates h^{-1} rectangle $^{-1}$ from following bottom trawl surveys: Portugal (Q4), Spain (Q4), Ireland (Q4), France (Q4), Scotland (Q4), Scotland (Q1) and Norway (Q1).

Fourth Quarter 2006

Age 0 fish in quarter 4, 2006 (Fig 2.7.2.1)

- Catch rates were highest across the area extending from the NW of Ireland to the NW of Scotland, and the distribution was more extensive than for the previous few years. Celtic Sea recruitment appears to have partially recovered but is still lower than levels observed in 2004.
- Catch rates off the French, Spanish and Portuguese coasts are significantly larger than those observed in either 2005 or 2004.

Age 1 fish in quarter 4, 2006 (Fig 2.7.2.2)

- In the Celtic Sea catch rates have reduced further from the low levels seen in the previous 2 years. In the Bay of Biscay reasonable numbers were caught along the French coast, with rates slightly higher than in 2005.
- Catch rates off NW Ireland, NW Scotland and the Hebrides are slightly lower than 2005 but still higher than 2004.

The bottom trawl surveys have picked up both strong and weak recruiting year classes that have been seen to follow through into the adult catches. The catch rates reported here suggest that recruitment continues to improve. These data should be considered in conjunction with the first quarter and first winter data (see Figs. 2.7.2.5 and 2.7.2.6) presented below.

First quarter 2007

Age 1 fish in quarter 1, 2007 (Fig 2.7.2.3)

- High catch rates were recorded off NW Ireland, N and NW of Scotland and off the Hebrides. Catch rates are similar to those recorded in quarter 1 in 2003.
- Low catch rates were recorded between Shetland and the Norwegian coast, as noted in the 2006 report.
- No data were available from the Celtic Sea in time for WGMHSA.

Age 2 fish in quarter 1, 2006 (Fig 2.7.2.4)

- Catch rates off NW Ireland/Hebrides area were maintained at the high rates noted in the 2006 report.
- Catch rates in the North Sea continue to be weak.

As in previous years the data for the two quarters have also been merged to provide a picture over the entire area for which data were available. As the fish change age on the 1st of January, these fish are described as first and second winter fish (figures 2.7.2.5 & 6).

It should be noted that not all these surveys use the same survey gears. Most surveys in the western area use an IBTS GOV trawl (although with various non-standard modifications). The Irish surveys have historically used a smaller version of the GOV, but now use a standard one. The Portuguese gear is quite similar to the GOV. The Spanish surveys in the Cantabrian Sea use the *Bacca* trawl. This is towed slower and has a much lower headline height, and has a very low catchabilty for young mackerel. The conversion factor calculated in the EU SESITS project for this gear, against the GOV was 8.45. This correction has not been applied to date for the data used here.

As noted in previous reports, the coverage of the western area in the fourth quarter remains reasonably good. The gaps in the area west of Ireland are now surveyed. Most of the inner part of the Celtic Sea/Western Approaches is also being surveyed.

2.7.3 Distribution and migration of adult mackerel

In previous years (see 2004 WGMHSA report) the WG explored information on the timing of the migration of adult mackerel from IVa to the west at the onset of the spawning migration. In 2006 and 2007 a more pronounced northerly distribution and migration pattern of spawning and feeding mackerel has been observed from several international surveys along its entire distribution area. Also a more westerly distribution pattern was evident in the northern parts from a number of international and national surveys (See section 2.5.10).

2.7.3.1 Ecosystem survey in the Norwegian Sea in 2007

A coordinated ecosystem survey was carried out in the Norwegian Sea by two Norwegian commercial vessels from 15 July-6 August 2007. The results on NE Atlantic mackerel acoustic estimates, distribution, migration and feeding ecology are given in Section 2.5.9.1

2.7.4 Aerial surveys

No Russian summer aerial and acoustic surveys for pelagic species in the Norwegian Sea were carried out in 2006 and 2007. However, scientific observers collected biological samples for the pelagic species in the area onboard commercial vessels. These data can be used for biological and stock assessment purposes and were presented to the 2007 WGMHSA meeting.

2.7.5 Acoustic surveys

Five acoustic surveys were carried out on mackerel. None of these surveys are considered to cover the entire stock and therefore they are not used in the routine assessment as indicators of abundance. However, they do give useful information of abundance and distribution within localised areas. Biomass estimates for mackerel are very sensitive to the uncertain target strength used. The surveys were:

- An acoustic survey by the Institute of Marine Research, Bergen in October/November 2006 (Section 2.5.9.1).
- An acoustic survey by IEO in ICES Divisions VIIIc and IXa in April 2007. (Section 2.5.9.2)
- Portuguese acoustic surveys by IPIMAR in March 2007 (Section 2.5.9.2)
- French acoustic surveys by IFREMER in May 2007 (Section 2.5.9.2)

- Norwegian ecosystem survey in the Norwegian Sea in July-August 2007 (Section 2.5.9.1).

2.8 Data and Model Benchmark

2.8.1 Introduction

This section provides an exploration of some of the data and modelling issues for NE Atlantic mackerel. It deals first with the uncertainty in the absolute level of the catch because there have been efforts to improve enforcement and to obtain data on some aspects of missing catch. This section summarises work on modelling missing biomass and or unknown removals from the NE Atlantic mackerel population using an extended ICA assessment implemented in a Bayesian framework with a number of additional model variants.

This year NE Atlantic mackerel assessment is categorized as benchmark and it has been extensively explored with a sensitivity analysis using ICA, and exploration with TISVPA, AMCI and a Bayesian framework implemented in WINBUGS with equations similar to ICA. Section 2.9 details the final assessment. In 2006 the WG highlighted a number of issues for consideration:-

- Collation of survey data for recruit indices. There are some concerns about the validity of the adhoc database currently used for survey data. Full historic data sets back to 1990 should be supplied by national data coordinators during early 2007 and once assembled circulated. - This was done and most of the data was received before the WG and the remaining parts collated during the WG see Section 2.5.6.
- Revision of discard estimates should be carried out. See Section 2.5.6
- Good communications should be established to obtain the best preliminary egg survey estimates for the WG. - The egg survey data was efficiently supplied. See Section 2.5.1
- Examine incorporation of NS egg survey data from 1990. - Data should be circulated to interested parties See Section 2.5.2
- Tag mortality estimates for recent years should be updated. - This was provided at the meeting. See Section 2.5.7

Specific issues highlighted last year for consideration in the benchmark this year are:-

- Sensitivity of assessment and potential advice to underreporting
- Separable model assumptions
- Estimation of recruits for projections
- Reliability of the estimated terminal values of SSB and F relative to the historic values due to uncertainties in removals
- Evaluation of potential reliability and utility of advice in the context of management on a single and multi year management strategy.

The underreporting is investigated in Section 2.8.2, separable assumptions are discussed throughout 2.8.5-8. Reference points are discussed in section 2.13. The issues concerning advice are dealt with in section 2.14

2.8.2 Evaluation of potential unknown missing biomass and removals from the NE Atlantic population.

Over recent years improved enforcement has detected some undeclared landings in the UK and Ireland. In early 2007 the EU introduced a new regulation scheduling payback of some catches of mackerel (Section 2.1). Against this background, a WD (Simmonds WD2007) explored the potential magnitude of missing removals. The data used were the declared catches to 2005, tag data to 2003, and egg survey estimates of biomass data including estimates of egg mortality from 1992 to 2004. All this work was done prior to the WG without catch data from 2006 or the egg survey for 2007 available.

The main model used a 2 parameter logistic selection function at age, with temporal variability obtained through the addition of a random walk parameter relying on a single estimated variance for the random component for both parameters of the logistic function. The selection pattern was scaled to annual F with independent annual multipliers. The main model formulation is:-

$$F_{ay} = 1/(1+\exp(-2.944439(a - S_{1y}/S_{2y})))\overline{F}_y$$

where

$$S_{1y} = S_{1y-1} + dnorm(0,\sigma_s)....and....S_{2y} = S_{2y-1} + dnorm(0,\sigma_s)$$

s_s is estimated in the model.

$$SSB_y = \sum_a N_{a,y} \exp(-F_{a,y}P_F - Q_m M P_m) W_{a,y} A_{a,y}$$

Where proportions of fishing and natural mortality P_F, P_M mean weight $W_{a,y}$ and fraction adult $A_{a,y}$ are assumed to be estimated without error. The factor Q_m is an estimated factor on natural mortality.

The following observations are used to define an objective function with three main components each with a separate variance:-

1) Mackerel Egg Survey (MES) estimate of SSB

$$\ln(MES_y) = \ln(SSB_y) + \mathrm{dnorm}(0, s_{MES,y})$$

$s_{MES,y}$ was estimated from bootstrap of survey estimates of egg abundance, egg mortality, fecundity and atresia, individually for each year. Both value and variance are found to be different in different years and the variances were used as informative priors in the model. (see also model variants below12,13 and 14)

2) Observed or reported catch (assuming Popes approximation):-

$$\ln(C_{a,y}) = \ln(N_{a,y}F_{a,y}/(F_{a,y} + M)(1-\exp(-F_{a,y} - Q_m M))/Q_c) + dnorm(0,\sigma_c)$$

s_c is assumed to be independent of year and age and estimated in the model (see also model variants below 3 and 4)

3) Estimated total mortality at age from tags:-

$$Z_{a,y} = F_{a,y} + Q_m M + dnorm(0,\sigma_t)$$

s_t is assumed to be independent of year and age, the observations are dominated by noise, with very little change in total mortality over time, so the distribution of values has been used to choose the error distribution (Figure 3), the value of s_t is estimated in the model.

In this way the error in all these data were explicitly included in the model either as input values or estimated in the model. The dependence of the estimate of removals was investigated across the following model variants, the equation changes are detailed below:

Catch at age constraint model equations changes:

1) Catch selection based on 11 parameter independent at age, with variance assumed independent of age. Scaled to annual F with independent values.

$$F_{ay} = S_a \overline{F}_y$$

2) Catch selection based on a 2 parameter logistic function, variance assumed independent of age. Scaled to annual F with independent values

$$F_{ay} = 1/(1+\exp(-2.944439(a - S_1 / S_2)))\overline{F}_y$$

3) Catch selection based on a 2 parameter fixed separable period but with the observation variance on catch defined as a parabola through a minimum at age 3.5 and scaled to an estimated value for the total variance.

$s_{c,a} = s_c$ (a_{min}=3.5, c=0.006, s_{min})

4) Catch selection based on a 2 parameter fixed separable period with parabolic variance with age, with the three parameters describing the variance estimated in the model, i.e. minimum variance, age at minimum and curvature.

$s_{c,a} = s\,(a_{min}, s_{min}, c)$

5) As base model with parabolic variance for catch at age.

6) As base model but with the selection pattern more heavily constrained, s_s set to 0.5 estimated s_s

7) Reduced period for statistical catch at age fit by 2 years

8) Extended period for statistical catch at age fit, by 2 years

9) Extended period for statistical catch at age fit, by 4 years

10) Extended period for statistical catch at age fit, by 8 years

Values and Variance of Mackerel Egg Survey data model differences

11) Biomass estimates derived using year independent egg mortality, Although estimates of mortality are found to be significantly different between years, sensitivity to this is estimated by using values of MES_y derived assuming constant egg mortality over all years.

12) Variance s_{MES} arbitrarily increased by a factor of 4 ($s_{MES,y}$ *4)

13) Variance s_{MES} arbitrarily decreased by a factor of 4 ($s_{MES,y}$ /4)

14) The variance was set to 0.9 * estimated variance which improved some model diagnostics

In addition the egg survey variance s_{MES} was estimated within model but this failed to provide a plausible fit

Time and age trends in catch and natural mortality model equation changes

15) Linear trend in natural mortality multiplier at young ages, expressed as a mortality factor Q_{m0} for age 0 changing linearly to Q_m at age a_b, Q_{m0} and a_b are both greater than 0

$Q_{m,a} = Q_m(1\text{-}(a\text{-}a_b)(a<a_b)\ (1\text{-}Q_{m0})/a_b)$

16) Linear time trend with slope Q_{ms} in natural mortality multiplier Q_m with a lower limit of zero in all years.

$Q_{m,y} = \max(Q_m(1+Q_{ms}y), 0)$

17) Linear time trend with slope Q_{cs} in catch multiplier Q_c with an additional constraint of a lower limit of 1 in all years.

$Q_{c,y} = \max(Q_c(1+Q_{cs}y), 1)$

18) Random walk of Qc in time

$Q_{c,y} = \max(Q_{c,y-1}+Norm(0,s_r), 1)$

19) Combining 15 and 18, a linear trend on M at age and a random walk with Qc at year.

The detailed results were presented in the working paper. The key results are presented in here in Figure 2.8.2.1. which shows the estimates of the factor to be applied to catch to account for unaccounted removals under the different model assumptions listed above.

Results for Model variants

Catch at age variants.

Variability for different assumptions on selectivity function variants 1-3 and 6-10 make little difference to the results (Figure 2.8.2.1). Attempts to allow estimation of age dependence in the variance for catch at age proved difficult to stabilize. For a model including both a temporally varying selection function and parabolic variance with age (Variant 5), the model did not converge within uninformative priors and no useful results were obtained. For a fixed selection pattern with parabolic variance with age the model converged but the results indicated much higher removals than were plausible.

Overall the differences in the estimates of Q_c with catch modelling options were very small (Figure 9) , with the exception of the longest separable period, which suggested higher but not significantly different values of Q_c.

Mackerel Egg Survey variants

There is uncertainty in the precision of the MES. The analysis involves several aspects: egg abundance, egg mortality, fecundity and atresia, dealt with separately and combined to give an overall estimate of precision. The errors in each of these is obtained from analyses only for the Western Egg survey (which constitutes about 85% of the total abundance) and scaled to the full survey linearly (constant CV). The errors in the different components are treated separately and assumed to be independent, while this is likely to be true for atresia, fecundity and egg abundance. However, egg mortality may be correlated with egg abundance. The dominant error is the estimate of egg abundance, followed by egg mortality, with errors in the estimates of fecundity and atresia being unimportant by comparison.

Sensitivity to the assumptions on egg mortality were tested by applying annually invariate mortality, which showed no difference in estimates of Q_c from the values estimated using annually varying egg mortality for each triennial survey.

An attempt was made to estimate the variance of MES within the model, however, with only 5 observations this was not successful because the model became unstable. To investigate sensitivity of the conclusions to the observed value of variance, a factor of 4 change in variance was tested. This is well outside the range that could be expected, and resulted only in small changes to estimates of Q_c (Figure 2.8.2.1).

Trends in catch or natural mortality

Model formulations discussed above assume constant natural mortality over age and time, and constant unaccounted mortality factors over time. Options tested were a linear trend in Q_m at young age, linear trend of Qm or Qc in time and a random walk for Qc in time. In no cases could significant trends be estimated, though the probability of higher M at young ages is around 90%, the probability of increasing unaccounted mortality with time is about 80%. In contrast there is effectively no evidence at all of increasing natural mortality with time (probability of increase = 15%).

The main observations are that in all cases the change in Q_c is small, the greatest effect being with trend in Q_c with time, reducing the value for the early part of the time series. This option suggests a lower mean value overall, but similar for 1992 to 2004 (the period over which the egg survey data is available). In this case the positive slope in time gives higher values of Q_{cy} in recent past (Figure 2.8.2.1). The addition of a random walk with time to Qc fitted much better to the tag mortality data. However, again it was not possible to detect significant year on year change. Nevertheless, it seems unlikely that there is no variability from year to year, rather that the data is not sufficiently free of noise to characterize it. In order to show potential variability, trends in time in Qc and trend in Qm at age were combined. The trends in Qc were smoothed by an arbitrary factor of 0.5 constraint on the standard deviation of the random walk. The resulting annual factors show consistency from 1972 to around 1988, as there is no data to fit to. The variability increases more recently, explaining some of the variable mortality in tag data and annual variability catch at age as unaccounted mortality.

Tag mortality

The only aspect of the model which was not varied directly was the use of the estimates of tag mortality. With the assumptions of constant or linearly changing coefficients on catch, the relationship between observed and modelled estimates of total mortality is poor. The modelling results suggest that there is very little 'signal' in the total mortality age 2 to 10 from 1983 to 2003, the Fbar for this period has a mean of 0.29, the standard deviation is only 0.06. Thus most of the 'signal' is in the estimated mortality at age, which is dependent to some extent on assumptions about natural mortality in the model. For the main model the variance in the observations of mortality exceeds the variance of the modelled values by just over 6 times thus with some much 'noise' in the observations, there was little scope for further exploration directly. However, as discussed above if Qc is allowed to vary from year to year, through the addition of a random component, and natural mortality increases at young ages, estimates of Q_c are again similar.

Conclusions to missing biomass

The results of this analysis based on reported catch age structure, mackerel egg survey and total mortality based on tags show clearly that during the period 1992 to 2004 there has been a disparity in biomass in excess of reported landings and discards in the mackerel fishery. More formally the null hypothesis that reported catch explains the biomass of the stock can be rejected and it can be concluded that reported catches significantly underestimate the biomass in the stock. The estimate of unaccounted mortality lies between 95% intervals of 1.6 and 3.4 times the catch with the most probable estimate being 2.4 times the catch. These results are robust to a very wide range of model assumptions. None of the models estimate a 95% range of unaccounted mortality from 1992 to 2004 that includes unity (no unaccounted mortality). Almost all of the alternative model options, some of which fit more poorly to the data lead to similar or slightly higher levels of unaccounted mortality. Thus the results are robust to changes in separable assumptions, estimated variance of the MES, trends in natural mortality at age or over time and trends in unaccounted mortality over time.

The sources of difference may be assigned to a range of possibilities, the primary one is fishing, which consists of reported fishing, unreported discards, slippage, unaccounted mortality from escaped mackerel as well as undeclared landings. There may other sources of missing biomass such as a mismatch between the fished and surveyed stock. Nevertheless considering plausible values for all these quantities together, the under-reporting detected in the UK and Ireland (Section 2.1), and the discards (Section 1.3.3) reported by those countries that provide data represent plausible additions to their landings. These additions are not sufficient to account for the estimated total removals, suggesting there are other sources of unaccounted mortality not included in the current NE Atlantic mackerel data.

2.8.3 Summary of inferences from independent measurements of the stock

Fishery independent measures are described in sections 2.5 and 2.7. Information relevant to the assessment is summarised here. The recent estimates of egg survey SSB (Section 2.5.2) indicate a slight decreasing trend over the period 1992 to 2004, and a small rise to 2007. These indicate that the biomass is substantially higher than that indicated by the ICA assessment. The tagging data (Section 2.5.7) indicate that the level of the total mortality is in line with what is estimated in the analytic assessment. No clear time trend of the mortality can be seen in the tagging data, but they are not suited to detect recent changes in mortality. Biomass estimates from the tag material (Section 2.5.8) indicate that the biomass is well above that estimated in the ICA analytic assessment, and that it has decreased throughout the 1990s, but that it may have been increasing in the most recent years. Acoustic surveys (Section 2.7.9), on the other hand, suggest little trend in biomass in the Northern North Sea since 1999, but with important year-to-year variation observed. Recruitment estimates from recent recruit surveys (section 2.5.6) suggest reduced variance and improved agreement with the assessment in recent years but the data is still too unreliable to use as a basis for recruitment in the projections.

2.8.4 Log catch ratios

Log catch ratios are presented in Figure 2.8.4.1 by cohort. This Figure includes a reference line at slope 0.35 equivalent to a fishing mortality of 0.2 and a natural mortality of 0.15. Cohorts from 1994 to 1999 (age 7 in 2008) show steeper declines than earlier cohorts, though some of this decline is due to reduced catch in the latest years. The mean catch ratio for ages 4 to 8 inclusive is given in Figure 2.8.4.2a. by cohort and in 2.8.4.2b by year. In order to remove some of the effect on the log ratio due to changes in catch, a simple normalised version modified by the catch ratio in tonnes is included in Figure 2.8.4.2b by year.

$$LCR = \ln(C_{a,y}/C_{a+1,y+1})$$

This can be written as approximately as $(Z_y+Z_{y+1})/2 + \ln(F_y/F_{y+1})$

Assuming a constant biomass in the stock over the two years which for NEA mackerel is a reasonable assumption then:-

F_y/F_{y+1} may be approximated by the ratio of the harvest rates $(T_y/SSB)/(T_{y+1}/SSB) = T_y/T_{y+1}$

Thus $N.LCR = (Z_y+Z_{y+1})/2 \sim \ln(C_{a,y}/C_{a+1,y+1}) - \ln(T_y/T_{y+1})$

Assuming consistency in selection by the fishery this analysis suggests that total mortality has risen steadily since 1997 with a decline over the last three years but that this mortality may not yet have declined fully to pre 1999 levels. The absolute level is lower than that suggested by the assessment. This is most likely due primarily to the rising selection pattern seen in the fishery but may also be caused by natural mortality on older ages being set too high in the assessment model.

2.8.5 Exploratory assessment with ICA

ICA has been used to assess this stock since 1999. There are a number of assumptions and settings for ICA that need to be explored. Some of these are common to all assessments some are specific to ICA. Here we examine the influence of:

- changes of fraction of F and M prior to spawning (Section 2.4.5),
- the influence of choice of length of selection period and selection at oldest age.

- The effect of relative weight given to catch and survey in the minimisation

The influence of each of these is discussed in turn below. The criteria used for comparing the results were the sum of squares fit in the model and the retrospective bias in the assessment as expressed by Mohn's ρ (Mohn 1999).

Fraction of F and M before spawning

Section 2.4.5 documents observed values for time of spawning and proportion of F before and after spawning which are seen to be different from the values previously assumed. The mean fraction of M has been changed from 0.4 to 0.35 and showing no important annual variability. The mean fraction of F changes from 0.4 to 0.42 but exhibits some annual variability. To evaluate the influence of these values, the results of assessment using the standard setting from 2006 assessment (Mprop=0.4, Fprop=0.4), are compared with assessments using new averages (Mprop=0.35 and Pprop =0.42) and annually varying fractions of F and M prior to spawning. The differences in the assessment values are given as percentage changes in the fit, and the terminal SSB and F.

METRIC PARAMETER	CHANGE IN MEAN F AND M PROPORTIONS MPROP - 0.4 TO 0.35 FPROP 0.4 TO 0.42	ANNUALLY VARYING PROPORTIONS OF F AND M SEE SECTION 2.4.5
% change in model total sum of squares	-0.019	-0.027
% change in SSB	+0.225	+0.125
% change in mean F ages 4-8	-0.017	-0.024

The fit improves very slightly though overall the changes are negligible. As the new mean values are based on measurements they replace the previously values but the increased complexity in estimation variable proportions of F outside the model (See section 2.4.5) are not thought to be necessary, even though the fit improves slightly.

Changes in length of separable period and value at oldest age for the selection pattern

It was expected that with the shortage of tuning data for the assessment some stabilization in the model though the use of a reasonable length of separable period would be beneficial. An examination of the selection pattern suggested that residuals overall are small but with some evidence for trend with time, with the later period being different from the earlier period (c.f. Figure 2.9.1.2). The assessment was run with the separable period varied from the 14 years used last year to 8 years in steps of two years. The results are summarised in Figure 2.8.5.1. The differences in fit and retrospective criteria are not very compelling, with only small and inconsistent changes observed: better model fit at 12 years and better retrospective performance in SSB as well as slightly worse retrospective performance in F. On balance there is little advantage in the longer period but some evidence for poor results in fit and SSB estimation for shorter periods. The residuals for 14 or 12 years can be compared in Figure 2.8.5.2 but there is little difference.

The influence of changes in selection at age 11, the oldest true age, are illustrated in Figure 2.8.5.3. In ICA there is improved fit and reductions in retrospective bias in both SSB and F with higher selection at oldest age, the results are more or less asymptotic by 1.8.

Changes to relative weighting of survey and catch.

In 2006 the weighting of catch was set to 1 per value for ages 2 and older with data at age 0 and 1 down weighted by 100 and 10 times respectively. In comparison the surveys were weighted at 5 for each triennial survey. These values were selected rather arbitrarily. For each 3 year period in the fit this gives a weight of 30.33 to the catch and 5 to the survey. The effect of fitting was evaluated over a range 1 to 30 for the survey. The results are shown in Figure 2.8.5.4. As expected the survey residuals reduce and catch residuals increase slightly, but the overall weighted sum of squares reduces with increased weight on the survey (Figure 2.8.5.4c). The retrospective performance also increases with increasing weight on the survey (Figure 2.8.5.4a and b). The retrospectives plots are given Figure 2.8.4.5. The best results are obtained with a survey weight of 30, equivalent to equal weight to catch and survey over each 3 year period.

The weight on the survey is also investigated for the other methods, and the results interms of SSB and F were different in each model. For ICA and AMCI (Section 2.8.5.6) SSB increased with increasing weight on the survey, though the changes with ICA were much smaller. In contrast TISVPA and the WINBUGS model SSB decline with increasing weight on the survey.

Conclusions to ICA exploration

New measured fraction of F and M before spawning very slightly improve the model fit but the additional computational complexity required to use annually varying values does not seem to be justified. New measured values should be used.

Changes to separable period suggest 12 years may be slightly better than shorter or longer periods, though the results are marginal.

Changes to selection at older ages suggest higher values would be beneficial, up to 1.8.

Changes to survey weighting suggests that weights giving equivalent weight to survey and catch over each 3 year period would be beneficial.

2.8.6 Exploratory runs with AMCI.

Some assessment runs for NE Atlantic mackerel were done using the AMCI program to explore some specific problems:

1) The effect of weighting of the egg survey SSB index
2) Tracing how terminal F is influenced by data.
3) The shape of the selection at age

These runs were made to explore these specific questions, and not to provide an alternative assessment.

The conditioning of the model was fairy standard:

1) Initial numbers at age (in 1980) estimated as free parameters
2) Annual recruitments estimated as free parameters.
3) Selection at age slowly varying over time with a gain factor of 0.2 at all ages and years. Alternatively, the selection at age was kept fixed from 1996 onwards. Selection of the 12+ group was set equal to that at age 11.
4) Annual fishing mortalities estimated as free parameters in all years.
5) For 2007, fishing mortalities and recruitments were assumed equal to those for 2006.
6) Catchability for the SSB index constant over time, estimated as a free parameter.

The objective function had two components: A log SSQ of the individual catch data and a log SSQ of the SSB indices. The fit to catch data at age 0 and 1 was down-weighted by factors of 100 and 10 respectively as with ICA.

With this conditioning, the model may be at the edge of being over-parameterised, leading to a singular Hessian matrix. The main problems with over-parameterisation appeared to be in the initial numbers in 1980 at the oldest ages, and in the most recent selection at age.

The effect of weighting of the SSB index (relative to that of the catch data) was substantial (Figure 2.8.6.1 and 2.8.6.2). With settings that virtually ignor the survey, there should not be enough information in the remaining data to give an estimate of the model parameters. Nevertheless estimates are found which are probably a result of the way the noise in the data is organized. This view is confirmed by the results of bootstrap runs. In these runs the residuals are randomly distributed around the model values and in all realizations the fit to the model is far better than with the original data. In the AMCI context, this is normally regarded as an indication of inhomogeneity in the residuals. Hence, the effect of the noise in the data with this conditioning of AMCI was in the direction of high terminal fishing mortalities and low SSB estimates in the last years. A similar trend was found in the ICA exploratory runs, while the ISVPA and the ICA-like model under Winbugs, had the opposite trend, terminal SSB increased and terminal F decreased. With a higher weight on the survey, the recent SSB and accordingly the terminal fishing mortality settled to a level close to that indicated by the survey.

Further tracing of the impact of data on the recent upward trend in fishing mortalities was carried out by perturbing the terminal F and refitting, changes to residuals indicate the data that are most responsible for guiding F. The catch numbers at age 6 in 2006 appeared as an outlier which would get a better fit with a higher F. Also, catches at age 2 in 2002, at age 1 in 2004 and at age 3 in 2003 had that effect. The catch at age 5 and at age 0 in 2006 had the opposite effect. Although this exploration may highlight some outliers that may have an impact on the final assessment, it did not point to any data that might explain the divergence between models and the changes in terminal SSB and F were modest.

The selections at age for each year since 1996 is shown in Figure 2.8.6.3, together with the selection obtained by assuming a constant selection in this period. There are no strong indications of a shift in selection in this period, though the last two years are more variable. Generally this confirms the appropriateness of the fixed selection assumption in a model such as ICA.

2.8.7 Exploration of NE Atlantic mackerel assessment with TISVPA

Exploration runs with TISVPA were made using similar settings as last year (age range from 0 till 12+; year range from 1972 till 2006; two selection patterns were fitted: 1972-1988 and 1989-2007; unbiased model description in terms of residuals in logarithmic catch-at-age was ensured). The so called “mixed” version of the model, assuming errors both in catch-at-age data and in separable representation of fishing mortality (more precisely - of exploitation rates) giving equal weights was used.

The TISVPA - “triple-separable” version of the ISVPA, first presented at the Working Group in 2006 (Anon., 2006); see also the description of the model (Vasilyev, 2006)), can represent fishing mortality coefficients (more precisely – exploitation rates) as a product of three parameters: f(year)*s(age)*g(cohort). Different ways of normalization allows sub-models of two mechanisms of changes in selection pattern (or two sub-versions with respect to g-factors):

1) model of “within-year effort redistribution by ages” (normalization of s(a,y)=s(a)*g(cohort) to 1 by sum is hold for each year)

2) model of “gain (loss) in selection” (only s(a) are normalized to 1 by sum, but not s(a,y)).

The first sub-model assumes that in each year more fishing-attractive cohorts borrow a part of fishing effort from other cohorts by increasing its selection at the expense of diminished selections for other age groups in that year. The second model assumes that some cohorts has increased (or reduced) selections, but it does not cause direct change in selections for others. The first sub-model was in used in exploratory runs for NE Atlantic mackerel.

In the model the generation-dependent g-factors can be applied not to all age groups, but to some age “window”. This helps (1) to be closer to real situations (when it is known that only some range of age groups have peculiarities in their distribution) and (2) to diminish the influence of age groups having data of lower quality (usually - youngest and oldest ages). For age groups which are outside the chosen age range, the g-factors are stated to be unity, but in fact, as a result of global normalization of all g-factors to unity by average, they can get somewhat different values. For mackerel data the age range for estimation (and application) of g-factors was fixed as 1-10.

Respective minima of the components of the model objective function for egg surveys and catch-at-age are in similar positions (see Figure 2.8.7.1, left column). The second column of this figure represents profiles for the case when the 2007 survey was excluded.

Figure 2.8.7.2 compares the TISVPA results when the all data, only catch-at-age, only surveys data, and all data with excluded survey2007 were used. As it can be seen, exclusion of the 2007 survey results in somewhat higher stock estimates, this response is similar to WINBUGS but differs from AMCI and ICA.

Figures 2.8.7.3-5 shows the residuals in logarithmic catch-at-age, the estimated values of g-factors and the selection matrix. The age-dependent (s(a)) components of the selection matrix for two periods are shown on Figure 2.8.7.6, selection at oldest age is 1.5* selection at age 5 which matches AMCI.

Figures 2.8.7.7 and 2.8.7.8 represent the results of retrospective runs and the bootstrap-derived estimates of confidence intervals.

The results of NEA mackerel assessment by means of ISVPA are given in Tables 2.8.7.1-4.

2.8.8 Exploratory assessment using WINBUGS.

WINBUGS , (Spiegelhalter 2003) provides a framework for the fitting of models within a MCMC Bayesian framework. While the running of models within WINBUGS is slower than some other modelling Bayesian methods, writing the code is quicker and implementing the MCMC components is not required. In addition some standard diagnostics are already implemented. The WINBUGS scripting control allows for automated model runs and the CODA software for R (Best *et al*. 1997). allows simple extraction of the data in a moderately efficient way. The model code (equations and observation calculation) is given in Table 2.8.8.1, this code has been numerically evaluated in R by putting converged values of the estimated parameters from ICA in as starting values and checking that the results in terms of N and F at age and the estimated likelihood agree to 5 figures. For exploration this year a range of model formulations were tested:

- An ICA formulation with selection at age estimated independently, selection at oldest true age (11) = 1.5 times age 5, and with survey variance either estimated or specified from intrinsic analysis (Figure 2.8.8.1a)
- ICA formulation as above with selection at oldest age (11) estimated (Figure 2.8.81.b)

- Selection using a two term logistic function with the two parameters changing with year through use of a random walk, first with the random walk variance heavily constrained giving heavily damped change. (Figure 2.8.8.1c)
- Or secondly unconstrained random walk variance fitted in the model allowing a highly flexible model. (Figure 2.8.8.1d)

In all cases down-weighting of 0 group and 1 group was implemented by explicitly setting higher variance at 100 and 10 times the estimated variance on older ages respectively. While the model can be made similar to ICA it provides some advantages over ICA through incorporation of other factors described above and it provides a different way of including errors, in the data. It is currently regarded as a preliminary model of the stock.

The precision of the egg surveys was taken from an intrinsic error analysis (Simmonds et al 2003), with the value for the variance for the preliminary 2007 survey set equal to the 2004 survey, which is similar to the mean of the series. One additional trial was run with these variances estimated and the results were similar (< 10% smaller)

For all implementations all the priors, except for one in the second model option above, are uninformative see code in Table 2.8.8.1. For the second model option the prior on estimate of selection at age 11 had a slightly informative prior of 0.95 to 2.

Results from WINBUGS model.

The model convergence is illustrated in Figure 2.8.8.2. The Metropolis Hastings selection criteria Spiegelhalter(2003) shows the proportion of chain values retained indicates reasonable rates of parameter evaluation. The information from the three chains converge by around 3000 iterations (Figure 2.8.8.2b and c). The within and among chain variance criteria (Gelman Rubin statistic(Gelman and Rubin 1992)) show acceptable convergence of the model fit; the red line is asymptotic to unity and both blue and green lines are asymptotic to a value (Figure 2.8.8.2b), which suggests the model over 40001 to 10,000 iterations per chain represents the data reasonably well.

Figure 2.8.8.3 and Tables 2.8.8.2-4 show the stock estimated using the model with ICA type selection. The results compare very closely with the ICA assessment, though the precision of the egg survey is treated differently here from the treatment in ICA (Section 2.8.5). Here an intrinsic error analysis is used to provide values for variance. If the selection pattern is changed (Figure 2.8.8.1) this results in rather different perceptions of the stock. These changes are illustrated by comparing the estimated SSBs under different assumptions in Figure 2.8.8.4. Estimating selection at age 11 and 12+ results in a lower selection at these ages and a larger stock. But the results are unstable and sensitive to the prior on selection at age 11 which was set to a uniform distribution from 0.95 – 2. The results presented here are influenced by this lower boundary, though the extent of the influence is uncertain. Increasing flexibility in time with selection increases the uncertainty further, and the confidence intervals are seen to diverge for these models in Figure 2.8.8.4. The use of the logistic model forces a much more symmetrical pattern than the one that is found when the fit is to the ages independently. This suggests that such a model assumption cannot easily be supported. When estimating selection at age 11 this Bayesian implementation gives different results from both AMCI (Section 2.8.6) and TISVPA (Section 2.8.7) and differs also from the exploration with ICA (Section 2.8.5). This investigation highlights the sensitivity of any of the assessments to the choice of selection model and in particular the relationship between selection at mid and old ages.

2.8.9 Conclusions to data and model exploration

Changes to fraction of F and M before spawning make little difference but the values should be changed to mean values observed (Fprop= 0.42, Mprop = 0.35).

Choice of the correct approach to fitting selection is one of the key decisions for modelling NE Atlantic mackerel. Differences in results are illustrated in the exploration in AMCI and WINBUGS and the effect of selection has been explored to some extent with ICA using fit and retrospective metrics. AMCI and TISVPA fit the selection at oldest true age and suggest that the separable model should give selection at age 11 as 1.5 * selection at age 5. Scanning over the selection parameter alone in ICA supports a higher value than AMCI and TISVPA of 1.8 or maybe above. The fit in WINBUGS provide some doubts about the use of a logistic function and support independent selection at age. When fitting functions in WINBUGS with the age dependence the resulting function does not conform well to a logistic function, which gives a factor of 1.2 between age 5 and 11. The Bayesian fit to selection at oldest age suggests the value should be reduced to 1.1 but the model was constrained slightly by the lower bound on the prior of 0.95. It is unclear why the difference between maximum likelihood and Bayesian methods should give these differences, though in all cases the fit is weak. On the basis that the middle choice is supported by two models that fit to the data at 1.5 this value has been selected as a suitable value, matching ICA to AMCI and TISVPA, and allowing an ICA type of selection in WINBUGS.

The choice among models is difficult. TISVPA give substantially worse retrospective performance than ICA with the new proposed settings suggesting some instability. AMCI has not been explored fully, but has been used primarily to facilitate selection of settings for ICA. Further work would be required to investigate AMCI more fully to provide a full set up. The Bayesian implementation in WINBUGS gives similar results when set to mimic ICA selection. This confirms its utility and that this method of fitting can give similar results to the maximum likelihood methods, although in other ways it differs, particularly in the way the survey is fitted. Retrospective performance for the WINBUGS model has not been tested. The utility and provenance of ICA outweigh the use of the WINBUGS model for immediate future use.

Weighting of the survey relative to the catch in the models was previously arbitrary. Fit and retrospective performance in F and SSB are both improved in ICA with increased weight on the survey. Increasing weight on the survey in WINBUGS artificially decreases the confidence intervals, but otherwise makes little difference. Increased weight on the survey in AMCI gives bigger distortion when the model is fit with a flexible selection pattern, but this does not occur with the fixed selection in ICA. The magnitude of terminal SSB is influenced by weighting, though different models respond differently, AMCI and ICA give declines with reduced weight on the survey TISVPA and WINBUGS give increases, the differences for ICA are small. The scale of the increase selected implies that the model will assign similar weight to the catch at age matrix and the survey data for each 3 year period.

In conclusion the WG considers that ICA with the settings given in the next section provides an acceptable assessment.

2.9 Stock Assessment

2.9.1 State of the Stock

This is a benchmark assessment.

The change in the input data and settings used in ICA this year relative to other years is given in Table 2.9.1.1. Tables 2.9.1.2-7 show the input data to the assessment. The possible inputs for ICA have been discussed in detail above as part of the exploration benchmark for NEA mackerel. The changes compared to last year are:

1) Proportion of F before spawning was changed from 0.4 to 0.42
2) Proportion of M before spawning was changed from 0.4 to 0.35
3) The period of separable constraint was decreased from 14 to 12 years.

4) Selection at oldest age was increased from 1.2 to 1.5

5) The survey weight within the model fit was increased from 5 to 30

6) The landings and survey data was updated by an additional year

It is important to note that Section 2.8 describes the details of the model selection and the sensitivity to biases in the data; other aspects of uncertainty in the assessment of NEA mackerel are discussed in Section 2.9.2.

ICA fits to the catch-at-age data and the egg production estimates were used to examine the relationship between the indices and the catch-at-age data as estimated by a separable VPA. The model was fitted by a non-linear minimisation of:

$$\sum_{a=0}^{a=11}\sum_{y=1992}^{y=2005}\lambda_a\left(\ln(C_{a,y}) - \ln(F_y.S_a.\overline{N}_{a,y})\right)^2 +$$
$$\sum_{y=1992}^{y=2005}\sum\left(\ln(EPB_y) - \ln(Q\sum_a N_{a,y}.O_{a,y}.W_{a,y}.\exp(-PF.F_y.S_a - PM.M)\right)^2$$

subject to the constraints

$S_5 = 1.0$

$S_{11} = 1.5$

where _

N - mean exploited population abundance over the year.

N - population abundance on 1 January.

O - percentage maturity.

M - natural mortality.

F - fishing mortality at age 5.

S - selection at age over the time period 1992–2005, referenced to age 5.

λ - weighting factor set to 0.01 for age 0, to 0.1 for age 1 and 1.0 for all other ages.

a,y - age and year subscripts.

PF=0.42, PM=0.35 - proportion of fishing and natural mortality occurring before spawning.

EPB - Egg production estimates of mackerel spawning biomass.

C - Catches in number at age and year.

Q - the ratio between egg estimates of biomass and the assessment model of biomass.

Tables 2.9.1.8 and 2.9.1.9 present the estimated fishing mortalities, and population numbers-at-age. Tables 2.9.1.10 and Figures 2.9.1.1 and 2.9.1.2 present the ICA diagnostic output for fits to egg survey and catch respectively. The stock summary is presented in Table 2.9.1.11.

Figure 2.9.1.3 shows the catches from 1972 to 2006, the F(4-8) from 1977 to 2006, the recruitment from 1972-2006, and the SSB from 1980 to 2006, together with the egg survey SSB's (scaled by the estimated Q) from 1992 to 2007. The reason for the specific years is that the catch at age matrix uses an increasing age for the plus group in the first years. Recruitment and total catch are correctly estimated, but Fbar 4-8 is correct only when the plus group is greater than 8, and SSB is correctly estimated only when the plus group is consistent at age 12 (see ICES 2005/ACFM:08 section 2.8.

2.9.2 Reliability of the Assessment and Uncertainty estimation

The presented assessment in Section 2.9.1 is to be viewed with some caution. Section 2.8 on the data exploration and modelling provides extensive information on the aspects of the reliability of this assessment. 2.8.9 summarizes the conclusions of sections 2.8.2 – 2.8.8.

According to the assessment, the NEA mackerel stock has been relatively stable in the earlier period up to 1992, but then decreased gradually, and is now showing some indication of increasing biomass (Figure 2.9.1.3).

ICA was used to investigate the precision of the assessment, using the bootstrap facility. The results are shown in Figure 2.9.2.1. The central quartiles on SSB and F are estimated as 2.0 and 3.2 Mt and F=0.19 and 0.45 respectively. The 95% intervals are estimated at SSB =1.3 to 5.2Mt and F= 0.08 and 1.0 respectively. The Bayesian assessment mimicking ICA suggests a more precise assessment but this may seriously underestimate the model uncertainty.

The SSB, F(4-8) and recruitment estimates as obtained by analytic retrospective (1998-2006), are shown in Figure 2.8.5.6a Although the recent evaluations of long-term trend in biomass are consistent, the change in 2002 reflected the reduction in egg survey estimates to 4 instead of 5 and shows the sensitivity of the last 4 years to the value obtained in 2004.

The analysis of log catch ratios (Figure 2.8.4.1b) does not show the increase in mortality in the 1990s seen in the assessment (Figure 2.9.1.3) but does support the rise in mortality in the assessment from around 2000. and the decline in last few years.

The total mortality (Z) indicated by the tags is of a similar order to the assessment at 0.4 though the trajectory over time is flatter and shows less of the periods of higher mortality than that seen in the assessment and catch. The recent Z from tags does not show the rise since 1999 which is seen in the assessment and in the log catch ratios, however, these tag mortalities in these recent years are poorly estimated due to the relative shortage of returns from recent cohorts that is a feature of tagging programs.

The exploratory analyses (section 2.8) highlighted the potential considerable unaccounted mortality, assuming a range of factors applied to catch or to natural mortality. This suggests that a substantial biomass and potentially substantial removals are not included in the assessment.

The estimates of recruitment (Figure 2.9.2.1) are unreliable for 2005 and 2006 year-classes. Current investigations suggest the recruit surveys (section 2.5.5) may give some information on recruitment but are still under investigation. Retrospective plots therefore do not include recruit estimates.

There are strong indications that F has been high in recent years and although it is declining it has not yet declined to management targets.

The addition of new data and the changes to model settings in the benchmark assessment has revised the perception of the stock from the 2006 assessment to the new 2007 assessment presented in this report. The changes to recruitment, TSB, SSB and F4-8 from 2000 to 2005 between these two assessment is given in the text table below .

Percentage changes in perception of recruitment TSB, SSB and F4-8 between last years assessment of years 2000-2005 and this years assessment of the same period

	Recruitment	TSB	SSB	F2-4
2000	14%	0%	0%	9%
2001	1%	-1%	-2%	9%
2002	-5%	-1%	-3%	8%
2003	-11%	-2%	-2%	9%
2004	88%	-3%	-3%	12%

2005	-1%	-4%	14%

Changes in perceptions of recent TSB and SSB are small with slight downward revision in recent years. Current perceptions of F are of a higher fishing mortality than last year, declining more slowly. Revision of recent recruitment (2004) is substantial reflecting uncertainty in estimates of recruitment as yearclasses enter the fishery.

The main conclusions on the quality of assessments from the exploratory analyses and Figure 2.9.2.1 are:

- The terminal values of SSB and F are sensitive to the last egg survey value.
- The point estimate of SSB and F in the terminal year is very sensitive to model assumptions , particularly selection at oldest age.
- Initial estimates of recruits are uncertain.
- F estimates are thought to be less biased than SSB under the assumption of constant unaccounted mortality (see section 2.8.2).

The WG considers the current use of the ICA model to be very sensitive to variability in the SSB estimates from egg surveys. However, it may be difficult to improve on this situation without additional resources. Increase reliability of data on catches, more fishery independent data - e.g. more frequent egg surveys, or some other index would help. There are three avenues to be explored

- Better or more frequent indices of abundance and recruitment
- Selection of appropriate model to interpret the data
- Design of a management regime adapted to the uncertainty in the assessment process

The WG has explored the last two of these areas this year. Development of recruit indices is ongoing and evaluation of the effect of more frequent egg surveys will be evaluated as part of a management plan.

2.10 NE Mackerel Catch predictions for 2005

Table 2.10.1 lists the input data for the short term predictions.

Traditionally the ICA-estimated abundances of ages 2 to 12+ in 1^{st} of January in the assessment year are used as the starting populations in the prediction. For 2007 ages 2 to 12 consists of year-classes 2005 back to 1995. The recruitments of age 0 (year class 2007) and the abundance at age 1 (year class 2006) are routinely revised.

The working group considers that estimates of 0 and 1 from the assessment should not be used in the prediction. The recent work with recruit surveys (see Section 2.5.6) has shown high abundances in recent years. While the 2001 and 2002 and 2003 year classes have been indicative in the recruit surveys, early year classes have not. 2004 (age 2 in the last catch year) is currently evaluated as below average in the assessment while the recruit survey indicates a high value, indicating so far that WG practice of geometric mean was correct for that year class. The surveys have high variance with CV on mean indicating that they have low reliability. This aspect has been discussed in some detail in section 2.5.6. and the WG considers that year classes that are replaced in the projections should be estimated by geometric mean. The following assumptions were made regarding recruitment at age 0 and the abundance at age 1 in 2006:

Age 0 - Figure 2.9.1.3 shows the recruitment estimates of year classes 1972-2003 as obtained from this year's assessment. The value of 3696 million fish is calculated from the geometric mean of the North East Atlantic mackerel recruitments for the period 1972 - 2003, which value is used for the recruitment at age 0 for 2007 – 2009 in the predictions.

Age 1 - As in previous years the WG has taken the abundance at age 1 to be the geometric mean recruitment at age 0 (3696 million fish) brought forward 1 year by the total mortality at age 0 in that year (see Table 2.10.2), this corresponds to 3161.3 million fish.

As in previous years the exploitation pattern used in the predictions was the separable ICA F's, scaled to the F in the final year. As the model is fitted with 12 year separable period this effectively the mean exploitation from 1995 to 2006 inclusive.

Maturity at age was taken as an average of the values for the period 2004–2006.

Weight at age in the catch was taken as an average of the values for the period 2004–2006 for each area.

Weight at age in the stock was calculated from an average (2004–2006) of weights at age for the NEA mackerel stock.

The catch in the intermediate year (2007) is taken as a TAC constraint, this is the standard practice for this stock and is particularly applicable this year as the fishery has been particularly constrained due to increased enforcement.

The catch for 2007 is assumed to be 499 kt, which corresponds to the amount of the TAC of 501,865 kt expected to be taken in 2007 (see Section 2.1) reduced by 21.1681 kt due to adaptation of quota EU COMMISSION REGULATION (EC) No 147/2007 plus an assumed amount of discards of 17,970 kt (see Table 2.2.1.1), this conforms to the same procedure as last year.

Predictions were calculated by the MFDP program.

A detailed single fleet management option table is presented: Table 2.10.2 with *catch constraint* fishing (Catch = 499kt) in 2007 and status quo F=0.23 in 2008 and 2009. Table 2.10.3 provides multi option for 2007 with a catch constraint of 499kt in 2007 to give a range of F options from 0.0 up to 0.30.

As discussed in section 2.8.2 given the uncertainty in the recorded historic catch, the most appropriate advice may not be the exact level of a TAC. Therefore, to give advice on change in catch rather than on absolute values, a column giving the percentage change in catch associated with fishing mortality options has been included for information for managers.

2.11 Special Request

There were no separate special request from NE Atlantic mackerel in 2007 Currently there is ongoing work on a management plan for mackerel and western horse mackerel, for NE Atlantic mackerel see Section 1.8.2.

2.12 Long Term Yield

Yield per recruit was calculated using MFYPR, the results are presented in Figure 2.12.1 The evaluation of harvest control rules for NE Atlantic mackerel (see section 1.8.2) has evaluated the stock recruit relationship and has found a point of inflection in a hockey-stick stock recruit relationship at approximately 2.6Mt (Figure 2.12.2). The results from the yield per recruit analysis given in Figure 2.12.1 indicates that equilibrium biomass of 2.6Mt is obtained with an exploitation rate of F=0.254. This suggests that maximum long term yields are associated with biomasses that are above 2.6Mt and fishing mortalities that are below F=0.21.

2.13 Reference points for management purposes

The WG have not reconsidered the reference points in detail this year. Due to potential unaccounted mortality (Section 2.8.2) there are uncertainties in the level of the historic SSB.

While the current biomass reference point may not be applicable in the long term its level relative to the current level of SSB estimated from the assessment is considered applicable in the short term. There may also be some evidence for revision of biomass reference points as the fitted stock recruit relationship (Figure 2.12.2) suggests a point of inflection at around 2.6Mt, below which reduced recruitment is observed. This value is higher than the current Bpa of 2.3Mt. It may be necessary to re-evaluate the biomass reference points in the near future and this should done with reference to any further development of harvest rules and a management plan. The estimates of F reference points are probably more reliable than the biomass reference points.

2.14 Management Considerations

Currently the stock is estimated to be around 2.2Mt. The SSB is thought to have risen from a low of 1.7Mt in 2002. Over the last 15 years the indications are that the total adult mortality has been over 0.3 on average and is thought to have declined with reduced catches in 2005 and 2006.

The current assessment is imprecise but reflects a good compromise between a number of sources of information. The egg survey indicates a relatively consistent if fluctuating biomass over the last 15 years. The catch data supports a rise in exploitation rate from 1999 declining in the last two years. This is consistent with the decline and subsequent rise in SSB seen in the assessment during this period. The reductions in catch appear to have contributed to the rise in SSB in recent years but this rise has been limited to returning the stock to the SSB levels attained in the 1990s and has not taken it higher. F is still above the management plan. This has lead to lower stock size and a reduction of fraction of large fish in the population and catch.

There are conflicting signals concerning recent recruitment, between catch data and relatively noisy recruit surveys. Both the catch and surveys indicate a high 2002 yearclass which the assessment estimates at about 20% above previously observed highest recruitment. We have no clear picture of recruitment from 2004 to 2006. The catch data does not estimate year classes well until they are at least 3 years old, the recruit surveys are noisy and have found to be unreliable in the past (Section 2.5.6). There is some evidence of distributional changes of both juveniles and adults from survey data, suggesting a northerly movement of both (Section 2.5.10). Currently the stock appears to be subject to increased variability in recruitment and possible changes in distribution. This adds to uncertainty about the future.

The WG provides an annual assessment of the state of the stock and catch predictions for two years ahead, in 2008 and 2009. In using this information there are a number of considerations:

Currently management advice for NE Atlantic mackerel is derived from an assessment based on reported catch. The WG has found substantial levels of unaccounted mortality, much of which has been linked to the catch (see section 2.8), these unaccounted removals have been estimated (with a 95% probability) to be more than 60% of the reported catch. While it has been possible to obtain some indications of the overall unaccounted mortality it has not been possible to obtain any estimates of changes in underreporting over time. In this context it is important that the short term projections should be interpreted as estimates of relative changes in stock and catch rather than absolute measures of stock size and catch. For this reason the short term predictions are presented as percentage changes.

While historic estimates of F for NEA mackerel are more robust to underreporting than historic estimates of biomass, the terminal values of F and SSB in the current assessment are particularly sensitive to the value in this years egg survey. These survey estimates are currently provisional as work on the analysis has not yet been completed, however, previous preliminary values have not been subject to significant revisions. Current estimates of terminal F will also be subject to revision as the future catches give more information on the cohorts currently in the stock.

The short term forecast provides catch options for 2008. The SSB is seen to be relatively stable and catches at F = Fpa =0.17 would give yields of 392,493 and SSB rising to 2.37Mt. Exploitation at the extremes of the management plan (F = 0.15 and 0.2) would give catches of 349,349 and 455,791 with SSB levels of 2.42 and 2.3 Mt respectively.

Currently there is ongoing work on a management plan for NE Atlantic mackerel (see section 1.8.2)

If improvements in enforcement seen of the last few years continue or are extended, true catches of NE Atlantic mackerel are expected to decline relative to recent years. There is a reasonable probability that this will result in a slow increase in stock size in the future. It will also be some years before this is evident in the assessment as this increase will only be observed in the assessment when the egg survey detects increased egg production from the adult stock.

Table 2.2.1.1. NEA Mackerel catches by area. Discards not estimated prior to 1978. (Data submitted by Working Group members.)

Year	Sub-area VI			Sub-area VII and Divisions VIIIa,b,d,e			Sub-area IV and III			Sub-area I,II & Divs.V[1]	Divs. VIIIc, IXa	Total		
	Landings	Discards	Catch	Landings	Discards	Catch	Landings	Discards	Catch	Landings	Landings	Landings	Discards	Catch
1969	4,800		4,800	47,404		47,404	739,175		739,175	7	42,526	833,912		833,912
1970	3,900		3,900	72,822		72,822	322,451		322,451	163	70,172	469,508		469,508
1971	10,200		10,200	89,745		89,745	243,673		243,673	358	32,942	376,918		376,918
1972	13,000		13,000	130,280		130,280	188,599		188,599	88	29,262	361,229		361,229
1973	52,200		52,200	144,807		144,807	326,519		326,519	21,600	25,967	571,093		571,093
1974	64,100		64,100	207,665		207,665	298,391		298,391	6,800	30,630	607,586		607,586
1975	64,800		64,800	395,995		395,995	263,062		263,062	34,700	25,457	784,014		784,014
1976	67,800		67,800	420,920		420,920	305,709		305,709	10,500	23,306	828,235		828,235
1977	74,800		74,800	259,100		259,100	259,531		259,531	1,400	25,416	620,247		620,247
1978	151,700	15,100	166,800	355,500	35,500	391,000	148,817		148,817	4,200	25,909	686,126	50,600	736,726
1979	203,300	20,300	223,600	398,000	39,800	437,800	152,323	500	152,823	7,000	21,932	782,555	60,600	843,155
1980	218,700	6,000	224,700	386,100	15,600	401,700	87,931		87,931	8,300	12,280	713,311	21,600	734,911
1981	335,100	2,500	337,600	274,300	39,800	314,100	64,172	3,216	67,388	18,700	16,688	708,960	45,516	754,476
1982	340,400	4,100	344,500	257,800	20,800	278,600	35,033	450	35,483	37,600	21,076	691,909	25,350	717,259
1983	320,500	2,300	322,800	235,000	9,000	244,000	40,889	96	40,985	49,000	14,853	660,242	11,396	671,638
1984	306,100	1,600	307,700	161,400	10,500	171,900	43,696	202	43,898	98,222	20,208	629,626	12,302	641,928
1985	388,140	2,735	390,875	75,043	1,800	76,843	46,790	3,656	50,446	78,000	18,111	606,084	8,191	614,275
1986	104,100		104,100	128,499		128,499	236,309	7,431	243,740	101,000	24,789	594,697	7,431	602,128
1987	183,700		183,700	100,300		100,300	290,829	10,789	301,618	47,000	22,187	644,016	10,789	654,805
1988	115,600	3,100	118,700	75,600	2,700	78,300	308,550	29,766	338,316	120,404	24,772	644,926	35,566	680,492
1989	121,300	2,600	123,900	72,900	2,300	75,200	279,410	2,190	281,600	90,488	18,321	582,419	7,090	589,509
1990	114,800	5,800	120,600	56,300	5,500	61,800	300,800	4,300	305,100	118,700	21,311	611,911	15,600	627,511
1991	109,500	10,700	120,200	50,500	12,800	63,300	358,700	7,200	365,900	97,800	20,683	637,183	30,700	667,883
1992	141,906	9,620	151,526	72,153	12,400	84,553	364,184	2,980	367,164	139,062	18,046	735,351	25,000	760,351
1993	133,497	2,670	136,167	99,828	12,790	112,618	387,838	2,720	390,558	165,973	19,720	806,856	18,180	825,036
1994	134,338	1,390	135,728	113,088	2,830	115,918	471,247	1,150	472,397	72,309	25,043	816,025	5,370	821,395
1995	145,626	74	145,700	117,883	6,917	124,800	321,474	730	322,204	135,496	27,600	748,079	7,721	755,800
1996	129,895	255	130,150	73,351	9,773	83,124	211,451	1,387	212,838	103,376	34,123	552,196	11,415	563,611
1997	65,044	2,240	67,284	114,719	13,817	128,536	226,680	2,807	229,487	103,598	40,708	550,749	18,864	569,613
1998	110141	71	110,212	105,181	3,206	108,387	264,947	4,735	269,682	134,219	44,164	658,652	8,012	666,664
1999[2,3]	116,362	§	116,362	94,290	§	94,290	313,014	§	313,014	72,848	43,796	640,311	§	640,311
2000[2,3]	187,595	1	187,595	115,566	1,918	117,484	285,567	165	304,898	92,557	36,074	736,524	2,084	738,608
2001[2,3]	143,142	83	143,142	142,890	1,081	143,971	327,200	24	339,971	67,097	43,198	736,274	1,188	737,462
2002[2,3]	136,847	12,931	149,778	102,484	2,260	104,744	375,708	8,583	394,878	73,929	49,576	749,131	23,774	772,905
2003[3]	142,728	91	142,819	89,492		89,492	334,639	9,390	357,766	53,701	25,823	660,119	9,481	669,600
2004[3]	134,251	240	134,491	99,922	1,862	101,784	300,768	8,870	316,620	62,486	34,840	639,248	10,972	650,221
2005	79,960	11,400	91,361	90,278	5,878	96,156	249,740	2,482	252,223	54,129	49,618	523,726	19,760	543,486
2006	88,077	6,031	94,108	66,209	6,556	72,765	200,929	5,383	206,312	46,716	52,751	454,682	17,970	472,652

[1]For 1976–1985 only Division IIa. Sub-area I, and Division IIb included in 2000 only [2] Data revised for Northern Ireland; [3]data revised for unallocated catch. [§] Discards reported as part of unallocated catches

Table 2.2.1.2. NEA Mackerel catch(t) in the Norwegian Sea (Division IIa) and Area V (Data submitted by Working Group members.)

Country	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Denmark	11,787	7,610	1,653	3,133	4,265	6,433	6,800	1,098	251			4,746
Estonia									216		3,302	1,925
Faroe Islands	137				22	1,247	3,100	5,793	3,347	1,167	6,258	9,032
France		16				11		23	6	6	5	5
Germany, Fed. Rep.			99		380							
Germany, Dem. Rep.			16	292		2,409						
Iceland												
Ireland												
Latvia									100	4,700	1,508	389
Lithuania												
Netherlands												
Norway	82,005	61,065	85,400	25,000	86,400	68,300	77,200	76,760	91,900	100,500	141,114	93,315
Poland												
Sweden												
United Kingdom			2,131	157	1,413		400	514	802		1,706	194
USSR (Russia from 1990)	4,293	9,405	11,813	18,604	27,924	12,088	28,900	13,361	42,440	49,600	28,041	44,537
Misreported (IVa)											-109,625	-18,647
Misreported (VIa)												
Unallocated												
Discards												
Total	98,222	78,096	101,112	47,186	120,404	90,488	118,700	97,819	139,062	165,973	72,309	135,496

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Denmark	3,198	37	2,090	106	1,375	7	1				
Estonia	3,741	4,422	7,356	3,595	2,673	219					
Faroe Islands	2,965	5,777[1]	2,716	3,011	5,546	3,272	4,730		650	30	
France		270							2	1	
Germany	1										
Iceland	92	925	357				53	122		363	4,222
Ireland				100				495	471		
Latvia	233										
Lithuania					2,085						
Netherlands	561			661			569		34	2,393	
Norway	47,992	41,000	54,477	53,821	31,778	21,971	22,670	12,548	10,295	13,244	8,914
Poland		22									
Sweden						8					
United Kingdom	48	938	199	662		54	665	510	1,945		
USSR (Russia from 1990)	44,545	50,207	67,201	51,003	49,100[2]	41,566	45,811	40,026	49,489	40,491	33,580
Misreported (IVa)			-177	-40,011							
Misreported (VIa)				-100							
Misreported (unknown)							-570		-400		
Unallocated										-2,393	
Discards											
Total	103,376	103,598	134,219	72,848	92,557	67,097	73,929	53,701	62,486	54,129	46,716

1- Faroese catch revised from previously reported 7,628t

2- includes small bycatches in subareas I and IIb

Table 2.2.1.3. NEA Mackerel catch(t) in the North Sea, Skagerrak, and Kattegat (Subarea IV and III), (Data submitted by Working Group members).

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Belgium	20	37		125	102	191	351	106	62	114	125	177
Denmark	32,588	26,831	29,000	38,834	41,719	42,502	47,852	30,891	24,057	21,934	25,326	29,353
Estonia					400							
Faroe Islands		2,685	5,900	5,338		11,408	11,027	17,883	13,886	3,288[2]	4,832	4,370
France	1,806	2,200	1,600	2,362	956	1,480	1,570	1,599	1,316	1,532	1,908	2,056
Germany, Fed. Rep.	177	6,312	3,500	4,173	4,610	4,940	1,497	712	542	213	423	473
Iceland												357
Ireland		8,880	12,800	13,000	13,136	13,206	9,032	5,607	5,280	280	145	11,293
Latvia					211							
Netherlands	2,564	7,343	13,700	4,591	6,547	7,770	3,637	1,275	1,996	951	1,373	2,819
Norway	59,750	81,400	74,500	102,350	115,700	112,700	114,428	108,890	88,444	96,300	103,700	106,917
Poland												
Sweden	1,003	6,601	6,400	4,227	5,100	5,934	7,099	6,285	5,307	4,714	5,146	5,233
United Kingdom	1,002	38,660	30,800	36,917	35,137	41,010	27,479	21,609	18,545	19,204	19,755	32,396[3]
USSR (Russia from 1990)										3,525	635	345
Romania							2,903					
Misreported (IIa)							109,625	18,647				40,000
Misreported (VIa)	180,000	92,000	126,000	130,000	127,000	146,697	134,765	106,987	51,781	73,523	98,432	59,882
Unallocated	29,630	6,461	-3,400	16,758	13,566			983	236	1,102	3,147	17,344[4]
Discards	29,776	2,190	4,300	7,200	2,980	2,720	1,150	730	1,387	2,807	4,753	
Total	338,316	281,600	305,100	365,875	367,164	390,558	472,397	322,204	212,839	229,487	269,700	313,015

Country	2000[1]	2001	2002	2003	2004	2005	2006
Belgium	146	97	22	2	4	1	3
Denmark	27,720	21,680	34,375	27,508	25,665	23,212	24,219
Estonia							
Faroe Islands	10,614	18,751	12,548	11,754	11,705	9,739	12,008
France	1,588	1,981	2,152	1,467	1,538	1,004	285
Germany, Fed. Rep.	78	4,514	3,902	4,859	4,514	4,442	2,389
Iceland							
Ireland	9,956	10,284	20,715	17,145	18,901	15,605	4,125
Latvia							
Netherlands	2,262	2,441	11,044	6,784	6,366	3,915	4,093
Norway	142,320	158,401	161,621	150,858	147,069	106,434	113,079
Poland						109	
Sweden	4,994	5,090	5,232	4,450	4,437	3,204	3,209
United Kingdom	58,282[3]	52,988[3]	61,781[3]	51,736	50,474	37,118	28,628
USSR (Russia from 1990)	1,672	1				4	
Romania							
Misreported (IIa)							
Misreported (VIa)	8,591	39,024	49,918	46,407	18,480	37,911	8,719
Unallocated	34,761[4]	24,873[4]	22,985[4]	25,405[4]	18,597[4]	7,043	171
Discards	1,912	24	8,583	9,390	8,870	2,482	5,383
Total	304,896	339,970	394,878	357,765	316,620	252,223	206,311

1-includes small catches in IIIb and IIId

2-Faroese catches revised from previously reported 1,367t

3-catches revised for Northern Ireland

4-catches revised for unallocated catches

Table 2.2.1.4. NEA Mackerel catch(t) in the Western area (Sub-areas VI and VII and Divisions VIIIa,b,d,e), (Data submitted by Working Group members).

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Belgium												
Denmark	400	300	100		1,000		1,573	194		2,239	1,143	1,271
Estonia											361	
Faroe Islands	9,900	1,400	7,100	2,600	1,100	1,000				4,283	4,284	
France	7,400	11,200	11,100	8,900	12,700	17,400	4,095		2,350	9,998	10,178	14,347
Germany, Fed. Rep.	11,800	7,700	13,300	15,900	16,200	18,100	10,364	9,109	8,296	25,011	23,703	15,685
Guernsey												
Ireland	91,400	74,500	89,500	85,800	61,100	61,500	17,138	21,952	23,776	79,996	72,927	49,033
Jersey												
Lithuania												
Netherlands	37,000	58,900	31,700	26,100	24,000	24,500	64,827	76,313	81,773	40,698	34,514	34,203
Norway	24,300	21,000	21,600	17,300	700		29,156	32,365	44,600	2,552		
Poland									600			
Spain				1,500	1,400	400	4,020	2,764	3,162	4,126	4,509	2,271
United Kingdom	205,900	156,300	200,700	208,400	149,100	162,700	162,588	196,890	215,265	208,656	190,344	127,612
Misreported (IVa)		-148,000	-117,000	-180,000	-92,000	-126,000	-130,000	-127,000	-146,697	-134,765	-106,987	-51,781
Unallocated	75,100	49,299	26,000	4,700	18,900	11,500	-3,802	1,472		4,632	28,245	10,603
Discards	4,500			5,800	4,900	11,300	23,550	22,020	15,660	4,220	6,991	10,028
Total	467,700	232,599	284,100	197,000	199,100	182,400	183,509	236,079	248,785	251,646	270,212	213,272

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Belgium								1		
Denmark			552	82	835		392			
Estonia										
Faroe Islands	2,448[1]	3,681	4,239	4,863	2,161	2,490	2,260	674		59
France	19,114	15,927	14,311	17,857	18,975	19,726	21,213	18,549	15,182	14,625
Germany, Fed. Rep.	15,161	20,989	19,476	22,901	20,793	22,630	19,202	18,730	14,598	14,219
Guernsey										10
Ireland	52,849	66,505	48,282	61,277	60,168	51,457	49,715	41,730	30,082	36,539
Jersey									9	8
Lithuania										95
Netherlands	22,749	28,790	25,141	30,123	33,654	21,831	23,640	21,132	18,819	20,064
Norway	223									
Poland									461	
Spain	7,842	3,340	4,120	4,500	4,063	3,483	735	2,081	4,795	4,048
United Kingdom	128,836	165,994	127,094[2]	126,620[2]	139,589[2]	131,599[2]	130,762	122,311	115,683	67,187
Misreported (IVa)	-73,523	-98,255	-59,982	-3,775	-39,024	-43,339	-46,407	-18,049	-37,911	-8,719
Unallocated	4,577	8,351	21,652[3]	31,564[3]	37,952[3]	27,558[3]	33,767[3]	27,999[3]	8,521	4,783
Discards	16,057	3,277		1,920	1,164	15,191	91	2,102	17,278	12,587
Total	196,110	218,599	204,885	297,932	280,553	252,620	235,370	237,260	187,517	166,873

1 – Faroese catches revised from 2,158t

2 – catches revised for Northern Ireland

3 – catches revised for unallocated catches

Table 2.2.1.5. NEA Mackerel catch(t) in Divisions VIIIc and IXa, 1977–2005. (Data submitted by Working Group members).

Country	Div	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
France	VIIIc											
Poland	IXa	8										
Portugal	IXa	1,743	1,555	1,071	1,929	3,108	3,018	2,239	2,250	4,178	6,419	5,714
Spain	VIIIc	19,852	18,543	15,013	11,316	12,834	15,621	10,390	13,852	11,810	16,533	15,982
Spain	IXa	2,935	6,221	6,280	2,719	2,111	2,437	2,224	4,206	2,123	1,837	491
USSR	IXa	2,879	189	111								
Total	IXa	7,565	7,965	7,462	4,648	5,219	5,455	4,463	6,456	6,301	8,256	6,205
Total		27,417	26,508	22,475	15,964	18,053	21,076	14,853	20,308	18,111	24,789	22,187

Country	Div	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
France	VIIIc											
Poland	IXa											
Portugal	IXa	4,388	3,112	3,819	2,789	3,576	2,015	2,158	2,893	3,023	2,080	2,897
Spain	VIIIc	16,844	13,446	16,086	16,940	12,043	16,675	21,246	23,631	28,386	35,015	36,174
Spain	IXa	3,540	1,763	1,406	1,051	2,427	1,027	1,741	1,025	2,714	3,613	5,093
USSR	IXa											
Total	IXa	7,928	4,875	5,225	3,840	6,003	3,042	3,899	3,918	5,737	5,693	7,990
Total		24,772	18,321	21,311	20,780	18,046	19,719	25,045	27,549	34,123	40,708	44,164

Country	Div	1999	2000	2001	2002	2003	2004	2005	2006
France	VIIIc					226	177	151	43
Poland	IXa								
Portugal	IXa	2,002	2,253	3,119	2,934	2,749	2,289	1,509	2,620
Spain	VIIIc	37,631	30,061	38,205	38,703	17,381	28,428	42,851	43,063
Spain	IXa	4,164	3,760	1,874	7,938	5,646	3,946	5,107	7,025
USSR	IXa								
Total	IXa	6,165	6,013	4,993	10,873	8,395	6,234	6,616	9,645
Total		43,796	36,074	43,198	49,575	26,002	34,840	49,618	52,751

Table 2.2.3.1. NEA Mackerel. Pelagic fleet composition in 2006 of nations catching mackerel.

Country	Details given	Length (metres)	Engine power (Horse Power)	Gear	Storage	Discard estimate	No vessels
Denmark	y	39-57	1100-5200	Midwater Trawl	Tank	No	11
Denmark	y	51-65	2400-5900	Purse seine	Tank	No	6
Faroe Islands	y	40-62	515-1540 kW	Trawl	219-906	No	1
Faroe Islands	y	90	6468 kW	Trawl	1090	No	1
Faroe Islands	y	53-76	2208-8000 kW	Purse-seine/Trawl	1480-2600	No	9
France	n			Pelagic Trawler	Dry Hold	No	9
France	n			Pelagic Trawler	Freezer	No	3
Germany	y	85-125	3200-11000	Single Midwater Trawl	Freezer	Yes	4
Ireland*	y	>100	14400	Midwater Trawl	RSW/Freezer	no	1
Ireland*	y	70-80	3000	Midwater Trawl	RSW	no	2
Ireland*	y	60-70	2500-3000	Midwater Trawl	RSW	no	5
Ireland*	y	50-60	1500-6000	Midwater Trawl	RSW	no	7
Ireland*	y	40-50	700-1200	Midwater Trawl	RSW	no	9
Ireland*	y	30-40	500-1200	Pair Midwater Trawl	RSW	no	6
Ireland*	y	20-30	350-700	Pair Midwater Trawl	RSW	no	8
Ireland*	y	20-30	350-700	Pair Midwater Trawl	Dry Hold	no	25
Ireland*	y	<20	200-300	Demersal Trawl/HandLine	Dry Hold	no	22
Netherlands	y	55	2890	Pair Midwater Trawl	Freezer	Yes	2
Netherlands	y	88-140	4400-1045	Single Midwater Trawl	Freezer	Yes	14
Norway	y	≥21		Purse seiners		No	221
Norway	y	14-21		Purse seiners/fishnets		No	90
Norway	y	7-14		Purse seiners/trawlers		No	475
Norway	y	<7		Trawler		No	24
Russia	y	55-80	1000 to >5000	Single Midwater Trawl	Freezer	No	52
Spain	y	10 - 32	110 - 800	Single Trawl	Dry hold, ice	No	247
Spain	y	19.5 - 31.3	220 - 800	Pair Trawl	Dry hold, ice	No	74
Spain	y	16 - 33	200 - 800	Trawl	Dry hold, ice	No	134
Spain	y	8 - 38	16 - 1100	Purse Seine	Dry hold, ice	No	341
Spain	y	5 - 44	5 - 878	Artisanal: Hook	Dry hold, ice	No	246
Spain	y	4 - 27	9 - 425	Artisanal: Gillnet	Dry hold, ice	No	100
Spain	y	2 - 27	4 - 450	Artisanal: Others	Dry hold,ice	No	5513
Sweden	n					No	
UK (England & Wales)	y	92.05	5053.5	Pair Midwater Trawl	Freezer	No	2
UK (England & Wales)	y	47.3	1992	Midwater Trawl	RSW	No	3
UK (Northern Ireland	n					No	
Scotland**	y	<49m	2393.7	Trawl/Purse	655.0	Yes	3
Scotland**	y	50 - 60m	4246.3	Trawl/Purse	1296.0	Yes	7
Scotland**	y	60 - 70 m	6248.8	Trawl/Purse	1557.9	Yes	12
Scotland**	y	>=70m	9429.3	Trawl	2196.0	No	4

* figures are from 2006, no updated number of vessels available, some vessels were sold but quota were transferred to new vessels, to be clarified in 2008

** figures are from 2006, no updated number of vessels available, to be clarified in 2008

Table 2.2.4.1. Catches in tonnes of Scomber colias in Divisions VIIIb, VIIIc and IXa in the period 1982-2006.

Country	Sub-Divisions	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Spain	Division VIIIb	0	0	0	0	0	0	0	0	0	487	7	4	427
	VIIIc East	322	254	656	513	750	1150	1214	3091	1923	1502	859	1892	1903
	VIIIc west													
	Total	322	254	656	513	750	1150	1214	3091	1923	1502	859	1892	1903
	IXa North												2557	7560
	IXa South											895	800	1013
	Total	0	0	0	0	0	0	0	0	0	0	895	3357	8573
	Total Spain	322	254	656	513	750	1150	1214	3091	1923	1989	1761	5253	10903
Portugal	IXa Central-North	-	0	236	229	223	168	165	281	228	137	914	543	378
	IXa Central-South	-	244	3924	4777	3784	5299	838	2105	5792	6925	5264	5019	2474
	IXa South	-	129	3899	4113	4177	3409	2813	4061	2547	3080	2803	1779	1578
	Total Portugal	664	373	8059	9118	8184	8876	3816	6447	8568	10142	8981	7341	4430
TOTAL	**Division VIIIb**										487	7	4	427
	VIIIc East	322	254	656	513	750	1150	1214	3091	1923	1502	859	1892	1903
	VIIIc west													
	Division VIIIc	322	254	656	513	750	1150	1214	3091	1923	1502	859	1892	1903
	IXa North												2557	7560
	IXa Central-North		0	236	229	223	168	165	281	228	137	914	543	378
	IXa Central-South		244	3924	4777	3784	5299	838	2105	5792	6925	5264	5019	2474
	IXa South		129	3899	4113	4177	3409	2813	4061	2547	3080	3698	2579	2591
	Division IXa	664	373	8059	9118	8184	8876	3816	6447	8568	10142	9876	10698	13003
	Total	986	627	8715	9631	8934	10026	5030	9538	10491	12131	10742	12594	15333

Country	Sub-Divisions	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Spain	Division VIIIb	247	778	362	1218	632	344	426	99	157	40	222	262
	VIIIc East	2558	2633	4416	1753	414	1279	1442	1130	1200	1482	1237	853
	VIIIc west		47	610	12	3	626	54	379	1325	1260	1913	3407
	Total	2558	2679	5026	1765	418	1905	1496	1509	2525	2741	3150	4260
	IXa North	4705	5066	1727	412	104	531	1	54	33	6	504	2745
	IXa South	364	370	613	969	879	470	552	1512	948	882	307	239
	Total	5068	5437	2340	1381	983	1001	553	1566	981	888	812	2984
	Total Spain	7872	8894	7729	4364	2033	3250	2475	3174	3663	3670	4184	7506
Portugal	IXa Central-North	913	785	521	481	296	146	60	177	476	242	3033	2570
	IXa Central-South	1544	2224	2109	3414	10407	7450	2202	1380	3405	5990	5743	6684
	IXa South	1427	1749	2778	2796	3173	2924	1966	3744	4149	6193	6130	3777
	Total Portugal	3884	4759	5408	6690	13877	10520	4228	5301	8030	12425	14905	13031
TOTAL	**Division VIIIb**	247	778	362	1218	632	344	426	99	157	40	222	262
	VIIIc East	2558	2633	4416	1753	414	1279	1442	1130	1200	1482	1237	853
	VIIIc west		47	610	12	3	626	54	379	1325	1260	1913	3407
	Division VIIIc	2558	2679	5026	1765	418	1905	1496	1509	2525	2741	3150	4260
	IXa North	4705	5066	1727	412	104	531	1	54	33	6	504	2745
	IXa Central-North	913	785	521	481	296	146	60	177	476	242	3033	2570
	IXa Central-South	1544	2224	2109	3414	10407	7450	2202	1380	3405	5990	5743	6684
	IXa South	1790	2120	3391	3764	4052	3395	2518	5256	5097	7075	6438	4016
	Division IXa	8952	10195	7748	8071	14860	11521	4781	6867	9011	13313	15717	16015
	Total	11756	13653	13137	11054	15909	13770	6703	8475	11693	16094	19089	20537

Table 2.4.1.1 NE Atlantic Mackerel Catch Numbers at Age (000s)

Quarters1-4

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	VIa	VIIa	VIIb	VIIc	VIId
0	0.1	0.0		285.4					293.8	0.0	80.2		
1	356.4	28.5		12284.4	45.4	84.6	10.8	16.6	5130.4	1.4	3671.8	36.6	18640.3
2	2922.0	1047.5	0.1	56878.7	259.2	299.1	248.9	365.2	21991.1	3.9	8319.4	101.1	50374.0
3	5870.8	401.3	0.7	48751.9	98.4	90.5	387.5	576.1	39804.0	6.0	9014.0	13.6	3689.7
4	36036.0	1285.7	0.5	164905.9	260.7	212.7	1683.9	2535.5	111017.0	12.6	19109.5	32.9	6310.7
5	19172.7	277.3	0.3	86914.4	92.7	88.4	728.7	1074.5	35656.7	3.4	4738.1	15.2	5604.9
6	7277.3	107.3	0.3	38977.5	29.6	15.0	287.5	428.7	19221.1	2.1	2276.2	5.8	3734.7
7	7143.4	131.0	0.0	29122.3	22.8	8.1	295.2	427.1	16596.3	1.5	1540.5	4.2	1984.1
8	3487.0	123.8	0.1	14631.6	9.9	2.8	121.9	181.8	7470.7	0.7	886.8	3.3	1094.4
9	1815.0	32.2	0.0	8618.7	3.3	0.1	35.6	55.2	4146.7	0.4	692.7	0.9	480.7
10	1118.6	32.3		8587.9	1.4		29.9	44.6	1757.8	0.2	97.1	0.6	288.7
11	888.2	9.5		4142.5	1.9		22.3	31.9	1571.7	0.1	60.9	0.5	159.4
12	532.3	7.8		3182.8	1.3		29.3	47.3	763.1	0.1	78.5	0.3	133.1
13	664.5	1.6		1261.4	0.7		27.0	50.3	424.9	0.0	100.0	0.2	
14	211.7	0.4		396.8	0.3		2.8	4.1	159.5	0.0	1.5	0.1	133.0
15	195.7	0.1		388.6	0.1		3.2	6.8	144.0	0.0	19.5	0.1	
SOP	42395.3	1387.4	1.0	204649.5	253.9	188.6	1745.0	2604.7	94475.7	11.2	15409.1	44.6	16876.6
Catch	42376.1	1381.3	1.0	204481.2	255.6	192.7	1741.0	2599.0	94107.6	11.2	15503.3	44.8	17011.0
SOP%	100.0	99.6	99.9	99.9	100.7	102.2	99.8	99.8	99.6	99.5	100.6	100.6	100.8

Table 2.4.1.1 (cont) NE Atlantic Mackerel Catch Numbers at Age (000s)

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0	14.1	69.8	0.2	4.1	309.8		17.4	73.8	888.7		56255.8	1.1	58294.1
1	291.6	497.7	9.9	1417.9	1661.5		2355.7	2904.0	5648.9	87.0	13360.9	760.5	69302.8
2	1136.5	2127.0	14.1	3789.2	2564.7	1.0	3060.6	3409.9	2390.1	234.9	940.1	2655.4	165134.0
3	551.9	1048.0	13.3	1755.6	6687.8	512.1	5262.3	20269.9	6485.0	127.6	2252.0	2960.3	156630.6
4	502.9	943.7	19.3	7003.7	24512.8	3140.8	9922.0	55919.4	14488.5	641.9	5101.5	2802.6	468402.8
5	370.2	319.8	2.5	1703.8	6010.5	3338.3	2355.1	20302.4	2580.3	334.9	1905.5	556.7	194147.4
6	134.6	79.7	0.4	1439.0	5867.9	6444.2	1068.8	7241.4	724.0	484.3	739.2	230.3	96816.8
7	91.5	34.2	0.4	1119.8	4622.4	2608.0	571.7	5726.9	572.3	275.1	652.6	197.4	73748.9
8	27.6	13.0	0.1	356.0	1261.9	633.8	259.8	1919.0	240.6	59.3	322.1	125.9	33233.9
9	22.9	5.0	0.0	46.6	370.2	767.2	84.5	1260.5	125.6	55.0	151.5	14.7	18785.1
10	23.1	9.1		101.5	369.7	269.1	57.9	955.8	58.2	32.8	97.8	16.9	13950.8
11	5.4	0.4	0.0	90.4	325.3	496.7	46.2	292.4	41.0	30.8	72.7	23.1	8313.3
12	8.3	2.5	0.0	0.0	36.6	496.6	37.6	218.0	21.2	25.6	27.3		5649.6
13							0.1	20.1	6.9		8.2		2565.7
14	1.0	0.0			29.6	134.4	6.0			13.4			1094.5
15									1.7		1.4		761.1
SOP	727.0	971.9	15.7	5252.9	18510.0	7639.7	6290.9	35804.2	7312.9	818.9	7016.1	2619.8	473008.6
Catch	727.5	971.6	15.7	5324.1	18397.3	7642.3	6292.5	35792.9	7313.2	823.6	7025.3	2619.9	472651.8
SOP%	100.1	100.0	100.0	101.4	99.4	100.0	100.0	100.0	100.0	100.6	100.1	100.0	99.9

Table 2.4.1.1 (cont) NE Atlantic Mackerel Catch Numbers at Age (000s)

Quarter 1

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	VIa	VIIa	VIIb	VIIc	VIId
0				0.1									
1				5437.7					3871.1		632.1	36.6	18314.1
2				21431.8					19067.1		2125.8	101.1	49368.7
3				5477.3					37208.4		3799.3	13.6	3186.7
4				16499.8					106148.2		11176.9	32.9	3985.3
5				7286.3					34730.0		3301.8	15.2	3186.3
6				6068.4					19025.5		1985.8	5.8	797.0
7				5220.1					16456.7		1347.6	4.2	0.5
8				3658.4					7403.6		777.5	3.3	796.5
9				1693.6					4090.2		625.1	0.9	0.2
10				1824.0					1750.6		70.4	0.6	0.1
11				889.9					1552.4		49.2	0.5	0.0
12				512.9					708.8		31.9	0.3	0.0
13				148.8					386.5			0.2	
14				208.0					158.9			0.1	
15				142.0					110.2			0.1	
SOP				24008.5					90739.8		8423.5	44.6	12004.7
Catch				23989.6					90364.2		8601.0	44.8	12140.4
SOP%				99.9					99.6		102.1	100.6	101.1

Table 2.4.1.1 (cont) NE Atlantic Mackerel Catch Numbers at Age (000s)

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0													0.1
1	25.9			0.8			296.6	594.9	0.1	87.0	1109.5	73.9	30480.5
2	99.7	10.0		2.3	44.6	1.0	1285.6	2055.0	1999.7	234.9	452.1	2087.6	100366.9
3	31.7	9.1	0.0	113.0	5392.5	341.5	2355.5	15045.8	5576.2	114.2	1611.4	2183.1	82459.2
4	37.2	10.6	0.1	504.2	22912.3	1016.5	5653.8	42650.5	11937.9	440.9	3811.8	2315.7	229134.5
5	54.0	16.6	0.1	117.0	5203.6	1312.3	1019.0	16064.5	1489.6	147.3	1317.9	426.2	75687.5
6	12.5	3.8	0.3	127.7	5166.5	3260.2	668.4	5836.0	342.9	203.0	457.1	168.0	44128.7
7	6.1	2.1	0.1	103.7	4132.9	654.5	325.1	4564.3	239.6	87.5	368.6	148.3	33661.7
8	5.4	1.4	0.0	28.5	1173.5	328.7	143.4	1538.6	120.9	32.5	185.9	103.2	16301.4
9	4.3	1.4	0.0	3.9	228.0	327.8	47.9	1035.5	51.2	14.8	83.9	1.8	8210.3
10	5.8	1.9		6.0	303.6	0.3	24.9	828.6	25.7	6.0	54.3	3.4	4906.2
11	1.1	0.4	0.0	6.0	279.9	326.0	39.3	255.1	22.2	17.4	44.8	1.7	3486.0
12	7.3	2.5	0.0		7.0	326.0	30.2	182.7	12.3	12.2	17.4		1851.4
13							0.1	19.4	2.8		5.9		563.7
14													367.0
15									1.0		1.4		254.6
SOP	56.2	13.2	0.3	359.7	15794.7	3346.5	3043.1	27403.8	4837.4	427.7	2447.8	1893.9	194831.9
Catch	56.3	13.1	0.3	361.1	15773.3	3349.3	3047.8	27395.9	4837.3	432.4	2447.7	1894.0	194748.5
SOP%	100.0	99.6	96.6	100.4	99.9	100.1	100.2	100.0	100.0	101.1	100.0	100.0	100.0

Table 2.4.1.1 (cont) NE Atlantic Mackerel Catch Numbers at Age (000s)

Quarter 2

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	VIa	VIIa	VIIb	VIIc	VIId
0													
1	30.3	1.5		7.0	37.1	57.2			0.4				0.2
2	263.0	55.2		658.6	235.2	253.6			134.8	0.1	0.0		0.6
3	583.9	31.0		257.7	67.0	48.4			36.9	0.3	0.6		79.5
4	3311.2	106.8		809.7	217.8	155.0			96.7	0.6	1.7		1191.2
5	878.5	35.4		250.1	57.2	30.0			22.3	0.2	0.5		1111.8
6	465.7	15.5		109.5	18.9	3.0			3.9	0.2	0.3		1667.7
7	158.9	17.4		122.6	18.8	0.2			3.3	0.1	0.2		1111.7
8	197.6	6.0		56.5	7.2	0.1			1.4	0.1	0.1		158.9
9	106.4	2.5		23.7	3.0	0.0			1.7	0.0	0.1		238.3
10	47.3	0.9		17.7	1.4				0.2	0.0	0.0		158.9
11	4.5	1.7		14.0	1.9				0.4	0.0	0.0		79.4
12	135.9	1.1		9.3	1.2				0.0	0.0	0.0		79.4
13	290.9	0.6		3.8	0.7				0.0				
14	4.3	0.2		2.8	0.3								79.4
15	56.1			1.3	0.1								
SOP	2883.0	114.1		832.8	204.7	123.5			78.9	0.6	1.3		2319.1
Catch	2883.1	114.1		832.5	204.5	123.5			78.3	0.6	1.3		2318.9
SOP%	100.0	100.0		100.0	99.9	100.0			99.3	99.1	100.3		100.0

Table 2.4.1.1 (cont) NE Atlantic Mackerel Catch Numbers at Age (000s)

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0			0.1		0.3								0.5
1	0.0		5.7	1.4	14.3		116.7	1045.3	38.8		6021.1	6.9	7383.7
2	256.6	934.2	8.1	5.7	20.1		39.9	364.5	108.8		88.5	285.3	3712.8
3	130.0	469.5	7.7	1.6	48.7	107.0	431.8	4141.6	698.9	13.4	280.4	340.6	7776.7
4	131.7	423.5	11.1	4.5	471.2	1604.3	1879.9	11521.0	2265.5	201.0	796.5	342.5	25543.4
5	49.8	129.0	1.4	1.7	417.3	1497.3	597.6	3629.9	1015.7	187.6	490.1	59.2	10462.3
6	29.8	30.0	0.1	0.9	621.1	2246.1	312.7	1166.9	370.0	281.4	267.2	23.3	7633.8
7	15.1	2.7	0.2	0.3	414.4	1497.3	188.3	884.1	320.8	187.6	272.7	28.4	5245.0
8	2.6	1.8	0.1	0.3	59.3	213.9	86.3	279.2	118.3	26.8	133.8	14.9	1365.0
9	3.4	1.2		0.1	88.7	320.9	30.3	179.4	73.7	40.2	67.2	9.2	1189.9
10	3.5	5.1		0.1	59.2	213.9	23.7	121.6	32.5	26.8	43.4	10.1	766.2
11	1.0	0.0			29.6	107.0	5.1	35.7	18.7	13.4	27.9	7.2	347.5
12	1.0	0.0		0.0	29.6	107.0	6.1	35.3	8.9	13.4	9.9		438.1
13								0.7	4.1		2.3		303.1
14	1.0	0.0			29.6	107.0	4.6			13.4			242.6
15									0.7				58.2
SOP	135.8	385.6	8.9	4.1	885.6	3123.2	1137.7	6572.9	1563.7	391.2	1261.1	294.1	22321.8
Catch	135.7	385.2	8.9	4.1	885.6	3122.9	1137.1	6569.9	1563.5	391.2	1269.2	294.2	22324.4
SOP%	99.9	99.9	100.1	100.0	100.0	100.0	99.9	100.0	100.0	100.0	100.6	100.0	100.0

Table 2.4.1.1 (cont) NE Atlantic Mackerel Catch Numbers at Age (000s)

Quarter 3

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	VIa	VIIa	VIIb	VIIc	VIId
0				0.8					1.2	0.0	0.0		
1	324.6	25.4		399.6	1.1	4.8	10.8	16.6	112.4	1.4	82.5		
2	2653.0	986.1	0.1	14707.0	16.7	23.0	248.9	365.2	102.8	3.7	382.5		
3	5280.9	355.5	0.7	8073.2	25.1	23.3	387.5	576.1	101.1	5.6	261.7		53.6
4	32685.1	1144.4	0.5	28460.4	37.9	43.9	1683.9	2535.5	496.8	11.9	1213.4		803.8
5	18262.2	223.0	0.3	9420.4	26.5	30.9	728.7	1074.5	142.6	3.2	329.1		750.2
6	6798.4	83.5	0.3	4043.7	9.0	6.9	287.5	428.7	68.6	2.0	176.9		1125.4
7	6974.9	108.6	0.0	4624.5	2.4	2.9	295.2	427.1	26.1	1.4	54.6		750.2
8	3284.7	115.3	0.1	1597.7	2.7	2.8	121.9	181.8	27.7	0.7	72.5		107.2
9	1705.1	28.2	0.0	659.1	0.3	0.0	35.6	55.2	15.3	0.3	36.9		160.8
10	1068.3	30.1		240.7			29.9	44.6	7.0	0.2	16.4		107.2
11	882.2	6.9		462.1			22.3	31.9	1.1	0.1	1.5		53.6
12	394.9	6.2		259.3	0.0		29.3	47.3	18.7	0.1	46.6		53.6
13	373.0	0.7		193.2	0.0		27.0	50.3	38.4	0.0	100.0		
14	207.4	0.2		42.7			2.8	4.1	0.6	0.0	1.5		53.6
15	139.5	0.0		6.1			3.2	6.8	7.5	0.0	19.5		
SOP	39454.3	1227.4	1.0	30240.8	40.5	39.9	1745.0	2604.7	456.8	10.5	1099.2		1564.9
Catch	39434.0	1221.1	1.0	30222.0	41.5	41.2	1741.0	2599.0	457.9	10.4	1099.5		1564.7
SOP%	99.9	99.5	99.9	99.9	102.4	103.3	99.8	99.8	100.2	99.6	100.0		100.0

Table 2.4.1.1 (cont) NE Atlantic Mackerel Catch Numbers at Age (000s)

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0	13.6	69.6	0.1		0.0			28.8	146.1		33389.7		33649.9
1	124.7	447.7	3.8		1.0		10.2	592.0	2480.4		3716.3	205.1	8560.4
2	351.0	1027.6	5.5		2.4		44.9	483.7	147.7		251.4	178.0	21980.9
3	121.4	463.4	5.1		1.2	27.4	77.3	697.0	126.8		248.7	282.9	17195.6
4	122.6	451.8	7.5		1.6	411.5	137.1	1216.4	174.3		343.8	88.3	72072.3
5	33.0	102.9	0.9		0.3	384.0	28.2	477.8	45.2		74.6	45.0	32183.4
6	12.1	19.0	0.1		0.1	576.1	30.2	206.2	7.5		13.7	24.3	13920.0
7	0.7	3.6	0.1		0.0	384.0	20.5	231.0	6.3		11.1	11.9	13937.2
8	3.0	3.9	0.0		0.0	54.9	3.1	81.3	1.3		2.3	5.5	5670.1
9						82.3	4.2	33.9	0.7		0.4	2.5	2821.0
10						54.9	2.8	4.1	0.0			1.9	1608.0
11						27.4	1.4	0.1	0.0			9.9	1500.5
12						27.4	1.4						884.9
13													782.5
14						27.4	1.4						341.5
15													182.6
SOP	144.2	465.4	6.0		1.6	801.1	91.3	1293.5	428.8		2008.1	251.9	83975.5
Catch	144.3	465.7	6.0		1.6	801.0	91.2	1293.3	428.7		2007.9	251.9	83924.9
SOP%	100.1	100.1	100.1		100.1	100.0	99.9	100.0	100.0		100.0	100.0	99.9

Table 2.4.1.1 (cont) NE Atlantic Mackerel Catch Numbers at Age (000s)

Quarter 4

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	VIa	VIIa	VIIb	VIIc	VIId
0	0.1	0.0		284.5					292.6		80.1		
1	1.5	1.6		6440.1	7.3	22.5			1146.5	0.1	2957.2		325.9
2	6.1	6.2		20081.3	7.4	22.5			2686.5	0.1	5811.1		1004.7
3	6.0	14.7		34943.8	6.3	18.8			2457.6	0.1	4952.4		370.0
4	39.7	34.6		119136.1	5.1	13.8			4275.4	0.1	6717.6		330.4
5	32.1	18.8		69957.7	9.1	27.5			761.8	0.0	1106.8		556.6
6	13.2	8.4		28755.9	1.7	5.0			123.2	0.0	113.2		144.6
7	9.6	5.0		19155.1	1.7	5.0			110.3	0.0	138.1		121.6
8	4.7	2.5		9319.0	0.0				37.9		36.7		31.8
9	3.5	1.6		6242.3	0.0				39.5		30.6		81.4
10	3.0	1.3		6505.4	0.0						10.2		22.6
11	1.5	0.9		2776.5	0.0				17.8		10.2		26.4
12	1.5	0.6		2401.2					35.6				
13	0.6	0.2		915.6									
14	0.1	0.0		143.3									
15	0.1	0.1		239.2					26.4				
SOP	59.0	46.0		149569.8	8.8	25.2			3204.7	0.1	5885.4		988.0
Catch	59.0	46.0		149437.0	9.7	28.0			3207.2	0.1	5801.5		987.0
SOP%	100.0	99.9		99.9	110.3	111.1			100.1	103.3	98.6		99.9

Table 2.4.1.1 (cont) NE Atlantic Mackerel Catch Numbers at Age (000s)

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0	0.4	0.2	0.0	4.1	309.4		17.4	45.0	742.6		22866.1	1.1	24643.6
1	141.0	50.0	0.4	1415.7	1646.2		1932.1	671.9	3129.7		2514.0	474.6	22878.3
2	429.2	155.2	0.5	3781.2	2497.7		1690.3	506.8	133.9		148.2	104.6	39073.3
3	268.9	105.9	0.5	1641.0	1245.4	36.2	2397.7	385.6	83.1		111.5	153.7	49199.1
4	211.3	57.7	0.7	6495.0	1127.6	108.5	2251.3	531.6	110.7		149.4	56.1	141652.6
5	233.4	71.3	0.1	1585.1	389.3	144.8	710.4	130.2	29.9		22.9	26.4	75814.2
6	80.2	26.8		1310.4	80.2	361.8	57.5	32.3	3.8		1.3	14.7	31134.2
7	69.6	25.9	0.0	1015.9	75.0	72.3	37.9	47.4	5.6		0.3	8.8	20905.0
8	16.6	5.9		327.3	29.1	36.2	27.0	19.9	0.2		0.0	2.4	9897.4
9	15.2	2.4		42.6	53.4	36.2	2.2	11.7	0.1			1.2	6563.9
10	13.9	2.0		95.5	6.9		6.5	1.6	0.0			1.5	6670.4
11	3.2			84.4	15.8	36.2	0.5	1.6	0.0			4.4	2979.4
12						36.2							2475.1
13													916.4
14													143.5
15													265.7
SOP	390.8	107.6	0.5	4888.7	1828.6	368.8	2019.2	535.3	483.6		1301.4	179.8	171885.4
Catch	391.2	107.7	0.6	4959.0	1736.8	369.1	2016.3	533.9	483.6		1300.5	179.8	171654.0
SOP%	100.1	100.0	100.9	101.4	95.0	100.1	99.9	99.7	100.0		99.9	100.0	99.9

Table 2.4.1.2 NE Atlantic Mackerel Percentage Catch Numbers at Age. Zeros represent values <1%

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	VIa	VIIa	VIIb	VIIc	VIId
0	0%	0%		0%					0%	0%	0%		
1	0%	0%		3%	5%	11%	0%	0%	2%	4%	7%	17%	20%
2	3%	30%	3%	12%	31%	37%	6%	6%	8%	12%	16%	47%	54%
3	7%	12%	35%	10%	12%	11%	10%	10%	15%	18%	18%	6%	4%
4	41%	37%	23%	34%	31%	27%	43%	43%	42%	39%	38%	15%	7%
5	22%	8%	16%	18%	11%	11%	19%	18%	13%	10%	9%	7%	6%
6	8%	3%	17%	8%	4%	2%	7%	7%	7%	6%	4%	3%	4%
7	8%	4%	2%	6%	3%	1%	8%	7%	6%	5%	3%	2%	2%
8	4%	4%	3%	3%	1%	0%	3%	3%	3%	2%	2%	2%	1%
9	2%	0%	2%	2%	0%	0%	0%	0%	2%	1%	1%	0%	0%
10	1%	0%		2%	0%		0%	0%	0%	0%	0%	0%	0%
11	1%	0%		0%	0%		0%	0%	0%	0%	0%	0%	0%
12	0%	0%		0%	0%		0%	0%	0%	0%	0%	0%	0%
13	0%	0%		0%	0%		0%	0%	0%	0%	0%	0%	
14	0%	0%		0%	0%		0%	0%	0%	0%	0%	0%	0%
15	0%	0%		0%	0%		0%	0%	0%	0%	0%	0%	

Table 2.4.1.2 (cont) NE Atlantic Mackerel Catch Numbers at Age (000s)

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0	0%	1%	0%	0%	0%		0%	0%	3%		69%	0%	4%
1	9%	10%	16%	8%	3%		9%	2%	16%	4%	16%	7%	5%
2	36%	41%	23%	20%	5%	0%	12%	3%	7%	10%	1%	26%	12%
3	17%	20%	22%	9%	12%	3%	21%	17%	19%	5%	3%	29%	11%
4	16%	18%	32%	37%	45%	17%	40%	46%	42%	27%	6%	27%	34%
5	12%	6%	4%	9%	11%	18%	9%	17%	8%	14%	2%	5%	14%
6	4%	2%	0%	8%	11%	34%	4%	6%	2%	20%	0%	2%	7%
7	3%	0%	0%	6%	8%	14%	2%	5%	2%	11%	0%	2%	5%
8	0%	0%	0%	2%	2%	3%	1%	2%	0%	2%	0%	1%	2%
9	0%	0%	0%	0%	0%	4%	0%	1%	0%	2%	0%	0%	1%
10	0%	0%		0%	0%	1%	0%	0%	0%	1%	0%	0%	1%
11	0%	0%	0%	0%	0%	3%	0%	0%	0%	1%	0%	0%	0%
12	0%	0%	0%	0%	0%	3%	0%	0%	0%	1%	0%		0%
13							0%	0%	0%		0%		0%
14	0%	0%			0%	0%	0%			0%			0%
15									0%		0%		0%

Table 2.4.2.1 NE Atlantic Mackerel. Percentage length composition in catches by country and gear, 2006. Zeros represent values of less than 1%.

Len	DK	NL	PT	RU	IE	NO	UKS				DE	ES			UKE	FO
(cm)	all IVa	pel	all	pel trawl		Purse seine	IVa disc	Via disc	IVa	VIa	pel	Purse seine	trawl	artisanal	lines	Purse seine
13												0				
14												0				
15												0				
16					0						0	0	0			
17					0			0			0	3	0	0		
18		0			0			0		0	0	29	0	0		
19		6			0	0		2		0	0	13	0	0	0	
20		2			0	0	0	5	0	0	0	2	0	0	0	
21		0	0		0	0		4	0	0	0	5	0	0	0	
22	0	1	0		0		5	1	0	0	0	3	0	0	0	
23	0	0	0	0	0	0	8	3	0	0	0	3	0	0	0	
24	0	4	1	0	0	0	7	4	0	0	1	3	0	0	3	
25	0	6	1	0	0	0	4	3	0	0	1	3	0	0	3	0
26	0	6	0	0	1	0	14	3	0	0	1	2	0	0	5	0
27	0	11	1	0	1	0	25	6	0	2	2	1	1	0	14	
28	0	8	3	0	1	0	19	6	0	3	2	1	6	0	22	
29	0	7	4	0	1	0	5	3	0	1	3	4	14	2	16	
30	0	6	10	1	3	2	1	3	2	2	4	4	15	5	13	
31	1	4	17	2	6	3	0	9	4	6	8	4	12	5	8	
32	2	5	22	4	9	5	0	6	6	9	11	4	12	7	7	3
33	4	5	18	8	11	6	1	5	8	13	12	3	10	8	4	4
34	10	5	10	11	13	9	2	6	13	16	15	3	7	10	1	14
35	13	5	5	16	13	15	2	5	16	15	12	3	5	13	1	16
36	19	4	3	16	11	16	1	5	15	10	8	3	4	13	0	14
37	17	4	1	14	9	15	1	6	11	8	6	2	3	12	0	14
38	12	3	2	11	6	11	1	4	8	6	4	1	3	10	0	13
39	8	2	0	7	4	7	0	2	6	3	3	0	2	7	0	8

40	6	2	0	4	3	4	0	2	3	2	2	0	1	4		4
41	4	1	0	2	2	2	0	2	2	1	1	0	0	2		5
42	2	0	0	2	1	1	0	0	1	0	0	0	0	2		3
43	0	0	0	0	0	0		0	0	0	0	0	0	0		1
44	0	0	0	0	0	0		0	0	0	0	0	0	0		
45	0		0	0	0	0			0	0	0	0	0	0		
46			0	0	0	0			0		0	0	0	0		
47			0	0	0											
48			0		0											

Table 2.4.3.1 NE Atlantic Mackerel. Mean length (cm) at age by area.

Quarters1-4

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	Via	VIIa	VIIb	VIIc	VIId
0	21.1	21.1		22.1					19.1	22.4	23.4		
1	27.1	26.2		26.1	26.5	26.4	26.5	26.6	22.0	25.6	24.7	21.4	21.5
2	29.9	30.6	34.0	30.0	29.4	29.0	30.2	30.2	28.2	29.3	29.9	27.7	27.8
3	32.9	34.4	36.5	34.0	32.8	31.9	33.4	33.4	33.7	33.8	33.4	32.2	31.1
4	34.7	34.7	38.0	35.3	33.8	32.9	34.7	34.7	34.4	34.6	34.1	33.9	34.0
5	36.4	37.0	38.9	36.6	34.9	33.3	36.4	36.4	35.9	36.3	35.7	34.3	34.2
6	37.7	37.6	38.1	37.8	36.8	34.7	37.4	37.4	37.6	37.6	37.8	37.2	38.1
7	38.0	37.3	29.5	38.1	37.2	35.5	37.9	37.9	38.0	38.8	38.2	37.4	38.5
8	38.8	37.0	41.0	39.1	38.3	36.7	38.8	38.8	38.9	39.4	39.4	37.9	37.7
9	40.0	41.1	40.5	39.9	40.5	40.5	40.7	40.7	39.5	39.8	40.6	38.9	40.8
10	40.4	39.8		40.7	40.0		39.7	39.7	40.5	41.1	40.5	40.0	40.0
11	41.1	41.9		40.9	40.3		40.3	40.3	40.5	41.0	40.5	40.5	42.5
12	41.3	42.8		41.6	42.5		42.0	41.8	41.6	43.0	39.1	41.4	43.5
13	41.4	43.1		42.3	43.2		40.2	40.5	40.5	42.2	41.6	39.9	
14	41.9	44.4		42.9	43.7		44.1	44.1	41.3	41.4	44.0	41.3	42.5
15	42.8	45.4		44.0	42.8		42.0	42.4	40.9	41.3	43.2	41.1	

Table 2.4.3.1 (Continued) NE Atlantic Mackerel. Mean length (cm) at age by area.

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0	20.9	20.8	22.4	20.9	24.6		22.4	25.4	20.2		18.9	21.5	19.0
1	26.6	25.8	25.5	21.4	27.2		25.8	24.7	25.0	21.4	22.7	27.8	23.6
2	29.0	28.4	30.5	26.9	30.6	33.2	29.2	29.7	29.8	26.9	29.5	31.0	29.0
3	30.7	30.0	33.0	32.6	33.2	32.3	31.1	31.8	31.1	32.5	31.5	32.5	33.1
4	32.2	31.1	33.6	34.2	34.5	35.5	32.9	33.7	31.9	34.7	33.3	33.2	34.5
5	33.3	31.9	34.4	35.4	36.0	37.6	34.7	36.6	35.7	36.5	36.6	35.5	36.3
6	34.4	32.0	38.8	37.7	38.1	38.9	38.0	38.3	37.6	38.4	38.5	36.6	37.9
7	34.3	32.5	37.1	38.8	38.7	38.9	37.8	38.5	38.6	38.7	39.3	37.5	38.2
8	36.2	34.4	39.0	38.9	39.6	40.0	39.0	39.6	38.7	39.0	39.8	38.5	39.0
9	37.6	33.7	42.2	41.6	41.4	41.6	41.2	40.6	39.6	41.2	40.3	39.8	40.1
10	37.3	33.0		39.5	39.4	40.0	39.6	41.9	41.8	39.9	42.0	40.5	40.7
11	40.4	32.8	44.1	40.7	41.1	44.0	43.4	41.1	41.4	42.8	42.0	43.5	41.1
12	35.4	34.3	44.1	42.5	42.3	44.2	44.2	41.1	40.4	44.0	42.0		41.8
13							45.6	45.6	44.3		43.7		41.7
14	42.5	42.5			42.5	42.5	42.5			42.5			42.3
15									44.5		44.5		43.1

Table 2.4.3.1 (cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Quarter 1

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	Via	VIIa	VIIb	VIIc	VIId
0				21.1									
1				23.3					21.0		20.1	21.4	21.4
2				27.6					27.8		27.5	27.7	27.7
3				33.8					33.9		33.8	32.2	30.8
4				34.3					34.5		34.4	33.9	33.1
5				35.7					36.0		36.1	34.3	32.5
6				37.3					37.6		37.9	37.2	37.5
7				37.5					38.0		38.4	37.4	38.9
8				38.2					38.9		39.5	37.9	37.5
9				39.6					39.5		40.6	38.9	40.7
10				39.5					40.5		40.8	40.0	37.8
11				40.6					40.5		40.0	40.5	38.3
12				40.9					41.7		37.5	41.4	35.6
13				42.8					40.4			39.9	
14				42.0					41.3			41.3	
15				42.8					41.1			41.1	

Table 2.4.3.1 (cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0													21.1
1	21.4			21.2			21.4	24.7	22.5	21.4	21.3	27.3	21.7
2	27.4	26.6		27.6	32.1	33.2	28.1	29.3	29.7	26.9	29.0	30.8	27.9
3	30.1	30.0	32.2	33.4	33.3	32.6	31.0	31.7	30.9	32.6	31.4	32.3	32.9
4	31.9	31.7	35.0	34.5	34.5	35.1	32.6	33.8	31.5	34.3	33.2	33.1	34.1
5	32.2	32.2	38.6	36.0	36.1	39.0	35.5	36.7	34.9	36.5	36.4	35.3	36.0
6	33.7	33.3	39.4	38.3	38.1	39.4	38.3	38.3	36.9	38.6	38.1	36.5	37.9
7	34.4	34.4	39.9	38.7	38.8	40.0	37.9	38.5	38.2	39.2	39.0	37.4	38.2
8	35.0	34.4	41.3	40.0	39.7	41.5	39.6	39.7	38.1	39.8	39.5	38.5	38.9
9	33.9	33.9	42.3	42.4	41.8	42.5	41.8	40.6	39.5	42.2	40.1	39.6	40.0
10	32.3	32.3		38.5	39.2	41.3	40.2	41.9	42.1	39.5	42.2	40.4	40.3
11	32.5	32.5	44.4	41.5	41.0	44.5	43.6	41.3	41.4	43.1	41.8	42.4	41.0
12	34.3	34.3	44.1		37.5	44.5	44.5	41.1	39.7	44.5	41.8		41.8
13							45.5	45.6	44.0		43.7		41.3
14													41.7
15									44.5		44.5		42.1

Table 2.4.3.1 (cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Quarter 2

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	Via	VIIa	VIIb	VIIc	VIId
0													
1	27.8	26.2		26.2	26.7	26.7			21.4				21.4
2	29.3	30.4		29.7	29.4	29.1			29.2	28.6	33.2		27.7
3	32.8	33.5		32.7	32.8	32.3			31.8	34.0	34.2		31.5
4	33.9	34.8		34.2	33.9	33.2			33.4	34.9	34.6		35.7
5	36.2	36.7		35.7	35.5	33.4			34.0	36.5	36.5		36.5
6	38.1	37.6		37.3	37.4	36.5			37.9	37.9	38.0		38.3
7	37.6	37.6		37.6	37.6	34.8			37.9	39.3	39.1		38.5
8	38.2	38.6		38.2	38.5	41.0			38.3	40.0	40.0		38.0
9	40.1	40.7		40.1	40.5	40.5			39.7	40.2	41.2		40.8
10	39.0	40.7		39.5	40.0				42.2	41.1	41.3		40.0
11	43.8	40.3		40.4	40.3				40.2	41.2	39.5		42.5
12	40.2	43.0		42.0	42.7				44.1	43.3	37.5		43.5
13	41.6	43.3		43.3	43.3				43.7				
14	44.0	44.4		42.9	43.8								42.5
15	43.2			42.8	42.8								

Table 2.4.3.1 (cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0			22.5		22.5								22.5
1	21.4		25.5	26.6	25.5		21.5	21.5	23.2		21.6	27.4	21.7
2	28.3	28.3	30.6	28.3	30.6		29.1	30.6	31.1		28.9	31.1	29.4
3	30.1	30.1	33.0	31.1	32.1	31.5	31.8	32.0	32.3	31.5	31.5	32.4	31.9
4	31.8	31.2	33.6	34.3	35.6	35.7	34.1	33.5	33.7	35.7	34.1	33.1	33.9
5	33.2	31.9	34.3	35.5	36.5	36.5	36.4	36.4	36.9	36.5	37.9	35.4	36.4
6	36.4	31.4	38.0	35.4	38.3	38.3	37.8	38.1	38.2	38.3	39.3	36.5	38.2
7	38.4	35.8	36.5	38.2	38.5	38.5	37.9	38.1	39.1	38.5	39.8	37.4	38.5
8	37.7	36.2	38.5	37.3	38.0	38.0	39.0	39.4	39.3	38.0	40.3	38.4	38.7
9	40.5	37.8		40.9	40.8	40.8	40.5	40.5	39.7	40.8	40.5	39.6	40.6
10	37.3	33.4		41.9	40.0	40.0	40.3	41.6	41.6	40.0	41.7	40.4	40.3
11	42.5	42.5			42.5	42.5	42.6	39.9	41.3	42.5	42.3	43.3	42.1
12	43.5	43.5		42.5	43.5	43.5	43.3	40.7	41.4	43.5	42.3		42.1
13								45.8	44.6		43.5		41.7
14	42.5	42.5			42.5	42.5	42.5			42.5			42.5
15									44.5				43.2

Table 2.4.3.1 (cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Quarter 3

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	Via	VIIa	VIIb	VIIc	VIId
0				22.6					21.9	22.5	22.5		
1	27.0	26.0		26.3	23.8	24.7	26.5	26.6	25.1	25.6	26.8		
2	30.0	30.6	34.0	30.5	28.8	28.6	30.2	30.2	29.1	29.3	28.5		
3	32.9	34.4	36.5	33.3	33.5	32.1	33.4	33.4	32.9	33.8	32.3		31.5
4	34.7	34.7	38.0	34.8	33.4	32.7	34.7	34.7	33.9	34.6	33.8		35.7
5	36.4	37.0	38.9	36.6	34.7	34.0	36.4	36.4	35.9	36.3	35.9		36.5
6	37.6	37.5	38.1	37.5	35.8	34.1	37.4	37.4	37.9	37.6	37.4		38.3
7	38.0	37.2	29.5	37.6	34.7	35.4	37.9	37.9	37.7	38.8	37.6		38.5
8	38.8	36.9	41.0	38.6	37.6	36.6	38.8	38.8	38.4	39.4	37.8		38.0
9	40.0	41.2	40.5	40.7	40.5	40.5	40.7	40.7	40.1	39.8	40.1		40.8
10	40.5	39.8		40.7			39.7	39.7	39.2	41.2	39.0		40.0
11	41.1	42.3		40.3			40.3	40.3	43.1	41.0	44.0		42.5
12	41.7	42.8		43.0	36.5		42.0	41.8	40.1	43.0	40.2		43.5
13	41.1	43.3		43.3	40.5		40.2	40.5	41.6	42.2	41.6		
14	41.8	44.4		44.4			44.1	44.1	43.8	41.3	44.0		42.5
15	42.6	46.0		45.6			42.0	42.4	43.1	41.1	43.2		

Table 2.4.3.1 (cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0	20.7	20.7	22.2		22.5			25.5	20.2		18.9		18.9
1	25.8	25.5	25.5		25.9		22.6	27.2	25.0		24.0	31.1	25.1
2	28.3	28.3	30.5		29.2		27.8	30.9	30.1		30.4	32.2	30.2
3	30.1	29.9	33.0		32.5	31.5	30.0	32.9	32.8		32.4	33.6	33.0
4	31.3	31.0	33.6		33.3	35.7	32.0	33.8	33.1		32.7	34.3	34.7
5	32.3	32.1	34.3		33.5	36.5	35.6	36.3	34.0		34.1	36.4	36.4
6	31.8	32.9	37.6		31.8	38.3	38.2	37.8	36.3		36.2	37.3	37.6
7	38.5	38.5	36.8		36.5	38.5	38.3	38.1	37.5		36.7	38.7	37.9
8	31.8	32.5	38.3		33.2	38.0	38.2	39.3	39.4		38.8	39.5	38.7
9						40.8	40.8	41.0	40.5		40.2	40.5	40.3
10						40.0	40.0	42.5	43.5			40.8	40.4
11						42.5	42.5	43.3	43.5			43.8	40.9
12						43.5	43.5						42.2
13													41.7
14						42.5	42.5						42.4
15													42.8

Table 2.4.3.1 (cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Quarter 4

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	Via	VIIa	VIIb	VIIc	VIId
0	21.1	21.1		22.1					19.1		23.4		
1	29.0	29.6		28.4	25.9	25.9			25.0	26.3	25.7		28.6
2	32.6	33.2		32.3	29.2	29.1			31.2	30.4	30.9		31.2
3	34.4	35.9		34.3	31.0	30.8			31.2	32.0	33.2		33.8
4	35.7	36.3		35.6	31.8	31.2			32.7	33.1	33.8		35.4
5	36.6	37.5		36.7	32.5	32.3			33.0	32.5	34.5		36.6
6	37.7	38.5		38.0	34.8	34.5			35.0	32.1	37.6		38.8
7	38.2	38.9		38.5	35.6	35.5			36.9	32.0	36.7		38.8
8	39.3	39.8		39.6	40.1				40.3		39.3		40.5
9	39.8	40.0		39.9	40.2				41.0		40.8		40.9
10	40.5	40.6		41.0	40.7						40.5		40.5
11	40.8	41.4		41.1	42.2				42.8		42.5		42.2
12	41.5	41.5		41.5					40.8				
13	42.1	42.1		42.1									
14	44.0	44.0		43.6									
15	45.2	45.2		44.7					39.5				

Table 2.4.3.1 (cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0	24.5	24.5	22.5	20.9	24.7		22.4	25.3	20.2		18.9	21.5	19.1
1	28.3	28.3	25.5	21.4	27.2		26.8	27.7	25.0		24.0	26.4	26.2
2	30.4	30.2	30.6	26.9	30.5		30.1	29.4	29.2		29.8	32.2	31.2
3	31.2	30.4	33.0	32.6	32.9	32.5	31.2	31.4	32.5		31.6	33.6	33.7
4	33.1	30.9	33.6	34.1	34.0	35.2	32.7	32.3	33.0		31.9	34.5	35.3
5	33.8	31.8	34.2	35.4	35.1	39.0	32.1	35.6	33.9		32.6	36.4	36.5
6	34.2	31.7		37.7	37.1	39.4	34.6	37.8	36.4		34.8	37.3	38.0
7	33.4	31.2	35.9	38.8	37.3	40.0	35.8	38.8	36.7		35.9	38.6	38.4
8	37.1	35.1		38.8	39.9	41.5	35.7	39.8	40.0		38.6	39.5	39.5
9	38.0	31.5		41.5	41.0	42.5	38.9	41.1	40.6			40.5	40.0
10	39.4	32.5		39.5	40.5		34.7	43.5	43.5			41.1	41.0
11	42.5			40.6	41.6	44.5	41.5	43.5	43.5			43.5	41.2
12						44.5							41.6
13													42.1
14													43.6
15													44.2

Table 2.4.3.2 NE Atlantic Mackerel. Mean weight (kg) at age by area.

Quarters1-4

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	Via	VIIa	VIIb	VIIc	VIId
0	0.072	0.072		0.079					0.042	0.070	0.087		
1	0.179	0.157		0.147	0.144	0.143	0.169	0.171	0.080	0.121	0.108	0.064	0.066
2	0.258	0.268	0.351	0.239	0.212	0.196	0.262	0.262	0.178	0.196	0.208	0.153	0.154
3	0.353	0.402	0.453	0.372	0.310	0.252	0.364	0.363	0.316	0.316	0.296	0.272	0.231
4	0.431	0.431	0.523	0.417	0.340	0.275	0.414	0.412	0.341	0.344	0.316	0.320	0.291
5	0.508	0.525	0.558	0.472	0.397	0.307	0.487	0.486	0.392	0.405	0.369	0.326	0.295
6	0.561	0.489	0.524	0.521	0.473	0.360	0.531	0.534	0.455	0.453	0.449	0.471	0.434
7	0.576	0.538	0.600	0.526	0.486	0.371	0.530	0.530	0.475	0.508	0.458	0.452	0.418
8	0.625	0.522	0.644	0.574	0.525	0.380	0.573	0.580	0.519	0.539	0.524	0.457	0.424
9	0.687	0.708	0.641	0.610	0.669	0.641	0.792	0.781	0.547	0.551	0.561	0.516	0.518
10	0.705	0.532		0.648	0.583		0.651	0.650	0.591	0.617	0.586	0.563	0.529
11	0.742	0.677		0.659	0.659		0.673	0.674	0.591	0.605	0.550	0.587	0.604
12	0.730	0.732		0.700	0.739		0.722	0.714	0.651	0.724	0.558	0.636	0.659
13	0.748	0.802		0.728	0.797		0.660	0.688	0.605	0.678	0.777	0.564	
14	0.712	0.815		0.721	0.767		0.805	0.807	0.626	0.627	0.848	0.625	0.505
15	0.687	0.876		0.788	0.689		0.593	0.661	0.614	0.622	0.794	0.613	

Table 2.4.3.2(cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0	0.069	0.068	0.071	0.065	0.114		0.070	0.118	0.056		0.041	0.055	0.042
1	0.144	0.130	0.115	0.065	0.151		0.122	0.112	0.111	0.064	0.081	0.156	0.099
2	0.185	0.171	0.226	0.135	0.225	0.272	0.185	0.190	0.183	0.135	0.189	0.218	0.196
3	0.222	0.202	0.296	0.263	0.280	0.234	0.223	0.229	0.208	0.254	0.224	0.252	0.307
4	0.265	0.224	0.316	0.303	0.313	0.306	0.264	0.276	0.226	0.306	0.263	0.266	0.357
5	0.293	0.244	0.342	0.345	0.366	0.373	0.310	0.354	0.324	0.355	0.353	0.331	0.428
6	0.324	0.246	0.449	0.453	0.435	0.418	0.412	0.405	0.380	0.417	0.409	0.368	0.480
7	0.315	0.262	0.432	0.469	0.457	0.422	0.404	0.415	0.414	0.429	0.434	0.394	0.494
8	0.392	0.305	0.514	0.469	0.493	0.478	0.447	0.456	0.417	0.455	0.455	0.424	0.543
9	0.446	0.282	0.513	0.570	0.563	0.510	0.508	0.489	0.447	0.510	0.468	0.490	0.584
10	0.480	0.263		0.532	0.524	0.519	0.483	0.534	0.527	0.522	0.532	0.511	0.625
11	0.528	0.254	0.524	0.574	0.590	0.547	0.564	0.513	0.514	0.569	0.534	0.723	0.635
12	0.332	0.288	0.701	0.571	0.612	0.701	0.699	0.511	0.486	0.686	0.536		0.684
13							0.712	0.692	0.630		0.601		0.713
14	0.505	0.505			0.505	0.505	0.505			0.505			0.643
15									0.638		0.638		0.727

Table 2.4.3.2 (cont) NE Atlantic Mackerel. Mean weight (kg) at age by area.

Quarter 1

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	Via	VIIa	VIIb	VIIc	VIId
0				0.072									
1				0.096					0.068		0.049	0.064	0.064
2				0.166					0.168		0.143	0.153	0.152
3				0.318					0.319		0.291	0.272	0.221
4				0.337					0.342		0.309	0.320	0.269
5				0.386					0.394		0.370	0.326	0.244
6				0.444					0.455		0.439	0.471	0.554
7				0.451					0.475		0.458	0.452	0.479
8				0.479					0.518		0.506	0.457	0.418
9				0.534					0.546		0.554	0.516	0.562
10				0.529					0.591		0.570	0.563	0.452
11				0.580					0.589		0.528	0.587	0.457
12				0.594					0.652		0.416	0.636	0.339
13				0.696					0.589			0.564	
14				0.645					0.625			0.625	
15				0.688					0.613			0.613	

Table 2.4.3.2(cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0													0.072
1	0.064			0.063			0.064	0.103	0.073	0.064	0.067	0.146	0.071
2	0.147	0.135		0.149	0.249	0.272	0.156	0.177	0.178	0.135	0.167	0.213	0.160
3	0.199	0.195	0.232	0.282	0.280	0.240	0.212	0.226	0.202	0.259	0.215	0.243	0.279
4	0.234	0.227	0.276	0.313	0.312	0.281	0.251	0.276	0.216	0.300	0.257	0.263	0.312
5	0.239	0.238	0.395	0.365	0.368	0.405	0.329	0.354	0.301	0.363	0.341	0.320	0.371
6	0.290	0.264	0.432	0.446	0.439	0.433	0.431	0.404	0.360	0.442	0.395	0.353	0.442
7	0.290	0.290	0.440	0.454	0.462	0.442	0.409	0.413	0.397	0.462	0.422	0.381	0.458
8	0.316	0.289	0.517	0.500	0.494	0.522	0.468	0.452	0.398	0.486	0.445	0.416	0.493
9	0.277	0.277	0.513	0.570	0.575	0.518	0.518	0.485	0.442	0.532	0.462	0.454	0.534
10	0.240	0.240		0.496	0.522	0.586	0.506	0.535	0.536	0.534	0.541	0.485	0.552
11	0.244	0.244	0.524	0.615	0.588	0.526	0.557	0.517	0.515	0.543	0.527	0.565	0.573
12	0.286	0.286	0.701		0.416	0.716	0.712	0.513	0.459	0.716	0.529		0.625
13							0.709	0.692	0.614		0.604		0.621
14													0.636
15									0.638		0.638		0.655

Table 2.4.3.2 (cont) NE Atlantic Mackerel. Mean weight (kg) at age by area.

Quarter 2

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	Via	VIIa	VIIb	VIIc	VIId
0													
1	0.196	0.155		0.155	0.146	0.145			0.058				0.064
2	0.247	0.264		0.229	0.213	0.196			0.205	0.175	0.272		0.152
3	0.337	0.366		0.319	0.308	0.254			0.266	0.318	0.305		0.216
4	0.370	0.418		0.370	0.344	0.273			0.295	0.349	0.318		0.320
5	0.473	0.499		0.442	0.429	0.314			0.337	0.410	0.388		0.349
6	0.596	0.530		0.493	0.512	0.429			0.470	0.464	0.438		0.398
7	0.547	0.514		0.490	0.508	0.400			0.462	0.525	0.488		0.414
8	0.734	0.575		0.520	0.557	0.644			0.480	0.558	0.526		0.417
9	0.649	0.706		0.612	0.672	0.641			0.565	0.563	0.585		0.502
10	0.614	0.632		0.541	0.583				0.692	0.613	0.586		0.519
11	0.893	0.671		0.632	0.659				0.590	0.608	0.499		0.603
12	0.654	0.777		0.689	0.748				0.778	0.734	0.416		0.659
13	0.778	0.817		0.797	0.812				0.749				
14	0.847	0.814		0.704	0.767								0.505
15	0.794			0.688	0.688								

Table 2.4.3.2(cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0			0.071		0.071								0.071
1	0.064		0.115	0.142	0.115		0.066	0.066	0.082		0.065	0.147	0.067
2	0.166	0.166	0.226	0.171	0.227		0.173	0.201	0.207		0.165	0.217	0.200
3	0.200	0.200	0.296	0.229	0.248	0.216	0.229	0.231	0.233	0.216	0.217	0.246	0.241
4	0.236	0.225	0.317	0.303	0.320	0.320	0.289	0.269	0.270	0.320	0.281	0.262	0.294
5	0.271	0.239	0.340	0.342	0.349	0.349	0.351	0.345	0.357	0.349	0.389	0.322	0.362
6	0.352	0.233	0.496	0.336	0.398	0.398	0.392	0.397	0.397	0.398	0.434	0.355	0.412
7	0.410	0.335	0.429	0.411	0.414	0.414	0.399	0.401	0.425	0.414	0.450	0.382	0.420
8	0.403	0.348	0.517	0.401	0.417	0.417	0.438	0.444	0.434	0.417	0.469	0.415	0.482
9	0.492	0.394		0.510	0.502	0.502	0.492	0.480	0.449	0.502	0.474	0.453	0.509
10	0.420	0.276		0.549	0.519	0.519	0.503	0.522	0.519	0.519	0.521	0.483	0.523
11	0.603	0.603			0.603	0.603	0.605	0.468	0.512	0.603	0.545	0.603	0.585
12	0.659	0.659		0.571	0.659	0.659	0.639	0.502	0.524	0.659	0.546		0.641
13								0.700	0.641		0.593		0.775
14	0.505	0.505			0.505	0.505	0.505			0.505			0.514
15									0.638				0.790

Table 2.4.3.2 (cont) NE Atlantic Mackerel. Mean weight (kg) at age by area.

Quarter 3

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	Via	VIIa	VIIb	VIIc	VIId
0				0.094					0.082	0.071	0.071		
1	0.177	0.154		0.157	0.102	0.121	0.169	0.171	0.131	0.120	0.149		
2	0.258	0.267	0.351	0.265	0.208	0.201	0.262	0.262	0.221	0.196	0.189		
3	0.355	0.404	0.453	0.362	0.340	0.285	0.364	0.363	0.335	0.317	0.311		0.216
4	0.437	0.432	0.523	0.418	0.329	0.298	0.414	0.412	0.370	0.345	0.364		0.320
5	0.510	0.530	0.558	0.498	0.372	0.343	0.487	0.486	0.453	0.406	0.459		0.349
6	0.558	0.475	0.524	0.530	0.413	0.331	0.531	0.534	0.578	0.453	0.562		0.398
7	0.577	0.541	0.600	0.515	0.390	0.360	0.530	0.530	0.541	0.508	0.547		0.414
8	0.618	0.518	0.644	0.574	0.439	0.375	0.573	0.580	0.724	0.538	0.706		0.417
9	0.690	0.713	0.641	0.706	0.641	0.641	0.792	0.781	0.646	0.550	0.649		0.502
10	0.709	0.523		0.633			0.651	0.650	0.618	0.619	0.614		0.519
11	0.741	0.676		0.672			0.673	0.674	0.818	0.604	0.904		0.603
12	0.756	0.727		0.776	0.324		0.722	0.714	0.641	0.723	0.655		0.659
13	0.725	0.817		0.816	0.418		0.660	0.688	0.769	0.675	0.777		
14	0.709	0.814		0.813			0.805	0.807	0.838	0.625	0.848		0.505
15	0.644	0.900		0.885			0.593	0.661	0.793	0.613	0.794		

Table 2.4.3.2(cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0	0.067	0.067	0.070		0.071			0.119	0.063		0.041		0.042
1	0.130	0.125	0.115		0.124		0.079	0.153	0.111		0.098	0.224	0.118
2	0.171	0.171	0.225		0.194		0.150	0.240	0.219		0.226	0.255	0.255
3	0.208	0.202	0.295		0.280	0.216	0.190	0.294	0.291		0.281	0.297	0.347
4	0.235	0.224	0.316		0.307	0.320	0.235	0.326	0.299		0.288	0.321	0.419
5	0.267	0.252	0.339		0.320	0.349	0.326	0.419	0.332		0.333	0.400	0.495
6	0.242	0.270	0.468		0.253	0.398	0.397	0.480	0.414		0.407	0.439	0.526
7	0.427	0.427	0.435		0.428	0.414	0.408	0.493	0.465		0.430	0.502	0.538
8	0.253	0.257	0.507		0.318	0.417	0.421	0.544	0.551		0.519	0.544	0.596
9						0.502	0.502	0.631	0.607		0.588	0.598	0.679
10						0.519	0.519	0.716	0.776			0.617	0.671
11						0.603	0.604	0.762	0.776			0.805	0.710
12						0.659	0.659						0.742
13													0.752
14						0.505	0.505						0.676
15													0.674

Table 2.4.3.2 (cont) NE Atlantic Mackerel. Mean weight (kg) at age by area.

Quarter 4

Ages	IIa	IIIa	IIIb	IVa	IVb	IVc	Va	Vb	Via	VIIa	VIIb	VIIc	VIId
0	0.072	0.072		0.078					0.042		0.087		
1	0.196	0.215		0.190	0.143	0.143			0.115	0.131	0.119		0.177
2	0.295	0.319		0.299	0.190	0.188			0.247	0.218	0.234		0.238
3	0.372	0.425		0.383	0.215	0.207			0.271	0.264	0.299		0.318
4	0.438	0.453		0.428	0.247	0.221			0.304	0.300	0.320		0.374
5	0.479	0.510		0.477	0.266	0.260			0.307	0.272	0.342		0.404
6	0.531	0.557		0.536	0.370	0.359			0.380	0.255	0.452		0.466
7	0.549	0.574		0.550	0.382	0.375			0.450	0.257	0.426		0.478
8	0.606	0.620		0.612	0.617				0.617		0.564		0.627
9	0.615	0.621		0.620	0.621				0.650		0.585		0.595
10	0.660	0.660		0.682	0.649						0.648		0.648
11	0.670	0.694		0.683	0.728				0.769		0.606		0.606
12	0.714	0.714		0.715					0.640				
13	0.716	0.716		0.715									
14	0.825	0.825		0.804									
15	0.866	0.866		0.845					0.570				

Table 2.4.3.2(cont). NE Atlantic Mackerel. Mean length (cm) at age by area.

Ages	VIIe	VIIf	VIIg	VIIh	VIIj	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0	0.108	0.108	0.071	0.065	0.114		0.070	0.117	0.055		0.042	0.055	0.044
1	0.170	0.169	0.115	0.065	0.151		0.134	0.156	0.111		0.098	0.129	0.138
2	0.216	0.205	0.227	0.135	0.224		0.207	0.188	0.196		0.210	0.253	0.256
3	0.240	0.209	0.296	0.262	0.285	0.237	0.233	0.229	0.282		0.254	0.299	0.351
4	0.306	0.220	0.317	0.302	0.320	0.279	0.278	0.253	0.295		0.261	0.330	0.409
5	0.313	0.241	0.336	0.344	0.355	0.405	0.249	0.367	0.328		0.282	0.398	0.466
6	0.330	0.240		0.453	0.426	0.433	0.315	0.450	0.417		0.354	0.440	0.528
7	0.295	0.229	0.404	0.470	0.436	0.442	0.381	0.506	0.427		0.395	0.499	0.542
8	0.439	0.326		0.466	0.591	0.522	0.363	0.554	0.581		0.509	0.544	0.605
9	0.483	0.229		0.571	0.614	0.518	0.515	0.630	0.614			0.598	0.618
10	0.594	0.252		0.534	0.648		0.305	0.775	0.776			0.632	0.679
11	0.606			0.572	0.607	0.526	0.607	0.776	0.776			0.793	0.677
12						0.716							0.714
13													0.715
14													0.804
15													0.818

Table 2.4.6.1 Julian day by which 50% of the egg spawning had occurred in each of the egg survey years and the fraction of the year this represents.

Year	Julian Day	Fraction of year
1992	128	0.35
1995	130	0.36
1998	119	0.32
2001	136	0.37
2004	133	0.36
2007	130	0.36
Mean		0.35

Table 2.4.6.2. NEA mackerel. Proportion of F before spawning for every age and survey year; for all ages and every survey year; and as a mean for all ages and all years.

Fprop						
	1992	1995	1998	2001	2004	2006
0	0.000	0.000	0.000	0.000	0.001	0.000
1	0.030	0.235	0.205	0.074	0.096	0.471
2	0.270	0.269	0.264	0.243	0.190	0.587
3	0.306	0.264	0.340	0.401	0.410	0.519
4	0.327	0.358	0.391	0.410	0.393	0.478
5	0.342	0.394	0.469	0.419	0.441	0.350
6	0.356	0.439	0.457	0.443	0.475	0.451
7	0.377	0.443	0.579	0.387	0.524	0.438
8	0.425	0.469	0.505	0.365	0.495	0.459
9	0.536	0.509	0.594	0.360	0.501	0.401
10	0.473	0.594	0.632	0.397	0.456	0.313
11	0.442	0.476	0.551	0.386	0.376	0.386
12	0.519	0.617	0.584	0.364	0.371	0.314
All ages	0.392	0.435	0.478	0.378	0.414	0.429
Mean all ages	0.420	0.420	0.420	0.420	0.420	0.420

Table 2.5.5.1. NEA mackerel (Southern component). CPUE at age from bottom trawl surveys.

October Spain Survey, Bottom trawl survey (Catch: numbers)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10+
1984	1	1.47	0.20	0.11	0.37	0.15	0.21	0.04	0.01	0.03	0.02	0.07
1985	1	2.65	1.60	0.02	0.06	0.37	0.14	0.09	0.03	0.02	0.03	0.08
1986	1	0.03	0.17	0.14	0.02	0.03	0.06	0.03	0.00	0.00	0.00	0.03
1987												
1988	1	0.29	0.03	0.03	0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.00
1989	1	0.51	0.00	0.02	0.00	0.04	0.02	0.00	0.01	0.00	0.00	0.00
1990	1	0.40	0.94	0.04	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00
1991	1	0.13	0.27	0.22	0.27	0.34	0.07	0.03	0.01	0.03	0.00	0.01
1992	1	19.90	0.48	0.16	0.15	0.09	0.03	0.01	0.00	0.00	0.00	0.00
1993	1	0.07	1.26	0.79	0.03	0.06	0.02	0.01	0.00	0.00	0.00	0.01
1994	1	0.47	0.11	0.12	0.15	0.04	0.04	0.01	0.01	0.00	0.00	0.00
1995	1	0.92	0.03	0.19	0.16	0.05	0.01	0.01	0.00	0.00	0.00	0.00
1996	1	46.09	6.40	1.32	0.07	0.10	0.02	0.00	0.01	0.01	0.00	0.00
1997	1	5.73	27.11	6.28	0.67	0.39	0.00	0.00	0.00	0.00	0.00	0.00
1998	1	0.46	3.82	0.97	0.24	0.05	0.09	0.06	0.02	0.02	0.00	0.01
1999	1	3.93	0.98	2.42	0.53	0.12	0.01	0.00	0.00	0.00	0.00	0.00
2000	1	26.78	1.90	0.87	0.20	0.10	0.02	0.03	0.00	0.00	0.00	0.00
2001	1	0.31	1.21	1.07	0.32	0.15	0.08	0.00	0.00	0.00	0.00	0.00
2002	1	14.46	0.34	0.61	0.32	0.10	0.05	0.03	0.00	0.00	0.00	0.00
2003	1	1.43	3.34	0.71	0.15	0.07	0.01	0.02	0.00	0.00	0.00	0.00
2004	1	8.10	0.50	0.57	0.21	0.09	0.04	0.00	0.01	0.00	0.00	0.00
2005	1	52.94	1.06	0.87	0.73	0.12	0.01	0.02	0.00	0.00	0.00	0.00
2006	1	117.79	5.76	0.80	0.70	0.62	0.07	0.02	0.05	0.00	0.00	0.00

October Portugal Survey, Bottom trawl survey (Catch: numbers)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10+
1986	1	0.52	2.76	1.00	0.51	0.04	0.01	0.01	0.00	0.00	0.00	0.00
1987	1	1.03	23.28	14.79	2.94	0.55	0.00	0.00	0.00	0.00	0.00	0.00
1988	1	86.47	24.55	0.35	0.33	0.04	0.01	0.00	0.00	0.00	0.00	0.00
1989	1	11.64	28.43	4.71	3.45	0.02	0.01	0.00	0.00	0.00	0.00	0.00
1990	1	1.34	2.99	1.75	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1991	1	0.31	0.37	0.29	0.19	0.03	0.02	0.02	0.01	0.00	0.00	0.00
1992	1	123.55	2.74	0.66	0.30	0.06	0.01	0.01	0.00	0.00	0.00	0.00
1993	1	52.32	0.39	0.12	0.05	0.08	0.00	0.00	0.00	0.00	0.00	0.00
1994	1	12.21	0.77	0.30	0.11	0.04	0.05	0.02	0.01	0.00	0.00	0.00
1995	1	318.60	9.08	0.28	0.11	0.03	0.01	0.01	0.00	0.00	0.00	0.00
1996*	1	235.26	2.16	0.22	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	1	772.03	39.40	7.66	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	1	226.59	11.58	0.31	0.00	0.04	0.02	0.00	0.00	0.02	0.00	0.00
1999*	1	209.11	2.62	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	1	23.23	2.26	0.03	0.04	0.14	0.07	0.00	0.02	0.00	0.00	0.00
2001	1	299.04	12.19	3.89	1.70	0.19	0.05	0.02	0.00	0.01	0.01	0.01
2002	1	116.57	18.54	0.21	0.27	0.00	0.02	0.00	0.00	0.00	0.00	0.00
2003**	1	1.59	6.92	0.07	0.08	0.00	0.03	0.00	0.00	0.00	0.00	0.00
2004**	1	42.89	11.64	7.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005**	1	65.61	3.33	1.07	0.41	0.01	0.07	0.00	0.00	0.00	0.00	0.00
2006***	1	781.83	157.64	0.38	0.34	0.06	0.06	0.00	0.10	0.00	0.00	0.00

* DIFFERENT SHIP

** half hour trawl and different ship

*** HALF HOUR TRAWL

Table 2.5.6.1 NEA mackerel Quarter 4 bottom trawl survey mean catch for a 1 hour tow, number of stations per year and number of ICES rectangles covered by the survey. The coverage and effort increase from 1985 to 1997 and remains relatively stable subsequently.

Year	Mean Catch/hour	Number of Stations	No of ICES Stat Rectangles	CV of estimate
1985	376.3	291	75	0.54
1986	2.1	226	55	0.61
1987	5.6	126	58	0.29
1988	72.6	199	40	0.59
1989	40.1	279	85	0.35
1990	89.2	309	85	0.38
1991	266.7	271	89	0.54
1992	78.8	217	73	0.55
1993	265.0	281	85	0.77
1994	53.7	304	77	0.42
1995	303.9	332	103	0.70
1996	90.6	309	95	0.46
1997	64.9	495	175	0.41
1998	142.7	511	172	0.60
1999	279.9	503	171	0.50
2000	30.1	524	172	0.72
2001	90.6	535	180	0.31
2002	746.0	536	181	0.58
2003	50.6	570	180	0.37
2004	607.6	567	178	0.33
2005	402.4	572	178	0.31
2006	553.1	570	162	0.31

Table 2.5.6.2 NEA mackerel Quarter 1 western IBTS survey mean catch for a 1 hour tow, number of stations per year and number of ICES rectangles covered by the survey. The coverage and effort remains relatively stable.

Year	Mean Catch/hour	Number of Stations	No of ICES Stat Rectangles	CV of estimate
1985	143.4	67	36	0.69
1986	1.4	50	40	0.59
1987	23.0	61	45	0.82
1988	40.8	67	43	0.37
1989	1.2	54	43	0.50
1990	266.2	51	37	0.57
1991	31.1	65	43	0.62
1992	144.8	42	35	0.87
1993	407.5	45	37	0.88
1994	1408.2	45	36	0.54
1995	88.0	52	41	0.50
1996	56.0	53	47	0.29
1997	11.0	57	45	0.66
1998	319.1	55	46	0.90
1999	1450.7	65	48	0.89
2000	340.7	66	47	0.87
2001	4.5	57	48	0.72
2002	192.2	66	49	0.44
2003	3165.3	104	58	0.41
2004	738.0	66	54	0.78
2005	9343.4	67	51	0.34
2006	9363.6	77	53	0.34
2007	8353.0	70	45	0.36

Table 2.5.9.1.1. Annual changes in maximum spatial distribution measured in latitude and longitude for NEA mackerel in the Norwegian Sea in late summer. Latitude and longitude values are not coupled in the table, and represent independent values for each year.

Year	Latitude (N)	Longitude (W)
2002	70,00	6,00
2003	70,15	7,00
2004	70,15	8,00
2005	69,30	10,00
2006	70,15	5,00
2007	73,30	11,00

Table 2.5.9.2.1- NEA mackerel. Spanish acoustic surveys from 2001 to 2007. Mackerel Abundance in number of individuals (millions) and Biomass in tons by ICES sub-divisions, only for the Spanish area.

	ICES IXa-N		**ICES VIIIc-W**		**VIIIc-EW**		**VIIIc-EE**		TOTAL	
	Abundance	**Biomass**	**Abundance**	**Biomass**	**Abundance**	**Biomass**	**Abundance**	**Biomass**	**Abundance**	**Biomass**
2001	19	7,384	311	120,096	1,232	489,058	362	119,111	1,926	735,650
2002			822	333,748	3,804	1,191,051	37	9,993	4,668	1,534,793
2003	4,584	376,561	1,070	184,428	876	202,487	540	144,340	7,138	907,815
2004	609	118,570	1,030	304,335	1,502	515,729	30	6,986	3,173	945,619
2005	156	45,566	233	12,983	602	228,628	164	32,314	1,061	409,493
2006	8	673	385	100,475	149	41,463	16	3,962	557	146,572
2007	159	11,216	223	77,378	361	108,412	5	1,794	749	198,801

Table 2.5.9.2.2. NEA mackerel. Spanish acoustic surveys. Biomass (in number and weight), mean length and mean weight at age of mackerel from the acoustics surveys from 2001 to 2006 in ICES Sub-division IXa North and Division VIIIc.

	2001				2002				2003			
	Number	L	W	Biomass	Number	L	W	Biomass	Number	L	W	Biomass
AGE	(millions)	(cm)	(g)	t ('000)	(millions)	(cm)	(g)	t ('000)	(millions)	(cm)	(g)	t ('000)
1	29.03	25.94	126.21	3.66	621.44	23.33	80.54	50.05	5678.55	23.15	81.57	463.18
2	47.63	30.95	213.70	10.18	94.80	32.02	221.87	21.03	324.50	28.89	165.14	53.59
3	184.31	33.68	277.31	51.11	378.11	34.25	277.14	104.79	108.96	33.47	261.33	28.47
4	386.61	36.06	340.29	131.56	706.78	35.80	317.92	224.70	229.00	35.00	299.70	68.63
5	382.12	37.52	383.02	146.36	1065.88	36.85	348.00	370.93	265.16	37.09	359.09	95.22
6	393.57	37.98	397.69	156.52	604.56	38.24	390.93	236.34	230.14	37.95	385.71	88.77
7	202.67	39.50	446.73	90.54	674.54	39.07	419.19	282.76	94.25	39.76	443.38	41.79
8	143.52	40.01	464.48	66.66	191.43	39.88	447.20	85.61	88.53	40.11	454.61	40.25
9	83.71	40.51	481.74	40.33	158.39	40.30	461.39	73.08	19.55	41.47	505.14	9.88
10	17.00	40.16	469.27	7.98	100.16	41.04	490.19	49.10	10.00	41.93	519.88	5.20
11	26.28	42.12	541.39	14.23	53.95	41.41	503.95	27.19	13.98	42.61	549.62	7.69
12	12.26	41.90	533.82	6.54	12.38	43.50	586.72	7.26	3.80	41.50	503.13	1.91
13	1.88	41.50	517.12	0.97	0.00	0.00	0.00	0.00	3.69	43.11	566.94	2.09
14	6.14	43.50	596.47	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15+	9.41	42.76	568.10	5.35	2.90	45.46	676.91	1.96	2.00	43.34	578.06	1.15
TOTAL	1926.15	37.30	381.93	735.65	4665.31	35.49	328.98	1534.79	7072.12	25.53	128.37	907.82

Table 2.5.9.2.2 continued

	2004				2005				2006			
	Number	L	W	Biomass	Number	L	W	Biomass	Number	L	W	Biomass
AGE	(millions)	(cm)	(g)	t ('000)	(millions)	(cm)	(g)	t ('000)	(millions)	(cm)	(g)	t ('000)
1	195.23	25.03	114.60	22.37	43.44	24.79	112.12	4.64	83.70	20.77	58.51	4.90
2	952.36	28.29	164.48	156.64	106.50	29.24	181.77	18.96	9.31	29.69	177.18	1.65
3	599.27	32.80	258.15	154.70	229.10	32.25	245.43	56.14	57.33	31.94	223.13	12.79
4	227.54	37.46	377.85	85.97	259.58	36.50	349.40	92.36	230.74	33.54	262.72	60.62
5	425.56	38.05	395.53	168.32	82.56	38.33	403.43	34.21	104.71	36.68	345.04	36.13
6	336.69	39.13	428.35	144.22	163.83	38.76	417.58	70.42	34.20	38.46	398.15	13.62
7	181.46	40.15	461.71	83.78	114.88	39.45	438.44	51.98	22.18	39.18	420.53	9.33
8	106.11	40.78	483.18	51.27	63.83	39.80	451.67	29.82	7.55	40.94	483.34	3.65
9	76.46	41.03	492.49	37.66	33.55	41.02	493.88	17.23	1.97	41.85	513.64	1.01
10	31.07	42.33	538.03	16.72	15.28	42.29	535.41	8.54	3.44	41.34	495.11	1.70
11	18.90	42.22	533.89	10.09	13.66	41.81	518.75	7.38	1.43	42.68	545.72	0.78
12	13.49	43.27	573.84	7.74	6.59	42.00	526.61	3.62	0.53	42.82	551.13	0.29
13	3.21	43.95	599.81	1.92	11.31	42.47	544.07	6.43	0.13	43.79	590.73	0.08
14	0.00	0.00	0.00	0.00	5.10	43.77	592.63	3.17	0.00	0.00	0.00	0.00
15+	5.92	46.45	710.52	4.21	7.34	43.72	594.87	4.59	0.03	44.50	620.97	0.02
TOTAL	3173.25	33.80	298.00	945.62	1156.55	35.91	346.65	409.49	557.28	32.72	263.01	146.57

Table 2.6.1 NEA Mackerel (Southern component). Effort data by fleets.

	SPAIN					PORTUGAL
	TRAWL		HOOCK (HAND-LINE)		PURSE SEINE	TRAWL
	AVILES (Subdiv.VIIIc East) (Days * 100 CV)	LA CORUÑA (Subdiv.VIIIc West) (Days * 100 CV)	SANTANDER (Subdiv.VIIIc East) (Nº fishing trips)	SANTOÑA (Subdiv.VIIIc East) (Nº fishing trips)	VIGO (Subdiv.IXa North) (Nº fishing trips)	(Subdiv.IXa CN,CS &S) (Fishing hours)
YEAR	ANUAL	ANUAL	MARCH to MAY	MARCH to MAY	ANUAL	ANUAL
1983	12568	51017	-	-	20	-
1984	10815	48655	-	-	700	-
1985	9856	45358	-	-	215	-
1986	10845	39829	-	-	157	-
1987	8309	34658	-	-	92	-
1988	9047	41498	-	-	374	55178
1989	8063	44401	-	605	153	52514
1990	8492	44411	322	509	161	49968
1991	7677	40435	209	724	66	44061
1992	12693	38896	70	698	286	74666
1993	7635	44479	151	1216	-	47822
1994	9620	39602	130	1926	392	38719
1995	6146	41476	217	1696	677	42090
1996	4525	35709	560	2007	777	43633
1997	4699	35191	736	2095	304	42043
1998	5929	35191	754	3022	631	86020
1999	6829	30131	739	2602	546	55311
2000	4453	30073	719	1709	413	67112
2001	2385	29923	700	2479	88	74684
2002	2748	21823	1282	2672	541	-
2003	2526	12328	265	759	544	-
2004	-	19198	626	2151	186	-
2005	-	20663	553	1504	-	-
2006		12866	845	1933	530	

- Not available

Table 2.6.2 NEA mackerel (Southern component). CPUE series in commercial fisheries.

	SPAIN					PORTUGAL
	TRAWL		HOOCK (HAND-LINE)		PURSE SEINE	TRAWL
	AVILES (Subdiv.VIIIc East) (Kg * 100 CV)	LA CORUÑA (Subdiv.VIIIc West) (Kg * 100 CV)	SANTANDER (Subdiv.VIIIc East) (Kg/Nº fishing trips)	SANTOÑA (Subdiv.VIIIc East) (Kg/Nº fishing trips)	VIGO (Subdiv.IXa North) (t/Nº fishing trips)	(Subdiv.IXa CN,CS &S) (Kg/Fishing hours)
YEAR	ANUAL	ANUAL	MARCH to MAY	MARCH to MAY	ANUAL	ANUAL
1983	14.2	22.8	-	-	1.3	-
1984	24.1	26.7	-	-	5.6	-
1985	17.6	25.4	-	-	4.2	-
1986	41.1	22.8	-	-	5.0	-
1987	13.0	24.4	-	-	2.1	-
1988	15.9	32.5	-	-	3.7	36.4
1989	19.0	28.7	-	1427.5	2.1	26.8
1990	82.7	39.5	739.6	1924.4	2.7	39.2
1991	68.2	36.3	632.9	1394.4	2.0	39.9
1992	35.1	13.3	905.6	856.4	3.9	21.2
1993	12.8	12.8	613.3	1790.9	-	16.9
1994	57.2	44.0	2388.5	1590.6	1.1	20.9
1995	94.9	36.1	3136.1	1987.9	0.3	24.5
1996	124.5	32.9	1165.7	1508.9	0.8	23.8
1997	133.2	38.6	2137.9	1867.8	1.7	18.5
1998	142.1	80.1	2361.5	2128.0	3.3	15.4
1999	136.4	43.9	2438.0	2084.7	3.6	23.9
2000	311.6	65.2	1795.5	1879.7	3.8	25.7
2001	222.9	61.1	2323.2	2401.0	3.8	26.4
2002	342.5	58.3	2062.3	1871.2	5.0	-
2003	357.0	51.9	1868.2	1413.5	1.0	-
2004	-	18.7	2046.2	1312.6	1.5	-
2005	-	143.0	3617.7	2424.8	-	-
2006	-	442.4	2907.9	2741.8	2.9	-

- Not available

Table 2.6.3 NEA Mackerel (Southern component). CPUE at age from fleets.

VIIIc East handline fleet (Spain:Santoña) (Catch thousands)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10	Catch age 11	Catch age 12	Catch age 13	Catch age 14	Catch age 15+
1989	605	0	0	3	74	142	299	197	309	441	134	67	27	23	19	7	27
1990	509	0	0	0	17	71	210	465	177	384	378	127	40	51	2	7	5
1991	724	0	0	52	435	785	473	309	323	100	98	150	29	3	7	7	18
1992	698	0	0	35	568	442	477	139	69	77	20	15	17	4	4	0	1
1993	1216	0	0	40	65	1043	621	1487	771	345	339	215	126	59	66	30	52
1994	1926	0	23	168	526	1060	2005	1443	1003	406	360	176	98	54	24	24	9
1995	1696	0	41	83	793	1001	789	1092	998	928	519	339	300	159	83	81	63
1996	2007	0	0	28	401	1234	865	701	1361	802	773	330	288	105	13	28	18
1997	2095	0	7	255	709	3475	2591	894	880	693	471	248	146	98	24	11	11
1998	3022	0	1	100	1580	2017	4456	3461	1496	1015	1006	594	428	443	155	114	296
1999	2602	0	1	230	1435	3151	2900	3697	1956	758	424	317	233	131	75	21	18
2000	1709	0	1	34	619	877	2098	1297	1822	913	282	125	122	62	42	26	9
2001	2479	0	8	208	1230	2978	2859	3030	1654	1477	783	177	196	157	75	74	74
2002	2672	0	4	167	692	1587	2517	1938	2291	1355	990	465	213	64	48	24	11
2003	759	0	1	62	151	481	605	589	318	329	116	64	36	14	5	3	1
2004	2151	0	2	124	1776	858	1503	1265	950	419	287	107	74	39	8	0	6
2005	1504	0	31	255	1886	2375	891	1673	1203	566	363	109	70	80	45	5	10
2006	1933	0	0	109	1722	6933	3416	1400	1124	414	290	227	57	57	10	0	0

VIIIc East handline fleet (Spain:Santander) (Catch thousands)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10	Catch age 11	Catch age 12	Catch age 13	Catch age 14	Catch age 15+
1990	322	0	0	0	6	25	66	132	41	86	83	28	8	11	0	2	2
1991	209	0	0	5	45	96	60	39	43	14	14	23	4	1	1	1	4
1992	70	0	0	4	60	47	51	15	7	8	2	2	2	0	0	0	0
1993	151	0	0	1	2	43	26	63	33	15	15	9	5	3	3	1	2
1994	130	0	2	18	56	110	205	146	101	40	36	18	10	5	2	2	1
1995	217	0	3	33	171	168	144	225	227	222	107	70	56	22	9	11	9
1996	560	0	0	6	89	276	191	152	293	171	164	70	60	22	3	6	4
1997	736	0	0	22	170	963	754	368	472	398	328	170	100	74	18	8	10
1998	754	0	391	86	486	644	1419	1035	403	250	232	127	96	82	19	9	9
1999	739	0	24	211	668	1541	1006	1174	496	183	83	65	44	23	13	4	1
2000	719	0	0	2	110	285	781	534	777	388	133	62	58	35	21	13	3
2001	700	0	133	97	283	857	945	966	438	342	151	35	24	17	8	3	3
2002	1282	0	33	130	518	1254	1912	1194	1063	530	311	130	64	9	11	4	0
2003	265	0	3	51	80	297	332	304	133	122	32	17	9	3	1	0	0
2004	626	0	83	197	1034	586	920	557	335	98	58	12	5	2	0	0	0
2005	553	0	0	7	586	1562	579	1049	680	268	162	31	19	19	15	0	2
2006	845	0	0	28	391	2408	1908	836	616	208	151	109	27	16	0	0	0

VIIIc East trawl fleet (Spain:Aviles) (Catch thousands)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10	Catch age 11	Catch age 12	Catch age 13	Catch age 14	Catch age 15+
1988	9047	0	333	25	78	126	28	34	31	15	6	1	0	1	2	0	1
1989	8063	0	535	201	66	38	53	17	23	29	7	3	2	2	2	0	4
1990	8492	1834	6690	145	123	147	158	181	21	24	17	6	1	2	3	5	24
1991	7677	95	2419	592	205	108	99	57	55	16	14	26	4	3	2	1	13
1992	12693	236	1495	329	122	65	115	56	38	52	16	19	27	13	4	0	2
1993	7635	3	31	48	8	49	20	37	20	11	13	7	6	9	5	3	9
1994	9620	0	83	317	299	180	302	204	144	56	45	21	12	7	3	4	1
1995	6146	0	9	139	261	168	125	177	156	147	74	50	44	20	10	11	9
1996	4525	0	327	126	274	527	149	81	134	70	63	27	21	8	1	2	3
1997	4699	368	786	934	183	391	167	48	49	43	37	22	14	13	3	2	5
1998	5929	0	537	1442	868	237	341	221	74	34	29	15	10	9	1	0	1
1999	6829	2	601	746	685	730	262	284	117	41	15	10	6	2	2	0	0
2000	4453	1	380	594	1889	629	878	268	297	128	41	16	12	10	4	2	0
2001	2385	0	139	475	573	536	166	131	45	24	10	2	1	1	0	0	0
2002	2748	0	76	371	604	457	486	313	299	162	103	43	25	13	6	4	3
2003	2526	0	13	7	39	216	519	548	332	330	83	45	30	10	0	0	0
2004	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2.6.3. (Cont.)

VIIIc West trawl fleet (Spain:La Coruña) (Catch thousands)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10	Catch age 11	Catch age 12	Catch age 13	Catch age 14	Catch age 15+
1988	41498	0	6095	584	625	594	167	239	444	195	53	12	8	21	26	0	7
1989	44401	462	482	719	345	289	541	231	355	444	117	63	24	22	22	6	15
1990	44411	27	4535	939	175	235	370	624	184	409	405	145	45	69	5	9	5
1991	40435	1	39	454	573	839	551	445	504	165	165	266	53	4	10	11	23
1992	38896	1	154	102	298	251	355	128	61	84	25	32	38	14	6	0	2
1993	44479	0	307	440	118	528	188	265	98	41	33	21	11	3	4	2	3
1994	39602	0	237	1531	1085	821	1156	575	264	63	40	17	6	1	1	1	0
1995	41476	735	249	400	624	324	251	381	376	402	175	116	104	44	17	19	20
1996	35709	54	5865	104	562	695	148	77	127	65	59	27	20	8	1	2	2
1997	35191	13	626	1347	531	1234	493	136	140	114	88	49	32	25	6	3	6
1998	35191	3	6745	2965	2547	641	678	451	144	80	72	49	36	38	13	8	18
1999	30131	4461	444	292	409	512	314	399	220	112	85	74	59	34	20	6	17
2000	30073	40	9283	902	1932	642	781	170	158	79	24	12	11	9	5	4	3
2001	29923	0	184	886	1615	1799	814	648	201	128	48	11	7	9	4	4	7
2002	21823	12	52	993	1900	1263	762	120	69	25	17	7	4	0	1	0	0
2003	12328	0	51	410	149	368	310	277	130	144	63	36	19	8	5	3	14
2004	19198	0	112	452	363	75	124	94	61	25	21	6	7	2	1	0	1
2005	20663	113	33	159	389	176	39	46	29	13	7	3	2	1	1	0	1
2006	12866	81	130	123	339	748	140	39	31	13	7	3	2	1	0	0	0

IXa trawl fleet (Portugal) (Catch thousands)

Year	Effort (	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10	Catch age 11	Catch age 12	Catch age 13	Catch age 14	Catch age 15+
1988	55178	8076	4510	536	457	76	14	3	0	1	5	0	0	0	0	0	0
1989	52514	6092	6468	1080	572	185	51	15	4	7	4	3	0	0	0	0	0
1990	49968	2840	5729	1967	137	36	11	4	4	0	0	0	0	0	0	0	0
1991	44061	1695	2397	1904	1090	138	85	65	24	3	5	0	0	0	0	0	0
1992	74666	498	2211	1015	664	263	100	45	22	17	10	70	0	0	0	0	0
1993	47822	1010	2365	442	172	155	32	8	5	1	0	1	0	0	0	0	0
1994	38719	650	1128	1447	342	125	94	65	21	4	1	2	0	1	0	0	0
1995	42090	1001	2690	983	295	99	59	46	40	25	17	16	8	5	0	0	1
1996	43633	423	1293	778	490	269	86	88	129	98	109	66	34	17	6	0	1
1997	42043	318	885	1763	181	98	125	95	59	47	20	20	6	10	0	0	0
1998	86020	1873	3950	1265	171	47	39	40	56	23	14	19	51	32	13	0	5
1999	55311	2311	3615	1384	316	94	55	32	13	2	2	1	1	1	0	0	0
2000	67112	2730	6318	1328	424	226	135	71	40	20	9	13	4	11			
2001***	74684	3030	5539	1665	382	195	149	65	42	24	3	2	0	0			

*** preliminary

Table 2.8.7.1. NE Atlantic mackerel. TISVPA results

Year	R(0)	B	SSB (Jan.1)	SSB (sp.time)	F(4-8)
1972	2315	5606	4510	4133	0,018
1973	4878	5546	4737	4281	0,056
1974	4115	5474	4645	4166	0,091
1975	5075	5312	4505	4020	0,150
1976	4987	5126	4237	3634	0,213
1977	1012	4738	3877	3430	0,167
1978	3141	4359	3878	3353	0,173
1979	5188	3881	3416	2862	0,234
1980	5384	3497	2817	2423	0,227
1981	6874	3617	2858	2460	0,218
1982	1964	3510	2732	2367	0,202
1983	1458	3539	2949	2574	0,194
1984	7203	3198	2847	2441	0,209
1985	3249	3379	2749	2393	0,220
1986	3289	3336	2708	2379	0,237
1987	5127	3213	2737	2424	0,222
1988	3532	3296	2762	2394	0,239
1989	4399	3331	2761	2398	0,182
1990	3121	3102	2594	2249	0,190
1991	3573	3372	2894	2509	0,236
1992	4377	3477	2944	2493	0,254
1993	5115	3360	2788	2333	0,339
1994	4158	3187	2549	2133	0,382
1995	3769	3322	2697	2289	0,363
1996	3755	3104	2594	2235	0,246
1997	2942	3152	2616	2253	0,249
1998	2744	2938	2502	2109	0,298
1999	3216	2909	2474	2095	0,300
2000	2016	2666	2255	1876	0,328
2001	4221	2588	2242	1856	0,409
2002	7606	2332	1893	1528	0,498
2003	2577	2567	1845	1543	0,500
2004	3967	2460	1948	1688	0,401
2005	3573	2852	2341	2054	0,302
2006	10629	2901	2403	2108	0,238
2007			2529	2213	

Table 2.8.7.2. NE Atlantic mackerel. TISVPA. Residuals in LnC(a,y) and LnSSB(y)

1990	0,294	0,386	0,336	0,172	0,018	-0,089	-0,136	-0,078	-0,010	-0,313	-0,581	0,000	0,000	**0,000**	0
1991	-0,699	0,051	0,084	-0,008	0,062	0,062	-0,001	-0,100	0,383	0,141	0,024	0,000	0,000	**0,000**	0
1992	0,329	-0,021	0,041	0,000	-0,073	-0,228	-0,088	-0,141	-0,341	0,414	0,108	0,000	0,000	**0,000**	0,0909
1993	-0,709	0,186	0,081	0,144	0,005	-0,069	-0,118	0,096	0,008	-0,148	0,523	0,000	0,000	**0,000**	0
1994	-0,243	0,047	-0,023	0,100	0,095	-0,070	0,008	-0,034	0,209	0,208	-0,297	0,000	0,000	**0,000**	0
1995	-0,642	-0,307	0,188	0,097	0,004	-0,038	-0,045	0,156	0,044	0,324	0,219	0,000	0,000	**0,000**	0,1768
1996	0,433	0,237	-0,201	-0,047	-0,023	-0,135	-0,244	-0,049	-0,157	0,071	0,114	0,000	0,000	**0,000**	0
1997	0,623	0,364	-0,064	-0,222	0,018	-0,018	-0,111	-0,133	-0,203	-0,133	-0,121	0,000	0,000	**0,000**	0
1998	1,081	0,064	-0,049	-0,210	-0,129	-0,011	-0,034	-0,111	-0,064	-0,285	-0,254	0,000	0,000	**0,000**	-0,1833
1999	1,085	-0,052	-0,318	-0,375	-0,221	-0,056	-0,010	0,032	0,033	-0,008	-0,109	0,000	0,000	**0,000**	0
2000	0,862	0,078	-0,267	-0,078	-0,015	-0,079	0,003	-0,139	-0,085	-0,184	-0,096	0,000	0,000	**0,000**	0
2001	-0,201	0,124	-0,244	-0,112	0,004	0,031	0,113	0,185	-0,027	-0,043	0,171	0,000	0,000	**0,000**	-0,0541
2002	0,052	0,191	-0,269	0,064	0,122	-0,025	0,058	-0,033	0,081	-0,102	-0,140	0,000	0,000	**0,000**	0
2003	-0,325	-0,239	-0,244	-0,307	-0,038	0,121	0,244	0,116	0,196	0,333	0,145	0,000	0,000	**0,000**	0
2004	-1,579	-0,488	0,059	0,297	0,284	0,242	0,297	0,196	0,159	0,084	0,451	0,000	0,000	**0,000**	-0,0956
2005	-1,334	-0,562	0,611	0,357	-0,031	0,402	0,136	0,129	0,145	-0,055	0,202	0,000	0,000	**0,000**	0
2006	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	**0,000**	0
YearSUM	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	0,000	0,081

Table ISVPA 2 Above- old

Table 2.8.7.3. NE Atlantic mackerel. TISVPA. Estimates of fishing mortality coefficients

F(a,y)	0	1	2	3	4	5	6	7	8	9	10	11	12
1972	0,005	0,007	0,025	0,049	0,090	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1973	0,004	0,025	0,017	0,064	0,133	0,145	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1974	0,008	0,028	0,031	0,042	0,111	0,182	0,161	0,000	0,000	0,000	0,000	0,000	0,000
1975	0,008	0,019	0,029	0,068	0,088	0,162	0,145	0,352	0,000	0,000	0,000	0,000	0,000
1976	0,014	0,073	0,095	0,151	0,188	0,135	0,177	0,321	0,244	0,000	0,000	0,000	0,000
1977	0,007	0,046	0,107	0,111	0,128	0,096	0,104	0,198	0,310	0,187	0,000	0,000	0,000
1978	0,012	0,044	0,190	0,194	0,184	0,213	0,148	0,125	0,195	0,255	0,294	0,000	0,000
1979	0,024	0,157	0,100	0,290	0,237	0,235	0,278	0,250	0,167	0,296	0,330	0,443	0,000
1980	0,007	0,107	0,233	0,133	0,226	0,241	0,197	0,251	0,221	0,181	0,251	0,335	0,335
1981	0,009	0,067	0,171	0,189	0,087	0,181	0,247	0,232	0,342	0,243	0,294	0,315	0,315
1982	0,006	0,040	0,134	0,226	0,218	0,092	0,196	0,237	0,266	0,386	0,236	0,265	0,265
1983	0,005	0,031	0,162	0,180	0,262	0,220	0,090	0,178	0,223	0,205	0,325	0,246	0,246
1984	0,044	0,028	0,069	0,225	0,224	0,265	0,255	0,130	0,171	0,215	0,225	0,302	0,302
1985	0,028	0,049	0,022	0,058	0,207	0,212	0,276	0,249	0,158	0,193	0,259	0,242	0,242
1986	0,017	0,023	0,097	0,049	0,096	0,244	0,255	0,329	0,261	0,146	0,189	0,237	0,237
1987	0,002	0,016	0,076	0,202	0,092	0,148	0,236	0,271	0,363	0,338	0,308	0,218	0,218
1988	0,018	0,038	0,065	0,118	0,225	0,155	0,197	0,285	0,335	0,381	0,311	0,297	0,297
1989	0,016	0,023	0,098	0,127	0,138	0,216	0,137	0,179	0,240	0,290	0,378	0,365	0,365
1990	0,008	0,041	0,094	0,169	0,171	0,176	0,220	0,163	0,219	0,302	0,229	0,378	0,378
1991	0,003	0,024	0,076	0,118	0,213	0,218	0,206	0,258	0,285	0,287	0,460	0,366	0,366
1992	0,011	0,030	0,078	0,167	0,208	0,253	0,264	0,268	0,279	0,452	0,382	0,492	0,492
1993	0,004	0,038	0,093	0,175	0,270	0,286	0,345	0,419	0,378	0,439	0,603	0,541	0,541
1994	0,007	0,037	0,080	0,180	0,249	0,318	0,350	0,456	0,539	0,572	0,388	0,550	0,550
1995	0,004	0,025	0,107	0,161	0,227	0,256	0,343	0,468	0,522	0,694	0,574	0,519	0,519
1996	0,011	0,041	0,063	0,135	0,181	0,212	0,194	0,344	0,299	0,531	0,464	0,441	0,441
1997	0,013	0,050	0,078	0,114	0,213	0,228	0,238	0,255	0,312	0,352	0,436	0,442	0,442
1998	0,024	0,044	0,098	0,144	0,215	0,306	0,289	0,328	0,353	0,383	0,378	0,529	0,529
1999	0,023	0,035	0,071	0,120	0,193	0,272	0,310	0,335	0,389	0,398	0,457	0,483	0,483
2000	0,020	0,041	0,078	0,186	0,286	0,313	0,352	0,342	0,349	0,377	0,411	0,534	0,534
2001	0,007	0,026	0,076	0,170	0,300	0,380	0,430	0,515	0,422	0,416	0,617	0,528	0,528
2002	0,010	0,066	0,052	0,234	0,396	0,445	0,530	0,514	0,604	0,539	0,468	0,649	0,649
2003	0,006	0,029	0,095	0,079	0,267	0,430	0,590	0,570	0,642	0,843	0,659	0,539	0,539
2004	0,001	0,012	0,084	0,258	0,172	0,369	0,458	0,501	0,503	0,486	0,778	0,413	0,413
2005	0,002	0,014	0,079	0,182	0,222	0,207	0,298	0,362	0,421	0,365	0,486	0,342	0,342
2006	0,006	0,025	0,064	0,117	0,171	0,214	0,235	0,273	0,297	0,339	0,354	0,354	0,354

Table 2.8.7.4. NE Atlantic mackerel. TISVPA. Estimates of abundance-at-age

N(a,y)	0	1	2	3	4	5	6	7	8	9	10	11	12
1972	2314659	5705910	2255948	4392957	8189056	0	0	0	0	0	0	0	0
1973	4877769	1983638	4873359	1891654	3589878	6492511	0	0	0	0	0	0	0
1974	4115160	4179178	1671035	4106653	1528178	2746860	4893315	0	0	0	0	0	0
1975	5074611	3516508	3498294	1385232	3376058	1183644	2013035	3599481	0	0	0	0	0
1976	4987073	4335264	2958030	2880771	1110597	2687606	887001	1492177	2382048	0	0	0	0
1977	1011610	4237225	3499798	2320044	2119408	801816	2027891	628697	928835	1500135	0	0	0
1978	3141313	863992	3498654	2743620	1794443	1587356	616634	1582354	450093	613168	1030294	0	0
1979	5188064	2671757	715244	2612433	1967004	1289089	1100533	451742	1189760	311266	392857	615741	0
1980	5384138	4377214	2034615	559380	1749651	1278944	860588	706442	297800	850677	194184	213096	397785
1981	6874191	4589678	3436939	1453412	425711	1204053	854886	604938	466639	205749	618035	126370	797289
1982	1964464	5855120	3711829	2519171	1015882	326833	842798	575185	413574	298449	141389	424109	721715
1983	1457870	1676933	4815869	2843843	1747740	691683	251701	597382	388898	283469	191233	97730	653548
1984	7203114	1245361	1400433	3653310	2080568	1165732	470095	194928	423056	266775	200787	124596	286329
1985	3248899	6031476	1040995	1124683	2570788	1424044	739351	304731	144281	292067	177659	135131	489367
1986	3289477	2745265	4964611	864141	898643	1815008	995604	485329	199927	107116	204855	117450	414933
1987	5126618	2794980	2296931	3914814	698177	696406	1252304	684814	304272	130680	79958	141781	347725
1988	3532136	4389975	2347478	1845408	2885261	548648	526660	874757	463848	190398	83475	55326	241379
1989	4398625	2996243	3609706	1870626	1403117	2011728	409839	381832	562236	291819	110318	49024	126276
1990	3120611	3744184	2517321	2853453	1429579	1045016	1387774	305750	271861	353378	174345	56745	95464
1991	3572858	2666311	3113455	2000698	2107127	1039179	746637	939480	221954	187628	207176	104638	186408
1992	4376604	3061195	2242057	2490807	1529699	1476866	725251	522790	613946	151882	124179	113562	189118
1993	5115313	3732337	2556426	1787808	1813393	1058909	944762	471823	335068	368521	92364	74935	175865
1994	4157952	4375535	3103825	2013097	1309209	1192418	675431	558463	274553	198125	193281	51974	146576
1995	3768564	3551994	3632556	2463511	1462580	891275	734805	410564	300803	149044	104743	101108	105884
1996	3754563	3223756	2967788	2838565	1820341	1004227	589991	443966	232651	156487	74943	55467	92626
1997	2942198	3202578	2675453	2379592	2125963	1304479	686169	404558	267677	143286	81553	42115	75397
1998	2744103	2506737	2643330	2123820	1797509	1481831	891492	456908	263541	160374	83591	43397	60128
1999	3215711	2323972	2068332	2056350	1551341	1224114	937403	570925	275827	156680	84933	45229	87079
2000	2016055	2726286	1930181	1633882	1520199	1068240	794572	590525	353892	162382	90391	44357	79891
2001	4220689	1711298	2255279	1516133	1157229	979949	660829	481521	348014	210209	90421	49936	100012
2002	7605982	3605934	1437900	1777895	1087718	738748	581308	382487	264581	194740	117708	45494	84655
2003	2576787	6482906	2924400	1165422	1221378	650694	403902	301765	194038	129589	92952	59841	74410
2004	3967085	2202071	5395588	2255372	912557	799782	377521	213061	154535	96663	59288	44665	52861
2005	3572803	3400652	1866064	4281684	1562166	677572	502007	223255	118808	85061	52739	29489	39896
2006	10629215	3063965	2872399	1512280	3169506	1072428	493520	328692	137885	69886	50065	29822	35015
2007		9094569	2572929	2319830	1157509	2298961	745039	335834	215248	88218	42867	30237	18012

Table 2.8.8.1 NE Atlantic mackerel WINBUGS ICA exploratory assessment ICA based VPA model code

```
# ICA Mackerel assessment 2007
# with added factors
#  analysis for missing catch not implemented
# flexible selection not implemented
# tage data not implemented
##
model
{
for (i in 1:I3) {
FAV[i] ~ dunif(.001,2)  # i1 number of years of catch
}
#FA[1]<-FA1     # set  age 11 estimated or to data value
for (i in 1:6){       # amend loop to 2:6 if age 11 not estimated
FA[i] ~ dunif(0.95,2)
}
FA[7]<-FA7
for (i in 8:12){
FA[i] ~ dunif(0.001,1)
}
FAP<-FA[1]
# selection function priors - alternative logistic function replaces settings above
#S1C~dunif(0.1,6)              # catch ojive 50% age
#S2C~dunif(0.2,6)              # catch ojive 95% age - S1C
# Define the priors for survey Q  values coefficients of prportionality
QMES~dunif(.01,20)     # fit 1.36,
#QMstar~dgamma(1.5,0.5)  #  natural mortality multiplier estimated
QMstar<-1  # natural mortality set to data
QM<-QMstar
QC<-1  # no missing catch
#QC~dunif(0.1,30) # missing catch
for (i in 1:(I3-1))  {
Nstar[i] ~ dnorm(8000,.000000000000064)     # initial N prior 95% at 10 and ~ 20* highest fitted 95%
}
# starting pop in sep period - last year in final year
for (i in 1:I2){
Nin[i]<-4500*pow(10,i/5)
Nvar[i]<-.00001/pow(Nin[i]/4,2)
Nstar2[i] ~ dnorm(Nin[i],Nvar[i])
}
# Define the observation priors select for different conditions
tauy ~ dgamma(0.001,0.001)     # catch tau
sigy <- pow(1/tauy,.5)    # catch sigma
#mv~dnorm(3,1) # minimum at age 3 sd 1
#cv~dunif(0,0.07)
#y0~dunif(0.001,.3)
#bv<--2*mv*cv
#av<-y0+cv*pow(mv,2)
#taum <-5*tauy
#sigm <- pow(1/taum,.5)
#tauc ~ dgamma(0.001,0.001)
#sigc <- pow(1/tauc,.5)
#taus ~ dgamma(0.001,0.001)
#taus<-1000
#sigs <- pow(1/taus,.5)
```

```
tauy1<-tauy/10    # downweight catch fit age 1
tauy0<-tauy/100 # down weight catcg fot age 0

################# main algorithm
## flexible logistic selection curve parameters 2 per year starting in final year
#S1CV[1]<-S1C
#S2CV[1]<-S2C
#for (i in 2:I3) {
#ch1[i]~dnorm(0,taus)
#ch2[i]~dnorm(0,taus)
#ch2s[i]<-max(0.05,ch2[i])
#S1CV[i]<-S1CV[i-1]+ch1[i]
#S2CV[i]<-S2CV[i-1]+ch2s[i]
#}
# FA - the selection pattern relative F at age
#for (i in 1:I3 ){
#for (j in 1:I2) {
#FA[j,i]<-1/(1+exp(-2.944439*(age[j]-S1CV[i])/(S2CV[i])))          # selection pattern for catch
#}
#FAP[i]<-1/(1+exp(-2.944439*(agep-S1CV[i])/(S2CV[i])))
#}
######### population component of the likelihood
# Define the system process for the population data
# stop any negative population numbers - minimum 10
# set up pop numbers in oldest age first and final year second
for (i in 2:I3) {
N[1,i]<-max(Nstar[i-1],10)
}
for (i in 1:I2) {
N[i,1]<-max(Nstar2[i],10)
}
# constant selection pattern over sel period
for (i in 2:I3){
for (j in 1:I2){
F[j,i]<-FA[j]*FAV[i]                          # fishing mortality
INTF[j,i]<-F[j,i]/FA[j]
}
FP[i]<-FAP*FAV[i]                             # fishing mortality
}
# For first year - if catch is available use true values
# if not then use year before I4 = 1 or 2
for (j in 1:I2){
F[j,1]<-FA[j]*FAV[I4]                         # fishing mortality
INTF[j,1]<-F[j,1]/FA[j]
}
FP[1]<-FAP*FAV[I4]                            # fishing mortality
#Calculate N for ages 2 and greater and years after first year
for (i in 2:I3){
for (j in 2:I2){
N[j,i]<-N[j-1,i-1]*exp(F[j,i]+QM*M[j,i])
}
}
##############################
# set plusgroup using catch - except for last year if no catch
# if no catch assume status quo catch in plus group in final year
NP[1]<-QC*CANUMP[I4]*(FP[I4]+QM*MP[1])/FP[I4]/(1-exp(-FP[I4]-QM*MP[1]))
```

```
for (i in 2:I3){
NP[i]<-QC*CANUMP[i+1-I4]*(FP[i]+QM*MP[i])/FP[i]/(1-exp(-FP[i]-QM*MP[i]))
}
#Then VPA part  start with Ns age 0 to max age minus 2
#Then get Fs from Ns
# Mean F to set F on oldest real age and plus group
for (i in (I3+1):I1){
for (j in 2:(I2)){
N[j,i]<-N[j-1,i-1]*exp(QM*M[j,i])+QC*CANUM[j,i+1-I4]*exp(QM*M[j,i]/2)
F[j,i]<-log(N[j,i]/N[j-1,i-1])-QM*M[j,i]
#INTF[j,i]<-F[j,i]/FA[j,I3]
INTF[j,i]<-F[j,i]/FA[j]
}
# calculate mean F and use selection to get F oldest real age and plus group
FAV[i]<-mean(INTF[2:(I2-1),i])
# set Fs
F[1,i]<-FAV[i]*FA[1]
FP[i]<-FAV[i]*FAP
#F[1,i]<-FAV[i]*FA[1,I3]
#FP[i]<-FAV[i]*FAP[I3]
# then set Ns fopr oldest ages
N[1,i]<-QC*CANUM[1,i+1-I4]*(F[1,i]+QM*M[1,i])/F[1,i]/(1-exp(-F[1,i]-QM*M[1,i]))
NP[i]<-QC*CANUMP[i+1-I4]*(FP[i]+QM*MP[i])/FP[i]/(1-exp(-FP[i]-QM*MP[i]))
# now cycle back in years
}
## Observation process -------- create an vector with all models to match obs
#1 MES - SSB index ### coincident start of sep period and survey
for (i in 1:I1){
for (j in 1:I2){
SSBa[j,i]<-N[j,i]*exp((-F[j,i]*FPROP-QM*M[j,i]*MPROP))*WEST[j,i]*MATPROP[j,i] ## at spawning
time
}
SSB[i]<-sum(SSBa[,i])+NP[i]*exp((-FP[i]*FPROP-QM*MP[i]*MPROP))*WESTP[i]*MATPROPP[i] ##
at spawning time
Fbar[i]<-(F[4,i]+F[5,i]+F[6,i]+F[7,i]+F[8,i])/5 #### hard wired here should be flexible
}
##### no weighting
for (i in 1:MEST) {
ObsMESMod[i]<-log(SSB[i*3-I5]*QMES)
ObsMES[i] ~ dnorm(ObsMESMod[i],tauM[i])
#ObsMES[i] ~ dnorm(ObsMESMod[i],taum)
}
#for (j in 1:(I2-1)){
#sigy[j]<-av+bv*age[j]+cv*pow(age[j],2)
#tauy[j]<-1/pow(sigy[j],2)
#}
# 2 Catch  ##### assuming 25 survey values !!!!
# dont bother with 0 group j goes to I2-1
# start
for (i in I4:I3){
for (j in 1:(I2-2)){
ObsCatchMod[j,i+1-I4]<-log((N[j,i]*F[j,i]/(F[j,i]+QM*M[j,i])*(1-exp(-F[j,i]-QM*M[j,i])))/QC)
ObsCatch[j,i+1-I4] ~ dnorm(ObsCatchMod[j,i+1-I4],tauy)     # using tauy[j] as age dependent variance
}
# 1 group
```

```
ObsCatchMod[I2-1,i+1-I4]<-log((N[I2-1,i]*F[I2-1,i]/(F[I2-1,i]+QM*M[I2-1,i])*(1-exp(-F[I2-1,i]-
QM*M[I2-1,i])))/QC)
ObsCatch[I2-1,i+1-I4] ~ dnorm(ObsCatchMod[I2-1,i+1-I4],tauy1)     # using tauy[j] as age dependent
variance
# 0 group
ObsCatchMod[I2,i+1-I4]<-log((N[I2,i]*F[I2,i]/(F[I2,i]+QM*M[I2,i])*(1-exp(-F[I2,i]-QM*M[I2,i])))/QC)
ObsCatch[I2,i+1-I4] ~ dnorm(ObsCatchMod[I2,i+1-I4],tauy0)     # using tauy[j] as age dependent variance
}
# include below for tag data
# 3 total mortality estimates
#for (i in 1:MortCnt) {
#for (j in 1:Ma) {
#ModMort[j,i]<-F[Maind[j],Mortind[i]]+QM*M[Maind[j],Mortind[i]]
#ObsMort[j,i] ~ dnorm(ModMort[j,i],taum)
#}
#}
#mz<-mean(ModMort[,])
# End of model
}
```

Table 2.8.8.2 NE Atlantic mackerel WINBUGS ICA exploratory assessment (2007 data) Estimated SSB

year	Mean	sd	MC error	2.50%	median	97.50%	start	sample
1972	3968000	38000	1227	3898000	4047000	3967000	4001	18000
1973	4.03E+06	42830	1438	3.95E+06	4.12E+06	4.03E+06	4001	18000
1974	3.86E+06	47050	1630	3.78E+06	3.96E+06	3.86E+06	4001	18000
1975	3.59E+06	49550	1750	3.50E+06	3.69E+06	3.58E+06	4001	18000
1976	3.26E+06	50310	1799	3.17E+06	3.37E+06	3.26E+06	4001	18000
1977	3.08E+06	51260	1855	2.99E+06	3.19E+06	3.08E+06	4001	18000
1978	3.04E+06	51660	1904	2.94E+06	3.15E+06	3.04E+06	4001	18000
1979	2.59E+06	51120	1903	2.49E+06	2.69E+06	2.58E+06	4001	18000
1980	2.15E+06	44800	1717	2.07E+06	2.25E+06	2.15E+06	4001	18000
1981	2.18E+06	49560	1913	2.09E+06	2.29E+06	2.18E+06	4001	18000
1982	2.10E+06	46120	1826	2.02E+06	2.20E+06	2.10E+06	4001	18000
1983	2.40E+06	42980	1667	2.32E+06	2.49E+06	2.40E+06	4001	18000
1984	2.43E+06	44370	1606	2.35E+06	2.52E+06	2.43E+06	4001	18000
1985	2.38E+06	52950	1885	2.29E+06	2.49E+06	2.38E+06	4001	18000
1986	2.40E+06	51080	1780	2.30E+06	2.50E+06	2.40E+06	4001	18000
1987	2.38E+06	5.17E+04	1712	2.29E+06	2.49E+06	2.38E+06	4001	18000
1988	2.40E+06	56200	1774	2.29E+06	2.51E+06	2.39E+06	4001	18000
1989	2.47E+06	59270	1718	2.36E+06	2.59E+06	2.47E+06	4001	18000
1990	2.33E+06	59640	1589	2.22E+06	2.45E+06	2.33E+06	4001	18000
1991	2.59E+06	72920	1854	2.45E+06	2.73E+06	2.58E+06	4001	18000
1992	2.60E+06	73200	1842	2.46E+06	2.75E+06	2.60E+06	4001	18000
1993	2.44E+06	66860	1793	2.31E+06	2.58E+06	2.44E+06	4001	18000
1994	2.25E+06	60740	1784	2.14E+06	2.37E+06	2.25E+06	4001	18000
1995	2.38E+06	64330	1925	2.26E+06	2.52E+06	2.38E+06	4001	18000
1996	2.33E+06	65880	1922	2.21E+06	2.47E+06	2.33E+06	4001	18000
1997	2.38E+06	68310	1952	2.25E+06	2.52E+06	2.38E+06	4001	18000
1998	2.28E+06	67750	2076	2.15E+06	2.42E+06	2.28E+06	4001	18000
1999	2.32E+06	72770	2492	2.18E+06	2.47E+06	2.32E+06	4001	18000
2000	2.12E+06	72920	3022	1.98E+06	2.26E+06	2.11E+06	4001	18000
2001	2.09E+06	86640	4286	1.93E+06	2.27E+06	2.09E+06	4001	18000
2002	1.71E+06	95440	5335	1.53E+06	1.91E+06	1.71E+06	4001	18000
2003	1.69E+06	138500	8268	1.42E+06	1.97E+06	1.69E+06	4001	18000
2004	1.82E+06	210900	12590	1.42E+06	2.26E+06	1.82E+06	4001	18000
2005	2.24E+06	329900	1.95E+04	1.62E+06	2.91E+06	2.24E+06	4001	18000
2006	2.25E+06	400000	23830	1.50E+06	3.07E+06	2.25E+06	4001	18000
2007	2.32E+06	488500	29050	1.41E+06	3.32E+06	2.32E+06	4001	18000

Table 2.8.8.3 NE Atlantic mackerel WINBUGS ICA exploratory assessment (2007 data) Estimated Fbar ages 4-8

year	mean	sd	MC error	2.50%	median	97.50%	start	Sample
1972	0.08489	0.002332	0.0000841	0.0802	0.08939	0.08491	4001	18000
1973	0.119	0.002511	0.00008789	0.114	0.1238	0.1191	4001	18000
1974	0.142	0.002499	0.00008861	0.1369	0.1467	0.142	4001	18000
1975	0.1927	0.003326	0.000116	0.1859	0.199	0.1928	4001	18000
1976	0.2493	0.004163	0.000146	0.2408	0.2572	0.2494	4001	18000
1977	0.193	0.003238	0.0001187	0.1863	0.1991	0.1931	4001	18000
1978	0.1908	0.003076	1.18E-04	0.1845	0.1967	0.1909	4001	18000
1979	0.254	0.00395	1.55E-04	0.2459	0.2615	0.2541	4001	18000
1980	0.246	0.003937	1.56E-04	0.2379	0.2535	0.2461	4001	18000
1981	0.2285	0.004242	1.67E-04	0.2197	0.2365	0.2286	4001	18000
1982	0.2217	0.004374	1.70E-04	0.2128	0.2301	0.2218	4001	18000
1983	0.2124	0.003565	1.43E-04	0.2051	0.2192	0.2125	4001	18000
1984	0.2219	0.003502	1.40E-04	0.2147	0.2285	0.222	4001	18000
1985	0.2168	0.003636	1.33E-04	0.2095	0.2237	0.2169	4001	18000
1986	0.2295	0.004308	1.51E-04	0.2208	0.2377	0.2296	4001	18000
1987	0.2157	0.004898	1.63E-04	0.2059	0.2251	0.2158	4001	18000
1988	0.2385	0.006779	2.05E-04	0.2251	0.2515	0.2386	4001	18000
1989	0.1791	0.006312	1.67E-04	0.1667	0.1914	0.179	4001	18000
1990	0.1815	0.006282	1.65E-04	0.1694	0.1939	0.1814	4001	18000
1991	0.2256	0.008357	1.89E-04	0.2095	0.2427	0.2255	4001	18000
1992	0.2736	0.01682	2.69E-04	0.242	0.3077	0.2732	4001	18000
1993	0.3369	0.0201	3.64E-04	0.2987	0.3779	0.3365	4001	18000
1994	0.3461	0.02009	3.73E-04	0.3078	0.3865	0.3458	4001	18000
1995	0.3557	0.02027	3.97E-04	0.3167	0.3971	0.3552	4001	18000
1996	0.2628	0.01585	3.19E-04	0.2329	0.2953	0.2624	4001	18000
1997	0.2512	0.01514	3.03E-04	0.2224	0.2823	0.2508	4001	18000
1998	0.2865	0.01707	3.54E-04	0.2534	0.3209	0.2861	4001	18000
1999	0.2877	0.01713	3.66E-04	0.2548	0.3218	0.2874	4001	18000
2000	0.334	0.02016	5.16E-04	0.2967	0.3749	0.3334	4001	18000
2001	0.3774	0.0238	7.67E-04	0.3325	0.425	0.3767	4001	18000
2002	0.4311	0.03058	1.31E-03	0.3733	0.4938	0.4302	4001	18000
2003	0.4259	0.03959	2.07E-03	0.353	0.5089	0.4232	4001	18000
2004	0.3704	0.04745	2.74E-03	0.2885	0.4773	0.3651	4001	18000
2005	0.2727	0.04618	2.78E-03	0.1985	0.3833	0.2656	4001	18000
2006	0.2357	0.04964	3.03E-03	0.1609	0.3577	0.2264	4001	18000
2007	0.2357	0.04964	3.03E-03	0.1609	0.3577	0.2264	4001	18000

Table 2.8.8.4 NE Atlantic mackerel WINBUGS ICA exploratory assessment (2007 data) Estimated Recruitment age 0. (Estimates for 0 in 2006 are not fully estimated in the model. Age 0 for 2007 are not estimated and the entry shows the uninformative prior used for all age 0

year	Mean	sd	MC error	2.50%	Median	97.50%	Start	sample
1972	2.12E+06	1.79E+04	708.7	2.08E+06	2.15E+06	2.12E+06	4001	18000
1973	4.78E+06	2.99E+04	1202	4.72E+06	4.84E+06	4.77E+06	4001	18000
1974	4.01E+06	3.39E+04	1223	3.94E+06	4.08E+06	4.00E+06	4001	18000
1975	4.93E+06	26370	1053	4.88E+06	4.98E+06	4.93E+06	4001	18000
1976	4.95E+06	2.71E+04	1104	4.90E+06	5.01E+06	4.95E+06	4001	18000
1977	9.69E+05	13450	523.8	9.44E+05	9.97E+05	9.68E+05	4001	18000
1978	3.24E+06	14720	575.9	3.22E+06	3.27E+06	3.24E+06	4001	18000
1979	5.33E+06	17600	671.2	5.29E+06	5.36E+06	5.32E+06	4001	18000
1980	5.58E+06	30600	1205	5.52E+06	5.64E+06	5.57E+06	4001	18000
1981	7.31E+06	151300	2954	7.04E+06	7.65E+06	7.29E+06	4001	18000
1982	2.04E+06	86460	1929	1.90E+06	2.23E+06	2.04E+06	4001	18000
1983	1.59E+06	78220	1600	1.45E+06	1.76E+06	1.58E+06	4001	18000
1984	7.38E+06	170900	3340	7.07E+06	7.75E+06	7.37E+06	4001	18000
1985	3.36E+06	135500	2393	3.12E+06	3.65E+06	3.36E+06	4001	18000
1986	3.47E+06	150000	2479	3.19E+06	3.79E+06	3.47E+06	4001	18000
1987	5.09E+06	214900	3543	4.69E+06	5.54E+06	5.08E+06	4001	18000
1988	3.57E+06	185100	3189	3.23E+06	3.96E+06	3.57E+06	4001	18000
1989	4.29E+06	229500	3602	3.86E+06	4.77E+06	4.28E+06	4001	18000
1990	3.25E+06	184700	2868	2.91E+06	3.63E+06	3.25E+06	4001	18000
1991	3.71E+06	213100	3515	3.30E+06	4.14E+06	3.70E+06	4001	18000
1992	4.52E+06	260000	4197	4.02E+06	5.05E+06	4.51E+06	4001	18000
1993	5.15E+06	294400	4829	4.60E+06	5.75E+06	5.14E+06	4001	18000
1994	4.36E+06	252700	4130	3.89E+06	4.88E+06	4.36E+06	4001	18000
1995	3.91E+06	226400	4304	3.48E+06	4.37E+06	3.90E+06	4001	18000
1996	3.87E+06	246900	5214	3.41E+06	4.38E+06	3.86E+06	4001	18000
1997	3.14E+06	211100	5155	2.75E+06	3.57E+06	3.13E+06	4001	18000
1998	3.01E+06	227900	7339	2.60E+06	3.49E+06	3.00E+06	4001	18000
1999	3.47E+06	303200	11020	2.91E+06	4.10E+06	3.45E+06	4001	18000
2000	1.68E+06	175900	7754	1.36E+06	2.04E+06	1.67E+06	4001	18000
2001	4.69E+06	592900	27790	3.64E+06	5.95E+06	4.66E+06	4001	18000
2002	8.65E+06	1275000	59530	6.40E+06	1.14E+07	8.58E+06	4001	18000
2003	2.84E+06	556500	27450	1.85E+06	4.05E+06	2.80E+06	4001	18000
2004	3.25E+06	804300	35470	1.94E+06	5.03E+06	3.18E+06	4001	18000
2005	2.17E+06	1008000	29540	8.10E+05	4.64E+06	1.98E+06	4001	18000
2006	1.83E+07	11340000	296900	4.57E+06	4.79E+07	1.55E+07	4001	18000
2007	3.63E+07	5.25E+07	383300	1.00E+01	1.76E+08	1.71E+06	4001	18000

Table 2.9.1.1 North East Atlantic Mackerel Input parameters of the final ICA assessment for the years 1972-2007

Assessment year	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**	**1999**
First catch data year	1972	1972	1972	1972	1972	1972	1984	1984	1984
Final catch data year	2006	2005	2004	2003	2002	2001	2000	1999	1998
No of years for separable constraint ?	12	14 (covering last 5 egg survey SSB's)	13 (covering last 5 egg survey SSB's)	12 (covering last 5 egg survey SSB's)	11 (covering last 4 egg survey SSB's)	10 (covering last 4 egg survey SSB's)	9 (covering last 3 egg survey SSB's)	8 (covering last 3 egg survey SSB's)	7 (covering last 3 egg survey SSB's)
Constant selection pattern model (Y/N)	S1(1995-2006)	S1(1992-2004)	S1(1992-2004)	S1(1992-2003)	S1(1992-2002)	S1(1992-2001)	S1(1992-2000)	S1(1992-1999)	S1(1992-1998)
S to be fixed on last age	1.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Age range in canum, weca, west, matprop	0 - 12+	0 - 12+	0 - 12+	0 - 12+	0 - 12+	0 - 12+	0 - 12+	0 - 12+	0 - 12+
Natural mortality (M)	M=0.15 for all ages	M=0.15 for all ages	M=0.15 for all ages	M=0.15 for all ages	M=0.15 for all ages	M=0.15 for all ages	M=0.15 for all ages	M=0.15 for all ages	M=0.15 for all ages
Proportion of F before spawning	0.42	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Proportion of M before spawning	0.35	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Reference age for separable constraint	5	5	5	5	5	5	5	5	5
First age for calculation of reference F	4	4	4	4	4	4	4	4	4
Last age for calculation of reference F	8	8	8	8	8	8	8	8	8
Shrink the final populations	No	No	No	No	No	No	No	No	No

Tuning indices

SSB from egg surveys Years	1992,95,98,2001,04,07	1992 + 1995 + 1998 + 2001 + 2004	1992 + 1995 + 1998 + 2001 + 2004	1992 + 1995 + 1998 + 2001 + 2004	1992 + 1995 + 1998 + 2001	1992 + 1995 + 1998 + 2001	1992 + 1995 + 1998	1992 + 1995 + 1998	1992 + 1995 + 1998
Abundance index	relative index: linear	relative index: linear	relative index: linear	WG: absolute index ACFM: relative index	absolute index	absolute index	relative index: linear	relative index: linear	relative index: linear

Model weighting

Relative weights in catch at age matrix	all 1, except 0-gr 0.01 and 1-gr 0.1	all 1, except 0-gr 0.01 and 1-gr 0.1	all 1, except 0-gr 0.01 and 1-gr 0.1	all 1, except 0-gr 0.01 and 1-gr 0.1	all 1, except 0-gr 0.01	all 1, except 0-gr 0.01	all 1, except 0-gr 0.01	all 1, except 0-gr 0.01	all 1, except 0-gr 0.01
Survey indices weighting Egg surveys	30.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Stock recruitment relationship fitted?	No	No	No	No	No	No	No	No	No
Parameters to be estimated	46	48	48	45 (abs.) or 46 (rel.)	43	41	40	38	36
Number of observations	150	173	161	149	136	124	111	99	87

Table 2.9.1.2 North East Atlantic Mackerel. Catch in numbers at age

Output Generated by ICA Version 1.4

Mackerel NE Atlantic WG2007

Catch in Number

AGE	1972	1973	1974	1975	1976	1977	1978	1979
0	10.71	17.00	29.28	36.17	62.51	6.08	34.62	114.53
1	34.98	46.27	108.08	62.91	282.82	175.22	34.51	360.70
2	51.65	74.54	47.41	92.39	249.29	328.73	560.74	62.91
3	194.46	109.02	155.39	84.51	374.25	226.56	449.34	609.52
4	650.98	415.01	148.54	265.13	176.79	236.12	279.24	385.58
5	0.00	814.52	424.46	164.67	314.26	67.76	282.16	250.75
6	0.00	0.00	673.32	251.42	133.82	186.62	78.88	248.10
7	0.00	0.00	0.00	991.63	379.79	105.00	172.21	92.66
8	0.00	0.00	0.00	0.00	478.93	229.80	73.93	169.60
9	0.00	0.00	0.00	0.00	0.00	236.97	127.97	73.90
10	0.00	0.00	0.00	0.00	0.00	0.00	243.33	102.36
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	204.29
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

x 10 ^ 6

Catch in Number

AGE	1980	1981	1982	1983	1984	1985	1986	1987
0	33.10	56.68	11.18	7.33	287.29	81.80	49.98	7.40
1	411.33	276.23	213.94	47.91	31.90	268.96	58.13	40.13
2	393.02	502.37	432.87	668.91	86.06	20.89	424.56	156.67
3	64.55	231.81	472.46	433.74	682.49	58.35	38.39	663.38
4	328.21	32.81	184.58	373.26	387.58	445.36	76.55	56.68
5	254.17	184.87	26.54	126.53	251.50	252.22	364.12	89.00
6	142.98	173.35	138.97	20.18	98.06	165.22	208.02	244.57
7	145.38	116.33	112.48	90.15	22.09	62.36	126.17	150.59
8	54.78	125.55	89.67	72.03	61.81	19.56	42.57	85.86
9	130.77	41.19	88.73	48.67	47.92	47.56	13.53	34.80
10	39.92	146.19	27.55	49.25	37.48	37.61	32.79	19.66
11	56.21	31.64	91.74	19.75	30.11	26.96	22.97	25.75
12	104.93	199.62	156.12	132.04	69.18	97.65	81.15	63.15

x 10 ^ 6

Catch in Number

AGE	1988	1989	1990	1991	1992	1993	1994	1995
0	57.64	65.40	24.25	10.01	43.45	19.35	25.37	14.76
1	152.66	64.26	140.53	58.46	83.58	128.14	147.31	81.53
2	137.63	312.74	209.85	212.52	156.29	210.32	221.49	340.90
3	190.40	207.69	410.75	206.42	356.21	266.68	306.98	340.21
4	538.39	167.59	208.15	375.45	266.59	398.24	267.42	275.03
5	72.91	362.47	156.74	188.62	306.14	244.28	301.35	186.85
6	87.32	48.70	254.01	129.15	156.07	255.47	184.93	197.86
7	201.02	58.12	42.55	197.89	113.90	149.93	189.85	142.34
8	122.50	111.25	49.70	51.08	138.46	97.75	106.11	113.41
9	55.91	68.24	85.45	43.41	51.21	121.40	80.05	69.19
10	20.71	32.23	33.04	70.84	36.61	38.79	57.62	42.44
11	13.18	13.90	16.59	29.74	40.96	29.07	20.41	37.96
12	57.49	35.81	27.91	52.99	68.20	68.22	57.55	39.75

x 10 ^ 6

Table 2.9.1.2 (Cont'd)

Catch in Number

AGE	1996	1997	1998	1999	2000	2001	2002	2003
0	37.96	36.01	61.13	67.00	36.34	26.03	70.41	14.41
1	119.85	144.39	99.35	73.60	102.41	40.31	222.21	182.12
2	168.88	186.48	229.77	132.99	142.90	158.94	69.73	265.15
3	333.37	238.43	264.57	223.64	275.38	234.19	366.98	88.95
4	279.18	378.88	323.19	261.78	390.86	297.21	349.85	290.23
5	177.67	246.78	361.94	281.04	295.52	309.94	262.49	230.57
6	96.30	135.06	207.62	244.21	241.55	231.80	236.93	180.48
7	119.83	84.38	118.39	159.02	175.61	195.25	151.24	132.35
8	55.81	66.50	72.75	86.74	106.29	120.24	118.81	93.17
9	59.80	39.45	47.35	50.61	52.39	72.20	79.92	74.78
10	25.80	26.73	24.39	30.36	31.28	42.53	43.78	45.79
11	18.35	13.95	16.55	17.05	18.92	20.55	21.61	25.69
12	30.65	24.97	22.93	32.45	34.20	40.71	40.26	30.89

x 10 ^ 6

Catch in Number

AGE	2004	2005	2006
0	5.17	5.01	58.29
1	24.62	44.23	69.30
2	425.83	131.91	165.13
3	499.45	661.63	156.63
4	142.79	289.50	468.40
5	244.88	118.45	194.15
6	138.00	119.91	96.82
7	84.00	63.30	73.75
8	61.43	38.02	33.23
9	37.61	23.74	18.79
10	32.82	18.70	13.95
11	15.38	7.86	8.31
12	18.15	10.56	10.07

x 10 ^ 6

Table 2.9.1.3 North East Atlantic Mackerel. Catch weights at age

Weights at age in the catches (Kg)

AGE	1972	1973	1974	1975	1976	1977	1978	1979
0	0.05200	0.05000	0.05100	0.05000	0.05900	0.05600	0.03600	0.01600
1	0.13500	0.14500	0.13600	0.14800	0.13700	0.13600	0.13500	0.13700
2	0.27700	0.19400	0.22900	0.17700	0.20700	0.16900	0.16100	0.16100
3	0.34100	0.28500	0.26100	0.25900	0.26300	0.27500	0.25000	0.24300
4	0.42300	0.36800	0.33400	0.32300	0.32000	0.33300	0.32500	0.31800
5	0.00000	0.44800	0.39200	0.34800	0.34600	0.35200	0.34500	0.34800
6	0.00000	0.00000	0.48100	0.43000	0.40600	0.40700	0.40300	0.40100
7	0.00000	0.00000	0.00000	0.48800	0.44300	0.44600	0.42100	0.41600
8	0.00000	0.00000	0.00000	0.00000	0.51800	0.54600	0.51800	0.50600
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.53700	0.53600	0.51300
10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.52900	0.53700
11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.52200
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Weights at age in the catches (Kg)

AGE	1980	1981	1982	1983	1984	1985	1986	1987
0	0.05700	0.06000	0.05300	0.05000	0.03100	0.05500	0.03900	0.07600
1	0.13100	0.13200	0.13100	0.16800	0.10200	0.14400	0.14600	0.17900
2	0.24900	0.24800	0.24900	0.21900	0.18400	0.26200	0.24500	0.22300
3	0.28500	0.28700	0.28500	0.27600	0.29500	0.35700	0.33500	0.31800
4	0.34500	0.34400	0.34500	0.31000	0.32600	0.41800	0.42300	0.39900
5	0.37800	0.37700	0.37800	0.38600	0.34400	0.41700	0.47100	0.47400
6	0.45400	0.45400	0.45400	0.42500	0.43100	0.43600	0.44400	0.51200
7	0.49800	0.49900	0.49600	0.43500	0.54200	0.52100	0.45700	0.49300
8	0.52000	0.51300	0.51300	0.49800	0.48000	0.55500	0.54300	0.49800
9	0.54200	0.54300	0.54100	0.54500	0.56900	0.56400	0.59100	0.58000
10	0.57400	0.57300	0.57400	0.60600	0.62800	0.62900	0.55200	0.63400
11	0.59000	0.57600	0.57400	0.60800	0.63600	0.67900	0.69400	0.63500
12	0.58000	0.58400	0.58200	0.61400	0.66300	0.71000	0.68800	0.71800

Weights at age in the catches (Kg)

AGE	1988	1989	1990	1991	1992	1993	1994	1995
0	0.05500	0.04900	0.08500	0.06800	0.05100	0.06100	0.04600	0.07200
1	0.13300	0.13600	0.15600	0.15600	0.16700	0.13400	0.13600	0.14300
2	0.25900	0.23700	0.23300	0.25300	0.23900	0.24000	0.25500	0.23400
3	0.32300	0.32000	0.33600	0.32700	0.33300	0.31700	0.33900	0.33300
4	0.38800	0.37700	0.37900	0.39400	0.39700	0.37600	0.39000	0.39000
5	0.45600	0.43300	0.42300	0.42300	0.46000	0.43600	0.44800	0.45200
6	0.52400	0.45600	0.46700	0.46900	0.49500	0.48300	0.51200	0.50100
7	0.55500	0.54300	0.52800	0.50600	0.53200	0.52700	0.54300	0.53900
8	0.55500	0.59200	0.55200	0.55400	0.55500	0.54800	0.59000	0.57700
9	0.56200	0.57800	0.60600	0.60900	0.59700	0.58300	0.58300	0.59400
10	0.61300	0.58100	0.60600	0.63000	0.65100	0.59500	0.62700	0.60600
11	0.62400	0.64800	0.59100	0.64900	0.66300	0.64700	0.67800	0.63100
12	0.69700	0.73900	0.71300	0.70800	0.66900	0.67900	0.71300	0.67200

Table 2.9.1.3 (Cont'd)

Weights at age in the catches (Kg)

AGE	1996	1997	1998	1999	2000	2001	2002	2003
0	0.05800	0.07600	0.06500	0.06200	0.06300	0.06900	0.05200	0.08100
1	0.14300	0.14300	0.15700	0.17600	0.13500	0.17200	0.16000	0.17100
2	0.22600	0.23000	0.22700	0.23500	0.22700	0.22400	0.25600	0.27100
3	0.31300	0.29500	0.31000	0.30600	0.30600	0.30500	0.30700	0.33800
4	0.37700	0.35900	0.35400	0.36100	0.36300	0.37600	0.36700	0.38700
5	0.42500	0.41500	0.40800	0.40400	0.42700	0.42400	0.42500	0.43900
6	0.48400	0.45300	0.45200	0.45200	0.46300	0.47400	0.46000	0.47700
7	0.51800	0.48100	0.46200	0.50000	0.50100	0.49600	0.51200	0.52300
8	0.55100	0.52400	0.51800	0.53600	0.53400	0.54000	0.53700	0.57200
9	0.57600	0.55300	0.55000	0.56900	0.56700	0.57700	0.58000	0.61200
10	0.59600	0.57700	0.57300	0.58600	0.58600	0.60300	0.60100	0.63100
11	0.60300	0.59100	0.59100	0.60700	0.59400	0.61100	0.62900	0.64800
12	0.67000	0.63600	0.63100	0.68700	0.64400	0.66600	0.66500	0.71500

Weights at age in the catches (Kg)

AGE	2004	2005	2006
0	0.08600	0.06700	0.04200
1	0.16000	0.14900	0.09900
2	0.26700	0.27000	0.19600
3	0.32600	0.30700	0.30700
4	0.40200	0.36600	0.35700
5	0.42200	0.43400	0.42800
6	0.48800	0.44000	0.48000
7	0.52300	0.49500	0.49400
8	0.55700	0.53900	0.54300
9	0.57500	0.55600	0.58400
10	0.59800	0.58200	0.62500
11	0.63300	0.63500	0.63500
12	0.68600	0.65700	0.69000

Table 2.9.1.4 North East Atlantic Mackerel. Stock weights at age

Weights at age in the stock (Kg)

AGE	1972	1973	1974	1975	1976	1977	1978	1979
0	0.00800	0.00800	0.00800	0.00800	0.00800	0.00800	0.00800	0.00800
1	0.13200	0.13200	0.13000	0.12900	0.12800	0.12700	0.11100	0.11000
2	0.17800	0.17700	0.17300	0.17100	0.17000	0.16700	0.17500	0.17400
3	0.24300	0.24200	0.23800	0.23600	0.23600	0.23300	0.23800	0.23700
4	0.41100	0.30100	0.29600	0.29400	0.29300	0.28900	0.30000	0.29900
5	0.00000	0.43800	0.32200	0.31800	0.31800	0.31300	0.34600	0.34500
6	0.00000	0.00000	0.46900	0.36500	0.36500	0.36100	0.38200	0.38000
7	0.00000	0.00000	0.00000	0.49700	0.41900	0.41600	0.41000	0.40800
8	0.00000	0.00000	0.00000	0.00000	0.51200	0.44600	0.43200	0.43000
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.53000	0.45100	0.44900
10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.51400	0.50400
11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.51600
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Weights at age in the stock (Kg)

AGE	1980	1981	1982	1983	1984	1985	1986	1987
0	0.00800	0.00800	0.00800	0.00800	0.00000	0.00000	0.00000	0.00000
1	0.10900	0.08700	0.08600	0.08600	0.08100	0.08500	0.07700	0.07800
2	0.17300	0.18600	0.13500	0.17200	0.19400	0.16500	0.17900	0.14800
3	0.23600	0.25200	0.22100	0.23500	0.25300	0.29300	0.26700	0.24000
4	0.29700	0.31300	0.28000	0.28000	0.29500	0.30600	0.30400	0.28600
5	0.34300	0.32300	0.38500	0.33900	0.32400	0.34100	0.35600	0.37400
6	0.37900	0.37800	0.35300	0.37700	0.39300	0.38400	0.35100	0.38600
7	0.40700	0.41900	0.40800	0.40400	0.43600	0.43000	0.41600	0.41100
8	0.42900	0.43400	0.43700	0.43900	0.44100	0.45900	0.47300	0.42900
9	0.44800	0.44900	0.44600	0.50300	0.47900	0.46800	0.44300	0.48200
10	0.50300	0.44300	0.47900	0.47300	0.52000	0.55900	0.46800	0.49900
11	0.50800	0.52300	0.52600	0.55500	0.51000	0.57900	0.49700	0.47000
12	0.51800	0.53100	0.53400	0.56300	0.55000	0.60700	0.57500	0.54900

Weights at age in the stock (Kg)

AGE	1988	1989	1990	1991	1992	1993	1994	1995
0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1	0.07200	0.07600	0.07400	0.07500	0.07800	0.07800	0.07900	0.08100
2	0.15600	0.17700	0.13800	0.15500	0.21200	0.19700	0.17800	0.16400
3	0.23700	0.24400	0.22200	0.23000	0.25900	0.26800	0.23700	0.26700
4	0.30100	0.30600	0.28700	0.30700	0.31000	0.31500	0.30100	0.32600
5	0.32900	0.35200	0.33900	0.35700	0.36200	0.36000	0.36100	0.39800
6	0.42300	0.38000	0.37300	0.40900	0.40200	0.41600	0.41300	0.44800
7	0.44500	0.42900	0.41400	0.43200	0.42400	0.45400	0.46600	0.49100
8	0.43200	0.47400	0.40900	0.50200	0.46200	0.46500	0.47000	0.50800
9	0.45500	0.45700	0.43700	0.54100	0.48700	0.48400	0.48300	0.54600
10	0.52200	0.46600	0.51400	0.56600	0.52200	0.51100	0.55000	0.51400
11	0.58900	0.51000	0.52300	0.56600	0.55200	0.58500	0.60800	0.61900
12	0.63200	0.59500	0.52900	0.59400	0.58300	0.57700	0.58400	0.63900

Table 2.9.1.4 (Cont'd)

Weights at age in the stock (Kg)

AGE	1996	1997	1998	1999	2000	2001	2002	2003
0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1	0.07600	0.07600	0.07700	0.08100	0.07400	0.07800	0.07800	0.07400
2	0.13300	0.18600	0.14900	0.19400	0.18500	0.16400	0.18100	0.18100
3	0.25100	0.22800	0.22300	0.24200	0.23500	0.24100	0.23900	0.27300
4	0.31700	0.29600	0.28500	0.30100	0.28900	0.34200	0.31100	0.31600
5	0.36600	0.36100	0.34200	0.35300	0.35000	0.39000	0.36400	0.37100
6	0.44400	0.40200	0.40000	0.39600	0.39000	0.44600	0.41100	0.44600
7	0.46200	0.44500	0.42600	0.42300	0.42600	0.45900	0.43600	0.44600
8	0.50100	0.47800	0.46600	0.44000	0.44700	0.49900	0.46200	0.47500
9	0.56500	0.51900	0.50200	0.48500	0.48500	0.52900	0.50000	0.58400
10	0.57300	0.53700	0.54900	0.49800	0.49200	0.57600	0.52200	0.52700
11	0.61100	0.53200	0.52400	0.46500	0.53200	0.60300	0.53300	0.59900
12	0.63200	0.58500	0.58000	0.56500	0.54400	0.58600	0.56500	0.61000

Weights at age in the stock (Kg)

AGE	2004	2005	2006
0	0.00000	0.00000	0.00000
1	0.05900	0.07400	0.07600
2	0.13800	0.16800	0.17800
3	0.24600	0.23800	0.22800
4	0.31300	0.33600	0.29700
5	0.35500	0.38100	0.34500
6	0.41200	0.40100	0.39100
7	0.46300	0.48100	0.43600
8	0.46200	0.50100	0.45800
9	0.50800	0.55000	0.51700
10	0.52000	0.55000	0.52300
11	0.53800	0.57600	0.57800
12	0.59000	0.59000	0.61400

Table 2.9.1.5 North East Atlantic Mackerel. Natural mortality at age

Natural Mortality (per year)

AGE	1972	1973	1974	1975	1976	1977	1978	1979
0	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
1	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
2	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
3	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
4	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
5	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
6	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
7	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
8	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
9	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
10	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
11	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
12	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000

Natural Mortality (per year)

AGE	1980	1981	1982	1983	1984	1985	1986	1987
0	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
1	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
2	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
3	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
4	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
5	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
6	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
7	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
8	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
9	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
10	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
11	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
12	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000

Natural Mortality (per year)

AGE	1988	1989	1990	1991	1992	1993	1994	1995
0	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
1	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
2	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
3	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
4	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
5	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
6	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
7	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
8	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
9	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
10	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
11	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
12	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000

Table 2.9.1.5 (cont'd)

Natural Mortality (per year)

AGE	1996	1997	1998	1999	2000	2001	2002	2003
0	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
1	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
2	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
3	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
4	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
5	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
6	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
7	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
8	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
9	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
10	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
11	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000
12	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000	0.15000

Natural Mortality (per year)

AGE	2004	2005	2006
0	0.15000	0.15000	0.15000
1	0.15000	0.15000	0.15000
2	0.15000	0.15000	0.15000
3	0.15000	0.15000	0.15000
4	0.15000	0.15000	0.15000
5	0.15000	0.15000	0.15000
6	0.15000	0.15000	0.15000
7	0.15000	0.15000	0.15000
8	0.15000	0.15000	0.15000
9	0.15000	0.15000	0.15000
10	0.15000	0.15000	0.15000
11	0.15000	0.15000	0.15000
12	0.15000	0.15000	0.10000

Table 2.9.1.6 North East Atlantic Mackerel. Proportion of fish spawning

Proportion of fish spawning

AGE	1972	1973	1974	1975	1976	1977	1978	1979
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0500	0.0500	0.0500	0.0600	0.0600	0.0600	0.0600	0.0600
2	0.5300	0.5400	0.5400	0.5500	0.5500	0.5500	0.5600	0.5600
3	0.9000	0.9000	0.9000	0.8900	0.8900	0.8900	0.8900	0.8900
4	0.9800	0.9800	0.9800	0.9800	0.9800	0.9800	0.9800	0.9800
5	0.9800	0.9800	0.9800	0.9800	0.9800	0.9800	0.9800	0.9800
6	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	1980	1981	1982	1983	1984	1985	1986	1987
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0600	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700
2	0.5700	0.5700	0.5700	0.5800	0.5800	0.5800	0.5800	0.5800
3	0.8900	0.8800	0.8800	0.8800	0.8800	0.8800	0.8800	0.8800
4	0.9800	0.9800	0.9800	0.9800	0.9700	0.9700	0.9700	0.9700
5	0.9800	0.9800	0.9800	0.9800	0.9700	0.9700	0.9700	0.9700
6	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	1988	1989	1990	1991	1992	1993	1994	1995
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700
2	0.5800	0.5800	0.5800	0.5800	0.5800	0.5800	0.5800	0.5800
3	0.8800	0.8800	0.8800	0.8800	0.8800	0.8800	0.8800	0.8800
4	0.9700	0.9700	0.9700	0.9700	0.9700	0.9700	0.9700	0.9700
5	0.9700	0.9700	0.9700	0.9700	0.9700	0.9700	0.9700	0.9700
6	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 2.9.1.6 (Cont'd)

Proportion of fish spawning

AGE	1996	1997	1998	1999	2000	2001	2002	2003
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700
2	0.5800	0.5800	0.5800	0.5800	0.5800	0.5900	0.5900	0.5900
3	0.8800	0.8800	0.8600	0.8600	0.8600	0.8800	0.8800	0.8800
4	0.9700	0.9700	0.9800	0.9800	0.9800	0.9700	0.9700	0.9700
5	0.9700	0.9700	0.9800	0.9800	0.9800	0.9700	0.9700	0.9700
6	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900	0.9900
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	2004	2005	2006
0	0.0000	0.0000	0.0000
1	0.0700	0.0700	0.0700
2	0.5900	0.5800	0.5700
3	0.8800	0.8900	0.8900
4	0.9700	0.9800	0.9800
5	0.9700	0.9800	0.9800
6	0.9900	0.9900	0.9900
7	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000

Table 2.9.1.7 North East Atlantic Mackerel. Biomass estimates from egg surveys

INDICES OF SPAWNING BIOMASS

INDEX1

	1972	1973	1974	1975	1976	1977	1978	1979
1	*******	*******	*******	*******	*******	*******	*******	*******

x 10 ^ 3

INDEX1

	1980	1981	1982	1983	1984	1985	1986	1987
1	*******	*******	*******	*******	*******	*******	*******	*******

x 10 ^ 3

INDEX1

	1988	1989	1990	1991	1992	1993	1994	1995
1	*******	*******	*******	*******	3370.0	*******	*******	2840.0

x 10 ^ 3

INDEX1

	1996	1997	1998	1999	2000	2001	2002	2003
1	*******	*******	3750.0	*******	*******	2900.0	*******	*******

x 10 ^ 3

INDEX1

	2004	2005	2006	2007
1	2750.0	*******	*******	2898.0

x 10 ^ 3

Table 2.9.1.8 North East Atlantic Mackerel. Fishing mortality at age

Fishing Mortality (per year)

AGE	1972	1973	1974	1975	1976	1977	1978	1979
0	0.00547	0.00386	0.00794	0.00797	0.01376	0.00682	0.01162	0.02355
1	0.00728	0.02792	0.02900	0.02011	0.07542	0.04616	0.04621	0.15225
2	0.02680	0.01826	0.03429	0.02966	0.09808	0.11175	0.19276	0.10544
3	0.05170	0.06890	0.04565	0.07495	0.15252	0.11517	0.20770	0.31210
4	0.09392	0.14090	0.11974	0.09709	0.20929	0.12875	0.19191	0.26135
5	0.00000	0.15436	0.19805	0.17879	0.15120	0.10959	0.21144	0.24920
6	0.00000	0.18616	0.17467	0.16346	0.20429	0.11953	0.17022	0.27489
7	0.00000	0.20529	0.26340	0.39404	0.37229	0.23138	0.14627	0.29152
8	0.00000	0.21313	0.27346	0.24686	0.31644	0.38134	0.23946	0.19859
9	0.00000	0.22828	0.29290	0.26441	0.22360	0.24104	0.35733	0.37640
10	0.00000	0.23981	0.30769	0.27776	0.23489	0.17025	0.39242	0.50817
11	0.00000	0.23154	0.29708	0.26818	0.22680	0.16438	0.31715	0.62994
12	0.00000	0.23154	0.29708	0.26818	0.22680	0.16438	0.31715	0.62994

Fishing Mortality (per year)

AGE	1980	1981	1982	1983	1984	1985	1986	1987
0	0.00645	0.00849	0.00598	0.00509	0.04311	0.02704	0.01592	0.00157
1	0.10463	0.06474	0.03810	0.03033	0.02611	0.04910	0.02289	0.01508
2	0.23317	0.17007	0.12973	0.15185	0.06638	0.02033	0.09679	0.07523
3	0.14215	0.19849	0.22618	0.17575	0.21597	0.05559	0.04483	0.20363
4	0.26046	0.09461	0.22695	0.26507	0.22234	0.20187	0.09111	0.08187
5	0.25976	0.21668	0.09789	0.22679	0.27127	0.20861	0.23875	0.13788
6	0.20773	0.26789	0.23731	0.09521	0.26023	0.27161	0.25124	0.23628
7	0.24270	0.24608	0.26344	0.22552	0.13580	0.24801	0.32395	0.27464
8	0.26470	0.32203	0.28734	0.25397	0.22505	0.16209	0.25259	0.36004
9	0.21908	0.30731	0.37360	0.23577	0.25297	0.25558	0.15251	0.31837
10	0.33823	0.38195	0.32788	0.34564	0.27155	0.30416	0.26554	0.32498
11	0.54870	0.46209	0.41403	0.38982	0.34703	0.30202	0.29078	0.32474
12	0.54870	0.46209	0.41403	0.38982	0.34703	0.30202	0.29078	0.32474

Fishing Mortality (per year)

AGE	1988	1989	1990	1991	1992	1993	1994	1995
0	0.01788	0.01653	0.00840	0.00306	0.01080	0.00394	0.00580	0.00910
1	0.03842	0.02364	0.04248	0.02391	0.03015	0.03792	0.03556	0.03404
2	0.06241	0.09779	0.09506	0.07928	0.07809	0.09367	0.08075	0.08252
3	0.11683	0.11972	0.17033	0.12097	0.17492	0.17532	0.18194	0.15898
4	0.23936	0.13548	0.16018	0.21951	0.21409	0.28494	0.25236	0.24246
5	0.13631	0.23767	0.17148	0.20188	0.26451	0.29292	0.34199	0.31597
6	0.18443	0.12030	0.24644	0.19725	0.24200	0.34710	0.35538	0.38106
7	0.29349	0.17035	0.13896	0.29143	0.25267	0.36403	0.44293	0.42021
8	0.35440	0.24775	0.20389	0.23279	0.32149	0.33731	0.44736	0.43627
9	0.39711	0.32213	0.28868	0.26056	0.36359	0.48692	0.47974	0.46728
10	0.30016	0.39525	0.24083	0.38854	0.34437	0.48672	0.42494	0.49087
11	0.35521	0.31883	0.34257	0.33471	0.38415	0.47576	0.48321	0.47395
12	0.35521	0.31883	0.34257	0.33471	0.38415	0.47576	0.48321	0.47395

Table 2.9.1.8 Cont'd

Fishing Mortality (per year)

AGE	1996	1997	1998	1999	2000	2001	2002	2003
0	0.00642	0.00612	0.00714	0.00755	0.00893	0.01020	0.01157	0.01131
1	0.02403	0.02290	0.02671	0.02826	0.03339	0.03816	0.04327	0.04231
2	0.05825	0.05551	0.06475	0.06851	0.08095	0.09251	0.10489	0.10257
3	0.11223	0.10694	0.12476	0.13200	0.15595	0.17824	0.20208	0.19762
4	0.17116	0.16310	0.19027	0.20131	0.23785	0.27183	0.30819	0.30139
5	0.22305	0.21254	0.24795	0.26233	0.30994	0.35423	0.40162	0.39275
6	0.26901	0.25633	0.29903	0.31639	0.37381	0.42722	0.48437	0.47368
7	0.29664	0.28267	0.32976	0.34889	0.41221	0.47111	0.53413	0.52234
8	0.30798	0.29347	0.34236	0.36223	0.42796	0.48912	0.55455	0.54230
9	0.32987	0.31433	0.36669	0.38797	0.45838	0.52388	0.59396	0.58084
10	0.34652	0.33019	0.38520	0.40755	0.48151	0.55032	0.62394	0.61016
11	0.33457	0.31881	0.37192	0.39350	0.46491	0.53135	0.60242	0.58913
12	0.33457	0.31881	0.37192	0.39350	0.46491	0.53135	0.60242	0.58913

Fishing Mortality (per year)

AGE	2004	2005	2006
0	0.01010	0.00753	0.00654
1	0.03777	0.02815	0.02448
2	0.09157	0.06825	0.05933
3	0.17643	0.13149	0.11432
4	0.26907	0.20053	0.17434
5	0.35063	0.26132	0.22719
6	0.42288	0.31517	0.27400
7	0.46632	0.34755	0.30215
8	0.48414	0.36083	0.31370
9	0.51855	0.38647	0.33600
10	0.54472	0.40598	0.35296
11	0.52594	0.39198	0.34079
12	0.52594	0.39198	0.34079

Table 2.9.1.9 North East Atlantic Mackerel. Population numbers at age

Population Abundance (1 January)

AGE	1972	1973	1974	1975	1976	1977	1978	1979
0	2113.1	4747.5	3984.5	4905.5	4924.4	962.3	3226.6	5296.7
1	5190.1	1808.8	4070.4	3402.3	4188.7	4180.6	822.6	2745.1
2	2102.4	4434.7	1514.0	3403.3	2870.1	3343.3	3435.9	676.1
3	4153.2	1761.7	3747.9	1259.2	2843.7	2239.6	2573.4	2438.8
4	7811.2	3394.6	1415.4	3081.9	1005.5	2101.3	1717.9	1799.5
5	0.0	6120.5	2537.7	1080.8	2407.2	702.0	1590.1	1220.4
6	0.0	0.0	4514.4	1791.8	777.9	1781.2	541.5	1107.8
7	0.0	0.0	0.0	3262.9	1309.6	545.8	1360.3	393.1
8	0.0	0.0	0.0	0.0	1893.8	776.8	372.8	1011.5
9	0.0	0.0	0.0	0.0	0.0	1187.8	456.6	252.5
10	0.0	0.0	0.0	0.0	0.0	0.0	803.4	274.9
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	467.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

x 10 ^ 6

Population Abundance (1 January)

AGE	1980	1981	1982	1983	1984	1985	1986	1987
0	5544.3	7217.1	2018.1	1556.3	7327.5	3300.4	3408.1	5072.9
1	4452.8	4741.4	6159.3	1726.7	1332.7	6040.7	2764.9	2887.1
2	2029.0	3451.8	3825.1	5103.2	1441.8	1117.5	4950.1	2325.9
3	523.7	1383.2	2506.4	2891.7	3773.5	1161.2	942.5	3867.6
4	1536.4	391.0	976.2	1720.6	2087.8	2617.0	945.4	775.6
5	1192.6	1019.1	306.2	669.6	1136.1	1438.7	1840.7	742.9
6	818.7	791.7	706.3	238.9	459.4	745.5	1005.2	1247.8
7	724.3	572.5	521.3	479.5	187.0	304.8	489.0	672.9
8	252.8	489.1	385.3	344.8	329.4	140.5	204.7	304.4
9	713.8	167.0	305.1	248.8	230.2	226.4	102.8	136.9
10	149.2	493.5	105.7	180.7	169.2	153.8	150.9	76.0
11	142.4	91.5	289.9	65.5	110.1	111.0	97.7	99.6
12	265.7	577.6	493.4	438.3	253.0	401.9	345.1	244.2

x 10 ^ 6

Population Abundance (1 January)

AGE	1988	1989	1990	1991	1992	1993	1994	1995
0	3502.2	4295.5	3120.8	3530.3	4353.1	5293.6	4721.2	4213.5
1	4359.4	2961.0	3636.6	2663.7	3029.3	3706.5	4538.3	4040.1
2	2447.7	3610.7	2489.0	2999.8	2238.5	2529.9	3071.5	3769.8
3	1856.8	1979.3	2818.3	1948.0	2385.2	1781.9	1982.8	2438.6
4	2715.5	1422.0	1511.4	2045.8	1485.6	1723.5	1287.1	1422.7
5	615.1	1839.8	1068.8	1108.3	1413.8	1032.3	1115.6	860.7
6	557.1	462.0	1248.5	775.0	779.6	934.0	662.9	682.1
7	848.0	398.7	352.6	839.9	547.6	526.8	568.2	399.9
8	440.1	544.3	289.4	264.1	540.2	366.1	315.0	314.0
9	182.8	265.8	365.6	203.2	180.1	337.1	224.9	173.4
10	85.7	105.8	165.8	235.8	134.8	107.8	178.3	119.8
11	47.3	54.6	61.3	112.1	137.6	82.2	57.0	100.3
12	206.2	140.7	103.2	199.8	229.2	192.9	160.8	112.7

x 10 ^ 6

Table 2.9.1.9 (cont'd)

Population Abundance (1 January)

AGE	1996	1997	1998	1999	2000	2001	2002	2003
0	3960.6	3064.4	2908.4	3372.8	1627.6	5136.6	8899.2	2575.7
1	3593.7	3387.1	2621.4	2485.4	2881.1	1388.5	4376.2	7571.5
2	3361.0	3019.7	2849.3	2196.8	2079.6	2398.4	1150.3	3607.1
3	2987.7	2729.1	2458.8	2298.7	1765.6	1650.8	1881.9	891.5
4	1790.4	2298.5	2110.7	1868.0	1733.8	1300.2	1188.9	1323.4
5	960.9	1298.6	1680.6	1501.9	1314.7	1176.4	852.7	751.9
6	540.1	661.7	903.7	1128.9	994.4	830.0	710.5	491.2
7	401.1	355.3	440.8	576.8	708.1	589.0	466.0	376.8
8	226.1	256.6	230.5	272.8	350.2	403.6	316.5	235.1
9	174.7	143.0	164.7	140.9	163.4	196.5	213.0	156.4
10	93.5	108.1	89.9	98.2	82.3	89.0	100.2	101.2
11	63.1	56.9	66.9	52.6	56.2	43.7	44.2	46.2
12	115.6	98.1	79.1	106.9	98.5	105.6	95.1	74.2

x 10 ^ 6

Population Abundance (1 January)

AGE	2004	2005	2006	2007
0	3431.4	1880.2	4295.3	3522.6
1	2192.0	2923.8	1606.1	3672.9
2	6246.9	1816.7	2446.7	1349.0
3	2802.0	4906.3	1460.5	1984.6
4	629.7	2021.7	3702.6	1121.3
5	842.7	414.1	1423.9	2677.0
6	436.9	510.8	274.5	976.5
7	263.3	246.4	320.8	179.6
8	192.3	142.1	149.8	204.1
9	117.7	102.0	85.3	94.2
10	75.3	60.3	59.7	52.5
11	47.3	37.6	34.6	36.1
12	47.5	34.9	37.4	44.1

x 10 ^ 6

Table 2.9.1.10 North East Atlantic Mackerel. Diagnostic output

PARAMETER ESTIMATES

Parm. No.		Maximum Likelh. Estimate	CV (%)	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. Distrib.
Separable model : F by year								
1	1995	0.3160	8	0.2657	0.3757	0.2892	0.3452	0.3172
2	1996	0.2230	8	0.1873	0.2657	0.2040	0.2439	0.2239
3	1997	0.2125	8	0.1791	0.2522	0.1948	0.2319	0.2134
4	1998	0.2479	8	0.2095	0.2934	0.2275	0.2702	0.2489
5	1999	0.2623	8	0.2223	0.3096	0.2411	0.2855	0.2633
6	2000	0.3099	8	0.2638	0.3642	0.2855	0.3365	0.3110
7	2001	0.3542	8	0.3010	0.4169	0.3260	0.3849	0.3555
8	2002	0.4016	8	0.3410	0.4730	0.3694	0.4366	0.4030
9	2003	0.3927	8	0.3316	0.4651	0.3603	0.4281	0.3942
10	2004	0.3506	9	0.2926	0.4202	0.3197	0.3845	0.3521
11	2005	0.2613	10	0.2144	0.3185	0.2362	0.2891	0.2627
12	2006	0.2272	10	0.1862	0.2773	0.2052	0.2515	0.2284
Separable Model: Selection (S) by age								
13	0	0.0288	61	0.0086	0.0966	0.0155	0.0534	0.0349
14	1	0.1077	20	0.0727	0.1596	0.0882	0.1316	0.1099
15	2	0.2612	8	0.2197	0.3104	0.2391	0.2852	0.2622
16	3	0.5032	8	0.4251	0.5955	0.4617	0.5483	0.5050
17	4	0.7674	8	0.6509	0.9048	0.7055	0.8347	0.7701
	5	1.0000	Fixed : Reference Age					
18	6	1.2060	8	1.0303	1.4118	1.1129	1.3070	1.2099
19	7	1.3300	7	1.1435	1.5467	1.2313	1.4365	1.3339
20	8	1.3808	7	1.1953	1.5951	1.2828	1.4863	1.3845
21	9	1.4789	7	1.2883	1.6977	1.3784	1.5868	1.4826
22	10	1.5536	7	1.3524	1.7847	1.4474	1.6675	1.5575
	11	1.5000	Fixed : Last true age					
Separable model: Populations in year 2006								
23	0	4295314	209	70588	261369061	528030	34940675	38644273
24	1	1606129	57	515322	5005895	899274	2868593	1900323
25	2	2446679	18	1717197	3486052	2042347	2931058	2486921
26	3	1460523	14	1097790	1943109	1262550	1689538	1476099
27	4	3702549	9	3056273	4485486	3357348	4083243	3720324
28	5	1423873	9	1179759	1718499	1293597	1567270	1430443
29	6	274481	10	222036	339312	246336	305841	276092
30	7	320783	10	261631	393309	289099	355939	322522
31	8	149812	10	121720	184388	134751	166556	150655
32	9	85286	10	68922	105535	76502	95078	85791
33	10	59660	11	47509	74918	53115	67010	60064
34	11	34576	12	26862	44506	30398	39329	34864
Separable model: Populations at age								
35	1995	100336	21	65810	152974	80911	124425	102686
36	1996	63118	16	45590	87385	53465	74514	63994
37	1997	56914	14	43097	75162	49386	65590	57490
38	1998	66897	12	52227	85687	58959	75903	67432
39	1999	52640	11	41808	66277	46802	59205	53005
40	2000	56247	11	45273	69881	50351	62834	56593
41	2001	43741	11	35184	54379	39143	48879	44011
42	2002	44158	11	35567	54824	39543	49311	44428
43	2003	46190	11	36959	57727	41224	51755	46490
44	2004	47329	11	37495	59742	42026	53301	47664
45	2005	37604	12	29423	48059	33180	42618	37900
SSB Index catchabilities								
INDEX1								
Linear model fitted. Slopes at age :								
46	1 Q	1.396	2	1.363	1.503	1.396	1.468	1.432

Table 2.9.1.10 (Cont'd)

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals

Age	1995	1996	1997	1998	1999	2000	2001	2002
0	-0.876	0.477	0.729	1.157	1.045	0.995	-0.620	-0.300
1	-0.432	0.414	0.707	0.437	0.134	0.153	-0.181	0.255
2	0.206	-0.045	0.208	0.325	-0.016	-0.051	-0.215	-0.424
3	0.020	0.122	-0.076	-0.014	-0.167	0.149	-0.069	0.135
4	-0.037	0.063	0.163	-0.052	-0.192	0.134	0.030	0.174
5	-0.151	-0.007	0.064	0.052	-0.139	-0.100	-0.055	-0.003
6	-0.019	-0.209	-0.032	-0.047	-0.156	-0.181	-0.150	-0.073
7	0.106	0.222	0.035	0.025	0.004	-0.240	-0.057	-0.176
8	0.090	-0.001	0.089	0.155	0.115	-0.069	-0.193	-0.058
9	0.135	0.267	0.093	0.004	0.180	-0.069	-0.037	-0.110
10	-0.023	0.010	-0.059	-0.095	-0.011	0.063	0.189	0.006
11	0.070	0.092	-0.038	-0.158	0.065	-0.032	0.198	0.145

Separable Model Residuals

Age	2003	2004	2005	2006
0	-0.624	-1.824	-0.960	0.807
1	-0.470	-1.121	-0.533	0.653
2	-0.210	-0.177	0.169	0.232
3	-0.515	0.169	0.163	0.065
4	-0.101	0.031	-0.167	-0.163
5	0.012	0.052	0.289	-0.328
6	0.042	-0.019	-0.071	0.457
7	-0.079	-0.087	-0.064	-0.056
8	0.013	-0.116	-0.055	-0.124
9	0.148	-0.168	-0.251	-0.189
10	0.057	0.104	-0.004	-0.171
11	0.289	-0.162	-0.370	-0.114

SPAWNING BIOMASS INDEX RESIDUALS

INDEX1

	1972	1973	1974	1975	1976	1977	1978	1979
1	*******	*******	*******	*******	*******	*******	*******	*******

INDEX1

	1980	1981	1982	1983	1984	1985	1986	1987
1	*******	*******	*******	*******	*******	*******	*******	*******

INDEX1

	1988	1989	1990	1991	1992	1993	1994	1995
1	*******	*******	*******	*******	-0.0451	*******	*******	-0.1106

INDEX1

	1996	1997	1998	1999	2000	2001	2002	2003
1	*******	*******	0.1217	*******	*******	-0.0094	*******	*******

INDEX1

	2004	2005	2006	2007
1	0.0748	*******	*******	-0.0314

Table 2.9.1.10 (Cont'd)

```
PARAMETERS OF THE DISTRIBUTION OF ln(CATCHES AT AGE)
 ----------------------------------------------------

 Separable model fitted from 1995  to 2006
 Variance                           0.0111
Skewness test stat.                -1.6955
Kurtosis test statistic             1.7475
Partial chi-square                  0.0971
Significance in fit                 0.0000
Degrees of freedom                      99

 PARAMETERS OF DISTRIBUTIONS OF THE SSB INDICES
 ----------------------------------------------

Separable model fitted from 1995  to 2006
 Variance                           0.0111
Skewness test stat.                -1.6943
Kurtosis test statistic             1.7490
Partial chi-square                  0.0971
Significance in fit                 0.0000
Degrees of freedom                      99

 PARAMETERS OF DISTRIBUTIONS OF THE SSB INDICES
 ----------------------------------------------

   DISTRIBUTION STATISTICS FOR   INDEX1

 Linear catchability relationship assumed

 Variance                           0.0715
Skewness test stat.                 0.2702
Kurtosis test statistic            -0.5482
Partial chi-square                  0.0239
Significance in fit                 0.0000
Number of observations                   6
Degrees of freedom                       5
Weight in the analysis             10.0000

 ANALYSIS OF VARIANCE
--------------------------

 Unweighted Statistics

Variance
                                       SSQ     Data    Parameters d.f. Variance
Total for model                     16.9741     150            46  104   0.1632
Catches at age                      16.9384     144            45   99   0.1711

SSB Indices
  INDEX1                             0.0357       6             1    5   0.0071

 Weighted Statistics

Variance
                                       SSQ     Data    Parameters d.f. Variance
Total for model                      4.6729     150            46  104   0.0449
Catches at age                       1.0989     144            45   99   0.0111

SSB Indices
  INDEX1                             3.5740       6             1    5   0.7148
```

Table 2.9.1.11 North East Atlantic Mackerel. Stock summary table

STOCK SUMMARY

Year	Recruits Age 0 thousands	Total Biomass tonnes	Spawning Biomass tonnes	Landings tonnes	Yield /SSB ratio	Mean F Ages 4- 8	SoP (%)
1972	2113070	5295849	3931319	361262	0.0919	0.0188	99
1973	4747470	5190559	3995311	570719	0.1428	0.1800	100
1974	3984490	5068335	3821699	607473	0.1590	0.2059	99
1975	4905470	4882710	3550090	784329	0.2209	0.2160	100
1976	4924420	4596981	3219315	828434	0.2573	0.2507	99
1977	962290	4291901	3046995	620016	0.2035	0.1941	99
1978	3226630	3940971	3000593	736519	0.2455	0.1919	99
1979	5296700	3508363	2544495	842739	0.3312	0.2551	100
1980	5544310	3188066	2126354	734950	0.3456	0.2471	99
1981	7217140	3312003	2154732	754045	0.3499	0.2295	99
1982	2018150	3240362	2073565	716987	0.3458	0.2226	99
1983	1556260	3355932	2365522	672283	0.2842	0.2133	99
1984	7327500	3127179	2382131	641928	0.2695	0.2229	99
1985	3300370	3311479	2330761	614371	0.2636	0.2184	100
1986	3408120	3309580	2345404	602201	0.2568	0.2315	100
1987	5072870	3170973	2334078	654992	0.2806	0.2181	100
1988	3502210	3244732	2341143	680491	0.2907	0.2416	100
1989	4295510	3316719	2414519	585920	0.2427	0.1823	99
1990	3120860	3096014	2275442	626107	0.2752	0.1842	99
1991	3530320	3374407	2521380	675665	0.2680	0.2286	99
1992	4353190	3463702	2525257	760690	0.3012	0.2589	100
1993	5293720	3355150	2341188	824568	0.3522	0.3253	100
1994	4721220	3187204	2127203	819087	0.3851	0.3680	100
1995	4213480	3354843	2272166	756277	0.3328	0.3592	100
1996	3960620	3191611	2304222	563472	0.2445	0.2536	100
1997	3064360	3357207	2437513	573029	0.2351	0.2416	100
1998	2908350	3220661	2378369	666316	0.2802	0.2819	100
1999	3372780	3289398	2419912	640309	0.2646	0.2982	99
2000	1627610	3023339	2167192	738606	0.3408	0.3524	99
2001	5136550	2888316	2096858	737463	0.3517	0.4027	99
2002	8899180	2556921	1680112	772905	0.4600	0.4566	99
2003	2575710	2870110	1672164	669600	0.4004	0.4465	99
2004	3431440	2720139	1827839	650221	0.3557	0.3986	99
2005	1880150	3052396	2251789	543486	0.2414	0.2971	99
2006	4295310	2915510	2231941	472652	0.2118	0.2583	99

No of years for separable analysis : 12
Age range in the analysis : 0 . . . 12
Year range in the analysis : 1972 . . . 2006
Number of indices of SSB : 1
Number of age-structured indices : 0

Parameters to estimate : 46
Number of observations : 150

Conventional single selection vector model to be fitted.

Table 2.10.1 North East Atlantic Mackerel. Short term prediction: INPUT DATA

2007 Age	Stock Size	Natural Mortality	Maturity ogive	Prop. Of F bef. spaw.	Prop. of M bef. spaw.	Stock weights	Exploitation pattern	Catch weights
0	3694105	0.15	0.00	0.421	0.35	0.000	0.007	0.065
1	3158819	0.15	0.07	0.421	0.35	0.070	0.024	0.136
2	1349000	0.15	0.58	0.421	0.35	0.161	0.059	0.244
3	1984600	0.15	0.89	0.421	0.35	0.237	0.114	0.313
4	1121300	0.15	0.98	0.421	0.35	0.315	0.174	0.375
5	2677000	0.15	0.98	0.421	0.35	0.360	0.227	0.428
6	976500	0.15	0.99	0.421	0.35	0.401	0.274	0.469
7	179600	0.15	1.00	0.421	0.35	0.460	0.302	0.504
8	204100	0.15	1.00	0.421	0.35	0.474	0.314	0.546
9	94200	0.15	1.00	0.421	0.35	0.525	0.336	0.572
10	52500	0.15	1.00	0.421	0.35	0.531	0.353	0.602
11	36100	0.15	1.00	0.421	0.35	0.564	0.341	0.634
12	44100	0.15	1.00	0.421	0.35	0.598	0.341	0.678

2008 Age	Stock Size	Natural Mortality	Maturity ogive	Prop. Of F bef. spaw.	Prop. of M bef. spaw.	Stock weights	Exploitation pattern	Catch weights
0	3694105	0.15	0.00	0.421	0.35	0.000	0.007	0.065
1	.	0.15	0.07	0.421	0.35	0.070	0.024	0.136
2	.	0.15	0.58	0.421	0.35	0.161	0.059	0.244
3	.	0.15	0.89	0.421	0.35	0.237	0.114	0.313
4	.	0.15	0.98	0.421	0.35	0.315	0.174	0.375
5	.	0.15	0.98	0.421	0.35	0.360	0.227	0.428
6	.	0.15	0.99	0.421	0.35	0.401	0.274	0.469
7	.	0.15	1.00	0.421	0.35	0.460	0.302	0.504
8	.	0.15	1.00	0.421	0.35	0.474	0.314	0.546
9	.	0.15	1.00	0.421	0.35	0.525	0.336	0.572
10	.	0.15	1.00	0.421	0.35	0.531	0.353	0.602
11	.	0.15	1.00	0.421	0.35	0.564	0.341	0.634
12	.	0.15	1.00	0.421	0.35	0.598	0.341	0.678

2009 Age	Stock Size	Natural Mortality	Maturity ogive	Prop. Of F bef. spaw.	Prop. of M bef. spaw.	Stock weights	Exploitation pattern	Catch weights
0	3694105	0.15	0.00	0.421	0.35	0.000	0.007	0.065
1	.	0.15	0.07	0.421	0.35	0.070	0.024	0.136
2	.	0.15	0.58	0.421	0.35	0.161	0.059	0.244
3	.	0.15	0.89	0.421	0.35	0.237	0.114	0.313
4	.	0.15	0.98	0.421	0.35	0.315	0.174	0.375
5	.	0.15	0.98	0.421	0.35	0.360	0.227	0.428
6	.	0.15	0.99	0.421	0.35	0.401	0.274	0.469
7	.	0.15	1.00	0.421	0.35	0.460	0.302	0.504
8	.	0.15	1.00	0.421	0.35	0.474	0.314	0.546
9	.	0.15	1.00	0.421	0.35	0.525	0.336	0.572
10	.	0.15	1.00	0.421	0.35	0.531	0.353	0.602
11	.	0.15	1.00	0.421	0.35	0.564	0.341	0.634
12	.	0.15	1.00	0.421	0.35	0.598	0.341	0.678

Input units are thousands and kg - output in tonnes

Table 2.10.2 North East Atlantic Mackerel Short term prediction single option table. Catch constraint of 499Kt in 2007 and F status quo for 2008 and 2009.

Year:	2007	F multiplier:	0.8792	Fbar:	0.2272				
Age	F	CatchNos	Yield	StockNo	Biomass	SSNo(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.0058	19675	1279	3694105	0	0	0	0	0
1	0.0215	62491	8499	3158819	220064	221117	15405	207915	14485
2	0.0522	63727	15571	1349000	217639	782420	126230	726273	117172
3	0.1005	176493	55301	1984600	471012	1759679	417630	1600483	379848
4	0.1533	148292	55609	1121300	353583	1095136	345333	974171	307189
5	0.1998	451327	193168	2677000	964612	2614537	942105	2280677	821804
6	0.241	194755	91405	976500	391902	966735	387983	828800	332625
7	0.2657	39046	19679	179600	82616	179600	82616	152378	70094
8	0.2759	45852	25050	204100	96675	204100	96675	172426	81672
9	0.2955	22461	12840	94200	49455	94200	49455	78927	41437
10	0.3104	13060	7858	52500	27878	52500	27878	43712	23211
11	0.2997	8714	5527	36100	20360	36100	20360	30193	17029
12	0.2997	10645	7213	44100	26372	44100	26372	36884	22057
Total		1256536	499000	15571924	2922168	8050224	2538042	7132840	2228622

Year:	2008	F multiplier:	1	Fbar:	0.2584				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNo(Jan)	SSB(Jan)	SSNos(ST)	SB(ST)
0	0.0065	22349	1453	3694105	0	0	0	0	0
1	0.0245	71000	9657	3161323	220239	221293	15418	207822	14478
2	0.0594	142433	34800	2660924	429295	1543335	248992	1428267	230426
3	0.1141	110706	34686	1102071	261558	977169	231915	883615	209712
4	0.1744	230001	86251	1544783	487122	1508737	475755	1330242	419470
5	0.2270	156688	67062	827925	298330	808607	291368	697250	251243
6	0.2738	421354	197757	1886832	757249	1867964	749676	1579281	633818
7	0.3020	160547	80916	660508	303834	660508	303834	551849	253851
8	0.3138	29747	16253	118511	56134	118511	56134	98535	46672
9	0.3358	35477	20281	133317	69991	133317	69991	109809	57649
10	0.3531	16735	10067	60336	32039	60336	32039	49343	26201
11	0.3409	8921	5660	33129	18685	33129	18685	27232	15359
12	0.3409	13777	9337	51152	30590	51152	30590	42047	25144
Total		1419745	574177	15934915	2965063	7984059	2524394	7004591	2183903

Year:	2009	F multiplier:	1	Fbar:	0.2584				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNo(Jan)	SSB(Jan)	SSNos(ST)	SB(ST)
0	0.0065	22349	1453	3694105	0	0	0	0	0
1	0.0245	70945	9649	3158814	220064	221118	15404	207656	14467
2	0.0594	142124	34724	2655170	428368	1540000	248454	1425179	229930
3	0.1141	216814	67936	2158318	512240	1913709	454187	1730492	410704
4	0.1744	125972	47240	846072	266794	826330	260570	728569	229742
5	0.2270	211364	90463	1116843	402435	1090783	393046	940567	338918
6	0.2738	126787	59506	567750	227856	562072	225578	475207	190717
7	0.3020	300113	151258	1234714	567968	1234714	567968	1031595	474534
8	0.3138	105481	57629	420226	199047	420226	199047	349392	165496
9	0.3358	19834	11337	74532	39130	74532	39130	61391	32230
10	0.3531	22742	13683	81994	43539	81994	43539	67055	35606
11	0.3409	9826	6234	36484	20577	36484	20577	29991	16915
12	0.3409	13893	9415	51588	30850	51588	30850	42406	25358
Total		1388294	560535	16097008	2958941	8052235	2498165	7087731	2164354

Input units are thousands and kg - output in tonnes

Table 2.10.3 North East Atlantic Mackerel. . Short term prediction; single area management option table. OPTION: Catch constraint 499Kt in 2007.

2007

Biomass	SSB	FMult	FBar	Landings
2921809	2231466	0.8792	0.2272	499000

2008					2009		% change
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB	in 2008 landings
2965063	2395284	0.000	0.00	0	3471734	2845364	-100%
.	2386687	0.039	0.01	24777	3449561	2814403	-95%
.	2378125	0.077	0.02	49332	3427591	2783858	-90%
.	2369598	0.116	0.03	73667	3405821	2753724	-85%
.	2361107	0.155	0.04	97783	3384251	2723994	-80%
.	2352650	0.194	0.05	121683	3362878	2694663	-76%
.	2344227	0.232	0.06	145370	3341699	2665725	-71%
.	2335840	0.271	0.07	168845	3320713	2637174	-66%
.	2327486	0.310	0.08	192111	3299919	2609005	-62%
.	2319167	0.348	0.09	215169	3279313	2581211	-57%
.	2310882	0.387	0.10	238022	3258894	2553787	-52%
.	2302630	0.426	0.11	260672	3238660	2526729	-48%
.	2294413	0.464	0.12	283120	3218610	2500030	-43%
.	2286229	0.503	0.13	305370	3198741	2473685	-39%
.	2278078	0.542	0.14	327422	3179052	2447690	-34%
.	2269961	0.581	0.15	349279	3159540	2422038	-30%
.	2261877	0.619	0.16	370943	3140205	2396726	-26%
.	2253826	0.658	0.17	392415	3121044	2371748	-21%
.	2245808	0.697	0.18	413698	3102055	2347099	-17%
.	2237822	0.735	0.19	434793	3083236	2322774	-13%
.	2229869	0.774	0.20	455703	3064587	2298770	-9%
.	2219436	0.813	0.21	476616	3046472	2274018	-4%
.	2211547	0.851	0.22	497167	3028152	2250624	0%
.	2203689	0.890	0.23	517538	3009996	2227537	4%
.	2195862	0.929	0.24	537731	2992002	2204751	8%
.	2188069	0.968	0.25	557747	2974168	2182263	12%
.	2180307	1.006	0.26	577588	2956495	2160069	16%
.	2172577	1.045	0.27	597255	2938978	2138163	20%
.	2164878	1.084	0.28	616751	2921618	2116542	24%
.	2157210	1.122	0.29	636078	2904411	2095202	27%
.	2149574	1.161	0.30	655236	2887358	2074139	31%

Input units are thousands and kg - output in tonnes

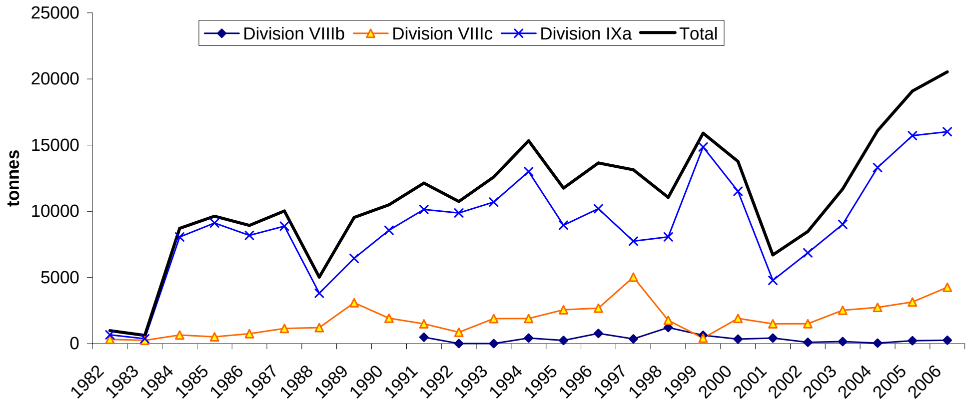


Figure 2.2.4.1 Annual landings of Scomber colias by ICES divisions since 1982 to 2006.

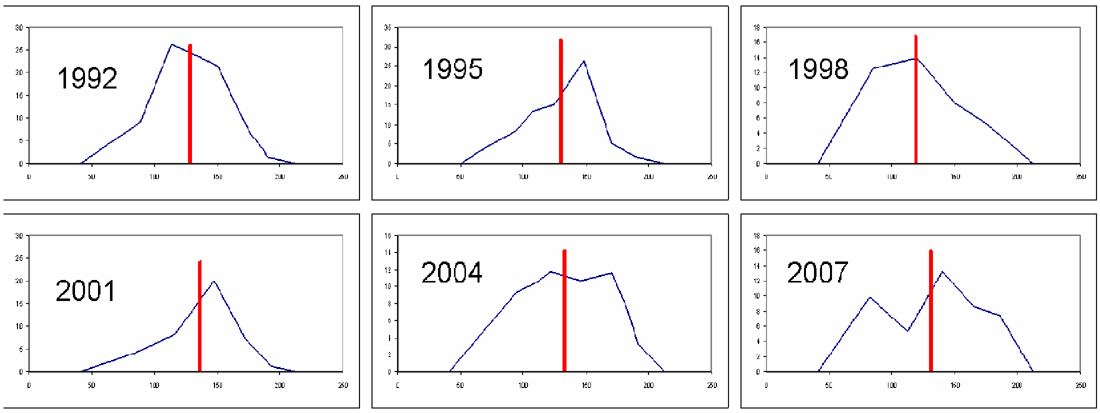


Figure 2.4.6.1. Average egg production in 10^12 per Julian day during spawning season for each year of the egg survey. The red line indicates the Julian day by which 50% of the egg spawning had occurred.

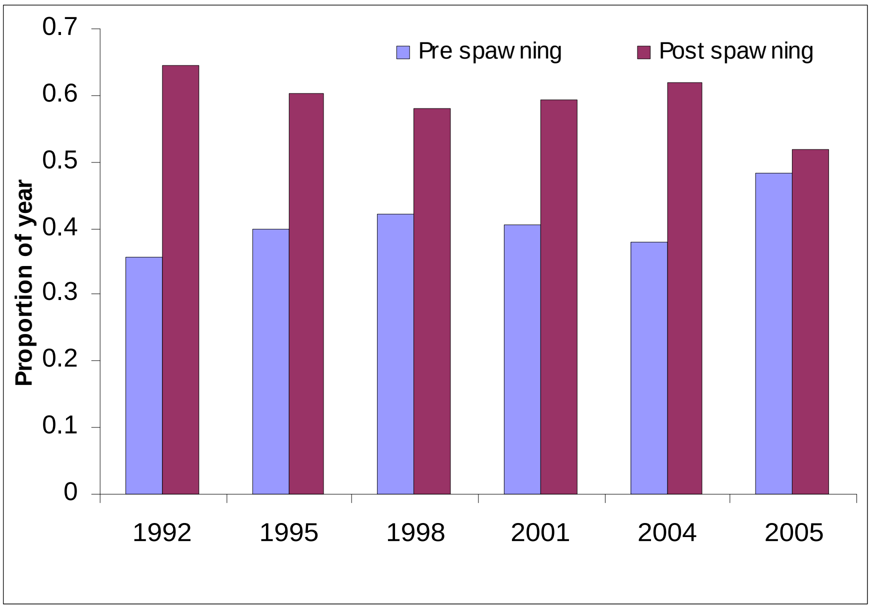


Figure 2.4.6.2. Proportion of catch weights in the fishery pre and post spawning over time.

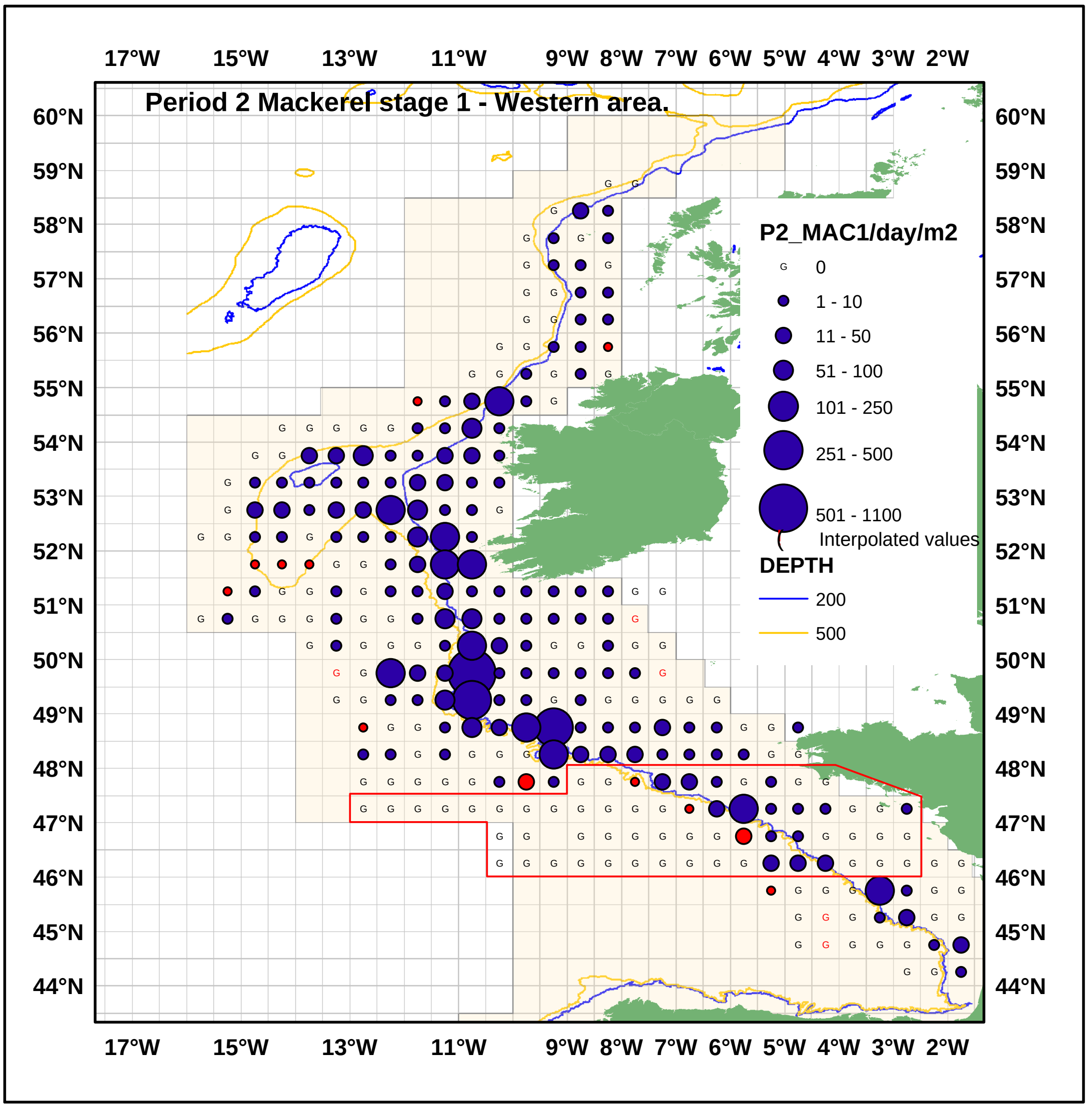


Figure 2.5.1.1a Period 2 – Mackerel stage 1 eggs in the western area (area outlined in red contains stations sampled within period 3 during AZTI period 2 survey).

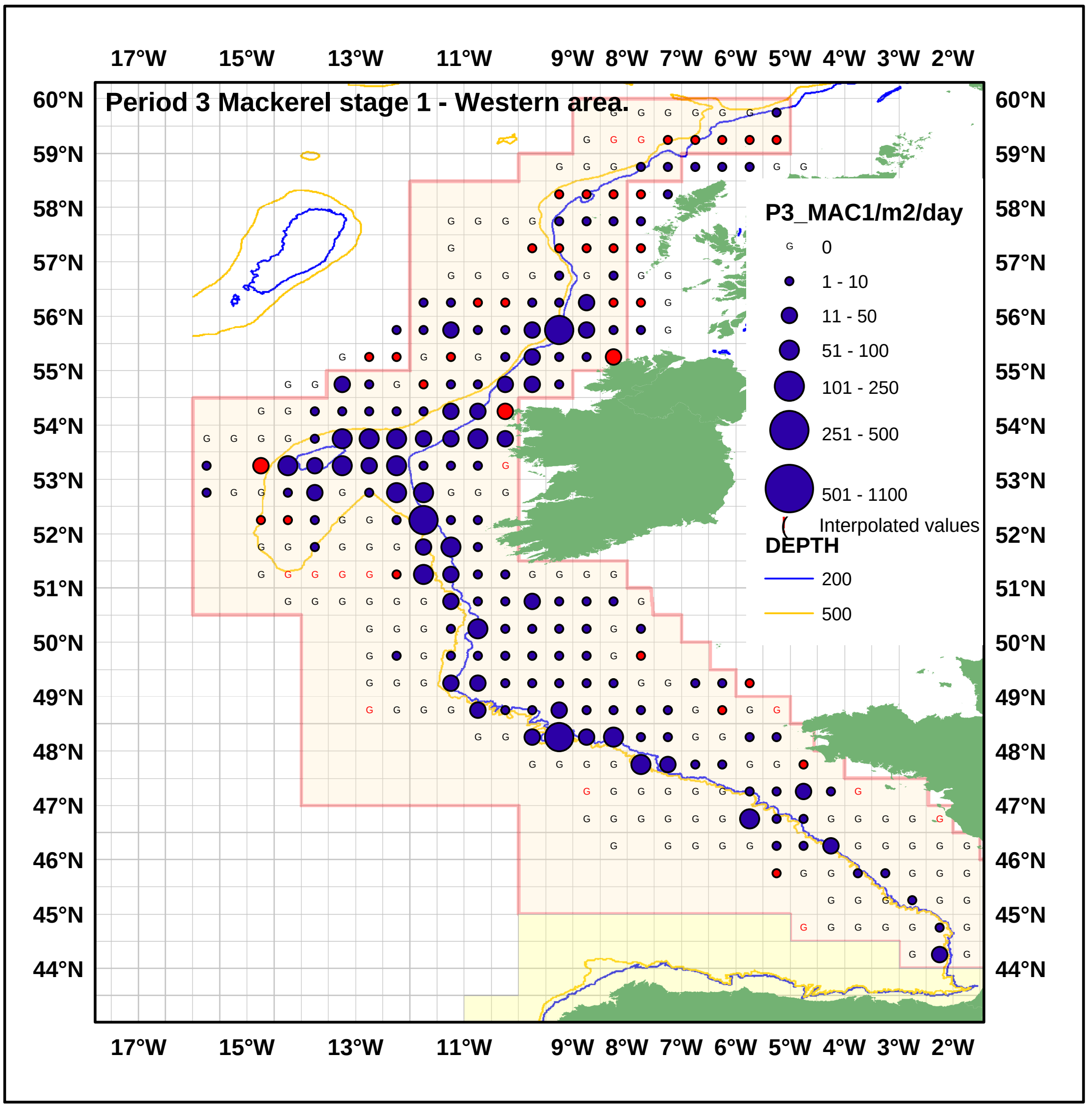


Figure 2.5.1.1.b Period 3 – Mackerel stage 1 eggs in the western arae

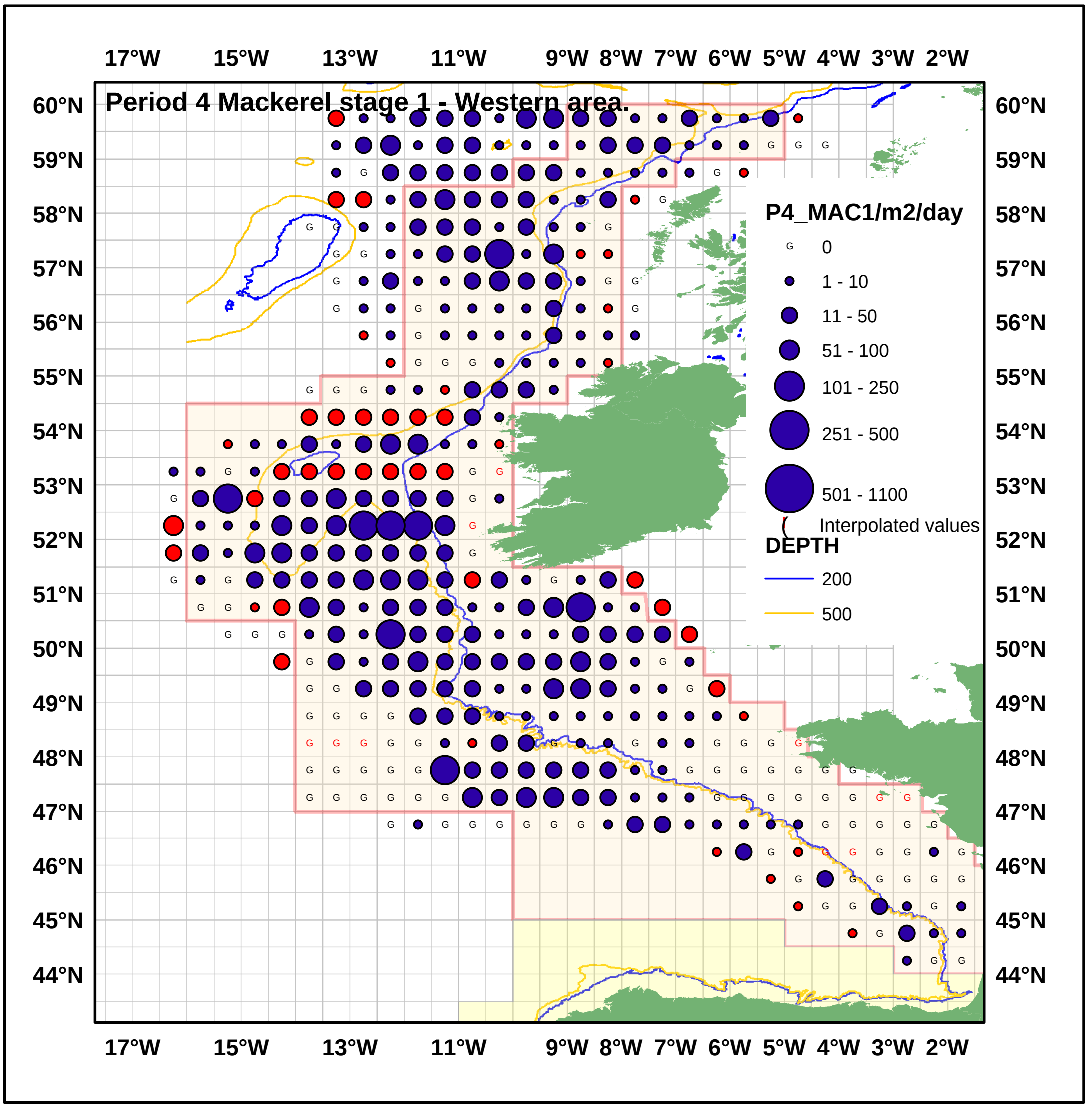


Figure 2.5.1.1.c Period 4 – Mackerel stage 1 eggs in the western area

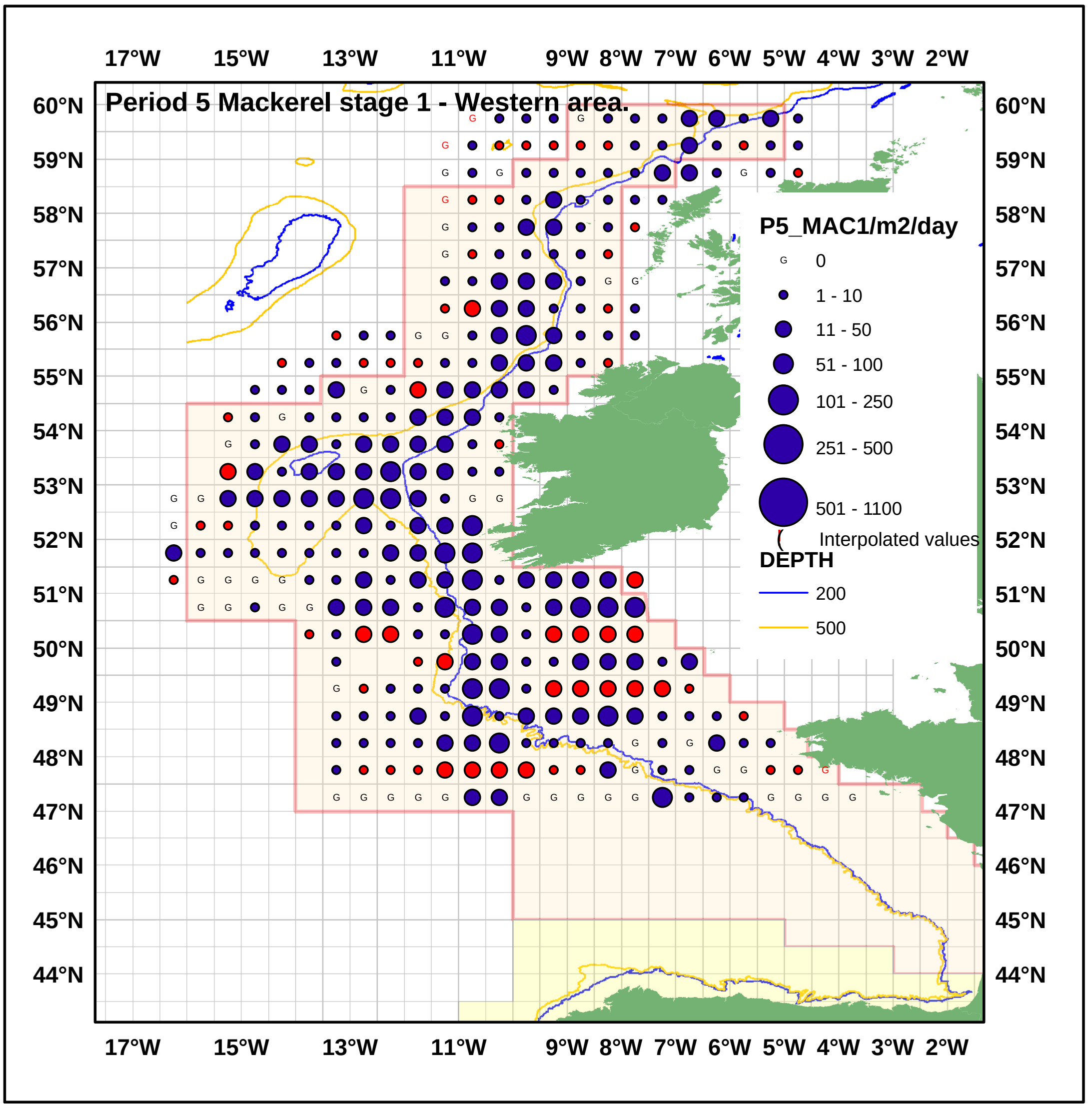


Figure 2.5.1.1.d Period 5 – Mackerel stage 1 eggs in the western area

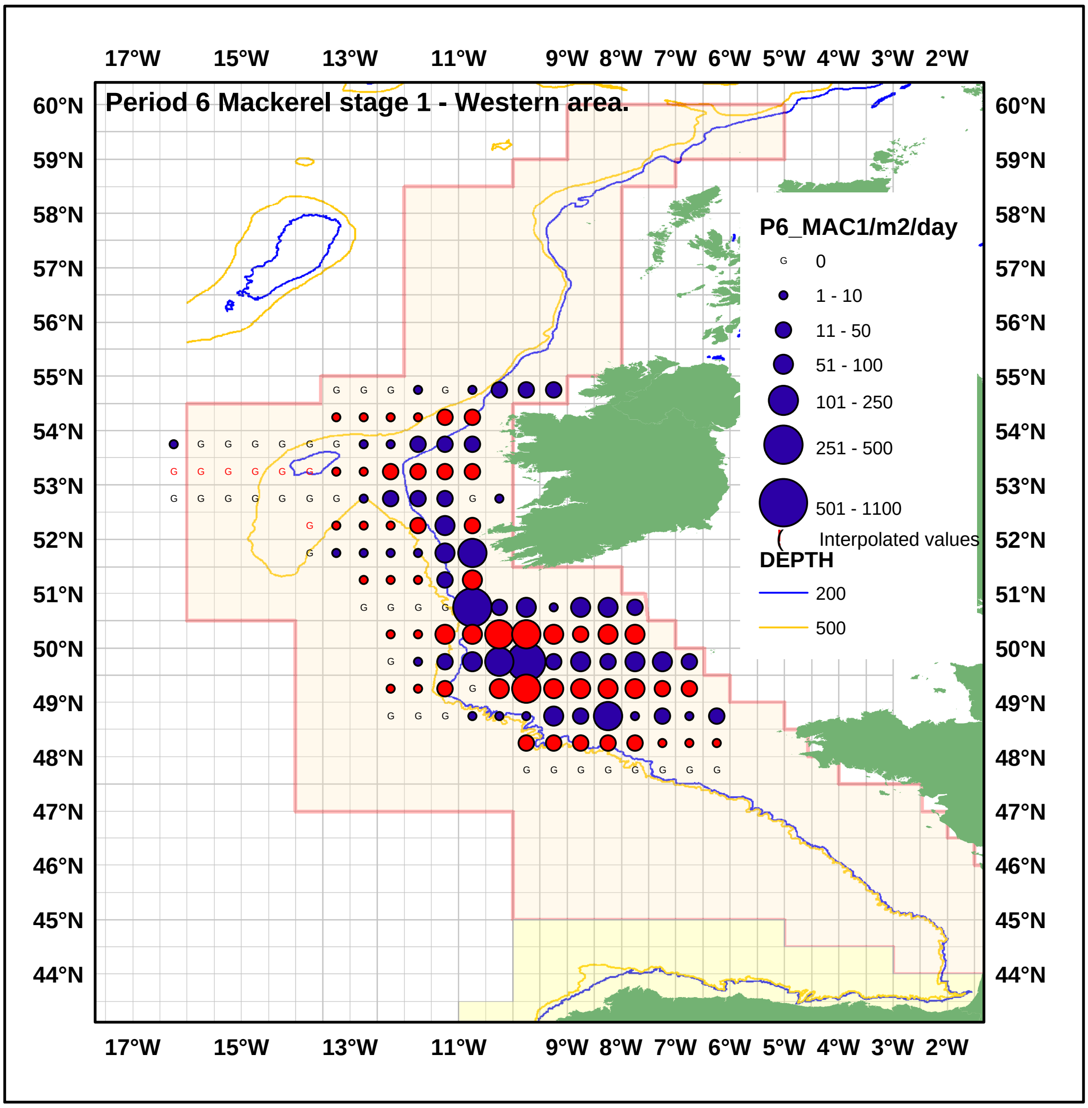


Figure 2.5.1.1.e Period 6 – Mackerel stage 1 eggs in the western area

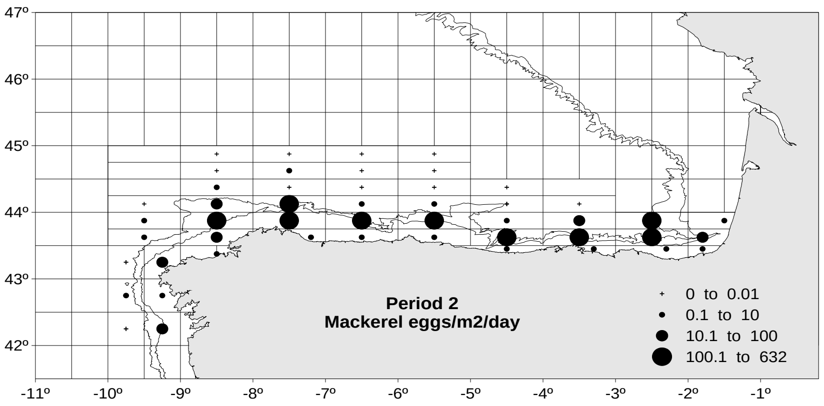


Figure 2.5.1.2.a Period 2 – Mackerel eggs stage 1 in the southern area

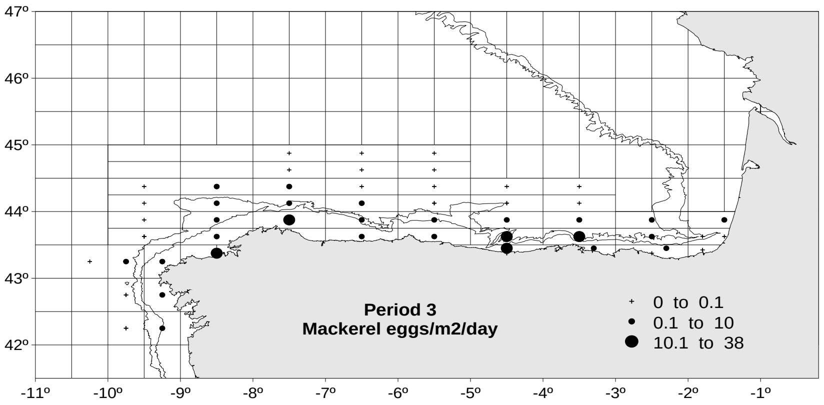


Figure 2.5.1.2.b Period 3 – Mackerel eggs stage 1 in the southern area

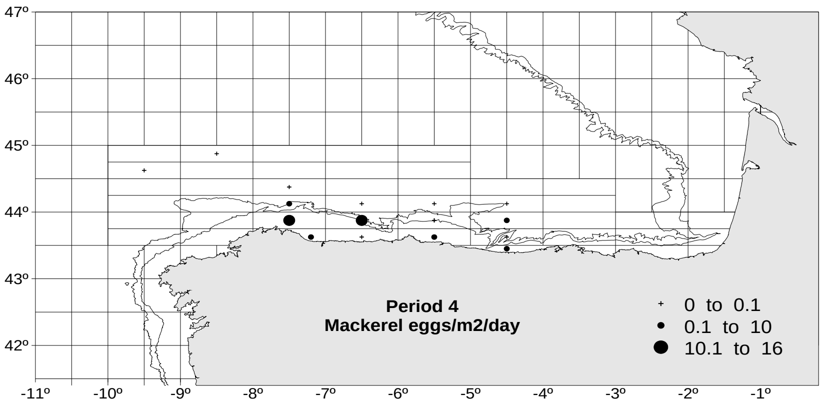


Figure 2.5.1.2.c Period 4 – Mackerel eggs stage 1 in the southern area

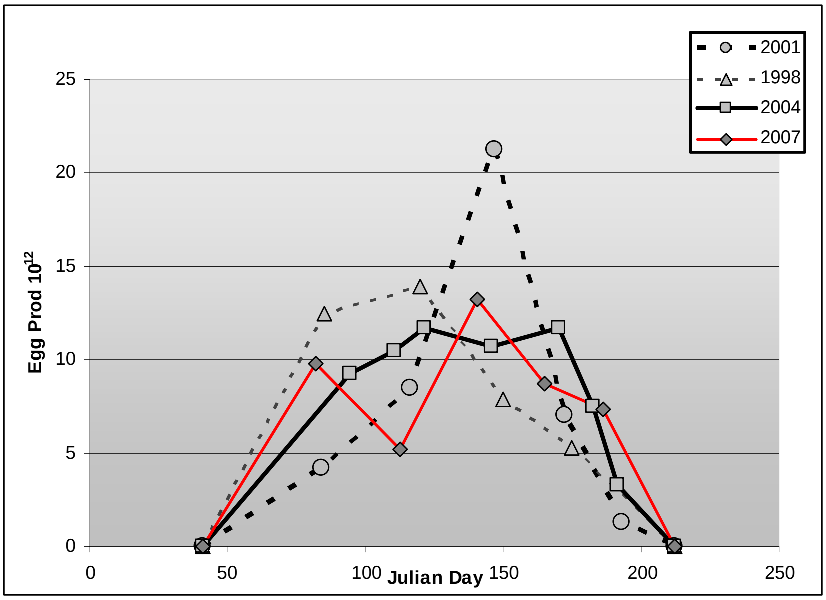
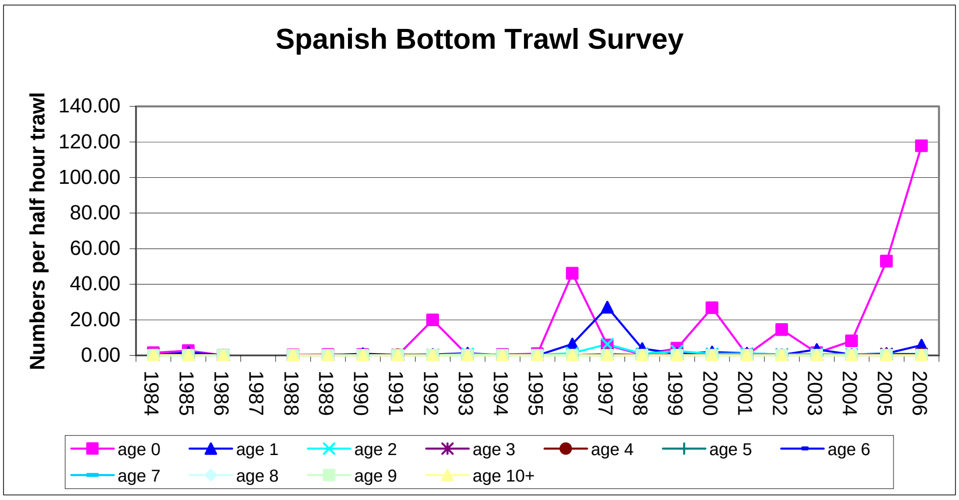


Figure 2.5.1.3 Annual egg production curve for western mackerel. Preliminary results.



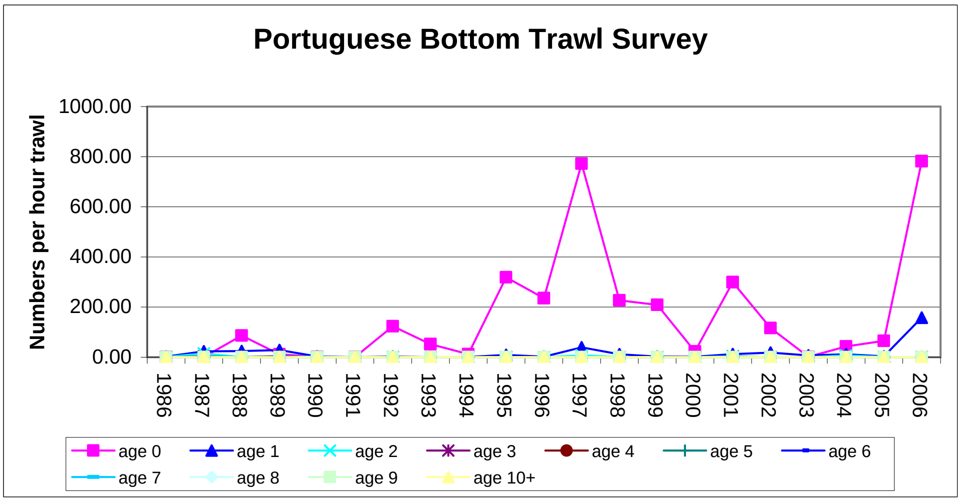


Figure 2.5.5.1.- NEA mackerel (southern component). Mackerel numbers at age from the Spanish and Portuguese bottom trawl surveys from 1984 to 2006 in Autumn.

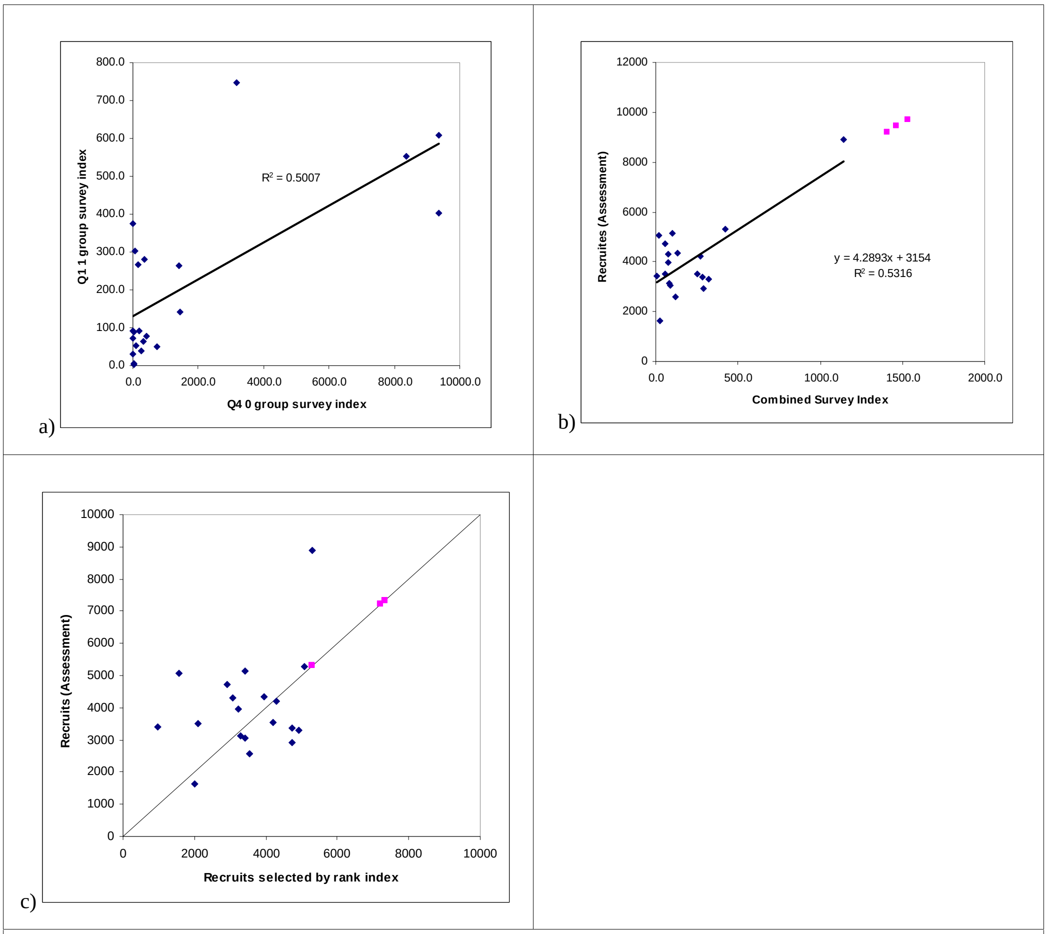


Figure 2.5.6.1 Relationships between recruit surveys and assessment estimates of recruitment. A) Comparison between Q4 0 group survey and Q1 1 group survey showing cluster of low observations and 4 recent high values. b) Regression between combined survey index and assessment, sensitivity to one value (2002) yearclass with three recent survey values estimated by the regression. C) Rank based estimation of recent values.

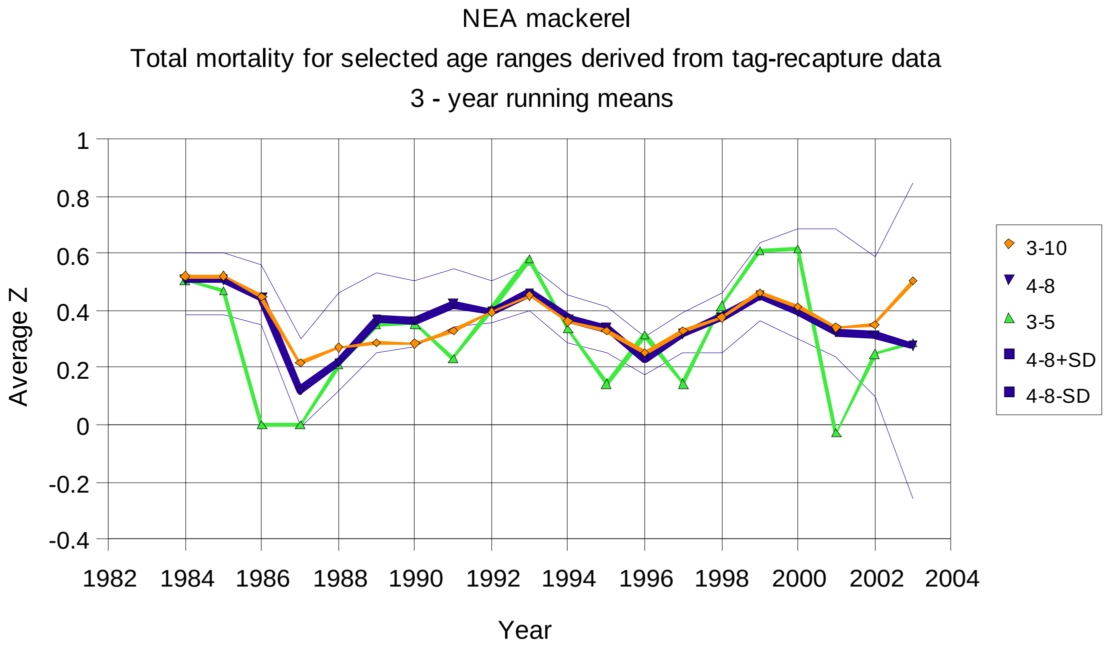


Figure 2.5.7.1. Estimates of total mortality from tag recaptures. 3-year running means of the average over ages as indicated. Mean +- Standatd deviation is shown for the are range 4-8.

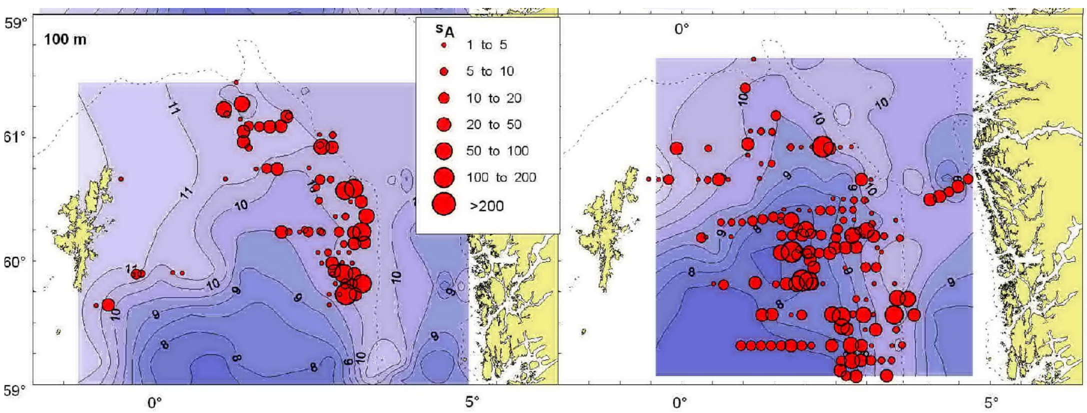


Figure 2.5.9.1.1. Acoustic surveys in the northern North Sea in October-November 2005 (left) and 2006 (right). The figures illustrate acoustic S_A values (1 - >200) overlaid temperature distribution at 100 m depth.

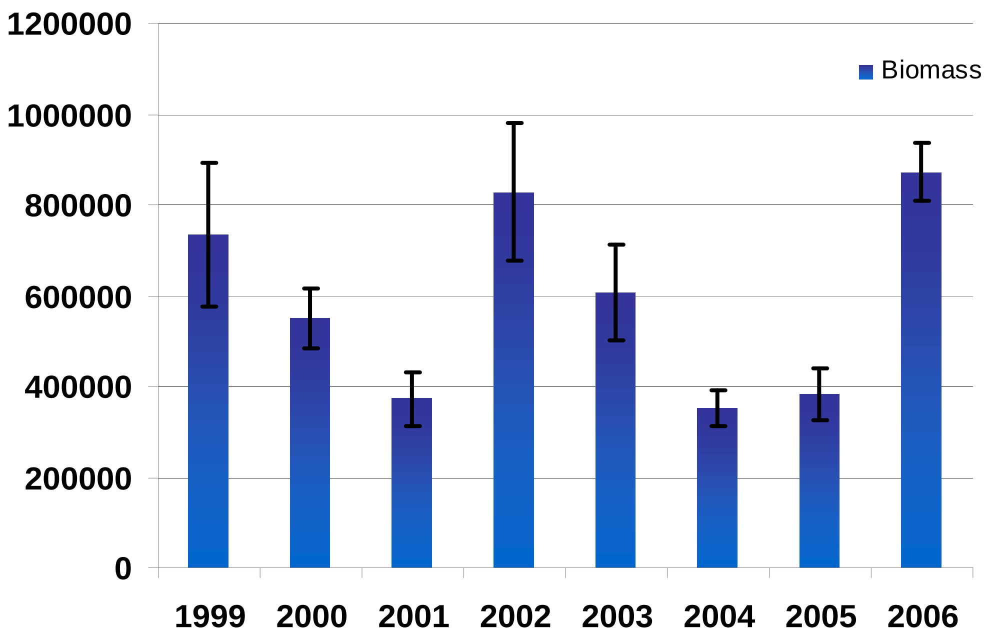


Figure 2.5.9.1.2. Acoustic biomass estimates in tons with standard deviation (SD) for NEA mackerel from the northern North Sea acoustic surveys during the period 1999-2006.

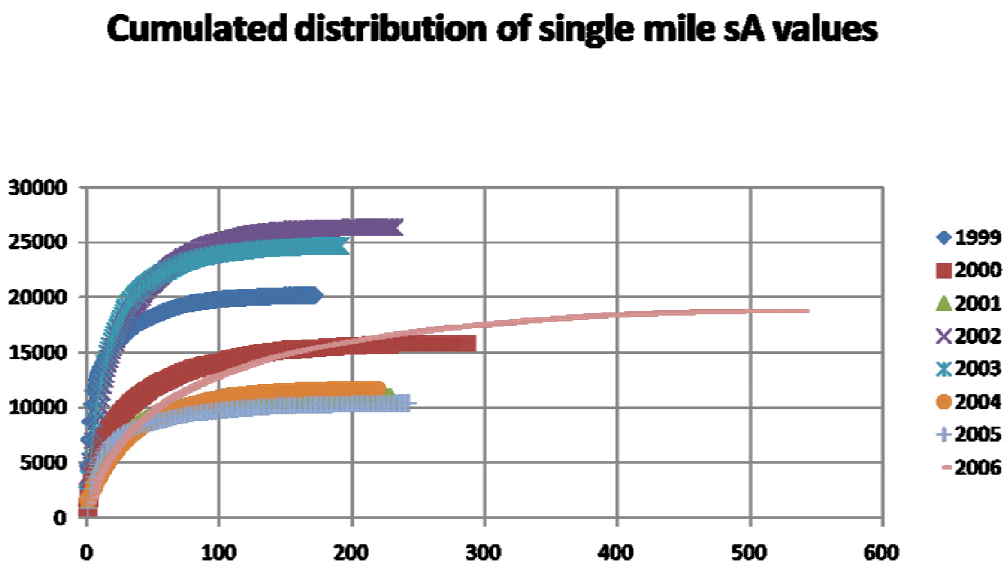


Figure 2.5.9.1.3. Accumulated distribution of single nautical mile S_A values for NEA mackerel in the Northern North Sea. Note how large proportion of the total accumulated S_A values, which originates from 10-20 nmil sampled distance.

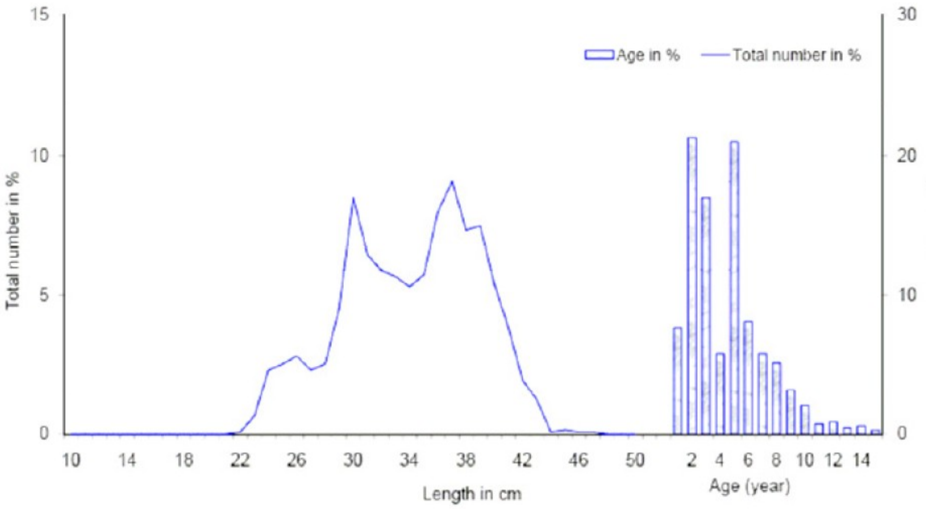


Figure 2.5.9.1.4. Length and age distribution of NEA mackerel based on intensive pelagic trawling with Egersund trawl in the Norwegian Sea applying the commercial fishing vessels Libas and Eros in July-August 2007.

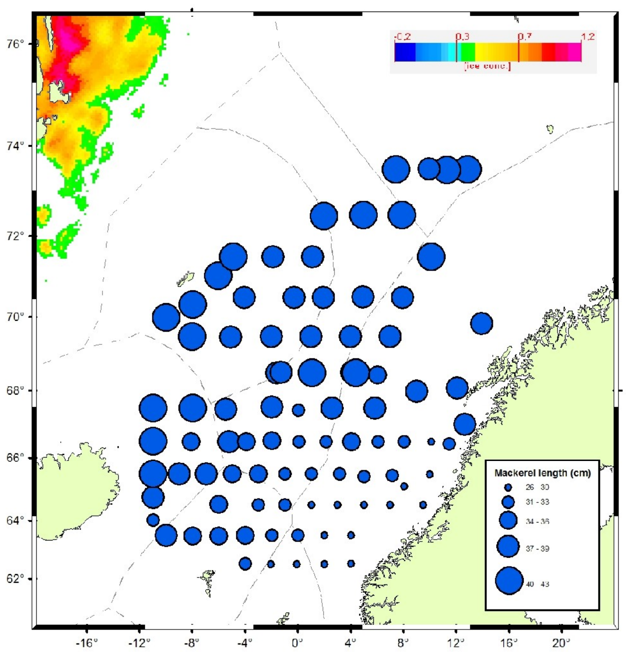


Figure 2.5.9.1.5. Mean mackerel length (cm) based on 5451 individual samples represented for each biological station within the categories shown on the map. No catch of mackerel is indicated as a blank along the cruise track.

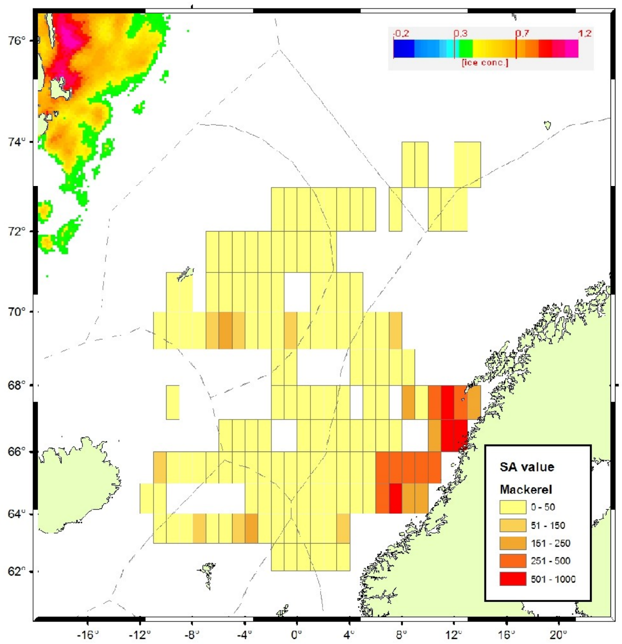


Figure 2.5.9.1.6. S_A or Nautical Area Scattering Coefficient (NASC) values of NEA mackerel for each 1º latitude * 1º longitude along the cruise track.

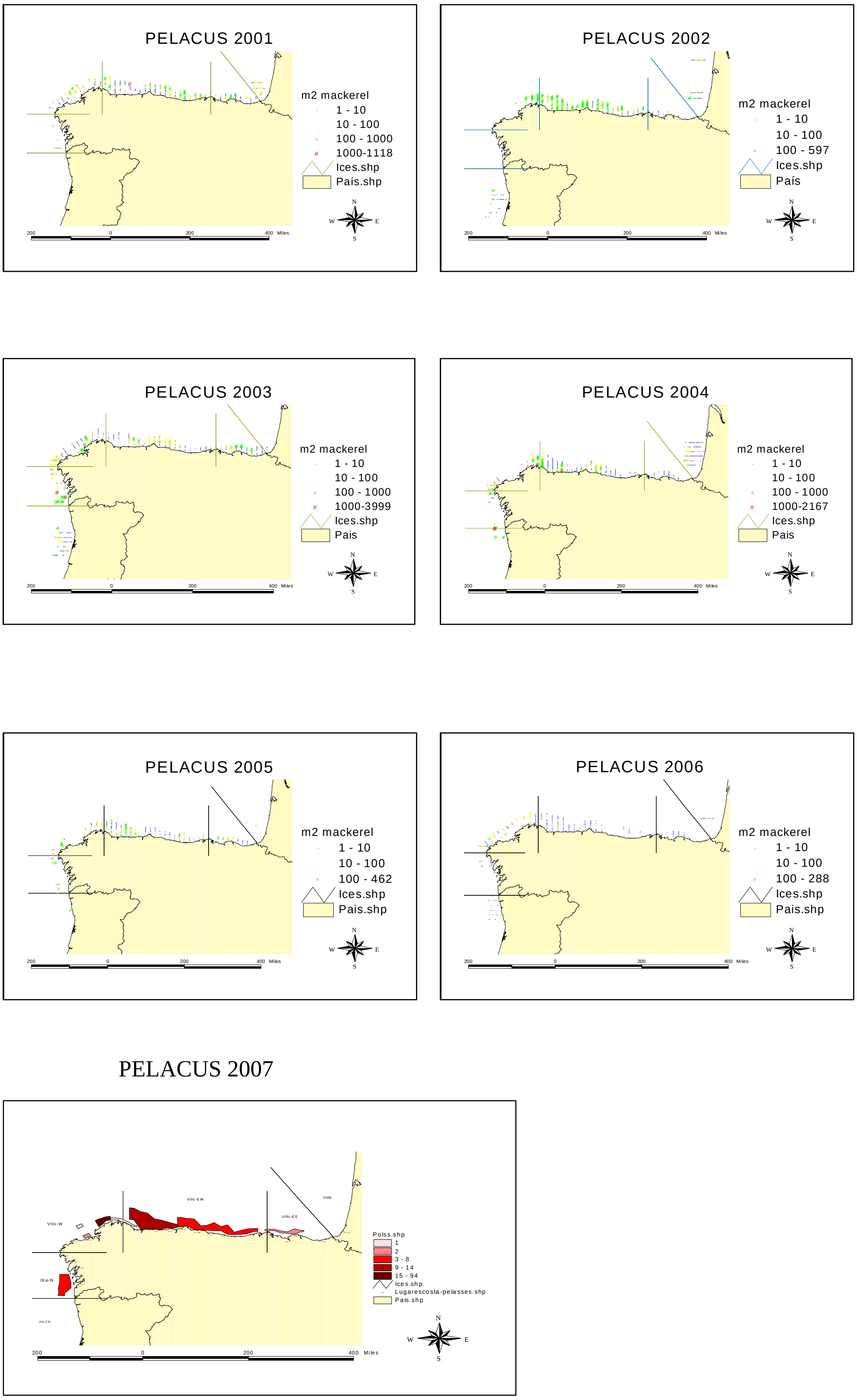
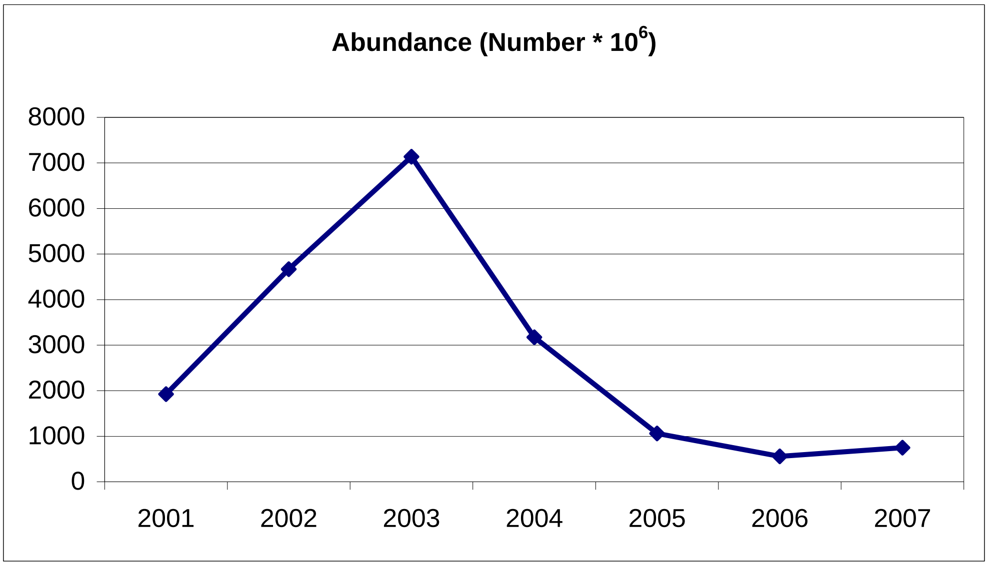


Figure 2.5.9.2.1 NEA mackerel. Mackerel distribution derived from backscattered energy (NASC). Spanish acoustic surveys PELACUS 2001-2007. In the 2007 survey polygons are drawn to encompass the observed echoes, and polygon colour indicates the average of values of integrated energy in m2 within each polygon.



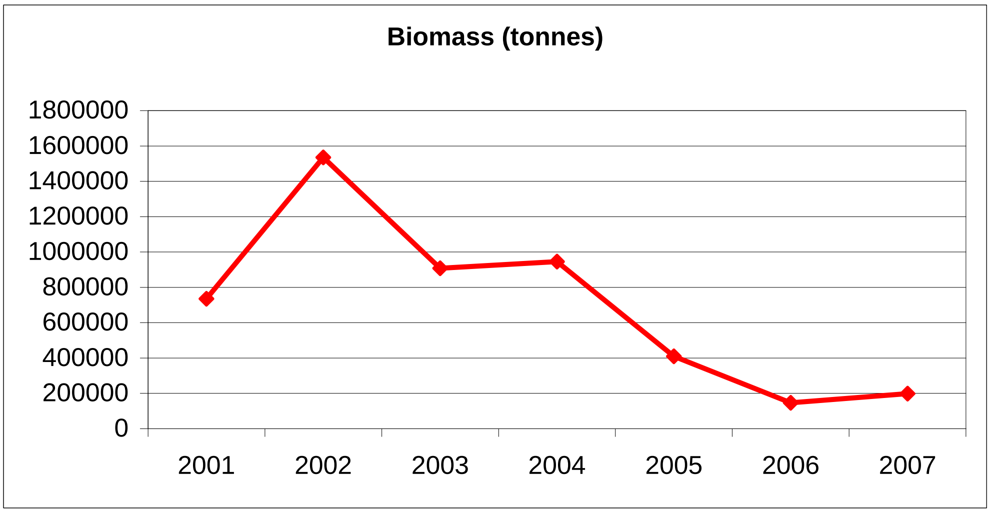


Figure 2.5.9.2.2. NEA mackerel. Spanish acoustic surveys from 2001 to 2007. Mackerel Abundance in number of individuals (millions) and Biomass in tons.

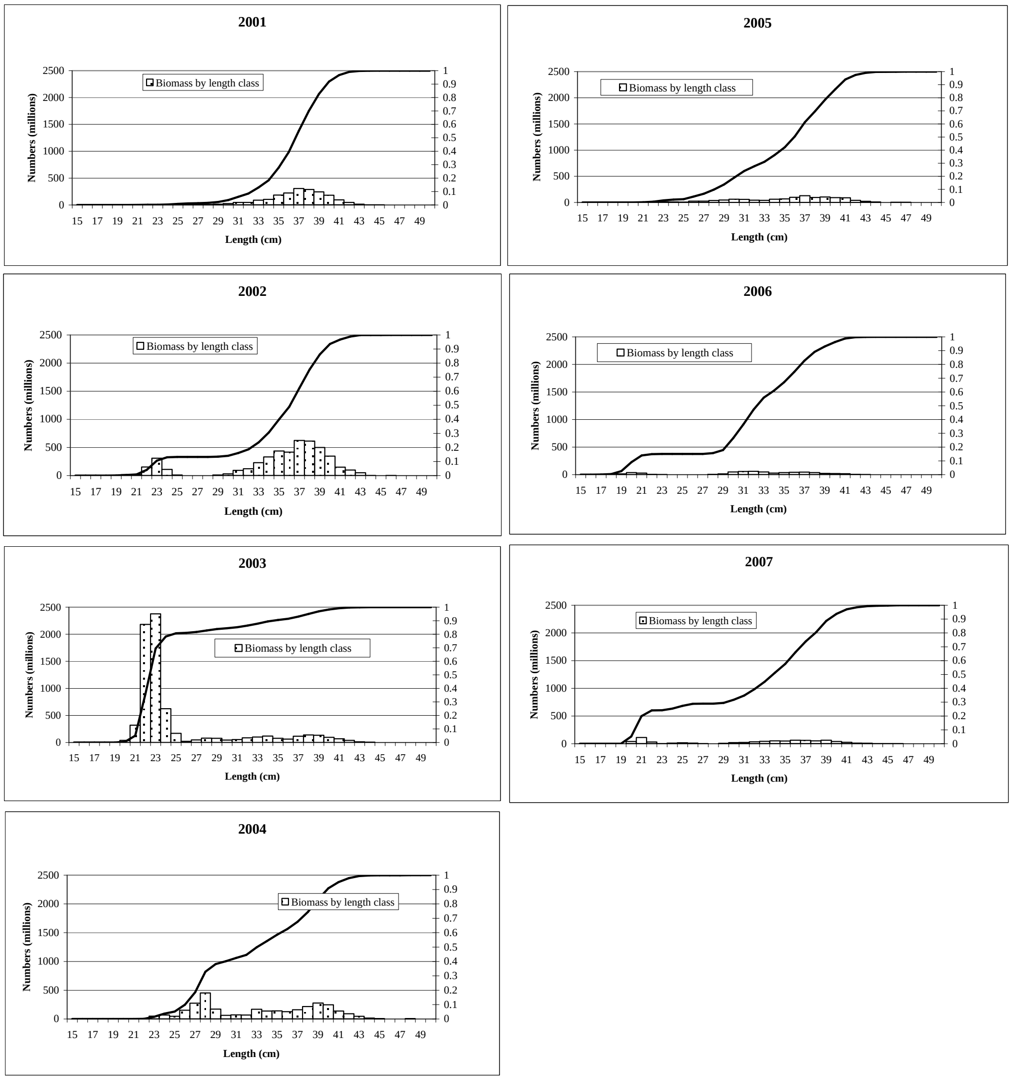


Figure 2.9.5.2.3. NEA mackerel. Mackerel length distribution for the Spanish acoustic survey from 2001 to 2007 in Sub-division IXa North and Division VIIIc (Spanish waters). The line denotes the cumulative frequency.

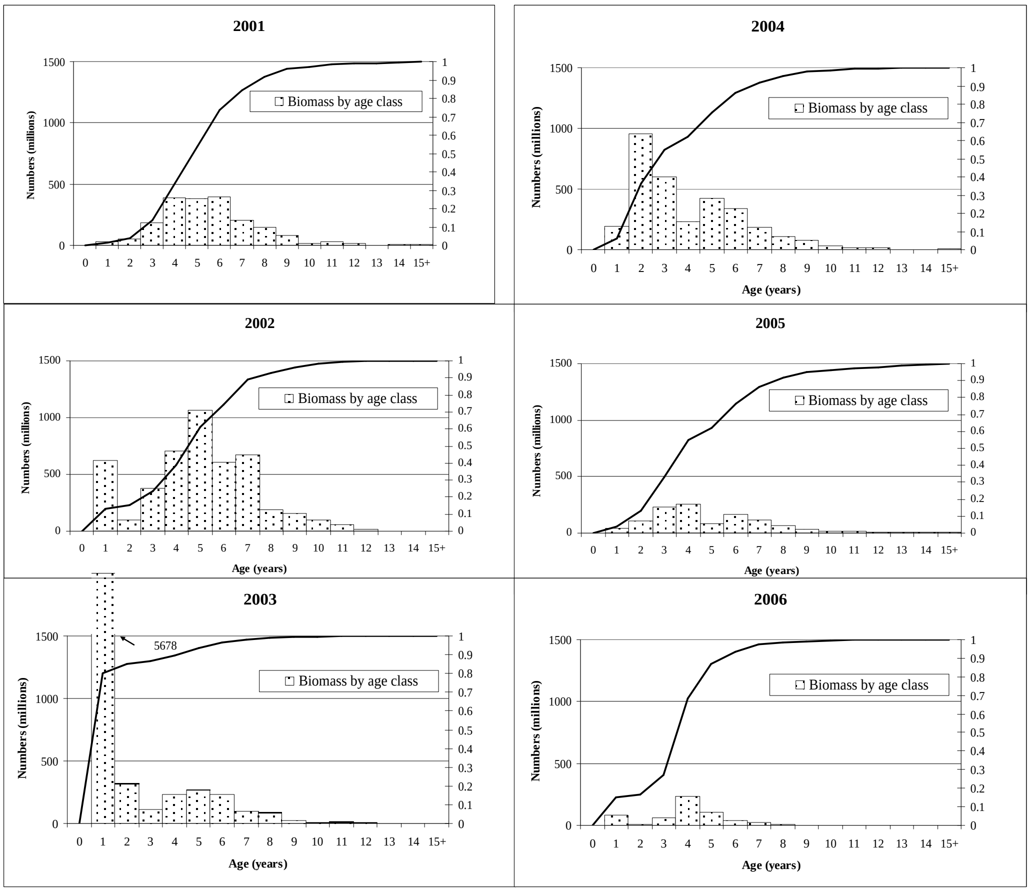


Figure 2.5.9.2.4 NEA Mackerel. Mackerel age distribution for the Spanish acoustic survey from 2001 to 2006 in Sub-division IXa North and Division VIIIc (Spanish waters). The line denotes the cumulative frecuency.

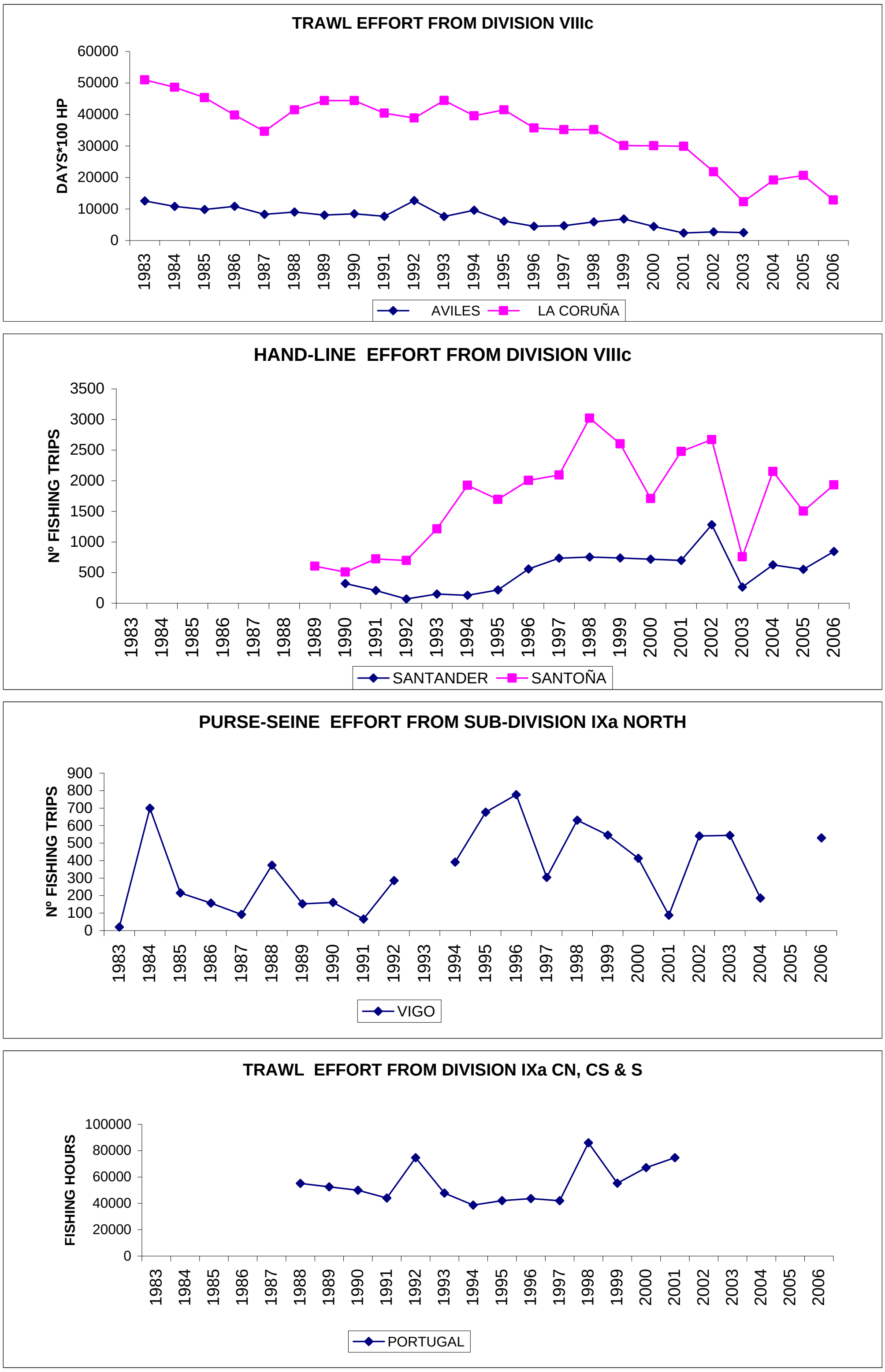


Figure 2.6.1. NEA mackerel (Southern component). Effort data by fleets and area .

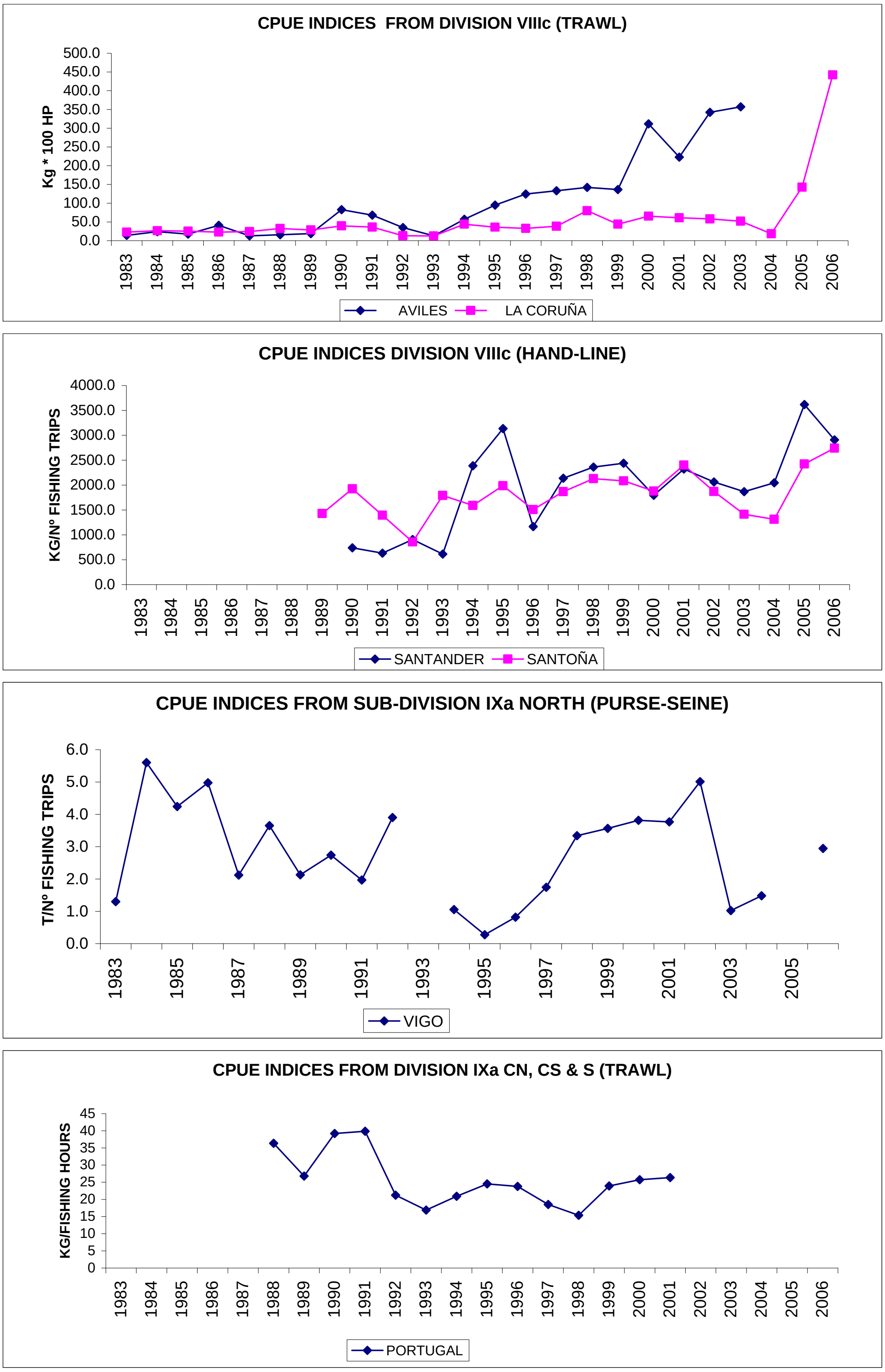


Figure 2.6.2. NEA mackerel (Southern component). CPUE indices by fleets and area

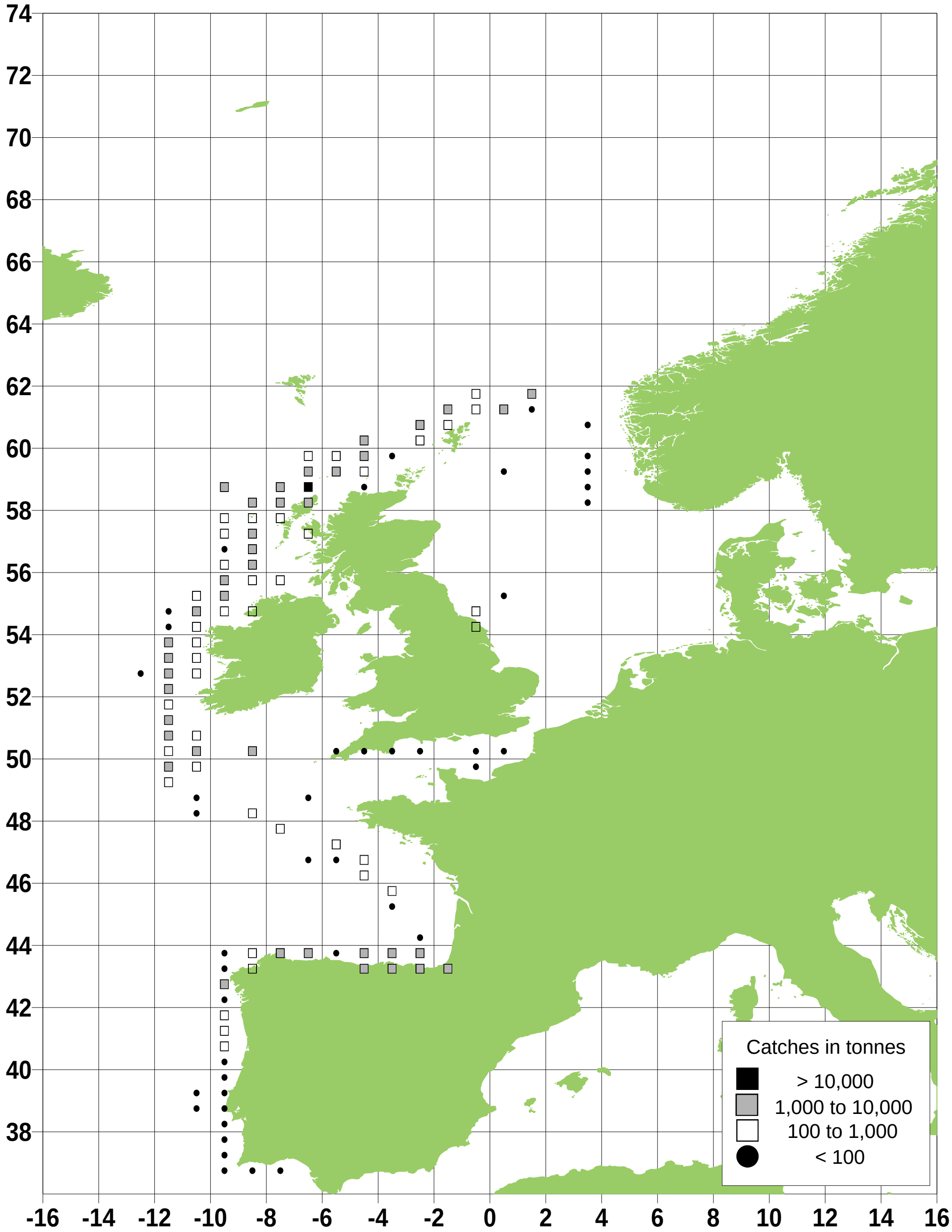


Figure 2.7.1.1. NEA Mackerel, commercial catches in quarter 1, 2006.

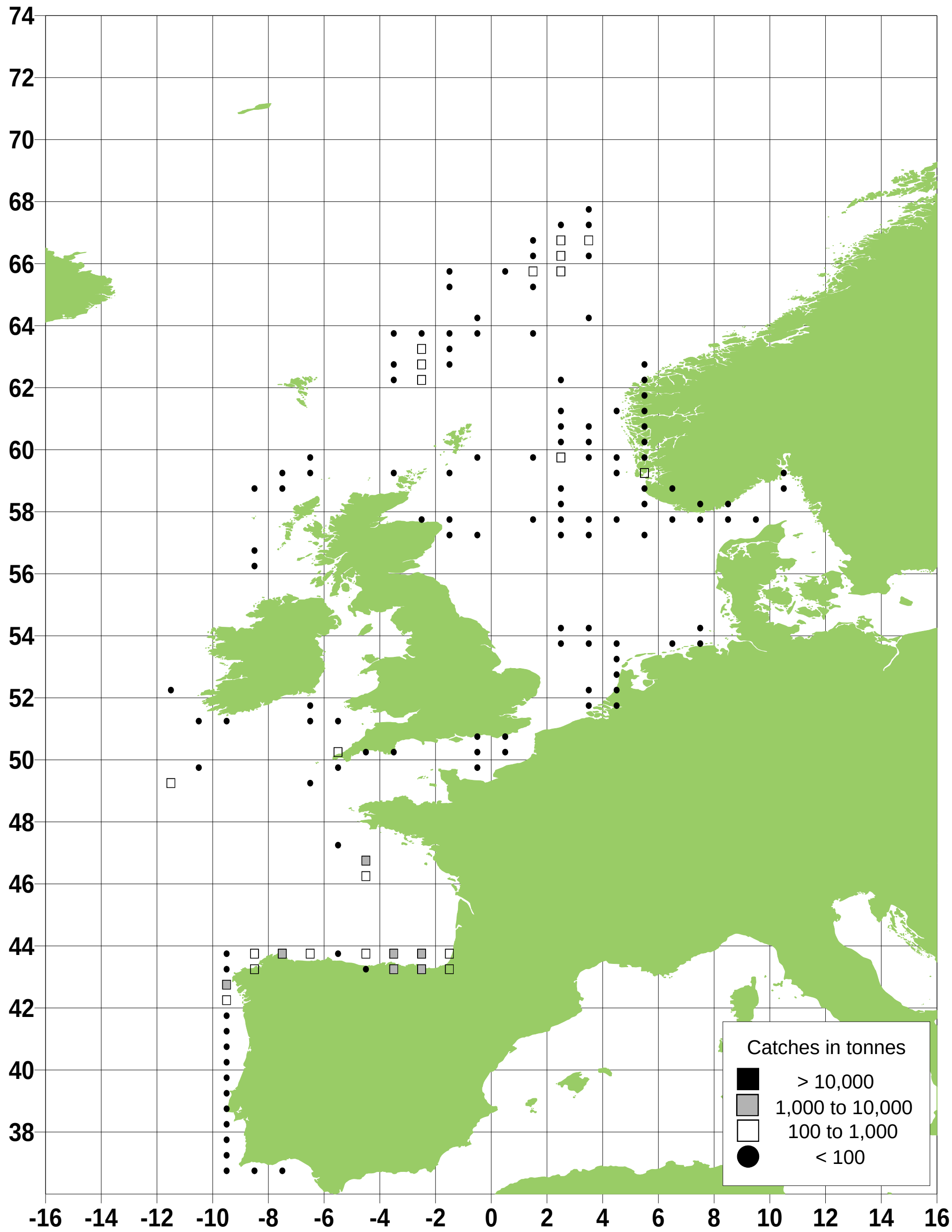


Figure 2.7.1.2. NEA Mackerel commercial catches in quarter 2, 2006.

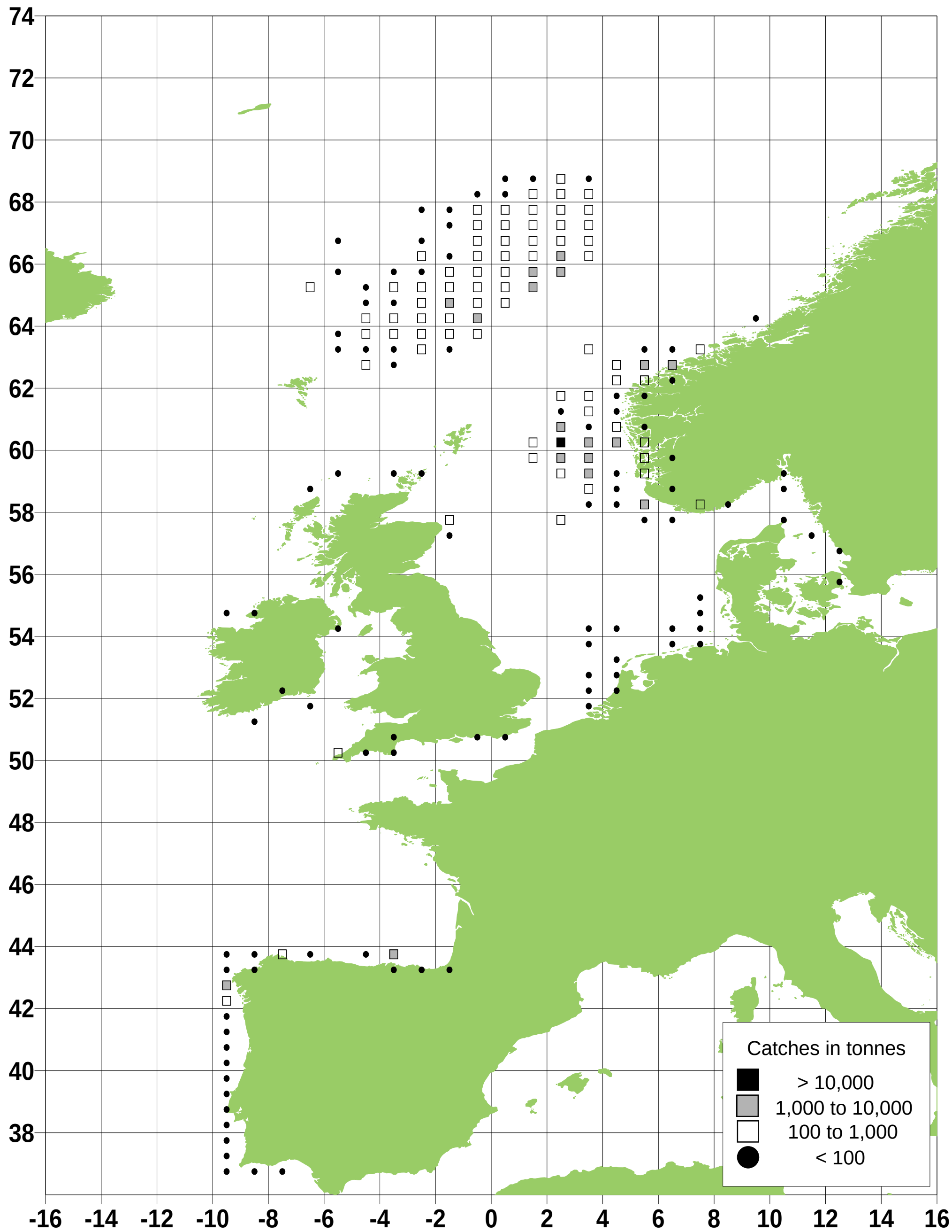


Figure 2.7.1.3. NEA Mackerel commercial catches in quarter 3, 2006.

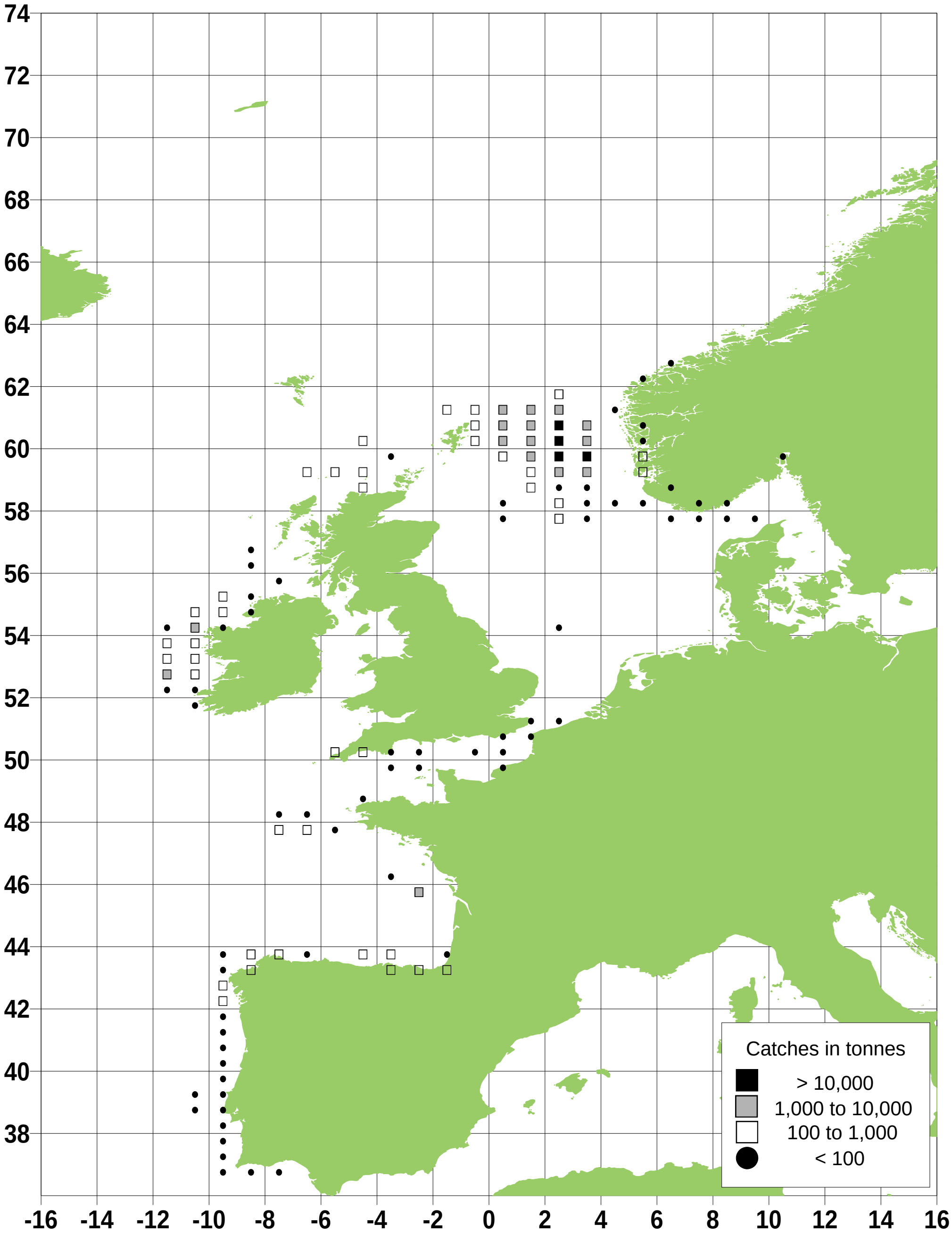


Figure 2.7.1.4. NEA Mackerel commercial catches in quarter 4, 2006.

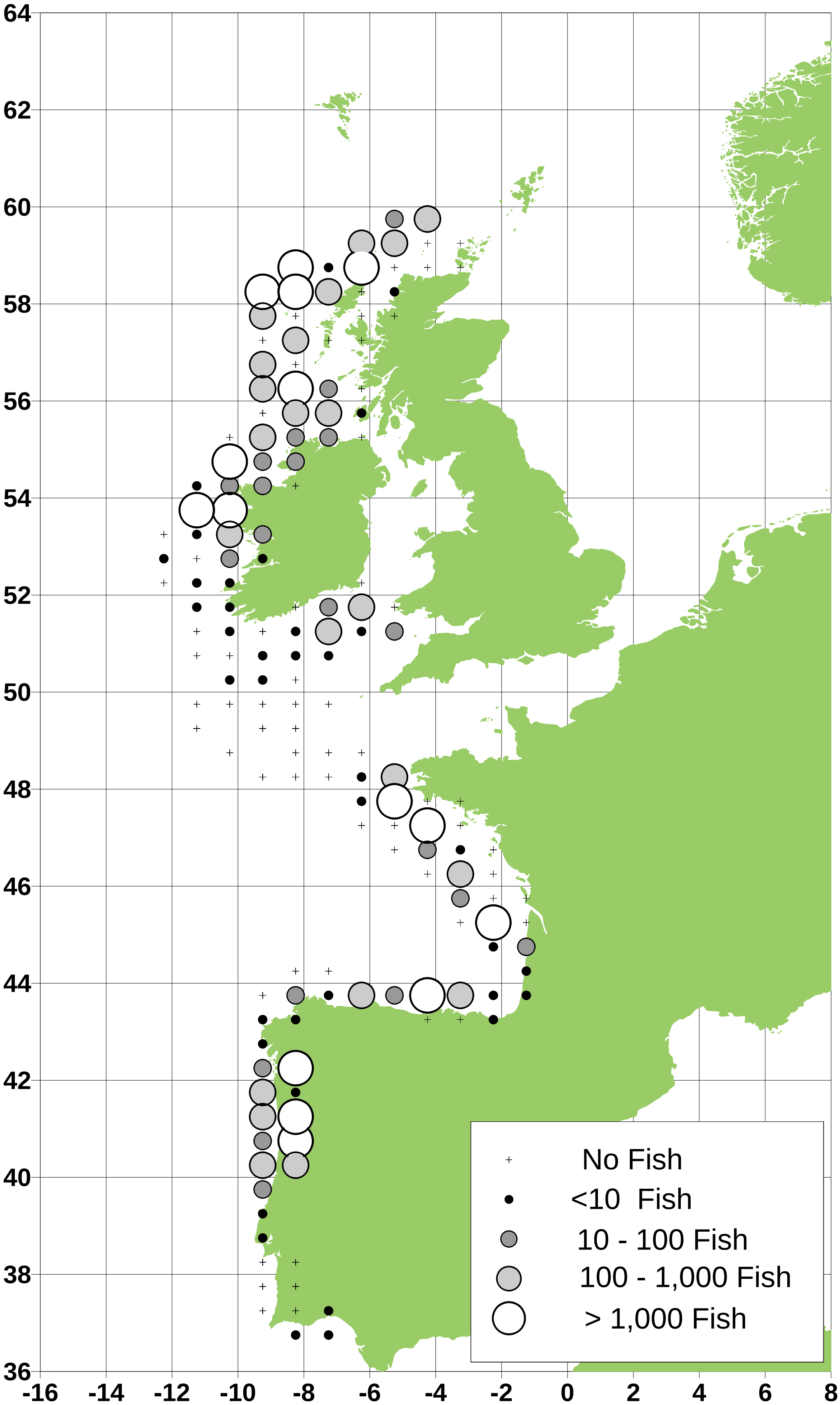


Figure 2.7.2.1. NEA Mackerel distribution of recruits, 2006 year class (age 0) in quarter 4, 2006.

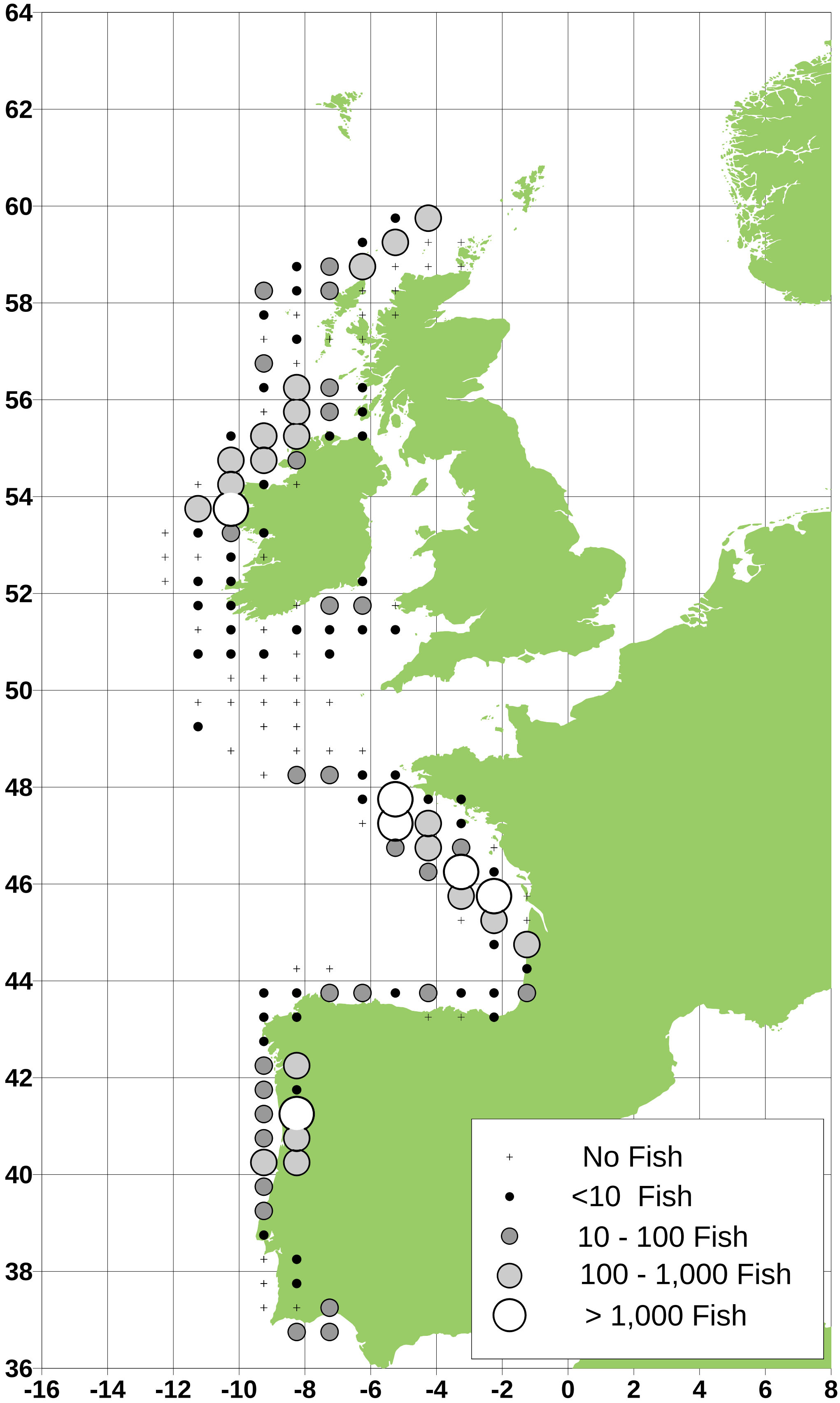


Figure 2.7.2.2. NEA Mackerel distribution of recruits, 2005 year class (age 1) in quarter 4, 2006.

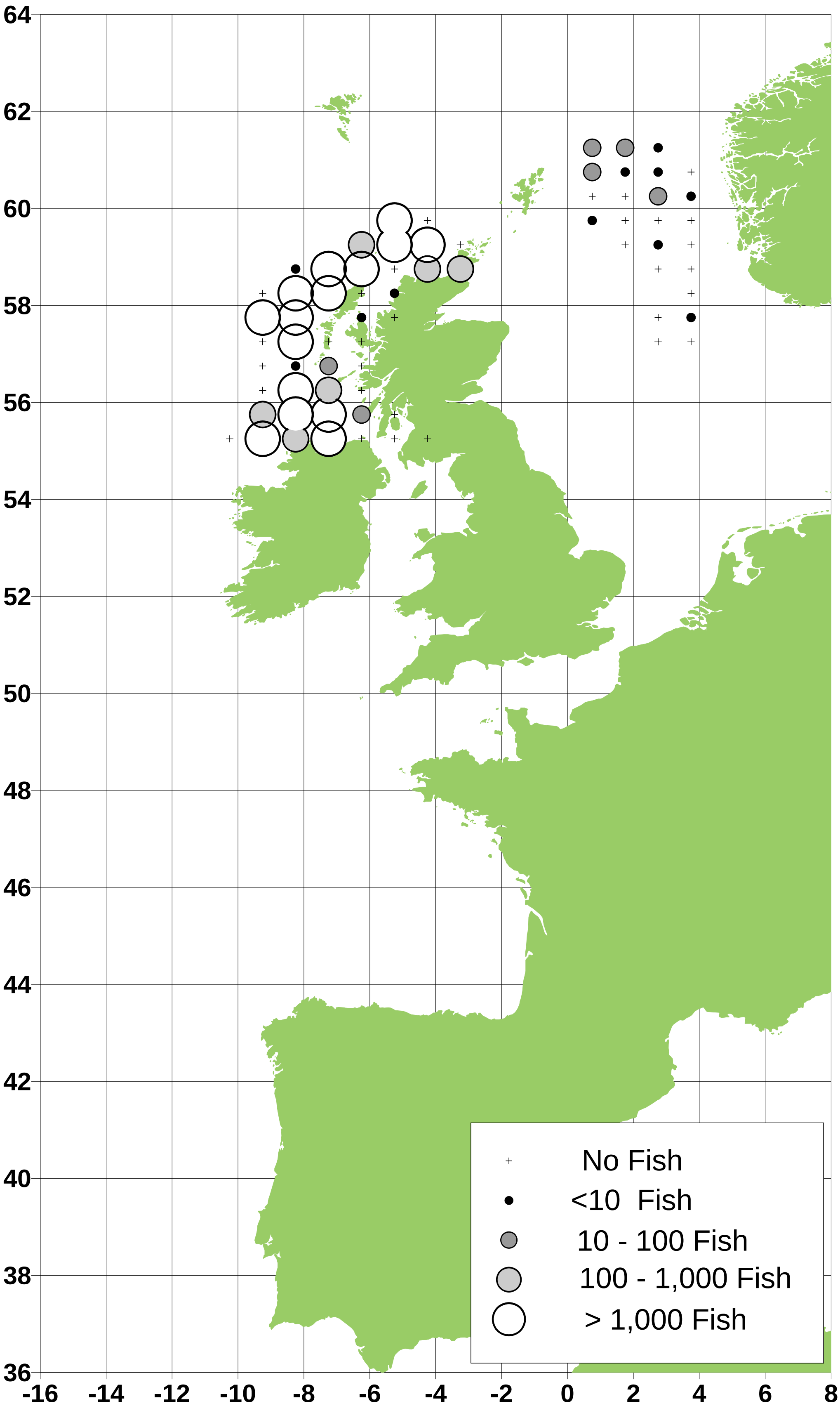


Figure 2.7.2.3. NEA Mackerel distribution of recruits, 2006 year class (age 1) in quarter 1, 2007.

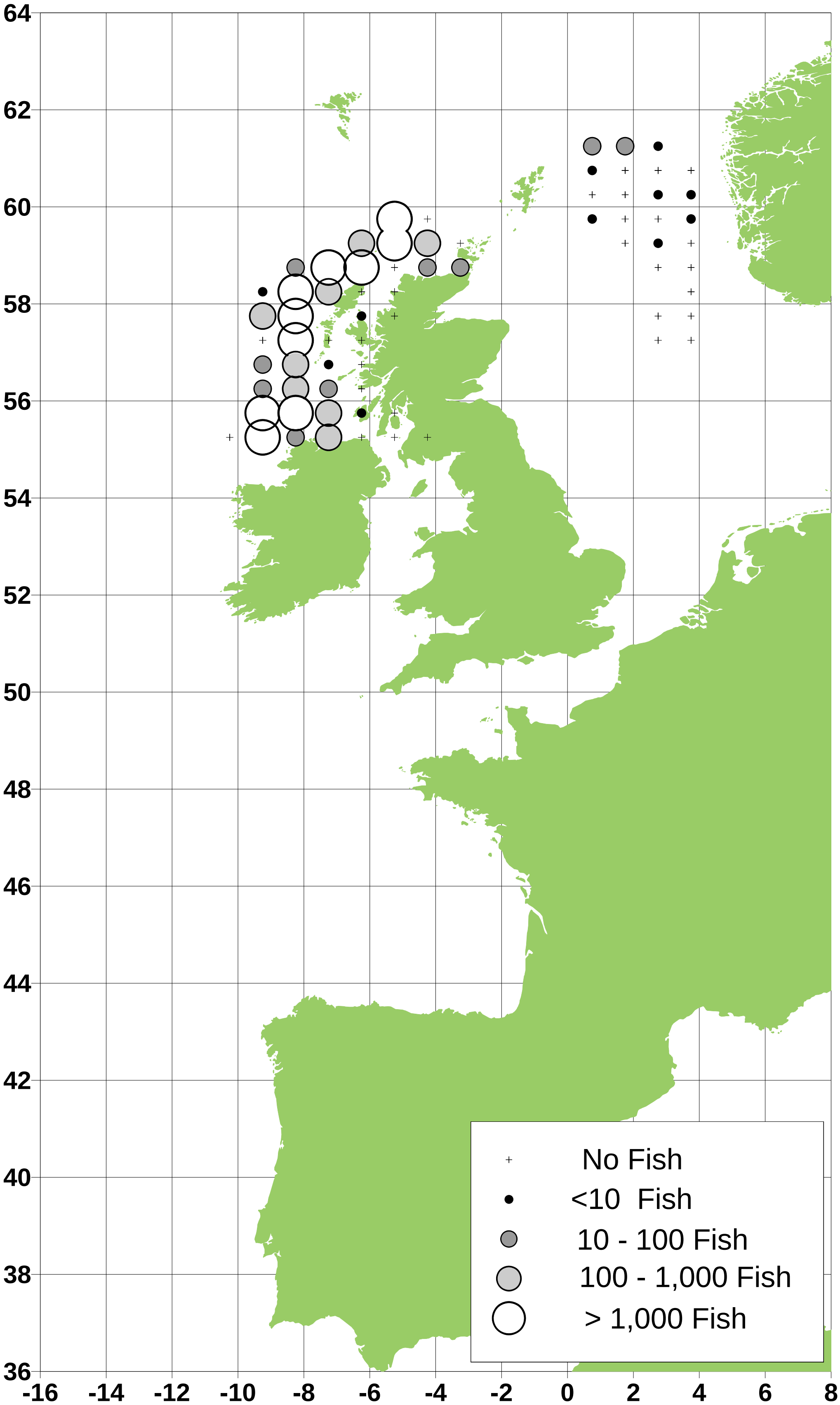


Figure 2.7.2.4. NEA Mackerel distribution of recruits, 2005 year class (age 2) in quarter 1, 2007.

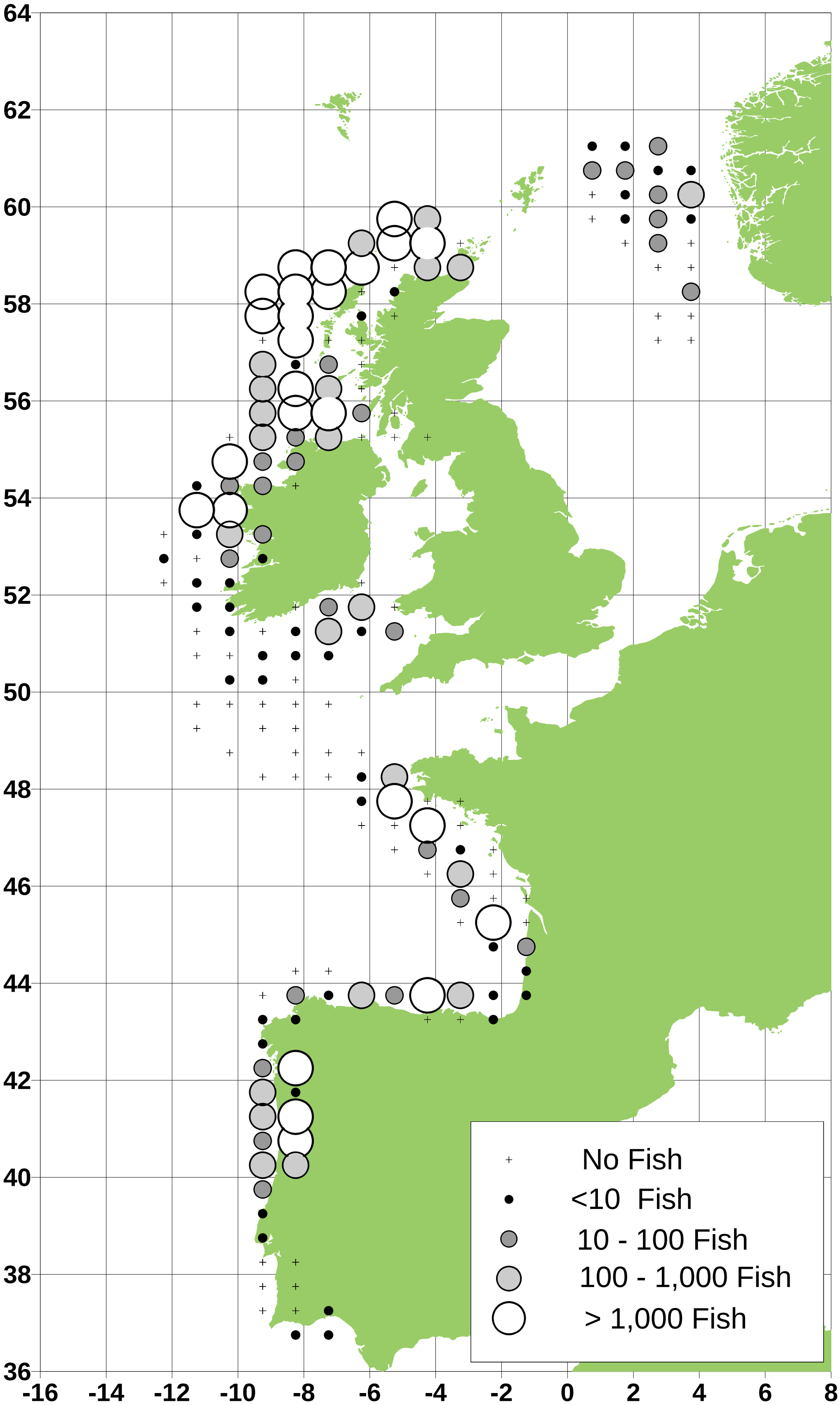


Figure 2.7.2.5. NEA Mackerel distribution of recruits, 2005 year class in first winter (2006/2007).

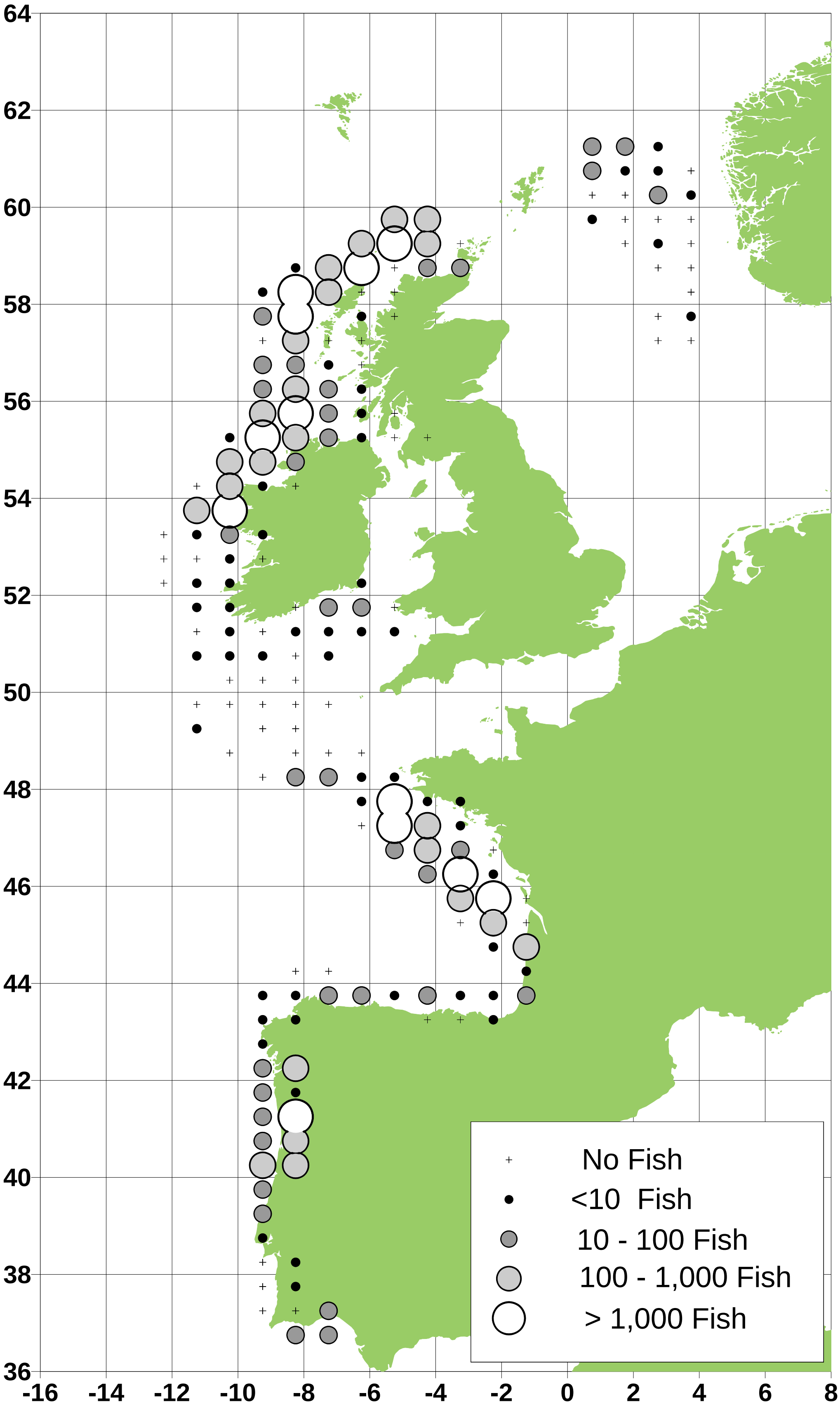


Figure 2.7.2.6. NEA Mackerel distribution of recruits, 2004 year class in second winter (2006/2007).

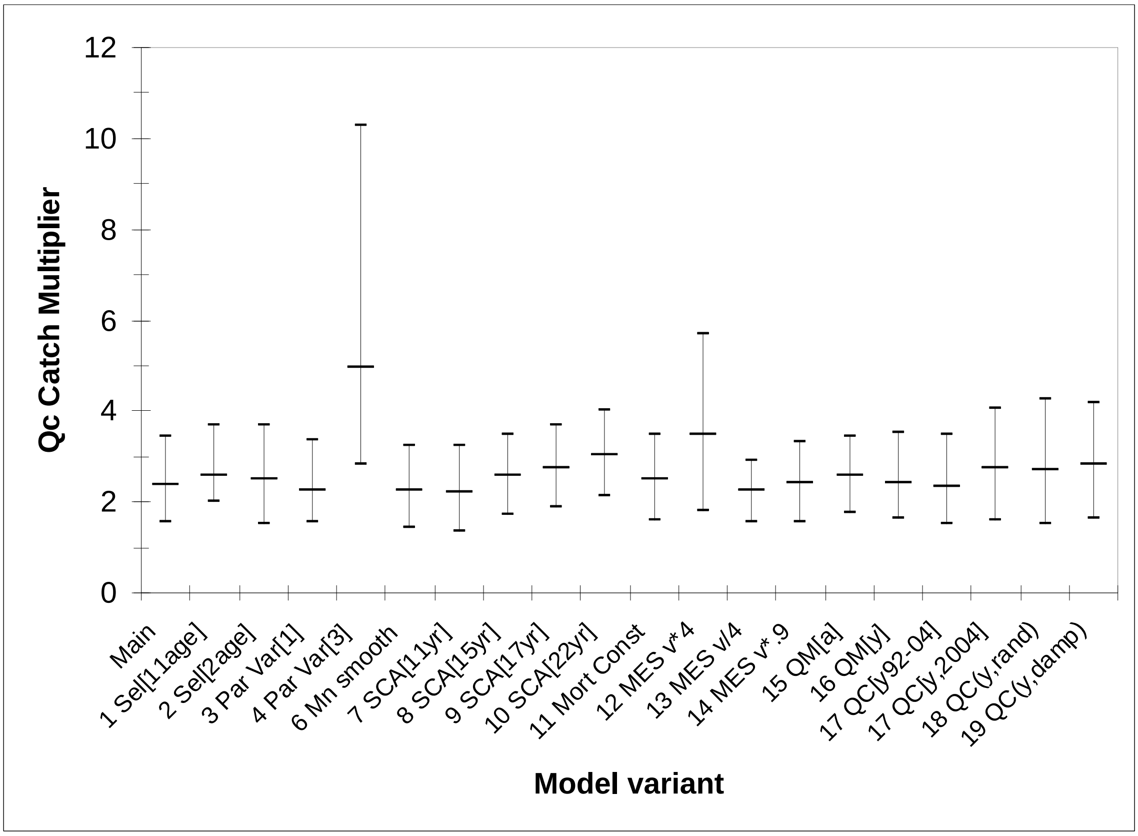


Figure 2.8.2.1. NE Atlantic mackerel estimated median and 95% intervals on Qc catch multiplier for unaccounted removals for different model variants by number (see text).

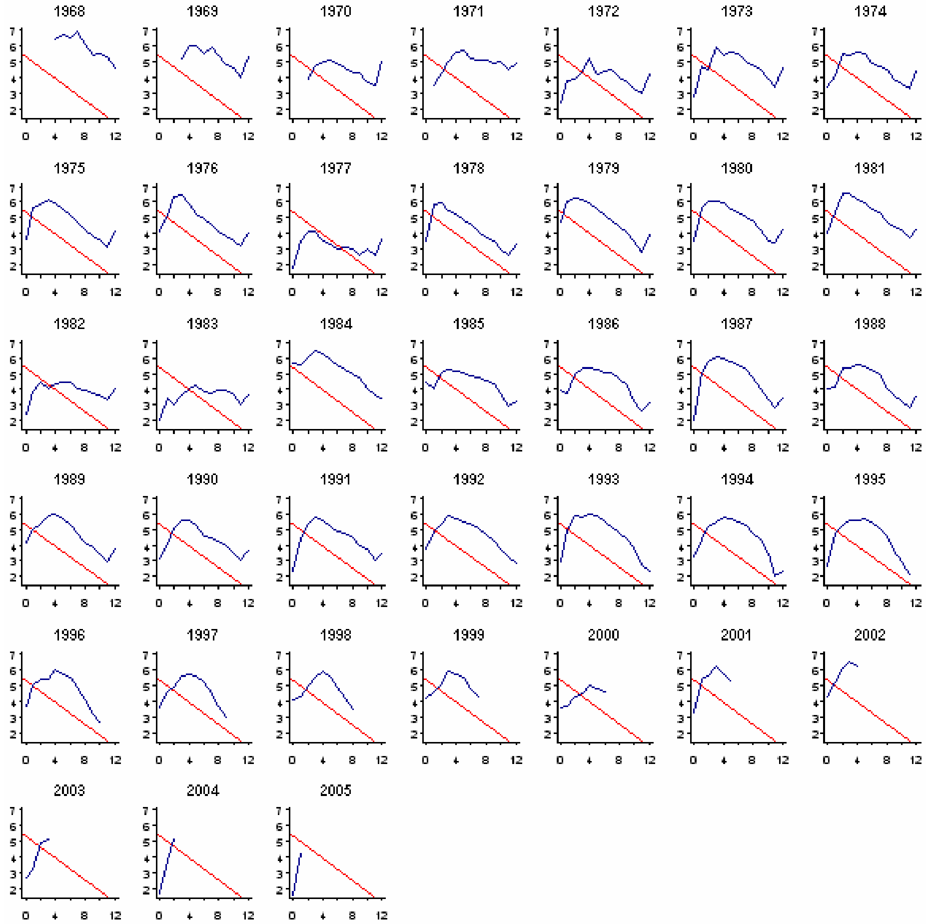


Figure 2.8.4.1 NE Atlantic mackerel log catch ratios by cohort from year-classes 1968 to 2005. The red line indicates a slope of 0.35 equivalent to a fishing mortality of 0.2 with a natural mortality of 0.15 . Cohorts from 1994 to 1999 (age 7 in 2008) show steeper declines than earlier cohorts, although some of this decline is due to reduced catch in the latest years.

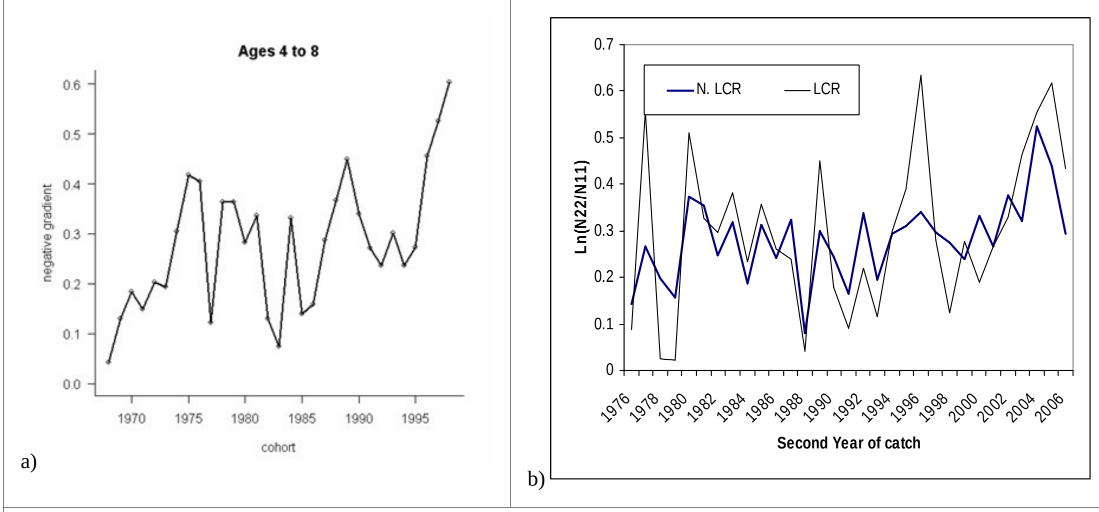


Figure 2.8.4.2 NE Atlantic mackerel mean log catch ratios by year from year-classes 1968 to 2005. a) by cohort, b) by year comparing ratios normalised by catch (N.LCR) and un-normalised (LCR) The cohorts 1995 to 1999 (age 7 in 2008) show steeper declines than earlier cohorts, though some of this decline is due to reduced catch in the latest years. Both LCR and N.LCR show rises from 1999 to 2004 and some decline over the last 3 years, but with levels above those before the mid 90s.

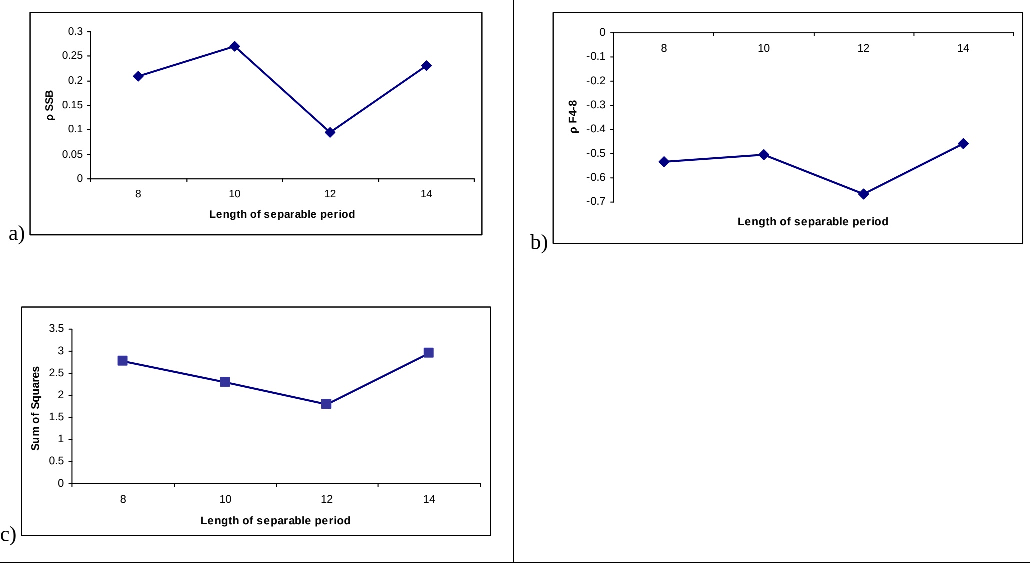


Figure 2.8.5.1 NE Atlantic mackerel ICA assessment; changes in retrospective bias in a) SSB, b) mean F 4-8 and c) model sum of squares with choice of separable period. A small improvement in model fit is seen at 12 years with some improvement in retrospective error in SSB and a deterioration in F

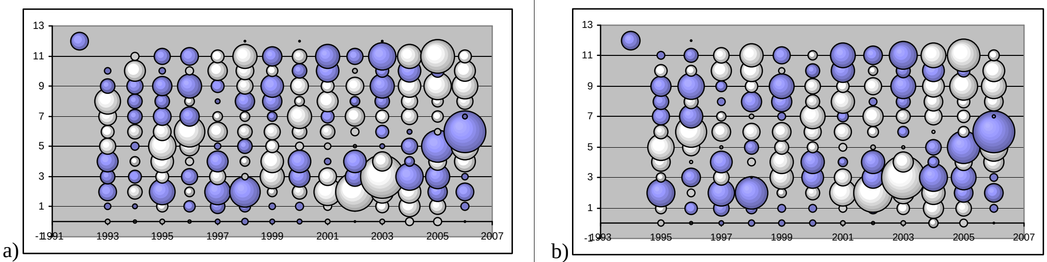


Figure 2.8.5.2 NE Atlantic mackerel ICA assessment; residuals in the separable period set to a) 14 years or b) 12 years. Changes are small.

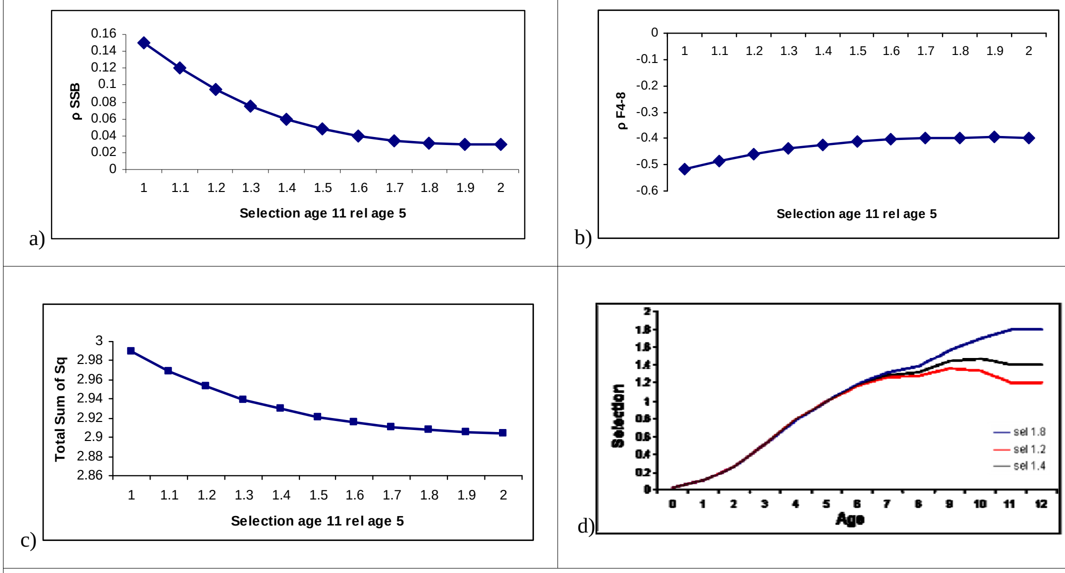


Figure 2.8.5.3 NE Atlantic mackerel ICA assessment; changes in retrospective bias in a) SSB, b) mean F 4-8 and c) model sum of squares with choice of selection at age 11 relative to age 5. Generally there is improvement in fit and retrospective bias with high selection on oldest ages. Results are asymptotic by about 1.8. Selection patterns are shown in d) for 1.2, 1.4 and 1.8.

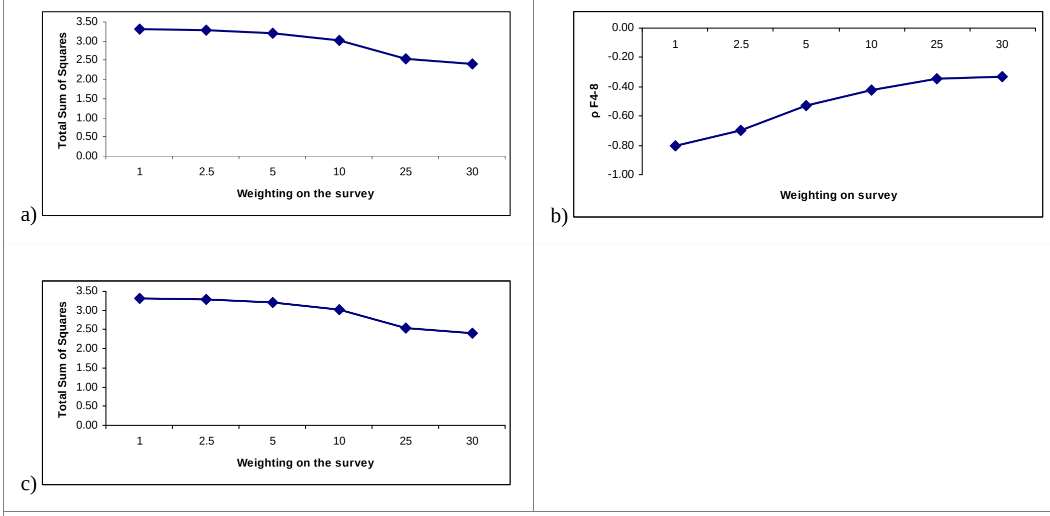


Figure 2.8.5.4 NE Atlantic mackerel ICA assessment; changes in retrospective bias in a) SSB, b) mean F 4-8 and c) model sum of squares with weighting on the survey. Sum of squares decreases and retrospective bias reduce as weighting is increased to 30 (equivalent to equal weight to catch and survey data).

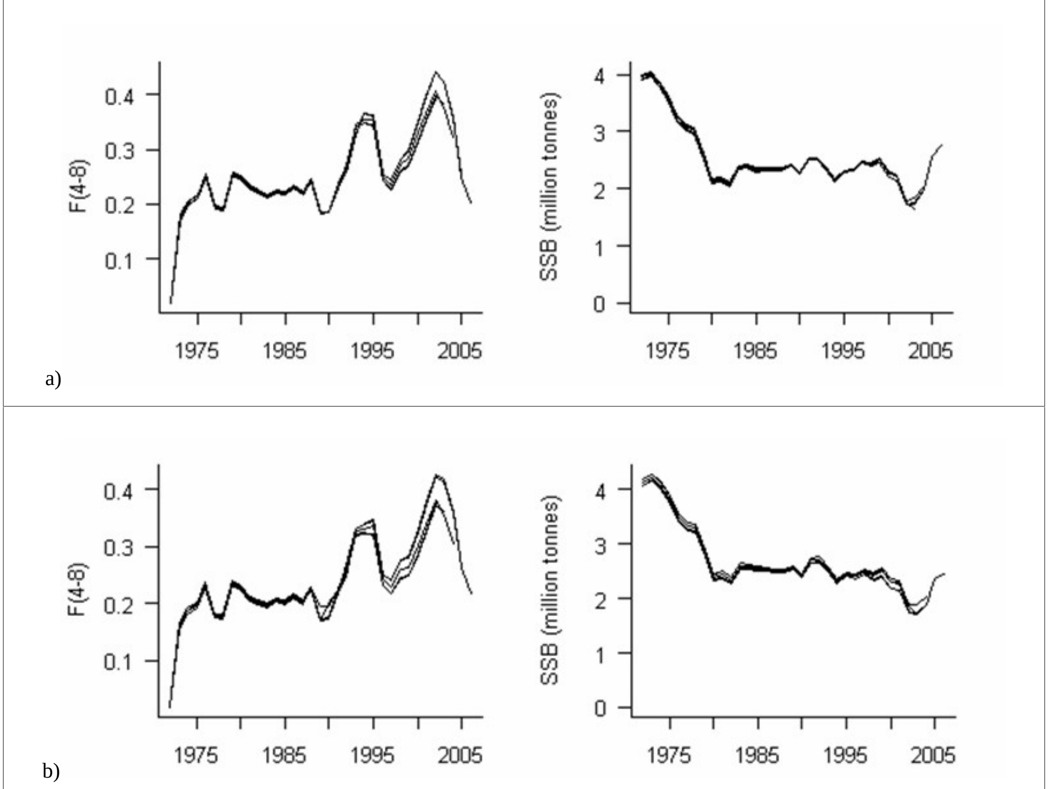


Figure 2.8.5.5 NE Atlantic mackerel; comparison of retrospective patterns from ICA assessment using survey weighting a) 30 equivalent to equal weight for same period of catch and , b) 5 used in previous assessments

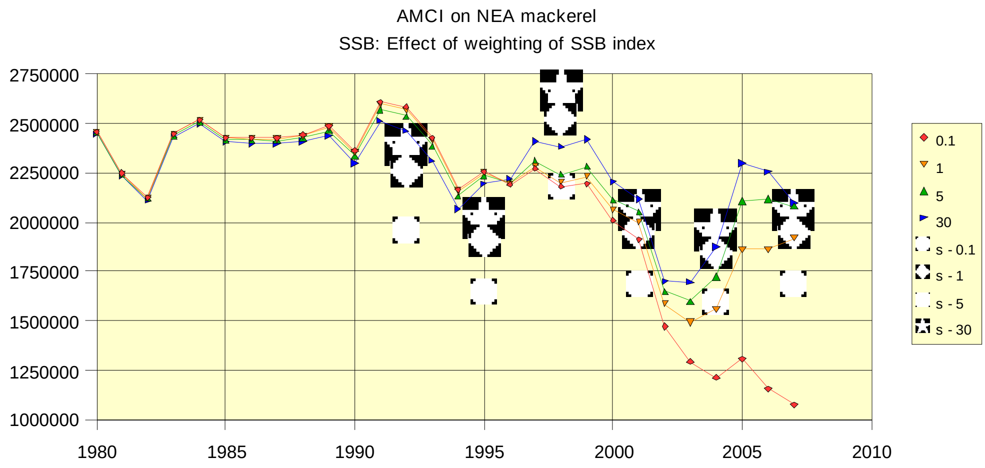


Figure 2.8.6.1. NE Atlantic mackerel estimates of SSB by AMCI with a range of weights on the SSB survey index. The single symbols are the observed survey indices, adjusted with the estimated catchabilities.

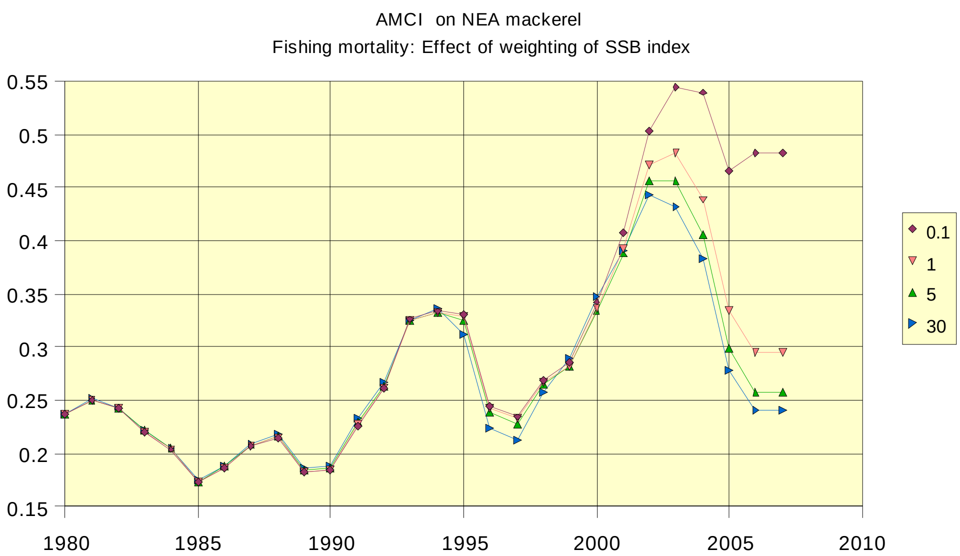


Figure 2.8.6.2. NE Atlantic mackerel estimates of F (4-8) by AMCI with a range of weights on the SSB survey index.

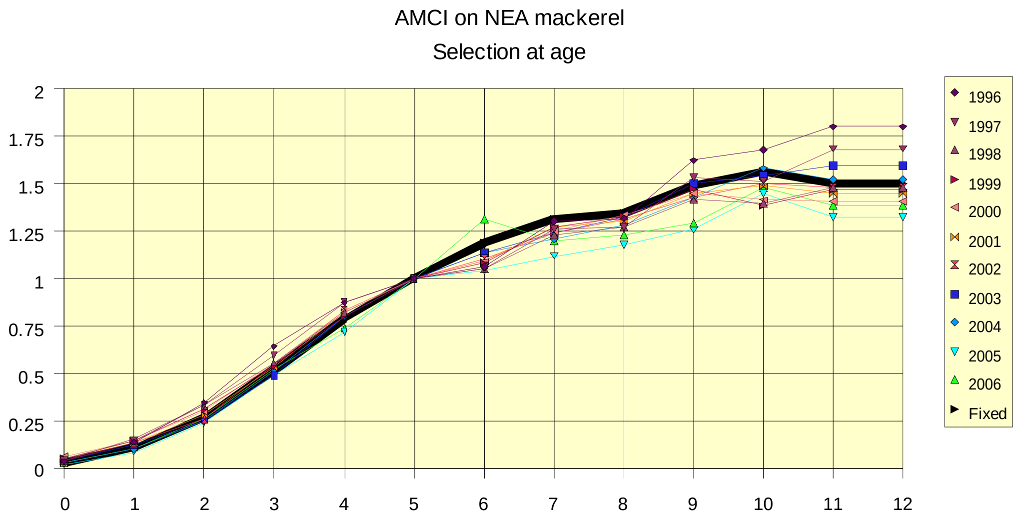


Figure 2.8.6.3. NE Atlantic mackerel selection at age estimated with AMCI for each year 1992 - 2006. The thick black line is the selection estimated by assuming it fixed throughout the period. A weighting of 5 was given to the SSB survey index.

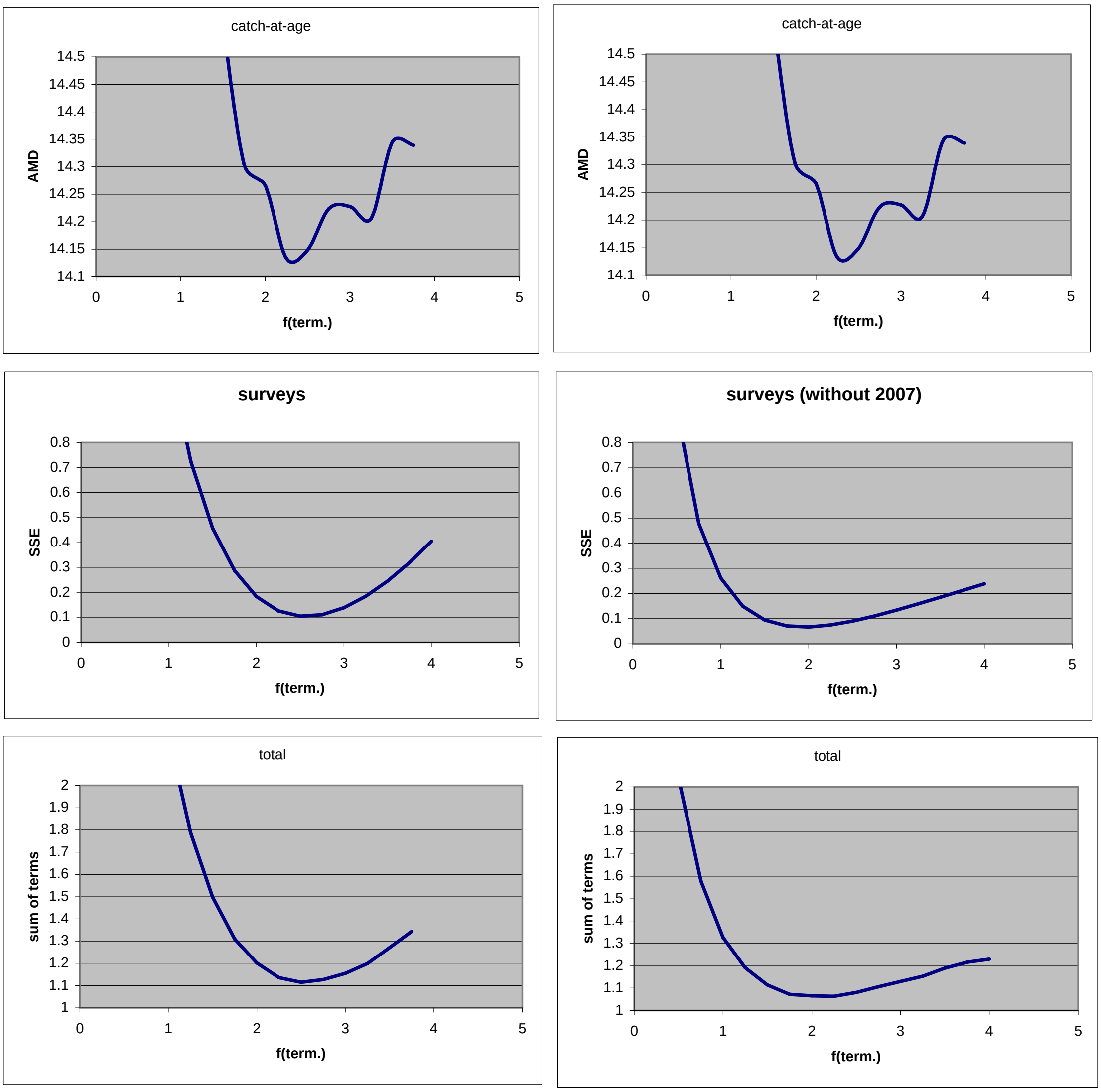


Figure 2.8.7.1 NE Atlantic mackerel profiles of components of the TISVPA loss function

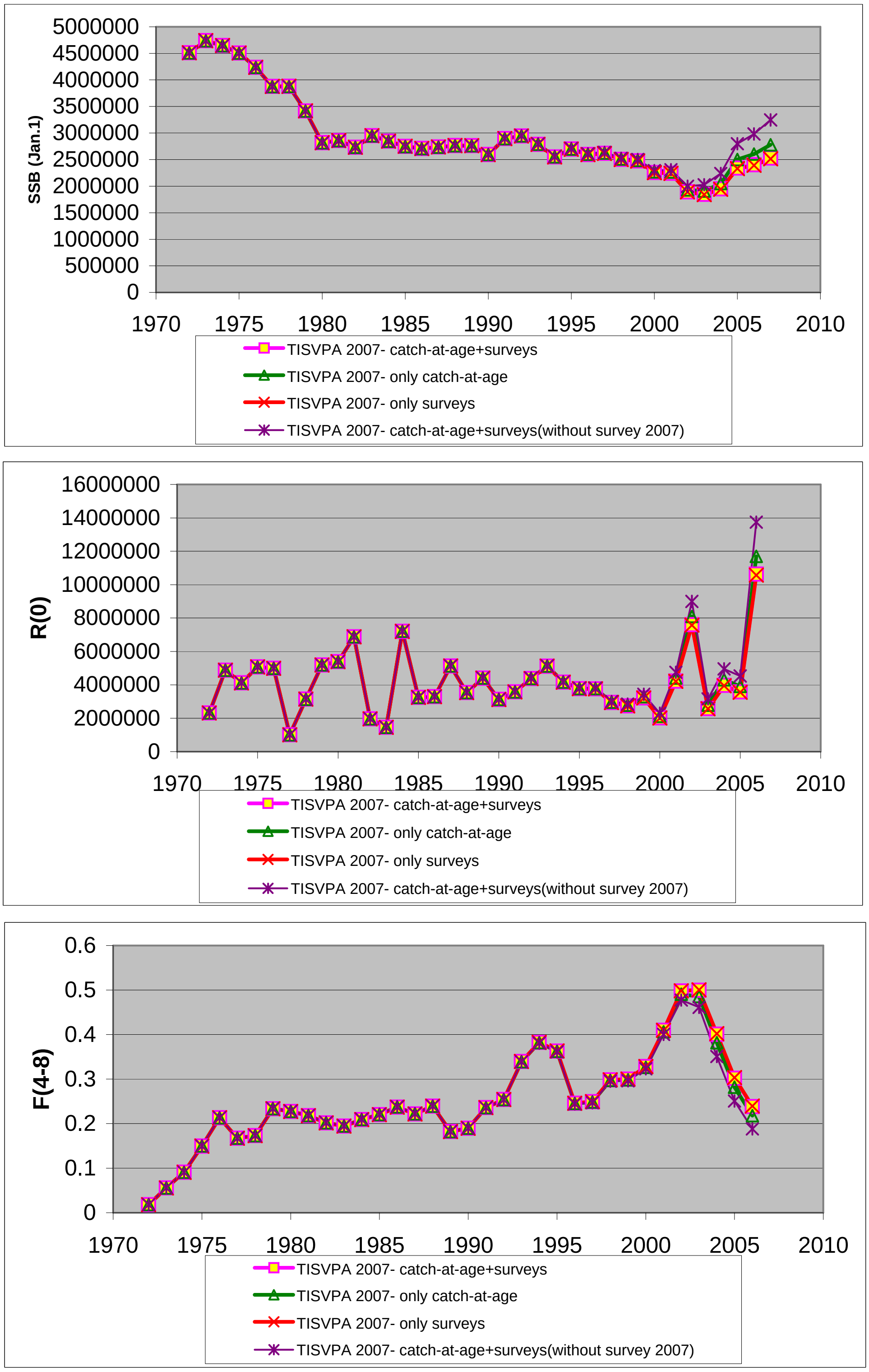


Figure 2.8.7.2. NE Atlantic mackerel TISVPA results for different data used

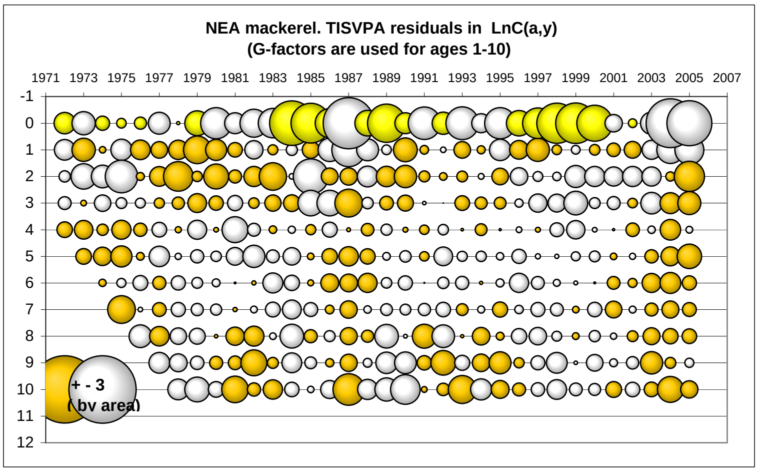


Figure 2.8.7.3. NE Atlantic mackerel TISVPA residuals in log-catch-at-age

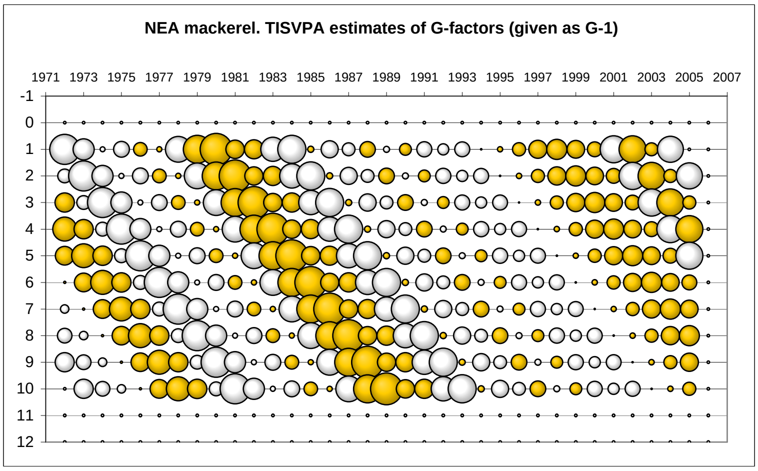


Figure 2.8.7.4. NE Atlantic mackerel. TISVPA. Estimates of G-factors

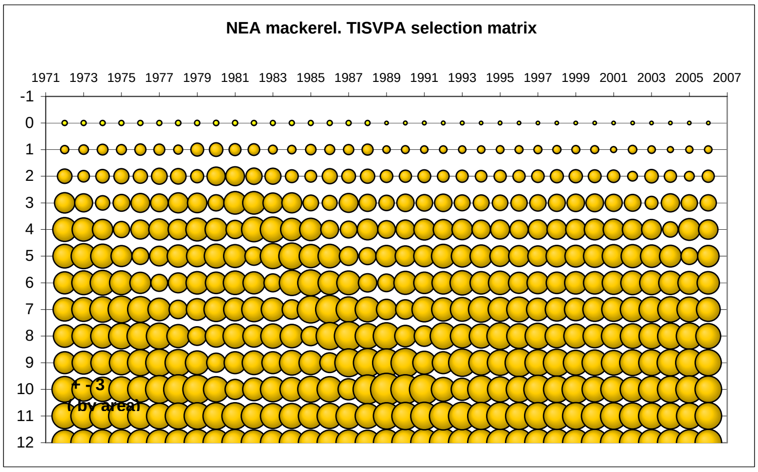


Figure 2.8.7.5. NE Atlantic mackerel. TISVPA. Estimates of selection matrix

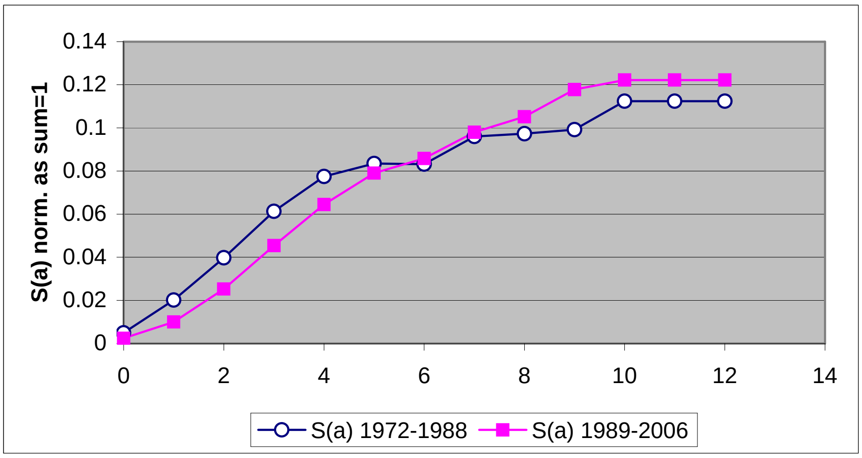


Figure 2.8.7.6. NE Atlantic mackerel. TISVPA. The estimates of age-dependent components of the selection matrix for two periods.

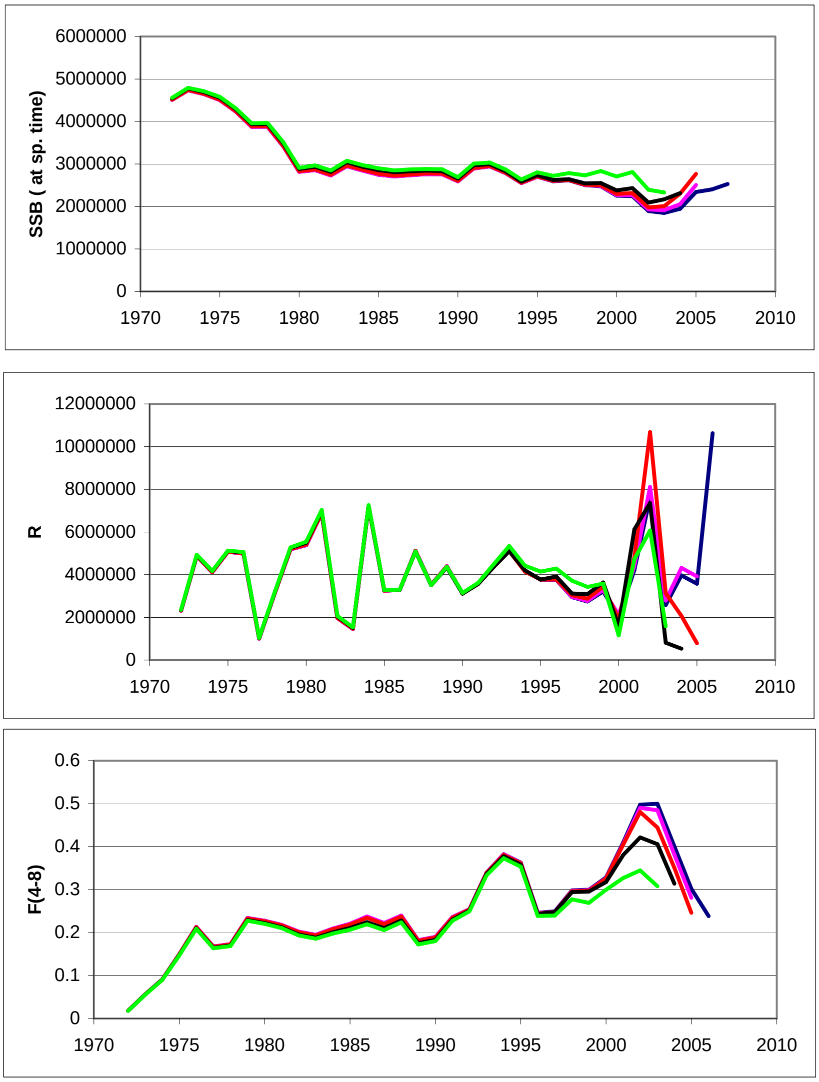


Figure 2.8.7.7. NE Atlantic mackerel. TISVPA. Retrospective runs.

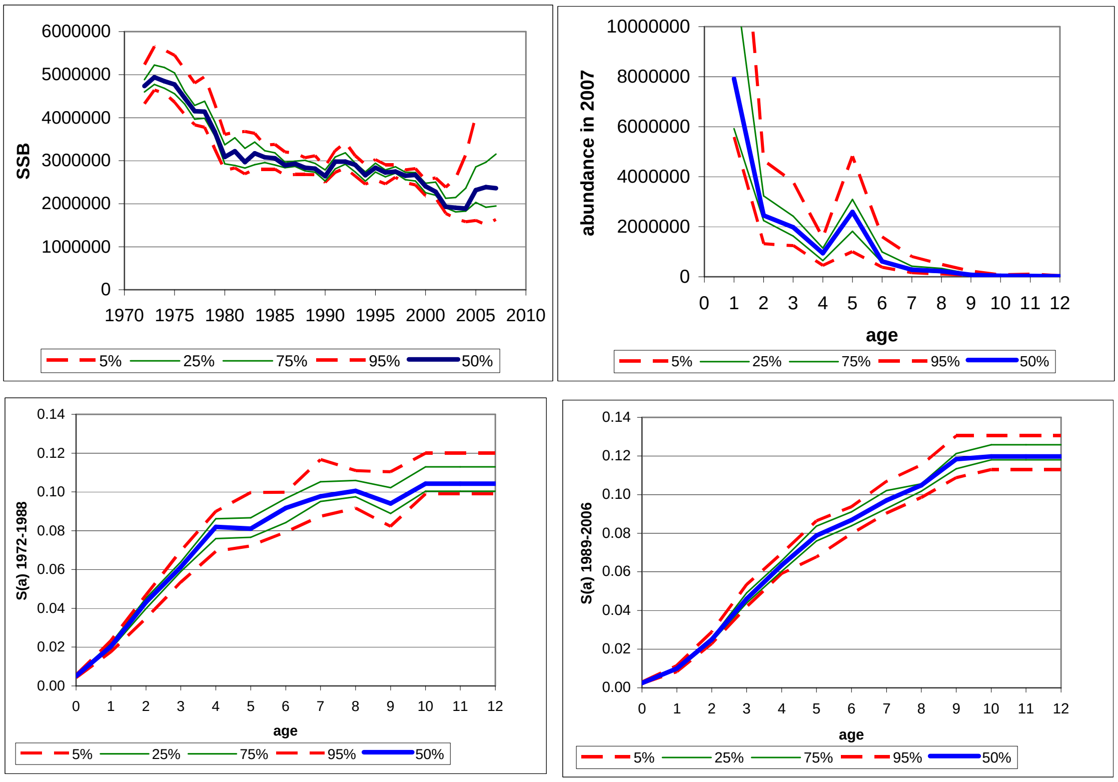


Figure 2.8.7.8 NE Atlantic mackerel. TISVPA. Bootstrap-analysis of uncertainty in the results

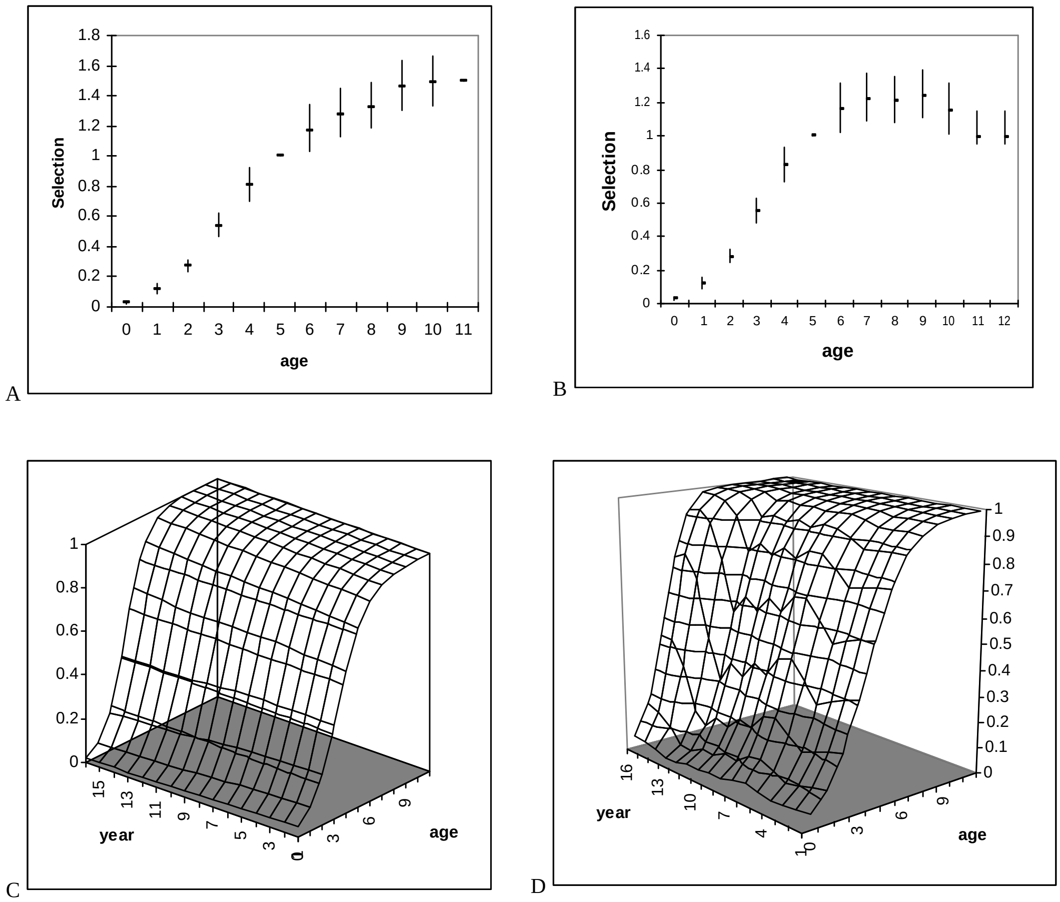


Figure 2.8.8.1 NE Atlantic mackerel. Different selection models fitted in Bayesian Framework. A) ICA 10 ages independently with age 11 &12+ = 1.5*age 5. b) 11 ages fitted independently age 12+ = age 11. c) Logistic function changing smoothly with year. D) logistic function changing rapidly with year.

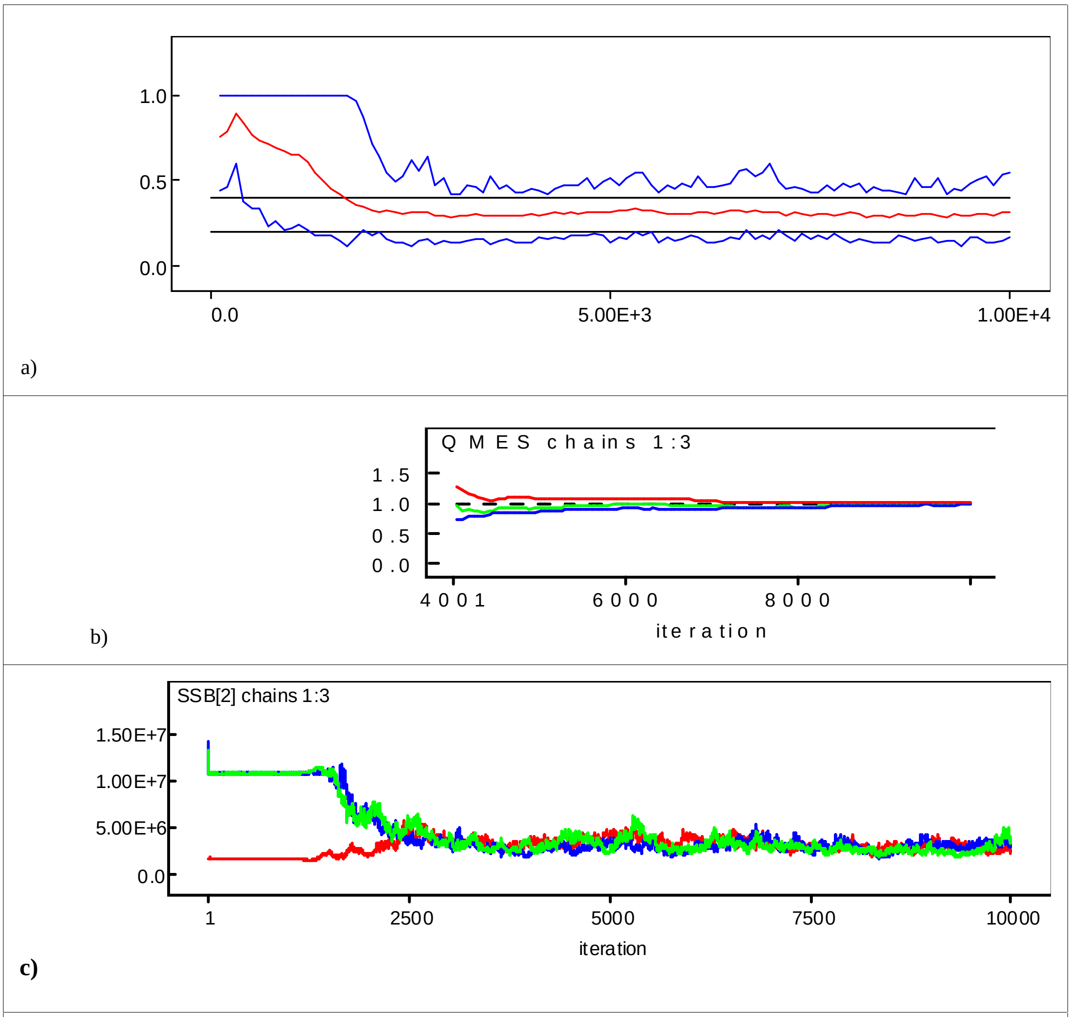
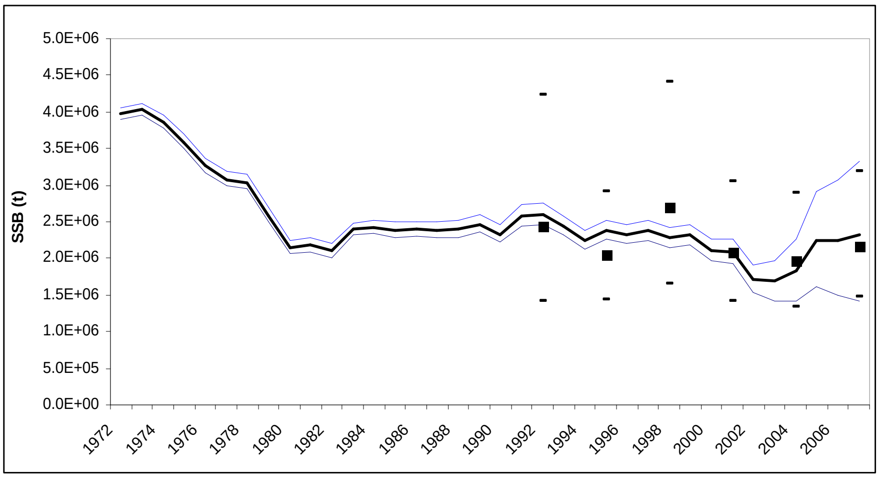
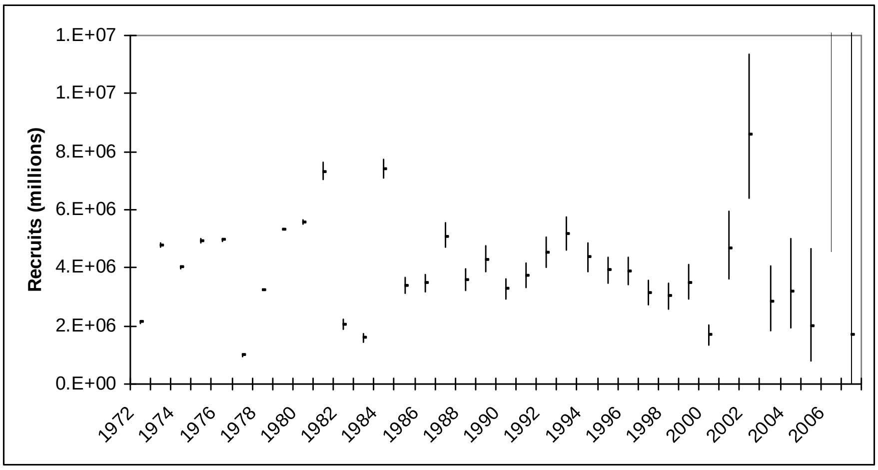


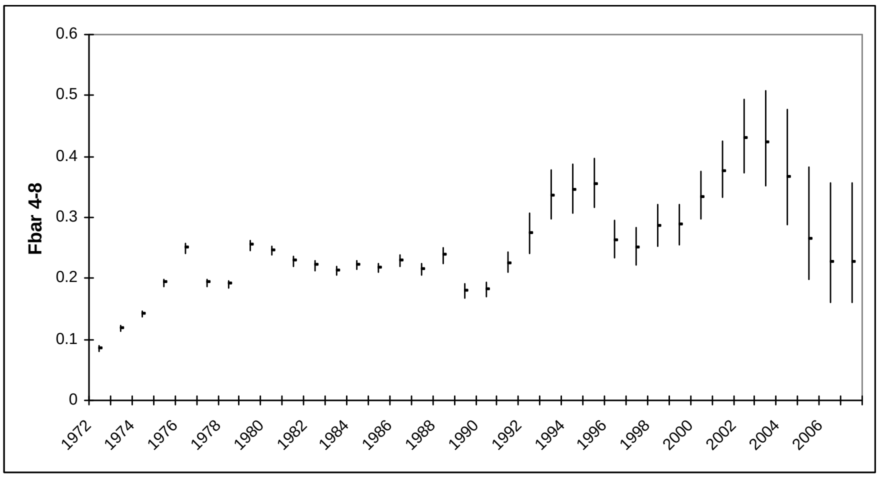
Figure 2.8.8.2 NE Atlantic mackerel example of fit criteria in WINBUGS. a) Metropolis convergence criteria from ICA separable model, showing convergence by about 3,000 iterations, Data used is from 4,001 to 10,000. b) Gelman Rubin statistic (for model s) which examines variance within and across chains, red line should be above 1 and asymptotic to it, green and blue lines should be asymptotic to a final value. c) Estimating terminal SSB (2006) typical convergence of 3 separate chains (red, blue and green) showing separate staring points, convergence by around 3000 iterations.



a)

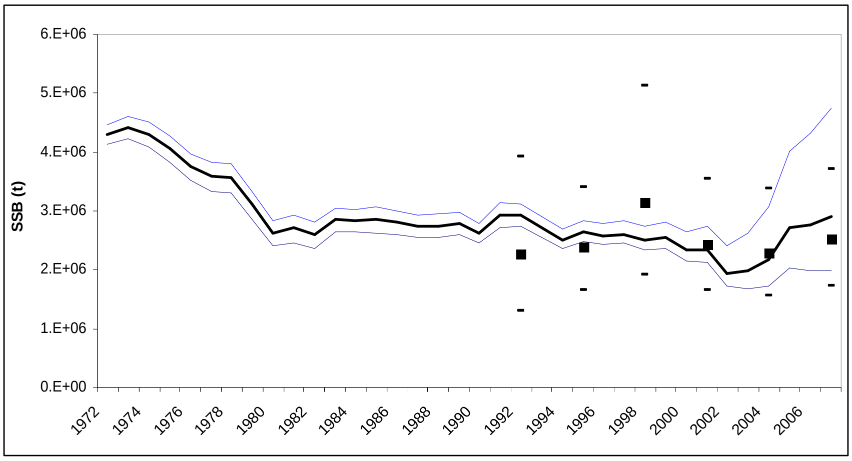


b)

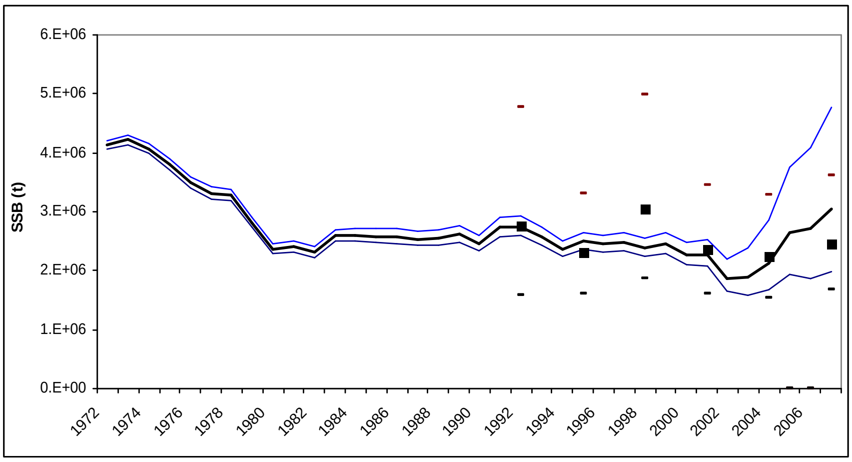


c)

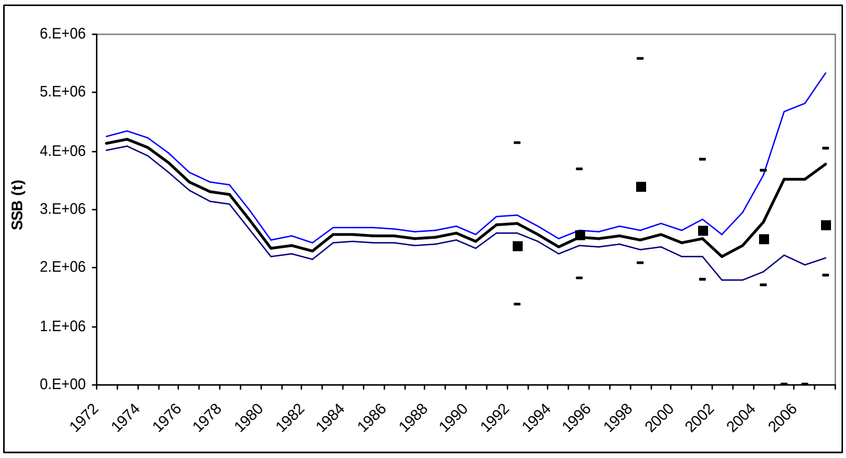
Figure 2.8.8.3 NE Atlantic mackerel. WINBUGS Bayesian assessment with model similar to ICA, a) Estimated median SSB with 95% intervals (lines) and fitted mackerel egg survey values (points) with 95% intervals (dashes). b) Estimated 95% and median recruitment age 0. c) Estimated 95% and median mean fishing mortality ages 4-8.



a)



b)



c)

Figure 2.8.8.3.4 NE Atlantic mackerel WINBUGS Bayesian assessment showing different perceptions of median SSB with 95% intervals (lines), and fitted mackerel egg survey values (points) and 95% intervals (dashes) with different model assumptions on selection pattern a) selection at age 11 estimated. b) smooth logistic selection c) flexible logistic selection. See Figure 2.8.3.3.

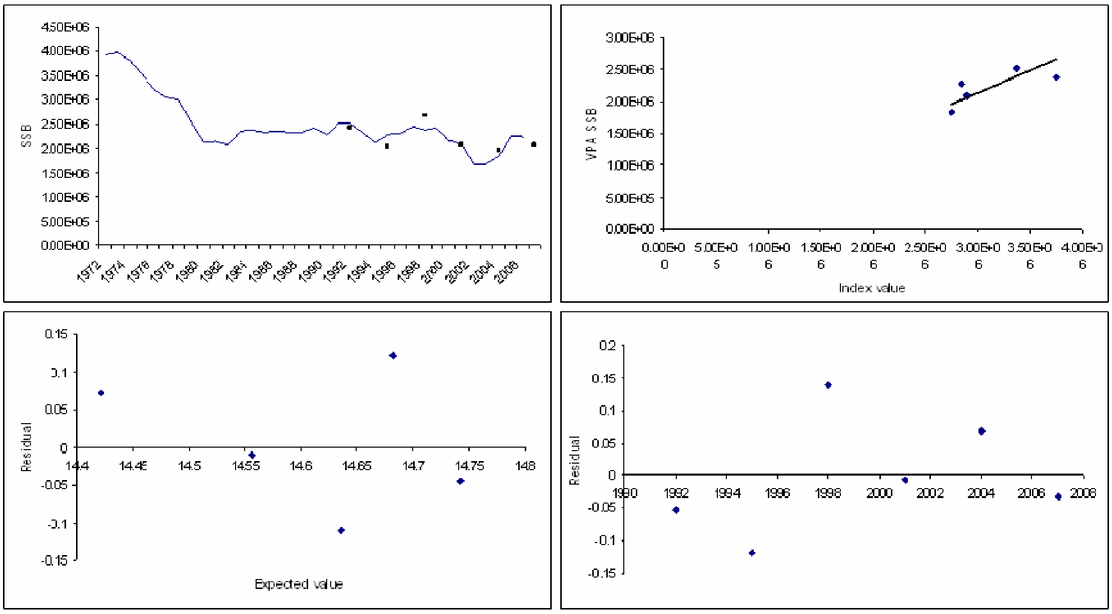
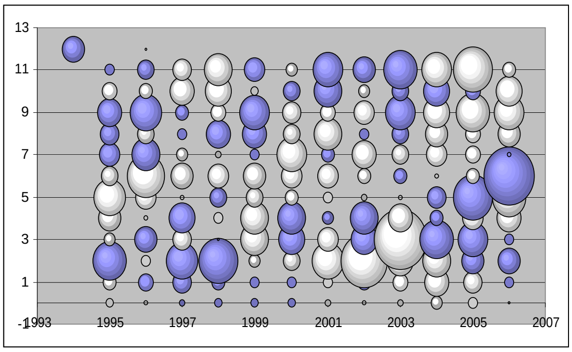
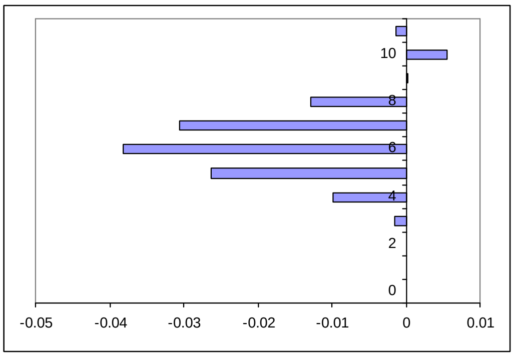


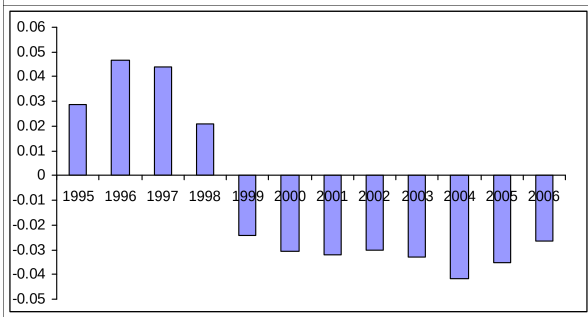
Figure 2.9.1.1 NE Atlantic mackerel final assessment ICA diagnostics for fit to mackerel egg survey.



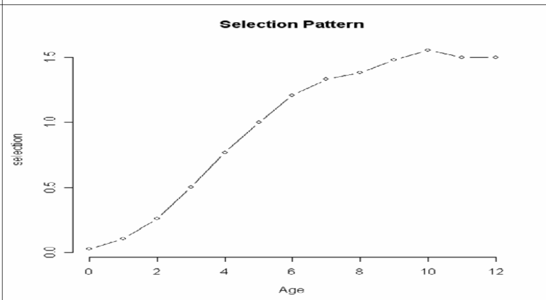
a)



b)



c)



d)

Figure 2.9.1.2 NE Atlantic mackerel final assessment ICA diagnostics for fit of catch to the separable period, a) log residuals by year (age, 0 and 1 down weighted). Average residuals b) by age, c) by year, d) fitted selection pattern

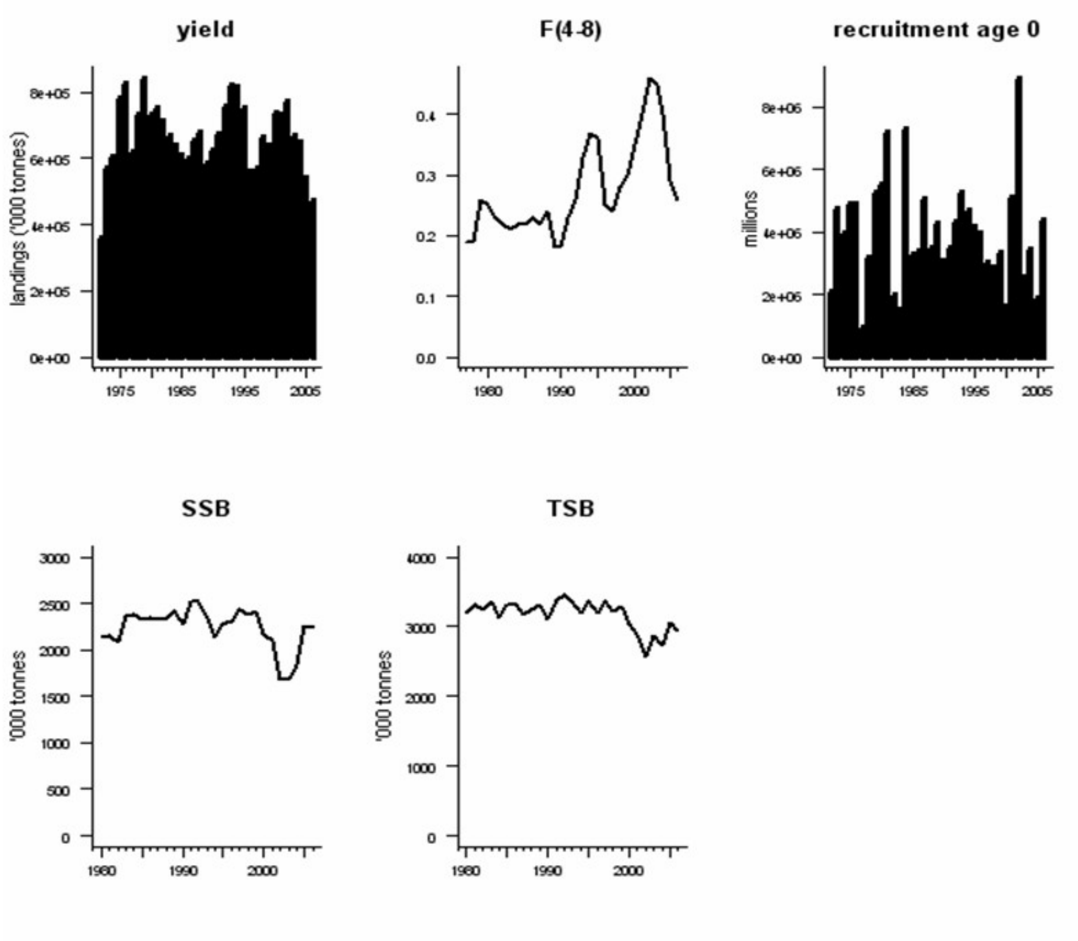


Figure 2.9.1.3 NE Atlantic mackerel final ICA assessment catch, mean F ages 4-8, recruitment age 0, Spawning Stock Biomass (SSB) and Total Stock Biomass (TSB).

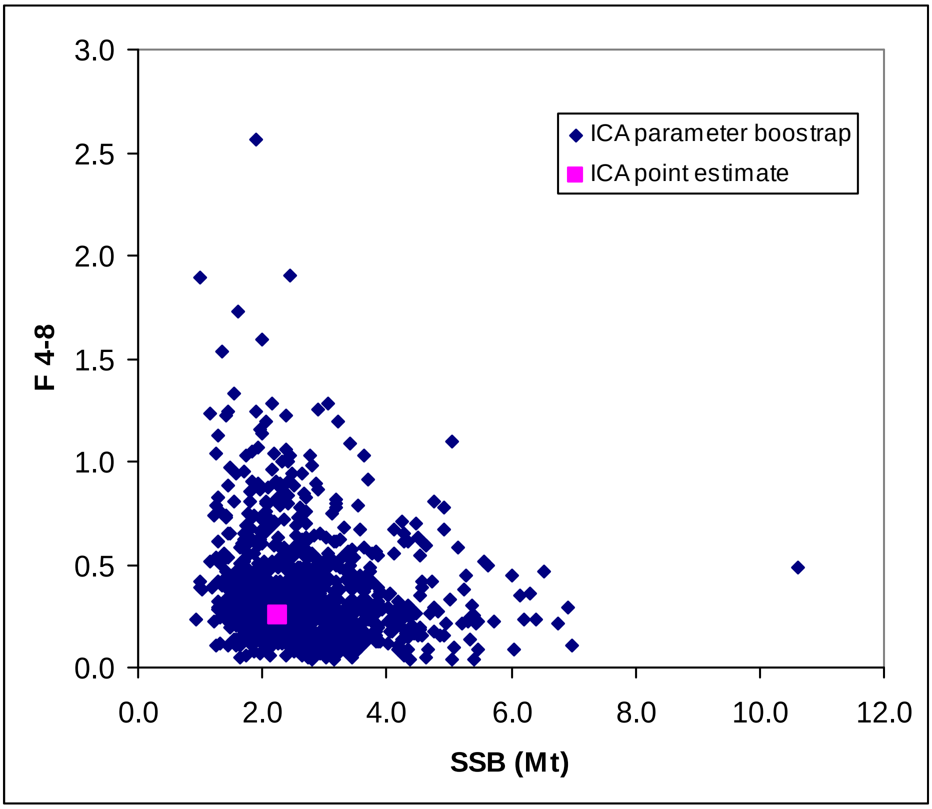
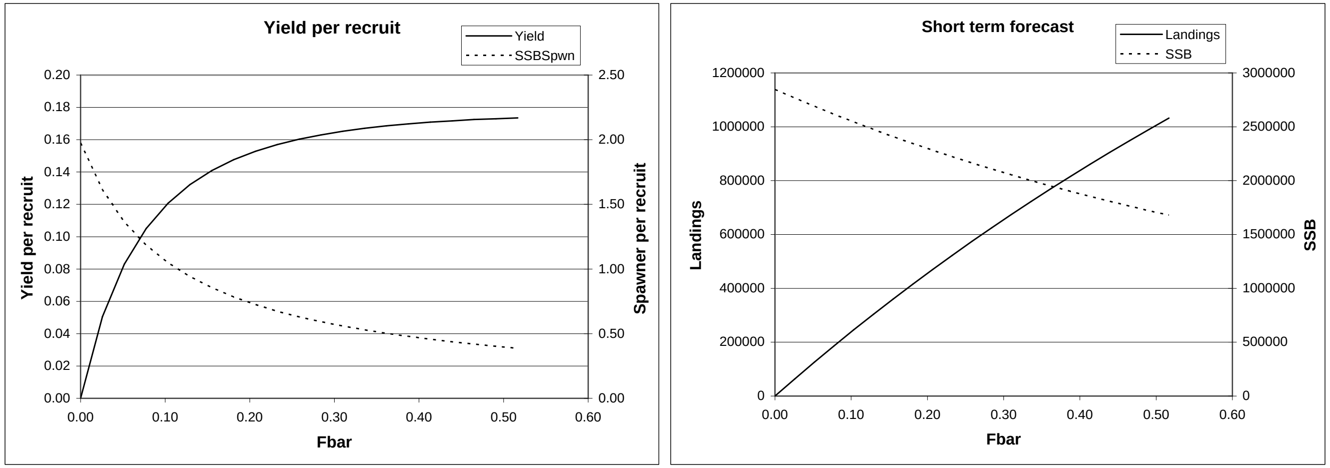


Figure 2.9.2.1 NE Atlantic mackerel, precision of ICA estimates of terminal SSB and F4-8 from bootstrap of parameter residuals in ICA. Showing scatter plot of 1000 realisations and the point estimate.



MFYPR version 2a
Run: run2.test
Time and date: 19:30 12/09/2007

Reference point	F multiplier	Absolute F
Fbar(4-8)	1.0000	0.2584
FMax	2.8051	0.7247
F0.1	0.6654	0.1719
F35%SPR	0.8646	0.2234

Weights in kilograms

MFDP version 1a
Run: run.2
Mackerel NE Atlantic WG2007
Time and date: 13:57 11/09/2007
Fbar age range: 4-8

Input units are thousands and kg - output in tonnes

Figure 2.12.1 NE Atlantic mackerel Yield Per Recruit and Short Term Forecast.

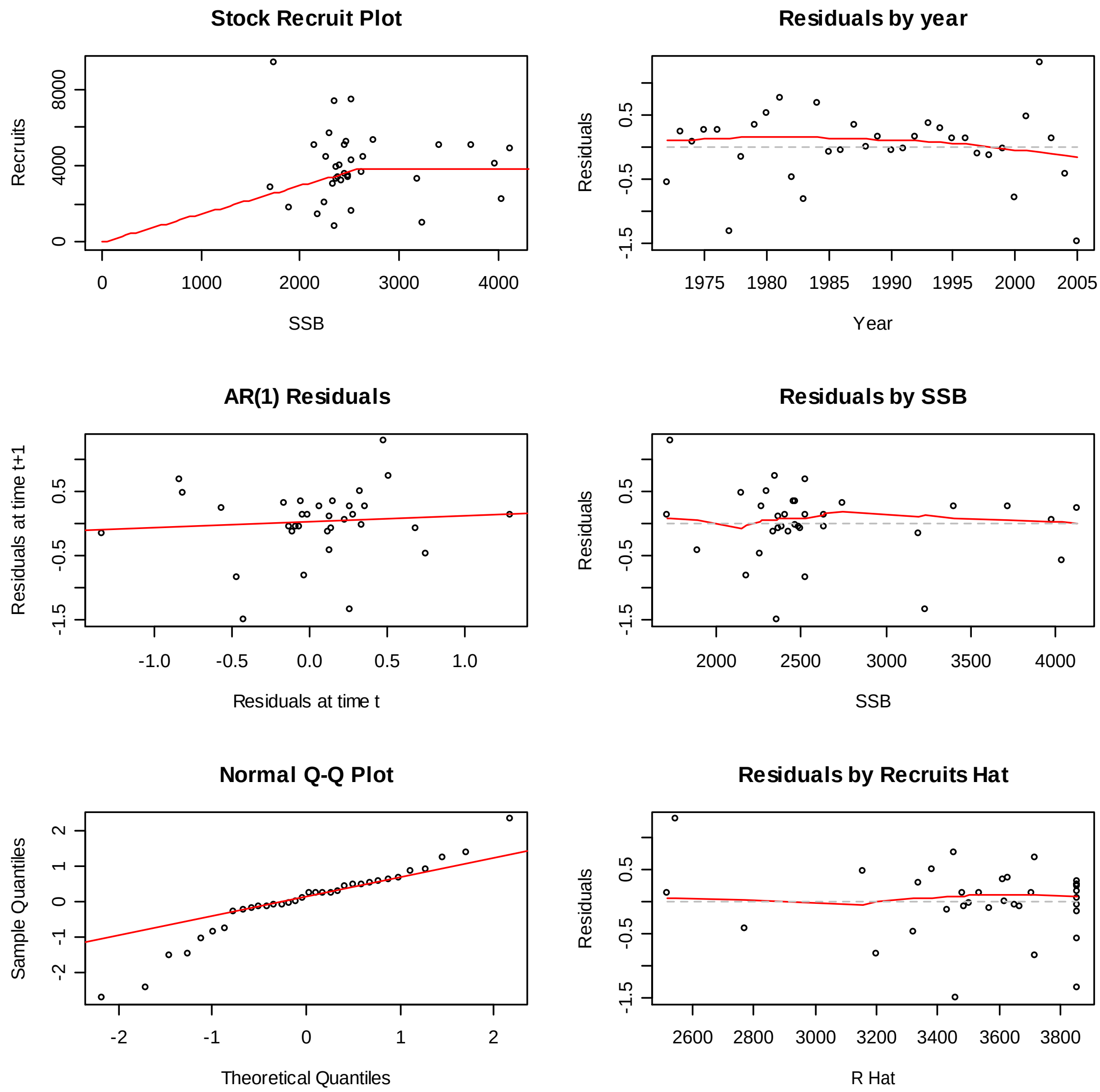


Figure 2.12.2 NE Atlantic mackerel fitted stock recruit relationship using FLSR with hokey-stock (segmented regression) model with lognormal distribution for SSB and recruitment from 1972 to 2003.

3 Horse Mackerel

3.1 Fisheries in 2006

The total international catches of horse mackerel in the North East Atlantic are shown in Table 3.1.1 and Figure 3.3.1. The total catch from all areas in 2006 was 215,277 tons which is 19,600 tons less than in 2005. Ireland, Denmark, Scotland, England and Wales, France, Germany and the Netherlands have a directed trawl fishery and Norway a directed purse seine fishery for horse mackerel. Spain and Portugal have both directed and mixed trawl and purse seine fisheries. In earlier years most of the catches were used for meal and oil while in later years most of the catches have been used for human consumption.

The quarterly catches of horse mackerel by Division and Subdivision in 2006 are given in Table 3.1.2 and the distribution of the fisheries are given in Figure 3.1.1.a–d. The figures are based on data provided by England and Ireland, Germany, Netherlands, Norway, Scotland, Portugal and Spain representing 80 % of the total catches.

The geographical distribution of the catches was similar to previous years. As for several years relatively large catches taken in the juvenile area (Divisions VIIa,c,d,f,g,h, VIIIa,b,c,d and IXa). About 48% and 55% of the total horse mackerel catches were taken here in 2005 and 2006 respectively.

The French, Dutch and German fleets operated mainly west of the Channel, in the Channel area, and in the southern North Sea. The Spanish and Portuguese fleets operated mainly in their respective waters. Ireland fished mainly west of Ireland and Norway in the north eastern part of the North Sea. For the first time Lithuania reported catches of horse mackerel, 9206 tons, and their main catches were reported from Sub Divisions IVc, VIa, VIIb and VIIh.

First quarter: 53,500 tons. This is 24,800 tons less than in 2005. The fishery was mainly carried out west of Ireland, south of England, in the Channel, along the Spanish and Portuguese coast (Figure 3.1.1.a). Some catches were taken in the central part of the North Sea.

Second quarter: 16,200 tons. This is 9,600 tons less than in 2005. As usual, rather low catches were taken during the second quarter, which is the main spawning period. Most of the catches were taken south of Ireland, in the Bay of Biscay and along the Spanish and Portuguese coast. Only very low catches were taken in the south eastern part of the North Sea (Figure 3.1.1.b).

Third quarter: 25,000 tons. This is 6,700 tons more than in 2005. Most of the catches were taken in Portuguese, Spanish and Irish waters. A few small catches were reported from the northern part of the North Sea while larger catches were taken in the Channel area (Figure 3.1.1.c).

Fourth quarter: 120,600 tons. This is 8,600 tons more than in 2005 and the catches were distributed in four main areas: Portuguese waters, Irish waters, the northern part of the North Sea and in the Channel (Figure 3.1.1.d).

3.2 Stock Units

For many years the Working Group has considered the horse mackerel in the north east Atlantic as separated into three stocks: the North Sea, The Southern and the Western stocks (ICES 1990/Assess: 24, ICES 1991/Assess: 22). According the technical minutes from the group reviewing last year's Working Group report, they discussed and questioned the stock unit definitions. Until the results from the EU project (HOMSIR, QLK5-Ct1999-01438),was available the separation into stocks was based on the observed egg distributions and the temporal and spatial distribution of the fishery.. The extremely strong 1982 year class turned for the first time up in the eastern part of the North Sea in 1987 during the third and mainly the fourth quarter. This year class was the basis for the start of the Norwegian horse mackerel fishery in the eastern part of North Sea during the third and mainly the fourth quarter (see section 5.3.3). Since Western horse mackerel are assumed to have broadly similar migration patterns as NEA mackerel the Norwegian catches have been considered to be fish of western origin migrating to this area to feed. In addition there is a fishery further south in the North Sea which is considered to be fish of North Sea origin. These views were supported by results from the mentioned EU project which was reviewed in ICES(2004/ACFM:8) which also concluded to include Division VIIIc as part of the distribution area of the western horse mackerel stock. The boundaries for the different stocks are given in Figure 3.2.1.

3.3 Allocation of Catches to Stocks

Based on spatial and temporal distribution of the horse mackerel fishery the catches were allocated to the three stocks as follows:

Western stock: Divisions IIa, IIIa (western part), Vb, IVa (third and fourth quarter), VIa, VIIa–c,e–k and VIIIa-e. Allthough it seems strange that only catches from western part of Division IIIa are allocated to this stock. The reason for this is that the catches in the western part of this Division taken in the fourth quarter often are taken in neighbouring area of catches of western fish in Division IVa. The Working Group is not sure if catches in Divisions IIIa and IVa the first two quarters are of western or North Sea origin. Usually this is a minor problem because the catches here during this period are small. However, in 2006 relatively larger catches were taken in this area during the first half of the year (3,600 tons) and these catches were allocated to the North Sea stock.

North Sea stock: Divisions IIIa (eastern part), IVa (first and second quarter), IVb,c and VIId. All catches from these Divisions were allocated to the North Sea stock.

Southern stock: Division IXa. All catches from these areas are allocated to the southern stock. **The catches by stock** are given in Table 3.3.1, Figure 3.3.1. and by stock and country in 2006 in Table 3.3.2.

3.4 Estimates of discards

Over the years only one and in later years two countries have provided data on discards and the amount of discards given in Table 3.1.1 are therefore not representative for the total fishery. During the later years only the Netherlands and Germany have provided discard data. Estimated discard levels for Germany and the Netherlands were presented in two working documents (WD Dickey-Collas & van Helmond 2007, WD Ulleweit & Panten 2007) estimated at 823 tons which is about 650 tons less than given in Table 3.1.1. No data about discard were provided during 1998-2001.Based on the limited data available it is impossible to estimate the amount of discard in the horse mackerel fisheries (see section 1.3.3).

3.5 *Trachurus* Species Mixing

3.6 Length Distribution by Fleet and by Country:

Germany, Ireland, Netherlands, Norway, Portugal and Spain provided length distribution data for parts or for the total of their catches in 2006. These length distributions cover 78 % of the total landings and are shown in Table 3.6.1.

3.7 Egg surveys

The ICES Triennial Mackerel and Horse Mackerel Egg Survey was carried out during February - July 2007. It is planned to present the results of the survey at the WGMEGS in April 2008. However, it was agreed at the WGMEGS meeting in Lisbon 1-4 April 2003 that the WG should aim to provide an estimate of western horse mackerel egg production in time for the meeting of the WGMHSA in Copenhagen, September 2007.

Details of the survey and the analysis methods are presented in section 2.5.1.

Plots of the distribution of horse mackerel egg production for the western area are presented in Figures 3.7.1a-e. In general the coverage in periods 3 – 6 was very good. There was a greatly reduced need for rectangle interpolation than in 2001.

As mentioned in section 2.5.1 most of the surveys ran and were completed within period give or take a couple of days with one notable exception to the rule was the AZTI period 2 survey which unfortunately straddled periods 2 and 3. By the time dates were finalised it actually occupied more time in period 3 than period 2. Given the proximity to the start of the surveys the decision was made to retain the survey within period two rather than splitting it between the periods which risked disrupting an otherwise settled survey plan. The large egg production estimate for period 2 compared to period 3 required a closer look at the contribution made by these late AZTI stations that were sampled within period 3.

For horse mackerel the contribution made by the late AZTI stations to the overall production was much higher than for mackerel as can be seen from Figure 3.7.1a, with the out of period stations contributing around 28% ($1.48*10^{12}$) to the total estimate for the period. It is worth noting that 3 stations were responsible for around 70% of the out of period abundance in period 2 and that these stations were all undertaken on the 13th April – only 5 days into period 3. The impact of removing these stations on the DEP estimate for period 2 was to reduce it from $5.35*10^{12}$ to $3.87*10^{12}$. This was early on in the spawning season so only resulted in a slight decrease of 4% to the Total Annual Egg Production (TAEP) horse mackerel ($1.43*10^{\mathbf{15}}$ to $1.38*10^{\mathbf{15}}$). Given that total production in period 2 amounts to just over 10% of the TAEP of horse mackerel it is suggested that the impact of including the ‘outwith period’ stations would again be minimal.

The Cantabrian stations contributed 49% ($2.72*10^{12}$) of the period 2 DEP total for horse mackerel and increased to 59% ($3.16*10^{12}$) in period 3. Collectively this accounts for around 13% ($1.88*10^{14}$) of the TAEP for horse mackerel. The Cantabrian Sea is not surveyed in the period 4-6 and therefore the total egg production is underestimated.

Egg production for each survey period was then calculated by raising each value to the rectangle area, summing across the whole period, and raising to the number of days in each period. Egg production in the unsampled periods were then calculated by simple linear interpolation from the adjacent periods. The observed and interpolated periods were then assembled to produce separate western and southern area egg production curves or histograms. TAEP was then calculated by integration of the histograms. The curve of Stage I horse mackerel eggs production for WESTERN area is shown in Figure 3.7.2. The curves for 1998, 2001 and 2004 are included for comparison. Although much larger, the pattern of the curve for 2007 was quite similar to that in 2004 albeit period 2 DEP is disproportionately larger. Estimate of total annual egg production for 2007 for the western area is $1.43 * 10^{15}$. This estimate includes Division VIIIc. Table 5.3.1 gives the previous egg production estimate adjusted for the inclusion of Division VIIIc in the western spawning area. The egg production in 2007 is 78% and 60% more than in 2001 and 2004 respectively.

Following the 2001 egg survey it was agreed that as horse mackerel was probably an indeterminate spawner, and therefore not possible to use fecundity data to convert egg production to biomass. For the time being the TAEP will be used as an index of abundance in the assessment.

This information will be presented in more detail at the meeting of WGMEGS in April 2008.

Table 3.1.1 HORSE MACKEREL general. Catches (t) by Sub-area. Data as submitted by Working Group members. Data of limited discard information are only available for some years.

Sub-area	1979	1980	1981	1982	1983	1984
II	2	-	+	-	412	23
IV + IIIa	1,412	2,151	7,245	2,788	4,420	25,987
VI	7,791	8,724	11,134	6,283	24,881	31,716
VII	43,525	45,697	34,749	33,478	40,526	42,952
VIII	47,155	37,495	40,073	22,683	28,223	25,629
IX	37,619	36,903	35,873	39,726	48,733	23,178
Total	137,504	130,970	129,074	104,958	147,195	149,485

Sub-area	1985	1986	1987	1988	1989	1990
II	79	214	3,311	6,818	4,809	11,414
IV + IIIa	24,238	20,746	20,895	62,892	112,047	145,062
VI	33,025	20,455	35,157	45,842	34,870	20,904
VII	39,034	77,628	100,734	90,253	138,890	192,196
VIII	27,740	43,405	37,703	34,177	38,686	46,302
IX	20,237	31,159	24,540	29,763	29,231	24,023
Total	144,353	193,607	222,340	269,745	358,533	439,901

Sub-area	1991	1992	1993	1994	1995	1996	1997
II + Vb	4,487	13,457	3,168	759	13,133	3,366	2,617
IV + IIIa	77,994	113,141	140,383	112,580	98,745	27,782	81,198
VI	34,455	40,921	53,822	69,616	83,595	81,259	40,145
VII	201,326	188,135	221,120	200,256	330,705	279,109	326,415
VIII	49,426	54,186	53,753	35,500	28,709	48,269	40,806
IX	21,778	26,713	31,944	28,442	25,147	20,400	27,642
Total	389,466	436,553	504,190	447,153	580,034	460,185	518,882

Sub-area	1998	1999	2000	2001	2002	2003	2004
II + Vb	2,538	2,557	1,169	60	1,324	24	47
IV + IIIa	31,295	58,746	31,583	19,839	49,691	34,226	30,540
VI	35,073	40,381	20,657	24,636	14,190	23,254	21,929
VII	250,656	186,604	137,716	138,790	97,906	123,046	116,139
VIII	38,562	47,012	54,211	75,120	54,560	41,711	24,125
IX	41,574	27,733	27,160	24,912	23,665	19,570	23,581
Total	399,698	363,033	272,496	283,357	241,335	241,831	216,361

Sub-area	2005	2006[1]
II + Vb	176	30
IV + IIIa	40,564	38,911
VI	22,055	15,751
VII	107,475	101,912
VIII	41,495	34,122
IX	23,111	24,557
Total	234,876	215,283

[1]Preliminary.

Table 3.1.2 HORSE MACKEREL general. Quarterly catches (1000 t) by Division and Sub-division in 2006.

Division	1Q	2Q	3Q	4Q	TOTAL
IIa+Vb	+	0	+	+	+
IIIa	0.9	0.1	+	+	1.1
IVa	2.6	+	0.1	27.1	29.8
IVbc	5.2	0.6	0.8	1.4	8.0
VIId	7.7	+	+	16.2	23.9
VIa,b	1.9	+	1.0	12.9	15.8
VIIa–c,e–k	18.3	2.4	11.1	46.3	78.1
VIIIa,b,d,e	8.9	1.7	0.1	10.0	20.7
VIIIc	2.3	4.1	4.4	2.7	13.5
IXa	5.3	7.3	7.9	4.0	24.5
Sum	53.5	16.2	25.4	120.6	215.3

+ less than 50 t

Table 3.3.1 HORSE MACKEREL general. Landings and discards (t) by year and Division, for the North Sea, Western, and Southern horse mackerel stocks.

(Data submitted by Working Group members.)

Year	IIIa	IVa	IVb,c	Discards	VIId	**North Sea Stock**	IIa	IIIa	IVa	VIa,b	VIIa-c,e-k	VIIIa,b,d,e	VIIIc	Disc	**Western Stock**	**Southern Stock** (IXa)	All stocks
1982	2,788[1]		-		1,247	4,035	-		-	6,283	32,231	3,073	19,610	-	61,197	39,726	104,958
1983	4,420[1]		-		3,600	8,020	412		-	24,881	36,926	2,643	25,580	-	90,442	48,733	147,195
1984	25,893[1]		-		3,585	29,478	23		94	31,716	38,782	2,510	23,119	500	96,744	23,178	149,400
1985	-		22,897		2,715	26,750	79		203	33,025	35,296	4,448	23,292	7,500	103,843	20,237	150,830
1986	-		19,496		4,756	24,648	214		776	20,343	72,761	3,071	40,334	8,500	145,999	31,159	201,806
1987	1,138		9,477		1,721	11,634	3,311		11,185	35,197	99,942	7,605	30,098	-	187,338	24,540	223,512
1988	396		18,290		3,120	23,671	6,818		42,174	45,842	81,978	7,548	26,629	3,740	214,729	29,763	268,163
1989	436		25,830		6,522	33,265	4,809		85,304[2]	34,870	131,218	11,516	27,170	1,150	296,037	29,231	358,533
1990	2,261		17,437		1,325	18,762	11,414	14,878	112,753[2]	20,794	182,580	21,120	25,182	9,930	398,645	24,023	441,430
1991	913		11,400		600	12,000	4,487	2,725	63,869[2]	34,415	196,926	25,693	23,733	5,440	357,288	21,778	391,066
1992			13,955	400	688	15,043	13,457	2,374	101,752	40,881	180,937	29,329	24,243	1,820	394,793	26,713	436,548
1993			3,895	930	8,792	13,617	3,168	850	134,908	53,782	204,318	27,519	25,483	8,600	458,628	31,945	504,190
1994			2,496	630	2,503	5,689	759	2,492	106,911	69,546	194,188	11,044	24,147	3,935	413,022	28,442	447,153
1995	112		7,948	30	8,666	16,756	13,133	128	90,527	83,486	320,102	1,175	27,534	2,046	538,131	25,147	580,034
1996	1,657		7,558	212	9,416	18,843	3,366		18,356	81,259	252,823	23,978	24,290	16,870	420,942	20,400	460,185
1997			14,078	10	5,452	19,540	2,617	2,037	65,073[3]	40,145	318,101	11,677	29,129	2,921	471,700	27,642	518,882
1998	3,693		10,530	83	16,194	30,500	2,540[4]		17,011	35,043	232,451	15,662	22,906	830	326,443	41,574	398,523
1999			9,335		27,889	37,224	2,557[5]	2,095	47,316	40,381	158,715	22,824	24,188		298,076	27,733	363,033
2000			25,954		22,471	48,425	1,169[6]	1,105	4,524	20,657	115,245	32,227	21,984		196,911	27,160	272,496
2001	85	69	8,157		38,114	46,356	60	72	11,456	24,636	100,676	54,293	20,828		212,090	24,911	283,357
2002			12,636	20	10,723	23,379	1,324	179	36,855	14,190	86,878	32,450	22,110	305	194,292	23,665	241,336
2003	48	623	10,309		21,098	32,078	24	1,974	21,272	23,254	101,948	21,732	19,979		190,183	19,570	241,831
2004	351		18,348		16,455	35,154	47		11,841	21,929	98,984	8,353	15,772	701	157,627	23,581	216,361
2005	357		13,892	62	15,460	29,711	176		26,315	22,054	91,431	26,483	14,775	760	181,994	23,111	234,876
2006	1,099	2,661	7,998	78	23,790	35,626	30		27,152	15,722	77,970	20,651	13,470	99	155,094	24,557	215,277

[1]Divisions IIIa and IVb,c combined.

[2]Norwegian catches in IVb included in Western horse mackerel.

[3] Includes Norwegian catches in IVb (1,426 t).

[4]Includes 1,937 t from Vb.

[5]Includes 132 t from Vb.

[6]Includes 250 t from Vb.

Table 3.6.1 Horse mackerel general. Length distributions (%) catches by fleet and country in 2006. (0:0= <0.05%)

	Neth	Germany						Ireland	Norway	Spain			Portugal
	P.trawl	Trawl						Trawl	P.seine	P.seine	Dem.trawl	Gill net	All
cm	All	VIa	VIIb	VIId	VIIe	VIIj	VIIIa	All	IVa	All	All	All	IXa
5													
6													
7										0,0			
8										0,0			
9										0,0			
10				0,0						0,3			0,0
11				0,0						0,9	0,0		0,2
12				0,0						2,0	0,2		3,2
13										2,2	1,1		9,6
14					0,0					3,8	3,5		9,6
15										6,7	5,8	0,0	8,2
16										8,1	3,5		11,8
17					0,4					12,2	1,3		17,0
18	0,3				2,7					10,5	1,2	0,5	12,4
19	1,0			0,8	7,4					6,5	0,9	3,4	5,7
20	1,5			3,1	4,6					4,1	0,9	3,9	2,1
21	3,5			3,6	6,5		0,1			4,2	2,5	2,9	1,0
22	6,8	0,1		9,7	11,5		1,2			3,2	2,6	7,0	0,9
23	16,2	1,2	1,4	20,5	17,4	1,4	7,8	0,5		3,1	1,5	8,9	1,1
24	28,6	10,2	8,0	24,3	18,6	12,2	30,0	6,2		3,8	2,0	6,8	1,4
25	19,6	18,7	25,8	15,7	11,9	26,7	41,2	18,4		3,5	2,8	7,6	6,2
26	7,1	16,1	32,0	9,4	7,1	25,7	16,7	23,2	0,1	4,1	2,7	6,7	1,6
27	4,5	15,5	17,7	6,2	4,8	16,5	2,3	19,7	0,1	4,6	4,0	6,4	1,6
28	3,5	12,5	8,6	3,3	3,6	8,8	0,6	12,0	0,3	4,8	4,7	7,8	1,5
29	2,8	10,8	3,6	1,8	1,9	4,6	0,1	6,8	0,7	3,4	7,2	6,4	1,3
30	1,6	6,5	2,0	1,1	1,4	1,9	0,1	4,1	3,6	2,7	7,8	8,2	1,0
31	0,7	3,8	0,4	0,3	0,2	1,4		2,8	6,5	2,1	8,2	6,1	0,7
32	0,8	2,4	0,1	0,1	0,2	0,5		2,5	11,8	1,6	8,4	4,9	0,4
33	0,6	1,1	0,3	0,1		0,2		1,6	15,1	0,7	6,5	4,6	0,2
34	0,3	0,5		0,0				1,1	15,6	0,5	6,9	2,9	0,2
35	0,3	0,3		0,0		0,1		0,5	14,6	0,1	5,2	2,7	0,2
36	0,3	0,2		0,0		0,1		0,3	12,0	0,1	2,9	1,2	0,2
37	0,0	0,2		0,0	0,0			0,2	9,8	0,0	2,5	0,4	0,2
38	0,0	0,1		0,0				0,1	5,6	0,0	1,5	0,4	0,2
39	0,0							0,0	2,8	0,0	1,1	0,2	0,2
40		0,1						0,0	1,0	0,0	0,3	0,2	0,1
41									0,4	0,0	0,2		0,0
42+								0,0	0,1	0,0	0,0		0,0

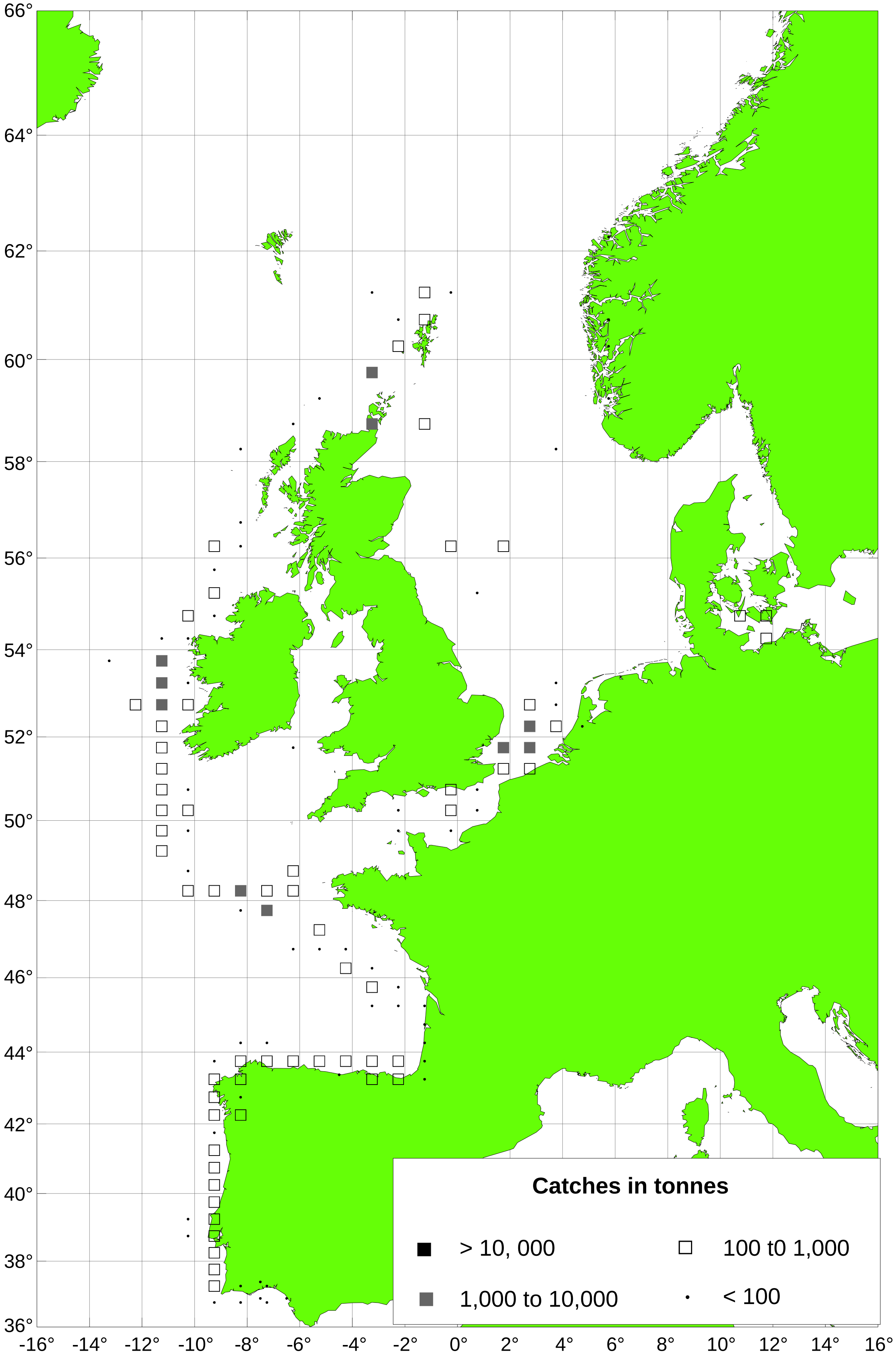


Figure 3.1.1a Horse mackerel catches in quarter 1 2006

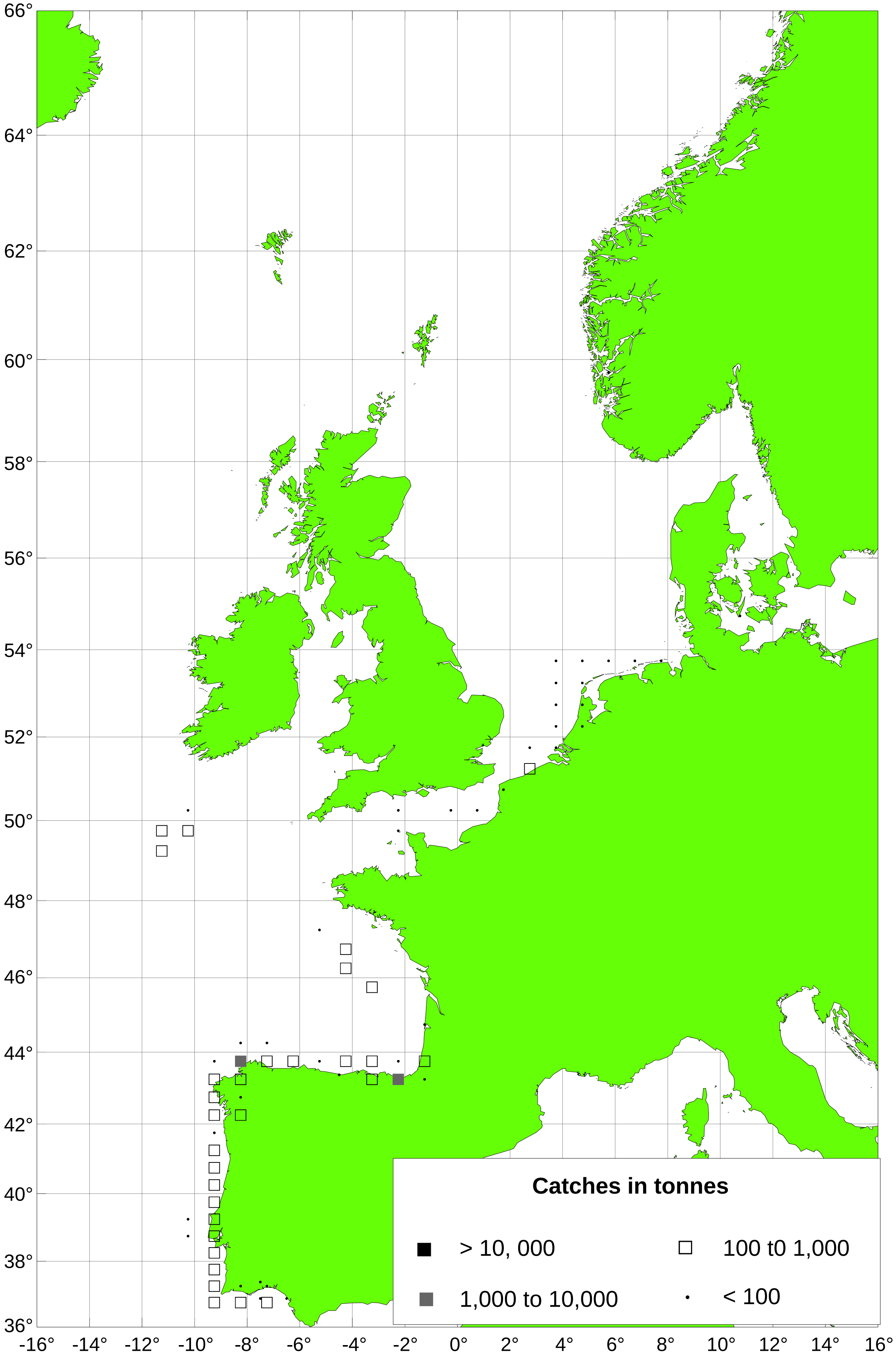


Figure 3.1.1b Horse mackerel catches in quarter 2 2006

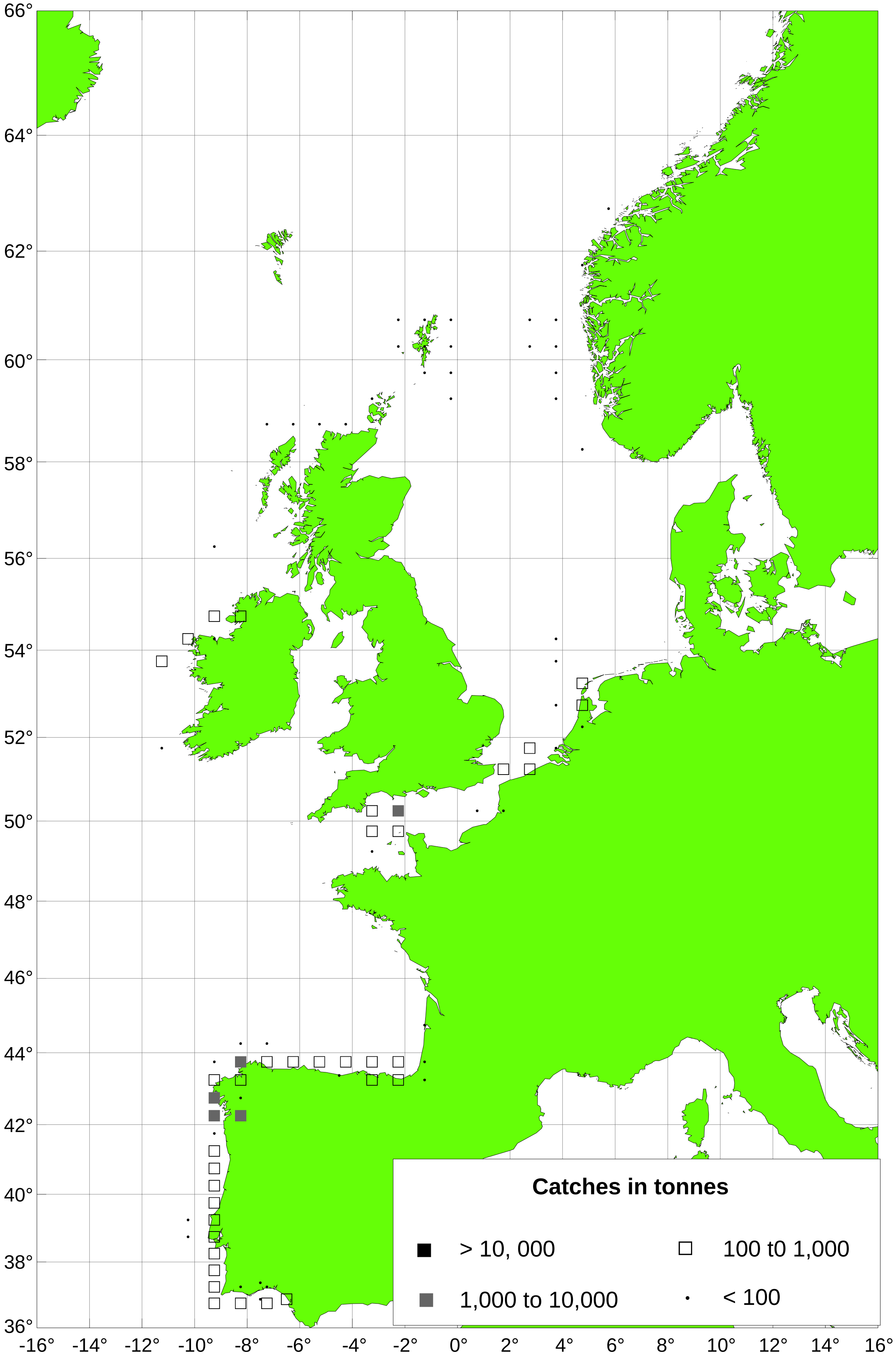


Figure 3.1.1c Horse mackerel catches in quarter 3 2006

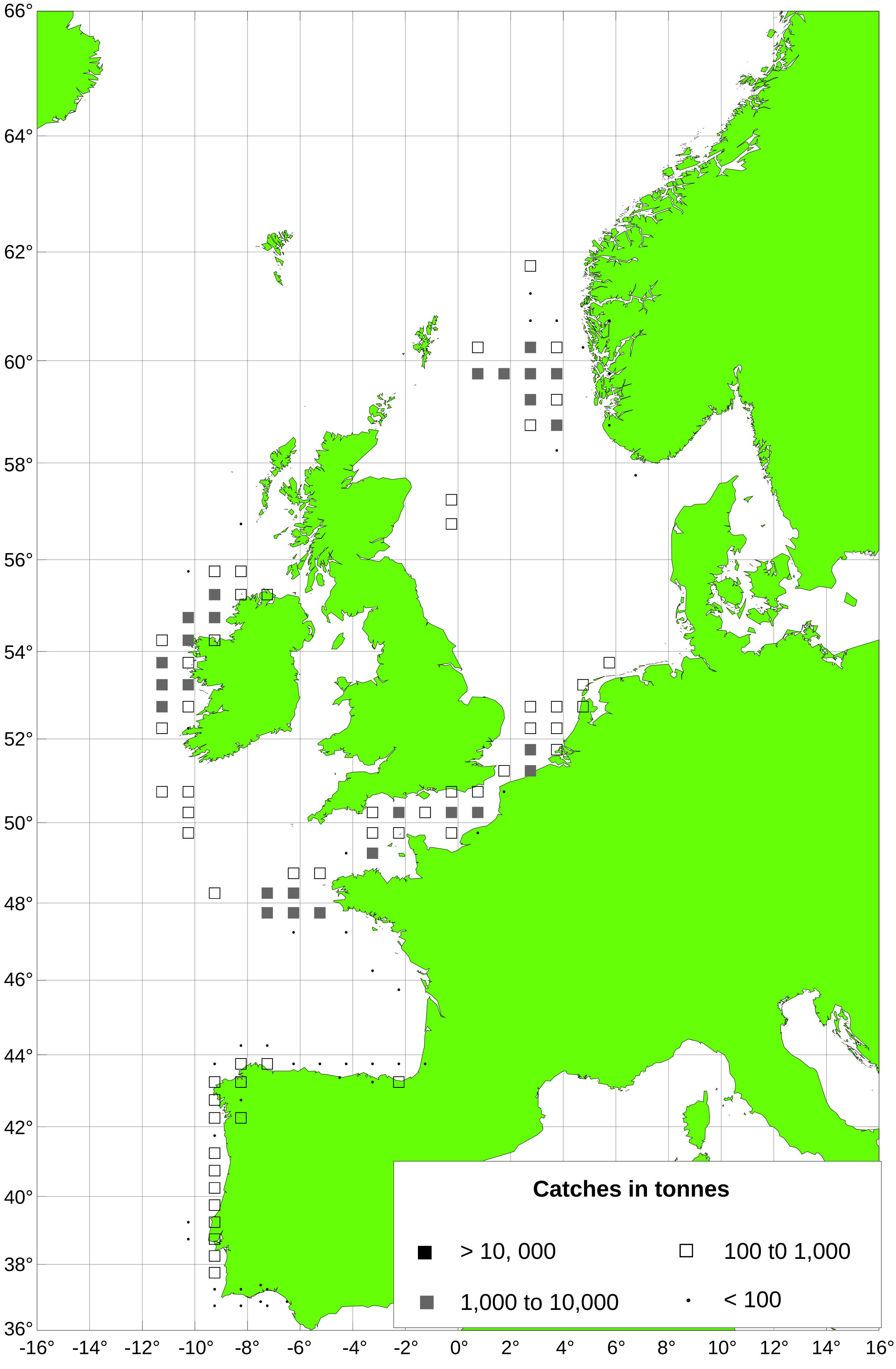


Figure 3.1.1d Horse mackerel catches in quarter 4 2006

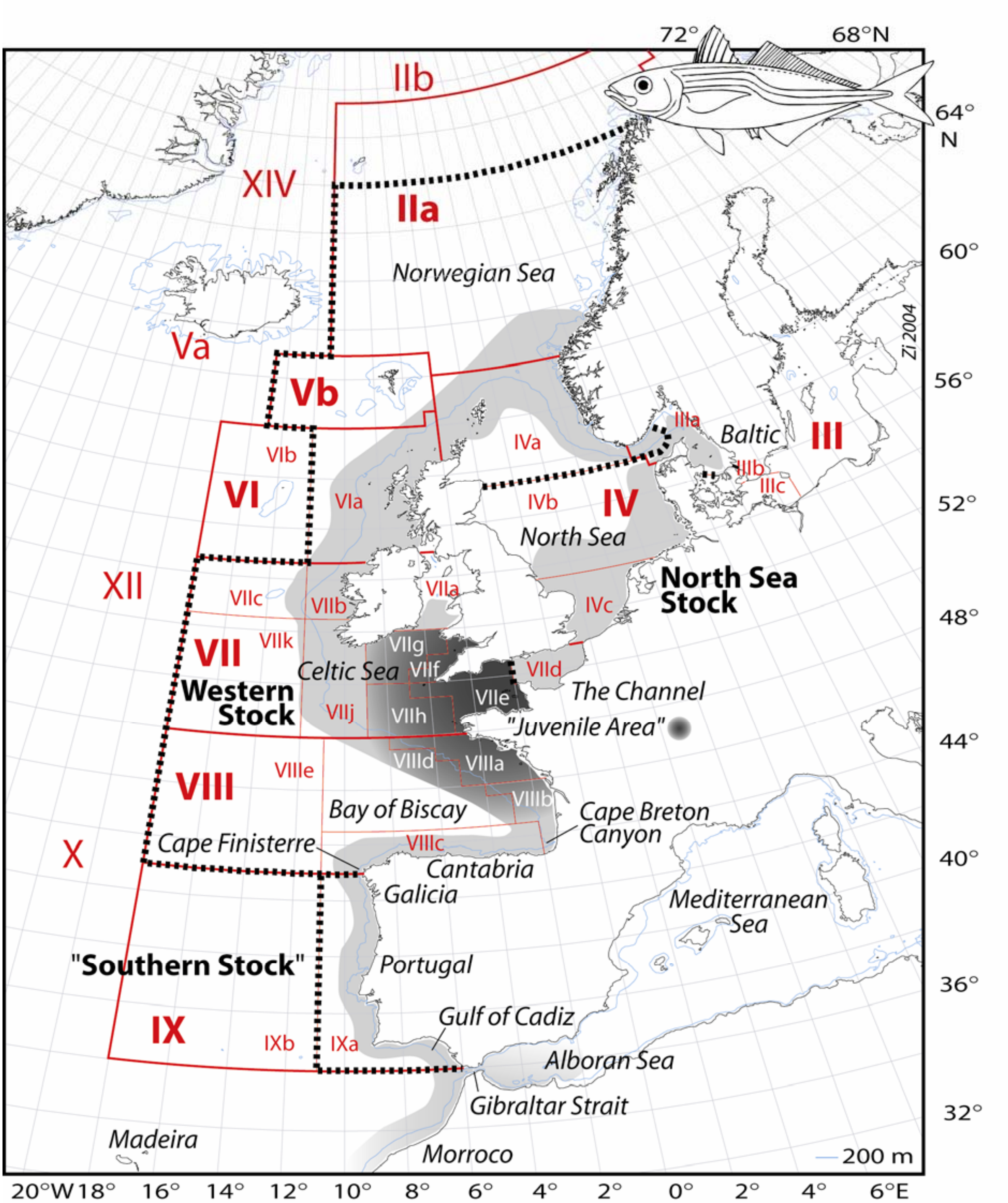


Figure 3.2.1: Distribution of Horse Mackerel in the Northeast-Atlantic: Stock definitions as used by the 2004 WG MHSA. Note that the "Juvenile Area" is currently only defined for the Western Stock distribution area – juveniles do also occur in other areas (like in Div. VIId). Map source: GEBCO, polar projection, 200 m depth contour drawn

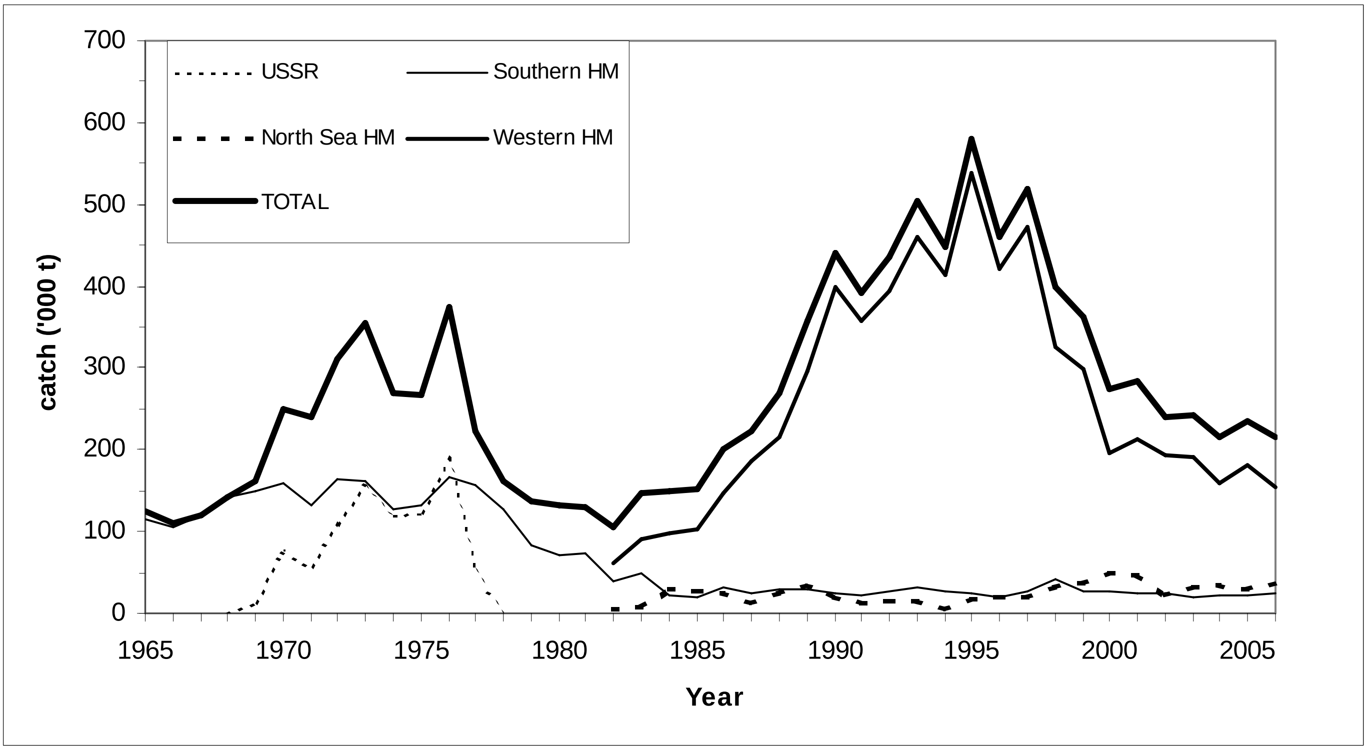


Figure 3.3.1 **Horse mackerel general. Total catches in the northeast Atlantic during the period 1665 – 2006. The catches taken by the USSR and catches taken from the southern, western and North Sea horse mackerel stocks are shown in relation to the total catches in the northeast Atlantic. Catches from Div VIIIc are transferred from southern stock to western stock from 1982 onwards.**

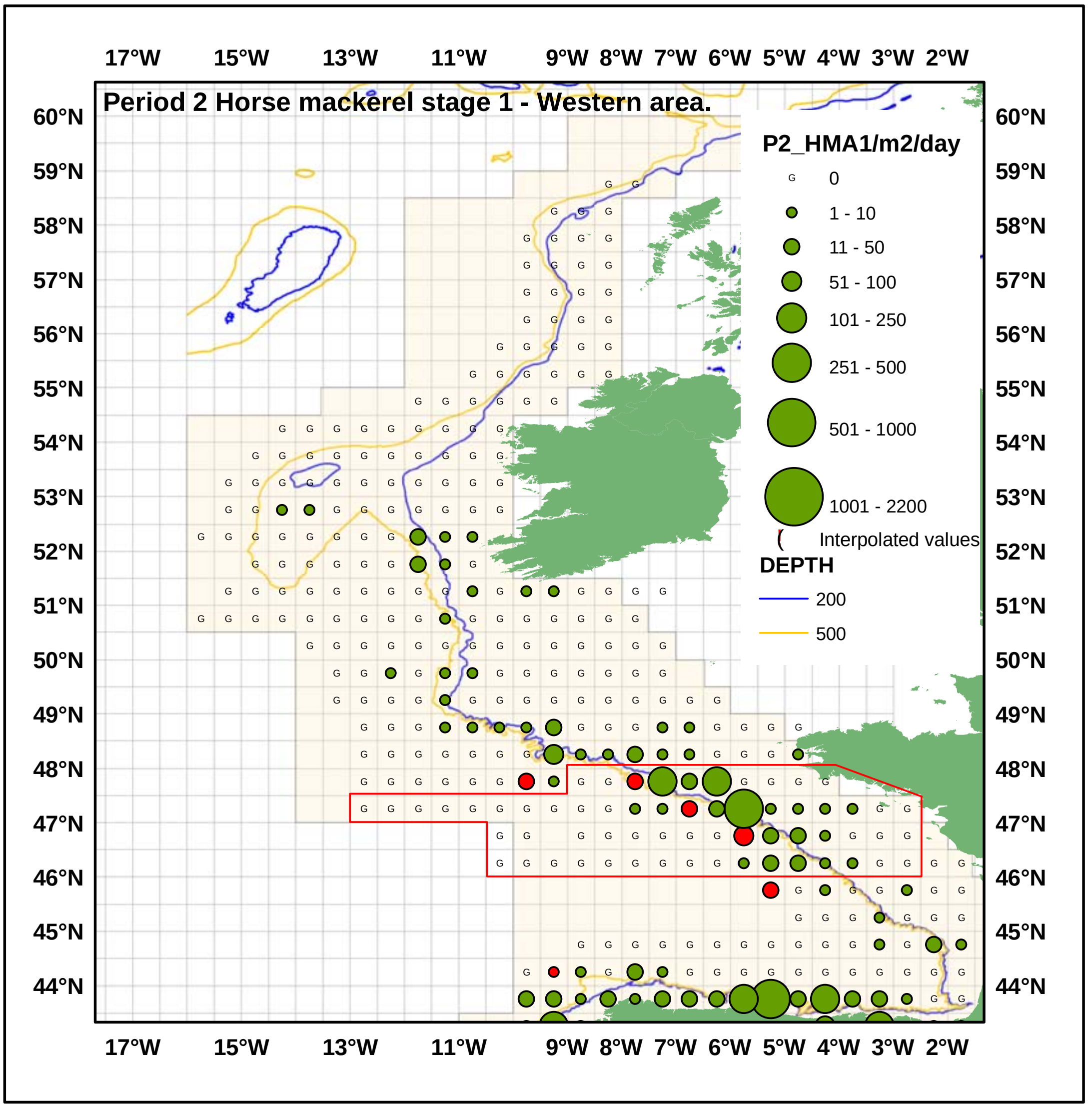


Figure 3.7.1.a Period 2 – Horse mackerel stage 1 eggs (area outlined in red contains stations sampled within period 3 during AZTI period 2 survey)

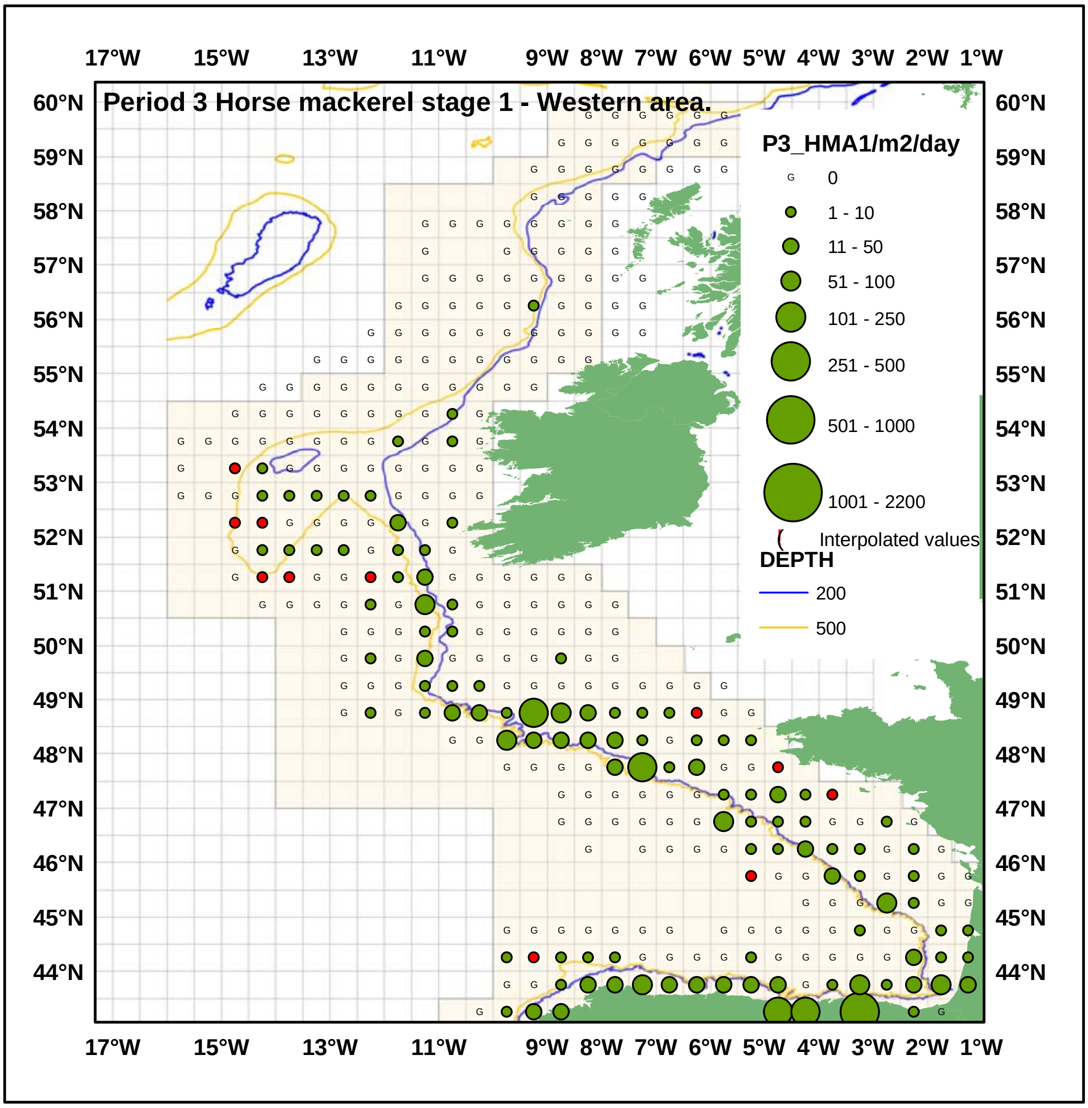


Figure 3.7.1.b Period 3 – Horse mackerel stage 1 eggs

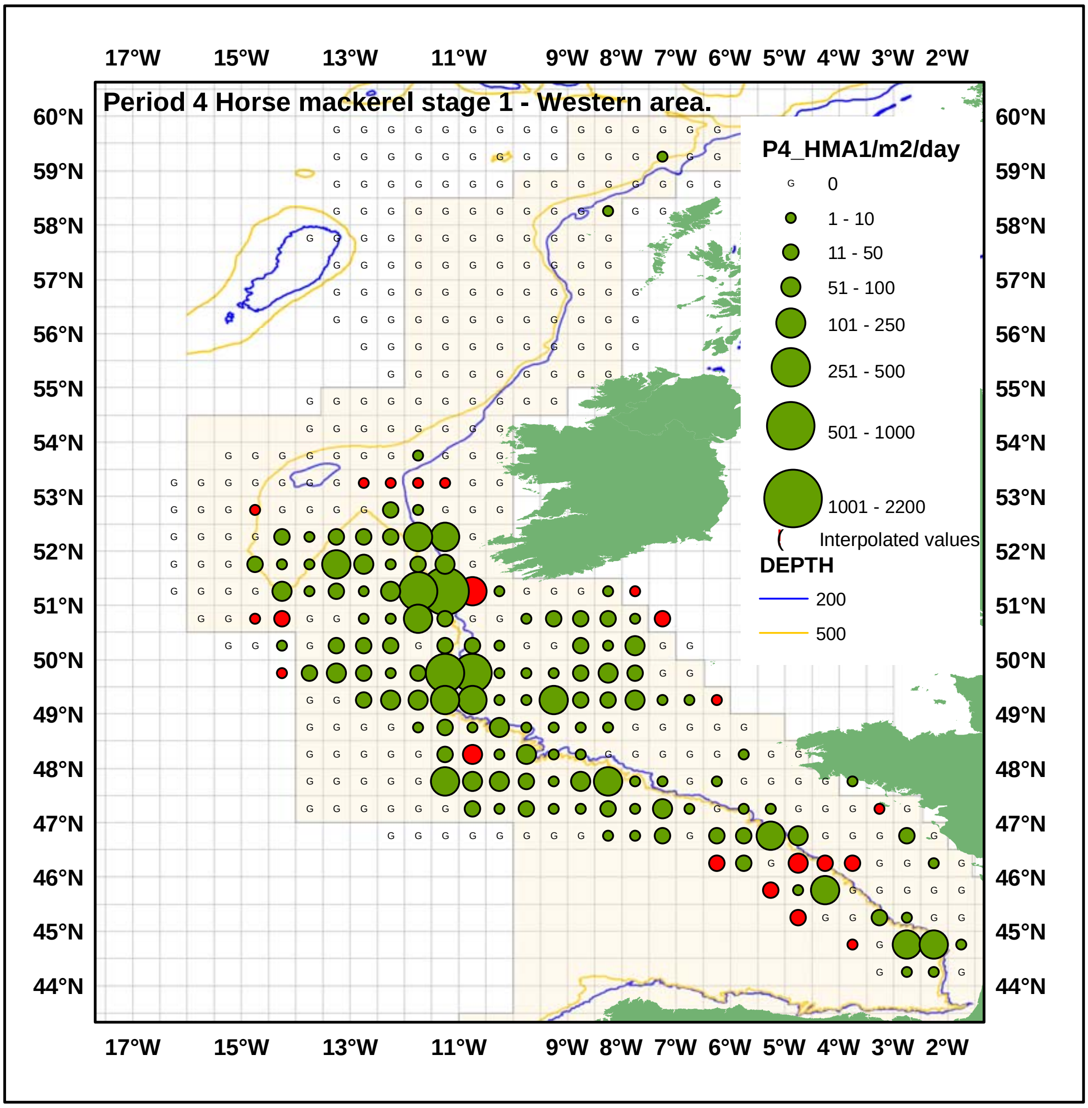


Figure 3.7.1.c Period 4 – Horse mackerel stage 1 eggs

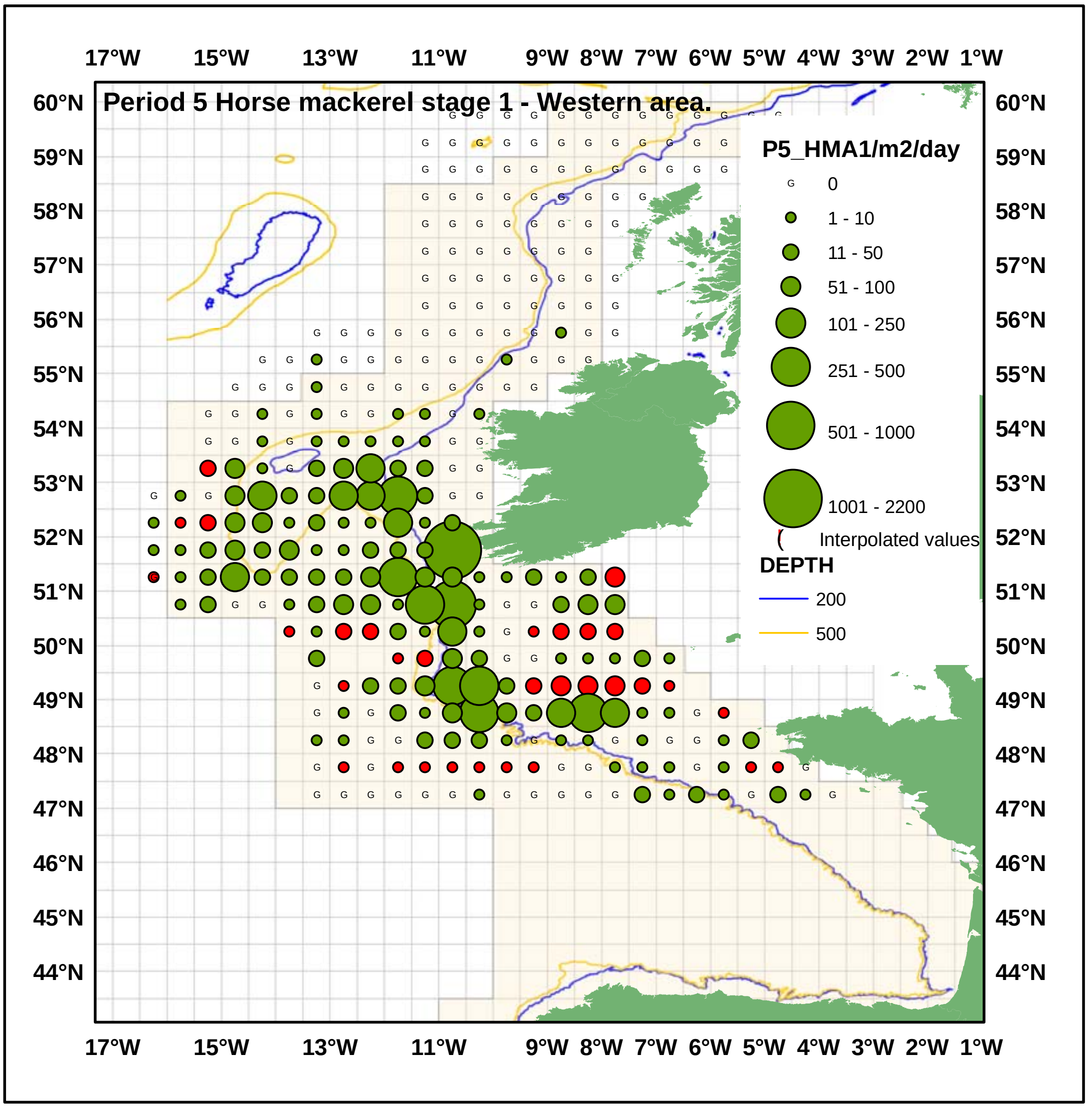


Figure 3.7.1.d Period 5 – Horse mackerel stage 1 eggs

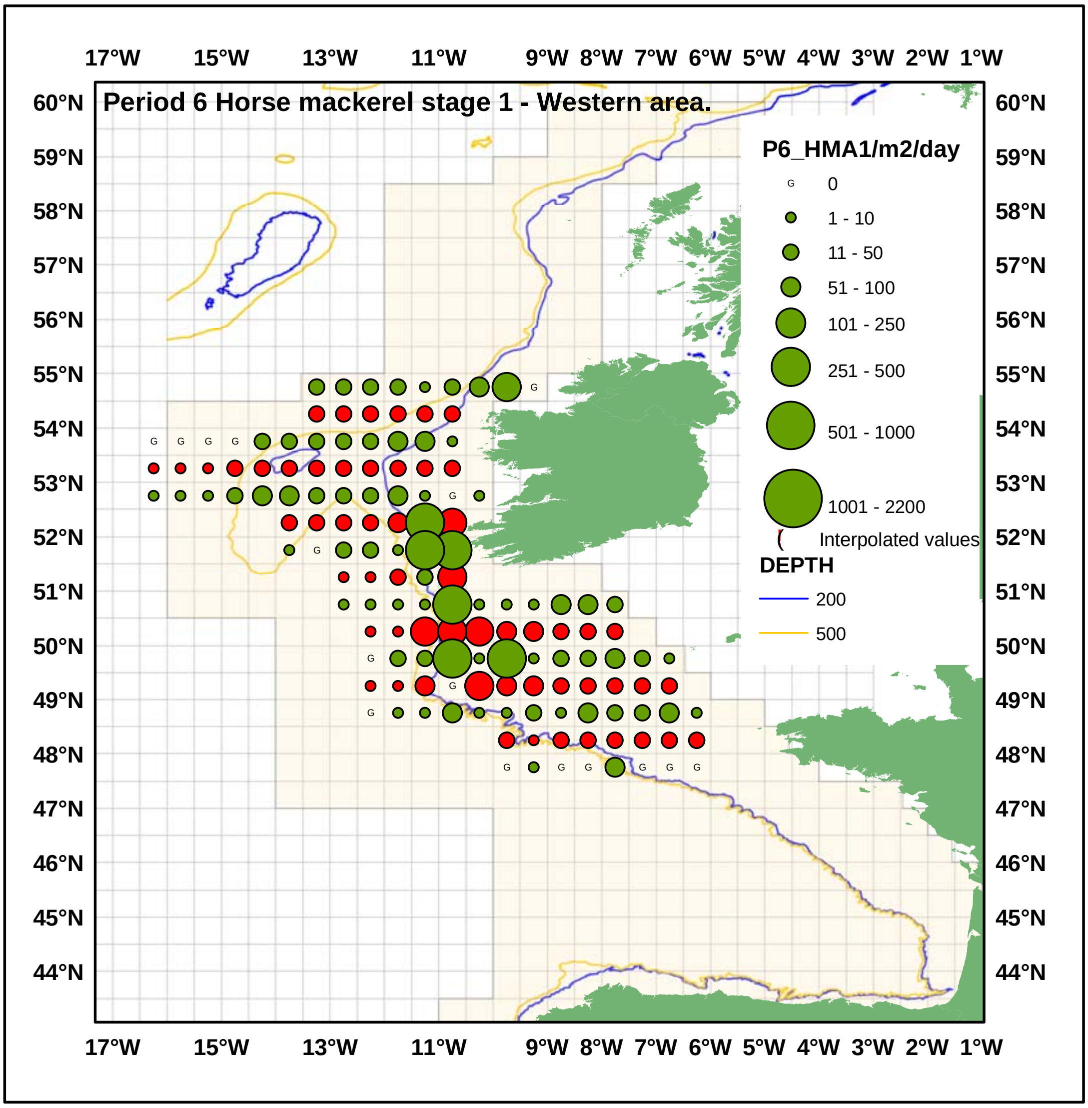


Figure 3.7.1.e Period 6 – Horse mackerel stage 1

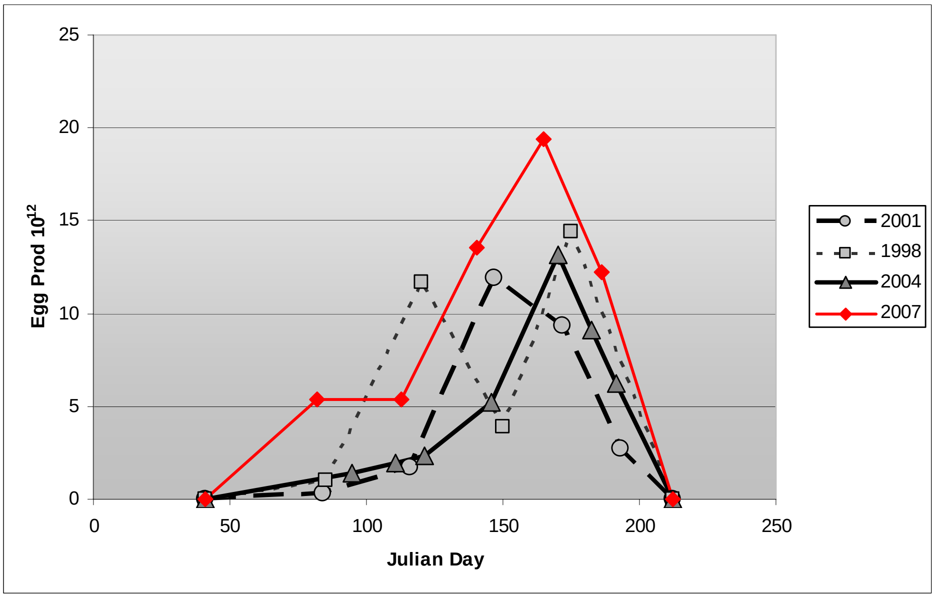


Figure 3.7.2: Annual egg production curve for western horse mackerel. Preliminary results

4 North Sea Horse Mackerel (Divisions IIIa (Excluding Western Skagerrak), IVb, IVc and VIId

4.1 ICES advice Applicable to 2006

The ICES advice has been the same since 2002. Also for 2005 and 2006 ICES *recommended that catches should not be more than the 1982-1997 average of 18 000 t, in order to avoid an expansion of the fishery until there is more information about the structure of horse mackerel stocks, and sufficient information to facilitate an adequate assessment.* The TAC for this stock should apply to all areas in which North Sea horse mackerel are fished, i.e., Divisions IIIa, (eastern part), IVb, IVc and VIId.

EU has since 1987 set three TACs for horse mackerel in different EU waters. Two of these TACs cover part of the North Sea stock and thereby do not correspond to the distribution areas of neither the North Sea stock, nor the western and southern stocks.

4.2 The Fishery in 2006 on the North Sea stock

Catches taken in Divisions IVb, IVc and VIId are regarded as belonging to the North Sea horse mackerel and in some years also catches from Division IIIa - except in the western part of Skagerrak. Table 3.3.1 shows the reported catches of this stock from 1982–2006. The catches were relatively low during the period 1982-1997 with an average of 18,000 tons. The catches increased from 1998 (30,500 tons) until record high in 2000 (48,400 tons). In 2005 the catch was reduced to 29,231 tons but increased to 35,600 tons in 2006.

In previous years most of the catches from the North Sea stock were taken as a by-catch in the small-mesh industrial fisheries in the fourth quarter carried out mainly in Divisions IVb and VIId, but in recent years a large part of the catch has been taken in a directed horse mackerel fishery for human consumption.

4.3 Fishery-independent Information

4.3.1 Egg Surveys

No egg surveys for horse mackerel have been carried out in the North Sea since 1991. Such surveys were carried out during the period 1988-1991. SSB estimates are available historically. However, they were calculated assuming horse mackerel to be a determinate spawner. For determinate spawners the fecundity is determined prior to spawning, which implies that in an individual fish the development of vitellogenic oocytes stops prior to spawning. New information indicates that horse mackerel is probably an indeterminate spawner, where fecundity is not determined prior to spawning, because in an individual fish the development of vitellogenic oocytes even continues after the onset of spawning in which case the potential fecundity can not be estimated. Therefore it is not possible currently to provide a realistic estimate of the spawning biomass. The mackerel egg surveys in the North Sea do not cover the spawning area of horse mackerel.

4.4 Biological Data

4.4.1 Catch in Numbers at Age

Catch in numbers at age by quarter and annual values for 2006 were calculated according to Dutch samples from Division IVc, Dutch and German samples collected in Division VIId and Irish samples from first quarter in IVa Annual catch numbers at age are given in Table 4.4.1.1.

Table 4.4.1.2 shows catch number by quarter and by area in 2005. Earlier years age compositions were presented based on samples taken from smaller Dutch commercial catches and research vessel catches. These are available for the period 1987–1995, and cover only a small proportion of the total catch, but give a rough indication of the age composition of the stock (Figure 4.4.1.1). Therefore, age estimations prior to 1995 are not considered to be representative for the entire fishery. The catches this year from areas IVa (Quarters 1 and 2, southern part (See figure 3.1.1a and 3.3))) and IIIc are included in the Table 4.4.1.2. In previous years, these catches were negligible.

At present the sampling intensity is rather low and the quality of the catch at age data may be questionable and involve large uncertainties. If a dependable analytical assessment is to be done in the future, the sampling needs to be improved considerably. From 1995 onwards the proportion of the catches taken for human consumption has been high. The Dutch samples after 1996 covered all their catches, and as this catch represent the largest part, the coverage has been around 70 % in recent years. In 2005 the coverage was 48% , but increased to 70% in 2006 as shown in table 4.4.3.

4.4.2 Mean weight at age and mean length at age

Table 4.4.2.1 shows weight and length by quarter and by area in 2006. The annual average values are shown in Table 4.4.1.2.

4.4.3 Maturity at age

No data has been made available for this Working Group.

4.4.4 Natural mortality

There is no specific information available about natural mortality of this stock.

4.5 Data exploration

4.5.1 Commercial catch data

Figure 4.5.1.1 shows the developments of horse mackerel landings from the western stock and the North Sea stock, by four areas, (1) Western stock minus VIIacek (2) VIIacek (3) VIId (4) Ivabc+IIIac. The purpose of this figure is to evaluate the hypothesis that the two stocks mix in area VII, in particular that the western stock mix with the North Sea stock in area VIId. The hypothesis wil be further discussed in section 4.6.

Estimates of the age composition of the catches are available since 1987. However, the age composition for 1995 and 1996 was partly based on research vessel samples, which may not be representative for the commercial fishery. The catch-at-age pattern can be seen in Figure 4.4.1.1 and 4.5.1.2. The catch-at-age pattern appears to have changed during the period from 1995 to 2006, with a large reduction in mean age, mean length and mean weight. Younger age groups appear in the catches in recent times, especially in 2000 and 2001. This coincides with the disappearance of the large 1982-year class. The change in pattern around year 2000 could reflect a change in the fishery, a change in abundance, distribution pattern, or a change in sampling strategy. Sampling did not change from 1997 onwards, so a change in the fishery or a change in abundance seem more likely. In recent years, a fishery for human consumption has developed. This fishery targets small sized horse mackerel for the Japanese market (Eltink, pers. com.). However, a change in abundance cannot be excluded. The overall impression from Figures 4.4.1.1 and 4.5.1.2. is rather confusing, as e.g. the 1998 year class appeared as a large one in the years 2000 and 2001, while disappeared in 2002. In general, it is difficult to trace the cohorts in the balloon diagram, which may be caused by age reading problems and selective sampling; it has been noted that 2-year olds may have been interpreted as 1-year olds, especially in the case of slow growing fish of an abundant year class (Eltink, pers. com.). As the number of samples is small, they may not be representative for the entire stock.

Figure 4.5.1.3.a. displays the log catch ratios by age-class. The picture is rather chaotic: there is no uniform slope reflecting total mortality Z, neither over the ages nor over the year-classes. No clear age at full selection can be deduced from this figure. Selection at age seems to vary by year, and the more recent year-classes seem to have higher catches than the older year-classes (indicating either increased fishing, or increased year-class strength); however, this impression may also be an artefact of the low sampling level. The problem with age reading in 2001 may also confuse the picture. In general the slopes are rather flat; however, this does not necessarily indicate low total mortality (Z), because such a pattern could also arise from increasing selection at age. Because of the lack of any pattern in selection (over time or age), any analytical assessment model will suffer from either being too simplistic in its assumptions about selection or from over-parameterisation (e.g. in case selection would be estimated for each year and age). Figure 4.5.1.3.b. displays the smoothed (running average over 3 years) log catch ratios. From this, total mortality (Z) seems to be low at the youngest as well as the oldest ages; at intermediate ages Z is around 0.5. The pattern over time is rather strange; in early years Z is a bit lower, except for ages 9-10 and 11-12. Total mortality is very low (negative!) for ages 2-3 and 12-13. Total mortality becomes more equal between the ages over time.

The group decided that the catch data are not suitable for the use in an analytical assessment, to provide catch options for TAC-settings, or any application with a harvest control rule. Nevertheless, the group decided to do an exploratory assessment, based on a simplistic model (see Section 4.5.3).

4.5.2 IBTS survey data

From an initial exploration of the length frequency distribution of the quarter 3 the mean catch rates by year, using the North Sea IBTS data from 1995 to 2006, it was concluded that the 0-group is clearly separated from the older fish, with the boundary at 14 cm length. Therefore we decided to derive three indices from these data: (a) for fish <14 cm, (b) for fish $\geq$14 cm and <23 cm, and (c) for fish $\geq$23 cm. Half of the fish are mature at 23 cm in length. These three groups roughly correspond to (a) 0-group fish, (b) 1-, 2-, and possibly 3-year old juveniles, and (c) adults respectively. The mean catch rates in quarter 3 are plotted by ICES rectangle in the North Sea by year for each of these three groups separately (Figure 4.5.2.1). The rectangle shows the sub-areas of IVb and IVc used in the 2005 report.

A subset of ICES rectangles was selected in which hauls were taken in each of the years 1995-2006 and in which each of the three groups were reasonably abundant. These rectangles are represented as a shaded area in Figure 4.5.2.1. Indices were based on this subset of rectangles under the expectation that they might be representative for the development of the stock (Figure 4.5.2.2.a).

The peak of 0-group fish in 2001 comes back as a peak of older juveniles in 2002. however, the peak of 0-group fish in 1997 is not seen back in 1998 as older juveniles but appears to come back from 1999 onwards as adults. It is thought that juveniles often stay in area VIId and do not come back into the North Sea before they are adult (Eltink, pers. com.). Figure 4.5.2.2.a. also shows that abundance of adult fish has decreased considerably over time, and there is only a slight trace in 2004 of the entering 2001 year class. Although the commercial catch data seemed to indicate a large year class born in 1998 (seen in the catches in 2000 and 2001, see Figure 4.5.1.1.), there is no indication of this year class being large in the IBTS data. The lowest total index (all length groups combined was observed in 2006).

Figure 4.5.2.2.b shows ln(Index(y,a)/Index(y-1,a-1)), which should be index for the total mortality. As can be seen, no consistent pattern can be detected, for either ln(Index(y,2)/Index(y-1,1)) or ln(Index(y,3)/Index(y-1,2)) .

Figure 4.5.2.3. displays the length frequency distributions by year from the subset of ICES rectangles (the shaded area in Figure 4.5.2.1). The 0-group fish are clearly separated from the older fish. Again the strong year classes of 1997 and 2001 can be seen, and again of those year classes only the 2001 year class is seen back a year later as juveniles. In some cases it seems possible to separate 1-year olds from older fish.

The IBTS data showed no consistent signal that could be traced through the age groups (in this case size groups).

4.5.3 Exploratory analysis of data by Ad hoc method.

This Ad hoc method was tested for the first time in 2003, and the exercise was repeated in 2004. No exploratory assessments were made in 2005 and 2006. This year, however, the group decided to make a new exploratory assessment, using the IBTS index as defined in Section 4.5.2 (introduced in 2005).

4.5.3.1 Theory of Ad hoc method

Due to the low quality of data, the method deviates from other assessment methods in that the number of parameters is smaller, which is made possible by the introduction of a number of assumptions.

1) The selection ogive is given by one logistic curve.
2) The selection parameters are assumed to remain constant within pre-selected sequences of years.

In the actual application of the model, selection was assumed to remain constant during the two periods (1995-1998) and (1999-2006). This should reflect the observation that more young fish appear in the catches in recent years. The gear selection ogive in year "y" of age group "a" is

$$\mathrm{SEL(y,a)} = \frac{1}{1+\exp(\mathrm{Sel}_1(y)+\mathrm{Sel}_2\,(\mathrm{y})*\mathrm{Lgt}\ \ (a))}$$

where $\mathrm{Sel}_1(y) = \ln(3)* L_{50\%}(y)/(L_{75\%}(y) - L_{50\%}(y))$ and $\mathrm{Sel}_2(y) = \ln(3)/(L_{75\%}(y) - L_{50\%}(y))$

$L_{50\%}(y)$ = Length at which 50% of the fish entering the gear are retained (ignoring the right hand side selection)

$L_{75\%}(y)$ = Length at which 75 % of the fish entering the gear are retained of years with constant selection.

Thus the selection part of the separable VPA is replaced by only 2 parameters: $L_{50\%}$ and $L_{75\%}$ for each sequence of years.

The stock numbers in the first year were fitted to the catch numbers by $N=n_1*C*Z/F/(1-\exp(-Z))$, where the parameter "n_1" allows the level of all Ns in the first year to vary.

The object function to be minimized is the "modified χ^2 –criterion" (Sokal and Rolfs, 1981):

$$\chi^2 = \sum_y \sum_a \frac{(C_{Observed}(y,a) - C_{\Pr edicted}(y,a))^2}{C_{\Pr edicted}(y,a)} + W_B \sum_y \frac{(N_{\mathrm{Re}l}(y,1-3) - NumberIndex(y))^2}{N_{\mathrm{Re}l}(y,1-3)}$$

$$C_{\Pr edicted}(y,a) = N(y,a)\frac{F(y,a)}{Z(y,a)}(1-\exp(-Z(y,a)))$$

where $Z(y,a) = F(y,a) + M$, $F(y,a) = Sel(y,a)*F_{Max}(y)$ and W_B is the weight allocated to the IBTS-data, relative to the weight of the catch data. The parameter $W_{B,}$ is arbitrarily chosen, but unfortunately, it has a great influence on the result (see next subsection). $F_{Max}(y)$ is the fishing mortality of age groups under full exploitation. The "NumberIndex" is the relative CPUE of fish smaller than 23 cm from the IBTS in third quarter, as explained in Section 4.5.2. The "relative numbers" are

$$N_{\mathrm{Re}l}(y,1-3) = \sum_{a=1}^{3} N(y,a) / \sum_{i=1995}^{2006}\sum_{a=1}^{3} N(a,i)$$

The parameters of the ad Hoc model are

Name	Symbol	Number
Selection parameters	$L_{50\%}$ and $L_{75\%}$ for 1995-1998 $L_{50\%}$ and $L_{75\%}$ for 1999-2000	4
Level of stock size the first year	n_1	1
Recruitment (age 1)	N(1,1995),…..,N(1,2006)	12
Maximum F (over age groups)	F_{Max}(1995),…, F_{Max}(2006)	12

The number of observations are 15*12 = 180 catches and 12 survey indices, in total 192 observations to estimate 29 parameters. The method was implemented by the "R"-language, using the "optim" function.

The natural mortality is fixed at M=0.15 per year, thus M is not estimated.

Input to the Ac Hoc assessment are the horse mackerel data of the IBTS data base for third quarter (1995-2006), combined with the catch at age and weight at age data (Tables 4.5.3.1 and 2). The "number-index" is shown in Table 4.5.3.3.

4.5.3.2 Results of the Ad Hoc assessment method.

Several exploratory runs were made, of which two are presented in this report. One important subjective input option is the weight given to the IBTS relative to the catch at age data, when evaluating the object function. The SSD (sum of squares of deviations) for the catches has (Number of years)*(Number of age groups) terms, whereas the SSD from the Survey Index has only (Number of years) terms, so giving the weight 1 to catch data, and 10 to index data, roughly corresponds to giving 25% less weight to the survey index. Giving weight 100 to the Index roughly corresponds giving seven times as much weight to the index as to the catch data. Output are presented for two alternative runs,

1) Run 1: Weight on survey index, W_B = 10
2) Run 2: Weight on survey index, W_B = 100

Table 4.5.3.4.a and b shows the estimated fishing mortalities for the two runs, respectively. Recall that selection is modeled by an ascending logistic curve, so the selection is forced to be smooth. There is a considerable differences for the estimates depending on the two options for W_B, giving the more the the double value of F in some recent years.(see also Figure 4.5.3.3)

The estimated stock numbers and biomasses (Tables 4.5.2.5.a and b) are also different for the two runs. Figure 4.5.3.1. shows the catch residuals are very similar for the two choices of weight to the survey data. The residuals are more evenly distributed for the low weight to the survey index (W_B = 10), Figure 4.5.3.2. shows (not surprisingly) that high weight on survey gives a better correlation with the estimated stock numbers. With weight 100, the correlation is very high.

Which weight to choose for the survey index is a matter of belief in the two sources of information. One might estimate the best value of by choosing the W_B value that produces the lowest value per data observation. The text table below shows $\frac{1}{15}\chi^2_{CATCH} + \chi^2_{INDEX}$, which is the goodness of fit index accounting for that there are 15 times more catch observations than index observations. According to the table, 10-25 is the best choice for W_B.

W_B Weight of survey index	χ^2_{CATCH}	χ^2_{INDEX}	$\frac{1}{15}\chi^2_{CATCH} + \chi^2_{INDEX}$
0	2.49	0.52	0.68
5	2.80	0.35	0.54
10	**3.30**	**0.28**	**0.50**
15	**3.74**	**0.24**	**0.49**
25	**4.51**	**0.20**	**0.50**
50	5.94	0.16	0.56
75	7.26	0.14	0.63
100	20.89	0.30	1.69

Before presenting the summary of the assessment, the working group stresses that the results of this exercise are to be considered “data-exploration” rather than an assessment, due to the uncertainties of data, the short time series and the experimental nature of the model. The results are inconclusive, which may be due to errors in data allocation and stock identification.

Nevertheless, the results can be summarised as shown in Figure 4.5.3.3. Using the results with W_B = 10, the stock appears to have remained relatively stable, and with the highest level in the last year. Fishing mortality is estimated between 0.1 and 0.2 with lowest level in the first year. Thus, this uncertain exploratory analysis shows a stable lightly exploited stock.

The current results are very much driven by the introduction of the “number-index”. The number index, i.e. CPUE of fish shorter than 23 cm, are assumed to represent the age groups 1-3. Also the assumption concerning the stock distributions are crucial for the interpretation of results. The assumption is that no mixing with the western stock takes place.

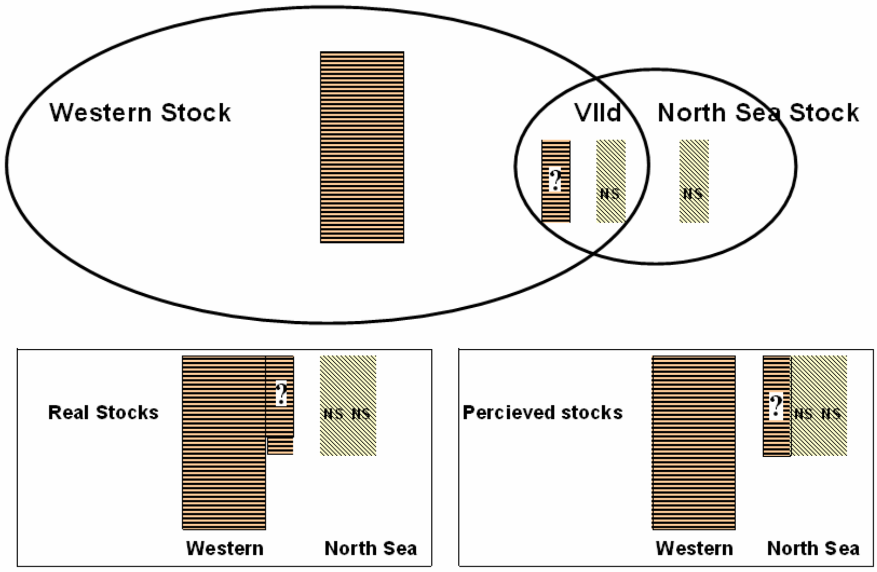
4.6 Future Prospects for the Assessment of North Sea Horse Mackerel

Over recent years various approaches to assess the stock of North Sea horse mackerel have not met with success in the sense that ACFM has rejected it. There are a range of reasons for this failure but primarily a lack of a coherent signal in the rate of decline of cohorts (in catch and survey) is the overriding problem.

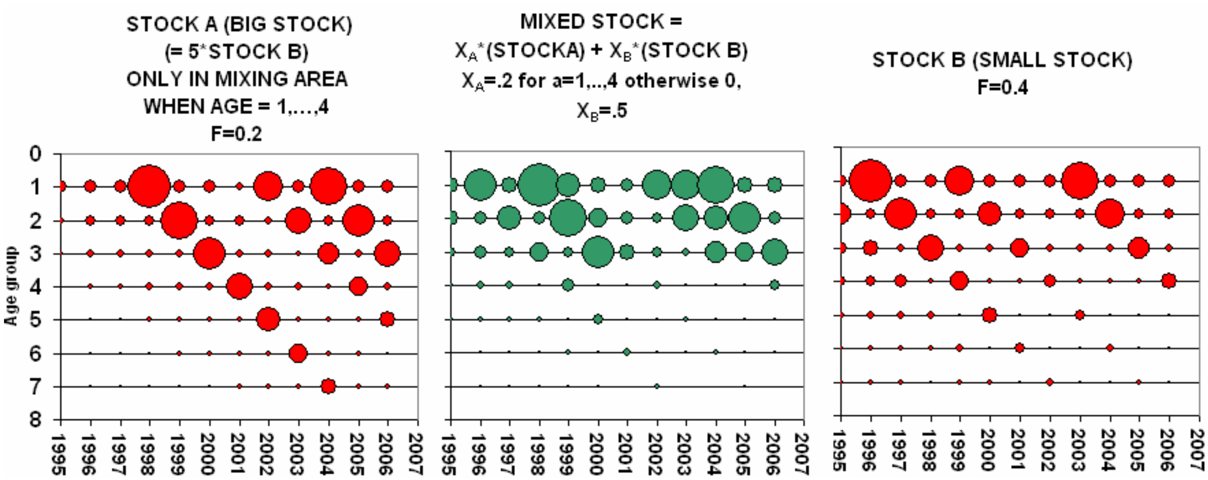
The commercial catch-at-age data are questionable for an analytical assessment.

It has been suggested that the length-based IBTS survey data could be explored with respect to their suitability for a length-based assessment; however, as no clear signal could be traced in these data (Figure 4.5.2.2.) the prospects are not that hopeful. A serious problem with IBTS in the context of North Sea Horse mackerel is that a major part of the catch is taken in area VIId that is not covered by the IBTS. Area VIId is also considered a nursery area. The VIId part of the stock may contain more juveniles than the IV component, which may bias the IBTS indices for juveniles (fish of length <23cm believed to represent age groups 1,2,3). However, mixing problems (discussed below) may bias IBTS observation from VIId, so how serious the problem with the lack of VIId data is remains a question mark.

The catches of the North Sea stock are split from the western stock dependent on time and location of the catch by the working group. The stock is thought to be separate from the western stock but it is unknown if the catches are mixed with those of the larger western horse mackerel stock. The figure below illustrates the assessment problem of mixed stocks. The rectangles represent stock sizes. It it hypothesized that a part of the North Sea stock is in area VIId together with an (unknown) part of the western stock. If the hypothesis is correct that will make the observer perceive the North Sea stock as bigger and the western stock as smaller, than the true stock sizes, if VIId is wrongly believed to contain only North Sea stock. As long as the western stock component in VIId remains unknown the stock assessment will remain questionable. It very likely that a part of the western stock is in area VIId, perhaps mainly during the juvenile stage of life, where after they move to the west (that is a hypothesis, it is not supported by observations). The separation line between areas VIIe and VIId , that is supposed to separate the stocks (Figure 3.2.1,), is rather arbitrary from a biological point of view. Figures 3.1.1.a and d show that the separation line is in the middle of some of the main fishing grounds of horse mackerel.



Another illustration of the mixing problem is given by two hypothetic stocks, (behaving exactly according the exponential decay model). One stock (A) is big and the other stock (B) is small. The recruitments and the fishing mortalities are different for the two stocks. 20 % of A mix with 50% of B for ages 1-4. For ages >4 stock A leaves the mixing area, whereas 50% of stock B stay after age 4. Comparing the bobble-diagram for the entire stock B with the diagram in the mixing area, shows that if samples to assess stock B are taken from the mixing area, the assessment may be highly biased. If the relative recruitment patterns and the fishing mortalities were the same for the two stocks, the samples from the mixing area would not be biased. It may in that case be considered to merge the two stocks into one unit for assessment purposes. Merging stocks would require an in depth analysis to work out the implications from both an assessment and from a management point of view.



The North Sea component of total catches used to be small, (2-5% in the early nineties), but from 2000 it has remained at a level around 25% of the total (Western + North Sea) as shown in Figure 4.5.1.1.(B). Figure 4.5.1.1 (A) shows the magnitude of four components of the catches, (1) Western stock minus VIIacek (2) VIIacek (3) VIId (4) Ivabc+IIIac. In 2006, the combined catches in area VIIacek and VIId make up 53% of the total Western + North Sea catches. So, if there is mixing of the two stocks in area VII, it will probably create bias for the assessments of both stocks.

In addition the assessment and EU quota areas are not consistent with the stock area definitions. There is little information to justify the allocation to each stock, and there is no science to support the temporal stability of the separation. Additionally there are still problems associated with the ageing of the horse mackerel which would also smooth the cohort signals.

There are also no surveys that target horse mackerel. The IBTS is designed to sample gadoids and clupeids, and horse mackerel that are caught in the IBTS are not aged. The egg survey of North Sea mackerel is of no utility because the spatial distribution of the spawning of North Sea mackerel is not the same as horse mackerel. The egg survey that used to occur stopped in the early 1990s. There are no horse mackerel acoustic surveys in the North Sea, and it would take a number of years of pilot studies to determine whether an acoustic survey could be useful.

Some of these problems can be solved; such as the continued effort to improve the precision of the estimation of age. However, the allocation of catches to appropriate stock needs much more attention. The lack of any suitable survey is also a problem which is unlikely to be solved until someone decides that the North Sea horse mackerel stock deserves the resources to execute a dedicated survey (of what ever type).

4.7 Reference Points for Management Purposes

At present there is not sufficient information to estimate appropriate reference points.

4.8 Harvest Control Rules

No harvest control rules were considered since no assessment was carried out.

4.9 Management Measures and Considerations

No forecast for the North Sea stock has been made for 2007.

The data were insufficient to define a management plan for this stock.

The points listed below should be taken into account when considering management options for the North Sea horse mackerel:

1) The stock units are incompatible with the management units. EU has since 1987 set a TAC for EU waters in Division IIa and Sub-area IV. However, this TAC includes Divisions IIa and IVa and does not include Division VIId, compared to the areas where the North Sea horse mackerel is distributed in.

2) The current management area TAC does not constrain catches (Division VIId catches are taken from the western horse mackerel TAC).

3) Increase in catches during the last decade. Catches have remained high in last decade. The major part of the increased catches are taken in Division VIId in quarters 1 and 4.

4) Recent catches are above the advised TACs of 18,000t. The average annual catch in the period 1995-2006 was 32 000 tons.

5) The horse mackerel fishery creates by-catches of mackerel.

6) Management should take into account that the knowledge about this stock is limited, and consequently the dynamics (including growth, migrations and mix with the western stock) is not well understood. The stock is long-lived, so the F at MSY is probably low.

Table 4.4.1.1 Catch in numbers at age (millions), weight at age (kg) and length at age (cm) for the North Sea horse mackerel stock 1995-2006

millions	Catch number											
Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	1.76	4.58	12.56	2.30	12.42	70.23	12.81	60.42	13.81	15.65	52.4	5.01
2	3.12	13.78	27.24	22.13	31.45	77.98	36.36	16.82	56.15	17.54	29.8	23.72
3	7.19	11.04	14.07	36.69	23.13	28.41	174.34	19.27	23.44	34.38	27.8	61.47
4	10.32	11.87	14.93	38.82	17.59	21.42	87.81	11.90	33.21	14.51	12.6	40.86
5	12.08	9.64	14.58	20.79	23.12	31.27	18.51	5.61	26.93	27.77	16.7	72.95
6	13.16	12.49	12.38	12.10	26.19	19.64	11.49	5.83	10.59	20.17	5.2	23.38
7	11.43	7.96	10.12	13.99	20.64	19.47	18.25	5.54	6.33	10.58	2.9	13.73
8	12.64	6.60	8.64	10.79	21.75	9.00	14.70	10.48	9.56	3.82	2.4	5.86
9	7.25	1.48	2.45	8.26	12.91	11.50	10.22	6.33	10.90	5.37	3.8	1.58
10	5.87	5.31	0.75	4.01	8.21	8.96	9.98	6.75	1.51	10.95	5.8	1.36
11	0.01	0.29	0.34	2.72	2.14	6.98	9.58	5.12	3.43	6.22	2.3	0.19
12	8.84	1.28	0.25	0.71	0.43	3.07	5.35	3.02	3.29	4.47	4.1	1.69
13	0.20	8.92	0.00	1.81	1.40	1.61	3.73	2.17	2.25	6.16	2.5	0.62
14	4.37	8.01	1.38	0.31	3.78	0.00	1.95	1.29	3.40	2.25	9.9	0.96
15+	0.00	0.00	0.00	5.11	4.03	12.22	5.81	2.71	4.70	8.52	9.6	0.82

kg	weight											
Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.076	0.107	0.063	0.063	0.063	0.075	0.055	0.066	0.073	0.076	0.079	0.069
2	0.126	0.123	0.102	0.102	0.102	0.101	0.072	0.095	0.105	0.104	0.077	0.095
3	0.125	0.143	0.126	0.126	0.126	0.136	0.071	0.129	0.123	0.120	0.103	0.116
4	0.133	0.156	0.142	0.142	0.142	0.152	0.082	0.154	0.137	0.147	0.132	0.124
5	0.146	0.177	0.160	0.160	0.160	0.166	0.120	0.172	0.166	0.174	0.158	0.141
6	0.164	0.187	0.175	0.175	0.175	0.194	0.183	0.195	0.181	0.198	0.196	0.177
7	0.161	0.203	0.199	0.199	0.199	0.198	0.197	0.216	0.195	0.225	0.251	0.210
8	0.178	0.195	0.231	0.231	0.231	0.213	0.201	0.227	0.212	0.229	0.270	0.244
9	0.165	0.218	0.250	0.250	0.250	0.247	0.235	0.228	0.238	0.256	0.280	0.231
10	0.173	0.241	0.259	0.259	0.259	0.280	0.246	0.251	0.259	0.291	0.291	0.284
11	0.317	0.307	0.300	0.300	0.300	0.279	0.260	0.302	0.245	0.301	0.344	0.237
12	0.233	0.211	0.329	0.329	0.329	0.342	0.286	0.292	0.295	0.300	0.361	0.257
13	0.241	0.258	0.367	0.367	0.367	0.318	0.287	0.318	0.356	0.302	0.332	0.268
14	0.348	0.277	0.299	0.299	0.299	0.325	0.295	0.319	0.319	0.338	0.376	0.291
15+	0.348	0.277	0.360	0.360	0.360	0.332	0.336	0.390	0.380	0.401	0.367	0.402

cm	length											
Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	19.2	19.2	19.2	19.2	19.2	19.0	18.7	17.1	20.2	19.8	20.54	19.89
2	22.0	22.0	22.0	22.0	22.0	21.5	20.4	21.4	22.4	22.2	21.49	21.94
3	23.5	23.5	23.5	23.5	23.5	23.9	20.6	22.9	23.8	23.6	23.00	23.38
4	24.8	24.8	24.8	24.8	24.8	24.9	21.3	24.9	24.6	25.2	24.69	24.13
5	25.5	25.5	25.5	25.5	25.5	26.0	25.0	26.2	26.2	26.6	25.53	25.42
6	26.4	26.4	26.4	26.4	26.4	27.8	27.4	26.6	27.3	27.5	27.77	27.01
7	27.2	27.2	27.2	27.2	27.2	28.3	28.0	27.4	28.2	28.9	30.42	28.53
8	29.2	29.2	29.2	29.2	29.2	28.6	28.4	28.2	29.0	29.2	31.19	29.84
9	29.5	29.5	29.5	29.5	29.5	30.0	29.7	29.2	29.9	30.5	31.82	30.63
10	29.5	29.5	29.5	29.5	29.5	31.3	30.2	30.8	30.8	31.5	32.32	31.55
11	30.6	30.6	30.6	30.6	30.6	31.4	30.7	32.5	30.8	32.0	34.41	31.18
12	32.1	32.1	32.1	32.1	32.1	33.7	32.0	33.8	31.9	31.8	36.16	30.75
13	33.3	33.3	33.3	33.3	33.3	33.5	31.7	33.8	32.9	32.0	34.20	32.13
14	31.1	31.1	31.1	31.1	31.1	33.4	32.1	32.4	32.7	33.0	34.90	32.15
15+	32.5	32.5	32.5	32.5	32.5	33.4	33.4	34.4	34.6	34.8	35.39	35.42

Table 4.4.1.2. North Sea Horse Mackerel catch in numbers (1000), mean weight and length at age by quarter and area in 2006

Q1	Catch number 1000s							Weight Kg							Length Cm						
Ages	IIIa	IIIc	IVa	IVb	IVc	VIId	Total	IIIa	IIIc	IVa	Ivb	IVc	VIId	Total	IIIa	IIIc	IVa	IVb	IVc	VIId	Total
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.0	0.0	0.0	0.0	0.0	1129.4	1129.4	0.000	0.000	0.000	0.000	0.000	0.060	0.060	0.00	0.00	0.00	0.00	0.00	19.50	19.50
2	179.0	0.0	0.0	0.0	0.0	3953.0	4132.0	0.111	0.000	0.000	0.000	0.000	0.094	0.095	22.83	0.00	0.00	0.00	0.00	22.21	22.24
3	782.3	7.7	48.5	826.4	5538.3	7461.3	14664.4	0.121	0.095	0.095	0.112	0.112	0.114	0.113	23.65	23.50	23.50	23.25	23.25	23.56	23.43
4	278.0	117.7	741.5	1239.5	8307.4	3183.8	13867.9	0.120	0.112	0.112	0.120	0.120	0.117	0.119	24.15	24.73	24.73	24.17	24.17	23.83	24.13
5	1652.0	1680.3	10589.0	2065.9	13845.7	8181.8	38014.6	0.133	0.133	0.133	0.135	0.135	0.172	0.142	25.78	26.08	26.08	25.10	25.10	27.07	25.87
6	127.0	80.1	504.6	826.4	5538.3	7821.6	14897.9	0.162	0.169	0.169	0.145	0.145	0.219	0.185	26.84	28.03	28.03	25.75	25.75	28.78	27.44
7	222.5	193.6	1219.9	206.6	1384.4	6487.6	9714.4	0.185	0.197	0.197	0.203	0.203	0.230	0.219	28.60	29.37	29.37	28.50	28.50	29.16	29.07
8	128.2	152.4	960.1	0.0	0.0	684.8	1925.4	0.215	0.215	0.215	0.000	0.000	0.314	0.250	30.18	30.18	30.18	0.00	0.00	32.62	31.05
9	97.3	115.7	729.0	0.0	0.0	564.7	1506.6	0.215	0.215	0.215	0.000	0.000	0.260	0.232	30.17	30.17	30.17	0.00	0.00	31.50	30.67
10	22.0	26.2	164.8	0.0	0.0	1129.4	1342.3	0.252	0.252	0.252	0.000	0.000	0.290	0.284	31.79	31.79	31.79	0.00	0.00	31.50	31.55
11	18.9	22.5	141.7	0.0	0.0	0.0	183.1	0.237	0.237	0.237	0.000	0.000	0.000	0.237	31.18	31.18	31.18	0.00	0.00	0.00	31.18
12	50.9	60.5	381.2	0.0	0.0	1129.4	1621.9	0.216	0.216	0.216	0.000	0.000	0.275	0.257	30.25	30.25	30.25	0.00	0.00	31.00	30.77
13	61.4	73.0	460.1	0.0	0.0	0.0	594.5	0.267	0.267	0.267	0.000	0.000	0.000	0.267	32.12	32.12	32.12	0.00	0.00	0.00	32.12
14	39.5	47.0	296.2	0.0	0.0	564.7	947.4	0.218	0.218	0.218	0.000	0.000	0.342	0.292	30.24	30.24	30.24	0.00	0.00	33.50	32.18
15+	25.9	30.8	193.9	0.0	0.0	533.2	783.7	0.406	0.406	0.406	0.000	0.000	0.405	0.406	36.8	36.8	36.8	0	0	34.9	35.5
Q2	IIIa	IIIc	IVa	IVb	IVc	VIId	Total	IIIa	IIIc	IVa	Ivb	IVc	VIId	Total	IIIa	IIIc	IVa	IVb	IVc	VIId	Total
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.000	0.000	0.000	0.000	0.000	0.060	0.060	0.00	0.00	0.00	0.00	0.00	19.50	19.50
2	0.0	0.0	0.0	0.0	0.0	1.2	1.2	0.000	0.000	0.000	0.000	0.000	0.094	0.094	0.00	0.00	0.00	0.00	0.00	22.21	22.21
3	0.8	0.9	0.9	270.6	428.2	2.3	703.7	0.095	0.095	0.095	0.112	0.112	0.114	0.112	23.50	23.50	23.50	23.25	23.25	23.56	23.25
4	11.9	14.3	13.3	406.0	642.3	1.0	1088.7	0.112	0.112	0.112	0.120	0.120	0.117	0.120	24.73	24.73	24.73	24.17	24.17	23.83	24.19
5	169.3	203.8	190.4	676.6	1070.5	2.5	2313.1	0.133	0.133	0.133	0.135	0.135	0.172	0.135	26.08	26.08	26.08	25.10	25.10	27.07	25.34
6	8.1	9.7	9.1	270.6	428.2	2.4	728.1	0.169	0.169	0.169	0.145	0.145	0.219	0.146	28.03	28.03	28.03	25.75	25.75	28.78	25.84
7	19.5	23.5	21.9	67.7	107.0	2.0	241.6	0.197	0.197	0.197	0.203	0.203	0.230	0.202	29.37	29.37	29.37	28.50	28.50	29.16	28.74
8	15.4	18.5	17.3	0.0	0.0	0.2	51.3	0.215	0.215	0.215	0.000	0.000	0.314	0.215	30.18	30.18	30.18	0.00	0.00	32.62	30.19
9	11.7	14.0	13.1	0.0	0.0	0.2	39.0	0.215	0.215	0.215	0.000	0.000	0.260	0.215	30.17	30.17	30.17	0.00	0.00	31.50	30.18
10	2.6	3.2	3.0	0.0	0.0	0.4	9.1	0.252	0.252	0.252	0.000	0.000	0.290	0.253	31.79	31.79	31.79	0.00	0.00	31.50	31.78
11	2.3	2.7	2.6	0.0	0.0	0.0	7.5	0.237	0.237	0.237	0.000	0.000	0.000	0.237	31.18	31.18	31.18	0.00	0.00	0.00	31.18
12	6.1	7.3	6.9	0.0	0.0	0.4	20.6	0.216	0.216	0.216	0.000	0.000	0.275	0.217	30.25	30.25	30.25	0.00	0.00	31.00	30.26
13	7.4	8.9	8.3	0.0	0.0	0.0	24.5	0.267	0.267	0.267	0.000	0.000	0.000	0.267	32.12	32.12	32.12	0.00	0.00	0.00	32.12
14	4.7	5.7	5.3	0.0	0.0	0.2	15.9	0.218	0.218	0.218	0.000	0.000	0.342	0.219	30.24	30.24	30.24	0.00	0.00	33.50	30.28
15+	3.1	3.7	3.5	0.0	0.0	0.2	10.5	0.406	0.406	0.406	0.000	0.000	0.405	0.406	36.8	36.8	36.8	0	0	34.9	36.7
Q3	IIIa	IIIc	IVa	IVb	IVc	VIId	Total	IIIa	IIIc	IVa	IVb	IVc	VIId	Total	IIIa	IIIc	IVa	IVb	IVc	VIId	Total
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000	0.000	0.000	0.012	0.012	0.00	0.00	0.00	0.00	0.00	11.85	11.85
1	0.0	0.0	0.0	0.0	0.0	2.3	2.3	0.000	0.000	0.000	0.000	0.000	0.077	0.077	0.00	0.00	0.00	0.00	0.00	20.68	20.68
2	8.7	0.0	0.0	560.7	191.8	11.4	772.7	0.111	0.000	0.000	0.111	0.111	0.099	0.111	22.83	0.00	0.00	22.83	22.83	22.33	22.82
3	37.7	0.0	0.0	2429.9	831.3	25.0	3323.9	0.121	0.000	0.000	0.121	0.121	0.119	0.121	23.65	0.00	0.00	23.65	23.65	23.59	23.65
4	8.7	0.0	0.0	560.7	191.8	13.4	774.6	0.124	0.000	0.000	0.124	0.124	0.132	0.124	23.83	0.00	0.00	23.83	23.83	24.51	23.84
5	11.6	0.0	0.0	747.7	255.8	17.8	1032.8	0.130	0.000	0.000	0.130	0.130	0.148	0.130	24.00	0.00	0.00	24.00	24.00	25.48	24.03
6	2.9	0.0	0.0	186.9	64.0	4.5	258.3	0.154	0.000	0.000	0.154	0.154	0.167	0.154	25.50	0.00	0.00	25.50	25.50	26.47	25.52
7	2.9	0.0	0.0	186.9	64.0	4.2	258.0	0.153	0.000	0.000	0.153	0.153	0.193	0.154	26.50	0.00	0.00	26.50	26.50	27.44	26.52
8	0.0	0.0	0.0	0.0	0.0	1.8	1.8	0.000	0.000	0.000	0.000	0.000	0.221	0.221	0.00	0.00	0.00	0.00	0.00	28.60	28.60
9	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.000	0.000	0.000	0.000	0.000	0.231	0.231	0.00	0.00	0.00	0.00	0.00	29.25	29.25
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000	0.000	0.000	0.359	0.359	0.00	0.00	0.00	0.00	0.00	33.50	33.50
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.000	0.000	0.000	0.000	0.000	0.258	0.258	0.00	0.00	0.00	0.00	0.00	30.26	30.26
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000	0.000	0.000	0.359	0.359	0.00	0.00	0.00	0.00	0.00	33.50	33.50

14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15+	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.000	0.000	0.000	0.000	0.000	0.297	0.297	0	0	0	0	0	31.9	31.9
Q4	IIIa	IIIc	IVa	IVb	IVc	VIId	Total	IIIa	IIIc	IVa	IVb	IVc	VIId	Total	IIIa	IIIc	IVa	IVb	IVc	VIId	Total
0	0.0	0.0	0.0	0.0	0.0	8.0	8.0	0.000	0.000	0.000	0.000	0.000	0.012	0.012	0.00	0.00	0.00	0.00	0.00	11.85	11.85
1	0.0	0.0	0.0	0.0	0.0	3875.7	3875.7	0.000	0.000	0.000	0.000	0.000	0.072	0.072	0.00	0.00	0.00	0.00	0.00	20.01	20.01
2	47.4	0.0	0.0	92.3	1256.1	17421.1	18816.9	0.111	0.000	0.000	0.111	0.111	0.093	0.094	22.83	0.00	0.00	22.83	22.83	21.75	21.83
3	205.5	0.0	0.0	399.9	5443.1	36729.1	42777.6	0.121	0.000	0.000	0.121	0.121	0.116	0.117	23.65	0.00	0.00	23.65	23.65	23.29	23.34
4	47.4	0.0	0.0	92.3	1256.1	23735.1	25130.9	0.124	0.000	0.000	0.124	0.124	0.128	0.128	23.83	0.00	0.00	23.83	23.83	24.15	24.13
5	63.2	0.0	0.0	123.0	1674.8	29725.3	31586.4	0.130	0.000	0.000	0.130	0.130	0.141	0.140	24.00	0.00	0.00	24.00	24.00	24.99	24.93
6	15.8	0.0	0.0	30.8	418.7	7030.0	7495.3	0.154	0.000	0.000	0.154	0.154	0.167	0.167	25.50	0.00	0.00	25.50	25.50	26.37	26.31
7	15.8	0.0	0.0	30.8	418.7	3053.3	3518.5	0.153	0.000	0.000	0.153	0.153	0.194	0.189	26.50	0.00	0.00	26.50	26.50	27.29	27.19
8	0.0	0.0	0.0	0.0	0.0	3877.9	3877.9	0.000	0.000	0.000	0.000	0.000	0.241	0.241	0.00	0.00	0.00	0.00	0.00	29.24	29.24
9	0.0	0.0	0.0	0.0	0.0	31.8	31.8	0.000	0.000	0.000	0.000	0.000	0.231	0.231	0.00	0.00	0.00	0.00	0.00	29.25	29.25
10	0.0	0.0	0.0	0.0	0.0	3.9	3.9	0.000	0.000	0.000	0.000	0.000	0.359	0.359	0.00	0.00	0.00	0.00	0.00	33.50	33.50
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.0	0.0	0.0	0.0	0.0	43.9	43.9	0.000	0.000	0.000	0.000	0.000	0.258	0.258	0.00	0.00	0.00	0.00	0.00	30.26	30.26
13	0.0	0.0	0.0	0.0	0.0	3.9	3.9	0.000	0.000	0.000	0.000	0.000	0.359	0.359	0.00	0.00	0.00	0.00	0.00	33.50	33.50
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15+	0.0	0.0	0.0	0.0	0.0	25.8	25.8	0.000	0.000	0.000	0.000	0.000	0.297	0.297	0	0	0	0	0	31.9	31.9
1-4Q	IIIa	IIIc	IVa	IVb	IVc	VIId	Total	IIIa	IIIc	IVa	IVb	IVc	VIId	Total	IIIa	IIIc	IVa	IVb	IVc	VIId	Total
0	0.0	0.0	0.0	0.0	0.0	8.0	8.0	0.000	0.000	0.000	0.000	0.000	0.012	0.012	0.00	0.00	0.00	0.00	0.00	11.85	11.85
1	0.0	0.0	0.0	0.0	0.0	5007.7	5007.7	0.000	0.000	0.000	0.000	0.000	0.069	0.069	0.00	0.00	0.00	0.00	0.00	19.89	19.89
2	235.2	0.0	0.0	653.0	1447.9	21386.7	23722.8	0.111	0.000	0.000	0.111	0.111	0.093	0.095	22.83	0.00	0.00	22.83	22.83	21.84	21.94
3	1026.3	8.6	49.3	3926.7	12240.9	44217.8	61469.6	0.121	0.095	0.095	0.119	0.117	0.116	0.116	23.65	23.50	23.50	23.54	23.46	23.34	23.38
4	346.0	131.9	754.8	2298.5	10397.7	26933.2	40862.1	0.120	0.112	0.112	0.121	0.121	0.127	0.124	24.12	24.73	24.73	24.07	24.12	24.11	24.13
5	1896.2	1884.0	10779.4	3613.2	16846.8	37927.4	72946.9	0.133	0.133	0.133	0.134	0.134	0.148	0.141	25.74	26.08	26.08	24.83	24.97	25.44	25.42
6	153.8	89.8	513.6	1314.7	6449.1	14858.5	23379.5	0.161	0.169	0.169	0.147	0.146	0.194	0.177	26.74	28.03	28.03	25.71	25.73	27.64	27.01
7	260.7	217.0	1241.8	491.9	1974.1	9547.0	13732.5	0.184	0.197	0.197	0.181	0.191	0.218	0.210	28.51	29.37	29.37	27.61	28.01	28.56	28.53
8	143.5	170.8	977.4	0.0	0.0	4564.7	5856.4	0.215	0.215	0.215	0.000	0.000	0.252	0.244	30.18	30.18	30.18	0.00	0.00	29.75	29.84
9	109.0	129.7	742.1	0.0	0.0	596.8	1577.5	0.215	0.215	0.215	0.000	0.000	0.258	0.231	30.17	30.17	30.17	0.00	0.00	31.38	30.63
10	24.6	29.3	167.8	0.0	0.0	1133.7	1355.4	0.252	0.252	0.252	0.000	0.000	0.290	0.284	31.79	31.79	31.79	0.00	0.00	31.51	31.55
11	21.2	25.2	144.2	0.0	0.0	0.0	190.6	0.237	0.237	0.237	0.000	0.000	0.000	0.237	31.18	31.18	31.18	0.00	0.00	0.00	31.18
12	57.0	67.8	388.0	0.0	0.0	1173.8	1686.6	0.216	0.216	0.216	0.000	0.000	0.274	0.257	30.25	30.25	30.25	0.00	0.00	30.97	30.75
13	68.8	81.9	468.4	0.0	0.0	3.9	622.9	0.267	0.267	0.267	0.000	0.000	0.359	0.268	32.12	32.12	32.12	0.00	0.00	33.50	32.13
14	44.3	52.7	301.5	0.0	0.0	564.9	963.3	0.218	0.218	0.218	0.000	0.000	0.342	0.291	30.24	30.24	30.24	0.00	0.00	33.50	32.15
15+	29.0	34.5	197.4	0.0	0.0	559.3	820.1	0.406	0.406	0.406	0.000	0.000	0.400	0.402	36.8	36.8	36.8	0	0	34.8	35.4

Table 4.4.3. Percentage landings covered from research vessel and commercial fishing vessels from 1995-2006.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
% of landings covered	62	55	57	66	77	71	50	60	67	38	48	70
Samples from	RV	RV+FV	FV	FV	FV	FV	FV	FV	FV	FV	FV	FV

(RV = Research Vessel, FV = Commercial fishing Vessels)

Table 4.5.3.1. Input to Ad Hoc method. Catch at age (millions).

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	1.76	4.58	12.56	2.30	12.42	70.23	12.81	60.42	13.81	15.65	52.40	5.01
2	3.12	13.78	27.24	22.13	31.45	77.98	36.36	16.82	56.15	17.54	29.80	23.72
3	7.19	11.04	14.07	36.69	23.13	28.41	174.34	19.27	23.44	34.38	27.80	61.47
4	10.32	11.87	14.93	38.82	17.59	21.42	87.81	11.90	33.21	14.51	12.60	40.86
5	12.08	9.64	14.58	20.79	23.12	31.27	18.51	5.61	26.93	27.77	16.70	72.95
6	13.16	12.49	12.38	12.10	26.19	19.64	11.49	5.83	10.59	20.17	5.20	23.38
7	11.43	7.96	10.12	13.99	20.64	19.47	18.25	5.54	6.33	10.58	2.90	13.73
8	12.64	6.60	8.64	10.79	21.75	9.00	14.70	10.48	9.56	3.82	2.40	5.86
9	7.25	1.48	2.45	8.26	12.91	11.50	10.22	6.33	10.90	5.37	3.80	1.58
10	5.87	5.31	0.75	4.01	8.21	8.96	9.98	6.75	1.51	10.95	5.80	1.36
11	0.01	0.29	0.34	2.72	2.14	6.98	9.58	5.12	3.43	6.22	2.30	0.19
12	8.84	1.28	0.25	0.71	0.43	3.07	5.35	3.02	3.29	4.47	4.10	1.69
13	0.20	8.92	0.01	1.81	1.40	1.61	3.73	2.17	2.25	6.16	2.50	0.62
14	4.37	8.01	1.38	0.31	3.78	0.01	1.95	1.29	3.40	2.25	9.90	0.96
15+	0.10	0.10	0.10	5.11	4.03	12.22	5.81	2.71	4.70	8.52	9.60	0.82

Table 4.5.3.2. Input to Ad Hoc method. Weight at age.

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.076	0.107	0.063	0.063	0.063	0.075	0.055	0.066	0.073	0.076	0.079	0.072
2	0.126	0.123	0.102	0.102	0.102	0.101	0.072	0.095	0.105	0.104	0.077	0.094
3	0.125	0.143	0.126	0.126	0.126	0.136	0.071	0.129	0.123	0.120	0.103	0.117
4	0.133	0.156	0.142	0.142	0.142	0.152	0.082	0.154	0.137	0.147	0.132	0.128
5	0.146	0.177	0.160	0.160	0.160	0.166	0.120	0.172	0.166	0.174	0.158	0.140
6	0.164	0.187	0.175	0.175	0.175	0.194	0.183	0.195	0.181	0.198	0.196	0.167
7	0.161	0.203	0.199	0.199	0.199	0.198	0.197	0.216	0.195	0.225	0.251	0.189
8	0.178	0.195	0.231	0.231	0.231	0.213	0.201	0.227	0.212	0.229	0.270	0.241
9	0.165	0.218	0.250	0.250	0.250	0.247	0.235	0.228	0.238	0.256	0.280	0.231
10	0.173	0.241	0.259	0.259	0.259	0.280	0.246	0.251	0.259	0.291	0.291	0.359
11	0.317	0.307	0.300	0.300	0.300	0.279	0.260	0.302	0.245	0.301	0.344	0.300
12	0.233	0.211	0.329	0.329	0.329	0.342	0.286	0.292	0.295	0.300	0.361	0.258
13	0.241	0.258	0.367	0.367	0.367	0.318	0.287	0.318	0.356	0.302	0.332	0.359
14	0.348	0.277	0.299	0.299	0.299	0.325	0.295	0.319	0.319	0.338	0.376	0.330
15+	0.348	0.277	0.360	0.360	0.360	0.332	0.336	0.390	0.380	0.401	0.367	0.297

Table 4.5.3.3. Input to Ad Hoc method. IBTS index (as defined in section 4.5.2). Fish of length <= 23 cm.

Year	Number-Index
1995	66
1996	110
1997	462
1998	72
1999	104
2000	213
2001	412
2002	416
2003	208
2004	76
2005	145
2006	39

Table 4.5.3.4.a. . Output Ad Hoc method. Fishing Mortality. Low weight to Index (Weight=10)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.009	0.026	0.016	0.022	0.026	0.084	0.110	0.056	0.064	0.068	0.094	0.140
2	0.017	0.050	0.031	0.043	0.051	0.138	0.180	0.092	0.105	0.111	0.154	0.229
3	0.030	0.088	0.054	0.075	0.089	0.163	0.213	0.109	0.124	0.132	0.182	0.271
4	0.045	0.133	0.081	0.113	0.135	0.171	0.223	0.114	0.130	0.138	0.190	0.284
5	0.058	0.172	0.105	0.147	0.175	0.173	0.225	0.115	0.131	0.139	0.193	0.287
6	0.067	0.198	0.121	0.169	0.202	0.173	0.226	0.115	0.132	0.140	0.193	0.288
7	0.072	0.213	0.130	0.181	0.216	0.173	0.226	0.115	0.132	0.140	0.193	0.288
8	0.075	0.220	0.134	0.188	0.224	0.173	0.226	0.115	0.132	0.140	0.193	0.288
9	0.076	0.224	0.136	0.190	0.227	0.173	0.226	0.115	0.132	0.140	0.193	0.288
10	0.076	0.225	0.137	0.192	0.229	0.173	0.226	0.115	0.132	0.140	0.193	0.288
11	0.077	0.226	0.138	0.192	0.230	0.173	0.226	0.115	0.132	0.140	0.193	0.288
12	0.077	0.226	0.138	0.193	0.230	0.173	0.226	0.115	0.132	0.140	0.193	0.288
13	0.077	0.226	0.138	0.193	0.230	0.173	0.226	0.115	0.132	0.140	0.193	0.288
14	0.077	0.226	0.138	0.193	0.230	0.173	0.226	0.115	0.132	0.140	0.193	0.288
15+	0.077	0.226	0.138	0.193	0.230	0.173	0.226	0.115	0.132	0.140	0.193	0.288

Table 4.5.3.4.b . Output Ad Hoc method. Fishing Mortality. High weight to Index (Weight=100).

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.002	0.044	0.038	0.044	0.055	0.098	0.178	0.077	0.135	0.162	0.176	0.108
2	0.005	0.107	0.092	0.107	0.134	0.218	0.396	0.171	0.299	0.361	0.391	0.241
3	0.008	0.170	0.146	0.171	0.213	0.271	0.493	0.212	0.372	0.449	0.486	0.299
4	0.009	0.200	0.173	0.202	0.251	0.282	0.513	0.221	0.387	0.467	0.505	0.312
5	0.010	0.210	0.181	0.211	0.263	0.284	0.516	0.222	0.390	0.470	0.509	0.314
6	0.010	0.213	0.184	0.214	0.267	0.284	0.517	0.223	0.390	0.471	0.509	0.314
7	0.010	0.213	0.184	0.215	0.268	0.284	0.517	0.223	0.390	0.471	0.509	0.314
8	0.010	0.214	0.185	0.215	0.268	0.284	0.517	0.223	0.390	0.471	0.509	0.314
9	0.010	0.214	0.185	0.215	0.268	0.284	0.517	0.223	0.390	0.471	0.509	0.314
10	0.010	0.214	0.185	0.215	0.268	0.284	0.517	0.223	0.390	0.471	0.509	0.314
11	0.010	0.214	0.185	0.215	0.268	0.284	0.517	0.223	0.390	0.471	0.509	0.314
12	0.010	0.214	0.185	0.215	0.268	0.284	0.517	0.223	0.390	0.471	0.509	0.314
13	0.010	0.214	0.185	0.215	0.268	0.284	0.517	0.223	0.390	0.471	0.509	0.314
14	0.010	0.214	0.185	0.215	0.268	0.284	0.517	0.223	0.390	0.471	0.509	0.314
15+	0.010	0.214	0.185	0.215	0.268	0.284	0.517	0.223	0.390	0.471	0.509	0.314

Table 4.5.3.5.a . Output Ad Hoc method. Stock Numbers (millions) and biomass (000' tons). Low weight to Index (Weight=10)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	365.74	449.94	459.16	248.92	527.45	501.19	583.02	576.78	175.25	191.05	253.96	16.77
2	139.50	312.08	377.47	389.08	209.63	442.32	396.47	449.48	469.32	141.47	153.61	198.94
3	184.49	118.05	255.47	315.10	320.88	171.46	331.71	285.08	352.97	363.77	108.94	113.37
4	176.71	154.13	93.05	208.40	251.63	252.56	125.38	230.79	220.14	268.39	274.50	78.17
5	160.64	145.40	116.17	73.86	160.19	189.24	183.28	86.37	177.31	166.42	201.28	195.29
6	152.45	130.44	105.37	90.02	54.90	115.75	137.05	125.93	66.27	133.84	124.61	142.88
7	123.64	122.69	92.07	80.35	65.44	38.63	83.79	94.11	96.59	50.00	100.17	88.41
8	132.38	99.01	85.34	69.59	57.69	45.36	27.96	57.52	72.18	72.87	37.42	71.06
9	74.81	105.74	68.37	64.22	49.65	39.69	32.83	19.19	44.12	54.45	54.54	26.54
10	60.17	59.69	72.78	51.34	45.69	34.04	28.73	22.54	14.72	33.28	40.75	38.69
11	0.10	47.98	41.02	54.60	36.48	31.28	24.64	19.72	17.29	11.11	24.91	28.91
12	90.21	0.08	32.95	30.76	38.77	24.95	22.64	16.92	15.13	13.04	8.31	17.67
13	2.04	71.91	0.06	24.70	21.83	26.51	18.06	15.54	12.97	11.41	9.76	5.90
14	44.56	1.63	49.36	0.04	17.53	14.93	19.19	12.40	11.92	9.79	8.54	6.92
15+	0.21	35.68	25.60	56.20	39.91	39.28	39.23	40.11	40.27	39.37	36.79	32.16
Biomass`	**244**	**303**	**271**	**269**	**268**	**278**	**215**	**271**	**258**	**249**	**229**	**175**

Table 4.5.3.5.b. Output Ad Hoc method. Stock Numbers (millions) and Biomass (000' tons). High weight to Index (Weight=100)

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	430.27	779.41	1257.97	294.20	318.72	1646.00	2352.63	1089.36	302.34	310.36	315.50	291.76
2	934.26	369.58	642.07	1042.49	242.28	259.66	1284.56	1694.25	868.31	227.47	227.09	227.79
3	1355.95	800.13	285.93	504.00	805.92	182.44	179.78	743.93	1229.45	554.22	136.48	132.27
4	1649.76	1157.86	581.30	212.57	365.70	560.82	119.79	94.53	517.85	729.57	304.54	72.27
5	1841.18	1406.72	815.84	420.87	149.56	244.90	364.21	61.74	65.24	302.69	393.65	158.11
6	1980.40	1569.22	981.51	585.69	293.20	98.93	158.75	187.08	42.55	38.04	162.82	203.70
7	1714.34	1687.66	1091.93	702.98	406.91	193.29	64.11	81.50	128.89	24.80	20.45	84.21
8	1894.19	1460.88	1173.51	781.58	488.04	268.01	125.25	32.91	56.15	75.11	13.33	10.58
9	1086.22	1614.13	1015.63	839.84	542.52	321.38	173.67	64.29	22.67	32.72	40.38	6.89
10	879.41	925.61	1122.11	726.82	582.93	357.23	208.25	89.15	44.29	13.21	17.59	20.88
11	1.50	749.38	643.46	803.02	504.48	383.83	231.48	106.90	61.42	25.81	7.10	9.10
12	1324.34	1.28	520.95	460.48	557.36	332.17	248.72	118.82	73.65	35.79	13.88	3.67
13	29.96	1128.52	0.89	372.81	319.61	366.99	215.24	127.67	81.86	42.92	19.24	7.18
14	654.68	25.53	784.52	0.64	258.76	210.45	237.81	110.49	87.96	47.70	23.07	9.95
15+	2.22	559.77	406.88	852.60	592.21	560.32	499.45	378.45	336.84	247.55	158.72	94.01
Biomass`	**2622**	**2852**	**2344**	**1943**	**1496**	**1186**	**878**	**743**	**629**	**463**	**296**	**188**

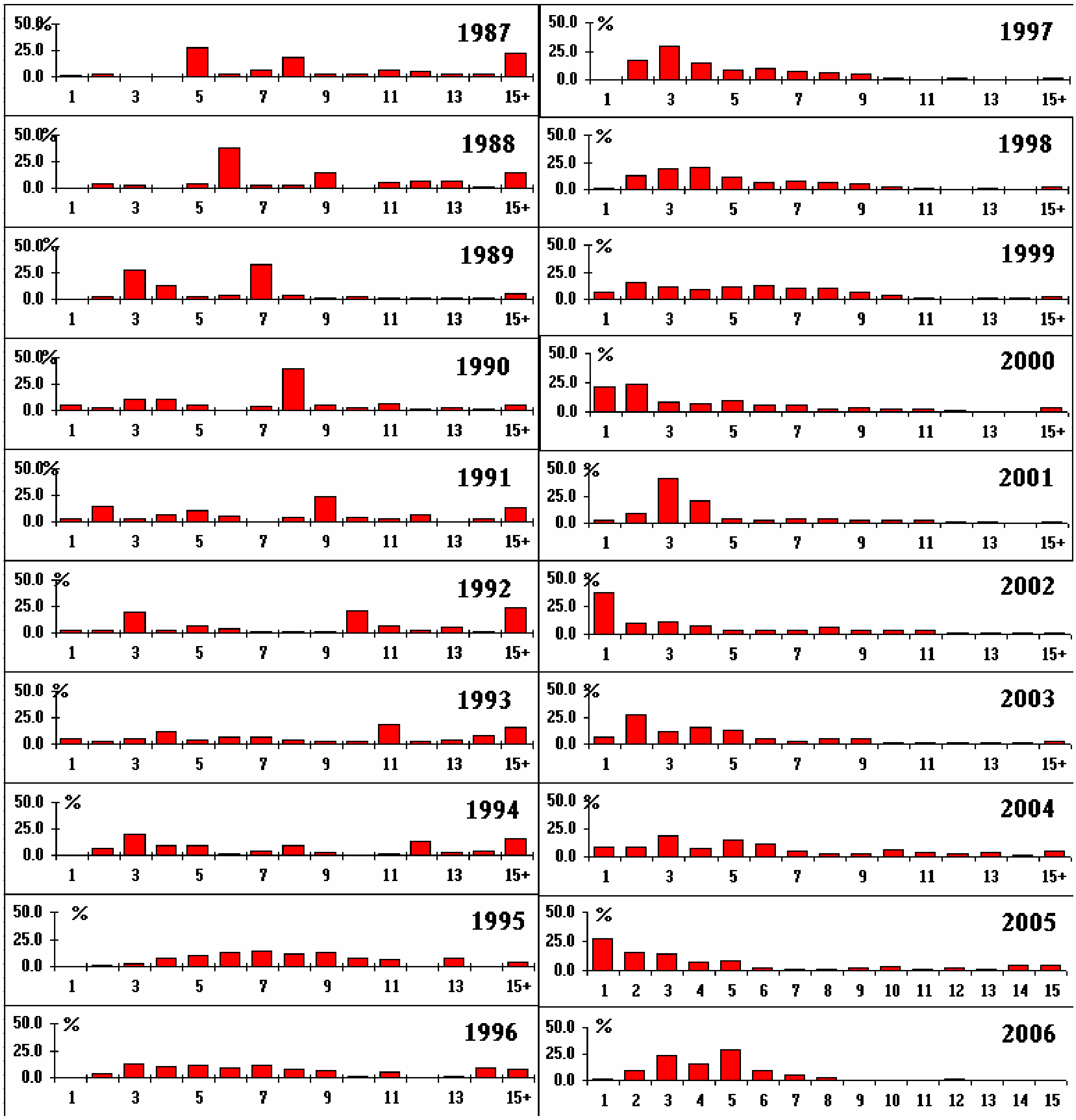


Figure 4.4.1.1. The age composition based on commercial and research vessel samples 1987-2006.

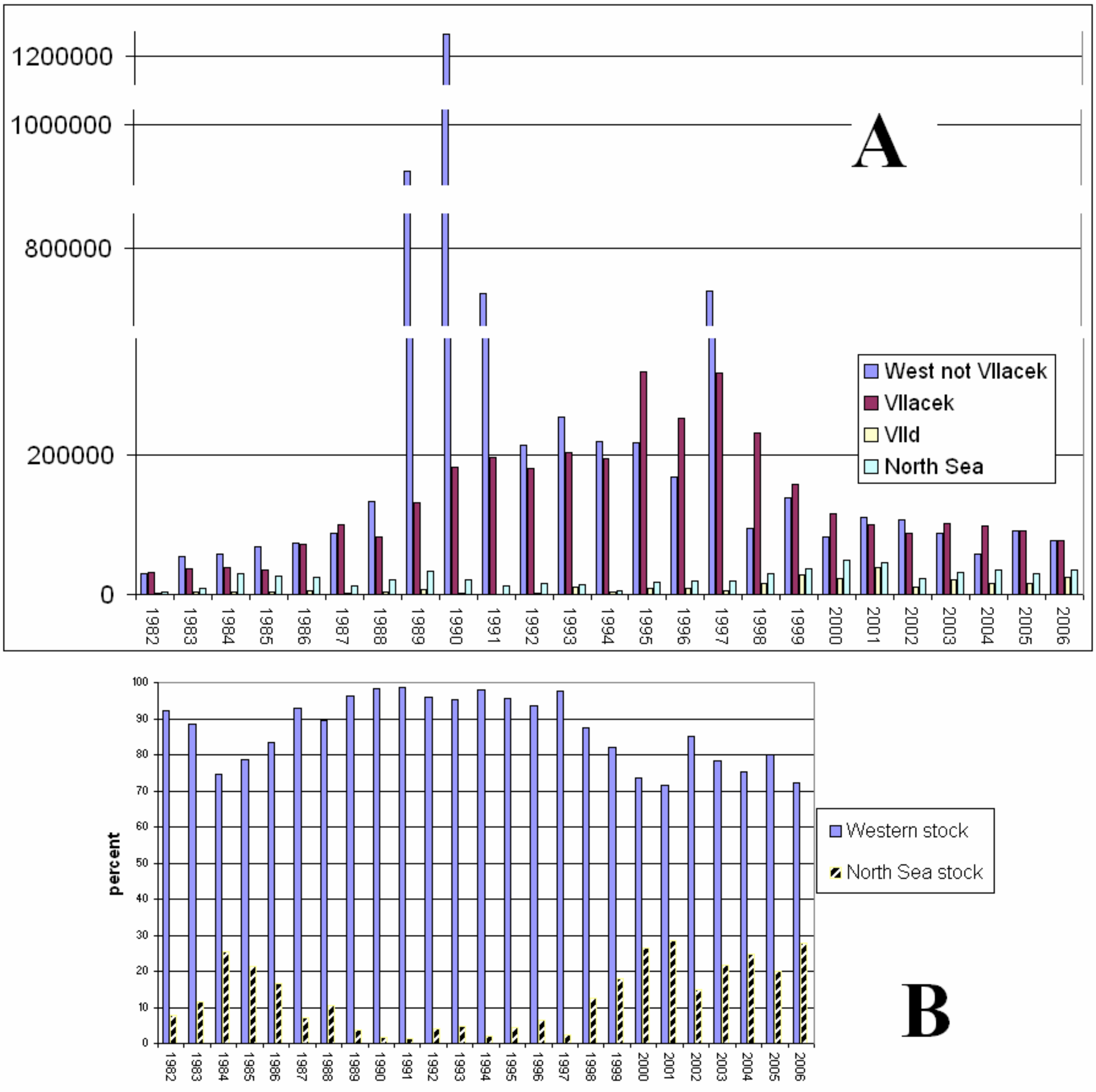


Figure 4.5.1.1. A: North Sea and Western horse mackerel landings by four areas. B: Relative contribution to total landings.

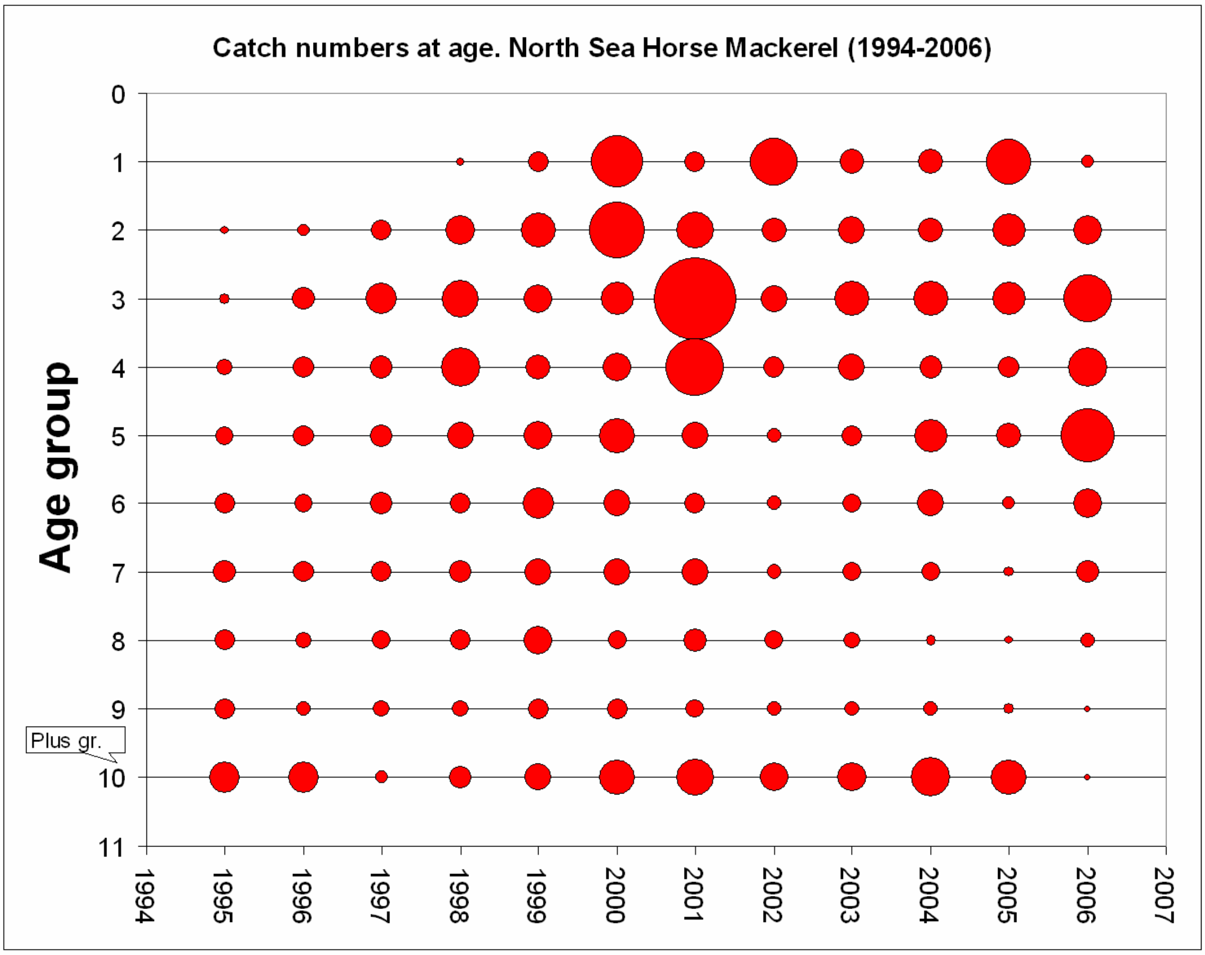


Figure 4.5.1.2. The catch-at-age of North Sea horse mackerel, 1994-2006. Note that the age composition for 1995 and 1996 was partly based on research vessel samples and may not be representative for the commercial catches.

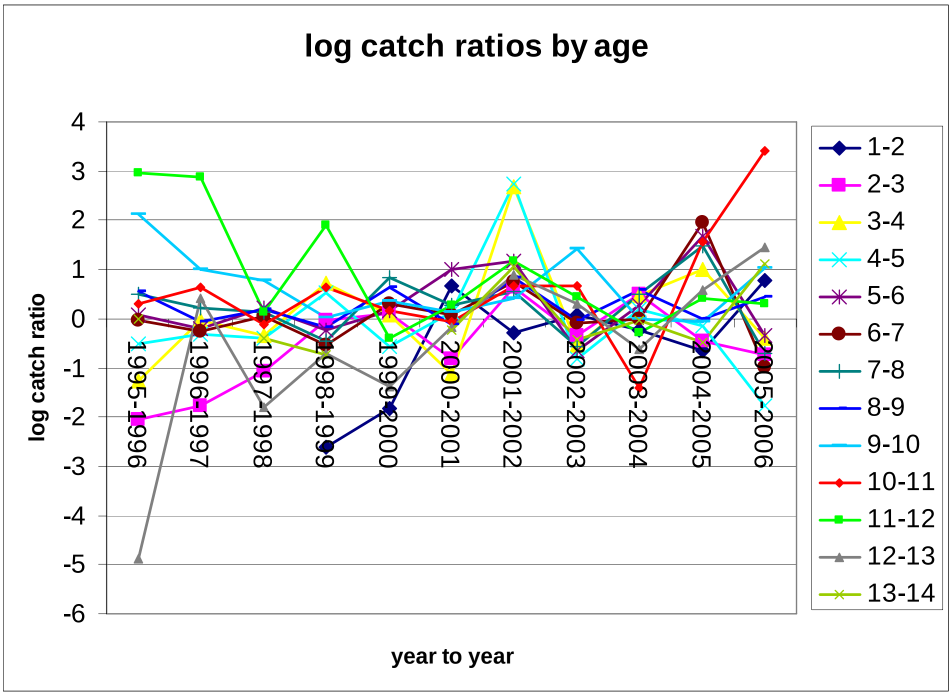


Figure 4.5.1.3.a. Log catch ratios of North Sea horse mackerel.

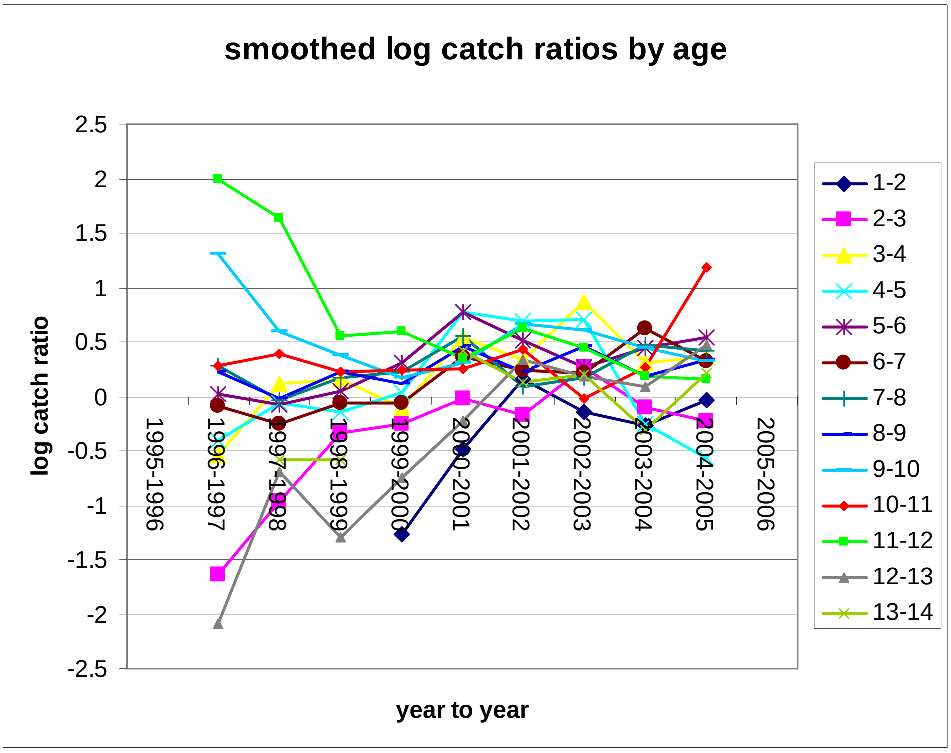


Figure 4.5.1.3.b. Smoothed (moving average over 3 years) log catch ratios of North Sea horse mackerel.

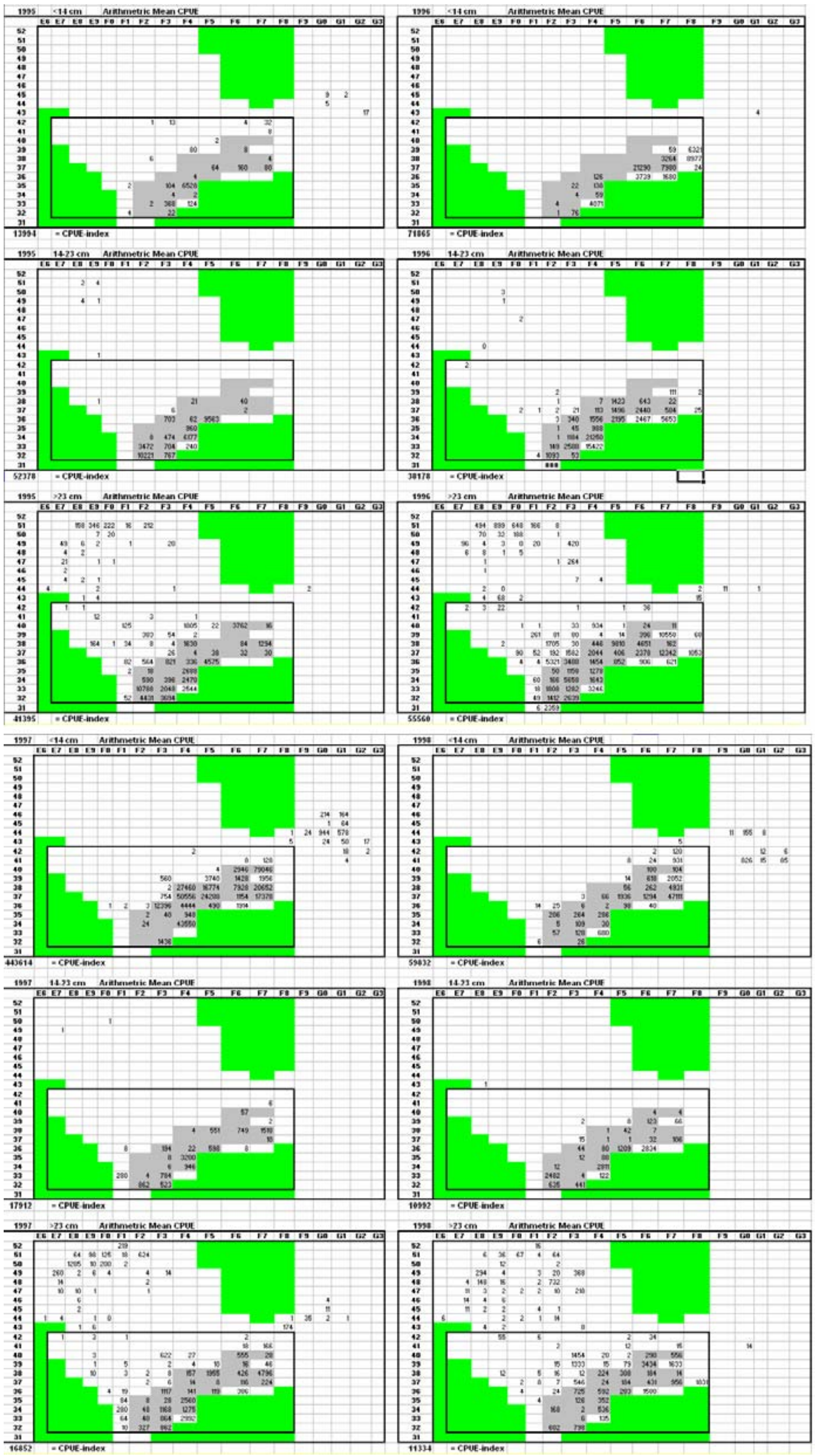


Figure 4.5.2.1. Mean IBTS catch rates of horse mackerel in quarter 3 by year and by ICES rectangle (North Sea) for fish <14 cm, for fish ≥14 cm and <23 cm, and for fish ≥23 cm. Dark green rectangles roughly correspond to land; light grey rectangles are selected for the indices. In the bottom of each panel is the index (mean catch rate in numbers/hour) based on the shaded rectangles. (Note the unexpected location of hauls in 2006)

Figure 4.5.2.1. Continued

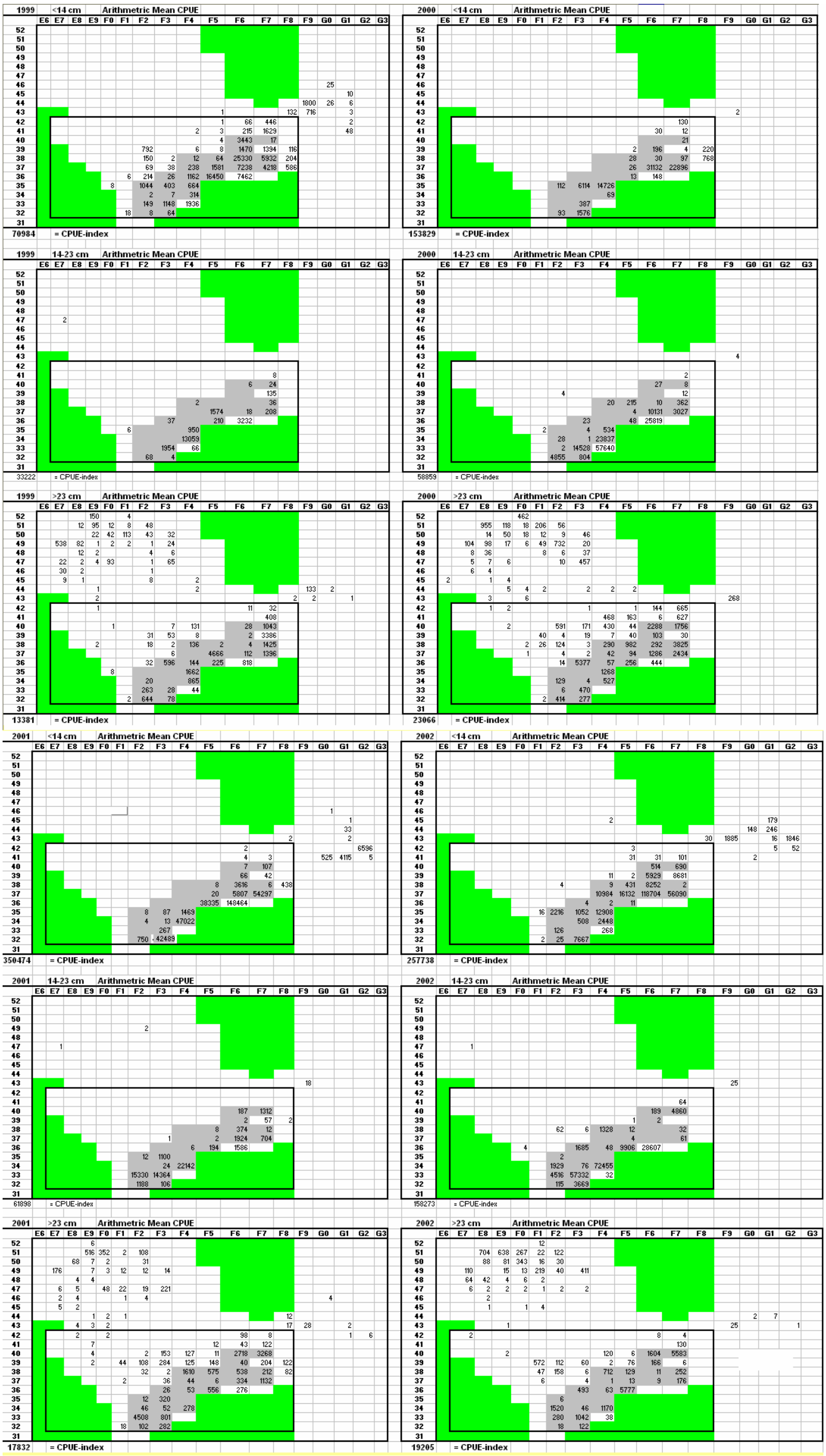
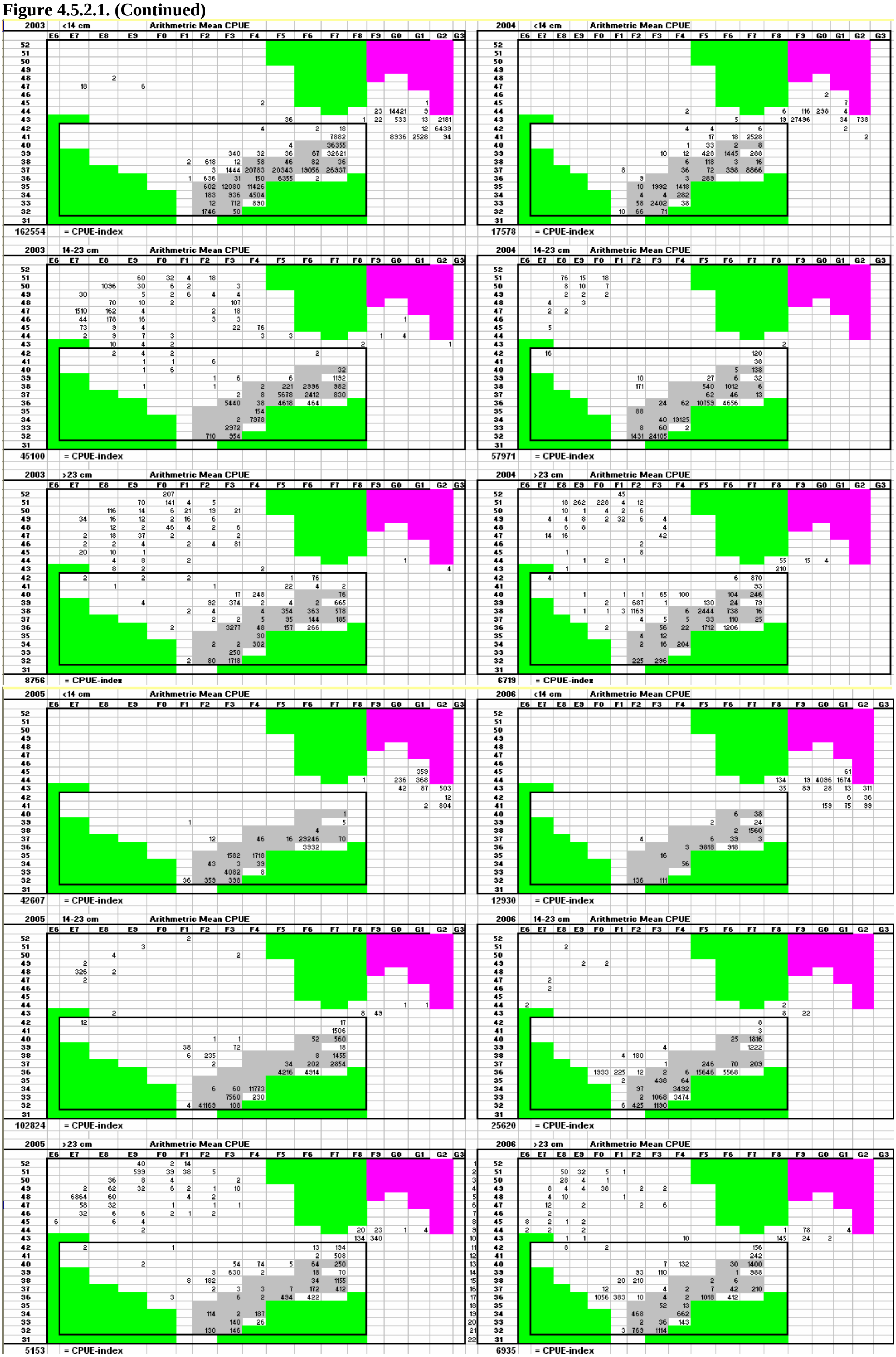


Figure 4.5.2.1. (Continued)



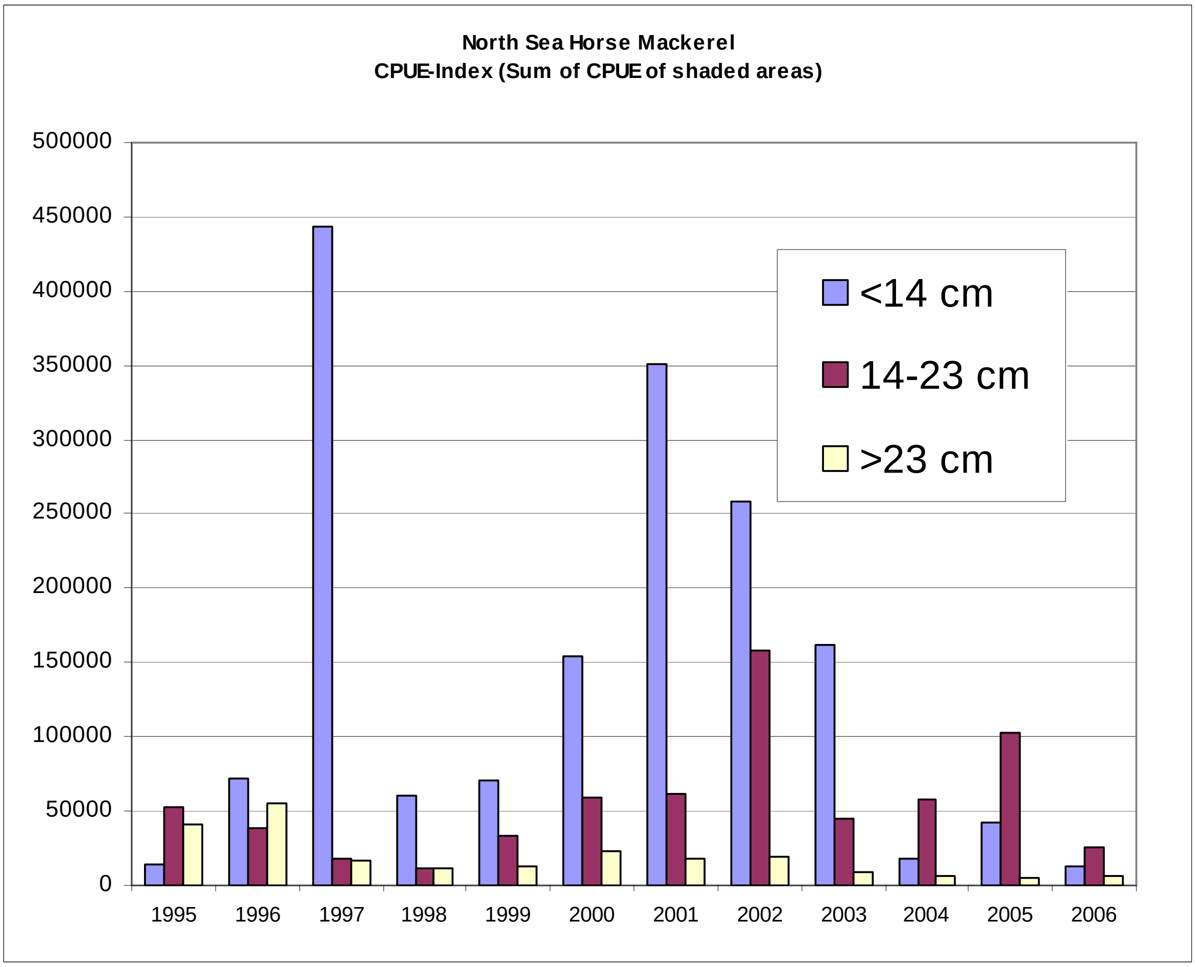


Figure 4.5.2.2.a. Indices are mean IBTS catch rates of horse mackerel in quarter 3 by year.

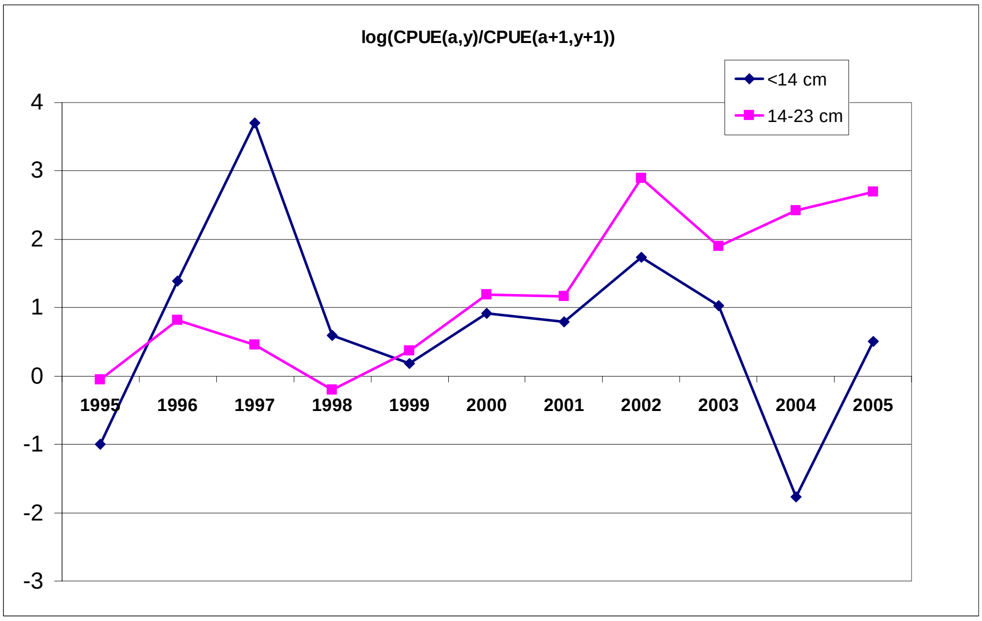


Figure 4.5.2.2.b. Log(Index(y,a)/Index(y+1,a+1)). Indices are mean IBTS catch rates of horse mackerel in quarter 3 by year.

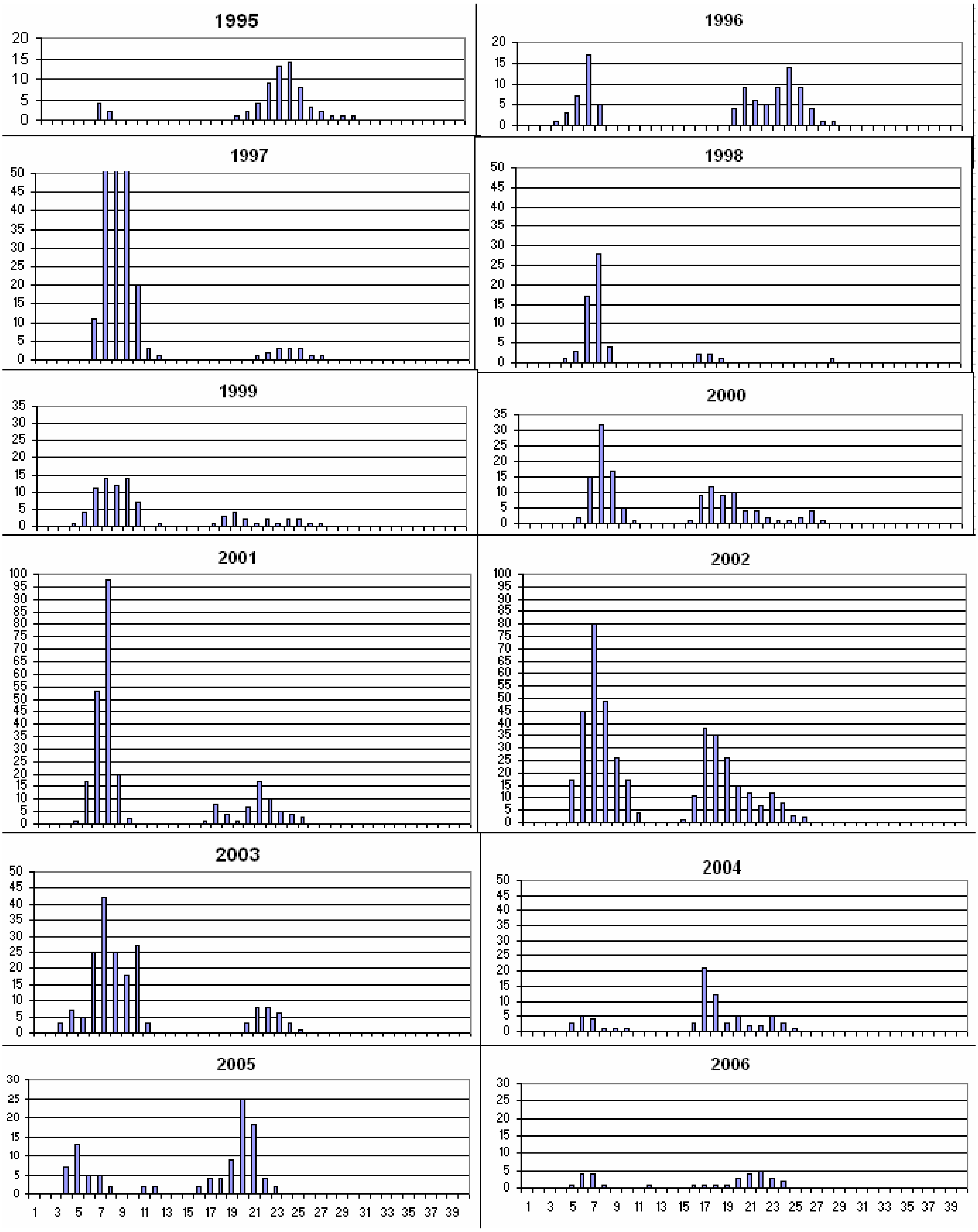


Figure 4.5.2.3. Length frequency distributions. Mean IBTS catch rates of horse mackerel in quarter 3 by year, in ICES rectangles which are shaded in Figure 4.5.2.1.

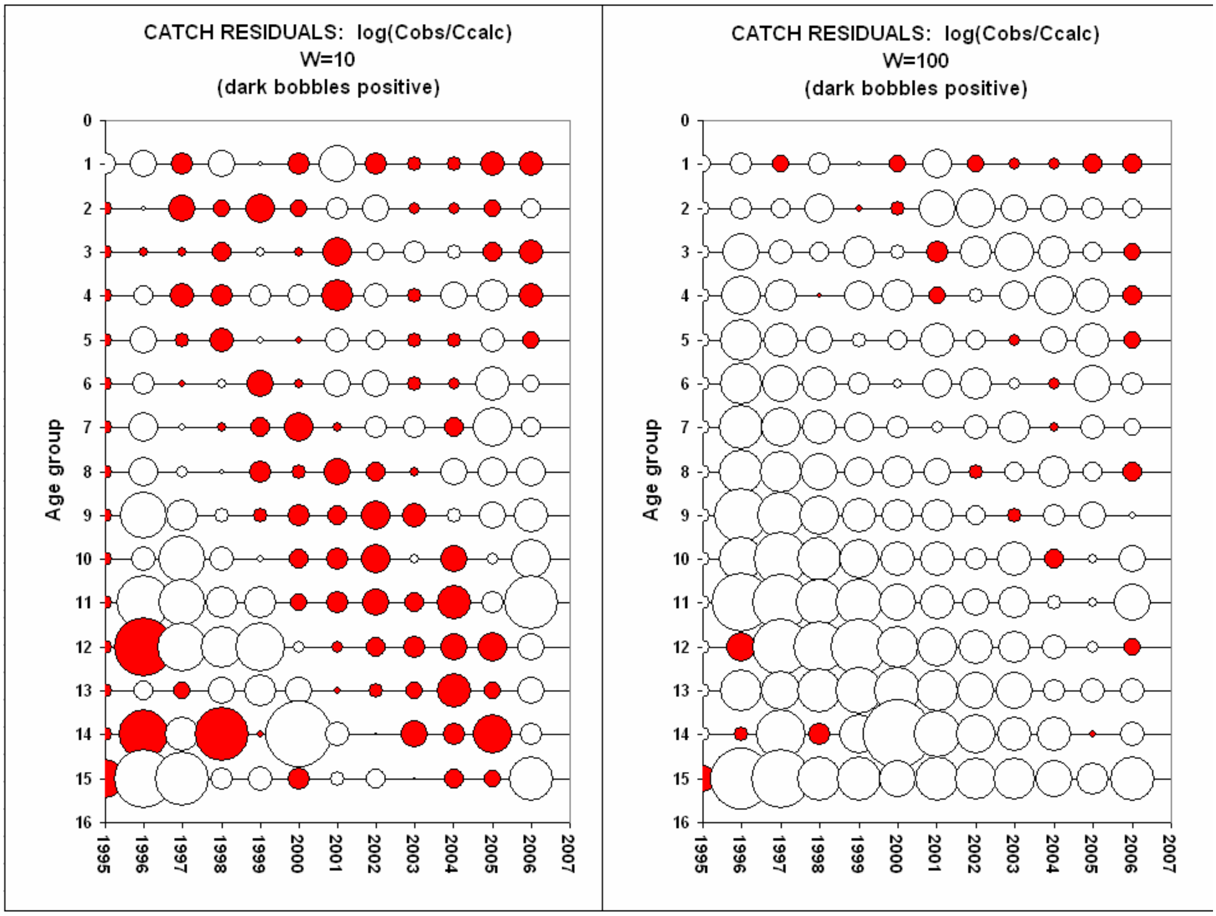


Figure 4.5.3.1. Output Ad Hoc method. Catch Residuals. Left: Weight of Index =10 (min:-5.4, max:4.4), Right W=100 (Min-8.5, max:1.7)

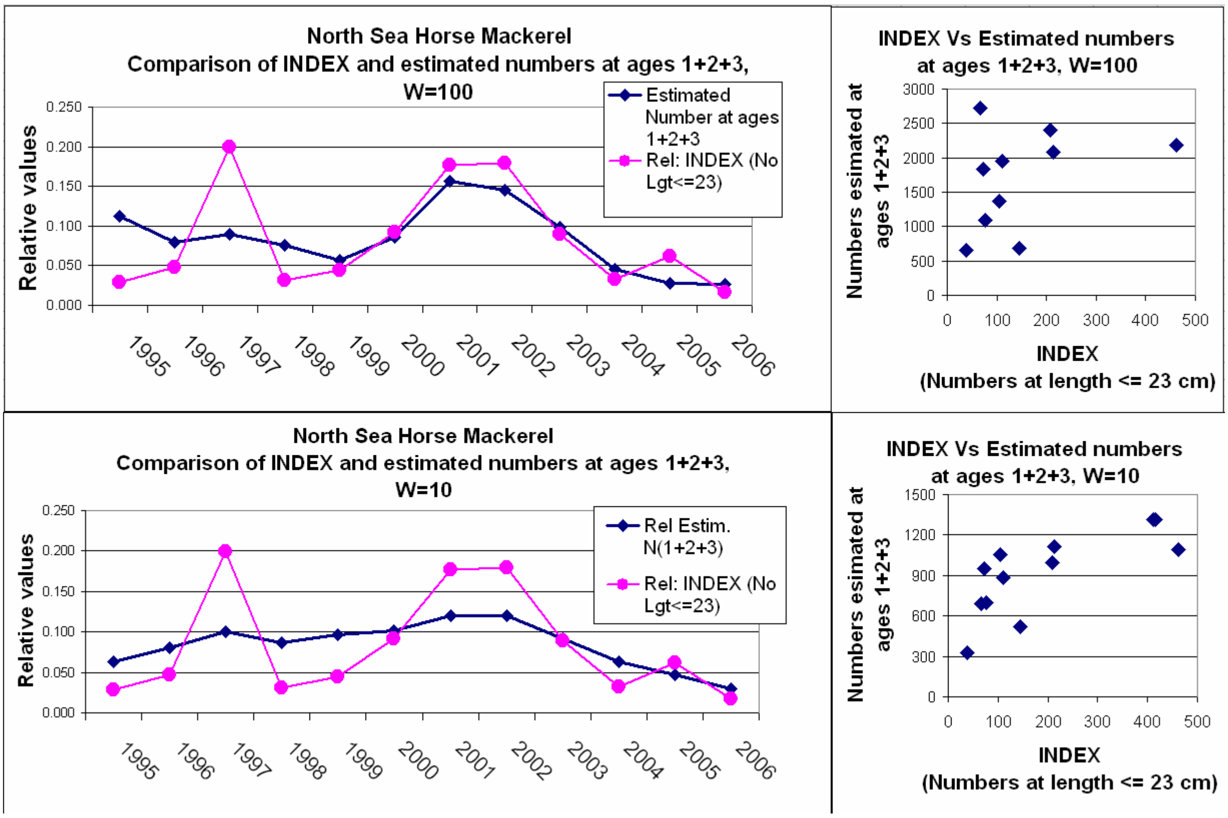


Figure 4.5.3.2. Output Ad Hoc method. Relative Index vs relative estimates. Upper Figure: High weight to Index. Lower Figure: Low weight to Index

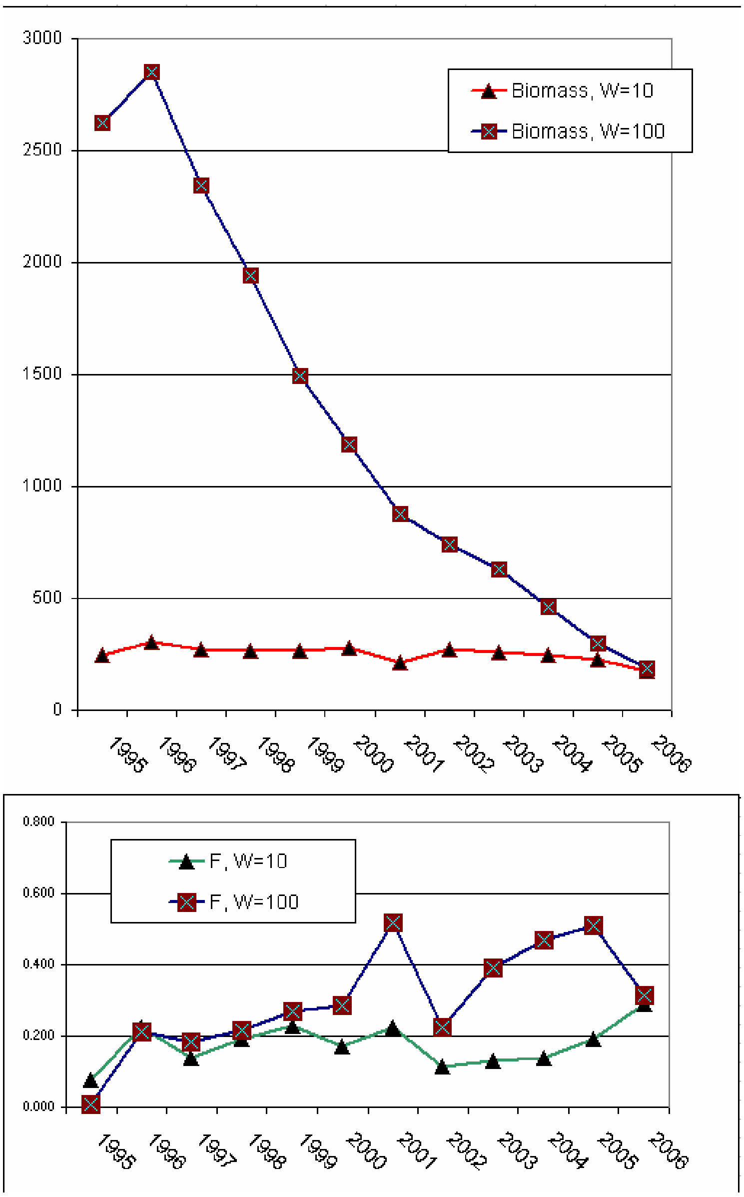


Figure 4.5.3.3. Stock biomass (000' tons) and F (for fully exploited age groups) estimated by the Ad hoc method for North Sea Horse Mackerel (with low and high weight to survey index).

5 Western Horse Mackerel (Divisions IIa, IIIa (Western Part), IVa, Vb, VIa, VIIa-c, VIIe-k, AND VIIIa,b,d,e

5.1 ACFM Advice Applicable to 2006 and 2007

Previously ICES gave advice for the western stock excluding Division VIIIc, this changed in 2005, when ICES advised that catches in 2005 be limited to less than 150,000 t for the whole distribution of the stock.

EU has set TACs for western horse mackerel in EU waters since 1987. However, these TACs cover a mixture of western, North Sea and southern horse mackerel areas. For 2007, the TACs were equal to the TACs in 2006 and 2005, and can be summarised as follows:

Areas in EU waters.	TAC 2007	Stocks fished in this area
Div Vb, Sub areas VI and VII, Div VIIIa,b,d,e	137,000 t	Western & North Sea stocks
Div IIa and Subarea IV	42,727 t	Western & North Sea stocks
Division VIIIc and Subarea IX	55,000 t	Southern & Western stocks

The TAC for the western stock should apply to the distribution area of western horse mackerel i.e. Divisions IIa, IIIa (western part, second half of the year), IVa (second half of the year), Vb, VIa, VIIa-c,e-k, and VIIIa,-e. The TAC for the North Sea stock should apply to those areas where North Sea horse mackerel are fished i.e. Divisions IVa (first half of the year), IVb,c, IIIa (first half of the year) and Division VIId. The TAC for the southern stock should apply to Division IXa.

There was a very small shift in the allocation of the TACs, where the EC TAC in Div IIa and Subarea IV increased from 40,957 to 40,983. Also, the EC TAC in Div Vb, Sub areas VI and VII, Div VIIIa,b,d,e increased from 135,257 to 135,518. The TACs of the Faroe islands were reduced proportionally.

5.2 The Fishery in 2006 of the Western Stock

Information on the development of the fisheries by quarter and division is shown in Table 3.1.2 and in Figures 3.1.1.a–d. The total catch allocated to western horse mackerel (including Division VIIIc) in 2006 was approximately 155,000 t (Table 3.3.1) which is 27,000 tons less than in 2005.

Divisions IIa and Vb

The catches in this area have varied from year to year (Table 5.2.1.). Over the last 10 years, these catches have been taken almost entirely by Norway. During the 1990s the catches fluctuated between 800 tons and 14,000 tons. Since 2000, the landings are considerably lower, ranging between approximately 20 and 1200 tonnes. Catches in 2005 and 2006 were 176 and 30 tons respectively.

Subarea IV and Division IIIa

The total catches of horse mackerel in Division IIIa and Sub area IV and are shown in Table 5.2.2. The catches the two first quarters from Divisions IVa in 2006 were allocated to the North Sea stock and the catches from the two last quarters were allocated to the western stock. The catches of the western stock in Division IIIa have fluctuated between 4,500 -145,000 tons during the period 1987-2006. These fluctuations are mainly due to the availability of western horse mackerel for the Norwegian fleet in October –November (see section 5.3.3).

Subarea VI

The catches in this area increased from 21,000 t in 1990 to a historical high level of 84,000 tons in 1995 and 81,000 tons in 1996 (Table 5.2.3). The catches then declined to a lower level in 1997. In 2006 the total catch was about 16,000 tons. All catches from Division VIa are allocated to the western stock.

Subarea VII

The total catches of horse mackerel in Sub area VII are shown in Table 5.2.4. All catches from Sub area VII except Division VIId were allocated to the western stock. The main catches are usually taken in directed trawl fisheries in Divisions VIIb,e,h,j. The catches of western horse mackerel in Sub-area VII (Table 3.3.1) increased from below 100,000 tons prior 1989 to about 320,000 tons in 1995 and 1997 and were 102,000 t in 2006.

Subarea VIII

The total catches of horse mackerel by country for Sub-area VIII are given in Table 5.2.5. All catches from this Sub area (including division VIIIc) are allocated to the western stock. The catches of horse mackerel in these areas usually fluctuate between 22,000 and 55,000 t, except for the record high catch in 2001 of 75,000 tons. In 2006 the catches were 34,100 t.

5.3 Fishery Independent information

5.3.1 Egg survey estimates of spawning biomass

Since horse mackerel is considered a indeterminate spawner it is not possible to convert egg production to SSB but the egg production can be used as a proxy for the SSB of Western horse mackerel. In 2007 there has been a new egg survey on horse mackerel egg production. The results of the egg survey are given in section 3.7 and Table 5.3.1.1 The provisional egg production estimate for 2007 is approximately 1.6 times higher than the previous estimates in 2001 and 2004.

5.3.2 Bottom trawl surveys for western horse mackerel.

Due to the new definition of the boundaries of the western horse mackerel stock, the autumn Spanish bottom trawl surveys (DEMERSALES) operating in Division VIIIc is now available as fishery independent information of this stock. The surveys cover the whole Division VIIIc and the Subdivision IXa North. It is directed to demersal resources and is carried out in September/October. This survey provides valuable information on horse mackerel dynamics in the study area such the general distribution pattern or the gap in the catch length distribution observed between juveniles and young adults (18-23) cm, which roughly corresponds to the length at first maturity (Figure 5.3.2.1). This gap could explain the characteristic exploitation pattern of horse mackerel in northern Iberian waters with two peaks corresponding to juveniles and adult ages. Some cohorts can be followed in this survey (Figure 5.3.2.1) but there is almost no information on mortality along the cohorts showing almost flat slopes (Fig 5.3.2.2). This could be explained by the fact that it is likely that limited migrations occur between adjacent areas (mainly the French continental shelf). Therefore, the analysis of these data could benefit if information from other surveys carried out in adjacent areas (mainly from Divisions VIIIa,b) is available (Velasco and Abaunza WD, 2006). Furthermore, the surveys are carried out during the recruitment season and an index of recruitment and catch in numbers at age are provided (Table 5.3.2.1). However, this recruitment index should be taken with caution since the sampling intensity near the coast (depth strata < 120 m), where many juveniles are distributed, is very low due to the rocky nature of the seashore. In the data provided the Subdivision IXa North, which is defined as southern stock area, is also included. This information will be amended for next year Working Group to correspond with Division VIIIc only (Western stock).

The French bottom trawl surveys (EVHOE) cover the Bay of Biscay (French continental shelf) and part of the Celtic Sea. It is carried out in autumn and it is directed to demersal resources. Information on horse mackerel distribution and length distributions are available (Figure 5.3.2.3). The survey is carried out during the recruitment season and the juveniles are the majority in the catches.

It might useful for the WG to collect all information available about horse mackerel from other bottom trawl surveys carried out in the distribution area of the western horse mackerel stock (e.g. IBTS).

5.3.3 Acoustic surveys for western horse mackerel.

Horse mackerel data coming from the French acoustic PELGAS surveys are available as independent information about the western horse mackerel stock (ICES ICES CM 2006/LRC:18). This multidisciplinary survey is covering Divisions VIIIa and VIIIb during spring, collecting information on spatial distribution and length distribution. The survey estimates have been revised last year (WD Massé *et al*). Figure 5.3.3.1 and Table 5.3.3.1 show the length distributions of horse mackerel (in numbers) from 2000 to 2007.

Horse mackerel data coming from the Spanish acoustic PELACUS surveys are available as independent information about the western horse mackerel stock. This multidisciplinary survey is covering Divisions VIIIc and Subdivision IXa North during spring. In some years the survey is extended to the south of Subdivision IXa North and Division VIIIb. Information on distribution and abundance estimates are available since 1997. Figure 5.3.3.2 shows the biomass estimates of the historical series considering the Subdivision IXa North (Southern stock) and Division VIIIc (Western stock) until 2006 and Figure 5.3.3.3 the estimate for 2007.The information will be split up by stock and it is expected to be presented at WGACEGG next November 2007.

5.3.4 Environmental Effects

Since the strong 1982 year class of the western stock started to appear in the North Sea in 1987 there has (except for 2000) been good correlation between the modeled influx of Atlantic water to the North Sea the first quarter and the horse mackerel catches taken in the Norwegian EEZ (NEZ) later the same year (Iversen *et al.* 2002). The correlation has been used locally to predict the catch level in NEZ since 1997. The predicted and actual catch matched very well in 2006. The influx in 2007 indicates an increase in the catch rate from 27,000 tons in 2006 to more than 60,000 tons in 2007 (Iversen et. al WD 2007).

5.4 Effort and catch per unit of effort.

Information on effort and catch per unit effort is only available from the southern limit of the stock distribution area. Since Division VIIIc became part of the western stock in 2005, the bottom trawl fleet operating in Subdivision VIIIc West (north of the Galician coast) is exploiting the western stock. The effort series from this fleet has been revised, in order to obtain a more reliable estimates. This time series is also used for other species. The effort decreased by about 26% since 2001, and it maintained this low level in 2006 (see the table below). The very low values obtained in 2003 can partially be explained by area and season closures in response to the Prestige oil spill effects. Catch per unit of effort was available for the old effort time series but due to the new effort estimates the CPUE values and the CPUE at age data are still under revision.

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Effort (Days/100 *HP)	51017	48655	45358	39829	34658	41498	44401	44411	40435	38896	44479	39602

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Effort	41476	35709	35191	-----	30131	30073	29923	21823	12328	19198	20663	19264

5.5 Biological Data

5.5.1 Catch in numbers

Since 1998 there has been an increase in age readings compared with previous years. This has improved the quality of the catch at age matrix for recent years of the western horse mackerel. In 2006, Denmark (VIIh), the Netherlands (Divisions VIa, VIIb,e,h,j, VIIIa,d), Norway (Division IVa), Ireland (Divisions VIa and VIIb),Germany (Divisions VIa,VIIb,d,e,j, VIIIa) and Spain (Divisions VIIIb, VIIIc east, VIIIc west) provided landings in numbers at age. The catches sampled for age readings in 2006 covered 73 % of the total catches.

Catches from other countries were converted to numbers at age using adequate samples from other countries. The procedure has been carried out using the specific software for calculating international catch at age (Patterson, WD 1998). The landings in numbers by year class for each of the fishing divisions are shown in Figure 5.5.1.1.

Both Germany and the Netherlands provided samples and age readings from fourth quarter in Division VIIe,. The age distribution of the German and Dutch samples was significantly different. The Dutch samples were dominated by five years old fish, while the German samples contained relatively more 2-7 years old fish. Differences in age distributions between Dutch and German samples in Divisions VIIe, h have also in previous years been observed. Catches from Division VIIe in the fourth quarter 2006 were converted to numbers at age using the German and Dutch information weighed by sample number.

The total annual and quarterly catch-at-age for western horse mackerel in 2006 are shown in Table 5.5.1.1. The sampling intensity is discussed in Section 1.3. The catch at age matrix shows the predominance and the dominance of the 1982 year class in the catches since 1984 (Figure 5.5.1.2 and Table 5.5.1.2). The log catch ratios show considerable variability between years, especially for the cohorts in the beginning in the time series (Figure 5.5.1.2). The 1982 year class has been included in the plus group since 1996. Since 2002 the 2001 year class of horse mackerel has been caught in considerable numbers (Figure 5.5.1.2). In 2006 large catches were taken of this year class. 52% of the catch in number was of this year class. The total catch in the juvenile areas was 62,600 tons which is 40% of the catch of the western stock. These catches were mainly taken in Divisions VIIh and VIIIa. In 2006 40% of the total western catch was taken in the juvenile area.

5.5.2 Mean length at age and mean weight at age.

The mean weight and mean length at age in the landings by year, and by quarter in 2006 are shown in Tables 5.5.2.1-5.5.2.2.

Mean weight at age in the stock

The mean weight at age for the two years old was assumed equal to last years estimate. The weight for the older ages is based on the fish sampled from Dutch freezer trawlers in the first and second quarter in Division VIIj (see Table 5.2.4). Previous years, also samples from VIIk were used, but these were not available in 2006. The mean weight by age groups in the stock and in the catches were lower than usual in 2001, but returned to normal in 2002-2006 (Table 5.5.2.3 and Figure 5.5.2.1).

5.5.3 Maturity ogive

Due to difficulties in estimating a maturity ogive (ICES, 2000/ACFM:05 and ICES, 2000/G:01) the working group was unable to update the maturity ogive annually. Therefore the same maturity at age was used as last year (Table. 5.5.3.1)

5.5.4 Natural mortality

The natural mortalities applied in previous assessments of western horse mackerel are summarised and discussed in ICES (1998/Assess:06). The natural mortality is uncertain but probably low. In previous assessments the Working Group applied M=0.15.

5.6 Data exploration and preliminary modelling

Three different types of stock assessments have been used to explore the available data: Two assessment methods that combine a separable VPA with an "ADAPT" model structure (SAD and SADVF) and an assessment method that extends ISVPA (TISVPA).

The SAD model has been used by the working group since the 2000 meeting. The WGMHSA Review Group of ACFM in 2005 stated that the SAD model purposely designed to assess this stock, was likely to be the most appropriate tool. A detailed description of the SAD assessment model and rationale for its use is provided in the 2002 Working Group report (ICES CM2003/ACFM:07). Figure 5.6.1 presents an illustration of the model structure and the “free” parameters estimated by maximum likelihood (i.e. those estimated directly), and Table 5.6.1. summarises it’s main features.

In 2005 the WG identified aspects of the assessment that warranted further investigation/exploration:

- the availability of additional information, particularly in relation to fecundity, that would allow scaling the model;
- an estimate of the variability in fecundity for horse mackerel stocks in the assessment period.

Accordingly, The new version of SAD assuming variable fecundity (SADVF) was run alongside the original (SAD) model. SADVF differs with respect to SAD in the fact that it assumes a relation between the fish weight and fecundity. The traditional SAD on the other hand assumes fecundity is independent of fish weight. This difference ensures that SADVF takes into take account the indications that fecundity changed with changing stock structure in the period considered in the assessment (WGMHSA 2005 report, WGMEGGS 2005 report).

There is evidence that standing stock fecundity per gram increases with fish weight (ICES CM 2002/G:06) and total realised fecundity (*trf)* would be expected to follow the same pattern. In line with this argument, the stock average fecundity would have increased as the 1982 year-class matured (as individuals gained weight) and then decreased when the strong year-class was fished out.

Using estimates of batch fecundity, spawning fraction and duration of the spawning season from Eltink (1991), mean *trf* was estimated at 1040 oocytes/gram-female for 1991. Eltink (1991) states that this figure is likely to be an underestimate. The *trf* estimate of 1040 oocytes/g-female was taken into account by introducing a penalty term. This is done to provide bounds for the estimate of the intercept of the relationship between *trf* per gram and fish weight.

The "free" parameters estimated directly in the model are:

1) Fishing mortality year effects (F_y) for the final four years for which catch data are available;
2) Fishing mortality age effects (S_a, the selectivities) for ages 1-10 (excluding age 7, which is set at 1);
3) scaling parameter (F_{scal}) for fishing mortality at age 10 relative to the average for ages 7-9 (ignoring the 1982 year-class where applicable);
4) fishing mortality on the 1982 year-class at age 10 in 1992 ($F_{92,10}$) and
5) the intercept (*a*) for the fecundity / female gram relationship that links the egg production estimates and the SSB model estimates.

The estimate for *b* is likely to be lower than the "true" slope, (P. Witthames *pers comm.*) because larger (older) fish are likely to spawn more often and for a longer period than younger ones. Hence, only the data of standing stock fecundity (*ssf*) per g female (*ssf* is the fecundity at the start of the the season) were used to estimate the slope (*b*), and the model was as follows:

$$ssf = a + b*w$$

The intercept of the relationship between *trf* per gram and fish weight was expected to be higher than for the standing stock fecundity. In order to estimate the intercept (*a*) and corresponding CV (cva_{obs}), fecundity data per gram by observed fish weights were generated so that on average they resulted on *trf* - as estimated by Eltink (1991). The model described above was fitted to both the original (*ssf /g*) and simulated data. The CV is then simply s.d. of *a* divided by estimate of *a*.

To conclude the SAD and the SADVF model differ with respect to 1) the assumptions in the relation between fecundity and fish weight, and 2) a penalty term in the likelihood estimation, binding estimates of fecundity in the SADVF model. This difference of SADVF with respect to SAD was expected to help scaling the assessment.

Input data for the model were as presented in Tables 5.3.1.1, 5.5.1.1, 5.5.2.3 and 5.5.3.1. Natural mortality (constant at age and by year at 0.15), maturity-at-age and stock weights-at-age and the proportions of F and M before spawning (0.45), are assumed to be known precisely. It should be noted that there has been a new egg production estimate for Western horse mackerel in 2007. Although the estimate is marked as preliminary, it is used in this year's assessment.

Results

Results are presented for SAD and SADVF, along with brief results from TISVPA (Model description from D. Vasilyev included as Annex 2 of this report). Also, a consistency check was carried out between the SAD model and the SADVF model with *b*=0 and no penalty term. As is expected, the models are then structurally similar, and predictions were identical within the convergence limits of the fitter predicting SSB for 2007, with a difference of less than 0.5%.

The model optimisation was examined by looking at the Hessians that describe the correlations of parameters during the optimisation process. SAD had a high correlation between fecundity and the separable F's, and strong positive correlations between all SSB estimates (Figure 5.6.2) – the model optimised by adjusting F and scaling the overall level of the population. In contrast

SADVF had weaker correlations between F's and fecundity and correlations between SSBs that started positive and became negative over time (Figure 5.6.2).

Plots of the model fits to data for the three components of the likelihood, together with plots of normalised residuals, are shown in Figures 5.6.3 for SAD and on 5.6.6 for SADVF. The normalized egg residuals for SADVF are consistently smaller since 1992. For the SAD model, no such decrease in the size of the residuals is found. Additional analysis of the variability of the egg estimate residuals for both models indicates that the non-normalized residuals are smaller for SADVF than for SAD since 1992. No apparent patterns in the log-catch residuals are found that can be attributed to a change in the fishery. However, the log catch residuals for older ages (from age 5) in both 2003 and 2005 are all negative. The residual plots for the plus-group catch are similar for the two models. The plus-group catch appear free of systematic patterns apart from the early part of the series in Figure 5.6.3(c) and Figure 5.6.6(c), likely caused by the 1982 plus-group population numbers having to be estimated directly from the plus-group catches to initiate the dynamic pool. The 1997 peak in estimated plus-group catch results from a high F in 1997 which is based on the plus-group catch data and the estimated numbers at age. As noted by ACFM in 2004 the error bars in the estimates of age 0 are large (Figure 5.6.3 (c-d) and Figure 5.6.6 (c-d)). This is related to the fact that the younger ages are poorly represented in the catch and there is no consistent survey information for these age groups. The largest recent residual occurred around 2002, corresponding to the beginning of the separable period.

Figures 5.6.4 and 5.6.7 show the selectivity pattern for the separable period, the SSB and age-0 trajectories, with error-bars reflecting 95% confidence bounds for SAD and SADVF, respectively. The selectivity pattern in the separable period estimated by SAD is highest for age 5, while the highest average value for SADVF is found at age 7. The CVs for the selectivity parameters for SAD, are in the range 18-30%. For the SADVF model the CVs for the selectivity parameters were consistently higher, ranging between 25% and 45%. For both models precision of the estimated selectivity is lowest for the younger ages. Figures 5.6.5 and 5.6.8 show the estimates for some key parameters and the three components of the likelihood.

A retrospective analysis for the SAD and SADVF model comparing separable 2002-2006 with separable 2001-2005 and separable 2001-2004 period indicated that the selectivity pattern was relatively stable between years. For SADVF the 2001-2004 and 2001-2005 data having selectivity shifted towards older age classes (Figure 5.6.9). Some of this difference may result from the presence of the new egg data. The historic consistency of the selection pattern may be taken as a conformation of the appropriateness of the separable assumption underlying both models.

It should be noted that there is a marked shift in the selectivity pattern on the transition between the separable part of the model and the ADAPT part of the model (Fig 5.6.10). High fishing mortality for the oldest age classes is estimated in the ADAPT part, that is not found in the separable part. For the period up to the mid 90's the high fishing mortalities for the older age classes can be explained by the targeting of the fishery of the strong 1982 year class. However, there is also a marked difference between the fishing mortality of the older ages when entering the separable period. Although this may be a result of the "smoothing effect" of the selectivity pattern by the separability assumption, the exact cause is unknown.

The SSB estimates for both SADVF and SAD show an increasing trend since 2003. This is in line with the estimation of the strong 2001 year class and the high egg production estimate in 2007. The CV estimates for the model fit of SAD are larger than the CVs for the SADVF estimates of SSB. However, there is a marked difference in the level at which the SSB is estimated in the most recent part of the assessment. The SSB estimate for 2007 in case of SAD is approximately 3.4 million tonnes, while the SSB estimate for SADVF is 1.9 million tonnes. In relative terms, the SSB is 2.2 times higher than the SSB_{1982} for the SAD model, and 1.5 times higher for the SADVF model.

The fishing mortality F(1-10) in the terminal year is different for the two models. The SAD model estimates the terminal fishing mortality at approximately 0.03, while the SADVF model estimates the terminal fishing mortality at 0.05, corresponding to their difference in SSB estimate. These F estimates are considerably lower than the assumed value for natural mortality (M=0.15). Reviewers have commented that the assumed value for M should be investigated. However, there is no data available (such as tagging) that could assist to estimate M more accurately.

The recruit estimates show the large 1982 year class. Since then several moderately strong year classes have occurred in the early 1990s. The most recent strong year class is estimated to be 2001, which is now 5 years old and making up the majority of the catch. The estimate at age 0 for this year class is now estimated to be approximately 25% of the size of the 1982 year class. Error estimates for the recruitment in the most recent years (2004-2006) are large, between 45% and 50% for the two models. This is a consequence of the small and erratic age class 0 catches. The error estimates for the strong 2001 year class are considerably smaller for the two models.

In response to the review group, the available data was used to also do a TISVPA assessment. This model is an extension of a separable model. There are two separable periods, split in 1990. The results are summarised in figures 5.6.11 -5.6.12) The TISVPA predicts a strong 2001 year class that was comparable to the 1982 year class. It also predicted higher selectivities in the older age classes than was estimated for the separable years for SADVF. As a consequence the increase in SSB in the most recent period was very steep. The fit between the egg production and SSB was not always good and showed consistent bias in the residuals In their evaluation the group did not feel they could accept the model results because of the failure of the model to account for the changes in selectivity between the 1990s and the 2000s.

To conclude, the models show similar trends in SSB, consistent with the sparse information available, being the catch-at-age data and the survey egg production estimates. However, by including auxiliary information on fecundity and constraining the SSB by binding fecundity estimates, the SADVF model estimates lower SSBs. Basically by doing so the model was taken away from the ‘true’ minimum parameters’ space. The two models in essence reflect different views on the “biological realism” of the model. The Working Group supported the SADVF approach because it takes into account available biological information using a simple model to scale the assessment.

5.7 State of the Stock

5.7.1 Stock assessment

Due to the uncertainties presented in Section 5.6 no assessment is presented as a definitive state of the stock.

5.7.2 Reliability of the assessment

This section reflects on the stock assessments in the preliminary modelling, since no final assessment model is presented as a definitive state of the stock. The fisheries independent data for this stock is extremely limited, with only a single data point for egg production every three years. The reliability of this assessment depends on: the reliability and stability of the VPA part of the model, the intrinsic reliability of the egg production data, the biological realism of the fecundity relationships and the ability of the model to use this data to calibrate the stock model.

Retrospective stability analysis of the selectivity showed that the selectivity pattern in the separable period was stable. Explorations of the sensitivity of the estimates to starting values indicated that convergence was robust to input values, in particular with respect to fecundity.

Although estimates for the uncertainty of the egg input data are available, the SADVF model does not take this uncertainty into account. This is one area that might need addressing in the future if a systematic estimation of likely error in the model is to be evaluated. The inclusion of independent estimates of the uncertainty of the egg production would improve the reliability of the assessment

The fecundity relationship for the SADVF model makes use of one independent estimate of the variation of fecundity with fish weight and is constrained by the SSB to egg production relationship between 1992 and 2001. The recent low residuals of recent egg estimates, especially the 2007 egg survey data lend support to the fecundity relationships used in the assessment. The weak fits for the data prior to 1992, raise doubts about the longer-term stability of the fecundity relations. It is conceivable that there is some shift in the population dynamics of the stock that explains this discrepancy. Ultimately the reliability of the assessment hinges on the accuracy of the SSB to fecundity relationships used by the model. Because of the paucity of egg estimates and the need for information on slope and intercept of fecundity, it is important that this fecundity information is as independent as possible from the data. The values for the applied fecundity regression (penalty term) have been applied to avoid underestimation of the fecundity intercept term. The result is that the variable fecundity model is more likely to underestimate SSB than to overestimate it.

It should be noted that the CVs for the recruitment were extremely high for the more recent three years – the 95% lower confidence limit is barely positive. This result is to be expected given the negligible input the first three age classes make to SSB and the limited catch data for recruits. This uncertainty increases as the assessment is updated without additional egg production survey data. The estimate for the 2001 year class at age 0 is the second largest since 1982, with an CV of 27%.

The evaluation could be improved by information such as survey tuning indices. However, obtaining a reliable tuning series is likely to be hampered by the large geographic area in which the stock occurs and the strong migration patterns. It does not seem that changes to the modelling methodology alone will fundamentally solve this problem.

5.8 Catch Prediction

Due to the uncertainties presented in Section 5.6 no assessment is presented as a definitive state of the stock.

5.9 Short and medium term risk analysis

For reasons stated above, these analyses have not been carried out for this stock.

5.10 Reference Points for Management Purposes

The absolute levels of SSB, F and R are considered uncertain. As this affects also the historic perception of the stock, a definition of reference points in absolute terms is currently not possible. The stock is characterised by infrequent, extremely large recruitments.

Biomass reference points. It could be assumed that the likelihood of a strong year class appearing would decline if stock size were to fall below the stock size at which the only such event has been observed. The WG therefore considers the biomass that produced the extraordinary 1982 yc as a good proxy for B_{lim}. This follows the rationale of SGPRP 2003 proposing to use the stock size in 1982 for B_{lim}. However, the method used to estimate the SSB in 1982 (based on the egg production estimate obtained by a survey) can not be applied any more because of the uncertainty of the fecundity type of the species, so B_{lim} can only be defined in relative terms.

Fishing mortality reference points. Again, there is high uncertainty about the absolute level of F at present and in the past. Current fishing mortalities cannot be compared to the estimates prior to 2002, because the age range for mean F was changed last year from F(4-10) to F(1-10) to include both the exploited age groups of the juveniles as the adults. No reliable estimate of total mortality is available for the stock, which could be used to judge the level of F. There are, however, indications that the assumed natural mortality (0.15) might be too high. However, there is insufficient data to estimate M.

ACFM has not defined any fishing mortality reference points for this stock in the past but in its advice it has used $\mathbf{F}_{0.1}$ as the highest F that is consistent with the Precautionary Approach.

5.11 Harvest control rules

This year, the pelagic RAC has put forward a management plan for Western horse mackerel. An evaluation of this plan is provided in section 1.8.1. This plan makes use of the information available in the egg production surveys, and bases tri-annual TACs on the slope of the three previous egg production estimates.

5.12 Management considerations

There are indications that the 2001 year-class is strong given that this year class is now well recruited to the fishery. However, this year-class does not appear to be of the same order of magnitude as the 1982 year-class. Rather, it appears to be at a similar level as those in the mid-90s. The current catch in the juvenile area accounts for 40% of the total catch and, according to the models the fishery is not particularly selecting this year-class therefore the WG has some confidence on the estimates of the strength of the 2001 year-class. In 2006, approximately 50% of the total catch was of the 2001 year class.

So far, the juvenile fishery in the Western stock distribution area has mainly taken place in Divisions VIIe,f,g,h and VIIIa-d. From about 1994 onwards the fishery shifted from a fishery on adults towards a fishery on juveniles. This may be due to the lack of older fish (decline of the 1982 year class) and the development of a market for juveniles. The percentage of catch (in weight) in the juvenile areas increased gradually from about 40% in 1997 to about 65% in 2003 and dropped to 46% in 2005. In 2006 it is back at a level of approximately 40%.

In 2007, there has been a new egg survey for horse mackerel. The preliminary egg production estimate is approximately 1.6 times higher than the previous estimate in 2004. This corroborates with the strong 2001 year class maturing.

The Working Group has put forward a hypothesis that a large-scale shift in the spatial distribution of NEA mackerel has taken place in 2005-2007. The spatial distributions of mackerel and horse mackerel have always been considered to have substantial overlap. If such a large-scale change in distribution and migration pattern has occurred this may have consequences for future abundance, spawning, growth and recruitment of western horse mackerel.

The TAC has only been given for parts of the distribution and fishing areas (EU waters). The Working Group advises that if a TAC is set for this stock, it should apply to all areas where western horse mackerel are caught, i.e. Divisions IIa, IIIa (western part), IVa, Vb, VIa, VIIa–c, e–k and VIIIa-e. Note that Div. VIIIc is now included in the Western stock distribution area. If the management area limits were revised, measures should be taken to ensure that misreporting of juvenile catch taken in VIIe,h and VIId (the latter then belonging to the North Sea stock management area) is effectively hindered. This could be done for example by imposing a separate TAC for the juvenile areas of both neighbouring stocks. This mis-match between TACand fishing areas has resulted in the catch exceeding those advised by ICES.

Finally, the Pelagic RAC has put forward a management plan for Western horse mackerel. An evaluation of this plan is provided in section 1.8.1. This plan makes use of the information available in the egg production surveys, and bases tri-annual TACs on the slope of the three previous egg production estimates.

Table 5.2.1 Horse mackerel general. Catches (t) in Subarea II. (Data as submitted by Working Group members.)

Country	1980	1981	1982	1983	1984	1985	1986	1987
Denmark	-	-	-	-	-	-	-	39
France	-	-	-	-	1	1	-[2]	-[2]
Germany, Fed.Rep	-	+	-	-	-	-	-	-
Norway	-	-	-	412	22	78	214	3,272
USSR	-	-	-	-	-	-	-	-
Total	-	+	-	412	23	79	214	3,311

	1988	1989	1990	1991	1992	1993	1994	1995
Faroe Islands	-	-	9643	1,115	9,157[3]	1,068	-	950
Denmark	-	-	-	-	-	-	-	200
France	-2	-	-	-	-	-	55	-
Germany, Fed. Rep.	64	12	+	-	-	-	-	-
Norway	6,285	4,770	9,135	3,200	4,300	2,100	4	11,300
USSR / Russia (1992 -)	469	27	1,298	172	-	-	700	1,633
UK (England + Wales)	-	-	17		-	-	-	-
Total	6,818	4,809	11,414	4,487	13,457	3,168	759	14,083

	1996	1997	1998	1999	2000	2001	2002	2003
Faroe Islands	1,598	799[3]	188[3]	132[3]	250[3]	-		
Denmark	-	-	1,755[3]			-		
France	-	-	-			-		
Germany	-	-	-			-		
Norway	887	1,170	234	2,304	841	44	1,321	22
Russia	881	648	345	121	84[3]	16	3	2
UK (England + Wales)	-	-	-			-		
Estonia	-	-	22					
Total	3,366	2,617	2,544	2557	1175	60	1,324	24

	2004	2005	2006[1]
Faroe Islands	-	-	3
Denmark	-	-	-
France	-	-	-
Germany	-	-	-
Norway	42	176	27
Russia			
UK (England + Wales)	-	-	-
Estonia	-	-	-
Total	42	176	30

[1]Preliminary.
[2]Included in Subarea IV.
[3]Includes catches in Division Vb.

Table 5.2.2 Horse mackerel general. Catches (t) in North Sea Subarea IV and Skagerrak Division IIIa by country. (Data submitted by Working Group members). Catches partly concern the North Sea horse mackerel.

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
Belgium	8	34	7	55	20	13	13	9	10
Denmark	199	3,576	1,612	1,590	23,730	22,495	18,652	7,290	20,323
Faroe Islands	260	-	-	-	-	-	-	-	-
France	292	421	567	366	827	298	231[2]	189[2]	784[2]
Germany, Fed.Rep.	+	139	30	52	+	+	-	3	153
Ireland	1,161	412	-	-	-	-	-	-	-
Netherlands	101	355	559	2,029[3]	824	160[3]	600[3]	850[4]	1,060[3]
Norway[2]	119	2,292	7	322	[3]	203	776	11,728[4]	34,425[4]
Poland	-	-	-	2	94	-	-	-	-
Sweden	-	-	-	-	-	-	2	-	-
UK (Engl. + Wales)	11	15	6	4	-	71	3	339	373
UK (Scotland)	-	-	-	-	3	998	531	487	5,749
USSR	-	-	-	-	489	-	-	-	-
Total	2,151	7,253	2,788	4,420	25,987	24,238	20,808	20,895	62,877

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
Belgium	10	13	-	+	74	57	51	28	-
Denmark	23,329	20,605	6,982	7,755	6,120	3,921	2,432	1,433	648
Estonia	-	-	-	293	-		17	-	-
Faroe Islands	-	942	340	-	360	275	-	-	296
France	248	220	174	162	302		-	-	-
Germany, Fed.Rep.	506	2,469[5]	5,995	2,801	1,570	1,014	1,600	7	7,603
Ireland	-	687	2,657	2,600	4,086	415	220	1,100	8,152
Netherlands	14,172	1,970	3,852	3,000	2,470	1,329	5,285	6,205	37,778
Norway	84,161	117,903	50,000	96,000	126,800	94,000	84,747	14,639	45,314
Poland	-	-	-	-	-	-	-	-	-
Sweden	-	102	953	800	697	2,087	-	95	232
UK (Engl. + Wales)	10	10	132	4	115	389	478	40	242
UK (N. Ireland)	-	-	350	-	-		-	-	-
UK (Scotland)	2,093	458	7,309	996	1,059	7,582	3,650	2,442	10,511
USSR / Russia (1992 -)	-	-	-						
Unallocated + discards	12,482[4]	-317[4]	-750[4]	-278[6]	-3,270	1,511	-28	136	-31,615
Total	112,047	145,062	77,904	114,133	140,383	112,580	98,452	26,125	79,161

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006[1]
Belgium	19	21	19	19	1,004	5	4	6	3
Denmark	2,048	8,006	4,409	2,288	1,393	3,774	8,735	4,258	1,343
Estonia	22	-	-						
Faroe Islands	28	908	24	-	699	809		35	
France	379	60	49	48	-	392	174	3,876	2,380
Germany	4,620	4,071	3,115	230	2,671	3,048	4,905	1,811	965
Ireland	-	404	103	375	72	93	379	753	2,077
Lithuania									2,354
Netherlands	3,811	3,610	3,382	4,685	6,612	17,354	21,418	24,679	20,984
Norway	13,129	44,344	1,246	7,948	35,368	20,493	10,709	24,937	27,200
Russia	-	-	2	-	-	-			
Sweden	3,411	1,957	1,141	119	575	1,074	665	239	491
UK (Engl. + Wales)	2	11	15	317	1,191	1,192	2,552	1,778	423
UK (Scotland)	3,041	1,658	3,465	3,161	255	1	1	22	
Unallocated+discards	737	-325	14613	649	-149	-14,009	-19,103	-21,830	314 -19,623
xTotal	31,247	64,725	31583	19,839	49,691	34,226	30,435	40,564	38,911

[1-]Preliminary. [2] Includes Division IIa. [3] Estimated from biological sampling. [4] Assumed to be misreported. [5] Includes 13 t from the German Democratic Republic. [6] Includes a negative unallocated catch of -4000 t.

Table 5.2.3 Horse mackerel general. Catches (t) in Subarea VI by country. (Data submitted by Working Group members).

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
Denmark	734	341	2,785	7	-	-	-	769	1,655
Faroe Islands	-	-	1,248	-	-	4,014	1,992	4,450[3]	4,000[3]
France	45	454	4	10	14	13	12	20	10
Germany, Fed. Rep.	5,550	10,212	2,113	4,146	130	191	354	174	615
Ireland	-	-	-	15,086	13,858	27,102	28,125	29,743	27,872
Netherlands	2,385	100	50	94	17,500	18,450	3,450	5,750	3,340
Norway	-	5	-	-	-		83	75	41
Spain	-	-	-	-	-		-[2]	-[2]	-[2]
UK (Engl. + Wales)	9	5	+	38	+	996	198	404	475
UK (N. Ireland)						-	-	-	-
UK (Scotland)	1	17	83	-	214	1,427	138	1,027	7,834
USSR	-	-	-		-	-	-	-	-
Unallocated + disc.						-19,168	-13,897	-7,255	-
Total	8,724	11,134	6,283	19,381	31,716	33,025	20,455	35,157	45,842

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
Denmark	973	615	-	42	-	294	106	114	780
Faroe Islands	3,059	628	255	-	820	80	-	-	-
France	2	17	4	3	+	-	-	-	52
Germany, Fed. Rep.	1,162	2,474	2,500	6,281	10,023	1,430	1,368	943	229
Ireland	19,493	15,911	24,766	32,994	44,802	65,564	120,124	87,872	22,474
Netherlands	1,907	660	3,369	2,150	590	341	2,326	572	498
Norway	-	-	-	-	-	-	-	-	-
Spain	-2	-2	1	3	-	-	-	-	-
UK (Engl. + Wales)	44	145	1,229	577	144	109	208	612	56
UK (N.Ireland)	-	-	1,970	273	-	-	-	-	767
UK (Scotland)	1,737	267	1,640	86	4,523	1,760	789	2,669	14,452
USSR/Russia (1992-	-	44	-	-	-	-	-	-	-
)	6,493	143	-1,278	-1,940	-6,960[4]	-51	-41,326	-11,523	837
Unallocated + disc.									
Total	34,870	20,904	34,456	40,469	53,942	69,527	83,595	81,259	40,145

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006[1]
Denmark	-	-	-	-	-	-	-	-	-
Faroe Islands	-	-	-	-	-	-	-	-	-
France	221	25,007	-	428	55	209	172	41	411
Germany	414	1,031	209	265	149	1,337	1,413	1,958	1,025
Ireland	21,608	31,736	15,843	20,162	12,341	20,915	15,702	12,395	9,780
Lithuania									2,822
Netherlands	885	1,139	687	600	450	847	3,701	6,039	1,892
Spain	-	-	-	-	-	-	-	-	-
UK (Engl.+Wales)	10	344	41	91	-	46	5	52	-
UK (N.Ireland)	1,132	-	-			453		210	82
UK (Scotland)	10,447	4,544	1,839	3,111	1,192		377	62	43
Unallocated+disc.	98	1,507	2,038	-21	3	-553	559	1,298	-304
Total	34,815	65,308	20,657	24,636	14,190	23,254	21,929	22,055	15,751

[1]Preliminary.

[2]Included in Subarea VII.

[3]Includes Divisions IIIa, IVa,b and VIb.

[4]Includes a negative unallocated catch of -7000 t.

Table 5.2.4 Horse mackerel general . Catches (t) in Subarea VII by country. (Data submitted by the Working Group members).

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
Belgium	-	1	1	-	-	+	+	2	-
Denmark	5,045	3,099	877	993	732	1,477[2]	30,408[2]	27,368	33,202
France	1,983	2,800	2,314	1,834	2,387	1,881	3,801	2,197	1,523
Germany, Fed.Rep.	2,289	1,079	12	1,977	228	-	5	374	4,705
Ireland	-	16	-	-	65	100	703	15	481
Netherlands	23,002	25,000	27,500[2]	34,350	38,700	33,550	40,750	69,400	43,560
Norway	394	-	-	-	-	-	-	-	-
Spain	50	234	104	142	560	275	137	148	150
UK (Engl. + Wales)	12,933	2,520	2,670	1,230	279	1,630	1,824	1,228	3,759
UK (Scotland)	1	-	-	-	1	1	+	2	2,873
USSR	-	-	-	-	-	120	-	-	-
Total	45,697	34,749	33,478	40,526	42,952	39,034	77,628	100,734	90,253

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
Faroe Islands	-	28	-	-	-	-	-	-	-
Belgium	-	+	-	-	-	1	-	-	18
Denmark	34,474	30,594	28,888	18,984	16,978	41,605	28,300	43,330	60,412
France	4,576	2,538	1,230	1,198	1,001	-	-	-	27,201
Germany, Fed.Rep.	7,743	8,109	12,919	12,951	15,684	14,828	17,436	15,949	28,549
Ireland	12,645	17,887	19,074	15,568	16,363	15,281	58,011	38,455	43,624
Netherlands	43,582	111,900	104,107	109,197	157,110	92,903	116,126	114,692	81,464
Norway	-	-	-	-	-	-	-	-	-
Spain	14	16	113	106	54	29	25	33	-
UK (Engl. + Wales)	4,488	13,371	6,436	7,870	6,090	12,418	31,641	28,605	17,464
UK (N.Ireland)	-	-	2,026	1,690	587	119	-	-	1,093
UK (Scotland)	+	139	1,992	5,008	3,123	9,015	10,522	11,241	7,931
USSR / Russia (1992-)	-	-	-	-	-	-	-	-	-
Unallocated + discards	28,368	7,614	24,541	15,563	4,0103	14,057	68,644	26,795	58,718
Total	135,890	192,196	201,326	188,135	221,000	200,256	330,705	279,100	326,474

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006[1]
Faroe Islands	-	-	550	-	-	-	-	3,660	1,201
Belgium	18	-	-	-	1	-	+	+	+
Denmark	25,492	19,223	13,946	20,574	10,094	10,867	11,529	9,939	6,838
France	24,223	-	20,401	11,049	6,466	7,199	8,083	8,469	7,928
Germany	25,414	15,247	9,692	8,320	10,812	13,873	16,352	10,437	7,139
Ireland	51,720	25,843	32,999	30,192	23,366	13,533	8,470	20,406	16,841
Lithuania									3,569
Netherlands	91,946	56,223	50,120	46,196	37,605	48.222	41,123	31,156	35,467
Spain	-	-	50	7	0	1	27	12	60
UK (Engl. + Wales)	12,832	8,885	2,972	8,901	5,525	4,186	7,178	4,752	2,935
UK (N.Ireland)	-	-	-	-	-			217	142
UK (Scotland)	5,095	4,994	5,152	1,757	1,461	268	1,146	59	413
Unallocated+discards	12,706	31,239	1,884	11,046	2,576	24,897	18,485	18,368	19,379
Total	249,446	161,654	137,766	138,042	97,906	123,046	112,393	107,475	101,912

[1]Provisional.

[2]Includes Subarea VI.

Table 5.2.5 Horse mackerel general. Catches (t) in Subarea VIII by country. (Data submitted by Working Group members).

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
Denmark	-	-	-	-	-	-	446	3,283	2,793
France	3,361	3,711	3.073	2,643	2,489	4,305	3,534	3,983	4,502
Netherlands	-	-	-	-	-[2]	-[2]	-[2]	-[2]	-
Spain	34,134	36,362	19,610	25,580	23,119	23,292	40,334	30,098	26,629
UK (Engl.+Wales)	-	+	1	-	1	143	392	339	253
USSR	-	-	-	-	20	-	656	-	-
Total	37,495	40,073	22,684	28,223	25,629	27,740	45,362	37,703	34,177

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
Denmark	6,729	5,726	1,349	5,778	1,955	-	340	140	729
France	4,719	5,082	6,164	6,220	4,010	28	-	7	8,690
Germany, Fed. Rep.	-	-	80	62	-		-	-	-
Netherlands	-	6,000	12,437	9,339	19,000	7,272	-	14,187	2,944
Spain	27,170	25,182	23,733	27,688	27,921	25,409	28,349	29,428	31,081
UK (Engl.+Wales)	68	6	70	88	123	753	20	924	430
USSR/Russia (1992-)	-	-	-	-	-	-	-	-	-
Unallocated+discards	-	1,500	2,563	5,011	700	2,038	-	3,583	-2,944
Total	38,686	43,496	46,396	54,186	53,709	35,500	28,709	48,269	40,930

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006[1]
Denmark	1,728	4,818	2,584	582	-	-		-	1,513
France	1,844	74	7	5,316	13,676	-	2,161	3,540	3,944
Germany	3,268	3,197	3,760	3,645	2,249	4,908	72	4,776	3,325
Ireland	-	-	6,485	1,483	704	504	1,882	1,808	158
Lithuania									401
Netherlands	6,604	22,479	11,768	36,106	12,538	1,314	1,047	6,607	6,073
Russia	-	-	-	-	-	6,620			-
Spain	23,599	24,190	24,154	23,531	22,110	24,598	16,245	16,624	13,874
UK (Engl. + Wales)	9	29	112	1,092	157	982	516	838	821
UK (Scotland)	-	-	249	-	-	-		-	-
Unallocated+discards	1,884	-8658	5,093	4,365	1,705	2,785	2,202	7,302	4,013
Total	38,936	46,129	54,212	76,120	54,560	41,711	24,125	41,495	34,122

[1]Preliminary.

[2]Included in Subarea VII.

Table 5.3.1.1 Western horse mackerel. The time series of egg production estimates(*10^{-12}) for the western horse mackerel.

Year	Egg Production
1983	513.1
1989	1762.1
1992	1712.1
1995	1264.5
1998	1135.7
2001	820.8
2004	889.0
2007	1434.0*

*provisional estimate

Table 5.3.2.1. Western horse mackerel. CPUE at age from Spanish bottom trawl survey carried out in Division VIIIc and Subdivision IXa North. Since 1997 a new sampling design (new stratification) has been applied.

	age																
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1984	24.2	326.7	237.8	3.6	19.1	17.9	9.7	39.8	3.9	16.3	0.1	0.8	0.4	3.2	1.0	2.6	706.9
1985	75.7	32.9	116.6	164.7	2.6	2.3	1.6	1.4	1.6	1.8	1.2	0.3	0.3	0.1	0.2	1.6	405.0
1986	129.5	27.8	6.7	3.0	16.1	1.8	1.9	4.1	1.5	2.3	3.2	0.9	0.4	0.2	0.3	1.1	200.8
1987																	0.0
1988	71.2	6.2	4.1	2.6	1.6	2.6	19.8	1.8	2.6	3.4	2.5	1.3	3.8	0.9	1.3	9.2	134.9
1989*	100.3	5.7	1.8	17.9	4.2	13.2	12.0	41.5	5.3	6.8	15.7	0.3	0.2	2.0	0.2	2.2	229.2
1990	6.1	9.7	1.4	1.3	7.4	2.7	3.5	2.8	32.5	1.3	1.9	0.4	0.3	0.2	0.2	0.5	72.2
1991	23.6	7.1	2.5	0.1	0.7	0.7	0.3	0.2	0.7	8.7	1.3	0.9	0.6	0.4	0.8	0.6	49.1
1992	85.5	44.8	0.7	1.1	0.4	2.1	4.5	4.4	5.7	5.1	47.6	5.1	1.6	0.6	0.2	3.6	212.8
1993	138.6	31.9	3.5	0.6	2.2	4.6	13.8	17.1	4.5	4.4	3.9	22.1	0.2	0.0	0.2	0.3	247.8
1994	937.8	64.9	20.9	1.3	1.5	2.5	4.9	9.6	11.6	2.5	1.5	0.9	4.5	0.4	0.2	0.4	1065.4
1995	38.3	172.6	12.5	6.9	5.8	3.9	6.3	9.7	14.5	11.9	3.5	1.9	0.3	8.6	0.1	0.1	296.8
1996	43.3	47.2	26.8	19.6	35.0	19.1	6.6	11.0	2.7	21.9	7.0	1.1	1.7	0.0	3.7	0.1	246.8
1997	6.7	11.1	4.8	8.7	7.6	6.3	3.9	4.1	12.5	4.1	10.7	8.1	0.5	0.3	0.1	2.7	91.9
1998	22.7	7.4	20.5	26.3	54.2	28.3	19.4	11.1	4.6	2.6	0.9	2.1	2.2	0.5	0.3	2.5	205.4
1999	2.4	33.3	12.2	3.4	18.1	16.3	10.0	13.7	12.3	9.1	4.6	1.1	1.3	0.1	0.1	0.1	137.8
2000	46.0	4.2	2.9	8.5	18.4	28.6	47.1	20.5	6.9	7.5	1.4	0.5	0.9	0.9	4.3	1.1	199.8
2001	6.9	4.5	19.3	10.5	6.0	3.7	1.3	27.9	17.3	3.5	5.7	3.4	0.5	0.6	0.2	0.5	111.7
2002	1.2	2.4	2.9	2.7	6.4	3.1	4.4	9.7	12.8	8.1	4.3	2.4	0.7	1.1	1.7	0.2	64.0
2003	38.8	20.1	68.0	9.1	7.7	5.5	8.2	7.7	8.4	16.5	7.2	2.9	1.3	0.1	0.2	1.8	203.3
2004	59.1	11.4	3.2	11.2	3.5	3.6	2.9	1.4	3.3	2.7	1.9	0.0	0.6	0.1	0.2	0.9	106.0
2005	724.7	78.2	20.0	8.4	31.0	1.6	3.2	3.0	4.6	5.9	1.2	3.6	5.8	1.2	0.6	0.2	893.2
2006	15.6	47.6	38.2	10.2	5.3	7.5	7.9	4.9	2.5	1.4	1.2	3.1	5.9	3.8	1.0	2.7	158.8

Table 5.3.3.1 Western horse mackerel. Length distribution of horse mackerel (1000s) from the French PELGAS pelagic survey (spring).

length (cm)	year 2000	2001	2002	2003	2004	2005	2006	2007
8	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.2
9	1.3	0.0	5.2	0.0	1.2	100.1	0.0	0.6
10	30.7	0.0	44.0	0.0	311.8	455.2	0.1	5.0
11	419.6	3.4	263.8	0.0	1330.5	375.7	0.5	21.0
12	949.5	21.0	1055.6	0.5	1350.8	103.6	3.9	19.3
13	444.1	93.7	2082.2	65.4	977.5	17.0	5.7	13.6
14	115.2	122.0	1044.1	30.7	567.7	2.8	16.0	26.4
15	91.6	100.6	423.9	60.8	209.1	12.4	16.3	12.9
16	114.1	19.9	30.7	631.3	21.4	52.0	7.7	45.5
17	163.1	179.7	24.9	1054.3	47.6	92.9	140.2	91.0
18	127.9	381.1	21.3	898.3	146.3	121.4	105.5	72.4
19	71.1	378.7	7.1	400.6	596.6	130.2	171.7	63.0
20	59.8	173.6	78.5	195.0	519.8	125.1	683.7	83.4
21	79.1	132.2	267.6	57.4	100.5	389.0	462.0	75.3
22	98.4	95.6	277.7	22.5	26.8	494.0	119.5	30.1
23	218.4	41.9	135.7	12.6	13.9	164.0	123.4	19.8
24	439.9	52.2	62.7	21.5	8.4	59.5	51.3	8.2
25	331.3	47.0	45.9	33.4	15.0	14.3	12.4	9.1
26	117.3	36.1	39.4	43.1	12.6	30.0	7.1	12.5
27	41.2	11.7	22.5	37.4	5.1	34.6	6.1	9.0
28	24.3	7.2	12.6	23.5	8.3	16.0	4.9	7.6
29	16.2	7.3	13.5	12.1	2.4	11.7	4.8	4.7
30	5.1	8.0	4.7	10.1	4.6	7.0	2.2	4.1
31	6.0	8.9	2.3	5.9	2.5	4.3	1.7	2.3
32	4.2	0.1	2.5	2.1	0.7	2.3	0.3	1.6
33	2.4	3.4	1.7	1.4	0.4	3.0	0.6	1.2
34	0.8	3.4	1.1	1.5	0.0	2.8	0.2	0.4
35	4.3	0.0	1.0	0.2	0.1	1.9	0.2	0.0
36	0.2	0.7	0.8	0.3	0.1	1.8	0.0	0.2
37	0.0	0.0	0.1	0.3	0.0	1.3	0.0	0.2
38	1.2	0.0	0.0	0.3	0.0	0.7	0.0	0.0
39	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
40	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.5.1.1 Western horse mackerel. Landing numbers-at-age (1000) by quarter and area in 2006.

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	4555	10	291	6409	0	0	0	0	0	0	0	0	0	0	11264
2	0	0	0	6694	4	498	1968	0	0	0	0	0	0	0	0	0	0	9164
3	0	0	1992	2125	3	300	1453	89	0	0	0	0	0	1	49	54	35	6101
4	9	0	1992	475	1	114	299	200	0	278	0	1	0	30	4662	977	691	9727
5	67	0	42010	219	1	460	510	1068	0	12752	317	2	0	220	24884	12278	5142	99928
6	5	0	1992	2	1	590	222	156	0	2772	317	0	0	37	3999	2041	681	12815
7	11	0	0	2	1	626	164	22	0	3060	422	0	0	37	3789	2433	1170	11738
8	7	0	0	3	1	824	252	22	0	1698	633	1	0	32	4831	1253	1107	10664
9	1	0	0	4	1	651	153	22	0	583	106	0	0	10	1122	607	169	3428
10	0	0	0	3	1	559	139	22	0	240	0	0	0	12	2329	359	0	3663
11	0	0	0	3	1	807	257	0	0	399	0	1	0	32	6131	577	0	8208
12	1	0	1992	2	2	901	513	22	0	637	0	2	0	48	9351	1117	96	14685
13	1	0	0	2	1	250	142	22	0	810	106	1	0	17	2992	648	169	5158
14	1	0	0	1	0	104	81	22	0	280	106	0	0	10	1663	509	169	2946
15+	5	0	0	1	0	100	117	0	0	439	528	1	0	27	4701	991	843	7752

Q2

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	1477	0	2570	7553	0	0	0	0	0	0	0	0	0	0	11600
2	0	0	116	5324	0	451	3191	0	0	0	0	2	0	0	0	0	0	9085
3	0	0	116	406	0	606	1206	119	0	0	6	4	0	0	0	1517	0	3979
4	0	0	116	520	0	440	1116	269	0	0	128	5	0	0	0	0	0	2592
5	0	0	4628	680	0	1207	2124	1433	0	0	931	15	0	3	0	3539	1	14559
6	0	0	231	470	0	1056	966	209	0	0	75	1	0	1	0	1517	0	4526
7	0	0	116	359	0	888	708	30	0	0	150	0	0	1	0	0	0	2251
8	0	0	116	390	0	977	866	30	0	0	103	0	0	0	0	1011	0	3494
9	0	0	0	374	0	738	573	30	0	0	14	0	0	0	0	505	0	2234
10	0	0	116	200	0	636	505	30	0	0	0	0	0	0	0	0	0	1486
11	0	0	0	216	0	903	818	0	0	0	0	0	0	0	0	0	0	1938
12	0	0	116	101	0	961	1287	30	0	0	17	0	0	1	0	2528	0	5041
13	0	0	0	96	0	276	349	30	0	0	14	0	0	0	0	505	0	1272
14	0	0	0	17	0	111	175	30	0	0	14	0	0	0	0	0	0	347
15+	0	0	0	105	0	125	212	0	0	0	72	0	0	0	0	1517	0	2031

Q3

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0	0	0	0	0	1419	459	0	0	0	0	0	0	0	0	0	0	1877
1	0	0	0	1606	0	7437	11751	0	0	0	0	0	0	0	0	0	0	20793
2	0	0	0	205	0	1821	3223	0	0	0	0	6808	0	0	0	0	0	12057
3	0	1	0	8	0	585	659	0	2	54	22	12053	0	0	0	0	90	13474
4	0	1	0	2	0	608	523	0	17	1191	200	13403	0	0	0	5	804	16754
5	1	15	0	5	0	1213	830	0	129	2381	1507	43491	0	1	0	27	6074	55675
6	0	5	0	6	0	1541	991	0	2	1191	25	4355	0	0	0	4	102	8223
7	1	39	0	2	0	1037	566	0	1	325	13	399	0	0	0	7	52	2441
8	2	60	0	3	0	1159	531	0	0	704	3	0	0	0	0	6	14	2482
9	1	23	0	2	0	646	502	0	0	271	3	0	0	0	0	4	14	1466
10	0	13	0	1	0	675	495	0	0	271	0	0	0	0	0	3	0	1458
11	1	16	0	2	0	624	507	0	0	162	0	0	0	0	0	1	0	1313
12	1	32	0	2	0	841	841	0	0	54	0	0	0	0	0	1	0	1772
13	0	6	0	1	0	579	554	0	0	54	0	0	0	0	0	0	0	1195
14	0	8	0	1	0	173	205	0	0	54	0	0	0	0	0	0	0	441
15+	2	49	0	1	0	164	388	0	0	54	0	0	0	0	0	0	0	658

Q4

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0	0	0	0	0	11	13	0	0	0	0	0	0	0	0	0	0	24
1	0	0	0	1767	3	336	2060	0	0	0	0	1574	0	0	0	0	0	5739
2	0	0	957	401	4	390	4135	0	0	0	0	3174	0	0	0	0	71	9132
3	0	251	5602	237	2	207	2360	151	0	477	16	5437	0	0	2165	742	383	18031
4	0	314	8308	118	1	168	1128	76	0	4334	130	6779	2	0	15157	5196	3074	44787
5	1	3685	47113	154	2	274	1095	1438	0	56545	778	38711	10	0	90940	31176	59086	331006
6	0	1185	8159	152	2	341	1224	227	0	13596	164	533	0	0	0	0	6151	31734
7	2	9444	759	54	1	235	541	0	0	6919	96	997	0	0	0	0	3946	22995
8	3	14589	1804	60	1	291	497	0	0	7098	102	194	0	0	0	0	2389	27028
9	1	5534	0	45	1	190	331	0	0	3127	40	48	0	0	0	0	701	10019
10	1	3145	0	22	1	204	343	0	0	1557	22	28	0	0	0	0	343	5666
11	1	3766	0	46	1	183	301	0	0	2666	39	30	0	0	0	0	765	7798
12	1	7777	0	32	1	255	548	0	0	3728	55	0	0	0	0	0	1126	13524
13	0	1541	0	15	1	195	514	0	0	2736	28	56	0	0	0	0	722	5808
14	0	1917	0	8	0	71	201	0	0	1917	28	25	0	0	0	0	261	4429
15+	2	11890	0	12	1	123	539	0	0	3088	26	3	0	0	0	0	329	16014

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Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0	0	0	0	0	1430	471	0	0	0	0	0	0	0	0	0	0	1901
1	0	0	0	9404	13	10634	27772	0	0	0	0	1574	0	0	0	0	0	49396
2	0	0	1073	12624	8	3160	12518	0	0	0	0	9985	0	0	0	0	71	39439
3	1	252	7709	2776	5	1697	5679	360	2	531	45	17494	0	1	2214	2313	507	41585
4	9	315	10416	1115	2	1330	3066	545	17	5803	458	20187	2	30	19818	6177	4570	73860
5	68	3701	93750	1057	3	3154	4559	3939	129	71678	3533	82219	10	223	115824	47019	70303	501168
6	6	1190	10383	630	3	3528	3403	592	2	17559	581	4890	0	37	3999	3561	6934	57299
7	14	9483	875	417	2	2786	1979	52	1	10304	681	1396	0	38	3789	2440	5168	39424
8	12	14649	1919	456	3	3252	2146	52	0	9500	842	195	0	32	4831	2269	3509	43667
9	3	5556	0	426	2	2225	1559	52	0	3980	164	48	0	10	1122	1117	884	17148
10	1	3158	116	225	2	2074	1482	52	0	2068	22	29	0	12	2329	361	343	12274
11	1	3782	0	268	2	2517	1881	0	0	3228	39	32	0	32	6131	578	765	19256
12	4	7809	2108	137	3	2958	3190	52	0	4419	73	2	0	49	9351	3646	1222	35022
13	2	1548	0	114	1	1299	1560	52	0	3600	148	56	0	17	2992	1154	890	13433
14	2	1925	0	26	1	459	663	52	0	2251	148	25	0	10	1663	509	430	8164
15+	9	11939	0	119	1	512	1255	0	0	3582	625	4	0	28	4701	2507	1172	26454

Table 5.5.1.2: Western horse mackerel: catch numbers at age used in the exploratory assessments

	Age											
Year	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0	3713	21072	134743	11515	13197	11741	8848	1651	414	1651	81385
1983	0	7903	2269	32900	53508	15345	44539	52673	17923	3291	5505	129139
1984	0	0	241360	4439	36294	149798	22350	38244	34020	14756	4101	58370
1985	0	1633	4901	602992	4463	41822	100376	12644	16172	6200	9224	40976
1986	0	0	0	1548	676208	8727	65147	109747	25712	21179	15271	56824
1987	0	99	493	0	2950	891660	2061	41564	90814	11740	9549	62776
1988	876	27369	6112	2099	4402	18968	941725	12115	39913	67869	9739	76096
1989	0	0	0	20766	18282	5308	14500	1276731	12046	59357	83125	78951
1990	0	20406	45036	138929	61442	33298	10549	20607	1384850	37011	70512	226294
1991	20632	33560	89715	23034	207751	143072	73730	25369	25584	1219646	23987	137131
1992	14887	229703	36331	80552	56275	256085	127048	49020	19053	23449	1103480	152305
1993	46	109152	94500	16738	62714	94711	317337	144610	70717	32693	4822	1309609
1994	3686	60759	911713	115729	53132	44692	38769	221970	106512	40799	42302	998180
1995	2702	165382	470498	424563	215468	59035	90832	35654	245230	119117	99495	1362342
1996	10729	19774	658727	860992	186306	85508	51365	55229	53379	57131	56962	729283
1997	4860	110145	465350	735919	410638	244328	119062	127658	134488	109962	109165	601196
1998	744	91505	184443	488662	360116	219650	157396	122583	81499	68264	50555	389594
1999	14822	97561	83714	176919	265820	254516	212225	187250	147328	77691	35635	252044
2000	637	78856	131112	52716	71779	150869	170393	177995	133290	61578	18010	168770
2001	58685	69430	246525	151707	98454	101344	116952	234832	203823	103968	36076	132706
2002	13707	461055	120106	164977	126329	64449	69828	94429	130285	85325	45798	150103
2003	1843	303721	585700	165666	152117	88944	57445	45596	49476	92758	50503	109994
2004	21246	140299	110976	474273	76136	103011	69844	43981	31618	49188	56109	63823
2005	1260	71508	170936	310085	531221	68559	74392	61641	43454	22304	27127	99898
2006	1901	49396	39439	41585	73860	501168	57299	39424	43667	17148	12274	102329

Table 5.5.2.1 Western horse mackerel. Mean landings weight-at-age (kg) by quarter and area in 2006.

Q1

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.000	0.000	0.000	0.024	0.037	0.048	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.025
2	0.000	0.000	0.000	0.036	0.062	0.062	0.061	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.043
3	0.122	0.000	0.100	0.067	0.092	0.092	0.091	0.095	0.000	0.000	0.000	0.000	0.093	0.093	0.093	0.093	0.122	0.086
4	0.112	0.000	0.880	0.091	0.131	0.145	0.116	0.105	0.000	0.122	0.000	0.097	0.102	0.102	0.100	0.102	0.114	0.262
5	0.131	0.000	0.100	0.097	0.153	0.171	0.134	0.112	0.000	0.133	0.138	0.117	0.119	0.119	0.119	0.120	0.129	0.114
6	0.180	0.000	0.930	0.193	0.169	0.176	0.162	0.103	0.000	0.155	0.187	0.135	0.136	0.136	0.136	0.137	0.182	0.269
7	0.196	0.000	0.000	0.183	0.187	0.185	0.190	0.248	0.000	0.167	0.207	0.145	0.153	0.153	0.152	0.157	0.197	0.166
8	0.209	0.000	0.000	0.188	0.223	0.200	0.246	0.196	0.000	0.177	0.216	0.139	0.158	0.158	0.150	0.170	0.214	0.173
9	0.215	0.000	0.000	0.205	0.220	0.199	0.242	0.249	0.000	0.174	0.215	0.159	0.183	0.183	0.177	0.185	0.215	0.189
10	0.000	0.000	0.000	0.203	0.221	0.200	0.243	0.140	0.000	0.195	0.000	0.156	0.176	0.176	0.165	0.196	0.000	0.178
11	0.000	0.000	0.000	0.202	0.228	0.205	0.252	0.000	0.000	0.200	0.000	0.164	0.181	0.181	0.172	0.190	0.000	0.180
12	0.201	0.000	0.127	0.206	0.244	0.226	0.262	0.088	0.000	0.206	0.000	0.185	0.200	0.200	0.192	0.205	0.201	0.189
13	0.278	0.000	0.000	0.212	0.244	0.220	0.269	0.162	0.000	0.194	0.278	0.165	0.185	0.185	0.175	0.204	0.278	0.192
14	0.250	0.000	0.000	0.206	0.265	0.241	0.288	0.150	0.000	0.240	0.250	0.164	0.173	0.173	0.169	0.181	0.250	0.191
15+	0.395	0.000	0.000	0.239	0.282	0.252	0.312	0.000	0.000	0.244	0.395	0.191	0.215	0.215	0.203	0.255	0.395	0.249

Q2

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.000	0.000	0.000	0.022	0.000	0.033	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.036
2	0.000	0.000	0.068	0.039	0.000	0.056	0.050	0.000	0.000	0.000	0.000	0.084	0.000	0.000	0.000	0.000	0.000	0.044
3	0.000	0.000	0.103	0.055	0.000	0.103	0.103	0.095	0.000	0.000	0.122	0.113	0.000	0.093	0.000	0.098	0.122	0.096
4	0.000	0.000	0.085	0.136	0.000	0.129	0.120	0.105	0.000	0.000	0.112	0.119	0.000	0.102	0.000	0.000	0.112	0.121
5	0.000	0.000	0.096	0.137	0.000	0.148	0.135	0.112	0.000	0.000	0.131	0.127	0.000	0.119	0.000	0.104	0.131	0.114
6	0.000	0.000	0.120	0.144	0.000	0.163	0.157	0.103	0.000	0.000	0.180	0.139	0.000	0.136	0.000	0.191	0.180	0.165
7	0.000	0.000	0.134	0.171	0.000	0.175	0.174	0.248	0.000	0.000	0.196	0.171	0.000	0.153	0.000	0.000	0.196	0.174
8	0.000	0.000	0.151	0.195	0.000	0.197	0.215	0.196	0.000	0.000	0.209	0.000	0.000	0.158	0.000	0.154	0.209	0.188
9	0.000	0.000	0.000	0.172	0.000	0.197	0.216	0.249	0.000	0.000	0.215	0.000	0.000	0.183	0.000	0.235	0.215	0.207
10	0.000	0.000	0.120	0.171	0.000	0.199	0.217	0.140	0.000	0.000	0.000	0.000	0.000	0.176	0.000	0.000	0.000	0.194
11	0.000	0.000	0.000	0.250	0.000	0.203	0.225	0.000	0.000	0.000	0.000	0.000	0.000	0.181	0.000	0.000	0.000	0.217
12	0.000	0.000	0.107	0.269	0.000	0.226	0.246	0.088	0.000	0.000	0.201	0.000	0.000	0.200	0.000	0.211	0.201	0.221
13	0.000	0.000	0.000	0.305	0.000	0.224	0.247	0.162	0.000	0.000	0.278	0.000	0.000	0.185	0.000	0.239	0.278	0.242
14	0.000	0.000	0.000	0.205	0.000	0.254	0.261	0.150	0.000	0.000	0.250	0.000	0.000	0.173	0.000	0.000	0.250	0.246
15+	0.000	0.000	0.000	0.385	0.000	0.278	0.282	0.000	0.000	0.000	0.395	0.000	0.000	0.215	0.000	0.275	0.395	0.286

Q3

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0.000	0.000	0.000	0.000	0.000	0.033	0.046	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.036
1	0.000	0.000	0.000	0.032	0.000	0.043	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.046
2	0.000	0.000	0.000	0.044	0.000	0.064	0.059	0.000	0.000	0.000	0.000	0.084	0.000	0.000	0.000	0.000	0.000	0.074
3	0.178	0.178	0.000	0.080	0.000	0.100	0.098	0.000	0.132	0.138	0.132	0.113	0.000	0.134	0.000	0.134	0.132	0.112
4	0.227	0.227	0.000	0.128	0.000	0.134	0.124	0.000	0.137	0.125	0.137	0.119	0.000	0.127	0.000	0.121	0.137	0.121
5	0.320	0.320	0.000	0.137	0.000	0.146	0.136	0.000	0.141	0.140	0.141	0.127	0.000	0.133	0.000	0.135	0.141	0.130
6	0.301	0.301	0.000	0.142	0.000	0.155	0.144	0.000	0.155	0.154	0.155	0.139	0.000	0.000	0.000	0.179	0.155	0.145
7	0.356	0.356	0.000	0.147	0.000	0.172	0.174	0.000	0.166	0.172	0.166	0.171	0.000	0.000	0.000	0.178	0.166	0.175
8	0.379	0.379	0.000	0.161	0.000	0.190	0.193	0.000	0.182	0.182	0.182	0.000	0.000	0.000	0.000	0.183	0.182	0.193
9	0.450	0.450	0.000	0.157	0.000	0.202	0.237	0.000	0.182	0.203	0.182	0.000	0.000	0.000	0.000	0.191	0.182	0.218
10	0.457	0.457	0.000	0.162	0.000	0.204	0.242	0.000	0.000	0.185	0.000	0.000	0.000	0.000	0.000	0.205	0.000	0.216
11	0.431	0.431	0.000	0.168	0.000	0.205	0.243	0.000	0.000	0.194	0.000	0.000	0.000	0.000	0.000	0.170	0.000	0.221
12	0.441	0.441	0.000	0.220	0.000	0.202	0.258	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.000	0.222	0.000	0.233
13	0.524	0.524	0.000	0.324	0.000	0.206	0.265	0.000	0.000	0.220	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.236
14	0.544	0.544	0.000	0.332	0.000	0.219	0.280	0.000	0.000	0.208	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.252
15+	0.477	0.477	0.000	0.398	0.000	0.248	0.314	0.000	0.000	0.180	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.299

Q4

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0.000	0.000	0.000	0.000	0.043	0.035	0.052	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.044
1	0.000	0.000	0.000	0.029	0.066	0.062	0.070	0.000	0.000	0.000	0.000	0.066	0.000	0.000	0.000	0.000	0.000	0.056
2	0.000	0.000	0.123	0.059	0.079	0.077	0.082	0.000	0.000	0.000	0.000	0.091	0.000	0.000	0.000	0.000	0.188	0.089
3	0.178	0.178	0.126	0.092	0.096	0.099	0.093	0.117	0.000	0.134	0.134	0.120	0.134	0.000	0.134	0.134	0.134	0.121
4	0.227	0.227	0.125	0.109	0.117	0.126	0.108	0.153	0.000	0.129	0.128	0.128	0.127	0.000	0.127	0.127	0.147	0.129
5	0.320	0.320	0.130	0.129	0.135	0.143	0.128	0.127	0.000	0.152	0.147	0.129	0.133	0.000	0.133	0.133	0.155	0.141
6	0.301	0.301	0.138	0.135	0.143	0.151	0.135	0.137	0.000	0.177	0.165	0.167	0.000	0.000	0.000	0.000	0.180	0.169
7	0.356	0.356	0.144	0.142	0.171	0.178	0.165	0.000	0.000	0.196	0.183	0.180	0.000	0.000	0.000	0.000	0.187	0.256
8	0.379	0.379	0.182	0.160	0.193	0.196	0.189	0.000	0.000	0.209	0.196	0.212	0.000	0.000	0.000	0.000	0.203	0.298
9	0.450	0.450	0.000	0.156	0.217	0.217	0.217	0.000	0.000	0.229	0.202	0.217	0.000	0.000	0.000	0.000	0.203	0.348
10	0.457	0.457	0.000	0.160	0.220	0.218	0.222	0.000	0.000	0.227	0.213	0.228	0.000	0.000	0.000	0.000	0.241	0.354
11	0.431	0.431	0.000	0.166	0.226	0.222	0.231	0.000	0.000	0.231	0.206	0.204	0.000	0.000	0.000	0.000	0.208	0.324
12	0.441	0.441	0.000	0.204	0.250	0.235	0.265	0.000	0.000	0.253	0.230	0.000	0.000	0.000	0.000	0.000	0.213	0.358
13	0.524	0.524	0.000	0.296	0.278	0.250	0.307	0.000	0.000	0.269	0.233	0.227	0.000	0.000	0.000	0.000	0.210	0.331
14	0.544	0.544	0.000	0.303	0.300	0.269	0.332	0.000	0.000	0.260	0.226	0.254	0.000	0.000	0.000	0.000	0.260	0.386
15+	0.477	0.477	0.000	0.395	0.378	0.345	0.410	0.000	0.000	0.315	0.300	0.282	0.000	0.000	0.000	0.000	0.310	0.439

Q1-4

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0.000	0.000	0.000	0.000	0.043	0.033	0.046	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.036
1	0.000	0.000	0.000	0.026	0.042	0.041	0.043	0.000	0.000	0.000	0.000	0.066	0.000	0.000	0.000	0.000	0.000	0.040
2	0.000	0.000	0.117	0.038	0.071	0.064	0.065	0.000	0.000	0.000	0.000	0.086	0.000	0.000	0.000	0.000	0.188	0.063
3	0.131	0.178	0.119	0.067	0.094	0.100	0.095	0.104	0.132	0.134	0.131	0.115	0.134	0.094	0.133	0.109	0.133	0.111
4	0.113	0.227	0.269	0.114	0.121	0.132	0.116	0.112	0.137	0.128	0.128	0.122	0.126	0.102	0.121	0.123	0.140	0.144
5	0.134	0.320	0.115	0.128	0.143	0.150	0.133	0.118	0.141	0.148	0.139	0.128	0.133	0.119	0.130	0.127	0.152	0.134
6	0.189	0.301	0.289	0.142	0.152	0.161	0.146	0.116	0.155	0.172	0.178	0.142	0.136	0.136	0.136	0.160	0.180	0.188
7	0.232	0.356	0.143	0.168	0.179	0.176	0.173	0.248	0.166	0.186	0.201	0.177	0.153	0.153	0.152	0.157	0.189	0.220
8	0.276	0.379	0.180	0.191	0.209	0.195	0.207	0.196	0.182	0.201	0.213	0.212	0.158	0.158	0.150	0.163	0.206	0.253
9	0.365	0.450	0.000	0.170	0.219	0.201	0.226	0.249	0.182	0.219	0.211	0.217	0.183	0.183	0.177	0.208	0.205	0.286
10	0.457	0.457	0.120	0.170	0.221	0.203	0.229	0.140	0.000	0.218	0.213	0.227	0.176	0.176	0.165	0.196	0.241	0.266
11	0.431	0.431	0.000	0.234	0.228	0.205	0.234	0.000	0.000	0.225	0.206	0.203	0.181	0.181	0.172	0.190	0.208	0.245
12	0.364	0.441	0.126	0.252	0.246	0.220	0.255	0.088	0.000	0.246	0.223	0.185	0.200	0.200	0.192	0.209	0.212	0.261
13	0.360	0.524	0.000	0.303	0.266	0.219	0.275	0.162	0.000	0.251	0.269	0.226	0.185	0.185	0.175	0.220	0.223	0.261
14	0.362	0.544	0.000	0.238	0.285	0.240	0.292	0.150	0.000	0.256	0.245	0.253	0.173	0.173	0.169	0.181	0.256	0.302
15+	0.431	0.477	0.000	0.385	0.350	0.279	0.350	0.000	0.000	0.304	0.391	0.265	0.215	0.215	0.203	0.267	0.371	0.368

Table 5.5.2.2 Western horse mackerel. Mean landings lengths-at-age (cm) by quarter and area in 2006.

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	14.7	15.8	17.8	13.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3
2	0.0	0.0	0.0	16.8	19.4	19.4	19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5
3	26.0	0.0	23.5	20.7	22.3	22.3	22.3	22.5	0.0	0.0	0.0	0.0	23.5	23.5	23.5	23.5	26.0	22.2
4	25.1	0.0	23.5	23.1	25.2	26.1	24.3	24.4	0.0	25.2	0.0	24.0	24.5	24.5	24.3	24.6	25.3	24.2
5	26.1	0.0	23.7	23.6	26.5	27.7	25.3	24.3	0.0	26.1	26.2	25.2	25.5	25.5	25.4	25.5	26.1	24.8
6	28.9	0.0	23.5	29.8	27.6	28.0	27.1	24.6	0.0	27.6	28.8	26.8	26.7	26.7	26.7	26.7	28.8	26.6
7	29.5	0.0	0.0	29.3	28.5	28.5	28.6	29.5	0.0	28.3	29.3	26.5	27.4	27.4	27.3	27.8	29.3	28.0
8	30.0	0.0	0.0	29.6	30.3	29.3	31.3	28.5	0.0	28.8	29.5	26.9	27.8	27.8	27.4	28.3	29.6	28.3
9	30.5	0.0	0.0	30.4	30.2	29.2	31.2	29.5	0.0	28.8	30.5	28.5	29.3	29.3	29.1	29.3	30.5	29.3
10	0.0	0.0	0.0	30.3	30.2	29.3	31.2	27.5	0.0	29.7	0.0	27.9	28.8	28.8	28.3	29.8	0.0	28.8
11	0.0	0.0	0.0	30.3	30.6	29.5	31.7	0.0	0.0	30.1	0.0	28.0	29.0	29.0	28.4	29.5	0.0	28.8
12	30.5	0.0	25.5	30.5	31.4	30.6	32.2	22.5	0.0	30.2	0.0	29.5	29.9	29.9	29.7	29.9	30.5	29.3
13	33.5	0.0	0.0	30.8	31.4	30.2	32.5	27.5	0.0	29.4	33.5	29.0	29.6	29.6	29.3	30.1	33.5	29.8
14	32.5	0.0	0.0	30.5	32.2	31.2	33.2	26.5	0.0	32.1	32.5	28.8	28.9	28.9	28.9	29.0	32.5	29.7
15	36.1	0.0	0.0	32.1	32.9	31.7	34.1	0.0	0.0	32.3	36.1	30.3	30.6	30.6	30.5	32.0	36.1	31.8

Q2

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	14.3	0.0	15.5	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.1
2	0.0	0.0	21.5	17.4	0.0	18.7	18.0	0.0	0.0	0.0	0.0	20.8	0.0	0.0	0.0	0.0	0.0	17.7
3	0.0	0.0	24.5	19.4	0.0	23.2	23.2	22.5	0.0	0.0	26.0	22.9	0.0	23.5	0.0	22.2	26.0	22.4
4	0.0	0.0	23.5	26.5	0.0	25.1	24.6	24.4	0.0	0.0	25.1	23.8	0.0	24.5	0.0	0.0	25.1	25.0
5	0.0	0.0	23.8	26.6	0.0	26.3	25.5	24.3	0.0	0.0	26.1	24.3	0.0	25.5	0.0	23.4	26.1	24.5
6	0.0	0.0	25.5	27.0	0.0	27.3	26.9	24.6	0.0	0.0	28.9	24.9	0.0	26.7	0.0	27.5	28.9	27.1
7	0.0	0.0	25.5	28.5	0.0	27.9	27.8	29.5	0.0	0.0	29.5	27.5	0.0	27.4	0.0	0.0	29.5	28.0
8	0.0	0.0	27.5	29.5	0.0	29.1	29.9	28.5	0.0	0.0	30.0	0.0	0.0	27.8	0.0	26.0	30.0	28.4
9	0.0	0.0	0.0	28.5	0.0	29.1	30.0	29.5	0.0	0.0	30.5	0.0	0.0	29.3	0.0	29.5	30.5	29.3
10	0.0	0.0	26.5	28.5	0.0	29.2	30.4	27.5	0.0	0.0	0.0	0.0	0.0	28.8	0.0	0.0	0.0	29.3
11	0.0	0.0	0.0	32.1	0.0	29.4	30.5	0.0	0.0	0.0	0.0	0.0	0.0	29.0	0.0	0.0	0.0	30.2
12	0.0	0.0	25.5	33.1	0.0	30.5	31.5	22.5	0.0	0.0	30.5	0.0	0.0	29.9	0.0	28.9	30.5	29.8
13	0.0	0.0	0.0	34.4	0.0	30.4	31.5	27.5	0.0	0.0	33.5	0.0	0.0	29.6	0.0	29.5	33.5	30.6
14	0.0	0.0	0.0	30.5	0.0	31.8	32.1	26.5	0.0	0.0	32.5	0.0	0.0	28.9	0.0	0.0	32.5	31.5
15	0.0	0.0	0.0	37.7	0.0	32.8	33.0	0.0	0.0	0.0	36.1	0.0	0.0	30.6	0.0	31.5	36.1	32.2

Q3

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0.0	0.0	0.0	0.0	0.0	15.5	17.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0
1	0.0	0.0	0.0	16.2	0.0	17.0	18.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.6
2	0.0	0.0	0.0	18.0	0.0	19.4	19.1	0.0	0.0	0.0	0.0	20.8	0.0	0.0	0.0	0.0	0.0	20.1
3	27.0	27.0	0.0	21.8	0.0	22.9	22.7	0.0	25.2	25.5	25.2	22.9	0.0	24.5	0.0	24.5	25.2	22.9
4	28.7	28.7	0.0	25.9	0.0	25.4	24.8	0.0	25.5	24.7	25.5	23.8	0.0	24.4	0.0	24.4	25.5	24.0
5	31.5	31.5	0.0	26.6	0.0	26.2	25.6	0.0	25.8	25.8	25.8	24.3	0.0	25.2	0.0	25.4	25.8	24.6
6	31.2	31.2	0.0	26.9	0.0	26.8	26.1	0.0	26.8	26.9	26.8	24.9	0.0	0.0	0.0	27.8	26.8	25.7
7	33.1	33.1	0.0	27.2	0.0	27.8	27.8	0.0	27.5	28.0	27.5	27.5	0.0	0.0	0.0	28.1	27.5	27.9
8	33.5	33.5	0.0	28.1	0.0	28.8	28.9	0.0	28.5	28.5	28.5	0.0	0.0	0.0	0.0	28.3	28.5	28.9
9	35.1	35.1	0.0	27.8	0.0	29.3	31.0	0.0	28.5	29.5	28.5	0.0	0.0	0.0	0.0	28.8	28.5	30.0
10	35.5	35.5	0.0	28.0	0.0	29.5	31.2	0.0	0.0	28.9	0.0	0.0	0.0	0.0	0.0	29.0	0.0	30.0
11	34.8	34.8	0.0	28.4	0.0	29.5	32.3	0.0	0.0	29.2	0.0	0.0	0.0	0.0	0.0	27.5	0.0	30.6
12	35.2	35.2	0.0	30.7	0.0	29.4	31.9	0.0	0.0	28.5	0.0	0.0	0.0	0.0	0.0	30.5	0.0	30.7
13	36.9	36.9	0.0	35.1	0.0	29.5	32.1	0.0	0.0	30.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.8
14	36.2	36.2	0.0	35.5	0.0	30.2	32.8	0.0	0.0	29.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.4
15	35.9	35.9	0.0	38.2	0.0	31.5	34.2	0.0	0.0	29.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3

Q4

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0.0	0.0	0.0	0.0	17.0	15.8	18.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.1
1	0.0	0.0	0.0	15.6	19.8	19.4	20.2	0.0	0.0	0.0	0.0	19.5	0.0	0.0	0.0	0.0	0.0	18.6
2	0.0	0.0	24.6	19.8	21.2	20.9	21.4	0.0	0.0	0.0	0.0	21.9	0.0	0.0	0.0	0.0	28.5	21.9
3	27.0	27.0	25.0	23.1	22.6	22.8	22.4	24.0	0.0	26.0	26.0	23.9	24.5	0.0	24.5	24.5	25.4	24.3
4	28.7	28.7	24.9	24.5	24.2	24.8	23.6	26.5	0.0	25.6	25.5	24.3	24.4	0.0	24.4	24.4	26.3	24.7
5	31.5	31.5	25.2	26.0	25.5	26.0	24.9	25.0	0.0	26.8	26.6	24.9	25.2	0.0	25.2	25.2	26.6	25.8
6	31.2	31.2	25.6	26.4	26.0	26.5	25.5	26.2	0.0	28.1	27.6	27.0	0.0	0.0	0.0	0.0	28.1	27.4
7	33.1	33.1	26.6	26.9	27.7	28.1	27.3	0.0	0.0	29.0	28.5	27.2	0.0	0.0	0.0	0.0	28.4	30.4
8	33.5	33.5	27.5	28.0	28.9	29.1	28.8	0.0	0.0	29.7	29.2	29.0	0.0	0.0	0.0	0.0	29.2	31.5
9	35.1	35.1	0.0	27.7	30.1	30.1	30.0	0.0	0.0	30.4	29.4	29.1	0.0	0.0	0.0	0.0	29.1	32.9
10	35.5	35.5	0.0	27.9	30.2	30.2	30.3	0.0	0.0	30.5	30.0	29.5	0.0	0.0	0.0	0.0	31.0	33.3
11	34.8	34.8	0.0	28.3	30.5	30.3	30.6	0.0	0.0	30.4	29.5	28.5	0.0	0.0	0.0	0.0	29.6	32.4
12	35.2	35.2	0.0	30.0	31.4	30.8	32.0	0.0	0.0	31.4	30.7	0.0	0.0	0.0	0.0	0.0	29.7	33.5
13	36.9	36.9	0.0	33.9	32.5	31.4	33.6	0.0	0.0	32.0	30.7	29.5	0.0	0.0	0.0	0.0	29.6	33.1
14	36.2	36.2	0.0	34.2	33.4	32.2	34.7	0.0	0.0	31.6	30.3	30.5	0.0	0.0	0.0	0.0	31.8	33.7
15	35.9	35.9	0.0	38.1	36.3	35.1	37.5	0.0	0.0	33.8	33.6	31.5	0.0	0.0	0.0	0.0	33.7	35.5

Q1-4

Ages	IIa	IVa	VIIIa	VIIIb	VIIIc	VIIIc e	VIIIc w	VIIId	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIa	Total
0	0.0	0.0	0.0	0.0	17.0	15.5	17.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0
1	0.0	0.0	0.0	15.1	16.6	16.7	16.9	0.0	0.0	0.0	0.0	19.5	0.0	0.0	0.0	0.0	0.0	16.6
2	0.0	0.0	24.3	17.2	20.3	19.5	19.6	0.0	0.0	0.0	0.0	21.1	0.0	0.0	0.0	0.0	28.5	19.3
3	26.1	27.0	24.6	20.7	22.4	22.9	22.6	23.1	25.2	26.0	25.6	23.2	24.5	23.5	24.5	22.9	25.4	23.4
4	25.1	28.7	24.6	24.8	24.5	25.3	24.2	24.7	25.5	25.4	25.4	23.9	24.4	24.5	24.3	24.4	26.0	24.5
5	26.2	31.5	24.5	25.9	25.9	26.4	25.3	24.5	25.8	26.6	26.1	24.6	25.2	25.5	25.2	25.1	26.5	25.4
6	29.0	31.2	25.2	26.9	26.5	27.1	26.1	25.2	26.8	27.9	28.4	25.1	26.7	26.7	26.7	27.0	28.1	27.0
7	30.3	33.1	26.4	28.3	28.1	28.0	27.7	29.5	27.5	28.7	29.2	27.3	27.4	27.4	27.3	27.8	28.6	29.4
8	31.4	33.5	27.5	29.3	29.7	29.0	29.6	28.5	28.5	29.4	29.5	29.0	27.8	27.8	27.4	27.3	29.3	30.3
9	33.4	35.1	0.0	28.4	30.1	29.3	30.4	29.5	28.5	30.1	30.2	29.1	29.3	29.3	29.1	29.4	29.3	31.4
10	35.5	35.5	26.5	28.5	30.2	29.4	30.7	27.5	0.0	30.2	30.0	29.5	28.8	28.8	28.3	29.7	31.0	31.1
11	34.8	34.8	0.0	31.4	30.5	29.5	31.1	0.0	0.0	30.3	29.5	28.5	29.0	29.0	28.4	29.5	29.6	30.5
12	33.7	35.2	25.5	32.3	31.4	30.2	31.8	22.5	0.0	31.2	30.6	29.5	29.9	29.9	29.7	29.2	29.8	31.0
13	34.6	36.9	0.0	34.3	32.1	30.1	32.5	27.5	0.0	31.4	33.0	29.5	29.6	29.6	29.3	29.9	30.4	31.4
14	33.9	36.2	0.0	31.7	32.9	31.1	33.3	26.5	0.0	31.6	32.1	30.5	28.9	28.9	28.9	29.0	32.0	32.1
15	36.0	35.9	0.0	37.7	35.3	32.7	35.4	0.0	0.0	33.5	36.0	31.3	30.6	30.6	30.5	31.7	35.4	34.1

Table 5.5.2.3. Western horse mackerel: stock weights-at-age.

year	age 0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.000	0.000	0.050	0.080	0.207	0.232	0.269	0.280	0.292	0.305	0.369	0.352
1983	0.000	0.000	0.050	0.080	0.171	0.227	0.257	0.276	0.270	0.243	0.390	0.311
1984	0.000	0.000	0.050	0.077	0.122	0.155	0.201	0.223	0.253	0.246	0.338	0.287
1985	0.000	0.000	0.050	0.081	0.148	0.140	0.193	0.236	0.242	0.289	0.247	0.306
1986	0.000	0.000	0.050	0.080	0.105	0.134	0.169	0.195	0.242	0.292	0.262	0.342
1987	0.000	0.000	0.050	0.080	0.105	0.126	0.150	0.171	0.218	0.254	0.281	0.317
1988	0.000	0.000	0.050	0.080	0.105	0.126	0.141	0.143	0.217	0.274	0.305	0.366
1989	0.000	0.000	0.050	0.080	0.105	0.103	0.131	0.159	0.127	0.210	0.252	0.336
1990	0.000	0.000	0.050	0.080	0.105	0.127	0.135	0.124	0.154	0.174	0.282	0.345
1991	0.000	0.000	0.050	0.080	0.121	0.137	0.143	0.144	0.150	0.182	0.189	0.333
1992	0.000	0.000	0.050	0.080	0.105	0.133	0.151	0.150	0.158	0.160	0.182	0.287
1993	0.000	0.000	0.050	0.080	0.105	0.153	0.166	0.173	0.172	0.170	0.206	0.222
1994	0.000	0.000	0.050	0.080	0.105	0.147	0.185	0.169	0.191	0.191	0.190	0.235
1995	0.000	0.000	0.050	0.066	0.119	0.096	0.152	0.166	0.178	0.187	0.197	0.233
1996	0.000	0.000	0.050	0.095	0.118	0.129	0.148	0.172	0.183	0.185	0.202	0.238
1997	0.000	0.000	0.050	0.080	0.112	0.124	0.162	0.169	0.184	0.188	0.208	0.238
1998	0.000	0.000	0.050	0.090	0.108	0.129	0.142	0.151	0.162	0.174	0.191	0.215
1999	0.000	0.000	0.050	0.110	0.120	0.130	0.160	0.170	0.180	0.190	0.210	0.222
2000	0.000	0.000	0.050	0.087	0.108	0.148	0.170	0.173	0.193	0.202	0.257	0.260
2001	0.000	0.000	0.070	0.074	0.082	0.100	0.121	0.131	0.142	0.161	0.187	0.268
2002	0.000	0.000	0.050	0.109	0.120	0.135	0.146	0.153	0.177	0.206	0.216	0.275
2003	0.000	0.000	0.050	0.110	0.142	0.139	0.161	0.169	0.169	0.176	0.176	0.206
2004	0.000	0.000	0.050	0.104	0.114	0.127	0.142	0.157	0.168	0.166	0.178	0.213
2005	0.000	0.000	0.085	0.095	0.110	0.141	0.163	0.182	0.197	0.181	0.209	0.243
2006	0.000	0.000	0.085	0.098	0.095	0.113	0.167	0.157	0.164	0.205	0.195	0.229

Table 5.5.3.1. Western horse mackerel. Maturity-at-age.

year	Age 0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.00	0.00	0.40	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1983	0.00	0.00	0.30	0.70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1984	0.00	0.00	0.10	0.60	0.85	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1985	0.00	0.00	0.10	0.40	0.80	0.95	1.00	1.00	1.00	1.00	1.00	1.00
1986	0.00	0.00	0.10	0.40	0.60	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1987	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00
1988	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00
1989	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00
1990	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00
1991	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00
1992	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00
1993	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00
1994	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00
1995	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00
1996	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00
1997	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00
1998	0.00	0.00	0.05	0.25	0.70	0.95	1.00	1.00	1.00	1.00	1.00	1.00
1999	0.00	0.00	0.05	0.25	0.70	0.95	1.00	1.00	1.00	1.00	1.00	1.00
2000	0.00	0.00	0.05	0.25	0.70	0.95	1.00	1.00	1.00	1.00	1.00	1.00
2001	0.00	0.00	0.05	0.25	0.70	0.95	1.00	1.00	1.00	1.00	1.00	1.00
2002	0.00	0.00	0.05	0.25	0.70	0.95	1.00	1.00	1.00	1.00	1.00	1.00
2003	0.00	0.00	0.05	0.25	0.70	0.95	1.00	1.00	1.00	1.00	1.00	1.00
2004	0.00	0.00	0.05	0.25	0.70	0.95	1.00	1.00	1.00	1.00	1.00	1.00
2005	0.00	0.00	0.05	0.25	0.70	0.95	1.00	1.00	1.00	1.00	1.00	1.00
2006	0.00	0.00	0.05	0.25	0.70	0.95	1.00	1.00	1.00	1.00	1.00	1.00

Table 5.6.1 A summary of the main features of the SAD model used for the exploratory assessment of western horse mackerel.

Model	SAD
Version	2004 Working Group (WGMHSA)
Model type	A linked separable VPA and ADAPT VPA model, so that different structural models are applied to the recent and historic periods. The separable component is short (currently 4 years) and applies to the most recent period, while the ADAPT VPA component applies to the historic period. Model estimates from the separable period initiate a historic VPA for the cohorts in the first year of the separable period. Fishing mortality at the oldest true age (age 10) in the historic VPA is calculated as the average of the three preceding ages (7-9, ignoring the 1982 year-class where applicable), multiplied by a scaling parameter that is estimated in the model. In order to model the directed fishing of the dominant 1982 year-class, fishing mortality on this year-class at age 10 in 1992 is estimated in the model.
Data used	Egg production estimates, used as relative indices of abundance and catch-at-age data (numbers). Weights-at-age in the stock and maturity-at-age vary temporally, but are assumed to be known without error. Natural mortality and the proportions of fishing and natural mortality before spawning are fixed and year-invariant.
Selection	The separable period assumes constant selection-at-age, and requires estimation of fishing mortality age- and year-effects (the former reflecting selectivity-at-age) for ages 1-10 and the final four years for which catch data are available. Selectivity at age 7 is assumed to be equal to 1.
Fishing mortality assumptions	The fishing mortality at age 10 (the final true age) is equal to the average of the fishing mortalities at ages 7-9 (ignoring the 1982 year-class where applicable) multiplied by a scaling parameter estimated within the model. The fishing mortality at age 10 in 1992 (applicable to the 1982 year-class) is estimated separately. The plus-group fishing mortality is assumed equal to that of age 10.
Estimated parameters	The parameters treated as “free” in the model (i.e. those estimated directly) are: (1) Fishing mortality year effects for the final four years for which catch data are available; (2) Fishing mortality age effects (selectivities) for ages 1-10 (except for selectivity at age 7 which is set to 1); (3) scaling parameter for fishing mortality at age 10 relative to the average for ages 7-9 (ignoring the 1982 year-class where applicable); (4) fishing mortality on the 1982 year-class at age 10 in 1992; (5) catchability linking the egg production estimates and the SSB estimates from the model.
Catchabilities	The catchability parameter links the egg production estimates and the SSB estimates from the model.
Plus-group	A dynamic pool is assumed (plus group this year is the sum of last year’s plus group and last year’s oldest true age, both depleted by fishing and natural mortality). The plus group modelled in this manner allows the catch in the plus group to be estimated, and making the assumption that log-catches are normally distributed allows an additional component in the likelihood, fitting these estimated catches to the observed plus-group catch.

Objective function	The estimation is based on maximum likelihood. There are three components to the likelihood, corresponding to egg estimates, catches for the separable period, and catches for the plus-group. The variance of each component is estimated.
Variance estimates / uncertainty	Estimates of precision may be calculated by several methods, the simplest (based on the delta method) being used for results shown.
Program language	AD Model Builder (Otter Research Ltd)
References	Description in Working Group reports.

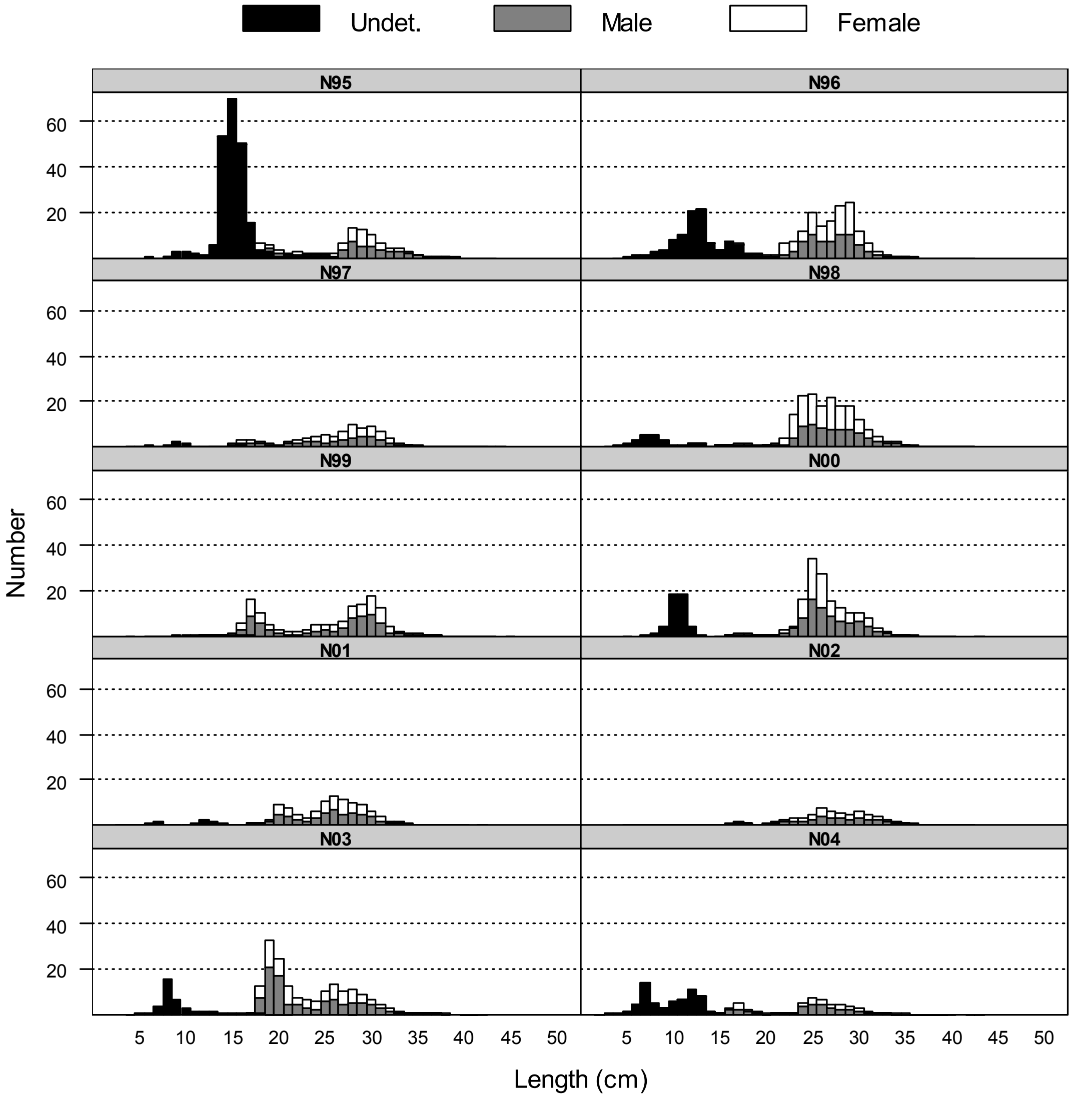


Figure 5.3.2.1. Mean stratified length distributions of horse mackerel in North Spanish Coast bottom trawl surveys (1995-2004)

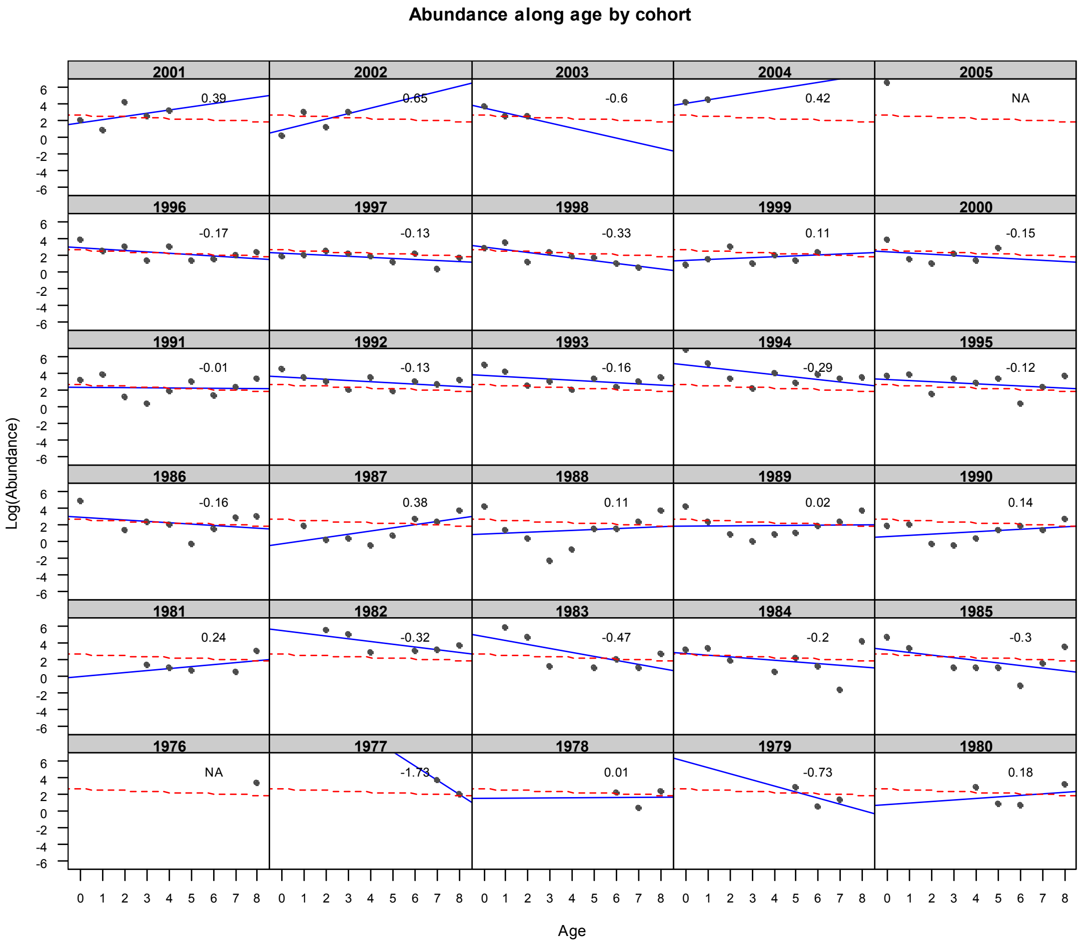


Figure 5.3.2.2. Western Horse mackerel. Horse mackerel abundance (No./30 min haul) evolution in logarithmic scale along each cohort sampled in North Spanish Coast surveys. Solid lines mark the linear regression fitted by cohort to the log(abundance)~age, the figure in the right corner of each panel corresponds to the slope. Dashed line marks the linear regression fitted to the overall time series.

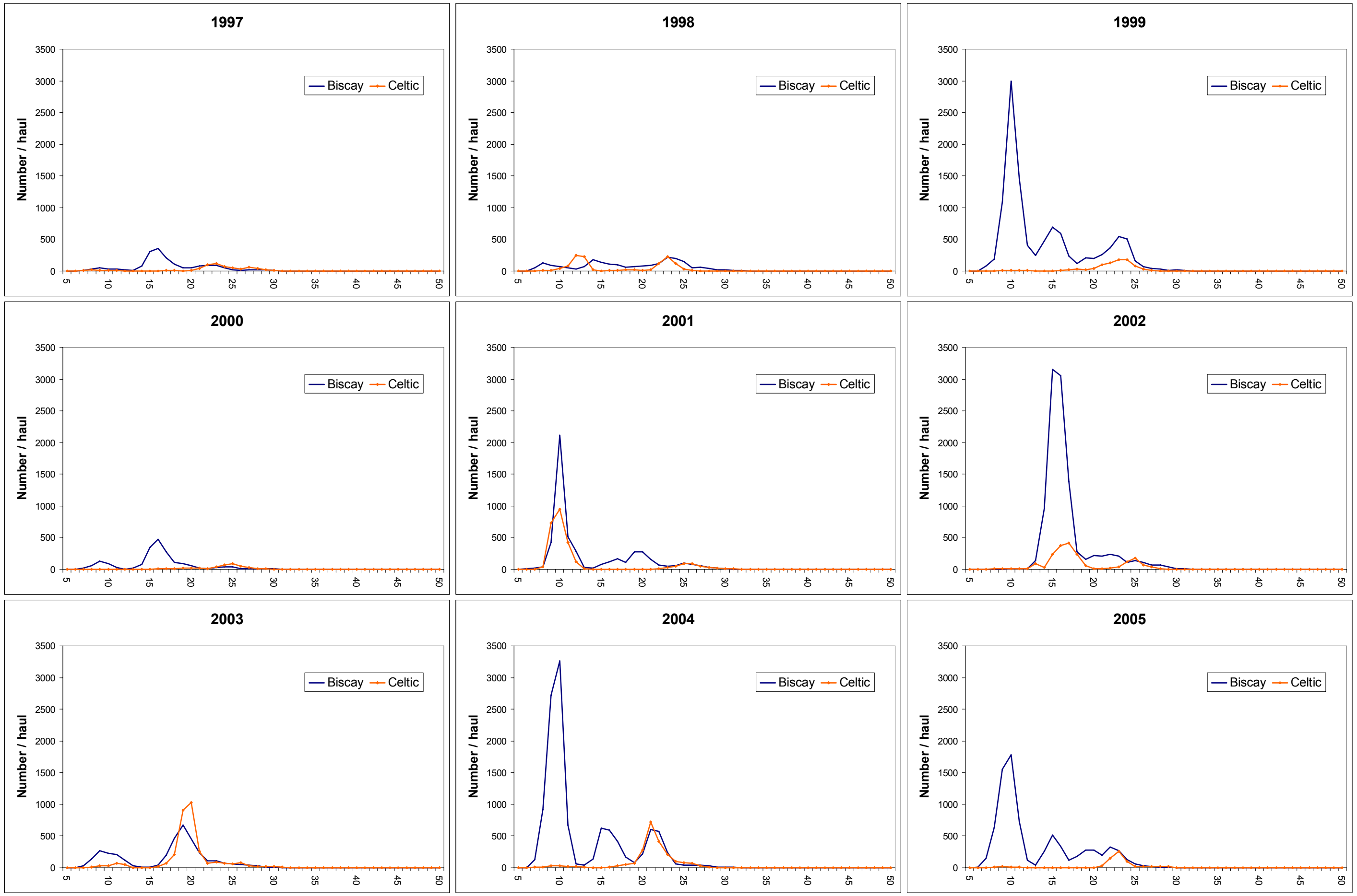


Figure 5.3.2.3. Western Horse mackerel. Length distributions of horse mackerel by area from EVHOE bottom trawls carries out in Bay of Biscay and Celtic Sea.

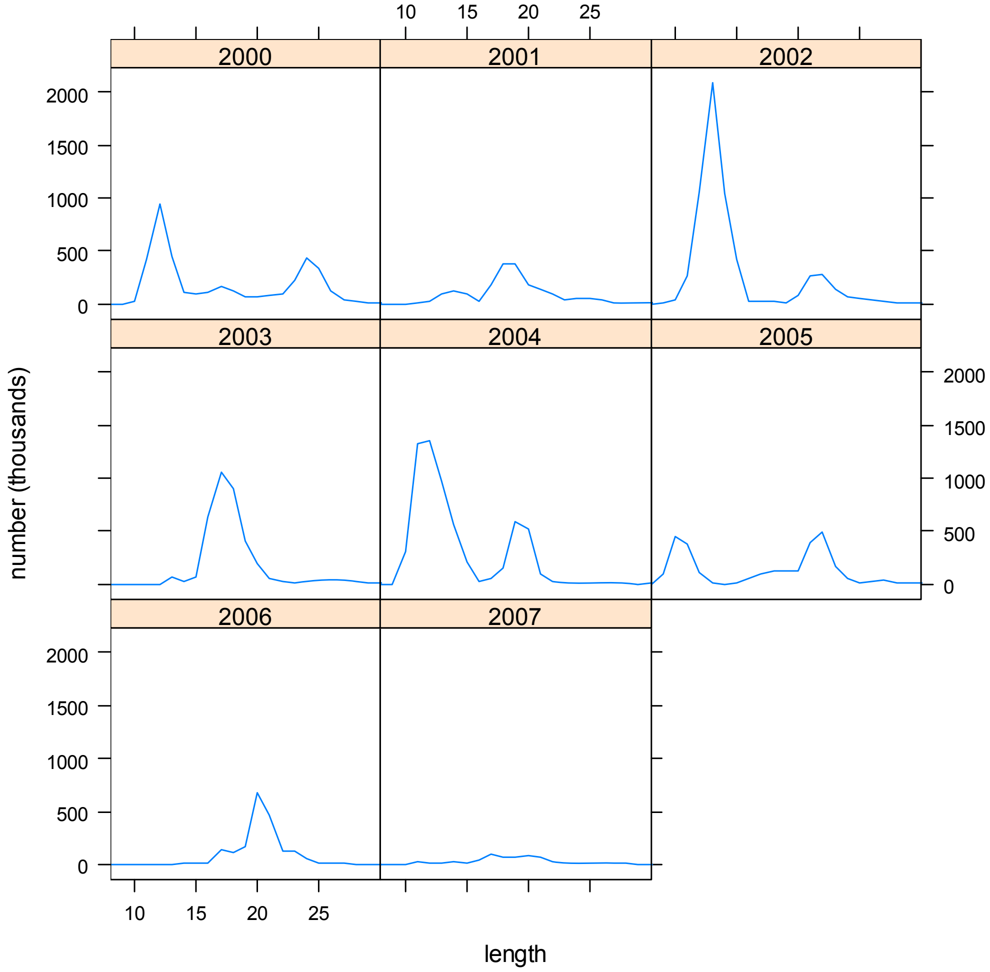


Figure 5.3.3.1. Western horse mackerel length frequency distribution from the PELGAS survey, from 2000 to 2007. This survey has been revised last year, now giving estimates in numbers.

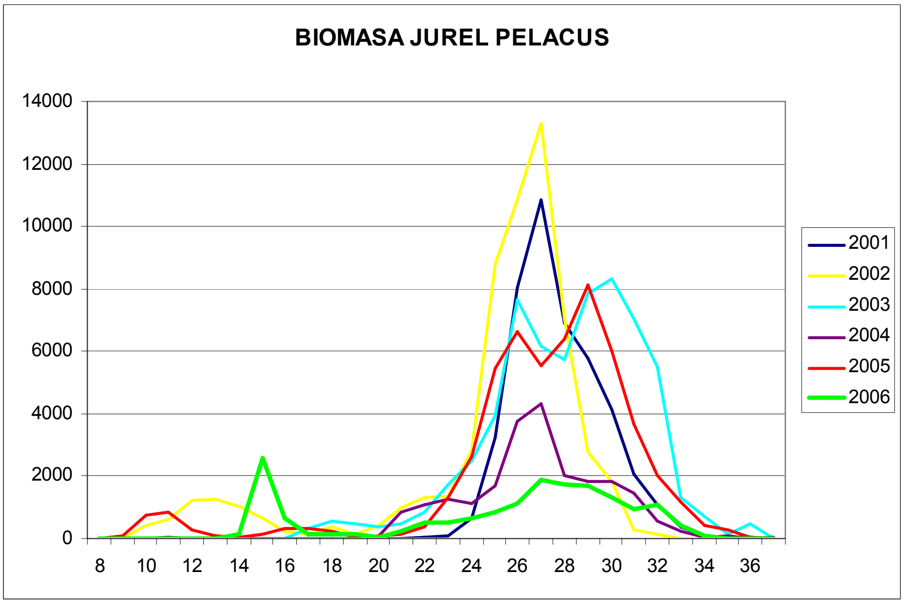


Figure 5.3.3.2. Western horse mackerel. Horse mackerel biomass by length class, assessed at IEO-PELACUS surveys (2001-2006). In the y-axes: biomass in tonnes; in the x-axes: total length in cm.

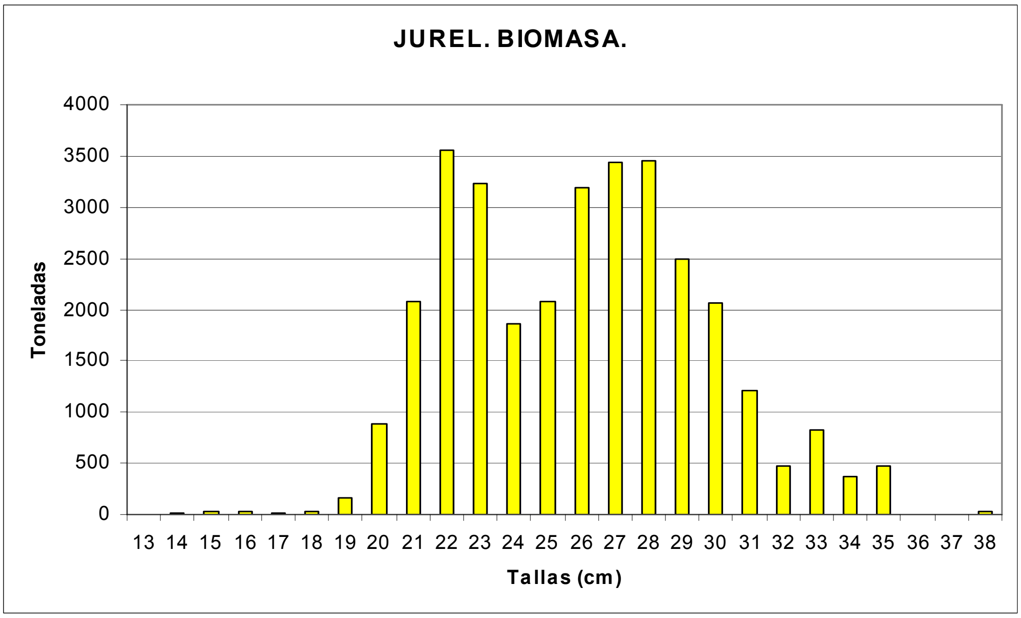
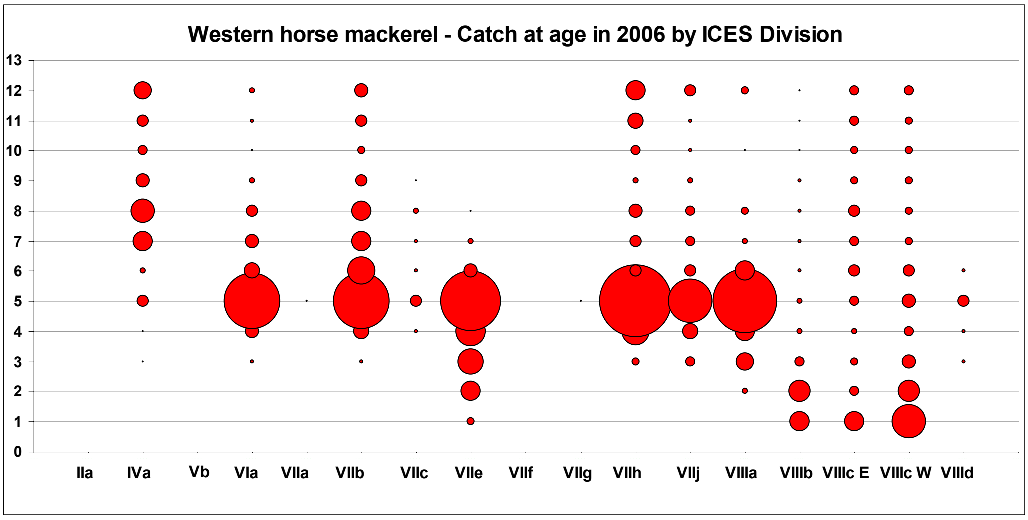


Figure 5.3.3.3. Western horse mackerel. Horse mackerel biomass by length class, assessed at IEO PELACUS survey in 2007. In the y-axes biomass in tonnes; in the x-axes: total length in cm.



5.5.1.1 Western horse mackerel. Catch numbers by area and age in 2006.

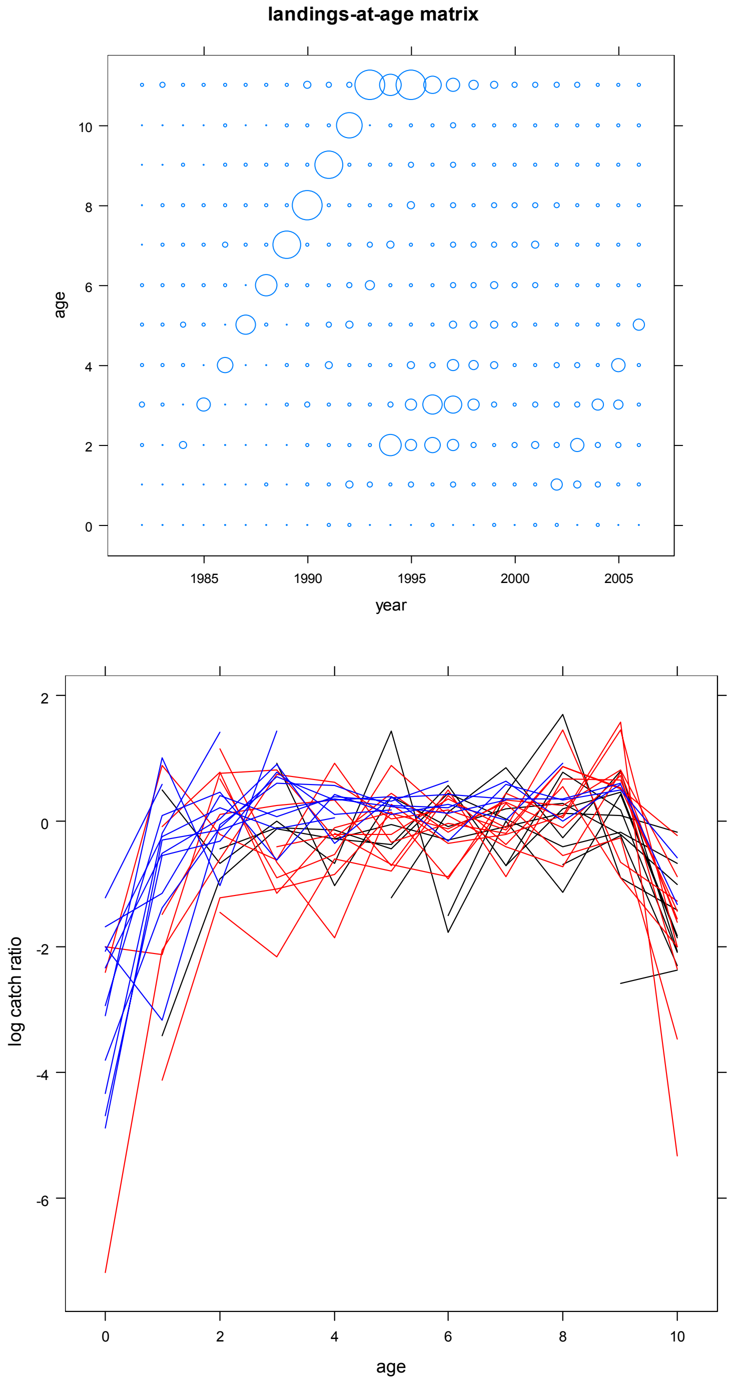


Figure 5.5.1.2 Western horse mackerel. Catch-at-age matrix (left panel) and log catch ratios (right panel) for cohorts 1972-1982 (black), 1983-1993 (red) and 1994-2005 (blue)

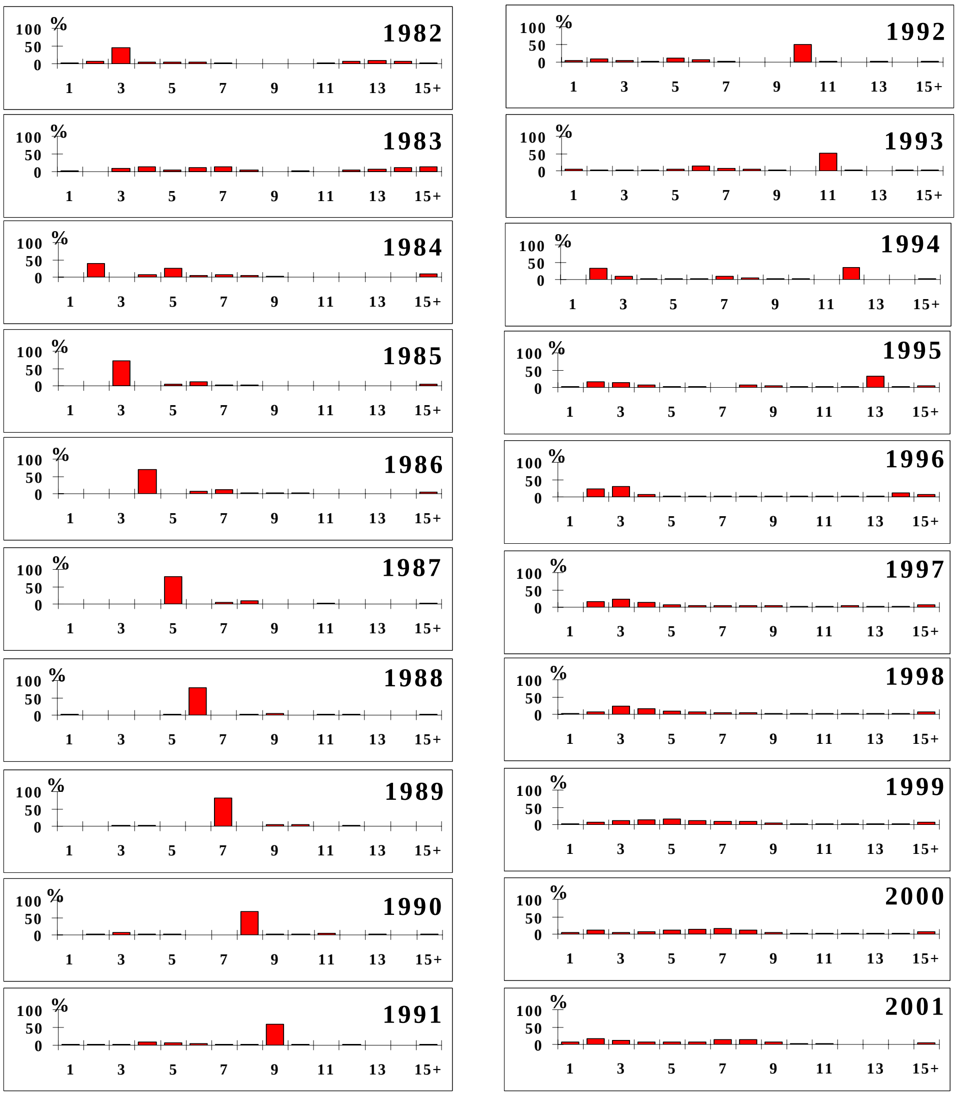


Figure 5.5.1.3a Western horse mackerel. Age composition (percentages) of international catches between 1982 and 2001.

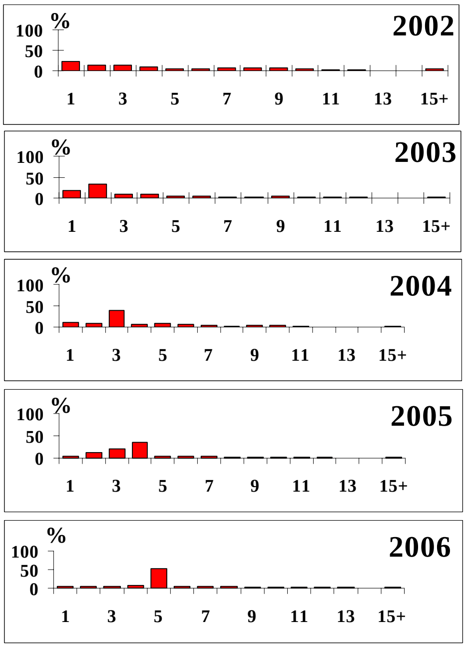
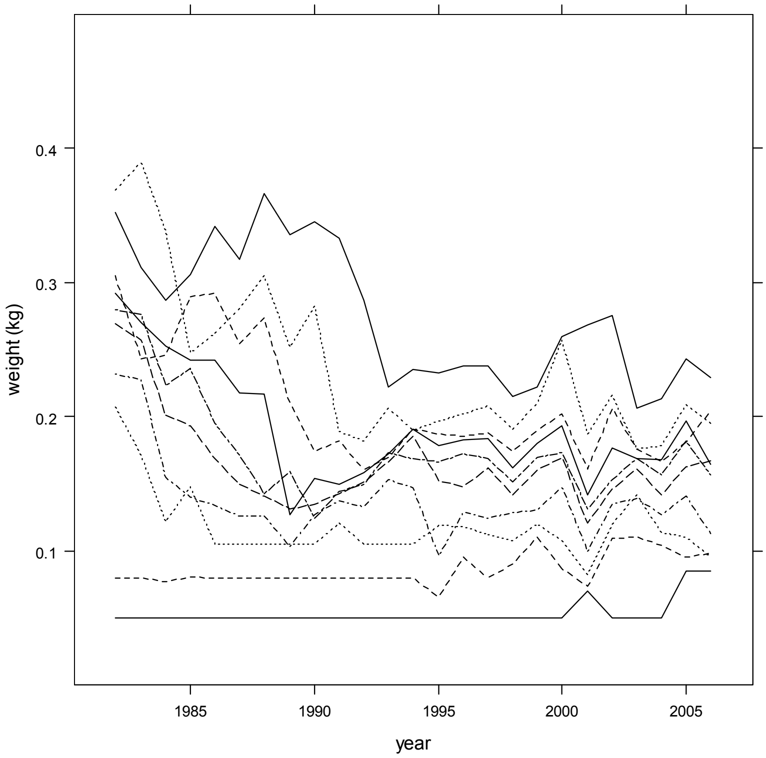


Figure 5.5.1.3b Western horse mackerel. Age composition (percentages) of international catches between 2002 and 2006.



5.5.2.1 Western horse mackerel. Stock weights-at-age (right panel) for ages 2 to 10 and the plusgroup in 2006.

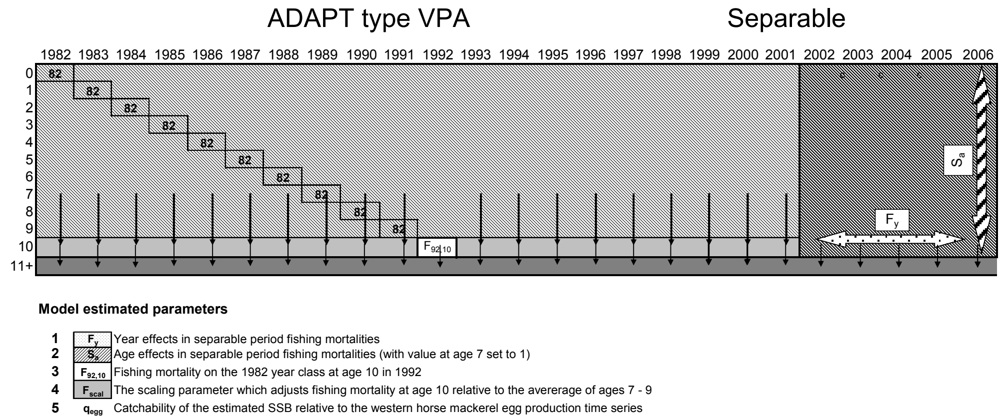


Figure 5.6.1. Western horse mackerel. Illustration of the SAD model structure used for the assessment of the western horse mackerel stock and the "free" parameters estimated by maximum likelihood.

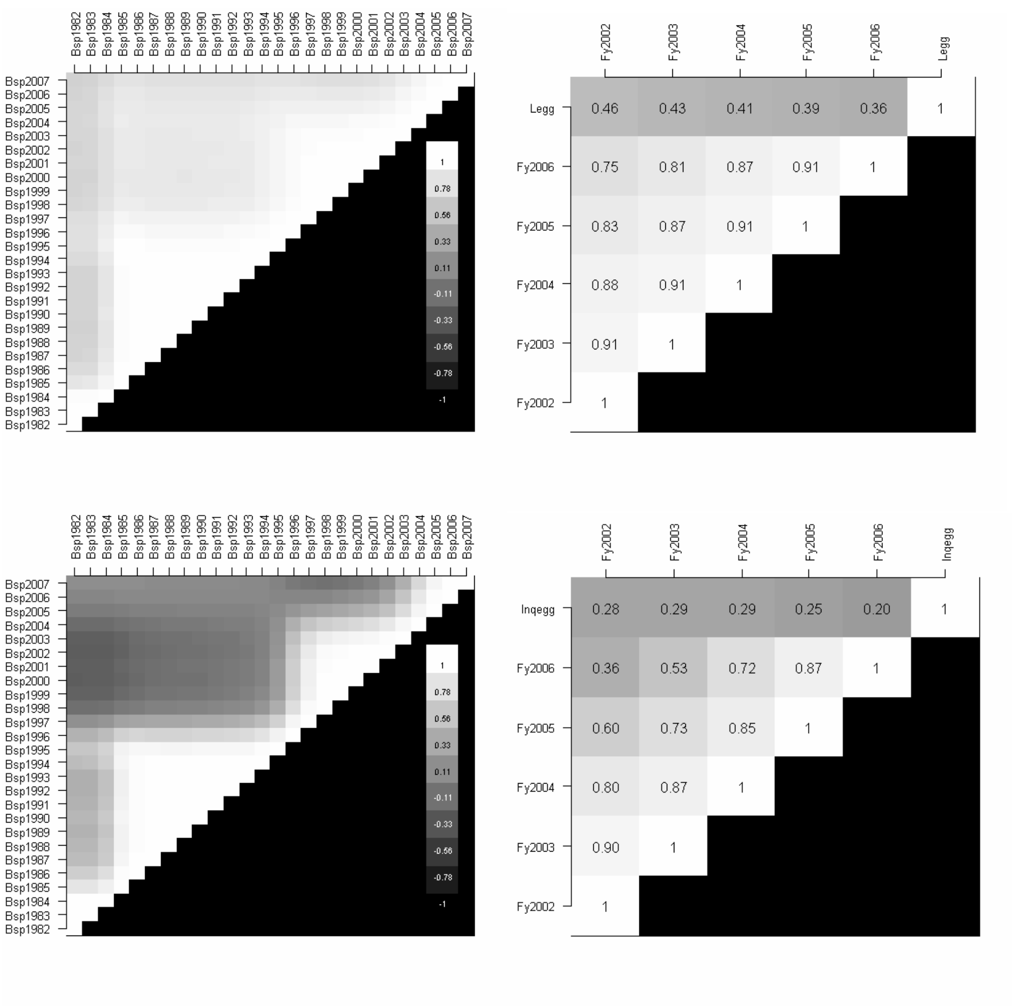


Figure 5.6.2. Western horse mackerel. Hessian matrices for SAD (top panels) and SADVF (lower panels). Left panels show correlations SSB estimates for different years. Right panels shows correlation between fecundity and Fishing mortality estimates in the separable period.

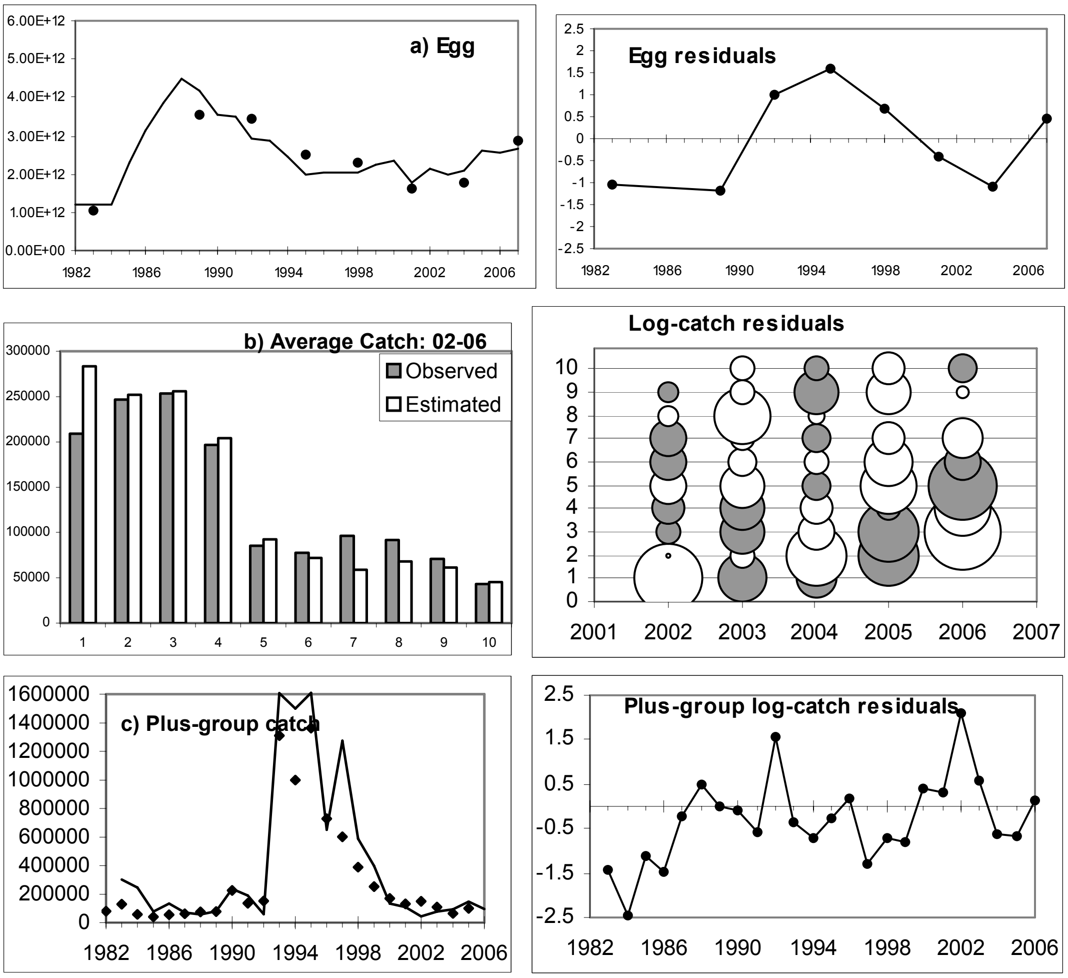


Figure 5.6.3. Western horse mackerel. SAD model. Model fits to data for the three components of the likelihood corresponding to (a) the egg estimates, (b) the catches in the separable period, and (c) to the catches in the plus-group. The left-hand column shows the actual fit to the data (average catches are shown in (b) for ease of presentation), and the right-hand column normalised residuals, of the form: $(\ln X - \ln \hat{X})/\sigma$. In the residual plot for (b), the area of a bubble reflects the size of the residual, with the largest bubble corresponding to a normalised log residual of 2.83.

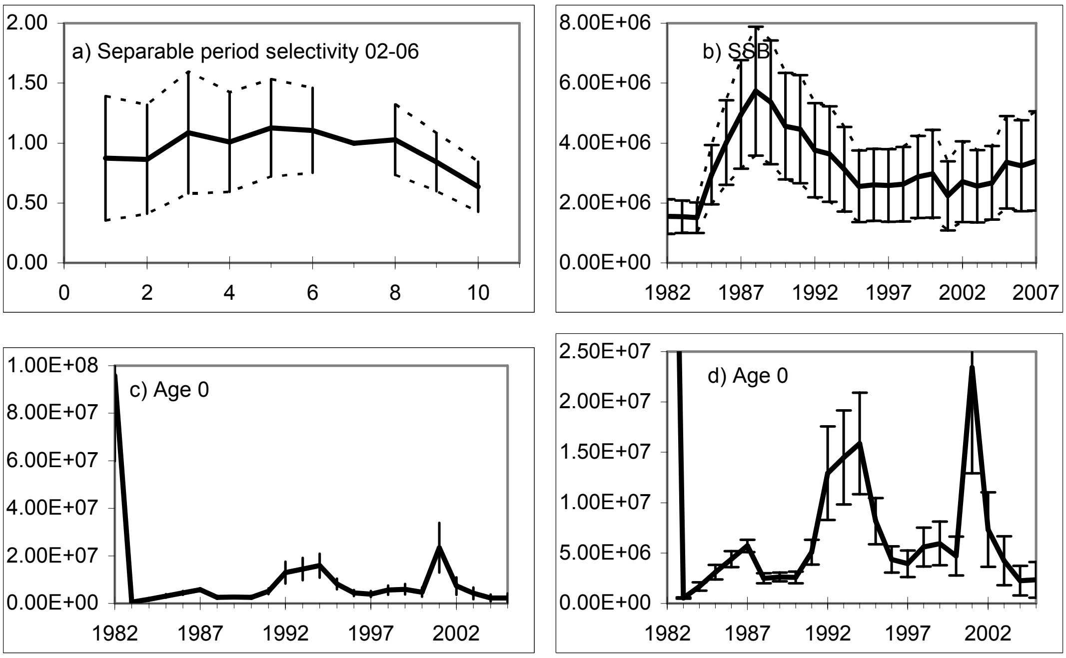


Figure 5.6.4. Western horse mackerel . SAD model. Plots of (a) the selectivity pattern, (b) the SSB trajectory, (c) numbers at age 0, and (d) the same as (c) but scaled to capture more detail. The error bars are 2 standard deviations (indicating roughly 95% confidence bounds).

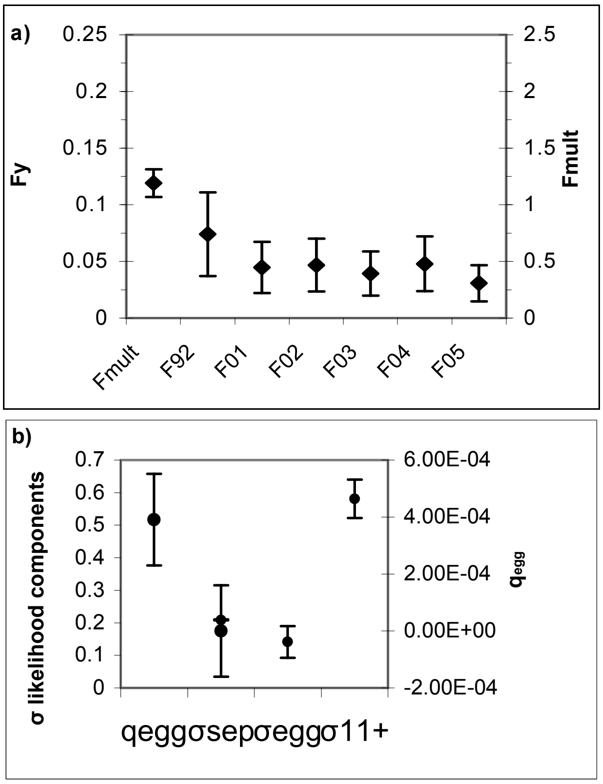


Figure 5.6.5. Western horse mackerel. SAD model Estimates for some key parameters, with (a) corresponding to fishing mortality parameters (the scaling parameter F_{scal}, fishing mortality at age 10 in 1992, $F_{92,10}$, and the fishing mortality year effects for the separable period, F_y), and (b) the catchability parameter q_{egg}, and estimates of variance, plotted as standard deviations, for the three components of the likelihood (σ_{sep}, σ_{egg} and σ_{11+}). The error bars are 2 standard deviations (indicating roughly 95% confidence bounds).

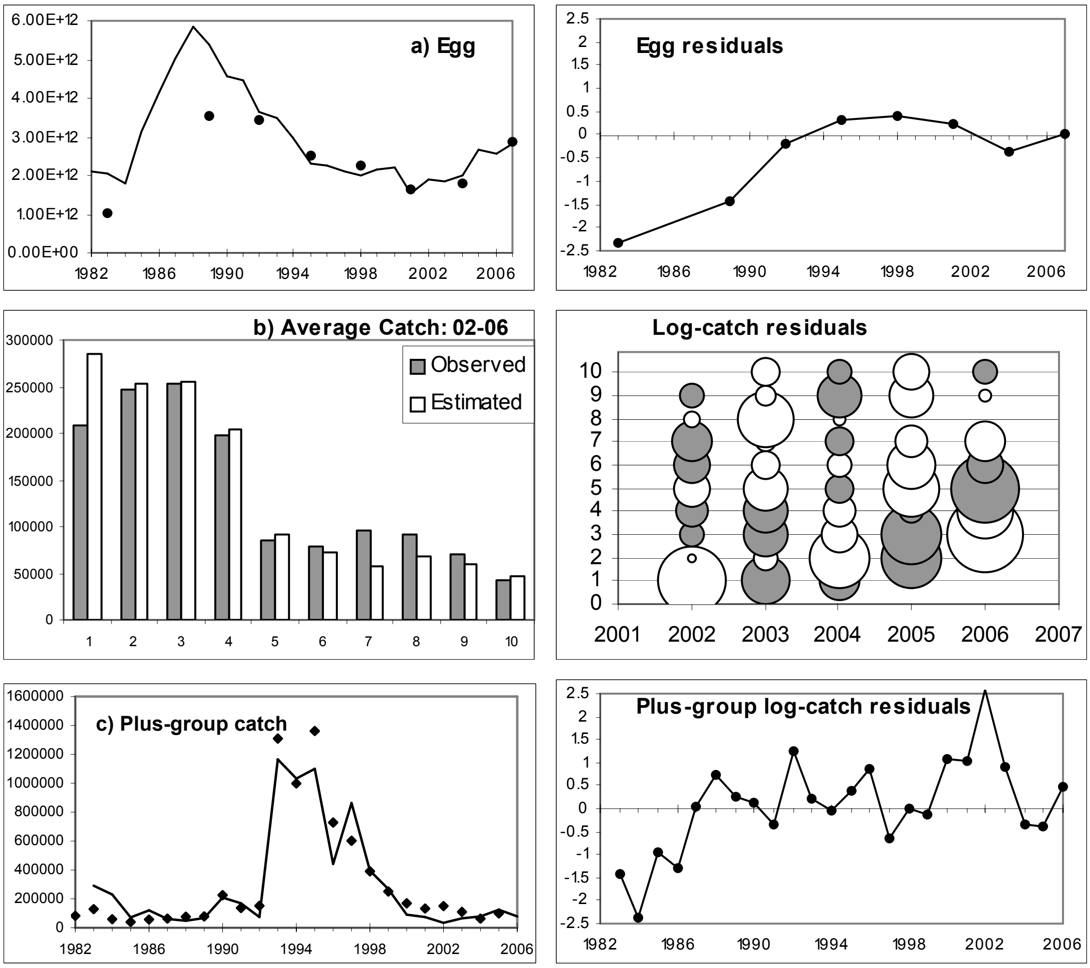


Figure 5.6.6. Western horse mackerel, variable fecundity model (sadVF). Model fits to data for the three components of the likelihood corresponding to (a) the egg estimates, (b) the catches in the separable period, and (c) to the catches in the plus-group. The left-hand column shows the actual fit to the data (average catches are shown in (b) for ease of presentation), and the right-hand column normalised residuals, of the form: $(\ln X - \ln \hat{X})/\sigma$. In the residual plot for (b), the area of a bubble reflects the size of the residual, with the largest bubble corresponding to a normalised log residual of 2.83.

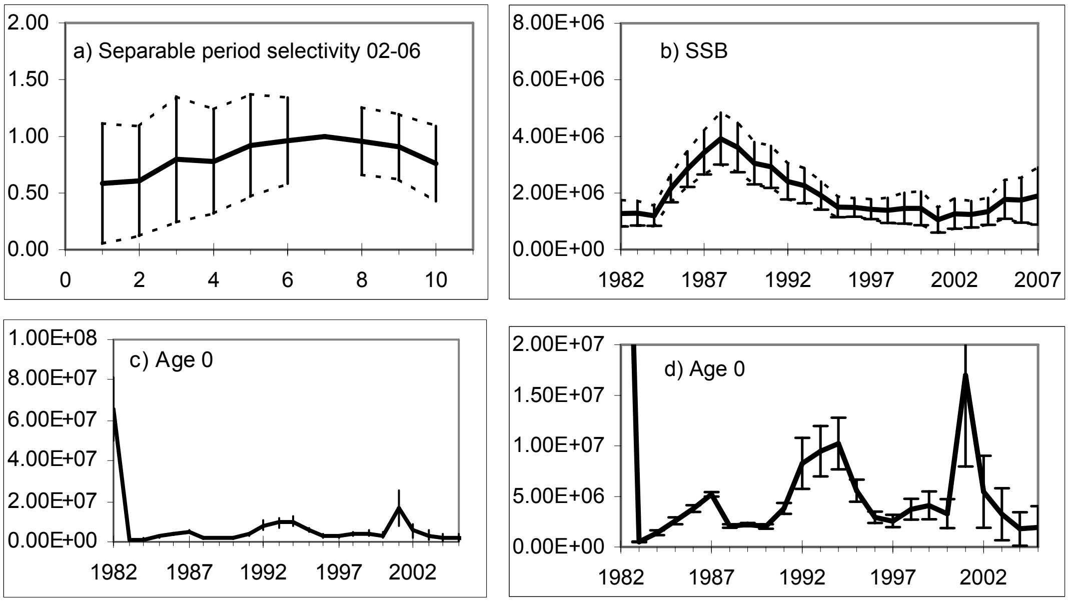


Figure 5.6.7. Western horse mackerel sadVF. Plots of (a) the selectivity pattern, (b) the SSB trajectory, (c) numbers at age 0, and (d) the same as (c) but scaled to capture more detail. The error bars are 2 standard deviations (indicating roughly 95% confidence bounds).

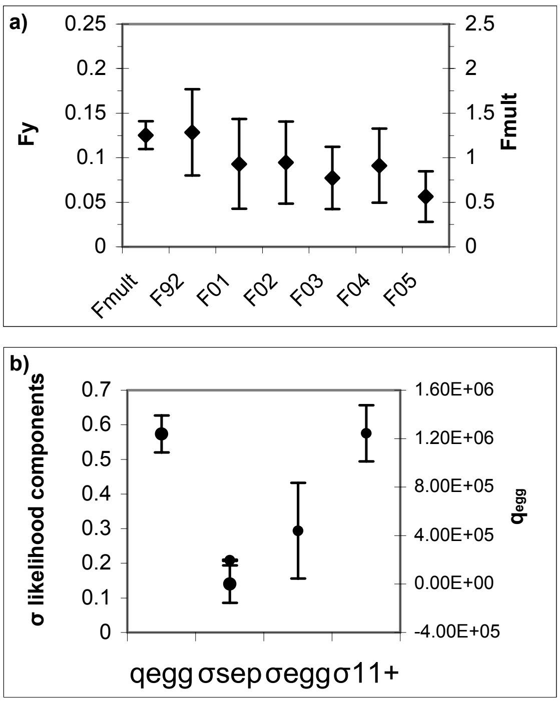


Figure 5.6.8. Western horse mackerel. Estimates for some key parameters, with (a) corresponding to fishing mortality parameters (the scaling parameter F_{scal}, fishing mortality at age 10 in 1992, $F_{92,10}$, and the fishing mortality year effects for the separable period, F_y), and (b) the catchability parameter q_{egg}, and estimates of variance, plotted as standard deviations, for the three components of the likelihood (σ_{sep}, σ_{egg} and σ_{11+}). The error bars are 2 standard deviations (indicating roughly 95% confidence bounds). (sadVF)

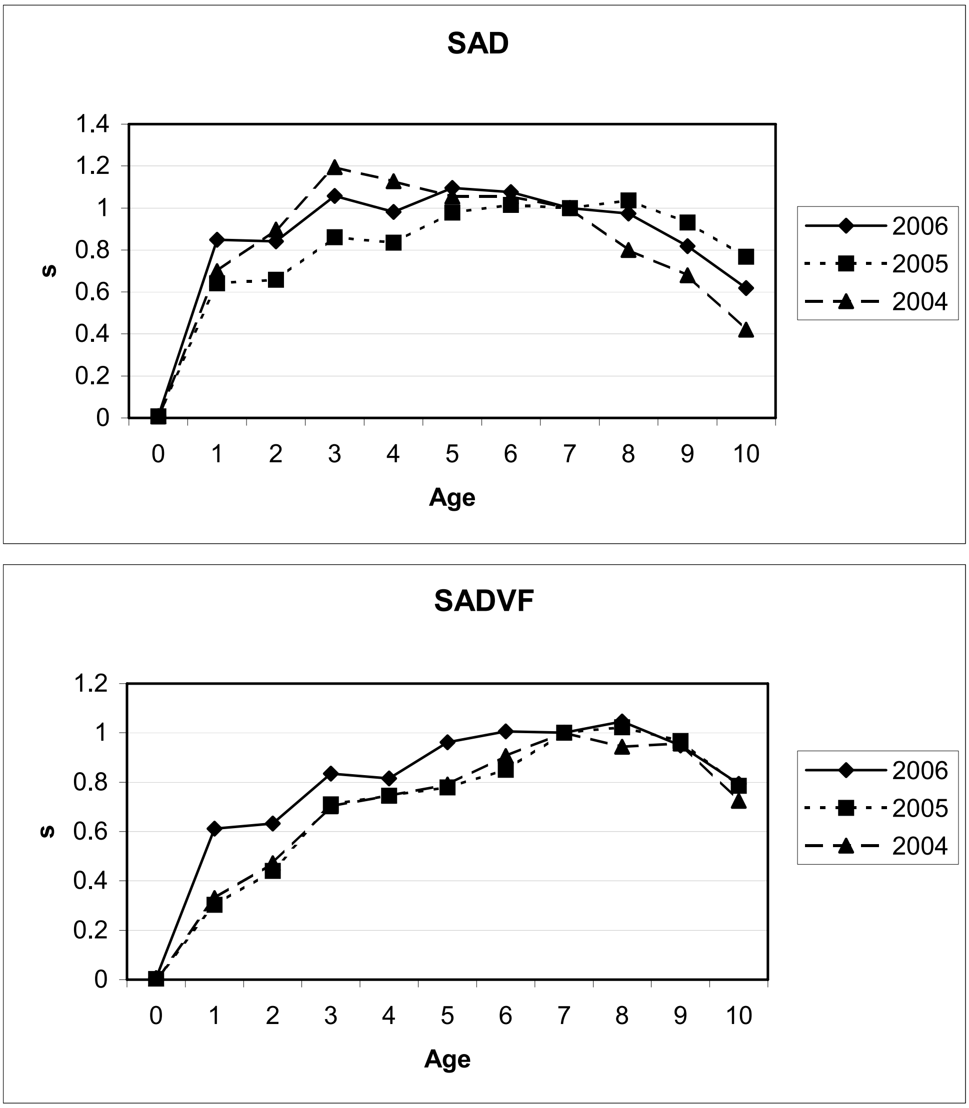


Figure 5.6.9. Western horse mackerel. Retrospective analysis for the selectivity pattern in the separable. The separable period has been analysed for 2002-2006 (2006), 2001-2005 (2005) and 2001-2004 (2004). The final year of data was set corresponding to the final year in the separable period. The 2004 analysis has a shorter separable period than the other two analysis because the selectivity pattern is believed to have shifted between 2000 and 2001.

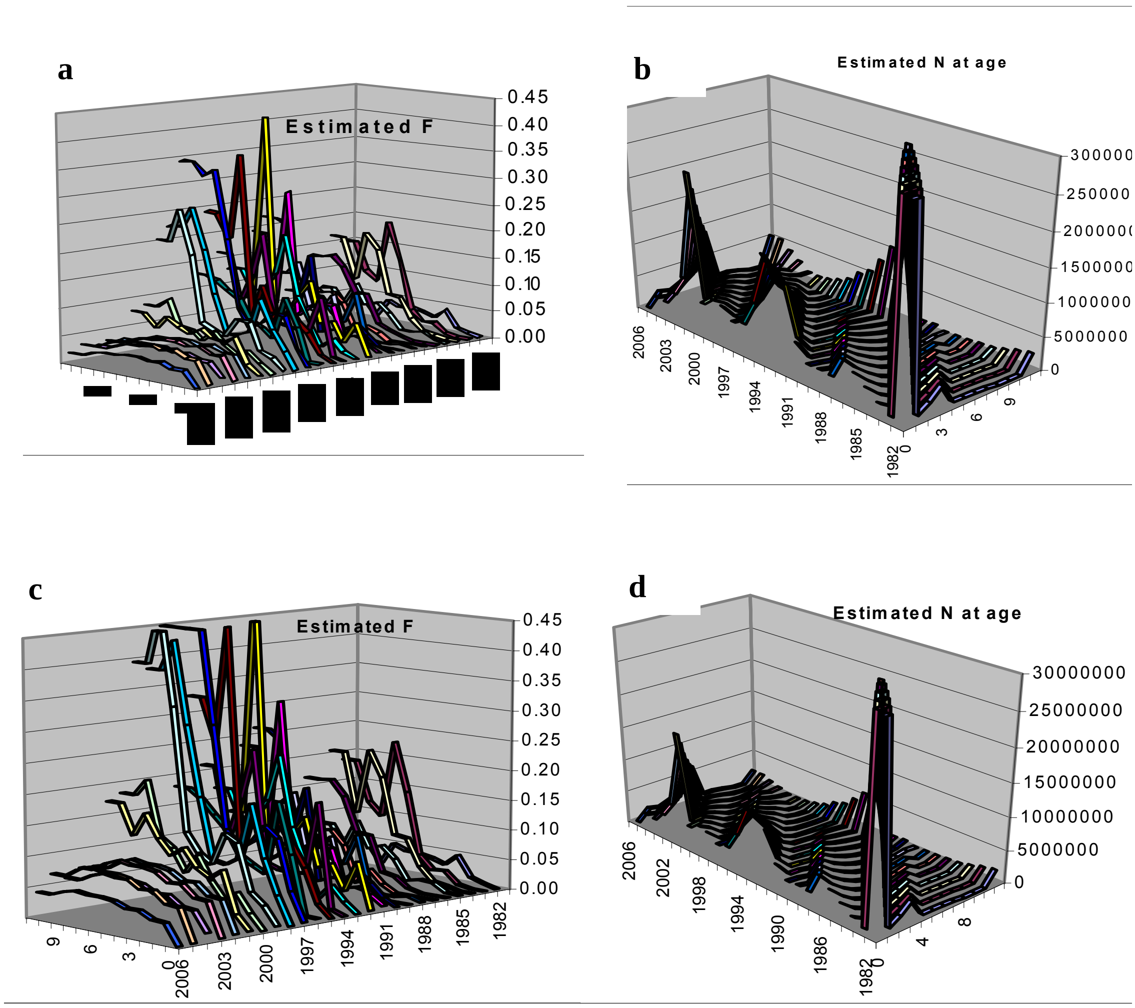


Figure 5.6.10. Western horse mackerel estimated F and numbers at age from SAD (a & b) and from sadVF (c & d).

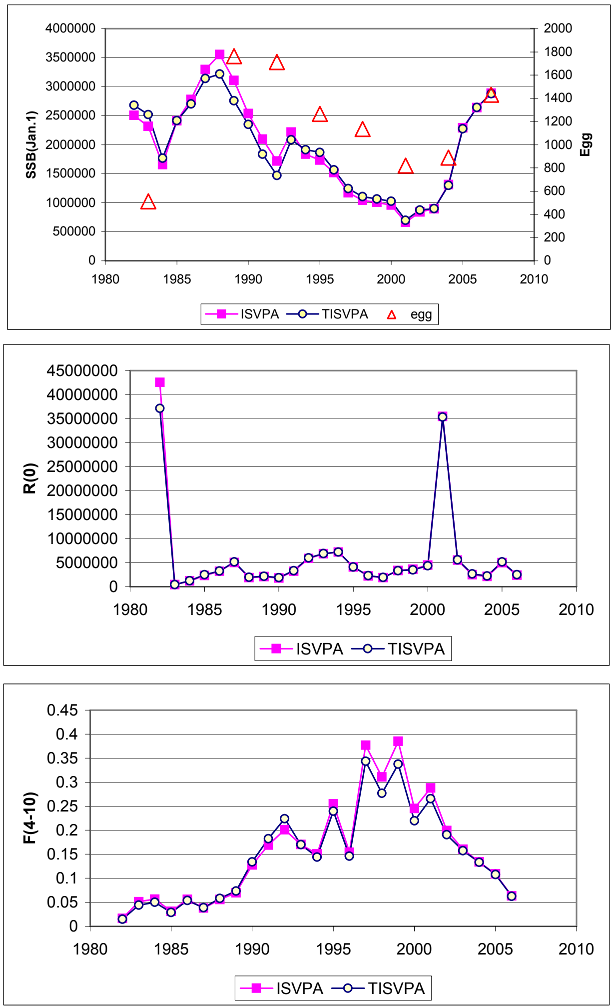
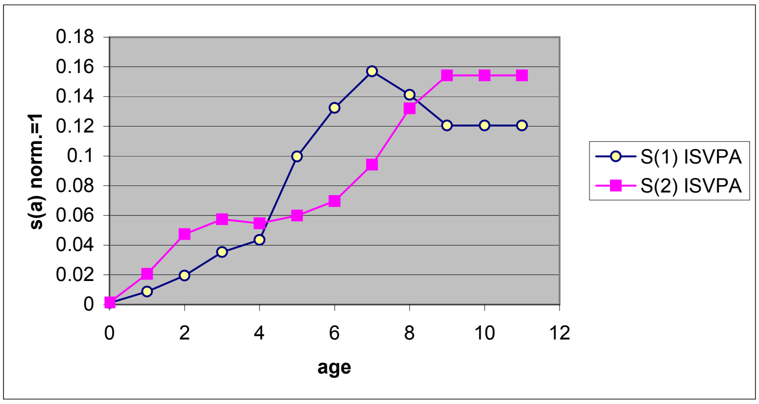


Figure 5.6.11. Western horse mackerel. SSB, R and F(4-10) from TISVPA and ISVPA. The triangles in the upper panel represent the Egg estimates.



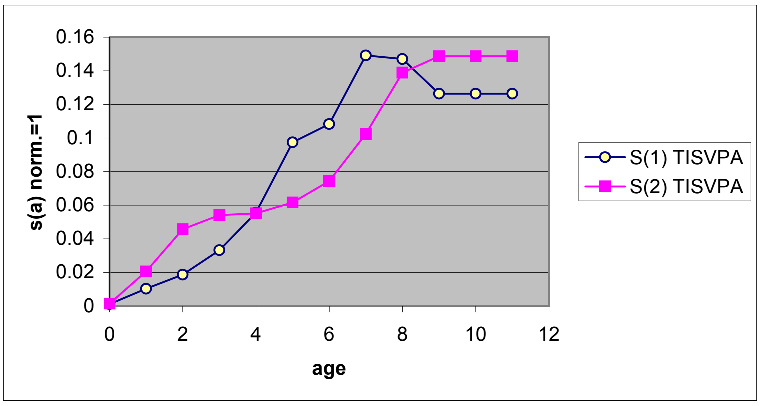


Figure 5.6.12 Western horse mackerel. Selectivity estimates in the two separable periods for ISVPA(upper panel) and TISVPA (lower panel). S(1) denotes the first separable period, while s(2) denotes the second separable periods.

6 Southern Horse Mackerel (Division IXa)

6.1 ICES advice applicable to 2006 and 2007

In 2006 ICES considered that the state of the stock was unknown. In the absence of a reliable assessment and precautionary reference points, the state of the stock cannot be evaluated.

Given the unknown state of the stock, fishing effort must not increase and catches in 2007 should not exceed the 2000-2004 average of around 25, 000 t. The reference period excludes 2003 because of the reduced effort as an effect of the "Prestige" oil spill.

The TAC for this stock should only apply to *Trachurus trachurus*.

6.2 The Fishery in 2006

Catches

The catches of horse mackerel in Division IXa (Subdivision IXa North, Subdivision IXa Central-North, Subdivision IXa Central-South and Subdivision IXa South) are allocated to the Southern horse mackerel Stock. In the years before 2004 the catches from Subdivisions VIIIc West and VIIIc East, were also considered to belong to the southern horse mackerel stock. These catches were already removed in 2004 to obtain the historical series of stock catches back to 1991 (Table 6.2.1 and Figure 6.2.1). However, the definition of the Subdivisions was set quite recently (ICES, 1992) and some of the previous catch statistics came from an area that comprises more than one Subdivision. This is the case of the Galician coasts where the Subdivisions VIIIc West and Subdivision IXa North are located. Further work is necessary to collect the catches by port and to distribute them by Subdivision. The time series is expected to go back in time until 1939 (Portuguese catches are available since 1927) during the next years.

The Spanish catches in Subdivision IXa South (Gulf of Cádiz) are available since 2002. They will not be included in the assessment data until de time series is completed, to avoid a possible bias in the assessment results. On the other hand, the total catches from the Gulf of Cádiz are scarce and represent less than the 5% of the total catch (2.6 % in 2006). Therefore, their exclusion should not affect the reliability of the assessment. The Portuguese catches range from 51% of the total catch of the stock in 2004 and 1998 to 89% in 1992 (Table 6.2.1). In 2006 the Portuguese catches were the 59.5 % of the total catch. The catch time series during the assessment period shows a decreasing trend since the peak reached in 1998 until 2003, when the lowest level of the time series was reached (Fig. 6.2.1). This low catch level was mainly due to the markedly decrease (-21%) observed in Portuguese catches as compared to the catch reported in 2002. The "Prestige" oil spill had also an effect in the fishery activities in the Spanish area in 2003. The catches in 2006 showed a slight increase of 6 % compared with those obtained in 2005 mainly due to the increase of the Portuguese catches in Subdivision IXa Central-South. In the assessment period the level of catches (excluding the catches from the Gulf of Cádiz) for this stock is about 26,000 (± 5,200) tonnes. The Spanish catches increased markedly from 1991 until 1998, whereas the Portuguese ones are more stable showing a smooth decreasing trend since the peak obtained in 1992 (with a secondary peak in 1998). Catches by Subdivision show a stable time series in Subdivisions IXa Central-South and IXa South. In Subdivisions IXa Central-North catches showed a decreasing trend whereas in Subdivision IXa North they increased markedly until 1998 (an outstanding catches = 20,000 t) and since then the catches were always higher than 7,000 t (Fig. 6.2.2). The catches from bottom trawlers are the majority in both countries (more than 60 %). The rest of the catches are taken by purse seiners (especially in the Spanish area) and by the artisanal fleet (more important in the Portuguese area).

Fishing fleets

The descriptions of the Portuguese fishing fleets operating in Division IXa and the Spanish fishing fleets operating in Division IXa (Southern stock) and Division VIIIc (Western stock) are shown in Tables 6.2.2 and 6.2.3, respectively.

The Spanish bottom trawl fleet operating in ICES Divisions VIIIc (Western stock) and Subdivision IXa north (Southern stock), historically relatively homogeneous, has evolved in the last decade (approximately since 1995) to incorporate several new fishing strategies. A classification analysis for this fleet between the years 2002 and 2004 was made based on the species composition of the individual trips (Castro and Punzón 2005). The analysis resulted in the identification of five catch profiles in the bottom otter trawl fleet: 1) targeting horse mackerel (>70% in landings), 2) targeting mackerel (>73% in landings); 3) targeting blue whiting (>40% in landings); 4) targeting demersal species; and 5) a mixed “metier”. In the bottom pair trawl fleet the classification analysis showed two métiers: 1) targeting blue whiting; and 2) targeting hake. These results should help in obtaining standardized and more coherent CPUE series from fishing fleets.

6.3 Biological data:

6.3.1 Catch in numbers at age

The sampling scheme is believed to achieve a good coverage of the fishery (about 96% of the total catch). The number of fish aged seems also to be sufficient through the historical series. Catch in numbers at age have been obtained by applying a quarterly ALK to each of the catch length distribution estimated from the samples of each Subdivision. In the case of Subdivision IXa north the catch in number estimates before 2003 have changed. In previous years the age length key applied to the length distributions from Subdivision IXa north had included otoliths from Division VIIIc, which has been defined recently as part of the Western stock. Since 2003 the catch in numbers at age from Subdivision IXa north were estimated using age length keys which included only otoliths from Division IXa. In the time series of the catch in numbers at age, the 1994 year class showed high catches at ages 11 and 12 and the 1996 year class appears to be conspicuous at juvenile ages (0, 1 and 2) and reappearing again at ages 8 and 10 (Table 6.3.1.1 and Figure 6.3.1.1). In general, catches are dominated by juveniles and young adults (ages 0 to 4).

6.3.2 Mean length and mean weight-at-age

Table 6.3.2.1 and Table 6.3.2.2 show the mean weight at age in the catch, and the mean length at age in catch respectively. They were calculated by applying the mean weighted by the catch over the mean weights at age or mean lengths at age obtained by Subdivision. The mean weight at age in the catch increased significantly in 2004 for the intermediate ages (3-9) when compared to the levels obtained in 2003 and were for the majority of these ages the highest of the historical series (Fig. 6.3.2.1). On contrary, in 2005 and 2006 the mean weight at age of these intermediate ages decreased. In parallel the mean length at age showed a smooth increase trend for those ages since 2002 with a decrease in 2005 and 2006 (table 6.3.2.2).

<u>Mean weight at age in the stock:</u> Taking in consideration that: the spawning season is very long, spawning is almost from September to June, and that the whole length range of the species has commercial interest in the Iberian Peninsula, with probably very scarce discards, there is no special reason to consider that the mean-weight in the catch is significantly different from the mean weight in the stock.

6.3.3 Maturity-at-age

For multiple spawners, such as horse mackerel, macroscopical analysis of the gonads cannot provide a correct and precise means to follow the development of both ovaries and testes. Histological analysis has to be included because it provides precise information on oocyte developmental stages and it can distinguish between immature gonads and regressing ones or those partly spawned (Abaunza et al., 2007a). The HOMSIR project provided microscopical maturity ogives from the different IXa subdivisions. The maturity ogive from Subdivision IXa South is adopted here as the maturity at age for all years of the southern stock, since it was based on a better sampling than in the others subdivisions. The percentage of mature female individuals per age group was adjusted to a logistic model with the following results (see the equation below and figure 6.3.3.1):

$Y = 1/(1 + \exp(-1 * ((-3.21055) + (2.3921) * X)));$

where Y is the proportion of maturity individuals at age X. This maturity ogive is in accordance with the values of age at first maturity estimated by Arruda (1984) in Portuguese waters.

6.3.4 Natural mortality

Natural mortality is considered to be 0.15, which is the same value as the used in previous years. This level of natural mortality was adopted all horse mackerel stocks since 1992 (ICES 1992/Assess: 17).

6.4 Fishery Independent Information and CPUE Indices of Stock Size

6.4.1 Trawl surveys

There are currently 2 bottom-trawl survey series that can be used for tuning the assessment: the Portuguese and Spanish October surveys. These surveys cover Sub-divisions VIIIc East, VIIIc West, IXa North (Spain) and Sub-divisions IXa Central-North, Central-South and South (Portugal) from 20-500 m depth. The Spanish survey was disaggregated by Subdivision in order to use the data from the subdivision IXa North which is part of the southern horse mackerel stock. The same sampling methodology was used in both surveys but there are differences in the gear design, as described in ICES (1991/G: 13). The Portuguese and the Spanish October survey indices are estimated for the whole range of distribution of horse mackerel in the area, which has been consistently sampled over the years.

The CPUE matrices from these surveys are shown in Table 6.4.1.1. In the Spanish September/October survey, the ages from 1 to 5 are almost absent (except in 1993 and 2004), whereas in the Portuguese survey the oldest adults are not well represented. The total number per haul is dominated by the catch of the incoming year classes in the two time series of surveys. In the Spanish survey appeared an outstanding year class in 2005 but its strength has not be confirmed at age 1 in 2006 (Table 6.4.1.1).

The two bottom-trawl surveys series, available to use as tuning data in the assessment, were joined as in the past. The weight given to each data set was proportional to the respective number of hauls, roughly 75% to the Portuguese data and 25% to the Spanish one (Table 6.4.1.2). The variances of the survey indices in each age and year were approximated by the following expression:

$var(I) = A^2 . var(Q) + Q^2 . var(A)$,

where A is the abundance index in each year and length class, and Q is the proportion of each age in each length class in the age-length keys applied to the survey data. The variance of A was calculated across all hauls in each year, and var(Q) = p . (1 - p) where p is the proportion of fish of a given length class that are in that age class in the age-length key.

Figure 6.4.1.1 shows the evolution of several year-classes in the combined data set. The patterns in the combined data show a coherent decreasing pattern for each year class.

6.4.2 Egg surveys

Recent work suggests that horse mackerel has indeterminate fecundity, which makes the Annual Egg Production Method (AEPM) unsuitable to estimate SSB for this species. For species with indeterminate fecundity, the Daily Egg Production Method (DEPM) must be used instead. The existence of different series of data from egg surveys covering the whole area of the southern horse mackerel stock, makes it possible to obtain egg production estimates using DEPM.

Work is ongoing to calculate SSB estimates from DEPM egg sampling directed at sardine in 2002 and 2005 (Vendrell et al, in prep.) and from horse mackerel adult samples collected at the same time of those surveys (Gonçalves et al., in prep). At this time, only the SSB estimate for 2002 is available. Also, in February 2007, the first DEPM survey directed at the southern stock of horse mackerel was carried out. Samples are being analysed and a SSB estimate will be available next year.

The 2002 DEPM SSB estimate was calculated as: SSB = P / (F . S . R) where P is the daily egg production for the total area, F is the female batch fecundity per tonne, S is the spawning fraction of females and R is the sex-ratio, taken here as a constant of 0.5. The variance of the SSB estimate was approximately calculated with the expression:

var(SSB)= (F.S.R)^-2 . var(P) + P^2 . (F^2.S.R)^-2 . var(F) + P^2 . (F.S^2.R)^-2 . var(S)

assuming that the covariances between P, F and S are zero.

The estimates obtained were:

P = 8.77e11; var(P) = 5.34e21

F = 171.5e6; var(F) = 534.5e12

S = 0.11; var(S) = 0.056,

and the final SSB estimate for 2002 was 92956t, with a CV of 216%.

6.5 Effort and Catch per Unit Effort

Useful statistics of Portuguese bottom trawl fleet were collected to monitor the state of the stock with a historic perspective. The time series of number of vessels and number of trips from this fleet are now available from 1937 to 1998 and 1991 respectively. The time series of the specific catch from this fleet is available from 1963 to 1998. During the period 1969-1978 there were outstanding high catches which were not in relation with the small increase in effort, suggesting an increase in the abundance of horse mackerel in that period. However, the effort showed an increasing trend since 60’ until 1987 (figure 6.5.1). In the future, it is expected to use this information with appropriate models (e.g. biomass dynamic models) to examine the dynamics of this stock through a large time series.

Looking at the historical series of the catches from Portugal and Spain (available since 1930 until now), it can be observed periods with significant higher catches (figures 6.5.2 and 6.5.3). However, it is clear that the current catch level is not abnormally low when compared with the catches of the first half of the 20th century. Instead, the catches from 1962-1978, appear exceptionally high when looking to the whole time series. Many hypotheses have been proposed to explain this pattern (Murta and Abaunza, 2000) and some of them could be tested in the next future with the analysis of the catch and effort data from the Portuguese bottom trawl fleet available since 1963.

Recently it has been presented a new CPUE at age series for southern horse mackerel stock (Abaunza et al., Working Document). This series corresponds to Marín bottom trawl fleet that operates mainly in Subdivision IXa North (Galicia, NW Spain). The effort series for this fleet is available from 1994 to 2006. Taking in consideration that the Horse Power of each vessel is now under revision, we have considered provisionally the number of fishing trips as the unit of effort. The number of vessels and the number of fishing trips showed a clear decreasing trend since 1997 until 2002, remaining at relatively low level since then. Length distributions of horse mackerel catches from this fleet by month are available from 1999 to 2005. It is expected to retrieve other years back in time in the future and the year 2006 in a short period of time. Age –length keys estimated by semester were applied to quarterly length distributions to obtain the catches at age. The CPUE data was obtained dividing the catch at age data by the number of fishing trips (Table 6.5.1). The figures of the CPUE at age (in logarithms) by cohort showed that the juvenile ages are very variable and the trend in young adult ages (from 3 to age 8) is null or even slightly positive indicating a possible immigration of those ages from other areas (figure 6.5.4) (Murta et al., 2007). Another explanation that could be proposed is that the fishing fleet target these intermediate ages. For the older ages (greater than 8 years old) the slopes are negative (Figure 6.5.4) showing that the fishing fleet could be useful in obtaining information on mortality for those ages. In any case, the time series is at the moment quite short and the analysis of the complete cohorts is not possible.

6.6 Recruitment forecast

No recruitment forecast was carried out.

6.7 State of the stock

6.7.1 Data exploration

Last year, an assessment was attempted using the "Extended Survivors Analysis" (XSA) (Darby and Flatman, 1994; Shepherd, 1999) which was the method used for the assessment of the southern horse mackerel stock since 1992. Since the correct delimitation of the stock boundaries in 2004 (Abaunza et al, 2007b), the XSA assessments started to provide less satisfactory diagnostics. As pointed out by the review group last year, the XSA assessment showed poor diagnostics, such as negative slopes for some age groups and the algorithm did not converge. With these problems in mind, this year a complete new approach was followed, using a statistical catch-at-age model - ASAP (Legault and Restrepo, 1998 - in the Annex 3 of this Report).

The ASAP model is a flexible, forward computing algorithm, which uses the optimisation method of automatic differentiation (Griewank and Corliss, 1991) to minimise an objective function based on likelihoods. The automatic differentiation routines were developed using the commercial package AD Model Builder (Otter Research). ASAP is currently used in many stock assessments in North American waters (e.g. red grouper, yellowtail flounder, Pacific sardine, Greenland halibut, Florida lobster and several cod stocks), being therefore a well tested methodology. ASAP differs from the virtual population analysis methods, such as XSA, in that:

(1) calculations proceed from the initial conditions to the present and into the future,

(2) the catch at age is not assumed to be known exactly,

(3) fishing mortality is separable but selection at age is allowed to change gradually over time,

(4) separate components of the fishery are treated independently,

(5) a stock recruitment relationship is required, and

(6) some parameters, which are assumed constant in XSA, such as the catchability coefficients associated with tuning indices, may be allowed to change over time.

The model begins in the first year of available data with an estimate of the population abundance at age. Recruitments are entered for each year as deviations from a Beverton and Holt model. These deviations can be constrained but for the present stock they were left unconstrained. The spawning stock for that year is calculated, and the expected recruitment for next year generated from the spawner-recruit relationship. Each cohort estimated in the initial population abundance at age is then reduced by the total mortality rate, and projected into the next year and next age. This process of estimating recruitment and projecting the population forward continues until the final year of data is reached.

The fishing mortality rates for each sector in the fishery are assumed to be separable into an age component (called selectivity) and a year component (called the F multiplier). The selectivity patterns are allowed to change over time as a random walk. Expected catches are computed according to the usual catch equation using the determined fishing mortality rate, the assumed natural mortality rate, and the estimated population abundance described above. The statistical fitting procedure used with the model will try to match the indices and the catch at age. The emphasis of each of these sources of information depends on the values of the relative weights assigned to each component by the user.

The minimization processes proceeds in phases in which groups of parameters are estimated simultaneously, while the remaining parameters are maintained at their initially assigned values. Once the objective function is minimized for a particular phase, more parameters are treated as unknown and added to those being estimated. This process of estimation in phases continues until all parameters to be estimated contribute to the objective function and the best set of all parameters that minimize the objective function value is determined.

The input file, for the application of the ASAP model to the southern horse mackerel stock, is in Table 6.7.1.1. Initial values were given for the log of virgin stock size, log of first year catchability and numbers at age in the first year. During the exploratory runs with the model it was evident that the model was extremely robust to changes in these initial values.

The separability in the fishing mortality was assumed during the whole time series, and one vector of selectivity was estimated for 1991 and kept fixed during the whole assessment period. This vector contained a selectivity parameter for each age, which were estimated independently from each other. Other runs were made, with selectivity parameters for more that one year, however despite this increase in the number of parameters, the selectivity surface did not change significantly. A F multiplier was estimated for the first year, and was allowed to change in time by estimating deviations to this parameter for each year. The fishing mortality at each age and year resulted from the product of the F multipliers by the selectivity parameter at each age.

Besides the catch data, this assessment has as tuning data the combined Portuguese-Spanish bottom-trawl survey. The ASAP method calibrates the survey indices with a combination of fleet-wise catchabilities and selectivities at age. For this assessment, the catchabilities were estimated for each age separately assuming a selectivity equal to that in the fishery, which is an option supported by the fact that most of the catches are taken by similar gears as those used in the bottom trawl surveys.

The model uses a series of arbitrary weights given to the different parts of the objective function (see details in Annex 3 of this Report). Several parts of the objective function were given a weight of 1 which in practice implies that these terms are neglected. These were the ones corresponding to the deviations of the F multipliers and of the recruitment, and it was verified in preliminary runs that changes to these weights had practically no influence in the fitting of the model. The parameter corresponding to the virgin stock size in the stock-recruitment relationship (SRR) was also estimated, but the steepness one was removed from the model, given that even with this parameter in the model, the SRR was completely flat.

The most important parts of the objective function to be minimised are the ones corresponding to:

1. Annual total catch assuming a log-normal distribution (expression 16 in Annex 3),
2. Annual proportions at age of the catches as numbers, assuming a multinomial distribution, (expression 17 in Annex 3)
3. Annual survey indices at age assuming a log-normal distribution (Expression 18 in Annex 3).

In exploratory runs it was verified that the fitting of the model was greatly dependent on the weight of these data sets relative to each other. Therefore, we have assigned a weight of 100 to the parts of the objective function corresponding to the total catch per year and to the proportion of catches at each age in each year (expressions 16 and 17 of the paper in Annex 3), and performed a sensitivity analysis to changes in weight of the part of the objective function corresponding to the abundance indices (expression 18 in Annex 3). Twelve runs were made with the same parametrisation, except for the weights given to the indices, that took the values 1, 5, 10, 20, 30, 50, 70, 100, 120, 150, 170, and 200. The trajectories of the SSB from these runs were compared (Figure 6.7.1.1) revealing robustness of the model to small changes of these weights. For weights ranging from 1 to 10 (therefore to a maximum of 10% of the survey weights relative to the catch data weights) the SSB shows a stable trajectory above 120000t. For weights between 20% and 70% of the ones given to the catches, the SSB shows a sharply decreasing trend, and also unlikely high values. For weights of the indices from 100% to 200% of those given to the catches, the SSB trajectory shows the same pattern in all runs, and becomes highly variable in time at a very low level.

Weights of 1 were given to the parts of the objective function corresponding to expressions 21 to 24 in Annex 3. Expressions 16 and 17 in Annex 3 had weight 100 and just the weight given to the part corresponding to expression 18 in Annex 3 was tested for sensitivity. In order to chose the best fit by comparing the values of the objective function from the different runs, an unweighted objective function (UOF) was calculated as:

$$UOF = OF - L1 - L2 - L3 + L1/100 + L2/100 + L3/W$$

were OF is the value of the objective function, L1, L2 and L3 correspond to the values obtained for the parts of the objective function corresponding to expressions 16, 17 and 18 in the Annex 3, respectively, and W was the weight given to expression 18 in Annex 3 in a given run. The values of the UOF obtained for each run are in Table 6.7.1.2, showing a minimum (therefore the best fit) that corresponds to a weight of 5 given to the survey data. This is just the slightly best fit, in a range of values that give very similar results. A relative weighting of the survey data with a weight less that 10% of those given to the catch data, fits well with empirical observations that the surveys have an interannual variability, probably due to poorly known aspects of the biology of the species. The catch data seem less prone to bias or variability, since they are obtained with a high sampling effort, and there are series of data from on board observers that point out to a very low level of discards (unpublished).

The output file of the assessment corresponding to the best fit of the model is shown in Table 6.7.1.3. A total of 69 parameters were estimated, some of which were fixed relatively to each other. The correlation matrix between the remaining parameters is shown in Figure 6.7.1.2. Most parameters are uncorrelated. There are some clusters of weakly correlated parameters but none of these are detrimental for the fitting of the model.

The overall adjustment of the model to the total catch data is very good (Figure 6.7.1.3), while the fitting to the catch proportions at age also shows small residuals, ranging from -0.14 to 0.23, without noticeable patterns (Figure 6.7.1.4). The residuals from the survey indices are higher (ranging from -3 to 3), with some year effects (mostly negative or positive residuals in a given year), such as in 1998, 1999 and 2005 (Figure 6.7.1.5).

6.7.2 Stock assessment

The numbers at age in the stock, estimated in the assessment, are shown in Table 6.7.2.1 and in the plot of Figure 6.7.2.1. Figure 6.7.2.2 shows the recruitment estimates in each year. In those figures it is clear the strong year class of 1996, and strong year classes in two of the most recent years (2004 and 2005). These recent strong recruitments are likely responsible for the increase in SSB that is shown in Figure 6.7.2.3 (upper panel). In that figure it is also marked the SSB estimate for 2002 from the daily egg production method (DEPM). This estimate is slightly below the SSB estimate from the assessment, however, the DEPM estimate does not take into account the biomass in the Spanish area (ICES subdivision IXa North) because no egg samples were available from there. Therefore, it is likely that without that bias, the DEPM SSB estimate would be at the same level or slightly above the SSB estimate from the assessment. Nevertheless this agreement between two independent estimates supports the idea that the real level of SSB must be close to the values obtained by the assessment.

In Figure 6.7.2.3 (lower panel) it is also shown the variation in fishing mortality during the assessment period. There is a high peak in 1998, caused by shortage of sardine in the Spanish area, which made the fishermen to turn to horse mackerel and raised the catches to the double of the current level. For the most recent years, the total fishing mortality seems to be stable at a level around 0.16/year. Table 6.7.2.2 shows the fishing mortality rates at age in each year, which are also plotted in Figure 6.7.2.4.

The selectivity surface estimated by the model is shown in Figure 6.7.2.5. The selectivity at age shows a depression at the age range 5 to 8, which is a well-known pattern observed in different data sets from this stock, but which is difficult to explain by taking into account the fishing practice. The catchabilities at age estimated for the survey data are shown in Figure 6.7.2.6.

6.7.3 Reliability of the assessment

The stock assessment is based on a matrix of catch at age data and another of abundance indices from bottom-trawl surveys. The catch data is believed to be accurate, given the large number of samples, the good spatial and temporal coverage of the landings and the lack of discards and black landings (horse mackerel usually has a market price good enough to avoid discarding but not so high as to motivate black landings). Although horse mackerel is usually labeled as a pelagic species, the fact is that most of the catches in Iberian waters are taken by bottom-trawl. The association of this species with the sea floor (e.g. Lloris and Moreno, 1995; Murta et al, 2007) is much higher than that of other typically pelagic fish, such as scombrids or tunnids. Therefore, abundance data from bottom-trawl surveys, although variable over the years, seem to provide estimates reliable enough to be used in the assessment. That is also supported by the signal along the year classes shown in Figure 6.4.1.1.

The survey residuals indicate some quite strong year-effects for example in 2005, which will reduce the precision of the estimates for the most recent years. A retrospective analysis, done by removing sequentially the last 3 years from the assessment, is shown in Figure 6.7.3.1. This figure shows a pattern that divides the assessments including the years 2005 and 2006 from the ones done just to 2003 and 2004. The latest assessments seem to revise the SSB to a higher level and the fishing mortality to a lower level than the assessments done with a smaller data series. Although this is a conservative pattern in terms of the hypothetical advice for management, it is difficult to explain regarding the modelling of the stock dynamics. According to the perception of the stock given by the latest assessment, the stock seems to have increased sharply, both in numbers and biomass, since 2004. It is possible that this sudden increase in abundance may have provoked this overall change in the perception of the SSB and F trajectories given by the model. The strong year-effect in 2005 can also be responsible for this pattern.

There is one DEPM estimate of SSB for 2002. This was not used in the assessment, nevertheless the estimate of SSB from the assessment is close to the DEPM estimate.

6.8 Short-term catch predictions

Short-term predictions were carried out by fixing a TAC at the current catch level (24000t) and assuming a constant recruitment at the same level as the geometric mean of the recruitments from 1991 to 2005 (615.89e6 individuals). The input data for the short term predictions are shown in Table 6.8.1. The outputs (Table 6.8.2) indicate that in these conditions the SSB would increase roughly by 11.5% from 2007 to 2009. When setting the F in 2008 at status quo level, the increase in SSB in 2009 would be only about 5% in comparison with the SSB in 2007. The SSB would decrease in 2009, comparing with the levels from 2007, if F multipliers higher than 1.2 are applied during 2008.

6.9 Management considerations

This stock has supported a more or less stable exploitation level for a long time period. The assessment indicates an increase in biomass, linked to two strong recruitments in recent years (2004, 2005). However, the real strength of these recruitments is still uncertain until the year class reaches at least the age of 2-3 years. Therefore, to keep the current catch level seems to be most adequate option.

Table 6.2.1. Time series of southern horse mackerel historical catches by country (in tonnes).

	Country		
Year	Portugal (Subdivisions: IX a central north; IXa central south and IXa south)	Spain (Subdivisions IXa North and IXa south*)	Total Catch
1991	17,497	4,275	21,772
1992	22,654	3,838	26,492
1993	25,747	6,198	31,945
1994	19,061	6,898	25,959
1995	17,698	7,449	25,147
1996	14,053	8,890	22,943
1997	16,736	10,906	27,642
1998	21,334	20,230	41,564
1999	14,420	13,313	27,733
2000	15,348	11,812	27,160
2001	13,760	11,152	24,910
2002	14,270	8,236 // (9,393)*	22,506 // (23,663)*
2003	11,242	7,645 // (8,324)*	18,887 // (19,566)*
2004	11,875	11,377 // (11,702)*	23,252 // (23,577)*
2005	13,307	9,388 // (9,804)*	22,695 // (23,111)*
2006	14,607	9,295 // (9,951)*	23,902 // (24,558)*

(*) In parenthesis: the Spanish catches from Subdivision IXa south are also included. These catches are only available since 2002 and they will not be considered in the assessment data until the rest of the time series be completed.

Table 6.2.2.- Description of the Portuguese fishing fleets that catch horse mackerel in Division IXa (only trawlers and purse seiners). Note that horse mackerel is also caught in all polyvalent and most small scale fisheries.

Gear	Length	Storage	Number of boats
Trawl	10-20	Freezer	2
Trawl	20-30	Freezer	7
Trawl	30-40	Freezer	5
Trawl	0-10	Other	259
Trawl	10-20	Other	68
Trawl	20-30	Other	60
Trawl	30-40	Other	29
Purse seine	0-10	Other	79
Purse seine	10-20	Other	103
Purse seine	20-30	Other	79

Table 6.2.3.- Description of the Spanish fishing fleets that catch horse mackerel in Division IXa (sourthern horse mackerel stock) and in Division VIIIc (Western horse mackerel stock). It is indicated the range and the arithmetic mean (in parenthesis). Legends of gear type: Trawl 1 = Bottom trawl; Trawl 2 = Pair trawl; Artisanal 1 = Hook; Artisanal 2 = Gillnet; Artisanal 3 = Others artisanal. Data from official census.

Length Category	Engine power category	Gear	Storage	Discard estimates	Number of vessels
16 - 33 (28)	200 - 800 (442)	TRAWL	Dry hold with ice	NO	134
8 - 38 (22)	16 - 1100 (333)	PURSE SEINE	Dry hold with ice	NO	341
5 - 44 (20)	5 - 878 (250)	ARTISANAL 1	Dry hold with ice	NO	246
4 - 27 (15)	9 - 425 (131)	ARTISANAL 2	Dry hold with ice	NO	100
2 - 27 (6)	4 - 450 (29)	ARTISANAL 3	Dry hold with ice	NO	5513

Table 6.3.1.1 Southern horse mackerel. Catch in numbers at age. Numbers in thousands.

	AGES															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1991	13914	72287	15701	7725	7182	10684	7133	8453	8333	19754	12079	9346	5765	4015	1763	522
1992	11966	102521	160026	43207	12516	10030	5615	7672	5633	4902	13783	4700	3409	1924	1213	1846
1993	5121	73007	154366	98963	34999	13410	13128	10972	6080	4317	3878	9537	1286	565	436	1741
1994	11943	54418	76970	95856	30476	8115	4567	3213	4646	3176	5534	2234	1579	1763	1266	3436
1995	6241	58241	28682	52856	28399	11225	4068	3124	2536	3496	2490	5251	6852	9705	3704	5677
1996	40207	12439	12449	27937	37498	11584	8353	5834	4148	10065	4481	4170	4808	3253	1109	4049
1997	3770	304637	115808	25895	17418	12323	7532	5259	4131	3393	2013	1957	1560	2065	2225	3042
1998	19023	54319	328147	84414	18308	11144	9281	21127	16389	7877	6562	3136	2624	3377	1849	4560
1999	39363	30615	26945	62894	42044	16994	16382	7464	4093	6772	3751	2874	3221	1429	847	3305
2000	9821	56973	31437	37675	35549	17438	20611	14007	7868	6323	4353	966	1497	1499	1261	2675
2001	107632	76414	28214	32098	27406	16641	14151	13436	8513	3488	4887	3062	1591	2053	272	1492
2002	17826	86185	95747	27782	12360	10982	9151	9996	8897	8910	5199	3103	1452	1673	1061	1071
2003	37403	5268	34426	33693	23880	13535	11363	10853	9847	7403	4994	1696	1485	491	69	2134
2004	6689	111702	51898	20474	10655	15629	12927	15350	10223	3582	5132	591	1508	214	438	2505
2005	27753	104789	46912	23480	18274	12407	11641	8217	8729	6514	4920	5062	2145	1417	1485	1700
2006	2892	84591	99525	23228	7139	12800	11318	6552	7632	8118	8852	4914	3779	2071	1834	2263

Table 6.3.2.1. Southern horse mackerel. Mean wight at age in the catch

	AGES															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1991	0.026	0.036	0.073	0.101	0.122	0.153	0.170	0.179	0.210	0.217	0.221	0.215	0.256	0.296	0.398	0.374
1992	0.032	0.034	0.044	0.067	0.104	0.131	0.148	0.172	0.187	0.200	0.232	0.258	0.280	0.324	0.331	0.416
1993	0.023	0.029	0.038	0.066	0.089	0.130	0.166	0.208	0.243	0.243	0.253	0.269	0.319	0.341	0.369	0.413
1994	0.040	0.036	0.063	0.069	0.091	0.131	0.157	0.193	0.225	0.248	0.272	0.286	0.343	0.336	0.325	0.380
1995	0.036	0.035	0.060	0.083	0.097	0.124	0.164	0.168	0.200	0.222	0.230	0.255	0.284	0.292	0.331	0.391
1996	0.022	0.049	0.070	0.087	0.112	0.140	0.172	0.186	0.216	0.239	0.258	0.264	0.293	0.275	0.362	0.380
1997	0.028	0.031	0.051	0.073	0.112	0.138	0.166	0.200	0.236	0.264	0.255	0.288	0.324	0.332	0.348	0.443
1998	0.028	0.031	0.039	0.067	0.102	0.127	0.169	0.212	0.170	0.245	0.251	0.270	0.290	0.315	0.364	0.447
1999	0.022	0.040	0.060	0.084	0.108	0.140	0.163	0.191	0.217	0.249	0.271	0.284	0.300	0.321	0.397	0.474
2000	0.024	0.035	0.053	0.087	0.111	0.134	0.160	0.188	0.220	0.235	0.252	0.275	0.283	0.321	0.324	0.339
2001	0.024	0.029	0.067	0.083	0.087	0.131	0.157	0.183	0.199	0.232	0.241	0.281	0.279	0.306	0.330	0.428
2002	0.027	0.030	0.044	0.069	0.097	0.124	0.147	0.168	0.196	0.226	0.246	0.270	0.311	0.322	0.341	0.409
2003	0.022	0.033	0.045	0.063	0.088	0.124	0.146	0.179	0.204	0.235	0.254	0.280	0.299	0.318	0.440	0.344
2004	0.039	0.028	0.047	0.084	0.120	0.159	0.184	0.209	0.228	0.254	0.266	0.268	0.284	0.274	0.370	0.361
2005	0.019	0.026	0.043	0.072	0.115	0.148	0.167	0.183	0.22	0.241	0.253	0.281	0.284	0.309	0.286	0.412
2006	0.029	0.029	0.045	0.063	0.093	0.125	0.140	0.167	0.194	0.225	0.249	0.290	0.309	0.363	0.386	0.399

Table 6.3.2.2. Southern horse mackerel. Mean length at age in the catch

	AGES															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1991	13.31	13.57	20.56	23.62	25.14	26.93	28.13	28.37	29.58	29.67	30.17	29.67	31.50	31.83	36.12	35.68
1992	14.93	15.59	17.47	19.84	23.18	25.79	27.38	28.65	29.60	31.15	31.53	32.64	33.28	33.93	34.70	36.81
1993	13.96	15.54	17.41	18.89	21.28	28.23	29.56	31.09	31.70	31.66	32.05	32.45	34.08	34.72	35.81	37.18
1994	13.37	14.58	18.11	21.08	22.66	24.76	27.01	29.53	31.15	31.71	32.38	32.19	33.27	34.17	34.37	36.46
1995	16.04	15.44	19.88	21.77	23.12	24.49	28.64	26.54	30.14	30.90	31.61	32.61	33.95	33.99	35.23	36.94
1996	13.29	18.99	19.68	21.82	24.68	26.32	28.02	28.56	30.34	30.74	31.47	31.95	33.42	32.54	36.15	37.00
1997	13.36	15.81	18.89	20.72	24.27	26.30	27.62	29.46	31.15	32.40	31.88	33.05	34.64	34.82	35.45	38.54
1998	14.49	13.92	15.92	20.45	23.51	25.52	28.31	30.31	26.86	31.69	31.98	32.73	33.44	34.54	36.45	39.08
1999	13.41	16.39	18.97	22.27	24.48	26.20	27.51	28.98	30.29	31.70	32.69	33.26	33.88	34.74	37.31	39.59
2000	13.61	16.37	18.43	21.68	24.76	26.00	27.23	28.57	30.22	30.80	31.52	32.28	32.66	34.23	34.49	34.99
2001	14.11	15.62	20.24	21.85	22.46	25.44	27.36	28.73	29.59	30.85	31.18	32.98	32.84	33.99	34.73	38.23
2002	15.05	15.69	17.51	20.34	23.06	25.38	26.60	28.01	29.58	30.86	31.76	32.60	34.20	34.68	35.43	36.88
2003	13.00	15.72	18.75	20.70	23.14	26.08	26.73	29.19	30.00	31.21	31.96	32.90	33.55	33.93	38.86	35.31
2004	16.17	14.43	17.23	21.17	24.04	26.67	28.08	29.40	30.47	31.62	32.29	32.23	33.05	32.25	36.37	35.88
2005	12.50	13.93	16.62	20.08	23.54	25.92	27.12	28.09	30.02	31.14	31.64	32.79	32.58	33.55	32.59	37.22
2006	14.61	14.66	17.04	19.21	22.21	24.62	25.63	27.21	28.72	30.33	31.48	33.22	34.00	35.86	36.70	37.00

Table 6.4.1.1. Sourthern horse mackerel. CPUE at age from bottom trawl surveys

Portuguese October Survey

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1991	368.430	31.460	20.500	16.410	13.540	5.730	1.920	1.360	1.440	1.920	1.000	0.740	0.380	0.090	0.020	0.040
1992	225.530	686.050	159.250	38.330	24.190	13.010	8.210	6.160	4.540	3.850	6.970	2.160	1.370	0.390	0.220	0.070
1993	1505.320	268.640	338.760	167.840	34.350	5.500	3.550	3.420	0.790	1.290	0.860	2.240	0.580	0.380	0.090	0.080
1994	4.150	7.780	59.970	47.330	14.430	3.230	0.720	1.670	0.740	0.490	0.320	0.130	0.040	0.000	0.000	0.010
1995	12.360	33.940	88.960	125.380	41.330	10.760	1.790	0.750	0.320	0.230	0.170	0.420	0.450	0.640	0.230	0.170
1996*	1591.830	9.310	13.850	19.970	18.650	4.470	2.060	0.680	0.200	0.120	0.050	0.080	0.050	0.050	0.010	0.010
1997	1913.820	72.040	95.550	23.720	41.940	34.190	11.130	7.080	5.010	3.940	2.090	0.930	0.170	0.180	0.120	0.130
1998	39.940	50.810	90.790	71.330	2.720	2.810	1.860	1.070	0.540	0.290	0.140	0.020	0.000	0.000	0.000	0.000
1999*	185.070	24.980	42.110	47.770	4.280	1.420	0.750	0.190	0.050	0.080	0.020	0.000	0.000	0.010	0.000	0.000
2000	1.460	13.910	18.470	24.500	14.030	7.590	4.440	1.190	0.440	0.130	0.030	0.010	0.000	0.000	0.000	0.000
2001	903.470	43.370	5.650	25.550	98.920	9.140	10.270	13.990	7.490	3.340	1.840	0.320	0.180	0.180	0.010	0.000
2002 [1]	28.730	1.920	9.930	13.960	10.370	5.450	1.800	1.270	0.860	0.520	0.990	0.320	0.230	0.110	0.050	0.030
2003*	74.760	9.490	9.150	16.290	14.680	4.640	2.350	1.350	0.890	0.530	0.240	0.010	0.010	0.010	0.000	0.000
2004	119.300	38.380	206.490	20.350	7.490	4.750	2.800	6.300	5.050	0.550	0.080	0.000	0.000	0.000	0.000	0.000
2005	1924.500	22.200	56.400	8.200	7.200	30.700	22.500	6.400	2.300	0.550	0.220	0.180	0.130	0.020	0.080	0.000
2006	93.113	95.228	253.400	63.136	3.757	12.107	8.745	7.192	2.925	1.605	0.727	0.157	0.044	0.000	0.000	0.000

Spanish October Survey (only Subdivision IXa North)

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1991	0.146	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.878	1.860	0.782	0.829	2.734	1.438	1.699	1.812
1992	6.575	0.000	0.000	0.000	0.092	0.000	0.011	0.200	0.181	0.300	3.386	1.553	1.919	1.086	0.302	2.246
1993	92.068	1.652	5.164	3.945	0.354	0.000	1.152	5.175	5.724	8.721	5.228	10.801	2.235	1.646	0.415	0.958
1994	0.148	0.000	0.477	0.000	0.000	0.000	0.000	0.191	0.574	1.432	2.631	0.191	16.133	12.757	1.255	6.413
1995	0.092	0.000	0.000	0.001	0.000	0.003	0.018	0.018	0.339	0.175	0.761	2.534	3.967	8.751	2.450	2.203
1996	33.649	0.000	0.000	0.000	0.000	0.026	0.260	0.348	0.903	2.708	0.564	0.447	1.838	2.561	1.001	4.410
1997**	2.033	0.007	0.000	0.000	0.016	0.126	0.248	0.980	1.158	1.711	0.779	0.235	0.259	0.800	1.098	2.617
1998	0.976	0.000	0.000	0.000	0.000	0.000	0.134	0.926	0.540	0.253	0.146	0.043	0.078	0.126	0.041	0.163
1999	0.041	0.000	0.000	0.000	0.000	0.000	0.170	0.270	0.630	2.175	3.168	2.597	4.653	1.939	1.633	0.286
2000	0.478	0.000	0.000	0.000	0.000	0.005	0.374	2.792	3.686	3.241	0.721	0.578	0.427	0.537	0.294	0.719
2001	12.742	2.857	0.000	0.000	0.000	0.190	0.411	2.544	4.412	4.127	3.151	1.793	0.998	0.930	0.122	0.312
2002	0.143	0.000	0.000	0.000	0.000	0.000	0.594	1.240	7.291	7.091	8.949	10.386	3.540	4.463	1.336	2.295
2003	8.775	0.000	0.000	0.000	0.000	0.026	0.061	0.194	0.110	0.810	0.880	0.348	0.222	0.119	0.067	0.917
2004	89.967	1.191	2.500	16.218	5.390	4.599	1.710	1.306	0.653	0.290	0.797	0.100	0.350	0.044	0.056	0.070
2005	3520.441	0.045	0.000	0.000	0.348	0.409	0.259	0.252	0.515	0.479	0.140	0.637	0.288	0.194	0.099	0.045
2006	28.401	0.096	0.035	0.114	0.061	0.072	0.044	0.027	0.041	0.075	0.155	0.192	0.256	0.159	0.030	0.218

***** The surveys were carried out with a different vessel

****** Since 1997 another stratification design was applied in the Spanish surveys

[1] In 2002 started a new series in which the duration of the trawling per haul has changed from one hour to thirty minutes

Table 6.4.1.2. Southern horse mackerel. Historical series of catch in numbers at age from combined survey

	AGE											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1991	239.488	26.812	15.434	15.997	18.804	8.843	4.923	2.663	3.280	2.769	1.202	3.408
1992	393.326	426.216	136.692	47.657	21.246	8.260	5.571	5.865	3.135	2.672	4.384	3.530
1993	1572.099	208.846	210.581	129.730	30.606	4.010	2.622	2.748	2.262	3.132	1.892	6.204
1994	3.087	7.658	53.061	48.424	20.156	4.982	2.250	1.584	0.897	0.771	0.917	9.322
1995	17.196	67.875	97.226	58.918	26.238	4.977	1.028	1.206	0.457	0.224	0.369	6.179
1996	1218.356	8.506	13.843	22.368	22.479	4.263	1.785	0.770	0.472	0.812	0.188	2.781
1997	980.466	69.120	114.142	34.053	55.395	32.084	6.551	5.401	2.347	2.758	1.044	1.637
1998	87.060	36.681	103.084	14.924	5.539	3.075	1.684	1.874	0.391	0.112	0.059	0.153
1999	110.423	23.484	44.143	52.022	4.367	1.503	0.831	0.258	0.205	0.616	0.812	2.789
2000	2.752	17.029	22.907	25.744	12.525	6.990	3.705	1.800	1.481	0.887	0.221	0.732
2001	548.288	1.580	3.531	2.776	3.834	5.495	6.700	11.107	6.807	2.884	1.816	1.675
2002	31.224	1.976	6.640	10.927	8.694	4.474	1.559	1.256	2.470	2.161	2.999	6.107
2003	64.038	7.856	7.880	15.252	13.568	3.881	2.120	1.341	0.849	0.676	0.420	0.439
2004	69.801	29.798	106.122	45.471	10.026	4.888	2.194	4.755	5.947	0.986	0.386	0.174
2005	1167.742	1106.410	177.905	60.788	29.960	13.028	15.269	15.511	11.961	6.267	3.785	10.878
2006	76.935	71.445	190.059	47.381	2.833	9.098	6.570	5.401	2.204	1.222	0.584	0.365

Table 6.4.1.3. Southern horse mackerel. Coefficient of variation of the abundance indices from the combined survey.

	AGE											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1991	3.683	3.725	3.488	3.027	3.208	3.400	2.979	3.582	3.327	2.893	2.220	0.689
1992	2.956	3.148	2.081	2.237	2.097	2.388	2.853	2.546	2.968	2.858	2.337	1.120
1993	1.883	2.027	1.619	1.495	1.970	2.610	3.279	1.331	1.110	1.007	1.182	0.894
1994	2.726	4.312	3.478	2.230	2.317	2.726	3.007	4.472	2.341	1.801	0.835	0.050
1995	3.561	5.326	4.911	2.308	2.416	3.194	3.538	5.822	2.653	2.962	1.580	0.297
1996	2.903	2.621	3.161	2.500	2.162	2.604	3.250	2.658	1.745	0.580	1.164	0.221
1997	3.263	3.835	2.480	2.811	3.593	4.400	6.856	5.844	5.801	5.866	5.694	0.772
1998	2.881	3.984	6.340	5.423	2.994	3.383	3.890	2.993	3.129	3.221	2.928	1.419
1999	2.767	3.303	3.421	3.197	4.361	2.591	2.576	2.512	1.062	0.470	0.115	0.033
2000	4.187	5.846	4.810	5.150	2.790	4.005	4.982	2.291	1.584	0.419	0.831	0.442
2001	2.994	2.326	3.522	3.521	2.941	3.511	2.965	3.481	3.343	2.766	2.354	1.299
2002	6.720	6.378	4.717	4.544	4.627	4.680	3.233	2.589	1.385	1.348	1.267	0.334
2003	6.324	4.321	3.722	4.219	4.494	2.391	3.425	3.436	2.736	2.016	1.627	0.289
2004	2.217	3.875	3.497	3.253	3.163	2.458	2.476	4.117	4.950	4.554	3.312	1.310
2005	0.888	2.719	3.623	4.818	5.752	3.588	3.216	4.128	3.885	4.109	4.190	2.689
2006	3.630	3.458	2.705	2.903	6.664	6.669	7.232	8.026	3.864	3.461	3.305	1.975

Table 6.5.1. Southern horse mackerel. Marín bottom trawl fleet. CPUE at age time series.

	Age															
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
1999	0.001	1.360	6.300	23.553	28.662	29.119	27.787	18.919	12.381	17.313	10.097	7.069	9.688	4.362	2.676	4.503
2000	0.000	0.002	0.436	3.970	10.715	9.484	36.772	89.936	79.794	60.716	12.658	11.002	7.062	6.660	2.929	4.620
2001	1.034	1.071	8.334	15.324	14.187	57.378	114.489	181.163	158.618	111.662	81.657	47.366	28.695	19.487	1.326	3.477
2002	0.000	54.004	35.769	20.005	7.158	8.001	46.143	86.064	177.139	111.396	57.724	45.110	11.976	17.099	3.744	5.998
2003	0.000	0.003	0.171	0.186	0.628	13.429	29.377	77.771	94.658	100.433	85.274	25.255	14.039	5.972	0.159	25.156
2004	6.364	49.687	17.695	110.186	52.609	55.791	47.621	67.870	52.579	18.749	41.416	3.948	11.387	1.749	0.859	10.115
2005	1.302	40.004	29.336	36.787	36.736	24.976	29.493	39.253	67.946	58.202	41.397	41.823	11.668	9.765	3.349	2.366

Table 6.7.1.1. Southern horse mackerel. Input file for the ASAP assessment.

```
# Southern horse mackerel - Assess 2007
# Number of Years
16
# First Year
1991
# Number of Ages
12
# Natural Mortality Rate by Age
0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15
# Fecundity Option
0
# Maturity Vector
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
0.04 0.31 0.83 0.98 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
# Weight at Age Vector
0.030 0.040 0.070 0.100 0.120 0.150 0.170 0.180 0.210 0.220 0.220 0.260
0.030 0.030 0.040 0.070 0.100 0.130 0.150 0.170 0.190 0.200 0.230 0.300
0.020 0.030 0.040 0.070 0.090 0.130 0.170 0.210 0.240 0.240 0.250 0.300
0.040 0.040 0.060 0.070 0.090 0.130 0.160 0.190 0.230 0.250 0.270 0.340
0.040 0.030 0.060 0.080 0.100 0.120 0.160 0.170 0.200 0.220 0.230 0.310
0.020 0.050 0.070 0.090 0.110 0.140 0.170 0.190 0.220 0.240 0.260 0.310
0.030 0.030 0.050 0.070 0.110 0.140 0.170 0.200 0.240 0.260 0.260 0.360
0.030 0.030 0.040 0.070 0.100 0.130 0.170 0.210 0.170 0.240 0.250 0.350
0.020 0.040 0.060 0.080 0.110 0.140 0.160 0.190 0.220 0.250 0.270 0.360
0.020 0.030 0.050 0.090 0.110 0.130 0.160 0.190 0.220 0.240 0.250 0.310
0.020 0.030 0.070 0.080 0.090 0.130 0.160 0.180 0.200 0.230 0.240 0.310
0.030 0.030 0.040 0.070 0.100 0.120 0.150 0.170 0.200 0.230 0.250 0.310
0.020 0.030 0.050 0.060 0.090 0.120 0.150 0.180 0.200 0.230 0.250 0.310
0.040 0.030 0.050 0.080 0.120 0.160 0.180 0.210 0.230 0.250 0.270 0.330
0.020 0.030 0.040 0.070 0.120 0.150 0.170 0.180 0.220 0.240 0.250 0.300
0.029 0.029 0.045 0.063 0.093 0.125 0.140 0.167 0.194 0.225 0.249 0.331
# Number of Fleets
1
#$FLEET-1
# Selectivity Start Age
1
# Selectivity End Age
12
# Selectivity Est. Start Age
1
# Selectivity Est. End Age
12
# Release Mortality
0.0
# Number of Selectivity Changes by Fleet
1
# Selectivity Change Years
1991
# Fleet 1 Catch at Age - Last Column is Total Weight
13914.47  72287.35  15701.39  7724.97  7181.56  10684.24  7132.64  8453.47  8332.73  19753.56
12079.02
21410.32 21772
11966.1  102521.3  160026  43207.34  12515.83  10030.33  5614.63  7672.17  5632.59  4902.14
13783.05
13091.18 26492
5120.87 73006.98 154366.1 98962.86 34998.91 13409.78 13127.59 10972.2 6080 4317.14 3877.59
13565.24 31945
11942.95  54418.05  76970.17  95856.36  30475.72  8114.91  4566.51  3212.77  4645.86  3176.19
5533.67
10276.61 25959
6241.02  58241.15  28681.81  52855.91  28398.69  11224.69  4067.52  3124.37  2535.53  3495.73
2490.34
```

```
31189.85 25147
40206.93  12438.59  12448.79  27936.64  37498.01  11583.69  8353.17  5833.82  4147.7  10064.86
4481.16
17388.61 22943
3769.98 304637.4 115808 25895.09 17418.13 12322.8 7532.07 5258.81 4130.63 3392.52 2013.3
10849.11 27642
19023  54318.57  328147.3  84414.29  18307.78  11143.63  9280.81  21126.83  16389.04  7877.01
6562.28
15545.79 41564
39362.65  30615.37  26945.29  62893.68  42044.15  16994.34  16382.47  7463.94  4092.5  6771.66
3750.55
11676.32 27733
9820.62  56973.06  31436.55  37675.42  35548.98  17438.25  20611.07  14007.04  7867.87  6323.12
4353.17
7897.59 27160
107631.7  76414.47  28214.07  32098.01  27406.11  16641.46  14150.83  13435.57  8513.13  3488.1
4887.41
8471.02 24910
17825.66  86184.94  95747.4  27782.18  12359.88  10982.44  9150.89  9996.38  8896.98  8910.22
5199.22
8360.11 22506
37402.73  5268.2  34425.92  33693.27  23879.58  13534.56  11362.57  10853.4  9847.19  7403.18
4994.16
5875 18887
6688.61  111701.8  51898.13  20474.01  10654.99  15628.59  12926.61  15350.34  10222.95  3581.72
5132.21
5254.86 23252
27753.01  104789  46911.74  23480.13  18274.19  12407.44  11641.49  8216.84  8729.11  6513.76
4919.75
11808.4 23111
2891.89  85207.35  97313.14  22986.05  7253.69  12740.64  11134.39  6626.32  7696.12  8147.34
8832.33
14628.47 23902
# Fleet 1 Discards at Age - Last Column is Total Weight
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
# Fleet 1 Proportion Released at Age
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
# Number of Indices
12
#$INDEX-1
#$INDEX-2
#$INDEX-3
#$INDEX-4
#$INDEX-5
#$INDEX-6
#$INDEX-7
#$INDEX-8
#$INDEX-9
#$INDEX-10
#$INDEX-11
#$INDEX-12
```

```
# Index Weight Flag
1
# Index Units
2 2 2 2 2 2 2 2
2 2 2 2
# Index Month
10 10 10 10 10 10 10 10
10 10 10 10
# Index Start Age
1 2 3 4 5 6 7 8
9 10 11 12
# Index End Age
1 2 3 4 5 6 7 8
9 10 11 12
# Index Fix Age
1 2 3 4 5 6 7 8
9 10 11 12
# Index Selectivity Choice
1 1 1 1 1 1 1 1
1 1 1 1
# Index Data - Year, Index, CV, Selectivity
# INDEX - 1
1991 239.49 3.68 1 0 0 0 0 0 0 0 0 0 0 0
1992 393.33 2.96 1 0 0 0 0 0 0 0 0 0 0 0
1993 1572.1 1.88 1 0 0 0 0 0 0 0 0 0 0 0
1994 3.09 2.73 1 0 0 0 0 0 0 0 0 0 0 0
1995 17.2 3.56 1 0 0 0 0 0 0 0 0 0 0 0
1996 1218.36 2.9 1 0 0 0 0 0 0 0 0 0 0 0
1997 980.47 3.26 1 0 0 0 0 0 0 0 0 0 0 0
1998 87.06 2.88 1 0 0 0 0 0 0 0 0 0 0 0
1999 110.42 2.77 1 0 0 0 0 0 0 0 0 0 0 0
2000 2.75 4.19 1 0 0 0 0 0 0 0 0 0 0 0
2001 548.29 2.99 1 0 0 0 0 0 0 0 0 0 0 0
2002 31.22 6.72 1 0 0 0 0 0 0 0 0 0 0 0
2003 64.04 6.32 1 0 0 0 0 0 0 0 0 0 0 0
2004 69.8 2.22 1 0 0 0 0 0 0 0 0 0 0 0
2005 1167.74 0.89 1 0 0 0 0 0 0 0 0 0 0 0
2006 76.94 3.63 1 0 0 0 0 0 0 0 0 0 0 0
# INDEX - 2
1991 26.81 3.72 0 1 0 0 0 0 0 0 0 0 0 0
1992 426.22 3.15 0 1 0 0 0 0 0 0 0 0 0 0
1993 208.85 2.03 0 1 0 0 0 0 0 0 0 0 0 0
1994 7.66 4.31 0 1 0 0 0 0 0 0 0 0 0 0
1995 67.88 5.33 0 1 0 0 0 0 0 0 0 0 0 0
1996 8.51 2.62 0 1 0 0 0 0 0 0 0 0 0 0
1997 69.12 3.83 0 1 0 0 0 0 0 0 0 0 0 0
1998 36.68 3.98 0 1 0 0 0 0 0 0 0 0 0 0
1999 23.48 3.3 0 1 0 0 0 0 0 0 0 0 0 0
2000 17.03 5.85 0 1 0 0 0 0 0 0 0 0 0 0
2001 1.58 2.33 0 1 0 0 0 0 0 0 0 0 0 0
2002 1.98 6.38 0 1 0 0 0 0 0 0 0 0 0 0
2003 7.86 4.32 0 1 0 0 0 0 0 0 0 0 0 0
2004 29.8 3.87 0 1 0 0 0 0 0 0 0 0 0 0
2005 1106.41 2.72 0 1 0 0 0 0 0 0 0 0 0 0
2006 71.44 3.46 0 1 0 0 0 0 0 0 0 0 0 0
# INDEX - 3
1991 15.43 3.49 0 0 1 0 0 0 0 0 0 0 0 0
1992 136.69 2.08 0 0 1 0 0 0 0 0 0 0 0 0
1993 210.58 1.62 0 0 1 0 0 0 0 0 0 0 0 0
1994 53.06 3.48 0 0 1 0 0 0 0 0 0 0 0 0
1995 97.23 4.91 0 0 1 0 0 0 0 0 0 0 0 0
1996 13.84 3.16 0 0 1 0 0 0 0 0 0 0 0 0
1997 114.14 2.48 0 0 1 0 0 0 0 0 0 0 0 0
1998 103.08 6.34 0 0 1 0 0 0 0 0 0 0 0 0
1999 44.14 3.42 0 0 1 0 0 0 0 0 0 0 0 0
2000 22.91 4.81 0 0 1 0 0 0 0 0 0 0 0 0
2001 3.53 3.52 0 0 1 0 0 0 0 0 0 0 0 0
2002 6.64 4.72 0 0 1 0 0 0 0 0 0 0 0 0
2003 7.88 3.72 0 0 1 0 0 0 0 0 0 0 0 0
2004 106.12 3.5 0 0 1 0 0 0 0 0 0 0 0 0
2005 177.9 3.62 0 0 1 0 0 0 0 0 0 0 0 0
2006 190.06 2.71 0 0 1 0 0 0 0 0 0 0 0 0
# INDEX - 4
1991 16 3.03 0 0 0 1 0 0 0 0 0 0 0 0
1992 47.66 2.24 0 0 0 1 0 0 0 0 0 0 0 0
1993 129.73 1.5 0 0 0 1 0 0 0 0 0 0 0 0
1994 48.42 2.23 0 0 0 1 0 0 0 0 0 0 0 0
```

```
1995 58.92 2.31 0 0 0 1 0 0 0 0 0 0 0 0
1996 22.37 2.5 0 0 0 1 0 0 0 0 0 0 0 0
1997 34.05 2.81 0 0 0 1 0 0 0 0 0 0 0 0
1998 14.92 5.42 0 0 0 1 0 0 0 0 0 0 0 0
1999 52.02 3.2 0 0 0 1 0 0 0 0 0 0 0 0
2000 25.74 5.15 0 0 0 1 0 0 0 0 0 0 0 0
2001 2.78 3.52 0 0 0 1 0 0 0 0 0 0 0 0
2002 10.93 4.54 0 0 0 1 0 0 0 0 0 0 0 0
2003 15.25 4.22 0 0 0 1 0 0 0 0 0 0 0 0
2004 45.47 3.25 0 0 0 1 0 0 0 0 0 0 0 0
2005 60.79 4.82 0 0 0 1 0 0 0 0 0 0 0 0
2006 47.38 2.9 0 0 0 1 0 0 0 0 0 0 0 0
# INDEX - 5
1991 18.8 3.21 0 0 0 0 1 0 0 0 0 0 0 0
1992 21.25 2.1 0 0 0 0 1 0 0 0 0 0 0 0
1993 30.61 1.97 0 0 0 0 1 0 0 0 0 0 0 0
1994 20.16 2.32 0 0 0 0 1 0 0 0 0 0 0 0
1995 26.24 2.42 0 0 0 0 1 0 0 0 0 0 0 0
1996 22.48 2.16 0 0 0 0 1 0 0 0 0 0 0 0
1997 55.39 3.59 0 0 0 0 1 0 0 0 0 0 0 0
1998 5.54 2.99 0 0 0 0 1 0 0 0 0 0 0 0
1999 4.37 4.36 0 0 0 0 1 0 0 0 0 0 0 0
2000 12.53 2.79 0 0 0 0 1 0 0 0 0 0 0 0
2001 3.83 2.94 0 0 0 0 1 0 0 0 0 0 0 0
2002 8.69 4.63 0 0 0 0 1 0 0 0 0 0 0 0
2003 13.57 4.49 0 0 0 0 1 0 0 0 0 0 0 0
2004 10.03 3.16 0 0 0 0 1 0 0 0 0 0 0 0
2005 29.96 5.75 0 0 0 0 1 0 0 0 0 0 0 0
2006 2.83 6.66 0 0 0 0 1 0 0 0 0 0 0 0
# INDEX - 6
1991 8.84 3.4 0 0 0 0 0 1 0 0 0 0 0 0
1992 8.26 2.39 0 0 0 0 0 1 0 0 0 0 0 0
1993 4.01 2.61 0 0 0 0 0 1 0 0 0 0 0 0
1994 4.98 2.73 0 0 0 0 0 1 0 0 0 0 0 0
1995 4.98 3.19 0 0 0 0 0 1 0 0 0 0 0 0
1996 4.26 2.6 0 0 0 0 0 1 0 0 0 0 0 0
1997 32.08 4.4 0 0 0 0 0 1 0 0 0 0 0 0
1998 3.08 3.38 0 0 0 0 0 1 0 0 0 0 0 0
1999 1.5 2.59 0 0 0 0 0 1 0 0 0 0 0 0
2000 6.99 4.01 0 0 0 0 0 1 0 0 0 0 0 0
2001 5.5 3.51 0 0 0 0 0 1 0 0 0 0 0 0
2002 4.47 4.68 0 0 0 0 0 1 0 0 0 0 0 0
2003 3.88 2.39 0 0 0 0 0 1 0 0 0 0 0 0
2004 4.89 2.46 0 0 0 0 0 1 0 0 0 0 0 0
2005 13.03 3.59 0 0 0 0 0 1 0 0 0 0 0 0
2006 9.1 6.67 0 0 0 0 0 1 0 0 0 0 0 0
# INDEX - 7
1991 4.92 2.98 0 0 0 0 0 0 1 0 0 0 0 0
1992 5.57 2.85 0 0 0 0 0 0 1 0 0 0 0 0
1993 2.62 3.28 0 0 0 0 0 0 1 0 0 0 0 0
1994 2.25 3.01 0 0 0 0 0 0 1 0 0 0 0 0
1995 1.03 3.54 0 0 0 0 0 0 1 0 0 0 0 0
1996 1.79 3.25 0 0 0 0 0 0 1 0 0 0 0 0
1997 6.55 6.86 0 0 0 0 0 0 1 0 0 0 0 0
1998 1.68 3.89 0 0 0 0 0 0 1 0 0 0 0 0
1999 0.83 2.58 0 0 0 0 0 0 1 0 0 0 0 0
2000 3.7 4.98 0 0 0 0 0 0 1 0 0 0 0 0
2001 6.7 2.96 0 0 0 0 0 0 1 0 0 0 0 0
2002 1.56 3.23 0 0 0 0 0 0 1 0 0 0 0 0
2003 2.12 3.42 0 0 0 0 0 0 1 0 0 0 0 0
2004 2.19 2.48 0 0 0 0 0 0 1 0 0 0 0 0
2005 15.27 3.22 0 0 0 0 0 0 1 0 0 0 0 0
2006 6.57 7.23 0 0 0 0 0 0 1 0 0 0 0 0
# INDEX - 8
1991 2.66 3.58 0 0 0 0 0 0 0 1 0 0 0 0
1992 5.86 2.55 0 0 0 0 0 0 0 1 0 0 0 0
1993 2.75 1.33 0 0 0 0 0 0 0 1 0 0 0 0
1994 1.58 4.47 0 0 0 0 0 0 0 1 0 0 0 0
1995 1.21 5.82 0 0 0 0 0 0 0 1 0 0 0 0
1996 0.77 2.66 0 0 0 0 0 0 0 1 0 0 0 0
1997 5.4 5.84 0 0 0 0 0 0 0 1 0 0 0 0
1998 1.87 2.99 0 0 0 0 0 0 0 1 0 0 0 0
1999 0.26 2.51 0 0 0 0 0 0 0 1 0 0 0 0
2000 1.8 2.29 0 0 0 0 0 0 0 1 0 0 0 0
2001 11.11 3.48 0 0 0 0 0 0 0 1 0 0 0 0
2002 1.26 2.59 0 0 0 0 0 0 0 1 0 0 0 0
2003 1.34 3.44 0 0 0 0 0 0 0 1 0 0 0 0
```

```
2004 4.76 4.12 0 0 0 0 0 0 0 1 0 0 0 0
2005 15.51 4.13 0 0 0 0 0 0 0 1 0 0 0 0
2006 5.4 8.03 0 0 0 0 0 0 0 1 0 0 0 0
# INDEX - 9
1991 3.28 3.33 0 0 0 0 0 0 0 0 1 0 0 0
1992 3.13 2.97 0 0 0 0 0 0 0 0 1 0 0 0
1993 2.26 1.11 0 0 0 0 0 0 0 0 1 0 0 0
1994 0.9 2.34 0 0 0 0 0 0 0 0 1 0 0 0
1995 0.46 2.65 0 0 0 0 0 0 0 0 1 0 0 0
1996 0.47 1.75 0 0 0 0 0 0 0 0 1 0 0 0
1997 2.35 5.8 0 0 0 0 0 0 0 0 1 0 0 0
1998 0.39 3.13 0 0 0 0 0 0 0 0 1 0 0 0
1999 0.21 1.06 0 0 0 0 0 0 0 0 1 0 0 0
2000 1.48 1.58 0 0 0 0 0 0 0 0 1 0 0 0
2001 6.81 3.34 0 0 0 0 0 0 0 0 1 0 0 0
2002 2.47 1.38 0 0 0 0 0 0 0 0 1 0 0 0
2003 0.85 2.74 0 0 0 0 0 0 0 0 1 0 0 0
2004 5.95 4.95 0 0 0 0 0 0 0 0 1 0 0 0
2005 11.96 3.88 0 0 0 0 0 0 0 0 1 0 0 0
2006 2.2 3.86 0 0 0 0 0 0 0 0 1 0 0 0
# INDEX - 10
1991 2.77 2.89 0 0 0 0 0 0 0 0 0 1 0 0
1992 2.67 2.86 0 0 0 0 0 0 0 0 0 1 0 0
1993 3.13 1.01 0 0 0 0 0 0 0 0 0 1 0 0
1994 0.77 1.8 0 0 0 0 0 0 0 0 0 1 0 0
1995 0.22 2.96 0 0 0 0 0 0 0 0 0 1 0 0
1996 0.81 0.58 0 0 0 0 0 0 0 0 0 1 0 0
1997 2.76 5.87 0 0 0 0 0 0 0 0 0 1 0 0
1998 0.11 3.22 0 0 0 0 0 0 0 0 0 1 0 0
1999 0.62 0.47 0 0 0 0 0 0 0 0 0 1 0 0
2000 0.89 0.42 0 0 0 0 0 0 0 0 0 1 0 0
2001 2.88 2.77 0 0 0 0 0 0 0 0 0 1 0 0
2002 2.16 1.35 0 0 0 0 0 0 0 0 0 1 0 0
2003 0.68 2.02 0 0 0 0 0 0 0 0 0 1 0 0
2004 0.99 4.55 0 0 0 0 0 0 0 0 0 1 0 0
2005 6.27 4.11 0 0 0 0 0 0 0 0 0 1 0 0
2006 1.22 3.46 0 0 0 0 0 0 0 0 0 1 0 0
# INDEX - 11
1991 1.2 2.22 0 0 0 0 0 0 0 0 0 0 1 0
1992 4.38 2.34 0 0 0 0 0 0 0 0 0 0 1 0
1993 1.89 1.18 0 0 0 0 0 0 0 0 0 0 1 0
1994 0.92 0.84 0 0 0 0 0 0 0 0 0 0 1 0
1995 0.37 1.58 0 0 0 0 0 0 0 0 0 0 1 0
1996 0.19 1.16 0 0 0 0 0 0 0 0 0 0 1 0
1997 1.04 5.69 0 0 0 0 0 0 0 0 0 0 1 0
1998 0.06 2.93 0 0 0 0 0 0 0 0 0 0 1 0
1999 0.81 0.12 0 0 0 0 0 0 0 0 0 0 1 0
2000 0.22 0.83 0 0 0 0 0 0 0 0 0 0 1 0
2001 1.82 2.35 0 0 0 0 0 0 0 0 0 0 1 0
2002 3 1.27 0 0 0 0 0 0 0 0 0 0 1 0
2003 0.42 1.63 0 0 0 0 0 0 0 0 0 0 1 0
2004 0.39 3.31 0 0 0 0 0 0 0 0 0 0 1 0
2005 3.78 4.19 0 0 0 0 0 0 0 0 0 0 1 0
2006 0.58 3.3 0 0 0 0 0 0 0 0 0 0 1 0
# INDEX - 12
1991 3.41 0.69 0 0 0 0 0 0 0 0 0 0 0 1
1992 3.53 1.12 0 0 0 0 0 0 0 0 0 0 0 1
1993 6.2 0.89 0 0 0 0 0 0 0 0 0 0 0 1
1994 9.32 0.05 0 0 0 0 0 0 0 0 0 0 0 1
1995 6.18 0.3 0 0 0 0 0 0 0 0 0 0 0 1
1996 2.78 0.22 0 0 0 0 0 0 0 0 0 0 0 1
1997 1.64 0.77 0 0 0 0 0 0 0 0 0 0 0 1
1998 0.15 1.42 0 0 0 0 0 0 0 0 0 0 0 1
1999 2.79 0.03 0 0 0 0 0 0 0 0 0 0 0 1
2000 0.73 0.44 0 0 0 0 0 0 0 0 0 0 0 1
2001 1.67 1.3 0 0 0 0 0 0 0 0 0 0 0 1
2002 6.11 0.33 0 0 0 0 0 0 0 0 0 0 0 1
2003 0.44 0.29 0 0 0 0 0 0 0 0 0 0 0 1
2004 0.17 1.31 0 0 0 0 0 0 0 0 0 0 0 1
2005 10.88 2.69 0 0 0 0 0 0 0 0 0 0 0 1
2006 0.36 1.97 0 0 0 0 0 0 0 0 0 0 0 1
# Phase Control Data
# Phase for Selectivity in 1st Year
1
# Phase for Selectivity Deviations
-5
# Phase for F mult in 1st Year
```

```
1
# Phase for F mult Deviations
3
# Phase for Recruitment Deviations
3
# Phase for N in 1st Year
2
# Phase for Catchability in 1st Year
1
# Phase for Catchability Deviations
-5
# Phase for Stock Recruitment Relationship
1
# Phase for Steepness
-5
# Recruitment CV by Year
0.25
0.25
0.25
0.25
0.25
0.25
0.25
0.25
0.25
0.25
0.25
0.25
0.25
0.25
0.25
0.25
#Lambda for Each Index (cv=0.4)
5 5 5 5 5 5 5 5
5 5 5 5
# Lambda for Total Catch in Weight
100
# Lambda for Total Discards at Age
0
# Lambda for Catch at Age by Year & Fleet
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
# Lambda for Discards at Age by Year & Fleet
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
# Lambda for F mult Deviations by Fleet
1
# Lambda for N in 1st Year Deviations
0
```

```
# Lambda for Recruitment Deviations
1
# Lambda for Catchability Deviations by Index
1 1 1 1 1 1 1 1
1 1 1 1
# Lambda for Selectivity Deviations by Fleet
1
# Lambda for Selectivity Curvature at Age
0
# Lambda for Selectivity Curvature Over Time
0
# Lambda for Deviations from Initial Steepness
0
# Lambda for Deviation from Initial log of Virgin Stock Size
0
# NAA for Year 1
10000 9000 8000 7000 6000 5000 4000 3000 2000 2000 2000 2000
# Log of F mult in 1st year by Fleet
-3
# log of Catchability in 1st year by index
-4 -4 -4 -4 -4 -4 -4 -4
-4 -4 -4 -4
# Initial log of Virgin Stock Size
10
# Initial Steepness
0.7
# Selectivity at Age in 1st Year by Fleet
0.1
0.2
0.5
0.8
0.9
1
1
1
1
1
1
1
# Where to do Extras
2
# Ignore Guesses
0
# Projection Control Data
# Year for SSB ratio Calculation
1991
# Fleet Directed Flag
1
# Final Year of Projections
2008
# Year Projected Recruits, What Projected, Target, non- directed F mult
2007 -1 3 -99 1
2008 -1 3 -99 1
# Test Value
-23456
#####
# ---- FINIS ----
```

Table 6.7.1.2. Southern horse mackerel. Results from the sensitivity analyses

Objective function	Total catch	Prop. of catch in numbers	Survey	Weight survey	Unweighted objective function
299	0.12	174	122	1	126.62
767	3.28	186	568	5	125.21
1321	14	207	1082	10	128.41
2286	89	263	1905	20	127.77
3211	155	315	2703	30	132.8
4939	280	449	4157	50	143.43
6553	378	599	5513	70	151.53
9343	493	991	7785	100	166.69
10880	546	1129	9126	120	171.8
13135	607	1289	11151	150	181.3
14468	768	1215	12389	170	188.71
16637	859	1323	14352	200	196.58

Table 6.7.1.3. Output file from the ASAP assessment

```
obj_fun = 768.064
Component RSS nobs Lambda Likelihood
Catch_Fleet_1 0.0346587 16 100 3.46587
Catch_Fleet_Total 0.0346587 16 100 3.46587
Discard_Fleet_1 0 16 0 0
Discard_Fleet_Total 0 16 0 0
CAA_proportions N/A 192 see_below 185.87
Discard_proportions N/A 192 see_below 0
Index_Fit_1 49.2798 16 5 123.2
Index_Fit_2 36.9636 16 5 92.4091
Index_Fit_3 19.8276 16 5 49.569
Index_Fit_4 9.19357 16 5 22.9839
Index_Fit_5 10.4652 16 5 26.1629
Index_Fit_6 7.22717 16 5 18.0679
Index_Fit_7 11.2896 16 5 28.224
Index_Fit_8 18.5522 16 5 46.3805
Index_Fit_9 18.094 16 5 45.235
Index_Fit_10 10.614 16 5 26.535
Index_Fit_11 13.7604 16 5 34.401
Index_Fit_12 22.2417 16 5 55.6044
Index_Fit_Total 227.509 192 60 568.772
Selectivity_devs_fleet_1 0 1 1 0
Selectivity_devs_Total 0 1 1 0
Catchability_devs_index_1 0 16 1 0
Catchability_devs_index_2 0 16 1 0
Catchability_devs_index_3 0 16 1 0
Catchability_devs_index_4 0 16 1 0
Catchability_devs_index_5 0 16 1 0
Catchability_devs_index_6 0 16 1 0
Catchability_devs_index_7 0 16 1 0
Catchability_devs_index_8 0 16 1 0
Catchability_devs_index_9 0 16 1 0
Catchability_devs_index_10 0 16 1 0
Catchability_devs_index_11 0 16 1 0
Catchability_devs_index_12 0 16 1 0
Catchability_devs_Total 0 192 12 0
Fmult_fleet_1 0.915366 15 1 0.915366
Fmult_fleet_Total 0.915366 15 1 0.915366
N_year_1 24.9036 11 0 0
Stock-Recruit_Fit 2.18997 16 1 6.84953
Recruit_devs 2.18997 16 1 2.18997
SRR_steepness 0 1 0 0
SRR_virgin_stock 13.3393 1 0 0
Curvature_over_age 1.44592 10 0 0
Curvature_over_time 0 168 0 0
F_penalty 0.0815553 192 0.001 8.15553e-05
Mean_Sel_year1_pen 0 12 1000 0
Max_Sel_penalty 0.142127 1 100 0
Fmult_Max_penalty 0 ? 100 0
Input and Estimated effective sample sizes for fleet 1
1991 100 70.6758
1992 100 26.7863
1993 100 40.4194
1994 100 57.3036
1995 100 36.7528
1996 100 19.8009
1997 100 15.8988
1998 100 19.4294
1999 100 26.5724
2000 100 107.291
2001 100 11.7942
2002 100 33.6345
2003 100 22.227
2004 100 22.9577
2005 100 92.6495
2006 100 85.8568
Total 1600 690.05
Input and Estimated effective Discard sample sizes for fleet 1
1991 0 1e+15
1992 0 1e+15
1993 0 1e+15
1994 0 1e+15
1995 0 1e+15
1996 0 1e+15
1997 0 1e+15
1998 0 1e+15
1999 0 1e+15
2000 0 1e+15
2001 0 1e+15
2002 0 1e+15
2003 0 1e+15
2004 0 1e+15
2005 0 1e+15
2006 0 1e+15
Total 0 1.6e+16
```

```
Observed and predicted total fleet catch by year
fleet 1 total catches
1991 21772 21884.7
1992 26492 26771.1
1993 31945 33667.7
1994 25959 27953.8
1995 25147 26553
1996 22943 23614
1997 27642 27876.4
1998 41564 44718.5
1999 27733 27649.2
2000 27160 26188.7
2001 24910 23163.6
2002 22506 21325.3
2003 18887 18315.5
2004 23252 21945.5
2005 23111 21832.3
2006 23902 24008.9
Observed and predicted total fleet Discards by year
fleet 1 total Discards
1991 0 0
1992 0 0
1993 0 0
1994 0 0
1995 0 0
1996 0 0
1997 0 0
1998 0 0
1999 0 0
2000 0 0
2001 0 0
2002 0 0
2003 0 0
2004 0 0
2005 0 0
2006 0 0
Index data
index number 1
units = 2
month = 10
starting and ending ages for selectivity = 1 1
selectivity choice = 1
year, sigma2, obs index, pred index
1991 1 0.582143 0.403907
1992 1 0.956091 0.332539
1993 1 3.8214 0.249533
1994 1 0.00751105 0.204894
1995 1 0.0418091 0.244576
1996 1 2.96154 0.591163
1997 1 2.38329 0.277361
1998 1 0.211622 0.196204
1999 1 0.268405 0.236275
2000 1 0.00668459 0.198141
2001 1 1.33276 0.290514
2002 1 0.0758884 0.169506
2003 1 0.155666 0.370963
2004 1 0.169667 0.508918
2005 1 2.8385 0.496548
2006 1 0.187023 0.224114
index number 2
units = 2
month = 10
starting and ending ages for selectivity = 2 2
selectivity choice = 1
year, sigma2, obs index, pred index
1991 1 0.203172 0.27864
1992 1 3.22999 0.318045
1993 1 1.58271 0.252728
1994 1 0.0580493 0.195192
1995 1 0.51441 0.159014
1996 1 0.0644908 0.194569
1997 1 0.523807 0.461594
1998 1 0.27797 0.194638
1999 1 0.177937 0.150849
2000 1 0.129057 0.181752
2001 1 0.0119736 0.153862
2002 1 0.0150049 0.225917
2003 1 0.0595649 0.134717
2004 1 0.225831 0.29658
2005 1 8.38463 0.407716
2006 1 0.541389 0.39581
index number 3
units = 2
month = 10
starting and ending ages for selectivity = 3 3
selectivity choice = 1
year, sigma2, obs index, pred index
1991 1 0.189437 0.321599
```

```
1992 1 1.67817 0.720648
1993 1 2.58533 0.780388
1994 1 0.651428 0.642199
1995 1 1.19371 0.492631
1996 1 0.169916 0.414609
1997 1 1.40132 0.496171
1998 1 1.26553 1.01484
1999 1 0.541915 0.478122
2000 1 0.28127 0.3755
2001 1 0.0433385 0.45802
2002 1 0.0815205 0.388986
2003 1 0.0967442 0.588451
2004 1 1.30286 0.354749
2005 1 2.18411 0.783679
2006 1 2.3334 1.07023
index number 4
units = 2
month = 10
starting and ending ages for selectivity = 4 4
selectivity choice = 1
year, sigma2, obs index, pred index
1991 1 0.404788 0.385632
1992 1 1.20576 0.482785
1993 1 3.28207 1.0266
1994 1 1.22499 1.14574
1995 1 1.49063 0.939236
1996 1 0.565944 0.742375
1997 1 0.861439 0.61315
1998 1 0.377465 0.636872
1999 1 1.31607 1.43349
2000 1 0.651203 0.68946
2001 1 0.0703319 0.547588
2002 1 0.276521 0.670502
2003 1 0.385813 0.585744
2004 1 1.15036 0.896913
2005 1 1.53794 0.542687
2006 1 1.19868 1.19157
index number 5
units = 2
month = 10
starting and ending ages for selectivity = 5 5
selectivity choice = 1
year, sigma2, obs index, pred index
1991 1 1.05072 0.555634
1992 1 1.18765 0.418991
1993 1 1.71077 0.501156
1994 1 1.12673 1.09263
1995 1 1.46654 1.21632
1996 1 1.25639 1.02271
1997 1 3.09571 0.795929
1998 1 0.309627 0.582098
1999 1 0.244236 0.65455
2000 1 0.700293 1.50304
2001 1 0.214056 0.729805
2002 1 0.485678 0.581678
2003 1 0.758418 0.729666
2004 1 0.56057 0.644411
2005 1 1.67444 0.989954
2006 1 0.158167 0.595892
index number 6
units = 2
month = 10
starting and ending ages for selectivity = 6 6
selectivity choice = 1
year, sigma2, obs index, pred index
1991 1 1.18014 0.535249
1992 1 1.10271 0.599237
1993 1 0.535336 0.435719
1994 1 0.664831 0.53116
1995 1 0.664831 1.15636
1996 1 0.568711 1.31293
1997 1 4.28269 1.09111
1998 1 0.411181 0.771573
1999 1 0.20025 0.599388
2000 1 0.933166 0.685859
2001 1 0.734251 1.58658
2002 1 0.596746 0.77264
2003 1 0.517981 0.62762
2004 1 0.652816 0.794371
2005 1 1.73951 0.703406
2006 1 1.21485 1.07624
index number 7
units = 2
month = 10
starting and ending ages for selectivity = 7 7
selectivity choice = 1
year, sigma2, obs index, pred index
1991 1 1.20459 0.726652
```

```
1992 1 1.36373 0.530606
1993 1 0.641469 0.570718
1994 1 0.55088 0.42562
1995 1 0.252181 0.516591
1996 1 0.438256 1.15206
1997 1 1.60367 1.28731
1998 1 0.411324 0.957262
1999 1 0.203213 0.733506
2000 1 0.905891 0.576798
2001 1 1.6404 0.666023
2002 1 0.381943 1.54475
2003 1 0.519051 0.769222
2004 1 0.53619 0.630277
2005 1 3.73864 0.799879
2006 1 1.60857 0.704819
index number 8
units = 2
month = 10
starting and ending ages for selectivity = 8 8
selectivity choice = 1
year, sigma2, obs index, pred index
1991 1 0.669814 0.891091
1992 1 1.47561 0.612896
1993 1 0.692477 0.426598
1994 1 0.39786 0.473052
1995 1 0.30469 0.350905
1996 1 0.193894 0.438405
1997 1 1.35977 0.959044
1998 1 0.470884 0.937908
1999 1 0.0654706 0.76825
2000 1 0.453258 0.597125
2001 1 2.79761 0.474698
2002 1 0.31728 0.549842
2003 1 0.337425 1.30984
2004 1 1.19862 0.659
2005 1 3.90557 0.541698
2006 1 1.35977 0.683428
index number 9
units = 2
month = 10
starting and ending ages for selectivity = 9 9
selectivity choice = 1
year, sigma2, obs index, pred index
1991 1 1.16183 1.05043
1992 1 1.1087 0.819629
1993 1 0.800531 0.534068
1994 1 0.318796 0.384387
1995 1 0.16294 0.423927
1996 1 0.166482 0.324736
1997 1 0.832411 0.397248
1998 1 0.138145 0.748564
1999 1 0.0743857 0.814097
2000 1 0.524242 0.678642
2001 1 2.41222 0.533894
2002 1 0.874917 0.425982
2003 1 0.301085 0.508375
2004 1 2.10759 1.22552
2005 1 4.23644 0.618842
2006 1 0.779278 0.505369
index number 10
units = 2
month = 10
starting and ending ages for selectivity = 10 10
selectivity choice = 1
year, sigma2, obs index, pred index
1991 1 1.53092 2.23249
1992 1 1.47565 1.11816
1993 1 1.72988 0.817293
1994 1 0.425561 0.555316
1995 1 0.121589 0.396704
1996 1 0.447668 0.455181
1997 1 1.52539 0.339569
1998 1 0.0607945 0.346236
1999 1 0.34266 0.745083
2000 1 0.491883 0.82581
2001 1 1.59171 0.698754
2002 1 1.19378 0.552037
2003 1 0.37582 0.456849
2004 1 0.54715 0.552881
2005 1 3.46528 1.33863
2006 1 0.674266 0.670529
index number 11
units = 2
month = 10
starting and ending ages for selectivity = 11 11
selectivity choice = 1
year, sigma2, obs index, pred index
1991 1 0.911248 1.13972
```

```
1992 1 3.32606 1.94828
1993 1 1.43522 0.905391
1994 1 0.698624 0.693381
1995 1 0.280968 0.467497
1996 1 0.144281 0.349225
1997 1 0.789748 0.389095
1998 1 0.0455624 0.235988
1999 1 0.615093 0.279002
2000 1 0.167062 0.614898
2001 1 1.38206 0.693075
2002 1 2.27812 0.589389
2003 1 0.318937 0.485348
2004 1 0.296156 0.408291
2005 1 2.87043 0.49662
2006 1 0.440437 1.19152
index number 12
units = 2
month = 10
starting and ending ages for selectivity = 12 12
selectivity choice = 1
year, sigma2, obs index, pred index
1991 1 0.968062 1.04677
1992 1 1.00213 1.0109
1993 1 1.76011 1.12875
1994 1 2.64585 0.967132
1995 1 1.75444 0.800788
1996 1 0.789212 0.662347
1997 1 0.465578 0.522154
1998 1 0.0425834 0.360358
1999 1 0.792051 0.278372
2000 1 0.207239 0.247215
2001 1 0.474095 0.323715
2002 1 1.73456 0.395342
2003 1 0.124911 0.429487
2004 1 0.0482612 0.429501
2005 1 3.08872 0.409165
2006 1 0.1022 0.417611
Selectivity by age and year for each fleet rescaled so max=1.0
fleet 1 selectivity at age
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
0.136044 0.527782 0.720417 0.679656 0.581378 0.456262 0.537619 0.644976 0.720306 0.881714
1
0.997438
Fmult by year for each fleet
```

1991 0.211713
1992 0.286102
1993 0.362869
1994 0.293345
1995 0.314876
1996 0.257475
1997 0.302874
1998 0.543301
1999 0.323307
2000 0.333466
2001 0.311499
2002 0.309358
2003 0.259978
2004 0.249037
2005 0.244897
2006 0.256545
Directed F by age and year for each fleet
fleet 1 directed F at age
0.0288024 0.111738 0.152522 0.143892 0.123085 0.0965967 0.113821 0.13655 0.152498 0.18667
0.211713
0.211171
0.0389226 0.151 0.206113 0.194451 0.166334 0.130538 0.153814 0.184529 0.206081 0.25226
0.286102
0.285369
0.0493663 0.191516 0.261417 0.246626 0.210964 0.165564 0.195085 0.234042 0.261377 0.319947
0.362869
0.36194
0.0399079 0.154822 0.211331 0.199374 0.170544 0.133842 0.157708 0.189201 0.211299 0.258647
0.293345
0.292594
0.0428371 0.166186 0.226842 0.214007 0.183062 0.143666 0.169283 0.203088 0.226807 0.277631
0.314876
0.314069
0.035028 0.13589 0.185489 0.174994 0.14969 0.117476 0.138423 0.166065 0.185461 0.227019
0.257475
0.256815
0.0412043 0.159852 0.218196 0.20585 0.176084 0.13819 0.162831 0.195347 0.218162 0.267049
0.302874
0.302098
0.073913 0.286744 0.391404 0.369258 0.315863 0.247888 0.292089 0.350416 0.391343 0.479036
0.543301
0.541909
0.0439841 0.170636 0.232916 0.219737 0.187963 0.147513 0.173816 0.208525 0.23288 0.285064
0.323307
0.322479
0.0453661 0.175997 0.240235 0.226642 0.19387 0.152148 0.179278 0.215078 0.240198 0.294022
0.333466
0.332612
0.0423777 0.164404 0.22441 0.211712 0.181099 0.142125 0.167468 0.20091 0.224375 0.274653
0.311499
0.310701
0.0420864 0.163274 0.222867 0.210257 0.179854 0.141148 0.166317 0.199529 0.222833 0.272765
0.309358
0.308565
0.0353685 0.137211 0.187292 0.176695 0.151145 0.118618 0.139769 0.167679 0.187264 0.229226
0.259978
0.259311
0.03388 0.131437 0.179411 0.169259 0.144784 0.113626 0.133887 0.160623 0.179383 0.219579
0.249037
0.248399
0.0333168 0.129252 0.176428 0.166445 0.142377 0.111737 0.131661 0.157952 0.176401 0.215929
0.244897
0.244269
0.0349014 0.1354 0.184819 0.174362 0.149149 0.117052 0.137923 0.165465 0.184791 0.226199
0.256545
0.255887
Discard F by age and year for each fleet
fleet 1 Discard F at age
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
Total F
0.0288024 0.111738 0.152522 0.143892 0.123085 0.0965967 0.113821 0.13655 0.152498 0.18667
0.211713
0.211171

```
0.0389226 0.151 0.206113 0.194451 0.166334 0.130538 0.153814 0.184529 0.206081 0.25226
0.286102
0.285369
0.0493663 0.191516 0.261417 0.246626 0.210964 0.165564 0.195085 0.234042 0.261377 0.319947
0.362869
0.36194
0.0399079 0.154822 0.211331 0.199374 0.170544 0.133842 0.157708 0.189201 0.211299 0.258647
0.293345
0.292594
0.0428371 0.166186 0.226842 0.214007 0.183062 0.143666 0.169283 0.203088 0.226807 0.277631
0.314876
0.314069
0.035028 0.13589 0.185489 0.174994 0.14969 0.117476 0.138423 0.166065 0.185461 0.227019
0.257475
0.256815
0.0412043 0.159852 0.218196 0.20585 0.176084 0.13819 0.162831 0.195347 0.218162 0.267049
0.302874
0.302098
0.073913 0.286744 0.391404 0.369258 0.315863 0.247888 0.292089 0.350416 0.391343 0.479036
0.543301
0.541909
0.0439841 0.170636 0.232916 0.219737 0.187963 0.147513 0.173816 0.208525 0.23288 0.285064
0.323307
0.322479
0.0453661 0.175997 0.240235 0.226642 0.19387 0.152148 0.179278 0.215078 0.240198 0.294022
0.333466
0.332612
0.0423777 0.164404 0.22441 0.211712 0.181099 0.142125 0.167468 0.20091 0.224375 0.274653
0.311499
0.310701
0.0420864 0.163274 0.222867 0.210257 0.179854 0.141148 0.166317 0.199529 0.222833 0.272765
0.309358
0.308565
0.0353685 0.137211 0.187292 0.176695 0.151145 0.118618 0.139769 0.167679 0.187264 0.229226
0.259978
0.259311
0.03388 0.131437 0.179411 0.169259 0.144784 0.113626 0.133887 0.160623 0.179383 0.219579
0.249037
0.248399
0.0333168 0.129252 0.176428 0.166445 0.142377 0.111737 0.131661 0.157952 0.176401 0.215929
0.244897
0.244269
0.0349014 0.1354 0.184819 0.174362 0.149149 0.117052 0.137923 0.165465 0.184791 0.226199
0.256545
0.255887
Population Numbers at the Start of the Year
831649 589704 193713 109622 104518 69066.5 71491.1 76709.2 70592.7 98612.8 38720.8 81604.7
690500 695484 453902 143144 81707.2 79541.5 53972.4 54913.1 57597.1 52165.9 70423.8
83835.4
522672 571631 514713 317910 101433 59549.5 60083.8 39831.6 39300 40341.9 34888.9 99776.2
425802 428199 406254 341105 213822 70699.5 43434.1 42549 27129.4 26045.5 25215.1 80689.7
509509 352153 315692 283056 240523 155182 53228.6 31929.7 30309.3 18903 17308.5 68017.7
1.22354e+06 420150 256693 216572 196692 172389 115692 38679.6 22431.1 20793.6 12325.7
53637.5
577023 1.01686e+06 315677 183532 156480 145758 131931 86704.8 28197.9 16038.4 14262.4
43910.8
419462 476600 745926 218443 128579 112939 109263 96490.9 61384.8 19513.1 10569.2 37008.1
492686 335312 307949 434077 129965 80695.1 75865.1 70222.6 58500.3 35723.9 10402.5 23810.7
413644 405811 243332 209981 299911 92693.9 59929.3 54879.6 49064.9 39891.1 23121.3 21325.1
604978 340236 292917 164711 144081 212643 68522 43115.7 38094.3 33213.2 25588.2 27418.8
352901 499104 248449 201438 114718 103469 158775 49883.3 30355.5 26198.1 21721.3 33426.1
768007 291226 364870 171121 140502 82485.6 77333.6 115720 35168.8 20908.3 17165.9 34852.7
1.05231e+06 638059 218522 260408 123430 103968 63054.9 57879.3 84225.2 25100.7 14309.4
34538.4
1.02625e+06 875560 481542 157194 189235 91917.3 79874.2 47471 42425 60588.9 17345.2 32790
463804 854359 662229 347431 114552 141261 70750 60267.4 34888.8 30610.3 42021.6 33792.4
q by index
index 1 q over time
1991 5.63705e-07
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index 2 q over time
1991 5.87674e-07
1992 5.87674e-07
1993 5.87674e-07
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2006 5.87674e-07
index 3 q over time
1991 2.1362e-06
1992 2.1362e-06
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index 4 q over time
1991 4.49408e-06
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index 5 q over time
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index 6 q over time
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index 7 q over time
1991 1.26635e-05
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index 8 q over time
1991 1.47496e-05
1992 1.47496e-05
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index 9 q over time
1991 1.91464e-05
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2006 1.91464e-05
index 10 q over time
1991 2.9971e-05
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2006 2.9971e-05
index 11 q over time
1991 3.9789e-05
1992 3.9789e-05
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index 12 q over time
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2005 1.7332e-05
2006 1.7332e-05
Proportions of catch at age by fleet
fleet 1
Year 1 Obs = 0.0679896 0.353214 0.076721 0.0377462 0.0350909 0.0522059 0.0348519 0.0413058 0.0407158 0.0965209 0.0590212 0.104616
Year 1 Pred = 0.110353 0.291678 0.128268 0.0687609 0.0566387 0.0297473 0.0359841 0.0458211 0.0467367 0.078635 0.034608 0.0727687
Year 2 Obs = 0.0306068 0.262228 0.409313 0.110515 0.0320129 0.0256555 0.014361 0.0196238 0.014407
0.0125386 0.0352541 0.0334845
Year 2 Pred = 0.0788836 0.292105 0.253531 0.075846 0.0375282 0.0291631 0.0230603 0.027741 0.0321669
0.0348987 0.052599 0.0624769
Year 3 Obs = 0.0118592 0.169074 0.35749 0.229184 0.0810525 0.0310552 0.0304016 0.0254101 0.0140804
0.00999789 0.00897995 0.0314152
Year 3 Pred = 0.0596568 0.236506 0.281315 0.165057 0.0458074 0.0215622 0.0252798 0.0197409 0.0214764 0.0262633 0.0252576 0.0720779
Year 4 Obs = 0.0386266 0.176002 0.248942 0.310024 0.0985664 0.0262457 0.0147693 0.0103909 0.0150259 0.0102726 0.0178973 0.0332372
Year 4 Pred = 0.0534372 0.197301 0.248783 0.19818 0.107722 0.0284442 0.0203583 0.023572 0.0166113
0.0190934 0.0206292 0.0658682
Year 5 Obs = 0.0268377 0.250449 0.123338 0.227292 0.12212 0.0482686 0.0174912 0.0134355 0.0109033
0.0150324 0.010709 0.134123
Year 5 Pred = 0.0704273 0.17801 0.211687 0.180146 0.132864 0.068542 0.0273679 0.0193834 0.0203211
0.01515 0.0154642 0.0606369
Year 6 Obs = 0.208995 0.0646557 0.0647087 0.145214 0.194914 0.0602119 0.0434197 0.0303242 0.0215597 0.0523171 0.023293 0.0903859
Year 6 Pred = 0.159304 0.202182 0.16469 0.131739 0.103581 0.0723474 0.056642 0.0224226 0.0143895
0.016012 0.0106125 0.0460779
Year 7 Obs = 0.00734849 0.593803 0.225734 0.050475 0.0339516 0.0240197 0.0146816 0.0102505 0.00805147 0.00661274 0.00392435 0.0211472
Year 7 Pred = 0.0622936 0.402344 0.165864 0.0915054 0.0676799 0.050373 0.0530993 0.0412268 0.0148138 0.0100809 0.00999968 0.0307189
Year 8 Obs = 0.032126 0.0917332 0.554175 0.142559 0.0309182 0.0188194 0.0156734 0.035679 0.0276778
0.0133027 0.0110824 0.0262537
Year 8 Pred = 0.0479807 0.19126 0.389417 0.10868 0.0560783 0.0398957 0.0445542 0.0459511 0.0320424
0.0119841 0.00715424 0.0250019
Year 9 Obs = 0.146333 0.113815 0.100171 0.233812 0.156302 0.0631776 0.060903 0.0277477 0.0152142
0.0251741 0.0139429 0.0434075
Year 9 Pred = 0.0677037 0.168245 0.204818 0.274059 0.071247 0.0353885 0.0387169 0.0422956 0.0389034
0.0283816 0.009209 0.0210328
Year 10 Obs = 0.0392899 0.227935 0.12577 0.15073 0.142223 0.0697662 0.0824599 0.0560388 0.0314774
0.0252973 0.017416 0.0315963
Year 10 Pred = 0.061442 0.219686 0.174457 0.142935 0.177341 0.043873 0.0329962 0.0356434 0.0351723
0.034138 0.0220365 0.0202804
Year 11 Obs = 0.31531 0.223858 0.0826539 0.094032 0.080287 0.0487516 0.0414553 0.0393599 0.0249395
0.0102185 0.0143178 0.0248161
Year 11 Pred = 0.0937614 0.192956 0.22043 0.117636 0.0893015 0.105362 0.0395274 0.0293707 0.0286632
0.0298809 0.0256674 0.0274433
Year 12 Obs = 0.0591436 0.285952 0.317679 0.0921782 0.0410087 0.0364385 0.0303617 0.0331669
0.0295192 0.0295631 0.0172504 0.0277379
Year 12 Pred = 0.053692 0.27798 0.183648 0.141308 0.0698315 0.0503452 0.0899498 0.0333756 0.0224351
0.0231551 0.0214077 0.0328711
Year 13 Obs = 0.188389 0.0265347 0.173396 0.169705 0.120276 0.0681705 0.0572307 0.0546661 0.0495981 0.0372881 0.0251545 0.0295911
Year 13 Pred = 0.114307 0.160128 0.267421 0.118916 0.0845372 0.0395573 0.0432611 0.0766395 0.0257724 0.0183889 0.0168786 0.0341923
Year 14 Obs = 0.0248172 0.414455 0.192561 0.0759662 0.039534 0.0579879 0.0479625 0.0569555 0.0379309 0.0132895 0.0190424 0.0194975
Year 14 Pred = 0.132655 0.29775 0.13606 0.153701 0.0630459 0.0423001 0.0299381 0.0325521 0.0524342
0.0187693 0.0119693 0.0288246
Year 15 Obs = 0.0972272 0.367108 0.164346 0.082258 0.06402 0.043467 0.0407837 0.0287861 0.0305807
0.0228197 0.0172354 0.0413684
Year 15 Pred = 0.104003 0.328718 0.241309 0.0746673 0.0777728 0.0300834 0.0305116 0.0214846

```
0.0212569 0.0364747 0.0116831 0.022036
Year 16 Obs = 0.0101307 0.298494 0.340902 0.0805235 0.0254107 0.0446323 0.0390054 0.023213
0.0269606 0.0285413 0.0309409 0.0512457
Year 16 Pred = 0.0428768 0.291967 0.301754 0.150094 0.0428411 0.0420995 0.024599 0.0248121
0.0158954 0.0167418 0.0256991 0.0206198
Proportions of Discards at age by fleet
fleet 1
Year 1 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 1 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 2 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 2 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 3 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 3 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 4 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 4 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 5 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 5 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 6 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 6 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 7 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 7 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 8 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 8 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 9 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 9 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 10 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 10 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 11 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 11 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 12 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 12 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 13 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 13 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 14 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 14 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 15 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 15 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 16 Obs = 0 0 0 0 0 0 0 0 0 0 0 0
Year 16 Pred = 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
F Reference Points Using Final Year Selectivity Scaled Max=1.0
refpt F slope to plot on SRR
F0.1 0.133548 2.43001
Fmax 9.99999 314.33
F30%SPR 0.225234 3.58393
F40%SPR 0.155377 2.68796
Fmsy 0.144616 2.5595 SSmsy 304702 MSY 30403.2
Foy 0.108462 xxxxxx SSoy 382968 OY 29510.1
Fcurrent 0.256545 4.02083
Stock-Recruitment Relationship Parameters
alpha = 1.04077e+06
beta = 101929
virgin = 849409
steepness = 0.7
Spawning Stock, Obs Recruits(year+1), Pred Recruits(year+1)
1991 145426 690500 611896
1992 130853 522672 585046
1993 137850 425802 598344
1994 140085 509509 602430
1995 133909 1.22354e+06 590952
1996 144052 577023 609499
1997 143682 419462 608850
1998 141777 492686 605474
1999 138175 413644 598944
2000 130539 604978 584431
2001 122814 352901 568745
2002 111206 768007 543037
2003 110438 1.05231e+06 541238
2004 132961 1.02625e+06 589137
2005 132402 463804 588058
2006 137988 xxxx 598600
average F (ages 4 to 8 unweighted) by year
Projection into Future
Projected NAA
598600 385508 642233 473804 251188 84934.8 108154 53049.7 43962.1 24962.5 21012.9 50502.9
622129 505182 307426 498083 369630 198766 68436.1 86126 41594 34095.3 18913.3 53280.2
Projected Directed FAA
0.0196742 0.0763258 0.104184 0.0982892 0.0840766 0.0659828 0.0777484 0.0932739 0.104168
0.12751
0.144616 0.144246
0.0196742 0.0763258 0.104184 0.0982892 0.0840766 0.0659828 0.0777484 0.0932739 0.104168
0.12751
0.144616 0.144246
Projected Discard FAA
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
Projected Nondirected FAA
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
```

```
Projected Catch at Age
10832  26332.1  59083.6  41238.6  18829.4  5040.34  7520.02  4392.25  4043.79  2779.49  2632.07
6310.88
11257.8  34506.4  28282.3  43351.8  27708  11795.5  4758.39  7130.81  3825.96  3796.39  2369.08
6657.93
Projected Discards at Age (in numbers)
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
Projected Yield at Age
314.129  763.63  2658.76  2598.03  1751.14  630.043  1052.8  733.506  784.495  625.385  655.386
2088.9
326.476  1000.69  1272.7  2731.16  2576.84  1474.44  666.174  1190.85  742.237  854.188  589.9
2203.78
Year, Total Yield (in weight), Total Discards (in weight), SSB, proj_what, SS/SSmsy
2007 14656.2 0 151472 3 0.497116
2008 15629.4 0 168769 3 0.55388
M = 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15
mature = 0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
0.04 0.31 0.83 0.98 1 1 1 1 1 1 1 1
Weight at age
0.03 0.04 0.07 0.1 0.12 0.15 0.17 0.18 0.21 0.22 0.22 0.26
0.03 0.03 0.04 0.07 0.1 0.13 0.15 0.17 0.19 0.2 0.23 0.3
0.02 0.03 0.04 0.07 0.09 0.13 0.17 0.21 0.24 0.24 0.25 0.3
0.04 0.04 0.06 0.07 0.09 0.13 0.16 0.19 0.23 0.25 0.27 0.34
0.04 0.03 0.06 0.08 0.1 0.12 0.16 0.17 0.2 0.22 0.23 0.31
0.02 0.05 0.07 0.09 0.11 0.14 0.17 0.19 0.22 0.24 0.26 0.31
0.03 0.03 0.05 0.07 0.11 0.14 0.17 0.2 0.24 0.26 0.26 0.36
0.03 0.03 0.04 0.07 0.1 0.13 0.17 0.21 0.17 0.24 0.25 0.35
0.02 0.04 0.06 0.08 0.11 0.14 0.16 0.19 0.22 0.25 0.27 0.36
0.02 0.03 0.05 0.09 0.11 0.13 0.16 0.19 0.22 0.24 0.25 0.31
0.02 0.03 0.07 0.08 0.09 0.13 0.16 0.18 0.2 0.23 0.24 0.31
0.03 0.03 0.04 0.07 0.1 0.12 0.15 0.17 0.2 0.23 0.25 0.31
0.02 0.03 0.05 0.06 0.09 0.12 0.15 0.18 0.2 0.23 0.25 0.31
0.04 0.03 0.05 0.08 0.12 0.16 0.18 0.21 0.23 0.25 0.27 0.33
0.02 0.03 0.04 0.07 0.12 0.15 0.17 0.18 0.22 0.24 0.25 0.3
0.029 0.029 0.045 0.063 0.093 0.125 0.14 0.167 0.194 0.225 0.249 0.331
Fecundity
0.0012 0.0124 0.0581 0.098 0.12 0.15 0.17 0.18 0.21 0.22 0.22 0.26
0.0012 0.0093 0.0332 0.0686 0.1 0.13 0.15 0.17 0.19 0.2 0.23 0.3
0.0008 0.0093 0.0332 0.0686 0.09 0.13 0.17 0.21 0.24 0.24 0.25 0.3
0.0016 0.0124 0.0498 0.0686 0.09 0.13 0.16 0.19 0.23 0.25 0.27 0.34
0.0016 0.0093 0.0498 0.0784 0.1 0.12 0.16 0.17 0.2 0.22 0.23 0.31
0.0008 0.0155 0.0581 0.0882 0.11 0.14 0.17 0.19 0.22 0.24 0.26 0.31
0.0012 0.0093 0.0415 0.0686 0.11 0.14 0.17 0.2 0.24 0.26 0.26 0.36
0.0012 0.0093 0.0332 0.0686 0.1 0.13 0.17 0.21 0.17 0.24 0.25 0.35
0.0008 0.0124 0.0498 0.0784 0.11 0.14 0.16 0.19 0.22 0.25 0.27 0.36
0.0008 0.0093 0.0415 0.0882 0.11 0.13 0.16 0.19 0.22 0.24 0.25 0.31
0.0008 0.0093 0.0581 0.0784 0.09 0.13 0.16 0.18 0.2 0.23 0.24 0.31
0.0012 0.0093 0.0332 0.0686 0.1 0.12 0.15 0.17 0.2 0.23 0.25 0.31
0.0008 0.0093 0.0415 0.0588 0.09 0.12 0.15 0.18 0.2 0.23 0.25 0.31
0.0016 0.0093 0.0415 0.0784 0.12 0.16 0.18 0.21 0.23 0.25 0.27 0.33
0.0008 0.0093 0.0332 0.0686 0.12 0.15 0.17 0.18 0.22 0.24 0.25 0.3
0.00116 0.00899 0.03735 0.06174 0.093 0.125 0.14 0.167 0.194 0.225 0.249 0.331
SSmsy_ratio = 0.562653
Fmsy_ratio = 1.77397
that's all
```

Table 6.7.2.1. Southern horse mackerel. Population numbers from the ASAP model

Year	Age 0	1	2	3	4	5	6	7	8	9	10	11+
1991	831649	589704	193713	109622	104518	69067	71491	76709	70593	98613	38721	81605
1992	690500	695484	453902	143144	81707	79542	53972	54913	57597	52166	70424	83835
1993	522672	571631	514713	317910	101433	59550	60084	39832	39300	40342	34889	99776
1994	425802	428199	406254	341105	213822	70700	43434	42549	27129	26046	25215	80690
1995	509509	352153	315692	283056	240523	155182	53229	31930	30309	18903	17309	68018
1996	1220000	420150	256693	216572	196692	172389	115692	38680	22431	20794	12326	53638
1997	577023	1020000	315677	183532	156480	145758	131931	86705	28198	16038	14262	43911
1998	419462	476600	745926	218443	128579	112939	109263	96491	61385	19513	10569	37008
1999	492686	335312	307949	434077	129965	80695	75865	70223	58500	35724	10403	23811
2000	413644	405811	243332	209981	299911	92694	59929	54880	49065	39891	23121	21325
2001	604978	340236	292917	164711	144081	212643	68522	43116	38094	33213	25588	27419
2002	352901	499104	248449	201438	114718	103469	158775	49883	30356	26198	21721	33426
2003	768007	291226	364870	171121	140502	82486	77334	115720	35169	20908	17166	34853
2004	1050000	638059	218522	260408	123430	103968	63055	57879	84225	25101	14309	34538
2005	1030000	875560	481542	157194	189235	91917	79874	47471	42425	60589	17345	32790
2006	463804	854359	662229	347431	114552	141261	70750	60267	34889	30610	42022	33792

Table 6.7.2.2. Southern horse mackerel. Fishing mortality estimates from the ASAP model

Year	Age 0	1	2	3	4	5	6	7	8	9	10	11+	Avg.2-8
1991	0.03	0.11	0.15	0.14	0.12	0.1	0.11	0.14	0.15	0.19	0.21	0.21	0.13
1992	0.04	0.15	0.21	0.19	0.17	0.13	0.15	0.18	0.21	0.25	0.29	0.29	0.18
1993	0.05	0.19	0.26	0.25	0.21	0.17	0.2	0.23	0.26	0.32	0.36	0.36	0.23
1994	0.04	0.15	0.21	0.2	0.17	0.13	0.16	0.19	0.21	0.26	0.29	0.29	0.18
1995	0.04	0.17	0.23	0.21	0.18	0.14	0.17	0.2	0.23	0.28	0.31	0.31	0.19
1996	0.04	0.14	0.19	0.17	0.15	0.12	0.14	0.17	0.19	0.23	0.26	0.26	0.16
1997	0.04	0.16	0.22	0.21	0.18	0.14	0.16	0.2	0.22	0.27	0.3	0.3	0.19
1998	0.07	0.29	0.39	0.37	0.32	0.25	0.29	0.35	0.39	0.48	0.54	0.54	0.34
1999	0.04	0.17	0.23	0.22	0.19	0.15	0.17	0.21	0.23	0.29	0.32	0.32	0.2
2000	0.05	0.18	0.24	0.23	0.19	0.15	0.18	0.22	0.24	0.29	0.33	0.33	0.21
2001	0.04	0.16	0.22	0.21	0.18	0.14	0.17	0.2	0.22	0.27	0.31	0.31	0.19
2002	0.04	0.16	0.22	0.21	0.18	0.14	0.17	0.2	0.22	0.27	0.31	0.31	0.19
2003	0.04	0.14	0.19	0.18	0.15	0.12	0.14	0.17	0.19	0.23	0.26	0.26	0.16
2004	0.03	0.13	0.18	0.17	0.14	0.11	0.13	0.16	0.18	0.22	0.25	0.25	0.15
2005	0.03	0.13	0.18	0.17	0.14	0.11	0.13	0.16	0.18	0.22	0.24	0.24	0.15
2006	0.03	0.14	0.18	0.17	0.15	0.12	0.14	0.17	0.18	0.23	0.26	0.26	0.16

Table 6.8.1. Southern horse mackerel. Input data for the short term predictions

MFDP version 1a
Run: hom_soth_2
Time and date: 13:53 25/09/2007
Fbar age range: 2-8

2007

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	615890	0.15	0.04	0	0	0.0297	0.0424	0.0297
1	385508	0.15	0.31	0	0	0.0297	0.1704	0.0297
2	642233	0.15	0.83	0	0	0.0450	0.2371	0.0450
3	473804	0.15	0.98	0	0	0.0710	0.2309	0.0710
4	251188	0.15	1	0	0	0.1110	0.1977	0.1110
5	84934.8	0.15	1	0	0	0.1450	0.1609	0.1450
6	108154	0.15	1	0	0	0.1633	0.1912	0.1633
7	53049.7	0.15	1	0	0	0.1857	0.2624	0.1857
8	43962.1	0.15	1	0	0	0.2147	0.3511	0.2147
9	24962.5	0.15	1	0	0	0.2383	0.2563	0.2383
10	21012.9	0.15	1	0	0	0.2563	0.3511	0.2563
11	50502.9	0.15	1	0	0	0.3203	0.1292	0.3203

2008

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	615890	0.15	0.04	0	0	0.0297	0.0424	0.0297
1	.	0.15	0.31	0	0	0.0297	0.1704	0.0297
2	.	0.15	0.83	0	0	0.0450	0.2371	0.0450
3	.	0.15	0.98	0	0	0.0710	0.2309	0.0710
4	.	0.15	1	0	0	0.1110	0.1977	0.1110
5	.	0.15	1	0	0	0.1450	0.1609	0.1450
6	.	0.15	1	0	0	0.1633	0.1912	0.1633
7	.	0.15	1	0	0	0.1857	0.2624	0.1857
8	.	0.15	1	0	0	0.2147	0.3511	0.2147
9	.	0.15	1	0	0	0.2383	0.2563	0.2383
10	.	0.15	1	0	0	0.2563	0.3511	0.2563
11	.	0.15	1	0	0	0.3203	0.1292	0.3203

2009

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	615890	0.15	0.04	0	0	0.0297	0.0424	0.0297
1	.	0.15	0.31	0	0	0.0297	0.1704	0.0297
2	.	0.15	0.83	0	0	0.0450	0.2371	0.0450
3	.	0.15	0.98	0	0	0.0710	0.2309	0.0710
4	.	0.15	1	0	0	0.1110	0.1977	0.1110
5	.	0.15	1	0	0	0.1450	0.1609	0.1450
6	.	0.15	1	0	0	0.1633	0.1912	0.1633
7	.	0.15	1	0	0	0.1857	0.2624	0.1857
8	.	0.15	1	0	0	0.2147	0.3511	0.2147
9	.	0.15	1	0	0	0.2383	0.2563	0.2383
10	.	0.15	1	0	0	0.2563	0.3511	0.2563
11	.	0.15	1	0	0	0.3203	0.1292	0.3203

Input units are thousands and kg - output in tonnes

Table. 6.8.2. Southern horse mackerel. Short-term predictions with the management option table

MFDP version 1a
Run: hom_soth_2
hom-sothMFDP Index file 24-09-2007
Time and date: 13:53 25/09/2007
Fbar age range: 2-8

2007				
Biomass	**SSB**	**FMult**	**FBar**	**Landings**
196912	165894	0.7043	0.1641	24000

2008					2009	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
208528	177540	0	0	0	245848	213709
.	177540	0.1	0.0233	3738	241353	209326
.	177540	0.2	0.0466	7397	236956	205039
.	177540	0.3	0.0699	10978	232655	200847
.	177540	0.4	0.0932	14484	228448	196747
.	177540	0.5	0.1165	17916	224331	192737
.	177540	0.6	0.1398	21276	220304	188815
.	177540	0.7	0.1631	24566	216364	184979
.	177540	0.8	0.1864	27787	212509	181227
.	177540	0.9	0.2097	30940	208738	177556
.	177540	1	0.233	34028	205048	173966
.	177540	1.1	0.2563	37051	201437	170454
.	177540	1.2	0.2796	40012	197903	167019
.	177540	1.3	0.303	42911	194446	163658
.	177540	1.4	0.3263	45751	191062	160370
.	177540	1.5	0.3496	48532	187751	157153
.	177540	1.6	0.3729	51255	184511	154006
.	177540	1.7	0.3962	53923	181339	150927
.	177540	1.8	0.4195	56536	178235	147914
.	177540	1.9	0.4428	59095	175197	144966
.	177540	2	0.4661	61602	172224	142082

Input units are thousands and kg - output in tonnes

Table 6.9.1 A summary of the main features of the ASAP model used for the assessment of southern horse mackerel.

Model	ASAP
Version	1.4.2
Model type	The ASAP model is a flexible, forward computing algorithm, which uses the optimisation method of automatic differentiation to minimise an objective function based on likelihoods. The automatic differentiation routines were developed using the commercial package AD Model Builder (Otter Research). ASAP differs from the virtual population analysis methods in that: calculations proceed from the initial conditions to the present and into the future, the catch at age is not assumed to be known exactly, fishing mortality is separable but selection at age is allowed to change gradually over time, separate components of the fishery are treated independently, a stock recruitment relationship is required, and some parameters, which are usually assumed constant, such as the catchability coefficients associated with tuning indices, may be allowed to change over time. The model begins in the first year of available data with an estimate of the population abundance at age. Recruitments are entered for each year as deviations from a Beverton and Holt model. These deviations can be constrained but for the present stock they were left unconstrained. The spawning stock for that year is calculated, and the expected recruitment for next year generated from the spawner-recruit relationship. Each cohort estimated in the initial population abundance at age is then reduced by the total mortality rate, and projected into the next year and next age. This process of estimating recruitment and projecting the population forward continues until the final year of data is reached. Expected catches are computed according to the usual catch equation using the determined fishing mortality rate, the assumed natural mortality rate, and the estimated population abundance described above. The statistical fitting procedure used with the model will try to match the indices and the catch at age. The emphasis of each of these sources of information depends on the values of the relative weights assigned to each component by the user.
Data used	The weights-at-age in the stock (variable with time) and maturity-at-age (fixed in time) are assumed to be known without error. The natural mortality rate is fixed at 0.15/year and year-invariant. The catch-at-age data (numbers) and a bottom-trawl survey series, obtained by combining the data from the Portuguese and Spanish surveys, are taken as being measured with error. The weights given to the survey data from each country was proportional to the respective number of hauls, roughly 75% to the Portuguese data and 25% to the Spanish one. The variances of the survey indices in each age and year were approximated by the following expression: var(I) = A^2 . var(Q) + Q^2 . var(A), where A is the abundance index in each year and length class, and Q is the proportion of each age in each length class in the age-length keys applied to the survey data. The variance of A was calculated across all hauls in each year, and var(Q) = p . (1 - p) where p is the proportion of fish of a given length class that are in that age class in the age-length key.
Selection	Selectivity-at-age was estimated for ages 0-11+. Selectivity could be allowed to change in time, however that did not improve the fitting of the model in this particular case. The selectivity in the survey is assumed to be the same as the selectivity in the fishery.
Fishing mortality assumptions	The fishing mortality rates are assumed to be separable into an age component (called selectivity) and a year component (called the F multiplier).
Estimated parameters	Vector of selectivities-at-age for 1991 and kept fixed during the whole assessment period (12 parameters); F multiplier for the first year (1 parameter);

	Deviations to the F multiplier for each year except the 1st one (16 parameters); Vector of catchabilities-at-age, kept fixed during the whole assessment period (12 parameters); Vector of the recruitment deviations from the mean for each year (16 parameters); Vector of deviations, for each age, from the number at age 0 in the 1st year (11 parameters); Virgin biomass for the stock-recruitment relationship (1 parameter).
Catchabilities	The catchability-at-age parameters link the survey estimates and the number-at-age estimates from the model. These were kept fixed during the whole assessment period.
Plus-group	A dynamic pool is assumed (plus group this year is the sum of last year's plus group and last year's oldest true age, both depleted by fishing and natural mortality).
Objective function	The estimation is based on maximum likelihood. There is a maximum of eleven components to the objective function, from which only seven were used in this case. These are the ones corresponding to: total catch in weight, catch-at-age proportions, indices of abundance, F multipliers, recruitment, N at first year and stock-recruitment relationship.
Variance estimates / uncertainty	Variances and correlations between parameters are estimated from the Hessian matrix resulting from the optimisation process.
Program language	Calculations made with AD Model Builder (Otter Research) and graphical user's interface made with Visual Basic.
References	Legault, C. and Restrepo, V. 1998. A flexible forward age-structured assessment program. ICCAT working document SCRS/98/58.

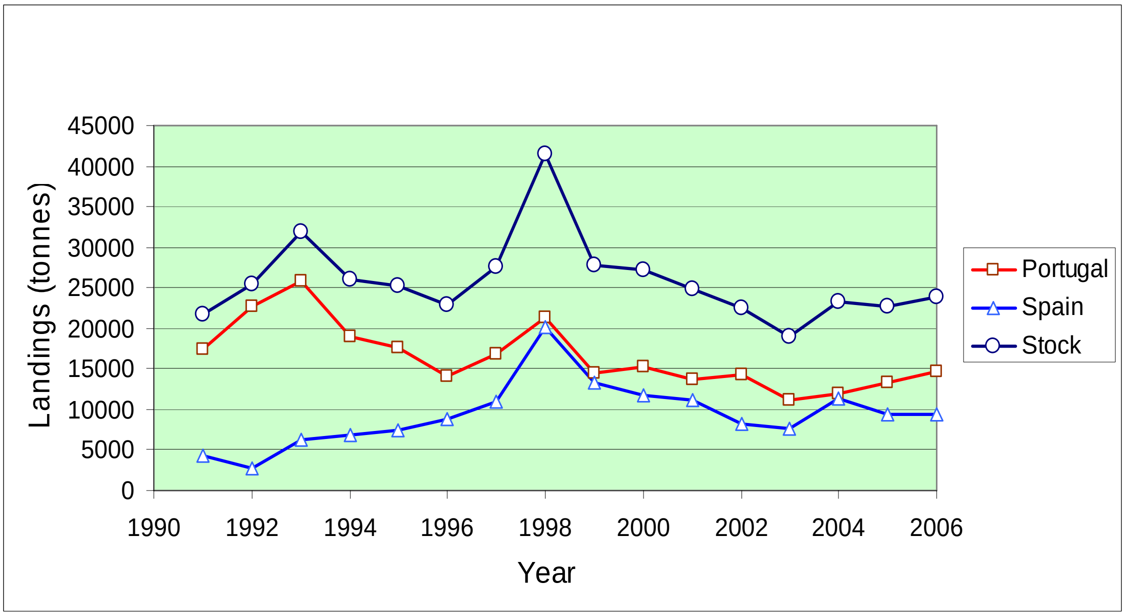


Figure 6.2.1. Southern horse mackerel. Time series of the total southern horse mackerel catches, with information of the catches by country, for the period 1991-2006 (without including catches from the Gulf of Cádiz).

Figure 6.2.2. Southern horse mackerel. Historical series of catches by Subdivision. (Catches from the Gulf of Cádiz in Subdivision IXa South are not included)

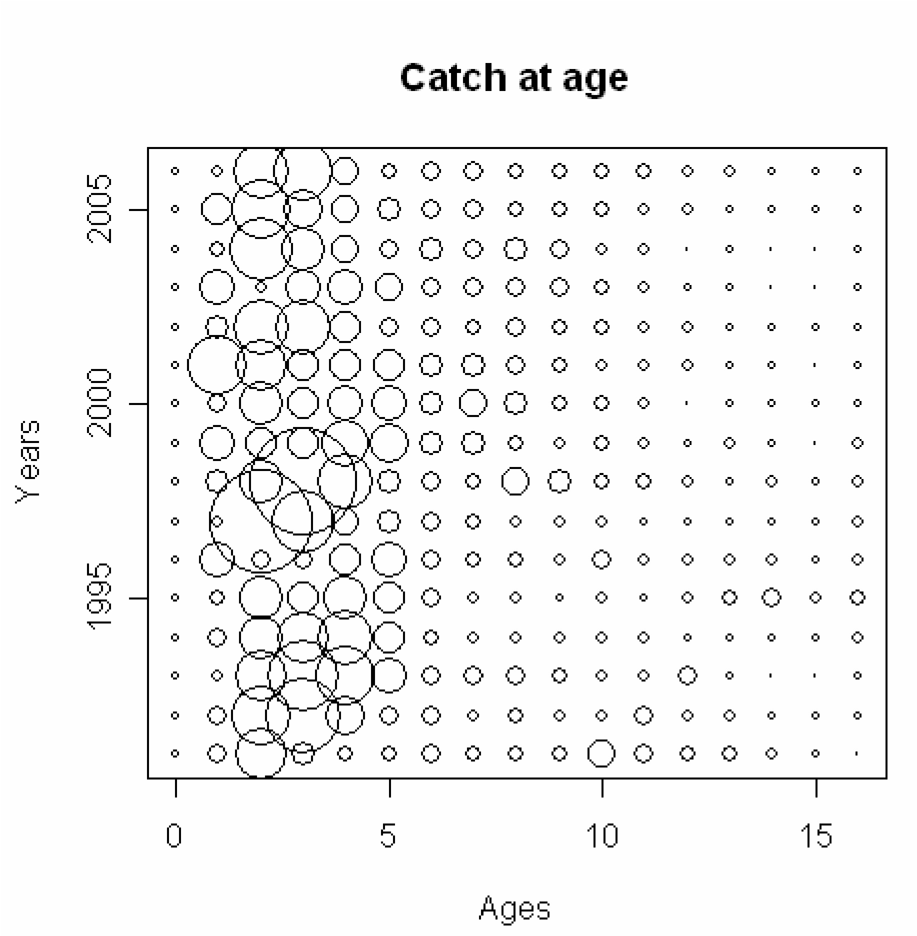


Figure 6.3.1.1. Southern horse mackerel. Buble plot of catch in numbers at age.

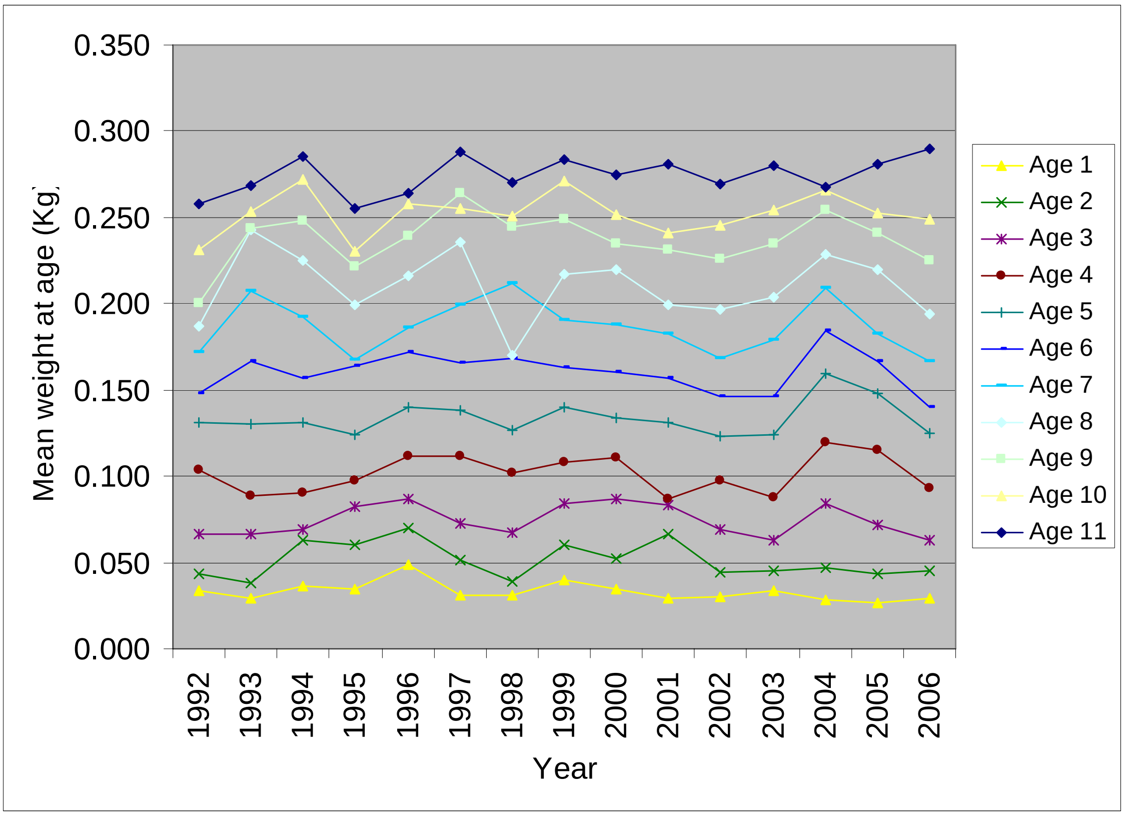


Figure 6.3.2.1. Southern horse mackerel. Time series of southern horse mackerel mean weight at age in the catch (from ages 1 to 11).

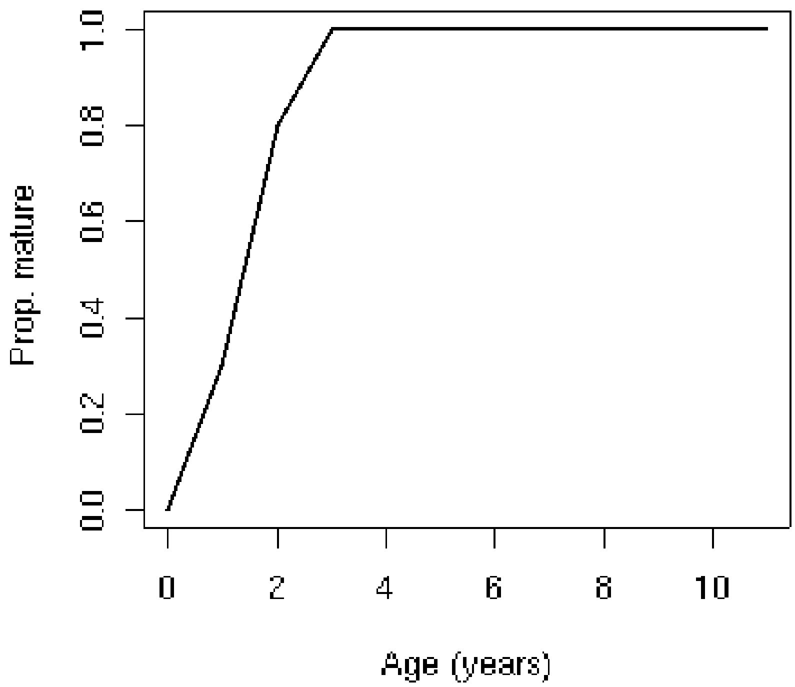


Figure 6.3.3.1 Maturity at age

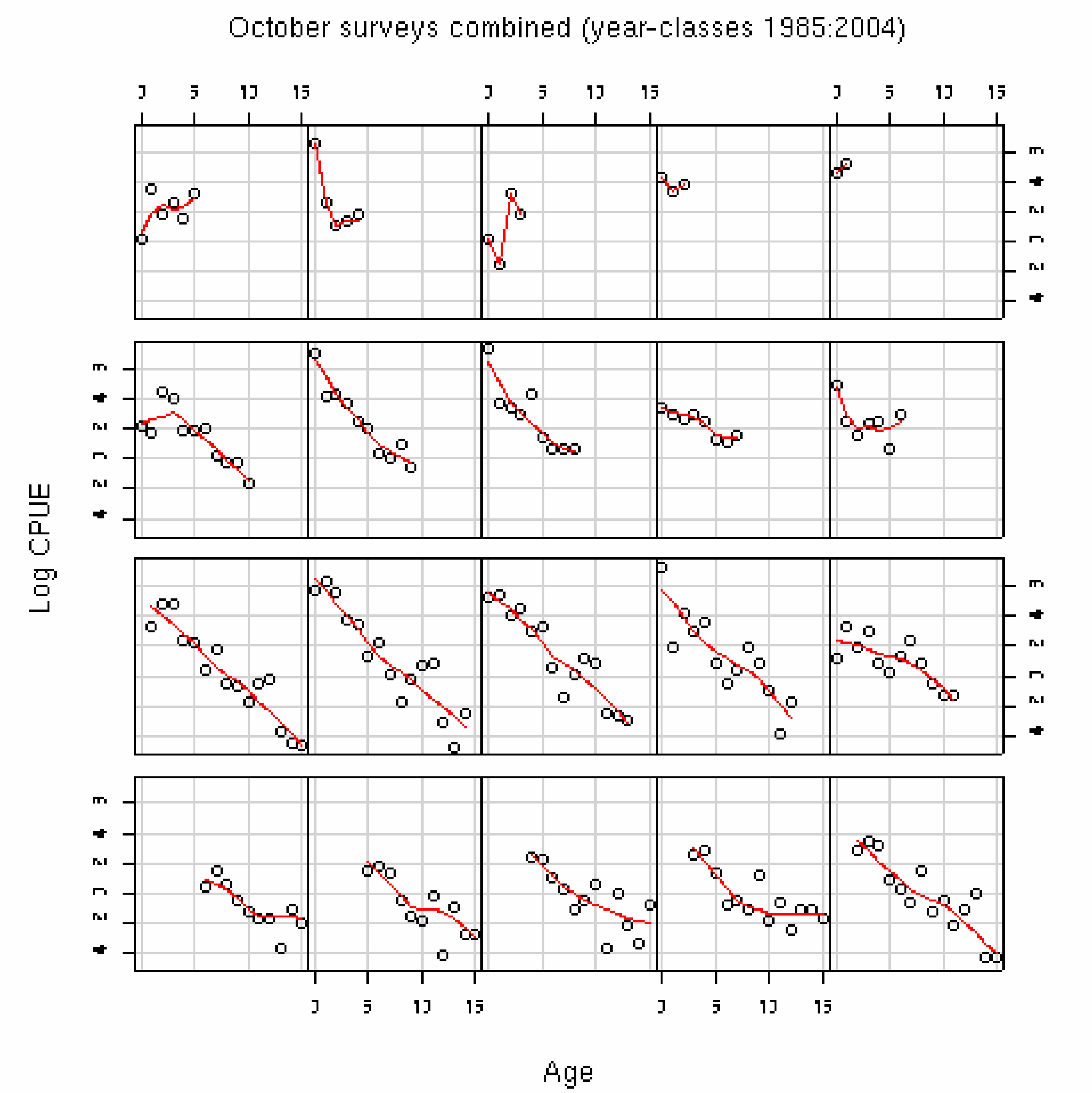


Figure 6.4.1.1. Southern horse mackerel. Evolution of the cohorts in the October combined bottom trawl survey, from left to the right and bottom to top. Line is loess interpolator.

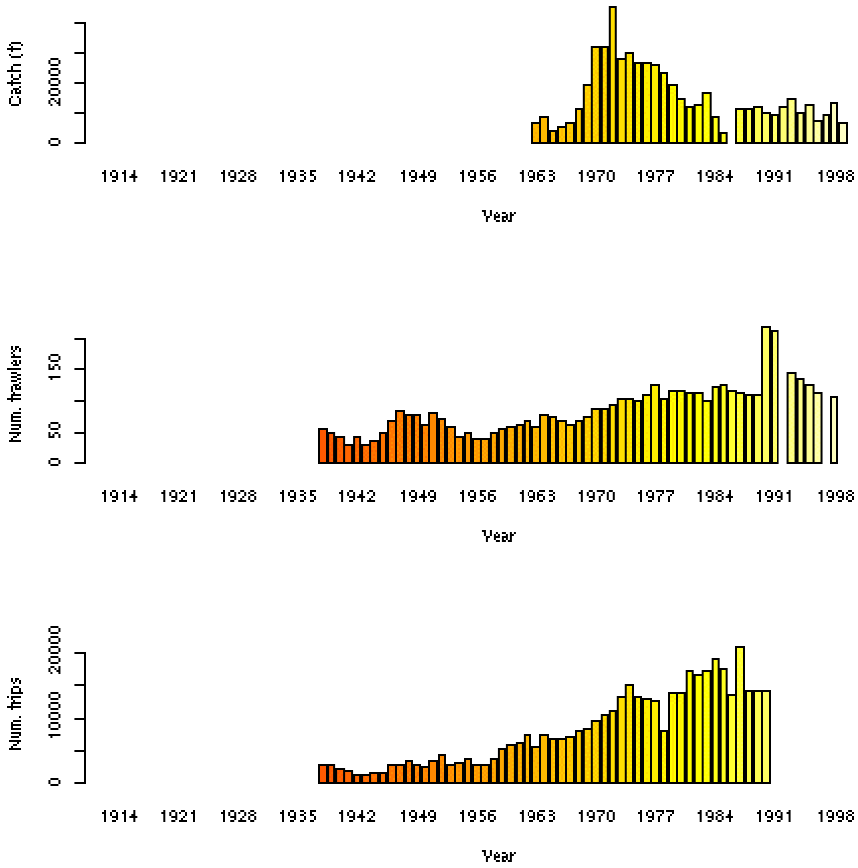


Figure 6.5.1. Southern horse mackerel. Time series of catch and effort from Portuguese bottom trawlers operating in Division IXa.

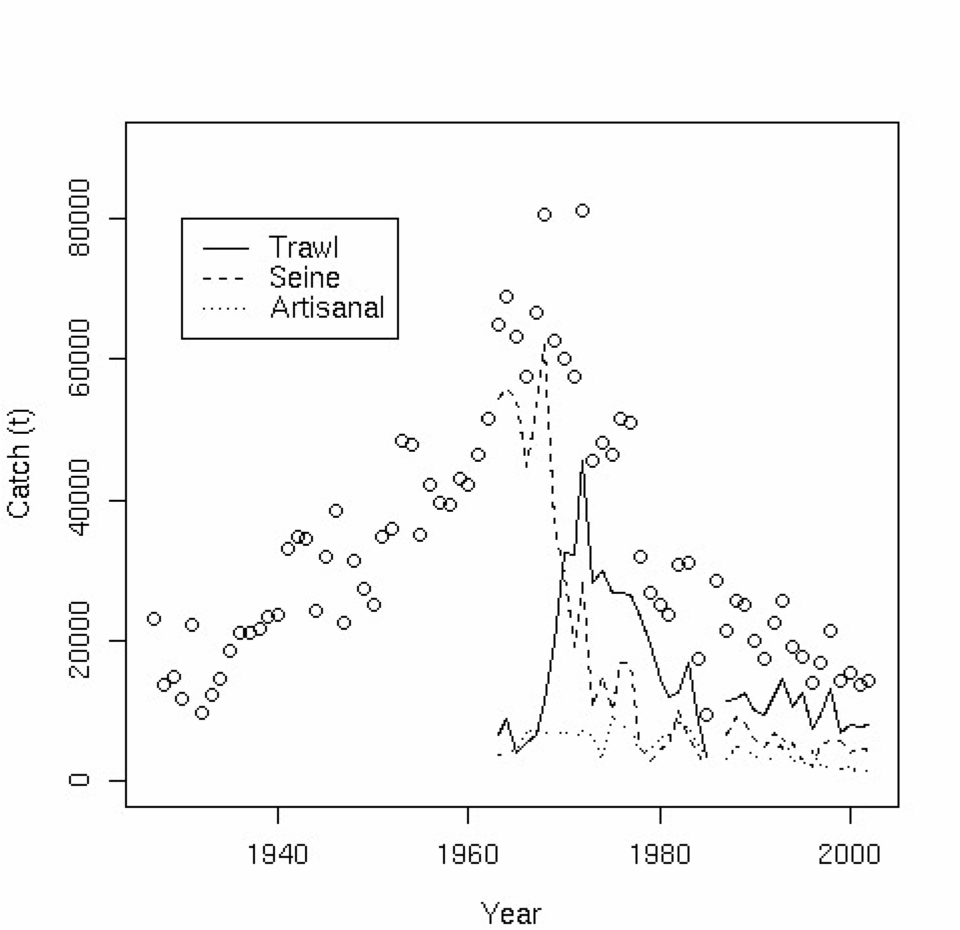


Figure 6.5.2. Southern horse mackerel. Time series of the Portuguese catches of horse mackerel in Division IXa: total and by fishing gear

Figure 6.5.3. Southern horse mackerel. Time series of the Spanish catches of horse mackerel in Division IXa (Southern stock) and in Division VIIIc (Western stock): total and by fishing gear.

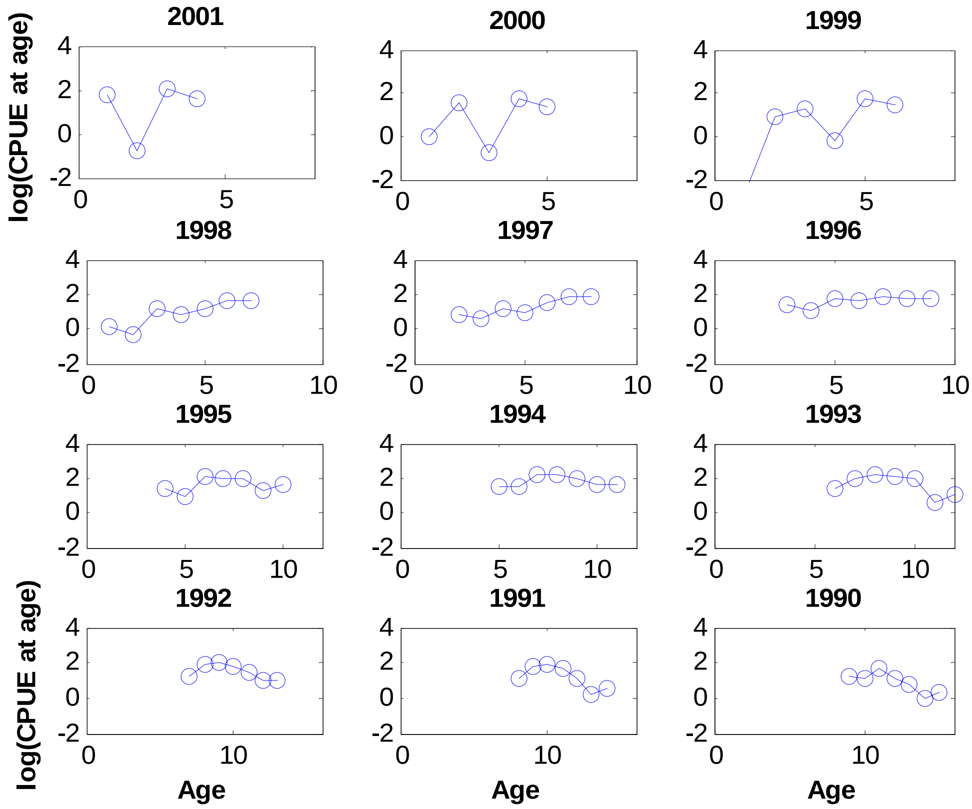


Figure 6.5.4. Southern horse mackerel. Marín bottom trawl fleet. Evolution of the index of abundance of several year classes (1990-2001).

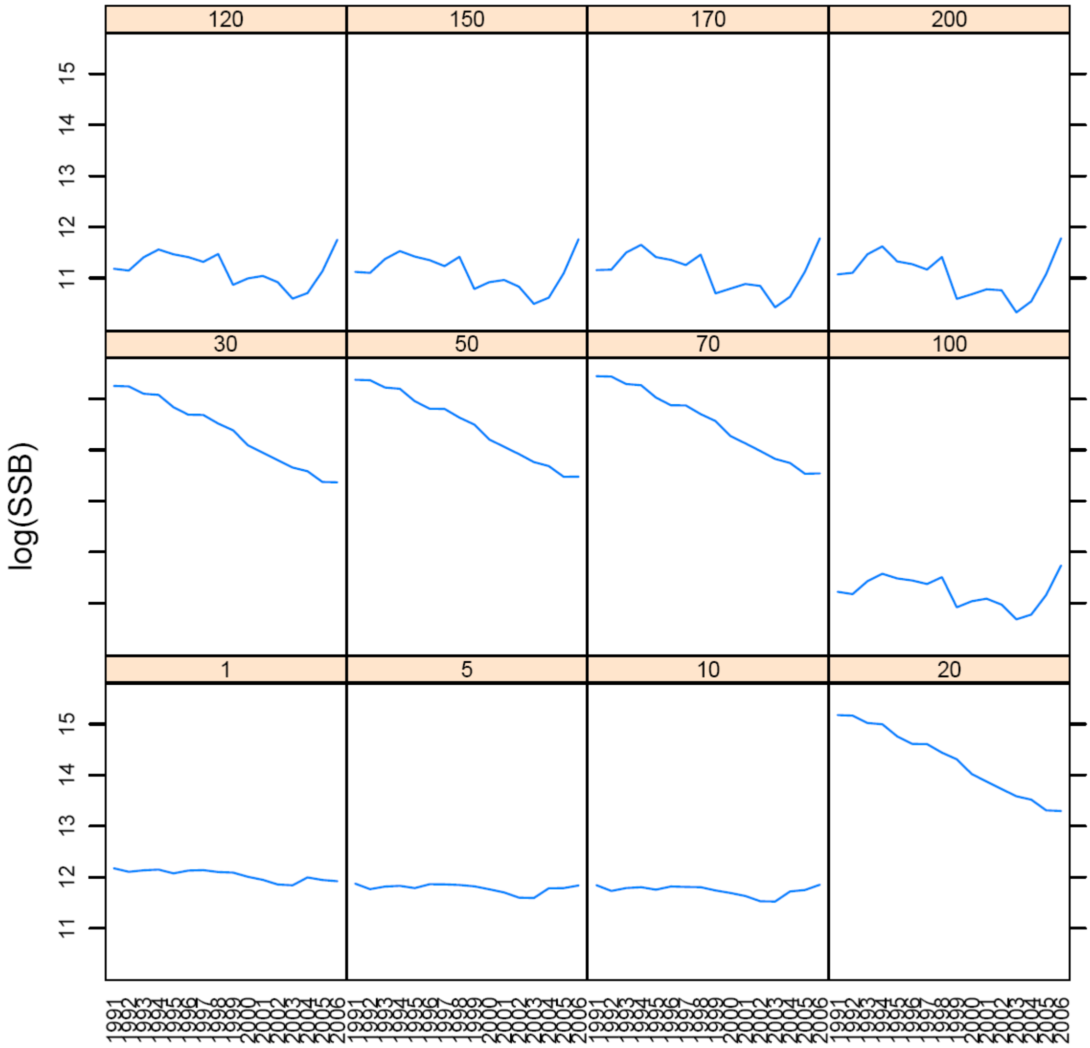


Figure 6.7.1.1. Southern horse mackerel. Results from the sensitivity analysis showing the influence on SSB of giving different weights to the survey and maintaining the weight to the catches constant = 100. From the bottom and left to the right, the weight to the survey is increased (number on the top of each subplot).

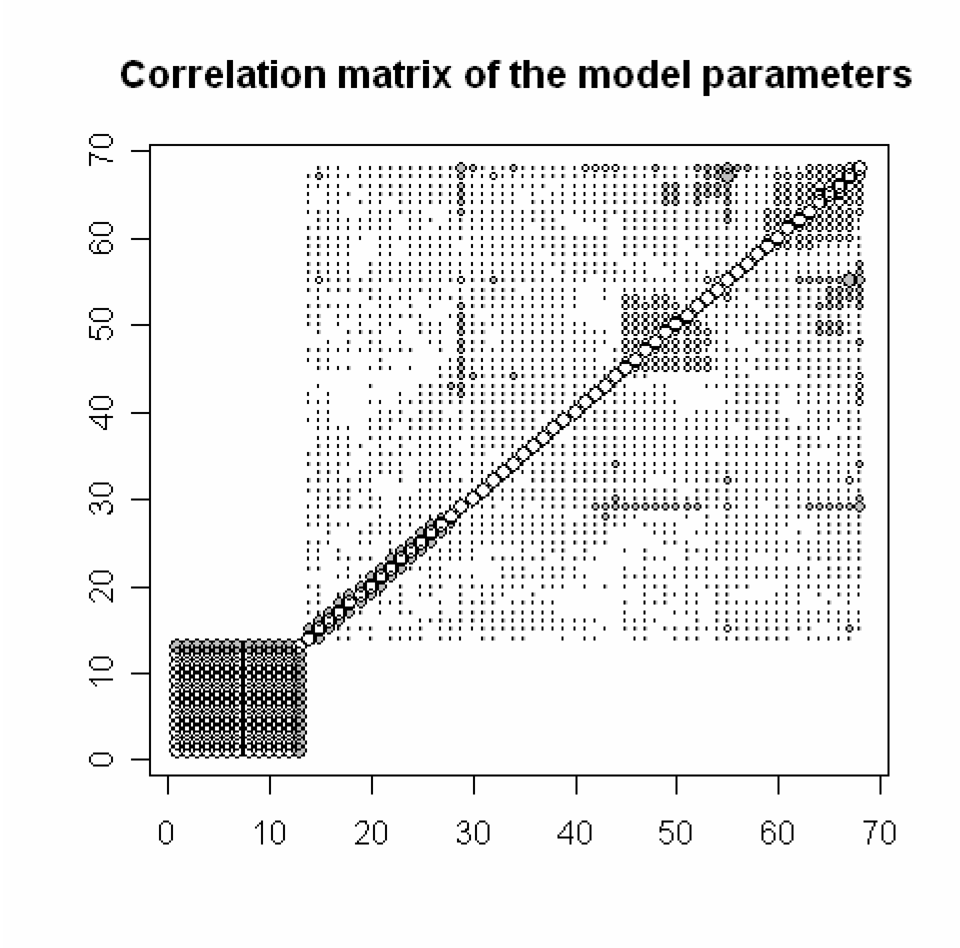


Figure 6.7.1.2. Southern horse mackerel. Correlation matrix of the ASAP model parameters (69 parameters in total). The size of the circles is proportional to the correlation value. White areas = correlation value equal to 0.

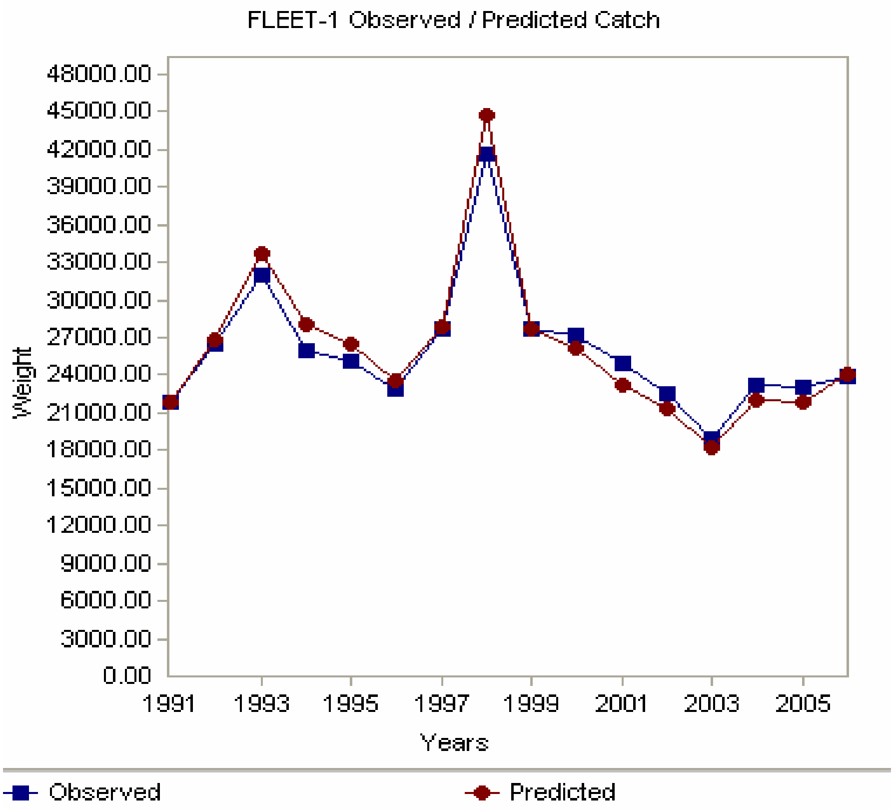


Figure 6.7.1.3. Southern horse mackerel. Comparison of the observed and predicted catch from the ASAP model.

Figure 6.7.1.4. Southern horse mackerel. Buble plot of residuals of catch proportion at age. The range of the values is between -0.14 and 0.23.

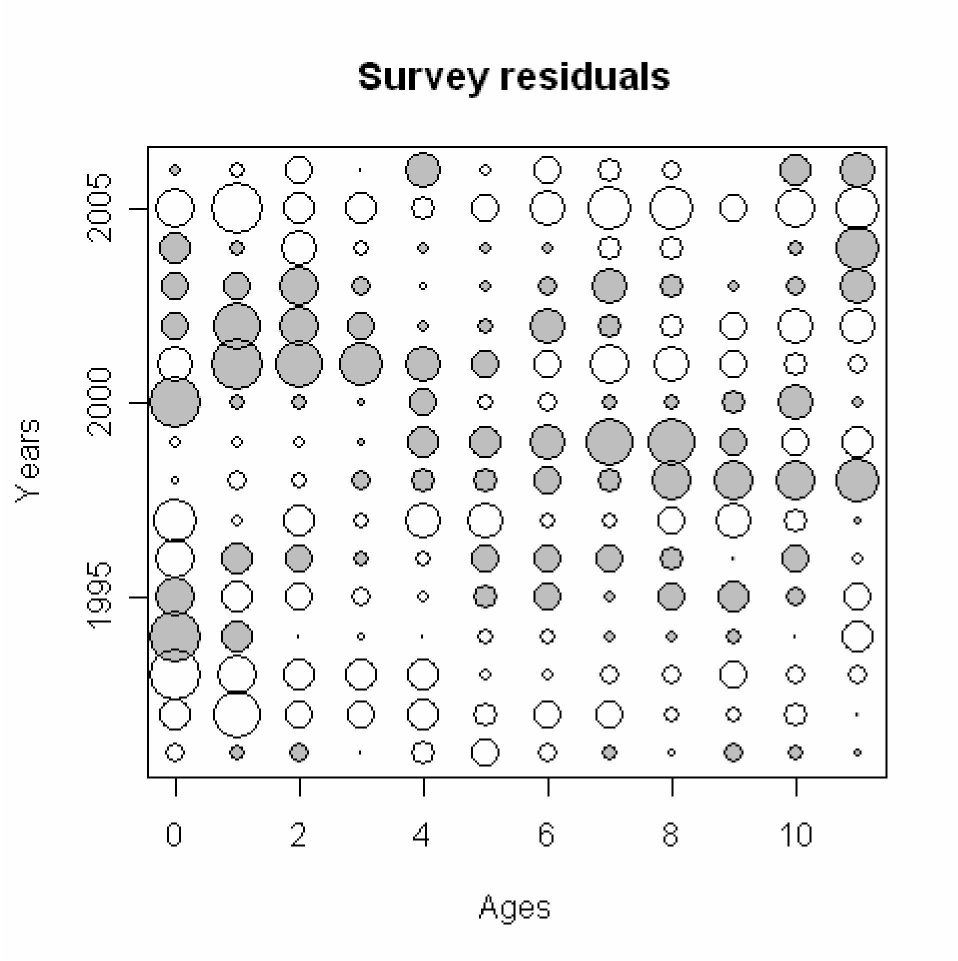


Figure 6.7.1.5. Southern horse mackerel. Buble plot of combined survey residuals. The range of values is between -3 and 3.

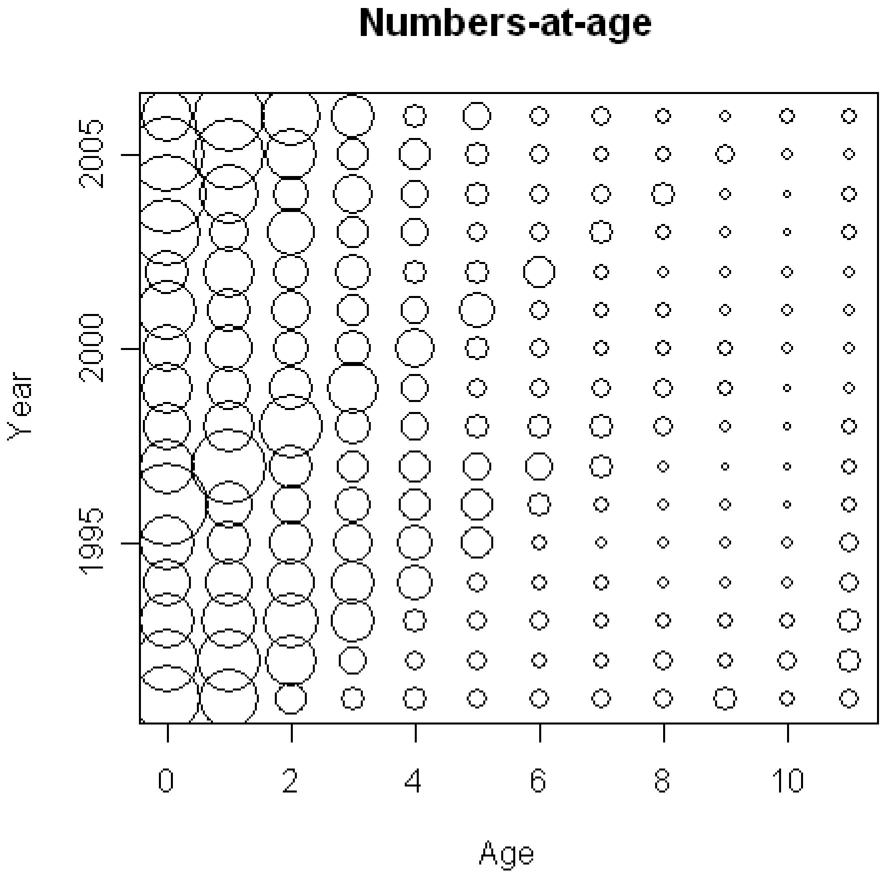


Figure 6.7.2.1. Southern horse mackerel. Buble plot of stock numbers at age.

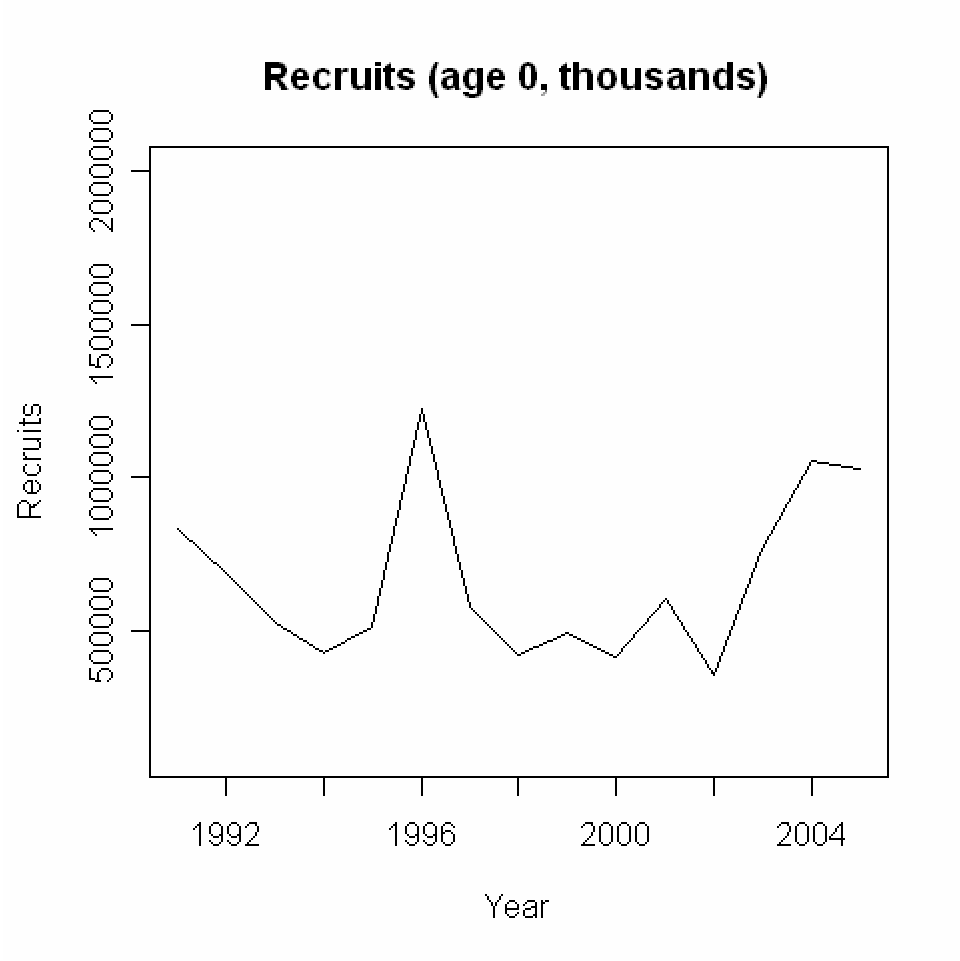
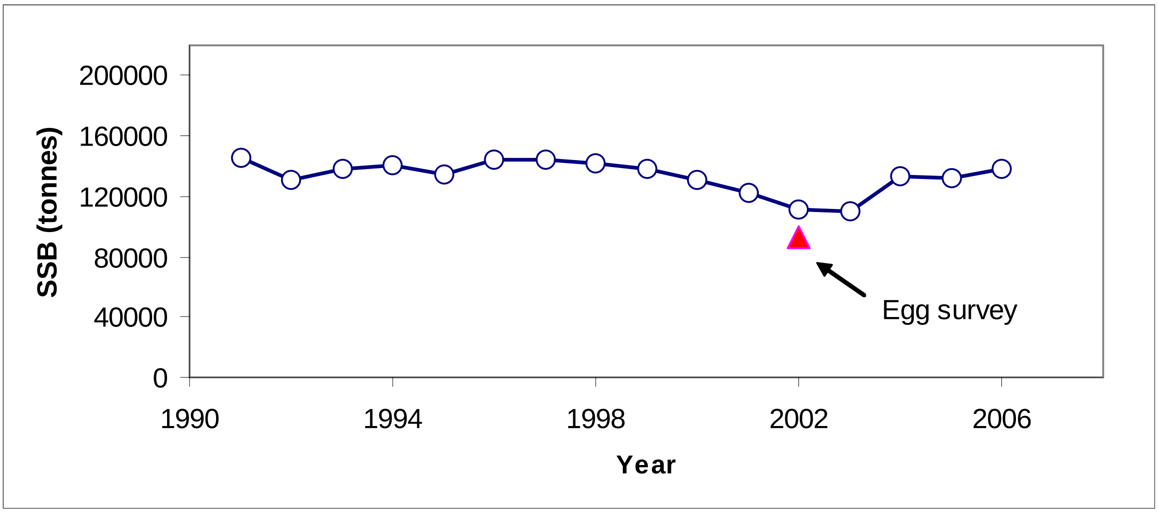


Figure 6.7.2.2. Southern horse mackerel. Time series of recruitment estimates.



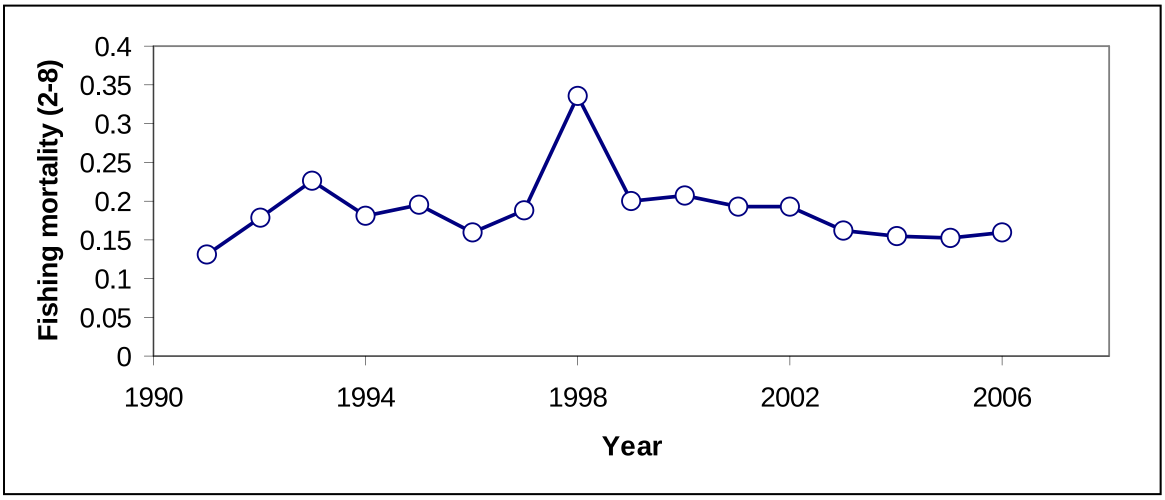


Figure 6.7.2.3. Southern horse mackerel. ASAP assessment results: historical series of SSB (upper panel), with an indication of the 2002 egg survey estimate (pink triangle), and historical series of fishing mortality (bottom figure).

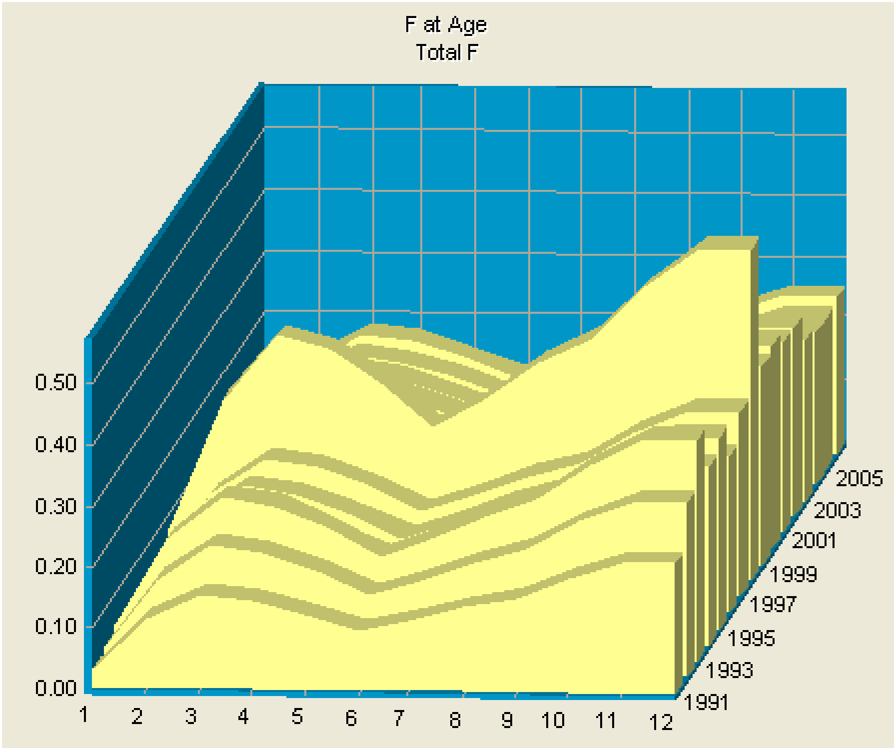


Figure 6.7.2.4. Southern horse mackerel. Historical series of F at age estimates.

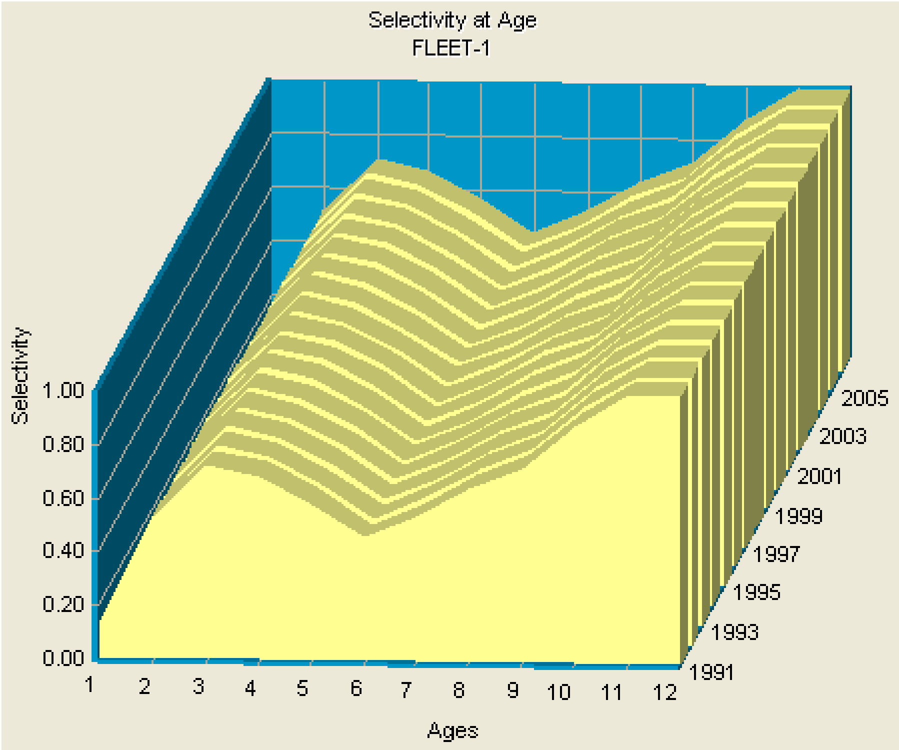


Figure 6.7.2.5. Southern horse mackerel. Selectivity at age estimated from the ASAP model.

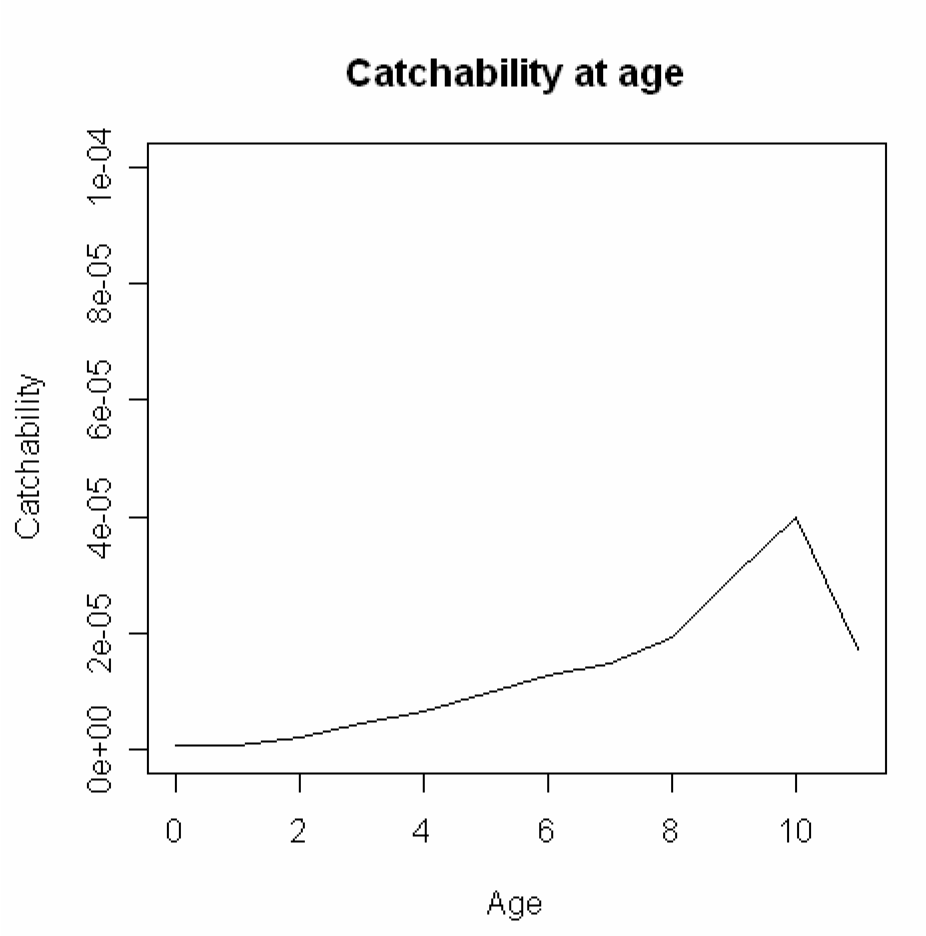
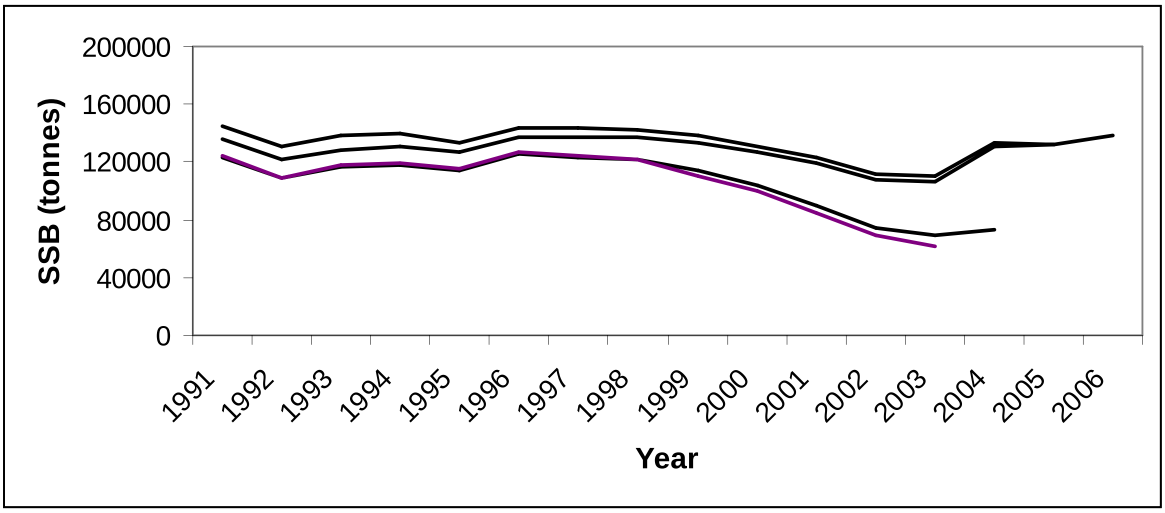


Figure 6.7.2.6. Southern horse mackerel. Catchability at age estimates



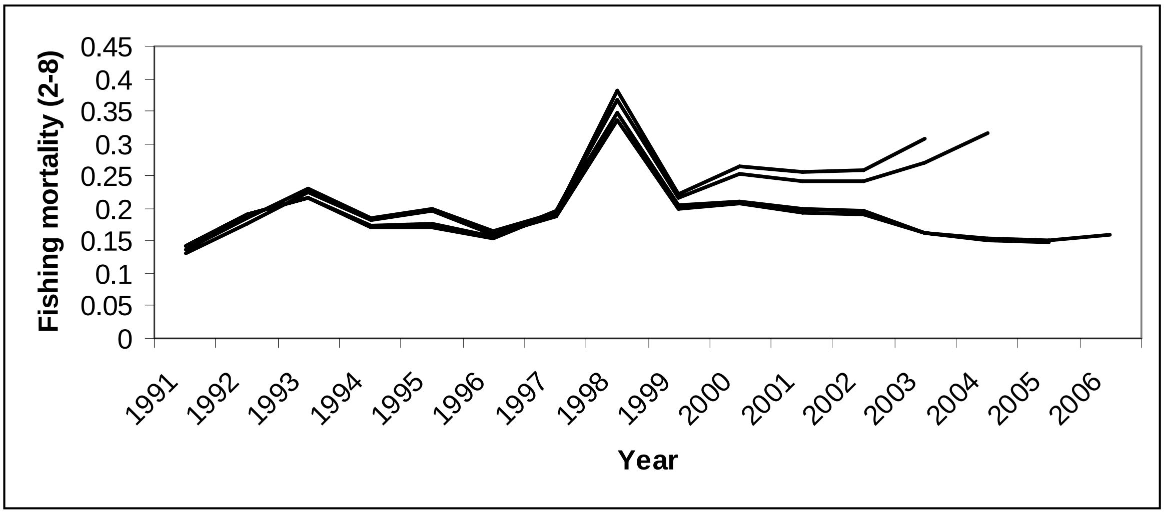


Figure 6.7.3.1. Southern horse mackerel. Retrospective analysis (2006-2003) of SSB (upper panel) and fishing mortality (estimated as the average between ages 2 and 8).

7 Sardine general

7.1 The fisheries for sardine in the ICES area

Sardine distribution in the North-East Atlantic covers a wide area, ranging from southern Mauritania to the northern part of the North Sea. The sardine stock assessed by ICES covers the Atlantic waters of the Iberian Peninsula (ICES areas VIIIc and IXa) and the characteristics of the fishery, surveys and assessment of the species in the stock area are discussed in section 8. This section 7 lists the information available on sardine outside the stock area, both from fisheries and surveys. Estimates of sardine biomass from acoustic surveys off the French coast, as well as survey and catch data on age and length distribution for this species have been provided to the WG. The time series comprises data from 2000 onwards and was first presented in 2004. There is no management requested for sardine outside the Iberian Peninsula (ICES areas VIIIc and IXa) and no assessment is carried out.

7.1.1 Catches for sardine in the ICES area

Commercial catch data for 2006 were provided by Portugal, Spain, France, UK (England and Wales), the Netherlands, Ireland and Germany (Table 7.1.1.1). Total reported catch was 131 265 tonnes, divided as follows: 42% of the catches by Portugal, 25% by Spain and 22% by France. The remaining 11% catches are reported for division VIId-f by England and Wales, for divisions VIId,h and VIIIc by Germany, for divisions VIId,e,h and VIIIa by the Netherlands and for divisions IVa, VIa, VIIa,b,d,e,g,h,j and VIIIa,b,d,e by Ireland. Catches in VIIIc and IXa amount to 66% of the total sardine catches. It should be noted that fishing activities are limited in both Spain and Portugal (see section 8.11) while there are no catch regulations in place in the other countries. In 2006, there is a 5% decrease with respect to the total 2005 sardine catches in European waters, with decreases of 4% in Portuguese and 19% in Spanish catches, respectively. Landings in France in 2006 show an increase of 10% compared to the landings in 2005. Catches from England and Wales have decreased by 19% in 2006 with respect to 2005, while caches by the remaining countries (The Netherlands, Germany and Ireland) have increased.

There are also important landings (about 12 300 t) taken in division VIId in the north of France, resulting from the catches of two single pelagic trawlers. However no biological data are collected on this fishery.

7.2 Sardine in VIIIa and VIIIb

7.2.1 The fishery in 2006

An update of the French and Spanish catch data series in Divisions VIIIa and VIIIb (from 1983 and 1996 for France and Spain, respectively) including 2006 catches was presented to this year´s WG (Table 7.2.1.1). French catches have increased along the series, with values ranging from 4 367 tonnes in 1983 to 15 916 tonnes in 2006 with some small fluctuations. Spanish catches are taken by purse seines from the Basque Country operating only in division VIIIb. Spanish landings peaked in 1998 and 1999 with almost 8 thousand tonnes but have decreased in the last four years to below 1 thousand tonnes. This Spanish fishery takes place mainly during March and April and in the fourth quarter.

In France, the main fishery takes place in the north part of the Bay of Biscay (VIIIa – 15 916 tonnes). A total of 90% of the catches are taken by purse seiners while the remaining 10% is reported by pelagic trawlers (mainly pair trawlers). A substantial part of the French catches originates in divisions VIIh and VIIe, but these catches have been assigned to division VIIIa due to their very concentrated location at the boundary between VIIIa, VIIh and VIIe. Numbers by length-class for divisions VIIIa,b by quarter are shown in Table 7.2.1.2.

Both purse seiners and pelagic trawlers target sardine in French waters (ICES 2006, WD Duhamel, 2006). Average vessel length is about 18m. Purse seiners operate mainly in coastal areas (<10 nautical miles) while trawlers are allowed to fish within 3 nautical miles from the coast. Both pair trawlers and purse seiners operate close to their base harbour when targeting sardine. Sardine landings show a seasonal pattern, with the highest catches being taken in the summer months (Figure 7.2.1.1). Almost all the catches are taken in south-west Brittany. Due to the closure of the anchovy fishery in autumn 2005 and again in 2006, one fourth of the purse seiners operating in the northern part of the Bay of Biscay stopped fishing during a month and a half in exchange for a financial compensation. This decrease in effort is apparent in the autumn landings recorded in those years.

The geographical distribution of sardine catches by the French fleet during 2002-06 is shown in Figure 7.2.1.2. Purse seiners fish sardine in the northern part of the Bay of Biscay all year round (in larger quantities in spring and summer), while pelagic trawlers fish sardine in the central Bay of Biscay targeting small fish, mainly during spring. Additionally, a smaller purse seine fleet targeting several species also operates in the Basque Country.

Figure 7.2.1.3. shows French annual sardine landings by the different fleet components. Catches by purse seiners are increasing, while catches by pelagic trawlers show the opposite trend. Catches by purse seiners in 2006 show a small decrease compared with the catches by this fleet in 2005.

Numbers by length-class for divisions VIIIb by quarter taken by Spanish vessels are shown in Table 7.2.1.3. This table shows the typical seasonality of the catches which are again concentrated in the first and fourth quarters. Spanish landings in division VIIIb are mainly formed by sardine bigger than 18 cm while French catches in divisions VIIIa and VIIIb are constituted by fish of a wider range of sizes.

7.2.2 Fishery independent information: Acoustic surveys

Numbers at age for ICES subdivisions VIIIa and VIIIb estimated from the spring French acoustic surveys since 2000 have been made available to the WG. These data together with numbers at age estimated from both Spanish and Portuguese spring acoustic surveys for the same period for subdivisions VIIIc and IXa are shown in Figures 7.2.2.1-2. These figures show the importance of each age class within each subarea in relation to the total sardine population in that subarea (i.e. the proportion of all age classes within subarea sum to 1) and in addition, a pie chart is included to represent the contribution of each subarea to the total estimated numbers. Figures 7.2.2.1-2 show the evolution of the strong recruitments of 2000, 2001 and 2004 mainly located in the western area of the Iberian Peninsula. The figures also show evidence of an additional recruitment area in French waters and that the Gulf of Cádiz show the influence of different pulses of recruitment from those of the northwestern Iberian areas.

7.2.2.1 French Spring Acoustic survey 2007

The French acoustic survey (PELGAS) is routinely carried out each year in spring in the Bay of Biscay and information on sardine distribution and abundance is available, with a time series starting in 2000. The 2007 survey (PELGAS07) took place from the 26th April to 26th May on board the RV “Thalassa”. The objectives, methodology employed and sampling strategy are described in section 10.4.2.

With the exception of 2003 which was an atypical year, the abundance of sardine estimated during PELGAS07 was the lowest observed since 2000 (126 237 tonnes).

	Year							
	2000	2001	2002	2003[1]	2004	2005	2006	2007
Biomass (tonnes)	286 391	214 200	301 023		323 021	429 521	229 071	126 237

[1]No sardine abundance was estimated for the 2003 cruise.

Sardine was distributed all along the coast in the southern part of the Bay of Biscay (Landes) mixed with anchovy while along the southern Brittany coast pure sardine fishing hauls were obtained (Figure 7.2.2.1.1). In the offshore area, sardine was generally mixed with horse mackerel in the south and with mackerel in front of the Gironde. Rarely it was found as isolated big schools near the surface. Small fish were found along the southern Landes coast. The distribution of sardine observed during PELGAS07 was similar to the one observed in previous surveys although small fish is generally found also along the Brittany coast which was not the case in 2007.

Sardine ranged in length from 14.5 to 24.5 cm and showed a bimodal length distribution with a mode at 15.5. cm (juvenile fish) and another at 20.5 cm (adult fish) (Figure 7.2.2.1.2). Figure 7.2.2.1.3 shows sardine length distribution by subdivision and depth strata. Adult fish dominated the population in division VIIIa in offshore waters (depth > 60 m) while young fish dominated in division VIIIb in inshore waters. Both juvenile and adult fish were present in division VIIIa in waters less than 60 m depth but in waters deeper than 60 m in division VIIIb. Applying the ALK obtained from the fish sampled during the survey, most fish in the entire surveyed area were assigned to age class 3 (2004 year class) (Figure 7.2.2.1.4), although age 1 fish were also abundant. The length and age distributions for the whole time series (all 8 years) are shown in Figures 7.2.2.1.5 and 7.2.2.1.6., respectively. The abundance of age 1 fish in 2006 and 2007 is very low compared to previous years.

7.2.3 Biological data

Biological data were provided by France for sardine caught in divisions VIIIa and VIIIb since 2003 and by Spain for sardine caught in division VIIIb since 2002. Samples for the age length keys in both France and Spain were pooled on a half year basis. There is a single age length key applied to French catches in divisions VIIIa and VIIIb. The age length key applied to the Spanish catches in VIIIb is constructed with samples collected from VIIIb and occasionally from the eastern part of VIIIc (VIIIcE-e) close to the boundary with VIIIb from the same year.

7.2.3.1 Catch numbers at length and age

Tables 7.2.3.1.1 and 7.2.3.1.2 shows the catch-at-age in numbers for each quarter for each year for French and Spanish landings respectively. In general, in France, fish of age 1 and 2 dominate the fishery in all years. The 2004 recruitment can be followed in the catches while in the Spanish landings the 2004 year class is only seen as strong in 2005. The 2003 year class was prominent in the catches in 2004 and 2006.

7.2.3.2 Mean length and mean weight at age

Mean length and mean weight at age by quarter and year are shown in Tables 7.2.3.2.1 and 7.2.3.2.2 for French landings and in Tables 7.2.3.2.3 and 7.2.3.2.4 for Spanish landings.

7.3 Future research and monitoring for sardine

A summary of the main findings from the SARDYN project with relevance to sardine assessment was presented in last years' report. Since the conclusion of the project, several of the analyses presented as annex documents in the final report were further developed and submitted for publication. In most cases modifications have been relatively minor, with the new documents simply being more easily traced and cited after publication (see WD Stratoudakis et al.).

The WG considers that the SARDYN findings do not contradict the short-term maintenance of the current stock delimitation, given the present state of data availability within the European North Atlantic. However the group considers that the northern stock boundary issue should be further explored, by identifying the relative contributions of recruitment foci from western Iberia and the Bay of Biscay to the Cantabrian sardine population and search for possible variations in migration routes over time.

The accumulation of additional catch and survey data from the Biscay region and the eventual extension of the triennal DEPM survey to this area (profiting from the anchovy DEPM survey carried out annually) are important steps to achieve this goal. It is also desirable to collect data within surveys (e.g. Herring surveys in the Celtic Sea) and fisheries (e.g. in the English Channel) off the northern areas to clarify the relationship between sardine from the Bay of Biscay and that distributed further north. At present, there are no management or assessment requirements for sardine in areas outside the Iberian Peninsula. However, catch data reported to this WG suggest that some expansion of the fisheries north of Biscay is taking place. Adressing the future of assessment of sardine outside the actual stock area will require additional efforts both on data gathering, exploratory analysis and development of methodology, and the WG encourages development in these directions. This will provide a firm scientific basis for advice in case management of this area becomes relevant in the longer term.

The development of a new tagging study is currently considered impractical, so new information on sardine migration should be sought through indirect means. Further explorations with otolith analysis techniques seem to be warranted; the results of Castro (2007) demonstrated that the method has potential to provide useful insights on sardine dynamics and it could possibly be complemented with otolith shape and isotope ratios analyses (Silva 2007). There is the intention to development research along these lines in the near future.

Sardine will continue to be monitored annually in spring by Spanish and Portuguese acoustic surveys within the stock area and by the French spring survey within the Gulf of Biscay. Both acoustic and DEPM surveys are coordinated within the ICES WGACEGGS. A DEPM survey covering the whole stock area will continue to take place every 3 years and its expansion to the Gulf of Biscay will be discussed within the next meeting of the WGACEGGS. In order to address the issue of combination of acoustic surveys' data for the assessment, a calibration exercise is planned for 2008 off northern Portugal with the simultaneous coverage of several transects by the RVs Thalassa (Spanish survey) and Noruega (Portuguese survey). This is a timely initiative, as the merging of data from these surveys remains an outstanding issue in the current assessment.

The November Portuguese acoustic survey is not used within the assessment model since 2006 (benchmark assessment) as it does not provide an abundance index for the entire stock area. However, it continues to be used to corroborate estimates of recruitment (at age 0) obtained in the assessment. This survey provides sufficient and timely information on sardine recruitment, given that it covers the two main recruitment grounds of the Iberian stock area – off northern Portugal and the inner Gulf of Cadiz. In years of strong recruitment, the November survey has been useful to the national administration and in the past, it has facilitated national and international decisions that have reduced the waste of undersized fish and pacified the fishery. There are plans to re-organised this survey to become a recruitment survey, possibly limiting the geographic range to the recruitment grounds and providing a better bathymetric coverage of the recruits distribution. The specific design of this survey and the possibility to initiate a similar series in southern Biscay (during the recruitment survey for anchovy that takes place in September/October) will be discussed within WGACEGGS. The WG supports the re-organization of the Portuguese November survey as a recruitment survey since it will provide useful information for the assessment and may facilitate management by providing an early information about recruitment strength.

Table 7.1.1.1: Sardine general: 2006 commercial catch data from the ICES area, available to the Working Group. Unit Tonnes.

Divisions	Netherlands	Germany	UK (Engl&Wal)	Ireland	France	Spain	Portugal	Total
IVa				21				21
IVc	0				489			489
VIa				15				15
VIIa				728				728
VIIb				198				198
VIIc								0
VIId	1738	12	2	639	12339			14730
VIIe	427		1201	1765				3393
VIIf			1597					1597
VIIg				596				596
VIIh	124	235		92				451
VIIi								0
VIIj				752	16			768
VIIIa	2			703	15916			16621
VIIIb				3409		825		4234
VIIIc		78				15377		15455
VIIId				188	84			272
VIIIe				50				50
IXaN						10856		10856
IXaCN							30 152	30152
IXaCS							19 061	19061
IXaS-Alg							5 798	5798
IXaS-Cad						5779		5779
Total	2292	325	2800	9156	28844	32837	55011	131265

Table 7.2.1.1: Sardine general: Landings by France (1983-2006) and Spain (1996-2006) in ICES divisions VIIIa and VIIIb

Year	Catch (tonnes)	
	France	Spain*
1983	4,367	n/a
1984	4,844	n/a
1985	6,059	n/a
1986	7,411	n/a
1987	5,972	n/a
1988	6,994	n/a
1989	6,219	n/a
1990	9,764	n/a
1991	13,965	n/a
1992	10,231	n/a
1993	9,837	n/a
1994	9,724	n/a
1995	11,258	n/a
1996	9,554	2,053
1997	12,088	1,608
1998	10,772	7,749
1999	14,361	7,864
2000	11,939	3,158
2001	11,285	3,720
2002	13,849	4,428
2003	15,494	1,113
2004	13,855	342
2005	15,462	898
2006	15,916	825

* all landings from division VIIIb

n/a = not available

Table 7.2.1.2: Sardine general: French catch length composition (thousands) by ICES divisions VIIIa,b in 2006.

				Second Quarter	
Length	**1st quarter**	**2nd quarter**	**3rd quarter**	**4th quarter**	**Total**
7					
7.5					
8					
8.5					
9					
9.5					
10	3				3
10.5					
11	10	51	49	10	121
11.5	31	177	123	24	355
12	66	231	222	43	561
12.5	87	517	370	72	1 045
13	111	884	734	91	1 819
13.5	81	1 152	1 008	218	2 460
14	100	1 211	1 888	58	3 258
14.5	108	1 432	2 309	30	3 880
15	135	2 020	2 660	26	4 841
15.5	180	2 683	2 495	16	5 374
16	238	2 377	1 370	17	4 002
16.5	228	2 252	1 161	21	3 663
17	204	2 222	1 296	33	3 755
17.5	159	1 966	1 610	180	3 915
18	115	1 211	2 752	35	4 113
18.5	84	1 149	2 649	26	3 909
19	160	1 893	3 603	14	5 670
19.5	215	3 807	8 874	1367	14 263
20	265	5 112	15 002	2871	23 249
20.5	274	4 258	20 653	2569	27 753
21	357	3 513	21 778	2417	28 065
21.5	605	2 879	14 174	1962	19 620
22	791	3 025	8 219	1509	13 545
22.5	1 070	2 342	5 993	1660	11 066
23	869	2 245	2 740	1660	7 513
23.5	682	1 561	856	1509	4 609
24	636	976	342	1962	3 916
24.5	465	439	171	1057	2 132
25	233	146		755	1 134
25.5	78	49	171		298
26	16				16
26.5					
27					
27.5					
28					
28.5					
29					
Total	8 657	53 781	125 273	22 212	209 923
Mean L	21.2	19.2	20.2	21.8	20.2
sd	3.30	3.06	2.26	2.16	2.64
Catch	**792**	**3580**	**9 413**	**2130**	**15 916**

Table 7.2.1.3: Sardine general: Spanish catch length composition (thousands) in ICES division VIIIb in 2006.

				Second Quarter	
Length	**1st quarter**	**2nd quarter**	**3rd quarter**	**4th quarter**	**Total**
7					
7.5					
8					
8.5					
9					
9.5					
10					
10.5					
11					
11.5					
12					
12.5					
13					
13.5					
14					
14.5	9				9
15	13				13
15.5	35				35
16	30				30
16.5	35				35
17	44				44
17.5	28				28
18	72	6			78
18.5	49	25			73
19	111	139		2	252
19.5	215	319		17	551
20	368	304		51	723
20.5	362	351		212	926
21	642	230	1	337	1 210
21.5	674	230	1	505	1 409
22	678	338	1	718	1 735
22.5	595	263	1	535	1 394
23	326	198		231	755
23.5	135	87		112	335
24	82	54		38	174
24.5	23	21		7	51
25	3	8		3	14
25.5				2	2
26	3				3
26.5					
27					
27.5					
28					
28.5					
29					
Total	4 530	2 573	5	2 770	9 879
Mean L	21.5	21.4	22.0	22.1	21.6
sd	1.63	1.39	1.10	0.87	1.43
Catch	**370**	**208**		**247**	**825**

Table 7.2.3.1.1: Sardine general: French landings in divisions VIIIa and VIIIb: catch in numbers (thousands) at age by quarter and year.

				First Quarter
Age	**2003**	**2004**	**2005**	**2006**
0				
1	6192	1765	2917	1586
2	1954	4075	492	1269
3	1507	1827	331	1124
4	2077	712	516	1093
5	1393	572	707	1037
6	835	414	639	829
7	706	167	511	669
8	411	107	480	553
9	93	28	344	306
10			23	115
11			28	45
12				13
13				18
Total	15169	9668	6988	8657
Catch (Tons)	1157	722	540	792

				Second Quarter
Age	**2003**	**2004**	**2005**	**2006**
0				
1	21560	45623	27723	17299
2	10030	11971	9398	17308
3	4312	8593	6247	7213
4	3178	3517	7563	4065
5	2058	1901	5952	2893
6	1238	1182	4300	2114
7	1377	458	2470	1266
8	691	211	1135	1017
9	127	55	424	412
10			75	128
11				47
12				8
13				11
Total	44572	73512	65285	53781
Catch (Tons)	2959	3386	4307	3580

				Third Quarter
Age	**2003**	**2004**	**2005**	**2006**
0	4057	18991	3380	8360
1	50623	21426	52448	15459
2	35992	27906	28025	56617
3	12960	20653	18698	16727
4	6133	8136	11547	11545
5	2614	4975	8777	7335
6	1672	575	2653	3906
7	431	388	1088	2744
8	231	183	894	1012
9	216	135	385	272
10			8	110
11				24
12				
13				
Total	114928	103368	127904	124112
Catch (Tons)	8574	7312	9553	9413

				Fourth Quarter
Age	**2003**	**2004**	**2005**	**2006**
0	325	3078	734	536
1	6531	18183	2042	753
2	9559	5350	1531	7567
3	5323	4219	1404	2818
4	3152	1858	1518	2461
5	2450	1313	1341	2217
6	1716	322	949	1951
7	484	186	781	1919
8	201	64	584	744
9	233	31	340	630
10		23	63	192
11			31	277
12				126
13				
Total	29975	34627	11316	22190
Catch (Tons)	2805	2436	1062	2130

				Whole Year
Age	**2003**	**2004**	**2005**	**2006**
0	4382	22069	4114	8896
1	84906	86997	85129	35097
2	57535	49301	39446	82760
3	24102	35292	26680	27882
4	14541	14224	21144	19164
5	8515	8762	16776	13482
6	5461	2493	8541	8801
7	2998	1200	4850	6597
8	1534	565	3093	3325
9	670	250	1493	1621
10		23	169	545
11			59	393
12				147
13				29
Total	204644	221174	211493	208740
Catch (Tons)	15494	13856	15462	15916

Table 7.2.3.1.2: Sardine general: Spanish landings in ICES division VIIIb: catch in numbers (thousands) at age by quarter and year.

Age					First Quarter
	2002	**2003**	**2004**	**2005**	**2006**
0					
1	3375	3		3370	337
2	2857	45	363	591	585
3	1989	31	299	613	1159
4	1011	25	515	633	973
5	422	18	481	486	825
6	222	7	228	266	328
7	89	7	97	110	212
8	49	1	53	43	77
9	36	1	25	40	33
10	1		8		
11					
12				3	
13					
Total	10049	138	2069	6155	4530
Catch (Tons)	555	10	150	298	370

Age					Second Quarter
	2002	**2003**	**2004**	**2005**	**2006**
0					
1	20789	4349	1041	2113	154
2	2792	2551	59	435	556
3	1455	1477	91	286	613
4	824	882	85	317	497
5	290	520	40	253	391
6	107	225	16	155	169
7	40	236	8	70	122
8	19	40	3	28	57
9	18	17	1	29	15
10				0	
11				0	
12				4	
13					
Total	26333	10298	1344	3690	2573
Catch (Tons)	979	582	44	189	208

Age					Third Quarter
	2002	**2003**	**2004**	**2005**	**2006**
0			48		
1	0	2		1	
2	0	21		3	2
3	0	20		5	1
4	0	12		3	1
5	0	6		2	1
6	0	5		1	0
7	0	1		0	0
8		1		0	0
9	0	1		0	0
10					0
11					
12					
13					
Total	0	69	48	14	5
Catch (Tons)	0	6	1	1	0

Age					Fourth Quarter
	2002	**2003**	**2004**	**2005**	**2006**
0			166		
1	5534	214	268	758	
2	14222	1993	460	1005	853
3	10636	1817	509	1522	682
4	4578	1085	285	900	373
5	2459	586	105	466	505
6	1034	508	59	227	220
7	290	92	24	85	15
8	72	71	11	3	99
9	248	48		9	22
10	72				1
11					
12					
13					
Total	39146	6414	1888	4976	2770
Catch (Tons)	2894	516	147	410	247

Age					Whole Year
	2002	**2003**	**2004**	**2005**	**2006**
0			214		
1	29699	4569	1309	6242	491
2	19870	4610	883	2034	1995
3	14080	3344	900	2425	2455
4	6413	2004	886	1853	1844
5	3172	1131	626	1207	1722
6	1363	746	302	649	718
7	418	336	129	265	349
8	140	112	67	75	233
9	301	67	26	77	70
10	73		8	0	1
11				0	
12				8	
13					
Total	75529	16919	5350	14834	9879
Catch (Tons)	4428	1113	342	898	825

Table 7.2.3.2.1: Sardine general: French landings in divisions VIIIa and VIIIb:
Mean length (cm) at age by quarter and year.

				First Quarter
Age	**2003**	**2004**	**2005**	**2006**
0				
1	17.3	17.9	15.3	15.3
2	19.5	19.5	19.8	19.6
3	21.3	20.6	21.3	21.8
4	22.4	21.8	21.9	22.4
5	22.7	22.7	22.7	22.9
6	23.1	22.8	22.9	23.2
7	23.6	23.5	23.2	23.7
8	23.5	24.4	23.8	23.6
9	23.2	23.4	24.5	24.3
10			23.0	24.5
11			26.0	24.7
12				25.5
13				25.0

				Second Quarter
Age	**2003**	**2004**	**2005**	**2006**
0				
1	16.8	14.3	15.7	15.4
2	19.7	19.8	20.1	19.5
3	20.8	20.9	21.0	21.1
4	22.6	21.6	21.5	22.0
5	23.1	22.4	22.0	22.6
6	23.7	22.7	22.3	22.7
7	24.4	23.6	22.4	23.2
8	24.1	24.1	23.1	23.3
9	23.5	23.4	23.8	23.8
10			23.0	24.2
11				24.5
12				25.5
13				25.0

				Third Quarter
Age	**2003**	**2004**	**2005**	**2006**
0	13.3	13.5	13.5	14.3
1	18.9	18.6	18.6	17.7
2	21.0	21.1	20.9	20.4
3	21.7	21.6	21.4	21.3
4	22.0	21.8	21.7	21.5
5	22.8	22.0	21.7	21.9
6	23.1	23.2	22.4	22.5
7	23.6	23.3	22.9	22.5
8	24.6	23.9	23.0	22.7
9	23.9	23.7	23.2	23.5
10			24.5	23.0
11				24.5
12				
13				

				Fourth Quarter
Age	**2003**	**2004**	**2005**	**2006**
0	13.2	13.2	12.0	13.3
1	19.9	19.0	19.3	19.0
2	21.2	21.0	21.2	20.4
3	22.2	22.0	22.0	21.6
4	22.6	22.1	22.4	22.3
5	23.2	22.5	22.8	22.8
6	23.5	23.7	23.0	23.3
7	24.3	23.5	23.4	23.6
8	24.5	24.1	23.6	23.5
9	23.9	23.8	23.9	23.9
10		24.9	26.2	24.3
11			33.0	24.7
12				25.0
13				

				Whole Year
Age	**2003**	**2004**	**2005**	**2006**
0	13.3	13.5	13.2	14.3
1	18.3	16.4	17.6	16.5
2	20.7	20.6	20.7	20.2
3	21.6	21.4	21.3	21.3
4	22.3	21.8	21.7	21.7
5	23.0	22.2	21.9	22.2
6	23.4	23.0	22.5	22.8
7	24.1	23.5	22.7	23.1
8	24.1	24.1	23.3	23.2
9	23.7	23.6	23.8	23.9
10		24.9	24.3	24.1
11			29.7	24.7
12				25.1
13				25.0

Table 7.2.3.2.2: Sardine general: French landings in divisions VIIIa and VIIIb:
Mean weight (kg) at age by quarter and year.

	First Quarter			
Age	**2003**	**2004**	**2005**	**2006**
0				
1	0.045	0.050	0.030	0.030
2	0.067	0.067	0.070	0.067
3	0.088	0.080	0.089	0.096
4	0.105	0.096	0.098	0.105
5	0.110	0.109	0.109	0.113
6	0.115	0.112	0.113	0.118
7	0.125	0.123	0.118	0.126
8	0.123	0.139	0.129	0.125
9	0.117	0.121	0.141	0.137
10			0.114	0.141
11			0.171	0.144
12				0.162
13				0.151

	Second Quarter			
Age	**2003**	**2004**	**2005**	**2006**
0				
1	0.041	0.024	0.032	0.031
2	0.069	0.070	0.073	0.066
3	0.082	0.083	0.085	0.086
4	0.108	0.093	0.092	0.098
5	0.116	0.105	0.098	0.107
6	0.126	0.109	0.103	0.109
7	0.138	0.124	0.104	0.117
8	0.134	0.133	0.117	0.119
9	0.122	0.121	0.128	0.129
10			0.114	0.135
11				0.140
12				0.161
13				0.151

	Third Quarter			
Age	**2003**	**2004**	**2005**	**2006**
0	0.019	0.020	0.019	0.024
1	0.060	0.056	0.057	0.048
2	0.084	0.086	0.084	0.076
3	0.095	0.093	0.090	0.088
4	0.099	0.096	0.094	0.091
5	0.111	0.099	0.095	0.097
6	0.116	0.118	0.105	0.106
7	0.125	0.119	0.113	0.107
8	0.143	0.129	0.114	0.109
9	0.129	0.127	0.118	0.122
10			0.141	0.114
11				0.141
12				
13				

	Fourth Quarter			
Age	**2003**	**2004**	**2005**	**2006**
0	0.018	0.018	0.013	0.019
1	0.070	0.061	0.064	0.060
2	0.087	0.085	0.087	0.077
3	0.102	0.099	0.099	0.093
4	0.107	0.101	0.105	0.103
5	0.118	0.107	0.110	0.111
6	0.124	0.126	0.115	0.120
7	0.136	0.123	0.121	0.124
8	0.140	0.133	0.125	0.123
9	0.129	0.129	0.130	0.130
10		0.148	0.175	0.138
11			0.377	0.145
12				0.151
13				

	Whole Year			
Age	**2003**	**2004**	**2005**	**2006**
0	0.019	0.020	0.018	0.024
1	0.055	0.040	0.048	0.039
2	0.081	0.080	0.081	0.074
3	0.094	0.091	0.089	0.089
4	0.104	0.096	0.094	0.095
5	0.114	0.102	0.098	0.102
6	0.121	0.114	0.106	0.111
7	0.133	0.122	0.110	0.116
8	0.133	0.133	0.119	0.118
9	0.126	0.125	0.129	0.129
10		0.148	0.138	0.133
11			0.280	0.144
12				0.152
13				0.151

Table 7.2.3.2.3: Sardine general: Spanish landings in ICES division VIIIb mean length (cm) at age by quarter and year.

				First Quarter	
Age	**2002**	**2003**	**2004**	**2005**	**2006**
0					
1	16.0	18.1		14.3	17.9
2	19.7	19.9	15.2	20.1	19.7
3	20.9	20.6	20.2	21.1	21.5
4	21.7	21.4	21.3	21.7	21.9
5	22.3	22.1	21.8	21.8	22.3
6	22.7	22.4	22.0	22.4	22.5
7	23.1	22.7	22.5	22.7	23.4
8	23.4	22.8	23.2	23.0	24.1
9	23.5	22.8	23.5	23.3	22.8
10	24.8		24.6		
11					
12				24.3	
13					

				Second Quarter	
Age	**2002**	**2003**	**2004**	**2005**	**2006**
0					
1	15.8	16.9	13.5	15.8	19.5
2	19.5	19.7	20.1	19.6	19.9
3	20.9	20.4	21.2	21.0	21.3
4	21.6	21.1	21.8	21.8	21.8
5	22.1	21.9	21.9	21.9	22.4
6	22.6	22.3	22.4	22.6	22.6
7	23.0	22.6	23.0	22.8	23.5
8	23.4	23.8	23.5	23.1	24.2
9	23.6	22.8	25.3	23.4	22.8
10					
11					
12				24.3	
13					

				Third Quarter	
Age	**2002**	**2003**	**2004**	**2005**	**2006**
0			14.4		
1	20.0	20.6		20.5	
2	20.9	20.9		21.3	21.3
3	21.4	21.3		21.9	22.3
4	21.9	21.7		22.0	22.2
5	22.1	22.0		22.8	22.5
6	23.0	22.1		23.3	22.4
7	22.1	23.4		23.0	24.4
8		23.8		24.3	23.5
9	23.8	23.8		23.3	23.8
10					25.3
11					
12					
13					

				Fourth Quarter	
Age	**2002**	**2003**	**2004**	**2005**	**2006**
0			17.0		
1	19.9	20.6	20.1	19.9	
2	21.0	20.9	21.4	21.2	21.5
3	21.6	21.3	21.8	21.8	22.3
4	22.2	21.7	22.0	22.0	22.3
5	22.6	22.0	22.4	22.6	22.5
6	23.3	22.1	22.5	22.9	22.4
7	22.9	23.4	23.0	23.1	24.4
8	25.1	23.8	23.7	24.3	23.5
9	24.1	23.8		23.3	23.8
10	25.1				25.3
11					
12					
13					

				Whole Year	
Age	**2002**	**2003**	**2004**	**2005**	**2006**
0			16.4		
1	16.6	17.0	14.8	15.5	18.4
2	20.6	20.2	18.8	20.5	20.5
3	21.4	20.9	21.2	21.6	21.7
4	22.1	21.5	21.5	21.9	21.9
5	22.5	21.9	21.9	22.2	22.4
6	23.1	22.2	22.1	22.6	22.5
7	22.9	22.8	22.6	22.9	23.5
8	24.3	23.7	23.3	23.1	23.9
9	24.0	23.5	23.6	23.3	23.1
10	25.1		24.6		25.3
11					
12				24.3	
13					

Table 7.2.3.2.4: Sardine general: Spanish landings in ICES division VIIIb mean weight (kg) at age by quarter and year.

					First Quarter
Age	**2002**	**2003**	**2004**	**2005**	**2006**
0					
1	0.031	0.047		0.022	0.046
2	0.057	0.064	0.03	0.066	0.062
3	0.069	0.071	0.07	0.076	0.081
4	0.077	0.080	0.08	0.084	0.086
5	0.084	0.088	0.08	0.085	0.092
6	0.088	0.093	0.09	0.093	0.094
7	0.093	0.096	0.09	0.097	0.106
8	0.097	0.097	0.10	0.101	0.117
9	0.098	0.097	0.11	0.105	0.097
10	0.115		0.12		
11					
12				0.119	
13					

					Second Quarter
Age	**2002**	**2003**	**2004**	**2005**	**2006**
0					
1	0.030	0.037	0.019	0.030	0.059
2	0.056	0.061	0.065	0.061	0.063
3	0.069	0.069	0.077	0.076	0.078
4	0.076	0.077	0.084	0.085	0.085
5	0.082	0.086	0.087	0.087	0.093
6	0.087	0.091	0.092	0.095	0.095
7	0.091	0.095	0.101	0.098	0.107
8	0.097	0.112	0.109	0.102	0.118
9	0.099	0.097	0.135	0.106	0.097
10					
11					
12				0.119	
13					

					Third Quarter
Age	**2002**	**2003**	**2004**	**2005**	**2006**
0			0.022		
1	0.060	0.070		0.069	
2	0.069	0.073		0.079	0.078
3	0.074	0.079		0.086	0.091
4	0.079	0.084		0.088	0.090
5	0.082	0.088		0.098	0.094
6	0.092	0.089		0.105	0.093
7	0.081	0.107		0.100	0.122
8	0.000	0.111		0.119	0.108
9	0.101	0.111		0.104	0.111
10					0.135
11					
12					
13					

					Fourth Quarter
Age	**2002**	**2003**	**2004**	**2005**	**2006**
0			0.039		
1	0.059	0.070	0.066	0.063	
2	0.070	0.073	0.079	0.077	0.081
3	0.076	0.079	0.084	0.085	0.091
4	0.083	0.084	0.088	0.087	0.091
5	0.088	0.088	0.093	0.095	0.093
6	0.096	0.089	0.094	0.099	0.092
7	0.093	0.107	0.101	0.102	0.122
8	0.125	0.111	0.110	0.119	0.108
9	0.108	0.111		0.104	0.111
10	0.125				0.135
11					
12					
13					

					Whole Year
Age	**2002**	**2003**	**2004**	**2005**	**2006**
0			0.035		
1	0.035	0.039	0.028	0.030	0.050
2	0.066	0.067	0.058	0.070	0.070
3	0.075	0.074	0.077	0.082	0.083
4	0.081	0.081	0.082	0.086	0.087
5	0.086	0.087	0.086	0.089	0.092
6	0.094	0.090	0.089	0.095	0.094
7	0.093	0.099	0.096	0.099	0.107
8	0.111	0.111	0.105	0.102	0.113
9	0.107	0.107	0.109	0.105	0.101
10	0.125		0.124		0.135
11					
12				0.119	
13					

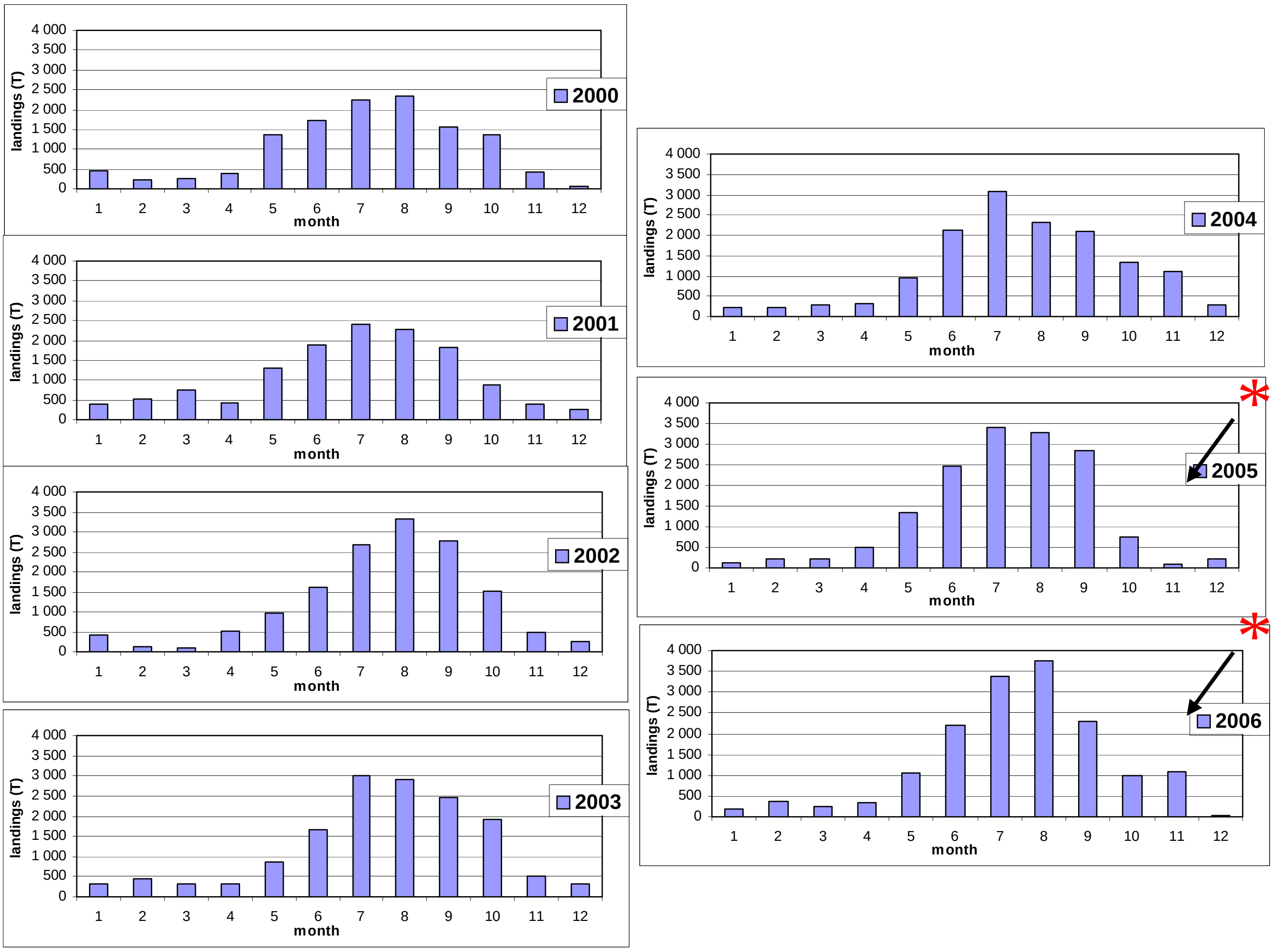


Figure 7.2.1.1: Sardine general: French landings in divisions VIIIa and VIIIb: Monthly distribution of sardine landings for 2002-06. * = marks the point in time when 6 out of the 25 purse seiners stopped fishing during 45 days due to the closure of the anchovy fishery.

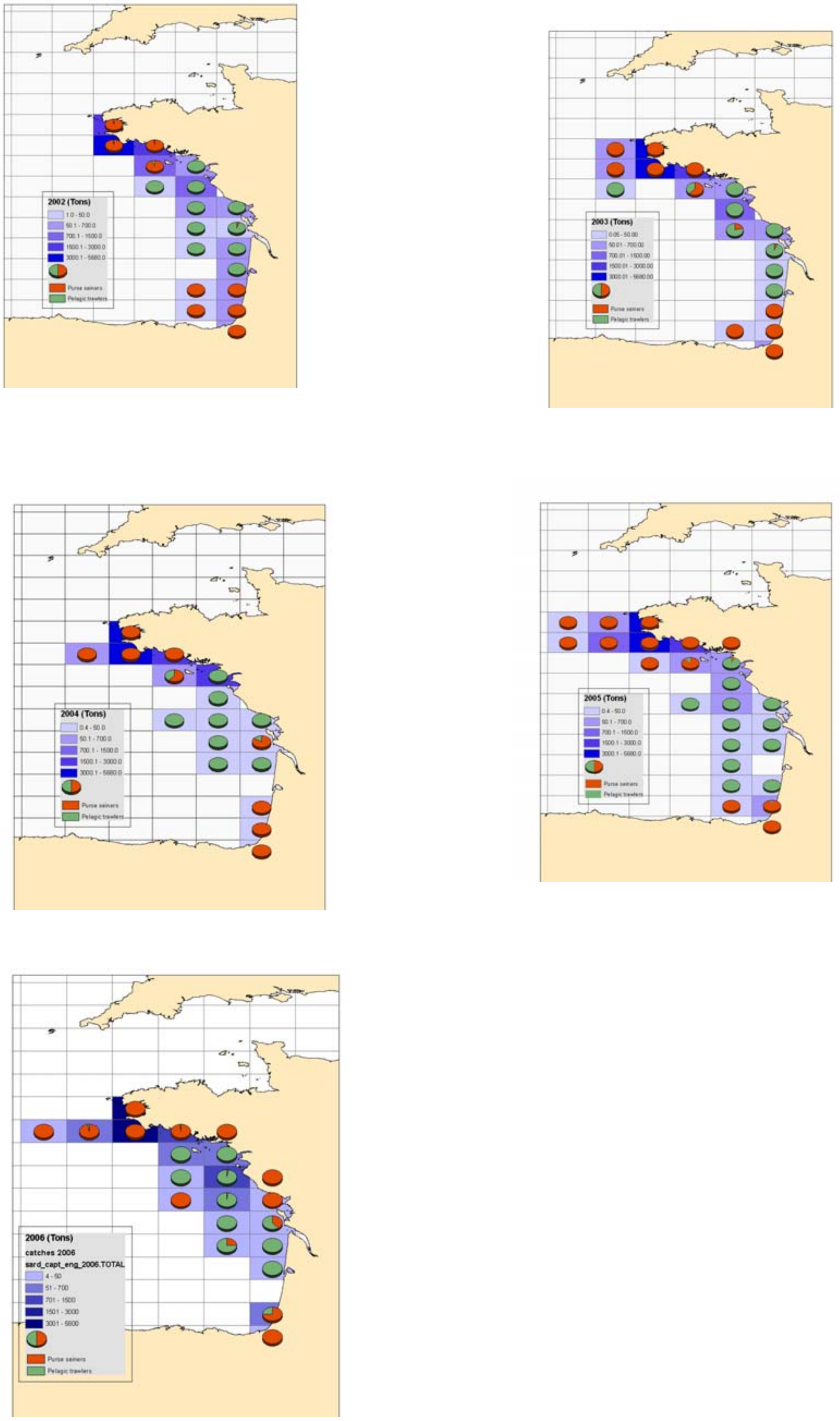


Figure 7.2.1.2: Sardine general: French landings in divisions VIIIa and VIIIb: Geographical distribution of sardine catches by the French fleet (purse seiners and pelagic trawls combined) during 2002-06. The colour of the square represents the amount of catches while the pies in each square indicate the proportion of those catches taken by purse seiners and trawlers.

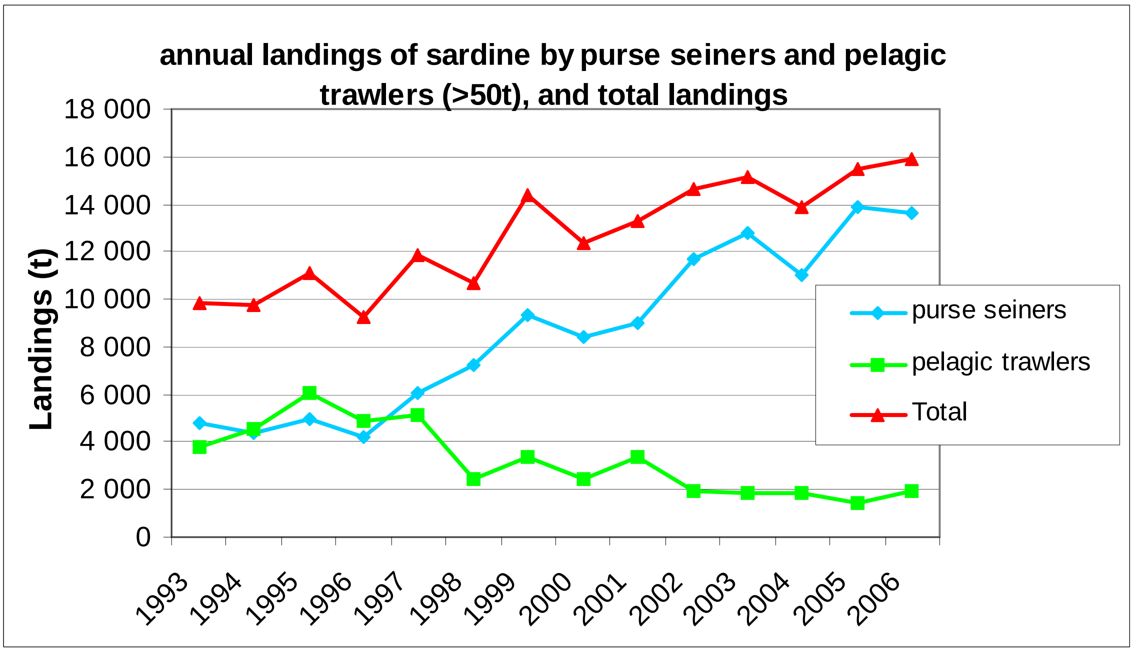


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Figure 7.2.1.3: Sardine general: French landings in divisions VIIIa and VIIIb. Annual sardine landings by the different French fleet components.

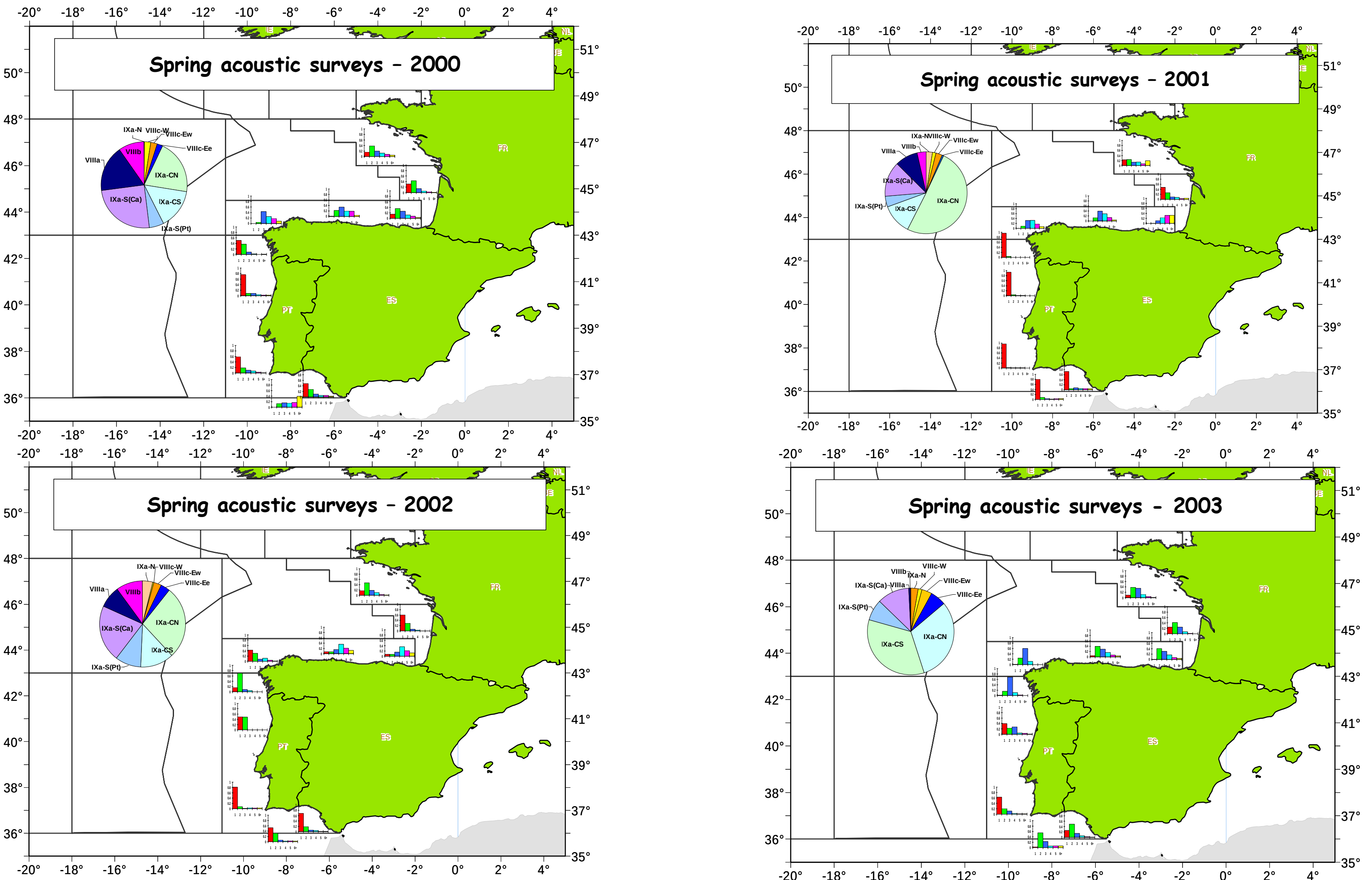


Figure 7.2.2.1: Sardine general: Sardine age frequency distribution by subarea showing the importance of each age class in each subarea in relation to the total sardine population in that subarea as estimated by the spring surveys carried out by France, Spain and Portugal (2000-2003). Age categories are: 1, 2, 3,…and 6+. The pie chart represents the contribution of each subarea to the total numbers.

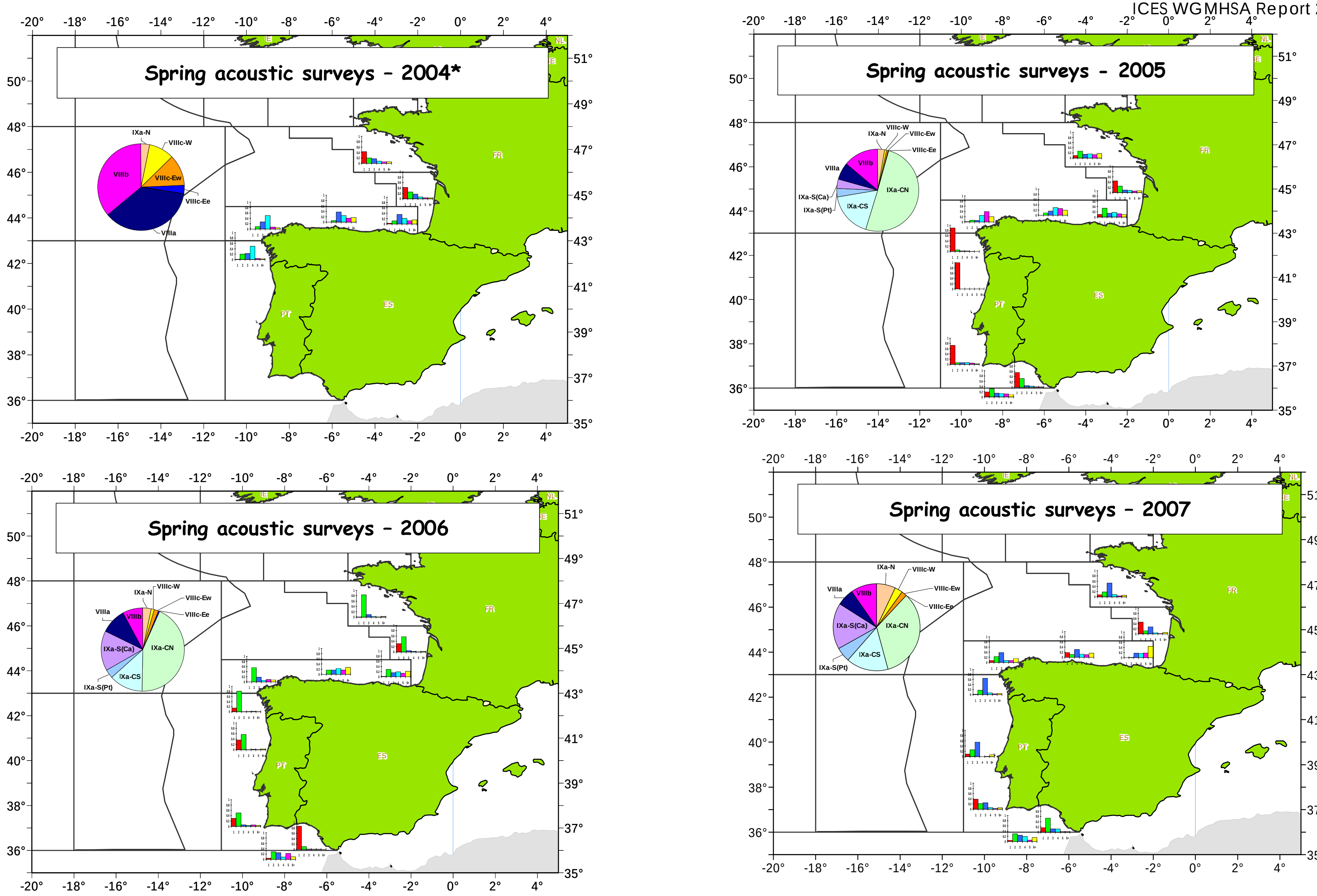


Figure 7.2.2.2: Sardine general: Sardine age frequency distribution by subarea showing the importance of each age class in each subarea in relation to the total sardine population in that subarea as estimated by the spring surveys carried out by France, Spain and Portugal (2004-2007). Age categories are: 1, 2, 3,…and 6+. The pie chart represents the contribution of each subarea to the total numbers.*No Portuguese survey was carried out in spring 2004.

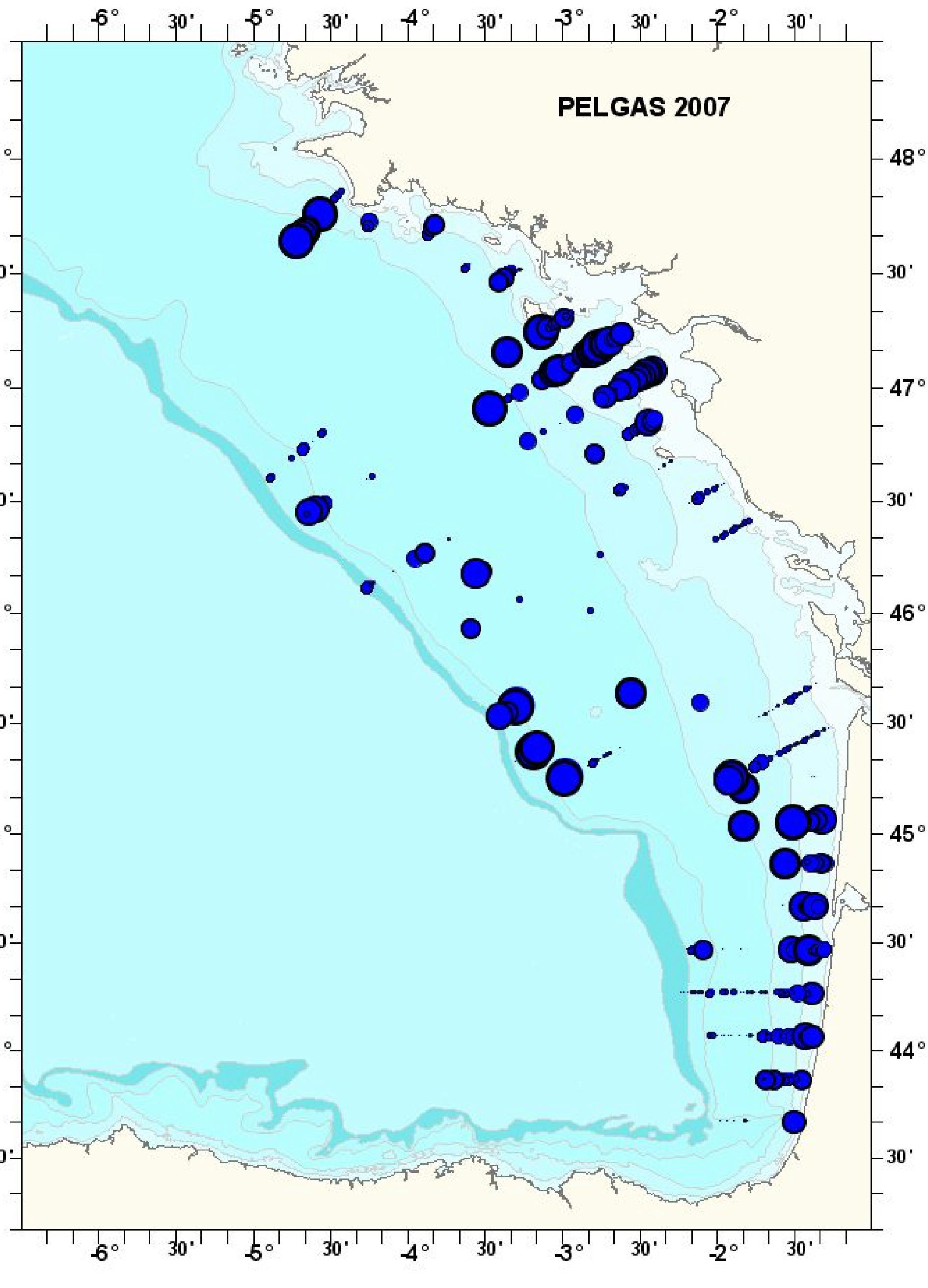


Figure 7.2.2.1.1: Sardine general: Distribution of sardine as observed during the French acoustic survey PELGAS07.

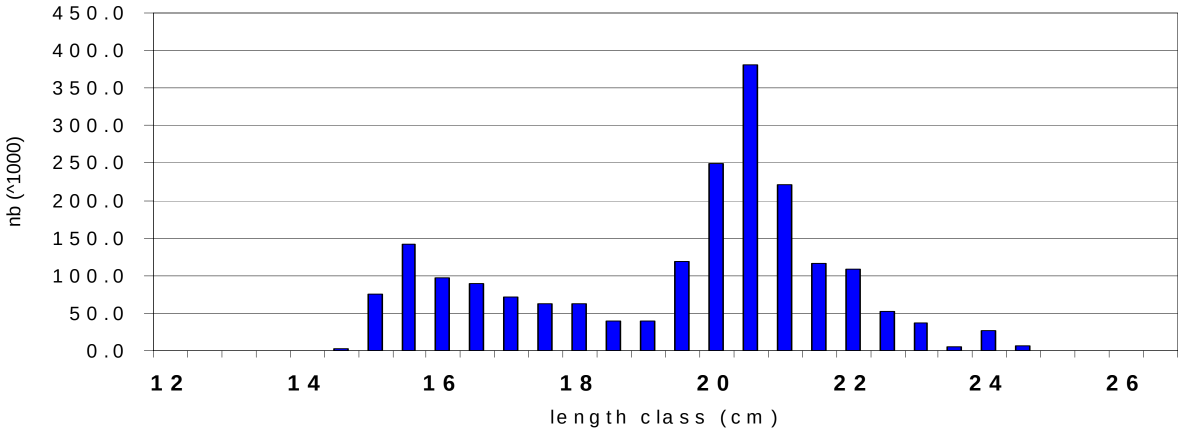


Figure 7.2.2.1.2: Sardine general: Sardine length distribution in numbers of fish as observed during the French acoustic survey PELGAS07 for divisions VIIIa and VIIIb.

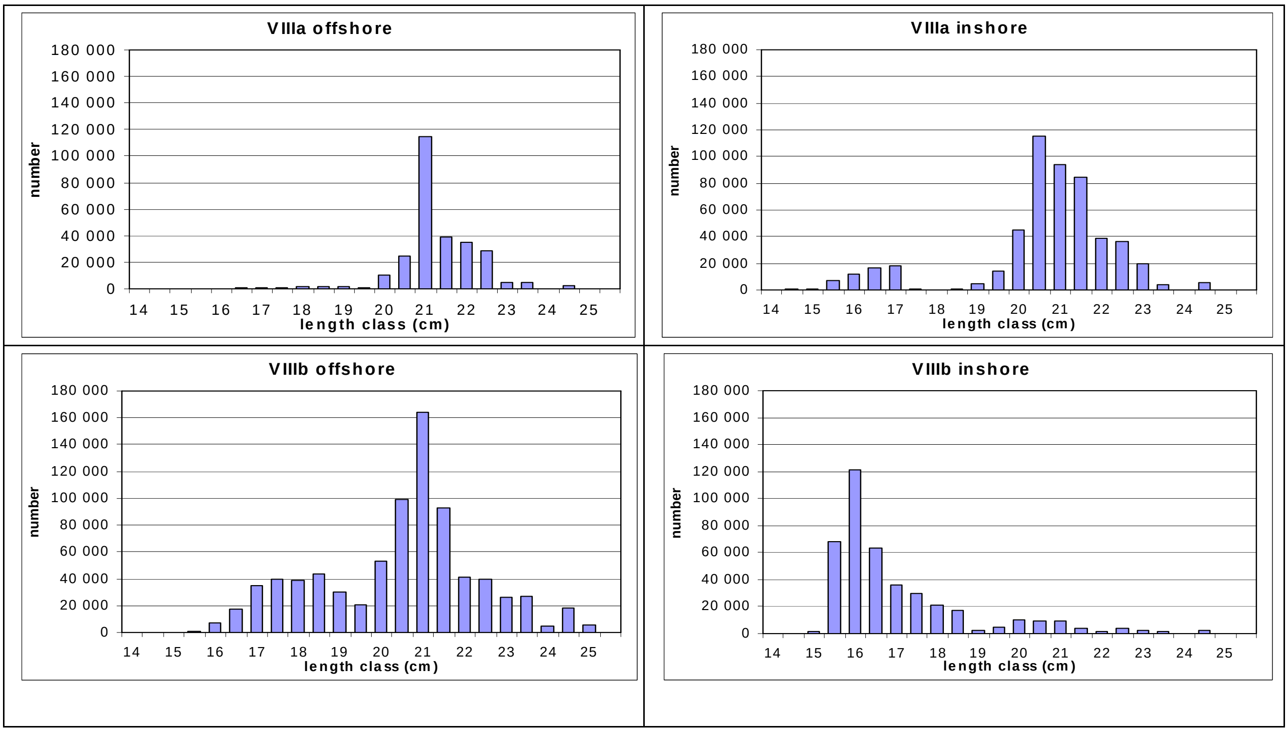


Figure 7.2.2.1.3: Sardine general: sardine length distribution by division: VIIIa (North of 46° N) and VIIIb (South of 46° N) and depth strata: inshore (depth<60m) and offshore (depth>60m) as observed during the French PELGAS07 survey.

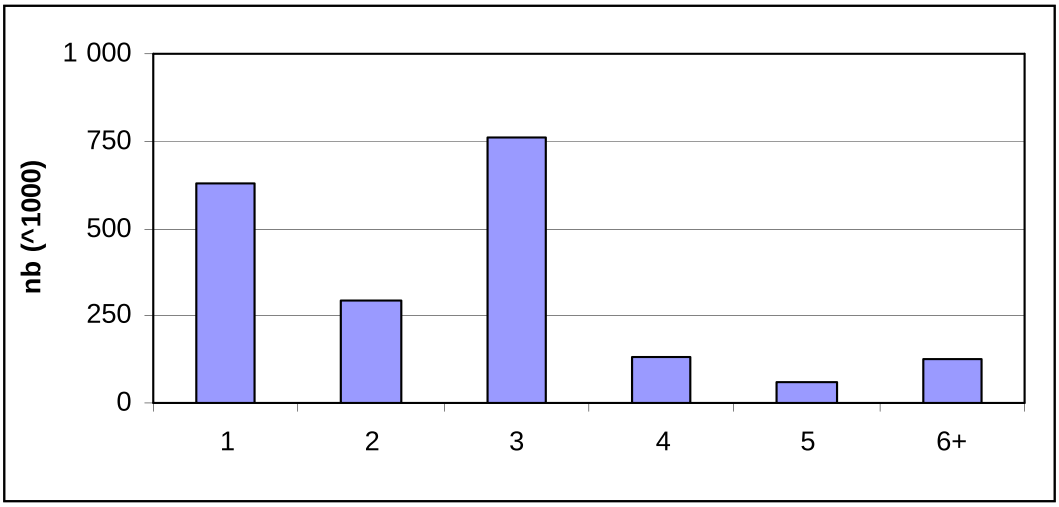


Figure 7.2.2.1.4: Sardine general: Sardine age distribution in numbers of fish for divisions VIIIa and VIIIb as observed during the French PELGAS07 survey.

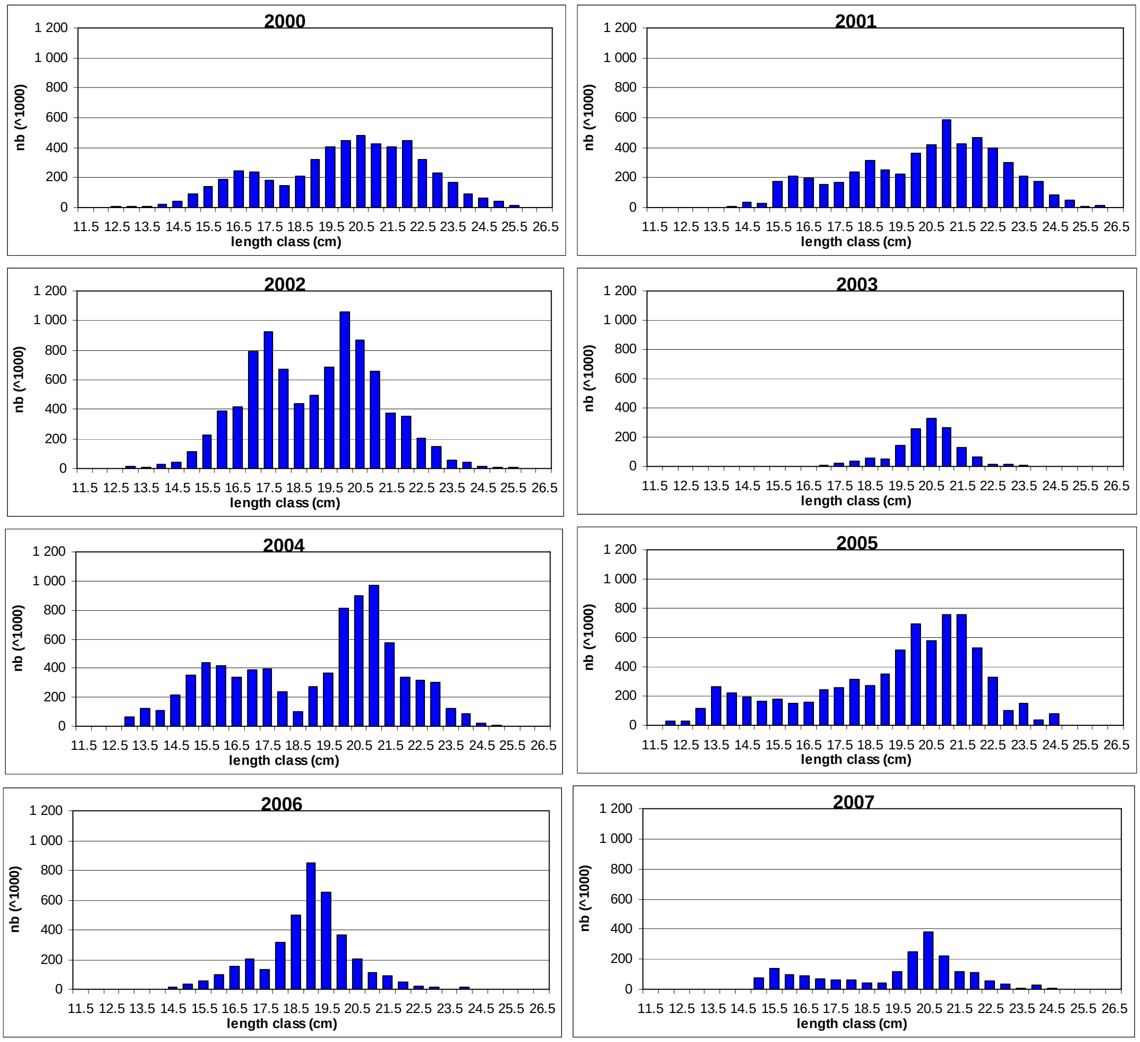


Figure 7.2.2.1.5: Sardine general: Sardine length distribution in numbers of fish for divisions VIIIa and VIIIb in the French acoustic surveys PELGAS 2000 – 2007.

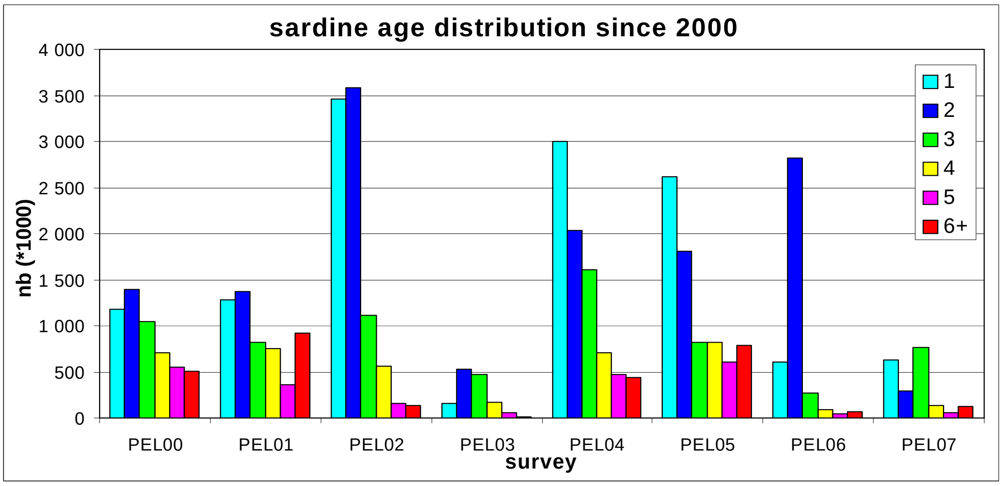


Figure 7.2.2.1.6: Sardine general: Sardine age distribution in numbers of fish for divisions VIIIa and VIIIb in the French acoustic surveys PELGAS 2000 – 2007.

8 Sardine in VIIIc and IXa

8.1 ACFM Advice Applicable to 2006

ICES recommended that fishing mortality should not increase above the level in 2002-4 of 0.22, corresponding to a catch of less than 96 000 t in 2006. Fishing mortality in 2006 should not increase because, even though the SSB is considered to be at a satisfactory level, the abundance of sardine in some areas of the stock continues to be low when compared to the mid-1980s. The SSB is expected to increase from 2005 onwards due to the strong 2004 recruitment but the absolute value of this recruitment has to be confirmed.

The 2004 year class is mainly distributed off northwest Iberia and its impact on other areas depends on dispersal. In addition, the 2000 year-class appears to have been depleted faster than strong year classes from the 1980s. The implication of this is that the stock is now more dependent on the strength of the incoming recruitment.

8.2 The fishery in 2006

As estimated by the Working Group, sardine landings in 2006 shows a decrease in comparison with those of 2005 (Tables 8.2.1 and 8.2.2, Figure 8.2.1). Total 2006 landings in divisions VIIIc and IXa were 87 023 t, i.e. a decrease of 11% with respect to the 2005 values (97 345 tonnes). The bulk of the landings (99%) were made by purse-seiners. In Spain, landings of sardine (32 012 tonnes) showed a decrease of 20% with respect to the values from 2005 (39 855 tonnes). All ICES subdivisions in Spanish waters showed the decrease in catches (ranging from a 7% reduction in subdivision IXaN to the 31% decrease in IXaS Cadiz). In Portugal, landings in 2006 (55 011 tonnes) were 4% smaller than the landings in 2005 (57 490 tonnes). Almost all ICES subdivisions in Portuguese waters showed the reduction in landings, with the exception of IXaCN (with catches 17% higher than in 2005).

The historical time series may provide further insights when catch data is considered at a broader temporal scale, for instance landings of the last decade (1995-2006) (Table 8.2.2). Values for area VIIIc have been rather stable (between 15 000 to 19 800 tonnes) with the exception of catches in 1999 and 2000 (values around 12,000). Although landings in this area had been increasing before 2006, they show a decrease again last year. Values for IXa North also present a sharp decrease in 1998-2000, increasing slowly with some fluctuations afterwards until 2006 when landings decreased again. IXaCN values have been quite stable for the past few years with a decrease in landings in 2004 and 2005 followed by an increase last year. The same could be said for IXaCS, which remains relatively stable, although with some fluctuations. The southern part of stock shows a decreasing trend in landings for both Algarve and Gulf of Cádiz since 2002. In the case of Algarve the landings in 2006 are at their lowest for this period (1995-2006).

Table 8.2.1 summarises the quarterly landings and their relative distribution by ICES Subdivision. Fifty-seven percent of the catches were landed in the second semester (34% in the third quarter) while almost 35% of the landings took place off the northern Portuguese coast (IXaCN). This value is higher than the one reported for last year. The percentage of catches in the northern area of the stock (VIIIc and IXaN) remain at similar levels from last year (30%). The southern areas accounts for 13% of the total values in 2006, similar to previous years (although with small decreases in both Algarve and Gulf of Cádiz landings).

8.2.1 Fleet Composition in 2006

Details about the vessels operated by both Spain and Portugal targeting sardine are given in table 8.2.1.1. In northern Spanish waters, sardine is taken by purse seiners (n = 346) ranging in size from 8 to 38 m (mean vessel length = 22 m). Vessel engine power ranges widely between

24 to 1100 (mean = 327). Half of the purse seiners (51%) are licensed in Galicia, where most of the smaller boats are found since part of the fishing takes place inside the rías. Purse seiners from the Basque Country (27% of the fleet) and Cantabria (17%) are bigger (they generally take longer trips while fishing). The remaining 5% of the fleet is licensed in Asturias.

In the Gulf of Cadiz, purse seiners taking sardine are generally targeting anchovy (n = 104) and range in size from 10.5 to 25 m with a mean vessel length of 16 m (horse power between 28 to 500 with a mean of 195). In Portuguese waters, sardine is taken by purse seiners (n = 121) ranging in size from 10.5 to 27 m (mean vessel length = 20 m). Vessel engine power ranges between 71 to 447 (mean = 249).

8.3 Fishery independent information

Figures 8.3.1 and 8.3.2 show the time series of fishery independent information for the sardine stock.

8.3.1 DEPM – based SSB estimates

DEPM surveys are planned for 2008 by both Spain and Portugal. Results from these surveys are expected to be available for the 2009 WGMHSA meeting. The last DEPM survey was carried out in 2005 and the SSB estimates obtained together with those from previous DEPM surveys are presented below:

YEAR	1997	1999	2002	2005
SSB (thousand tonnes)	342.7	269.0	453.6	418.6
CV	35	37	28	23

8.3.2 Acoustic surveys

The methodology used in the Portuguese and Spanish acoustic surveys was standardized within the framework of the Planning Group for Pelagic Acoustic Surveys in ICES Divisions IX and VIII (ICES CM 1998/G:2). Surveys are undertaken within the framework of the EU DG XIV project “Data Directive”.

8.3.2.1 Portuguese November 2006 and April 2007 Acoustic Surveys

During 2006/2007, two acoustic surveys were carried to estimate sardine and anchovy abundance in IXa. The November 2006 survey (SAR06NOV) aims to cover the early spawning and recruitment season while the April 2007 survey (PELAGOS07) aims to cover the late spawning season. Borth surveys took place onboard the RV “Noruega” and followed the standard methodology adopted by the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX (ICES 1986, 1998).

The November 2006 survey took place from the 27th of October to the 22nd of November covering the Portuguese coast and the Gulf of Cádiz. All planned 69 acoustic transects were covered although due to a problem with the pelagic net fewer trawls than planned were performed in the Cádiz area. A total of 27 trawl hauls were performed of which 21 were pelagic and 6 took place at the bottom (Figure 8.3.2.1.1). Sardine was present in 18 of those, being predominant in the subdivision IXa Central North (between Póvoa de Varzim and Lisbon) where it presented a coastal distribution, in depths mainly around 70-80 m. In subdivision IXa Central South sardine was scarce, being almost absent between Setúbal and Cape S. Vicente. In Algarve the biggest concentrations of sardine were found between Portimão and Faro and near Vila Real de Santo António. In the Cádiz area, sardine was also scarce, being found mainly in the first 3 transects (those closer to the border with Portugal). Total sardine biomass estimated in the surveyed area was 411 thousand tonnes (86% of it being located in Portuguese waters) corresponding to 8 131 million individuals of which 84% were located in Portuguese waters (Table 8.3.2.1.1). The biomass and abundance values obtained for the subdivision IXa Central North (257 thousand tonnes; 4 577 million individuals) represent a decrease of almost 31% in biomass and 52% in abundance compared with the values estimated by last year spring survey. The values obtained for subdivision IXa Central South (69 thousand tonnes, 1 602 million individuals) indicated a decrease in 50% of biomass and 44% in abundance from the values obtained by SARD06ABR. For Algarve, the estimated values (27 thousand tonnes, 635 million individuals) were among the lowest since 1995 in the series of Portuguese surveys (spring and autumn), while values for the Cádiz area were also low (58 thousand tonnes, 1 317 million individuals). Adult fish dominated in all the surveyed area (Figures 8.3.2.1.2 and 8.3.2.1.3) which indicates a poor 2006 recruitment. In subdivision IXa Central North, juvenile fish (length =16 cm) represented only 7% of the total fish found in the area. Subdivision Central South had a bimodal age structure with both juveniles (mode at 9cm) and adults (mode at 19 cm) present in the area. The percentage of juvenile fish in this area was 29% (located mainly between Cabo da Roca and Cascais). In the Algarve, juvenile fish represented 41% of the total number of fish and in Cádiz the population was again dominated by adult fish (juveniles represented only 3% of the total). Subdivision IXaCN was dominated by age 2 fish (2004 year class) while age 0 fish (2006 year class) dominated in subdivision IXaCS and in Algarve. Sardines from 2005 (age 1) were the most abundant age class in Cádiz (Table 8.3.2.1.1).

Surface water temperature measured during the survey ranged between 17-21℃, higher than in previous years (Figure 8.3.2.1.4). The distribution of salinity values throughout the surveyed area can be seen in Figure 8.3.2.1.4 and it is the result of the heavy rain registered at the start of the survey. The highest fluorescence values were associated with the river plumes and were located between the rivers Douro and Minho and in the south of the Bay of Cádiz. Sardine eggs were found throughout the surveyed area, with bigger densities located in the nortwestern area (north pof Carvoeiro Cape) (Figure 8.3.2.1.4).

The April 2007 survey (PELAGOS07) also took place onboard the RV “Noruega” from the 11th of April to the 8th of May and covered the Portuguese and Gulf of Cadiz waters ranging from 20 to 200 m depth. A total of 48 fishing stations were carried out with sardine being present in 31 of those (Figure 8.3.2.1.5). Sardine was found throughout the surveyed area mainly distributed in subdivision IXaCN (from Póvoa de Varzim to Lisbon). Sardine was scarce in subdivision IXaCS (specially between Cape Espichel and Sines). In the Algarve, the biggest concentrations were found in the eastern part (mainly near Sagres) while in the Cádiz area big densities were found near Cape Trafalgar.

Total estimated sardine biomass in the surveyed area was 451 thousand tonnes corresponding to 8 872 million individuals (Table 8.3.2.1.2). These values represent a decrease of 29% in biomass of 46% in numbers compared with the values estimated by last year spring survey (Figures 8.3.1. and 8.3.2) but are very close to the values obtained in the autumn 2006 survey. Slightly less than half the total estimated biomass and abundance (48% and 47% respectively) were located in subdivision IXaCN (215 thousand tones, 4 181 million individuals) which represents a decrease of 16% in biomass and of 9% in the abundance with respect to the autumn 2006 values and of 42% in biomass and 56% in abundance with respect to the spring 2006 values. In subdivision IXaCS a total of 89 thousand tones (1 924 million fish) was estimated, representing an increase of 29% in biomass and of 20% in abundance with respect to the values estimated by the 2006 autumn survey but a decrease of 36% in biomass and of 33% in abundance with respect to the values estimated by the 2006 spring survey. An increase in biomass (48%) and abundance (9%) was also apparent in the Algarve area (40 thousand tonnes, 690 million individuals in 2007) since the 2006 autumn survey making the 2007 values in this area very similar to those obtained by the 2006 spring survey. Finally, in the Cádiz area, the 2007 estimate of 107 thousand tones (2 077 million individuals) represents also an increase in both biomass (84%) and abundance (58%) with respect to the 2006 autumn survey values but an increase of 20% in biomass and a decrease of 39% in abundance with respect to the values estimated by the spring 2006 survey. Adult fish dominated in all the surveyed area (Figures 8.3.2.1.6 and 8.3.2.1.7) which confirms the indication of a poor 2006 recruitment obtained in the 2006 autumn survey. By areas, juvenile fish (length =16 cm) represented only 5% of the total number estimated in subdivision IXaCN while in subdivision IXa Central South they represented 33% of the total and were mainly located between Ericeira and Cascais. Sardine in subdivision IXaCN showed a bimodal length distribution with a mode at 16 cm (young fish) and another at 19 cm (adult fish). In the Algarve and Cádiz regions, adult fish dominated the population with juvenile sardines representing only 2% of the total. Subdivision IXaCN was dominated by age 3 fish (2004 year class) while age 1 fish (2006 year class) dominated in subdivision IXaCS and sardines from 2005 (age 2) were the most abundant age class in both Algarve and Cádiz (Table 8.3.2.1.2).

Surface water temperature measured during the survey ranged between 13.5-16.5°C in the western area and between 15.5-17.5°C in the southern coast. For the western area, these values are much lower than those registered in 2006 in subdivision IXaCN and slightly lower than those registered in 2005 in subdivision IXaCS. For the Gulf of Cádiz and Algarve, temperatures were lower than those registered in 2006 and 2005 (Figure 8.3.2.1.8). The distribution of salinity values throughout the surveyed area is similar to the one found in previous surveys and can be seen in Figure 8.3.2.1.8. It was also apparent the strong signal and the wide extension reached over the shelf of the Douro river plume. Fluorescence values detected during the survey are within the range of those measured in previous years. In the eastern Algarve region a colder water mass (with less florescence) was apparent, extending up to the mouths of rivers Tinto and Odiel. This water mass could be the result of a coastal upwelling in the area. Sardine eggs sampled during the survey were concentrated in the shelf south of the Nazaré canyon with few eggs being present in the northwestern area (with the exception of a few stations where higher egg numbers were found). The areas of higher concentrations were between Carvoeiro Cape and Raso, between the mouh of the Sado River and Sines and near Cádiz (Figure 8.3.2.1.8). This egg distribution is similar to the one found in the 2005 spring survey but different to the one obtained in the 2006 spring survey.

The strong 2004 cohort is evident in northern Portuguese waters, while in the south, age 2 fish (2005 cohort) dominates. Results from both surveys indicate a poor recruitment in 2006.

8.3.2.2 Spanish April 2007 Acoustic Survey

The Spanish spring acoustic surveys time series comprises data from 1986 onwards, with three gaps in 1989, 1994 and 1995. Surveys have been carried out with the main aim of acoustically assessing the pelagic resources inhabiting shelf waters in ICES subdivisions IXaN (south Galicia) and VIIIc (Cantabrian Sea). Since 1997, the survey has been carried out onboard the R/V Thalassa. The survey was originally mainly targeted at sardine (*Sardina pilchardus*), although other pelagic species of commercial interest such as anchovy (*Engraulis encrasicolus*), mackerel (*Scomber scombrus*), horse mackerel (*Trachurus trachurus*) and blue whiting (*Micromesistius poutassou*) were also evaluated. PELACUS0407, the most recent survey in the series, obtained for the first time abundance and biomass estimates for all the main pelagic species found in the area not just those of economic value (WD Iglesias et al., 2007).

Survey design for PELACUS0407 consisted of a systematic grid, normal to the coastline, with transects evenly distributed each 8 nm (Figure 8.3.2.2.1). The area of the continental shelf covered in 2007 (27th March to 23rd April) extended from 30 to 200 m depth, from northern Portuguese waters to southern French waters. During the survey, in addition to measuring the acoustic energy reflected by marine organisms, data are also routinely collected on the hydrography and hydrodynamics of the water masses (with rosettes and CTD), on the composition of the ichthyoplankton (using a Continuous Underwater Fish Egg Sampler, CUFES) and fish communities (from trawl stations). In 2007, data have been also collected on the presence and behaviour of top predators (marine mammals and seabirds) for the first time in the historical series. Figure 8.3.2.2.1 shows an outline of the sampling effort. As in 2006, all fishing stations were sampled only by the R/V Thalassa (pelagic trawls) since no purse-seiner was chartered to accompany the Thalassa.

Sardines were present in 21 of the 53 trawl hauls completed during the survey (47 in Spanish waters, see Figure 8.3.2.2.2) although only in 16 cases was the species caught in sufficient numbers to present a representative length distribution. Sardine abundance was estimated as 1 482 million individuals, while biomass was estimated to be 96.4 thousand tonnes (Table 8.3.2.2.1). Sardine biomass was amongst the highest of all the pelagic species assessed in the survey (Table 8.3.2.2.2). Most fish (83% by number and 80% of the biomass) were found in Galician waters (ICES subdivisions IXaN, VIIIcW) very close to the coast in high densities. Sardine was also found, although at lower densities, throughout the shelf in the Cantabrian and Basque Country areas (Figure 8.3.2.2.3).

Sardine ranged in length from 14.5 to 25.5 cm without a clear mode (Figure 8.3.2.2.4). Applying the ALK obtained from the fish sampled during the survey, most fish (52% by number and 51% of the biomass) in the entire surveyed area were assigned to age class 3 (2004 year class) (Table 8.3.2.2.1). Considering the age distribution by sub-area, the highest proportion of older fish (up to 10 years old although in very low numbers) was found in Basque Country waters (ICES subdivision VIIIcEe), the only sub-area where age class 3 was not predominant. No fish older than 6 years were found in south Galician waters (ICES subdivision IXaN). Age 3 fish predominated in Galician and Cantabrian waters but with a south-north gradient in importance (from almost 64% of both numbers and biomass in IXaN, 38% of both estimates in VIIIcW, to 33% of the biomass and 30% by number in VIIIcEw).

Low temperature values were found in Galicia and the west Cantabrian area mainly in the stations closest to the coast (areas influenced by the coastal upwelling). Higher temperatures were measured in the east Cantabrian area (Figure 8.3.2.2.5). During the survey low values of salinity were not found in Galician area while all the Cantabrian area was influenced by river runoff. High fluorescence values were found in the stations close to the capes in Galicia and Portugal as a consequence of the stronger upwelling in these areas. In 2007, sardine eggs showed a wide distribution (eggs were found not only in shelf waters but also along the slope and in offshore areas) (Figure 8.3.2.2.5). In addition, samples from a substantial number of stations in the south of Galicia contained sardine eggs while in the border between Galicia an Asturias substantial egg patches were found in offshore waters (these eggs were in an advanced stage of development, stage XI).

The results on sardine abundance, biomass and distribution obtained from PELACUS0407 are in line with those estimated in the previous years (Figure 8.3.1). Historically, sardine abundance in numbers shows a high inter-annual variability since 1986 and up to 1993. An important decrease is apparent from 1996 to 1999, followed by an important recovery in 2001, due to the strong 2000 recruitment. Abundance and biomass were at their highest in 2002 following the strong 2000 recruitment (first detected as 1-year old fish in IXaN in 2001, see Figure 8.3.2.2.6). In the following years both number of fish and biomass show a continuous decrease until 2005. In this year, there was evidence (again first detected in IXaN, Figure 8.3.2.2.6) that another good recruitment had taken place in 2004. Sardines born in this year probably halted the downward trend, stabilising the number of fish and slightly increasing the biomass of the stock (as fish grow they become heavier) in the next 2 years. Values obtained for numbers of fish per age class seem to indicate that the 2004 recruitment was not at the level of the 2000 recruitment (Figure 8.3.2.2.7) or that the influence of this recruitment in Spanish waters was much reduced, both numerical abundance and biomass are now at their lowest levels since 2001.

The distribution area of the species (measured in nm^2) shows some interannual variation but has been decreasing since 2001, with the lowest value being reached in 2007 (Figure 8.3.2.2.8).

The distribution of sardine eggs in 2007 shows some differences in relation to previous years (for comparison, Figure 8.3.2.2.9 shows the egg distribution found throughout the PELACUS time series, 2000-07) and a somewhat contrasting picture when compared with the results obtained for adult fish. Firstly, the total number of eggs sampled is the highest of the time series and showed a wider distribution, occupying not only the shelf but also in some cases the slope and further offshore (although at least part of these eggs could have originated in shelf waters since there was evidence of oceanographic mesoscale phenomena which could have acted as a transport mechanism for the eggs and also the eggs found in these offshore patches were in advanced stages of development, mainly stages X and XI). Secondly, while in previous years almost no eggs were found in the south of Galicia (Rias Bajas), in 2007 a substantial number of stations in the area contained them.

In Spanish waters, although sardines born in 2004 are still apparent in almost all of the surveyed area (age 3 fish predominated in ICES subdivisions IXaN, VIIIcW and VIIIcEe), the small numbers of adult fish detected in the survey (generally concentrated in the Cantabrian area, Figure 8.3.2.2.6) indicate that new recruits are now disappearing faster from the area than in the 1980s and early 1990s (Figure 8.3.2). As referred in previous reports, these numbers reflects that sardine population is highly dominated by young fish from good year-classes which support the fishery.

8.4 Biological data

Biological data were provided by both Spain and Portugal. In Spain, samples for age length keys were pooled on a half year basis for each subdivision while length/weight relationships were calculated for each quarter. Age length key and length/weight relationship from Cádiz area (IXaS Cádiz) have also been used. In Portugal, both age length keys and length/weight relationships were compiled on a quarterly and subdivision basis.

8.4.1 Catch numbers at length and age

Tables 8.4.1.1a,b,c,d show the quarterly length distributions of landings from each subdivision. Annual length distributions are generally unimodal in Spain with the exception of IXaS Cádiz were a more complex length distribution was found. As usual, the general decrease in the length distributions from VIIIcE to IXaN was apparent in the catches with modes observed at 21.5 cm for VIIIcE, at 20.5 cm for VIIIcW and at 19 cm for IXaN. For Portugal, single modes were observed for IXaCN at 18 cm and for IXaCS at 19.5 cm. For IXaS-Algarve most sardine caught in 2006 were between 18 and 20 cm.

Table 8.4.1.2 shows the catch-at-age in numbers for each quarter and subdivision. In Table 8.4.1.3, the relative contribution of each age group in each Sub-Division is shown as well as their relative contribution to the catches. In the area of Galicia (VIIIcW and IXaN) and all Portugal catches are dominated by the strong 2004 year class (2-group in 2006). The 2004 year class however is not apparent in the remaining areas, age 1 fish (2005 year class) dominates the catches in Cádiz. In the subdivision VIIIcE older fish dominate the catches.

0-group catches are mainly concentrated in sub-division IXaN (south Galician waters). Older fish (age groups 5 and 6+) concentrate in the Bay of Biscay/Cantabrian area (VIIIcE).

8.4.2 Mean length and mean weight at age

Mean length and mean weight at age by quarter and Sub-Division are shown in Tables 8.4.2.1 and 8.4.2.2.

8.4.3 Maturity and stock weights at age

A revision of the maturity ogives and stock weights for the period 1996-2005 was presented to last years WG (WD2006 Silva et al). For this revision, biological samples from Portuguese and Spanish spring acoustic surveys were used to estimate maturity and weight length for the northern, western and southern stock areas. Predicted values from these models are raised to population numbers using length frequency distributions (from acoustic estimation) and age-length-keys, separately for each year and area. These are combined to produce annual stock values using population numbers-at-age assuming equal catchability of the two surveys.

The maturity ogive and stock weights for 2006 (see below) were calculated according to the procedure described in WD2006 Silva et al.. The maturity at age 1 was the highest of the series (see Figure 8.7.1.5 for historical perspective).

AGE	0	1	2	3	4	5	6+
% mature fish	0	88.5	98.5	99.7	100	100	100

AGE	0	1	2	3	4	5	6+
Weight, kg	0	0.030	0.042	0.060	0.068	0.068	0.075

8.4.4 Natural mortality

Natural mortality was estimated at 0.33 by Pestana (1989), and is considered constant for all ages and years.

8.5 Effort and catch per unit effort

No new information on fishing effort review has been presented to the WG.

8.6 Relevant information on ecological/environmental studies related to sardine

8.6.1 Ecosystem considerations

Sardine forms large schools distributed all along the shelf in Iberian waters in depths ranging generally from 10 to 100 m. Juvenile fish tend to be separated from adults and are found closer inshore associated to river mouths and rías (Cabanas *et al*., 2007).

Sardine is a passive filter-feeder taking phytoplankton (diatoms) as well as zooplankton. There is also a degree of cannibalism by adults on eggs (Garrido *et al*., 2007).

In waters off the Iberian Peninsula and the Bay of Biscay, sardine has been found in the diet of several cetacean species, as well as in other fish species. Sardine is one of the main prey species in the diet of common dolphins (*Delphinus delphis*), as revealed from analysis of stomach contents from stranded and bycaught dolphins in Galician (NW Spain) (Santos *et al.*, 2004) and Portuguese waters (Silva, 2001). Anchovy and sardine were found to be the numerically most important prey taken by common dolphins stranded on the Atlantic French coast (Meynier, 2004). Common dolphins are the most abundant cetacean species in the area, with numbers estimated to reach several thousands (López *et al*., 2004). Other less common cetacean species also known to predate on sardine to a lesser extent are: harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*), and white-sided dolphin (*Lagenorhynchus acutus*) (e.g. Santos *et al*., 2007).

Predator-prey systems comprise a web of complex and dynamic relationships. A fundamental aspect of this complexity is that predators do not exploit individual prey species at a constant rate; rather they change their prey selection behaviour in relation to changes in prey density. Thus, typically, an increase in prey density would lead to an increase in predation rate (functional response). Analyses of the diet of common dolphins in Galicia (NW Spain) showed that interannual trends in the importance of sardine in the stomach contents appear to track trends in spawning stock biomass (Santos *et al.*, 2004). Additionally, the good 2000 recruitment can also be followed in the dietary data.

As predators and fishery target the same concentrated resource there is potential for interaction between them in the form of by-catches of predators and disturbance to the fishery practise. In the case of the purse seine fishery in the Iberian Peninsula, results from studies carried out both in Galicia and Portugal (López et al., 2003; Wise *et al*., 2007) do not consider by-catch as a serious issue in this particular gear. However, both studies highlighted the perceived importance by the fishermen of the disturbance to the fishery of marine mammal presence while fishing is taking place. This disturbance has been reported in the form of dolphins scaring the fish and/or damaging the net.

8.6.2 Recruitment forecasting and Environmental effects

The RG2006 suggested the consideration of wind-driven recruitment indices for sardine. However, results from a recent particle simulation study (Oliveira and Stratoudakis, in press; see also Anon., 2006 and WD Stratoudakis et al.) questioned the role of wind-induced transport on the modulation of recruitment dynamics in sardine. This study indicated large sensitivity in the estimated fate of particles as a function of the components considered in the velocity field, with the probability of retention within the continental shelf being always enhanced when mesoscale and mean circulation components were added to the wind-induced circulation. Although the original objective of the study was to explore the possible relation between advection/retention and sardine recruitment off western Iberia (by considering the period 1998-2004, within which large contrasts in year class strength were observed), it soon became clear that no relationship could be established and the objective of the study was modified to explore average dispersion patterns on a larger spatial scale and perform sensitivity analyses.

Another recent study explored the relationship between environmental variables at large and local spatial scale and sardine recruitment in the Galician sardine fishery (Cabanas et al., 2007). For their analysis, the authors used a time series spanning from 1978 to 2005. The final model attempted to explain the variability in recruitment as a function of several indices, related to the North Atlantic Oscillation, the variability in the position of the Gulf Stream, upwelling strength and the poleward current. The fitted model matched quite well the predicted recruitment during the 80s but when the whole time series was considered the performance of the model was poor. The authors also noted that a shift in 1995 seems to be apparent in the general trend of the environmental variables coinciding by several consecutive poor recruitments at the end of the 1990s.

The WG considers that it is not advisable to derive recruitment indices for sardine based on wind indices. Instead, given the fidelity of sardine recruitment to relatively small areas (northern Portugal, Gulf of Cadiz), a better approach to improve understanding of sardine recruitment is to identify the main hydrological and environmental reasons that turn these areas into important nursery grounds.

8.7 Data and model exploration

This year, the assessment of sardine is an update and therefore no extensive data and model exploration was carried out. Catch and survey data were updated. A few changes to model assumptions were explored to address pending issues from last years' assessment and comments from the Review Group 2006 (RG2006).

8.7.1 Data exploration

Sardine catch-at-age data and abundance-at-age data from the combined spring acoustic survey are presented in Figures 8.7.1.1 and 8.7.1.2 and listed in Table 8.8.1.1 f,g, respectively. Both catches and abundance data support the strength of the 2004 year-class and suggest a poor 2006 year-class. Figures 8.7.1.3 to 8.7.1.5 show the mean weights-at-age in the catch and in the stock and maturity ogive (data listed in Table 8.8.1.1 a,b,c). Sardine mean weights-at-age in the stock show an increasing trend since the late 1990s particularly in 2+ individuals. A substantial increase is observed from 2005 to 2006 at age 1. Trends in mean weight-at-age are also noticeable in the catches but these are less pronounced. Maturity-at-age 1 also increased sharply from 2005 (19%) to 2006 (89%); these estimates correspond to the lowest and highest values in the time series, respectively. L_{50} was observed to decline ca. 2 cm (from 15.6 to 13.2 cm, see also ICES, 2006, WD2006 Silva et al) from 2005 to 2006. There is some evidence of density-dependence in sardine L_{50} (Silva et al., 2006) and it is possible that changes in maturity-at-length and age are related to extensive variations of recruitment in recent years (strong in 2004, low in 2005 and very low in 2006). However, these issues need to be further investigated.

8.7.2 Model exploration

As highlighted by the RG2006, the selection for the 6+ group in the 2006 assessment was substantially below those for age groups 4 and 5 years. This problem was extensively explored in the last assessment, e.g. by linking the 6+ mortality to Fs at previous ages, but most attempts resulted in considerably poorer fit to the catches (ICES, 2006). Survey catchability also drops substantially in the 6+. To explore this effect, an AMCI run was set up based on the spaly07 run with the additional assumption that catchability of the 6+ group is equal to catchability at ages 4 and 5 (run-fixedQ6). Another run was carried out using SSB from DEPM as an absolute index of abundance (run-absDEPM). This option aimed to decrease the number of parameters estimated by the model, which shows some signs of overparametrisation (e.g. slow convergence). This option seems reasonable given that a catchability estimate around 1 was obtained when the SSB index was used as relative (ICES, 2006). Finally, a run combining the two previous assumptions was carried out (run-fixedQ6&absDEPM). Results from these runs were compared to those from the spaly07 run.

As expected, the model converged faster by fixing either one or two parameters. Plots showing the catchability curves (Figure 8.7.2.1), survey residuals (Figure 8.7.2.2) and stock summaries (Figure 8.7.2.3) for the different runs are presented. Catch residuals were similar among runs (see Figure 8.8.1.2 for the spaly07 run) while a slight improvement in residuals from recent surveys occurred with fixed 6+ catchability. The results confirm that the assumption of an absolute SSB has negligible effects in model fitting and output. The assumption of fixed 6+ catchability has a scaling effect on SSB (downward) and F (upward) compared to the spaly07 run. There was also a small increase of selection in the 6+ group in these runs although the decline from ages 4-5 persisted.

In summary, although the stability of the assessment improved by fixing catchability for the 6+ group and for the DEPM survey, the former assumption did not overcome the problem of low selection of the 6+ group. There may be biological reasons for the decline of selection in the plus group; older fish may be distributed in more offshore areas which are not exploited by the fishery or there may be size/age related migrations along the coast out of the main fishing areas. Although survey areas extend to the 200 m contour, 6+ sardines are also less caught in surveys than expected from younger age groups. It is possible that fish older than 6 years are less detectable in surveys than younger fish due to low abundance and more dispersed distribution. For these reasons, the depletion of year-classes may be apparently faster at older ages and the assumed constant natural mortality with age may be inadequate. The WG considered that the information presently available is insufficient to decide on the best model structure regarding this effect and suggests that the causes of low 6+ selection and catchability of sardine be further investigated.

8.8 State of the stock

8.8.1 Stock assessment.

The final stock assessment was made with AMCI for one area.

The following data were used:

- Catch numbers at age: 1978-2006
- Combined March acoustic survey: Indices from the Spanish march survey, covering Division VIIIc and Subdivision IXaN, and the Portuguese March survey, covering the remainder of Division IXa, added together without weighting, for the years 1996 to 2007.
- DEPM estimates of spawning biomass, covering VIIIc and IXa, for the years 1997, 1999, 2002 and 2005

The model was conditioned as follows:

- Selection at age in the fishery at age 4 equal to age 5
- Survey catchability at age 4 equal to age 5
- DEPM survey as a relative index of SSB
- Selection at age was allowed to change gradually, using the recursive updating algorithm in AMCI, with a gain factor of 0.2 for all ages and years.
- Survey catchability assumed constant over time.
- Catchability of the DEPM survey constant over time.
- Natural mortality: Constant at 0.33 (Pestana, 1989).

The following model parameters were estimated:

- Initial numbers in 1978 and recruitments each year except in 2007. Recruitment in 2007 was assumed at $9*10^9$
- Initial selection at age in the fishery, for all ages, but assumed equal for ages 4 and 5. Selection in 2007 assumed equal to 2006.
- Survey catchability at age, for all ages, but assumed equal for ages 4 and 5.
- Catchability for the DEPM survey.
- Annual fishing mortalities.

The objective function was a sum of squared log residuals for catch numbers at age, survey indices at age and DEPM indices. Catches at age 0 were downweighed by a factor of 0.1. The weighting specified was equal for all other observations. The internal weighting in AMCI implies that the set of all acoustic survey observations, and the set of DEPM observations, each are given the same weight as each year of catch numbers at age.

Results from the assessment are listed in Table 8.8.1.1a-i. Summary plots are presented in Figure 8.8.1.1 and catch and survey residuals are shown in Figures 8.8.1.2 and 8.8.1.3, respectively. Fishing mortalities at age are shown in Figure 8.8.1.4, and the survey catchability-at-age in Figure 8.8.1.5.

Overall, the results from this years' assessment are comparable to those obtained last year (Figure 8.8.1.1) . Catch and survey residuals do not raise serious concern although some clustering of mostly negative or positive residuals is perceptible. There is a large negative residual in the 6+ group in the 1996 survey (also detected in previous assessments). The reasons for this residual are unclear and a closer examination of its origin is recommended.

Selection shows an increase up to ages 3-4 years (constrained to be equal at ages 4 and 5) and declines sharply in the 6+ group, in recent years. Survey catchability is the highest at age 1, relatively flat from ages 2 to 5 (constrained to be equal at ages 4 and 5) and also drops in the 6+ group.

SSB shows an increase of almost 300 thousand tonnes from 2005 (389 thousand tonnes) to 2006 (658 thousand tonnes) due to the 2004 strong recruitment, presently estimated as stronger than the 2000 recruitment and the second highest of the historical series (after the 1983 year-class). The large proportion of mature individuals and higher mean weights-at-age 1 in 2006 also contribute to the sharp raise in SSB this year. Fishing mortality (F_{2-5}) continued to decline in 2006, in consistency with the decline of catches and increasing stock abundance, and shows the lowest historical level, 0.17 year^{-1}. The 2005 recruitment is confirmed to be low and the 2006 recruitment is estimated to be extremely low of the historical series (940 thousand individuals, CV=0.24).

Coefficients of variation of the estimated parameters, as derived from the Hessian matrix, are given in Table 8.8.1.2. Correlations between parameter estimates as derived from the Hessian were all below 0.3. It should be noted that since the objective function is not a proper likelihood function due to the externally set weighting of the observations, these CVs and correlations can only be taken as indicative of the uncertainties in the results.

Bootstrap estimates of uncertainty in SSB, recruitment and fishing mortality were made by re-sampling the residuals of all data around the model values. The main results from 100 replicas are shown in Figure 8.8.1.6. 90% confidence limits for the recruitment are narrow and both SSB and fishing mortality seem to be estimated with a reasonable and consistent precision across the time series.

8.8.2 Reliability of the assessment

The results from this years' assessment are comparable to those obtained last year. This assessment is an update and therefore, comments reported last year on the reliability of the sardine assessment are still applicable. Limited data and model exploration was carried out this year. Model exploration mainly confirmed that the catchability of the DEPM survey is close to unity and supported the perception that the decline of both selection and catchability of the 6+ group may have a biological cause.

8.9 Catch predictions

8.9.1 Divisions VIIIc and IXa

Catch predictions were carried out using results from the final AMCI assessment. Predictions were carried out for two scenarios of recruitment in 2006:

- in scenario 1, the input value for the 2006 recruitment was calculated as the geometric mean of the recruitments for the last 10 years of the time series (1995-2005), excluding the highest values, 2000 and 2004; $R_{GMlow(96-05)}$ = 4329 million individuals; numbers at age 1 at 1st January 2007 (3020 million individuals) were calculated from $R_{GMlow(96-05)}$ with the fishing mortality rate F_{age0} for 2006;
- in scenario 2, the input value for the 2006 recruitment was that estimated in the assessment, R_{2006}=940 million individuals; numbers at age 1 at 1st January 2007 (656 million individuals) were calculated from R_{2006} with the fishing mortality rate F_{age0} for 2006;

The remaining assumptions were equal in the two scenarios:

- Input values for 2007, 2008 and 2009 recruitments were set equal to the geometric mean of 1995-2005 ($R_{GM(96-05)}$ = 5287 million individuals.
- Weights-at-age in the stock and in the catch were calculated as the arithmetic mean value of the last three years (2004-2006);
- The maturity ogive corresponded to the 2006 values;
- As in the assessment, input value for natural mortality was 0.33 and input values for the proportion of F and M before spawning were 0.25;
- The exploitation pattern and F_{sq} were the average F(2004-06) unscaled. F_{sq} = 0.19 year^{-1}

Assumptions in scenario 1 are equal to those used in catch predictions performed in last years' assessment. Scenario 2 takes into account the extremely low 2006 recruitment estimated by the assessment and supported by 2006 and 2007 acoustic survey data (see also section 8.3.2.1).

For scenario 1, input values are shown in Table 8.9.1.1. and results are shown in Table 8.9.1.2. The predicted catches with Fsq (0.19) for 2007 are 103 thousand tonnes. Predicted SSB for 2007 is 590 thousand tonnes. If fishing mortality remains at the Fsq level (0.19), the predicted yield in 2008 (92 thousand tonnes) is slightly below the catch level in recent years (average of 96 thousand tonnes, 2002 – 2006). Predicted SSB for 2008 is 519 thousand tonnes, which means a decrease of 21% with respect to the estimated 2006 SSB.

In scenario 2, the predicted yield for 2008 is 82 thousand tonnes (Table 8.9.1.3). Predicted SSB for 2008 is 459 thousand tonnes, which means a decrease of 30% with respect to the estimated 2006 SSB.

In summary, both scenarios predict a short-term decline of SSB although predicted levels for 2008 will be close to the average of the historical series (485 thousand tonnes, 1978 – 2006). According to catch predictions, the average catch level in the last five years (96 thousand tonnes, 2002-2006) will not be sustainable in any of the scenarios. If the extremely low 2006 recruitment is confirmed and the 2007 recruitment has an average level, catches in 2008 are predicted to decline 11% (ca. 14 thousand tonnes) compared to the average catch level in recent years.

As in previous years, it should be pointed out that the outcome of short term deterministic predictions has a high uncertainty due to the use of assumed values of recruitment, possible bias in the assessment and the assumption that current levels of fishing mortality will remain constant in 2007.

8.10 Reference points for management purposes

The RG2006 recommended the development of reference points for the sardine stock. Reference points have not been established for this stock so far, mostly due to the lack of stable assessments (see also WD Stratoudakis et al).

The establishment of reference points should be seen in the context of the management of the fishery for this stock. No TACs are set by management. However, effort and catch limitations have been gradually enforced at the national level since 1997 (see section 8.11) as a response to the decline of the stock and fishery in the mid-1990s (more pronounced in northern Spain than off Portugal). Market constraints have meant that in recent years the increase in sardine abundance has not been translated to higher catches. At present, the fishery for sardine aims at maintaining catches at a level that satisfies the needs of a stable market. This has led to an exploitation with a fishing mortality that mostly has been below the assumed natural mortality. The fishing mortality has fluctuated inversely to fluctuations in the SSB, as one would expect with a stable catch regime. In the last 8-10 years the trend in fishing mortality has been declining.

Although maximum absolute biomass in the Iberian sardine stock is lower than in other sardine stocks worldwide, fluctuations in biomass are also smaller than in other sardine fisheries. This may be due to the regulation of the fishery by a stable market, but may also be related to the heterogeneity of oceanographic conditions and the spatial distribution of the stock, which facilitates the maintenance of a minimum stock level by periodic large recruitments. Thus, the recruitment of the Iberian sardine is variable, but with some regularity, leading to periodic fluctuations in the SSB. In the stock-recruit data, there is nothing to indicate any breakpoint where there is evidence that reduced recruitment is due to reduced SSB. Hence, the standard procedure to establish a Blim does not seem to be relevant. Likewise, there does not seem to be any rationale for defining an Flim.

With this kind of fishery, a precautionary management should primarily aim at establishing rules to ensure proper action if the situation comes out of control, either because of increased exploitation or reduced productivity. Hence, a biomass reference point is needed to trigger action in these situations. A possible route to take would be to evaluate trigger points and strengths of the response by simulations of a fixed catch regime. The WGMHSA recommends that this approach is followed. When designing such simulation studies one may draw on the experience from simulation of similar rules for e.g. mackerel (see Study Group on Multiannual Management of the NEA mackerel). These rules should also take into account the importance of spatial distribution of the stock. In the absence of a S/R assumption, avoiding a stock size where the recruitment dynamics are unknown, can be considered as a basis for a precautionary approach to setting a limit biomass reference point. Thus if a reference biomass is needed to evaluate risks, the WG suggests using the lowest SSB observed.

8.11 Management considerations

No TAC is set to manage the stock. National management measures implemented in each country since 1997 continued to be enforced in 2006 (see Section 8.1.1).

The Spawning Stock Biomass of this stock is at a high value in the historical series (657 894 tonnes in 2006), and has increased substantially compared to the 2002 – 2005 average level due to the strong 2004 year-class. Fishing mortality shows a decreasing trend since 1998. The assessment estimates the 2004 recruitment as the second strongest in the historical series while the 2005 recruitment is low and the 2006 recruitment is almost one order of magnitude below the geometric mean of the last 10 years. Estimates of this recruitment in acoustic surveys, both at age 0 (in the Portuguese November survey) and at age 1 (in the combined Portuguese and Spanish acoustic survey in spring 2007) support the low strength of this year class. In addition, the abundance of sardine in the Cantabrian Sea estimated in the acoustic survey shows a declining trend in recent years.

At present, the stock size is large. Short term predictions indicate that recent catch levels will not be sustainable in 2008 at the assumed (average of last three years) fishing mortality level, if the 2006 recruitment is confirmed to be low and no strong recruitment occurs in 2007. If management aims to maintain recent catch levels, fishing mortality must be allowed to increase. However, if the recruitment in the near future continues to be low then, maintaining the recent catch levels will lead to an escalating fishing mortality and further decline of SSB, unless measures are taken to reduce the catches. In the past, extended periods of successive low recruitments have been associated with periods of minimum SSB in the stock history. In the most recent of these periods (late 1990s) the sardine fisheries experienced a critical phase, which was mainly felt in the northern Spanish areas. As outlined in section 8.10 both the spatial distribution of the stock and the avoidance of a stock size where the recruitment dynamics are unknown should be considered in the management advice for this stock.

Table 8.2.1: Sardine in VIIIc and IXa: Quaterly distribution of sardine landings (t) in 2006 by ICES Sub-Division. Above absolute values; below, relative numbers.

VIIIc-E	2734	1768	1735	1521	**7758**
VIIIc-W	457	2479	3350	1333	**7619**
IXa-N	1991	3469	3497	1898	**10856**
IXa-CN	3209	6494	10142	10307	**30152**
IXa-CS	4454	5053	6182	3372	**19061**
IXa-S (A)	1306	1223	2054	1214	**5798**
IXa-S (C)	1629	1024	2761	364	**5779**
Total	**15781**	**21510**	**29721**	**20010**	**87023**

Sub-Div	**1st**	**2nd**	**3rd**	**4th**	**Total**
VIIIc-E	3.14	2.03	1.99	1.75	**8.92**
VIIIc-W	0.52	2.85	3.85	1.53	**8.75**
IXa-N	2.29	3.99	4.02	2.18	**12.47**
IXa-CN	3.69	7.46	11.65	11.84	**34.65**
IXa-CS	5.12	5.81	7.10	3.88	**21.90**
IXa-S (A)	1.50	1.41	2.36	1.40	**6.66**
IXa-S (C)	1.87	1.18	3.17	0.42	**6.64**
Total	**18.13**	**24.72**	**34.15**	**22.99**	

Table 8.2.1.1: Sardine in VIIIc and IXa: Spanish and Portuguese composition of the fleet catching sardine in 2006. Length category: range (average) in m, Engine power category: range (average) in HP.

COUNTRY	DETAILS GIVEN	LENGTH (METRES)	ENGINE POWER (HORSE POWER)	GEAR	STORAGE	DISCARD ESTIMATE	NO VESSELS
Spain (northern)	yes	8 – 38 (22)	24 – 1100 (327)	Purse seine	Dry hold with ice	No	346
Spain (Gulf of Cadiz)	yes	10.5 – 25 (16)	28 – 500 (195)	Purse seine	Dry hold with ice	No	104
Portugal	yes	10.5 – 27 (20)	71 – 447 (249)	Purse seine	Dry hold with ice	No	121

Table 8.2.2: Sardine in VIIIc and IXa: Iberian Sardine Landings (tonnes) by sub-area and total for the period 1940-2006.

	Sub-area										
Year	VIIIc	IXa North	IXa Central North	IXa Central South	IXa South Algarve	IXa South Cadiz	All sub-areas	Div. IXa	Portugal	Spain (excl.Cadiz)	Spain (incl.Cadiz)
1940	66816		42132	33275	23724		**165947**	**99131**	**99131**	**66816**	**66816**
1941	27801		26599	34423	9391		**98214**	**70413**	**70413**	**27801**	**27801**
1942	47208		40969	31957	8739		**128873**	**81665**	**81665**	**47208**	**47208**
1943	46348		85692	31362	15871		**179273**	**132925**	**132925**	**46348**	**46348**
1944	76147		88643	31135	8450		**204375**	**128228**	**128228**	**76147**	**76147**
1945	67998		64313	37289	7426		**177026**	**109028**	**109028**	**67998**	**67998**
1946	32280		68787	26430	12237		**139734**	**107454**	**107454**	**32280**	**32280**
1947	43459	21855	55407	25003	15667		**161391**	**117932**	**96077**	**65314**	**65314**
1948	10945	17320	50288	17060	10674		**106287**	**95342**	**78022**	**28265**	**28265**
1949	11519	19504	37868	12077	8952		**89920**	**78401**	**58897**	**31023**	**31023**
1950	13201	27121	47388	17025	17963		**122698**	**109497**	**82376**	**40322**	**40322**
1951	12713	27959	43906	15056	19269		**118903**	**106190**	**78231**	**40672**	**40672**
1952	7765	30485	40938	22687	25331		**127206**	**119441**	**88956**	**38250**	**38250**
1953	4969	27569	68145	16969	12051		**129703**	**124734**	**97165**	**32538**	**32538**
1954	8836	28816	62467	25736	24084		**149939**	**141103**	**112287**	**37652**	**37652**
1955	6851	30804	55618	15191	21150		**129614**	**122763**	**91959**	**37655**	**37655**
1956	12074	29614	58128	24069	14475		**138360**	**126286**	**96672**	**41688**	**41688**
1957	15624	37170	75896	20231	15010		**163931**	**148307**	**111137**	**52794**	**52794**
1958	29743	41143	92790	33937	12554		**210167**	**180424**	**139281**	**70886**	**70886**
1959	42005	36055	87845	23754	11680		**201339**	**159334**	**123279**	**78060**	**78060**
1960	38244	60713	83331	24384	24062		**230734**	**192490**	**131777**	**98957**	**98957**
1961	51212	59570	96105	22872	16528		**246287**	**195075**	**135505**	**110782**	**110782**
1962	28891	46381	77701	29643	23528		**206144**	**177253**	**130872**	**75272**	**75272**
1963	33796	51979	86859	17595	12397		**202626**	**168830**	**116851**	**85775**	**85775**
1964	36390	40897	108065	27636	22035		**235023**	**198633**	**157736**	**77287**	**77287**
1965	31732	47036	82354	35003	18797		**214922**	**183190**	**136154**	**78768**	**78768**
1966	32196	44154	66929	34153	20855		**198287**	**166091**	**121937**	**76350**	**76350**
1967	23480	45595	64210	31576	16635		**181496**	**158016**	**112421**	**69075**	**69075**
1968	24690	51828	46215	16671	14993		**154397**	**129707**	**77879**	**76518**	**76518**
1969	38254	40732	37782	13852	9350		**139970**	**101716**	**60984**	**78986**	**78986**
1970	28934	32306	37608	12989	14257		**126094**	**97160**	**64854**	**61240**	**61240**
1971	41691	48637	36728	16917	16534		**160507**	**118816**	**70179**	**90328**	**90328**
1972	33800	45275	34889	18007	19200		**151171**	**117371**	**72096**	**79075**	**79075**
1973	44768	18523	46984	27688	19570		**157533**	**112765**	**94242**	**63291**	**63291**
1974	34536	13894	36339	18717	14244		**117730**	**83194**	**69300**	**48430**	**48430**
1975	50260	12236	54819	19295	16714		**153324**	**103064**	**90828**	**62496**	**62496**
1976	51901	10140	43435	16548	12538		**134562**	**82661**	**72521**	**62041**	**62041**
1977	36149	9782	37064	17496	20745		**121236**	**85087**	**75305**	**45931**	**45931**
1978	43522	12915	34246	25974	23333	5619	**145609**	**102087**	**83553**	**56437**	**62056**
1979	18271	43876	39651	27532	24111	3800	**157241**	**138970**	**91294**	**62147**	**65947**
1980	35787	49593	59290	29433	17579	3120	**194802**	**159015**	**106302**	**85380**	**88500**
1981	35550	65330	61150	37054	15048	2384	**216517**	**180967**	**113253**	**100880**	**103264**
1982	31756	71889	45865	38082	16912	2442	**206946**	**175190**	**100859**	**103645**	**106087**
1983	32374	62843	33163	31163	21607	2688	**183837**	**151463**	**85932**	**95217**	**97905**
1984	27970	79606	42798	35032	17280	3319	**206005**	**178035**	**95110**	**107576**	**110895**
1985	25907	66491	61755	31535	18418	4333	**208439**	**182532**	**111709**	**92398**	**96731**
1986	39195	37960	57360	31737	14354	6757	**187363**	**148168**	**103451**	**77155**	**83912**
1987	36377	42234	44806	27795	17613	8870	**177696**	**141319**	**90214**	**78611**	**87481**
1988	40944	24005	52779	27420	13393	2990	**161531**	**120587**	**93591**	**64949**	**67939**
1989	29856	16179	52585	26783	11723	3835	**140961**	**111105**	**91091**	**46035**	**49870**
1990	27500	19253	52212	24723	19238	6503	**149429**	**121929**	**96173**	**46753**	**53256**
1991	20735	14383	44379	26150	22106	4834	**132587**	**111852**	**92635**	**35118**	**39952**
1992	26160	16579	41681	29968	11666	4196	**130250**	**104090**	**83315**	**42739**	**46935**
1993	24486	23905	47284	29995	13160	3664	**142495**	**118009**	**90440**	**48391**	**52055**
1994	22181	16151	49136	30390	14942	3782	**136582**	**114401**	**94468**	**38332**	**42114**
1995	19538	13928	41444	27270	19104	3996	**125280**	**105742**	**87818**	**33466**	**37462**
1996	14423	11251	34761	31117	19880	5304	**116736**	**102313**	**85758**	**25674**	**30978**
1997	15587	12291	34156	25863	21137	6780	**115814**	**100227**	**81156**	**27878**	**34658**
1998	16177	3263	32584	29564	20743	6594	**108924**	**92747**	**82890**	**19440**	**26034**
1999	11862	2563	31574	21747	18499	7846	**94091**	**82229**	**71820**	**14425**	**22271**
2000	11697	2866	23311	23701	19129	5081	**85786**	**74089**	**66141**	**14563**	**19644**
2001	16798	8398	32726	25619	13350	5066	**101957**	**85159**	**71695**	**25196**	**30262**
2002	15885	4562	33585	22969	10982	11689	**99673**	**83787**	**67536**	**20448**	**32136**
2003	16436	6383	33293	24635	8600	8484	**97831**	**81395**	**66528**	**22819**	**31303**
2004	18306	8573	29488	24370	8107	9176	**98020**	**79714**	**61965**	**26879**	**36055**
2005	19800	11663	25696	24619	7175	8391	**97345**	**77545**	**57490**	**31464**	**39855**
2006	15377	10856	30152	19061	5798	5779	**87023**	**71646**	**55011**	**26233**	**32012**

Div. IXa = IXa North + IXa Central-North + IXa Central-South + IXa South-Algarve + IXa South-Cadiz

Table 8.3.2.1.1: Sardine in VIIIc and IXa: Sardine Assessment from the 2006 Portuguese autumn acoustic survey. Number in thousand fish and biomass in tonnes.

AREA		0	1	2	3	4	5	6+	Total
Oc. Norte	Biomass	11519	29864	195539	9942	3494	4639	2026	257022
	%	4	12	76	4	1	2	1	
	Mean Weight	29.0	50.6	58.8	73.7	71.9	80.7	99.0	
	No fish	397637	590581	3327512	134911	48557	57486	20470	4577154
	%	9	13	73	3	1	1	0	
	Mean Length	15.4	18.0	18.7	19.9	19.8	20.4	21.6	
Oc. Sul	Biomass	8987	11259	28445	8238	5496	4924	1921	69270
	%	13	16	41	12	8	7	3	
	Mean Weight	15.1	48.0	58.7	66.5	74.8	79.9	72.9	
	No fish	596819	234783	484745	123840	73514	61596	26330	1601626
	%	37	15	30	8	5	4	2	
	Mean Length	11.3	17.9	19.0	19.7	20.5	20.9	20.3	
Algarve	Biomass	7459	4873	6506	2701	1703	1537	2259	27039
	%	29	39	51	58	65	68	72	
	Mean Weight	24.0	43.8	51.5	56.3	59.2	65.9	73.5	
	No fish	255771	124513	127606	46729	26005	22455	31472	634550
	%	40	20	20	7	4	4	5	
	Mean Length	15.2	16.8	18.4	19.2	20.1	20.3	20.7	
Cadiz	Biomass	10099	28428	11098	2088	2434	1263	2690	58100
	%	29	39	51	58	65	68	72	
	Mean Weight	39.3	42.7	45.6	56.7	52.1	56.8	60.2	
	No fish	257009	666182	243470	36859	46752	22261	44656	1317189
	%	20	51	18	3	4	2	3	
	Mean Length	16.9	17.4	17.8	19.1	18.6	19.1	19.5	
Total	Biomass	38064	74425	241588	22969	13126	12363	8896	411431
Portugal	%	9	18	59	6	3	3	2	
	Mean Weight	27.4	46.7	58.0	67.5	67.8	76.1	75.2	
	No fish	1507235	1616058	4183334	342338	194829	163798	122928	8130519
	%	19	20	51	4	2	2	2	
	Mean Length	14.0	17.6	18.7	19.7	19.8	20.4	20.3	

Table 8.3.2.1.2: Sardine in VIIIc and IXa: Sardine Assessment from the 2007 Portuguese spring acoustic survey (PELAGOS07). Number in thousand fish and biomass in tonnes.

AREA		1	2	3	4	5	6+	Total
Oc. Norte	**Biomass**	14018	52988	122079	630	4123	21499	**215336**
	%	7	25	57	0	2	10	
	Mean Weight	34.7	48.6	52.7	67.7	69.2	71.0	
	No fish	404220	1089406	2315361	9308	59544	303343	**4181182**
	%	10	26	55	0	1	7	
	Mean Length	16.5	18.4	18.9	20.5	20.6	20.8	
Oc. Sul	**Biomass**	22114	19678	27379	7619	3466	8783	**89039**
	%	25	22	31	9	4	10	
	Mean Weight	29.9	47.2	57.4	62.3	67.2	74.3	
	No fish	739132	416470	476585	122384	51594	118237	**1924402**
	%	38	22	25	6	3	6	
	Mean Length	15.5	18.0	19.2	19.7	20.2	20.9	
Algarve	**Biomass**	1429	10441	9417	8283	2511	7664	**39744**
	%	4	26	24	21	6	19	
	Mean Weight	38.1	51.0	56.0	61.1	69.5	71.1	
	No fish	37490	204595	168148	135617	36158	107873	**689881**
	%	5	30	24	20	5	16	
	Mean Length	16.4	18.3	18.9	19.5	20.5	20.6	
Cadiz	**Biomass**	16114	56294	14449	15061	3258	2275	**107452**
	%	15	52	13	14	3	2	
	Mean Weight	43.3	50.7	54.7	61.5	63.5	68.2	
	No fish	372426	1111035	264115	244830	51324	33420	**2077150**
	%	18	53	13	12	2	2	
	Mean Length	17.3	18.4	18.9	19.7	19.9	20.4	
Total	**Biomass**	37560	83107	158875	16531	10100	37946	**344119**
Portugal	**%**	11	24	46	5	3	11	
	Mean Weight	32.0	48.6	53.7	61.9	68.6	71.8	
	No fish	1180841	1710472	2960095	267309	147295	529453	**6795465**
	%	17	25	44	4	2	8	
	Mean Length	15.9	18.3	19.0	19.7	20.4	20.8	
Total	**Biomass**	53674	139401	173324	31592	13358	40221	**451571**
	%	12	31	38	7	3	9	
	Mean Weight	34.7	49.4	53.8	61.7	67.3	71.6	
	No fish	1553267	2821507	3224209	512139	198619	562873	**8872615**
	%	18	32	36	6	2	6	
	Mean Length	16.2	18.3	19.0	19.7	20.3	20.8	

Table 8.3.2.2.1: Sardine in VIIIc and IXa: Sardine abundance in number (thousands of fish) and biomass (ton by age groups and ICES subdivision in PELACUS0407.

AREA VIIIcE east	AGE										
	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	0	5	75	83	92	88	67	63	4	7	484
% Biomass	0	1.1	15.6	17.1	18.9	18.2	13.8	13	0.8	1.5	100
Abundance (in '000)	0	83	930	902	988	920	691	618	33	60	5225
% Abundance	0	1.6	17.8	17.3	18.9	17.6	13.2	11.8	0.6	1.2	100
Medium Weight (gr)	0	62	81.1	91.6	92.6	95.9	96.5	101.4	117.6	122.6	95.7
Medium Length (cm)	0	19.9	21.9	22.8	22.9	23.2	23.3	23.7	25	25.3	23.1
AREA VIIIcE west	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	1794	1388	6171	2797	2290	2545	834	399	171	0	18389
% Biomass	9.8	7.6	33.6	15.2	12.5	13.8	4.5	2.2	0.9	0	100
Abundance (in '000)	49222	27103	75763	32673	25605	27501	8080	3738	1640	0	251325
% Abundance	19.6	10.8	30.1	13	10.2	10.9	3.2	1.5	0.7	0	100
Medium Weight (gr)	36.4	51.2	81.4	85.6	89.4	92.5	103.2	106.9	104.2	0	83.4
Medium Length (cm)	16.6	18.5	21.9	22.3	22.7	22.9	23.8	24.1	23.9	0	21.9
AREA VIIIcW	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	1129	5216	9435	1945	2239	2342	1923	346	0	0	24576
% Biomass	4.6	21.2	38.4	7.9	9.1	9.5	7.8	1.4	0	0	100
Abundance (in '000)	28721	82067	136636	25106	29074	29071	23223	3375	0	0	357273
% Abundance	8	23	38.2	7	8.1	8.1	6.5	0.9	0	0	100
Medium Weight (gr)	39.3	63.6	69.1	77.5	77	80.6	82.8	102.6	0	0	74.1
Medium Length (cm)	17	20.1	20.7	21.5	21.5	21.9	22	23.8	0	0	21.1
AREA IXaN	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	509	8604	33852	4471	2217	3288	0	0	0	0	52941
% Biomass	1	16.3	63.9	8.4	4.2	6.2	0	0	0	0	100
Abundance (in '000)	13849	153973	562963	66010	29130	42634	0	0	0	0	868558
% Abundance	1.6	17.7	64.8	7.6	3.4	4.9	0	0	0	0	100
Medium Weight (gr)	36.8	55.9	60.1	67.7	76.1	77.1	0	0	0	0	62.3
Medium Length (cm)	16.6	19.2	19.7	20.6	21.4	21.5	0	0	0	0	19.8
TOTAL SPAIN	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	3432	15213	49533	9296	6837	8264	2824	809	175	7	96390
% Biomass	3.6	15.8	51.4	9.6	7.1	8.6	2.9	0.8	0.2	0	100
Abundance (in '000)	91792	263225	776293	124690	84796	100126	31994	7731	1673	60	1482381
% Abundance	6.2	17.8	52.4	8.4	5.7	6.8	2.2	0.5	0.1	0	100
Medium Weight (gr)	37.4	57.8	63.8	74.6	80.6	82.5	88.3	104.6	104.5	122.6	81.7
Medium Length (cm)	16.7	19.4	20.1	21.2	21.8	22	22.5	23.9	23.9	25.3	21.7

	Sp	Ee	Ss	Sc	Tt	Tp	Bb	Mp	Ca	Total
Abundance	1482	127	749	38	243	33	82	140	2327	**5221**
Biomass	96390	2861	198801	6957	31962	2147	14840	4920	147591	**506469**

Table 8.3.2.2.2: Sardine in VIIIc and IXa: Acoustic estimates of abundance (in millions of individuals) and biomass (in tons) for the different pelagic species assessed in PELACUS0407: Sp = Sardina pilchardus, Ee= Engraulis encrasicolus, Ss= Scomber scombrus, Sc= Scomber colias, Tt = Trachurus trachurus, Tp = Trachurus picturatus, Bb = Boops boops, Mp = Micromesistius poutassou, Ca = Capros aper.

Table 8.4.1.1: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in 2006.

Total								
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5								
8			9					9
8.5			32					32
9			40					40
9.5			40					40
10			91					91
10.5			134				93	228
11	2		317	745			47	1 111
11.5	15		404	1 127			253	1 800
12	170	54	601	1 925		4	880	3 634
12.5	385	333	448	3 241		6	2 052	6 465
13	295	662	590	4 326		18	4 319	10 211
13.5	226	271	526	3 757		14	7 699	12 493
14	83	887	1 018	4 681	2	34	7 874	14 579
14.5	57	545	1 194	7 360		40	7 017	16 213
15	76	746	1 609	13 442		146	5 521	21 540
15.5	94	187	1 584	19 075	252	128	5 049	26 370
16	63	144	4 635	28 688	938	506	9 185	44 160
16.5	72	47	5 589	30 422	2 023	1 762	12 311	52 227
17	46	58	6 653	57 626	4 845	6 549	17 641	93 418
17.5	38	92	8 080	83 291	11 224	9 040	13 641	125 406
18	159	770	14 137	117 237	21 459	12 855	11 703	178 320
18.5	775	3 583	19 108	79 855	36 404	12 555	7 532	159 812
19	1 161	7 914	21 510	52 524	46 346	13 344	7 370	150 169
19.5	1 901	14 831	19 209	30 904	47 073	10 808	7 417	132 143
20	4 012	15 221	17 474	21 903	42 986	12 732	6 298	120 626
20.5	8 643	15 325	14 193	11 576	37 762	7 037	3 398	97 934
21	11 685	12 088	12 115	7 339	28 061	4 772	1 682	77 743
21.5	14 919	10 063	7 448	3 404	15 291	1 570	694	53 388
22	13 992	6 753	6 208	1 262	6 055	707	264	35 240
22.5	12 290	4 584	2 730	629	1 712	89	58	22 092
23	8 982	1 976	1 671	342	484	50		13 504
23.5	4 605	962	639	137	248	3		6 593
24	2 503	296	220	62	61	4		3 146
24.5	950	81	50	8				1 090
25	167			1	34			202
25.5	23							23
26	33							33
26.5								
27	29							29
27.5								
28								
28.5								
29								
Total	88 454	98 473	170 304	586 891	303 261	94 773	139 996	1482 154
Mean L	21.9	20.5	19.3	18.	19.8	19.2	17.	18.9
sd	1.61	1.71	1.99	1.61	1.21	1.27	2.15	2.05
Catch	**7758**	**7619**	**10856**	**30152**	**19061**	**5797**	**5778**	**87021**

Table 8.4.1.1a: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the first quarter 2006.

				First Quarter				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5								
8								
8.5								
9								
9.5								
10			1					1
10.5			3				93	97
11			27	745			47	819
11.5			32	1 106			253	1 391
12			72	1 847			880	2 799
12.5			117	3 011		2	2052	5 183
13			254	4 092		7	4285	8 637
13.5			367	3 139		12	7285	10 804
14			546	3 658		6	7556	11 767
14.5	12		961	6 263		14	6381	7 250
15			1136	10 063		57	4348	11 257
15.5	35		1103	11 323	223	56	2155	12 740
16			1850	14 409	735	114	670	17 107
16.5			3491	11 002	1 458	68	977	16 019
17	23	9	4237	7 707	2 086	237	1756	14 299
17.5	19	49	4122	4 615	5 687	321	1310	14 813
18	88	47	3195	2 860	9 048	784	1989	16 023
18.5	566	79	3253	1 837	9 656	1406	1181	16 797
19	930	217	2880	1 603	9 838	2661	2634	18 130
19.5	1 208	437	2955	1 193	9 932	3078	2151	18 803
20	2 077	577	2344	1 258	12 600	5187	2240	24 043
20.5	2 911	480	2141	806	10 297	3467	644	20 103
21	3 862	653	1646	624	7 187	2745	651	16 717
21.5	5 254	621	1319	401	3 606	831	439	12 033
22	5 674	951	1011	151	1 452	418	264	9 658
22.5	5 035	980	717	68	444	35		7 279
23	3 060	626	593	187	172	29		4 667
23.5	1 514	255	408	116	65	3		2 361
24	834	90	118	20				1 063
24.5	232	23	35	8				299
25	96				34			130
25.5	8							8
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	33 439	6 096	40 935	94 112	84 520	21 540	52 242	303 096
Mean L	21.9	21.7	18.5	16.	19.6	20.1	15.7	18.2
sd	1.29	1.39	2.24	1.96	1.35	1.13	2.49	2.88
Catch	**2 734**	**457**	**1 991**	**3209**	**4454**	**1306**	**1 629**	**15 780**

Table 8.4.1.1b: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the second quarter 2006.

Second Quarter								
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5								
8								
8.5								
9								
9.5								
10			0					
10.5			0					
11								
11.5			3					3
12			9	57		4		69
12.5			11	76		4		91
13			38	171		2	34	245
13.5			46	342				389
14	3		83	678	2	1	147	913
14.5	18		73	854		4	295	1 244
15	31		101	3179		13	949	4 274
15.5	32		115	7409	29	12	1989	9 586
16	40		425	13372	204	179	3384	17 605
16.5	42		670	16857	414	777	1776	20 536
17	14	5	1 038	29096	2 097	2854	2273	37 377
17.5	14	18	2 331	30534	4 275	3289	2599	43 061
18	51	691	7 225	25314	7 953	4177	2780	48 192
18.5	173	3 012	11 774	10268	11 854	3167	2158	42 406
19	175	5 758	11 206	5081	13 380	3383	1334	40 317
19.5	199	8 498	7 459	2965	9 801	1908	1264	32 095
20	748	6 286	5 332	2796	8 524	1489	970	26 146
20.5	1 411	4 313	3 433	1535	9 627	541	821	21 681
21	2 440	2 432	2 399	1133	8 115	199	380	17 099
21.5	2 930	1 764	867	365	4 317	62	233	10 537
22	3 128	1 113	511	180	1 642	29		6 603
22.5	3 144	628	199	30	471			4 472
23	2 421	343	83	6	127			2 980
23.5	1 314	169	70	0	112			1 665
24	707	28	15		37	4		791
24.5	297	20						317
25	60			0				60
25.5	8							8
26	30							30
26.5								
27	8							8
27.5								
28								
28.5								
29								
Total	19 439	35 077	55 516	152 300	82 982	22 096	23 387	390 799
Mean L	22.1	20.2	19.3	17.6	19.7	18.6	17.7	18.8
sd	1.33	1.06	1.19	1.21	1.28	1.07	1.62	1.76
Catch	**1 768**	**2479**	**3 470**	**6494**	**5053**	**1223**	**1 024**	**21 511**

Table 8.4.1.1c: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the third quarter 2006.

Third Quarter

Length	VIIIc E	VIIIc W	IXa N	IXa CN	IXa CS	IXa S	IXa S (Ca)	Total
7								
7.5								
8			9					9
8.5			32					32
9			40					40
9.5			40					40
10			90					90
10.5			131					131
11			286					286
11.5	2		362	21				385
12	11	44	501	21				577
12.5	21	309	296	63				689
13	39	529	179			9		756
13.5	52	44.11	36	21			414	567
14	35	88	15			9	170	317
14.5	24	44	9	42		5	341	464
15	43	88	2	42			224	399
15.5	27	44	7	176		15	905	1 174
16	24	44	30	697		164	5130	6 088
16.5	16	2	57	1506	61	848	9454	11 943
17	8	33	280	12828	257	3337	13417	30 160
17.5	5	13	1 007	27664	801	4970	9133	43 593
18	5	32	2 736	42047	2 786	6762	6174	60 543
18.5	15	492	3 032	29303	10 274	6420	3247	52 783
19	3	1 823	5 671	21475	15 289	4646	2303	51 210
19.5	125	5 682	7 742	14847	17 580	3037	3085	52 100
20	768	7 686	7 828	8610	13 690	1963	2334	42 880
20.5	1 786	9 305	5 750	4422	11 410	694	1515	34 881
21	2 176	6 360	4 838	1669	8 475	370	420	24 310
21.5	3 377	3 613	2 860	598	5 049	123		15 620
22	2 357	2 273	2 408	95	1 746	47		8 928
22.5	2 653	1 384	721	109	524	9		5 400
23	2 139	636	442	21	124	9		3 370
23.5	1 314	400	66		57			1 837
24	371	153	11		24			559
24.5	166	18						184
25	8	0						8
25.5	3							3
26	3							3
26.5								
27	22							22
27.5								
28								
28.5								
29								
Total	17 600	41 141	47 512	166 277	88 147	33 439	58 265	452 380
Mean L	22.	20.6	19.8	18.6	20.	18.6	17.7	19.2
sd	1.47	1.59	2.07	0.98	1.02	1.01	1.29	1.64
Catch	**1 735**	**3350**	**3 497**	**10142**	**6182**	**2054**	**2 761**	**29 721**

Table 8.4.1.1d: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the fourth quarter 2006.

				Fourth Quarter				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5								
11	2		4					6
11.5	13		8					21
12	159	10	19					189
12.5	363	25	23	91				502
13	256	133	119	64		1		573
13.5	173	227	77	255		2		734
14	46	798	374	346		17		1 581
14.5	4	500	151	201		18		874
15	2	657	370	158		77		1 263
15.5		143	358	168		45		714
16		100	2 331	210		49		2 689
16.5	14	45	1 371	1057	91	69	104	2 751
17		10	1 099	7995	406	121	196	9 827
17.5		12	620	20478	461	460	599	22 629
18	14		980	47016	1 672	1132	760	51 574
18.5	20		1 050	38448	4 620	1562	946	46 645
19	53	115	1 752	24365	7 838	2655	1099	37 877
19.5	370	213	1 053	11899	9 760	2785	916	26 994
20	419	672	1 970	9239	8 171	4093	754	25 318
20.5	2 535	1 227	2 870	4813	6 428	2334	417	20 625
21	3 206	2 643	3 232	3913	4 284	1459	231	18 967
21.5	3 358	4 065	2 402	2039	2 319	553	23	14 759
22	2 832	2 415	2 278	836	1 214	212		9 788
22.5	1 459	1 592	1 092	421	273	45	58	4 941
23	1 362	372	553	128	62	12		2 488
23.5	462	138	95	21	14			730
24	591	26	75	42				733
24.5	255	20	15					290
25	3	0		1				4
25.5	4							4
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	17 975	16 159	26 341	174 202	47 611	17 698	6 102	306 088
Mean L	21.4	20.6	19.7	18.8	20.	19.8	19.2	19.4
sd	2.3	2.72	2.37	1.08	1.03	1.13	1.11	1.65
Catch	**1 521**	**1333**	**1 898**	**10307**	**3372**	**1214**	**364**	**20 009**

Table 8.4.1.2: Sardine in VIIIc and IXa: Catch in numbers (thousands) at age by quarter and by subdivision in 2006

							First	Quarter
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								0
1	713	1	8619	39642	1068	555	29879	80477
2	5781	2000	21690	49160	32968	2034	10236	123868
3	6597	414	1894	1097	8144	5388	6542	30078
4	5658	661	2437	1458	15217	2823	2488	30743
5	7612	1534	4506	1065	14472	7655	1331	38176
6	3826	1096	1788	1529	10057	2386	1263	21944
7	2263	260		123	1714	401	503	5265
8	645	130		37	329	146		1287
9	344				207	152		704
10					345			345
Total	33439	6096	40935	94112	84520	21540	52242	332886
Catch (Tons)	2734	457	1991	3209	4454	1306	1629	15780

							Second	Quarter
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								0
1	334		1589	23561	1331	2391	2263	31469
2	2411	24675	38853	116530	34367	9295	9558	235689
3	3794	2453	5153	3624	9809	6445	7018	38297
4	3302	2781	4125	3250	11823	1580	2153	29013
5	4789	2989	4644	2374	12267	1642	1291	29996
6	2330	1839	1152	2725	10974	485	972	20478
7	1643	263		221	1043	259	132	3561
8	517	77		15	910			1519
9	320				458			777
10								0
Total	19439	35077	55516	152300	82982	22096	23387	390799
Catch (Tons)	1768	2479	3470	6494	5053	1223	1024	21511

							Third	Quarter
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	279	1191	2422	1000		315	3598	8804
1	513	4808	13472	26712	5998	9821	35361	96686
2	3327	21200	19632	130479	38142	13296	13376	239453
3	3158	3081	6108	2888	12479	3567	3399	34680
4	2224	4498	3576	1900	10697	3295	1281	27470
5	3594	4843	1503	3018	15533	2040	518	31049
6	2022	1160	792	170	3797	503	366	8811
7	1069	360	4	109	1051	509	366	3468
8	1022		4		175	51		1252
9	381				274			655
10	11					42		53
Total	17600	41141	47512	166277	88147	33439	58265	452380
Catch (Tons)	1735	3350	3497	10142	6182	2054	2761	29721

							Fourth	Quarter
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	1018	2493	2949	2747		277	14	9498
1	729	593	7625	25587	2789	1756	2072	41151
2	3882	4882	7872	132722	18925	5560	2300	176142
3	3798	1493	3408	3632	8857	3555	838	25581
4	2296	2442	2140	2984	7102	3587	419	20969
5	2965	3205	1525	3918	7398	2567	181	21759
6	1674	729	762	2271	1577	275	139	7427
7	659	322	30	341	416	70	139	1976
8	666		30		495	51		1242
9	257				53			311
10	32							32
Total	17975	16159	26341	174202	47611	17698	6102	306088
Catch (Tons)	1521	1333	1898	10307	3372	1214	364	20009

							Whole	Year
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	1296	3684	5371	3747		592	3613	18303
1	2289	5402	31305	115502	11187	14523	69575	249783
2	15400	52757	88048	428891	124401	30184	35470	775152
3	17348	7441	16563	11242	39289	18955	17797	128636
4	13480	10382	12278	9592	44838	11285	6341	108196
5	18960	12571	12179	10375	49671	13904	3320	120980
6	9852	4824	4494	6696	26405	3649	2740	58660
7	5634	1205	34	794	4225	1239	1140	14271
8	2851	207	34	52	1908	248		5300
9	1302				993	152		2447
10	43				345	42		429
Total	88454	98473	170304	586891	303261	94773	139996	1482154
Catch (Tons)	7758	7619	10856	30152	19061	5797	5778	87021

Table 8.4.1.3: Sardine in VIIIc and IXa: Relative distribution of sardine catches. Upper pannel, relative contribution of each group within each subdivision. Lower pannel, relative contribution of each subdivision within each Age Group.

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	Xa-S (Ca)	Total
0	1%	4%	3%	1%	0%	1%	3%	1%
1	3%	5%	18%	20%	4%	15%	50%	17%
2	17%	54%	52%	73%	41%	32%	25%	52%
3	20%	8%	10%	2%	13%	20%	13%	9%
4	15%	11%	7%	2%	15%	12%	5%	7%
5	21%	13%	7%	2%	16%	15%	2%	8%
6+	22%	6%	3%	1%	11%	6%	3%	5%
	100%	100%	100%	100%	100%	100%	100%	100%

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	Xa-S (Ca)	Total
0	7%	20%	29%	20%	0%	3%	20%	100%
1	1%	2%	13%	46%	4%	6%	28%	100%
2	2%	7%	11%	55%	16%	4%	5%	100%
3	13%	6%	13%	9%	31%	15%	14%	100%
4	12%	10%	11%	9%	41%	10%	6%	100%
5	16%	10%	10%	9%	41%	11%	3%	100%
6+	24%	8%	6%	9%	42%	7%	5%	100%

Table 8.4.2.1: Sardine VIIIc and IXa: Sardine Mean length (cm) at age by quarter and by subdivision in 2006.

							First Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	19.0	14.8	15.8	14.4	16.3	16.8	14.0	14.5
2	20.3	20.3	18.2	16.9	18.4	19.0	16.2	17.7
3	21.5	21.4	19.8	19.5	19.6	19.5	18.9	19.9
4	22.0	21.9	20.8	19.9	20.2	20.2	19.8	20.6
5	22.5	22.4	21.7	21.0	20.6	20.6	19.4	21.1
6	22.7	22.6	22.4	21.0	20.9	20.9	20.0	21.4
7	23.1	22.9		22.8	21.5	20.7	21.9	22.3
8	23.7	23.3		23.8	21.9	21.7		23.0
9	24.0				22.3	21.6		23.0
10					23.4			23.4

							Second Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	17.5		16.4	15.8	17.5	17.5	15.7	16.1
2	20.7	19.8	18.9	17.7	18.6	18.1	17.1	18.3
3	21.6	20.4	19.7	18.8	19.7	18.8	18.3	19.4
4	22.1	20.5	20.4	19.7	20.4	19.5	19.1	20.4
5	22.6	21.4	21.1	20.2	20.8	19.9	18.5	21.0
6	22.9	21.5	21.5	20.6	21.0	20.4	19.6	21.2
7	23.3	22.5		21.0	21.3	21.0	21.5	22.2
8	23.9	23.2		22.4	21.3			22.3
9	24.2				21.9			22.8
10								

							Third Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	14.3	13.5	12.8	15.7		17.0	15.7	14.6
1	20.3	19.8	19.3	18.1	19.1	17.8	17.4	18.1
2	21.1	20.6	20.2	18.6	19.4	18.6	18.4	19.1
3	21.8	21.2	20.9	20.3	20.3	19.1	19.2	20.4
4	22.0	21.4	21.1	20.6	20.6	19.5	19.6	20.7
5	22.5	21.7	22.1	20.8	20.9	19.8	20.6	21.2
6	22.7	22.1	22.1	20.8	21.2	20.4	20.6	21.6
7	23.3	23.0	24.3	21.6	21.5	20.1	20.6	21.9
8	23.5		24.3		22.5	21.5		23.3
9	24.0				21.8			23.1
10	26.8					22.3		23.2

							Fourth Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	13.0	14.6	15.7	15.7		15.8	16.9	15.1
1	20.4	19.4	18.1	18.4	18.6	18.2	18.5	18.4
2	21.1	21.3	20.6	18.7	19.4	19.5	19.3	19.0
3	21.6	21.9	21.4	20.3	20.0	19.9	19.7	20.6
4	21.8	21.9	21.6	21.0	20.8	20.5	19.9	21.1
5	22.4	22.0	22.3	21.0	20.7	20.7	20.8	21.3
6	22.5	22.4	22.3	21.3	21.6	21.1	20.9	21.8
7	23.4	22.8	24.3	22.5	21.7	21.7	20.9	22.6
8	23.6		24.3		21.2	21.7		22.6
9	24.2				23.0			24.0
10	24.8							24.8

							Whole Year	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	13.3	14.2	14.4	15.7		16.4	15.8	14.9
1	19.5	19.8	17.9	16.4	18.5	17.8	15.9	16.7
2	20.7	20.3	19.2	18.2	18.9	18.6	17.5	18.6
3	21.6	21.1	20.5	19.7	19.9	19.3	18.8	20.0
4	22.0	21.3	20.9	20.3	20.4	20.0	19.5	20.7
5	22.5	21.8	21.6	20.7	20.8	20.4	19.3	21.1
6	22.7	22.0	22.1	20.9	21.0	20.8	20.0	21.4
7	23.2	22.8	24.3	22.0	21.5	20.6	21.3	22.2
8	23.7	23.2	24.3	23.4	21.5	21.7		22.8
9	24.1				22.0	21.6		23.1
10	25.3				23.4	22.3		23.5

Table 8.4.2.2: Sardine VIIIc and IXa: Sardine Mean weight (kg) at age by quarter and by subdivision in 2006.

							First Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	0.054	0.025	0.030	0.023	0.032	0.037	0.023	0.024
2	0.065	0.062	0.045	0.036	0.044	0.052	0.033	0.042
3	0.077	0.072	0.057	0.056	0.052	0.056	0.048	0.058
4	0.083	0.077	0.066	0.060	0.057	0.062	0.054	0.063
5	0.088	0.082	0.075	0.069	0.060	0.065	0.051	0.069
6	0.092	0.084	0.082	0.069	0.063	0.068	0.055	0.071
7	0.096	0.087		0.089	0.067	0.066	0.069	0.081
8	0.102	0.091		0.101	0.071	0.076		0.090
9	0.105				0.074	0.075		0.089
10					0.085			0.085

							Second Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	0.044		0.041	0.031	0.043	0.048	0.048	0.034
2	0.074	0.067	0.059	0.043	0.051	0.052	0.052	0.050
3	0.084	0.072	0.066	0.052	0.061	0.057	0.057	0.061
4	0.090	0.074	0.073	0.060	0.067	0.063	0.063	0.069
5	0.096	0.083	0.079	0.064	0.071	0.066	0.066	0.076
6	0.100	0.084	0.084	0.068	0.073	0.070	0.070	0.076
7	0.104	0.095		0.072	0.076	0.075	0.075	0.090
8	0.113	0.104		0.088	0.077			0.091
9	0.116				0.083			0.097
10								

							Third Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	0.022	0.023	0.022	0.035		0.048	0.034	0.030
1	0.077	0.072	0.067	0.056	0.062	0.055	0.044	0.054
2	0.086	0.080	0.076	0.061	0.065	0.061	0.052	0.064
3	0.095	0.088	0.084	0.081	0.072	0.065	0.059	0.077
4	0.097	0.090	0.086	0.086	0.075	0.069	0.062	0.080
5	0.105	0.093	0.099	0.088	0.079	0.073	0.071	0.085
6	0.107	0.099	0.098	0.086	0.081	0.078	0.070	0.091
7	0.115	0.111	0.130	0.100	0.085	0.075	0.070	0.094
8	0.119		0.130		0.095	0.089		0.114
9	0.126				0.088			0.110
10	0.174					0.098		0.113

							Fourth Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	0.016	0.029	0.036	0.033		0.040	0.042	0.031
1	0.069	0.069	0.055	0.055	0.059	0.056	0.053	0.056
2	0.077	0.088	0.080	0.058	0.066	0.066	0.060	0.062
3	0.085	0.095	0.089	0.076	0.071	0.069	0.064	0.077
4	0.088	0.095	0.091	0.087	0.079	0.074	0.066	0.083
5	0.095	0.097	0.100	0.085	0.078	0.076	0.074	0.086
6	0.098	0.101	0.101	0.090	0.086	0.079	0.074	0.092
7	0.111	0.106	0.129	0.110	0.088	0.085	0.074	0.102
8	0.114		0.129		0.083	0.085		0.101
9	0.123				0.102			0.120
10	0.128							0.128

							Whole Year	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	0.018	0.027	0.030	0.034		0.044	0.034	0.031
1	0.062	0.071	0.052	0.039	0.056	0.053	0.035	0.042
2	0.074	0.074	0.061	0.053	0.056	0.059	0.044	0.056
3	0.083	0.083	0.076	0.068	0.065	0.061	0.051	0.068
4	0.088	0.086	0.079	0.073	0.068	0.068	0.056	0.073
5	0.094	0.091	0.083	0.080	0.071	0.068	0.054	0.078
6	0.098	0.090	0.089	0.076	0.071	0.070	0.059	0.079
7	0.104	0.101	0.129	0.095	0.076	0.073	0.070	0.089
8	0.113	0.096	0.129	0.097	0.079	0.080		0.098
9	0.118				0.083	0.075		0.101
10	0.139				0.085	0.098		0.092

Table 8.8.1.1.a Sardine in VIIIc and IXa: Mean weights-at-age (kg) in the catch.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1979	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1980	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1981	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1982	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1983	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1984	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1985	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1986	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1987	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1988	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1989	0.013	0.035	0.052	0.059	0.066	0.071	0.100
1990	0.024	0.032	0.047	0.057	0.061	0.067	0.100
1991	0.020	0.031	0.058	0.063	0.073	0.074	0.100
1992	0.018	0.045	0.055	0.066	0.070	0.079	0.100
1993	0.017	0.037	0.051	0.058	0.066	0.071	0.100
1994	0.020	0.036	0.058	0.062	0.070	0.076	0.100
1995	0.025	0.047	0.059	0.066	0.071	0.082	0.100
1996	0.019	0.038	0.051	0.058	0.061	0.071	0.100
1997	0.022	0.033	0.052	0.062	0.069	0.073	0.100
1998	0.024	0.040	0.055	0.061	0.064	0.067	0.100
1999	0.025	0.042	0.056	0.065	0.070	0.073	0.100
2000	0.025	0.037	0.056	0.066	0.071	0.074	0.100
2001	0.023	0.042	0.059	0.067	0.075	0.079	0.100
2002	0.028	0.045	0.057	0.069	0.075	0.079	0.100
2003	0.024	0.044	0.059	0.067	0.079	0.084	0.100
2004	0.020	0.040	0.056	0.066	0.072	0.082	0.100
2005	0.023	0.037	0.055	0.068	0.074	0.075	0.100
2006	0.031	0.042	0.056	0.068	0.073	0.078	0.100
2007	0.031	0.042	0.056	0.068	0.073	0.078	0.100

Table 8.8.1.1.b Sardine in VIIIc and IXa: Mean weights-at-age (kg) in the stock.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1979	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1980	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1981	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1982	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1983	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1984	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1985	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1986	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1987	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1988	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1989	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1990	0.000	0.015	0.038	0.050	0.064	0.067	0.100
1991	0.000	0.019	0.042	0.050	0.064	0.071	0.100
1992	0.000	0.027	0.036	0.050	0.062	0.069	0.100
1993	0.000	0.022	0.045	0.057	0.064	0.073	0.100
1994	0.000	0.031	0.040	0.049	0.060	0.067	0.100
1995	0.000	0.029	0.050	0.062	0.072	0.079	0.100
1996	0.000	0.021	0.042	0.050	0.057	0.065	0.077
1997	0.000	0.024	0.032	0.052	0.059	0.064	0.072
1998	0.000	0.029	0.037	0.048	0.054	0.059	0.066
1999	0.000	0.024	0.040	0.052	0.059	0.067	0.073
2000	0.000	0.017	0.043	0.056	0.061	0.067	0.067
2001	0.000	0.021	0.041	0.060	0.071	0.072	0.074
2002	0.000	0.024	0.040	0.055	0.068	0.074	0.074
2003	0.000	0.019	0.043	0.053	0.065	0.070	0.076
2004	0.000	0.020	0.045	0.061	0.069	0.076	0.100
2005	0.000	0.019	0.045	0.059	0.068	0.073	0.079
2006	0.000	0.030	0.042	0.060	0.068	0.068	0.075
2007	0.000	0.030	0.042	0.060	0.068	0.068	0.075

Table 8.8.1.1.c. Sardine in VIIIc and IXa: Annual maturity ogives 1978 – 2007.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1979	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1980	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1981	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1982	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1983	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1984	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1985	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1986	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1987	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1988	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1989	0.00	0.23	0.83	0.91	0.92	0.94	0.98
1990	0.00	0.60	0.81	0.88	0.89	0.94	0.99
1991	0.00	0.74	0.91	0.96	0.97	1.00	1.00
1992	0.00	0.79	0.91	0.95	0.98	1.00	1.00
1993	0.00	0.47	0.93	0.94	0.97	0.99	1.00
1994	0.00	0.80	0.89	0.96	0.96	0.97	1.00
1995	0.00	0.73	0.98	0.97	0.99	1.00	1.00
1996	0.00	0.54	0.93	0.99	0.99	1.00	1.00
1997	0.00	0.64	0.94	1.00	1.00	1.00	0.99
1998	0.00	0.69	0.85	0.96	0.98	0.99	0.99
1999	0.00	0.84	0.99	1.00	1.00	1.00	1.00
2000	0.00	0.47	0.92	0.96	0.97	0.98	0.98
2001	0.00	0.43	0.82	0.94	0.97	0.97	0.98
2002	0.00	0.59	0.93	0.98	0.99	1.00	1.00
2003	0.00	0.50	0.94	0.97	0.99	0.99	0.99
2004	0.00	0.49	0.94	0.97	0.98	0.99	1.00
2005	0.00	0.19	0.85	0.97	0.99	0.99	1.00
2006	0.00	0.89	0.99	1.00	1.00	1.00	1.00
2007	0.00	0.89	0.99	1.00	1.00	1.00	1.00

Table 8.8.1.1.d

Run id 20070920 113032.980
Stocknumbers at age,
in area 1
Data by 1. Jan., except at youngest age which are
at recruitment time

	1978	1979	1980	1981	1982	1983	1984	1985
0	11788.0	13851.7	15053.8	9556.7	6974.8	20179.5	8584.3	6561.3
1	7636.8	9360.2	11049.0	12194.6	7580.8	5628.9	16364.8	7031.1
2	3731.2	4194.5	5189.3	6532.8	6952.1	4469.2	3435.5	9893.6
3	1258.8	1811.0	2061.9	2766.0	3255.9	3537.9	2400.5	1921.4
4	638.2	630.0	910.2	1151.8	1453.3	1750.5	1955.6	1345.4
5	193.9	334.6	322.9	516.0	628.1	798.0	993.9	1135.8
6	84.8	148.3	252.1	332.9	468.4	605.5	795.9	1039.4

	1986	1987	1988	1989	1990	1991	1992	1993
0	5471.5	9181.8	5906.2	5877.0	5562.4	12867.3	10748.9	4796.7
1	5384.3	4447.3	7277.1	4658.9	4655.6	4405.2	10237.0	8642.8
2	4365.2	3237.3	2690.5	4387.4	2796.7	2751.5	2758.8	6517.5
3	5563.7	2317.5	1731.6	1439.3	2320.3	1449.4	1577.2	1620.9
4	1081.0	3013.8	1245.2	915.2	739.4	1130.5	774.7	869.0
5	782.8	581.7	1643.3	668.2	480.6	357.1	609.3	426.4
6	1284.4	1169.6	1002.7	1462.4	1188.4	890.6	728.7	785.1

	1994	1995	1996	1997	1998	1999	2000	2001
0	4681.5	3965.5	5040.3	3906.4	4009.3	3899.2	11034.7	7334.4
1	3871.1	3859.3	3283.3	4152.9	3185.7	3203.6	3133.1	8903.7
2	5484.0	2607.4	2599.9	2225.2	2722.2	2042.1	2046.3	1998.2
3	3748.8	3454.2	1638.5	1627.4	1317.9	1556.9	1193.0	1204.2
4	841.7	2141.2	1932.7	891.4	823.7	633.6	793.8	620.2
5	454.3	478.5	1199.7	1046.0	430.5	376.8	305.9	391.7
6	696.7	707.3	722.9	1117.7	1216.3	960.6	798.0	665.7

	2002	2003	2004	2005	2006	2007
0	3962.4	3149.3	15321.7	4775.6	940.0	9000.0
1	5993.3	3259.0	2570.7	12493.9	3916.7	773.5
2	5738.1	3900.5	2108.1	1663.3	8199.7	2594.5
3	1224.1	3574.0	2423.0	1299.7	1034.6	5176.3
4	674.9	713.5	2084.9	1403.4	774.7	628.6
5	332.2	379.3	402.3	1166.3	822.0	463.3
6	648.4	619.0	623.9	634.8	1104.8	1231.5

Table 8.8.1.1.e

Total yearly fishing mortalities at age

	1978	1979	1980	1981	1982	1983	1984	1985
0	0.0656	0.0611	0.0456	0.0666	0.0494	0.0445	0.0346	0.0327
1	0.2692	0.2599	0.1955	0.2320	0.1984	0.1638	0.1732	0.1467
2	0.3928	0.3802	0.2992	0.3664	0.3455	0.2915	0.2511	0.2456
3	0.3623	0.3580	0.2523	0.3136	0.2906	0.2628	0.2490	0.2452
4	0.3158	0.3382	0.2375	0.2764	0.2695	0.2360	0.2133	0.2115
5	0.3158	0.3382	0.2375	0.2764	0.2695	0.2360	0.2133	0.2115
6	0.2672	0.2807	0.1900	0.2468	0.2562	0.2390	0.2135	0.1811
Fref	0.3467	0.3536	0.2566	0.3082	0.2938	0.2566	0.2317	0.2285

	1986	1987	1988	1989	1990	1991	1992	1993
0	0.0423	0.0675	0.0722	0.0680	0.0682	0.0637	0.0531	0.0494
1	0.1787	0.1726	0.1760	0.1803	0.1959	0.1380	0.1215	0.1249
2	0.3032	0.2957	0.2956	0.3070	0.3273	0.2265	0.2018	0.2231
3	0.2831	0.2912	0.3077	0.3361	0.3890	0.2965	0.2660	0.3253
4	0.2898	0.2765	0.2925	0.3142	0.3979	0.2882	0.2670	0.3185
5	0.2898	0.2765	0.2925	0.3142	0.3979	0.2882	0.2670	0.3185
6	0.2102	0.2042	0.2164	0.2274	0.2603	0.1773	0.1527	0.1750
Fref	0.2915	0.2850	0.2970	0.3179	0.3780	0.2748	0.2504	0.2963

Table 8.8.1.1.e. cont.

	1994	1995	1996	1997	1998	1999	2000	2001
0	0.0281	0.0238	0.0287	0.0389	0.0593	0.0537	0.0496	0.0369
1	0.0652	0.0650	0.0590	0.0923	0.1147	0.1182	0.1198	0.1093
2	0.1322	0.1346	0.1385	0.1938	0.2288	0.2075	0.2002	0.1600
3	0.2301	0.2507	0.2787	0.3509	0.4023	0.3436	0.3242	0.2490
4	0.2349	0.2493	0.2840	0.3980	0.4521	0.3982	0.3763	0.2943
5	0.2349	0.2493	0.2840	0.3980	0.4521	0.3982	0.3763	0.2943
6	0.1094	0.1116	0.1038	0.1221	0.1354	0.1142	0.1084	0.0873
Fref	0.2080	0.2209	0.2463	0.3351	0.3838	0.3369	0.3193	0.2494

	2002	2003	2004	2005	2006	2007
0	0.0304	0.0380	0.0390	0.0333	0.0299	0.0299
1	0.0995	0.1056	0.1054	0.0911	0.0819	0.0819
2	0.1435	0.1461	0.1537	0.1448	0.1300	0.1300
3	0.2098	0.2090	0.2161	0.1874	0.1683	0.1683
4	0.2462	0.2430	0.2508	0.2050	0.1841	0.1841
5	0.2462	0.2430	0.2508	0.2050	0.1841	0.1841
6	0.0753	0.0820	0.0904	0.0790	0.0709	0.0709
Fref	0.2114	0.2102	0.2179	0.1855	0.1666	0.1666

Table 8.8.1.1.f

YEARLY CATCH NUMBERS BY FLEET 1
IN AREA 1
****

Modelled catches by year, fleet 1 area 1

	1978	1979	1980	1981	1982	1983	1984	1985
0	690736.2	757407.8	619811.0	568415.5	310397.6	811539.7	269536.0	194928.8
1	1546455.6	1839869.3	1681833.9	2166924.7	1172004.8	730143.7	2230520.2	822937.2
2	1043549.8	1142434.7	1151344.5	1722011.9	1744455.3	969681.9	654183.8	1847548.6
3	329118.4	468957.9	394590.6	639726.5	705267.6	701469.3	453424.7	357998.6
4	148495.7	155295.0	164979.0	238896.0	294737.9	315561.5	322009.9	219821.0
5	45110.9	82481.1	58535.9	107022.9	127379.5	143851.1	163660.8	185577.9
6	17070.0	31159.6	37392.1	62468.6	90751.8	110230.1	131013.9	147585.7

	1986	1987	1988	1989	1990	1991	1992	1993
0	209129.0	552980.3	379791.6	356595.1	339052.2	732899.3	513099.2	213573.4
1	757232.4	605530.1	1009148.5	661118.3	713704.0	488511.2	1007123.8	874169.2
2	980863.0	711749.7	591702.2	997453.8	672880.3	479606.8	433137.2	1121133.3
3	1178391.9	502645.7	393788.5	352962.1	643660.1	319080.0	315948.8	386471.5
4	233346.9	624676.9	271036.1	211957.7	208711.4	242787.8	155574.2	203471.8
5	168980.6	120561.2	357699.5	154747.0	135655.8	76681.2	122358.3	99847.0
6	209152.6	185518.7	167578.0	255673.6	234461.3	124385.9	88690.5	108410.5

	1994	1995	1996	1997	1998	1999	2000	2001
0	119935.5	86165.0	131581.7	137848.7	213279.0	188413.5	492842.7	245571.4
1	210853.5	209627.3	162622.6	315735.5	297231.5	306872.3	303628.3	789838.4
2	584056.8	282274.0	289284.0	337439.7	479377.6	329148.6	319209.0	253595.3
3	659871.3	656194.8	341767.6	414391.1	376112.9	389548.4	284124.5	227865.3
4	150847.6	404710.2	409654.2	251608.9	257986.4	178957.1	213942.9	135591.5
5	81423.7	90433.1	254301.9	295226.0	134819.0	106416.7	82445.6	85643.3
6	62026.7	64158.8	61388.1	110932.8	132973.5	89487.6	70681.8	47918.6

	2002	2003	2004	2005	2006	2007
0	109670.3	108365.5	541282.3	144148.6	25524.2	244387.5
1	485857.8	279490.4	220146.6	931216.8	263325.6	52006.2
2	657270.9	454294.3	257306.3	191800.0	855029.4	270545.1
3	198608.9	577705.5	403686.6	190184.3	137166.4	686265.3
4	126143.8	131848.9	396365.0	222724.8	111478.1	90452.0
5	62091.1	70092.7	76483.4	185099.0	118278.9	66668.2
6	40418.9	41814.7	46214.6	41284.4	64774.3	72199.0

Observed catches by year, fleet 1 area 1

	1978	1979	1980	1981	1982	1983	1984	1985
0	869437.0	674489.0	856671.0	1025961.0	62000.0	1070000.0	118000.0	268000.0
1	2296646.0	1535557.0	2037400.0	1934838.0	795000.0	577000.0	3312000.0	564000.0
2	946698.0	956132.0	1561971.0	1733725.0	1869000.0	857000.0	487000.0	2371000.0
3	295360.0	431466.0	378785.0	679001.0	709000.0	803000.0	502000.0	469000.0
4	136661.0	189107.0	156922.0	195304.0	353000.0	324000.0	301000.0	294000.0
5	41744.0	93185.0	47302.0	104545.0	131000.0	141000.0	179000.0	201000.0
6	16468.0	36038.0	30006.0	76466.0	129000.0	139000.0	117000.0	103000.0

Observed catches by year, fleet 1 area 1

	1986	1987	1988	1989	1990	1991	1992	1993
0	304000.0	1437000.0	521000.0	248000.0	258000.0	1580579.0	498265.0	87808.0
1	755000.0	543000.0	990000.0	566000.0	602000.0	477368.0	1001856.0	566221.0
2	1027000.0	667000.0	535000.0	909000.0	517000.0	436081.0	451367.0	1081818.0
3	919000.0	569000.0	439000.0	389000.0	707000.0	406886.0	340313.0	521458.0
4	333000.0	535000.0	304000.0	221000.0	295000.0	265762.0	186234.0	257209.0
5	196000.0	154000.0	292000.0	200000.0	151000.0	74726.0	110932.0	113871.0
6	167000.0	171000.0	189000.0	245000.0	248000.0	105186.0	80579.0	120282.0

Observed catches by year, fleet 1 area 1

	1994	1995	1996	1997	1998	1999	2000	2001
0	120797.0	30512.0	277053.0	208570.0	449115.0	246016.0	489836.0	219973.0
1	60194.0	189147.0	101267.0	548594.0	366176.0	475225.0	354822.0	1172301.0
2	542163.0	280715.0	347690.0	453324.0	501585.0	361509.0	313972.0	256133.0
3	1094442.0	829707.0	514741.0	391118.0	352485.0	339691.0	255523.0	195897.0
4	272466.0	472880.0	652711.0	337282.0	233672.0	177170.0	194156.0	126389.0
5	112635.0	70208.0	197235.0	225170.0	178735.0	105518.0	97693.0	75145.0
6	72091.0	64485.0	46607.0	70268.0	105884.0	72541.0	64373.0	49547.0

Observed catches by year, fleet 1 area 1

	2002	2003	2004	2005	2006	2007
0	106882.0	198412.0	589910.0	169229.0	18347.0	0.0
1	587354.0	318695.0	180522.0	1005530.0	250200.0	0.0
2	753897.0	446285.0	263521.0	266213.0	777315.0	0.0
3	181381.0	518289.0	386715.0	206657.0	128695.0	0.0
4	112166.0	114035.0	377848.0	191013.0	108244.0	0.0
5	55650.0	61276.0	78396.0	116628.0	121043.0	0.0
6	40219.0	51172.0	55312.0	46087.0	81149.0	0.0

Table 8.8.1.1.f cont

Residuals: log (Obs/mod), fleet 1 area 1

	1978	1979	1980	1981	1982	1983	1984	1985
0	0.23	-0.12	0.32	0.59	-1.61	0.28	-0.83	0.32
1	0.40	-0.18	0.19	-0.11	-0.39	-0.24	0.40	-0.38
2	-0.10	-0.18	0.31	0.01	0.07	-0.12	-0.30	0.25
3	-0.11	-0.08	-0.04	0.06	0.01	0.14	0.10	0.27
4	-0.08	0.20	-0.05	-0.20	0.18	0.03	-0.07	0.29
5	-0.08	0.12	-0.21	-0.02	0.03	-0.02	0.09	0.08
6	-0.04	0.15	-0.22	0.20	0.35	0.23	-0.11	-0.36

Residuals: log (Obs/mod), fleet 1 area 1

	1986	1987	1988	1989	1990	1991	1992	1993
0	0.37	0.95	0.32	-0.36	-0.27	0.77	-0.03	-0.89
1	0.00	-0.11	-0.02	-0.16	-0.17	-0.02	-0.01	-0.43
2	0.05	-0.06	-0.10	-0.09	-0.26	-0.10	0.04	-0.04
3	-0.25	0.12	0.11	0.10	0.09	0.24	0.07	0.30
4	0.36	-0.15	0.11	0.04	0.35	0.09	0.18	0.23
5	0.15	0.24	-0.20	0.26	0.11	-0.03	-0.10	0.13
6	-0.23	-0.08	0.12	-0.04	0.06	-0.17	-0.10	0.10

Residuals: log (Obs/mod), fleet 1 area 1

	1994	1995	1996	1997	1998	1999	2000	2001
0	0.01	-1.04	0.74	0.41	0.74	0.27	-0.01	-0.11
1	-1.25	-0.10	-0.47	0.55	0.21	0.44	0.16	0.39
2	-0.07	-0.01	0.18	0.30	0.05	0.09	-0.02	0.01
3	0.51	0.23	0.41	-0.06	-0.06	-0.14	-0.11	-0.15
4	0.59	0.16	0.47	0.29	-0.10	-0.01	-0.10	-0.07
5	0.32	-0.25	-0.25	-0.27	0.28	-0.01	0.17	-0.13
6	0.15	0.01	-0.28	-0.46	-0.23	-0.21	-0.09	0.03

Residuals: log (Obs/mod), fleet 1 area 1

	2002	2003	2004	2005	2006	2007
0	-0.03	0.60	0.09	0.16	-0.33	0.00
1	0.19	0.13	-0.20	0.08	-0.05	0.00
2	0.14	-0.02	0.02	0.33	-0.10	0.00
3	-0.09	-0.11	-0.04	0.08	-0.06	0.00
4	-0.12	-0.15	-0.05	-0.15	-0.03	0.00
5	-0.11	-0.13	0.02	-0.46	0.02	0.00
6	0.00	0.20	0.18	0.11	0.23	0.00

Table 8.8.1.1.g

RESULTS FOR SURVEY FLEET 1
****

Modelled surveys indices by year, fleet 1

	1978	1979	1980	1981	1982	1983	1984	1985
0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
2	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
3	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
4	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
5	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
6	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

	1986	1987	1988	1989	1990	1991	1992	1993
0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
2	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
3	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
4	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
5	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
6	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

	1994	1995	1996	1997	1998	1999	2000	2001
0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
1	-1.0	-1.0	5136473.6	6469096.4	4948727.1	4976852.5	4867192.4	13855887.0
2	-1.0	-1.0	2799593.9	2379151.7	2897926.0	2180516.8	2187308.2	2147282.9
3	-1.0	-1.0	1532479.7	1507738.6	1213520.6	1443524.0	1108811.4	1129515.5
4	-1.0	-1.0	2231030.6	1015406.9	932165.5	721683.3	906419.9	715081.4
5	-1.0	-1.0	1384961.5	1191430.3	487132.7	429148.3	349300.1	451665.2
6	-1.0	-1.0	317828.3	489979.0	532159.4	421553.5	350521.5	293347.3

	2002	2003	2004	2005	2006	2007
0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
1	9339424.9	5075133.9	4002841.8	19489661.4	6117039.8	1208101.7
2	6180940.7	4200512.7	2268187.0	1792155.2	8851297.8	2800693.4
3	1153815.0	3369213.3	2282236.6	1228646.0	980354.8	4904871.1
4	782555.4	827627.6	2415999.7	1635043.5	904846.9	734181.7
5	385193.2	439978.2	466196.3	1358829.0	960047.5	541132.8
6	286227.1	273097.9	274976.8	280242.1	488240.5	544205.2

Observed surveys indices by year, fleet 1

	1978	1979	1980	1981	1982	1983	1984	1985
0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
2	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
3	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
4	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
5	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
6	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

	1986	1987	1988	1989	1990	1991	1992	1993
0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
2	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
3	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
4	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
5	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
6	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

	1994	1995	1996	1997	1998	1999	2000	2001
0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
1	-1.0	-1.0	1635624.0	6400640.0	2146029.0	5926268.0	6673110.0	19659943.0
2	-1.0	-1.0	2136446.0	3501235.0	4118108.0	2712998.0	2455735.0	1037373.0
3	-1.0	-1.0	2505075.0	1677442.0	2271278.0	1595295.0	1657118.0	701978.0
4	-1.0	-1.0	3256833.0	1383544.0	1467734.0	968748.0	998930.0	480259.0
5	-1.0	-1.0	600318.0	1425779.0	1205597.0	624070.0	720824.0	374475.0
6	-1.0	-1.0	36743.0	263797.0	1005403.0	533150.0	681348.0	249742.0

	2002	2003	2004	2005	2006	2007
0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
1	13040557.0	5884533.0	-1.0	22921588.0	7454560.0	1645060.0
2	6998075.0	4584129.0	-1.0	1302100.0	8309214.0	3084732.0
3	1164108.0	3567936.0	-1.0	685187.0	577248.0	4000502.0
4	1130977.0	1008979.0	-1.0	763181.0	443151.0	636829.0
5	565547.0	570302.0	-1.0	652746.0	577657.0	283416.0
6	442031.0	338076.0	-1.0	369282.0	606933.0	704458.0

Survey residuals by year, fleet 1

	1978	1979	1980	1981	1982	1983	1984	1985
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	1986	1987	1988	1989	1990	1991	1992	1993
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	1994	1995	1996	1997	1998	1999	2000	2001
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	-1.14	-0.01	-0.84	0.17	0.32	0.35
2	0.00	0.00	-0.27	0.39	0.35	0.22	0.12	-0.73
3	0.00	0.00	0.49	0.11	0.63	0.10	0.40	-0.48
4	0.00	0.00	0.38	0.31	0.45	0.29	0.10	-0.40
5	0.00	0.00	-0.84	0.18	0.91	0.37	0.72	-0.19
6	0.00	0.00	-2.16	-0.62	0.64	0.23	0.66	-0.16

	2002	2003	2004	2005	2006	2007
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.33	0.15	0.00	0.16	0.20	0.31
2	0.12	0.09	0.00	-0.32	-0.06	0.10
3	0.01	0.06	0.00	-0.58	-0.53	-0.20
4	0.37	0.20	0.00	-0.76	-0.71	-0.14
5	0.38	0.26	0.00	-0.73	-0.51	-0.65
6	0.43	0.21	0.00	0.28	0.22	0.26

Table 8.8.1.1.h

SPAWNING STOCK BIOMASS

Year	Modelled Total		Expected By fleet	Observed/q By fleet
1997	384936.94	1	384936.94	365576.48
1999	334460.34	1	334460.34	287040.50
2002	454020.81	1	454020.81	484020.70
2005	388156.08	1	388156.08	446673.42

Table 8.8.1.1.i

SUMMARY TABLE

Year	Recruits age 0	SSB	F 2 - 5	Catch SOP
1978	11787980	307769	0.3467	173761
1979	13851653	378205	0.3536	162454
1980	15053824	468340	0.2566	204861
1981	9556662	586651	0.3082	242574
1982	6974781	619999	0.2938	214148
1983	20179479	576217	0.2566	176636
1984	8584259	630783	0.2317	215114
1985	6561279	735950	0.2285	219928
1986	5471528	685496	0.2915	192838
1987	9181830	580716	0.2850	176283
1988	5906226	505908	0.2970	157273
1989	5877000	425137	0.3179	146539
1990	5562421	386978	0.3780	142966
1991	12867319	392924	0.2748	132785
1992	10748940	511724	0.2504	131196
1993	4796681	570743	0.2963	144949
1994	4681472	578714	0.2080	138725
1995	3965516	635839	0.2209	126755
1996	5040258	432792	0.2463	115179
1997	3906410	384936	0.3351	117250
1998	4009256	333170	0.3838	112033
1999	3899214	334460	0.3369	95793
2000	11034670	269194	0.3193	87272
2001	7334350	312978	0.2494	102903
2002	3962423	454020	0.2114	101741
2003	3149293	460804	0.2102	99113
2004	15321661	460834	0.2179	98464
2005	4775561	388156	0.1855	97282
2006	939973	657894	0.1666	88816
2007	9000000	569367	0.1666	0

Table 8.8.1.2. Sardine in VIIIc and IXa: Coefficient of variation of estimated parameters from the inverse Hessian

Run id 20070920 102937.120

Coeff. of variation and correlations from inverse Hessian

	Parameter	Param. value	CV
1	Initial number 1978 age1	7636777.5432	0.0600
2	Initial number 1978 age2	3731167.2621	0.0483
3	Initial number 1978 age3	1258842.5364	0.1386
4	Initial number 1978 age4	638238.3446	0.0828
5	Initial number 1978 age5	193887.8426	0.0734
6	Initial number 1978 age6	84839.1356	0.0773
7	Recruitment age0 1978	11787980.7482	0.0919
8	Recruitment age0 1979	13851653.9587	0.1040
9	Recruitment age0 1980	15053824.3367	0.0530
10	Recruitment age0 1981	9556662.0901	0.0367
11	Recruitment age0 1982	6975238.2982	0.0781
12	Recruitment age0 1983	20179479.5228	0.0828
13	Recruitment age0 1984	8584259.6135	0.0392
14	Recruitment age0 1985	6561279.1155	0.0889
15	Recruitment age0 1986	5471528.8108	0.0638
16	Recruitment age0 1987	9181830.0237	0.1043
17	Recruitment age0 1988	5906226.2289	0.0440
18	Recruitment age0 1989	5877000.7384	0.1083
19	Recruitment age0 1990	5562421.1812	0.0934
20	Recruitment age0 1991	12867319.5804	0.0409
21	Recruitment age0 1992	10748940.4887	0.0589
22	Recruitment age0 1993	4796681.9252	0.1010
23	Recruitment age0 1994	4681472.4717	0.0589
24	Recruitment age0 1995	3965516.4257	0.0376
25	Recruitment age0 1996	5040258.5362	0.1027
26	Recruitment age0 1997	3906410.8157	0.0427
27	Recruitment age0 1998	4009256.6533	0.1025
28	Recruitment age0 1999	3899214.9170	0.0430
29	Recruitment age0 2000	11034670.2909	0.0562
30	Recruitment age0 2001	7334350.0875	0.0563
31	Recruitment age0 2002	3962423.6450	0.0457
32	Recruitment age0 2003	3149293.9618	0.1410
33	Recruitment age0 2004	15321661.9027	0.0674
34	Recruitment age0 2005	4775561.7544	0.1442
35	Recruitment age0 2006	939973.1860	0.2388
36	F-select year 1978 age 0	0.5205	0.1998
37	F-select year 1978 age 1	1.0677	0.0731
38	F-select year 1978 age 2	1.5582	0.1703
39	F-select year 1978 age 3	1.4370	0.0951
40	F-select year 1978 age 4	1.2527	0.1467
41	F-select year 1978 age 6	1.0599	0.0618
42	F year 1978	0.3467	0.1045
43	F year 1979	0.3536	0.0389
44	F year 1980	0.2566	0.0565
45	F year 1981	0.3082	0.0939
46	F year 1982	0.2938	0.0547
47	F year 1983	0.2566	0.0322
48	F year 1984	0.2317	0.1024
49	F year 1985	0.2284	0.0628
50	F year 1986	0.2915	0.0994
51	F year 1987	0.2849	0.0373
52	F year 1988	0.2970	0.1036
53	F year 1989	0.3179	0.0296
54	F year 1990	0.3780	0.0484
55	F year 1991	0.2748	0.0429
56	F year 1992	0.2504	0.0686
57	F year 1993	0.2963	0.0824
58	F year 1994	0.2080	0.0565
59	F year 1995	0.2210	0.0655
60	F year 1996	0.2463	0.0498
61	F year 1997	0.3352	0.0417
62	F year 1998	0.3839	0.0302
63	F year 1999	0.3369	0.0633
64	F year 2000	0.3193	0.0357
65	F year 2001	0.2494	0.0368
66	F year 2002	0.2114	0.0562
67	F year 2003	0.2103	0.0442
68	F year 2004	0.2179	0.0949
69	F year 2005	0.1855	0.0438
70	F year 2006	0.1666	0.0512
71	Joint Spring Acoustic age 1	1.6441	0.2269
72	Joint Spring Acoustic age 2	1.1429	0.0800
73	Joint Spring Acoustic age 3	1.0079	0.2262
74	Joint Spring Acoustic age 4	1.2445	0.0687
75	Joint Spring Acoustic age 6	0.4646	0.1947
76	Q for ssb year 1988	0.9372	0.0475

Table 8.9.1.1. Sardine in VIIIc and IXa: Input data for short term catch predictions.

MFDP version 1a
Run: sar1
Time and date: 13:09 20-09-2007
Fbar age range: 2-5

2007

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	5286883	0.33	0	0.25	0.25	0.000	0.034	0.025
1	3020370	0.33	0.89	0.25	0.25	0.023	0.093	0.040
2	2594533	0.33	0.99	0.25	0.25	0.044	0.143	0.056
3	5176261	0.33	1	0.25	0.25	0.060	0.190	0.067
4	628584	0.33	1	0.25	0.25	0.068	0.213	0.073
5	463300	0.33	1	0.25	0.25	0.072	0.213	0.078
6	1231482	0.33	1	0.25	0.25	0.085	0.080	0.100

2008

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	5286883	0.33	0	0.25	0.25	0.000	0.034	0.025
1	.	0.33	0.89	0.25	0.25	0.023	0.093	0.040
2	.	0.33	0.99	0.25	0.25	0.044	0.143	0.056
3	.	0.33	1	0.25	0.25	0.060	0.190	0.067
4	.	0.33	1	0.25	0.25	0.068	0.213	0.073
5	.	0.33	1	0.25	0.25	0.072	0.213	0.078
6	.	0.33	1	0.25	0.25	0.085	0.080	0.100

2009

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	5286883	0.33	0	0.25	0.25	0.000	0.034	0.025
1	.	0.33	0.89	0.25	0.25	0.023	0.093	0.040
2	.	0.33	0.99	0.25	0.25	0.044	0.143	0.056
3	.	0.33	1	0.25	0.25	0.060	0.190	0.067
4	.	0.33	1	0.25	0.25	0.068	0.213	0.073
5	.	0.33	1	0.25	0.25	0.072	0.213	0.078
6	.	0.33	1	0.25	0.25	0.085	0.080	0.100

Input units are thousands and kg - output in tonnes

Table 8.9.1.2. Sardine in VIIIc and IXa: short term prediction with management option table: scenario 1.

MFDP version 1a
Run: sar1
Sardine (VIIIc+IXa), 2006 WG
Time and date: 13:09 20-09-2007
Fbar age range: 2-5

2007				
Biomass	SSB	FMult	FBar	Landings
674934	589594	1	0.19	102555

2008					2009	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
597193	540542	0	0	0	616758	557993
.	538346	0.1	0.019	9896	608307	548034
.	536160	0.2	0.038	19635	599998	538284
.	533984	0.3	0.057	29221	591827	528738
.	531818	0.4	0.076	38655	583794	519392
.	529661	0.5	0.095	47941	575894	510240
.	527515	0.6	0.114	57081	568126	501279
.	525378	0.7	0.133	66078	560487	492504
.	523250	0.8	0.152	74935	552975	483911
.	521132	0.9	0.171	83654	545587	475496
.	519024	1	0.19	92237	538322	467254
.	516925	1.1	0.209	100687	531176	459182
.	514835	1.2	0.228	109006	524148	451276
.	512755	1.3	0.247	117197	517235	443533
.	510685	1.4	0.266	125261	510436	435948
.	508623	1.5	0.285	133202	503749	428517
.	506571	1.6	0.304	141021	497170	421239
.	504528	1.7	0.323	148720	490699	414108
.	502494	1.8	0.342	156302	484334	407122
.	500470	1.9	0.361	163769	478071	400277
.	498454	2	0.38	171122	471911	393571

Input units are thousands and kg - output in tonnes

Table 8.9.1.3. Sardine in VIIIc and IXa: short term prediction with management option table: scenario 2.

MFDP version 1a
Run: sar2
Sardine (VIIIc+IXa), 2006 WG
Time and date: 13:17 20-09-2007
Fbar age range: 2-5

2007				
Biomass	SSB	FMult	FBar	Landings
620551	546046	1	0.19	95467

2008					2009	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
529018	478393	0	0	0	549922	496450
.	476419	0.1	0.019	8852	542420	487653
.	474454	0.2	0.038	17562	535046	479042
.	472498	0.3	0.057	26132	527798	470615
.	470551	0.4	0.076	34564	520674	462366
.	468614	0.5	0.095	42862	513670	454291
.	466685	0.6	0.114	51026	506786	446386
.	464765	0.7	0.133	59061	500018	438647
.	462853	0.8	0.152	66969	493364	431071
.	460951	0.9	0.171	74751	486823	423653
.	459058	1	0.19	82409	480392	416390
.	457173	1.1	0.209	89948	474068	409279
.	455296	1.2	0.228	97367	467851	402315
.	453429	1.3	0.247	104670	461738	395495
.	451570	1.4	0.266	111859	455727	388817
.	449719	1.5	0.285	118936	449816	382277
.	447877	1.6	0.304	125902	444003	375871
.	446044	1.7	0.323	132760	438287	369596
.	444219	1.8	0.342	139512	432666	363451
.	442402	1.9	0.361	146160	427137	357431
.	440594	2	0.38	152705	421700	351533

Input units are thousands and kg - output in tonnes

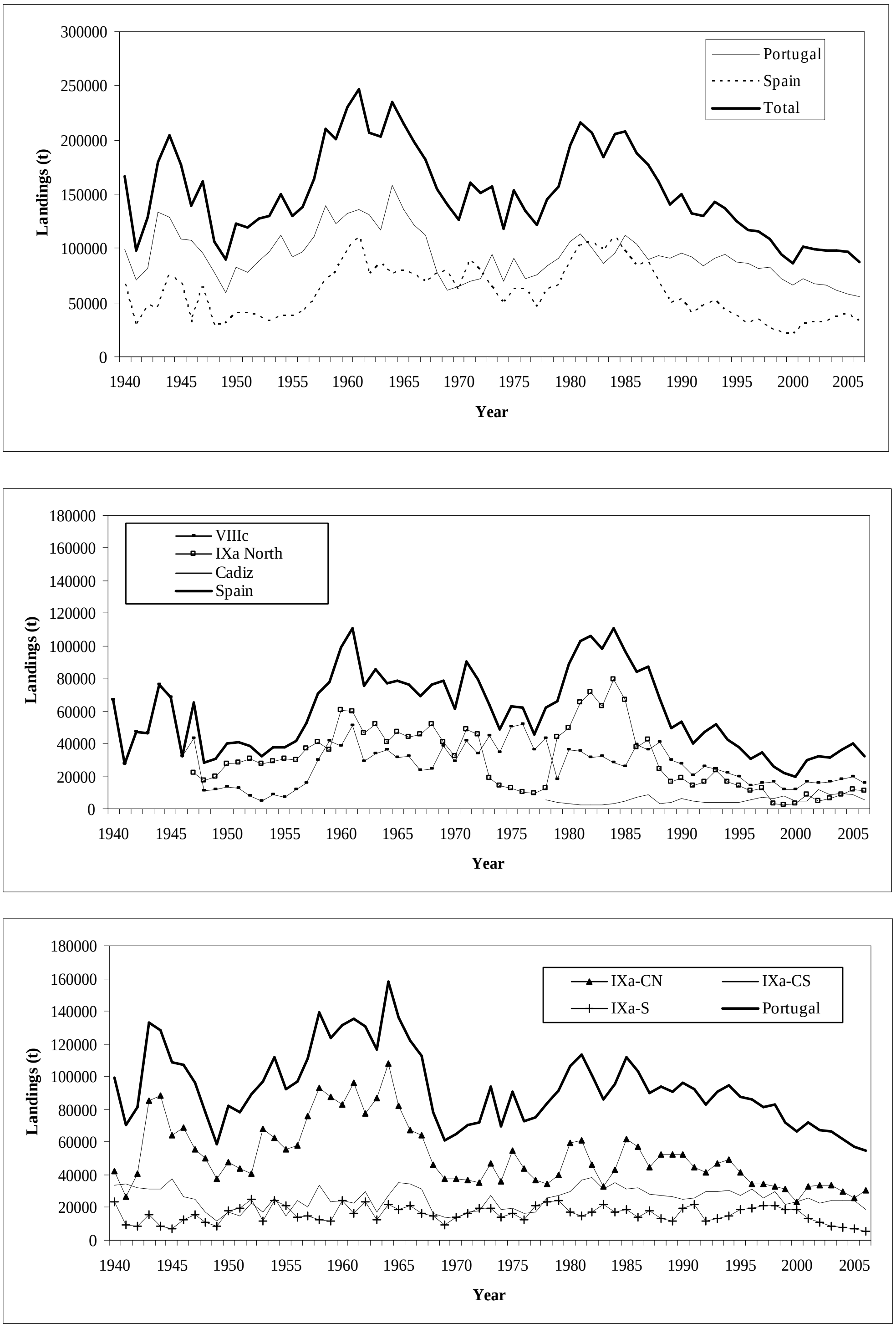


Figure 8.2.1: Sardine in VIIIc and IXa: Annual landings of sardine, by country (upper pannel) and by ICES subdivision and country

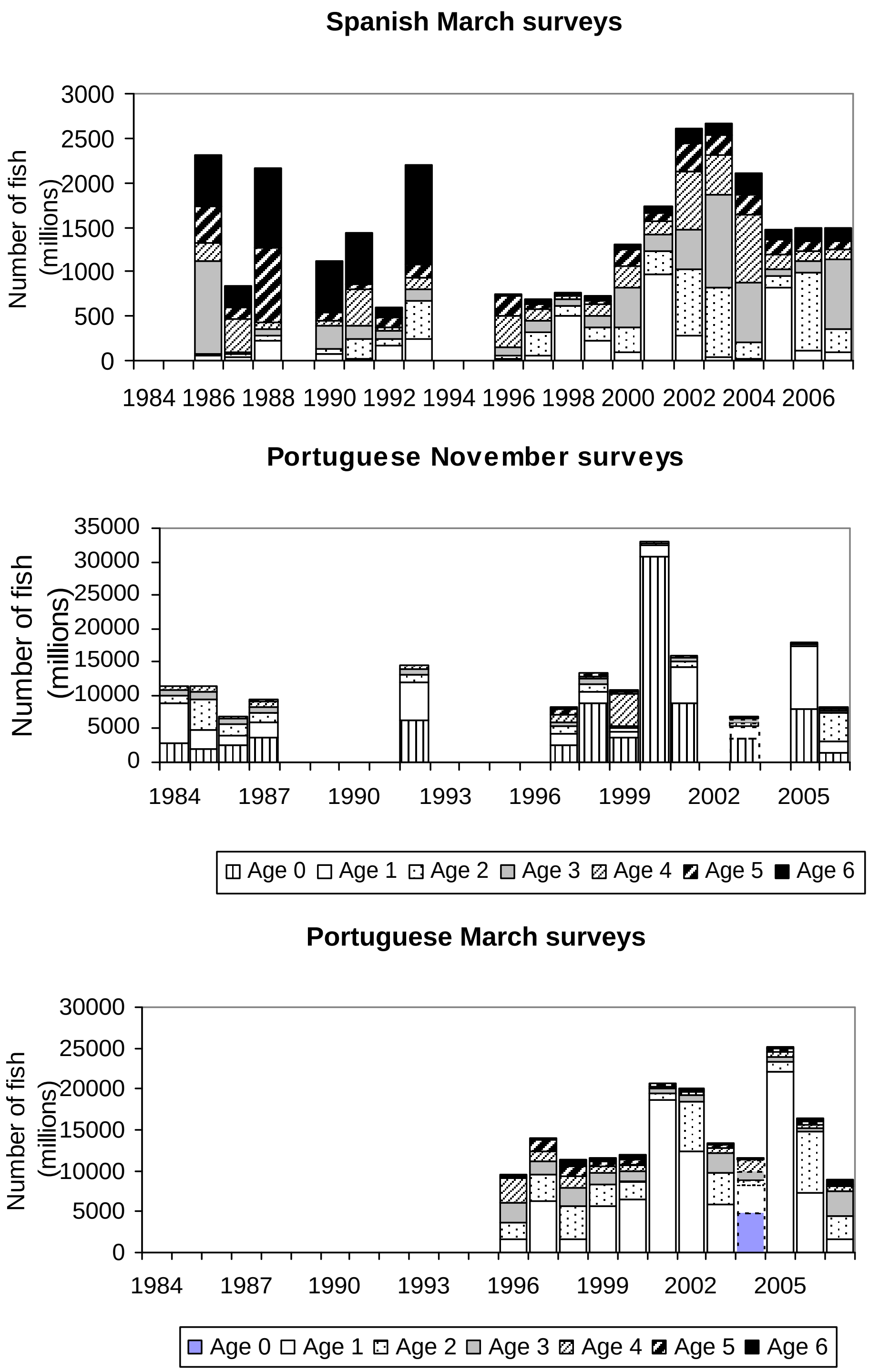


Figure 8.3.1: Sardine in VIIIc and IXa: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish March survey series covers area VIIIc and IXa-N (Galicia), the Portuguese March surveys covers the Portuguese area and the Gulf of Cadiz (Subdivisions IXa-CN, IXa-CS, IXa-S-Algarve and IXa-S-Cadiz) and the Portuguese November survey covers only the Portuguese waters. Estimates from Portuguese acoustic surveys in November 2003 and June 2004 are considered as indications of the population abundance and are not included in assessment.

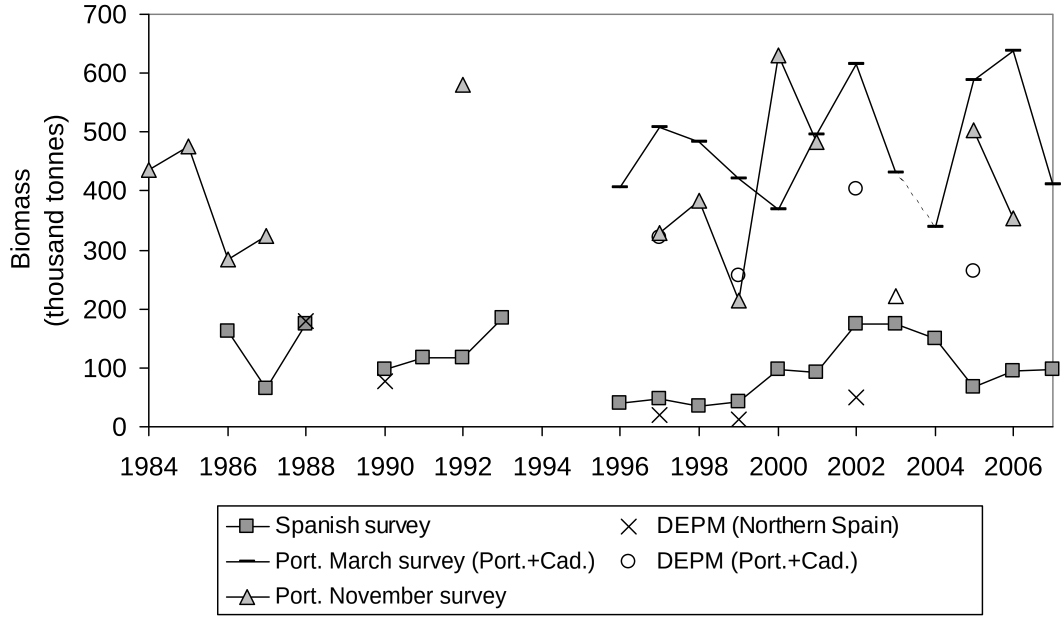


Figure 8.3.2: Sardine in VIIIc and IXa: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.

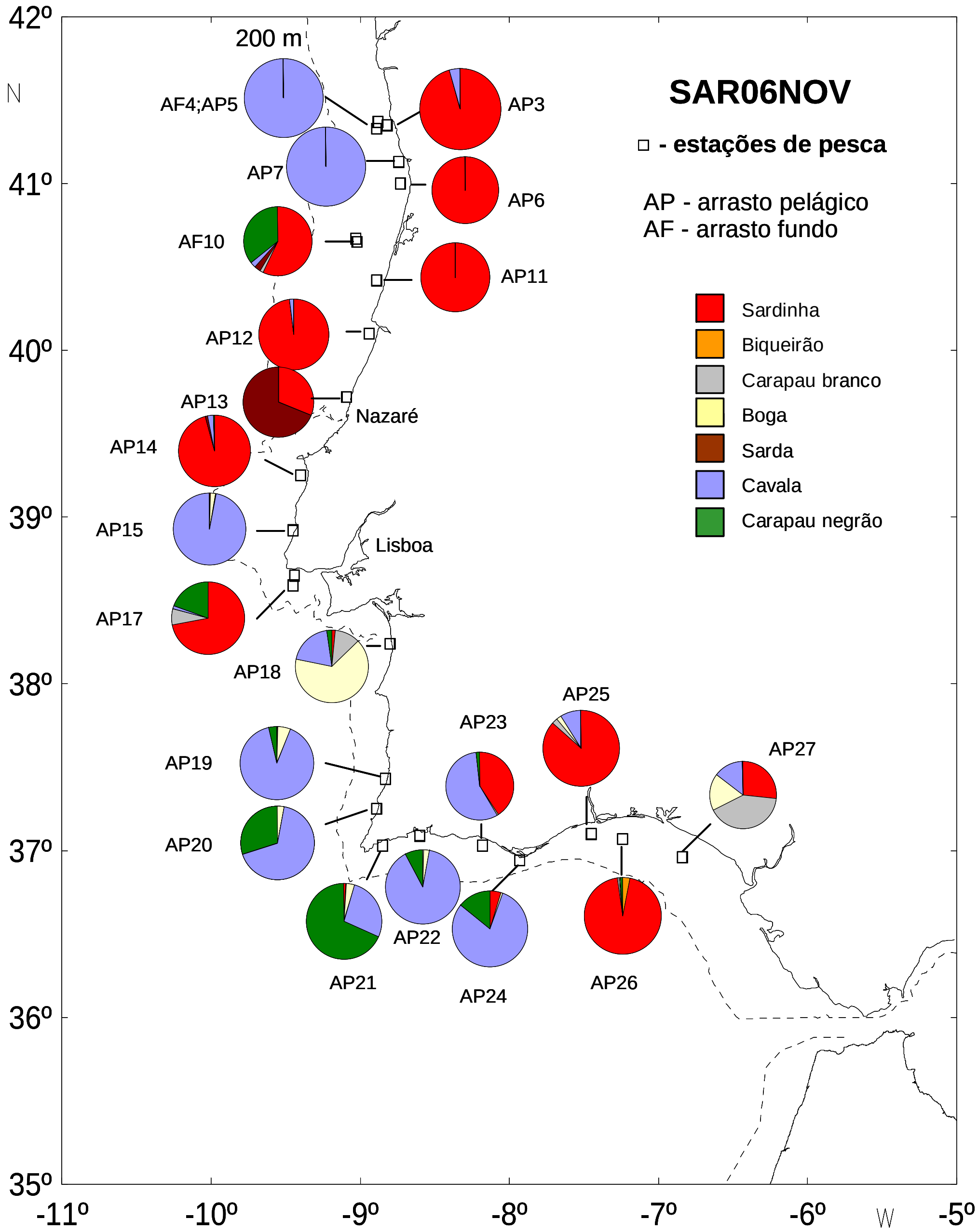


Figure 8.3.2.1.1: Sardine in VIIIc and IXa: Portuguese autumn acoustic survey in 2006. Pelagic (AP) and bottom (AF) trawl locations and species composition (in % weight) during SAR06NOV (n = 27).

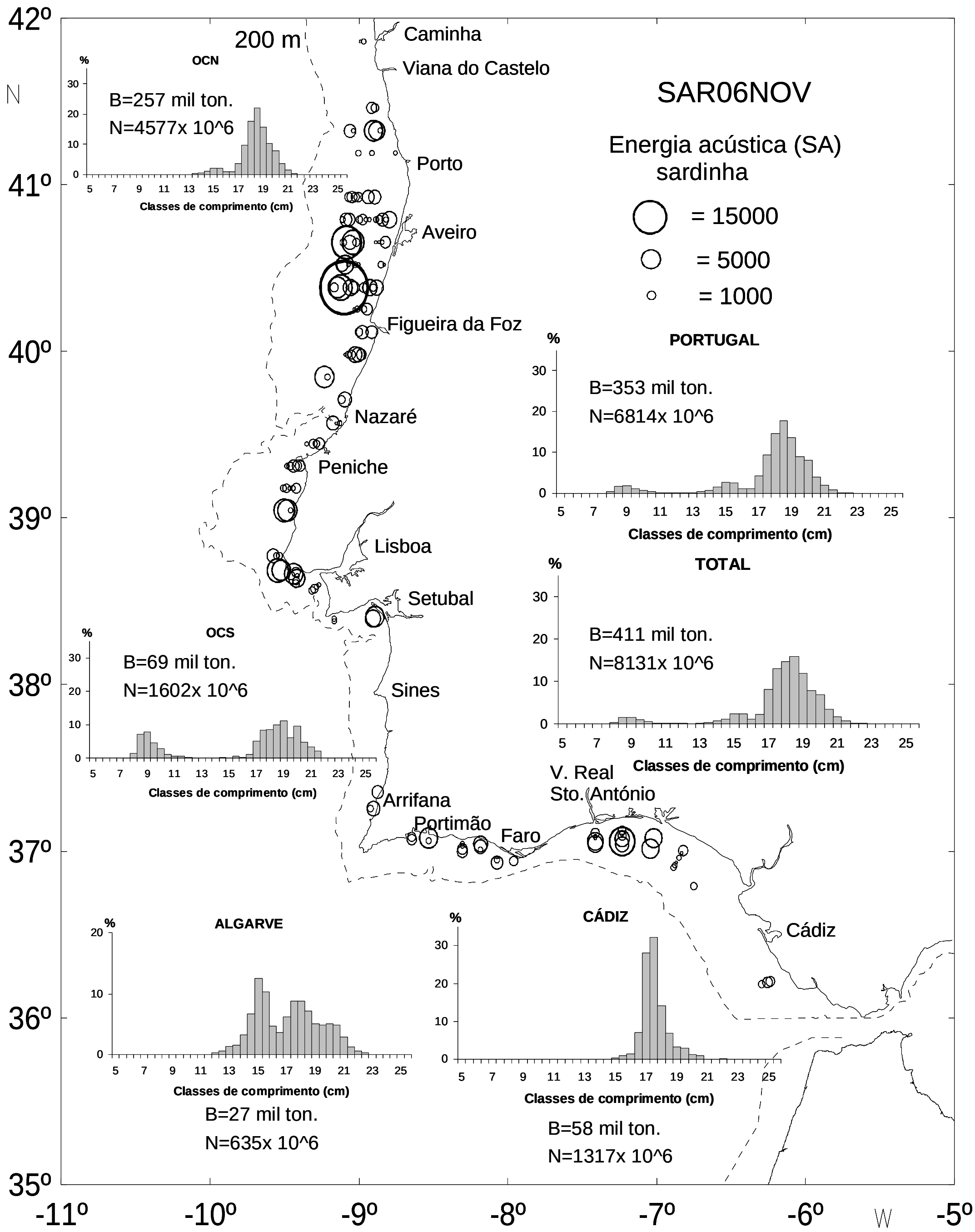


Figure 8.3.2.1.2: Sardine in VIIIc and IXa: Portuguese autumn acoustic survey in 2006. Acoustic energy by nautical mile and abundance and length structure by area. Circle area is proportional to the acoustic energy (S_A m^2/nm^2).

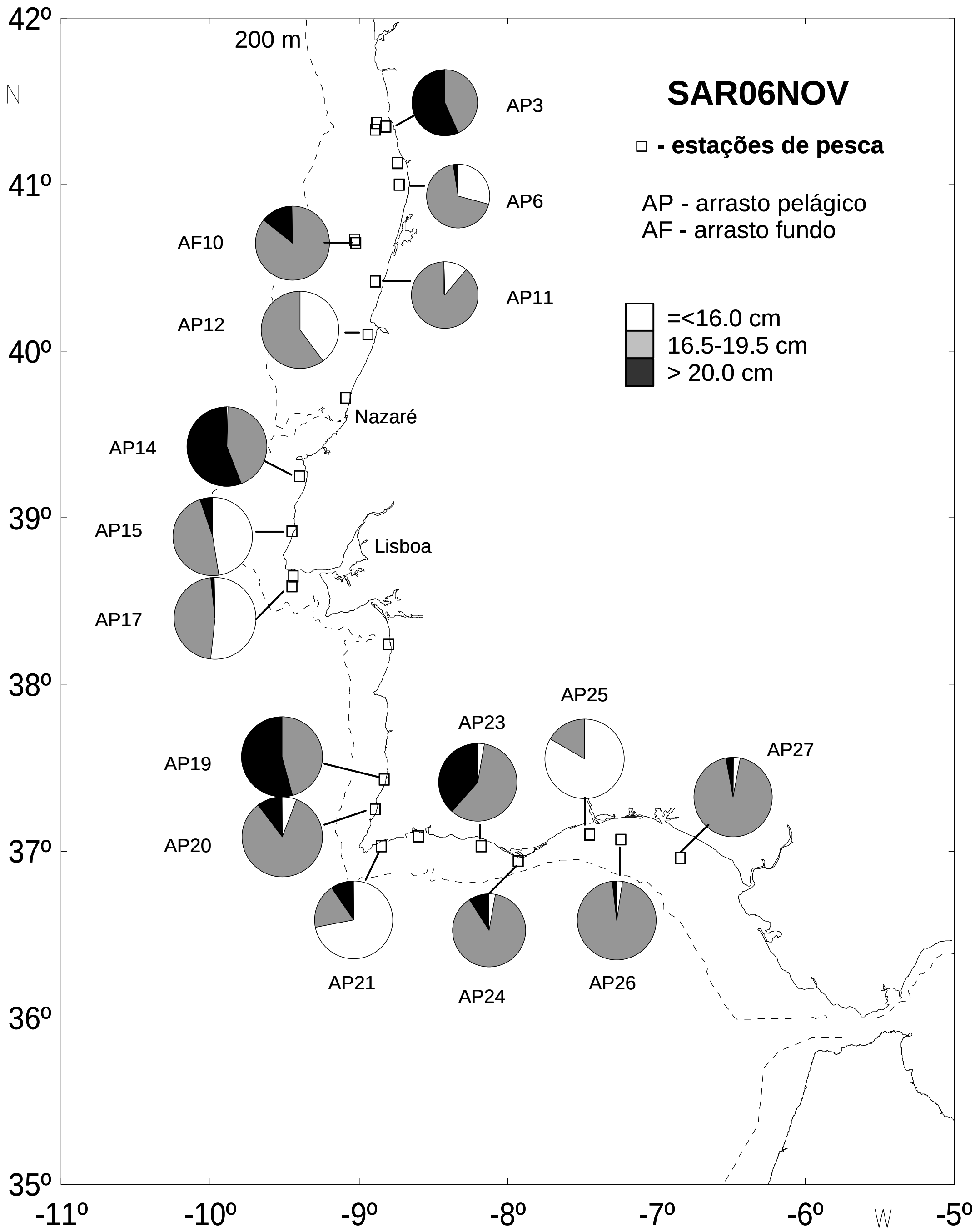


Figure 8.3.2.1.3: Sardine in VIIIc and IXa: Portuguese autumn acoustic survey in 2006. Sardine length (=16 cm; 16,5-19,5 cm; >20 cm) composition by fishing station (circles).

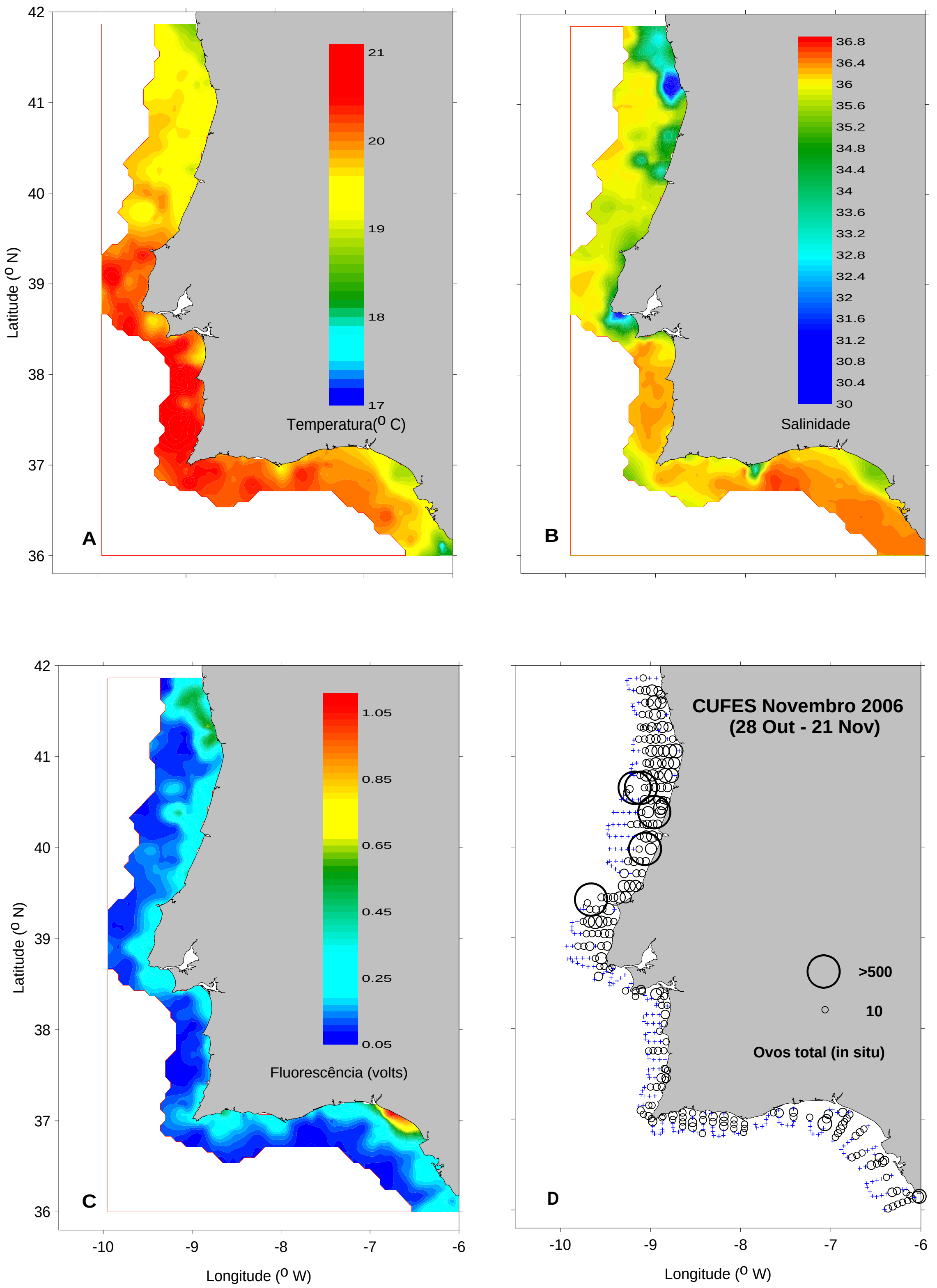


Figure 8.3.2.1.4: Sardine in VIIIc and IXa: Portuguese autumn acoustic survey in 2006. Values of temperature (top left graph), salinity (top right graph), fluorescence (bottom left graph) and total number of sardine eggs (bottom right) obtained during the survey.

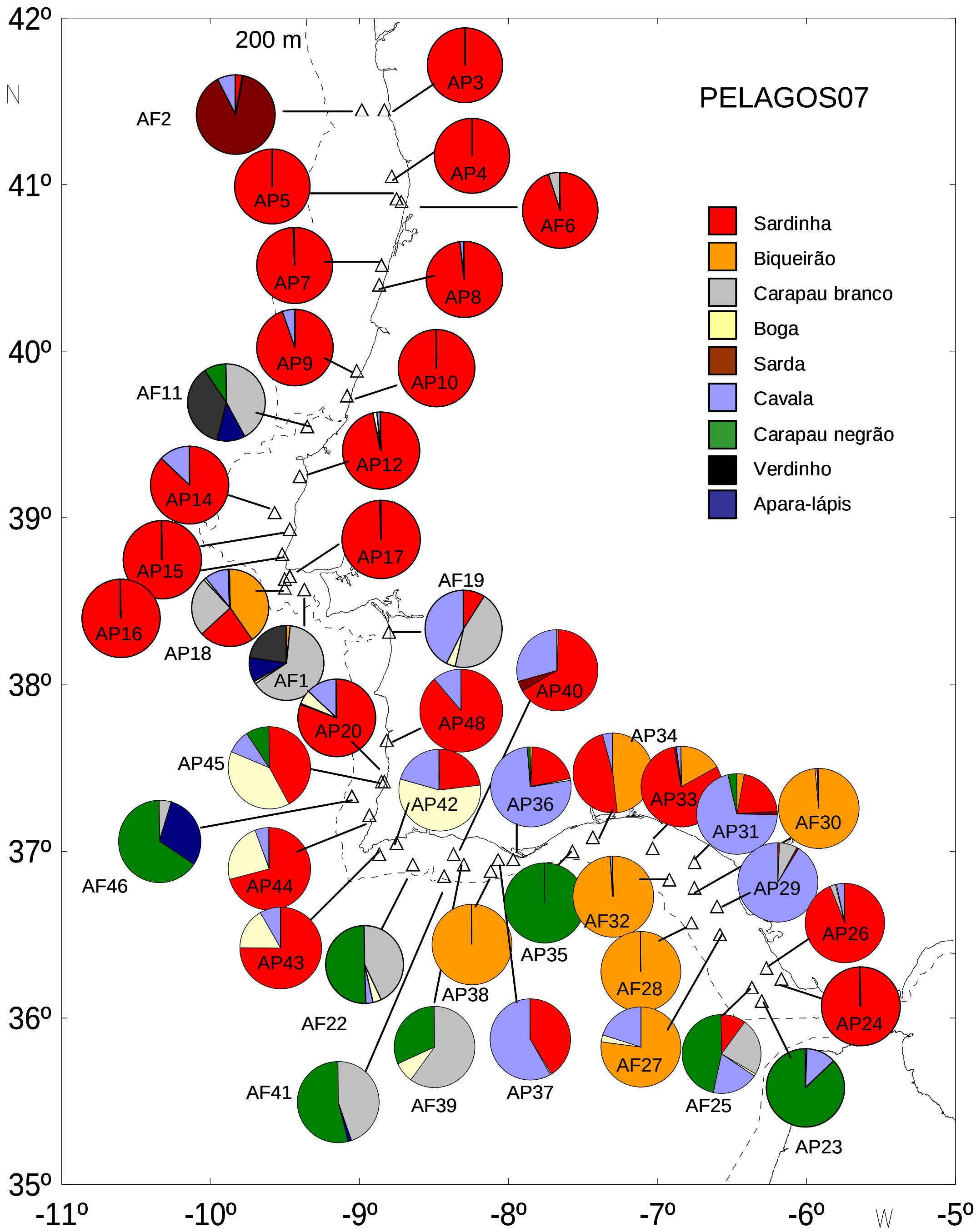


Figure 8.3.2.1.5: Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2007. Pelagic (AP) and bottom (AF) trawl locations and species composition (in % weight) during PELAGOS07 (n = 48).

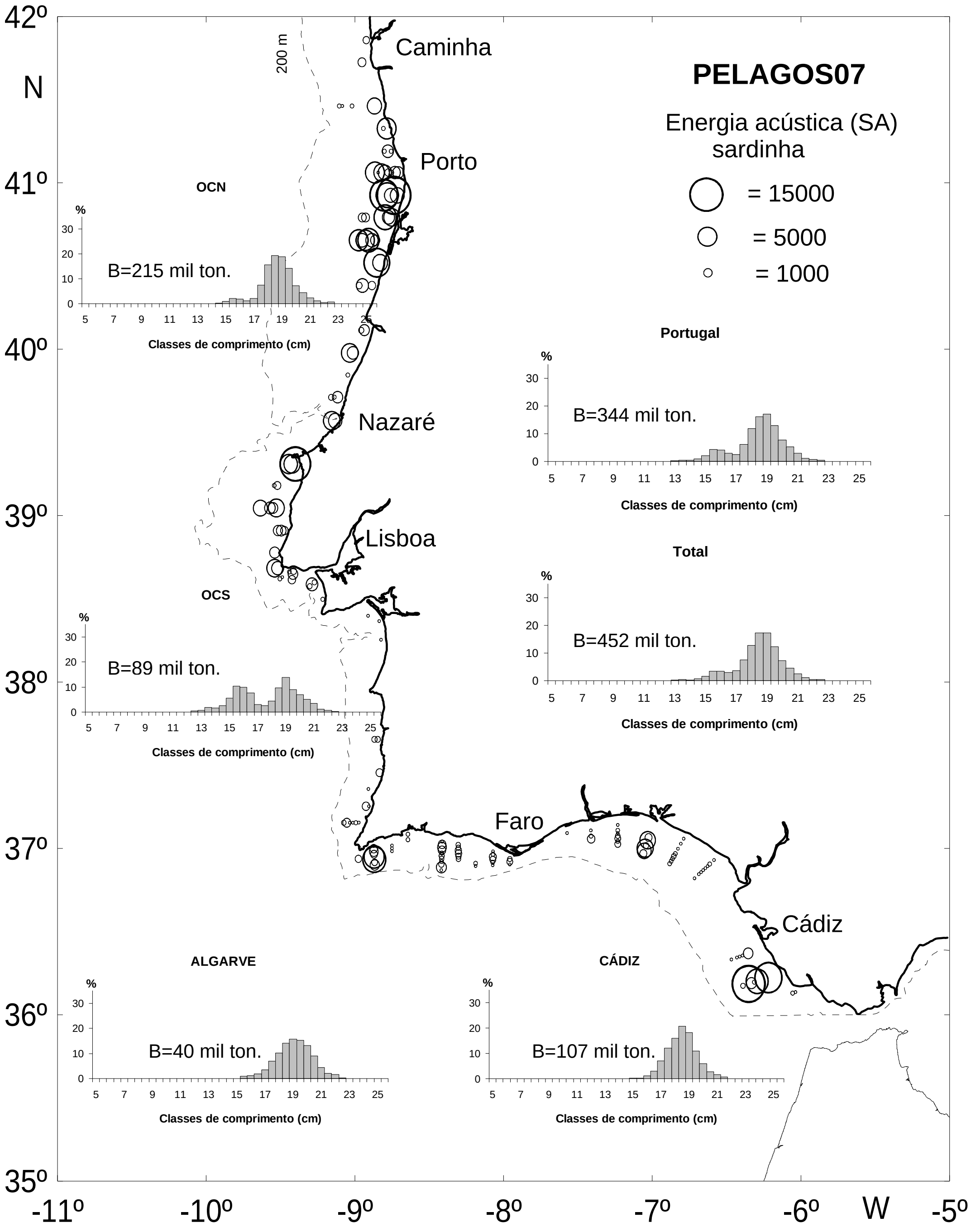


Figure 8.3.2.1.6: Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2007. Acoustic energy by nautical mile and abundance and length structure by area. Circle area is proportional to the acoustic energy (S_A m^2/nm^2).

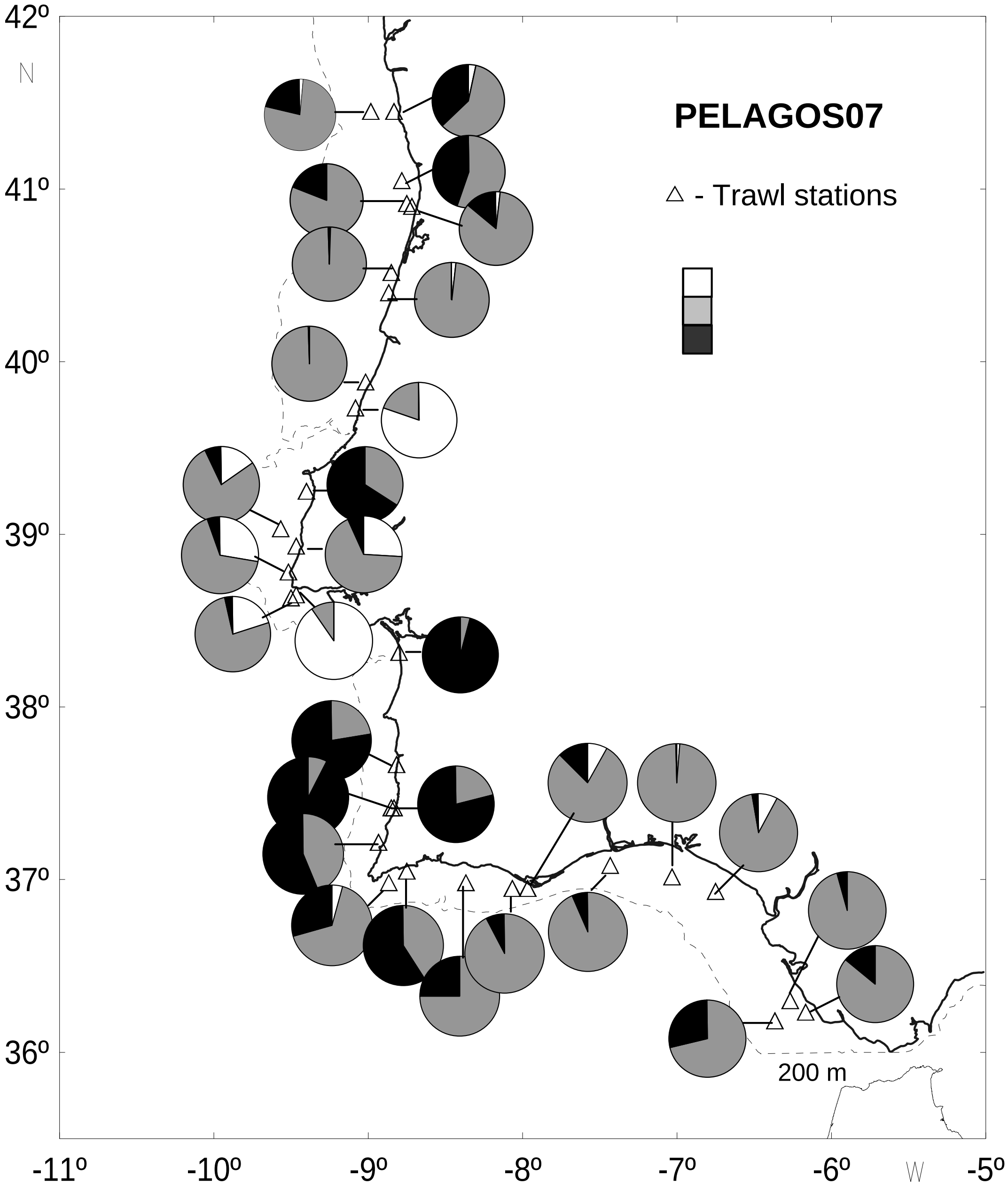


Figure 8.3.2.1.7: Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2007. Sardine length (=16 cm; 16,5-19,5 cm; >20 cm) composition by fishing station (circles).

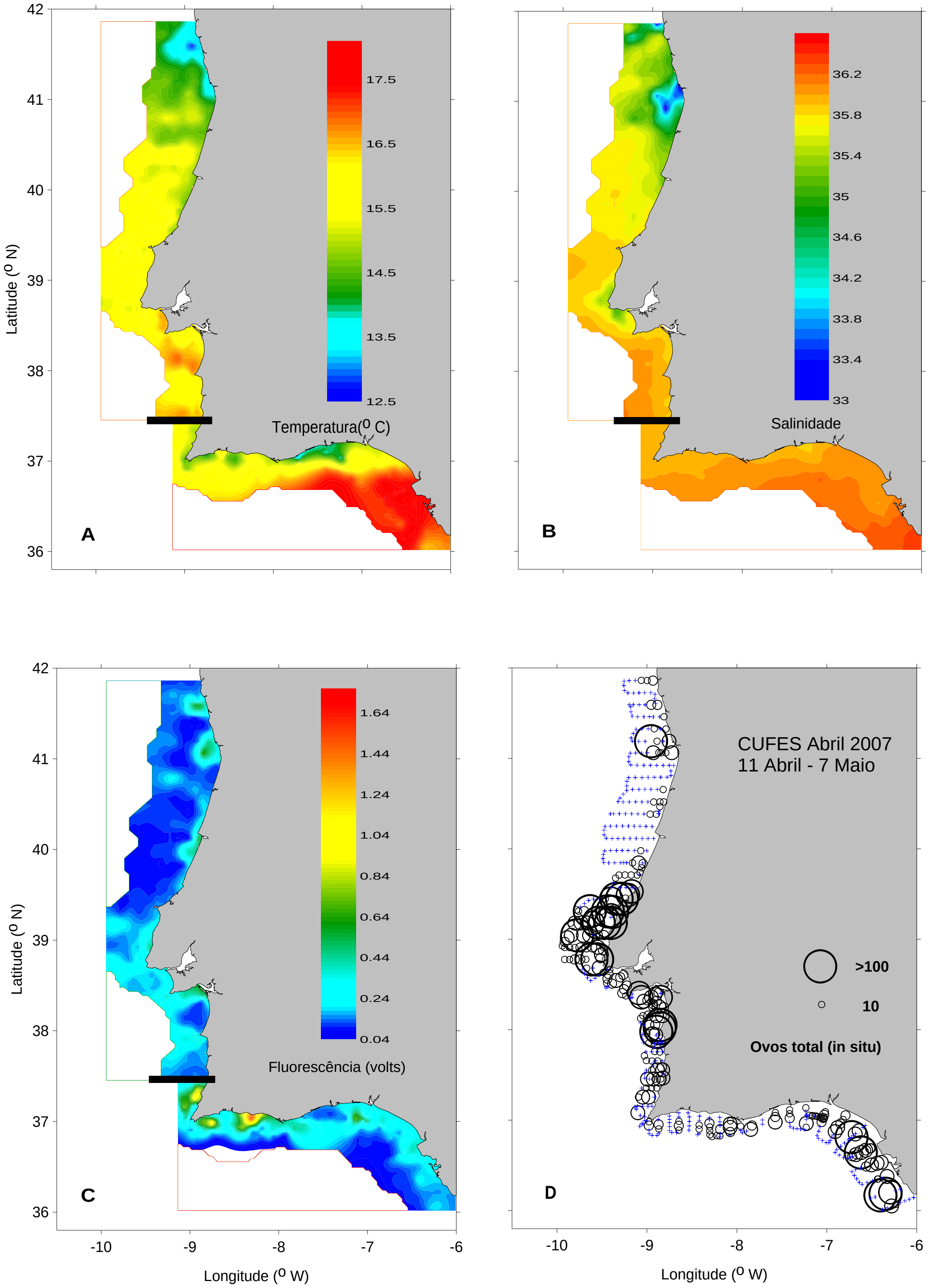


Figure 8.3.2.1.8: Sardine in VIIIc and IXa: Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2007. Values of temperature (top left graph), salinity (top right graph), fluorescence (bottom left graph) and total number of sardine eggs (bottom right graph) obtained during the survey. The horizontal black line shows the position of the joining of both survey halfs (1st from the 13th to the 23rd of April with a north-south direction and the 2nd from the 28th of April to the 7th of May with a east-west-north direction).

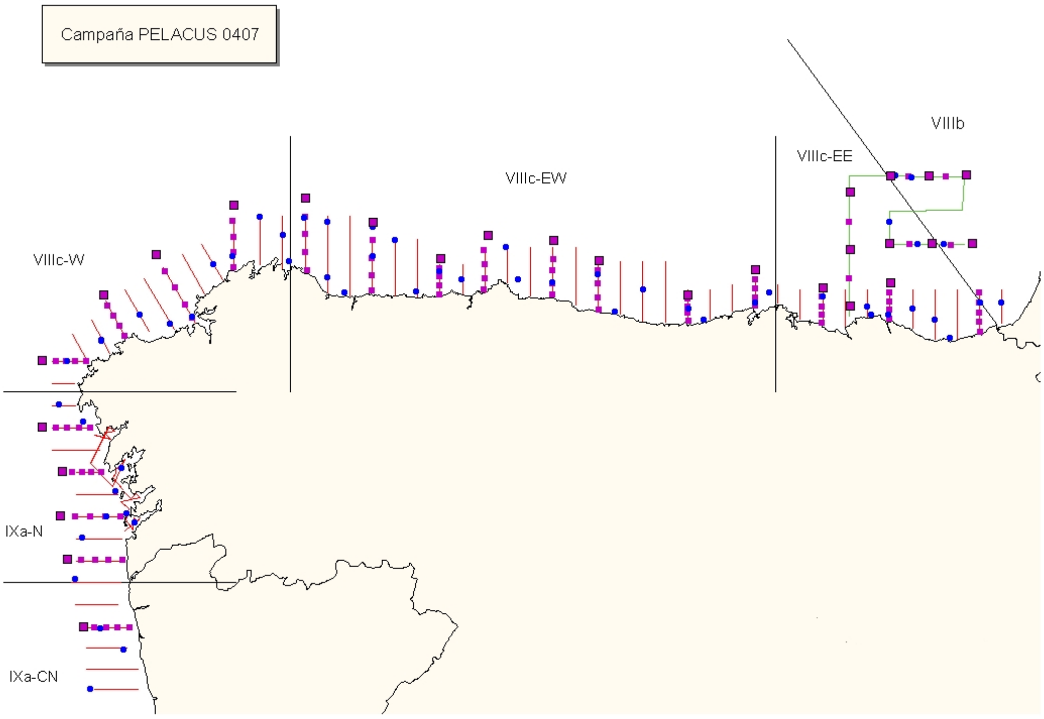


Figure 8.3.2.2.1: Sardine in VIIIc and IXa: PELACUS0407 sampling effort. Red and green (additional offshore sampling) lines indicate acoustic transects, blue circles indicate fishing stations, and purple squares indicate hydrography stations (small ones indicate normal stations, large ones indicate intensive stations with multinet).

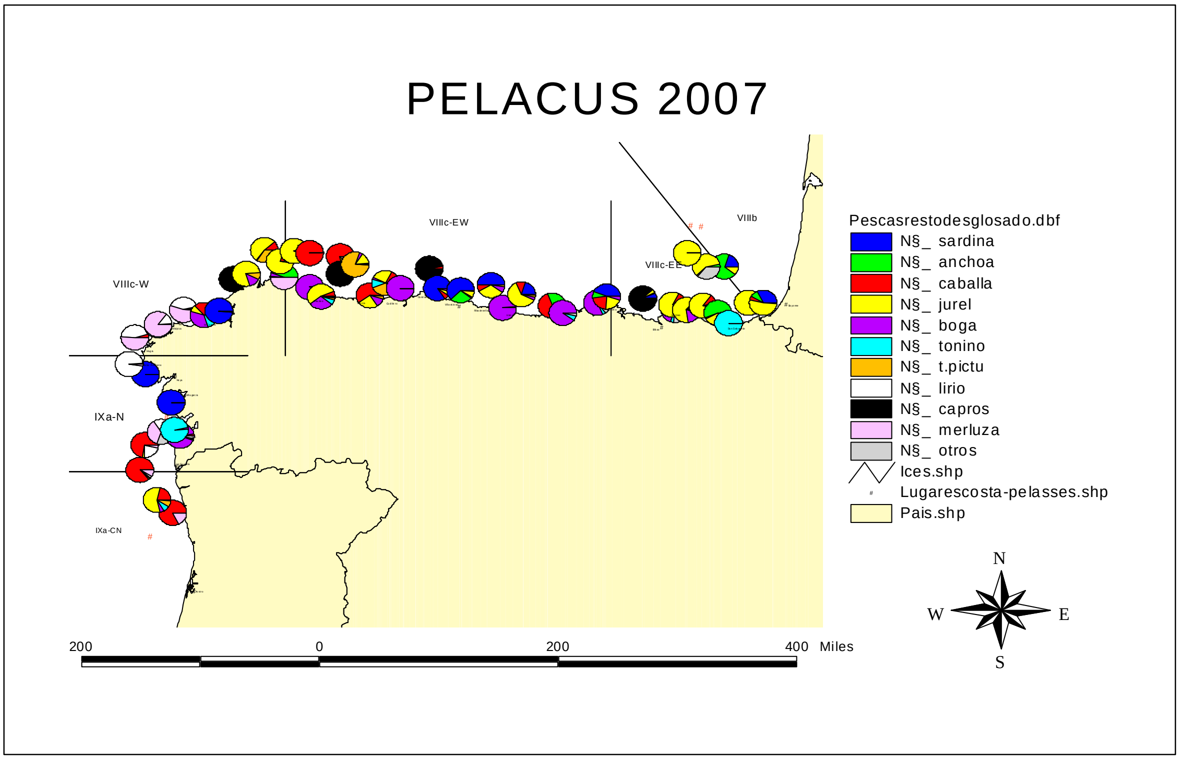


Figure 8.3.2.2.2: Sardine in VIIIc and IXa: Pelagic trawl locations and species composition during PELACUS0407 (n = 57). (The figure also shows the hauls carried out in Portuguese and French waters although those results are not presented in the text).

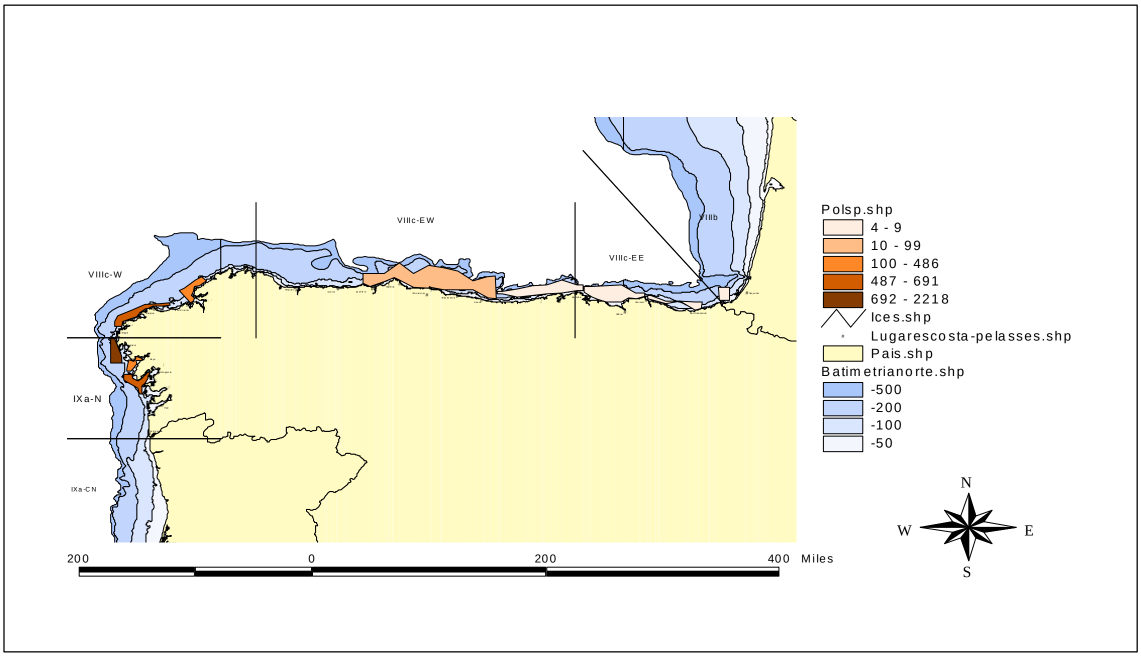
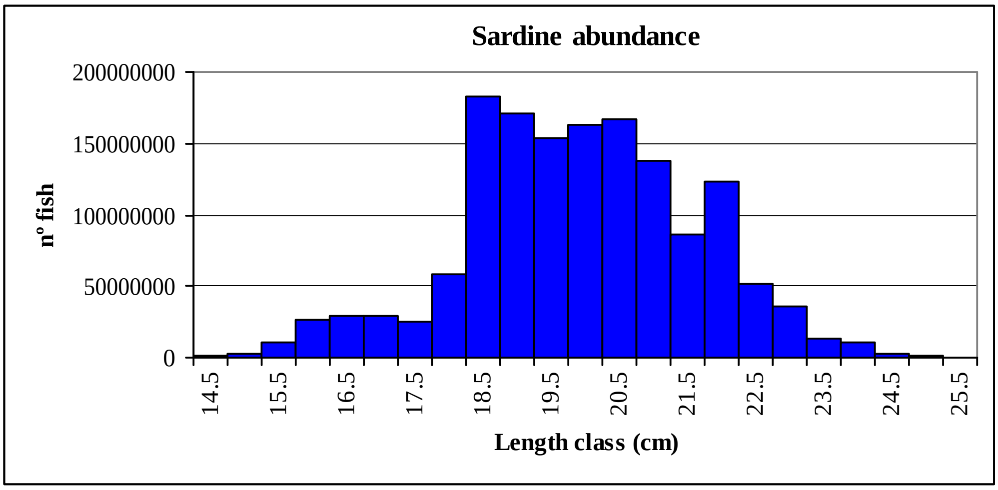


Figure 8.3.2.2.3: Sardine in VIIIc and IXa: Spatial distribution of energy allocated to sardine during the PELACUS0407 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m2 within each polygon.



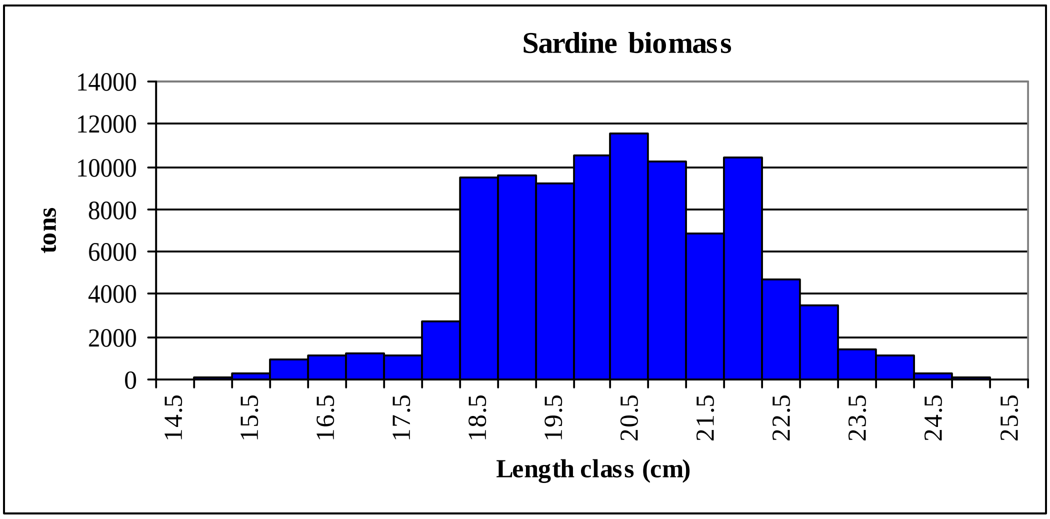


Figure 8.3.2.2.4: Sardine in VIIIc and IXa: Sardine length distribution in numbers (top) and biomass (bottom) during the PELACUS0407 survey.

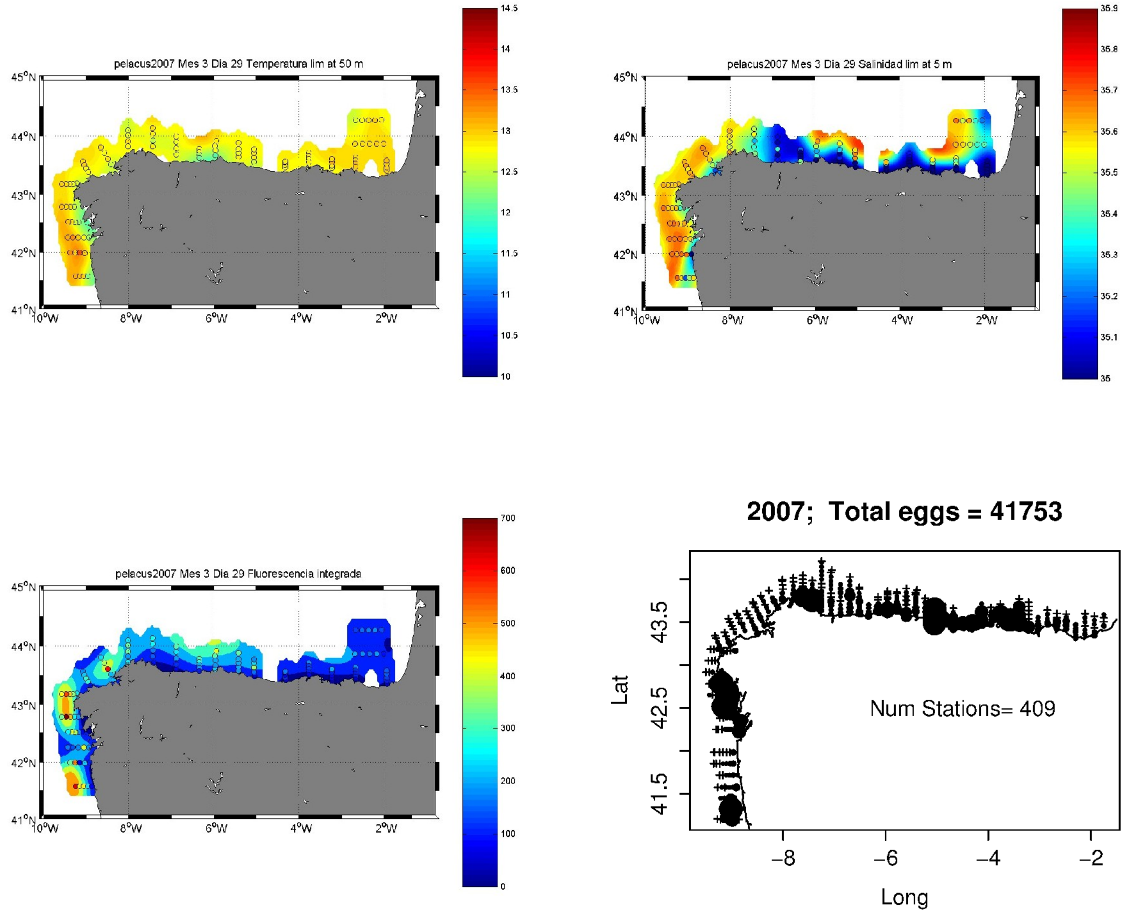


Figure 8.3.2.2.5: Sardine in VIIIc and IXa: Values of temperature (measured at 50 m depth, top left graph), salinity (measured at 5 m depth, top right graph), fluorescence (bottom left graph) and total number of sardine eggs (bottom right graph) obtained during the PELACUS0407 survey.

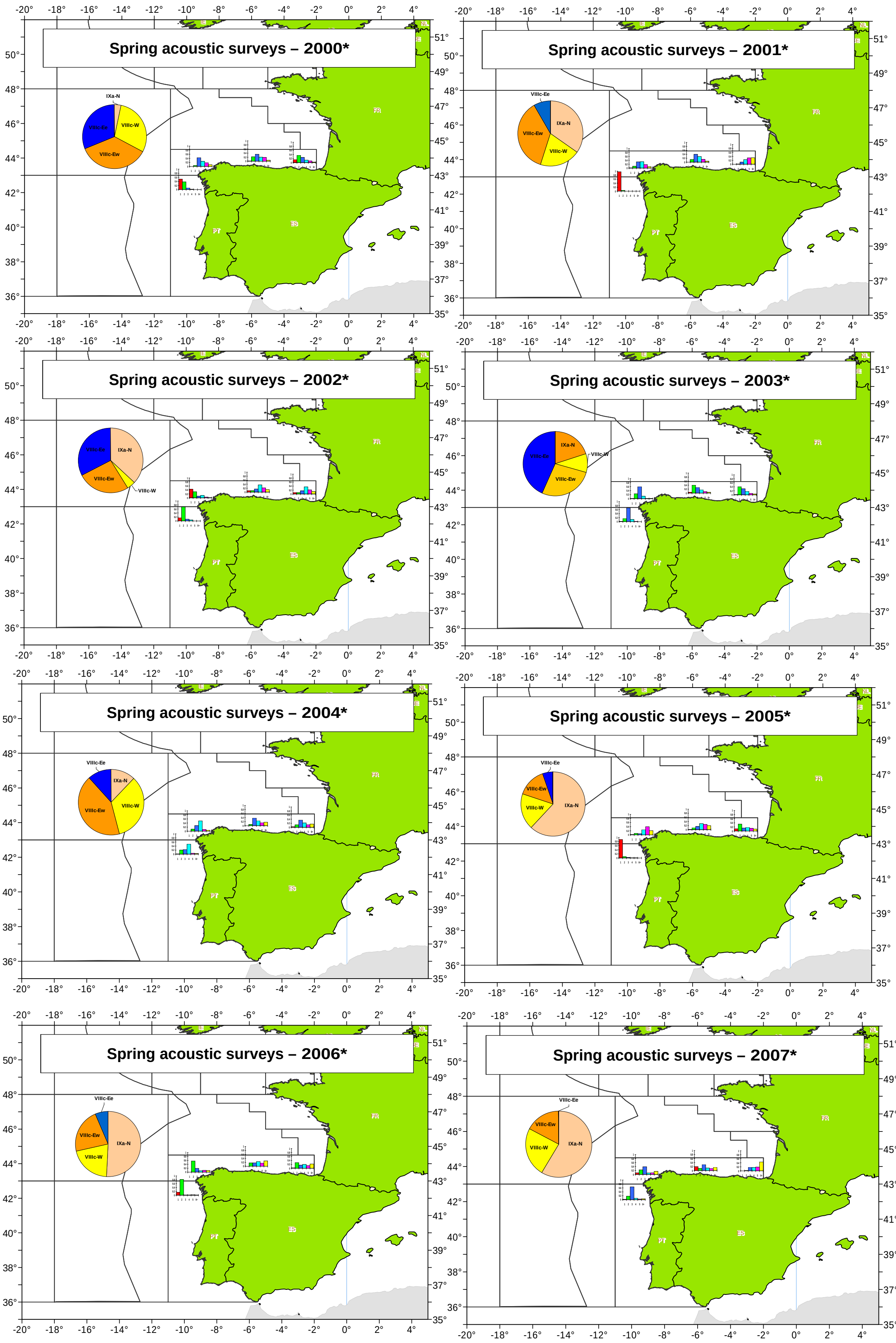


Figure 8.3.2.2.6: Sardine in VIIIc and IXa: Sardine relative abundance at age in each sub-area (i.e. the proportions of all age classes within each sub-area sum to 1) estimated in the PELACUS spring surveys (2000-2007). The pie chart shows the contribution of each sub-area to the total stock numbers.

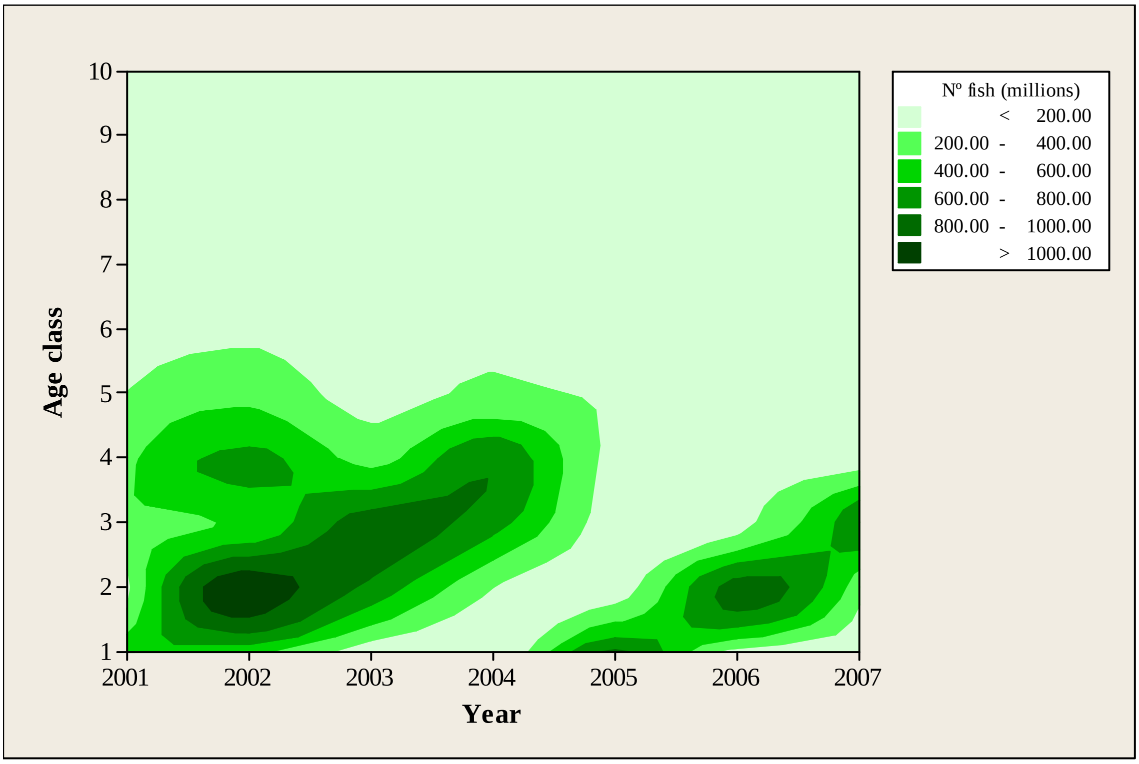


Figure 8.3.2.2.7: Sardine in VIIIc and IXa: Number of fish (millions) by age class in the PELACUS spring acoustic surveys (2001-2007).

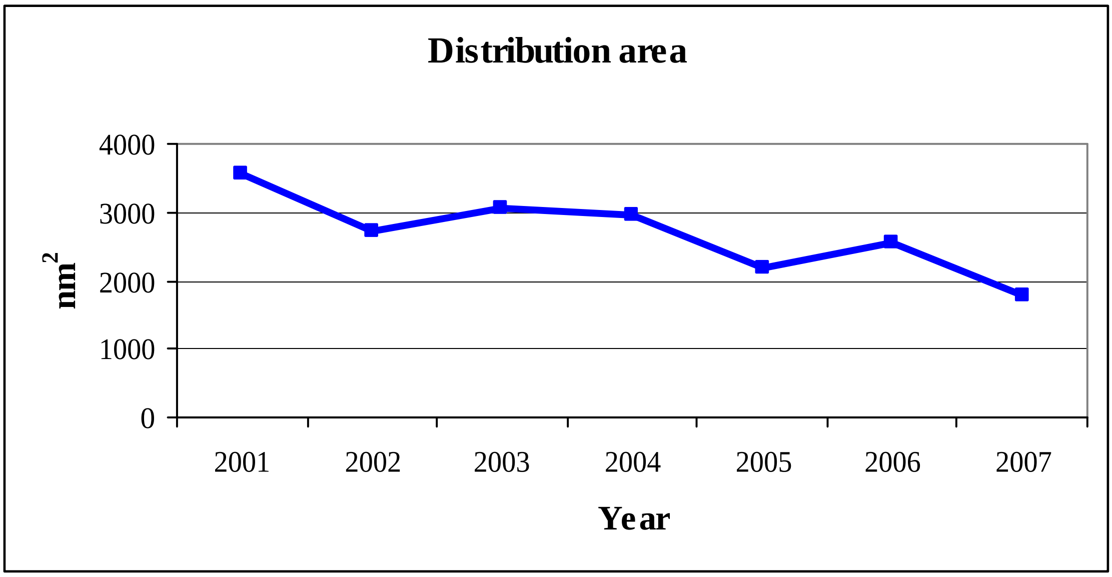


Figure 8.3.2.2.8: Sardine in VIIIc and IXa: Values of distribution area (measured in nm2) estimated in the PELACUS spring acoustic surveys (2001-2007).

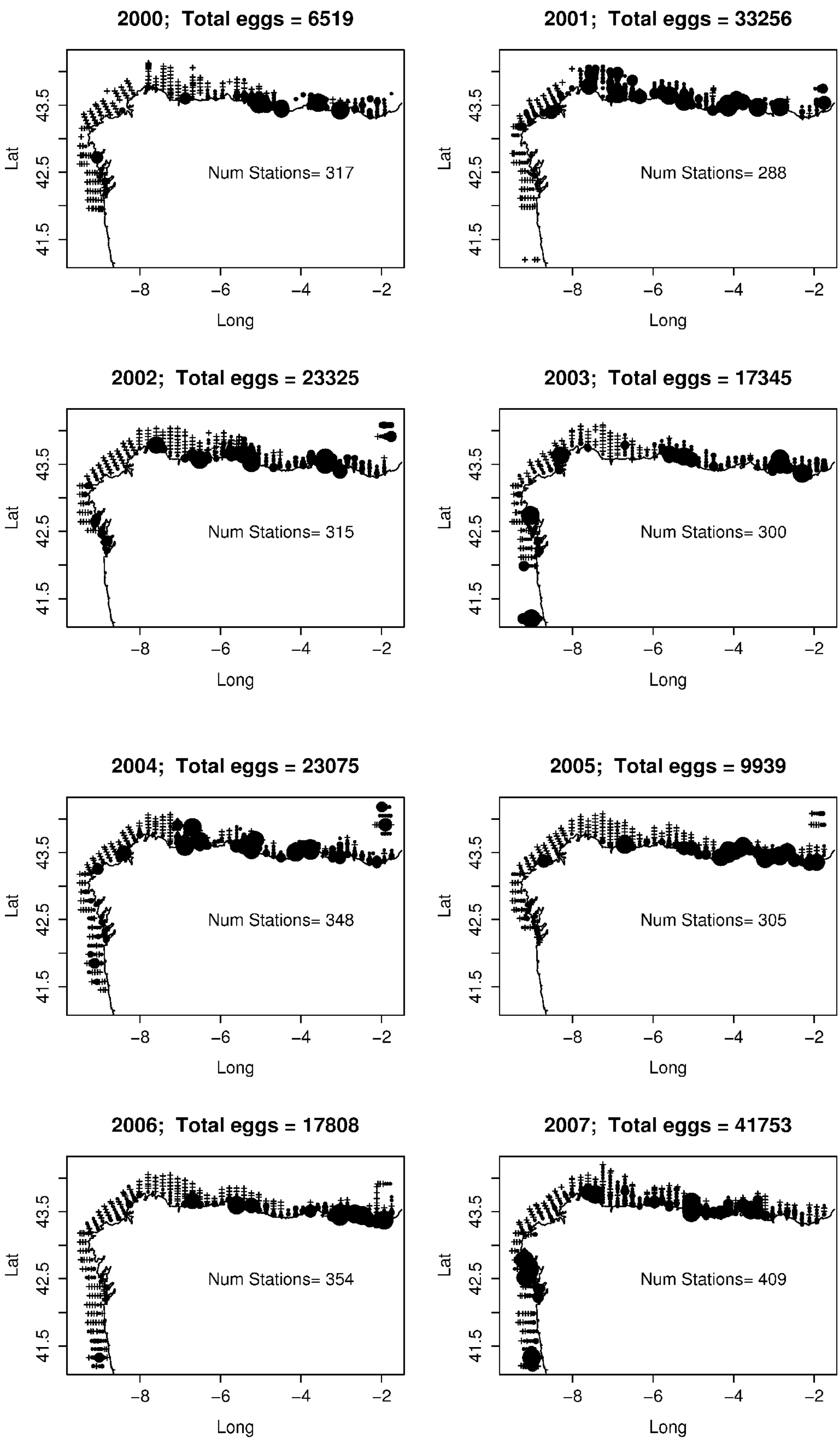


Figure 8.3.2.2.9: Sardine in VIIIc and IXa: Distribution of sardine eggs through the PELACUS time series (2000-2007). Crosses indicate negative stations, while circles indicate positive stations, with diameter proportional to egg abundance. All figures have the same scale.

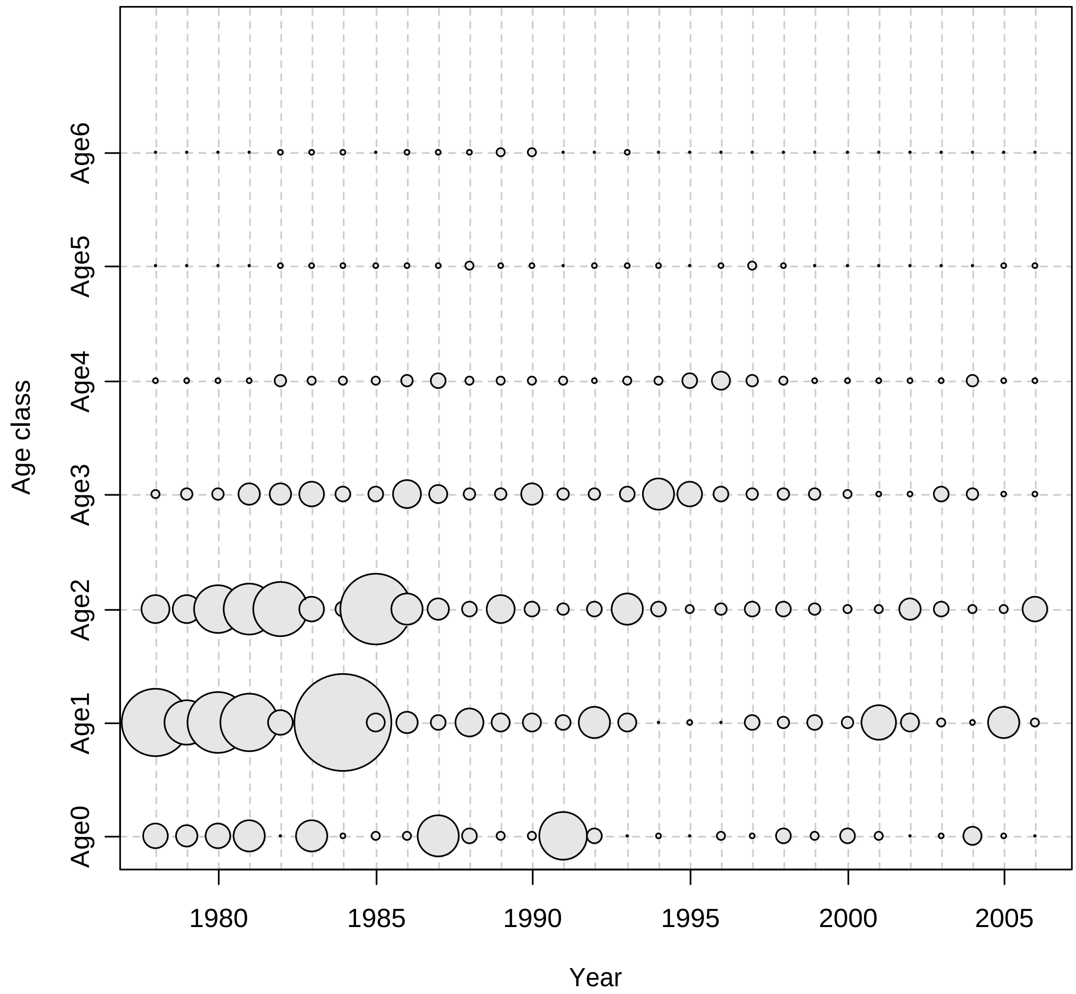


Figure 8.7.1.1: Sardine VIIIc and IXa: Catches-at-age for 1978 – 2006.

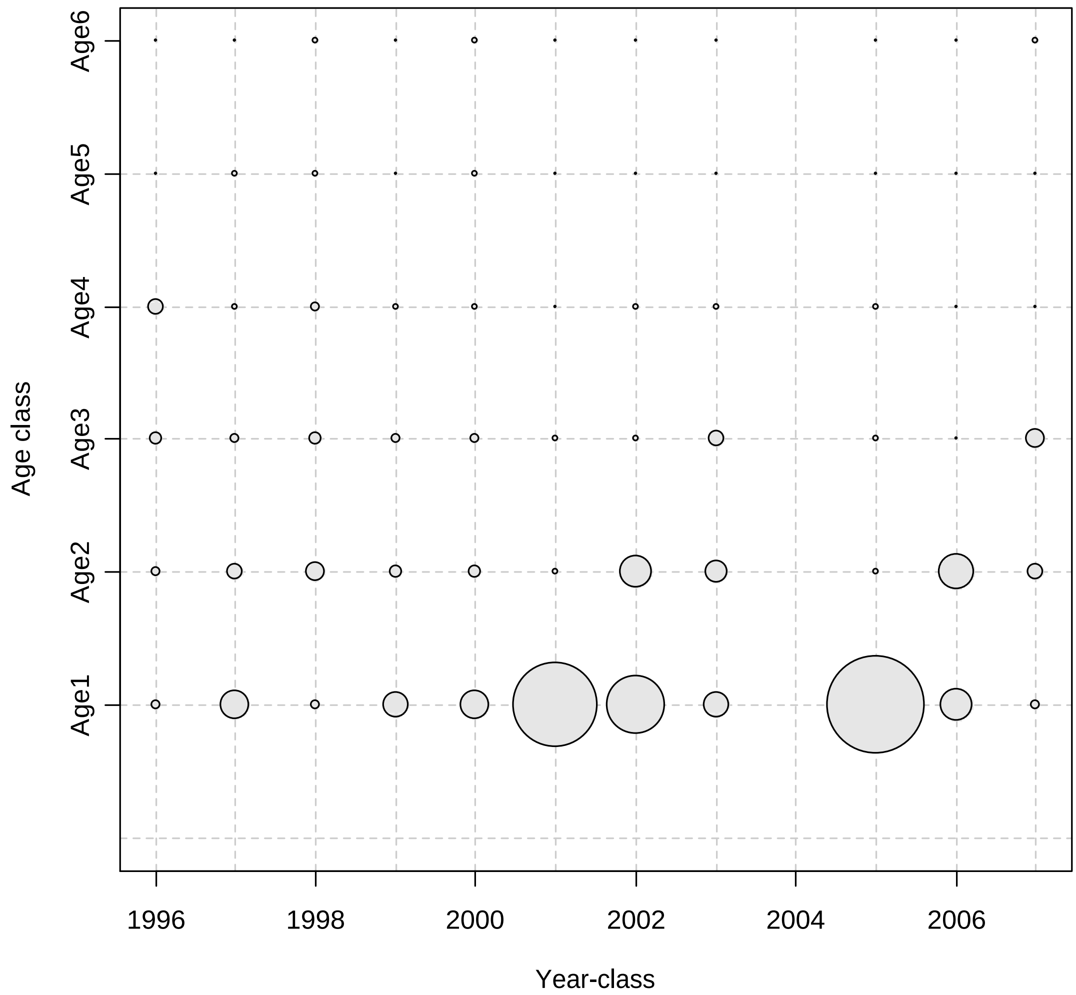


Figure 8.7.1.2: Sardine VIIIc and IXa: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996 – 2007.

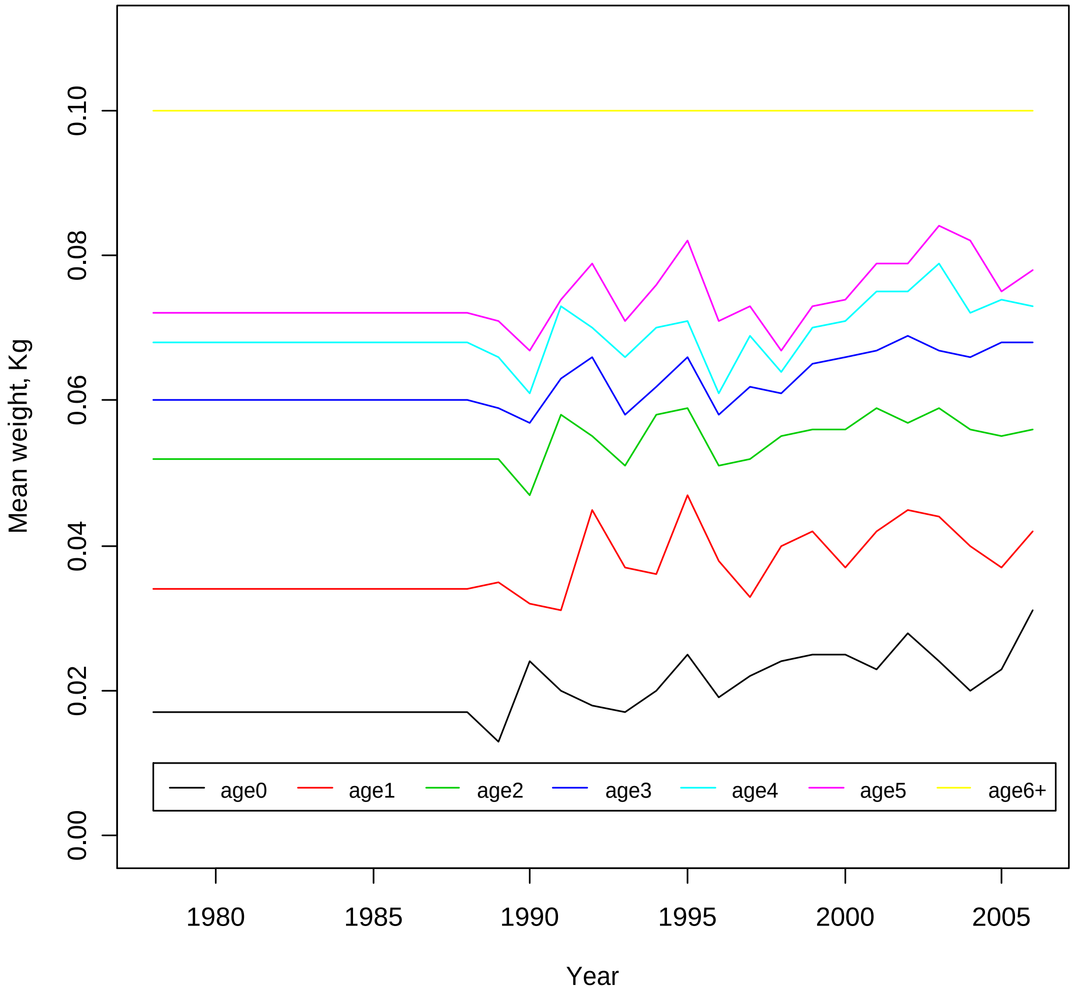


Figure 8.7.1.3: Sardine VIIIc and IXa: Mean weight-at-age in the catches 1978 – 2006.

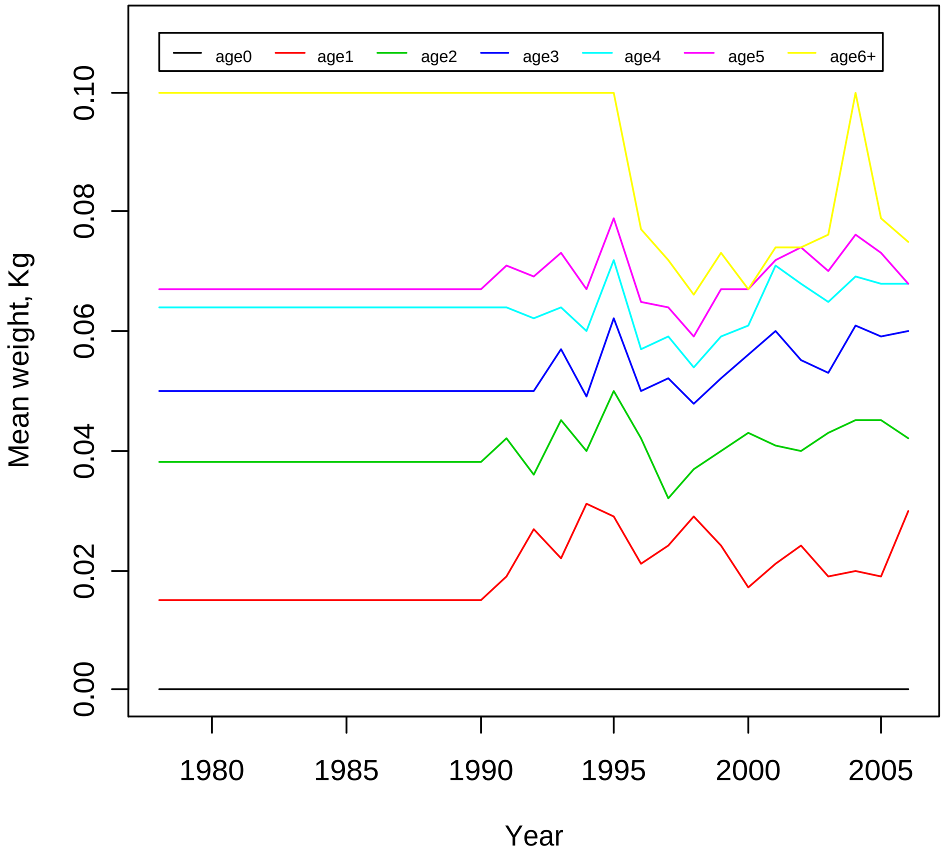


Figure 8.7.1.4: Sardine VIIIc and IXa: Mean weight-at-age in the stock 1978 – 2006.

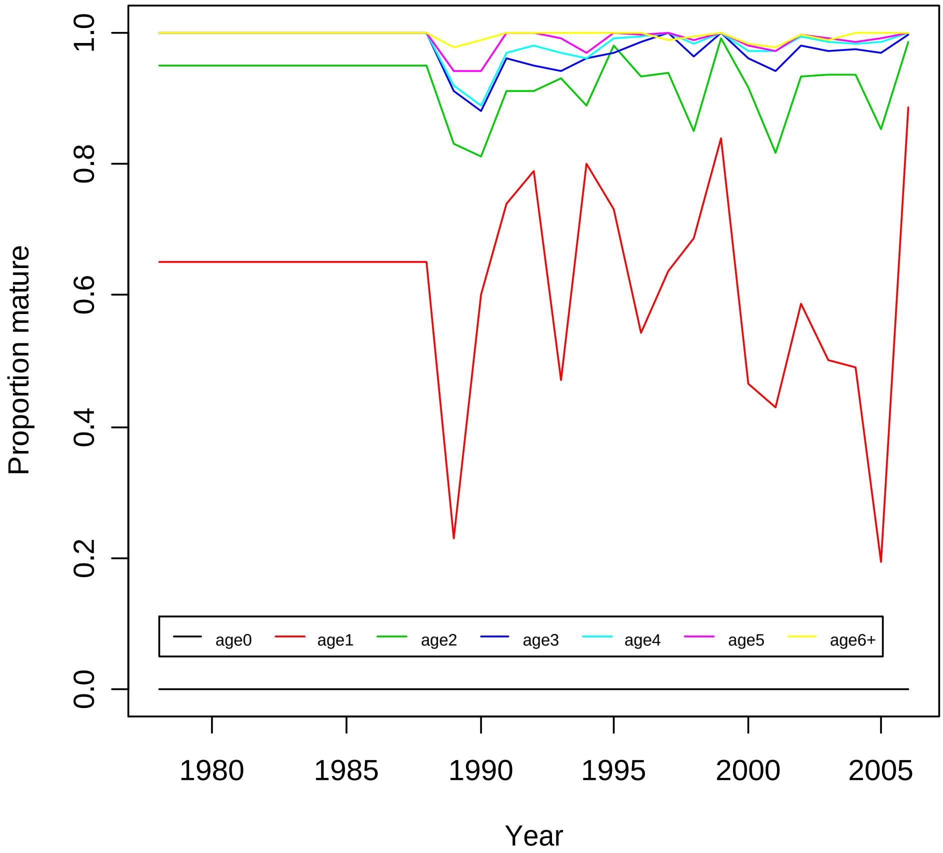


Figure 8.7.1.5: Sardine VIIIc and IXa: Maturity ogives 1978 – 2006.

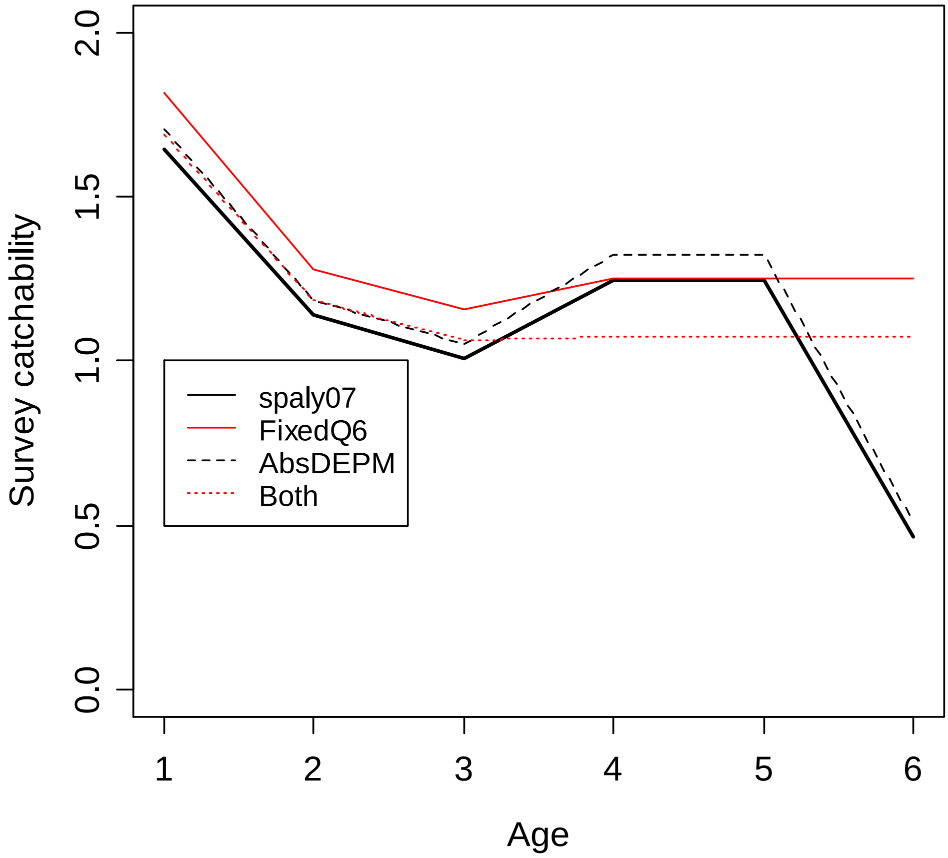


Figure 8.7.2.1: Sardine VIIIc and IXa: Survey catchability curves for ages 1-6+ in the exploratory runs.

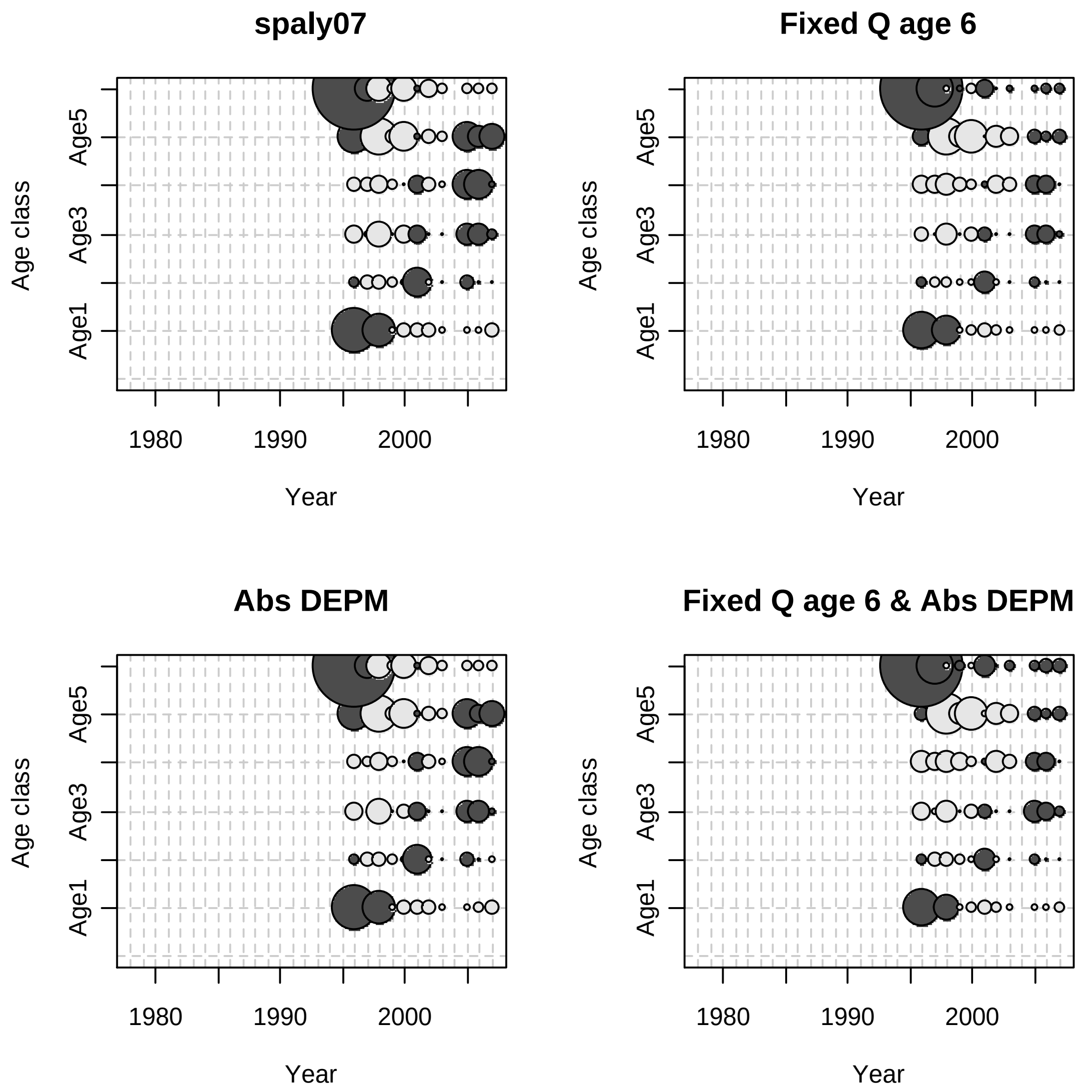


Figure 8.7.2.2: Sardine VIIIc and IXa: Survey residuals for ages 1-6+ in the exploratory runs. Values in the range [-2.2 – 0.91] for runs Spaly07 and Abs DEPM and in the range [-2.6 – 1.2] for runs Fixed Q age 6 and Fixed Q age 6 & Abs DEPM.

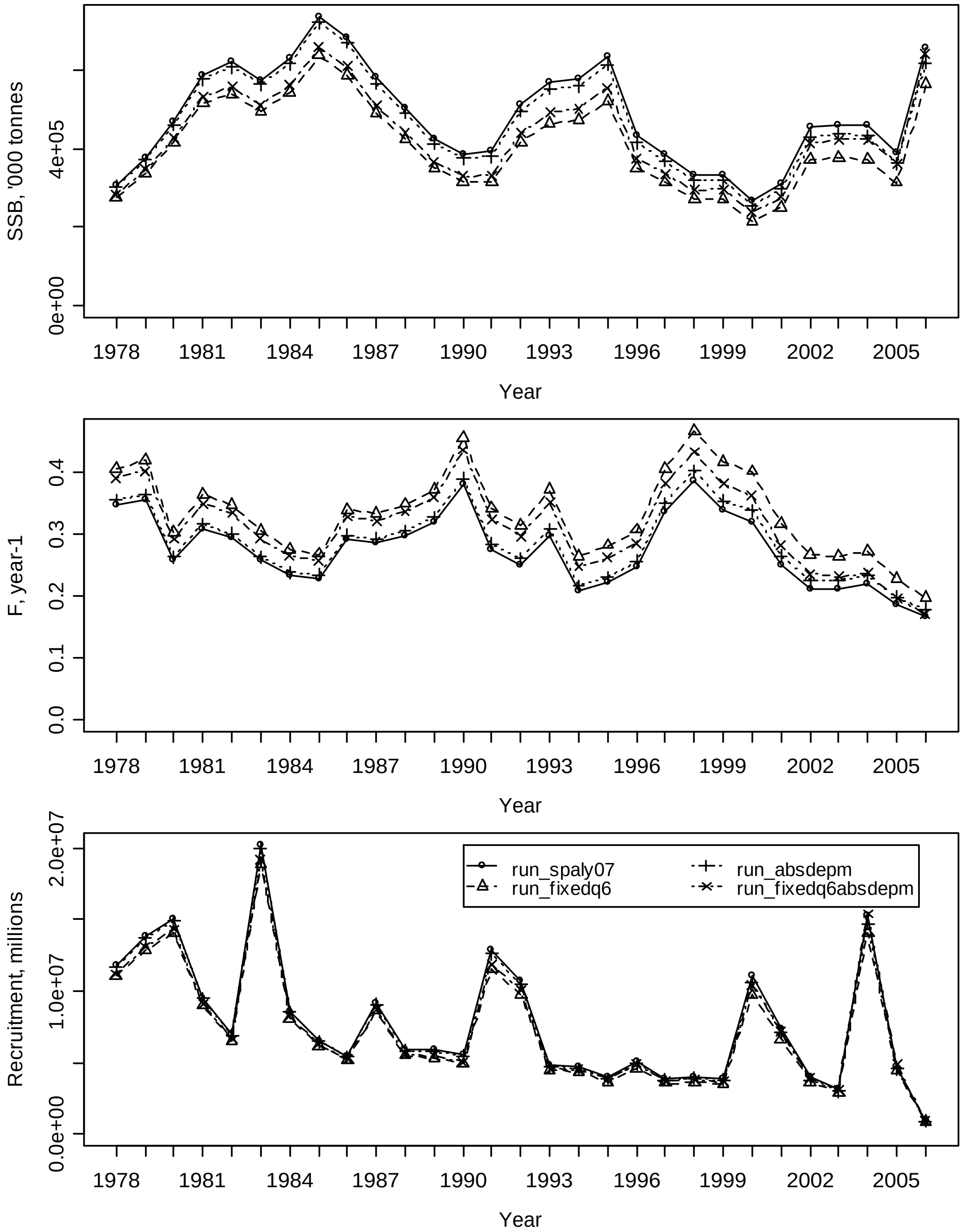


Figure 8.7.2.3: Sardine VIIIc and IXa: SSB (top), $F_{(2\text{-}5)}$ (middle) and recruitment (bottom) trajectories for exploratory runs.

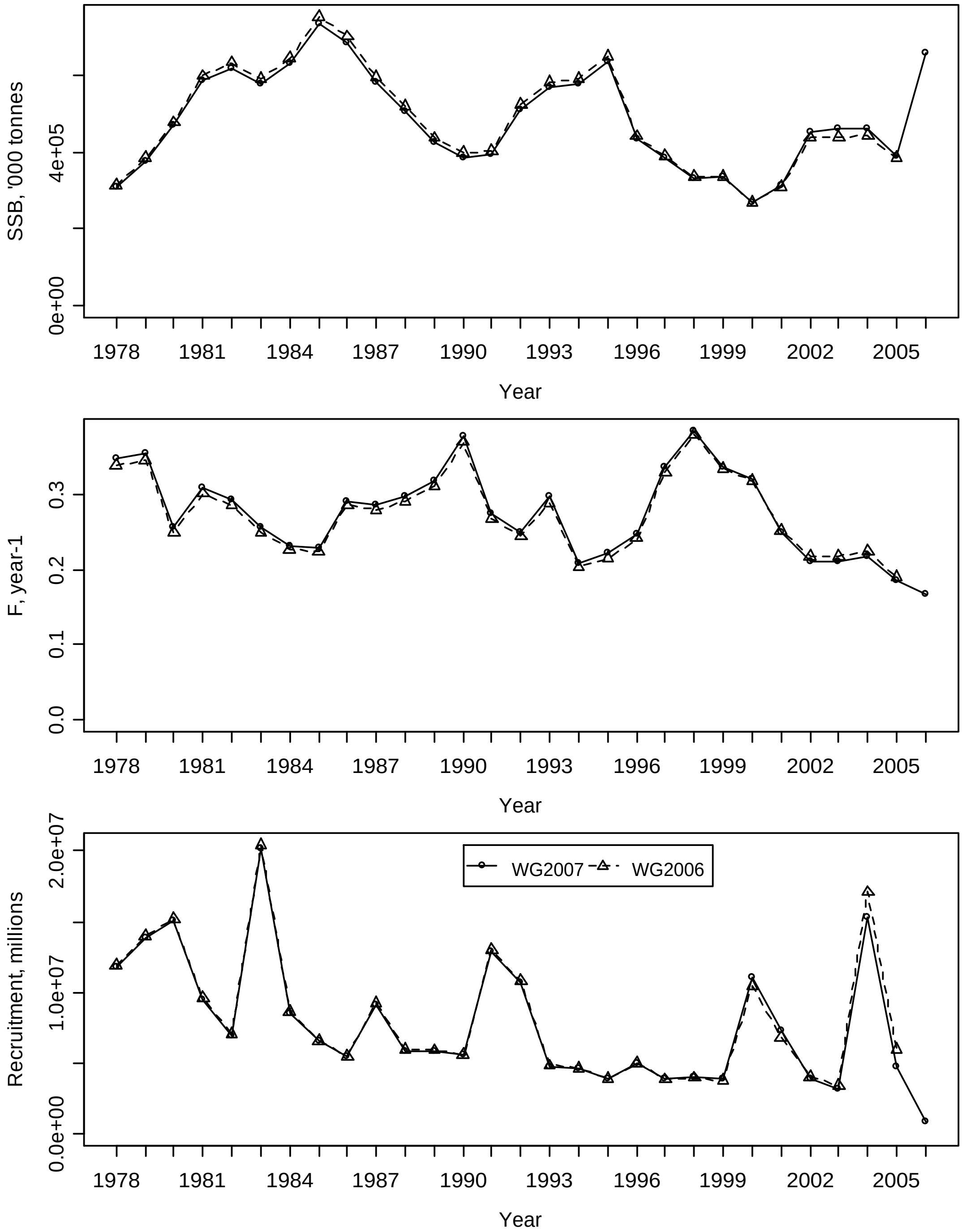


Figure 8.8.1.1: Sardine VIIIc and IXa: SSB (top), F (middle) and recruitment (bottom) trajectories in the period 1978 – 2006 from the sardine AMCI final assessment (WG2007). The WG2006 assessment is shown for comparison.

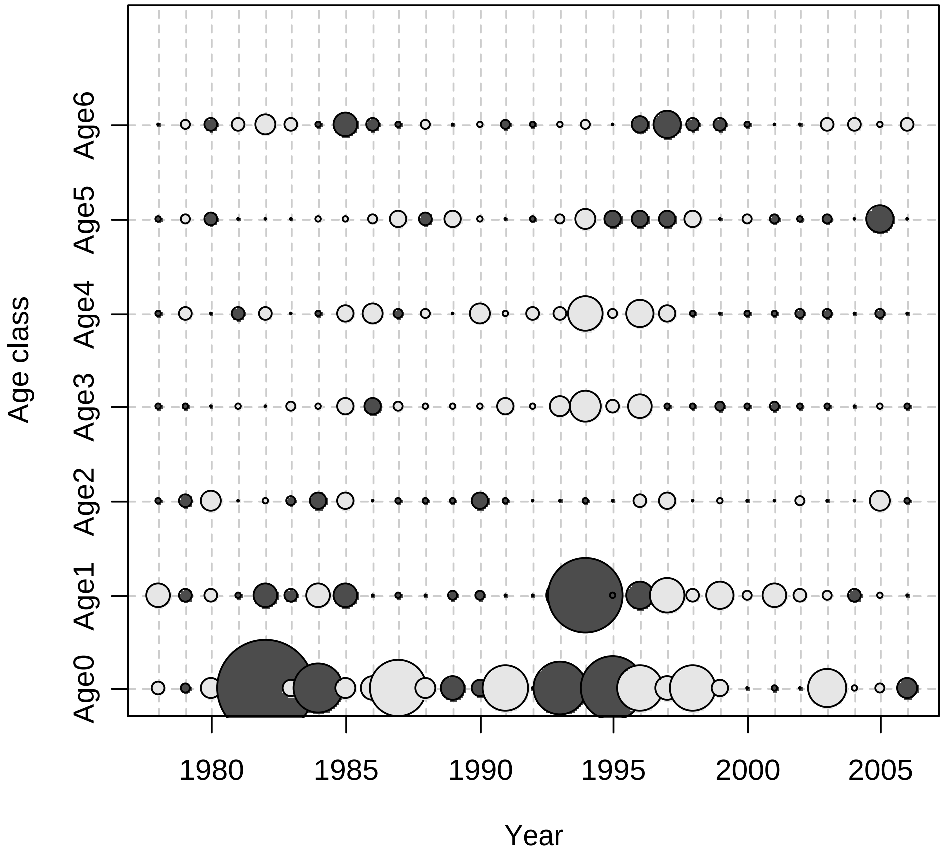


Figure 8.8.1.2: Sardine VIIIc and IXa: Catch residuals 1978 – 2006 (unweighted, negative in black, positive in grey) for the final AMCI assessment. Values are in the range [-1.6, 0.96].

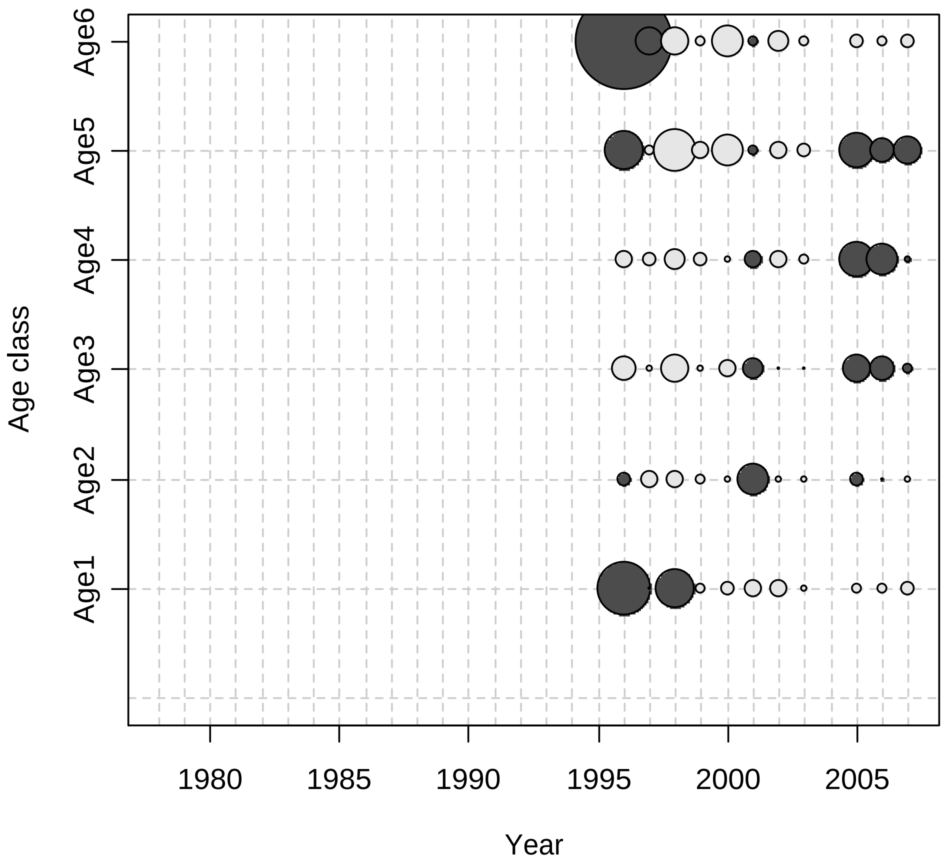


Figure 8.8.1.3: Sardine VIIIc and IXa: Survey residuals (for the combined Iberian spring acoustic survey) for the final assessment. Negative residuals in black, positive in grey, values in the range [-2.2, 0.91].

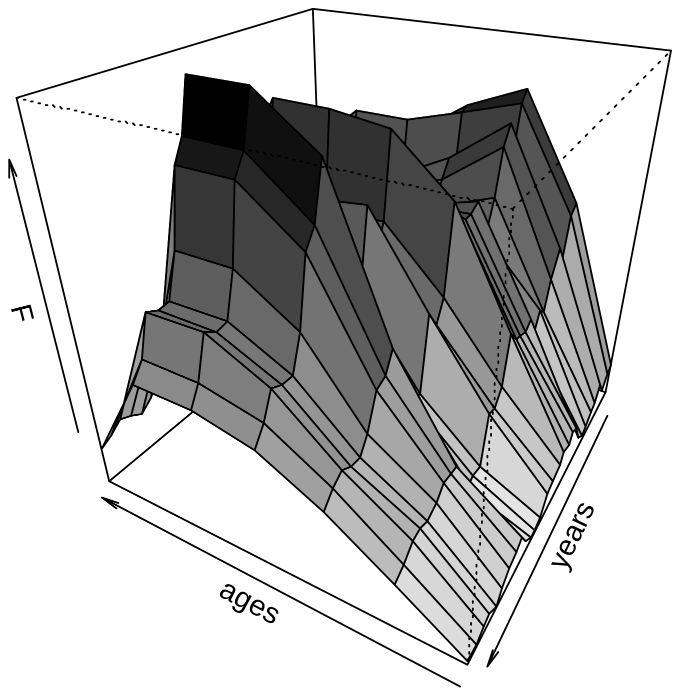


Figure 8.8.1.4: Sardine VIIIc and IXa: Year and age specific fishing mortalities estimated by the final assessment model.

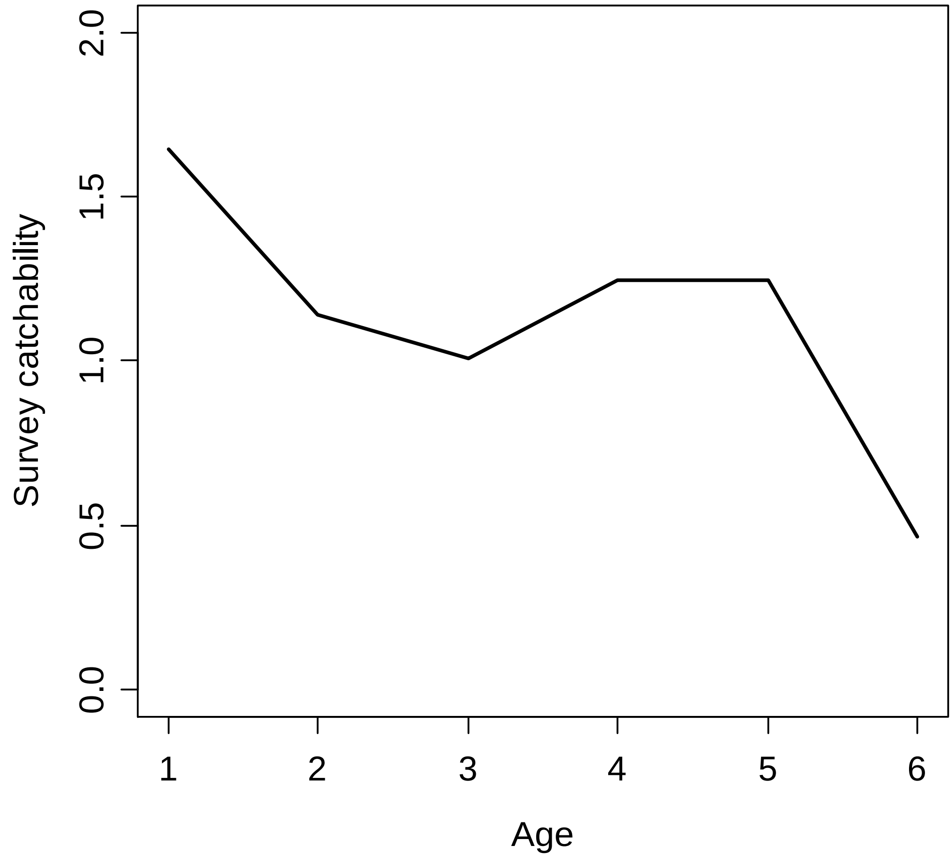


Figure 8.8.1.5: Sardine VIIIc and IXa: Survey catchability for ages 1 to 6+ in the final assessment model.

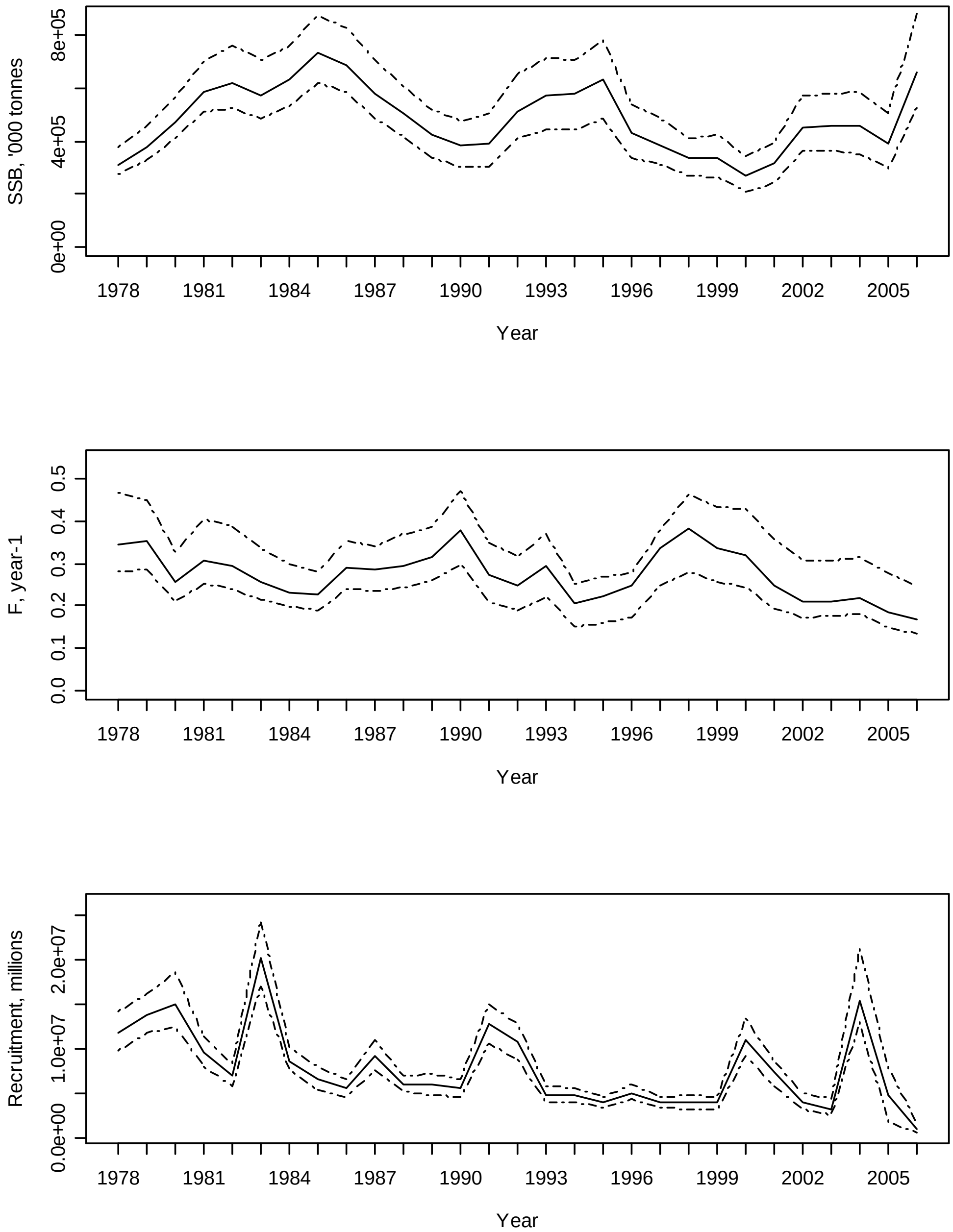


Figure 8.8.1.6: Sardine VIIIc and IXa: Bootstrap trajectories of SSB, recruitment and F for the final assessment model. Dotted lines represent the 90% limits

9 Anchovy – General

9.1 Stock Units

The WG reviewed the basis for the discrimination of the stocks in Sub-area VIII and Division IXa. No detailed study has been made to discriminate sub-populations along the whole European Atlantic distribution of the anchovy. Morphological studies have shown large variability among samples of anchovies coming from different areas, from the central part of the Bay of Biscay to the West of Galicia (Prouzet and Metuzals, 1994; Junquera, 1993). These authors explained that the variability is reflecting the different environments in the recruitment zones where the development of larvae and juveniles took place. They suggested that the population may be structured into sub-populations or groups with a certain degree of reproductive isolation. In the light of information like the well defined spawning areas of the anchovy at the South-east corner of the Bay of Biscay (Motos *et al*., 1996) and the complementary seasonality of the fisheries along the coasts of the Bay of Biscay (showing a general migration pattern; Prouzet *et al.,* 1994), the WG considers that the anchovy in this area has to be dealt with as a single management unit for assessment purposes. Recent genetic studies carried out on samples collected during 2001 and 2002 French acoustic surveys seem to show that two well separate types of fish exist but that they are both present all over the distribution area of the species in the Bay of Biscay. This is totally in agreement with the idea to deal with this population as a single management unit for assessment purposes at the stage of the art.

Some observations made in 2000 during the PELASSES survey in winter suggest the presence of anchovy in the Celtic Sea (Carrera, 2000). So far, these observations not affect our perception of one stock in the Bay of Biscay area. Anchovy found in the Celtic sea area is probably linked to the population of anchovy found in the Channel in spring by the professional fisheries.

Junquera (1993) suggested that anchovy in the Central and Western part of Division VIIIc may be more closely related to the anchovy found off the Western Galician coasts than with the anchovy at the South-east corner of the Bay of Biscay (where the major fishery takes place). Morphological studies, as mentioned previously, are influenced by environmental conditions and further investigations, especially on genetic characteristics, are necessary in order to be more certain. The WG considers that for assessment and management purposes the anchovy population along the Atlantic Iberian coasts (Division IXa) should be dealt with as a management unit independent of the one in the Bay of Biscay

In Division IXa, the differences found between areas in length distributions, mean length- and mean weight at age, and maturity-length ogives, which were estimated from both fishery data and acoustic surveys, support the view that the populations inhabiting IXa may be not entirely homogeneus, showing different biological characteristics and dynamics (ICES 2001/ACFM:06). The recent catch distribution of anchovy along Division IXa confirms that anchovy fishery is mainly concentrated in the Spanish waters of the Gulf of Cadiz (more than 80% of total landings), which is also corroborated by direct estimates of the stock biomass (about 90% of total biomass). Such data seem to suggest the existence of an anchovy stable population in the Gulf of Cadiz which may be relatively independent of the remaining populations in Division IXa. These others populations seem to be latent ones, which only develop when suitable environmental conditions take place, as occurred in 1995. (See section 11 and Ramos *et al*., 2001)

Recent studies on anchovy catches between North of Morocco, the Gulf of Cadiz and South of Portugal (Silva and Chlaida, WD 2003) show parallel changes of the catches in the period

1963-2000. There is a need for further studies on the dynamic on the anchovy in IXa and its possible connection with anchovies from other areas.

9.2 Distribution of the Anchovy Fisheries

The observations collected by the members of the Working group allowed defining the principal areas of fishing according to quarters. **Table 9.2.1** shows the distribution of catches of anchovy by quarters for the period 1991-2006.

In Subarea VIII during the first quarter in 2006, the very scarce landings were caught around the Gironde estuary from 45ºN up to 47ºN by the French fleet. During the second quarter, the main landings were caught in the Southern part of the Bay of Biscay (south of 45°N), mainly in Sub-area VIIIb. The Spanish Spring fishery in 2005 suffered a complete failure. Due to the results of the spring acoustic and eggs surveys, EU decided to close the fishery at the beginning of July 2005. For this reason, there are no catches in Sub-area VIII during third and fourth quarters. In 2006, both surveys have obtained the same result and the fishery was closed one more time. The fishery was still banned in 2007 but an experimental fishery takes place during spring. Fishermen were allowed to sell their catches under strict conditions, in order to avoid a too strong fishing pressure on an uncertain biomass and scientific surveys disturbance.

Anchovy fishery in Division IXa in 2006 was again located in the Gulf of Cadiz area (Spanish part of the Sub-division IXa South) throughout the year as observed in recent years. Highest landings this year from this Division occurred during the first and second quarters, which were mainly caught by the Spanish fleets fishing in the Gulf of Cadiz. Spanish catches from the Subdivision IXa North were negligible. Portuguese anchovy landings from Division IXa in 2006 were relatively low as compared with the Spanish ones. Most of the Portuguese anchovy was caught in the Subdivision IXa Central North during the second half of the year.

Changes in anchovy distribution: In the Bay of Biscay, the stock is seen to have nearly disappeared from the Spanish coast and lost spawning grounds. Anchovy distribution expanded in northern waters since 1994 with no particular change in the southern limit. The means by which anchovy is expanding in the North Sea was questioned. Some indices coming from many bottom surveys (from 1990 to 2005) are describing the expansion of anchovy in the North Sea. There are also two hypotheses: good recruitment in micro local northern populations or vagrancy of adults from southern populations attempting to establish new life cycles in the North. (Report of SGRESP, ICES CM 2005/G: 06).

Table 9.2.1: Anchovy general: Catch (t) distribution of anchovy fisheries by quarters in the period 1991-2007.

Q 1	DIVISION IXa				SUB-AREA VIII					
Year	IXa South	IXa CS	IXa CN	IXa North	VIIIc West	VIIIc Central	VIIIc East	VIIIb	VIIIa	VIIId
1991	1049	2	6	1	126	0	36	2797	1259	-
1992	1125	0	26	0	0	187	756	3666	958	-
1993	767	0	3	1	0	69	1605	4147	1143	-
1994	690	0	0	0	0	5	62	4601	786	27
1995	185	1	203	12	0	0	35		2380	
1996	41	0	1289	11	116	61	9	2345	0	-
1997	908	6.0	164	2	12	43	58	1548	925	-
1998	1782	109	424	192		472		4725	0	
1999	1638	65	91	76		65		4008	0	0
2000	416	61	41	0		88		4003	0	0
2001	1052	13	27	0		598		1406	0	0
2002	1775	80	6	3		14		3947	350	0
2003	1027	46	0	0		0		37	4	0
2004	1384	34	22	0		0		283	35	
2005	1383	4	21	1		2		413	0	0
2006	1294	9	58	1		4		29		0
2007	-	-	-	-		0		0		0

Q 2	DIVISION IXa				SUB-AREA VIII					
Year	IXa South	IXa CS	IXa CN	IXa North	VIIIc West	VIIIc Central	VIIIc East	VIIIb	VIIIa	VIIId
1991	3692	0	10	14	90	295	5848	3923	650	-
1992	1368	0	10	0	11	457	17532	2538	275	-
1993	921	0	6	0	25	24	10157	6230	658	-
1994	2055	0	0	0	1	79	11326	6090	163	75
1995	80	7	1989	1233	23	36	14843		6153	
1996	807	1	227	6	1	404	9366	8723	0	-
1997	1110	2	49	4	0	81	4375	3065	598	-
1998	2175	0	191	51		2215		5505	0	
1999	1995	0	4	7		7138		4169	0	0
2000	668	0	5	1		14690		3755	0	0
2001	3233	3	30	4		13462		7629	0	0
2002	2964	2	14	1		3312		2118	90	0
2003	2539	2	37	2		2007		2022	4	0
2004	1976	17	44	1		6010		2743	66	0
2005	2252	2	39	0		99		613	0	0
2006	2657	2	17	0		399		1225		0
2007	-	-	-	-		1		136		0

Q 3	DIVISION IXa				SUB-AREA VIII					
Year	IXa South	IXa CS	IXa CN	IXa North	VIIIc West	VIIIc Central	VIIIc East	VIIIb	VIIIa	VIIId
1991	703	0	0	0	24	15	145	386	1744	-
1992	499	0	4	27	192	390	632	191	4108	-
1993	167	0	0	0	1	8	1206	1228	6902	-
1994	210	8	29	1	61	6	1358	2341	3703	15
1995	148	52	1817	4043	1	10	55		3620	
1996	586	0	189	22	134	146	1362	171	6930	-
1997	2007	0	44	2	202	3	735	4189	2651	-
1998	2877	12	49	5		1579		205	11671	0
1999	1617	0	139	318		949		351	5750	0
2000	673	0	0	7		1238		211	8804	0
2001	3278	3	107	13		1314		249	8788	0
2002	2705	6	200	11		381		3181	2223	0
2003	984	0	52	9		46		159	3988	0
2004	1473	0	10	1		266		2514	3019	
2005	705	0	10	0		0		0	0	0
2006	415	0	2	3		7		88		0
2007										

Q 4	DIVISION IXa				SUB-AREA VIII					
Year	IXa South	IXa CS	IXa CN	IXa North	VIIIc West	VIIIc Central	VIIIc East	VIIIb	VIIIa	VIIId
1991	274	0	171	0	205	692	148	91	805	-
1992	4	1	96	6	8	18	204	27	5533	-
1993	105	1	13	0	0	0	574	1005	5106	-
1994	80	0	198	116	6	13	895	341	2520	14
1995	157	271	2716	42	398	148	18		2080	
1996	398	12	1002	5	21	12	158	204	4016	-
1997	589	0	353	54	93	83	530	1225	1354	-
1998	2710	32	231	123		27		1	5217	0
1999	692	30	723	12		98		0	4266	0
2000	603	0	25	2		98		266	3843	0
2001	1091	0	234	11		36		624	6042	0
2002	817	2	213	5		5		1041	845	0
2003	416	19	122	11		7		4	2317	0
2004	703	88	5	1		4		187	1181	
2005	82	1	13	3		0		0	0	0
2006	15	5	2	11		0		0		0
2007										

TOTAL	DIVISION IXa				SUB-AREA VIII					
Year	IXa South	IXa CS	IXa CN	IXa North	VIIIc West	VIIIc Central	VIIIc East	VIIIb	VIIIa	VIIId
1991	5717	3	187	15	445	1003	6177	7197	4458	-
1992	2996	1	136	33	211	1053	19122	6422	10874	-
1993	1960	1	22	1	26	101	13542	12609	13809	-
1994	3035	8	227	117	68	103	13641	13373	7172	130
1995	571	331	6725	5329	421	194	14951		14233	
1996	1831	13	2707	44	272	623	10895	11442	10946	-
1997	4614	8	610	62	307	210	5698	10027	5528	-
1998	9543	153	894	371		4294		10436	16888	0
1999	5942	96	957	413		8249		8529	10016	0
2000	2360	61	71	10		16113		8235	12647	0
2001	8655	19	397	27		15410		9908	14831	0
2002	8262	90	433	21		3713		10288	3508	0
2003	4968	67	211	23		2061		2222	6312	0
2004	5537	139	81	4		6280		5727	4300	0
2005	4423	6	82	4		101		1026	0	0
2006	4381	15	79	15		410		1342		0
2007	-	-	-	-		1		136		0

Not available

10 Anchovy Subarea VIII

10.1 ACFM advice and STECF recommendations applicable to 2006 and 2007

After the anchovy fishery was closed in the second half of 2005, the EU Council in December 2005 established for 2006 a provisional TAC of 5000 t, which may not be fished before the 1st of March, and required a ban on fishing activities if STECF advises that the spawning stock size in 2006 is less than 28 000 t.

In June 2006, the STECF assessed the Spawning Stock Biomass on the basis of the spring acoustic and DEPM surveys to be below Blim (21 000 tonnes) and recommended that the Biscay anchovy fishery should remain closed until reliable estimates of the 2007 SSB and 2006 year class become available based on the results from the spring 2007 acoustic and DEPM surveys. This implies a closure of the fishery until at least July 2007. Minimum levels of recruitment needed to provide an SSB above current B_{lim} and current B_{pa} in the absence of fishing are provided in the report. The subgroup emphasises that any recovery is entirely dependent on good incoming recruitment.

The closure of the anchovy fishery until the end of 2006 was established by the European Commission on 20th July 2006 stating that as the anchovy spawning stock biomass at spawning time in 2006 is below the threshold of 28 000 tonnes, the fishery has to be prohibited for the remainder of 2006.

In December 2006, the EU Council decided to continue the fishery closure and established a zero TAC for the Bay of Biscay anchovy in 2007. In addition, the EU Council stated that to gather information on the state of the stock, after consultation of the STECF and under the supervision of the Commission, a maximum of 10 % of the French and Spanish fishing effort (20 Spanish vessels and 8 French vessels) may be deployed in zone VIII for experimental fishing with scientific observers on board from 15 April until 15 June 2007. Catch reports have to be submitted to the Commission every 15 days by the Member States concerned. The Commission will suspend the experimental fishery once sufficient data has been collected. The Commission will then, as appropriate, adopt the decision foreseen in Article 5(5) of this Regulation on the basis of an STECF advice.

Accordingly, in an attempt to maximise the utility of any information from the fishery for stock assessment, the STECF convened an expert working group in February 2007. The STECF considered that the current spring surveys are already sufficient to assess the status of the stock in spring and provide management advice for the rest of the year and that a free commercial fishery would not provide any useful additional data for an evaluation of stock status or incoming year-class strength in 2007. Therefore, the STECF recommended that the commercial vessel effort proposed for such a fishery would be better deployed in a “consort” role to provide supporting fishing and surveying activity for the existing research vessel surveys in the spring of 2007 (PELGAS, PELACUS and BIOMAN) and that if additional commercial vessel effort beyond that to support the surveys is allowed to take place in 2007, a multi-vessel acoustic/fishing survey (“Rake” survey) should be carried out by commercial vessels.

In April 2007, the Commission and the concerned member states agreed the conditions for the 10 fishing vessels (7 Spanish and 3 French vessels) participating in the consort surveys for the BIOMAN and PELGAS Spring surveys and for the experimental fishing of the remaining 18 vessels (13 Spanish and 5 French vessels). The Spanish purse seines not participating in the consort surveys collaborated in a rake survey, whereas the French vessels conducted an experimental fishing.

The STECF met again in June 2007 to assess the anchovy spawning stock biomass based on the information from the spring scientific surveys and to analyse the value of the information gathered by the commercial vessels. The STECF noted that there are clear signs that the stock situation has improved compared to 2005. However, spawning stock biomass remains very low and maximum protection of the remaining spawning population is required. STECF recommended that the fishery should remain closed in 2008 until reliable estimates of the 2008 SSB and 2007 year class become available based on the results from the spring 2008 acoustic and DEPM surveys. This implies a closure of the fishery until at least July 2008.

Following the STECF advice and after close examination of the submissions made by member states, the Commission decided on 19th July 2007 that the Bay of Biscay anchovy fishery will not be reopened until the end of the year.

10.2 The fishery in 2006 and 2007

Introduction: Two fleets operate on anchovy in the Bay of Biscay: Spanish purse seines and French fleet constituted of purse seiners and pelagic trawlers. The pattern of each fishery has not changed in recent years (Table 10.2.1.1 and Figure 10.2.1.1). The seasonal fisheries by countries are described in the MHSAWG report (ICES 2004). In general (1992-2004), most of Spanish landings (85 %) are usually caught in divisions VIIIc and VIIIb in spring, while 35 % of the French landings are caught in divisions VIIIb in the first half of the year and 65% in summer and autumn in division VIIIa (Table 10.2.1.2). Catches by fleet is given in Table 10.2.1.3, showing the seasonal distribution by area of each country in 2006.

Spanish purse seine fleet: The Spanish fleet is composed of purse seines (of about 200 boats) that operate at the south-eastern corner of the Bay of Biscay (in Divisions VIIIc and b), mainly in spring, when usually more than 80 % of the Spanish annual catches occurred (table 10.2.1.2). The major part of this fleet goes for tuna fishing in summer time and by then they use small anchovies as live bait for its fishing. These catches are not landed but the observations collected from logbooks and fisherman interview (up to 1999) indicate that they are supposed to be less than 5 % of the total Spanish catches. The Spanish fleet did not go to fish in subarea VIIIa since 2002.

French fleet: the main catches are produced by pair trawlers. The French fishery starts normally at the beginning of the year in the centre of the bay of Biscay. Progressively, the fishery is moving towards the south of the bay of Biscay (generally in April). After a voluntary break of the pelagic fishery (bilateral agreement) in April and May, the fishery moves north, and reaches sometimes the northern part of VIIIa in August or September. Later, the fishery moves to the centre of the bay. The major fishing areas are the north of the VIIIb in the first half of the year and VIIIa, mainly, during the second half. Area VIIIc is prohibited to the French pelagic fleet. A part of pelagic trawlers are opportunistic: looking at annual catches vessel by vessel, a high number of them can catch a small amount of anchovy at least once a year. Therefore, a good proportion of them are polyvalent and a threshold of 50 tons per year has been decided to separate target trawlers to occasional one. Therefore, the number of vessels that fish anchovy with a pelagic trawl can be very variable from year to year. (Duhamel E. et al, WD 2004).

French purse seiners are also opportunistic and they always operate around their home harbour, in coastal waters. Catches of anchovy by purse seiners are not regular because their real target species is sardine. Some French purse seiners located in the Basque country fish mainly in spring in VIIIb and the Brittanish one fish occasionally anchovy during autumn in the north of the Bay of Biscay.

10.2.1 Catches for 2006 and first half of 2007

Catches in 2006 (Table 10.2.1.1): Since 2005, France and Spain agreed on a major reduction of the commercial fishery. Subsequently the fishery was stopped and claimed for financial aids in july 2005, along with a ban of the international fishery. It reopened in February 2006 with a small TAC and was stopped one more time in july 2006. The 2006 international catches of the first half of the year amounted about 1750 t, which represents only 19% of 2004 catches for the same period. (Table 10.2.1.2).

Due to the failure of the fishery and subsequent closure in July (both years 2005 and 2006), the catches made during the first half of the year accounted for the total annual catches.

Catches in the first half of 2007 : The fishery was still closed in 2007 but an experimental fishery took place during spring. Fishermen were allowed to sell their catches under strict conditions, in order to avoid a too strong fishing pressure on an uncertain biomass and scientific surveys disturbance. Landings by France amounted to 136 tons during this experimental fishery. Spanish fishermen did not participate in this experimental fishery and therefore, no significative landings were reported for Spain (around 1 ton);

For more detail about this experimental fishery, see chapter 10.2.3.

After the new review of the survey's SSB estimates, the fishery was closed in July 19th .2007.

10.2.2 Discards

There are no estimates of discards in the anchovy fishery but it does not appear to be a significant problem.

10.2.3 Experimental fishing surveys in 2007

In December 2006 the Council of Ministers established a zero TAC for the Bay of Biscay anchovy and decided to authorize the use of 28 commercial vessels (20 Spanish and 8 French vessels) from 15 April until 15 June 2007 to gather information on the state of the anchovy stock, in addition to the spring scientific surveys (acoustics and DEPM) regularly utilised to estimate both the strength of the incoming new year-class and the Spawning Stock Biomass (SSB).

In April 2007, after asking advice to the STECF about how to maximise the added value and utility of any information from the fishery for stock assessment, the Commission and the member states agreed that 10 vessels (7 Spanish and 3 French) participated in the 'consort fishing' in association with the scientific research vessels which were operating in the Bay of Biscay up till the end of May, whereas the remaining 18 vessels (13 Spanish and 5 French vessels) were allowed to conduct experimental fishing. Therefore, 3 kinds of surveys occurred :

1 Spanish rake survey (13 Spanish purse seiners) (**section 10.2.3.1**)

1 experimental fishing survey for 5 French vessels (4 pair trawlers and 1 purse seiner) under a range of constraints and limitations (**section 10.2.3.2**.)

2 consort surveys : one combined with PELGAS07 survey (3 Spanish purse seiners : 2 French pair trawlers and 1 French purse seiner) and one combined with BIOMAN survey (4 Spanish purse seiners) (see **sections 10.4.2.3. & 10.4.1.**)

10.2.3.1 Spanish Rake Survey (purse seine vessel fishing survey) in 2007

The Rake survey was carried out between May 4th and 22nd, although due to bad weather conditions it was interrupted on May 14, 15 and 16th. It started from Galicia (around 9º18' W) and the vessels were planned to follow established tracks from west to east along the

Cantabrian coast, and then to the North up to 45º30ºN along the French coast. Radials were always perpendicular to the coastline and extend to 20 nm beyond the shelfbreak in both Cantabrian and French coasts (**Figure 10.2.3.1.1**). The vessels made opportunistic hauls when fish shoals were detected. 6 of the vessels worked at day hour and the other 6 at night. An additional vessel coordinated the job of both groups.

A total of 110 fishing hauls were carried out. The overall catch of anchovy during the survey was around 4,500 kg with 106 kg by haul. Anchovy total and relative (by haul) catches during the Rake survey were higher than those obtained for a similar survey during the same period of the year in 2005 (PROA 2005 survey, Cotano, U. & A. Uriarte, 2005) (42 kg and 7 kg/haul respectively in 2005). This result seems to indicate a recovery of fishing profitability and from a qualitative point of view it seems to reflect an uncertain partial recovery of anchovy stock from 2005 to 2007.

Captures by haul and vessel were significantly lower that those obtained by commercial vessels during a normal fishing season (for example, 406 kg by haul in 2006, Cotano and Uriarte 2006) although the fishing strategy is completely different since a rake strategy does not allow to concentrate fishing activity in the high abundance areas such as a commercial fishing does. For this reason the relative captures by haul cannot be compared and no comparison with a normal fishery can be made from these results.

Anchovy was regularly found in the south-eastern area of the Bay of Biscay and over the French shelf. Two main areas of anchovy concentration were found, one at South of the French shelf, over the Cap Breton area and to the North, up to 44º30’N, especially in an area around 200m depths (**Figure 10.2.3.1.2**). The other area was that located slightly at south of the mouth of the Gironde River between the coast and with maximum depths of 100 m. This distribution closely matches with the spawning distribution found during the anchovy MPDH survey in 2007 (according to the eggs abundance distribution, Santos et al., 2007). Over the Cantabrian shelf the presence of anchovy was limited to small shoals from 5º10’W to 3º50’W and to the east of 2º10’W. Although some fish concentrations were detected from 3º50’W to 2º10’W there was no chance to verify if they were anchovy due to the bad weather conditions which did not allow to carry out any fishing haul by the time the survey passed trough.

Anchovy spatial distribution by size showed a high concentration of small anchovy around the mid south part of the Gironde River, bigger anchovies over the Cap Breton area and a wide anchovy size range over the Cantabrian shelf (**Figure 10.2.3.1.3**). This size distribution matches with those usually obtained in previous years from both commercial catches and from the anchovy DEPM surveys.

The percentage of 1 year old in the hauls can be considered as a gross index of the percentage of age 1 in the population if proportionality between hauls and anchovy abundance is assumed. This percentage (67%; CV= 7%) was similar to that obtained in 2006 from commercial catches (60%) and higher that those obtained for previous years, with the exception of 2004. Nevertheless this percentage was lower than that obtained for the population in 2006 by the DEPM (82.9 %; Santos *et al.*, 2006).

10.2.3.2 French experimental survey in 2007

Five French fishing vessels were allowed to carry out experimental fishing between 15/4 and 10/6. It was designed as a compromise between scientific, political and economical requirements. The design was not a rake one but the spatial coverage was hoped to be completed by setting some constraints on fishing operations: limitation of 3t / vessel / day, each location should not be revisited until 6 days after a catch has been done, and surveys area should be avoided 6 days before each scientific survey (PELGAS & BIOMAN) not to spoil the reliability of assessments.

From 15 April to 15 June, the total amount of Anchovy caught was 140.6 tonnes (**Figure 10.2.3.2.1**.), most of them from pelagic trawlers (500 kg from purse-seiners). This landings figure does not reflect what could have been the results of a free commercial fishery. This is due to the small amount of vessels involved (limiting the prospecting process), some bad weather during two weeks, the constraint mentioned above, and the lack of commercial market for anchovy.

The results in terms of precise locations and biological information were not still precisely analysed and only length distributions and biological data provided by some samples will be usable by comparison with the ones obtained during the scientific surveys. It was clear that any attempt to use these catch information for any comparison of catch rates, or as a possible index of abundance was not possible.

10.3 Biological data

10.3.1 Catch in numbers at Age

In 2006 the age composition for both countries was based on routine sampling of catches for length and for grade compositions and on biological samples collected from surveys and market sampling:. Table 10.3.1.1 provides the age compositions by quarters and by countries in 2006. In Spanish and French catches age 1 was predominant during the 1st semester. It must be noticed that fishery was closed at 20st july..

Table 10.3.1.2 records the age composition of the international catches since 1987, on a half-yearly basis. 1-year-old anchovies have usually predominate largely in the catches during both halves of most of the years. However 2 years old anchovies are predominant in international catches during the first half of 1999, 2002 and 2005. Figure 10.3.1.1 shows the Spanish and French catch at age compositions of the first half of the year since 1987. The Spanish age composition during the first half of several recent years (2002, 2003 and 2005) are predominated by the age 2. In the French fishery the age group 1 usually contributes to 62% of the landings of the first half of the year, with a few exceptions (1991, 1999, and 2002). In the first half of 2006, the age groups 1 to 3 contribute to 69%, 23% and 7 %, respectively.

No age composition of the French experimental fishery catches during the first half of 2007 were available for the WG, but the analysis of the surveys samples reveal a preponderance of 1 year old (reaching about 60 %, which is a classical situation).

The catches of anchovy corresponding to the Spanish live bait fishery have not been provided since 2000. The Table 10.3.1.3 gives the data available for the period 1987 – 1999. These are traditionally catches of small anchovy mainly of 0 and 1 year old groups amounting about 5 hundred tonnes or less. Fishermen reported that they could hardly catch any juvenile anchovies for live bait tuna fishing in summer-autumn 2004. A similar observation in 2001 was followed by the failure of recruitment in 2002. In 2005 an 2006, because of the ban on the fishery, live bait catches of anchovy were not allowed in Bay of Biscay. So, Spanish vessels went to the Galician coast or remain along the Cantabrian coast to get small sardine and mackerel.

10.3.2 Mean Length at age and mean Weight at Age

Table 10.3.2.1 and Figure 10.3.2.1 show the distribution of length of catches and the variation of mean length and weight by quarters in 2006 .

For the first quarter, in 2006 the fishery reopened at the end of the quarter. So, no significant landings were reported for Spain : only 4 tons, with a large length distribution. French catches amounted about only 29 tons, with a 13 cm mode.

For the second quarter, French catches showed a uni-modal distribution with a mean length of 13.86 cm. On average, the anchovies landed by the French fleet are a little bit smaller than those caught by the Spanish one in the second quarter (Figure 10.3.2.1)..

For the third quarter, catches represents just 3 weeks of fishing, because of the closure of the fishery at july 20^{th}. These very few landings are mainly due to the French vessels (88 tons against 7 for Spanish). The length distribution showed a 14 cm mode.

Because of the closure of the fishery, no catch were reported during the fourth quarter.

The series of mean weight at age in the fishery by half year, from 1987 to 2006, is shown in Table 10.3.2.2. The French mean weights at age in the catches are based on biological samplings from scientific survey and commercial catches.

Spanish mean weights at age were calculated from routine biological sampling of commercial catches.

Sampling during second half of 2006 was very poor because of the low level of catches (closure in July). Therefore, weight at age for this period are not really accurate. This has no impact on assessment as these data are not used in Bayesian model.

10.3.3 Maturity at Age

As reported in previous years reports, anchovies are fully mature as soon as they reach 1 year old, at the following spring after they hatched. No differences in specific fecundity (number of eggs per gram of female body weight) have been found so far according to age (Motos, 1994).

10.3.4 Natural Mortality

For the purpose of the assessment applied in the WG, a constant natural mortality of 1.2 is used. However, the natural mortality for this stock is high and probably variable. Natural mortality estimates after Prouzet et al, 1999 suggest that this parameter could vary from 0.5 to 3. From the results obtained, M (natural mortality) can vary widely among years and it seems that the assumption of a constant M used for the current management procedure is a strong simplification of the actual population dynamic.

In 2005, a seasonal separable VPA for the different fisheries operating on anchovy was carried out, by which estimating a pattern of natural mortality values were attempted. However, as with other analytical models, natural mortality is confounded with catchability and fishing mortality and recruitment. Without some independent measure it is difficult to estimate M with the current model formulation and with the available data. Therefore, at the end the conclusion from such analysis was that by the moment, the simplest approach is to stay with the assumption of constant natural mortality of 1.2 for ages and years, which is a solution as good as any other so far attempted and is around the minimum WSSQ obtained for a set of model fittings for a range of natural mortality values. The catchability of the adult sampling for the surveys or the potential for a changing in natural mortality across age or between years for this population are issues that deserve further independent analysis.

10.4 Fishery Independent Information

10.4.1 DEPM surveys

Egg surveys to estimate the spawning stock biomass (SSB) of the Bay of Biscay anchovy through the Daily Egg Production Method (DEPM) have been implemented from 1987 to 2007, with a gap in 1993 (**Table 10.4.1.1**).

Daily Egg Production Method on anchovy in 2007 (DEPM2007)

In 2007 the DEPM survey (BIOMAN07) was carried out in May 2007, between 3 and 23 of May, by AZTI-Tecnalia within the frame of the Spanish Fishery Monitoring National Programme contracted with the European Commission and co-founded by the Basque Government (Santos et al. WD2007). Preliminary SSB estimate presented at STECF in June 2007 at Ispra (Italy) was 25,309 tonnes with a C.V. 20% (STECF 2007). This estimate was based on the ratio of the total egg production (Ptot) and a Daily Fecundity (DF) inferred from a linear regression model between DF and sea surface temperature (SST). Until the histological process of adult samples is fully completed, the DF is hereby estimated based on a preliminary spawning frequency estimate inferred from its relationship with the Sea Surface Temperature (SST) in the historical series. **The preliminary biomass estimate for this ICES WG resulted in 25,973 t with a coefficient of variation of 14%.**

Sampling strategy was similar to previous years. The text table below summarises the different surveys contributing with samples to the application of the DEPM during May 2007:

Description of egg and adult samples obtained for the implementation of the DEPM

Parameters to estimate	Survey	Vessel	Date	Samples	Selected samples
Total egg production & Spawning area	Bioman 07	R/V Investigador	3-23 May	420	420 egg samples
Daily fecundity & Numbers at age	Bioman 07 Consorts Bioman 07 Pelgas 07	R/V Investigador Purse seines R/V Thalassa	3 - 23 May 3 - 23 May 27Apr - 27 May	4 34 84	10 adult samp. 20 adult samp. 0 adult samp.

The area covered was the southeast of the Bay of Biscay, from 43º20' to 46º37'N and from 1º10' to 5ºW, which corresponds to the main spawning area of anchovy. The total area surveyed was 56,079 km^2. The map of egg abundance and the positive spawning area for 2007 is shown in **Figure 10.4.1.1.** (number of eggs per 0.1 m^2) with the limits of the spawning area (34,449 km^2). The anchovy eggs were concentrated in two principal areas: the area of Cap Breton between at 43º50' N and 44º15' on the isoline of 200m, and at costal areas in the Gironde area between 45ºN and 46º10' until the isoline of 100m. Egg abundance was low across the Cantabric coast. From the 420 PairoVET samples, 235 stations were positive for anchovy eggs with an average of 16 eggs per station and a maximum of 308 eggs/0.1m^2 in the Gironde area.

Egg Production: Once the staged eggs were transformed into daily cohort abundances using the Bayesian ageing method developed within the GAM project (Ibaibarriaga et al. 2007), daily egg production (P0) and daily mortality (Z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age.

The model was fitted as Weighted Non Linear Regression Model and as Generalised Linear Model with Negative Binomial distribution and log link. In both cases, the ageing process and the model fitting are repeated until convergence. Eggs younger than 4 hours and older than 90% of the incubation time are removed from the model fitting to avoid any possible bias.

For both models this year the hourly mortality rate resulted to be non-significantly different from zero (p-value 0.846 and 0.1 for non linear regression and generalised linear models respectively). It was decided then to search for an alternative z based on the past historical series and then, to estimate P0 from the exponential mortality model based on the modelled value of z.

Two alternative models were considered for estimating z: (a) average daily mortality rate from the historical series and (b) natural logarithm of z depending linearly on sea surface temperature (SST) as has been previously proposed for pelagic fish eggs in Pepin (1991). Model (b) resulted to be significant (p-value=0.002) and explained around 40% of the variability (**Fig 10.4.1.2**). Its reliability in comparison with the average model (a) was checked by cross-validation following the approach described in Francis (2006)

The average sea surface temperature in the DEPM 2007 survey was 15.38ºC. Hence, the expected daily mortality rate value according to model (b) is 0.203. Based on this fixed value of z the resulting P_0 and P_{tot} estimates from the nonlinear regression and generalised linear model are given in **table 10.4.1.2.** F**igure 10.4.1.3** shows the exponential mortality model adjusted to the egg densities by ages per sampling surface unit using a GLM with a negative binomial distribution and a log link

The anchovy egg distribution in 2007 occupies an extension slightly higher than the last 4 years and the total egg production estimates is superior in approximately 29% comparing with the one estimated for 2006 applying a GLM.

Adult sampling: The adult samples were obtained from three different sources: samples taken during BIOMAN 07 on board R/V Emma Bardán (pelagic trawl), samples taken by the 4 consort commercial purse-seines and samples taken from the acoustic survey PELGAS 07 conducted by IFREMER. None of the samples from the French survey were selected for the analysis due to the differences in date and space with the egg samples. From a total of 44 samples 30 were selected according to its coincidence in time and space with the sampling of eggs (**Figure 10.4.1.4**).

Daily Fecundity estimates: Processing of adult samples for the estimation of the parameters sex ratio, mean weight of mature females and Batch fecundity were followed as applied in previous years, resulting in the values of **Table 10.4.1.3**. The examination of gonads for the spawning frequency (S) estimation is still in process and a revision of the procedure to estimate this parameter is being implemented; their results being expected for December this year (submitted to ICES WGACEGGS).

According to a lower mean weight and younger age composition of anchovies close to shore than those in the outer shelf regions (**Figure 10.4.1.5)**, a search for any difference in the batch fecundity was made (Santos *et al.* WD2007): no differences were found.

Since the spawning frequency (S) is not available yet, some inference of that value is required. Two models based on the historical series were considered (**Figure 10.4.1.6**): (a) S is just the average from the time series and (b) S is linearly dependent on Sea Surface Temperature (SST). Inference showed that model (b) resulted to be significant (p-value=0.04), explaining around 25% of the variability. In addition, the cross-validation method (Francis 2006) gave PVE=16%, indicating that model (b) is slightly more reliable than model (a). The final S of about 25% (CV=14.2%) was finally very close to the historical mean (25.8%, CV= 14.2%).

All these parameters resulted in a Daily Fecundity estimate of about 60 eggs/(gram & day) which is very similar to the one estimated in June at STECF meeting (61,3eggs/gram & day).

Spawning Population estimates: The current preliminary SSB estimate resulted in **25,973 t with CV of 14%**, similar to the one estimated in June (25,300 t) for the STECF. This supposes an increase of 21% regarding last year estimate. The current estimates of adult parameters and biomass from the DEPM in 2007 with their corresponding Standard error (S.e.) and coefficient of variation (CV) are shown in **table 10.4.1.3**.

For the purposes of producing population at age estimates (**Table 10.4.1.5**), the age readings based on 1,977 otolith from 10 samples collected on board R/V Emma Bardán and 24 on the 4 consorts purse-seines were available. Estimates of anchovy mean weights and proportions at age in the adult population were computed as a weighted average of the mean weight and age composition per samples where the weights were proportional to the population (in numbers) in each region. These weighting factors are proportional to the egg abundance per region divided by the numbers of samples in the region and the mean weight of anchovy per sample(**table 10.4.1.4**). Weighting factors were allocated according to the amount of samples in 5 regions defined in **figure 10.4.1.7**, and equally according to the relative egg abundance in those areas. (see details in Santos *et al* WD2007).

A summary of the past historical series of Biomass and Population at age are plotted in **figures 10.4.1.8** and **9**. Current recruitment is quite similar to the one observed in last year by the DEPM, so still of a low level regarding historical estimates (Table 10.4.1.1).

Concerning the input for the Bayesian Biomass Model (BBM) the numbers at age 1 imply in mass about 61,7% of the SSB (i.e. around 16,030 t).

10.4.2 Acoustic surveys

10.4.2.1 PELACUS04 Surveys spring

PELACUS0407 was carried out onboard R/V *Thalassa* between 28th March – 23rd April, with the main aim to assess the pelagic fish community off the North Iberian Peninsula (Figure 10.4.2.1.1). Biomass estimates are obtained for the main pelagic fishes in the survey area, including sardine, mackerel, horse mackerel and, whenever it is present in sufficient fishing hauls, anchovy. For the 2007 survey, a high number of anchovy eggs in the CUFES sampler (the largest in the available time series 2000-2007) was observed (Figure 10.4.2.1.2). Also, the eggs were covering most of the shelf in the area between 4 and 6 º W, west of the main egg distribution area. A total of 16 out of 52 fishing stations caught anchovy, and acoustic estimates of biomass of anchovy were 2,900 tn , distributed in a number of small patches through the Cantabric sea (Figure 10.4.2.1.3).

The PELACUS04 survey series does not cover the main area of anchovy distribution within the Bay of Biscay, and therefore anchovy biomass estimates from this survey are not used for its assessment. Nevertheless, the variable presence of anchovy in the area surveyed by PELACUS may be an index of changes in the spatial structure of the stock, related to either oceanographic or demographic properties. In this sense, anchovy data gathered in the PELACUS survey can be of interest to analyse changes in the Bay of Biscay anchovy distribution, and can be also used to improve the coverage of the acoustic and DEPM anchovy surveys.

10.4.2.2 PELGAS07 survey

The French acoustic survey estimates available from 1983 to date are shown in Table 10.4.2.2.1. In 1993, 1994 and 1995, the survey was targeted only on anchovy ecological observations and mainly close to the Gironde estuary, the Gironde being one of the major spawning areas for anchovy in the Bay of Biscay. In 1997, 1998 the surveys were broadened in scope to provide acoustic abundance indices for anchovy as well as the ecological work (Anon. 1993/ Assess:7).

In 2000 and 2001 a series of co-ordinated acoustic surveys were planned covering the whole continental shelf of south-western part of Europe (from Gibraltar to the English Channel). These were carried out within the frame of the EU Study Project PELASSES. The main objective of these cruises was the abundance estimation using the echo-integration method of the pelagic fish species present off the Portuguese, Spanish and French coast. Surveys were conducted in spring, using two research vessels: R/V Noruega for the southern area (from Gibraltar to Miño river – south Galicia) and R/V Thalassa for the northern area (North Spain and France) and combining two different survey methodologies: acoustics and CUFES. Since 2002, France continued regular spring surveys, using the same method as in the PELASSES project. These also followed the same transect layout in the overall area.

The 2007 acoustic survey PELGAS07 (Massé & al. WD 2007) was carried out in the bay of Biscay from April 26st to May 26th on board the French research vessel Thalassa. The objective was the same than since 2000, to study the abundance and distribution of pelagic fish in the Bay of Biscay and to study the pelagic ecosystem as a whole. The target species were mainly anchovy and sardine but were considered in a multi-species context.

To obtain an optimal horizontal and vertical description of the pelagic ecosystem in the area, two types of actions were combined: i) Continuous acquisition by storing acoustic data (from five different frequencies : 18, 38, 70, 120 & 200 kHz) and pumping sea-water under the surface, in order to evaluate the distribution of fish eggs using CUFES system, and ii) discrete sampling at stations (by trawls, plankton nets, CTD). Concurrently, a visual counting and identification of cetaceans and of birds (from board) was carried out in order to characterise the higher level predators of the pelagic ecosystem.

Abundance and distribution of adults from acoustics

A total of 1447 prospected nautical miles were usable for assessment purposes and 39 pelagic hauls were carried out for identification of echo-traces (figure 10.4.2.2.1).

As the previous years, after echogram scrutiny, the global area has been splitted into strata where coherent communities were observed (species associations) in order to minimise the variability due to the variable mixing of species (Figure 10.4.2.2.2). Allocation to species was therefore done using the standard method (Massé,J, WD2001) and biomass were estimated for main pelagic species according to aggregation categories and identification hauls (Table 10.4.2.2.2-a.).

Nota : In 2007, Commercial vessels were used as consorts during PELGAS survey (see chapter 10.4.2.3.) but the information from the six French trawlers, and two French and three Spanish purse seiners, were not used in the stock estimation for the assessment to maintain continuity in the time series. However data exploration showed that the inclusion of catch data from these vessels did not substantially alter the perspective of the stock. Biological information from some of the vessels was only used to improve the age determination for the estimate, and also to refine the stratification of the survey area for analysis.

Some bad weather occurred in the middle of the survey, nevertheless, the whole potential area for anchovy distribution has been covered in suitable conditions and its biomass assessment by acoustic was possible.

Anchovy was observed (figure 10.4.2.2.3.) all along the coast from Bayonne (43° 40 N) to l'Ile d'Yeu (46°40 N), mostly mixed with sardine in the south of the Gironde and with sprat in the north. On the platform, anchovy was omnipresent and usually mixed with horse mackerel. Echo-traces were most of the time vertically spatialized, horse mackerel closed to the bottom and anchovy as soft and small schools 15 to 25 m above. In the area called "Fer à cheval", anchovy was predominant between 90 m and 140 m bottom depth (between 44° 40 N and 45° 30 N), most of the time pure and observed as soft high "candles" between 10 m and 50 m above the bottom. The presence of anchovy was alternate with mixed mackerel and horse mackerel.

It must be noticed that contrary to what was observed during the recent years (ICES-2006) the aggregation pattern of anchovy during this PELGAS07 survey was more similar to the 80s and 90s than during the last 5 years. During the last surveys (until 2006), anchovy appeared more and more often close to the surface as very small schools or even scattered. This year they seemed to gather in small schools aligned 15 to 20 m above the bottom as it was the case in the 80s and 90s (Massé, 1996) and almost no surface schools were observed.

A biomass estimate in tons and in number has been processed for each area at age group (table 10.4.2.2.2.b.), using length distributions at each closest haul. Length distributions of anchovy are shown in figure 10.4.2.2.4, as usual, small fish is mainly present in the coastal area whereas bigger fish are offshore. According to these different length structure, the age/length key has been applied to each length distribution separately. Mean weight at age for 2007 are also gathered in table 10.4.2.2.2.b

Eggs abundance and distribution

During this survey, in addition of acoustic transects and pelagic trawl hauls, 650 CUFES samples were collected and counted, 47 vertical plankton hauls and 81 vertical profiles with CTD were carried out. Eggs were sorted and counted during the survey.

The number of eggs collected by CUFES during the survey (figure 10.4.2.2.5.) was far higher than previous years, even higher than during the year 2001 which was a strong maximum for the time period 2000-2006 (figure 10.4.2.2.6.).

The spawning areas were located as usual in the south of the Bay of Biscay, over almost the whole shelf, with maximum values along the south of ‘The Landes’ coast and over the slope, as well as over the 50 meters isobath in front of the Gironde estuary. No anchovy egg was counted north of the Loire estuary, and over the 100 meters isobath north of the 45°10’.

PELGAS series

These spring acoustic surveys are yearly carried out in the Bay of Biscay since 2000 applying the same surveying and sampling strategy. Looking at the series, two kinds of results may be considered. On the one hand the adult length distribution in absolute numbers (figure 10.4.2.2.7.) compared for the same series which shows the decrease in total abundance since 2003 and mainly in small individuals since 2002 with a slight increase in 2006 and 2007. It can be noticed that small anchovies are always present mainly in front of the Gironde.. On the other hand, the age compositions in numbers along the same series (figure 10.4.2.8) shows the same decrease and particularly the lack of age 1 in 2005 but an increase in 2006 and 2007 with a more normal age distribution with respectively 74% end 66% of age 1.

Biomass estimates by acoustic survey since 1983 are shown in Figure 10.4.2.9. with the exception of 1985-1988. During this period, estimated biomasses have fluctuated between circa 18,000 tonnes to more than 130,000 tonnes.

Hydrological conditions

Hydrological conditions observed during PELGAS07 are striking looking at the temperature. As soon as January, the surface temperature is about 1°C higher in 2007 when compared with a mean situation calculated over the years 1985-2001 (Figure 10.4.2.10.). It keeps warming more than usual to reach an anomaly maximum of 3°C during the beginning of the survey. The wind event at mid-May tends to reduce the temperature anomaly for the last part of the survey, which explains the strong temperature gradient between the south and the north of the Loire estuary observed on figure 10.4.2.11. The relative high river runoffs during the end of the winter tend to reduce the salinity over a large part of the Bay of Biscay, but the river plumes are not much visible during the survey due to low river discharges in April, especially the Loire plume (Figure 10.4.2.12.).

Conclusion :

The Pelgas07 acoustic survey has been carried out in good conditions, at least for the anchovy distribution area for which the biomass assessment was possible. The bad weather mainly occurred during the second half of the survey, when the potential area of anchovy presence was already covered. The biomass estimated during spring 2007 is globally higher than the biomass observed in 2006 and much higher than in 2005, but still below the period 2000-2004. In spring 2007, the anchovy spatial distribution was broad but generally not dense. It was present all along the coast from Bayonne to l'Ile d'Yeu mixed with sardine or sprat and offshore mainly in "fer à cheval" area or in the southern platform mixed with horse mackerel.

The anchovy biomass from the Pelgas07 survey has been estimated at 41 000t. The number of 1 year old anchovy was estimated at 1 437 millions fish. The global population observed in the Bay of Biscay was composed of 66.2 % of age 1 (bigger than 2005 year class), 29.1 % of age 2 and 4.7 % of age 3+. The mean length of age 3 seems to be lower than age 2.

On the one hand, it must be noticed that this better configuration of anchovy biomass is accompanied by a more traditional school pattern as it was usually observed in the ‘healthy’ years during the 90s or beginning of 2000. This can be also due to the fact that horse mackerel and sardine were very rarely observed during the survey. Another element is that marine mammals were very rarely observed this year. All these features could explain a rather good presence of fish behaving in similar way than in years when the biomass was at its highest levels.

On another hand, it can be also noticed that the number of eggs observed by CUFES was particularly high, twice the amount observed in 2001 which was the highest year among the 7 years series. The hydrological conditions which where characterized by a strong positive anomaly (about 2°) compared to the mean of the 15 previous years could be a part of this result.

10.4.2.3 PELGAS07 consort survey

In the frame of the experimental fishery allowed in may 2007, commercial vessels were used as consorts during PELGAS survey (see chapter 10.4.2.2.). This consort survey was organised at a very short notice. In addition to the French vessels (2 pair trawlers), 3 Spanish purse seiners were included in the process the day before the beginning of the survey. Finally, 6 commercial vessels (2 French pair trawlers, 1 coastal French purse seiner and 3 Spanish purse seiners) were part of this consort survey.

The commercial vessels were not equipped with scientific echo-sounder and so only their fishing operations could be considered. Further investigations of the differences in catchability between gears and vessels should be carried out before a fully use of the results of these fishing operations can be done.

During the first half of the survey, 68 identification hauls were carried out by commercial vessels : 32 hauls from the Pair trawlers , 23 from the Spanish purse seiners and 13 from the French purse seiners (**Figure 10.4.2.3.1**). Commercial vessels were not able to fish during the third week due to poor weather conditions.

Spanish purse seiners were mainly fishing sardine on rare mid-water schools whereas pelagic trawlers were fishing more anchovy on small echo-traces more close by the bottom. The French small purse seiner was exclusively fishing in shallow waters along the coast (where Thalassa was not efficient). The Spanish fishermen commented that anchovy was not schooling at the surface when the moon was in the ascendant phase.

For coherent assessment comparison, the acoustic biomass estimate (see section 10.4.2.2.) was only calculated on the basis of Thalassa data collected with the same strategy as during previous years. As an exercise (see the reason below) estimates were computed using consort fishing operations as extra identification hauls (**Figure 10.4.2.3.2**). Despite the differences between purse seiners and pair trawlers catches, results (**Table 10.4.2.3.1.**) were very similar because the main quantitative aspect was driven by acoustic data and fishing operations were only used to split energies into species and most of commercial vessels catches confirmed Thalassa catches.

During the last week of the survey, the whole fleet came back in potential anchovy areas in order to have particular observations on vertical eggs distribution and anchovy day and night behaviour. It has been a great opportunity to compare pelagic trawl and purse seine catches in the same small area in traditional conditions and during the descendant phase of the moon. These data are not yet analysed, species composition of catches seem to be more similar than during the first part of the survey.. A total of 38 hauls were carried out during these last 6 days, including 9 by Thalassa, 14 by pair trawlers hauls and 15 by Spanish purse seiner shoots (**Figure 10.4.2.3.3**).

The consort survey permitted to 6 commercial vessels (French and Spanish) to participate to the PELGAS survey in a very good spirit of collaboration. It was a great opportunity for fishermen to share opinions and experiences in real conditions, observing the same echoes at the same time, fishing together in similar areas. This experience proved to each other that the scientific observations and fishing operations were compatible with the commercial ones. This participation increased the mutual confidence in both fishing efficiency and echoes observations.

If such an action is repeated in the future, commercial vessels might be equipped of scientific echo-sounders in order to take into account not only qualitative data but also the quantitative aspect provided by the acoustic energies and therefore increase the precision of assessment by a better sampling strategy. In addition, the number of commercial fishing vessels participating in this survey could be reduced in accordance with the scientific objectives proposed (e.g. for identification of schools taking in consideration the different catchabilities of the anchovy metiers with two pair trawlers and one purse seiner is sufficient).

10.4.3 Surveys on anchovy juveniles

10.4.3.1 JUVENA surveys on anchovy juveniles.

Objectives

The JUVENA series (acoustic surveys for anchovy juveniles) aim at estimating the abundance and spatial distribution of anchovy juveniles during early autumn in the Bay of Biscay (Boyra et al., 2004, 2005a, 2005b, Boyra & Uriarte, 2005 and Boyra et al., 2007). The long term objective of the project is to be able to assess the strength of the anchovy recruitment entering the fishery the next year (as 1 year old) so as to help on the provision of scientific advice to managers. In addition, the spatial distribution of the juvenile population, the growth condition and the hydrological characterization were studied The survey is presented and coordinated within WGACEGG.

Material and Methods

So far, four surveys have been conducted (Boyra et al., 2004, 2005a&b, 2006 and Boyra et al., 2007) (**Table 10.4.3.1.1**). The surveys take place from September to the beginning of October, covering the area from the coast to 5º-6º W and up 46º-47º30’ N, onboard commercial rented purse-seines (for the first 3 years) and with both a purse seine and the R/V Enma Bardan –a pelagic trawler– in 2006. In the last two years, spatial coverage has been gradually enlarged to the north. Acoustic data is recorded with a 38 and 120 kHz Simrad EY60 split-beam, scientific echo sounder system (Kongsberg Simrad AS, Norway), calibrated using standard procedures (Foote et al. 1987). The water column is sampled with acoustics up to depths of 100 m. A threshold of -80dB is applied for data collection. Acoustic back-scattered energy by surface unit (s_A, MacLennan et al. 2002) is recorded for each geo-referenced nautical mile (1852 m). In addition, CTD casts are performed every 9 n.mi.

Fish identity and population size structure are obtained from fishing hauls and echo-trace characteristics. The hauls are grouped by strata of homogeneous species and size composition. Inside each of these homogeneous strata, the echo-integrated acoustic energy is separated by the contribution of each species according to the composition of the hauls. The composition by size and species of each homogeneous stratum is obtained by averaging the composition of the individual hauls contained in the stratum, being the contribution of each haul weighted to the acoustic energy found in its vicinity (2 nm). Afterwards, the energy corresponding to each specie-size is transformed into biomass using their corresponding conversion factor. The scattering cross section of anchovies according to their size is estimated using the parameters for anchovy detailed in Dinner & Marchand (1995).

2006 results

The last survey took place between the 13th of September and the 15th of October 2006, with two vessels, the R/V *Emma Bardan* and the rented purse seiner *Itxas Lagunak* (**Table 10.4.3.1.1**). The availability of two survey vessels, both equipped with acoustic sensors, provided the larger coverage in the temporal series, reaching to 6º W in the Cantabrian area and 47º 30’ N along the French Coast (**Figure 10.4.3.1.1**)

This year, the distribution of anchovy was confined practically to the continental shelf, extending from 6º W in the Cantabrian Coast to the 47º30’ N in the French Coast (**Figures 10.4.3.1.1** and **2**). In the Cantabrian Sea, anchovy was almost completely confined to the coastal area, in the proximities or inside the bays and beaches. In front of the Southern French Coast (Les Landes), the distribution of anchovy was again almost coastal. In this region, anchovy was found restricted to a narrow strip between the 15 m and 30 m isobaths. In the Northern area, around the plumes of the rivers Garonne and Loire, the distribution of anchovy notably broadened up, extending from the coast to waters of up to 100 m depth.

Although the Northern limit of the positive anchovy distribution was not found in this area (anchovy was detected even in the most northern latitudes), the decrease of relative abundance of anchovy in the hauls of the last transect may indicate the proximity of such limit.

Discussion

Given the positive performance of the fishing gears of both vessels, we consider that the combination of them provided a reliable estimation of the species composition in the different regions. The purse seine provides an efficient way of capturing anchovy juveniles, plus assures the methodological continuity of the temporal series. On the other hand, the pelagic trawl provides the capacity of fishing beyond the purse seine depth range (30-40 m depth) and a less selective sampling (at least a priori). In addition, the preliminary inspection of the intercalibration hauls found no differences in the size ranges obtained with each method.

The capacity of both vessels to fish in shallow waters, the large amount of positive anchovy hauls (53 of 80 hauls) and the capacity of sampling close to the bottom leads to a successful fishing capability for this survey and makes this year certainly the best in the whole series in terms of fish species identification.

Estimates based on the positive area (**Figure 10.4.3.1.2**) followed standard procedures. The survey results were first reported to the WGACEGG in November 2006 (Boyra et al. 2006). However, those estimates have been recently revised due to a configuration problem of the 38 khz echosounder on board the R/V Enma Bardan, as mentioned in the acoustic workshop report (Nantes , April 2007). This vessel covered alone about 60% of the area. The current revision bases the acoustic biomass estimate on the 120 khz echosounder. The result of this revision increases by 80% the provisional estimate provided in November 2006. This revision was reported to the STECF Working Group (Boyra et al., 2007) and have to be taken as a preliminary estimate that will be revised in the next coming ICES WGACEGG in Nov-Dec 2007.

Inter annual results

The acoustic estimates produced in 2003 and 2005 and 2006 cruises reported anchovy juvenile abundances two orders of magnitude greater than the estimates for year 2004 (**Table 10.4.3.1.2**, **Figure 10.4.3.1.3**). This poor result for 2004 is congruent with the subsequent crisis of the stock and collapse of the fishery during 2005. The occupied area in those years was also larger, in clear agreement with the larger juvenile abundance estimations. The anchovy juvenile acoustic estimate for 2006 is similar to that obtained in 2005. A graph of the historical series compared to the assessment of age 1 in year Y+1 is presented in **Figure 10.4.3.1.4**.

The acoustic biomass estimates provided by JUVENA series have to be taken as relative values not as absolute. The high total anchovy acoustic biomasses reported for the years 2005 and 2006 (of the order of 150 and 210 thousands tonnes), if taken as absolute, give a huge contrast compared with the SSB estimate at the following springs (around 20 to 30 thousand tonnes). These discrepancies in absolute levels of biomass can be attributed to several factors, starting for incorrect Ts values (probably due to the depth dependency of the Ts or possible changes in behaviour between different seasons) and due also to large natural mortality of anchovy in this juvenile phase. For instance, a natural mortality M of 2 throughout the 8 months elapsed time between these surveys could explain such reduction.

JUVENA surveys are still in a phase of consolidation and testing: Only four surveys have been conducted in the series. Although too soon for a proper testing, a preliminary analysis of its performance is presented below.

One of the strengths of this survey is that it is implemented when juveniles are usually found as pure schools in offshore grounds, in the upper layers of water, being therefore well detectable with acoustics and well fishable with purse seine, with little risk of species misidentification. Although certainly the coastal distribution found in 2006 supposes the first exception to that a priori expected distribution. The experimental surveys carried out by AZTI and IFREMER within JUVESU project (FAIR CT97-3374, Uriarte editor 2002) in 1998 and 1999, provide additional contrasting background on the abundances and spatial distribution of juveniles, which served to establish the current JUVENA survey design.

The survey has always covered the area where the bulk of juveniles is considered to be found (approximately east of 5º W and south of 46º N), although for the last years the coverage expanded until 47.30 thanks to the planned adaptive sampling design. The adaptive enlargement of the surveyed area in the last two years (**Figure 10.4.3.1.3**) cause warnings about the comparability of the results concerning the comparability of the percentage of the potential distribution area covered throughout the time series. However that is not considered to be a major problem according to:

a) during the first two years 2003 and 2004 the most northern radial (at 46ºN) was empty of anchovy detections and in the northern coastal areas around the Garonne (where relevant anchovy concentrations were found in 2006) little quantities of juveniles were found in those two years as in 2005 (see **Table 10.4.3.1.2**).

b) Concomitant information provided by the commercial fleet in these years indicates that juvenile concentration were not seen out from the covered areas. In addition, JUVAGA survey in 2003 (Petitgas *et al.* 2004) and in 2005 pointed out little detections of anchovy juveniles to the North of the surveyed areas.

All these suggest that the main juvenile concentrations were well covered during these surveys.

Recruitment prediction capacity

The JUVENA acoustic estimates of abundance of anchovy juveniles in the Bay of Biscay have been presented in **Table 10.4.3.1.2**. The survey has been surveying gradually increasing areas, larger than the standard one a priori defined at the beginning of the series. As discussed at the end of the previous section, beyond the doubts this fact may induce about the comparability of the surveys, there are reasons to believe that this was not a serious problem for the series. Therefore, for comparisons with the series of recruitment at age 1, the estimates over the total surveyed area will be used instead of using the estimates confined to the original standard area. However, the short number of indices available (just four years) severely limits the testing here presented.

Figure 10.4.3.1.4 compares the times series of the JUVENA anchovy juveniles abundance index with the assessment at age 1 (median values) produced by Bayesian assessment by the STECF (June 2007) using the results of the spring surveys on anchovy. By the time being, the results are encouraging, since the huge drop in juveniles abundance estimates recorded by JUVENA surveys in 2004 matched well with the drop in the recruitment of age 1 to the adult population occurring in 2005. On the other hand, a recovery of the recruitment at age 1 in 2006 and 2007 to similar levels are also in conformity with the JUVENA survey’s abundance indices. So, generally speaking, the time series of age 1 recruitment estimates from the last four years in the assessment have a globally parallel shape to that shown by the juvenile abundance index from JUVENA surveys: One very low recruitment and 3 low levels of recruitment. However that recovery was not as intense as the relative index would suggest.

The coefficient of correlation (0.64) is not significant, probably given the low amount of observations (4 years). Clearly, a lack of great contrast is seen in this series; the occurrence of a large recruitment should serve to further test the capabilities of this series to predict recruitment.

In summary, the results from the four points of the JUVENA abundance indices of anchovy juveniles are encouraging, but the short life of this series prevents yet a proper evaluation of its performance as a predictor of the age 1 entering the population and the fishery the next year.

The JUVENA 2007 survey

In 2007, the JUVENA survey will be sponsored by the Basque and Spanish Governments (Viceconsejería de Pesca and the MAPA respectively). It will take place from 3 to 30 of september and will operate with two vessels, a purse seine and a pelagic trawler, both equipped with scientific acoustic devices. This year, the survey will be coordinated with the survey PELACUS2007 conducted by the IEO and IFREMER, following a common survey strategy of alternate transects spaced 7.5 n.mi. The survey area will be partially overlapped by both surveys: JUVENA will cover the Cantabrian Area alone; both surveys will cover the French shelf and shelf break up to 47º30'; finally, PELACUS survey will assure the total coverage of the Northern anchovy juvenile distribution (**Figure 10.4.3.1.5**). This will produce the 5th estimation of juveniles in the series, which will allow further testing of the predictive capacity of this acoustic abundance index.

10.4.3.2 PELACUS2006. Surveys on juvenile anchovy

The PELACUS2006 cruise (IEO; with participation of Ifremer in the 2nd leg) was carried out on board the RV *Thalassa* from 22/09/06 to 17/10/06. This survey is the first of a proposed project to a) provide and index of juvenile abundance, and b) study the recruitment process. The survey is split in two legs: the 1st leg for systematic sampling (estimation of biomass), while the 2nd was adaptive in order to conduct more intensive sampling in zones of occurrence of anchovy juveniles. Survey coverage is shown in Figure 10.4.3.2.1, and acoustic energy allocated to anchovy during the first leg, and used for the evaluation of anchovy juveniles in autumn is shown in Figure 10.4.3.2.2. Total anchovy juveniles biomass estimate is 6,140 t, with main distribution areas located in front of the Garonne area and very close to the coast in the south and west areas of the Bay of Biscay.

10.4.3.3 Workshop on Juvenile acoustic surveys

Results of the PELACUS 1006 anchovy assessment **(section 10.4.3.2.)** were compared with those obtained by the 2006 JUVENA survey **(section 10.4.3.1.)**, both during WGACEGG (ICES 2006) and within a dedicated workshop recommended by the same ICES WG which took place in Nantes (16-20 April 2007). The comparison was made both on global terms (estimates of biomass from both surveys) and in a dedicated area in front of the Garonne river mouth, which was chosen prior to both surveys in order to intercallibrate their results. Original estimates from both surveys differ by nearly two orders of magnitude (6,140 t vs 130,000 t), but survey coverage also largely differs, and the JUVENA survey covered more inshore areas and areas to the north of the PELACUS coverage. However, after agreement on some scrutinity differences of echoes and some technical corrections, comparisons within the dedicated area showed more similar biomass levels, although the JUVENA estimates were revised after the workshop. Some recommendations and a protocol have been established for acoustics juvenile surveys which will be carried out in the Bay of Biscay in the future**.** Further comparison and intercallibration of both surveys (both are planned to be repeated in 2007) will be performed during next ICES WGACEGG.

10.5 Effort and Catch per Unit Effort

The evolution of the fishing fleets during recent years is shown in Table 10.5.1. For the French fleet, this table shows the number of vessels that have caught anchovy each year, and not the total number of vessels. The number of French pelagic trawlers involved in the anchovy fishery (more than 50 tons per vessel and per year) is variable: it depends on the biomass of fish available (e.g. 1992-1994 when biomass and vessel numbers increased). Since 1995 the number of pelagic trawlers is more stable (about 50). The total number of French purse seines are slightly increasing since 2000 (33 in 2000; 41 estimated in 2004), but it doesn't produce real increase in term of catches as their real target is still sardine. The number of Spanish purse seines is decreasing since 1997 (267 in 1997, 211 in 2004 and 197 in 2005).

The fishing effort developed by the two countries is nowadays similar although the fishing pattern is different, mainly since 1992 when the Pelagic French Fleet stopped fishing in spring during the first half of spawning season of anchovy in the Bay of Biscay. In the nineties, the effort may have been at the level that existed in this fishery at the beginning of the 1980's

(Anon. 1996/Assess:7), but the stop of the French pelagic fleet in spring allows to prevent a catch of a too large number of fish before their first spawning.

Because of the low biomass during the last 3 years and the ban on the anchovy fishery for the second half of years 2005 and 2006, it has been necessary to consider a lower threshold of annual catches to select commercial vessels who really target anchovy. decrease the threshold of 50 tons per years to 10 Tons to calculate the number of vessels targeting anchovy. This new threshold was fixed to10 tons/year instead of 50 before 2005.

10.6 Recruitment forecasting and environment

Two environmental recruitment index have been considered during the last 10 years : i) Borja 1998 which is an upwelling index and ii) Allain et al. 2001 which is a combination of upwelling and stratification breakdown. Both were considered as no more usable during the last years assessment as they failed for several years. Nevertheless the necessity to have an efficient index of recruitment in the future was still considered by ICES for further revision.

New indices have been presented this year by Ifremer (**Huret & Petitgas WD 2007**) 1) the previous "upwelling" and "stratification" one according to a new hydrodynamic model and 2) an adults spatial indicator. Nevertheless, the reliability of these new indices is too much premature to be used for management considerations.

The state of studies to day can be presented as following :

AZTI upwelling index

The series of Borja’s et al. (1996, 1998) upwelling index was presented in comparison with the ICA assessments during last year WGMHSA (ICES 2006). The index was positively related to the strength of next coming recruitment provided by ICA over the period (1987-1998), however afterwards it failed to predict the strong years classes of 1999 and 2000 and became not significant (in statistical terms). The succession of weak classes in recent years at low levels of this upwelling index has rendered it again statistically significant (at alpha 8%), with coefficient of determination of past recruitments about 15%. Even if the relationship is better for the recent years, the poor predictable performance of this index over the past decade renders it useless in quantitative terms for the forecast of year class strength and therefore it will not be used. No value of this upwelling index from March to July 2007 was provided to the WG (previous values were shown in past year report ICES2006).

IFREMER anchovy recruitment index

The hydrodynamic model of IFREMER has been modified (Lazure and Dumas, in press). In comparison to the former version this new model has a larger spatial extension, a finer resolution, new settings for the boundary conditions and forcing. In particular, the wind forcing is a re-analysis from Meteo-France that is now spatially resolved with a time resolution of the hour. The model is currently run for real-time forecasting on the web (http://www.previmer.org).

Both indices (upwelling and stratification - Allain et al. 2001) **were computed** with the new model. The upwelling index along the coast of Les Landes compares well with the former one (**Figure 10.6.1**), whereas the stratification breakdown does not. The second index is an indicator of the vertical turbulence mixing. The difference from one model to the other may be due to the fact that the new hydrodynamic model better implement the wind forcing which is now spatially resolved and updated every hour (when in the old model it was constant over the entire area and updated every 6 hours). This new index must be more scrutinized before to be considered as reliable.

A **new stratification index** has been defined from this new hydrodynamic model from 6-days averages of the potential energy deficit (number of occurrence from June to July when this variable is below one standard deviation from the average value calculated over the years 1990-2007). The higher the value, the lower the water column is stratified as compared with a climatological reference. **Figure 10.6.2.** shows the evolution of the water column thermal stratification for the years 1990 to 2007. For 2007, we can see that at the beginning of May the water column was more stratified than the whole time-series presented, whereas from the end of June, stratification was the lowest, comparable to 2002. This low stratification is due to the poor weather conditions during June and July, with both a continuous mixing by wind and a poor solar radiation over sea surface.

Until 2002, the correlative model between the anchovy recruitment and the indices derived from the old hydrodynamic model (upwelling and stratification breakdown) had made successful predictions. Since 2002 that model has failed in explaining the low recruitment levels. But no significant change could be identified in the environment (temperature, river discharges, wind regimes: Planque et al. WD to ICES WGMHSA 2005 meeting, ICES 2006a). Therefore changes in the spawning stock or in the critical period of early life mortality were suspected.

Spatial indicators have been developed in the EU project FISBOAT (Cotter et al., 2007; Woillez et al., 2007) and were estimated on the PelGas survey data series. Correlation between each spatial indicator in the current year and the ICES numbers at age 1 in the subsequent year (recruitment) were screened. The ICES numbers were those estimated during the 2006 meeting (ICES 2006b). The most significant correlation was obtained for the Equivalent Area of age 2+ fish. The Equivalent area is the integral range in the spatial correlation as estimated with the transitive covariogram. It can be considered as an index of aggregation in the spatial distribution. The aggregation of the age 2+ spawners seem to influence the numbers of age1 in the subsequent year (**Figure 10.6.3.**). The process behind this correlation could be the concentration in the ichtyoplankton which if too low would be detrimental to larval survival.

Three indices that relate to potential biological processes (conditions for spawning and larval survival) are therefore available but very new : i) the upwelling index, ii) the stratification breakdown index and iii) the spawning aggregation index. Nevertheless, a first approach using them to consider possible 2007 year class strength shows opposite results : the adult index of aggregation with potential positive effect while the upwelling and stratification indices are expected to have a negative effect. An integrated index should be interesting but is not available for the time being. These indices are so very new and have been presented for information but it is too soon to use them for management consideration.

10.7 Data and model exploration

Up to 2005 the Bay of Biscay anchovy stock has been assessed using ICA (Integrated Catch-at age Analysis, Patterson and Melvin 1996). However, in the last years a Bayesian biomass-based model (BBM) has been explored and developed as an alternative to ICA (ICES 2004, 2005 and 2006). In 2005 the WG presented the benchmark assessment for this stock based on the results from BBM (ICES 2006). And in 2006 ACFM adopted the BBM a the standard assessment.

In this section an analysis based on BBM is conducted before the final assessment of this stock is adopted. In the first subsection the input data for the assessment is analysed. In the second subsection the sensitivity of BBM assessment to different assumptions is explored.

10.7.1 General analysis of input data

The input data entering into the assessment of the anchovy stock consist on total biomass and biomass at age one as estimated by the research surveys conducted in spring, namely, DEPM and acoustic surveys (see section 10.4) and on catch information from the different fleets exploiting the stock that are described in section 10.2. In addition, the age composition and the mean weights at age derived from the biological sampling of the catches are also used.

Figure 10.7.1.1 compares the historical series of spawning stock biomass (SSB) from the DEPM and acoustic surveys. Except in some of the years, like 1994, 1998 or 2004, in which there are some discrepancies, the trends in biomass from both surveys are similar. In particular, in the last years a parallel trend but with larger biomass estimates from the acoustic surveys is apparent. The agreement between both surveys is higher when estimating the proportion of age 1 biomass (**Figure 10.7.1.2**).

Figure 10.7.1.3 shows the historical series of age 1 and total catches in the first period (1^{st} January-15^{th} May) and of the total catches in the second period (15^{th} May-31^{st} December), which are used in BBM. Catches in the second period are larger than in the first period and most of the catches in the first period correspond to age 1. In the last years due to the low level of the population and various fishery closures, the catches have been very low.

10.7.2 Bayesian biomass-based model (BBM)

The last benchmark assessment for this stock (ICES 2005) was based on the Bayesian biomass-based model (BBM) described in detail in **Section 10.8.1**. The consistency with the old assessment model (Integrated catch at age analysis, ICA) has been properly shown in the past. In this occasion ICA has not been applied due to the negligible level of catches in the last two years after various consecutive closures of the fishery, and the update nature of the assessment.

The BBM seeks to estimate recruitment at age 1 at the beginning of the year accounting for the signals of the inter-annual biomass variations obtained from the direct surveys (DEPM and acoustics) and the level of total catches produced each year. Last year an update of that assessment was presented. **Figure 10.7.2.1** shows the spawning stock biomass resulting from the update of last year assessment including the new data.

Two sets of prior distributions (same as in two previous years) have been considered in order to analyze the sensitivity of posterior inference to prior assumptions. For the first set of prior distributions, the Normal distributions of $\log(q_{depm})$ and $\log(q_{ac})$ are taken to have mean 0 (corresponding to absolute abundance indices) and precision (inverse of the variance) equal to 5, resulting in a prior 95 % central credible interval of (0.42, 2.4). The prior distribution of the precision of the observation equations, ψ_{depm} and ψ_{ac}, are taken as a Gamma distribution with mean 10. This corresponds to a coefficient of variation around 32.5 % for the spawning stock biomass estimates given by the DEPM and acoustics surveys. The prior distribution of ξ_{depm} and ξ_{ac} are taken as Normal with mean 4.68, in agreement with the variance of the age 1 proportion from the surveys. After an examination of the real series of DEPM and acoustic total biomass indices, the initial total biomass B_0 is taken as a Normal with mean and variance equal to the midpoint and the squared range of the observed series, respectively. Similarly, the prior distribution of recruitment is taken as Log-Normal with mean given by the midpoint of observed DEPM and acoustics age 1 biomass estimates, after accounting for the catches taken during the first period. Finally, the precision proportionality factor for the process errors ω_1 was assumed to be Gamma distributed with mean 10. The parameters of the second set of priors were specified so as to keep the same prior mean as in the first set, but have a larger variance in order to be less informative. **Table 10.7.2.1** summarises the hyper-parameter values for the two sets of prior distributions, together with the corresponding 95 % central credible intervals, and **Figure 10.7.2.2** compares both sets of prior density functions. Note that the second set of priors provides very wide prior credible intervals (see **Table 10.7.2.1**), minimizing its influence on the final results.

In addition, as in previous years and taking into account a suggestion from the reviewers of last year assessment, two different models have been explored depending on whether the DEPM surveys are absolute or relative (i.e. whether the catchability of the DEPM survey is fixed to one or has to be estimated):

- DEPM as relative and acoustics as relative
- DEPM as absolute (q_{depm}=1) and acoustics as relative

From a Bayesian perspective, assuming that the DEPM surveys are absolute can be interpreted as having a very informative prior distribution on the catchability parameter of the DEPM surveys.

Figure 10.7.2.3 shows the sensitivity of the posterior distributions of recruitment to the choice of different priors when both surveys are taken as relative and when DEPM is taken as absolute and acoustics as relative. In general, the posterior medians of recruitment series are similar for both set of prior distributions, but the second set of priors leads to wider posterior credibility intervals. The working group considered that given the small difference on the assessment for the two sets of priors, the first set of priors is more realistic and uninformative enough, supporting the use of first set of priors as done in the last two year's assessments.

Figure 10.7.2.4 compares the posterior distribution of recruitment and spawning biomass estimates when the DEPM surveys are taken as relative and when they are taken as absolute for the first set of prior distributions. The differences between different models (absolute and relative) are small, giving the model with both indices as relative slightly larger estimates (**Figure 10.7.2.5** bottom panel). The largest trend discrepancies correspond to years when there is no data available for some of the indices (1993, 2000). Furthermore, in these missing data years the credible intervals are wider reflecting a larger uncertainty on the estimates. However, in relative terms, depending on the assumption on the catchability of the DEPM surveys, when analysing the ratio of the spawning stock spawning biomass with respect to the spawning stock biomass in 1989, which sets B_{lim} for this stock as B_{loss} (ACFM 2003), the perception of the current state of the stock does not change (**Figure 10.7.2.5**). For any of the two models (DEPM absolute or relative), the median of the ratio for 2007 is between 1 (corresponding to B_{lim}) and 1.645 (corresponding to B_{pa}). So, despite the larger biomass levels arising from the use of the DEPM as a relative index in the assessment, the diagnostic of the stock would not change with respect to B_{lim} and B_{pa}, after the duly amendment of these values according to their respective definitions for this stock.

Posterior joint distributions of the parameters of q_{ac} and q_{depm}, of B_0 and q_{depm}, of $\log(R_1)$ and q_{depm} and of $\varepsilon_1(0_{(y)}, h_{1(y)})$ and ω_1 for the second set of priors when DEPM and acoustics are both taken as relative biomass indices are shown in **Figure 10.7.2.6**. This illustrates the parameter confounding issue as it was already pointed out in previous years (ICES 2004, 2005 and 2006). On the one hand, the catchability parameters q_{depm} and q_{ac} are positively correlated between them, whereas they are both negatively correlated with the initial biomass B_0 and the recruitments R_y. This means that the larger the catchability parameters for biomass are, the smaller the recruitments will be. On the other hand, the incorporation of process errors leads to posterior correlation between the process errors ε_1 and ω_1. The posterior correlation, and subsequently, the confounding between the parameters, increases for the less informative prior distributions. The usual practice by this working group regarding the Bay of Biscay anchovy stock in order to address the misidentification between the parameters has been to fix the catchability of the DEPM surveys to 1, assuming that the DEPM biomass estimates are absolute. This is based on the assumption that in the DEPM the spawning stock biomass is derived by estimating all the biological parameters unbiasedly. Even now that the estimation procedure of the Daily Fecundity of the DEPM is under revision, the WG considers that for an update assessment like this it is better to stay at the previous assumption of catchability fixed at 1 for the DEPM. For a short living species as anchovy no VPA approach is valid for knowing past levels of abundance due to the null convergence properties of the catch at age matrix. The assessment is completely based on the surveys and therefore, it is entirely dependent on the catchability assumptions of the direct survey estimates of abundance. By keeping the DEPM as an absolute index assumption the WG just acknowledge the indeterminacy of the absolute level of the population derived from the assessment and its dependency on the catchability assumption on the DEPM series. In addition, the assessment is consistent with all past assessments (including the STECF advice in June this year) and with the basis of the definition of the current precautionary biological reference limits for exploitation (B_{lim} and B_{pa}), which otherwise should be changed accordingly.

10.8 State of the stock

10.8.1 Stock assessment

Last year, ACFM adopted the assessment produced for anchovy from the Bayesian Biomass model (BBM). This year the final assessment for the Bay of Biscay anchovy population is an update of last year assessment based on the same Bayesian biomass-based model (BBM), with the same assumptions as past year.

Let $B(s_{(y)}, a)$ and $C(s_{(y)}, a)$ denote population biomass (in tones) and catch (in tones) of the *a* age class at time *s* of year *y* respectively. At the beginning of the year *y*, the total biomass is the new recruitment, $R_y = B(0_{(y)},1)$, plus the biomass surviving from previous year:

$$B(0_{(y)},1+) = R_y + B(f_{1(y-1)},1+) \exp\{-f_{2(y-1)}\, g\} - C(f_{1(y-1)} + h_{2(y-1)},1+) \exp\{-(f_{2(y-1)} - h_{2(y-1)})g\}$$

For the beginning of the second period of any year *y* (15th May) the age 1 and total biomasses are those surviving from the beginning of the year and accounting for the catch taken in the first period:

$$B(f_{1(y)},1) = R_y \exp\{-f_{1(y)}\, g\} \exp\{\varepsilon_1(0_{(y)}, h_{1(y)}) + \varepsilon_1(h_{1(y)}, f_{1(y)})\}$$
$$- C(h_{1(y)},1) \exp\{-(f_{1(y)} - h_{1(y)})\, g\} \exp\{\varepsilon_1(h_{1(y)}, f_{1(y)})\}$$

$$B(f_{1(y)},1+) = B(0_{(y)},1+) \exp\{-f_{1(y)}\, g\} - C(h_{1(y)},1+) \exp\{-(f_{1(y)} - h_{1(y)})\, g\}$$

The parameter *g* is a biomass decreasing rate accounting for growth (G) and natural mortality (M) rates. In particular, $g = M - G = 1.2 - 0.52 = 0.68$, $f_{1(y)}$ and $f_{2(y)}$ are fractions of the year corresponding to each period ($f_{1(y)} = f_1 = 0.375$ and $f_{2(y)} = 1 - f_{1(y)} = 1 - f_1 = 0.625$ assuming that the periods are the same all the years and surveys are conducted 15th May) and $h_{1(y)}$ and $h_{2(y)}$ are fractions within each period corresponding to the elapsed time from the beginning of the period to the date when catches are taken on average. The dynamics of biomass at age 1 in the first period of the year incorporates log-normal process errors through three new parameters in the model. On the one hand, $\varepsilon_1(0_{(y)}, h_{1(y)})$ and $\varepsilon_1(h_{1(y)}, f_{1(y)})$, that denote respectively the process error associated to the age 1 biomass change in the first period from the beginning of the year $0_{(y)}$ to the time the catches are taken $h_{1(y)}$ and from there to the end of the first period $f_{1(y)}$. These are normally distributed with mean 0 and variance proportional to the elapsed time interval:

$$\varepsilon_1(0_{(y)}, h_{1(y)}) \sim \text{Normal (mean = 0, var} = (h_{1(y)} - 0_{(y)}) / \omega_1)$$

and

$$\varepsilon_1(h_{1(y)}, f_{1(y)}) \sim \text{Normal (mean = 0, var} = (f_{1(y)} - h_{1(y)}) / \omega_1).$$

On the other hand, the parameter ω_1, that defines the precision of the process error.

The observation equations for the total biomass are log-normally distributed whereas the age 1 biomass proportions are taken as a beta distribution with mean given by the age 1 biomass proportion in the population and variance proportional to the product between the age 1 and age 2+ biomass proportions. This is analogous to the mean and variance of a binomial distribution but allows more flexibility. On top of it, it is on agreement with the experimental variance function of the age 1 biomass proportions from the DEPM. Both for the total biomass and the age 1 biomass proportion, the variances are allowed to be different for DEPM and acoustic indices. The observation equations are

$P_{depm}(f_{1(y)}) \sim Beta(\exp(\xi_{depm})\, P(f_{1(y)}) , \exp(\xi_{depm})\, (1-P(f_{1(y)})))$

$\log(B_{depm}(f_{1(y)},1+)) \sim N(\log(q_{depm}) + \log(B(f_{1(y)},1+)), 1/\psi_{depm})$

$P_{ac}(f_{1(y)}) \sim Beta(\exp(\xi_{ac})\, P(f_{1(y)}) , \exp(\xi_{ac})\, (1-P(f_{1(y)})))$

$\log(B_{ac}(f_{1(y)},1+)) \sim N(\log(q_{ac}) + \log(B(f_{1(y)},1+)), 1/\psi_{ac})$,

where all are assumed to be independent from each other. The parameters ξ_{depm} and ξ_{ac} define the variance of the observation equations for the age 1 biomass proportion of DEPM and acoustic indices, respectively.

The parameters to estimate are $\log(q_{depm})$, $\log(q_{ac})$, ψ_{depm}, ψ_{ac}, ξ_{depm}, ξ_{ac}, B_0, R_y for all years y, the state errors $\varepsilon_1(.,.)$ for all the time intervals and ω_1. The prior distributions considered are

$\log(q_{depm}) \sim N(\mu_{qdepm}, 1/\psi_{qdepm})$

$\log(q_{ac}) \sim N(\mu_{qac}, 1/\psi_{qac})$

$\psi_{depm} \sim Gamma\ (a_{\psi depm}, b_{\psi depm})$

$\psi_{ac} \sim Gamma\ (a_{\psi ac}, b_{\psi ac})$

$\xi_{depm} \sim N(\mu_{\xi depm}, 1/\psi_{\xi depm})$

$\xi_{ac} \sim N(\mu_{\xi ac}, 1/\psi_{\xi ac})$

$B_0 \sim N(\mu_0, 1/\psi_0)$

$Log(R_y) \sim N(\mu_r, 1/\psi_r)$

$\omega_1 \sim Gamma\ (a_{w1}, b_{w1})$

In order to avoid as much as possible problems in the MCMC algorithm due to the misidentification problems between R_y and $\varepsilon_1(0_{(y)}, h_{1(y)})$, a centered parameterization is considered:

R_y and $\varepsilon_1(0_{(y)}, h_{1(y)}) \quad \Rightarrow \quad R_y^* = R_y \exp(\varepsilon_1(0_{(y)}, h_{1(y)}))$ and $\varepsilon_1(0_{(y)}, h_{1(y)})$.

In addition, the parameters involved in the state equations have to be such that the biomass of each of the age classes is positive, which basically means that the recruitment entering the population is large enough to support the catches taken:

$B(s_{(y)},1) \geq 0$ at any time s for all y

$B(s_{(y)},2+) = B(f_{1(y)},1+) - B(f_{1(y)},1) \geq 0$ at any time s for all y

Sampling from the joint posterior distribution is carried out using Markov Chain Monte Carlo (MCMC) techniques (Gilks et al 1996). MCMC is implemented sampling the parameters one by one. On the one hand, $\log(q_{depm})$, $\log(q_{ac})$, ψ_{qdepm}, ψ_{qac} and ω_1 are sampled directly from their posterior conditional distributions using Gibbs sampling. B_0 and R_y , $\varepsilon_1(0_{(y)}, h_{1(y)})$ and $\varepsilon_1(h_{1(y)}, f_{1(y)})$ for all *y* have non standard posterior conditional distributions and are sampled using Metropolis-Hastings within Gibbs sampling. In order to find appropriate proposal distributions, first the mode of the target is found by numerical methods. In case the mode is lower than the lower bound, an exponential distribution with the same first derivative of the log posterior probability at the lower bound is chosen as proposal distribution. Otherwise, the proposal distribution is a normal distribution with the same first and second derivatives of the log posterior probability at the mode. All this is implemented in a program in Fortran.

The data used for BBM are detailed in **Table 10.8.1.1**.

From the set of models and assumptions explored in the previous section, the final results are the one corresponding to DEPM as absolute with the first set of priors (see **Table 10.7.2.1**). **Figures 10.8.1.1** and **10.8.1.2** compare prior and posterior distributions of the parameters. Summary statistics (median and 95% credible intervals) of the posterior distributions of recruitment (in tones), spawning stock biomass and harvest rates are shown in **Table 10.8.1.2** and **Figure 10.8.1.3**. The largest credible intervals correspond to the period in which some data is missing. In general recruitment is highly variable from year to year. However, in the last five years it has been kept at very low levels, being recruitment in 2005 the lowest of the historical series (posterior median of around 5200 tones and 95 % credibility interval between 3000 and 9 400 tones). In 2007 recruitment has kept at similar levels to the ones in 2006 and it is still among the lowest of the historical series together with 1989, 2002, 2005 and 2006. Alternatively, SSB has increased slightly in comparison to last year (posterior median around 29 900 tones), being the median still below B_{pa}.

Median and 95% posterior credible intervals of the ratio of spawning stock biomass with respect to 1989 spawning stock biomass, in which B_{lim} is based (ACFM 2003), are given in **Table 10.8.1.2**. Median of the ratio for 2007 is 1.53 (with a 95% interval between 0.8 and 2.6) indicating that current level of the population is slightly above 1989.

Figure 10.8.1.4 shows the posterior distribution of current level of spawning stock biomass in 2007. Current state of the population is summarized in **Table 10.8.1.3**. The median of posterior recruitment estimates for 2007 is 23,941 t. with 95% credible interval of 13 723 and 42 766 tones The estimated level of biomass in 2007 is 29 941 tones and the 95% credible intervals are 20 494 and 45 096 tones. The probability of SSB being below B_{lim} (21 000 tones), B_{pa} (33 000 tones) are respectively 3%, 69%. This estimates are very consistent with those estimated in June 2007 by STECF with the preliminary estimates of spawning biomasses obtained by the acoustic and DEPM surveys (median of spawning biomass and recruitment levels of 30,086 t and 23,082 t as estimated in June 2007).

In relative terms current assessment implies a gradual recovery of the population throughout recent years (increasing SSB by about 27% regarding 2006 and being 96% confident of being above B_{lim}) but there is still a high probability (69%) of being below B_{pa}.

10.8.2 Reliability of the assessment and uncertainty of the estimation

Current assessment produced spawning biomass and recruitments levels highly consistent with those obtained in past years (Figure 10.7.2.1) and with the assessment produced in June 2007 (STECF2007) after the preliminary SSB of the surveys were available.

The Bayesian biomass-based model (BBM) forms a simple but powerful tool to assess the Bay of Biscay anchovy stock. The observation equations of the model refer just to the age 1 biomass proportion and total biomass indices from the research surveys (DEPM and acoustics). Therefore, the results are completely driven by the surveys, and the reliability of the current assessment depends on the reliability of the surveys themselves. The working group emphasizes the importance of the continuity of the series of estimates from direct surveys, both in terms of total biomass and disaggregated by age in order to be able to assess the stock efficiently. In this model catch data are just accounted for in the development of the dynamics of the population. This basically means that the population has to be large enough to support the observed catches. However, it is necessary to continue the collection of total landings and catch at age data. This will allow on the one hand further work on BBM exploring the possibility of incorporating catch data in the observation equations in order to evaluate whether additional information can be extracted from the catch data, and on the other hand, the use of age disaggregated models as exploratory tools on the international seasonal fisheries.

The Bayesian state-space model framework provides a statistically well founded basis to BBM. This allows directly inferring the uncertainties of the estimates from the posterior distribution, including additional information through the prior distribution and projecting future states of the population.

The assessment is scaled by the assumption of absolute catchability of DEPM surveys. However, **Section 10.7.2** explains how the current perception of the population in relative terms (with respect to the definition of B_{lim}) is insensitive to the use of the DEPM survey as absolute or relative. However, it is the absolute level of the assessment results (i.e. the mass in tonnes corresponding to the spawning population) what is dependent on the catchability assumptions of the assessment. This implies that the absolute level of the harvest rate, defined as the ratio between total annual catches and spawning stock biomass, is also dependent on the catchability assumption. It therefore must be emphasized and admitted explicitly that the assessment should always be examined in relative terms, exploring the trends in biomasses or harvest rates even under the assumption of DEPM being an absolute abundance estimate.

The DEPM series of biomass are under revision due to changes in the procedures for Daily Fecundity estimates, and the revision will be available for the benchmark assessment of 2008. This may imply the revision of the current precautionary reference points for management since they are based on assessments using the DEPM SSB estimates as absolute biomass indices. Any revision on the use of the DEPM as absolute or relative, and consequently, on the reference points for management should be faced next year in the context of the benchmarck assessment and once the revision of the DEPM series is available.

In the current situation of fishery closure due to low levels of biomass, staying at the same procedures and assumptions as last years assures consistency with past assessments output levels and coherence with previous management advices based on current reference points for management. Moreover when it has been shown that in relative terms (regarding B_{lim} definition) current perception of the population is insensitive to the use of the DEPM survey as absolute or relative (**Section 10.7.2**).

Another important assumption of the current assessment is that both the natural mortality and growth rates are constant across ages and from year to year. This may imply some artificial reduction of the posterior probabilities profiles of the outputs from the assessment.

The BBM entails changes in both the methodology used for projecting the population forward and establishing catch options and in the terminology the assessment and consequent advice is given. Concepts such as fishing mortality or selectivity at age are not used in the model. Alternatively, harvest rates, defined as the ratio between total annual catches and spawning stock biomass, are used. The state of the stock is given in terms of spawning biomass, recruitment is understood as biomass at age 1 at the beginning of the year and management options may be given in terms of catches. On the other hand, due to the Bayesian framework, all the results are given in stochastic terms and deterministic points estimates are replaced by summary statistics of the posterior distributions of the parameters, such as medians and 95% intervals (see **Table 10.8.1.2**). In addition **Figure 10.8.1.4** shows the posterior distribution of current level of spawning stock biomass in May 2007 and **Table 10.8.1.3** further define the current situation relative to the reference points for management.

10.8.3 Reference points for management purposes

Reference points, B_{pa} and B_{lim}, were defined by ACFM (October 2003):

	ICES considers that:	ICES proposes that:
Limits reference points	B_{lim} is 21,000 t, the lowest observed biomass in 2003 assessment.	B_{pa}= 33,000 t.
	There is no biological basis for defining F_{lim}.	F_{pa} be established between 1.0-1.2.
Target reference points		

Technical basis:

$B_{lim} = B_{loss}$ = 21,000 t.	$B_{pa} = B_{loss}$ * 1.645.
	F_{pa}= F for 50% spawning potential ratio, i.e., the F at which the SSB/R is half of what it would have been in the absence of fishing

Precautionary reference points were not revised by the WG this year.

B_{lim} is defined by ICES as the SSB below which recruitment becomes impaired (ICES CM 2003/ACFM:15). For stocks with a clear plateau in the S/R scatter plot (a wide dynamic range of SSB, but no evidence that recruitment is impaired) it was recommended to identify B_{loss} as a candidate value of B_{lim}, below which the dynamics of the stock are unknown. For anchovy it was considered that "the dynamic range in SSB and R has been relatively large, but there is no clear signal in the S/R relationship. Furthermore, the assessment time-series is relatively short. B_{loss} should be maintained as B_{lim}." Hence B_{lim} was set equal to B_{loss} = 21 000 t, which was the lowest spawning biomass (SSB) in the ICA 2003 assessment (corresponding to year 1989).

Since 2002, due to a successive series of low recruitments, the anchovy spawning stock biomass has been around the precautionary reference points: B_{pa} and B_{lim}. In 2005, the population level was estimated as the lowest in the historical series, being the biomass far below B_{lim}, remaining subsequently, in 2006 and 2007, between B_{lim} and B_{pa} due to still repeated low levels of recruitments. Under current circumstances, it seems that at low spawning biomasses, around B_{lim}, the chances of successful recruitment and recovery of the stock can be diminished, supporting the current definition of B_{lim}.

According to BBM the SSB in 1989 is now estimated at about 19,246 t., close to the current B_{lim} definition. Thus, the new assessment model does not change our perception of the stock and subsequently, the current B_{lim} (set at 21,000 t) is still valid. However, since the reference points are based on the current assessment assumptions on catchability of surveys, natural mortality, etc. Any major future change on these assumptions as for instance the survey catchability explored in section 10.7.2 would imply a revision of the absolute levels of the reference points. However, it has been shown that this would not change the historical perspective of relative changes of biomass in relation to reference points (**Figure 10.7.2.5).**

10.9 Catch projections for 2007 and 2008

Population and catch projections for 2008

Given the short-lived nature of the stock, , the validity of the short-term predictions is severely compromised in the absence of a recruitment index. Under those circumstances, probabilistic forecast given a number recruitment scenarios is presented here as a basis for advice.

Input data

Based on the Bayesian biomass-based model used for the assessment of the stock (see section 10.8) a stochastic 1 year forward projection of the population is performed. The probability of SSB in 2008 of being below the biological reference points B_{lim} (21 000 tones) and B_{pa} (33 000 tones) under different recruitment scenarios, 0 catch in the 2^{nd} half of 2007 and alternative catch options for the first half of 2008 is estimated.

The predictive distribution of recruitment at age 1 (in mass) in January 2008 could be defined as a mixture of the past series of posterior distributions of recruitment:

$$R_{2008} = \sum_{y=1987}^{2007} w_y \, p(R_y \mid \cdot)\,,$$

where $p(R_y \mid \cdot)$ denotes the posterior distribution of recruitment in year y and w_y are the weights of the mixture distribution such that $\sum_y w_y = 1$. The weighting can be based on information about incoming recruitment or on assumptions regarding different scenarios. Since currently no reliable information is available to set the weights for the mixture of recruit distributions, all the years were equally weighted, and this is referred to as an undetermined recruitment scenario. The predictive distribution of recruitment in 2008 used in the forecast, is shown in **Figure 10.9.1,** under the label undetermined. This distribution has three peaks of decreasing height. The local minima between the peaks (approximately 42 400 and 72 000 tones that correspond to the 47 and 70 percentiles of the distribution respectively) can be used to split the recruitment in three regimes that can be interpreted as corresponding to low medium and high regimes. So that, this partition was used to define mixture weights for three additional recruitment scenarios:

- Low recruitment scenario: Give positive equal weight to all years for which the posterior median of recruitment falls in the leftmost interval (i.e. posterior median of recruitment is below 42 400 tones). Assign zero weight to all other years.
- Medium recruitment scenario: Give positive equal weight to all years for which the posterior median of recruitment falls in the central interval (i.e. posterior median of recruitment is between 42 400 and 72 000 tones). Assign zero weight to all other years.
- High recruitment scenario: Give positive equal weight to all years for which the posterior median of recruitment falls in the rightmost interval (i.e. posterior median of recruitment is above 72 000 tones). Assign zero weight to all other years.

The mixture weights for the four alternative recruitment scenarios (undetermined, low, medium and high) are summarised in **Table 10.9.1**. The resulting predictive distributions for recruitment in 2008 are shown in **Figure 10.9.1**.

Prediction

In mid July the European Commission decided that the Bay of Biscay anchovy fishery should remain closed and should not be reopened until the end of the year. Starting from the posterior distribution of SSB in 2007 the population was projected forward under alternative four recruitment scenarios assuming a 0 catch in the 2^{nd} half of 2007 in all cases. Risks of falling below reference points are shown in Table 10.9.2 and Figure 10.9.2 for a range of catches in the 1^{st} half of 2008 and for the recruitment scenarios considered. In the case of the low recruitment scenario the probability of SSB < Blim is at least about 10% for all catches explored, including 0. This probability increases rapidly as catch in first half of 2008 increases, getting to around 50% when total catch is around 19,000 tonnes. Alternatively, in the medium or high recruitment scenarios, the probability of SSB in 2008 being below B_{lim} is smaller than 5% even for catches of up to 33,000. If recruitment was assumed undetermined a

5% risk corresponds to a catch of 1,000 tons. Since 2002 the recruitment has been low and the last high recruitment was in 2001. Catch options and associated risks corresponding to the low recruitment scenario were the basis for June STECF advice. However, without clear guidance on acceptable level of risk for this stock it is difficult to indicate particular catch levels that would conform with the precautionary approach. Another criteria that could be used as a basis for advice is the maximum catch that would result in a predicted median SSB in 2008 > Bpa. For the scenario of undetermined recruitment a catch of 33,000 tonnes would meet such criteria, but with a risk of falling below Blim of about 33%.

ICES seeks management to keep the stock above B_{pa}, so that, according to its definition, it would correspond to reduce the probability of the stock falling below B_{lim} below 5%. In the case of a low recruitment scenario this certainty cannot be achieved even if the fishery is closed until the end of June in 2008, whereas for the medium and high recruitment scenarios it will always be fulfilled. For an undetermined recruitment the base level risk (no catches) is 4,4%.

June 2007 STECF advice

In June 2007 just after the preliminary biomass from surveys were available, population projections for a range of different catch levels from July 2007 to June 2008 were made for several recruitment scenarios affecting the first half of 2008 (as described in previous section). Based on them the risk of falling below Blim associated to each level of allowable catches were submitted to managers through STECF (2007). A summary of the analysis performed in June 2007 follows.

Starting from the posterior distribution of SSB in 2007 the population was projected forward under the alternative recruitment scenarios. The catch from the 15th May, in which SSB is estimated, to the end of June was taken as 71 tones. Total allowable catch between 1st July 2007 and 30 June 2008 were explored from 0 (fishery closure) to 33 000 tones (historical annual fixed TAC for this stock) with a step of 1000 tones. In addition, the effect of the percentage of those total allowable catches corresponding to the second half of 2007 was also studied by considering percentages from 0 to 100% with a step of 5%. The timing within the year in which the catches in the second half of 2007 and the first half of 2008 were assumed to occur were computed as the average time point from the historical series from 1987 to 2004 (2005-2007 were not considered as the fishery was closed during some part of the year). Similarly, the percentage of catches in the first half of 2008 taken before the 15th May, when SSB is estimated, was assumed to be equal to the average from the historical series between 1987 and 2004 (58%). Probability of SSB in 2008 being below B_{lim} and B_{pa} was derived for each of the recruitment scenarios, total catch options and split of the total catch in the second half of 2007 and first half of 2008 (**Figure 10.9.3**).

10.10 Harvest Control Rules.

For the last years a series of studies concerning harvest control rules (HCR) for anchovy have been proposed and partly evaluated, being presented to ICES or to STECF. Among others TACs on annual or on half year basis, technical measures such as area closures or minimal landing size have been considered. However, none of these proposals have been endorsed by scientists as the “best” proposal to managers. This is due to the fact that for any risk level there are several equally valid HCR with different implications on the local national fisheries. So decision should be taken by managers in a close dialogue with the stakeholders. That is probably why ACFM of ICES stated that the revision of the management procedure should be made “through a dialogue between ICES and managers”, without being more concrete on its HCR proposals in the past. No new HCR is suggested in this section. A summary review of past HCR is made and a discussion about the decision rule to follow according to acceptable levels of risks in order to reopening the fishery is made.

Summary of past Harvest Control Rules

So far two types of Harvest Control rules have been examined for this anchovy in addition to several technical measures (see a review in the WD of Uriarte & Ibaibarriaga presented to this WG) constant harvest strategy or a type of constant escapement strategy. In this WG a constant harvest strategy was examined in the past (Roel et al. 2003 and Ibaibarriaga et al. 2005). A summary of those works is presented in ICES 2006 (section 10.10.2). The rule is just a variant of a constant harvest strategy: Basically, the TAC is defined as a proportion γ' of the spawning stock biomass estimate $S\hat{S}B_y$ subject to special rules when it falls below B_{pa} or B_{lim} In general those analysis showed that in the present way of management by deciding a TAC for the whole year (January – December) :

The higher γ , the higher the risk

A capped TAC reduces the risk (particularly at $\gamma = 1$)

Having an operative index of recruitment should decrease the risk (almost halves it for all gamma)

The TAC revision at mid-year has limited impact on the risk as most of the risk is already taken during the first semester (55% of catches & spawning season)

Other technical measures like geographic and/or seasonal closures, size limitations, studied seems to have more limited effects on reducing the risk than analytical TAC. A combination of them will be of course of more efficient. .

Further work can be taken in those line of research

After the stock collapse in 2005, the STECF has provided advice in 2005 and 2006 (STECF-SGRST 2005 & 2006) based on a rule for reopening the fishery. If SSB in May is above B_{lim} catches could be allowed only if, in the case of a new low recruitment, the expected SSB for the following year will still be above B_{pa}. This approach takes ICES statement pointing that the TAC should “aims at keeping the stock safely above B_{lim} even if the incoming year class is poor” as assuring that the SSB will be above B_{pa}. This will be in agreement with ICES’s definition of B_{pa} as a secure biomass level which assures being above B_{lim}. <u>The HCR is a type of constant escapement strategy.</u> It is more precautionary that the example above and certainly diminishes the catch possibilities. It can be discussed whether this can be taken as a general HCR or as a particular one only devised for rebuilding the stock to B_{pa} in case of having fallen below B_{lim}.

In June 2007, STECF (STECF-SGRST 2007b) noted clear signs that the stock situation had improved compared to 2005 (with a population of about 30,000 t in 2007). However, since “spawning stock biomass remains very low and maximum protection of the remaining spawning population is required. STECF recommends that management measures other than complete closure of the fishery in 2007 should not be considered. STECF further recommends that the fishery should remain closed in 2008 until reliable estimates of the 2008 SSB and 2007 year class become available …” This recommendation implied in practice not allowing any catches until full recovery above B_{pa} is achieved, which is more restrictive than its previous deterministic table for catch options. The reason for this, although not explicitly dealt within the STECF-SGRST 2007b report, may arise from the probabilistic approach followed for the projections at the ad hoc working group on anchovy. This group (STECF-SGRST 2007) understood the objective of management as « ICES seeks management to keep the stock above B_{pa}, which according to its definition would correspond to reduce the probability of the stock falling below B_{lim} below 5%”. The ad hoc WG found that for a low recruitment scenario, this target cannot be achieved for any catch option (see also 10.9 of this report to understand the probabilistic forecasts used).

This lead to a Key point for discussion about what level of risk should be accepted for any commercial fishery to take place on this highly fluctuating and recruitment dependent population and for the current circumstances to allow reopening the fishery. In the remaining part of the section this issue is discussed presenting the basis for discussing this with managers, which implicitly should lead to adopt a HCR to decide conditions for reopening the fishery.

Allowable levels of risks and conditions for opening the fishery:

For a short living species as anchovy which shows quite large variation in recruitment, the fluctuations in spawning biomass are invariantly large. Hence, the probability of the SSB falling below B_{lim} after one or two successive failures of recruitment is certainly high, even after safe levels of the population. In this section we have tried to outline the usual levels of probabilities of falling below B_{lim} that can be expected for the Bay of Biscay anchovy. This could serve to confront scientists and managers to the difficulties of managing this population according to the different levels of allowable risks and to the various levels of exploitation. Furthermore, it could supply some thinking about what certainty would be desirable to re open the fishery.

Several projections of the anchovy population were made using the former population projection tool based on BBM. Instead of being conditioned to the actual SSB (May 2007) estimated by the latest assessment, the exercise covered a wide range of plausible starting SSB in May of any year, and projected forward the population under different recruitment scenarios (at the beginning of next year) and alternative catch options for the second half of the year and first half of the next one. In this way, the probabilities of SSB being below B_{lim} and B_{pa} were analysed as a function of different starting SSB conditions, among which the 2007 is just an approximation of a particular realisation.

The initial SSB distribution was considered to be Log-Normally distributed with a coefficient of variation of 25% and a median (in natural scale) varying from 5000 to 100 000 tones (with a step of 5000). The same recruitment scenarios as above (undetermined, low, medium and high) were explored. To mimic the situation in June where a decision has to be made about opening or keeping closed the fishery, no catch was considered from the 15th May to the end of June. Alternative total catch options between 1st July of the initial year and 30 June of the year after were explored: from 0 (fishery closure) to 40 000 tones with a step of 1000 tones. The percentage of these total allowable catches corresponding to the second half of the year was assumed to be the average from the historical series from 1987 to 2004 (rejecting 2005-2007 as the fishery was closed during some part of the year). Similarly, the timing within the year in which the catches in the second half of the initial year and the first half of the next year were assumed to occur and the percentage of catches in the first half of the next year taken before the 15th May, when SSB is estimated, were assumed to be equal to the average from the historical series between 1987 and 2004. Probability of next year SSB being below B_{lim} and B_{pa} were derived for each of the initial SSB distributions, recruitment scenarios and total catch options (**Figure 10.10.1**). In particular, when no catch would have been allowed, the results are shown in **Figure 10.10.2**.

The results show that under the undermined and low recruitment scenarios, to start allowing some catches with a probability of 5% of falling below B_{lim}, the distribution of the biomass in the starting year should have a median above 30,000 t or 35,000 t respectively. Since 1987 and up to 2005 when the fishery collapsed, median spawning biomasses below 35,000t were encountered in 5 out of 19 years, i.e about 25% of the annual fisheries operated with “a priori” risks higher than 5% of falling below B_{lim} (and at the 5th occasion it dropped below). Historically, the average biomass estimated for this stock is about 55,000 t. If the population was at this historical average biomass, then catches of about 20,000 t or 13,000 t would be allowable for the undetermined or low recruitment scenarios respectively for the same level of risk. Finally, in order to allow catches of about 30,000t (which has been the fix TAC for most of the history of this fishery) , spawning biomass levels of about 70,000 or about 80,000t would be required for these two scenarios and same levels of risks. This certainly implies that average catches of 30,000 t as allowed by the TAC in the past would imply higher levels of risk. For instance, for the average SSB of 55,000t, catches of 30,000 t would imply probabilities of falling below B_{lim} of 11 % and 29% for the undetermined and low recruitment scenarios.

In summary, there is a balance between the levels of acceptable risks for management and average level of catches that can be obtained. From the above analysis it should be clear that for the definition of any long term management plan, and in particular to test any harvest control rule, one of the first steps should be agreeing by managers, stake holders and scientists on the levels of risks that would be acceptable for this fishery. In order to facilitate the dialogue and to start up the discussion on the conditions to re-open the fishery, the above analysis was transformed into a maximum allowable catch table as a function of the probabilities of SSB being below B_{lim} and starting median biomass depending on different recruitment scenarios (**Table 10.10.1**). These tables can serve to establish a first dialogue with stakeholders and managers. It is important to note that this analysis is preliminary and it is based on a specific distribution of initial SSB with a fixed level of uncertainty. In addition recruitment is not modelled but is just obtained from past series estimates, which certainly influence the results (47% of past series of Recruitments were low). Other type of distributions or assumptions could also be explored in further analyses.

10.11 Management Measures and considerations:

Current state: The SSB in 2007 is 29% higher than in 2006. The population may be considered as above B_{lim} (with a probability of being below it of 3.2%) while in 2006 that probability was 40% (ICES 2006). However the recruitment at age 1 in 2007 is of similar level to that in 2006, both being in the lowest range of the past recruitment series. Therefore this assessment does not indicate a recovery of recruitment levels. Consequently, the WG considers that the situation of repeated low levels of recruitment has not changed during the last years since 2002.

At the current low levels of biomass, it is uncertain how long it will be before a new strong recruitment may appear. Therefore, given the current stock situation, the working group emphasises that any recovery is entirely dependent on good incoming recruitment. Therefore, protection of the spawning population is required. Following the precautionary approach the recruitment in 2008 should be presumed to be low. In addition, this is the more likely scenario based on the historical recruitment series (47%). Under that regime, the probability of SSB in 2008 being below Blim is always larger than 10%, even in case no catches are allowed. Under such precautionary approach the WG endorses the recommendation of STECF in June 2007 “that the fishery should remain closed in 2008 until reliable estimates of the 2008 SSB and 2007 year class become available based on the results from the spring 2008 acoustic and DEPM surveys. This implies a closure of the fishery until at least July 2008”.

However for this short living species the level of ordinary risk is higher than for most species, given the highly fluctuating recruitment and dependence of the population on it. Therefore aceptable levels of risks should be discussed and agreed between managers, stakeholders and scientists. Acknowledging that the ultimate decision is to be taken by managers, conditions for reopening the fishery under other levels of risks during 1st half of 2008 can be seen in the Table 10.9.2 for different levels of catches and under the three scenarios of potential recruitment. If some fishery were allowed it should be quite limited and strictly controlled to minimise the disruption to spawning until a reliable assessment of the recruitment and SSB in 2008 become available, based on the results from the spring 2008 acoustic and DEPM surveys. In addition, technical measures could be considered such as effort reduction and/or seasonal or area closures.

Scientific Monitoring of the Population required for a good management advise:

Monitoring of adult stock is required by acoustic and DEPM methods in spring and should be maintained since it provides the only reliable basis of the current assessment of the stock for the time being.

IN addition obtaining a recruitment index (through an acoustic survey or an environmental models) would enhance a lot the quality of the advise for management since the population entirely depends on recruits. Simulations have shown that such and index would improve the performance of any harvest control Rules. However the utility of any Recruitment estimator would depend on attaining a predictive power higher than R2 50% (De Oliveira et al. 2005).

Conditions for reopening and managing the fishery:

Managers may want to consider and discuss conditions for reopening the fishery after the gradual recovery of the last years, but this has to be made according to the levels of risks they will want to assume. For a short living species as anchovy which shows quite large variation in recruitment, the fluctuations in spawning biomass are invariantly large. Hence, the probability of the SSB falling below B_{lim} after one or two successive failures of recruitment is certainly high, even after safe levels of the population. In section 10.10 the usual levels of probabilities of falling below B_{lim} that can be expected for the Bay of Biscay anchovy are outlined. This could serve to confront scientists and managers to the difficulties of managing this population according to the different levels of allowable risks and to the various levels of exploitation. The results show that under an undetermined and low recruitment scenarios, to start allowing some catches with a probability of 5% of falling below B_{lim}, the distribution of the biomass in the starting year should have a median above 30,000 t or 35,000 t respectively (Table 10.10.1). The short term forecast produced for the first half of 2008 illustrate the ranges of expected SSB and risks of falling below Blim in 2008 according to the different levels of potential allowable catches and scenarios of recruitment (table 10.9.2). Those table should allow managers to take the decisions about the conditions for re opening the fishery.

The need of management Plan:

The need of Long term management plan has become evident after the recent collapse of the population and failures of the fishery. STECF has stressed the need of such management plan as well as fishermen of France and Spain. A WD was presented to this WG presenting a review of past concrete proposals for managing this fishery and potential objectives for setting up a Long term management plan (Uriarte & Ibaibarriaga WD2007). For the last years a series of studies concerning harvest control rules (HCR) for anchovy have been proposed and partly evaluated, being presented to ICES or to STECF. Among others TACs on annual or on half year basis, technical measures such as area closures or minimal landing size have been considered. However, none of these proposals have been endorsed by scientists as the “best” proposal to managers. This is due to the fact that for any risk level there are several equally valid HCR with different implications on the local national fisheries. So decision should be taken by managers in a close dialogue with the stakeholders.

This year, 2007, the Regional Advisory Committee (RAC) of South-Western waters has been established and become operative. Within it a subcommittee of pelagic fisheries will deal with the anchovy fishery in the Bay of Biscay, among others. This is a suitable forum where scientific proposals can be discussed with stakeholders. IF the EC would like to launch the formulation of a long term management plan for anchovy could be established through a dialogue with scientists (directly initially but through ICES ultimately), fishermen (RAC of South-Western waters) and managers.

Setting up a Management Plan includes several steps, starting with the clarification of the objectives of the management with their associated performance criteria, the implementation measures (e.g. input or output control), the decision rule (or Harvest Control Rule) and the definition of the relevant knowledge on which to base decisions (monitoring and assessment) (ICES SGMAS 2006). The definition of a management plan should as much as possible be formulated by consultations and agreements between the concerned stakeholders after evaluation of the proposed management measures and HCR (SGMAS2007). Here follow some considerations for the formulation of a draft management plan

Potential Management objectives

For the Bay of Biscay anchovy, several **objectives** could be formulated according to the different interests of the fishery, ecologists and managers, around which agreements should be reached:

Economic and Social objectives:

Fishery Sustainability

Maximize catches?

Maximize economic incomes?

Maximize employments and sustainability of current fishing fleets?

Catch stability

Adoption of minimum and/or maximum TACs.

Reduce the interannual variability in the TAC.

Minimize situation of fishery closures etc.

Comments: Maximize catches as much as possible conditioned to the sustainability of the resource seems the simplest objective nowadays. But economic studies including maximizing catches of the highest prizes (i.e. of the big and old anchovies) could also be considered at the expenses of reducing overall total catches.

Minimum or Maximum TACs are logic proposals to be considered given the fishermen and industrial requirements and market absorption capacity. Prior testing suggests that ceiling up the TACs (around 33,000 t) allows some biomass buffer that decreases the risks for the stock in the long term. Catch stability is an objective not achievable for this type of short living species and therefore inter year variability should expected to be relatively high according to fluctuation of recruitment when maximizing catches is pursued.

Biological and Ecological Objectives:

Population Biological objective:

Minimize risks of falling below Blim.

Sustainable Exploitation levels according to stock productivity under oceanographic climate regimes

MSY?

Ecological objectives

Assuring a surplus production as forage for the predators in the Bay of Biscay.

Comments: For minimizing the probability of falling below B_{lim} moderate exploitation levels are preferable for the type of short living species. ICES has set the F_{pa} at about 1- 1.2; according to the criteria for F for 50% spawning potential ratio, i.e., the F at which the SSB/R is half of what it would have been in the absence of fishing. This precautionary approach for the management of this short living species seems to be generally recommended and applied all over the world (Barange et al. 2001, 2007). In terms of Gamma (the harvest rate of the Biomass Based Model of this anchovy -BBM) values around 0.5 and 0.6 would conform those objectives of moderate exploitation.

Management measures could be:

Annual TAC or Two step TAC procedures?

Technical measures: area closures, minimum landing size, calendar of fishing fleet activities.

Scientific monitoring of the Population: Adult surveys, juvenile surveys?, integrated assessment and its timing.

Decision Rule (Harvest Control Rule).

Comments: Two step TAC procedure is to be preferred over the single annual TAC while no recruitment index is available, although it is not as much effective in reducing the risks for the stock as incorporating a Recruitment index into the management decision frame. Further work is required for the evaluation of the technical measures so far proposed for this fishery.

As a first approach a “classic” three stage HCR can be proposed with specified, usually fixed, values for F (or harvest rate) when B is below the lower trigger point or above the upper one, and with a smooth transition at biomass values between the two trigger points. Harvest control rules for a range of moderate exploitation levels as mentioned above can be considered as a starting point for the HCR evaluation procedure. Harvest rules only based on relative change in the survey indices (as prepared in FISBOAT project) can also be here proposed and tested.

Management strategy testing and evaluation.

This could be done:

Within ICES or in ad hoc STECF WG.

Following standards of ICES SGMAS (ICES 2006B, 2007)

Presentation and discussion with stakeholders and managers in a dynamic and iterative process until outlining “the best HCR” providing a good compromise across all objectives.

Table 10.2.1.1: Bay of Biscay Anchovy. Annual catches (in tonnes) (Subarea VIII). As estimated by the Working Group members.

COUNTRY	FRANCE	SPAIN	SPAIN	INTERNATIONAL
YEAR	**VIIIab**	**VIIIbc, Landings**	**Live Bait Catches**	**VIII**
1960	1 085	57 000	n/a	58 085
1961	1 494	74 000	n/a	75 494
1962	1 123	58 000	n/a	59 123
1963	652	48 000	n/a	48 652
1964	1 973	75 000	n/a	76 973
1965	2 615	81 000	n/a	83 615
1966	839	47 519	n/a	48 358
1967	1 812	39 363	n/a	41 175
1968	1 190	38 429	n/a	39 619
1969	2 991	33 092	n/a	36 083
1970	3 665	19 820	n/a	23 485
1971	4 825	23 787	n/a	28 612
1972	6 150	26 917	n/a	33 067
1973	4 395	23 614	n/a	28 009
1974	3 835	27 282	n/a	31 117
1975	2 913	23 389	n/a	26 302
1976	1 095	36 166	n/a	37 261
1977	3 807	44 384	n/a	48 191
1978	3 683	41 536	n/a	45 219
1979	1 349	25 000	n/a	26 349
1980	1 564	20 538	n/a	22 102
1981	1 021	9 794	n/a	10 815
1982	381	4 610	n/a	4 991
1983	1 911	12 242	n/a	14 153
1984	1 711	33 468	n/a	35 179
1985	3 005	8 481	n/a	11 486
1986	2 311	5 612	n/a	7 923
1987	4 899	9 863	546	15 308
1988	6 822	8 266	493	15 581
1989	2 255	8 174	185	10 614
1990	10 598	23 258	416	34 272
1991	9 708	9 573	353	19 634
1992	15 217	22 468	200	37 885
1993	20 914	19 173	306	40 393
1994	16 934	17 554	143	34 631
1995	10 892	18 950	273	30 115
1996	15 238	18 937	198	34 373
1997	12 020	9 939	378	22 337
1998	22 987	8 455	176	31 617
1999	13 649	13 145	465	27 259
2000	17 765	19 230	n/a	36 994
2001	17 097	23 052	n/a	40 149
2002	10 988	6 519	n/a	17 507
2003	7 593	3 002	n/a	10 595
2004	8 781	7 580	n/a	16 361
2005	952	176	n/a	1 128
2006	912	840	n/a	1 752
2007(Up end June)	136	1	n/a	137
AVERAGE (1990-04)	6 394	26 337	318	32 824

Table 10.2.1.2: Bay of Biscay Anchovy. Monthly catches by country (Sub-area VIII) (without live bait catches)

COUNTRY: FRANCE											Units: t.	1000	
YEAR\MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TOTAL**
1987	0	0	0	1 113	1 560	268	148	582	679	355	107	87	4 899
1988	0	0	14	872	1 386	776	291	1 156	2 002	326	0	0	6 822
1989	704	71	11	331	648	11	43	56	70	273	9	28	2 255
1990	0	0	16	1 331	1 511	127	269	1 905	3 275	1 447	636	82	10 598
1991	1 318	2 135	603	808	1 622	195	124	419	1 587	557	54	285	9 708
1992	2 062	1 480	942	783	57	11	335	1 202	2 786	3 165	2 395	0	15 217
1993	1 636	1 805	1 537	91	343	1 439	1 315	2 640	4 057	3 277	2 727	47	20 914
1994	1 972	1 908	1 442	172	770	1 730	663	2 125	3 276	2 652	223	0	16 934
1995	620	958	807	260	844	1 669	389	1 089	2 150	1 231	855	22	10 892
1996	1 084	630	614	206	150	1 568	1 243	2 377	3 352	2 666	1 349	0	15 238
1997	2 235	687	24	36	90	1 108	1 579	1 815	1 680	2 050	718		12 022
1998	1 523	2 128	783	0	237	1 427	2 425	4 995	4 250	2 637	2 477	103	22 987
1999	2 080	1 333	574	55	68	948	1 015	922	3 138	1 923	1 592	0	13 649
2000	2 200	948	825	5	58	1 412	2 190	2 720	3 629	2 649	1 127	0	17 765
2001	717	517	143	46	47	1 311	1 078	3 401	4 309	2 795	2 732	0	17 097
2002	1 435	2 561	1 560	1	30	758	350	979	1 957	771	578	0	10 978
2003	39	2	0	32	123	1 031	284	2 284	1 478	1 319	983	19	7 593
2004	210	106	3	13	145	1 625	853	1 995	2 464	555	813	0	8 781
2005	363	15	33	0	16	525	0	0	0	0	0	0	952
2006	1	0	29			795	88	0	0	0	0	0	912
2007	0	0	0	46	50	40	0	0	0	0	0	0	136
Average 87-05	962	823	474	310	488	894	699	1 555	2 197	1 459	923	34	10 818
in percentage	8.9%	7.6%	4.4%	2.9%	4.5%	8.3%	6.5%	14.4%	20.3%	13.5%	8.5%	0.3%	100%
Average 92-05	1 298	1 077	663	121	213	1 183	980	2 039	2 752	1 978	1 326	15	13 645
in percentage	9.5%	7.9%	4.9%	0.9%	1.6%	8.7%	7.2%	14.9%	20.2%	14.5%	9.7%	0.1%	100%

COUNTRY: SPAIN		1000											
YEAR\MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TOTAL**
1987	0	0	454	4 133	3 677	514	81	54	28	457	202	265	9 864
1988	6	0	28	786	2 931	3 204	292	98	421	118	136	246	8 266
1989	2	2	25	258	4 295	795	90	510	116	198	1 610	273	8 173
1990	79	6	2 085	1 328	9 947	2 957	1 202	3 227	2 278	123	16	10	23 258
1991	100	40	23	1 228	5 291	1 663	91	60	34	265	184	596	9 573
1992	360	384	340	3 458	13 068	3 437	384	286	505	63	94	89	22 468
1993	102	59	1 825	3 169	7 564	4 488	795	340	198	65	546	23	19 173
1994	0	9	149	5 569	3 991	5 501	1 133	181	106	643	198	74	17 554
1995	0	0	35	5 707	11 485	1 094	50	9	6	152	48	365	18 951
1996	48	17	138	1 628	9 613	5 329	1 206	298	266	152	225	17	18 937
1997	43	1	81	2 746	2 672	877	316	585	1 898	331	203	185	9 939
1998	35	235	493	371	4 602	1 083	1 518	44	47	3	22	1	8 455
1999	8	26	52	4 626	4 214	1 396	1 037	26	911	207	615	27	13 144
2000	18	0	99	1 952	11 864	3 153	958	342	413	346	83	0	19 230
2001	243	48	337	2 203	14 381	3 102	1 436	1	126	1 055	120	1	23 052
2002	1	0	13	914	2 476	1 340	323	56	1 013	381	1	0	6 519
2003	0	0	0	1 709	767	373	10	12	124	4	3	0	3 002
2004	0	0	0	2 364	3 102	1 616	50	22	423	1	1	2	7 580
2005	0	2	2	4	167	0	0	0	0	0	0	0	176
2006	0	0	4	124	630	75	7						840
2007	0	0	0	0	1	0	0	0	0	0	0	0	1
Average 87-05	55	44	325	2 324	6 111	2 100	577	324	469	240	227	114	12 910
in percentage	0.4%	0.3%	2.5%	18.0%	47.3%	16.3%	4.5%	2.5%	3.6%	1.9%	1.8%	0.9%	100%
			3.3%			81.6%			10.6%			4.5%	
Average 92-05	61	56	255	2 601	6 426	2 342	658	157	431	243	154	56	13 441
in percentage	0.5%	0.4%	1.9%	19.4%	47.8%	17.4%	4.9%	1.2%	3.2%	1.8%	1.1%	0.4%	100%

COUNTRY:	Total FRANCE + SPAIN												
Average 92-02	1 360	1 133	918	2 723	6 639	3 525	1 638	2 196	3 183	2 221	1 481	71	27 087
in percentage	5.0%	4.2%	3.4%	10.1%	24.5%	13.0%	6.0%	8.1%	11.8%	8.2%	5.5%	0.3%	100%

Table 10.2.1.3: Bay of Biscay Anchovy. Catches in the Bay of Biscay by country and divisions in 2006 (without live bait catches).

		QUARTERS				CATCH (t)	
COUNTRIES	**DIVISIONS**	1	2	3	4	ANNUAL	%
SPAIN	VIIIa	0	0	0	0	0	0.0%
	VIIIb	0	430	0	0	430	51.2%
	VIIIc	4	399	7	0	410	48.8%
	TOTAL	4	829	7	0	840	100
	%	0.5%	98.7%	0.8%	0.0%	100.0%	
FRANCE	VIIIa	0	0	0	0	0	0.0%
	VIIIb	29	795	88	0	912	100.0%
	VIIIc	0	0	0	0	0	0.0%
	TOTAL	29	795	88	0	912	100.0%
	%	3.2%	87.1%	9.6%	0.0%	100.0%	912
INTERNATIONAL	VIIIa	0	0	0	0	0	0.0%
	VIIIb	29	1225	88	0	1342	76.6%
	VIIIc	4	399	7	0	410	23.4%
	TOTAL	34	1623	95	0	1752	100.0%
	%	1.9%	92.7%	5.4%	0.0%	100.0%	

Table 10.3.1.1: Bay of Biscay Anchovy. Catch at age in thousands for 2006 by country, division and quarter (without the catches from the live bait tuna fishing boats).

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIbc	VIIIbc	VIIIabc	VIIIabc	VIIIabc
SPAIN	0					0
	1	208	21 068	355	0	21 631
	2	42	7 666	25	0	7 733
	3	5	3 582	7	0	3 594
	4					0
	TOTAL(n)	256	32 316	387	0	32 959
	W MED.	0.02	0.03	0.02	0.00	0.03
	CATCH. (t)	4.2	828.9	6.9	0.0	840.0
	SOP	4.2	838.8	7.1	0.0	850.2
	VAR. %	100.00%	101.20%	102.98%	0.00%	101.21%

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIab	VIIIab	VIIIab	VIIIab	VIIIab
FRANCE	0					0
	1	1 095	26 347	3 539	0	30 981
	2	340	9 123	966	0	10 430
	3	104	2 774	313	0	3 192
	4	1	48	2	0	51
	TOTAL(n)	1 541	38 292	4 820	0	44 653
	W MED.	0.02	0.02	0.02	0.00	23.33
	CATCH. (t)	29.5	794.5	87.9	0.0	911.9
	SOP	29.5	794.5	87.9	0.0	911.9
	VAR. %	100.00%	100.00%	100.00%	0.00%	100.00%

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIabc	VIIIabc	VIIIabc	VIIIabc	VIIIabc
TOTAL Sub-area VIII	0	0	0	0	0	0
	1	1 303	47 415	3 894	0	52 612
	2	383	16 789	991	0	18 163
	3	109	6 356	320	0	6 786
	4	1	48	2	0	51
	TOTAL(n)	1 797	70 608	5 207	0	77 612
	W MED.	0.02	0.02	0.00	0.00	13.43
	CATCH. (t)	33.7	1623.4	94.8	0.0	1 751.9
	SOP	33.7	1633.3	95.0	0.0	1 762.1
	VAR. %	100.00%	100.61%	100.22%	0.00%	100.58%

Table 10.3.1.2: Bay of Biscay Anchovy. Catches at age of the fishery in the Bay of Biscay on half year basis as reported up to 1998 to ICES WGs and updated since then.

INTERNACIONAL

YEAR	1987		1988		1989		1990		1991		1992		1993		1994	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	0	38 140	0	150 338	0	180 085	0	16 984	0	86 647	0	38 434	0	63 499	0	59 934
1	218 670	120 098	318 181	190 113	152 612	27 085	847 627	517 690	323 877	116 290	1 001 551	440 134	794 055	611 047	494 610	355 663
2	157 665	13 534	92 621	13 334	123 683	10 771	59 482	75 999	310 620	12 581	193 137	31 446	439 655	91 977	493 437	54 867
3	31 362	1 664	9 954	596	18 096	1 986	8 175	4 999	29 179	61	16 960	1	5 336	0	61 667	1 325
4	14 831	58	1 356	0	54	0	0	0	0	0	0	0	0	0	0	0
5	8 920	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	431 448	173 494	398 971	529 130	294 445	219 927	915 283	615 671	663 677	215 579	1 211 647	510 015	1 239 046	766 523	1 049 714	471 789
Internat Catches	11 718	3 590	10 003	5 579	7 153	3 460	19 386	14 886	15 025	4 610	26 381	11 504	24 058	16 334	23 214	11 417
Var. SOP	100.7%	100.4%	98.3%	101.9%	98.5%	99.3%	100.7%	99.1%	97.6%	98.5%	99.6%	99.9%	101.1%	99.5%	101.0%	100.2%
Annual Catch		15 308		15 581		10 614		34 272		19 635		37 885		40 392		34 631

YEAR	1995		1996		1997		1998		1999		2000		2001		2002	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	0	49 771	0	109 173	0	133 232	0	4 075	0	54 357	0	5 298	0	749	0	267
1	522 361	189 081	683 009	456 164	471 370	439 888	443 818	598 139	220 067	243 306	559 934	396 961	460 346	507 678	103 210	129 392
2	282 301	21 771	233 095	53 156	138 183	40 014	128 854	123 225	380 012	142 904	268 354	64 712	374 424	98 117	217 218	77 128
3	76 525	90	31 092	499	5 580	195	5 596	3 398	17 761	525	84 437	18 613	19 698	5 095	37 886	3 045
4	4 096	7	2 213	42	0	0	155	0	108	0	0	0	4 948	0	76	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	885 283	260 719	949 408	619 034	615 133	613 329	578 423	728 837	617 948	441 092	912 725	485 584	859 417	611 639	358 390	209 832
Internat Catches	23 479	6 637	21 024	13 349	10 704	11 443	12 918	18 700	15 381	11 878	22 536	14 458	23 095	17 054	11 102	6 406
Var. SOP	101.5%	98.2%	99.5%	100.4%	99.7%	102.1%	100.6%	94.8%	102.0%	103.0%	100.8%	97.6%	100.8%	101.1%	97%	102%
Annual Catch		30 116		34 373		22 147		31 617		27 259		36 994		40 149		17 507

YEAR	2003		2004		2005		2006	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	0	7 530	0	11 184	0	0	0	0
1	50 327	133 083	254 504	252 887	7 818	0	48 718	3 894
2	44 546	87 142	85 679	20 072	32 911	0	17 172	991
3	34 133	11 459	12 444	1 153	6 935	0	6 465	320
4	887	1 152	4 598	16	586	0	49	2
5	0	0	0	0	0	0	0	0
Total #	129 893	240 366	357 225	285 312	48 250	0	72 405	5 207
Internat Catches	4 074	6 521	9 183	7 177	1 127	0	1 657	95
Var. SOP	100%	100%	100%	100%	103%	0%	101%	100%
Annual Catch		10 595		16 360		1 127		1 752

Table 10.3.1.2. (Cont. 1): Bay of Biscay Anchovy.

SPAIN

YEAR		1987		1988		1989		1990		1991		1992		1993		1994	
Periods		1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age	0	0	35 452	0	141 918	0	174 803	0	11 999	0	81 536	0	13 121	0	63 499	0	59 022
	1	134 390	40 172	210 641	47 480	110 276	13 165	719 678	234 021	210 686	21 113	751 056	72 154	578 219	75 865	257 050	47 065
	2	119 503	7 787	61 609	2 690	92 707	9 481	47 266	43 204	139 327	1 715	131 221	5 916	266 612	11 904	315 022	24 971
	3	27 336	1 664	7 710	596	8 232	1 986	8 139	4 999	2 657	61	10 067	1	967	0	44 622	1 325
	4	14 831	58	1 356	0	54	0	0	0	0	0	0	0	0	0	0	0
	5	8 920	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #		304 980	85 134	281 414	192 684	211 270	199 435	775 083	294 222	352 670	104 425	892 344	91 192	845 798	151 268	616 694	132 383
Catch Spain		8 777	1 632	6 955	1 804	5 377	2 981	16 401	7 273	8 343	1 583	21 047	1 621	17 206	2 272	15 219	2 478
Var. SOP		100.7%	99.7%	97.9%	100.6%	97.1%	99.5%	100.9%	99.5%	94.7%	98.2%	99.3%	100.5%	100.8%	100.2%	101.3%	99.6%
Annual Catch			10 409		8 759		8 358		23 674		9 926		22 669		19 479		17 697

YEAR		1995		1996		1997		1998		1999		2000		2001		2002	
Periods		1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd haf
Age	0	0	31 101	0	52 238	0	91 400	0	4 075	0	29 057	0	439	0	748	0	239
	1	367 924	17 611	542 127	72 763	296 261	123 011	217 711	57 847	134 411	87 191	389 515	71 547	378 136	54 151	31 347	40 149
	2	206 387	1 333	163 010	12 403	74 856	9 435	41 171	9 515	231 384	37 644	199 233	8 640	327 090	43 487	98 700	22 621
	3	57 214	90	14 461	499	1 927	195	4 002	9	10 051	525	50 834	2 085	18 854	464	13 702	2 041
	4	4 096	7	2 213	42	0	0	155	0	108	0	0	0	4 948	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #		635 621	50 142	721 810	137 945	373 044	224 041	263 039	71 445	375 954	154 416	639 583	82 711	729 029	98 851	143748.2	65049.3
Catch Spain		18 322	902	16 774	2 361	6 420	3 897	6 818	1 812	10 323	3 287	17 087	2 143	20 314	2 738	4 745	1 774
Var. SOP		102.1%	100.1%	99.5%	100.4%	99.5%	98.7%	98.9%	99.8%	102.1%	101.7%	101.1%	100.7%	102.1%	101.7%	101%	101%
Annual Catch			19 224		19 135		10 317		8 630		13 610		19 230		23 052		6 519

YEAR		2003		2004		2005		2006	
Periods		1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age	0	0	49	0	115	0	0	0	0
	1	11 761	4 895	183 853	18 994	1096	0	21 276	355
	2	32 566	1 068	71 589	482	4631	0	7 708	25
	3	28 809	272	7 461	23	266	0	3 587	7
	4	434	0	4 340	16	16	0	0	0
	5	0	0			0	0	0	0
Total #		73 569	6 285	267 243	19 630	6 009	0	32 571	387
Catch Spain		2 848	154	7 081	498	176	0	833	7
Var. SOP		100%	101%	101%	101%	101%	0%	101%	103
Annual Catch			3 002		7 580		176		840

Table 10.3.1.2. (Cont. 2): Bay of Biscay Anchovy.

FRANCE

YEAR		1987		1988		1989		1990		1991		1992		1993		1994	
Periods		1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age	0	0	2 688	0	8 419	0	5 282	0	4 985	0	5 111	0	25 313	0	0	0	912
	1	84 280	79 925	107 540	142 634	42 336	13 919	127 949	283 669	113 191	95 177	250 495	367 980	215 836	535 182	237 560	308 598
	2	38 162	5 747	31 012	10 644	30 976	1 290	12 216	32 795	171 293	10 866	61 916	25 530	173 043	80 073	178 415	29 896
	3	4 026	0	2 245	0	9 863	0	36	0	26 522	0	6 893	0	4 369	0	17 045	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #		126 468	88 360	140 797	161 697	83 175	20 492	140 200	321 449	311 007	111 154	319 303	418 823	393 248	615 255	433 020	339 406
Catch France		2 941	1 958	3 048	3 775	1 776	479	2 985	7 613	6 682	3 027	5 334	9 883	6 851	14 062	7 994	8 939
Var. SOP		100.4%	101.0%	99.0%	102.5%	102.6%	97.8%	99.2%	98.7%	101.3%	98.6%	100.5%	99.8%	101.6%	99.4%	100.3%	100.4%
Annual Catch			4 899		6 822		2 255		10 598		9 708		15 217		20 914		16 934

YEAR		1995		1996		1997		1998		1999		2000		2001		2002	
Periods		1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd haf
Age	0	0	18 670	0	56 936	0	41 832	0	0	0	25 300	0	4 859	0	1	0	29
	1	154 437	171 470	140 882	383 401	175 109	316 877	226 107	540 293	85 656	156 115	170 418	325 413	82 210	453 527	71 864	89 243
	2	75 914	20 438	70 085	40 753	63 327	30 579	87 683	113 710	148 628	105 260	69 121	56 072	47 334	54 630	118 518	54 507
	3	19 311	0	16 631	0	3 653	0	1 594	3 389	7 710	0	33 603	16 528	844	4 631	24 184	1 005
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	76	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #		249 662	210 578	227 598	481 089	242 089	389 288	315 384	657 392	241 994	286 676	273 142	402 873	130 388	512 789	214641	144783
Catch France		5 157	5 735	4 251	10 987	4 284	7 546	6 099	16 888	5 058	8 591	5 449	12 316	2 782	14 316	6 357	4 631
Var. SOP		99.4%	97.9%	102.8%	99.8%	100.0%	103.9%	102.5%	94.3%	101.7%	103.4%	99.8%	97.0%	100.5%	101.3%	95%	102%
Annual Catch			10 892		15 238		11 830		22 987		13 649		17 765		17 097		10 988

YEAR		2003		2004		2005		2006	
Periods		1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age	0	0	7 481	0	11 069	0	0	0	0
	1	38 567	128 188	70 651	233 893	6722	0	27 442	3 539
	2	11 981	86 074	14 091	19 590	28281	0	9 464	966
	3	5 324	11 187	4 983	1 130	6669	0	2 878	313
	4	453	1 152	258	0	570	0	49	2
	5	0				0	0	0	0
Total #		56 325	234 082	89 982	265 683	42 242	0	39 833	4 820
Catch France		1 226	6 367	2 102	6 679	952	0	824	88
Var. SOP		100%	100%	100%	100%	104%	0%	100%	100%
Annual Catch			7 593		8 781		952		912

Table 10.3.1.3: Bay of Biscay Anchovy. Spanish half-yearly catches (2nd semester) by age in ('000) of Bay of Biscay anchovy from the live bait tuna fishing boats. (From Anon., 1986 and Uriarte et al., WD 1997). Since 1999 onwards are not being estimated.

AGE	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	10 020	97 581	6 114	11 999	12 716	2 167	3 557	7 872	10 154	8 102	33 078	1 032	17 230
1	24 675	17 353	6 320	21 540	13 736	14 268	20 160	5 753	10 885	6 100	8 238	15 136	20 784
2	1 461	203	1 496	139	0	0		477	209	522	58	0	810
3	912	3	0	0	0	0		0	0	0	0	0	0
Total	37 068	115 140	13 930	33 677	26 452	16 435	23 717	14 102	21 248	14 724	41 375	16 169	38 825
Catch (t)	546	493	185	416	353	200	306	143.2	273.2	197.5	378	175.5	465.126
meanW (g)	14.7	4.3	13.3	12.4	13.3	12.1	12.9	10.2	15.8	13.4	9.14	10.85	11.98

Table 10.3.2.1: Bay of Biscay Anchovy. Length distribution ('000) in Division VIIIabc by country and quarters in 2006.

	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4	
Length (half cm)	France VIIIab	Spain VIIIbc	France VIIIab	Spain VIIIbc	France VIIIab	Spain VIIIabc	France VIIIab	Spain VIIIabc
3.5								
4								
4.5								
5								
5.5								
6								
6.5								
7								
7.5								
8								
8.5		2		0		0		
9		2		2		0		
9.5		7		2		0		
10		11		11		0		
10.5		21	4	33		0		
11		32	10	83		0		
11.5	12	16	370	246		0		
12	54	20	961	716	9	0		
12.5	148	24	3 275	1 014	195	35		
13	279	20	5 376	809	687	96		
13.5	274	25	6 227	1 510	961	98		
14	220	18	5 585	2 432	983	49		
14.5	191	17	5 039	3 975	997	33		
15	108	16	2 913	4 763	475	46		
15.5	76	7	2 275	5 745	235	20		
16	71	10	2 420	3 455	132	2		
16.5	35	1	1 257	2 499	78	1		
17	29	3	1 006	1 648	36	1		
17.5	26	2	939	1 386	20	6		
18	8	3	302	1 033	6	0		
18.5	7	1	251	506	6	0		
19	2	0	84	337	2			
19.5				6				
20				104				
20.5				2				
21								
21.5								
22								
22.5								
23								
23.5								
24								
24.5								
25								
25.5								
26								
Number('000)	1 541	256	38 292	32 316	4 820	389	0	0
Catch (t)	29	4	795	829	88	7		
Mean Length(cm)	13.51	12.99	13.86	15.54	13.31	14.07		
Mean weight(g)	19.14	16.44	20.75	25.65	18.23	17.87		

Table 10.3.2.2: Bay of Biscay Anchovy. Mean weight at age in the international catches in Sub-area VIII on half year basis.

INTERNATIONAL

YEAR	1987		1988		1989		1990		1991		1992		1993		1994	
Sources	Anon. (1989 & 1991)		Anon. (1989)		Anon. (1991)		Anon. (1991)		Anon. (1992)		Anon. (1993)		Anon. (1995)		Anon. (1996)	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	0.0	11.7	0.0	5.1	0.0	12.7	0.0	7.4	0.0	14.4	0.0	12.6	0.0	12.3	0.0	14.7
1	21.0	21.9	20.8	23.6	19.5	24.9	20.6	23.8	18.5	25.1	19.6	23.0	15.5	20.9	16.8	25.3
2	32.0	34.2	30.3	30.4	28.5	35.2	28.5	27.7	25.2	29.0	30.9	28.8	27.0	29.4	26.8	28.1
3	37.7	39.2	34.5	44.5	29.7	42.7	44.8	40.8	28.2	39.0	37.7	27.4	30.5	0.0	30.7	30.0
4	41.0	40.0	37.6	0.0	27.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	42.0	0.0	48.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	27.3	20.8	24.6	10.7	23.9	15.6	21.3	24.0	22.1	21.1	21.7	22.5	19.6	21.2	22.3	24.3
SOP	11 795	3 605	9 828	5 685	7 043	3 434	19 515	14 752	14 668	4 538	26 264	11 497	24 314	16 257	23 440	11 442
mean weight 3+	39.3	39.2	35.0	44.5	29.7	42.7	44.8	40.8	28.2	39.0	37.7	27.4	30.5	30.5	30.7	30.0

YEAR	1995		1996		1997		1998		1999		2000		2001		2002	
Sources:	Anon. (1997)		Anon. (1998)		Anon. (1999)		Anon (2000)		WG data		WG data		WG data		WG data	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	0.0	15.1	0.0	12.0	0.0	11.6	0.0	10.2	0.0	15.7	0.0	19.3	0.0	14.3	0.0	9.5
1	22.5	26.9	19.1	23.2	14.4	20.3	21.8	23.7	17.1	27.0	21.7	28.2	22.7	27.5	25.0	28.8
2	32.3	31.3	29.3	27.7	26.9	30.1	24.3	27.7	29.8	33.5	29.1	33.0	31.8	31.1	31.6	33.4
3	36.4	36.4	35.0	35.7	32.0	29.7	31.9	28.7	34.7	38.9	32.8	36.9	36.3	38.6	42.8	36.5
4	37.3	29.1	46.1	39.7	0.0	0.0	31.9	0.0	55.9	0.0	0.0	0.0	40.7	0.0	45.6	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	26.9	25.0	22.2	21.6	17.3	19.1	22.5	24.3	25.4	27.7	24.9	29.0	27.1	28.2	30.9	30.6
SOP	23 830	6 520	21 066	13 139	10 672	11 687	12 996	17 727	15 686	12 229	22 715	14 106	23 272	17 247	11 073	6 415
mean weight 3+	36.5	35.9	35.8	36.0	32.0	29.7	31.9	28.7	34.9	38.9	32.8	36.9	37.2	38.6	42.8	36.5

YEAR	2003		2004		2005		2006	
Sources:	WG data		WG data		WG data		WG data	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half*
Age 0	0.0	15.4	0.0	15.5	0.0	0.0	0.0	0.0
1	21.0	25.4	21.7	24.9	19.3	0.0	20.3	17.8
2	36.2	29.5	35.7	33.5	24.5	0.0	27.7	19.7
3	40.3	36.4	39.3	40.7	27.6	0.0	31.3	19.7
4	36.9	37.9	44.0	42.8	24.5	0.0	37.3	34.3
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	31.4	27.1	26.0	25.2	24.1	0.0	23.0	18.2
SOP	4 078	6 524	9 271	7 181	1 162	0	1 667	95
mean weight 3+	40.2	36.6	40.6	40.7	27.3	0.0	31.3	19.7

* : low values due to poor sampling and low catches. Not used for assessment.

Table 10.4.1.1: Bay of Biscay anchovy: Time series of SSB estimates from the Daily Egg Production Method

YEAR		**1987**	**1988**	**1989(*)**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996****	**1997**	**1998**	**1999****	**2000*****	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Period of year		2 - 7 Jun	21 - 28 May	10 - 21 May	4 - 15 May	16May-07Jun	16May-13Jun	No survey	17 May-3June.	11 - 25 May	18 - 30 May	9 - 21 May	18 May - 8 Jun	22 May - 5 Jun	2 - 20 May	14 May - 8 June	6-21 May	22May-9Jun	2 - 22 May	8 - 28 May	4 -24 May	3-23 May
Julian Mid Day		155	145	136	130	148	151		146	138	144	135	149	149	131	147	134				132	
Positive area (km2)		23,850	45,384	17,546	59,757	24,264	67,796		48,735	31,189	28,448	50,133	73,131	51,019	37,883	72,022	35,980	42,535	23,124	27,863	24,614	34,449
Surveyed area (km2)		34,934	59,840	37,930	79,759	84,032	92,782		60,330	51,698	34,294	59,587	83,156	61,533	63,192	92,376	56,176	70,041	53,285	61,619	53,991	56,079
Po (Egg per 0.05 m^2)		4.60	5.52	2.08	3.78	2.55	4.27		3.93	4.98	4.87	2.69	3.83	3.65	3.45	5.89	3.28	2.53	1.82	0.79	2.16	
Ptot(Total DEP) (*E-12)		2.20	5.01	0.73	5.02	1.24	5.81		3.83	3.09	2.77	2.70	5.6	3.72	2.61	8.48	2.34	2.15	0.842	0.44	1.07	1.6
	C.V.	0.39	0.24	0.40	0.15	0.06	0.14		0.14	0.07	0.16	0.07	0.05	0.09	0.19	0.09	0.13	0.28	0.115	0.16	0.17	
Daily Fecundity		81.30	81.40	62.3	52.20	67.50	71.60		62.85	56.72		53.21	56.54			70.75	76.41	89.91	43.64	55.74	50.1	59.8
	C.V.	0.36	0.23	0.13	0.36	0.15	0.24		0.07	0.06		0.06	0.06			0.06	0.04	0.04	0.09	0.10	0.09	0.14
SSB (tonns)		**29,365**	**63,500**	**11,861**	**97,239**	**19,276**	**90,720**	**--**	**60,062**	**54,700**	**39,545**	**51,176**	**101,976**	**69,074**	**44,973**	**120,403**	**30,697**	**23,962**	**19,498**	**8,002**	**21,436**	**25,973**
	C.V.	0.48	0.31	0.41	0.17	0.14	0.20		0.17	0.09	0.16	0.10	0.09	0.15	0.15	0.11	0.13	0.28	0.15	0.19	0.19	0.20
Total (millions)		**1,129**	**2,675**	**470**	**5,843**	**966**	**5,797**	**--**	**2,954**	**2,644**		**3,738**	**6,282**			**5,897**	**1,039**	**1,296**	**980**	**292**	**1,204**	**1,268**
	C.V.					0.14	0.25		0.19	0.11		0.16	0.13			0.15	0.15	0.29	0.20	0.20	0.25	0.17
Numb. at age (millions)	**Age 1**	**656**	**2,349**	**246**	**5,613**	**671**	**5,571**		**2,030**	**2,257**		**3,243**	**5,467**			**4,114**	**284**	**1,042**	**837**	**95**	**998**	**902**
	C.V.					0.16	0.26		0.23	0.13		0.17	0.15			0.21	0.30	0.30	0.23	0.26	0.29	0.19
	Age 2	**331**	**258**	**206**	**190**	**290**	**209**		**874**	**329**		**482**	**760**			**1,638**	**621**	**180**	**115**	**189**	**157**	**317**
	C.V.					0.17	0.22		0.19	0.23		0.10	0.14			0.13	0.13	0.34	0.19	0.19	0.24	0.18
	Age 3+	**142**	**68**	**18**	**40**	**5**	**17**		**49**	**58**		**13**	**56**			**145**	**134**	**74**	**28**	**8**	**50**	**50**
	C.V.					0.42	0.51		0.30	0.30		0.27	0.36			0.27	0.14	0.38	0.26	0.37	0.24	0.59

(*) Likely sub-estimate according to authors (Motos &Santiago,1989). It is inputted into assessment raised up by 1 sd

(**) Estimates based on a log lineal model of biomass as function of positive spawning area and Po (Egg production per unit area)

(***) Estimates based on a log lineal model of biomass as function of positive spawning area and Po (Egg production per unit area) and Julian day of the mid day of the survey

Table 10.4.1.2: P_0, z and P_{tot} estimates depending on the model.

	1-Bayesian + N linear		2-Bayesian + GLM	
	Value	**CV**	**Value**	**CV**
P_0	4.21	0.10	4.51	0.04
z	0.2	0.0	0.2	0
Ptot	1.45.E+12	0.10	**1.55.E+12**	**0.04**

Table 10.4.1.3: DEPM 2007 estimates of the adult parameters and SSB in the total area with correspondent Standard error (S.e.) and coefficient of variation (CV)

Parameter	estimate	S.e.	CV
DEP	1,55E+12	6,06E+10	0,0391
R'	0,54	0,0058	0,0109
S	0,25	0,0331	0,1330
F	11.896,9	949	0,0798
Wf	26,56	1,92	0,0724
BIOMASS	25.973	3.701	0,1425

Table 10.4.1.4: Weighting factors for the proportions at age

Sub_Estrata	2	3	4	5	6	Addition
Total egg Abundance	1.40.E+12	2.41.E+11	5.52.E+11	7.51E+11	1.27E+12	4.21.E+12
% Egg abundance	33%	6%	13%	18%	30%	100%
Nº of adult samples	12	3	2	3	10	30
Egg% /sample	0.03	0.02	0.07	0.06	0.03	
M'i proport. to biomass referred to 2	1.00	0.69	2.37	2.15	1.09	
Weighting factor (Mi) proport. to numbers	1/wi	0.69/wi	2.37/wi	2.15/wi	1.09/wi	
Mean Weight of anchovies	32.9	19.6	30.6	25.9	13.1	
Standard Deviation	5.14	0.94	4.76	4.05	3.40	
CV	16%	5%	16%	16%	26%	

Table 10.4.1.5: Proportion at age and numbers at age of the population

Parameter	estimate	S.e.	CV
BIOMASS	25.973	3.701	0,1425
Wt	20,65	1,82	0,0882
POPULATION	1.268	215	0,1693
Pa 1	0,71	0,05	0,0636
Pa 2	0,25	0,04	0,1429
Pa 3	0,04	0,02	0,5516
Nage 1	902	175	0,1943
Nage 2	317	58	0,1830
Nage 3	50	30	0,5950
Nage 2+	366,74		

Table 10.4.2.2.1: Bay of Biscay Anchovy. Evaluation of anchovy abundance index from French acoustic surveys in the Bay of Biscay.

YEAR	1983	1984	1989 (2)	1990	1991	1992	1994	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007
DATE	20/4-25/4	30/4-13/5	23/4-2/5	12/4-25/4	6/4-29/4	13/4-30/4	15/5-27/5	6/5-22/5	20/5-7/6	8/04 - 14/0	27/04 - 6/0	6/05 - 6/06	27/5 - 25/6	27/4 - 25/5	3/05 - 31/0	1/05 - 31/0	26/04 - 26/05
Surveyed area	3 267	3 743	5 112	3,418 (3)	3388 (3)	2440(3)	2300(3)	1726(3)	9 400	19 838	21 300	10 667	12 917	12 225	16 354	17 204	18 876
									5600 (3)								
Biomass (t)	50 000	38 500	15 500	60-110,000 (4)	64 000	89 000	35 000	63 000	57 000	98 484	137,200 (5	97 051	29 428	46 018	16 446	30 649	40 876
Nb (10**(-6))	2 600	2 000	805	4,300-7,500 (4)	3 173	9 342	*na*	3351	*na*		7892 (6)	3569	1451	2678	631	1862	2170
Nb of age 1 (10**(-6	1,800 (1)	600	400	4,100-7,500 (4)	1 873	9 072	*na*	2481	*na*		6163 (6)	831	983	2290	128	1353	1437
Nb of age 2 (10**(-6	800*	1400*	405*	0 -200 (4)*	1300*	270*	*na*	870*	*na*		1728* (6)	2738*	468	249	401	390	632
*(age 2+ when *)*																	
Nb of age 3+ group(10**(-6))														139	102	118	101
Anchovy mean we	19.2	19.3	19.3	*na*	20.2	9.5	*na*	18.8	*na*		16.8 (6)	27.2	20.28	18.02	31.14	16.5	18.7

(1) Rough estimation
(2) Assumption of overestimate
(3) Positive area
(4) uncertainty due to technical problems
(*) area where anchovy shoals have been detected
(5) For the assessment performed in the WG of year 2001 the value used for 2001 biomass was 132800t becouse the definitive figure from the survey arrived too late to the WG
(6) based on the biomass estimate of areas 2, 4, 6 and 7 (13 2600 t)

Table 10.4.2.2.2-a – Biomass estimates in tons from acoustic survey PELGAS07

STRATA	*Area (nm²)*	Anchovy	Sardine	Sprat	Horse mackerel
1	*581*	362	541		4 427
2	*1 116*	7 869	2 958		3 154
3	*588*	13 001	14 741	7	47
4	*3 076*	7 643	12 498		5 824
5	*2 323*	11 763	833	14 070	400
6	*4 832*	12	40 407		11 787
7	*1 250*	177	35 657	3 235	1 923
8	*5 111*	49	18 602		17 535
Total	*18 876*	40 876	126 237	17 312	45 098

Table 10.4.2.2.2-b – Age distribution of Anchovy inshore and offshore during PELGAS07

	Biomass	numbers	G1	G2	G3	G4
Inshore (3, 5 & 7)	24 941	1 588 074	1155812	359792	69546	2925
Offshore (1,2,4,6,8)	15 935	582 136	281180	272235	26643	2078
Total	40 876	2 170 211	1436992	632027	96190	5003
% (numbers)			66.22 %	29.12 %	4.43 %	0.23 %
Mean weight (g)			*16.54*	*23.33*	*19.70*	*24.17*
Mean length (cm)			*13.50*	*14.97*	*14.23*	*15.13*
Coefficient of variation	*0.099*	*0.100*				

Table 10.4.2.3.1. - Different attempts to use consort commercial catches in addition to Thalassa samples. These results should be considered as preliminary, using all available data without checking validity or any correction for catchability. Therefore they must be taken with caution.

STRATA	Thalassa hauls	Thalassa + pair trawlers	Thalassa + pair trawlers + FR purse seiners	Thalassa + FR+SP purse seiners	Thalassa + all consort
1	362	204	204	362	204
2	7 869	7 985	7 985	4 792	5 758
3	13 001	10 951	9 231	9 678	9 231
4	7 643	6 916	6 916	6 722	6 515
5	11 763	12 432	13 624	14 352	14 165
6	12	2	2	9	2
7	177	93	88	158	87
8	49	26	26	49	26
Total	40 876	38 610	38 077	36 123	35 989

Table 10.4.3.1.1: Summary of the JUVENA acoustic surveys on juvenile anchovy carried out in the last years (including the one foreseen for 2006).

JUVENA SURVEYS SERIES

SURVEY	VESSEL	GEAR	PERIOD	Area in Bay of Biscay
JUVENA 2003	Divino Jesús de Praga	Purse seine	17 September - 15 October	South 46ºN East 5ºW
JUVENA 2004	Nuevo Erreinezubi	Purse seine	19 September - 20 October	South 46ºN East 5ºW
JUVENA 2005	Gure Aita José	Purse seine	12 September - 07 October	South 47ºN East 5ºW
	Mater Bi	Purse seine		
JUVENA 2006	Itxas Lagunak	Purse seine	13 September - 15 October	South 47º30'N East 6ºW
	Enma Bardan	Pelagic trawling		

Table 10.4.3.1.2: Summary of the anchovy abundance indices from the JUVENA acoustic surveys carried out in the last years spited by regions. (Area refers to the area where positive detection of anchovy was made. Size refers to the total length, and the Abundance index is split for adult and juvenile anchovy) (Boyra et al. STECF_WD2007).

Year	Region		<s_A>	Area	<length>_juv	<lenght>_adul	Biom_juv	Biom_adul	Biom_TOTAL
2003	Sur		369	3303	8.2		97,498.50	0	97,498.50
2003	Norte		444	173	11.1	14.1	1,103.00	1,383.50	2,486.50
2003	**TOTAL**						**98,601.50**	**1,383.50**	**99,985.00**
2004	Sur		1	47	6		1.9	0	1.9
2004	Norte		562	1860	11	13.8	2,404.10	3,451.00	5,855.10
2004	**TOTAL**						**2,406.00**	**3,451.00**	**5,857.00**
2005	Sur		722	5390	6.64		125,922.30	0	125,922.30
2005	Norte		326	2400	9.83	11.91	8,208.80	20,369.80	28,578.60
2005	**TOTAL**						**134,131.10**	**20,369.80**	**154,500.90**
2006	Sur	corrected	322	1200	7.2	11.5	19,829.53	171.2203408	20,000.75
2006	Norte	corrected	402	5691	11.2	12.4	110,535.85	80,733.85	191,269.70
2006	**TOTAL**	corrected					**130,365.38**	**80,905.07**	**211,270.45**

Table 10.5.1: Bay of Biscay Anchovy. Evolution of the French and Spanish fleets in Sub-area VIII (for Working Group members). Units: numbers of boats.

	France				Spain	
Year	P. seiner	P. trawl		Total	P. seiner	Total
1960	-	-			571	571
1972	-	-			492	492
1976	-	-			354	354
1980	-	-			293	293
1984	-	-			306	306
1987	-	-			282	282
1988	-	-			278	278
1989	18	6	(1,2)	24	215	239
1990	25	48	(1,2)	73	266	339
1991	19	53	(1,2)	72	250	322
1992	21	85	(1,2)	106	244	350
1993	34	108	(1,2)	142	253	395
1994	34	77	(1,2)	111	257	368
1995	33	44	(1,2)	77	257	334
1996	30	60	(1,2)	90	251	341
1997	27	52	(1,2)	79	267	346
1998	29	44	(1,2,3)	73	266	339
1999	30	49	(1,2)	79	250	329
2000	32	57	(1,2)	89	238	327
2001	34	60	(1,2)	94	220	314
2002	32	47	(1,2)	79	215	294
2003	19	47	(1,2)	66	208	274
2004	31	54	(1,2)	85	201	286
2005	8	41	(1,2,4)	49	197	245
2006	8	40	(1,2,4)	48	240	288

Table 10.7.2.1: Bay of Biscay Anchovy. Specification of the two sets of prior distributions used for BBM with the correspondent 95% confidence intervals.

Parameter	PRIORS 1			PRIORS 2		
	Distribution	95 % C.I.		Distribution	95 % C.I.	
Log(qdepm)	N(mu=0, prec=5)	0.416	2.403	N(mu=0, prec=0.5)	0.063	15.988
Log(qac)	N(mu=0, prec=5)	0.416	2.403	N(mu=0, prec=0.5)	0.063	15.988
ydepm	Gamma(a=5, b=0.5)	3.247	20.483	Gamma(a=0.1, b=0.01)	0	97.79
yac	Gamma(a=5, b=0.5)	3.247	20.483	Gamma(a=0.1, b=0.01)	0	97.79
xdepm	N(mu=4.68, pre=0.3)	1.102	8.258	N(mu=4.68, pre=0.2)	0.297	9.063
xac	N(mu=4.68, pre=0.3)	1.102	8.258	N(mu=4.68, pre=0.2)	0.297	9.063
B0	N(mu=78000, prec=6.5 E-11)	- 165 104	321 104	N(mu=78000, prec=1 E-11)	- 541 795	697 795
Ry	LN(mu=11.12, prec=1)	9 509	479 243	LN(mu=11.12, prec=0.1)	137	33 196 345
w1	Gamma(a=10, b=1)	4.795	17.085	Gamma(a=1, b=0.1)	0.253	36.889

Table 10.8.1.1: Bay of Biscay Anchovy. Input data for BBM.

			CATCH DATA			DEPM		ACOUSTICS	
Year	h1	h2	C(y,1,1)	C(y,1,1+)	C(y,2,1+)	B(y,1)	B(y,1+)	B(y,1)	B(y,1+)
1987	0.3068	0.1940	2711	8318	6543	14235	29365		
1988	0.3253	0.1774	2602	3864	10954	53087	63500		
1989	0.2820	0.2328	1723	3876	4442	7282	16720		
1990	0.3070	0.2057	9314	10573	23574	90650	97239		
1991	0.2347	0.1984	3903	10191	8196	11271	19276	28322	64000
1992	0.2542	0.2184	11933	16366	21026	85571	90720	84439	89000
1993	0.2368	0.2378	6414	14177	25431				
1994	0.2331	0.2050	3795	13602	20150	34674	60062		35000
1995	0.2917	0.1751	5718	14550	14815	42906	54700		
1996	0.2756	0.1978	4570	9246	23833		39545		
1997	0.2078	0.2624	4323	7235	13256	38536	51176	38498	63000
1998	0.1992	0.2567	5898	7988	23588	80357	101976		57000
1999	0.2304	0.2626	2067	10895	15511		69074		
2000	0.2569	0.1999	6298	12010	24882		44973		98484
2001	0.2984	0.2195	5481	11468	28671	69110	120403	90928	137200
2002	0.1833	0.2389	1962	7738	9754	6352	30697	17723	97051
2003	0.2997	0.2795	625	2379	8101	16575	23962	15732	29430
2004	0.2989	0.2126	2754	4623	11657	14649	19498	37124	46018
2005	0.1138	0.0741	102	790	372	2063	8002	2405	15603
2006	0.3266	0.0741	484	815	947	15280	21436	16686	30649
2007	0.3131		31	65		16025	25973	23971	40876

Table 10.8.1.2: Bay of Biscay Anchovy. Median and 95% credible intervals for recruitment, spawning stock biomass, harvest rates (Catch/SSB) and the ratio of SSB with respect to SSB in 1989 as resulted from BBM when the DEPM is taken as absolute and the first set of priors is used.

	R (tonnes)			SSB (tonnes)			Harvest rate			SSB/SSB_{1989}		
Year	2.50%	Median	97.50%	2.50%	Median	97.50%	2.50%	Median	97.50%	2.50%	Median	97.50%
1987	12036	18636	32161	18256	22911	34024	0.814	0.649	0.437	0.760	1.217	1.654
1988	28816	43608	69361	31953	38011	53935	0.464	0.390	0.275	1.527	1.998	2.327
1989	8214	13166	24163	14328	19246	31829	0.581	0.432	0.261	1.000	1.000	1.000
1990	59198	87520	129798	59068	67640	84957	0.578	0.505	0.402	2.253	3.532	4.796
1991	17155	27177	43596	24396	32089	46684	0.754	0.573	0.394	1.002	1.660	2.488
1992	71455	127703	235146	59849	102672	180565	0.625	0.364	0.207	2.657	5.215	9.813
1993	38313	88033	149770	81472	99454	121805	0.486	0.398	0.325	2.925	5.189	7.335
1994	31524	49206	79203	49772	61372	81325	0.678	0.550	0.415	1.784	3.198	4.855
1995	31834	59790	116298	29101	53232	99158	1.009	0.552	0.296	1.290	2.705	5.461
1996	31828	62562	105089	50775	60194	78449	0.651	0.550	0.422	1.913	3.141	4.495
1997	32701	51288	82621	38503	51677	73252	0.532	0.397	0.280	1.496	2.662	4.195
1998	46076	78892	140760	49078	75722	121108	0.643	0.417	0.261	2.052	3.856	6.969
1999	24182	74205	193846	37344	74174	163963	0.707	0.356	0.161	1.651	3.777	8.783
2000	57730	117309	185648	91272	116561	133719	0.404	0.317	0.276	3.290	5.999	8.356
2001	56096	84720	131760	90907	100153	118993	0.442	0.401	0.337	3.231	5.247	7.192
2002	8237	12619	21067	31142	36567	47885	0.562	0.478	0.365	1.198	1.911	2.725
2003	16562	26211	41192	25470	31133	38902	0.411	0.337	0.269	0.938	1.620	2.315
2004	25354	39552	62185	29920	37140	50196	0.544	0.438	0.324	1.155	1.923	2.869
2005	2934	5211	9371	10528	15177	23050	0.110	0.077	0.050	0.440	0.779	1.286
2006	12657	21601	37548	16541	23457	34542	0.107	0.075	0.051	0.660	1.199	2.008
2007	13723	23941	42766	20494	29873	45096	0.003	0.002	0.001	0.821	1.533	2.596

Table 10.8.1.3: Bay of Biscay Anchovy. Summary table of the current state of the stock from BBM.

R_{2007}	**Median**	23 941
	95 % C.I.	(13 723, 42 766)
SSB_{2007}	**Median**	29 873
	95 % C.I.	(20 494, 45 096)
P(SSB_{2007} < 21 000)		0.032
P(SSB_{2007} < 33 000)		0.689

Table 10.9.1: Bay of Biscay anchovy: Mixture weights to construct the predictive distribution of recruitment in 2008 under undetermined, low, medium and high scenarios.

Year	Undetermined	Low	Medium	High
1987	**0,048**	**0,111**	0,000	0,000
1988	**0,048**	0,000	**0,200**	0,000
1989	**0,048**	**0,111**	0,000	0,000
1990	**0,048**	0,000	0,000	**0,143**
1991	**0,048**	**0,111**	0,000	0,000
1992	**0,048**	0,000	0,000	**0,143**
1993	**0,048**	0,000	0,000	**0,143**
1994	**0,048**	0,000	**0,200**	0,000
1995	**0,048**	0,000	**0,200**	0,000
1996	**0,048**	0,000	**0,200**	0,000
1997	**0,048**	0,000	**0,200**	0,000
1998	**0,048**	0,000	0,000	**0,143**
1999	**0,048**	0,000	0,000	**0,143**
2000	**0,048**	0,000	0,000	**0,143**
2001	**0,048**	0,000	0,000	**0,143**
2002	**0,048**	**0,111**	0,000	0,000
2003	**0,048**	**0,111**	0,000	0,000
2004	**0,048**	**0,111**	0,000	0,000
2005	**0,048**	**0,111**	0,000	0,000
2006	**0,048**	**0,111**	0,000	0,000
2007	**0,048**	**0,111**	0,000	0,000

Table 10.9.2: Bay of Biscay anchovy: Median SSB and probability of SSB in 2008 being below Blim and Bpa according to different catch options for the first half of 2008 and different recruitment scenarios, assuming that no catch was taken in the second half of 2007.

Catch	R undetermined			R low			R medium			R high		
1st Half 2008	Median SSB	P(SSB < B_{lim})	P(SSB < B_{pa})	Median SSB	P(SSB < B_{lim})	P(SSB < B_{pa})	Median SSB	P(SSB < B_{lim})	P(SSB < B_{pa})	Median SSB	P(SSB < B_{lim})	P(SSB < B_{pa})
0	51170	0.044	0.251	31243	0.097	0.576	56006	0.000	0.004	87034	0.000	0.005
1000	50633	0.051	0.260	30706	0.110	0.598	55469	0.000	0.005	86497	0.000	0.005
2000	50095	0.057	0.272	30168	0.127	0.619	54932	0.000	0.006	85959	0.000	0.006
3000	49558	0.065	0.280	29631	0.141	0.641	54395	0.000	0.007	85422	0.000	0.006
4000	49021	0.073	0.289	29094	0.161	0.664	53857	0.000	0.009	84885	0.001	0.007
5000	48484	0.080	0.297	28557	0.178	0.684	53320	0.000	0.010	84348	0.001	0.007
6000	47946	0.089	0.304	28020	0.197	0.703	52783	0.000	0.013	83810	0.001	0.007
7000	47409	0.100	0.313	27482	0.218	0.723	52246	0.000	0.015	83273	0.001	0.008
8000	46872	0.108	0.321	26945	0.240	0.741	51709	0.000	0.018	82736	0.001	0.008
9000	46335	0.118	0.330	26408	0.261	0.759	51171	0.000	0.022	82199	0.001	0.009
10000	45798	0.129	0.337	25871	0.284	0.775	50634	0.000	0.027	81662	0.001	0.009
11000	45260	0.138	0.344	25333	0.307	0.791	50097	0.000	0.031	81124	0.002	0.010
12000	44723	0.148	0.350	24796	0.333	0.805	49560	0.000	0.036	80587	0.002	0.011
13000	44186	0.157	0.358	24259	0.356	0.816	49022	0.001	0.043	80050	0.002	0.012
14000	43649	0.167	0.366	23722	0.379	0.829	48485	0.001	0.049	79513	0.002	0.012
15000	43111	0.177	0.373	23185	0.403	0.842	47948	0.001	0.056	78975	0.002	0.013
16000	42574	0.186	0.381	22647	0.429	0.852	47411	0.001	0.065	78438	0.003	0.014
17000	42037	0.198	0.388	22110	0.453	0.862	46874	0.002	0.074	77901	0.003	0.015
18000	41500	0.209	0.397	21573	0.476	0.871	46336	0.002	0.084	77364	0.003	0.016
19000	40963	0.218	0.404	21036	0.498	0.879	45799	0.002	0.095	76827	0.003	0.017
20000	40425	0.227	0.410	20498	0.523	0.888	45262	0.002	0.109	76289	0.003	0.018
21000	39888	0.238	0.415	19961	0.545	0.897	44725	0.003	0.121	75752	0.004	0.018
22000	39351	0.247	0.421	19424	0.567	0.904	44187	0.003	0.138	75215	0.004	0.019
23000	38814	0.257	0.429	18887	0.590	0.911	43650	0.005	0.152	74678	0.005	0.020
24000	38276	0.268	0.436	18350	0.612	0.918	43113	0.006	0.168	74140	0.006	0.022
25000	37739	0.277	0.442	17812	0.634	0.924	42576	0.007	0.183	73603	0.006	0.023
26000	37202	0.286	0.451	17275	0.655	0.931	42039	0.008	0.199	73066	0.006	0.025
27000	36665	0.294	0.457	16738	0.678	0.936	41501	0.010	0.214	72529	0.007	0.025
28000	36128	0.302	0.463	16201	0.696	0.941	40964	0.012	0.233	71992	0.007	0.027
29000	35590	0.310	0.468	15663	0.717	0.945	40427	0.014	0.250	71454	0.008	0.028
30000	35053	0.319	0.475	15126	0.735	0.950	39890	0.017	0.266	70917	0.008	0.029
31000	34516	0.327	0.481	14589	0.753	0.954	39352	0.021	0.282	70380	0.009	0.032
32000	33979	0.335	0.488	14052	0.770	0.958	38815	0.025	0.301	69843	0.009	0.034
33000	33441	0.341	0.494	13515	0.786	0.962	38278	0.030	0.318	69306	0.010	0.035

Table 10.10.1 a: Catch options from July to June for different median spawning biomass perceived at mid May of the first year, as a function of alowable levels of risk and for different scenarios of the Recruitment level entering the fishery at the begining of the next year. Case: R undertemined

R_undetermined	P(SSB < Blim)																			
SSB	0,05	0,1	0,15	0,2	0,25	0,3	0,35	0,4	0,45	0,5	0,55	0,6	0,65	0,7	0,75	0,8	0,85	0,9	0,95	1
5000	0	0	0	0	0	3000	8000	15000	22000	29000	36000	40000	NA	NA	NA	NA	NA	NA	NA	NA
10000	0	0	0	0	2000	7000	12000	19000	26000	33000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA
15000	0	0	0	2000	7000	12000	17000	24000	30000	36000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA
20000	0	0	3000	8000	12000	17000	23000	29000	36000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
25000	0	3000	8000	13000	17000	22000	27000	33000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
30000	1000	7000	12000	17000	21000	26000	32000	38000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
35000	4000	11000	16000	21000	26000	31000	36000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
40000	8000	15000	20000	25000	30000	35000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
45000	11000	18000	24000	29000	34000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
50000	16000	23000	29000	34000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
55000	19000	26000	33000	38000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
60000	23000	30000	36000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
65000	26000	35000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
70000	30000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
75000	34000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
80000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
85000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
90000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
95000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
100000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

R_undetermined	P(SSB < Bpa)																			
SSB	0,05	0,1	0,15	0,2	0,25	0,3	0,35	0,4	0,45	0,5	0,55	0,6	0,65	0,7	0,75	0,8	0,85	0,9	0,95	1
5000	0	0	0	0	0	0	0	0	1000	7000	14000	23000	33000	40000	NA	NA	NA	NA	NA	NA
10000	0	0	0	0	0	0	0	0	5000	11000	18000	27000	36000	40000	NA	NA	NA	NA	NA	NA
15000	0	0	0	0	0	0	0	3000	10000	16000	23000	32000	40000	NA	NA	NA	NA	NA	NA	NA
20000	0	0	0	0	0	0	0	7000	13000	19000	27000	35000	40000	NA	NA	NA	NA	NA	NA	NA
25000	0	0	0	0	0	0	6000	12000	20000	26000	33000	40000	NA	NA	NA	NA	NA	NA	NA	NA
30000	0	0	0	0	0	5000	11000	16000	24000	31000	38000	40000	NA	NA	NA	NA	NA	NA	NA	NA
35000	0	0	0	0	4000	10000	15000	21000	27000	34000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA
40000	0	0	0	4000	9000	15000	21000	27000	34000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
45000	0	0	4000	9000	14000	19000	25000	30000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
50000	0	3000	8000	13000	18000	24000	29000	35000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
55000	0	6000	12000	17000	23000	28000	34000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
60000	2000	10000	16000	21000	27000	32000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
65000	6000	14000	20000	25000	31000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
70000	9000	18000	25000	31000	36000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
75000	13000	22000	29000	35000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
80000	16000	25000	32000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
85000	20000	30000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
90000	24000	34000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
95000	27000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
100000	30000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 10.10.1 b: Catch options from July to June for different median spawning biomass perceived at mid May of the first year, as a function of alowable levels of risk and for different scenarios of the Recruitment level entering the fishery at the begining of the next year. Case: R low

R_low	P(SSB < Blim)																			
SSB	**0,05**	**0,1**	**0,15**	**0,2**	**0,25**	**0,3**	**0,35**	**0,4**	**0,45**	**0,5**	**0,55**	**0,6**	**0,65**	**0,7**	**0,75**	**0,8**	**0,85**	**0,9**	**0,95**	**1**
5000	0	0	0	0	0	0	0	0	0	0	0	0	1000	3000	5000	8000	12000	17000	25000	40000
10000	0	0	0	0	0	0	0	0	0	0	1000	3000	5000	7000	10000	13000	16000	21000	29000	40000
15000	0	0	0	0	0	0	0	0	2000	4000	6000	8000	10000	12000	15000	18000	21000	26000	34000	40000
20000	0	0	0	0	0	0	3000	5000	7000	9000	11000	13000	15000	17000	20000	23000	26000	31000	38000	40000
25000	0	0	0	1000	3000	5000	7000	10000	11000	13000	15000	17000	19000	22000	25000	28000	31000	36000	40000	NA
30000	0	0	2000	5000	7000	9000	11000	14000	16000	18000	19000	22000	24000	27000	29000	33000	36000	40000	NA	NA
35000	0	4000	7000	10000	12000	14000	16000	18000	20000	23000	25000	27000	29000	32000	34000	37000	40000	NA	NA	NA
40000	2000	7000	10000	13000	16000	18000	20000	23000	24000	27000	29000	31000	33000	36000	39000	40000	NA	NA	NA	NA
45000	6000	10000	14000	17000	20000	22000	25000	27000	29000	32000	34000	36000	39000	40000	NA	NA	NA	NA	NA	NA
50000	10000	15000	19000	21000	24000	27000	29000	31000	34000	36000	38000	40000	NA	NA	NA	NA	NA	NA	NA	NA
55000	12000	18000	22000	25000	28000	30000	33000	35000	38000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
60000	16000	22000	26000	29000	32000	35000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
65000	20000	26000	29000	33000	36000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
70000	23000	29000	33000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
75000	27000	33000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
80000	29000	35000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
85000	33000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
90000	36000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
95000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
100000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

R_low	P(SSB < Bpa)																			
SSB	**0,05**	**0,1**	**0,15**	**0,2**	**0,25**	**0,3**	**0,35**	**0,4**	**0,45**	**0,5**	**0,55**	**0,6**	**0,65**	**0,7**	**0,75**	**0,8**	**0,85**	**0,9**	**0,95**	**1**
5000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4000	40000
10000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000	9000	40000
15000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000	6000	13000	40000
20000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2000	6000	11000	19000	40000
25000	0	0	0	0	0	0	0	0	0	0	0	0	0	1000	4000	7000	10000	15000	23000	40000
30000	0	0	0	0	0	0	0	0	0	0	0	1000	4000	6000	9000	12000	16000	20000	29000	40000
35000	0	0	0	0	0	0	0	0	0	2000	4000	6000	8000	11000	13000	17000	20000	25000	34000	40000
40000	0	0	0	0	0	0	0	2000	4000	6000	8000	10000	13000	16000	19000	22000	26000	31000	40000	NA
45000	0	0	0	0	0	2000	4000	6000	9000	11000	13000	16000	18000	21000	24000	27000	31000	37000	40000	NA
50000	0	0	0	0	3000	5000	8000	10000	13000	15000	17000	19000	22000	25000	28000	31000	36000	40000	NA	NA
55000	0	0	1000	5000	7000	10000	13000	15000	17000	20000	22000	25000	27000	30000	33000	37000	40000	NA	NA	NA
60000	0	1000	5000	8000	11000	14000	17000	19000	22000	24000	27000	30000	33000	35000	39000	40000	NA	NA	NA	NA
65000	0	5000	9000	12000	15000	18000	21000	23000	26000	28000	31000	34000	37000	40000	NA	NA	NA	NA	NA	NA
70000	2000	8000	12000	16000	19000	22000	25000	28000	30000	33000	36000	39000	40000	NA	NA	NA	NA	NA	NA	NA
75000	6000	12000	16000	20000	23000	27000	29000	32000	34000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA
80000	9000	15000	20000	24000	27000	30000	33000	36000	38000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
85000	12000	19000	24000	28000	31000	34000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
90000	14000	22000	27000	31000	35000	38000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
95000	18000	26000	31000	35000	38000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
100000	22000	29000	34000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 10.10.1 c: Catch options from July to June for different median spawning biomass perceived at mid May of the first year, as a function of alowable levels of risk and for different scenarios of the Recruitment level entering the fishery at the begining of the next year. Case: R medium

R_med	P(SSB < Blim)																			
SSB	**0,05**	**0,1**	**0,15**	**0,2**	**0,25**	**0,3**	**0,35**	**0,4**	**0,45**	**0,5**	**0,55**	**0,6**	**0,65**	**0,7**	**0,75**	**0,8**	**0,85**	**0,9**	**0,95**	**1**
5000	12000	17000	20000	23000	25000	28000	30000	32000	35000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA
10000	17000	21000	25000	28000	30000	33000	35000	37000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15000	21000	25000	29000	32000	34000	37000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20000	25000	30000	33000	36000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
25000	29000	34000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
30000	33000	38000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
35000	36000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
40000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
45000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
50000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
55000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
60000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
65000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
70000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
75000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
80000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
85000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
90000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
95000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
100000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

R_med	P(SSB < Bpa)																			
SSB	**0,05**	**0,1**	**0,15**	**0,2**	**0,25**	**0,3**	**0,35**	**0,4**	**0,45**	**0,5**	**0,55**	**0,6**	**0,65**	**0,7**	**0,75**	**0,8**	**0,85**	**0,9**	**0,95**	**1**
5000	0	0	0	2000	5000	7000	10000	12000	14000	17000	19000	22000	25000	29000	33000	38000	40000	NA	NA	NA
10000	0	1000	4000	7000	9000	12000	14000	17000	19000	21000	24000	27000	30000	34000	38000	40000	NA	NA	NA	NA
15000	0	4000	8000	11000	13000	16000	18000	21000	23000	26000	29000	32000	35000	38000	40000	NA	NA	NA	NA	NA
20000	4000	9000	12000	15000	18000	21000	23000	25000	28000	31000	33000	36000	40000	NA	NA	NA	NA	NA	NA	NA
25000	8000	13000	17000	20000	22000	25000	28000	30000	33000	35000	38000	40000	NA	NA	NA	NA	NA	NA	NA	NA
30000	12000	17000	21000	24000	27000	29000	32000	34000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
35000	16000	21000	25000	28000	31000	34000	36000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
40000	19000	25000	29000	32000	35000	38000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
45000	23000	29000	33000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
50000	27000	33000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
55000	30000	36000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
60000	34000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
65000	37000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
70000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
75000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
80000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
85000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
90000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
95000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
100000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 10.10.1 d: Catch options from July to June for different median spawning biomass perceived at mid May of the first year, as a function of alowable levels of risk and for different scenarios of the Recruitment level entering the fishery at the begining of the next year. Case: R high

R_high	P(SSB < Blim)																			
SSB	0,05	0,1	0,15	0,2	0,25	0,3	0,35	0,4	0,45	0,5	0,55	0,6	0,65	0,7	0,75	0,8	0,85	0,9	0,95	1
5000	34000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
25000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
30000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
35000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
40000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
45000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
50000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
55000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
60000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
65000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
70000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
75000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
80000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
85000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
90000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
95000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
100000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

R_high	P(SSB < Bpa)																			
SSB	0,05	0,1	0,15	0,2	0,25	0,3	0,35	0,4	0,45	0,5	0,55	0,6	0,65	0,7	0,75	0,8	0,85	0,9	0,95	1
5000	13000	26000	34000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10000	17000	30000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15000	22000	35000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20000	26000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
25000	31000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
30000	34000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
35000	39000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
40000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
45000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
50000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
55000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
60000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
65000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
70000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
75000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
80000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
85000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
90000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
95000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
100000	40000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

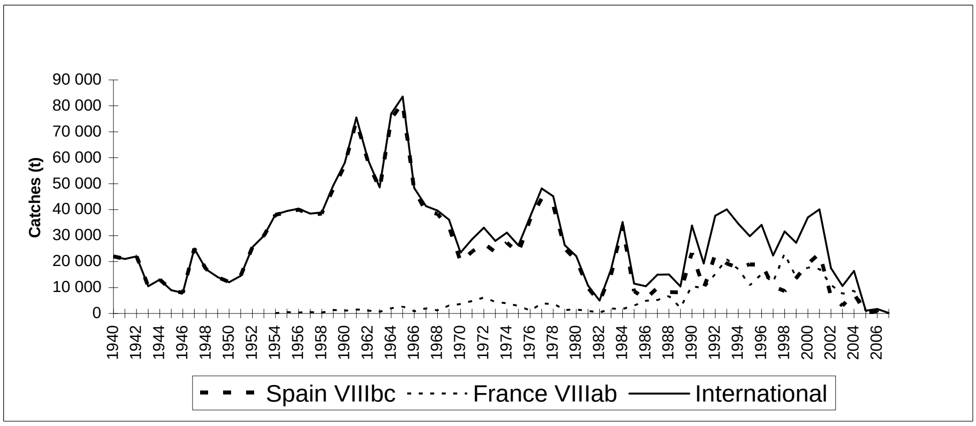


Figure 10.2.1.1 Bay of Biscay anchovy: Historical evolution of the fishery since 1940.

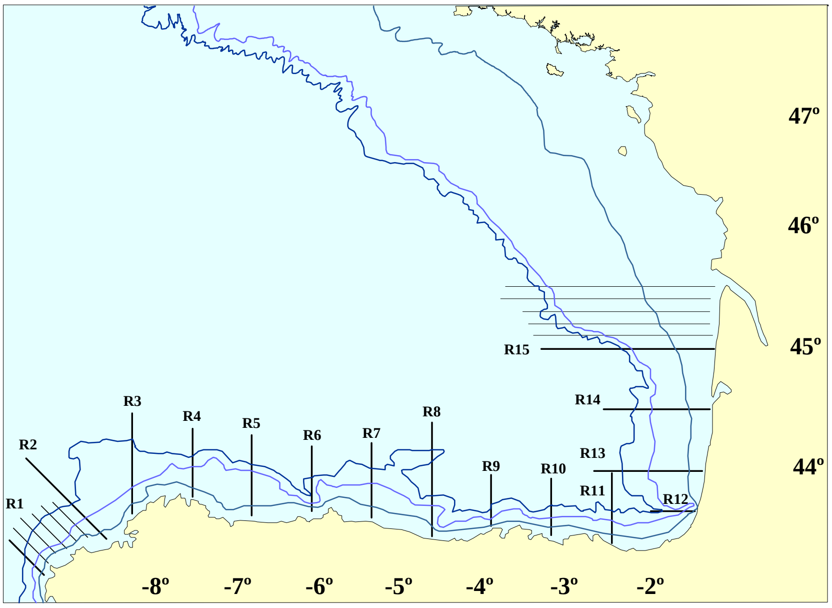


Figure 10.2.3.1.1.: Rake07 sampling design. In the picture only appear plotted the radials of one of the vessels. Between 2 consecutive radials would be those corresponding to the other five vessels (as it appears represented for R1 and R15). The vessels working at night hours made the same radials but during the night.

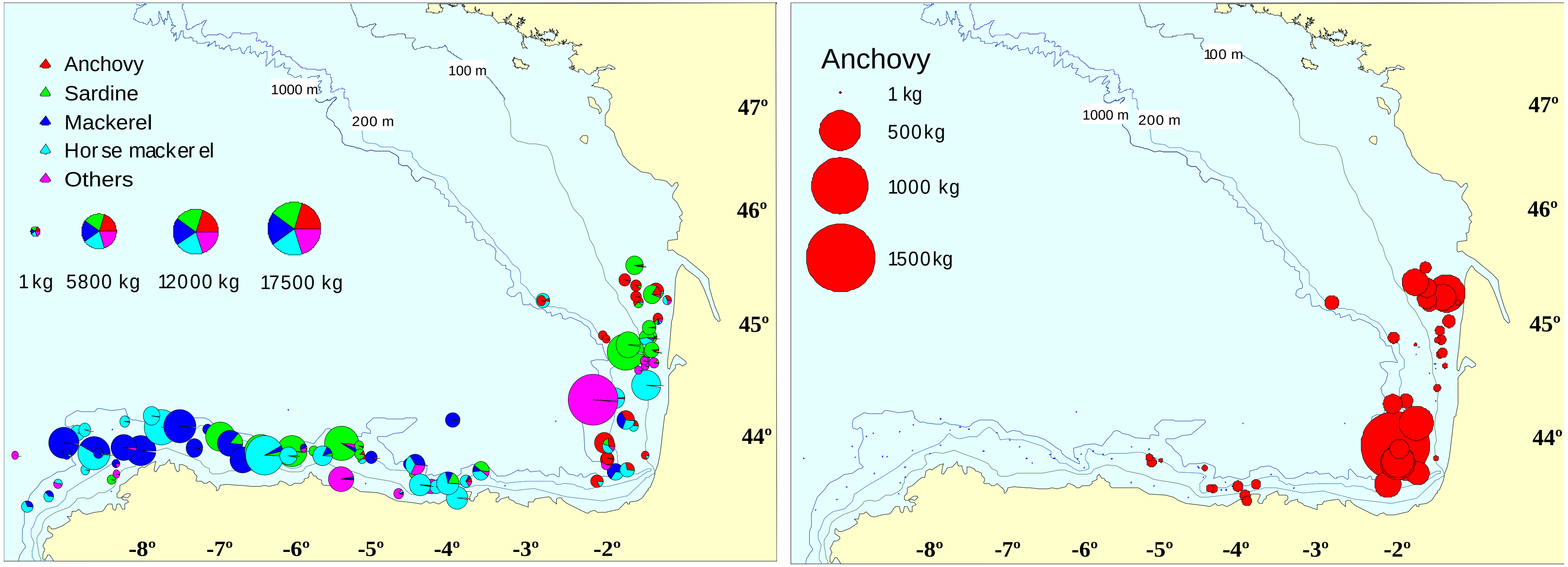
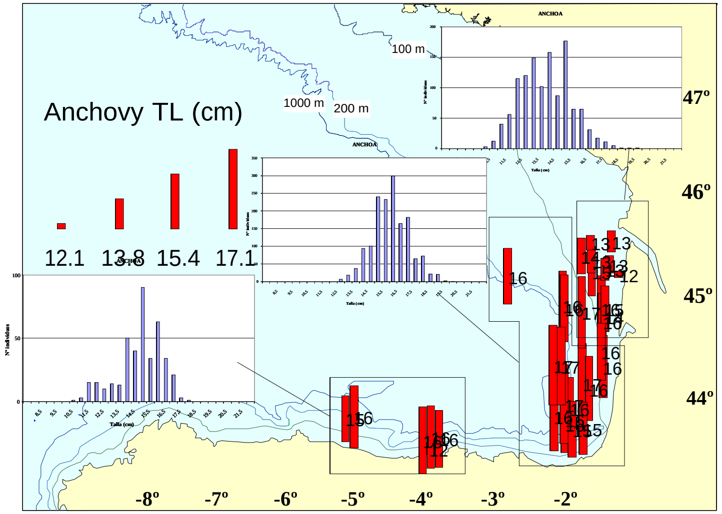


Figure 10.2.3.1.2.: Hauls species composition during Rake07 survey and catches of anchovy per fishing haul.



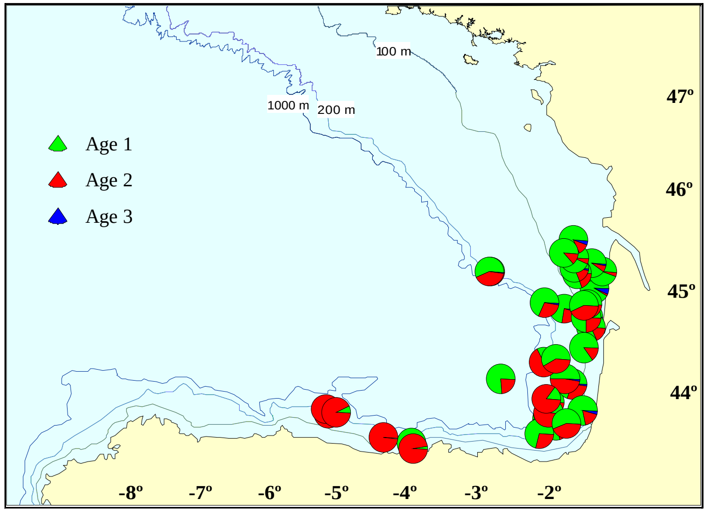


Figure 10.2.3.1.3.: Spatial distribution of anchovy by length and ages during the Rake07 survey.

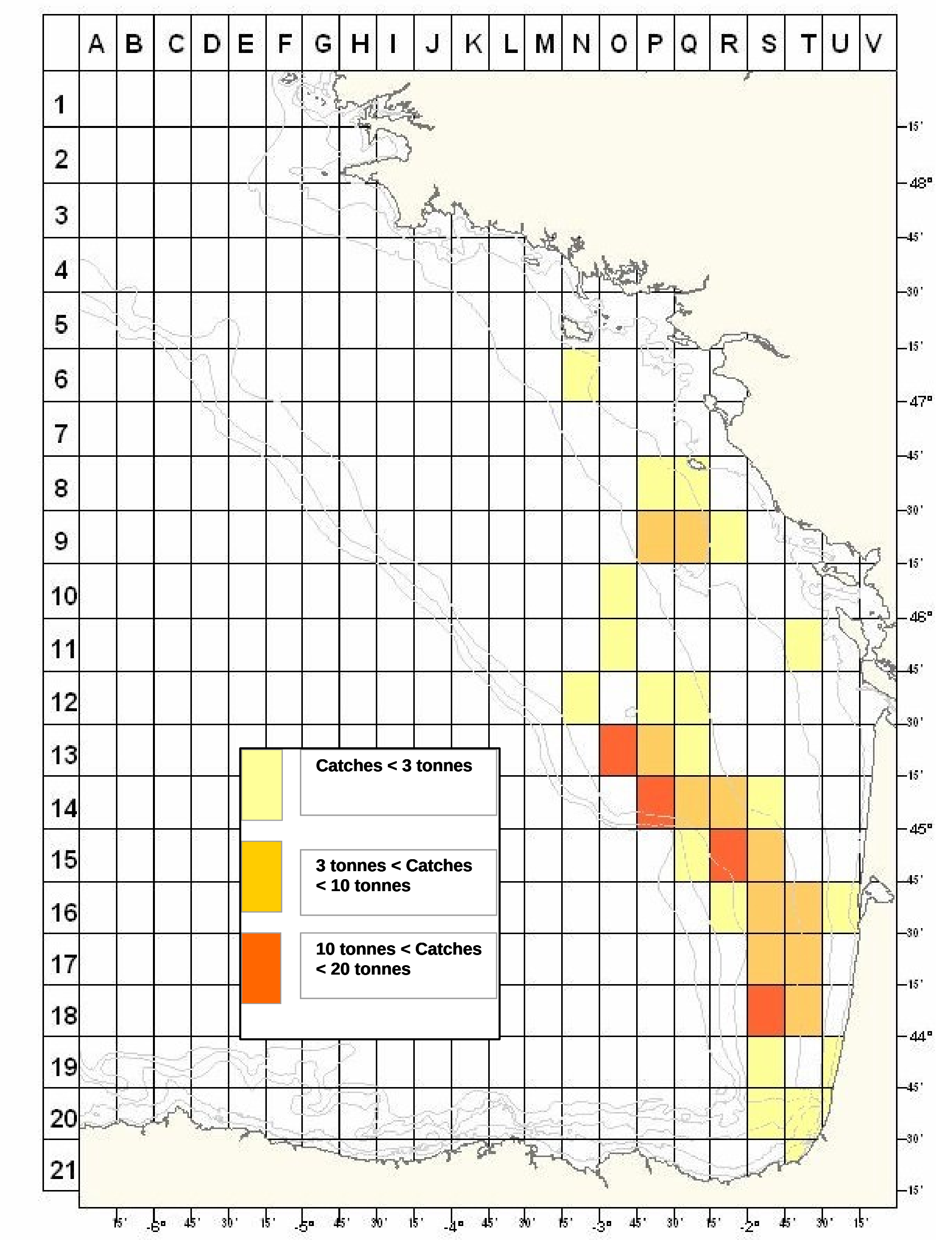


Figure 10.2.3.2.1. – Distribution of catches during the experimental survey by French commercial vessels (15 April – 10 June 2007)

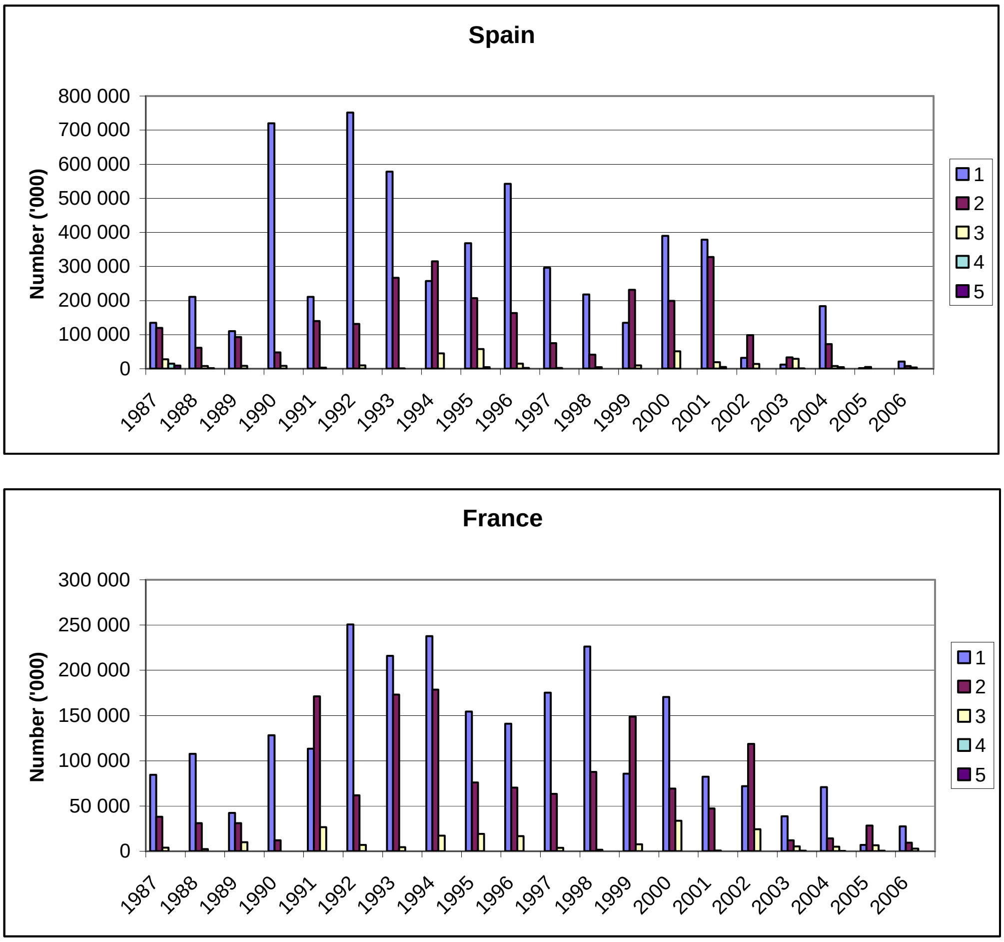


Figure 10.3.1.1. Bay of Biscay Anchovy. Spanish (upper panel) and French (Bottom panel) catch at age compositions of the first half of the year from 1987 to 2006.

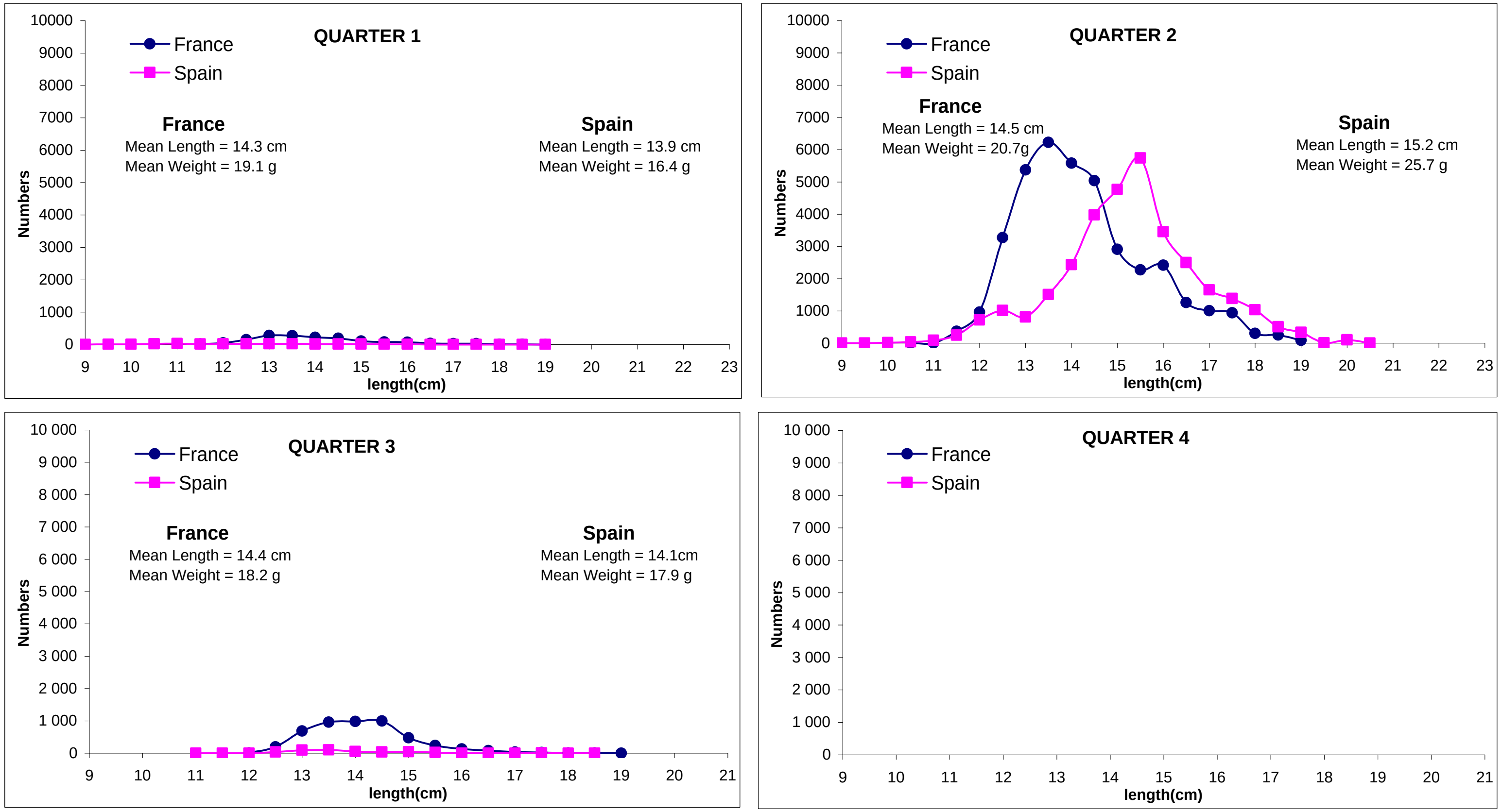


Figure 10.3.2.1. Bay of Biscay anchovy. Length distribution of catches by country in 2006 by quarter.

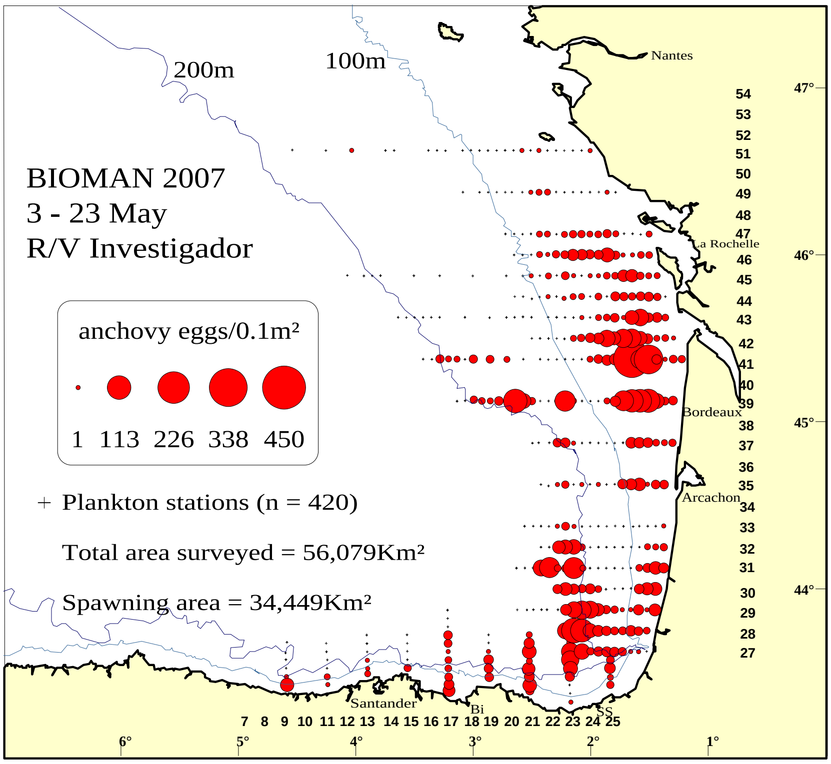


Figure 10.4.1.1: Plankton stations and egg abundances from the DEPM survey BIOMAN07 obtained with PairoVET ((eggs per 0.1m^2)

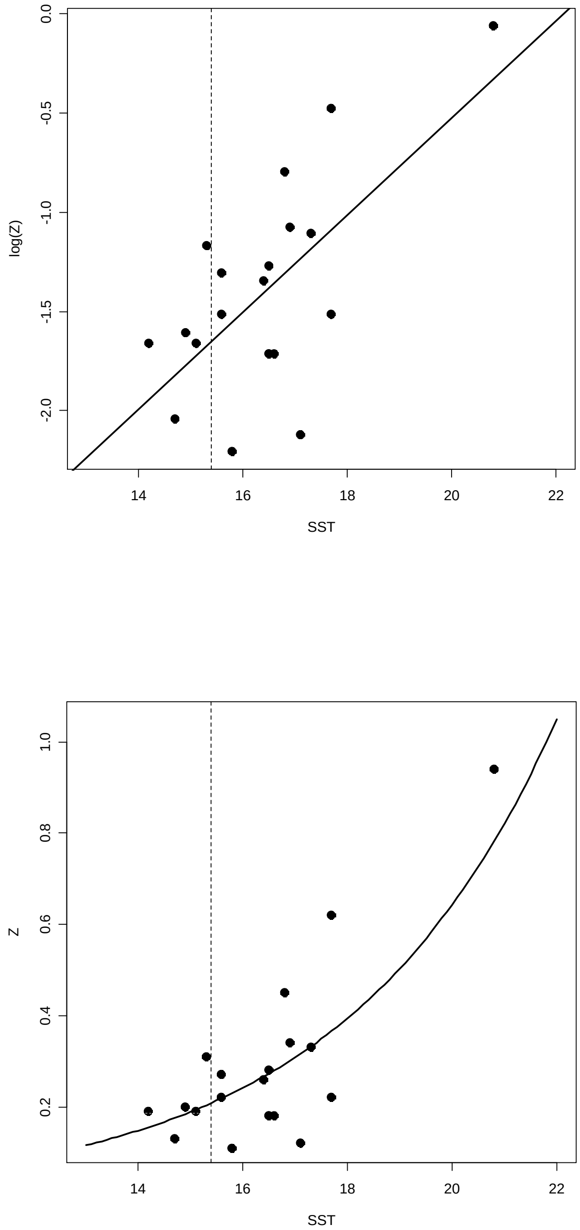


Figure 10.4.1.2: Plots for the model for z depending on SST from the historical series in log scale (top panel) and natural scale (bottom panel).

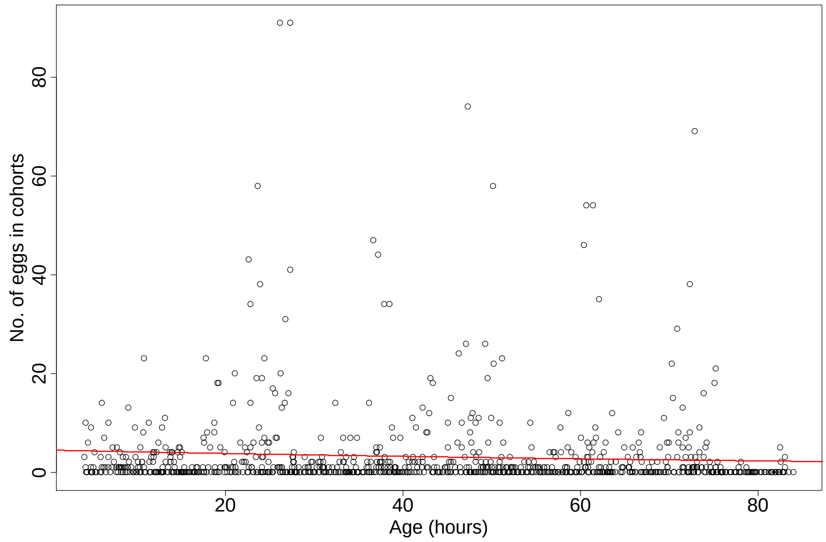


Figure 10.4.1.3: Exponential mortality model fitted using a GLM when the daily mortality rate z is fixed at 0.203, as inferred from the model of z depending on SST fitted to the historical series.

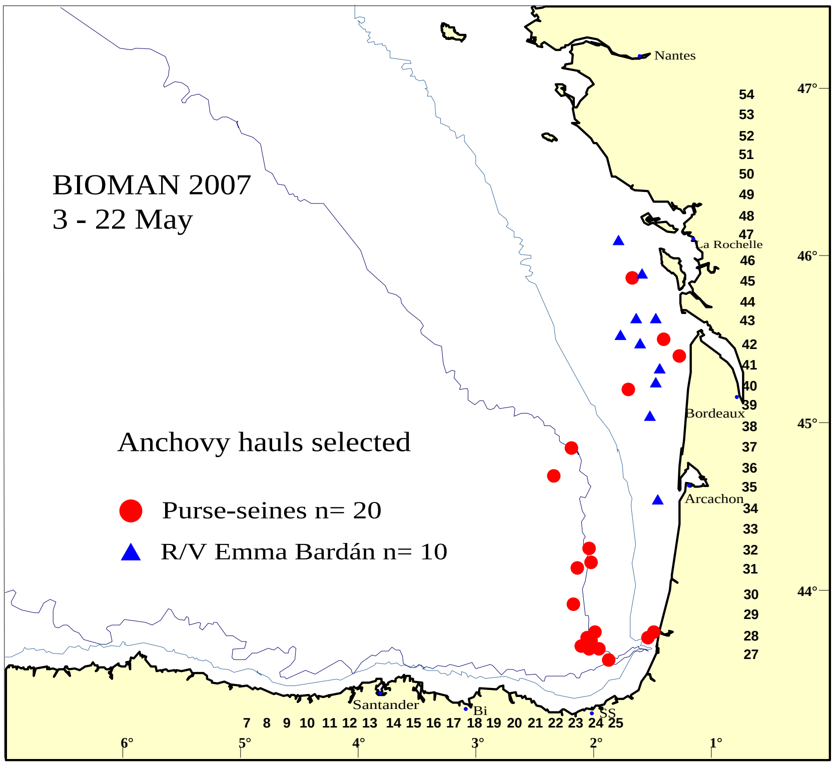


Figure 10.4.1.4: Adult samples selected for the analysis according to its coincidence in time and space with the sampling of eggs

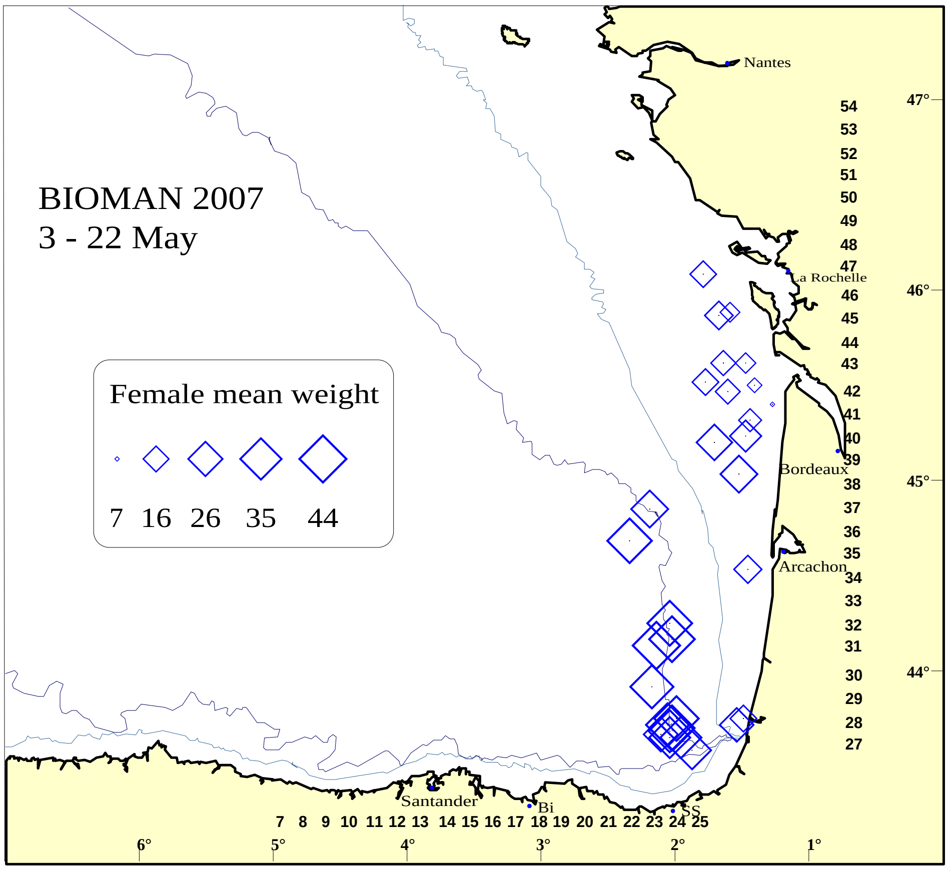


Figure 10.4.1.5: females distribution and mean weight (g)

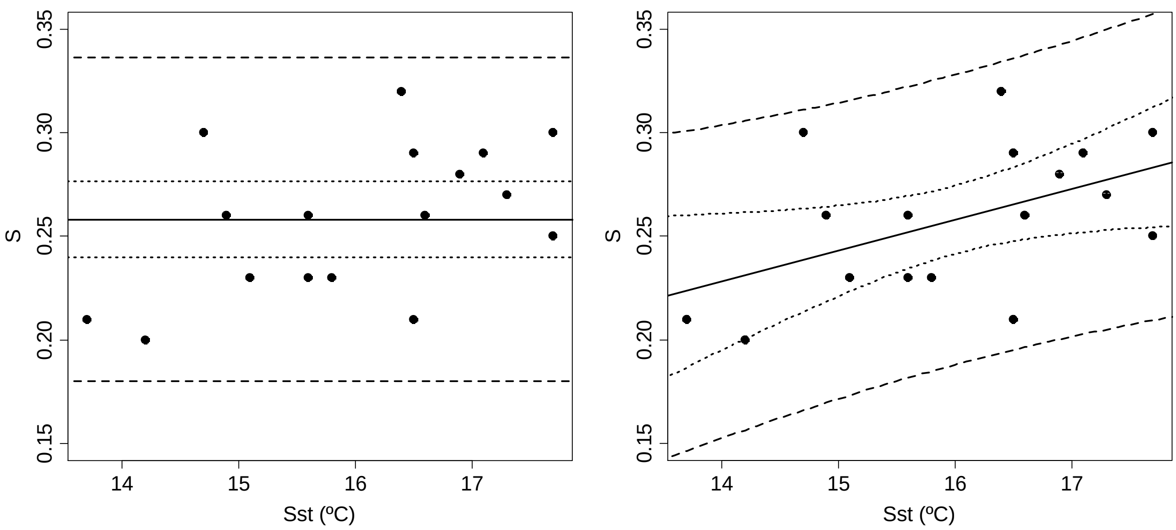


Figure 10.4.1.6: shows the two models for S fitted to the historical series data: (left) based on an average of S from the historical series, and the second one (right) on which S is linearly dependent on SST

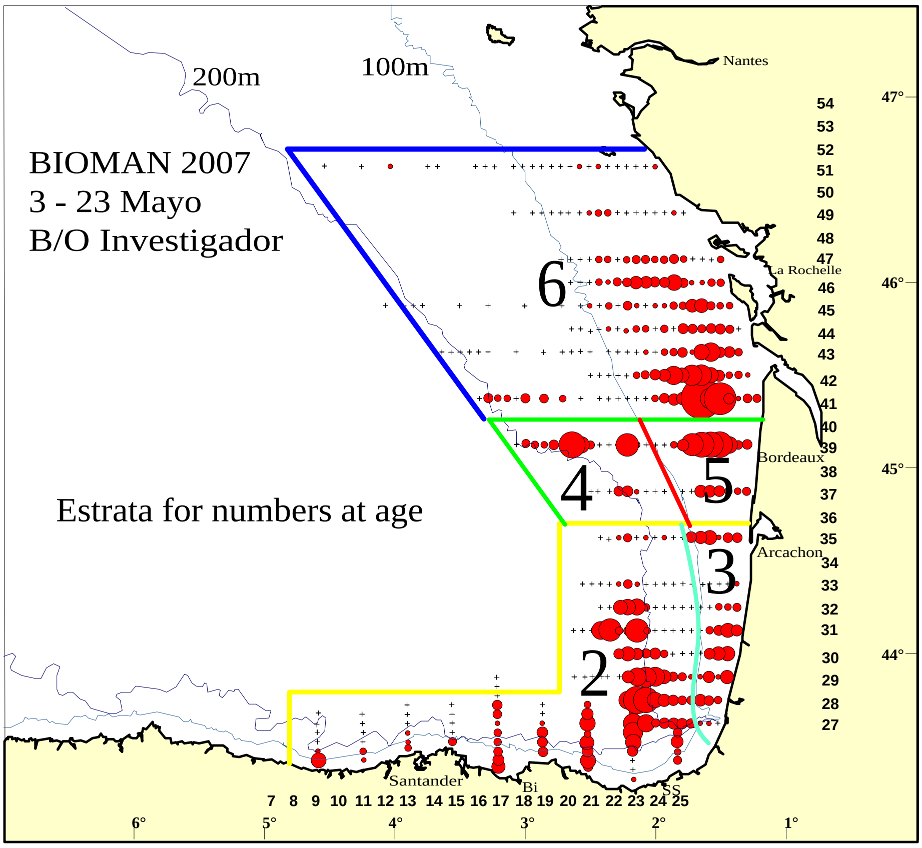


Figure 10.4.1.7: Five substrata defined for the estimation of the numbers at age

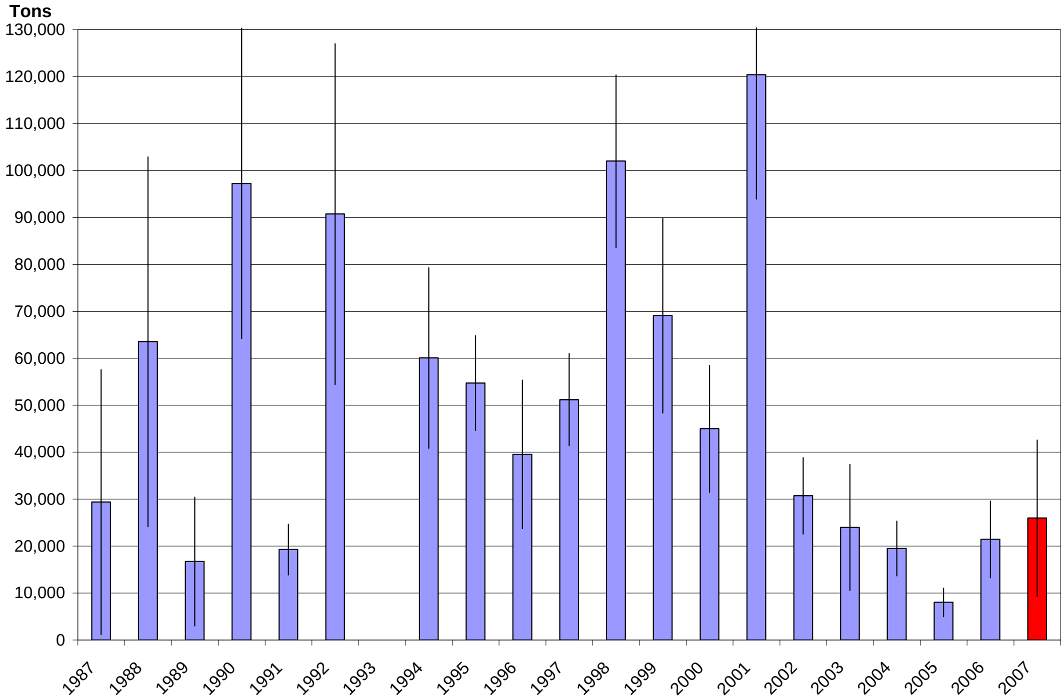


Figure 10.4.1.8: Series of Biomass estimates (tonnes) obtained from the DEPM since 1987. Most of them are full DEPM estimates, except in 1996, 1999, 2000 and 2007, for which some of the parameters were indirectly deduced.

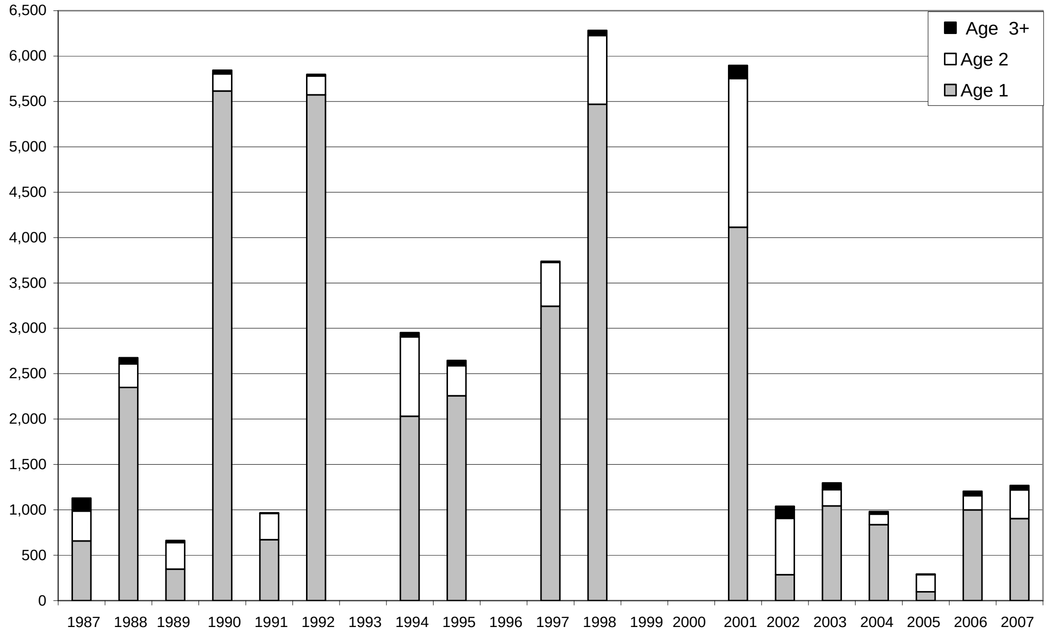


Figure 10.4.1.9: Historical series of numbers at age in the anchovy population obtained by the application of the DEPM

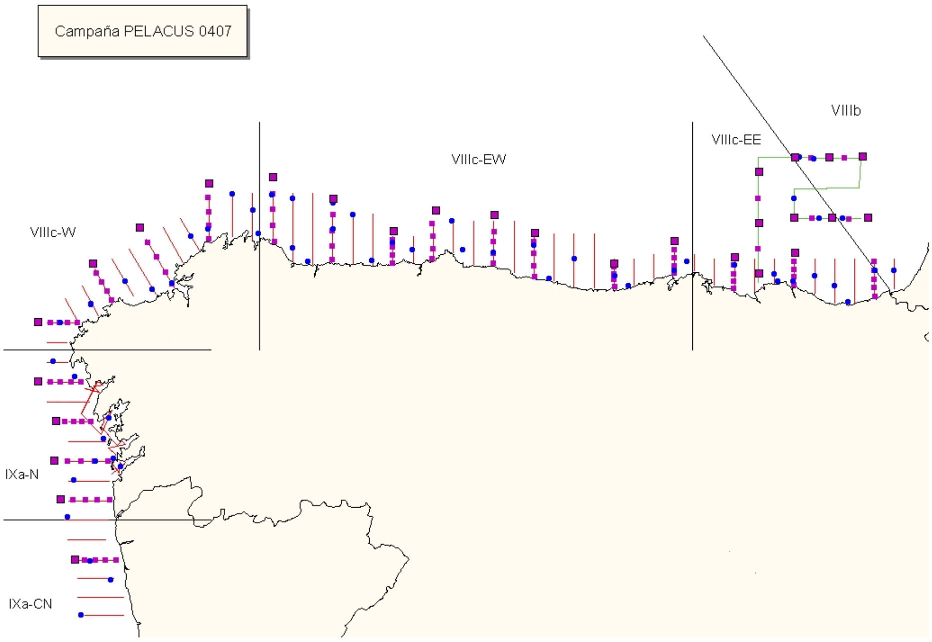


Figure 10.4.2.1.1 PELACUS0407 sampling effort. Red and green (additional offshore sampling) lines indicate acoustic transects, blue round points indicate fishing stations, and purple square indicate hydrography stations (small ones indicate normal stations, big ones indicate intensive stations with multinet).

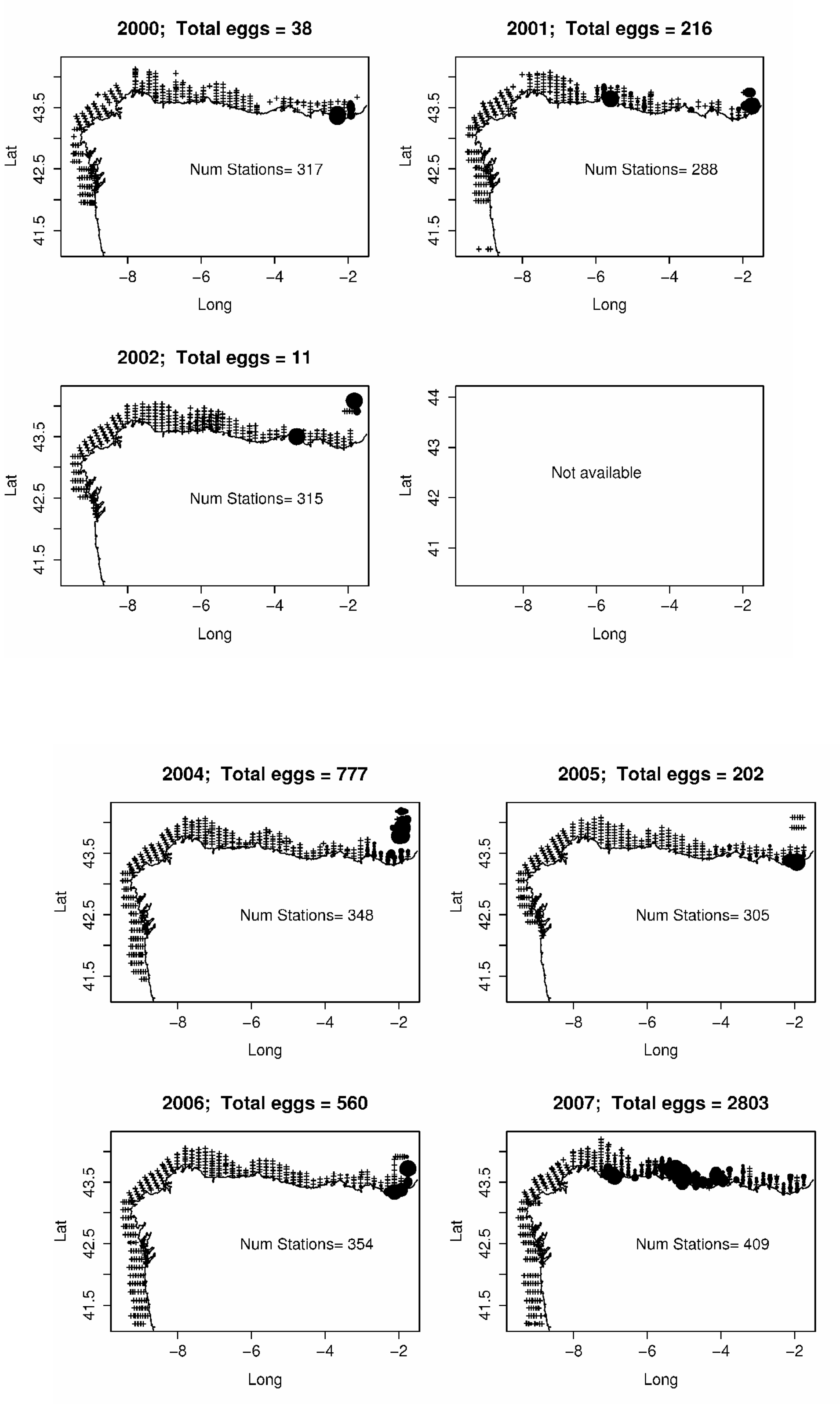


Figure 10.4.2.1.2 Distribution of anchovy eggs sampled with CUFES through the PELACUS time series (2000-2007). Crosses indicate negative stations, while circles indicate positive stations with diameter proportional to egg abundance. All figures in the same scale.

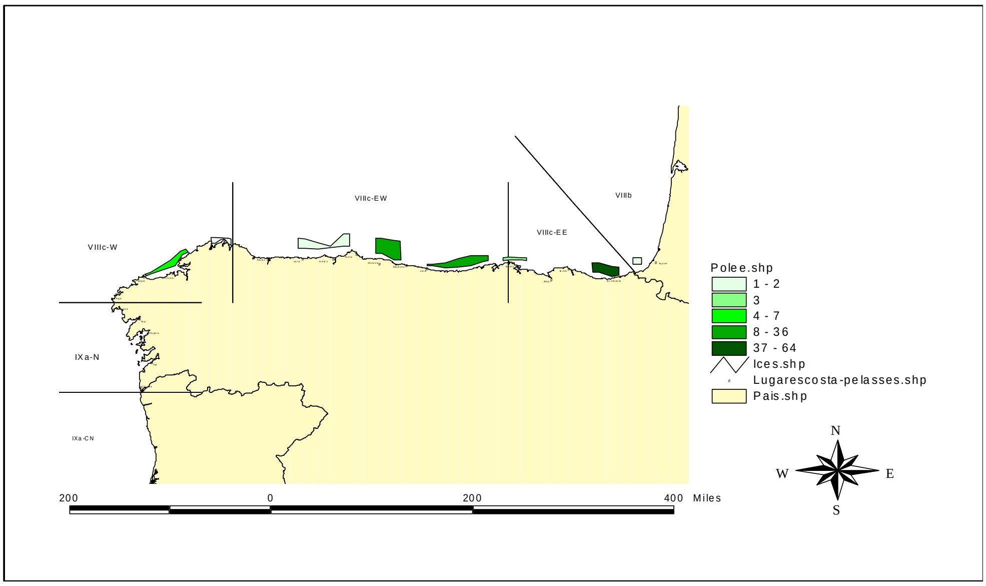


Figure 10.4.2.1.3 Spatial distribution of energy allocated to anchovy during the PELACUS0407 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the average value of integrated energy in m2 within each polygon.

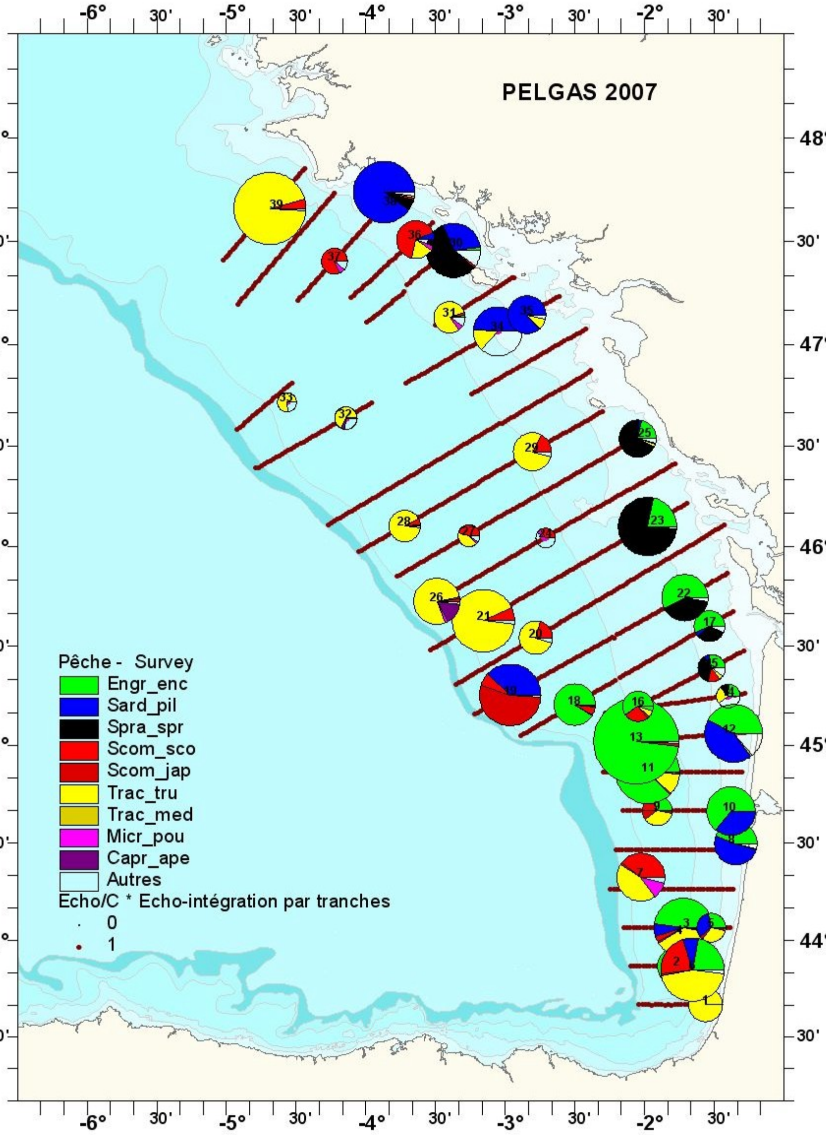


Figure 10.4.2.2.1 – Acoustic and CUFES transects and identification hauls carried out during PELGAS07 survey on board Thalassa

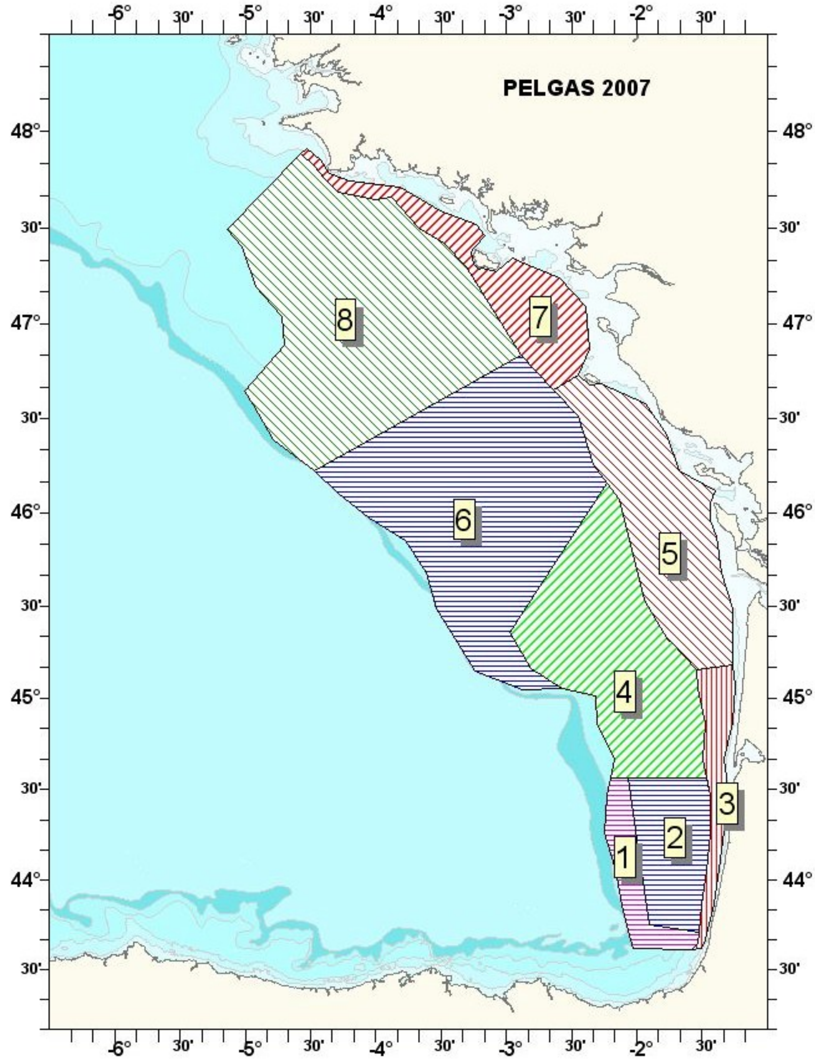


Figure 10.4.2.2.2. – Strata used for acoustic biomass estimated from PELGAS07 survey data, taking into account echogram scrutiny and coherent communities which were observed (species associations).

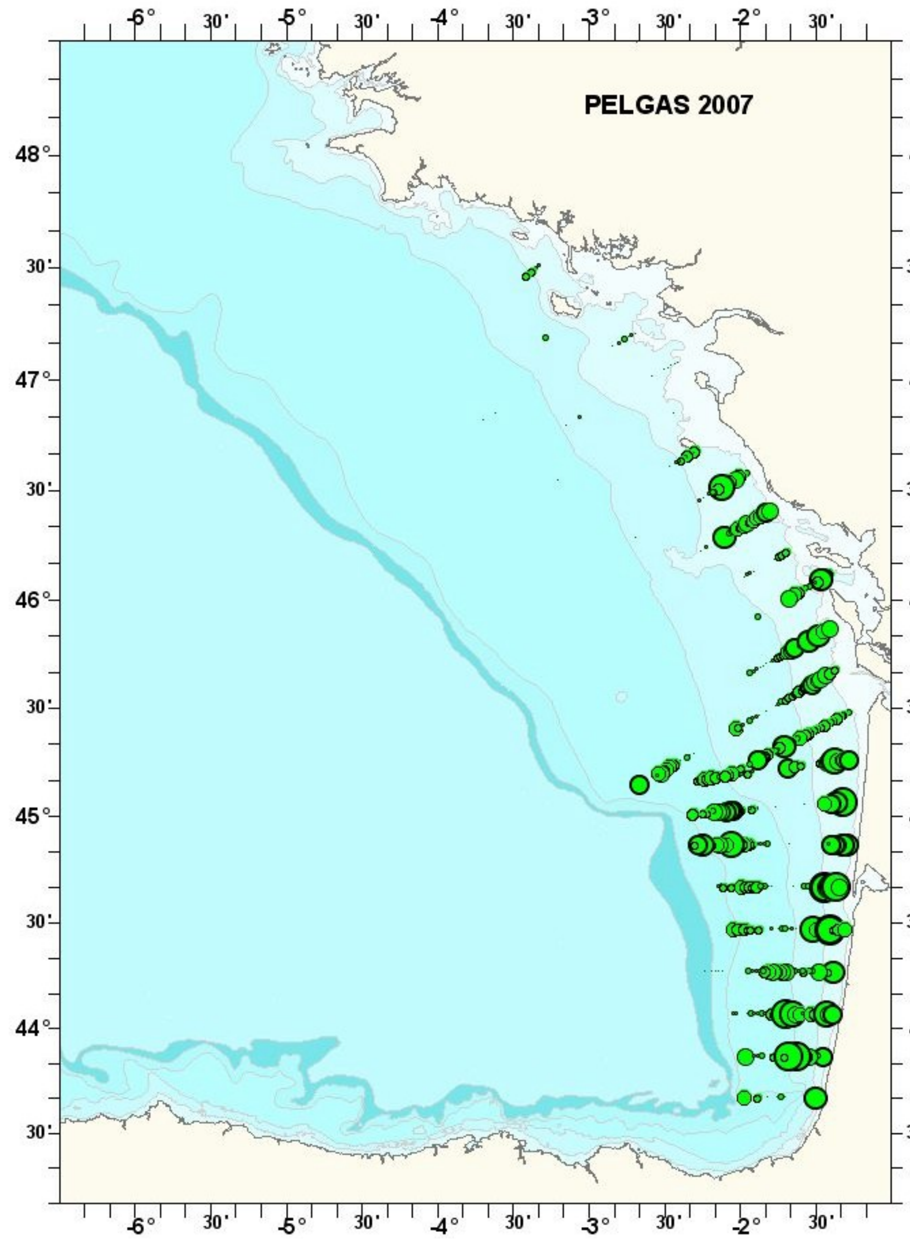
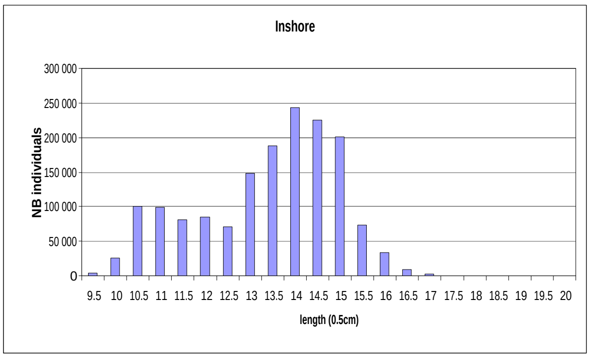
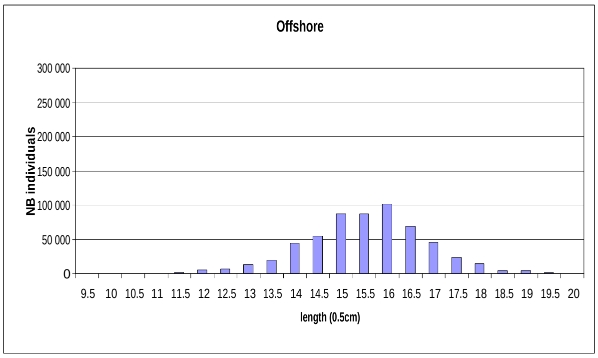


Figure 10.4.2.2.3. – anchovy distribution from acoustic and identification hauls during PELGAS07 survey.





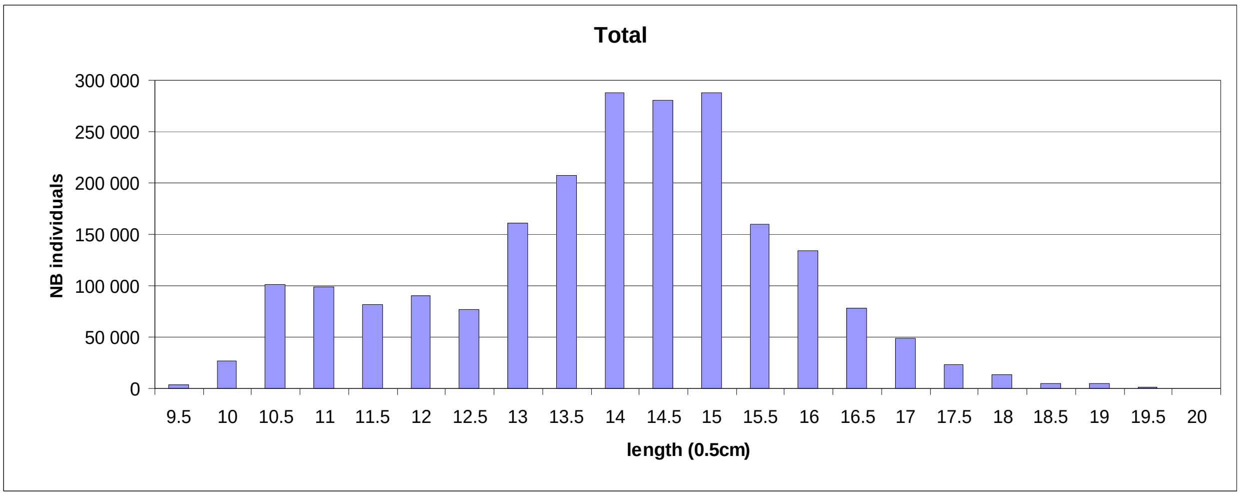


Figure 10.4.2.2.4. – anchovy length distribution in numbers from acoustic PELGAS07 survey - inshore (strata 3, 5 & 7) and offshore (strata 1, 2, 4, 6 & 8)at the top and global below).

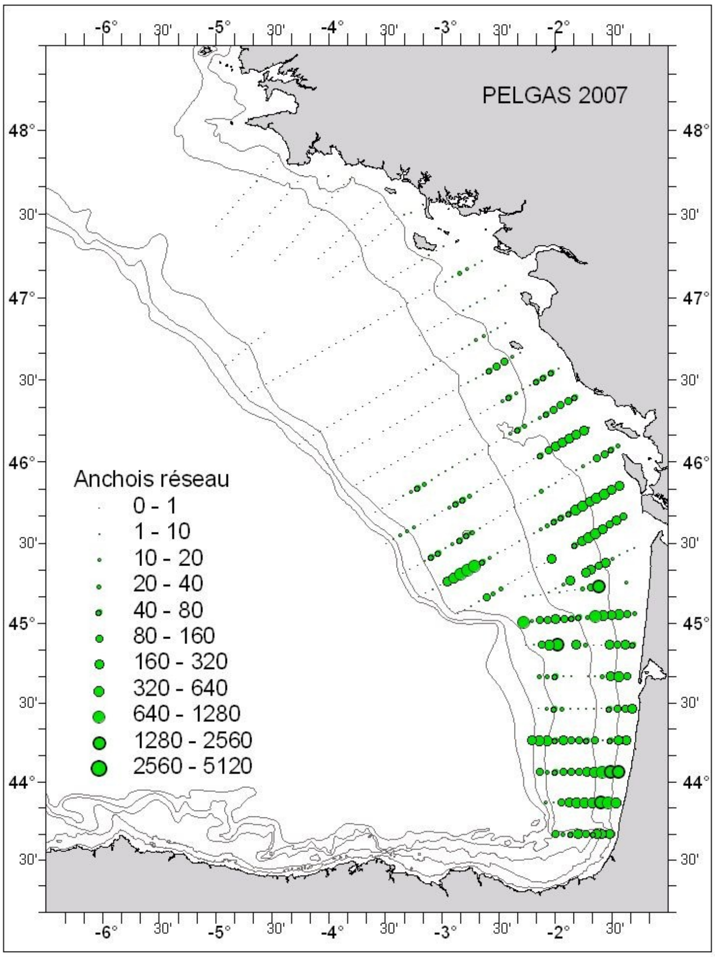


Figure 10.4.2.2.5. – anchovy eggs distribution from CUFES counting during PELGAS07 survey.

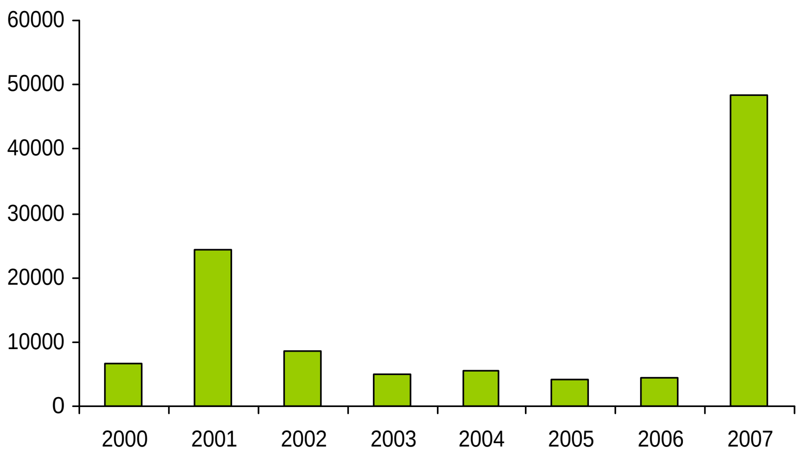


Figure 10.4.2.2.6. – anchovy eggs numbers from CUFES counting during PELGAS surveys between 2000 and 2007.

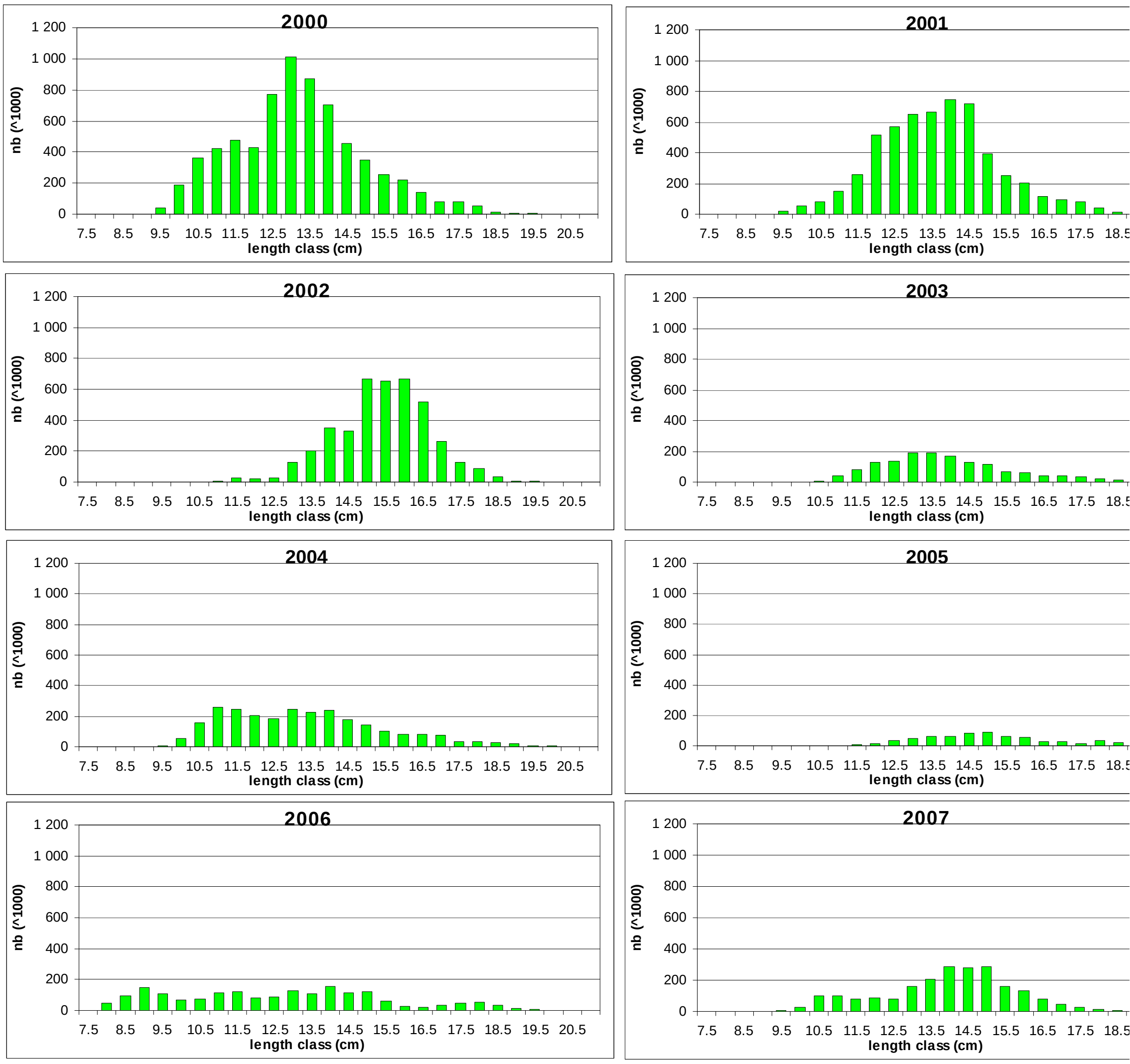


Figure 10.4.2.2.7. – length composition of anchovy as estimated by acoustics between 2000 and 2007.

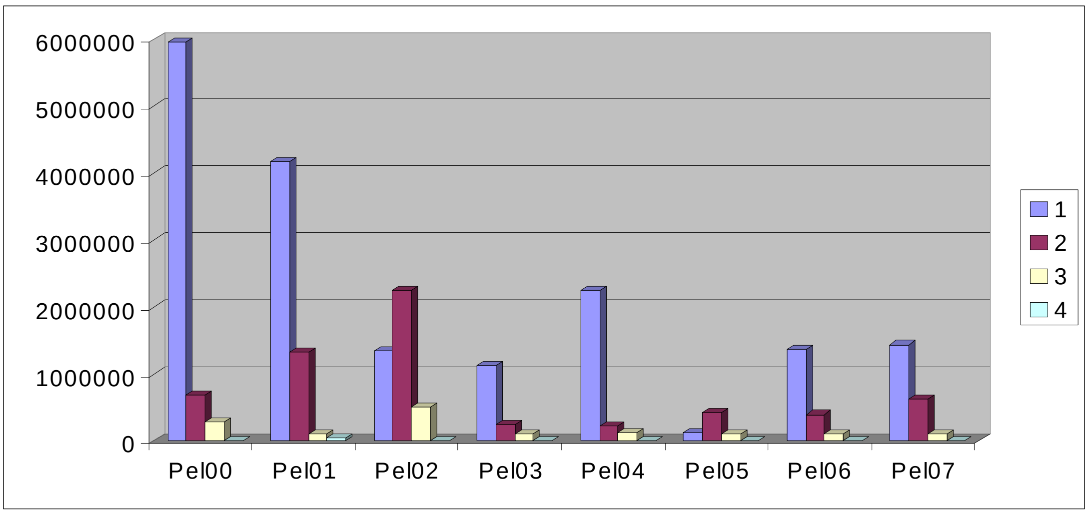


Figure 10.4.2.2.8. – Numbers at age of anchovy as observed during PELGAS surveys since 2000

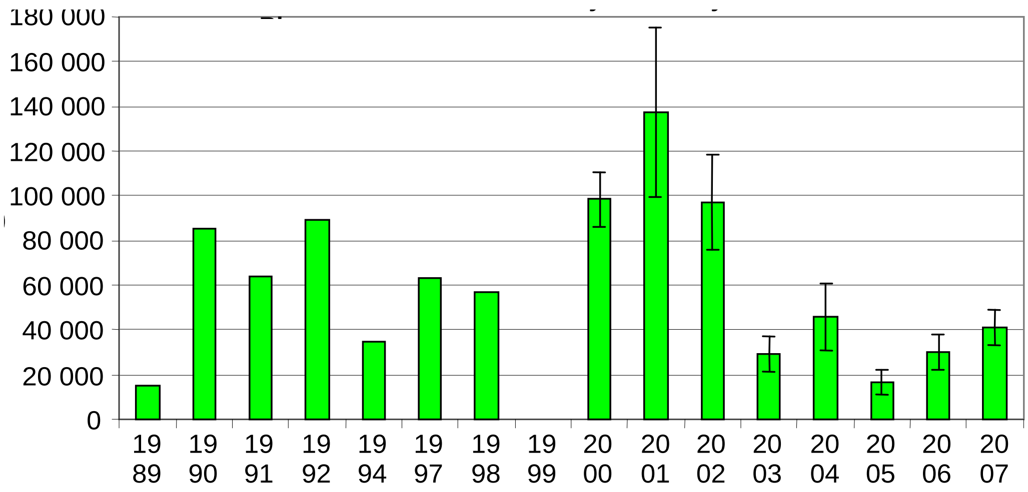


Figure 10.4.2.2.9. – Biomass (in tons) estimates series from PELGAS acoustic surveys from 2000 to 2007.

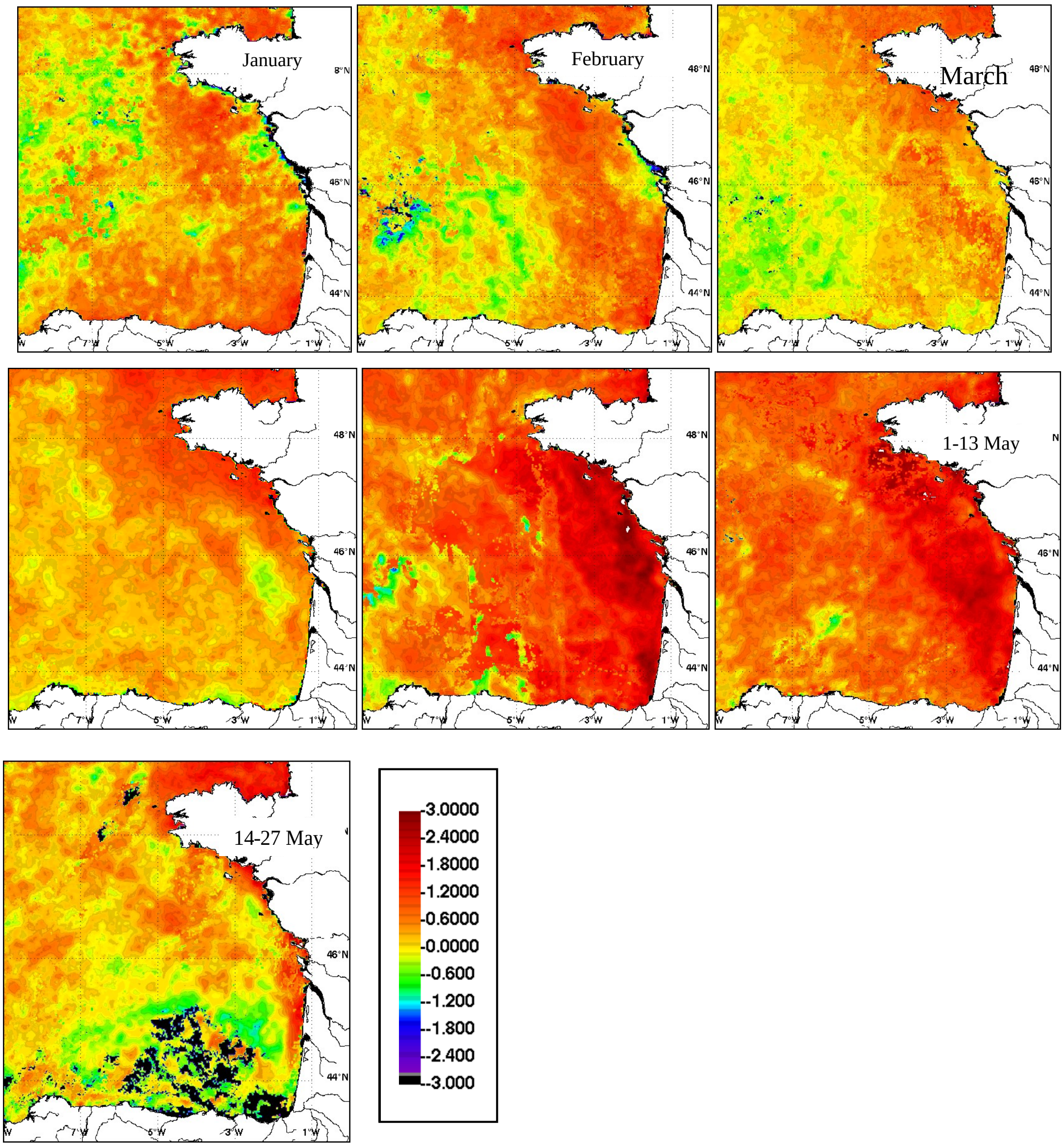


Figure 10.4.2.2.10. - Temperature anomaly from January to May 2007, calculated with a climatology covering the years 1985-2001.

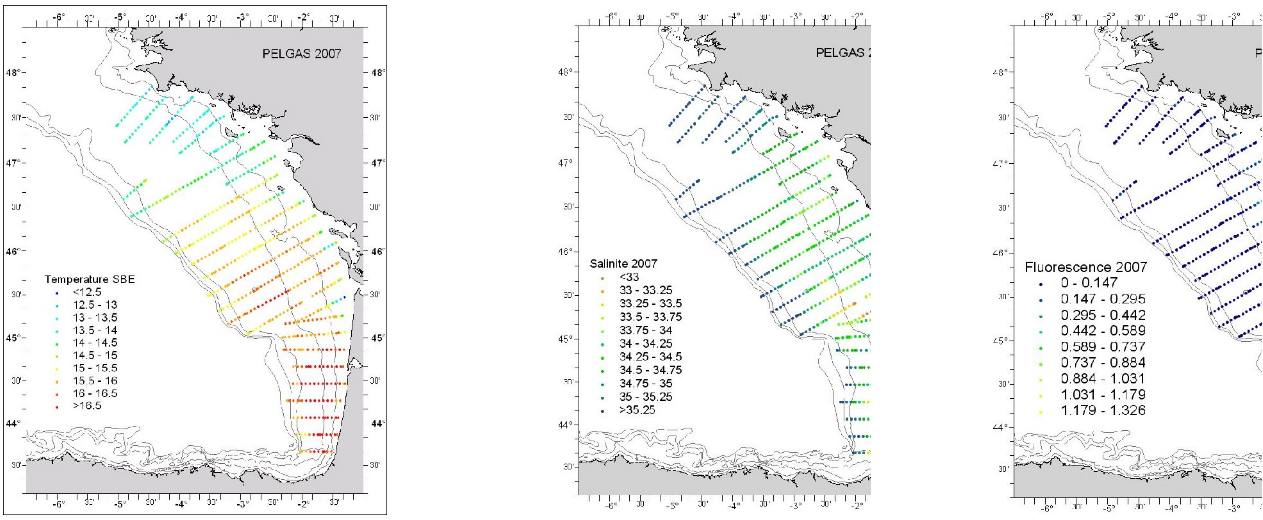


Figure 10.4.2.2.11. - Surface temperature, salinity and fluorescence observed during PELGAS07.

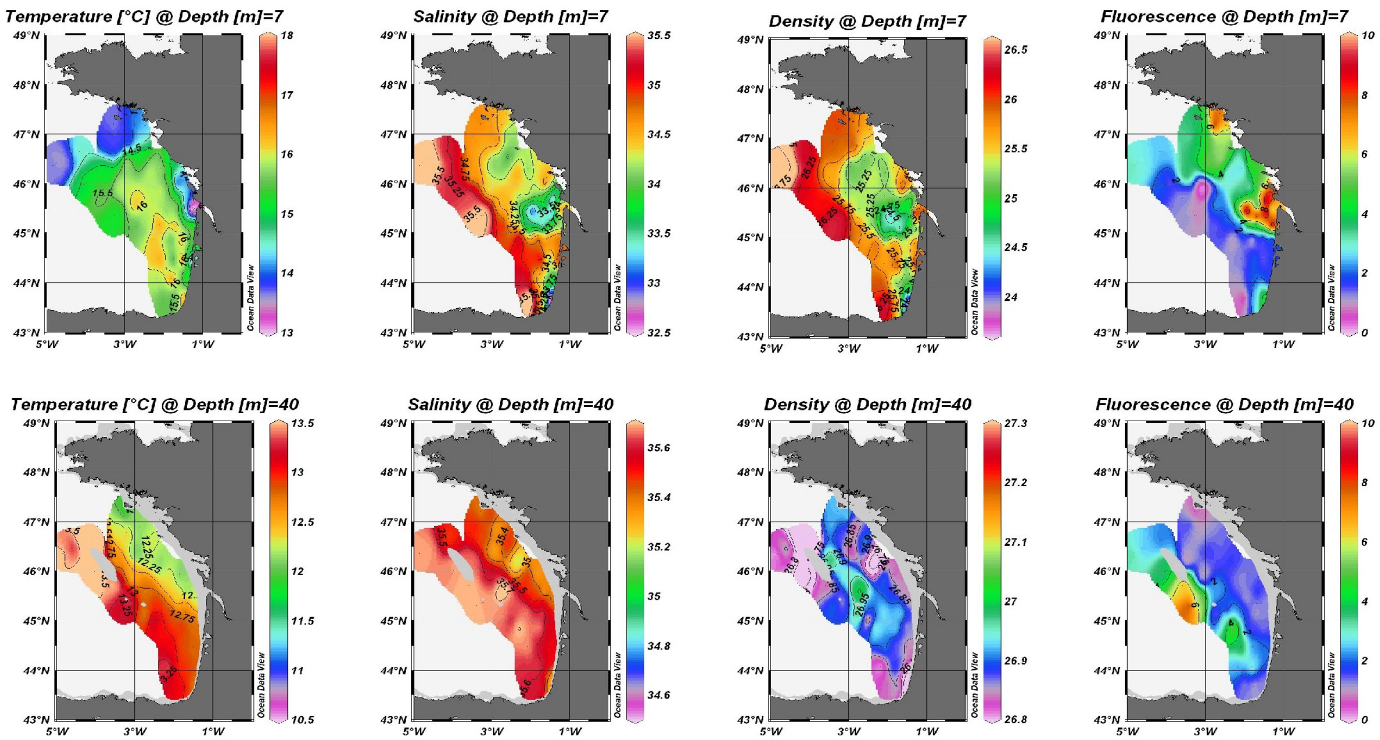
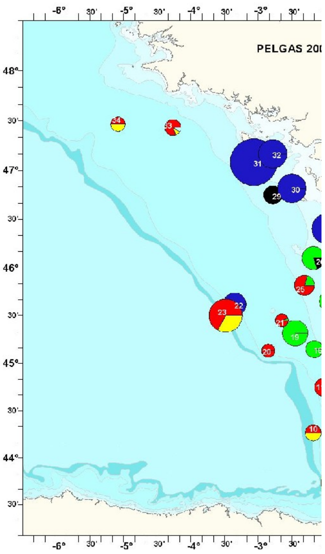
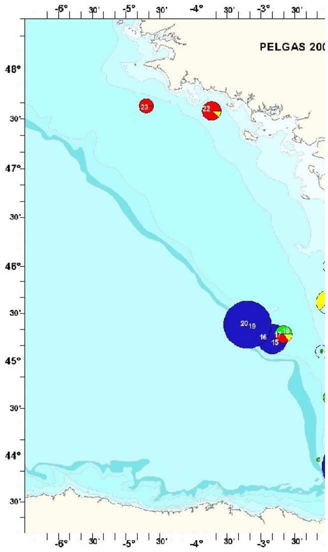


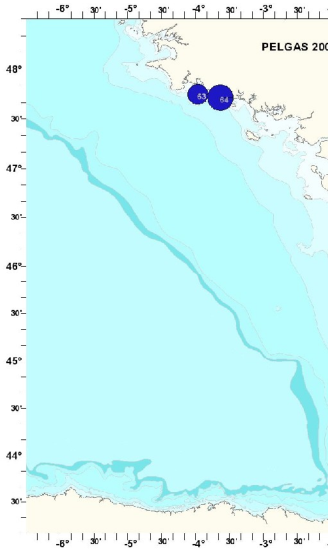
Figure 10.4.2.2.12. - Temperature, salinity, density and fluorescence observed during PELGAS06 at the surface (top) and at 40 m depth (bottom).



a) Pair trawlers (nb : 32)



b) Spanish purse seiners (nb : 23)



c) French purse seiners (nb : 13)

Figure 10.4.2.3.1. - Fishing operations carried out by commercial vessels during consort survey PELGAS07.

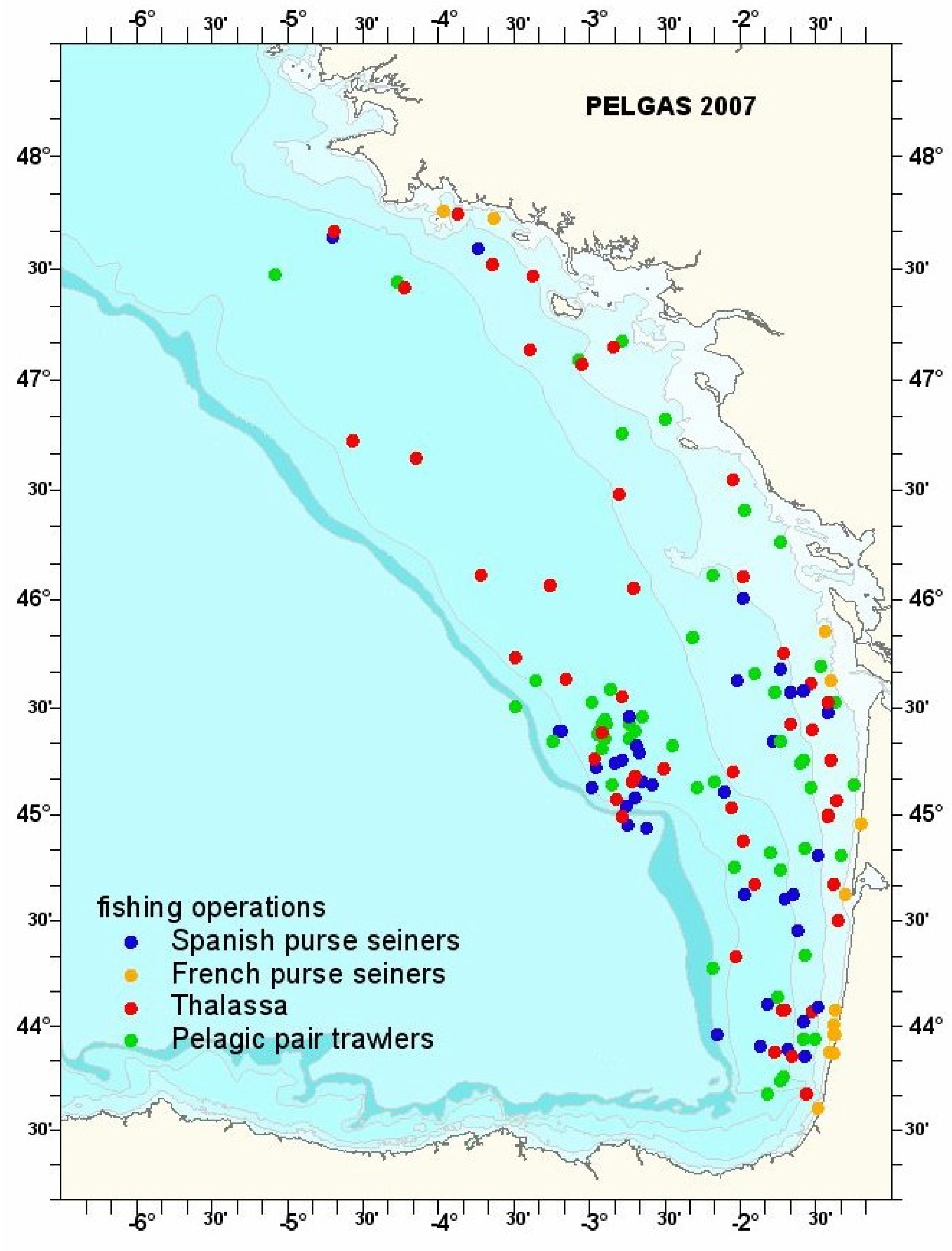


Figure 10.4.2.3.2. - Fishing operations carried out by THALASSA and the consort commercial vessels during the PELGAS07 survey.

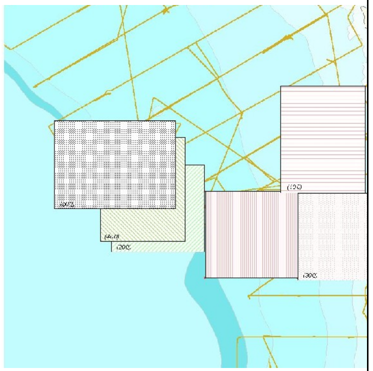
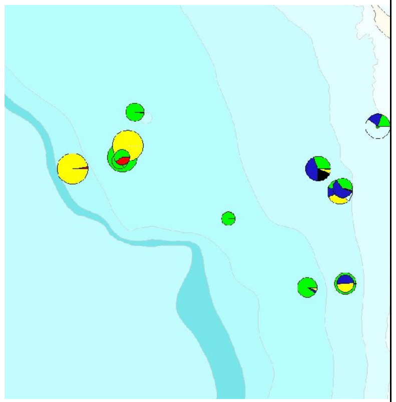
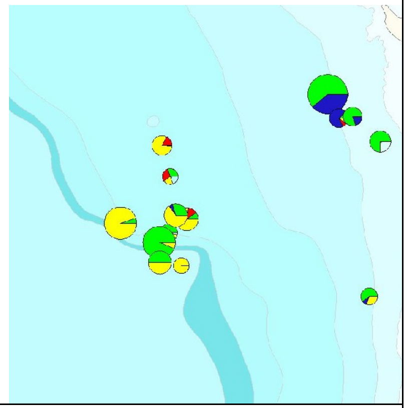
		
a) surveyed daily areas prospected by each type of vessels	b) pair trawlers catches (n = 14)	c) purse seiners catches (n = 15)

Figure 10.4.2.3.3. - Fishing operations carried out by commercial vessels during the last week of the PELGAS07 survey in order to compare specific catchability.

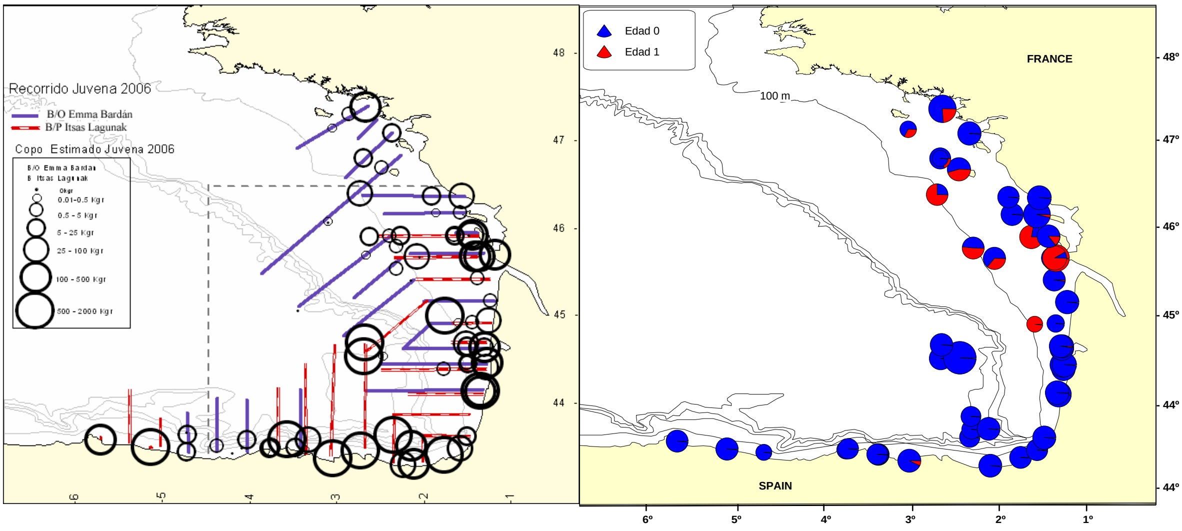


Figure 10.4.3.1.1: Summary of the JUVENA acoustic survey in 2006 survey tracks and fishing hauls (left panel) and anchovy catches by age group (0 & 1) (right panel).

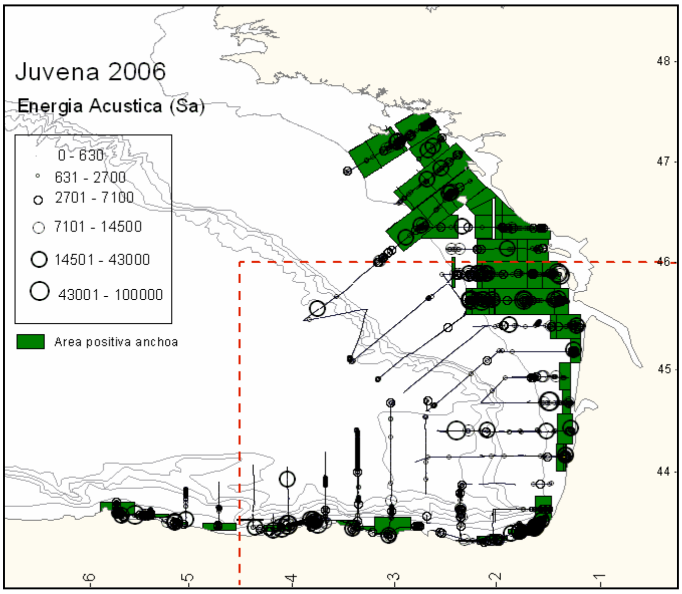


Figure 10.4.3.1.2: Survey tracks of JUVENA 2006 showing the spatial distribution of acoustic energy shading in green corresponding to areas with juvenile anchovy, included for the final estimates.

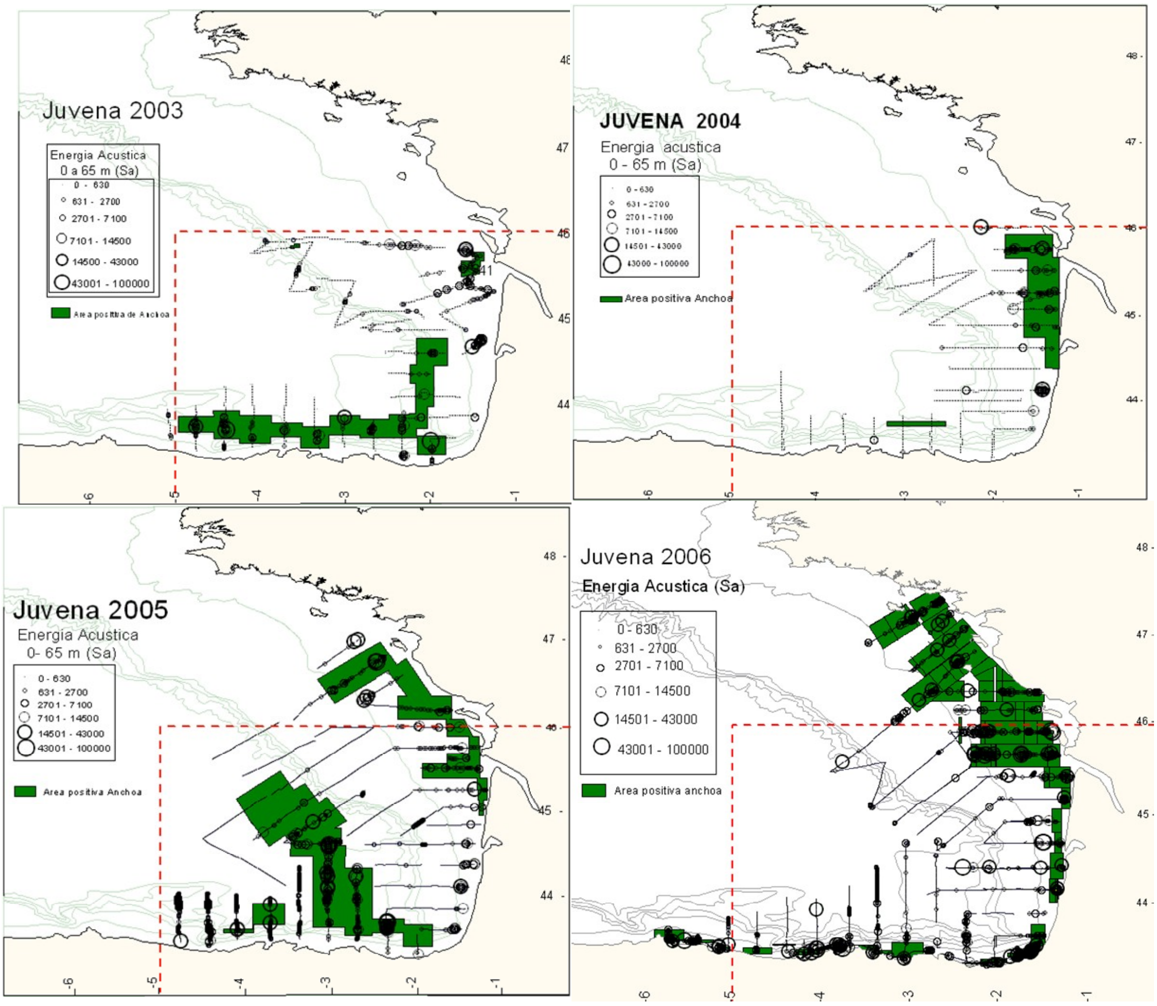


Figure 10.4.3.1.3: Survey tracks of JUVENA surveys (2003-2006) showing the spatial distribution of acoustic energy and shading in green the areas corresponding to presence of juvenile anchovy.

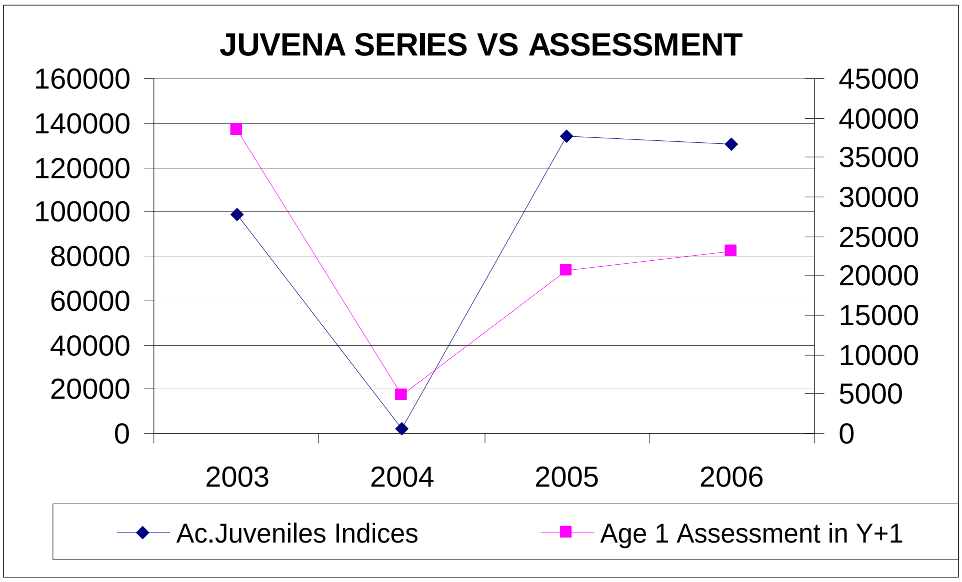


Figure 10.4.3.1.4: Times series of the JUVENA anchovy juveniles abundance index vs. the assessment at age 1 produced by the STECF June 2007 using the results of the spring surveys in the Bay of Biscay.

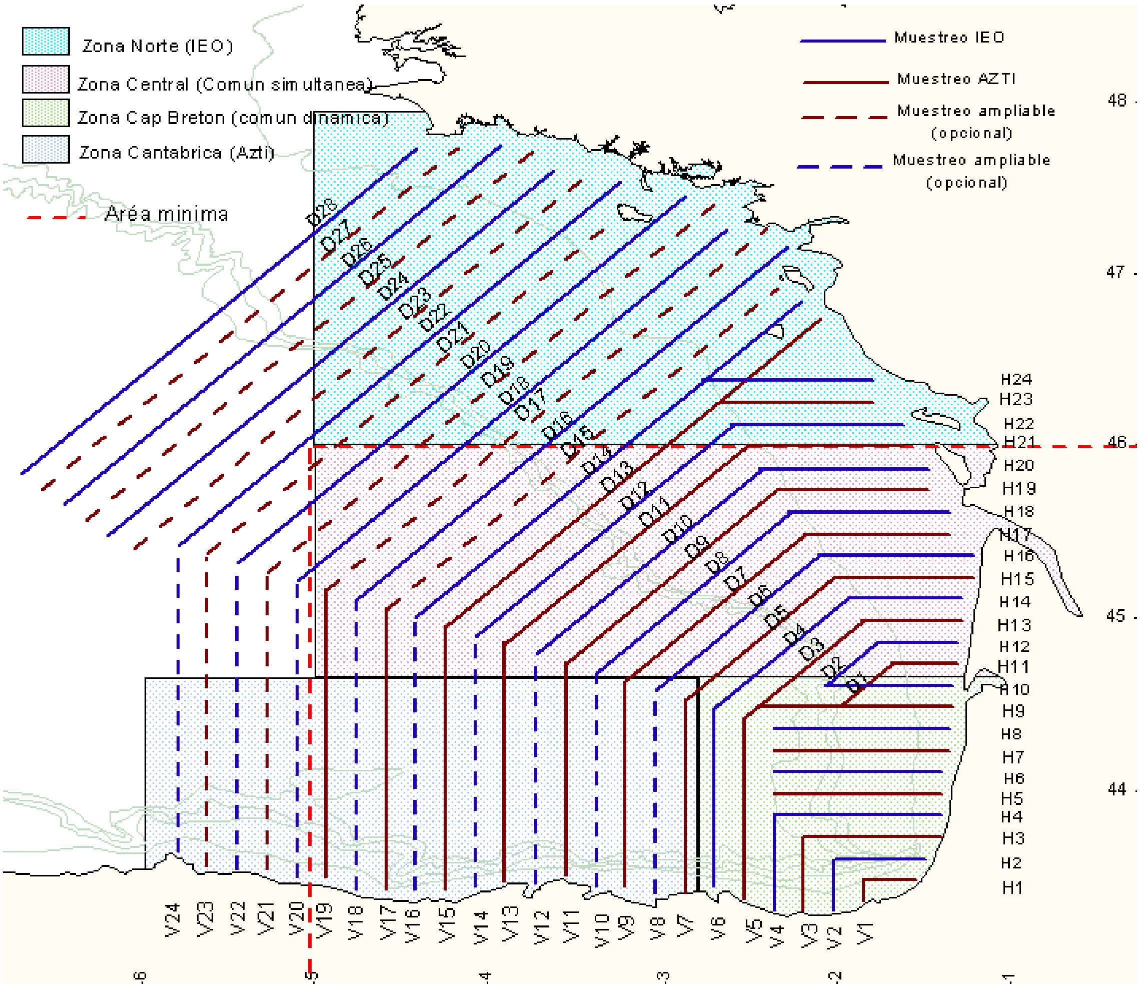


Figure 10.4.3.1.5. Survey design for the coordinated surveys. The survey JUVENA will cover the odd transects, and the PELACUS1007 survery will cover the even ones. The different coverage areas are distinguished: Cantabrian Area (JUVENA coverage), Cap Breton Area (common coverage with delay between surveys), France Central Area (simultaneous common coverage), France North Area (PELACUS coverage).

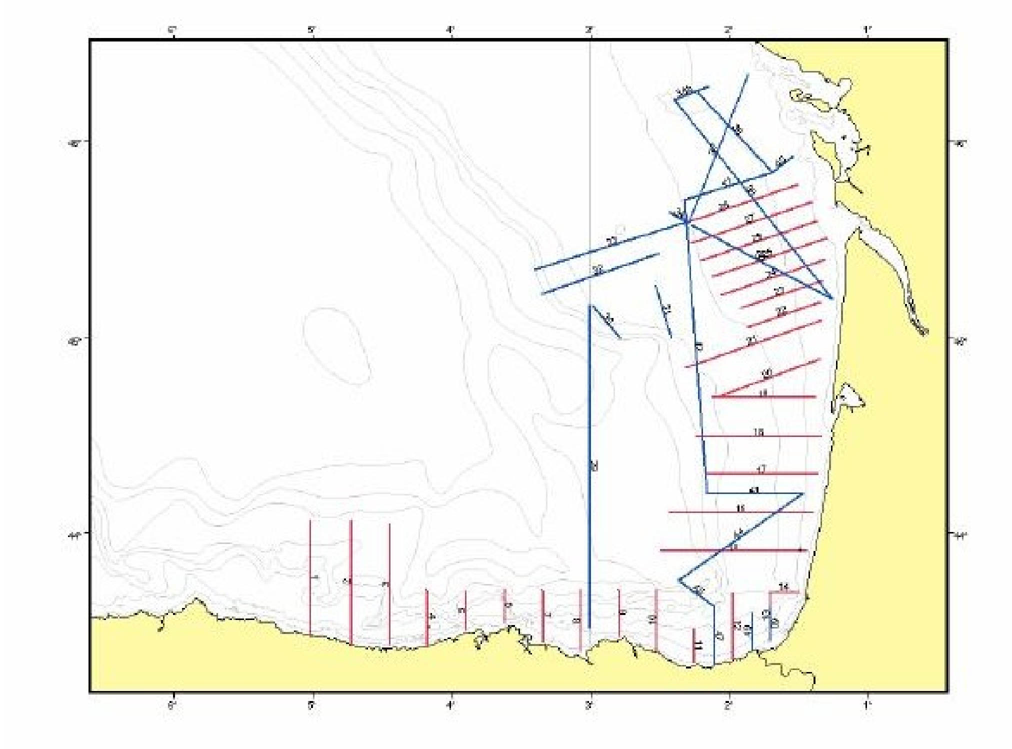


Figure 10.4.3.2.1 PELACUS1006 acoustic tracks. On red the acoustic tracks performed during the first leg and dedicated to the estimation of a juvenile biomass index, on blue the tracks performed on the second leg, dedicated to investigate the recruitment process.

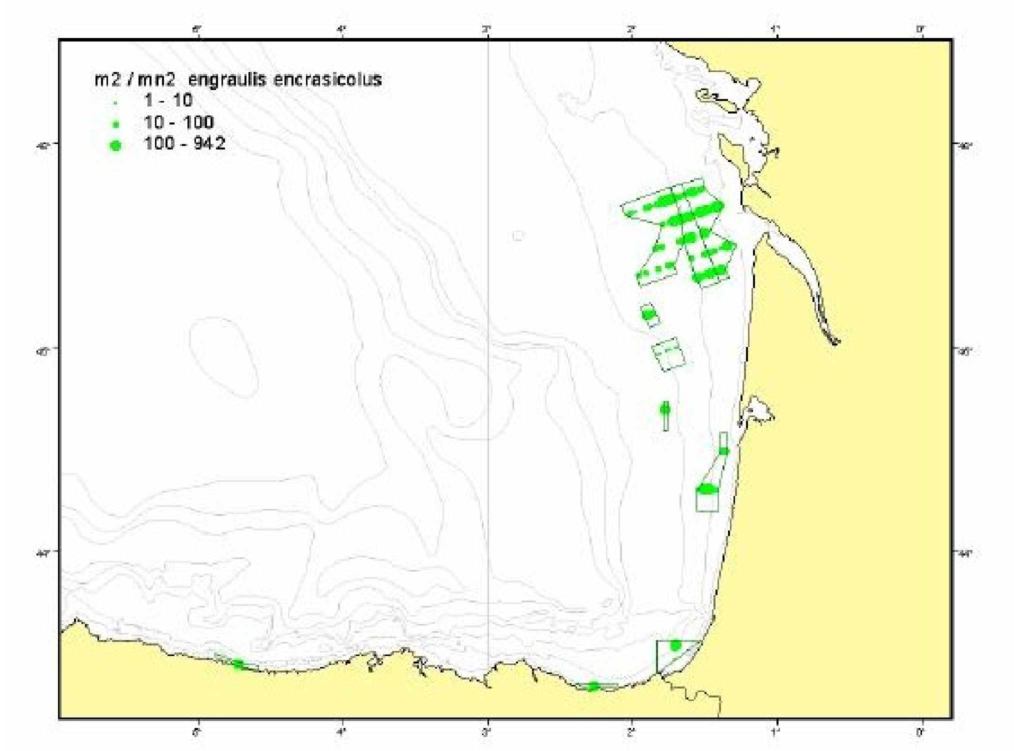


Figure 10.4.3.2.2 PELACUS1006 acoustic energy (in square meters by square nautical miles) allocated to anchovy

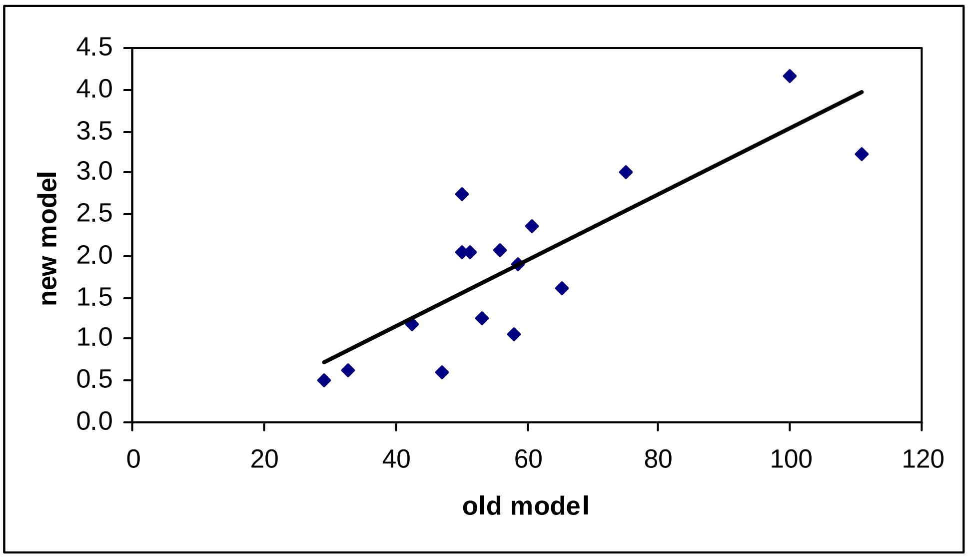


Figure 10.6.1: Correlation between the upwelling index as derived by the old version of IFREMER hydrodynamic model and the current one. The unit for the new index is s^{-1}.

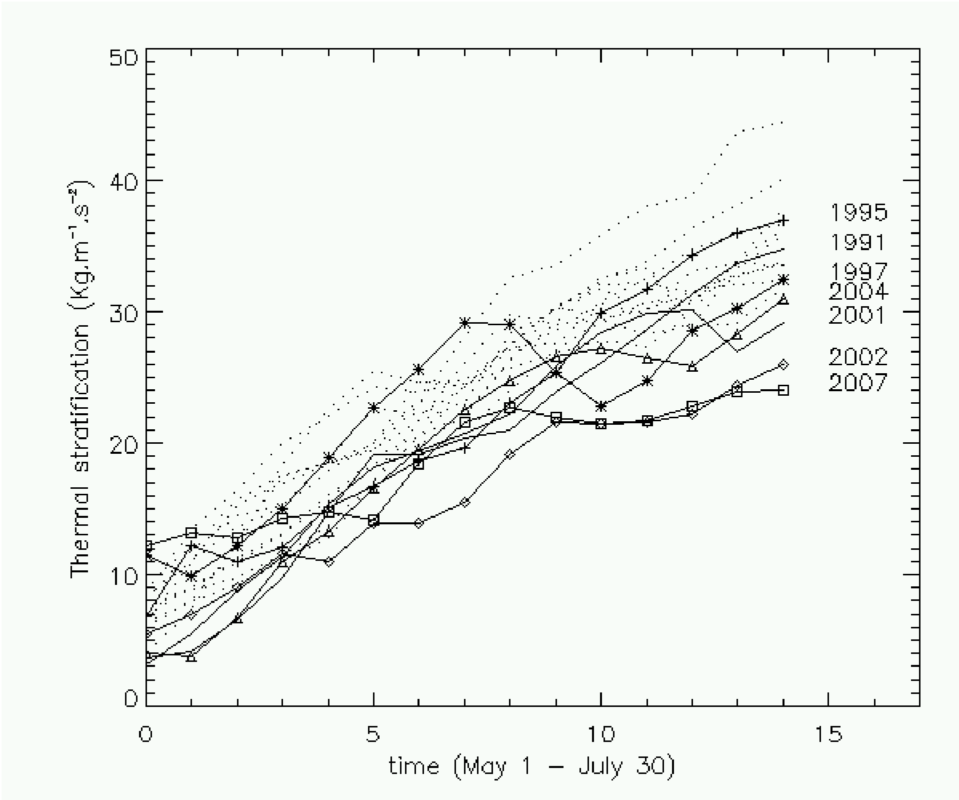


Figure 10.6.2.: Evolution of the mean thermal stratification over the southern part of the Bay of Biscay continental shelf. The serie runs from the beginning of May to the end of July, with values average over 6 days. The continuous lines correspond to the years when the stratification gets below one standard deviation from the mean, at least for one time step of the three month period.

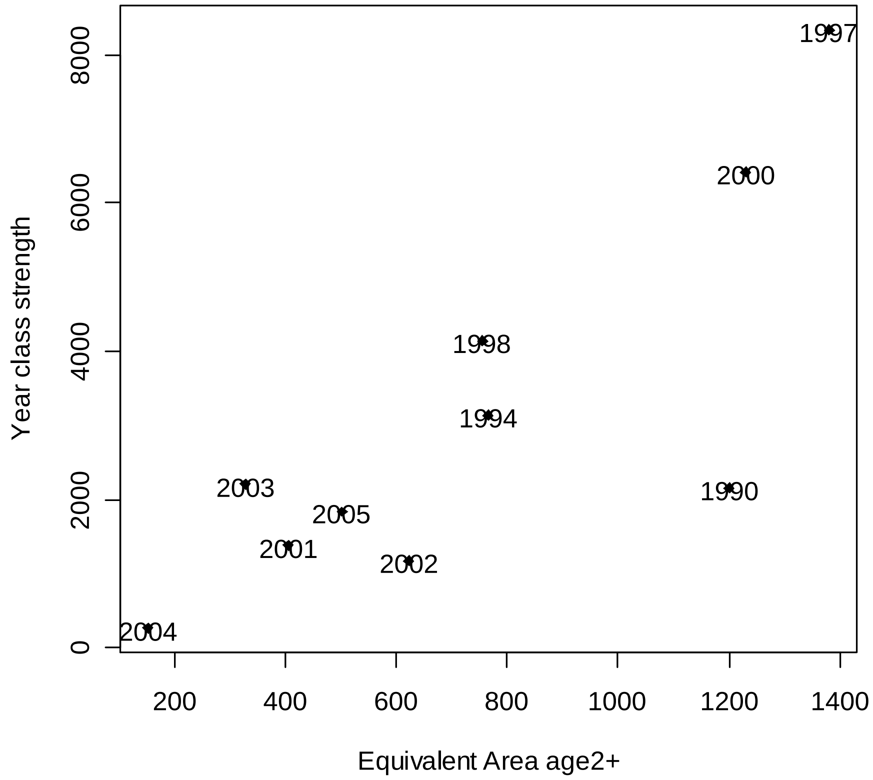


Figure 10.6.3.: Relationship between the aggregation of spawning adults (equivalent area of age2+ fish) and the incoming year class strength (ICES numbers at age 1 in the subsequent year).

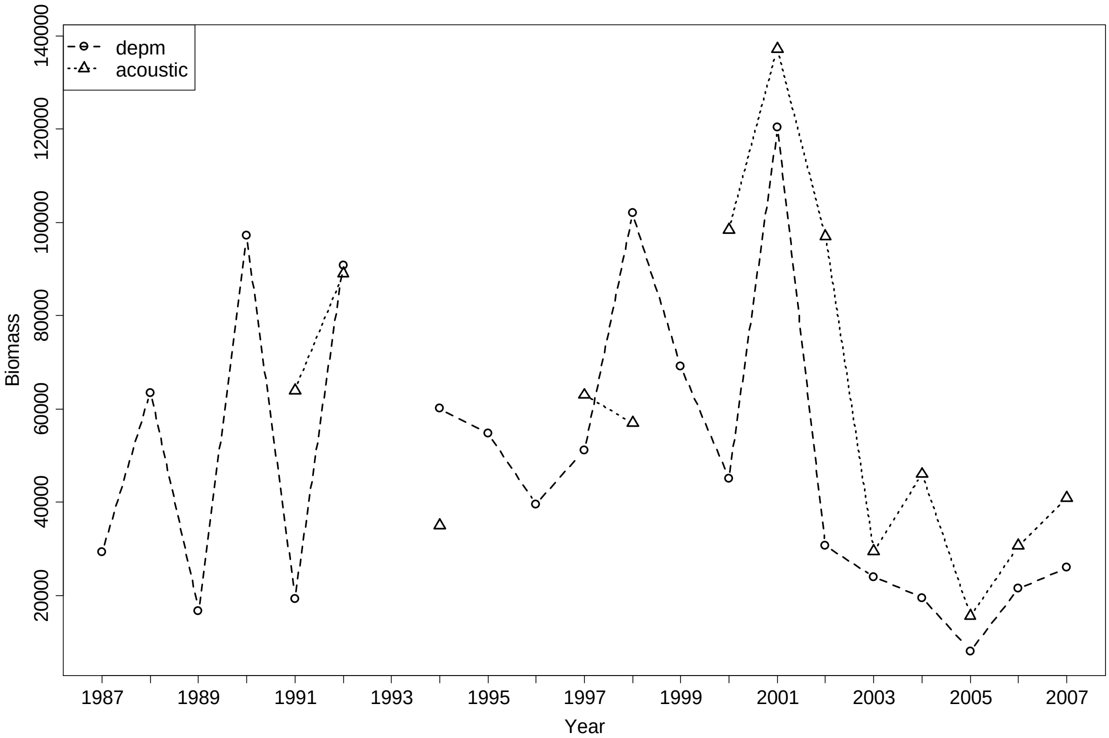


Figure 10.7.1.1: Bay of Biscay anchovy: Historical series of spawning stock biomass estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

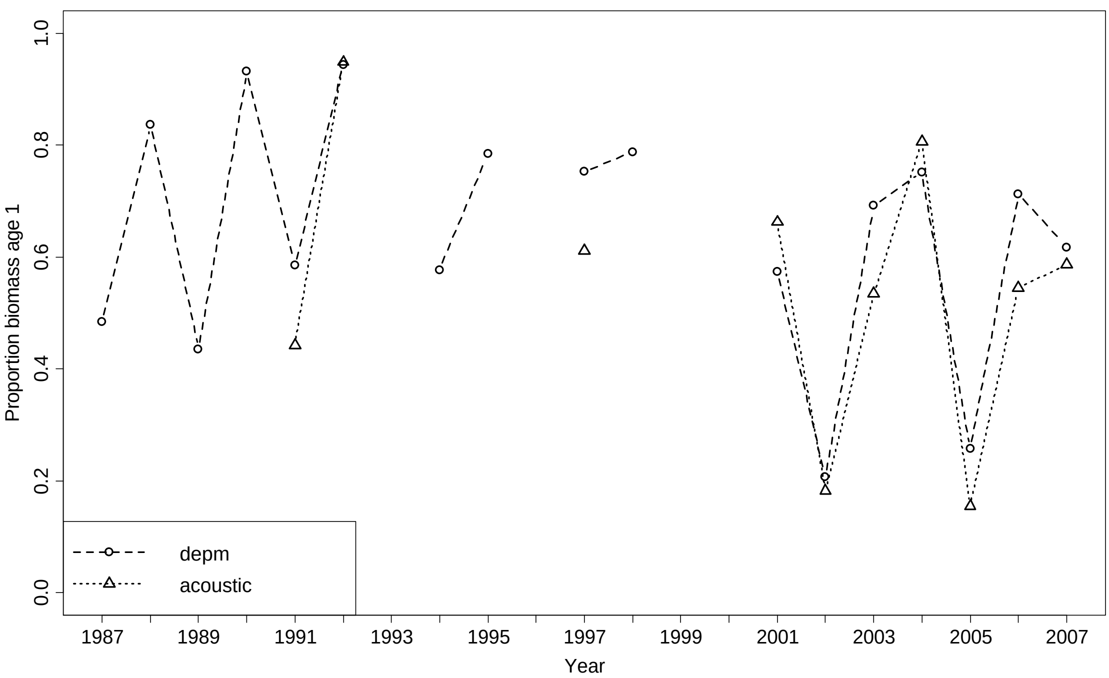


Figure 10.7.1.2: Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

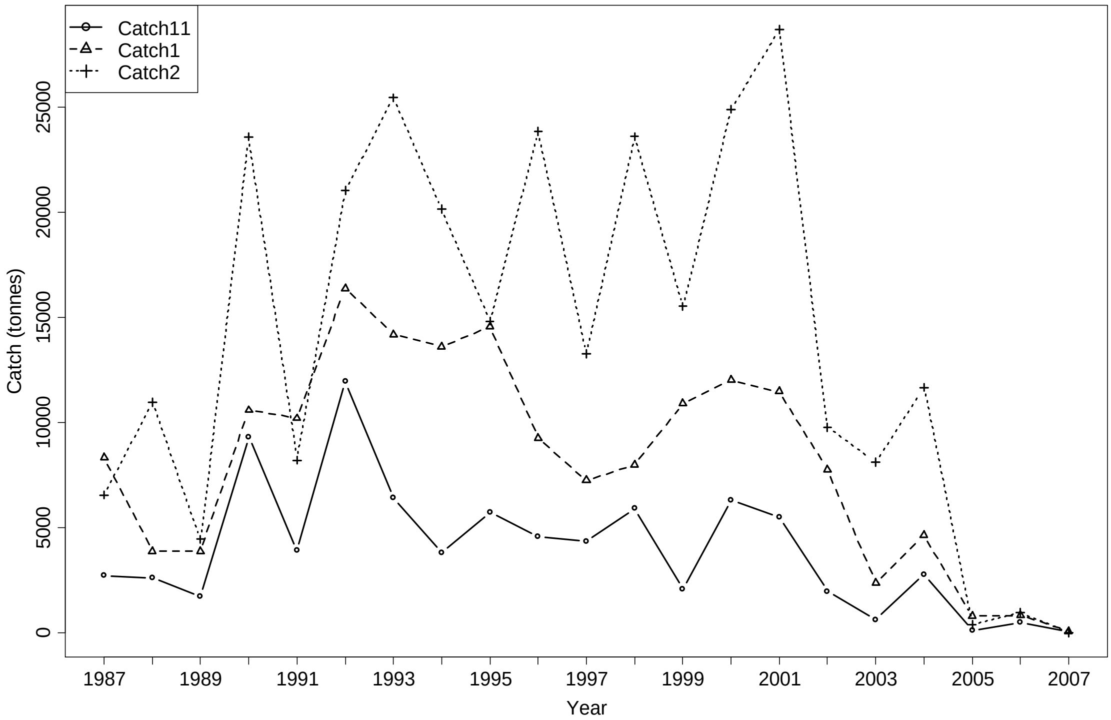


Figure 10.7.1.3: Bay of Biscay anchovy: Historical series of age 1 and total catch in the first period (1st January-15th May) (solid line and open circle and dashed line and triangle respectively) and of total catch in the second period (15th May-31st December) (dotted line and cross).

Figure 10.7.2.1: Bay of Biscay anchovy: Comparison of spawning stock biomass posterior median (solid lines) and corresponding 95 % credible intervals (dashed lines) for last year assessment (black) and the updated assessment (red).

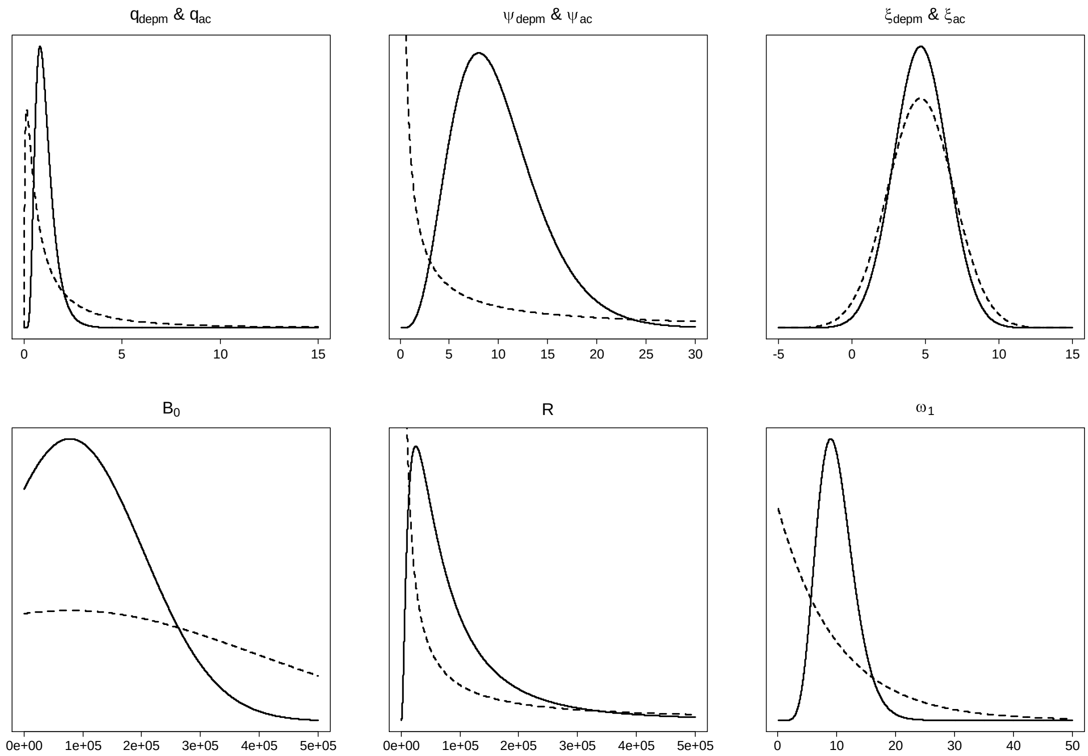


Figure 10.7.2.2: Bay of Biscay anchovy: First and second set of prior density functions, solid and dashed lines respectively, for the parameters of the Biomass Based Model (BBM).

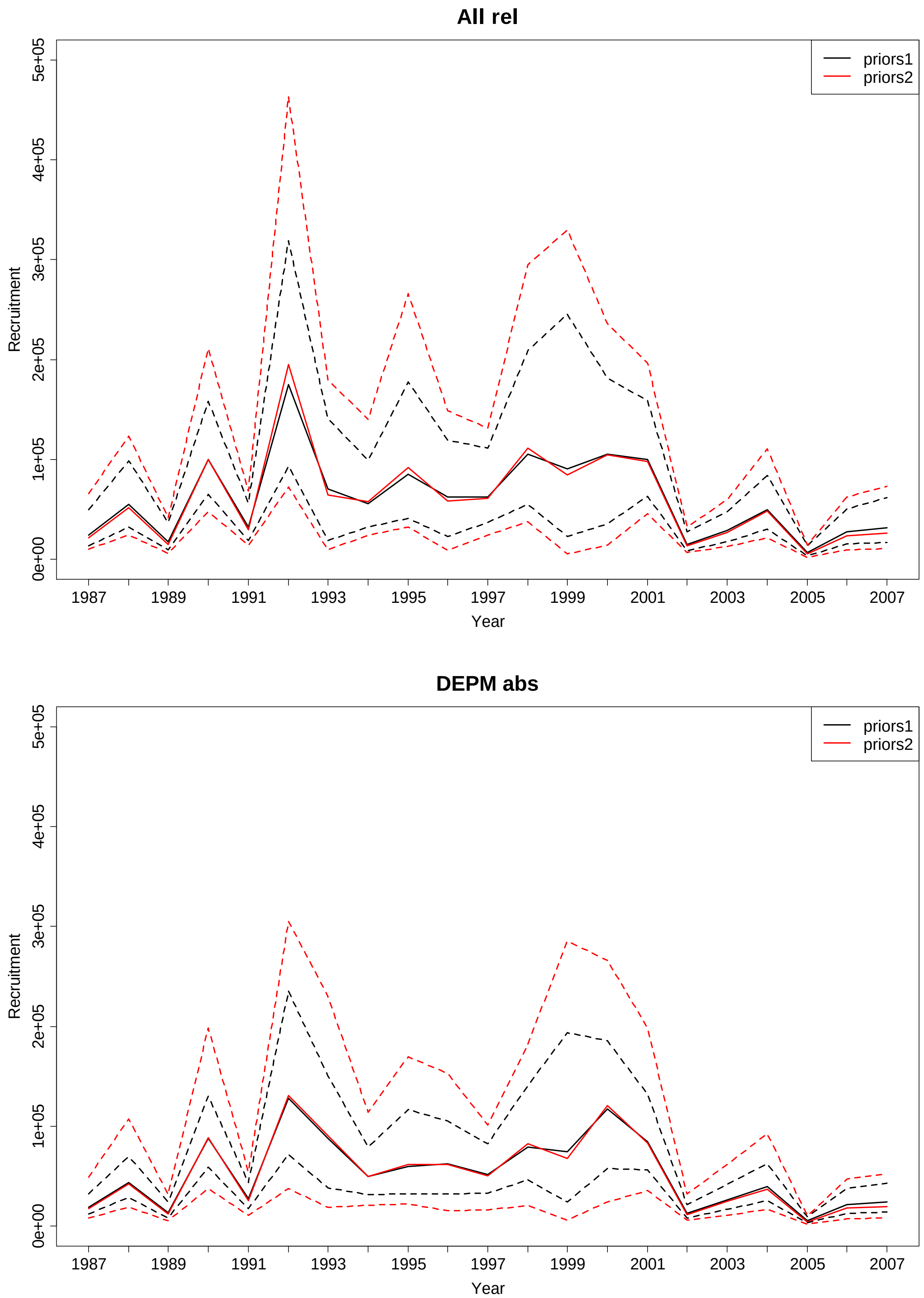


Figure 10.7.2.3: Bay of Biscay anchovy: Comparison of recruitment (in tonnes) posterior median (solid lines) and corresponding 95 % credible intervals (dashed lines) for the two set of priors when the DEPM is considered as relative (on the top panel) and as absolute (on the bottom panel).

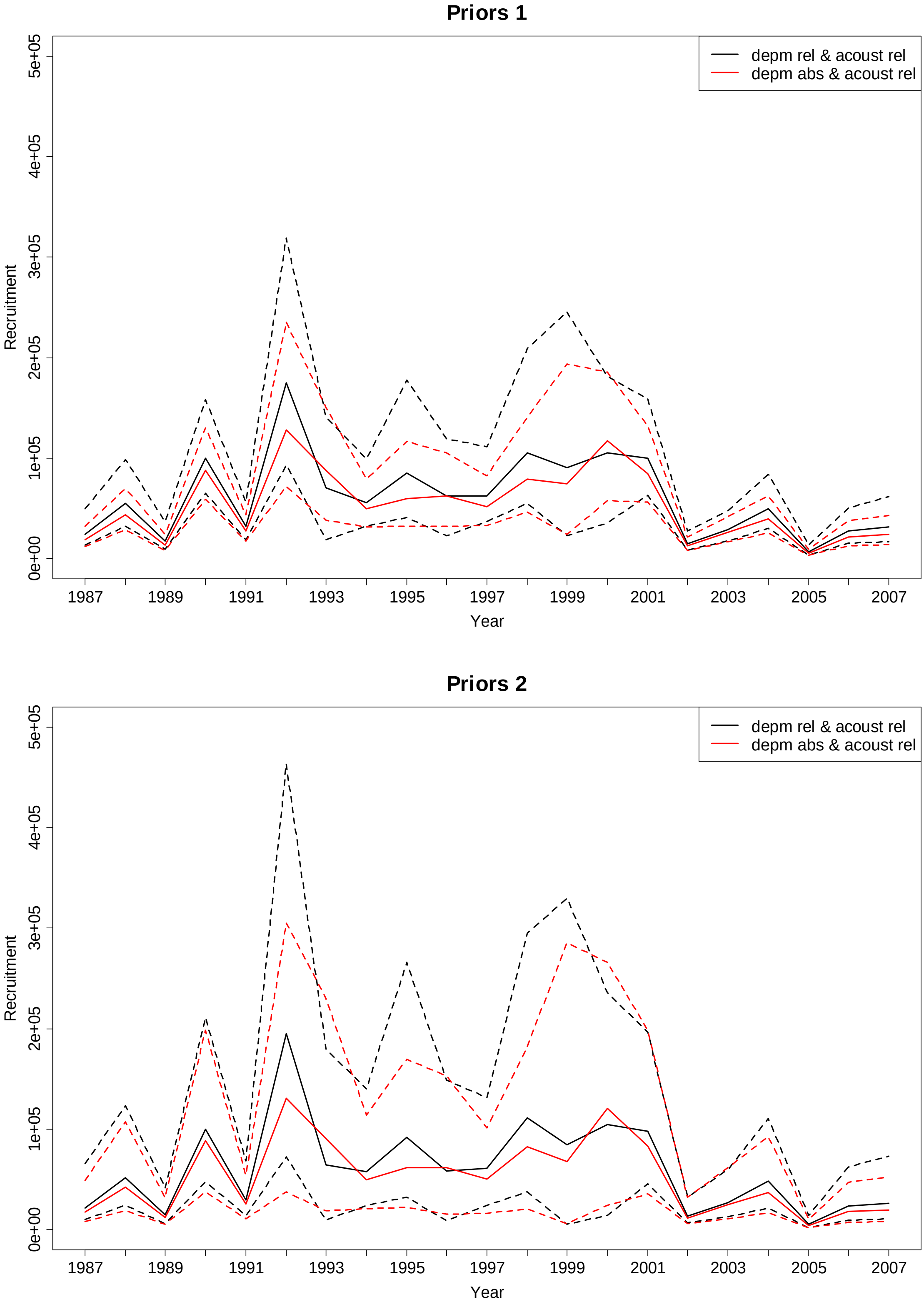


Figure 10.7.2.4: Bay of Biscay anchovy: Comparison of recruitment (in tonnes) posterior median (solid lines) and corresponding 95 % credible intervals (dashed lines) for different catchability assumptions of the DEPM surveys for the first (on the top) and the second set of priors (on the bottom).

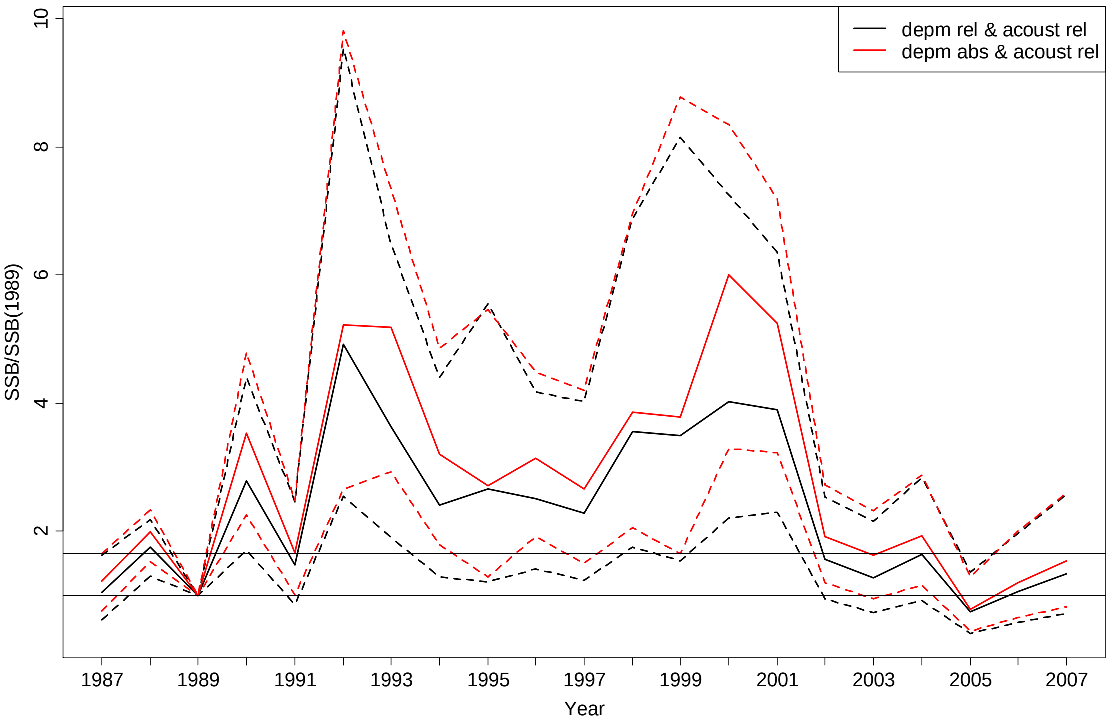


Figure 10.7.2.5: Bay of Biscay anchovy: Comparison of posterior median (solid lines) and corresponding 95 % credible intervals (dashed lines) of the ratio between SSB and SSB in 1989 (which is the one defining B_{lim}) for different catchability assumptions of the DEPM surveys with the first set of priors.

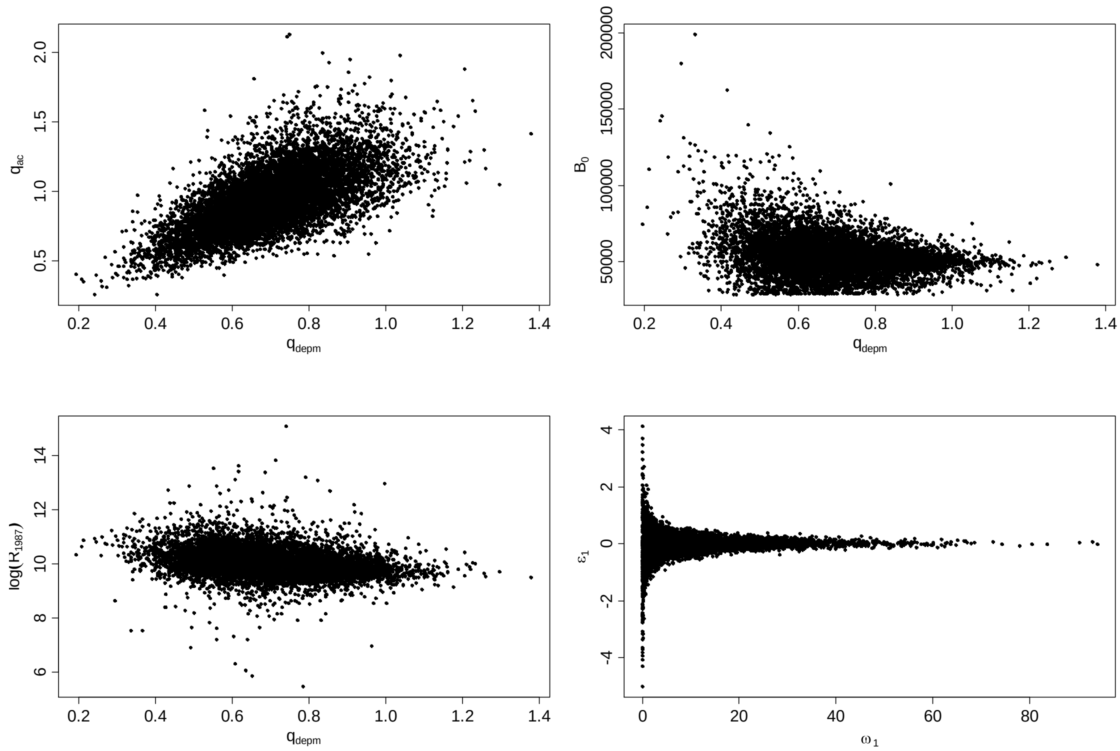


Figure 10.7.2.6: Bay of Biscay anchovy: Posterior correlation between some of the parameters in BBM for the second set of priors and when DEPM is taken as relative. From left to right and from top to bottom q_{ac} vs q_{depm}, B_0 vs q_{depm}, $\log(R_{1987})$ vs q_{depm} and $\varepsilon_1(0_{(1987)},h_{1(1987)})$ vs ω_1.

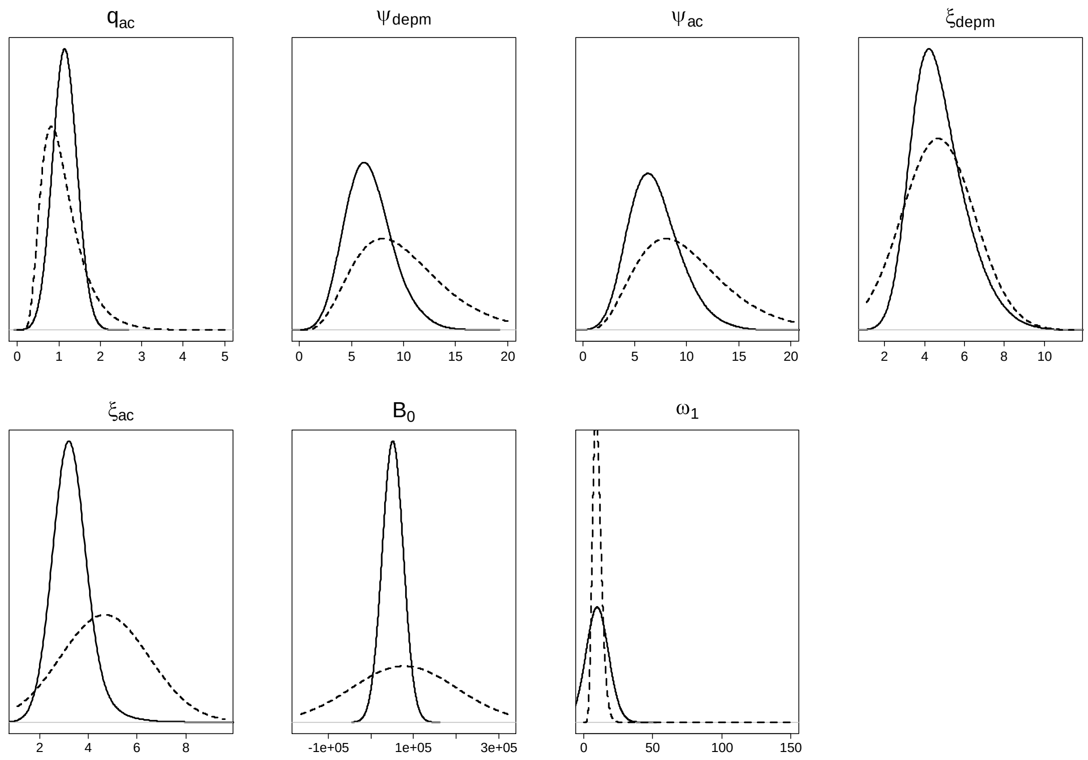


Figure 10.8.1.1: Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for some of the parameters of BBM when the DEPM is taken as absolute and the first set of priors is used.

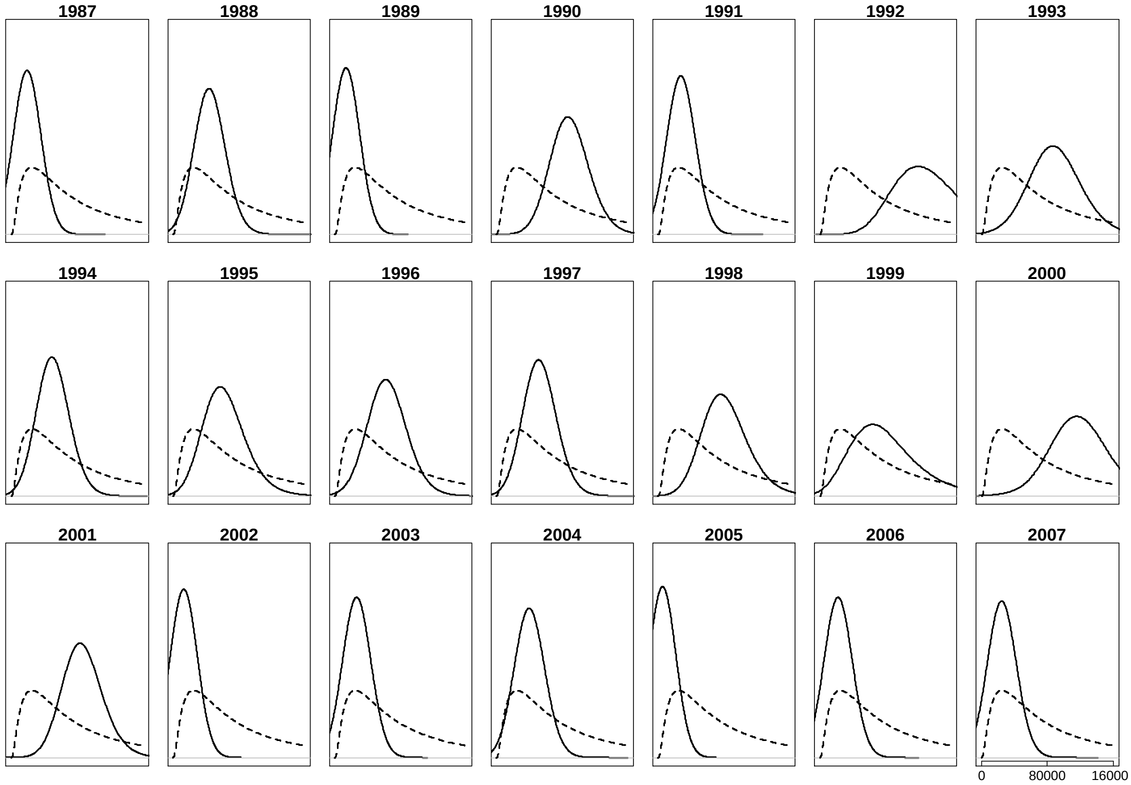


Figure 10.8.1.2: Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for each of the recruitments in the historical series from BBM when the DEPM is taken as absolute and the first set of priors is used.

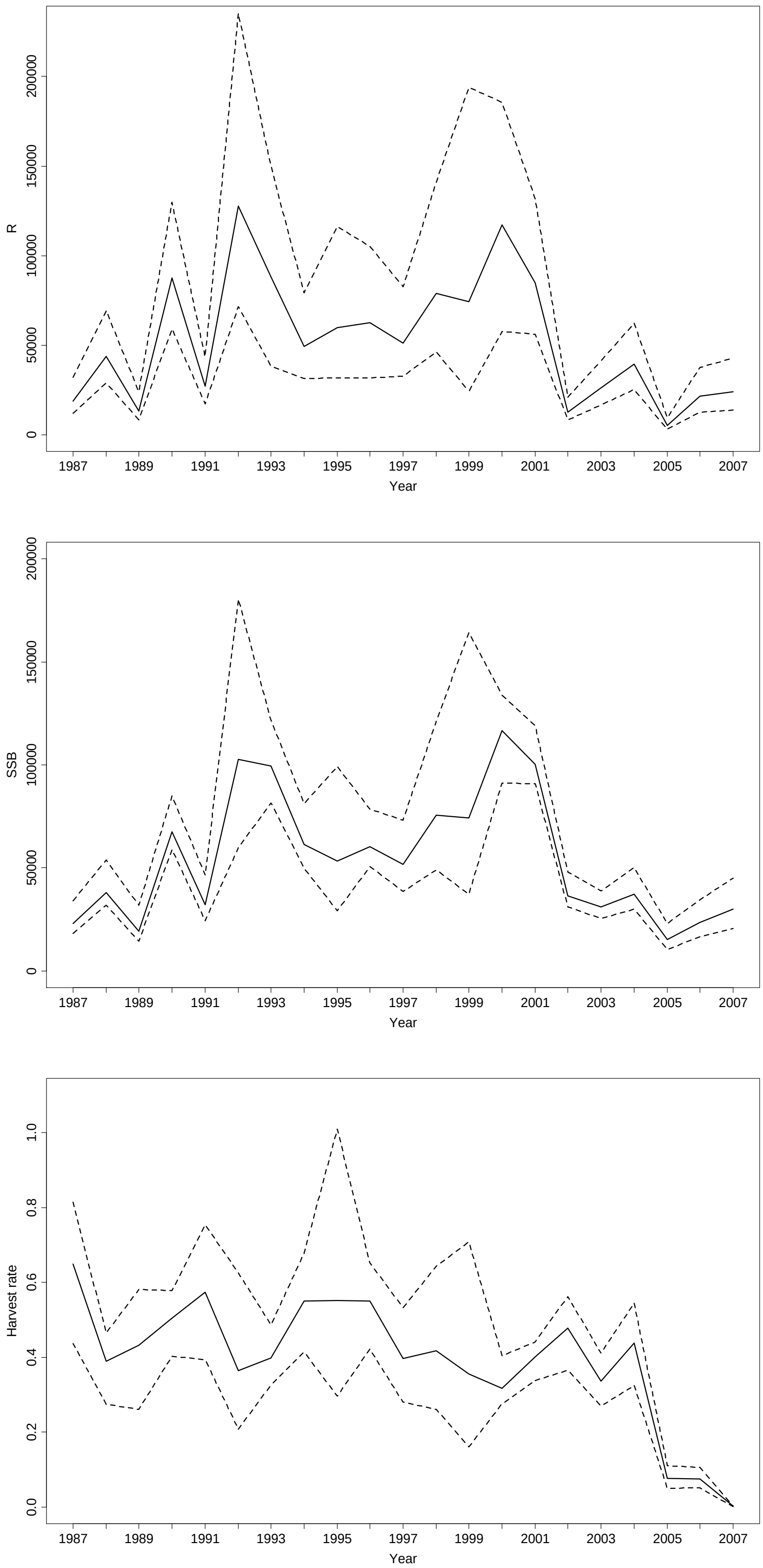


Figure 10.8.1.3: Bay of Biscay anchovy: Posterior median (solid line) and 95% credible intervals (dashed lines) for the recruitment series (in tones), the spawning stock biomass and the harvest rates (Catch/SSB) from the BBM.

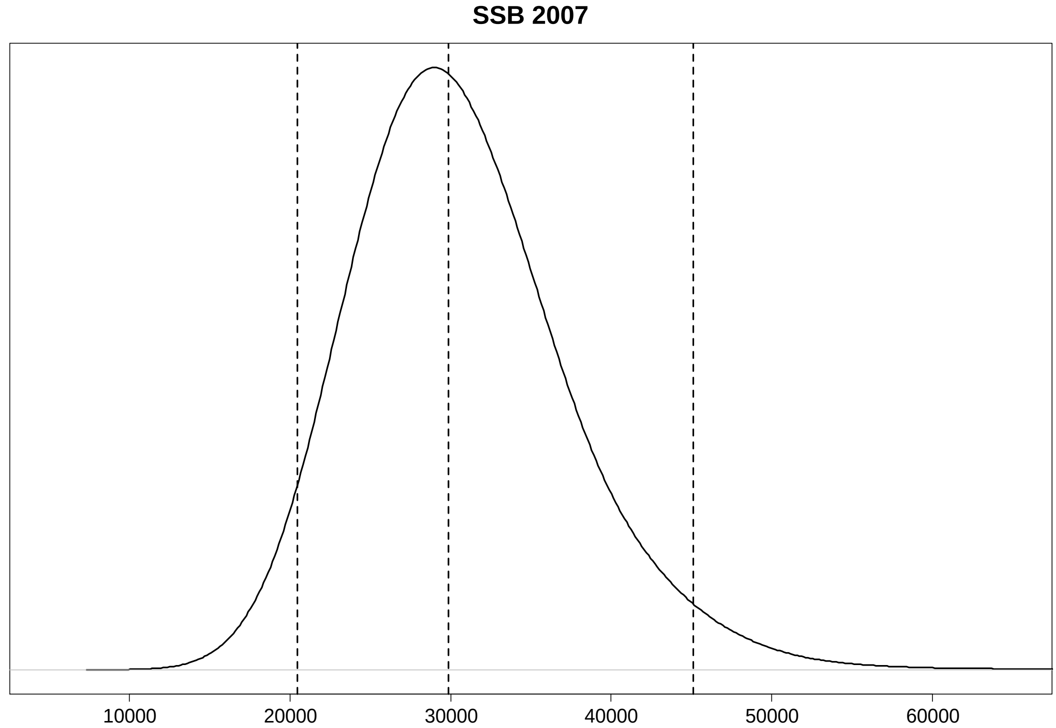


Figure 10.8.1.4: Bay of Biscay anchovy: Posterior distribution of spawning biomass in 2007 from BBM when the DEPM is taken as absolute and the first set of priors is used. Vertical dashed lines correspond to posterior median and 95% credibility intervals.

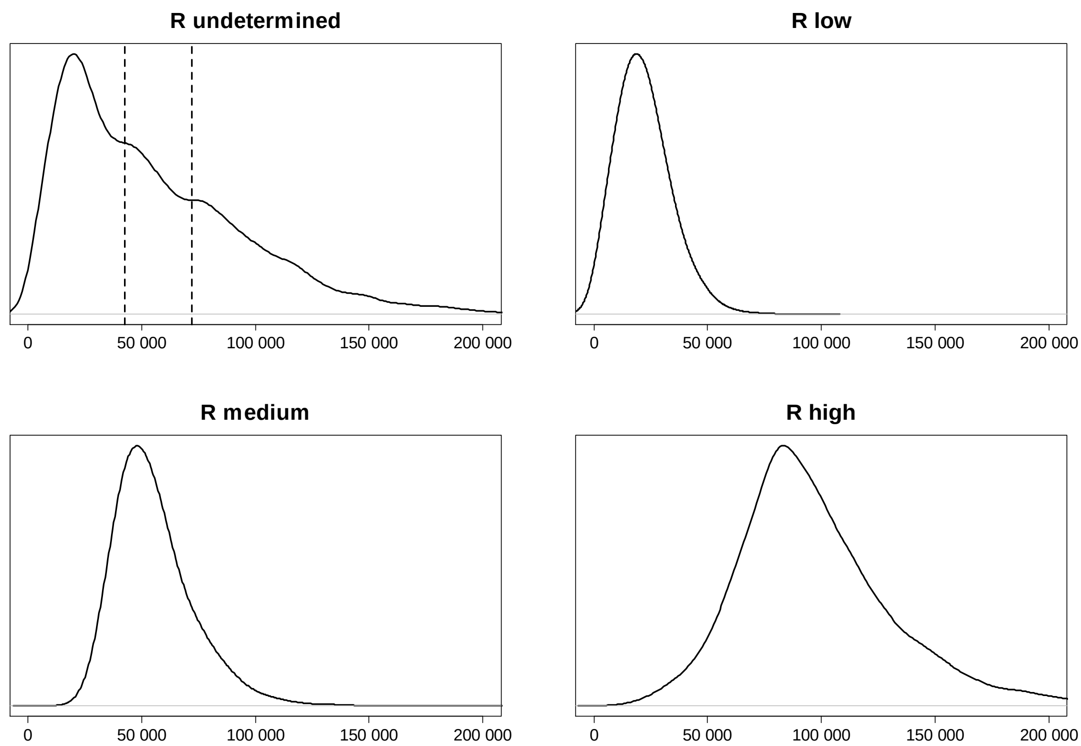


Figure 10.9.1: Bay of Biscay anchovy: Alternative recruitment scenarios for projecting the population one year ahead from 2007. From top to bottom and from left to right the predictive distribution of recruitment (in tones) in January 2008 for undetermined, low, medium and high scenarios.

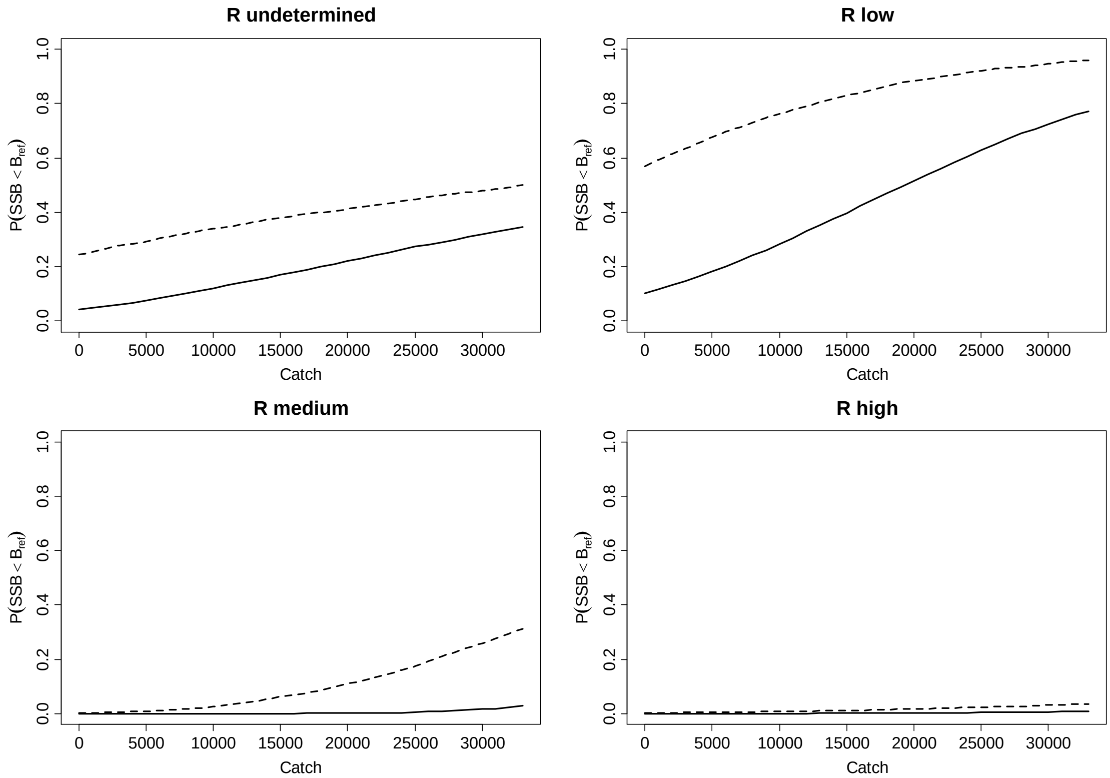


Figure 10.9.2: Bay of Biscay anchovy: Probability of SSB in 2008 being below B_{lim} (solid line) and B_{pa} (dashed line) according to different catch options for the first half of 2008, assuming that no catch is taken in the second half of 2007. From top to bottom and from left to right each of the panels correspond to a different recruitment scenario: undetermined, low, medium and high.

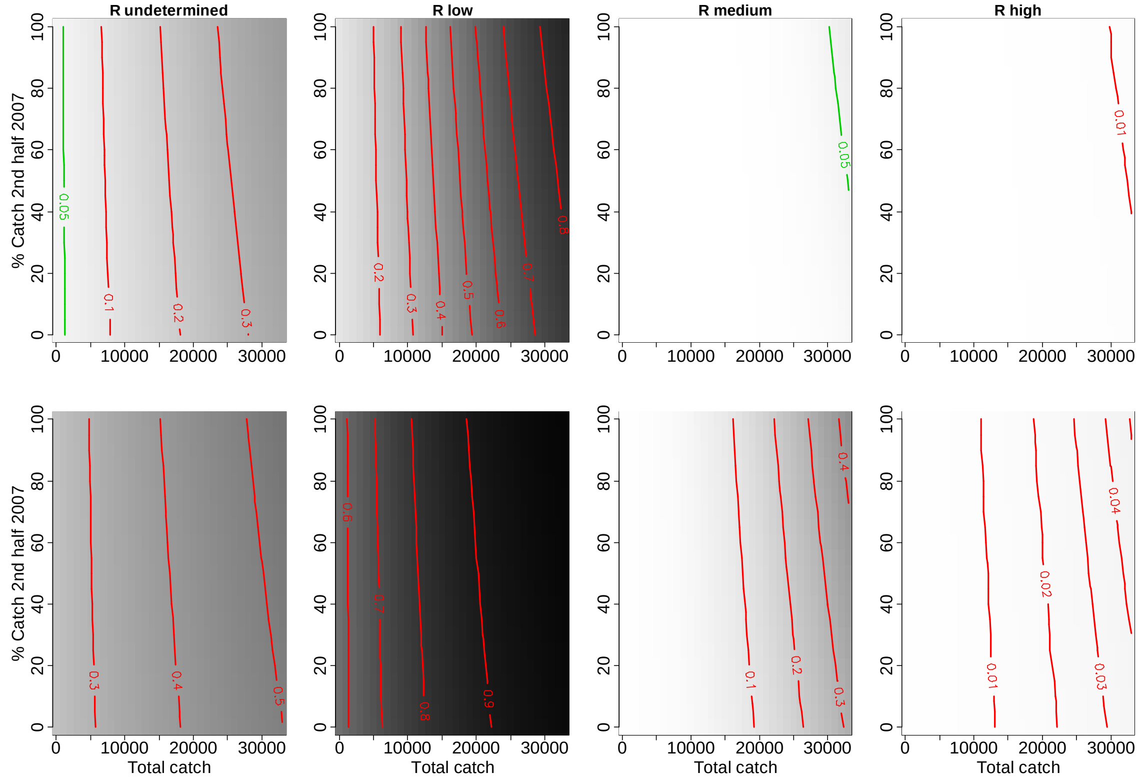


Figure 10.9.3: Bay of Biscay anchovy: Contour plots of the probability of SSB in 2008 being below B_{lim} (top row) and B_{pa} (bottom row) according to different total allowable catch between 1st July 2007 and 30 June 2008 in the x-axis and percentages of that total catch taken in the second half of 2007 in the y-axis. From left to right each of the columns correspond to a different recruitment scenario: undetermined, low, medium and high. Green contour line in the top row represents the 0.05 isolines for the probability of SSB being below B_{lim}.

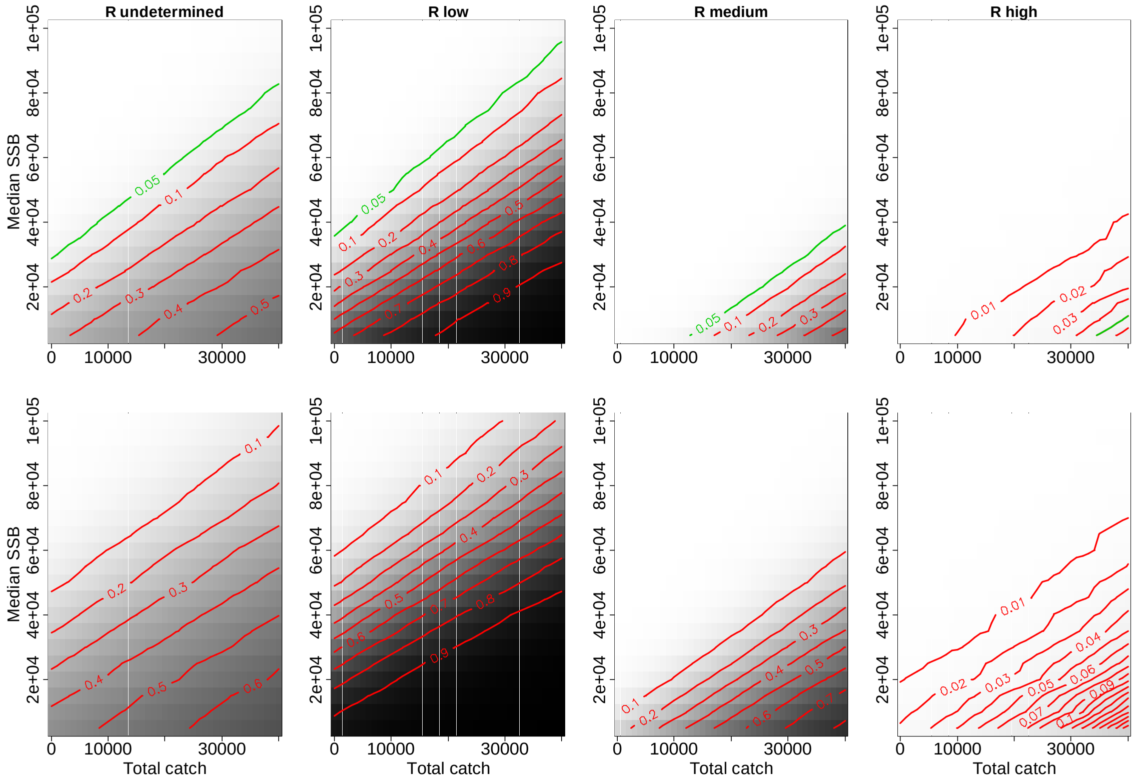


Figure 10.10.1: Bay of Biscay anchovy: Contour plots of the probability of SSB at the end of the forecasted year of being below B_{lim} (top row) and of B_{pa} (bottom row) according to different total allowable catch between 1st July of the initial year and 30 June of the following year (the x-axis) and to the median of the initial SSB distribution (y-axis). From left to right each of the columns correspond to a different recruitment scenario: undetermined, low, medium and high. Green contour line in the top row represents the 0.05 isolines for the probability of SSB being below B_{lim}.

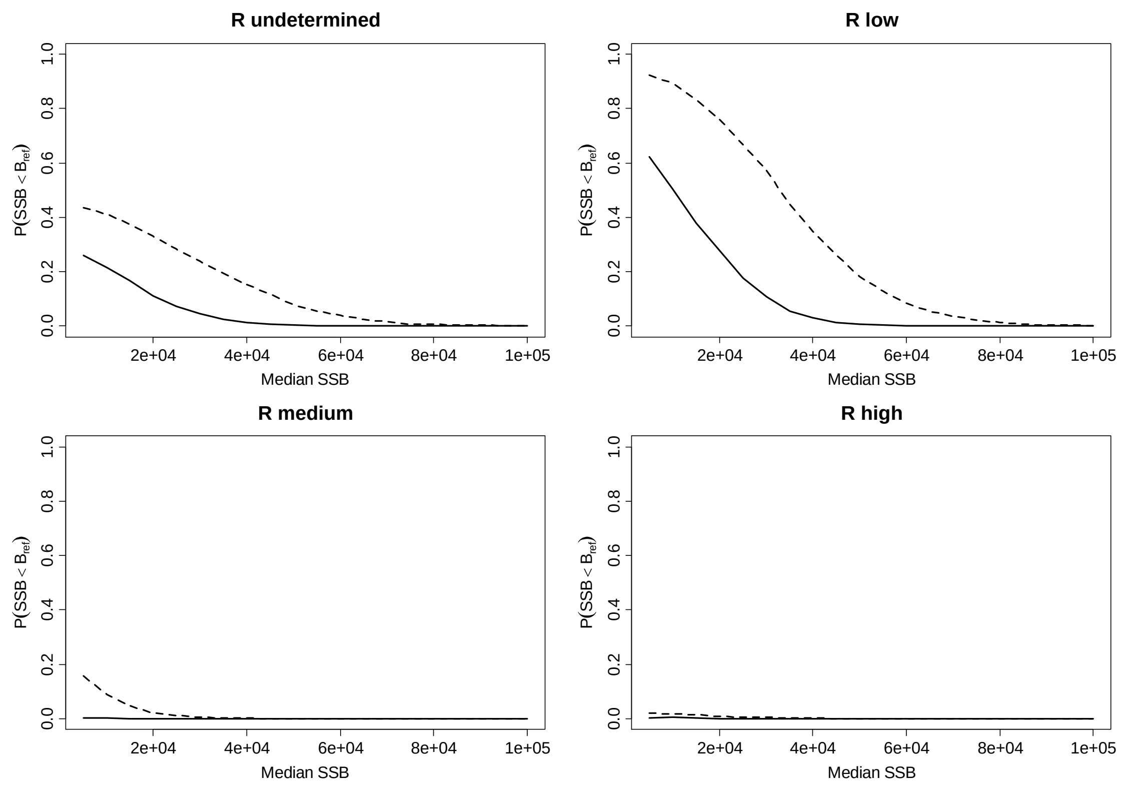


Figure 10.10.2: Bay of Biscay anchovy: Probability of SSB being below B_{lim} (solid line) and B_{pa} (dashed line) according to different medians in the initial SSB distribution (at mid May) , assuming that no catch is taken between the following 1st June and 15th May. From top to bottom and from left to right each of the panels correspond to a different recruitment scenario: undetermined, low, medium and high.

11 Anchovy in Division IXa

11.1 ACFM Advice Applicable to 2006 and 2007

ICES advice from ACFM recommendations in December 2005 (ICES, 2005 a) firstly stated that, at present, the state of the anchovy stock in Division IXa is unknown because of the inadequacy of the available information to evaluate the spawning stock or fishing mortality relative to risk (precautionary limits). So far, these shortcomings are preventing the provision of explicit management objectives for this stock and the estimation of appropriate reference points.

Accordingly, ICES advice in relation to the exploitation boundaries of this stock stated that catches in 2006 should be restricted to 4,700 t (mean catches from the period 1988-2000, excluding 1995 and 1998, and that this catch level should be maintained until the response of the stock to the fishery is known.

Given the high natural mortality experienced by this stock, its high dependence upon recruitment (the fishery depends largely on the incoming year class, the abundance of which cannot be properly estimated before it has entered the fishery), and the large inter-annual fluctuations observed in the spawning stock, ICES is aware that the state of this resource can change quickly. Therefore an in-year monitoring and management, or alternative management measures should be considered. However, such measures should take into account the data limitation on the stock.

The agreed TAC for anchovy since 2002 (for Sub-areas IX and X and CECAF 34.1.1) was of 8,000 t. Anchovy catches in Division IXa in 2006 (4,491 t) were at the same level than in 2005 (4,515 t), but represented a 23% and 15 % decreases in relation to the levels recorded in 2004 (5,844 t) and 2003 (5,269 t), respectively, and about half of the most recent maxima (recorded in 2001, 9,098 t and 2002, 8,806 t). For 2007 this TAC has been agreed again in 8,000 t, with national catch quotas being established at 3,826 t for Spain and 4,174 t for Portugal.

11.2 The Fishery in 2006

11.2.1 Landings in Division IXa

Anchovy total landings in 2006 were 4,491 t, which represented a negligible decrease with regard to the 2005 landings (4,515 t). However, landings are quite low (around half) when compared with those recorded in 2001 (9,098 t) and 2002 (8,806 t), respectively (**Table 11.2.1.1**, **Figure 11.2.1.1**). The contribution by each sub-division to the total catch was not very different from last year.

As usual, the anchovy fishery in 2006 was almost exclusively harvested by purse seine fleets (99% of total catches). Portuguese and Spanish purse-seine landings accounted for 52% and almost the total of their respective national total catches (**Table 11.2.1.2**). However, unlike the Spanish Gulf of Cadiz fleet, the remaining purse-seine fleets in the Division only target anchovy when its abundance is high. The Portuguese artisanal anchovy fishery in 2006 lost part of the representativity in their national landings reached in previous years (only 24 t, 22%). Landings from this fishery as well as from the trawls (both Spanish and Portuguese) were still small in relation to the whole anchovy fishery in the Division.

11.2.2 Landings by Sub-division

The anchovy fishery was mainly located in 2006 in the Sub-division IXa South (4,381 t, *i.e.*, 98% of total catch in the whole Division, **Table 11.2.2.1**, **Figure 11.2.1.1**). As observed in recent years, the bulk (99%) of these catches was fished in the Spanish Gulf of Cadiz (4,368 t vs 14 t landed in the Algarve). The relative importance of landings in the remaining Sub-divisions was negligible.

The Spanish fishery in 2006 followed the same distribution pattern described for recent years, with almost all anchovy being fished in the Gulf of Cadiz waters (only 15 t in Sub-division IXa North, *i.e*., southern Galician waters). The Gulf of Cadiz purse-seine fishery was closed the last two months of 2006 as part of the management measures included within the "*Plan for the conservation and sustainable management of the purse-seine fishery in the Gulf of Cadiz National Fishing Ground*". This purse-seine fishery management plan was firstly implemented in 2004 on October 30th and since then the fishery closures (that lasted 45 days in 2004 and 2005) are accompanied by a subsidized tie-up scheme for the purse-seine fleet. A more detailed description of this plan is given in **Section 11.10**. The effects of these closures on the purse-seine quarterly landings in 2004-2006 as compared with preceding years are shown in **Figure 11.2.2.1**. The years included in this figure are those when the whole purse-seine fleet has been exerting its greatest fishing capacity. As evidenced by the recent trend in autumn landings, the 2004 closed season did not seem to affect seriously the catch levels both in that season and in the total annual landings. In fact, the relative importance of autumn landings in 2004 was even greater (12%) than in preceding years (10% in 2002, 9% in 2003). This was not the case in the last two years, since their respective fourth quarters' landings were the lowest in the recent analysed series both in absolute and relative terms. Impacts of this management measure in the fishing effort will be discussed in **Section 11.5**.

A first attempt of identifying *métiers* in the Gulf of Cadiz purse-seine Spanish fishery has been presented to the Working Group (WD Silva *et al*., 2007). The study is part of the research work carried out by IEO, AZTI and IPIMAR within the *IBERMIX* project (*Identification and segmentation of mixed-species fisheries operating in the Atlantic Iberian Peninsula waters* (DG FISH/2004/03-33)). This study focuses on the application of a non-hierarchical clustering data-mining technique (*CLARA*, *C*lustering *LAR*ge *A*pplications) for classifying the fishing trips of the Spanish purse-seine fleet operating in the ICES Sub-division IXa South from 2003 to 2005 (26,225 fishing trips). The classification of individual trips was only based on the species composition of landings from logbooks, hence the preliminary character of this study as considered by the Working Group. Up to four clusters (catch profiles) were identified from each of the annual datasets according to the targeted species: 1) trips targeting anchovy, 2) trips targeting sardine; 3) trips targeting a mackerel species mixture; and 4) trips targeting an anchovy and sardine mixture. The first three groupings were considered by the authors as clearly identifiable *métiers* according to their knowledge on the fishery. A direct benefit from this study is the possibility of objectively defining cost-effective sampling strata (fisheries or *métiers*) in order to improve the national market sampling protocols within the DCR framework under the fishery/fleet-based approach. Notwithstanding the above, the Working Group encourages the application of a more sound analysis of fleet segmentation by taking into account additional information on technical characteristics of sampled vessels, home and landing ports, and location of catches, if available, in order to identify more properly the different components of the Gulf of Cadiz purse-seine fishery.

As described in previous reports, the Portuguese anchovy fishery in 2004 showed a shift in its usual distribution pattern exhibited since 1998. So, although from this year up to 2003 the fishery was concentrated in the IXa Central-North and IXa South, it seemed to experience a southward displacement in 2004, with relatively scanty catches in IXa Central-North to somewhat higher levels in their southernmost national fishing grounds. In 2005 and partially in 2006 (since landings came mostly from the Central-North area), the fishery exhibited again the usual aforementioned pattern for the 1998-2003 period. Historically, each of these three Sub-divisions has shown alternate periods of relatively high and low landings, anchovy fishery being located either in the IXa South (before 1984) or in the IXa Central-North (after 1984), (see **Table 11.2.1.1** and Pestana, 1996). In Portugal, a closure of the purse-seine fishery has been agreed by the producers organisations in the northern Portuguese coast (north of the 39º42" north, i.e. sub-division IXa Central-North) since 2003. This closure lasts for 2 months, although in 2006 it may be selected between 1st of February and 30th of April (*i.e.* boats stopped fishing in February to March or in March to April). Effects of these closures in the anchovy landings in the IXa Central-North area have not been analysed although they should be low since no targeted fishery to anchovy is developed there.

Seasonal distribution of catches by country and Sub-division in 2006 is shown in **Table 11.2.2.1**. Last year, although with a different intensity, anchovy catches were recorded throughout the year in all Sub-divisions. The scanty catches from the northernmost Spanish Sub-division (South Galicia) were mainly landed in the fourth quarter, those from Portuguese waters of the IXa Central-North during the first quarter, whereas catches from the Central-South and South areas were mostly allocated between the first and fourth quarters. Anchovy fishery season in the Spanish part of the IXa South (Gulf of Cadiz) occurred throughout the first half of the year, mainly in the spring months.

11.2.3 Discards

The Spanish National Sampling Scheme, adopted by the European Regulation (EC) Nº 1639/2001 of July 2001, is the Minimum Program of the European Commission. According to Appendix XII of this Regulation (modified in Nº 1581/2004), anchovy is included in the species list to be considered within the Division IXa (especifically in the Gulf of Cadiz) for discards. Moreover, discards' length distribution must be estimated if discards represent more than 10% of the total catch in weight or more than 20% of the catches in number, both on a yearly basis. Age-structured estimates must be computed only when discards occur for length ranges that are not represented in the landings.

No information on anchovy discarding in the Division IXa has been available until 2005. That year several pilot surveys for estimating discards in the Gulf of Cadiz Spanish fisheries (trawl, purse-seine and artisanal) were conducted by an IEO observer's programme onboard commercial vessels lasting five months and covering the whole study area. Preliminary results (average estimates from 6 purse-seine trips – 13 hauls –, not raised to total annual landings) from these pilot surveys were described in last year's WG report although there were concerns about the reliability of such estimates and the ratios derived from them due to their extremely high associated CVs. On the other hand, discarded anchovies were of commercial and legal size, between 10 and 15 cm (mode at 12.5 cm), but reasons for discarding anchovy were not reported to this WG. Anchovy catches in sampled trips from the bottom otter-trawl fleet were negligible.

There is no information about the continuity of this sampling programme in the future.

11.2.4 Fleet composition

Details on the purse-seine vessels operated by Spain in the Gulf of Cadiz, differentiated between total operative fleet and fleet targeting anchovy, are given in **Table 11.2.4.1** and **Figure 11.2.4.1**. The evolution of the number of vessels by fleet type exploiting this fishery through the historical series is now available for the period 1999-2006. During this period the number of purse-seine vessels has oscillated between 145 (in 2004) and 104 (in 2000) vessels, and the vessels within this fleet targeting anchovy between 90 (2001) and 135 (2004) vessels. As it will be described in detail in **Section 11.5**, the observed fluctuations during this period are mainly motivated by the ending of the fifth EU-Morocco Fishery Agreement (in 1999, which affected the heavy-tonnage fleet in the following two years), the rising of the light-tonnage purse seiners on those dates, and the fluctuations showed by the multipurpose vessels. In 2006, the entire Spanish purse-seine fleet fishing in the Gulf of Cadiz was composed by

113 vessels, with 96 vessels dedicated in a greater or lesser extent to the anchovy fishing. These vessels fishing for anchovy account for more than 85% of the whole fleet during the available series, evidencing the importance of anchovy as a target species in the Gulf of Cadiz purse-seine fishery (**Figure 11.2.4.1**).

11.3 Fishery-Independent Information

11.3.1 Acoustic Surveys

A summary list of the available acoustic surveys providing estimates for anchovy in IXa is given in the text table below.

SURVEYS	YEAR/ QUARTER	1993	....	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Portuguese Surveys	Q1				Mar		Mar	Mar	Feb				
	Q2									Jun	Apr	Apr	Apr
	Q3												
	Q4			Nov		Nov	Nov		Nov		Nov	Nov	
Spanish Surveys	Q1							Feb					
	Q2	Jun								Jun		Jun	Jul
	Q3												
	Q4												

The Portuguese surveys series (*SAR* series) correspond to those routinely performed for the acoustic estimation of the sardine abundance in Division IXa off the Portuguese continental shelf and Gulf of Cadiz, during March-April (sardine late spawning season) and November (early spawning and recruitment season). Anchovy estimates from these surveys started to be available since November 1998.

Spanish acoustic surveys in the Division have been sporadically conducted from 1993 to 2003 in Gulf of Cadiz waters. A consistent yearly series of late-spring acoustic surveys (*ECOCÁDIZ* series) estimating the anchovy abundance in the Subdivision IXa South (Algarve and Gulf of Cadiz) started in 2004. However, this new series may show, as happened in 2005, some gaps in those years coinciding (same dates and surveyed area) with the conduction of the (initially triennial) anchovy DEPM survey because of the available ship time. As for the text table, acoustic estimates from surveys on a black background are those ones used as tuning series in the exploratory assessment of anchovy in Sub-division IXa South (Algarve and Gulf of Cadiz, see **Section 11.7**). Surveys on a white background were carried out but did not provide any anchovy acoustic estimate because of its very low presence and/or for an incomplete geographical coverage (some areas were not covered). Surveys in light grey only covered the Spanish waters of the Gulf of Cadiz and the one in dark grey the whole Sub-division IXa South. Results from the acoustic surveys in the first half of 2006 were presented and discussed in last year's report (ICES, 2006 b). A Portuguese acoustic survey was conducted in November 2006 but did not provide any anchovy acoustic estimate. A summarised description of the results from the surveys conducted in the first half of 2007 is given below.

Portuguese Surveys

Two Portuguese acoustic surveys have been carried out during the intersession time: one survey in November 2006 (*SAR06NOV*) and the other one in April 2007 (*PELAGOS07*). Both surveys were carried out with the R/V 'Noruega' and followed the standard methodology adopted by the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX (ICES 1986, 1998). The surveyed area usually includes the waters of the Portuguese continental shelf and those of the Spanish Gulf of Cadiz (Sub-divisions IXa Central-North, Central-South, and South), between 20 and 200 m depth.

Unfortunately, due to problems with the pelagic net during the November 2006 survey, fewer trawls than planned were performed in the Cádiz area, and no anchovy acoustic estimate from this survey has been provided to the Working Group.

The April 2007 survey (*PELAGOS07*) took place from the 11th of April to the 8th of May. A total of 48 fishing stations were carried out. The anchovy total estimated biomass was 40 thousand tonnes (3,247 million fish), which represents a 54% increase in relation to the average value for the entire time series (24.9 thousand tonnes), and it was almost entirely located in the Sub-division IXa south (96.8% and 95.1% of the total estimated abundance and biomass in the whole Division). As in previous years, the area with the highest anchovy abundance and biomass was the Spanish waters off the Gulf of Cadiz (33.4 thousand tonnes, 2,860 million fish), accounting for 88 and 84% of the total estimated abundance and biomass (**Table 11.3.1.1**, **Figures 11.3.1.1** and **11.3.1.2**). The Portuguese coast presented an anchovy distribution pattern similar to the one described in previous years, with a low occurrence in front of Lisbon (between Cascais and Cabo Raso, 1.9 thousand tonnes and 103 million fish), and a somewhat denser concentrations in theAlgarve (between Faro and the Guadiana river mouth, 4.6 thousand tonnes, 284 million fish).

The anchovy length composition showed a spatial gradient, with the modes of the size distributions increasing from the Spanish waters of the Gulf of Cadiz (12 cm), through Algarve (13 cm), to the Cascais area (14 cm), (**Figure 11.3.1.2**).

A detailed description of the oceanographic conditions during this survey is given in **Section 8.3.2.1**.

Spanish Surveys

Spanish acoustic surveys aimed at sardine have been conducted in Sub-division IXa North and Division VIIIc since 1983. Results from these surveys for the Sub-division IXa North have shown the scarce presence or even the absence of anchovy in this area (Carrera *et al*., 1999; Carrera, 1999, 2001). This situation still continues in the most recent years (surveys in the 2003-2007 period, see Porteiro *et al*., 2005; WD Iglesias *et al*., 2007).

The most recent time series of Spanish spring acoustic surveys in the Gulf of Cadiz only comprises data from 2004 (*BOCADEVA 0604* acoustic-anchovy DEPM pilot survey) onwards (*ECOCÁDIZ 0606* and *0707* surveys), with one gap in 2005 (conduction of the anchovy full-scale DEPM survey, see **Section 11.3.2**). Surveys are carried out onboard R/V *Cornide de Saavedra*. The 2004 survey was mainly targeted at anchovy (with the aim of acoustically estimating the anchovy SSB), although other pelagic species of commercial interest such as sardine, mackerel and chub mackerel (*Scomber colias*), and horse mackerel were also assessed. Surveys within the *ECOCÁDIZ* series, but mainly *ECOCÁDIZ 0707*, have obtained for the first time abundance and biomass estimates for all the main pelagic species found in the area not just those of economic value (*i.e*, multi-species/ecosystem approach).

ECOCÁDIZ 0707 was carried out in the Subdivision IXa south between 3rd and 12th July 2007, (WD Ramos *et al*., 2007). Survey design consisted, as usual, of a systematic grid, normal to the coastline, with transects evenly distributed each 8 nm. The area of the continental shelf covered since 2006 extends from 20 to 200 m depth, from Cape San Vicente to Cape Trafalgar. As a difference from previous surveys, acoustic energy has been measured in this survey using an EK-60 scientific echosounder (Simrad) working at five frequencies (12, 38, 70, 120 and 200 KHz). Frequencies were calibrated prior to the survey using recommended methods (Foote *et al*., 1987). The elementary distance sampling unit (EDSU) was fixed at 1 nm. Acoustic data were obtained only during daytime at a survey speed of 10 knots. Data were stored in raw format and post-processed using SonarData Echoview software. The integration values are expressed as nautical area scattering coefficient (NASC) units or S_A values (m2 x nm -2) (MacLennan *et al*., 2002). Fish abundance was calculated with the 38 kHz frequency, as recommended at the PGAAM (ICES, 2002). Nevertheless, echograms from 120 kHz were used to visually discriminate between fish and other scatter-producing objects such as plankton or bubbles, and to distinguish different fish according to the strength of their echo. The threshold used to scrutinize the echograms was –60 dB. Backscattered energy (S_A) was allocated to fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975). For this purpose, the following TS-length (b20) values were used: sardine and anchovy, -72.6 dB (in previous surveys was used –71.2 dB for anchovy, as IPIMAR); horse mackerels (*Trachurus trachurus*, *T. picturatus* and *T. mediterraneus*), –68.7 dB; bogue (*Boops boops*), –67 dB; chub mackerel (*Scomber colias*), -68.7; mackerel (*Scomber scombrus*), –84.9 dB and blue whiting (*Micromesistius poutassou*), -67.5 dB. A total of 31 fishing stations were carried out (**Figure 11.3.1.3**). A more detailed description of material and methods are given in WD Ramos *et al*. (2007).

Although it occurred almost all over the shelf of the sampled area, anchovy was mainly distributed in the Spanish waters off the Gulf of Cadiz (23-160 m depth), with the highest densities occurring in the central part of the sampled area, mainly between 40 and 115 m depth. Two additional nuclei of high density were recorded in front the Bay of Cadiz between 30 and 100 m depth, and in front of the Coto de Doñana coast between 40 and 80 m depth. In the Portuguese waters the species was widely distributed (20-220 m) but in low densities, except in the area comprised between Albufeira and Cabo Santa María between 70 and 170 m depth, where, surprisingly, the highest S_A values attributed to the species in the survey were recorded (**Figure 11.3.1.4**).

Anchovy total biomass in the Sub-division was estimated at 12.6 thousand tonnes (805 million fish), values quite low when compared to the 38.0 thousand tonnes estimated shortly before in the Portuguese survey. The Spanish Gulf of Cadiz contributed with the 67% (8.5 thousand tonnes) of the total biomass and 75% of the total abundance (606 million fish), (**Table 11.3.1.2**).

As usual, size- and age-based estimates suggest a westward increasing size (-age) gradient, with the largest (and oldest) anchovies being more abundant in the westernmost limit of the sampled area, and a recruitment area located in shallow waters close to the Guadalquivir river (**Table 11.3.1.3**, **Figures 11.3.1.5** and **11.3.1.6**).

Some comments on recent trends in acoustic estimates from Subdivision IXa South

For comparative purposes, **Figure 11.3.1.7** shows the updated series of anchovy acoustic estimates from Subdivision IXa South available from the Portuguese surveys together with the estimates from the 2004 and 2006-2007 late-spring Spanish surveys. The depicted data series shows several gaps which make difficult to follow any clear trend, mainly in the last years. As stated in previous years WG reports, the picture of an alarming decreasing trend just in 2004-2005 should initially be considered with caution for causes either related to the undersampling of coastal waters (2004 Spanish survey), problems in echo-traces discrimination because of the mixing of target species with plankton (2005 Portuguese survey), or the differences found in the population structure (and an additional mortality) between March-April and June-July surveys makes difficult the comparison between surveys. Notwithstanding the above, the April 2005 estimates, which are more susceptible of being compared with the remaining ‘March’ data points, seem to reflect (although bearing in mind the problems in the echo-traces discrimination) a worrying decreasing trend in the recent population levels. Such a perception changes when the 2006 and the Portuguese 2007 estimates are taken into consideration since they are indicating some recovery of the population levels. **The Working Group is concerned due to the conflicting trends showed by the Portuguese and Spanish surveys**

and recommends that problems on the choice of the TS values set and survey design (i.e., undersampling of shallower waters than 20 m depth) in the Gulf of Cadiz area are analysed in the next WGACEGG in order to achieve a proper survey standardisation and reliable estimates for the whole population.

11.3.2 Egg Surveys

Spanish Surveys

Results from a pilot DEPM survey for anchovy in Subdivision IXa South performed during June 2004 (coupled to an acoustic survey, see previous Section) were reported both to the 2004 SGSBSA and WGMHSA (Anon., 2005; ICES, 2004; Jiménez *et al*., 2004, Millán *et al*., 2004). A full-scale DEPM survey for anchovy in the same surveyed area was then carried out in June 2005 (*BOCADEVA* 0605) taking into consideration the Study Group recommendations on the increase of sampling coverage. The agreed egg and adult sampling strategies were identical to those adopted in the Bay of Biscay. This survey was performed between 10th and 22nd June 2005 with the R/V *Cornide de Saavedra*. A summary of the methodological aspects of this survey was reported in the 2005 WGMHSA report (ICES, 2005 b). Preliminary results from this survey were presented to the 2005 WGACEGG (ICES 2006, Jiménez *et al*., 2005 a, 2005 b; Millán *et al*., 2005). However, no SSB estimate was available to that working group because of technical problems with the estimation of the spawning fraction which have recently been solved.

An internal IEO Workshop on standardisation of methodology, data exploratory analysis and (spatial) modelling of egg and adult parameters from recent IEO DEPM surveys under the R environment (see Bernal *et al*., 2004) was held in June 2006. Results from this Workshop relative to the 2005 survey parameter estimates were reviewed and discussed in November 2006 during the 2006 WGACEGG.

Egg Production estimation

The estimation of the Gulf of Cadiz anchovy daily egg production (P_0) was carried out using the R statistical package (Jiménez *et al*., 2006). A total of 119 stations were carried out during the survey. Positive stations for anchovy eggs accounted for 38.7% (46 stations), which rendered a total of 583 anchovy eggs, most of them (93%) taken in Spanish waters. **Figure 11.3.2.1** shows PAIROVET egg densities (egg/m^2) by station. Ninety-four per cent of the total captured eggs were classified into 11 development stages (according to Moser and Ahlstrom, 1985). All the stages but stage XI appeared in the samples. The most abundant stages were: II, III and IV (21.1, 26.2 and 18.9% respectively), (**Figure 11.3.2.2**).

The sampling area was estimated at 11,712.87 km^2. **Figure 11.3.2.3** shows the anchovy egg positive stations evidencing two clearly differentiated positive areas: the stratum 1, corresponding to the Spanish waters (4,470.14 km^2), and the stratum 2 in Portuguese waters (1,351.15 km^2).

Since an incubation model for the Gulf of Cadiz anchovy was not available during the estimation process, data from an incubation experiment carried out by AZTI for the Bay of Biscay anchovy were used instead. The applied models were: Lo, GAM and multinomial. According to its better statiscal performance, the multinomial model was considered as the best embryonic development model, as it was also stated by the 2005 WGACEGG (ICES, 2006 a).

The estimated egg parameters are given in **Table 11.3.2.1**. The differences in the values obtained by stratum are clear. P_{total} from stratum 1 is 108.09 E+10 eggs/day, and 2.61 E+10 eggs/day from the stratum 2. In the stratum 2 the estimated z was positive, although de SSB estimated by DEPM is very similar to the acoustic estimation. This maybe due to the low egg abundance recorded in this stratum.

Distribution and estimates of adult parameters

Adult anchovy samples for DEPM purposes were obtained from pelagic trawls (concurrently with the plankton survey). Additionally adult samples were also collected from a chartered commercial purse-seiner. The description of the characteristics of the fishing stations, the sampling strategy adopted for the collection of adult samples and the protocols used in the histological processing of these samples have been previously described by Millán *et al.* (2005).

Preliminary results of mean female weight (*W*) and sex-ratio (*R*) were presented in the 2005 WGACEGG but no batch fecundity (*F*) or spawning fraction (*S*) estimates, since samples still were under histological processing and analysis. In the 2006 WGACEEG revised and new estimates were presented for the whole set of adult parameters from the 2005 DEPM survey (Millán *et al*., 2006).

For each of the adult parameters, mean and variance were estimated following the Picquelle and Stauffer's (1985) weighting procedure. Routines for the adult parameters estimation were also developed under the R environment by Miguel Bernal during the aforementioned IEO internal 2006 Workshop.

Batch fecundity (*F*).

A spatial structure was clearly evidenced for the mature female mean weight and batch fecundity (**Figure 11.3.2.4**). In agreement with the spatial distribution of the daily egg production, a data post-stratification in two geographic strata was considered and tested for all the adult parameters. The limit of separation of these two different strata was established at the meridian 7º30' W, which in some extent split the whole study area into the Spanish (stratum 1) and Portuguese waters (stratum 2). The suitability of this post-stratification for the whole individual data set of this parameter was tested by considering 4 nested GLM models to check the differences between strata in the gonad-free weight and batch fecundity relationships (**Table 11.3.2.2**). The analysis confirmed that a post-stratification was necessary since significant differences between the two stratum were found (ANOVA, α=0.01) (**Table 11.3.2.3**; **Figure 11.3.2.5**).

This model was formulated as follows:

$F = -2{,}234.96 + 881.26 * W_{novS1} + 680.44 * W_{novS2}$

The batch fecundity estimates, *F*, in each stratum were:

Stratum 1: F_{S1}=11,470 eggs/batch (CV= 0.05)

Stratum 2: F_{S2}=13,808 eggs/batch (CV= 0.03)

Spawning fraction (*S*).

The distribution of the anchovy gonad stages among the spawning females during the period 14:00–02:00 GTM, based on data from the 2004 (pilot-) and 2005 (full scale-) surveys (**Figure 11.3.2.6),** showed that the anchovy daily spawning duration in the study area extends from 16:00 to 21:00 GMT (6 hours). The percentage of females in the spawning stage (recent POFs and hydrated plus POFs females) increased from 60% to 100% in the range time between 20:00 and 22:00 GMT. Therefore, it was assumed that the peak spawning time is about 21:00 GMT. POFs degeneration rates in the study area are unknown and POFs had to be assigned to stages-ages according to the traditional method (Motos, 1996), although considering as the peak spawning time the species-specific one in the study area.

The stratified estimates of the spawning fraction, S, were:

Stratum 1:S_{S1}= 0.210 (CV= 0.08)

Stratum 2: S_{S2}= 0.226 (CV= 0.11)

Mean female weight (*W*).

Total weight of hydrated females was corrected for the increase of weight due to hydration. Data on gonad-free-weight (W_{nov}) and corresponding total weight (W_t) of non-hydrated females from the surveys were related by a linear regression model:

W_t = -0.2136 + 1.0774 W_{nov} R^2 = 0.99

The mean weight estimates, *W*, were:

Stratum 1: W_{S1} = 16.54 g (CV= 0.04)

Stratum 2: W_{S2} = 25.19 g (CV= 0.03)

Sex ratio (*R*).

It was estimated as the percentage (in weight) of females in the mature population. The overall sex ratio by stratum was:

Stratum 1: R_{S1}= 0.537 (CV= 0.01)

Stratum 2: R_{S2}= 0.532 (CV= 0.01)

Spatial distribution and biomass estimates of the target species

During the analysis, in order to estimate both anchovy egg and adult parameters, some differences were detected In eggs, the spatial distribution of abundance and parameters were very different between Algarve and Spanish South Atlantic Region (Spanish waters of the Gulf of Cadiz). In adults parameters, the mean weight of female and the batch fecundity were different too (Millán *et al*., 2006). For this reason, it was decided to estimate the anchovy spawning-stock biomass in the Gulf of Cadiz (2005) for two strata independently: stratum 1, corresponding to Spanish waters, and stratum 2 corresponding to Portuguese waters. Routines for the adults and eggs parameters estimation were developed under R during the 2006 IEO DEPM Workshop. Routines for the SSB final estimation were developed during the 2006 WGACEGG. The resulting estimates were the following:

Anchovy SSB (Stratum 1, Spanish waters) = 13,821.85 tons

Anchovy SSB (Stratum 2, Portuguese waters) = 396.77 tons

Anchovy total SSB in the Gulf of Cadiz = 14,218 62 tons

Given the absence of anchovy DEPM-based studies in the area, the Working Group recognises the progress that is being made in this research field. The Working Group also considers the 2005 survey as a very positive development and encourages going forward in this direction. In this context, the Working Group was informed on the conduction of a new Gulf of Cadiz anchovy DEPM survey in 2008.

11.4 Biological Data

11.4.1 Catch Numbers at Age

Catch-at-age data from the whole Division IXa in 2006 are only available from the Spanish Gulf of Cadiz fishery (Sub-division IXa South). Data from the Spanish fishery in Sub-division IXa North are not available since commercial landings used to be negligible.

The age composition of the Gulf of Cadiz anchovy in Spanish landings from 1988 to 2006 is presented in **Table 11.4.1.1** and **Figure 11.4.1.1**. The catch-at-age series shows that 0, 1 and 2 age groups support the Gulf of Cadiz anchovy fishery and that the success of this fishery largely depends on the abundance of 1 year-old anchovies. The contribution of age-2 anchovies usually accounts for less than 1% of the total annual catch (except in 1997, 1999, and the 2001-2003 period, with contributions oscillating between 2% and 7%). Likewise, age-3 anchovies only occurred in the first quarter in 1992 but their importance in the total annual catch that year was insignificant.

The relative importance of 0- and 1-age groups in the fishery has experienced some changes throughout the series and it shows relatively opposite trends. Thus, 1 year-old anchovies constituted almost the whole of anchovy landed in the period 1988-1994 (with percentages higher than 80%). Between 1995 and 1997 the contribution of this age group decreased down to between 25% (1996) and 50% (1995), whereas since 1998 onwards the relative importance of 1 year-old anchovies was increased again, although up to percentages between 60-75% until 2001, and higher than 80% thereafter. The contribution of the 0-age group was relatively low in the 1988-1994 catches, and it increased considerably in the 1995-1997 period (percentages between 50 and 75%). Since then, this age group firstly showed a lower but relatively stable annual contribution during the 1998-2001 period (22-37%), then, in 2002 and 2003, it evidenced a considerable decrease in importance in the fishery (9% in 2002 and 15% in 2003), which was slightly increased in 2004 (21%), but decreased again in 2005 (7%) and 2006 (2%).

Total catch in the Gulf of Cadiz in 2006 was estimated at 508 million fish, which represents a 3% overall decrease compared to the previous year (524 millions), and it is still at a lower level than the recent maxima recorded in 2001 (723 millions) and 2002 (800 millions). The aforementioned slight decrease was mainly caused by the 30% decrease of the 0-age group fish while landings of 1 and 2 olds showed a 2% and 51% increase respectively in relation to those estimated in the previous year.

Landings of the 0 age-group anchovies are restricted to the second half of the year (mainly during the fourth quarter), whereas 1 and 2 year-old catches are present throughout the year . However, catches of 0 year olds in the fourth quarter in 2005 and 2006 were drastically reduced and those of 2 year fish completely absent, either in the same quarter (2005) or even through the whole second half year (2006), (**Table 11.4.1.1**).

11.4.2 Mean Length- and Mean Weight at Age

Length Distributions by Fleet

Annual length composition of anchovy landings in Division IXa are routinely provided by Spain for the Sub-division IXa South. This series dates back to 1988. Length distributions for the Spanish fishery in Sub-division IXa North are only available for the 1995-1999 period. Portugal has not provided length distributions of landings in Division IXa.

Gulf of Cadiz anchovy quarterly length distributions in 2006 are shown in **Table 11.4.2.1** and **Figure 11.4.2.1**. **Table 11.4.2.2** shows annual length distributions since 1988. **Figure 11.4.2.2** compares annual length distributions in Sub-divisions IXa South and IXa North since 1995. Note that, with the exception of 1998, the fish caught in the North are larger than 12.5 cm.

Smaller anchovy mean sizes and weights in the Gulf of Cadiz fishery are usually recorded in the first and fourth quarters as a consequence of a higher number of juveniles captured. This situation slighltly changed in 2006, when smaller mean quarterly estimates from both variables were recorded during the second half year (**Table 11.4.2.1**, **Figure 11.4.2.1**).

Gulf of Cadiz anchovy mean length and weight in the 2006 annual catch (10.8 cm and 8.0 g) were similar to those recorded in 2005 (**Table 11.4.2.2**, **Figures 11.4.2.1** and **11.4.2.2**).

Mean Length- and Mean Weight at Age in Landings

Mean length- and mean weight-at-age data are only available for Gulf of Cadiz anchovy catches (**Tables 11.4.2.3** and **11.4.2.4**, **Figure 11.4.2.3**). The analysis of small samples of otoliths from Subdivision IXa North in 1998 and 1999 rendered estimates of mean sizes at ages 1, 2 and 3 of 15.5 cm, 17.6 cm and 17.9 cm respectively (Anon., 2000, 2001). A sample of 78 otoliths from the same area was collected during the PELACUS 0402 acoustic survey. Mean lengths at age 1 and 2+ were 13.7 cm and 17.0 cm (Begoña Villamor, pers. comm.). Comparisons of these estimates with the ones from the Gulf of Cadiz anchovy indicate that southern anchovies attain smaller sizes at age.

Annual mean length and weight at age of Gulf of Cadiz anchovy were as follows (**Figure 11.4.2.3**):

Age group 0: mean length and weight in 2006 were 8.7 cm and 3.7 g respectively. Through the available data series (1988 onwards) these estimates have ranged between 5.8 cm and 1.3 g (1996), and 10.5 cm and 6.9 g (1989). A slight decreasing trend has been observed in both estimates in the most recent years.

Age group 1: mean length and weight in 2006 were 10.8 cm and 8.0 g respectively. Mean lengths and weights have oscilated between 8.9 cm-6.4 g (1996) and 12.0 cm-12.4 g (2001). Both estimates for this age group also show a slight decreasing trend in the last years.

Age group 2: mean length and weight in 2006 were 14.1 cm and 17.4 g respectively. Mean lengths have oscilated between 13.5 cm-14.9 g (1998) and 16.9 cm-33.5 g (1989). Since 2001 both estimates are experienced a remarkable decreasing trend.

Seasonally, 0 age-group anchovies off the Gulf of Cadiz are larger (and usually also heavier) in the fourth quarter. This general pattern was apparent in 2006 but it not in 2004 and 2005, when weights in the fourth quarter were rather similar to those estimated in the third quarter. The 1 and 2 year-old anchovies exhibit a clear and persistent pattern through the years, showing the larger mean length and heavier mean weight in the second half in the year. However, the absence of 2-year olds in the whole second half year in 2006 prevents from proposing any seasonal trend for this age group in that year.

11.4.3 Maturity at Age

Previous biological studies based on commercial samples of Gulf of Cadiz anchovy (Millán, 1999) indicate that its spawning season extends from late winter to early autumn with a peak spawning time for the whole population occurring from June to August. Length at maturity was estimated at 11.09 cm in males and 11.20 cm in females. However, it was evidenced that size at maturity may vary between years, suggesting a high plasticity in the reproductive process in response to environmental changes.

Annual maturity ogives for Gulf of Cadiz anchovy are shown in **Table 11.4.3**. They represent the estimated proportion of mature fish at age in the total catch during the spawning period (second and third quarters) after raising the ratio of mature-at-age by size class in monthly samples to the monthly catch numbers-at-age by size class.

11.4.4 Natural Mortality

Natural mortality is unknown for this stock. By analogy with anchovy in Sub-area VIII, natural mortality is probably high (M=1.2 is used for the data exploration, see **Section 11.6**).

11.5 Effort and Catch per Unit Effort

Data availability and standardisation

The annual series of both nominal fishing effort (number of fishing trips) and CPUE indices of anchovy in Division IXa are available for the Gulf of Cadiz purse-seine fishery since 1988. The data series from the Spanish purse-seine fishery off southern Galician waters (Sub-division IXa North) only comprise the 1995-1999 period whereas no data from the Portuguese purse-seine fisheries along the Division are available. Causes for this scarcity or even absence of data from the later fisheries must be found in their low anchovy annual catches during the last 3-4 decades and mainly by the fact that these fisheries target sardine (see **Section 11.2** and **Table 11.2.2.1**).

Regarding the Gulf of Cadiz anchovy fishery, data on annual values of nominal effort (fishing trips targeting on anchovy) and CPUE by fleet type have routinely been provided to this WG. A total of 8 fleets were initially differentiated according to their respective home-ports (Barbate, Sanlúcar, Punta Umbría and Isla Cristina) and degree of dedication to the purse-seine fishing (single- and multi-purpose fleets). Such data were however provided without a proper standardisation that considered the relative fishing power of the above fleets and thus preventing from the appreciation of overall trends in effort and CPUE.

The series of effective effort and CPUE from all of the fleets exploiting the Gulf of Cadiz anchovy purse-seine fishery were provided for the first time to the WG in 2004. For such a purpose, vessels from single-purpose fleets were additionally differentiated according to their tonnage in heavy- (≥30 GRT) and light- (<30 GRT) tonnage vessels, rendering a total of 11 fleet types.

The standardisation procedure was performed by fitting quarterly log-transformed CPUE's from fleet types composing the fishery to a GLM (without interaction) with the form (Robson, 1966; Gavaris, 1980):

$$LnCPUE_{(ft_i,\, quarter_i)} = intercept + quarter + fleettype$$

Reference fleet (métier or fleet type) and period used in the standardisation were the Barbate's single-purpose high-tonnage fleet and the first quarter in 1988 respectively.

The updated series (1988-2006) of standardised effort and CPUE from all of the fleets exploiting the fishery have been provided to the WG this year. Parameter estimates resulting from the generalised linear modelling used for CPUE standardisation are shown in **Table 11.5.1**. Goodness of fit of this model as assessed by ANOVA and model graphical diagnosis (residuals plots and profile plots of estimated marginal means of the dependent variable) are shown in **Table 11.5.2** and **Figure 11.5.1**. The model as implemented shows a relatively acceptable fit to observed data, explaining about 60% of the total variance (adjusted R^2= 0.59). Predicted versus observed data and residuals plots corroborate the appropiateness of the chosen model. Profile plots of marginal means run parallel indicating that interaction between factors may not be relevant.

Annual and half-year standardised CPUE series for the whole fleet were computed from the quotient between the sum of raw quarterly catches and that of standardised quarterly efforts within the respective time period. The resulting estimates are shown in **Tables 11.5.3** and **11.5.4**.

Recent trends in effort and CPUE: overall estimates and by fleet type

Series of standardised overall annual effort and CPUE and the historical series of landings are shown together in **Figure 11.5.2**. Landings associated to the sampled fishing effort are also included in the figure in order to show the sampling coverage of the fishing effort. An almost complete coverage of the whole fleet is evidenced since 1999 on, whereas some gaps in the information on effort occur in preceding years, mainly in the 1988-1993 period. Therefore any interpretation about trends during the above period should be taken with caution.

The description of the recent dynamics of the Spanish fleets in the Gulf of Cadiz has been summarised in previous WG reports, although based on not-standardised values. Nevertheless, the standardisation provides a similar perception that the one described previously. Thus, the fleets' behaviour in 1995 and 2000-2001 was mainly driven by a drastic reduction of the fishing effort exerted by the Barbate's heavy-tonnage purse-seiners which was coincident with the two minima in landings in 1995 and 2000. This fleet segment (the main responsible for anchovy exploitation in both the Moroccan and Gulf of Cadiz fishing grounds in previous years) accepted a subsidised tie-up scheme in those years because the corresponding fourth and fifth EU-Morocco Fishery Agreements either ended (1995) or ended and was not then renewed (2000). During the 2000-2001 period, the void left by these vessels in the fishing grounds was rapidly occupied by fleets with a lighter tonnage and lower fishing capacity, that were already experiencing remarkable increases in their exerted fishing efforts since 1999, due to the high anchovy yields recorded the previous year (**Figure 11.5.3**). From 2002 onwards Barbate's heavy-tonnage purse-seiners were fishing again in the Gulf of Cadiz gradually increasing their effort levels, at least until 2004. This last trend is accompanied by a progressive decrease in the effort by smaller vessels. Overall, such shifts in the fleet dynamics do not seem to affect the total fishing effort since the annual values are maintained at quite high levels since 1997 (even with a 45 day-fishing closure in late 2004). In 2005 and 2006, however, the possible combination of a fishing closure in the fourth quarter and the reduction of the number of active vessels fishing anchovy (from 135 vessels in 2004 to only 106 vessels in 2005 and 96 in 2006) led to a marked decrease in fishing effort. Such a decreasing trend seemed to have affected all the fleet segments in 2005, whereas in 2006 the reduction in the annual effort was only evident in the Barbate's home-based fleets.

As for the CPUE, the high yields estimated in 2001 and 2002 showed a remarkable decrease in 2003 and 2004, they increased in 2005, slightly decreasing again in 2006. This general trend was also observed in each of the fleet types but the multipurpose type, which still mantains the decreasing trend observed in recent years, and the westernmost fleets in 2006, which showed the same or slightly higher yield levels than in the previous year.

The Gulf of Cadiz purse-seine fishery closure in autumn 2004-2006: analysis of changes in standardised effort and CPUE before and after the closed seasons

Figure 11.5.4 shows the quarterly purse-seine landings and quarterly estimates of standardised effort and CPUE for the 2002-2006 period. The fishery closure during the last 45 days in 2004 caused a 33-35% decrease in the standardised overall effort exerted during the fourth quarter in that year (682 fishing trips) in comparison to the estimated for the same quarter in 2002 (1,056 trips) and 2003 (1,026 trips). Such a decrease also affected the contribution of this quarter (9.9%) to the total fishing effort in 2004 (6,920 fishing trips). In 2002 (total annual effort of 8,000 trips) and 2003 (6,699 trips) the relative importance of their respective fourth quarters in terms of fishing activity was 13.2% and 15.3%. However, as it is shown by the annual values during these years, the overall decrease in fishing effort in 2004 was almost negligible in relation to the effort levels recorded the previous year.

As in 2004 fishing closure, the effort exerted in the fourth quarter of 2005 (246 fishing trips) experienced a stronger decrease (76-77%) due to the closure of the fishery in relation to the effort exerted in the same quarters in years not affected by closed seasons (2002 and 2003). The contribution of this quarter to the total annual effort in 2005 (3,824 fishing trips) was only 6%.

In 2006, the closed season lasted for the 2 last months of the year. Fourth quarter effort levels were the lowest ever recorded in the available historical series (only 72 fishing days), and they only accounted for 1% of the total annual effort (5,077 fishing days).

Unlike 2004, 2005 and 2006 annual efforts were noticeably (mainly in 2005) affected by such a disminution of the effort levels in their respective fourth quarters, although other additional causes than the fishing closure (*e.g*., reduction in the number of active vessels and, possibly the decrease of effective fishing days because of bad weather as well) should also be taken into consideration to explain this trend.

As noted in **Subsection 11.2.2** (see also **Figure 11.2.2.1**), the effects of the 2004 closure in landings were not so evident at a seasonal scale, since the relative importance of autumn landings in 2004 was even greater (12%) than in preceding years (10% in 2002, 9% in 2003). In absolute terms the fourth quarter catches in 2004 (633 t) were either at the same level than its counterpart in 2002 (780 t) or even higher than in 2003 (412 t). As a consequence, the autumn CPUE in 2004 (0.916 t/fishing day) was higher than in preceding years in spite of the closure (0.747 t/fishing day in 2002, 0.395 t/fishing day in 2003). However, this was not the case in 2005 and 2006, when landings in their respective fourth quarters were the lowest recorded in the recent analysed series both in absolute (77 t and 9 t) and relative terms (2% and 0.2%). The low effort levels together with even more disminished catches in the fourth quarter resulted in a relatively low autumn CPUE both in 2005 (0.313 t/fishing day) and 2006 (0,128 t/fishing day).

11.6 Recruitment Forecasting

Recruitment forecasts of anchovy in Division IXa are not available. By analogy with the anchovy stock in Sub-area VIII, recruitment may be driven by environmental factors and may be highly variable as a result.

As described in **Section 11.3**, anchovy population estimates in the Sub-division IXa South by direct methods are available from the Portuguese acoustic survey series since 1998. Although Portugal provides such estimates as aggregated ones, an estimation of the recruits either from their November (as age-0 recruits in the year) or March surveys (as age-1 fish in the next year) may be derived after the application of Spanish age-length keys. However, such keys are based on commercial samples from purse-seine catches and therefore they may result in a biased picture of the population structure because of a different catchability. Since 2005 otolith collections from these surveys are being provided by IPIMAR to IEO in order to derive their corresponding age-length keys. Age reading is in progress and is expected that disaggregated acoustic estimates will be provided to this WG in the near future. Regardless the above and the considerations about the suitability of the sampling coverage in these surveys for sampling this population fraction (mainly age-0 fish or even adult fish in shallow waters), the series of point estimates is at present scattered and scarce, at least for the November series.

No progress has been carried out in relation to the updating of the anchovy pre-recruitment index series presented to this WG some years ago (see Ramos *et al*., 2003). This index, although highly provisional, aimed to summarise the incorporation of pre-recruits into the Guadalquivir River estuary, one of the main anchovy nursery areas in the Division. At present, previous and new raw data needed for the computation of the annual estimates (since 1997) are being explored in detail and the method of estimation is under revision. The WG encourages the continuation of their provision in next years.

So far, no information is still available to this WG about the influence of the environment on the anchovy recruitment in Division IXa and particularly in the Gulf of Cadiz area. Environmental indices, such as those described in **Section 10.6** for Anchovy in VIII c, have not been yet provided for the Sub-division IXa South, but it is expected that in medium-term they may be available to this WG allowing thus to understand their possible relationships with the anchovy recruitment in the area.

11.7 Data Exploration

Data availability and some fishery (recent catch trajectories) and biological evidence have been the basis for a data exploration of anchovy in Sub-division IXa South (Algarve and Gulf of Cadiz) (Ramos *et al*., 2001; Anon., 2002).

11.7.1 Data exploration with the ad hoc separable model

An *ad hoc* seasonal separable model implemented and run on a spreadsheet has been used in the last years for data exploration of anchovy catch-at-age data in IXa South since 1995 onwards. Given the nature of stock, short-lived, data in this model are analysed by half-year-periods, those from the Algarvian anchovy being previously compiled by applying Gulf of Cadiz ALKs (**Table 11.7.1**; **Figure 11.7.1**). Weights at age in the catches are estimated as usual, whereas weights at age in the stock correspond to yearly estimates calculated as the weighted mean weights-at-age in the catches for the second and third quarters.

The separable model has been fitted this year to the updated half-year catch-at-age data until 2006 and to the available acoustic estimates of anchovy aggregated biomass from the Portuguese “March-April” surveys only (**Table 11.7.1**; **Figure 11.7.2**).

Both the Portuguese acoustic surveys in March and in November were used as tuning indices in the past, assuming the same catchability coefficient. However, the surveys cover different fractions of the population so, the assumption of same catchability is probably inappropriate. Given that the model is unlikely to be able to estimate the extra parameter and that the March survey has a better coverage both in space and time, only this survey was used in the exploration.

The Spanish acoustic survey series (2004, 2006, 2007), was not used as a tuning index because it is short and it uses, at least in 2007, a different set of target strength values from the Portuguese series. The DEPM-based anchovy SSB not was included in the model because it has only one data point but it was provided for comparison with the acoustic and model-predicted biomass estimates.

The annual CPUE series from the whole Spanish purse-seine fleet has also been excluded as tuning index this year. The lack of a consistent series of a biomass index to tune the anchovy exploratory assessments (no DEPM estimates, gaps in the series of acoustic estimates) led in the last years to tentatively adopt the CPUE index as the only available alternative. However, both the Working Group members and the 2006 Review Group agree that purse-seine CPUE may not be a relevant stock indicator as is commonly the case for fleets fishing on schooling fish.

Catches at age are assumed by the model to be linked by the Baranov catch equations; the relationship between the index series and the stock sizes is assumed linear. A constant selection pattern is assumed for the whole period. Parameters estimated are selectivity at age for both half-year-periods in relation to the reference age (age 1), recruitment, survey catchability (Q) and annual F values per half-year-period. Parameters are estimated by minimising the sum of squares of the log-residuals from the catch-at-age and the acoustics biomass data. F values for 1995 are computed as an average of the Fs in subsequent years.

The procedure to set F in the 2nd half of the assessment’s last year is the same as the one followed in the 2006 assessment. Data and assumptions made for the 1st half of 2007 are the following:

- The March 2007 acoustic data is included;

- In the absence of catch data for 2007 catches at age are assumed the same as in 2006;
- Weights at age in the stock were set as the mean of the last 3 years;
- F was set as the mean over the last three years;
- Log-residuals of catch at age in 2007 were excluded from the minimisation routine whereas the residuals from the 2007 biomass acoustic estimate were included in the model fitting.

Three exploratory analyses were performed:

- **RUN 1**: Acoustic surveys as a relative tuning index and a weighting factor= 1.
- **RUN 2:** Acoustic surveys as a relative tuning index and a weighting factor= 6.
- **RUN 3**: Acoustic surveys as an absolute tuning index and a weighting factor= 1.

The rational for RUN 3 is the similarity between the estimates by the Portuguese survey and the Spanish DEPM in 2005 (14,000 and 14,200 tonnes respectively).

Figure 11.7.3 shows the trends exhibited by the main model outputs from all the runs (see **Tables 11.7.2** to **11.7.4** for details), including the last year's RUN 9, with similar settings than RUN 1, for comparison. Residuals from the model fit to the catch at age data are plotted in **Figure 11.7.4.**

Using the tuning index as absolute (*i.e*., RUN 3) drops up the absolute levels of recruitment and population biomass, notably decreasing the fishing mortality. Conversely, the two remaining runs using the relative tuning index (RUN 1 and 2) show a downscaled perception of the levels of recruitment and population biomass and higher fishing mortalities. At this point it must be reminded that the second semesters are not tuned by any index and the model in these cases follows to the trajectory of catches. As stated previously for the Biscay anchovy, such decreases in these model outputs are explained by the fact that the absolute level of the population is relying heavily on the level of catches at age. In this context, the assessment is reduced to a virtual population estimate, scaled to the level of catches, just tuned to relative trend series (from surveys). For a short living species as anchovy no convergence properties exist for a VPA estimate and scaling the population levels just to the VPA catch levels is inadequate.

According to the model, fishing mortality seemed to have been increasing until 1999 and then gone down in 2000, increasing again in the period 2001-2004, trend that has shifted in the last years, showing again low values, mainly in 2006, in agreement with the effects caused in the fishing effort by the successive closures in the last three years (**Figures 11.7.3** and **11.7.5**). The estimated selectivity for age 2 is different between runs 1 and 2 and run 3, probably as a result of assuming the survey index as absolute in run 3. However, a low selectivity at age 2, given the catch data and the level of natural mortality adopted, might be more in aggreement with the perception of the impact of the fishery on the stock. Direct evidences from acoustic surveys (at the peak of the fishing season) show that larger and older anchovies are more common in the westernmost waters of the Sub-division, where there is no fishery targeting anchovy.

The acoustic estimates of biomass predicted by the model only fit reasonably well to the observed values in the run 2, when the tuning index is upweighted and used as relative. This was not the case for the remaining runs. The fit of the average biomass as estimated by the model to the acoustic data was also poor (**Figure 11.7.6**). The point estimate of the acoustic survey catchability coefficient (Q around 4 according to the run considered; **Tables 11.7.2** and **11.7.3**) seemed high, which resulted in an acoustic estimate of biomass much higher than the one estimated by the assessment model.

11.7.2 Quality and reliability of the assessment

The suitability of the seasonal model itself and the biomass tuning indices used in the assessment has been discussed in previous WG and the same statements has been drawn this year. Thus, the model, as currently implemented, assesses the population biomass mainly according to catch levels. However, it must also be stated that the approach herein presented is the one that is possible to be carried out for the time being with the available data. It was also noticed that there is no reliable information about the true levels of both the stock, F and Catch/SSB ratios. So, the stock trajectory resulting from these exploratory runs is therefore a picture of a relative trend and therefore the assessment must be properly scaled.

For the above reasons, the Working Group has stressed in last years the necessity of the inclusion in the model of an absolute scaling factor of the biomass population. At present only one DEPM-based SSB estimate is available (2005). In this context, the Working Group recognises the progresses carried out in the direct surveying of the anchovy in Sub-division IXa South with the realisation of an Spanish Egg (DEPM) survey in 2005 and encourages the continuation of this triennial series in the future (the next survey will take place in 2008).

Although the assessment presented here is only considered for the purpose of data exploration and bearing in mind the uncertainty on the absolute levels of the estimates, the results suggest a recent increasing trend in the population biomass as a result of the combination of relatively high recruitments and low fishing mortalities in the last two years (**Figures 11.7.3** and **11.7.5**). Moreover, by analogy with the anchovy stock in Sub-area VIII, this stock may fluctuate widely due to variations in recruitment largely driven by environmental factors.

11.8 Reference Points for Management Purposes

It is not possible to determine limit and precautionary reference points based on the available information.

11.9 Harvest Control Rules

Harvest control rules cannot be provided, as reference points are not determined.

11.10 Management Considerations

Current management situation.

Portuguese producers organisations traditionally agree a voluntary closure of the purse-seine fishery in the northern part (north of the 39º 42” North) of the Portuguese coast. This closure usually lasted from the 1st of February to 31 of March. In 2006, the closure, also lasting 2 months, may however be selected between 1st of February and 30th of April (i.e. boats stopped fishing in February to March or in March to April).

The regulatory measures in force for the Spanish anchovy purse-seine fishing in the Division are the same as for the previous years and are summarised as follows:

- Minimum landing size: 12 cm total length in VIIIc and IXa North, 10 cm in Gulf of Cadiz (IXa South).
- Minimum vessel tonnage of 20 GRT with temporary exemption.
- Maximum engine power: 450 h.p.
- Purse-seine maximum length: 450 m.
- Purse-seine maximum height: 80 m.
- Minimum mesh size: 14 mm
- Fishing time limited to 5 days per week, from Monday to Friday.
- Cessation of fishing activities from Saturday 00:00 h to Sunday 12:00 h.

- Fishing prohibition inside bays and estuaries.

In the Gulf of Cadiz (Sub-division IXa South) the Spanish purse-seine fleet was performing a voluntary closure of three months (December to February) until 1997. Since 2004 two complementary sets of management measures affecting directly to the Gulf of Cadiz fishery have been implemented and are still in force. The first one was the new "*Plan for the conservation and sustainable management of the purse-seine fishery in the Gulf of Cadiz National Fishing Ground*". This plan is in force during 12 months since October the 30th and includes a fishery closure of either 45 days (between 17th of November to the 31st of December in 2004 and 2005) or two months (November and December in 2006), which is accompanied by a subsidized tie-up scheme for the purse-seine fleet. The plan also includes additional regulatory measures on the fishing effort (200 fishing days/vessel/year as a maximum) and daily catch quotas per vessel (3000 kg of sardine, 3000 kg of anchovy, 6000 kg of sardine-anchovy mixing but in no case each of these species can exceed 3000 kg). A new regulation approved in October 2006 establishes that up to 10% of the total catch weight could be constituted by fish below the established minimum landing size (10 cm) but fish must always be ≥9 cm.

As described in **Section 11.5** the 2004 fishery closure did not cause a serious impact in the fishery in terms of overall annual effort (6,920 standardised fishing days), at least when this level is compared with the one recorded the previous year (6,699 fishing days). The same was also observed in landings. The only remarkable effect of such a closure was the decreased annual contribution of the effort exerted in autumn 2004 as compared to the exerted in the same season in previous years (a 33-35% decrease). Therefore, such a measure seems to have halted the possibility of recording annual effort levels close to the historical maxima in 1998, 2001 and 2002. Conversely, in 2005 and specially in 2006, both fishing effort and landings in their respective fourth quarters experienced remarkable decreases both in absolute and relative terms in relation not only to their counterparts in previous years (including 2004), but also in relation to the total annual values. So, fishing efforts exerted in the 2005 and 2006 fourth quarters (246 and 72 fishing days respectively) represented only 6% and 1% of their total annual efforts (3,824 fishing days in 2005, 5,077 in 2006). In these years, although the fishing closures in the last 45 or 60 days in the year may be one of the main responsibles for such decreased trend, other additional causes occurring shortly before the closures (*e.g.*, reduction in the number of active vessels and, possibly the decrease of effective fishing days because of bad weather as well) should also be taken into consideration.

The second management action in force since 15th of July 2004 is the delimitation of a marine protected area (fishing reserve) in the mouth and sourrounding waters of the Guadalquivir river, a zone that plays a fundamental role as nursery area of fish (including anchovy) and crustacean decapods in the Gulf (**Figure 11.10.1**). Fishing in the reserve is only allowed (with pertinent regulatory measures) to gill-nets and trammel-nets, although in those waters outside the riverbed. Neither purse-seine nor bottom trawl fishing is allowed all over this MPA.

Scientific advice.

The WG considers that from a conservation point of view the implemented plan should be beneficial for the stock. However, the plan has not been formally evaluated. Given the current uncertainty in the stock status, the WG still recommends that effective effort should not increase above recent levels. Further, WG recommends that the fishery should not be allowed to further expand until the stock is properly assessed and there is evidence that the stock could support higher fishing pressure.

Given that the catch are comprised almost entirely of a single age group (age 1), in order to advise on sustainable harvest levels 2 years ahead of the most recent catch data an estimate of incoming recruitment is required. Currently the March Portuguese survey tracks the population best. Therefore, if this index were to be used as an estimate of recruitment (at age 1) strength, in-year management of this stock would be more appropriate.

In order to scale the assessment, additional DEPM estimates will be required.

Table 11.2.1.1. Anchovy in Division IXa. Portuguese and Spanish annual landings (tonnes), (from Pestana, 1989 and 1996, and WG members).

	Portugal				Spain			
Year	IXa C-N	IXa C-S	IXa South	Total	IXa North	IXa South	Total	TOTAL
1943	7121	355	2499	9975	-	-	-	-
1944	1220	55	5376	6651	-	-	-	-
1945	781	15	7983	8779	-	-	-	-
1946	0	335	5515	5850	-	-	-	-
1947	0	79	3313	3392	-	-	-	-
1948	0	75	4863	4938	-	-	-	-
1949	0	34	2684	2718	-	-	-	-
1950	31	30	3316	3377	-	-	-	-
1951	21	6	3567	3594	-	-	-	-
1952	1537	1	2877	4415	-	-	-	-
1953	1627	15	2710	4352	-	-	-	-
1954	328	18	3573	3919	-	-	-	-
1955	83	53	4387	4523	-	-	-	-
1956	12	164	7722	7898	-	-	-	-
1957	96	13	12501	12610	-	-	-	-
1958	1858	63	1109	3030	-	-	-	-
1959	12	1	3775	3788	-	-	-	-
1960	990	129	8384	9503	-	-	-	-
1961	1351	81	1060	2492	-	-	-	-
1962	542	137	3767	4446	-	-	-	-
1963	140	9	5565	5714	-	-	-	-
1964	0	0	4118	4118	-	-	-	-
1965	7	0	4452	4460	-	-	-	-
1966	23	35	4402	4460	-	-	-	-
1967	153	34	3631	3818	-	-	-	-
1968	518	5	447	970	-	-	-	-
1969	782	10	582	1375	-	-	-	-
1970	323	0	839	1162	-	-	-	-
1971	257	2	67	326	-	-	-	-
1972	-	-	-	-	-	-	-	-
1973	6	0	120	126	-	-	-	-
1974	113	1	124	238	-	-	-	-
1975	8	24	340	372	-	-	-	-
1976	32	38	18	88	-	-	-	-
1977	3027	1	233	3261	-	-	-	-
1978	640	17	354	1011	-	-	-	-
1979	194	8	453	655	-	-	-	-
1980	21	24	935	980	-	-	-	-
1981	426	117	435	978	-	-	-	-
1982	48	96	512	656	-	-	-	-
1983	283	58	332	673	-	-	-	-
1984	214	94	84	392	-	-	-	-
1985	1893	146	83	2122	-	-	-	-
1986	1892	194	95	2181	-	-	-	-
1987	84	17	11	112	-	-	-	-
1988	338	77	43	458		4263	4263	4721
1989	389	85	22	496	118	5330	5448	5944
1990	424	93	24	541	220	5726	5946	6487
1991	187	3	20	210	15	5697	5712	5922
1992	92	46	0	138	33	2995	3028	3166
1993	20	3	0	23	1	1960	1961	1984
1994	231	5	0	236	117	3035	3152	3388
1995	6724	332	0	7056	5329	571	5900	12956
1996	2707	13	51	2771	44	1780	1824	4595
1997	610	8	13	632	63	4600	4664	5295
1998	894	153	566	1613	371	8977	9349	10962
1999	957	96	355	1408	413	5587	6000	7409
2000	71	61	178	310	10	2182	2191	2502
2001	397	19	439	855	27	8216	8244	9098
2002	433	90	393	915	21	7870	7891	8806
2003	211	67	200	478	23	4768	4791	5269
2004	83	139	434	657	4	5183	5187	5844
2005	82	6	38	126	4	4385	4389	4515
2006	79	15	14	108	15	4368	4383	4491

(-) Not available

(0) Less than 1 tonne

Table 11.2.1.2. Anchovy in Division IXa. Catches (tonnes) by gear and country in 1988-2006.

Country/Gear	1988*	1989*	1990*	1991*	1992	1993	1994	1995*	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
SPAIN	4263	5454	6131	5711	3028	1961	3153	5900	1823	4664	9349	6000	2191	8244	7891	4791	5187	4389	4383
Artisanal IXa North																4	1		
Purse seine IXa North		118	220	15	33	1	117	5329	44	63	371	413	10	27	21	19	2	4	15
Purse seine IXa South	4263	5336	5911	5696	2995	1630	2884	496	1556	4410	7830	4594	2078	8180	7847	4754	5177	4385	4367
Trawl IXa South						330	152	75	224	190	1148	993	104	36	23	14	6	0.2	0.4
PORTUGAL	458	496	541	210	275	23	237	7056	2771	632	1613	1408	310	855	915	478	657	126	108
Trawl					4	9	1		56	46	37	43	6	16	13	7	5	7	27
Purse seine	458	496	541	210	270	14	233	7056	2621	579	1541	1346	297	806	888	287	455	62	57
Artisanal					1	1	3		94	7	35	20	7	32	13	184	197	57	24
Total	4721	5950	6672	5921	3303	1984	3390	12956	4594	5295	10962	7409	2502	9098	8806	5269	5844	4515	4491

* Portuguese catches not differentiated by gear

Table 11.2.2.1. Anchovy in Division IXa. Quarterly anchovy catches (tonnes) by country and Sub-division in 2006.

		QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4		ANUAL (2006)	
COUNTRY	**SUBDIVISIONS**	**C(t)**	**%**	**C(t)**	**%**	**C(t)**	**%**	**C(t)**	**%**	**C (t)**	**%**
SPAIN	**IXa North**	1	6.9	0.1	1.0	2.9	19.0	11	73.1	15	0.4
	IXa South	1289	29.5	2655	60.8	414	9.5	9	0.2	4368	99.6
	TOTAL	1290	29.4	2656	60.6	417	9.5	20	0.5	4383	100.0
PORTUGAL	**IXa Central North**	58	73.0	17	21.6	2	2.7	2	2.7	79	73.5
	IXa Central South	9	56.5	2	11.3	0.0	0.1	5	32.0	15	14.0
	IXa South	5	37.6	2	13.2	1	5.3	6	43.9	14	12.5
	TOTAL	72	66.3	21	19.1	3	2.7	13	12.0	108	100.0
TOTAL	**IXa North**	1.1	6.9	0	1.0	3	19.0	11	73.1	15	0.3
	IXa Central North	58	73.0	17	21.6	2	2.7	2	2.7	79	1.8
	IXa Central South	9	56.5	2	11.3	0.0	0.1	5	32.0	15	0.3
	IXa South	1294	29.5	2657	60.6	415	9.5	15	0.3	4381	97.6
	TOTAL	1361	30.3	2676	59.6	420	9.4	33	0.7	4491	100.0

Table 11.2.4.1. Anchovy in Division IXa. Spanish purse-seine fleet composition in the Gulf of Cadiz (differentiated into total fleet and vessels targeting Gulf of Cadiz anchovy) since 1999 (revised data for 2004 and 2005).The categories include both single purpose purse-seiners and trawl and artisanal vessels fishing with purse-seine in some periods through the year (multi-purpose vessels). Length criteria refers to length between perpendiculars.Storage: catches are dry hold with ice (fishing trip equals to fishing day). No discard estimates.

Total number of operative purse-seiners

1999	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	16	23	20	1	0	60
11-15	0	7	28	16	0	51
16-20	0	0	2	20	1	23
>20	0	0	0	3	0	3
Total	16	30	50	40	1	137

2000	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	14	13	27	1	0	55
11-15	1	7	33	6	0	47
16-20	0	0	0	2	0	2
>20	0	0	0	0	0	0
Total	15	20	60	9	0	104

2001	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	11	18	20	1	0	50
11-15	1	8	33	8	0	50
16-20	0	0	1	5	0	6
>20	0	0	0	0	0	0
Total	12	26	54	14	0	106

2002	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	8	16	20	0	0	44
11-15	1	10	27	16	0	54
16-20	0	0	4	17	0	21
>20	0	0	0	2	0	2
Total	9	26	51	35	0	121

2003	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	9	15	15	1	0	40
11-15	2	11	29	15	0	57
16-20	0	0	4	21	0	25
>20	0	0	0	0	0	0
Total	11	26	48	37	0	122

2004	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	11	12	19	0	0	42
11-15	2	16	46	16	0	80
16-20	0	0	3	20	0	23
>20	0	0	0	0	0	0
Total	13	28	68	36	0	145

2005	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	5	9	16	0	0	30
11-15	1	13	30	16	0	60
16-20	0	0	2	19	0	21
>20	0	0	0	0	0	0
Total	6	22	48	35	0	111

2006	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	6	8	12	0	0	26
11-15	1	13	31	18	0	63
16-20	0	0	3	20	0	23
>20	0	0	0	1	0	1
Total	7	21	46	39	0	113

Purse-seiners targeting anchovy

1999	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	9	21	19	1	0	50
11-15	0	6	25	16	0	47
16-20	0	0	2	19	0	21
>20	0	0	0	3	0	3
Total	9	27	46	39	0	121

2000	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	10	11	26	1	0	48
11-15	1	7	30	6	0	44
16-20	0	0	0	2	0	2
>20	0	0	0	0	0	0
Total	11	18	56	9	0	94

2001	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	8	14	20	1	0	43
11-15	1	8	29	6	0	44
16-20	0	0	1	2	0	3
>20	0	0	0	0	0	0
Total	9	22	50	9	0	90

2002	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	4	13	19	0	0	36
11-15	1	9	25	13	0	48
16-20	0	0	2	17	0	19
>20	0	0	0	2	0	2
Total	5	22	46	32	0	105

2003	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	5	11	15	0	0	31
11-15	2	10	27	14	0	53
16-20	0	0	3	20	0	23
>20	0	0	0	0	0	0
Total	7	21	45	34	0	107

2004	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	11	12	19	0	0	42
11-15	2	15	40	14	0	71
16-20	0	0	3	19	0	22
>20	0	0	0	0	0	0
Total	13	27	62	33	0	135

2005	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	5	8	14	0	0	27
11-15	1	13	28	16	0	58
16-20	0	0	2	19	0	21
>20	0	0	0	0	0	0
Total	6	21	44	35	0	106

2006	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	4	6	11	0	0	21
11-15	1	10	28	16	0	55
16-20	0	0	2	18	0	20
>20	0	0	0	0	0	0
Total	5	16	41	34	0	96

Table 11.3.1.1. Anchovy in Division IXa. Estimated abundance (millions) and biomass (tonnes) in Division IXa from Portuguese acoustic surveys by area and total.

		Portugal				Spain	TOTAL
Survey	Estimate	Central-North	Central-South	South (Algarve)	Total	South (Cadiz)	
November 1998	Number	30	122	50	203	2346	2549
	Biomass	313	1951	603	2867	30092	32959
March 1999	Number	22	15	*	37	2079	2116
	Biomass	190	406	*	596	24763	25359
November 2000	Number	4	20	*	23	4970	4994
	Biomass	98	241	*	339	33909	34248
March 2001	Number	25	13	285	324	2415	2738
	Biomass	281	87	2561	2929	22352	25281
November 2001	Number	35	94	-	129	3322	3451
	Biomass	1028	2276	-	3304	25578	28882
March 2002	Number	22	156	92	270	3731 **	4001 **
	Biomass	472	1070	1706	3248	19629 **	22877 **
February 2003	Number	0	14	*	14	2314	2328
	Biomass	0	112	*	112	24565	24677
April 2005	Number	0	59	0	59	1306	1364
	Biomass	0	1062	0	1062	14041	15103
April 2006	Number	-	-	319	319	1928	2246
	Biomass	-	-	4490	4490	19592	24082
April 2007	Number	0	103	284	387	2860	3247
	Biomass	0	1945	4607	6552	33413	39965

* Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to sub-area Algarve was included in Cadiz.

** Corrected estimates after detection of errors in the S_A values attributed to the Cadiz area (Marques & Morais, WD 2003)

Table 11.3.1.2. Anchovy in Division IXa. Estimated abundance (millions) and biomass (tonnes) in Sub-division IXa South from Spanish acoustic surveys by area and total.

					Observations		
Survey	Estimate	Portugal	Spain	TOTAL	R/V	Sampling grid	Sampled depth range
June 1993	Number	-	462	-	Cornide	Zig-zag	20-500 m
	Biomass	-	6569	-			
February 2002 (1)	Number	-	18202	-	Cornide	Parallel	20-200 m
	Biomass	-	212935	-			
June 2004 (2,3)	Number	91	804	894	Cornide	Parallel	30-200 m
	Biomass	1793	11376	13168			
June 2006 (3)	Number	103	2384	2487	Cornide	Parallel	20-200 m
	Biomass	1844	25924	27769			
July 2007 (3)	Number	199	606	805	Cornide	Parallel	20-200 m
	Biomass	4161	8463	12624			

(1) Estimates under revision.
(2) Preliminary estimates. Probably underestimated because of problems of sampling coverage.
(3) Estimates are expected to be re-evaluated using different TS-relationship for anchovy (-72.6 and -71.2 dB) for comparison and extended to all the pelagic species susceptible of being assessed.

Table 11.3.1.3. Anchovy in Division IXa. Age structure of the anchovy estimated abundance (millions) and biomass (tonnes) in Sub-division IXa South from July 2007 Spanish acoustic survey by area and total.

Age class	ALGARVE	CÁDIZ	TOTAL
	Number	Number	Number
0	0	0	0
I	148	591	738
II	49	16	65
III	2	0	2
TOTAL	199	606	805

Age class	ALGARVE	CÁDIZ	TOTAL
	Weight	Weight	Weight
0	0	0	0
I	2894	8129	11023
II	1210	330	1540
III	57	4	61
TOTAL	4161	8463	12624

Table 11.3.2.1. Anchovy in IXa. *BOCADEVA 0605* Gulf of Cadiz anchovy DEPM survey. Estimates of egg parameters.

PARAMETERS	STRATUM 1 Spanish waters	STRATUM 2 Portuguese waters
P_o (eggs/m2/day)	241.8	19.3
P_{total} (eggs/day)	108.09 E+10	2.61 E+10
Z (day-1)	-0.04	0.006

Table 11.3.2.2. Anchovy in Division IXa. *BOCADEVA 0605* survey. Nested Analysis of Variance Table for selecting the Generalised Linear Model, GLM, expressing the functional dependence between batch fecundity and gonad-free weight.

```
Model 1: Fobs ~ -1 + Stratum + Wnov:Stratum
Model 2: Fobs ~ Wnov:Stratum
Model 3: Fobs ~ -1 + Wnov:Stratum
Model 4: Fobs ~ -1 + Wnov
  Res.Df        RSS  Df  Sum of Sq       F    Pr(>F)
1    266  644974394
2    267  646442089  -1   -1467695  0.6053  0.437252
3    268  669232854  -1  -22790765  9.3994  0.002394 **
4    269  803650457  -1 -134417603 55.4364 1.346e-12 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table 11.3.2.3. Anchovy in Division IXa. *BOCADEVA 0605* survey. ANOVA table for GLM 2.

```
Call:
glm(formula = Fobs ~ Wnov:Stratum, data = adults.dat, weights = 1/sqrt(Wnov),
    na.action = "na.omit")

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-4061.75  -1034.18    -23.32   1041.50   4370.79

Coefficients:
                         Estimate  Std. Error  t value   Pr(>|t|)
(Intercept)        -2234.96     728.45   -3.068    0.00238 **
Wnov:Stratum1   881.26      42.19   20.886    < 2e-16 ***
Wnov:Stratum2   680.44      30.62   22.222    < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 2421131)

    Null deviance: 1907760248  on 269  degrees of freedom
Residual deviance:  646442089  on 267  degrees of freedom
AIC: 5134.1
Number of Fisher Scoring iterations: 2
```

Table 11.4.1.1. Anchovy in Division IXa. Spanish catch in numbers ('000) at age of Gulf of Cadiz anchovy (Sub-division IXa-South, 1988-2006) on a quarterl half-year (HY) and annual basis. Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's algorithm.

1988	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	13204	55286	0	68490	68490
	1	89197	188073	87183	18794	277269	105976	383245
	2	0	0	1928	0	0	1928	1928
	3	0	0	0	0	0	0	0
	Total (n)	89197	188073	102315	74080	277269	176394	453663
	Catch (t)	730	1815	1164	553	2545	1718	4263
	SOP	728	1810	1164	552	2537	1716	4253
	VAR.%	100	100	100	100	100	100	100

1989	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	2652	7981	0	10633	10633
	1	199286	302223	69570	3471	501509	73042	574551
	2	0	0	5747	0	0	5747	5747
	3	0	0	0	0	0	0	0
	Total (n)	199286	302223	77969	11452	501509	89421	590930
	Catch (t)	1314	2579	1327	110	3892	1437	5330
	SOP	1311	2563	1322	110	3874	1432	5306
	VAR.%	100	101	100	100	100	100	100

1990	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	18313	316191	0	334504	334504
	1	341850	206863	99526	5373	548713	104900	653612
	2	185	0	929	0	185	929	1114
	3	0	0	0	0	0	0	0
	Total (n)	342035	206863	118768	321565	548897	440333	989230
	Catch (t)	2273	1544	1169	740	3816	1909	5726
	SOP	2271	1543	1166	739	3814	1905	5719
	VAR.%	100	100	100	100	100	100	100

1991	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	11537	45411	0	56948	56948
	1	351314	334722	36156	1189	686036	37345	723381
	2	0	4053	1591	376	4053	1968	6021
	3	0	0	0	0	0	0	0
	Total (n)	351314	338775	49284	46977	690089	96261	786350
	Catch (t)	1049	3673	701	273	4722	975	5697
	SOP	1035	3638	696	271	4672	968	5640
	VAR.%	101	101	101	101	101	101	101

1992	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	2415	0	0	2415	2415
	1	159677	147523	42707	86	307200	42793	349993
	2	182	0	861	41	182	902	1084
	3	63	0	0	0	63	0	63
	Total (n)	159922	147523	45983	127	307445	46110	353555
	Catch (t)	1125	1367	499	4	2492	503	2995
	SOP	1120	1364	498	4	2484	502	2986
	VAR.%	100	100	100	100	100	100	100

1993	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	13797	23517	0	37314	37314
	1	73104	81486	12120	2025	154590	14145	168735
	2	576	649	0	12	1225	12	1237
	3	0	0	0	0	0	0	0
	Total (n)	73680	82135	25917	25555	155815	51472	207287
	Catch (t)	767	921	167	105	1688	272	1960
	SOP	761	914	166	105	1675	271	1946
	VAR.%	101	101	100	100	101	100	101

1994	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	1794	960	0	2755	2755
	1	130013	217610	5150	3512	347622	8662	356285
	2	1	31	4576	691	32	5267	5299
	3	0	0	0	0	0	0	0
	Total (n)	130014	217641	11521	5163	347655	16684	364339
	Catch (t)	690	2055	210	80	2745	290	3035
	SOP	687	2045	210	80	2732	290	3022
	VAR.%	100	100	100	101	100	100	100

1995	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	11256	23241	0	34497	34497
	1	19579	6928	6851	602	26508	7453	33961
	2	189	0	0	0	189	0	189
	3	0	0	0	0	0	0	0
	Total (n)	19769	6928	18107	23843	26697	41950	68647
	Catch (t)	185	80	148	157	265	305	571
	SOP	184	79	148	157	264	305	568
	VAR.%	101	101	100	100	101	100	100

1996	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	413465	71074	0	484540	484540
	1	12772	130880	11550	7281	143652	18832	162483
	2	13	882	826	333	894	1159	2053
	3	0	0	0	0	0	0	0
	Total (n)	12785	131761	425842	78688	144546	504530	649076
	Catch (t)	41	807	585	348	848	933	1780
	SOP	36	743	621	306	779	926	1706
	VAR.%	114	109	94	113	109	101	104

1997	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	237283	96475	0	333758	333758
	1	67055	123878	69278	19430	190933	88708	279641
	2	22601	9828	11649	745	32429	12394	44823
	3	0	0	0	0	0	0	0
	Total (n)	89656	133706	318211	116650	223362	434860	658223
	Catch (t)	906	1110	2006	578	2016	2584	4600
	SOP	844	1273	1923	596	2117	2519	4635
	VAR.%	107	87	104	97	95	103	99

1998	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	75708	360599	0	436307	436307
	1	325407	384529	220869	84729	709936	305599	1015535
	2	11066	879	1316	0	11944	1316	13260
	3	0	0	0	0	0	0	0
	Total (n)	336473	385408	297893	445329	721881	743221	1465102
	Catch (t)	1773	2113	2514	2579	3885	5092	8977
	SOP	1923	2127	2599	2654	4050	5254	9304
	VAR.%	92	99	97	97	96	97	96

1999	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	40549	84234	0	124784	124784
	1	249922	115218	86931	20276	365140	107207	472348
	2	10982	18701	2450	146	29683	2596	32279
	3	0	0	0	0	0	0	0
	Total (n)	260904	133919	129931	104656	394823	234587	629410
	Catch (t)	1335	1983	1582	687	3318	2269	5587
	SOP	1330	1756	1391	673	3087	2064	5150
	VAR.%	100	113	114	102	107	110	108

Table 11.4.1.1 (Contd)

2000	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	41028	77780	0	118808	118808
	1	75141	65947	46460	9949	141088	56409	197497
	2	638	2670	523	14	3307	537	3844
	3	0	0	0	0	0	0	0
	Total (n)	75779	68617	88011	87743	144395	175755	320150
	Catch (t)	329	660	655	537	989	1193	2182
	SOP	327	659	666	535	986	1201	2187
	VAR.%	101	100	98	100	100	99	100

2001	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	30987	127140	0	158126	158126
	1	98687	227388	177264	37992	326075	215256	541331
	2	4155	14028	4535	624	18183	5159	23342
	3	0	0	0	0	0	0	0
	Total (n)	102842	241416	212785	165756	344258	378541	722800
	Catch (t)	924	3031	3195	1066	3955	4261	8216
	SOP	908	3014	3145	1065	3922	4210	8132
	VAR.%	102	101	102	100	101	101	101

2002	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	45129	29271	0	74399	74399
	1	218090	304295	149120	36565	522385	185685	708070
	2	2004	6083	8808	620	8087	9428	17515
	3	0	0	0	0	0	0	0
	Total (n)	220094	310378	203057	66456	530471	269512	799984
	Catch (t)	1700	2814	2566	789	4515	3355	7870
	SOP	1617	2778	2524	818	3937	3342	7737
	VAR.%	105	101	102	96	115	100	102

2003	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	26034	45813	0	71847	71847
	1	96135	229184	49058	7028	325320	56087	381407
	2	10041	2587	481	0	12628	481	13109
	3	0	0	0	0	0	0	0
	Total (n)	106176	231772	75574	52841	337948	128415	466363
	Catch (t)	1025	2533	798	413	3557	1211	4768
	SOP	1031	2398	759	378	3430	1137	4567
	VAR.%	99	106	105	109	96	94	104

2004	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			31680	74278	0	105958	105958
	1	157200	165738	69542	6383	322937	75924	398862
	2	388	1419	248	534	1808	782	2590
	3	0	0	0	0	0	0	0
	Total (n)	157588	167157	101470	81195	324745	182665	507410
	Catch (t)	1382	1975	1192	634	3357	1826	5183
	SOP	1284	1844	1194	593	3129	1788	4916
	VAR.%	108	107	100	107	107	102	105

2005	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			24163	13743		37906	37906
	1	195482	249404	36999	371	444886	37370	482256
	2	2716	445	334	0	3161	334	3495
	3	0	0	0	0	0	0	0
	Total (n)	198198	249848	61496	14114	448046	75610	523656
	Catch (t)	1361	2241	705	77	3602	783	4385
	SOP	1302	2098	665	67	3401	732	4132
	VAR.%	105	107	106	115	106	107	106

2006	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	9552	1751	0	11303	11303
	1	152978	296608	41515	206	449586	41721	491307
	2	2944	2317	0	0	5261	0	5261
	3	0	0	0	0	0	0	0
	Total (n)	155922	298925	51068	1957	454847	53024	507871
	Catch (t)	1289	2655	414	9	3944	424	4368
	SOP	1206	2474	387	8	3680	395	4075
	VAR.%	107	107	107	108	107	107	107

Table 11.4.2.1. Anchovy in Division IXa. Length distribution ('000) of Anchovy in Division IXa by country and Sub-divisions in 2006.

	QUARTER 1			QUARTER 2			QUARTER 3			QUARTER 4			TOTAL		
Length (cm)	SPAIN IXa North	PORTUGAL IXa CN,CS,S	SPAIN IXa South	SPAIN IXa North	PORTUGAL IXa CN,CS,S	SPAIN IXa South	SPAIN IXa North	PORTUGAL IXa CN,CS,S	SPAIN IXa South	SPAIN IXa North	PORTUGAL IXa CN,CS,S	SPAIN IXa South	SPAIN IXa North	PORTUGAL IXa CN,CS,S	SPAIN IXa South
3.5	-	-		-	-		-	-		-	-		-	-	
4	-	-		-	-		-	-		-	-		-	-	
4.5	-	-		-	-		-	-		-	-		-	-	
5	-	-		-	-		-	-		-	-		-	-	
5.5	-	-		-	-		-	-		-	-		-	-	
6	-	-	40	-	-	333	-	-		-	-		-	-	373
6.5	-	-	79	-	-	707	-	-	47	-	-		-	-	833
7	-	-	134	-	-	1931	-	-	211	-	-	14	-	-	2290
7.5	-	-	593	-	-	5445	-	-	490	-	-	43	-	-	6570
8	-	-	1116	-	-	6228	-	-	1132	-	-	143	-	-	8619
8.5	-	-	3751	-	-	13470	-	-	3439	-	-	369	-	-	21029
9	-	-	13782	-	-	20789	-	-	7006	-	-	490	-	-	42067
9.5	-	-	20146	-	-	28286	-	-	5846	-	-	427	-	-	54706
10	-	-	17768	-	-	29754	-	-	4906	-	-	327	-	-	52755
10.5	-	-	20145	-	-	33717	-	-	5361	-	-	91	-	-	59314
11	-	-	19832	-	-	43446	-	-	4974	-	-	23	-	-	68275
11.5	-	-	17791	-	-	27725	-	-	4829	-	-	15	-	-	50360
12	-	-	17975	-	-	24400	-	-	3447	-	-	11	-	-	45833
12.5	-	-	11515	-	-	17862	-	-	3316	-	-	4	-	-	32697
13	-	-	7743	-	-	24453	-	-	2916	-	-		-	-	35112
13.5	-	-	1908	-	-	10634	-	-	1211	-	-		-	-	13754
14	-	-	1169	-	-	6236	-	-	1163	-	-		-	-	8568
14.5	-	-	348	-	-	1277	-	-	515	-	-		-	-	2140
15	-	-	87	-	-	1617	-	-	259	-	-		-	-	1963
15.5	-	-		-	-	172	-	-		-	-		-	-	172
16	-	-		-	-	441	-	-		-	-		-	-	441
16.5	-	-		-	-		-	-		-	-		-	-	
17	-	-		-	-		-	-		-	-		-	-	
17.5	-	-		-	-		-	-		-	-		-	-	
18	-	-		-	-		-	-		-	-		-	-	
18.5	-	-		-	-		-	-		-	-		-	-	
19	-	-		-	-		-	-		-	-		-	-	
19.5	-	-		-	-		-	-		-	-		-	-	
20	-	-		-	-		-	-		-	-		-	-	
20.5	-	-		-	-		-	-		-	-		-	-	
21	-	-		-	-		-	-		-	-		-	-	
21.5	-	-		-	-		-	-		-	-		-	-	
22	-	-		-	-		-	-		-	-		-	-	
Total N	-	-	155922	-	-	298925	-	-	51068	-	-	1957	-	-	507871
Catch (T)	1	72	1289	0.1	21	2655	3	3	414	11	13	9	15	108	4368
L avg (cm)	-	-	10.8	-	-	10.9	-	-	10.6	-	-	9.2	-	-	10.8
W avg (g)	-	-	7.7	-	-	8.3	-	-	7.6	-	-	4.3	-	-	8.0

Table 11.4.2.2: Anchovy in Division IXa. Annual Length distributions by Sub-division ('000) available from 1988 to 2006.

	1988	1989	1990	1991	1992	1993	1994	1995		1996		1997		1998		1999		2000	2001	2002	2003	2004	2005	2006
Length	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**	**SPAIN**
(cm)	**IXa South**	**IXa South**	**IXa South**	**IXa South**	**IXa South**	**IXa South**	**IXa South**	**IXa North**	**IXa South**	**IXa North**	**IXa South**	**IXa North**	**IXa South**	**IXa North**	**IXa South**	**IXa North**	**IXa South**	**IXa South**	**IXa South**	**IXa South**	**IXa South**	**IXa South**	**IXa South**	**IXa South**
3.5											1349								266	77				
4			4281	172	2	49					12677						1831	114	200	275	36		16	
4.5			18371	3937	29	707					67819		1333		4656		17055	856	1649	1463	116	25	130	
5	65		32251	54991	90	1832					160894		11492		25825		41100	5006	5489	3871	218	54	146	
5.5	86		46584	80537	369	3247					129791		38722		57086		36181	9391	9301	8742	653	213	81	
6			45810	43303	983	5031					52812		53185		82442		19366	12961	11832	13779	1763	396	445	373
6.5		1185	44454	28102	2685	6463	6092				33640		50275		76694		20421	11446	15051	17768	3132	759	734	833
7	226	3906	37065	17847	4094	6169	13330				32469		62492		68074		17749	11754	15911	14238	4800	1745	1112	2290
7.5	347	5609	34614	20448	7178	7507	20415		402		19088		42120		43197		19089	20386	10684	14800	5389	2358	3041	6570
8	1871	15959	32562	20037	15632	8325	26136		402		8949		45120		32964		20835	19704	16989	14137	10074	3613	14965	8619
8.5	7892	36001	43081	17916	22442	7748	24497		454		11776		36200		47796		15724	18590	19426	18211	17371	5683	37584	21029
9	13492	31905	53016	19745	16924	7820	22586		2799		12007		20009	156	78561		14937	19435	22924	29985	23525	15726	44826	42067
9.5	26090	36222	88097	34408	23280	8612	16520		9153		6844		13611	367	106350		17487	27397	29620	66330	33446	35970	39459	54706
10	42791	69717	115050	40656	37450	7320	26383		10743		4887		8951	754	132106		23530	34049	35897	67732	43164	57645	64282	52755
10.5	60760	82715	108001	59678	38310	9199	30570		13282		7156		12231	1486	150718		31482	26203	43145	60360	48805	61361	115117	59314
11	73499	82718	86757	67113	39426	8500	31536		8408		17343		22647	2047	158806		33604	21814	50672	66572	50797	64192	60964	68275
11.5	61624	64599	72875	63013	36883	10154	37310		7340		21738		27353	1477	133585		40004	18846	59031	65752	44753	60307	30119	50360
12	66239	50823	50592	65983	39500	24246	29363	74	5279		17855		39131	1267	99586		55614	18734	66873	79576	43017	62435	40492	45833
12.5	42651	42791	34023	54033	33181	33555	33560	711	4502		11544		45267	1178	76285		66384	14738	68648	61848	38544	46567	21081	32697
13	26053	20237	19022	45191	19867	27543	17543	3049	2299	8	6450	374	46852	2737	44979		52625	11841	59942	54683	33673	43285	19523	35112
13.5	9415	11846	12683	21333	7003	13059	9602	3381	1957	12	4468	997	38183	2403	25038	92	38719	9197	50964	54884	21756	22454	15870	13754
14	4954	8397	5779	13684	3785	5710	6493	14998	1205	258	3880	2004	19127	3038	11847	246	22962	6860	39385	32016	18802	14336	10081	8568
14.5	561	3048	1671	4097	2293	2793	5495	25944	194	335	1990	422	11268	2813	5712	497	13247	3713	23375	26055	8870	5367	2243	2140
15	6102	2147	817	2391	521	1082	4217	46371	219	375	790	48	6370	1976	2080	1075	6811	2812	16035	14275	7415	1720	835	1963
15.5	2985	1757	402	1194	1045	525	1054	42244	8	226	703	40	3764	890	579	1160	2422	983	9402	6655	3418	762	306	172
16	2995	4975	370	1943	271	75	977	44171		227	159	33	2224	560	138	1658	889	294	8305	3936	1609	107	201	441
16.5	2621	7842	489	2406	225	17	443	14369		151		10	296	330		2430	246	4	5034	946	721	329		
17	252	4584	275	1767	75		216	8378		104		10		438		2221		97	3065	784	493			
17.5	109	1325	133	595	12			778		94		13		311		1717			2731	234				
18		621	95	75				236		24						1045			38					
18.5			10							21						397								
19										1						317			38					
19.5																138								
20																								
20.5																								
21																								
21.5																								
22																								
Total N	453679	590930	989230	786595	353555	207287	364339	204705	68647	1835	649078	3951	658223	24231	1465102	12993	630315	327225	701921	799984	466363	507410	523656	507871
Catch (T)	4263	5330	5726	5697	2995	1960	3035	5329	571	44	1780	63	4600	371	8977	413	5587	2182	8216	7870	4768	5183	4385	4368
L avg (cm)	11.3	11.0	9.3	9.6	10.7	10.9	10.5	15.6	10.9	15.6	6.6	14.2	9.4	13.4	9.7	16.8	10.1	9.8	11.4	11.1	11.2	11.3	10.6	10.8
W avg (g)	9.4	9.0	5.8	7.2	8.4	9.4	8.3	26.0	8.3	23.7	2.6	16.1	7.0	15.3	6.3	31.8	8.1	6.8	11.3	9.7	9.8	9.7	7.9	8.0

Table 11.4.2.3. Anchovy in Division IXa. Mean length (TL, in cm) at age in the Spanish catches of Gulf of Cadiz anchovy (Sub-division IXa-South, 1988-2006) on a quarterly (Q), half-year (HY) and annual basis. Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.

1988	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9.4	10.2		10.0	10.0
	1	10.9	11.4	12.3	12.2	11.3	12.3	11.6
	2			16.4			16.4	16.4
	3							
	Total	10.9	11.4	12.0	10.7	11.3	11.5	11.3
1989	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			9.1	10.9		10.5	10.5
	1	10.1	10.8	13.3	13.3	10.5	13.3	10.9
	2			16.9			16.9	16.9
	3							
	Total	10.1	10.8	13.4	11.6	10.5	13.2	11.0
1990	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			9.4	6.9		7.1	7.1
	1	10.1	10.4	11.8	11.5	10.2	11.8	10.5
	2	15.2		16.9		15.2	16.9	16.6
	3							
	Total	10.1	10.4	11.5	7.0	10.2	8.2	9.3
1991	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			10.7	9.4		9.7	9.7
	1	7.2	11.5	13.1	16.1	9.3	13.2	9.5
	2		14.9	17.1	17.1	14.9	17.1	15.6
	3							
	Total	7.2	11.5	12.7	9.7	9.3	11.2	9.6
1992	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			9.5			9.5	9.5
	1	10.0	11.1	12.0	15.9	10.5	12.0	10.7
	2	16.3		15.7	16.7	16.3	15.7	15.8
	3	16.9				16.9		16.9
	Total	10.0	11.1	12.0	16.2	10.5	12.0	10.7
1993	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			6.3	7.7		7.2	7.2
	1	11.5	11.7	12.2	13.8	11.6	12.4	11.7
	2	14.7	14.9		16.5	14.8	16.5	14.8
	3							
	Total	11.5	11.8	9.1	8.2	11.6	8.6	10.9

1994	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9.2	9.2		9.2	9.2
	1	9.3	11.0	13.3	13.9	10.4	13.5	10.5
	2	12.8	14.3	15.3	15.4	14.3	15.3	15.3
	3							
	Total	9.3	11.0	13.4	13.2	10.4	13.4	10.5
1995	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			10.3	10.2		10.2	10.2
	1	11.3	11.8	11.4	13.0	11.5	11.6	11.5
	2	14.7				14.7		14.7
	3							
	Total	11.4	11.8	10.7	10.2	11.5	10.4	10.9
1996	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			5.6	7.3		5.8	5.8
	1	7.4	8.5	12.9	13.7	8.4	13.2	8.9
	2	14.0	13.9	15.2	15.6	13.9	15.3	14.7
	3							
	Total	7.4	8.5	5.8	7.9	8.4	6.1	6.6
1997	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			7.1	8.1		7.4	7.4
	1	10.0	10.5	13.1	13.0	10.3	13.0	11.2
	2	13.4	14.0	15.0	15.1	13.6	15.0	14.0
	3							
	Total	10.9	10.8	8.7	8.9	10.8	8.8	9.5
1998	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			7.1	8.8		8.5	8.5
	1	9.5	9.2	11.9	12.2	9.3	12.0	10.1
	2	13.2	14.0	15.0		13.3	15.0	13.5
	3							
	Total	9.6	9.2	10.7	9.5	9.4	10.0	9.7
1999	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			7.7	9.3		8.8	8.8
	1	8.2	12.2	12.7	12.5	9.5	12.7	10.2
	2	13.4	14.1	15.2	14.9	13.8	15.2	13.9
	3							
	Total	8.4	12.5	11.2	10.0	9.8	10.6	10.1

Table 11.4.2.3. (cont.)

2000	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			7.7	9.5		8.9	8.9
	1	8.2	10.9	11.9	12.5	9.4	12.0	10.2
	2	14.1	15.0	15.4	16.1	14.9	15.5	15.0
	3							
	Total	8.2	11.1	10.0	9.8	9.6	9.9	9.8

2001	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9.9	8.4		8.7	8.7
	1	10.7	11.4	13.2	13.0	11.2	13.1	12.0
	2	15.5	16.2	16.3	16.2	16.0	16.3	16.1
	3							
	Total	10.9	11.7	12.8	9.5	11.4	11.3	11.4

2002	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			7.9	10.2		8.8	8.8
	1	10.7	10.6	12.8	13.6	10.6	12.9	11.2
	2	15.0	15.1	15.6	15.7	15.1	15.6	15.4
	3							
	Total	10.7	10.7	11.8	12.1	10.7	11.9	11.1

2003	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9.6	10.1		9.9	9.9
	1	10.8	11.3	12.1	12.6	11.1	12.2	11.3
	2	15.1	15.4	16.5		15.1	16.5	15.2
	3							
	Total	11.2	11.3	11.3	10.4	11.3	10.9	11.2

2004	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9.9	10.1		10.0	10.0
	1	10.9	11.8	12.7	13.3	11.4	12.8	11.6
	2	15.8	14.5	15.9	15.2	14.8	15.4	15.0
	3							
	Total	10.9	11.8	11.8	10.4	11.4	11.2	11.3

2005	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9.0	9.4		9.1	9.1
	1	10.1	10.8	12.7	11.8	10.5	12.7	10.7
	2	13.9	14.3	15.2		14.0	15.2	14.1
	3							
	Total	10.2	10.8	11.3	9.4	10.5	10.9	10.6

2006	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			8.6	9.1		8.7	8.7
	1	10.7	10.8	11.1	10.2	10.8	11.1	10.8
	2	13.5	14.8			14.1		14.1
	3							
	Total	10.8	10.9	10.6	9.2	10.8	10.6	10.8

Table 11.4.2.4. Anchovy in Division IXa. Mean weight (in kg) at age in the Spanish catches of Gulf of Cadiz anchovy (Sub-division IXa-South, 1988-2006) on a quarterly (Q), half-year (HY) and annual basis. Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.

1988	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0.005	0.006		0.006	0.006
	1	0.008	0.010	0.012	0.011	0.009	0.012	0.010
	2			0.028			0.028	0.028
	3							
	Total	0.008	0.010	0.011	0.007	0.009	0.010	0.009
1989	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.004	0.008		0.007	0.007
	1	0.007	0.008	0.016	0.014	0.008	0.016	0.009
	2			0.034			0.034	0.034
	3							
	Total	0.007	0.008	0.017	0.010	0.008	0.016	0.009
1990	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.005	0.002		0.002	0.002
	1	0.007	0.007	0.010	0.009	0.007	0.010	0.008
	2	0.023		0.032		0.023	0.032	0.031
	3							
	Total	0.007	0.007	0.010	0.002	0.007	0.004	0.006
1991	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.008	0.005		0.006	0.006
	1	0.003	0.011	0.015	0.027	0.007	0.016	0.007
	2		0.024	0.036	0.033	0.024	0.035	0.028
	3							
	Total	0.003	0.011	0.014	0.006	0.007	0.010	0.007
1992	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.005			0.005	0.005
	1	0.007	0.009	0.011	0.029	0.008	0.011	0.008
	2	0.027		0.024	0.033	0.027	0.024	0.025
	3	0.030				0.030		0.030
	Total	0.007	0.009	0.011	0.030	0.008	0.011	0.008
1993	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.002	0.003		0.003	0.003
	1	0.010	0.011	0.012	0.016	0.011	0.012	0.011
	2	0.021	0.021		0.028	0.021	0.028	0.021
	3							
	Total	0.010	0.011	0.006	0.004	0.011	0.005	0.009

1994	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0.005	0.005		0.005	0.005
	1	0.005	0.009	0.017	0.017	0.008	0.017	0.008
	2	0.013	0.020	0.025	0.023	0.020	0.025	0.025
	3							
	Total	0.005	0.009	0.018	0.015	0.008	0.017	0.008
1995	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.007	0.006		0.007	0.007
	1	0.009	0.011	0.010	0.014	0.010	0.010	0.010
	2	0.021				0.021		0.021
	3							
	Total	0.009	0.011	0.008	0.007	0.010	0.007	0.008
1996	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.001	0.003		0.001	0.001
	1	0.003	0.006	0.014	0.015	0.005	0.015	0.006
	2	0.018	0.017	0.023	0.023	0.017	0.023	0.020
	3							
	Total	0.003	0.006	0.001	0.004	0.005	0.002	0.003
1997	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.003	0.003		0.003	0.003
	1	0.007	0.009	0.015	0.013	0.008	0.015	0.010
	2	0.016	0.019	0.023	0.021	0.017	0.023	0.018
	3							
	Total	0.009	0.010	0.006	0.005	0.009	0.006	0.007
1998	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.003	0.005		0.004	0.004
	1	0.005	0.005	0.011	0.011	0.005	0.011	0.007
	2	0.014	0.019	0.022		0.014	0.022	0.015
	3							
	Total	0.006	0.006	0.009	0.006	0.006	0.007	0.006
1999	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.003	0.005		0.005	0.004
	1	0.005	0.012	0.014	0.012	0.007	0.013	0.008
	2	0.015	0.020	0.023	0.020	0.018	0.023	0.018
	3							
	Total	0.005	0.013	0.011	0.006	0.008	0.009	0.008

Table 11.4.2.4.(cont.)

2000	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0.003	0.005		0.005	0.005
	1	0.004	0.009	0.011	0.012	0.006	0.011	0.008
	2	0.018	0.024	0.025	0.027	0.023	0.025	0.023
	3							
	Total	0.004	0.010	0.008	0.006	0.007	0.007	0.007
2001	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.006	0.004		0.005	0.005
	1	0.008	0.011	0.016	0.014	0.010	0.015	0.012
	2	0.025	0.032	0.031	0.028	0.030	0.031	0.030
	3							
	Total	0.009	0.012	0.015	0.006	0.011	0.011	0.011
2002	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.003	0.007		0.005	0.005
	1	0.007	0.009	0.014	0.016	0.008	0.015	0.010
	2	0.019	0.025	0.027	0.026	0.024	0.027	0.025
	3							
	Total	0.007	0.009	0.012	0.012	0.008	0.012	0.010
2003	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.006	0.006		0.006	0.006
	1	0.008	0.010	0.012	0.012	0.010	0.012	0.010
	2	0.022	0.026	0.030		0.023	0.030	0.023
	3							
	Total	0.010	0.010	0.010	0.007	0.010	0.009	0.010
2004	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.007	0.007		0.007	0.007
	1	0.008	0.011	0.014	0.015	0.010	0.014	0.010
	2	0.026	0.021	0.028	0.023	0.022	0.024	0.023
	3							
	Total	0.008	0.011	0.012	0.007	0.010	0.010	0.010
2005	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0			0.005	0.005		0.005	0.005
	1	0.006	0.008	0.015	0.009	0.008	0.008	0.008
	2	0.017	0.021	0.025		0.018	0.019	0.019
	3							
	Total	0.007	0.008	0.011	0.005	0.008	0.010	0.008

2006	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0.004	0.004		0.004	0.004
	1	0.008	0.008	0.008	0.006	0.008	0.008	0.008
	2	0.015	0.021			0.017		0.017
	3							
	Total	0.008	0.008	0.008	0.004	0.008	0.007	0.008

Table 11.4.3. Anchovy in Division IXa. Maturity ogives (ratio of mature fish at age) for Gulf of Cadiz anchovy (Sub-division IXa South).

Year	Age		
	0	1	2+
1988	0	0.82	1
1989	0	0.53	1
1990	0	0.65	1
1991	0	0.76	1
1992	0	0.53	1
1993	0	0.77	1
1994	0	0.60	1
1995	0	0.76	1
1996	0	0.49	1
1997	0	0.63	1
1998	0	0.55	1
1999	0	0.74	1
2000	0	0.70	1
2001	0	0.76	1
2002	0	0.72	1
2003	0	0.69	1
2004	0	0.95	1
2005	0	0.95	1
2006	0	0.77	1

Table 11.5.1. Anchovy in Division IXa. Parameter estimates of the GLM used for standardisation of CPUE data for Spanish fleets in Sub-division IXa-South (Gulf of Cadiz).

GLM Parameter Estimates
Dependent Variable: LNCPUE
Fleet type of reference= Barbate's high-tonnage single-purpose fleet (FLEETTYPE=11)
Quarter of reference= 1st quarter 1988 (QUARTER=76)

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta-Squared	Noncentrality Parameter	Observed Power (a)
					Lower Bound	Upper Bound			
Intercept	0.070	0.706	0.099	0.922	-1.320	1.459	0.000	0.099	0.051
[QUARTER=1,00]	-0.706	0.798	-0.885	0.377	-2.276	0.864	0.003	0.885	0.143
[QUARTER=2,00]	-0.137	0.768	-0.178	0.859	-1.649	1.376	0.000	0.178	0.054
[QUARTER=3,00]	1.109	0.768	1.443	0.150	-0.404	2.622	0.007	1.443	0.301
[QUARTER=4,00]	0.837	0.768	1.089	0.277	-0.675	2.350	0.004	1.089	0.192
[QUARTER=5,00]	0.135	0.779	0.174	0.862	-1.398	1.668	0.000	0.174	0.053
[QUARTER=6,00]	0.270	0.768	0.352	0.725	-1.242	1.783	0.000	0.352	0.064
[QUARTER=7,00]	1.428	0.768	1.859	0.064	-0.084	2.941	0.012	1.859	0.457
[QUARTER=8,00]	0.692	0.768	0.900	0.369	-0.821	2.204	0.003	0.900	0.146
[QUARTER=9,00]	0.491	0.761	0.646	0.519	-1.006	1.989	0.001	0.646	0.099
[QUARTER=10,00]	0.246	0.750	0.327	0.744	-1.231	1.722	0.000	0.327	0.062
[QUARTER=11,00]	0.387	0.760	0.508	0.612	-1.110	1.883	0.001	0.508	0.080
[QUARTER=12,00]	0.217	0.761	0.284	0.776	-1.282	1.715	0.000	0.284	0.059
[QUARTER=13,00]	-0.322	0.760	-0.424	0.672	-1.819	1.174	0.001	0.424	0.071
[QUARTER=14,00]	-0.139	0.760	-0.183	0.855	-1.636	1.357	0.000	0.183	0.054
[QUARTER=15,00]	0.707	0.760	0.929	0.353	-0.790	2.203	0.003	0.929	0.153
[QUARTER=16,00]	0.372	0.768	0.484	0.629	-1.141	1.885	0.001	0.484	0.077
[QUARTER=17,00]	0.221	0.761	0.290	0.772	-1.277	1.718	0.000	0.290	0.060
[QUARTER=18,00]	0.835	0.755	1.105	0.270	-0.652	2.321	0.004	1.105	0.196
[QUARTER=19,00]	0.525	0.755	0.695	0.488	-0.962	2.011	0.002	0.695	0.106
[QUARTER=20,00]	0.834	0.751	1.111	0.267	-0.643	2.312	0.004	1.111	0.198
[QUARTER=21,00]	0.747	0.755	0.989	0.324	-0.740	2.233	0.003	0.989	0.166
[QUARTER=22,00]	1.453	0.751	1.936	0.054	-0.024	2.931	0.013	1.936	0.488
[QUARTER=23,00]	1.449	0.747	1.940	0.053	-0.021	2.919	0.013	1.940	0.489
[QUARTER=24,00]	1.179	0.755	1.561	0.120	-0.308	2.665	0.008	1.561	0.343
[QUARTER=25,00]	0.490	0.761	0.644	0.520	-1.007	1.987	0.001	0.644	0.098
[QUARTER=26,00]	-0.045	0.769	-0.058	0.954	-1.558	1.468	0.000	0.058	0.050
[QUARTER=27,00]	0.067	0.782	0.086	0.931	-1.472	1.607	0.000	0.086	0.051
[QUARTER=28,00]	0.059	0.782	0.075	0.940	-1.481	1.598	0.000	0.075	0.051
[QUARTER=29,00]	-0.065	0.755	-0.086	0.932	-1.550	1.420	0.000	0.086	0.051
[QUARTER=30,00]	-0.141	0.755	-0.186	0.852	-1.626	1.345	0.000	0.186	0.054
[QUARTER=31,00]	0.079	0.755	0.105	0.917	-1.406	1.564	0.000	0.105	0.051
[QUARTER=32,00]	-0.044	0.755	-0.058	0.954	-1.529	1.442	0.000	0.058	0.050
[QUARTER=33,00]	0.247	0.779	0.317	0.751	-1.285	1.779	0.000	0.317	0.062
[QUARTER=34,00]	0.135	0.779	0.174	0.862	-1.397	1.668	0.000	0.174	0.053
[QUARTER=35,00]	0.222	0.779	0.285	0.776	-1.310	1.754	0.000	0.285	0.059
[QUARTER=36,00]	0.520	0.779	0.668	0.505	-1.013	2.052	0.002	0.668	0.102
[QUARTER=37,00]	-0.137	0.767	-0.179	0.858	-1.648	1.373	0.000	0.179	0.054
[QUARTER=38,00]	-0.001	0.767	-0.001	0.999	-1.512	1.510	0.000	0.001	0.050
[QUARTER=39,00]	-0.479	0.767	-0.624	0.533	-1.989	1.032	0.001	0.624	0.095
[QUARTER=40,00]	-0.951	0.778	-1.223	0.222	-2.482	0.580	0.005	1.223	0.230
[QUARTER=41,00]	-0.664	0.778	-0.853	0.394	-2.196	0.868	0.003	0.853	0.136
[QUARTER=42,00]	-0.270	0.778	-0.347	0.729	-1.802	1.262	0.000	0.347	0.064
[QUARTER=43,00]	-0.573	0.778	-0.736	0.462	-2.105	0.959	0.002	0.736	0.114
[QUARTER=44,00]	-0.694	0.797	-0.871	0.384	-2.263	0.874	0.003	0.871	0.140
[QUARTER=45,00]	-1.197	0.797	-1.502	0.134	-2.765	0.371	0.008	1.502	0.322
[QUARTER=46,00]	-1.024	0.797	-1.285	0.200	-2.592	0.544	0.006	1.285	0.249
[QUARTER=47,00]	-0.950	0.778	-1.221	0.223	-2.482	0.582	0.005	1.221	0.229
[QUARTER=48,00]	-1.445	0.794	-1.819	0.070	-3.008	0.119	0.011	1.819	0.442
[QUARTER=49,00]	-0.486	0.778	-0.625	0.532	-2.018	1.045	0.001	0.625	0.095
[QUARTER=50,00]	-0.077	0.778	-0.099	0.921	-1.609	1.454	0.000	0.099	0.051
[QUARTER=51,00]	0.097	0.794	0.122	0.903	-1.466	1.660	0.000	0.122	0.052
[QUARTER=52,00]	0.458	0.820	0.558	0.577	-1.156	2.071	0.001	0.558	0.086
[QUARTER=53,00]	-0.738	0.867	-0.851	0.395	-2.446	0.969	0.003	0.851	0.136
[QUARTER=54,00]	-1.248	0.998	-1.250	0.212	-3.213	0.717	0.005	1.250	0.238
[QUARTER=55,00]	-0.262	0.820	-0.320	0.749	-1.875	1.351	0.000	0.320	0.062
[QUARTER=56,00]	-0.485	0.869	-0.558	0.577	-2.195	1.225	0.001	0.558	0.086
[QUARTER=57,00]	-0.466	0.867	-0.538	0.591	-2.174	1.241	0.001	0.538	0.084
[QUARTER=58,00]	-0.865	0.998	-0.867	0.387	-2.830	1.100	0.003	0.867	0.139
[QUARTER=59,00]	-0.449	0.820	-0.548	0.584	-2.062	1.164	0.001	0.548	0.085
[QUARTER=60,00]	-0.146	0.820	-0.178	0.859	-1.759	1.467	0.000	0.178	0.054
[QUARTER=61,00]	-0.112	0.867	-0.129	0.897	-1.819	1.595	0.000	0.129	0.052
[QUARTER=62,00]	0.075	0.867	0.086	0.932	-1.633	1.782	0.000	0.086	0.051
[QUARTER=63,00]	0.063	0.869	0.072	0.943	-1.648	1.773	0.000	0.072	0.051
[QUARTER=64,00]	0.146	0.869	0.167	0.867	-1.565	1.856	0.000	0.167	0.053
[QUARTER=65,00]	-0.810	0.820	-0.989	0.324	-2.424	0.803	0.003	0.989	0.167
[QUARTER=66,00]	0.010	0.867	0.011	0.991	-1.697	1.717	0.000	0.011	0.050
[QUARTER=67,00]	-0.039	0.820	-0.048	0.962	-1.653	1.574	0.000	0.048	0.050
[QUARTER=68,00]	0.416	0.820	0.507	0.612	-1.197	2.029	0.001	0.507	0.080
[QUARTER=69,00]	-1.087	0.867	-1.254	0.211	-2.795	0.620	0.005	1.254	0.239
[QUARTER=70,00]	0.364	0.867	0.419	0.675	-1.344	2.071	0.001	0.419	0.070
[QUARTER=71,00]	0.399	0.869	0.459	0.647	-1.312	2.109	0.001	0.459	0.074
[QUARTER=72,00]	0	0.869	0.503	0.616	-1.273	2.147	0.001	0.503	0.079
[QUARTER=73,00]	-0.330	0.998	-0.331	0.741	-2.295	1.635	0.000	0.331	0.063
[QUARTER=74,00]	0.144	0.820	0.175	0.861	-1.470	1.757	0.000	0.175	0.053
[QUARTER=75,00]	-0.620	0.820	-0.756	0.450	-2.233	0.993	0.002	0.756	0.117
[QUARTER=76,00]	0.000	.	.	.	.	.	.	.	.
[FLEETTYPE=1,00]	-2.141	0.174	-12.285	0.000	-2.484	-1.798	0.345	12.285	1.000
[FLEETTYPE=2,00]	-2.040	0.224	-9.123	0.000	-2.480	-1.600	0.225	9.123	1.000
[FLEETTYPE=3,00]	-0.836	0.173	-4.826	0.000	-1.177	-0.495	0.075	4.826	0.998
[FLEETTYPE=4,00]	-1.555	0.140	-11.111	0.000	-1.831	-1.280	0.301	11.111	1.000
[FLEETTYPE=5,00]	-1.568	0.137	-11.410	0.000	-1.838	-1.297	0.313	11.410	1.000
[FLEETTYPE=6,00]	-1.649	0.164	-10.068	0.000	-1.972	-1.327	0.262	10.068	1.000
[FLEETTYPE=7,00]	-1.753	0.157	-11.159	0.000	-2.062	-1.444	0.303	11.159	1.000
[FLEETTYPE=8,00]	-0.965	0.151	-6.403	0.000	-1.262	-0.668	0.125	6.403	1.000
[FLEETTYPE=9,00]	-1.028	0.193	-5.321	0.000	-1.409	-0.648	0.090	5.321	1.000
[FLEETTYPE=10,00]	-0.808	0.282	-2.866	0.004	-1.362	-0.253	0.028	2.866	0.815
[FLEETTYPE=11,00]	0.000	.	.	.	.	.	.	.	.

a Computed using alfa = ,05
b A 0 value has been assigned to the parameter because is redundant.

FLEETTYPE CODE	Description of the metiérs
1	Isla Cristina's Multi-purpose
2	Punta Umbría's Multi-purpose
3	Sanlucar de Barrameda's Multi-purpose
4	Barbate's Multi-purpose
5	Isla Cristina's Light-tonnage Single-purpose
6	Punta Umbría's Light-tonnage Single-purpose
7	Sanlucar de Barrameda's Light-tonnage Single-purpose
8	Barbate's Light-tonnage Single-purpose
9	Isla Cristina's High-tonnage Single-purpose
10	Mediterranean High-tonnage Single-purpose
11	Barbate's High-tonnage Single-purpose

Table 11.5.2. Anchovy in Division IXa. ANOVA results of the GLM used for standardisation of CPUE data for Spanish fleets in Sub-division IXa-South (Gulf of Cadiz).

ANOVA:Tests of between-subjects effects
Dependent variable: Ln CPUE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta-Squared	Noncentrality parameter	Observed power (a)
Corrected Model	309.975	85	3.647	7.319	1.130E-37	0.685	622.078	1.000
Intercept	246.543	1	246.543	494.779	2.514E-64	0.634	494.779	1.000
QUARTER	124.174	75	1.656	3.323	2.231E-13	0.466	249.201	1.000
FLEETTYPE	146.182	10	14.618	29.337	1.814E-38	0.506	293.368	1.000
Error	142.511	286	0.498					
Total	797.530	372						
Corrected Total	452.485	371						

a Computed using alfa = ,05

b R Squared = ,685 (Adjusted R Squared = ,591)

Table 11.5.3. Anchovy in Division IXa. Effort data (no. of standardised fishing trips fishing anchovy) for Spanish fleets in Sub-division IXa-South (Gulf of Cadiz) (SP: single purpose; MP: multi purpose; HT: heavy GRT; LT: light GRT). Color intensities denote increasing problems in sampling coverage of fishing effort.

	SUB-DIVISION IXa SOUTH (Gulf of Cadiz)															
	PURSE SEINE															
FLEET	BARBATE			SANLÚCAR		P.UMBRÍA		I. CRISTINA			MEDIT.	SUBTOTAL	SUBTOTAL	TOTAL	TOTAL	OVERALL
	(SP-HT)	(SP-LT)	(MP)	(SP-LT)	(MP)	(SP-LT)	(MP)	(SP-HT)	(SP-LT)	(MP)	(SP-HT)	SP-HT	SP-LT	SP	MP	EFFORT
Year	No. fishing trips															
1988	5329	-	30	-	299	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	5329	?	5329	329	**5658**
1989	3351	-	65	-	318	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	3351	?	3351	383	**3734**
1990	4734	-	103	-	1633	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	4734	?	4734	1736	**6470**
1991	4563	-	63	-	750	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	4563	?	4563	813	**5377**
1992	4125	-	115	-	492	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	4125	?	4125	606	**4731**
1993	2025	-	10	-	188	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	2025	?	2025	197	**2223**
1994	1748	-	107	-	702	*n.a.*	*n.a.*	0	149	31	-	1748	149	1896	840	**2737**
1995	692	-	30	-	455	*n.a.*	*n.a.*	0	17	12	-	692	17	710	496	**1206**
1996	1286	-	186	-	1338	*n.a.*	*n.a.*	0	85	131	-	1286	85	1372	1655	**3026**
1997	5097	23	188	-	1167	*n.a.*	*n.a.*	0	48	16	-	5097	72	5169	1370	**6539**
1998	4854	59	0	2170	0	*n.a.*	*n.a.*	0	153	40	-	4854	2382	7236	40	**7276**
1999	3593	88	9	3006	0	477	643	0	208	325	-	3593	3780	7373	978	**8351**
2000	37	2309	0.4	2212	0	1151	134	0	878	0	-	37	6549	6587	135	**6721**
2001	171	1577	139	502	0	3063	12	140	2046	6	295	606	7188	7795	158	**7952**
2002	2658	759	39	638	0	3095	6	8	678	0	117	2784	5170	7954	46	**8000**
2003	2265	495	12	1795	0	1402	0	60	670	0	0	2325	4362	6687	12	**6699**
2004	2526	640	3	736	0	1866	30	134	978	7	0	2660	4219	6879	40	**6920**
2005	1088	389	0	620	0	1117	0	110	501	0	0	1198	2626	3824	0	**3824**
2006	910	291	0	1120	0	1412	0	210	1132	0	0	1120	3956	5077	0	**5077**

Table 11.5.4. Anchovy in Division IXa. Standardised CPUE data (Tonnes/fishing trip) for Spanish fleets in Sub-division IXa-South (Gulf of Cadiz) (SP: single purpose; MP: multi purpose; HT: heavy GRT; LT: light GRT).

	SUB-DIVISION IXa SOUTH (Gulf of Cadiz)																
	PURSE SEINE																
FLEET	BARBATE			SANLÚCAR		P.UMBRÍA		I. CRISTINA			MEDIT.	SUBTOTAL	SUBTOTAL	TOTAL	TOTAL	OVERALL
	(SP-HT)	(SP-LT)	(MP)	(SP-LT)	(MP)	(SP-LT)	(MP)	(SP-HT)	(SP-LT)	(MP)	(SP-HT)	SP-HT	SP-LT	SP	MP	CPUE
Year	Tonnes/fishing trip															
1988	0.778	-	0.260	-	0.295	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	0.778	?	0.778	0.292	**0.750**
1989	1.500	-	0.323	-	0.693	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	1.500	?	1.500	0.631	**1.411**
1990	1.102	-	0.256	-	0.260	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	1.102	?	1.102	0.260	**0.876**
1991	1.145	-	0.215	-	0.527	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	1.145	?	1.145	0.503	**1.048**
1992	0.685	-	0.175	-	0.356	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	0.685	?	0.685	0.322	**0.638**
1993	0.678	-	0.138	-	0.308	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	0.678	?	0.678	0.300	**0.644**
1994	1.233	-	0.168	-	0.510	*n.a.*	*n.a.*	0	0.268	0.156	-	1.233	0.268	1.158	0.453	**0.941**
1995	0.288	-	0.076	-	0.138	*n.a.*	*n.a.*	0	0.065	0.037	-	0.288	0.065	0.282	0.132	**0.220**
1996	0.617	-	0.151	-	0.306	*n.a.*	*n.a.*	0	0.122	0.066	-	0.617	0.122	0.586	0.269	**0.413**
1997	0.683	0.302	0.188	-	0.428	*n.a.*	*n.a.*	0	0.163	0.105	-	0.683	0.209	0.676	0.392	**0.616**
1998	1.386	0.590	0	0.228	0	*n.a.*	*n.a.*	0	0.280	0.149	-	1.386	0.240	1.009	0.149	**1.004**
1999	1.048	0.412	0.211	0.173	0	0.197	0.133	0	0.212	0.119	-	1.048	0.184	0.605	0.129	**0.549**
2000	1.701	0.437	0.369	0.207	0	0.262	0.179	0	0.255	0	-	1.701	0.304	0.312	0.179	**0.309**
2001	3.527	1.507	0.963	0.661	0	0.733	0.594	1.559	0.837	0.537	1.857	2.261	0.927	1.031	0.918	**1.029**
2002	1.994	0.821	0.498	0.355	0	0.403	0.321	0.829	0.450	0	0.993	1.948	0.465	0.984	0.473	**0.981**
2003	1.511	0.557	0.212	0.212	0	0.287	0	0.678	0.343	0	0	1.489	0.296	0.711	0.212	**0.710**
2004	1.467	0.558	0.330	0.253	0	0.285	0.210	0.550	0.314	0.184	0	1.421	0.327	0.750	0.213	**0.747**
2005	2.576	1.070	0	0.405	0	0.496	0	0.937	0.516	0	0	2.426	0.564	1.147	0	**1.147**
2006	2.388	0.866	0	0.359	0	0.512	0	0.859	0.562	0	0	2.101	0.509	0.860	0	**0.860**

Table 11.7.1. Anchovy in Sub-division IXa South (Algarve+Gulf of Cadiz) . Input values from the seasonal separable assessment model.

Anchovy IXa-South (Algarve+Gulf of Cadiz)
Years: 1995-2006
Fleets: All

Half-year Catch in number (in millions) at age (1995-2006)

	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
AGE	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	34.50	0	495.13	0	335.67	0	465.60	0	126.26	0	129.46	0	161.95	0	77.89	0	95.72	0	123.63	0	38.75	0	12.45
1	26.51	7.45	143.75	19.89	191.06	89.10	722.99	341.82	422.57	109.26	161.65	58.89	354.92	220.76	548.23	195.09	333.99	73.28	323.34	97.73	449.26	37.39	450.39	41.93
2	0.19	0.00	0.90	1.21	32.46	12.41	12.03	1.51	32.29	2.65	3.51	0.55	19.70	5.29	8.50	9.93	13.15	0.63	1.81	0.92	3.21	0.33	5.27	0.00

Mean weight at age in the stock (in g) and natural mortality (half-year) estimates

AGE	Mean weight												Natural mortality
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	
0	7.03	1.06	2.57	2.65	3.19	3.14	6.21	3.32	5.98	6.64	4.94	3.65	0.6
1	10.72	6.26	11.06	7.40	12.84	9.96	13.29	10.50	10.57	12.01	9.17	8.21	0.6
2	22.55	19.98	20.90	20.45	19.99	23.82	31.76	26.29	26.79	21.87	22.62	20.97	0.6

Acoustic Biomass estimates (tonnes) in Sub-division IXa South (Algarve+Gulf of Cadiz) (Portuguese surveys). Only March surveys series has been considered this year.

Nov.-98	Mar.-99	Nov.-99	Mar.-00	Nov.-00	Mar.-01	Nov.-01	Mar.-02	Nov.-02	Feb.-03	Nov.-03	Mar.-04	Nov.-04	Apr.-05	Nov.-05	Apr.-06	Nov.-06	Apr.-07
30695	24763	-	-	33909	24913	25580	21335	-	24565	-	-	-	14041	-	24082		38020

Exploratory runs with the seasonal separable model

	Portuguese March Ac. Surv.	Biomass Index	Weighting factor for index	F assumptions	Wage stock
RUN1	1999-2007	Relative	1	2005Fratio for FHY2-2006. FHY1-2007:average FHY1 in 3 last years (04-06).	Wage stock in 2007 as the average in 04-06
RUN2		Relative	6		
RUN3		Absolute	1		

Table 11.7.2. Anchovy in Sub-division IXa South (Algarve+Gulf of Cadiz) . Outputs from the seasonal separable assessment model. RUN1: Acoustic biomass index as relative and Weighting factor =1. See text for remaining settings.

Fishing Mortality per half-year period

	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
AGE	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0.0000	0.1200	0.0000	0.0711	0.0000	0.1615	0.0000	0.1456	0.0000	0.2007	0.0000	0.0603	0.0000	0.1304	0.0000	0.1675	0.0000	0.1550	0.0000	0.1834	0.0000	0.0345	0.0000	0.0095
1	0.8770	1.4559	0.3778	0.8623	0.7438	1.9604	0.9464	1.7675	1.5454	2.4356	0.7243	0.7320	0.7513	1.5826	0.6215	2.0333	1.6517	1.8808	0.8393	2.2256	1.1327	0.4190	0.3129	0.1157
2	1.0557	2.1838	0.4547	1.2935	0.8953	2.9406	1.1392	2.6512	1.8603	3.6534	0.8719	1.0980	0.9044	2.3740	0.7481	3.0499	1.9882	2.8212	1.0103	3.3384	1.3635	0.6285	0.3766	0.1736

Population abundance (millions)

	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
AGE	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	795	0	1802	0	3950	0	2466	0	1058	0	2166	0	1685	0	1190	0	1049	0	1337	0	2266	0	1689
1	91	21	387	146	921	240	1845	393	1170	137	475	126	1119	290	812	239	552	58	493	117	611	108	1201	482
2	1	0	3	1	34	8	19	3	37	3	7	2	33	7	33	8	17	1	5	1	7	1	39	15

Predicted Biomass Index values

	Mar. 99	Mar. 00	Mar. 01	Mar. 02	Feb. 03	Mar. 04	Apr. 05	Apr. 06
Acoustic Index (tonnes)	31005	-	40900	25135	17417	-	9749.8	27296

Fitted Selection Pattern

	1995-2006	
AGE	1st half	2nd half
0	0.0000	0.0824
1	1.0000	1.0000
2	1.2038	1.5000

Catchability indices

	Q
Acoustic Survey	4.0416

Table 11.7.2.(cont'd) Anchovy in Sub-division IXa South (Algarve+Gulf of Cadiz) . Outputs from the seasonal separable assessment model. RUN1: Acoustic biomass index as relative and Weighting factor =1. See text for remaining settings.

Average population Biomass (tonnes)

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
274	923	2696	3495	2993	1703	4319	2334	1299	1389	1951	5256

Residuals about the model fit

Separable model residuals

	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
AGE	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0		-0.678		1.669		-0.286		0.609		-0.146		0.303		0.038		-0.581		-0.176		-0.336		-0.402		0.032
1	-0.455	-0.545	0.433	-1.198	-0.679	-0.644	-0.206	0.251	-0.566	0.044	-0.165	0.142	-0.262	0.169	0.633	0.129	-0.082	0.596	0.388	0.071	0.313	0.276	0.603	0.051
2	-1.003		0.179	0.807	0.729	0.711	0.182	-0.529	0.238	-0.004	0.155	-0.366	0.234	-0.058	-0.457	0.363	0.074	-0.499	-0.300	0.107	-0.255	-0.053	-0.575	

Biomass index residuals

	Mar. 99	Mar. 00	Mar. 01	Mar. 02	Feb. 03	Mar. 04	Apr. 05	Apr. 06	Apr. 07
Acoustic Index (tonnes)	-0.225	-	-0.496	-0.164	0.344	-	0.365	-0.125	0.301

Table 11.7.3. Anchovy in Sub-division IXa South (Algarve+Gulf of Cadiz) . Outputs from the seasonal separable assessment model. RUN2: Acoustic biomass index as relative and Weighting factor =6. See text for remaining settings.

Fishing Mortality per half-year period

	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
AGE	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0.0000	0.1158	0.0000	0.0697	0.0000	0.1588	0.0000	0.1460	0.0000	0.1937	0.0000	0.0648	0.0000	0.1177	0.0000	0.1547	0.0000	0.1624	0.0000	0.1691	0.0000	0.0293	0.0000	0.0072
1	0.8795	1.4374	0.3806	0.8659	0.7533	1.9711	0.9484	1.8131	1.5025	2.4052	0.7343	0.8044	0.7326	1.4618	0.6492	1.9205	1.7788	2.0160	0.8621	2.0999	1.0707	0.3643	0.2617	0.0890
2	1.0437	2.1561	0.4517	1.2988	0.8940	2.9566	1.1255	2.7196	1.7831	3.6077	0.8714	1.2067	0.8694	2.1927	0.7705	2.8807	2.1111	3.0241	1.0231	3.1499	1.2707	0.5465	0.3105	0.1336

Population abundance (millions)

	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
AGE	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	798	0	1815	0	3962	0	2209	0	1068	0	1712	0	1699	0	1575	0	1020	0	1678	0	2360	0	2647
1	90	21	390	146	929	240	1855	394	1048	128	483	127	881	232	829	238	740	69	476	110	778	146	1258	531
2	1	0	3	1	34	8	18	3	35	3	6	1	31	7	30	8	19	1	5	1	7	1	56	22

Predicted Biomass Index values

	Mar. 99	Mar. 00	Mar. 01	Mar. 02	Feb. 03	Mar. 04	Apr. 05	Apr. 06
Acoustic Index (tonnes)	25634	-	29741	22836	20485	-	11574	27336

Fitted Selection Pattern

	1995-2006	
AGE	1st half	2nd half
0	0.0000	0.0806
1	1.0000	1.0000
2	1.1868	1.5000

Catchability indices

	Q
Acoustic Survey	3.6657

Table 11.7.3.(cont'd) Anchovy in Sub-division IXa South (Algarve+Gulf of Cadiz) . Outputs from the seasonal separable assessment model. RUN2: Acoustic biomass index as relative and Weighting factor =6. See text for remaining settings.

Average population Biomass (tonnes)

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
272	928	2706	3475	2725	1688	3562	2414	1636	1372	2564	5824

Residuals about the model fit

Separable model residuals

	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
AGE	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0		-0.648		1.680		-0.272		0.717		-0.124		0.468		0.126		-0.787		-0.191		-0.489		-0.283		-0.133
1	-0.447	-0.526	0.419	-1.206	-0.697	-0.646	-0.213	0.237	-0.442	0.115	-0.192	0.069	-0.004	0.429	0.579	0.159	-0.408	0.402	0.406	0.151	0.105	0.089	0.714	0.204
2	-0.996		0.178	0.796	0.728	0.707	0.201	-0.539	0.298	-0.037	0.193	-0.385	0.325	-0.001	-0.377	0.500	-0.055	-0.500	-0.338	0.102	-0.284	-0.105	-0.768	

Biomass index residuals

	Mar. 99	Mar. 00	Mar. 01	Mar. 02	Feb. 03	Mar. 04	Apr. 05	Apr. 06	Apr. 07
Acoustic Index (tonnes)	-0.035	-	-0.177	-0.068	0.182	-	0.193	-0.127	0.031

Table 11.7.4. Anchovy in Sub-division IXa South (Algarve+Gulf of Cadiz) . Outputs from the seasonal separable assessment model. RUN3: Acoustic biomass index as absolute and Weighting factor =1. See text for remaining settings.

Fishing Mortality per half-year period

	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
AGE	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0.0000	0.0722	0.0000	0.0866	0.0000	0.1596	0.0000	0.1333	0.0000	0.0807	0.0000	0.0284	0.0000	0.0851	0.0000	0.1198	0.0000	0.0474	0.0000	0.0425	0.0000	0.0068	0.0000	0.0040
1	0.4494	0.3565	0.2545	0.4274	0.8654	0.7880	0.6905	0.6583	0.9768	0.3984	0.1840	0.1404	0.3887	0.4202	0.4058	0.5915	0.7117	0.2341	0.2322	0.2097	0.1465	0.0333	0.0875	0.0199
2	0.0982	0.0481	0.0556	0.0577	0.1890	0.1064	0.1508	0.0889	0.2133	0.0538	0.0402	0.0190	0.0849	0.0567	0.0886	0.0799	0.1555	0.0316	0.0507	0.0283	0.0320	0.0045	0.0191	0.0027

Population abundance (millions)

	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
AGE	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	1403	0	2400	0	4717	0	3295	0	2468	0	3683	0	2620	0	1647	0	2342	0	4445	0	9072	0	4184
1	156	55	717	305	1208	279	2207	607	1583	327	1250	571	1965	731	1321	483	802	216	1226	533	2338	1108	4945	2487
2	1	0	21	11	109	50	70	33	173	77	121	64	272	137	264	132	147	69	94	49	237	126	588	317

Predicted Biomass Index values

	Mar. 99	Mar. 00	Mar. 01	Mar. 02	Feb. 03	Mar. 04	Apr. 05	Apr. 06
Acoustic Index (tonnes)	14642	-	25654	15422	10276	-	18669	37857

Fitted Selection Pattern

	1995-2006	
AGE	1st half	2nd half
0	0.0000	0.2025
1	1.0000	1.0000
2	0.2184	0.1350

Catchability indices

	Q
Acoustic Survey	1.0000

Table 11.7.4.(cont'd) Anchovy in Sub-division IXa South (Algarve+Gulf of Cadiz) . Outputs from the seasonal separable assessment model. RUN3: Acoustic biomass index as absolute and Weighting factor =1. See text for remaining settings.

Average population Biomass (tonnes)

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
4257	2309	9813	8122	5322	6687	11723	5082	5705	7547	10211	9834

Residuals about the model fit

Separable model residuals

	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006	
AGE	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0		-0.760		1.192		-0.452		0.403		-0.135		0.510		0.003		-0.591		0.158		-0.136		-0.170		-0.017
1	-0.492	-0.519	0.159	-1.410	-1.055	-0.288	-0.169	0.408	-0.610	0.282	0.014	0.040	-0.312	0.137	0.484	0.156	0.049	0.759	0.515	0.194	0.621	0.312	0.364	0.128
2	0.985		0.046	0.964	0.822	1.188	0.488	-0.338	0.248	-0.130	-0.020	-0.485	0.164	-0.075	-0.686	0.258	-0.196	-0.949	-0.659	-0.135	-0.563	-0.243	-0.463	

Biomass index residuals

	Mar. 99	Mar. 00	Mar. 01	Mar. 02	Feb. 03	Mar. 04	Apr. 05	Apr. 06	Apr. 07
Acoustic Index (tonnes)	0.525	-	-0.029	0.325	0.872	-	-0.285	-0.452	0.038

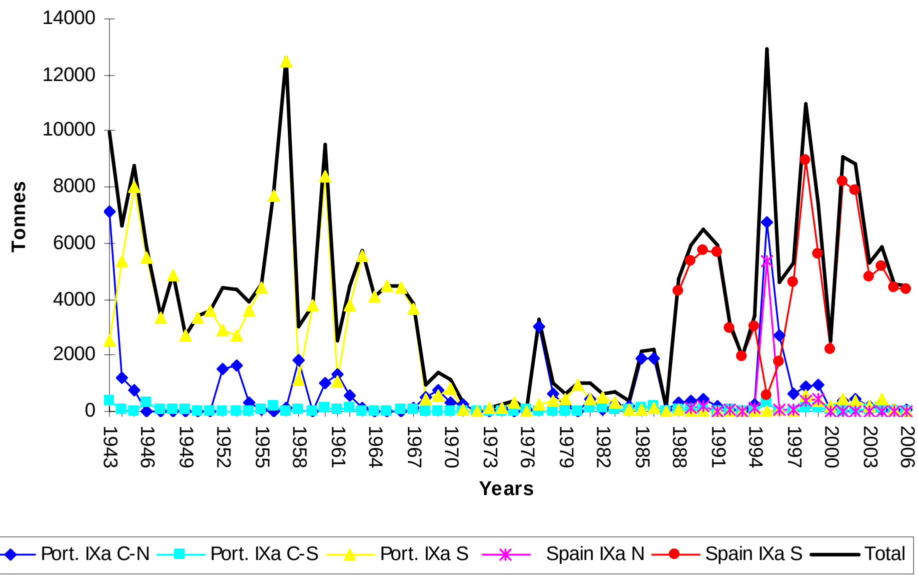


Figure 11.2.1.1. Anchovy in Division IXa. Historical series of Portuguese and Spanish anchovy landings in Division IXa (1943-2006).

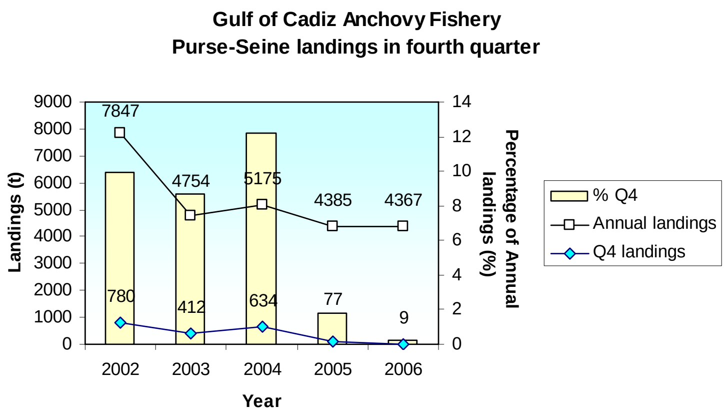
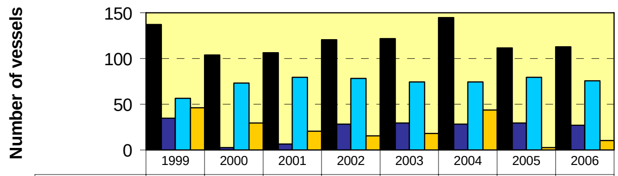


Figure 11.2.2.1. Anchovy in Division IXa. Gulf of Cadiz Anchovy (Subdivision IXa South): comparison of annual purse-seine landings with catches landed in the fourth quarter to assess the effects of the closed season in the fourth quarter in 2004-2006. Bar chart represents the relative importance of landings in the fourth quarter in relation to the annual landings.

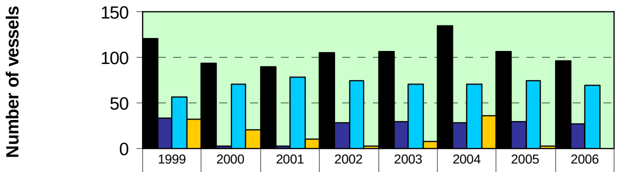
Spanish purse-seine fleets in the Gulf of Cadiz
Total number of operative vessels/fleet type



	1999	2000	2001	2002	2003	2004	2005	2006
Total	137	104	106	121	122	145	111	113
SP Heavy Tonn.	34	2	6	28	29	28	29	27
SP Light Tonn.	57	73	80	78	75	74	79	76
Multipurpose	46	29	20	15	18	43	3	10

Year

Spanish purse-seine fleets in the Gulf of Cadiz
No. of operative vessels fishing anchovy/fleet type



	1999	2000	2001	2002	2003	2004	2005	2006
Total	121	94	90	105	107	135	106	96
SP Heavy Tonn.	33	2	2	28	29	28	29	27
SP Light Tonn.	57	71	78	75	70	71	75	69
Multipurpose	32	21	10	2	8	36	2	0

Year

Spanish purse-seine fleets in the Gulf of Cadiz
Percentage of operative vessels fishing anchovy

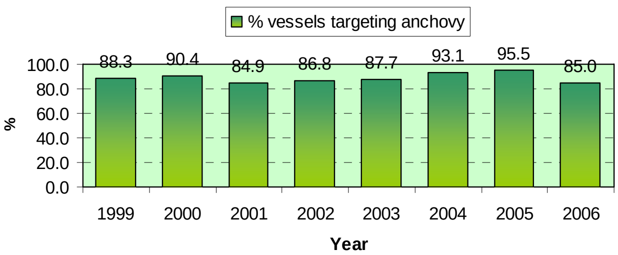


Figure 11.2.4.1. Anchovy in Division IXa. Spanish purse-seine fleet composition in the Gulf of Cadiz (differentiated into total fleet and vessels targeting Gulf of Cadiz anchovy) since 1999 (revised data for 2004 and 2005).The categories include both single purpose purse-seiners and trawl and artisanal vessels fishing with purse-seine in some periods through the year (multi-purpose vessels). Length criteria refers to length between perpendiculars. Storage: catches are dry hold with ice (fishing trip equals to fishing day). No discard estimates.

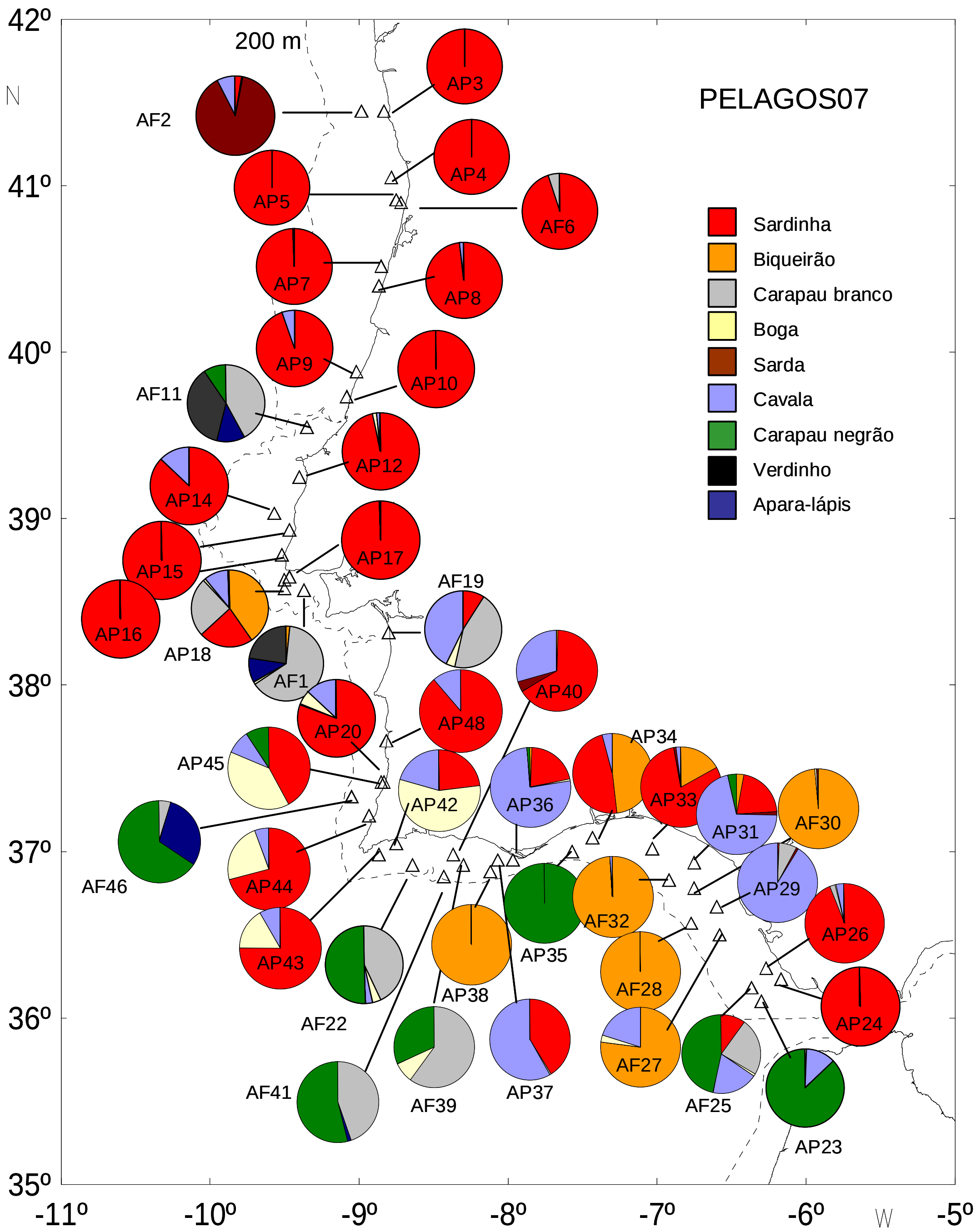


Figure 11.3.1.1. Anchovy in Division IXa. Fishing trawl location and haul species composition (percentages in weight. AP- Pelagic trawl; AF- Bottom trawl) in the April 2007 Portuguese acoustic survey.

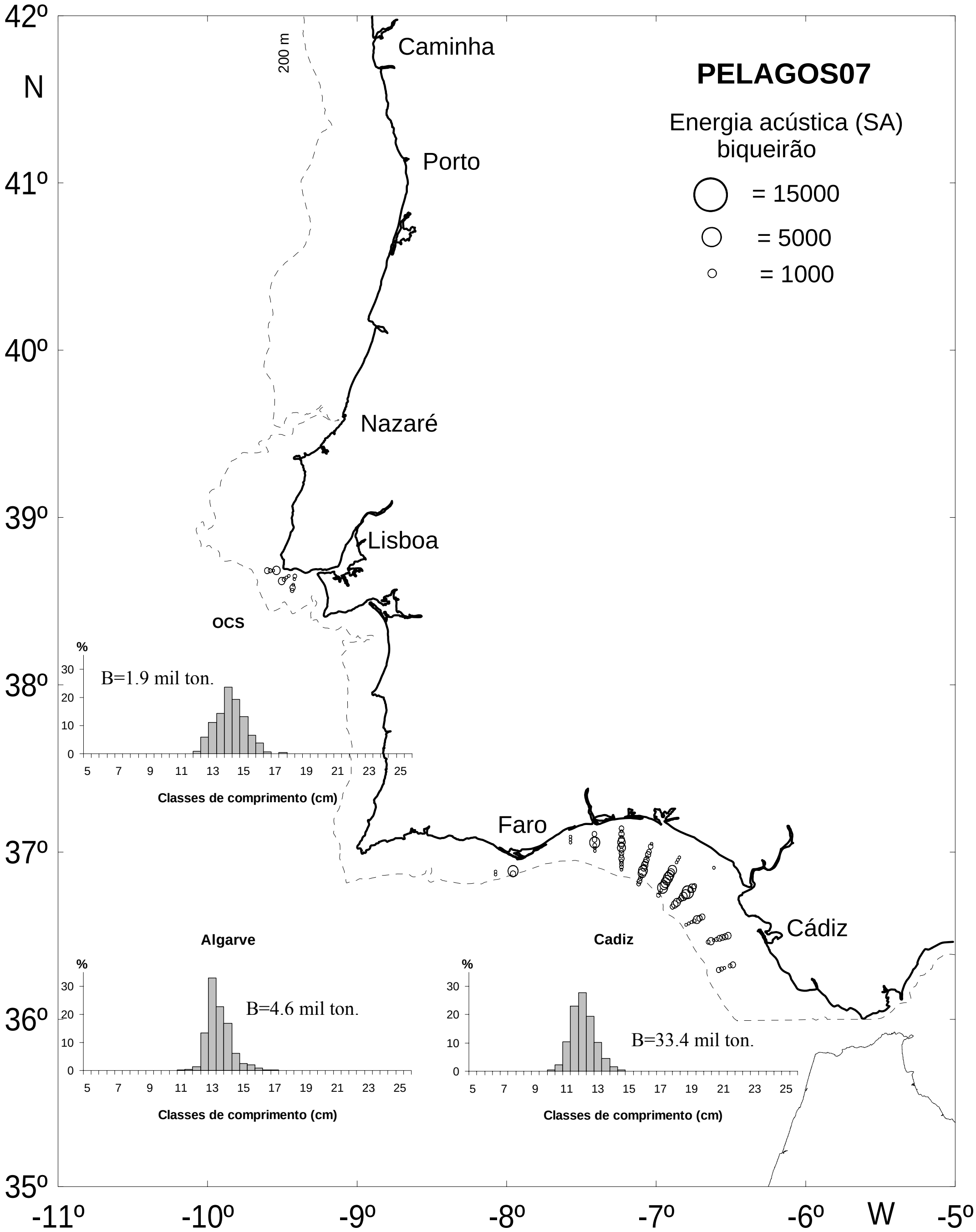


Figure 11.3.1.2. Anchovy in Division IXa. Acoustic energy distribution per nautical mile during the April 2007 Portuguese acoustic survey and distribution of length class frequency (%) by region of the estimated population. Circle diameter is propocional to the acoustic energy (S_A).

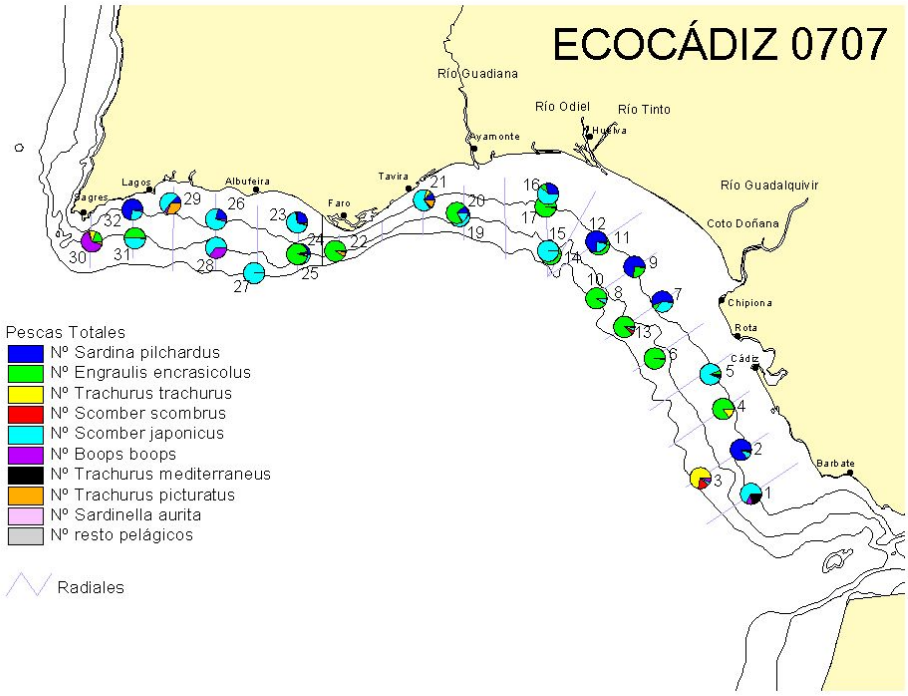


Figure 11.3.1.3. Anchovy in Division IXa. Fishing trawl location and haul species composition during the July 2007 Spanish acoustic survey in Sub-division IXa South.

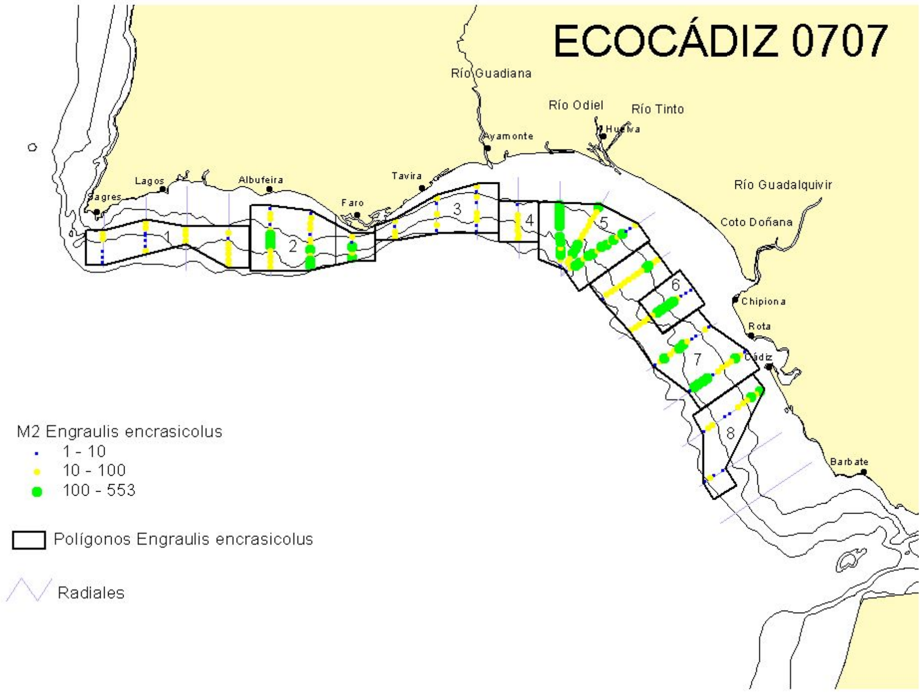


Figure 11.3.1.4. Anchovy in Division IXa. Acoustic energy distribution per nautical mile during the July 2007 Spanish survey in the Sub-division IXa South. Circle diameter and colour are proportional to the acoustic energy (S_A). Homogeneous size-based post-strata used in the biomass/abundance estimates are also shown.

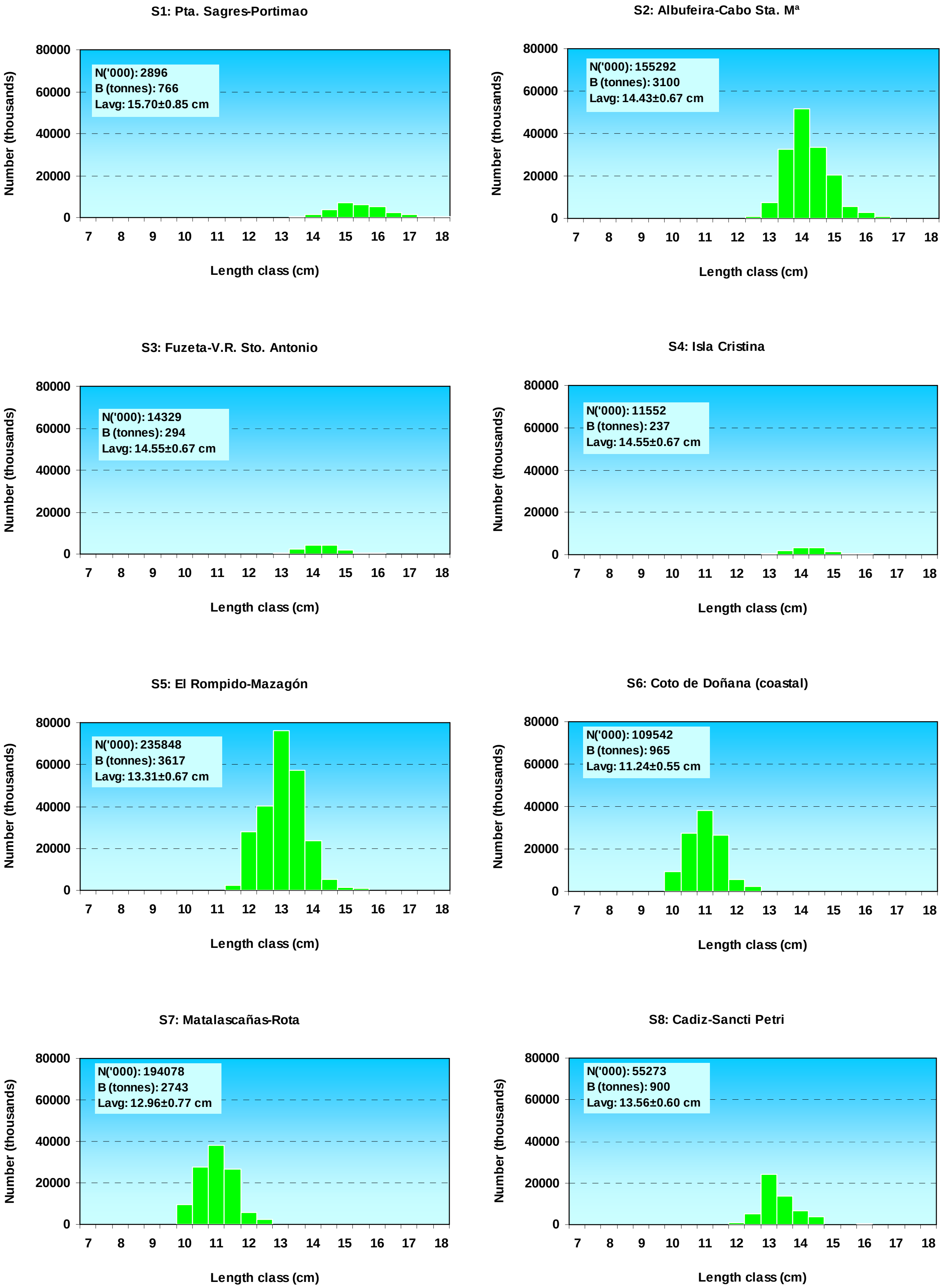


Figure 11.3.1.5. Anchovy in Division IXa. Estimated abundances by length class by sector during the July 2007 Spanish acoustic survey in Sub-division IXa South.

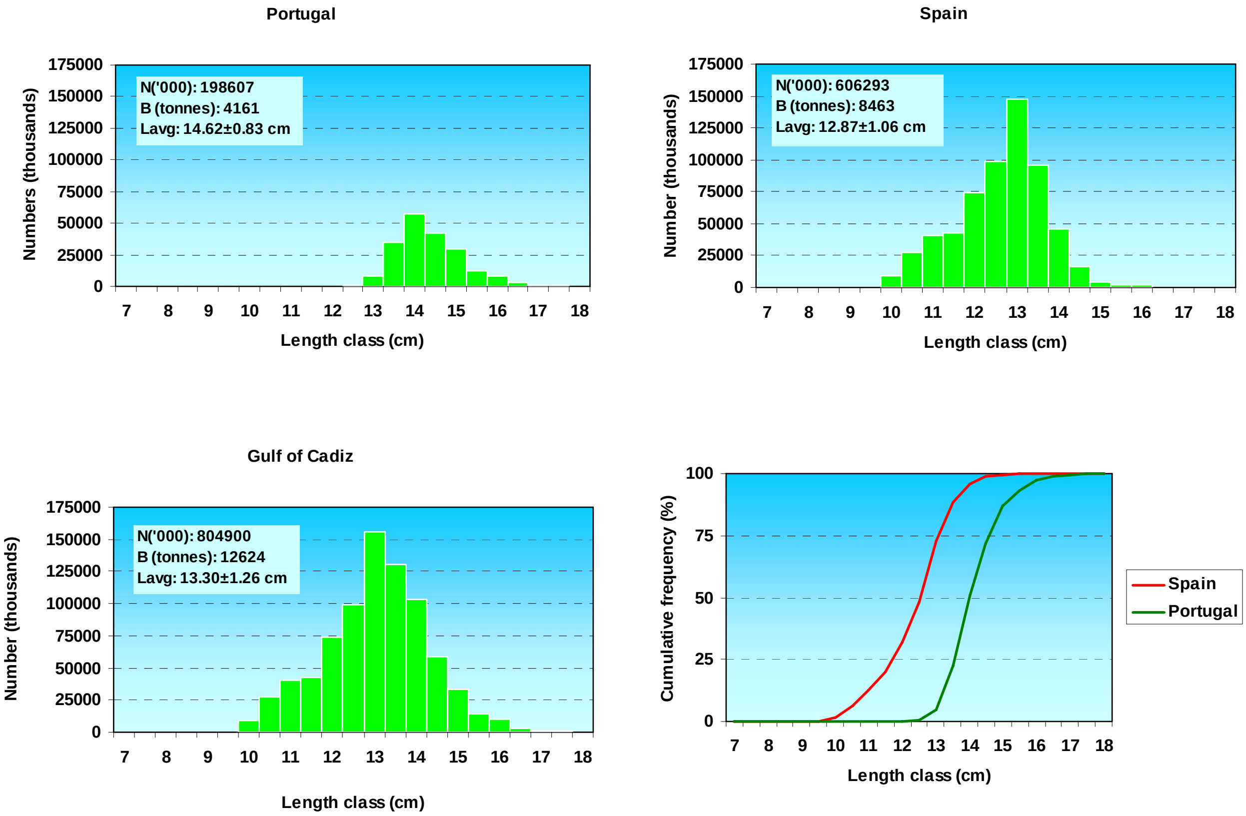


Figure 11.3.1.6. Anchovy in Division IXa. Estimated abundances by length class by region and total area during the July 2007 Spanish acoustic survey in Sub-division IXa South. Bottom right: cumulative frequency (%) by length class and region.

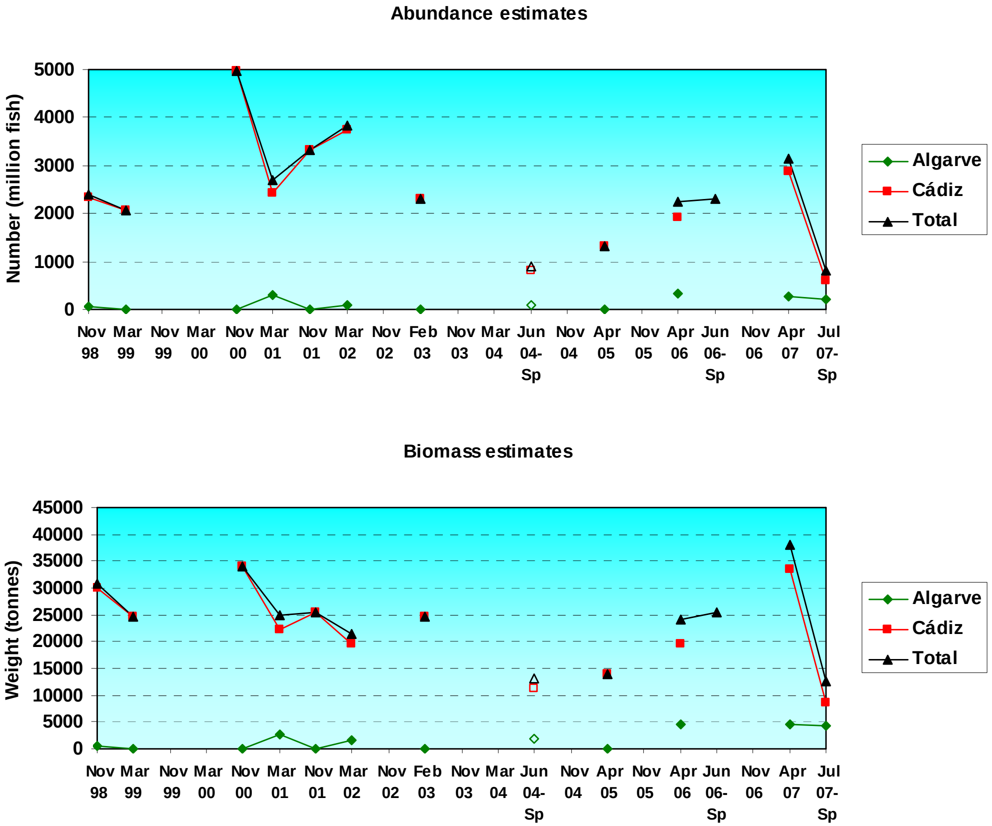


Figure 11.3.1.7. Anchovy in Division IXa. Portuguese historical series of acoustic estimates in Sub-division IXa South. Data for June 2004 and 2006 and July 2007 correspond to the Spanish acoustic surveys (2004 survey estimates under revision; new 2006 survey estimates after revision, but only available for the total sampled area).

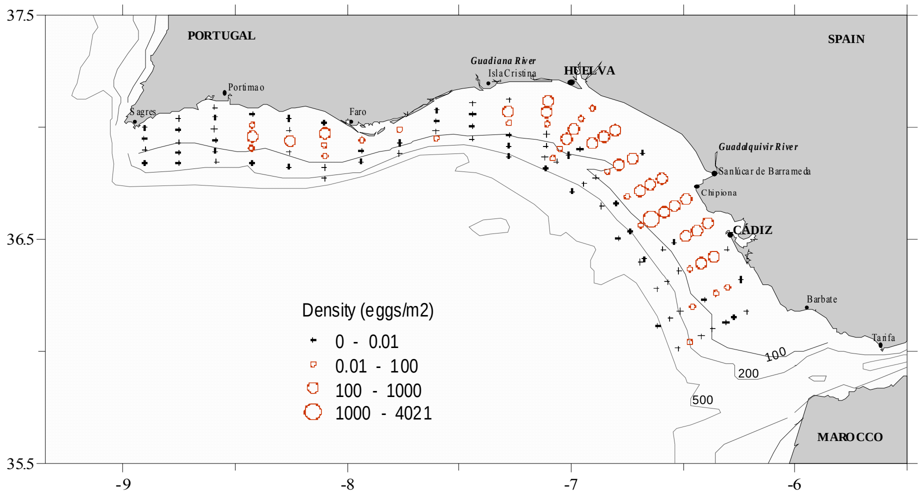


Figure 11.3.2.1. Anchovy in Division IXa. *BOCADEVA 0605* Gulf of Cadiz anchovy DEPM survey. Anchovy egg densities (eggs/m^2) by PAIROVET.

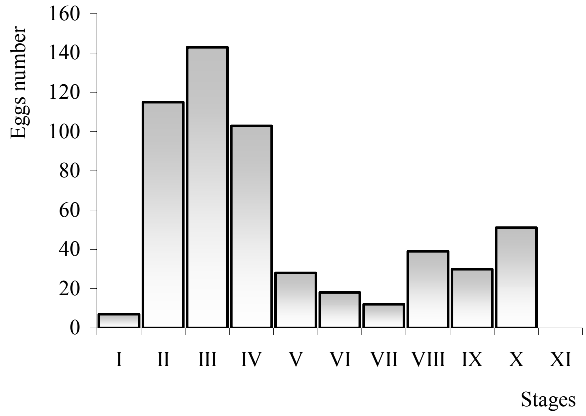


Figure 11.3.2.2. Anchovy in Division IXa. *BOCADEVA 0605* Gulf of Cadiz anchovy DEPM survey. Relative importance of anchovy egg development stages sampled by PAIROVET.

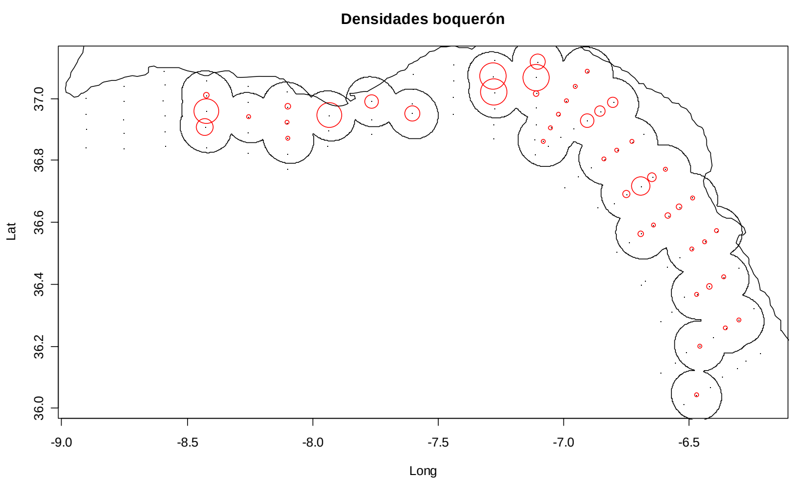


Figure 11.3.2.3. Anchovy in Division IXa. *BOCADEVA 0605* Gulf of Cadiz anchovy DEPM survey. Positive areas.

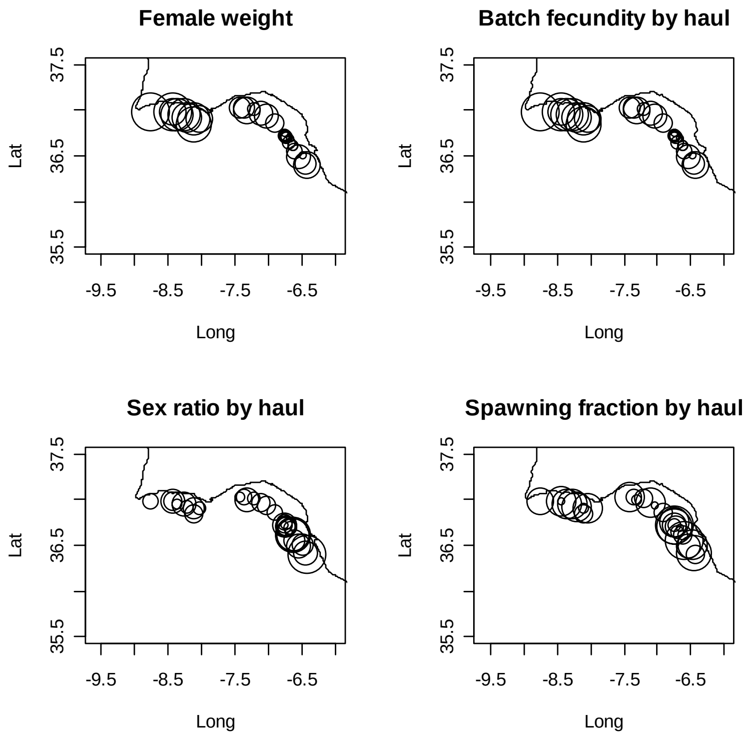


Figure 11.3.2.4. Anchovy in Division IXa. *BOCADEVA 0605* survey. Spatial distribution of mean estimates of the adult parameters per haul for the Gulf of Cadiz anchovy.

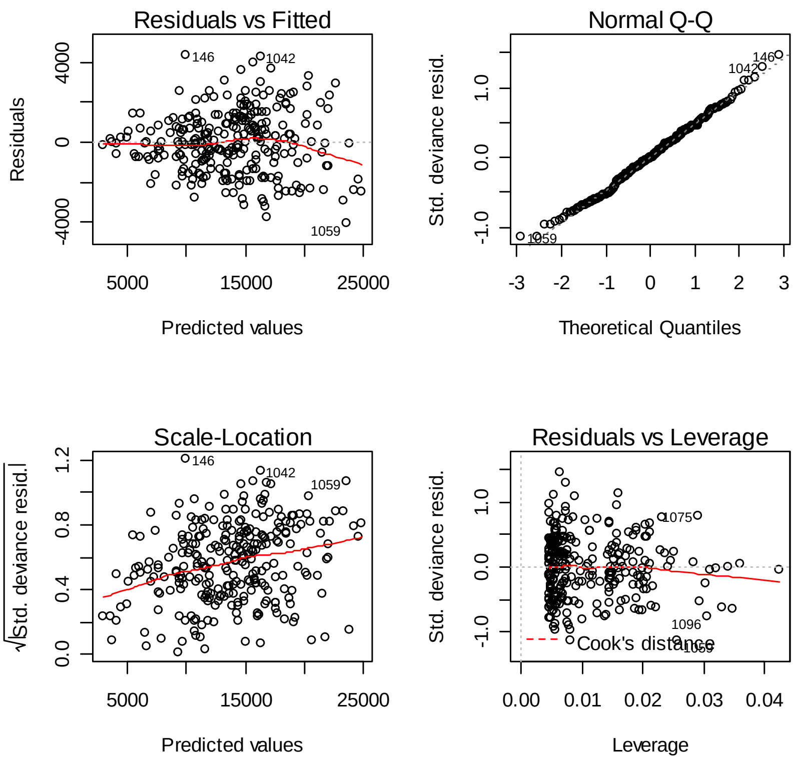


Figure 11.3.2.5. Anchovy in Division IXa. *BOCADEVA 0605* survey. Residual inspection plots for the Generalized Linear Model 2 (different slopes and equal intercept different from 0) fitted to anchovy batch fecundity data.

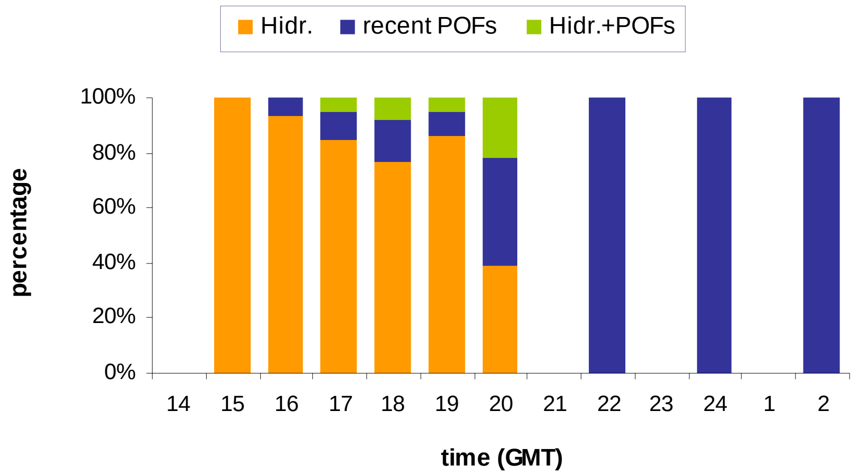


Figure 11.3.2.6. Anchovy in Division IXa. Distribution of anchovy gonad stages among the spawning females during the period 14:00-02:00 GMT (pooled data from the *BOCADEVA* 2004 and 2005 surveys).

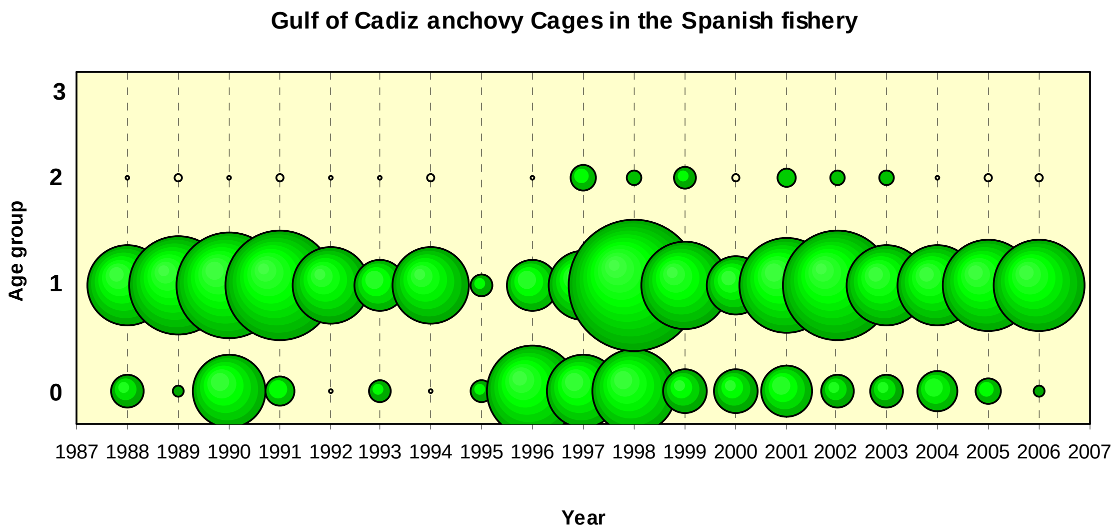


Figure 11.4.1.1. Anchovy in Division IXa. Age composition of Spanish catches of Gulf of Cadiz anchovy (Sub-division IXa-South; 1988-2006). Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.

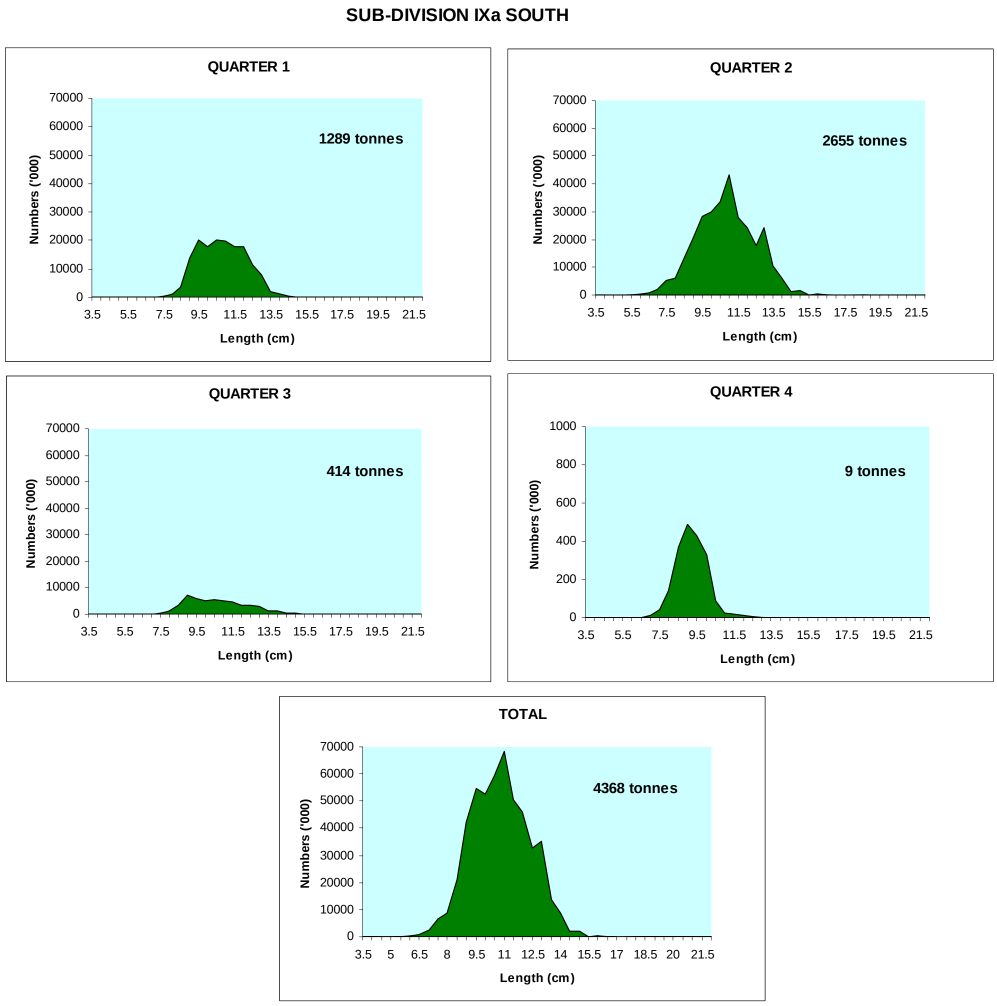


Figure 11.4.2.1. Anchovy in Division IXa. Length distribution ('000) of the Spanish quarterly and annual landings of anchovy in Sub-division IXa South (Gulf of Cadiz) in 2006. Note different scale in the y axis for the 4th quarter. Without data for Sub-division IXa North (Western Galicia).

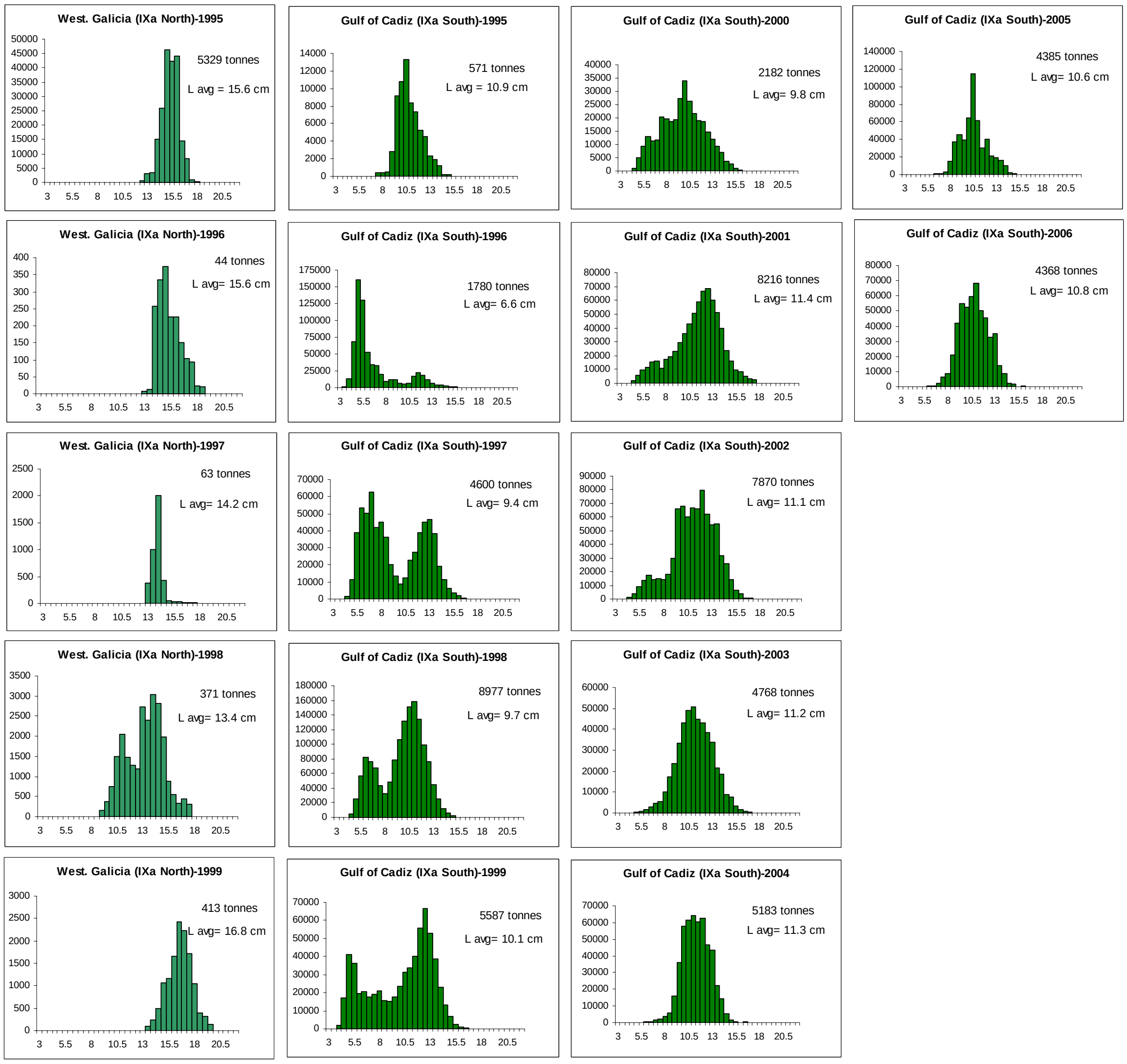
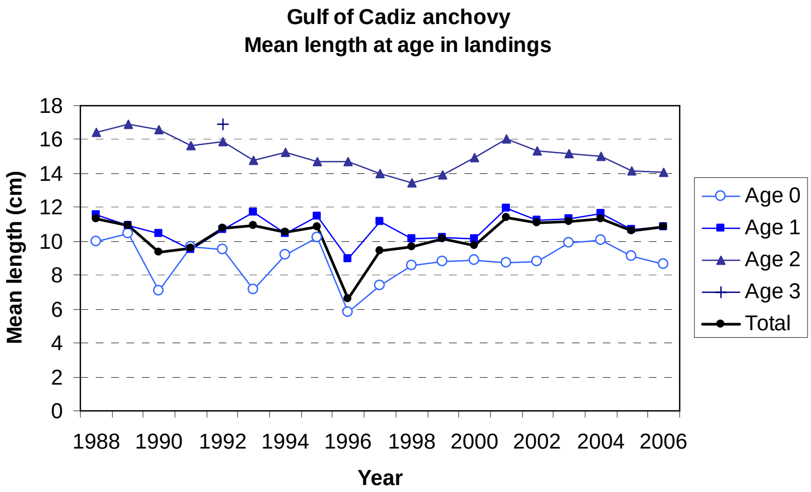


Figure 11.4.2.2. Anchovy in Division IXa. Length distribution ('000) of anchovy in Sub-divisions IXa South and IXa North (1995-2006).



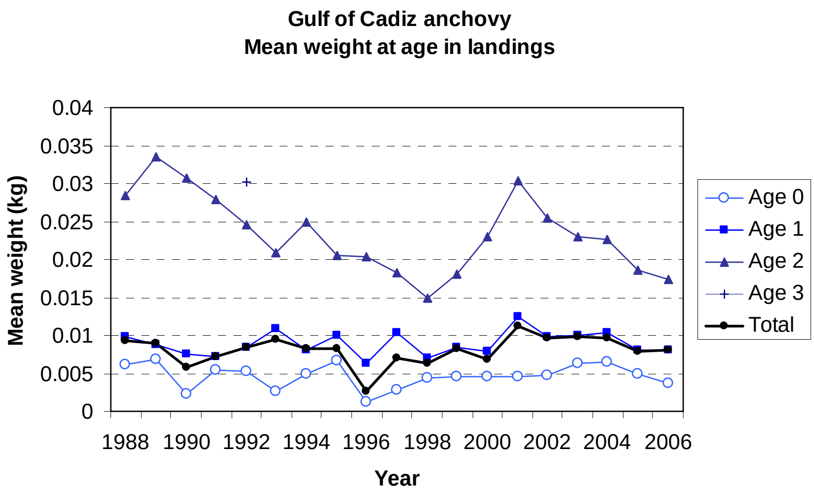
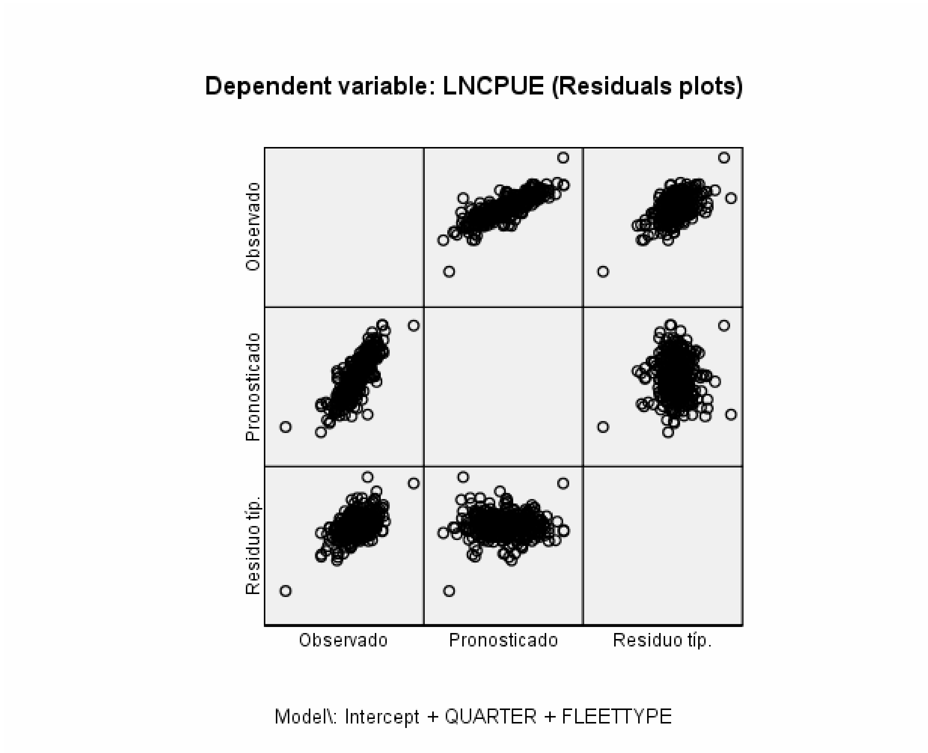


Figure 11.4.2.3. Anchovy in Division IXa. Yearly mean length (TL, in cm) and weight (kg) at age in the Spanish catches of Gulf of Cadiz anchovy (Sub-division IXa-South, 1988-2006). Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.



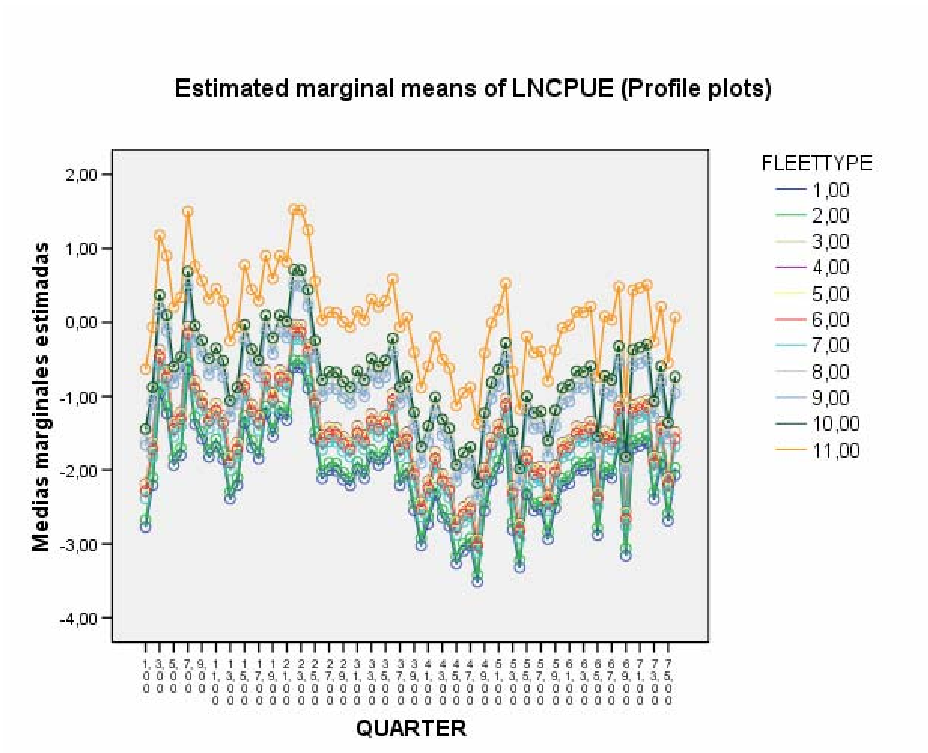


Figure 11.5.1. Anchovy in Division IXa. Residuals and Profile plots for the GLM used for the standardisation of the Spanish fleets' CPUE data in Sub-division IXa-South (Gulf of Cadiz).

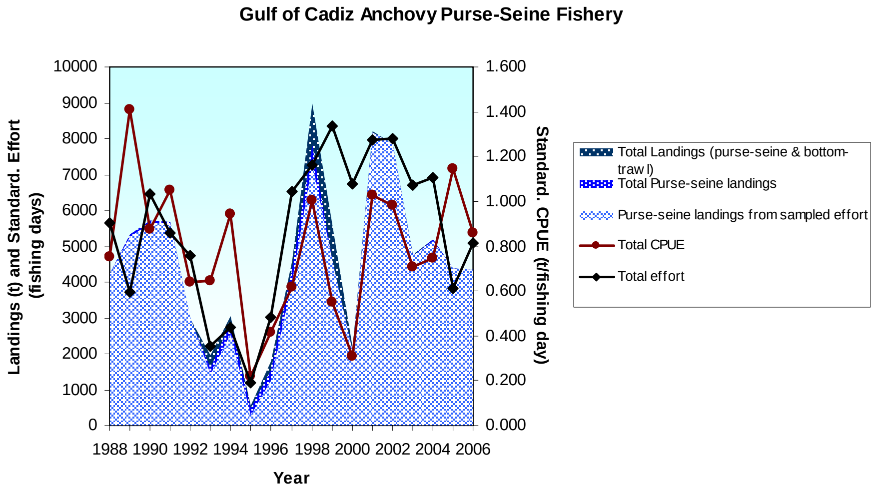
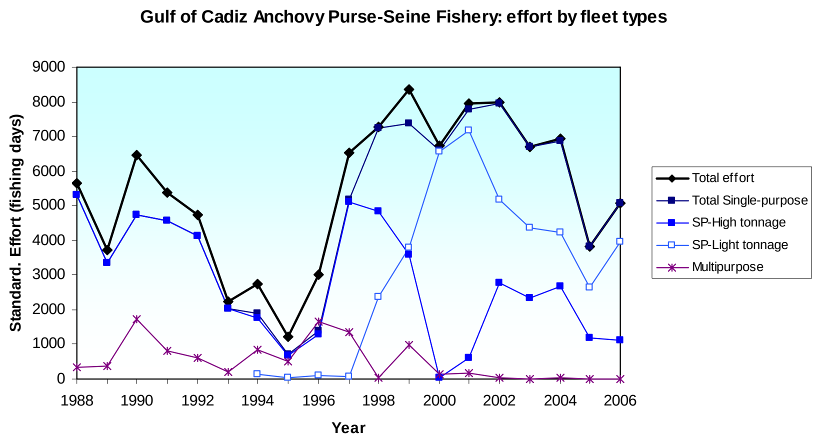


Figure 11.5.2. Anchovy in Division IXa. Gulf of Cadiz anchovy purse-seine fishery. Trends in annual landings, overall effort and CPUE. Landings are differentiated in total landings (purse-seine and bottom trawl fleets), purse-seine landings, and purse-seine landings corresponding to the sampled fishing effort.



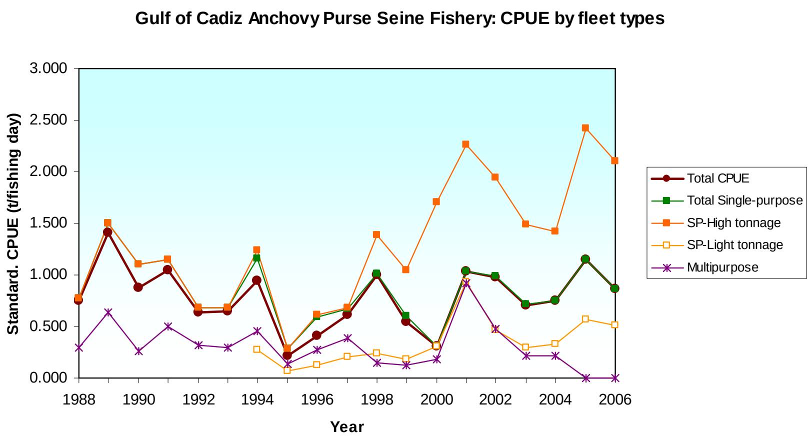


Figure 11.5.3. Anchovy in Division IXa. Gulf of Cadiz anchovy purse-seine fishery. Trends in annual series of effort (upper panel and CPUE (bottom panel) by fleet type. Single-purpose fleet is also differentiated in heavy and light GRT vessels.

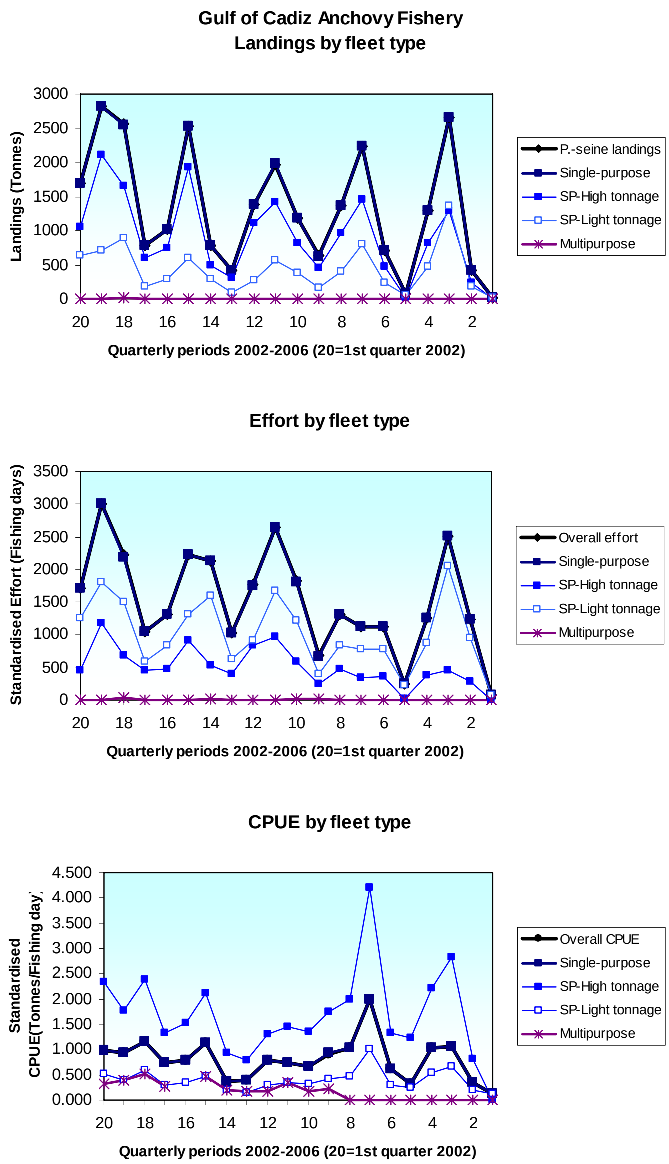


Figure 11.5.4. Anchovy in Division IXa. Gulf of Cadiz anchovy purse-seine fishery. Trends in quarterly series of landings (upper panel), effort (middle panel) and CPUE (bottom panel) by fleet type during the 2002-2006 period. A purse-seine fishery closure was implemented during the fourth quarter in 2004, 2005, and 2006 (2004-2005: 15th November-31st December; 2006: 1st November-31st December). Single-purpose fleet is also differentiated in heavy and light GRT vessels.

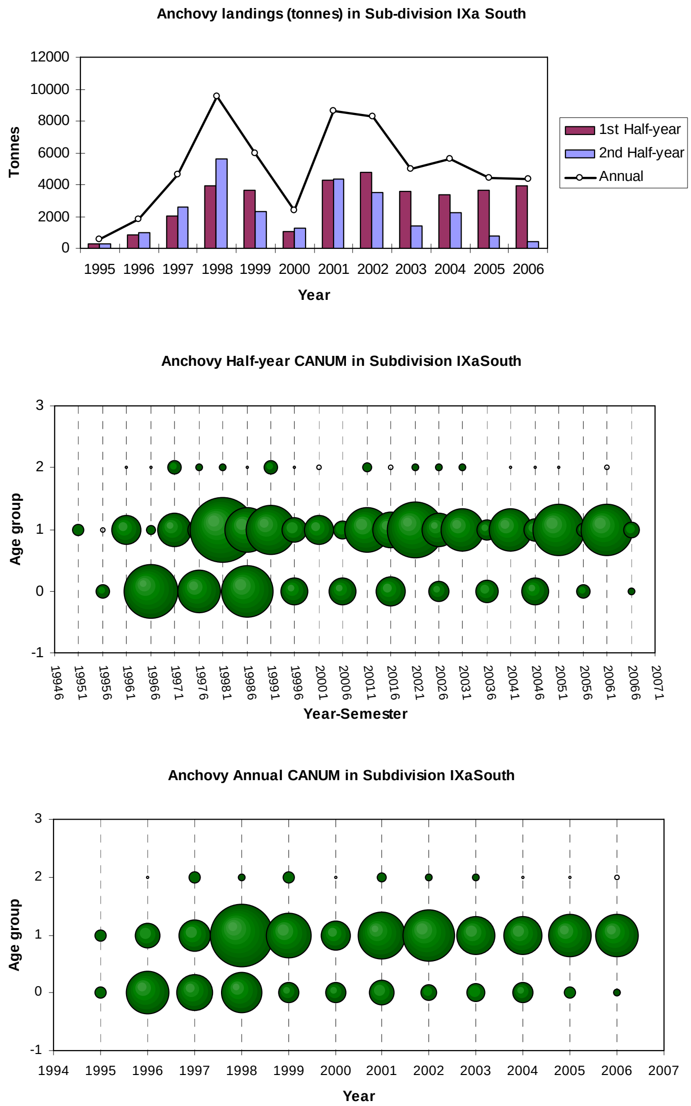
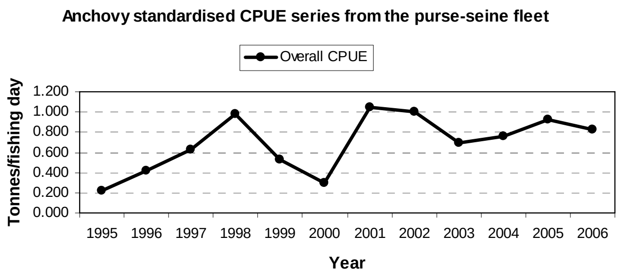


Figure 11.7.1. Anchovy in Division IXa. Anchovy in Sub-division IXa South (Algarve+Gulf of Cadiz). Trends in landings (upper panel) and catch-at-age numbers (both on an annual and half-year basis).



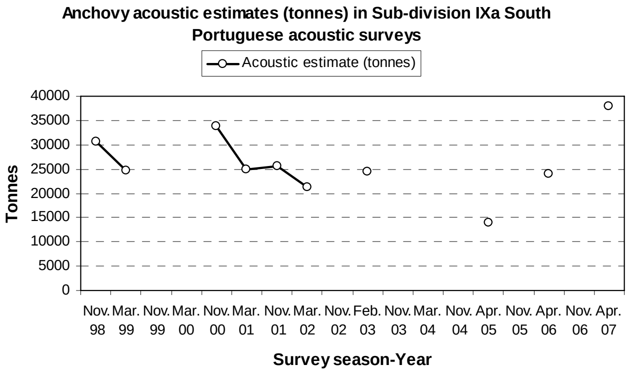
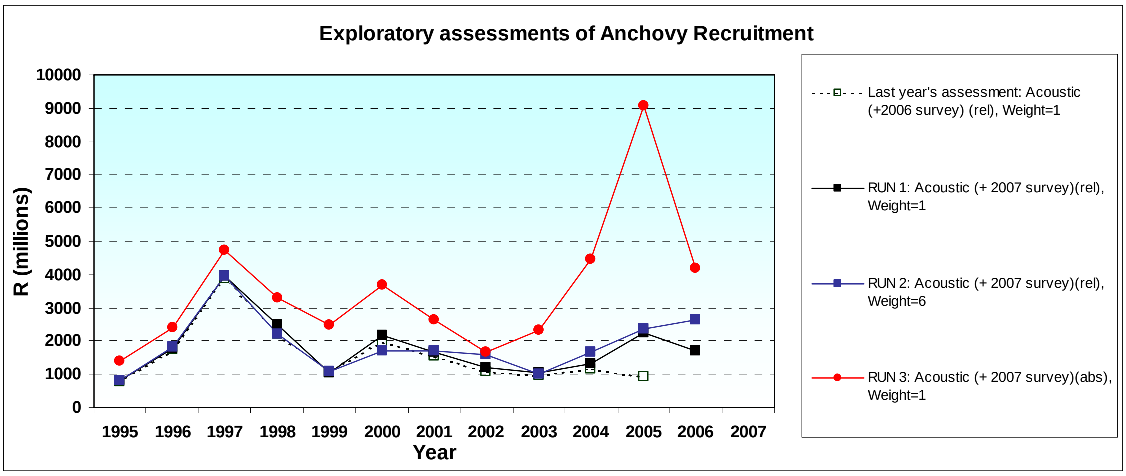
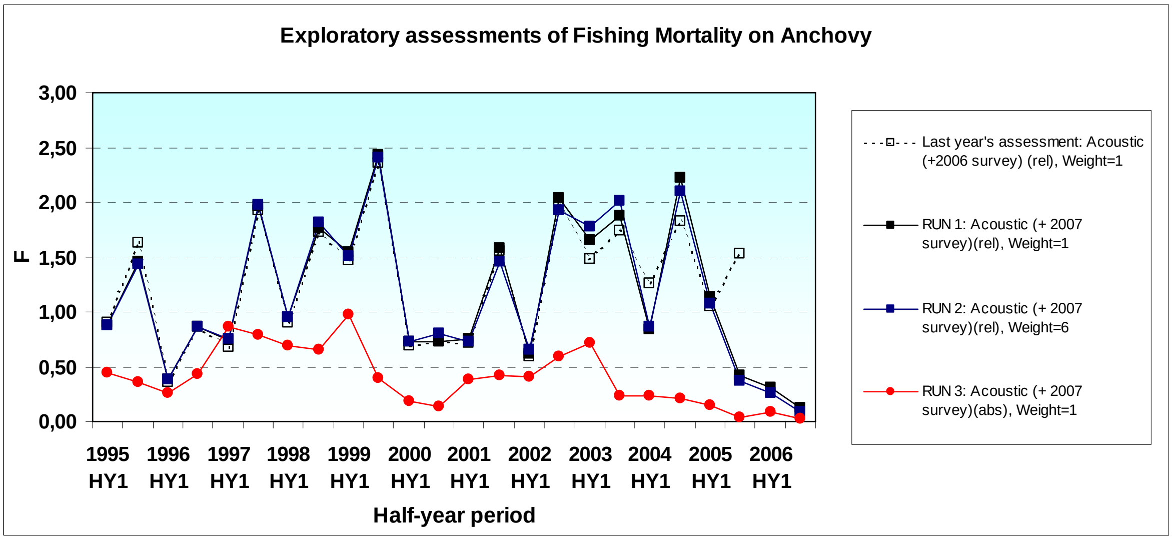


Figure 11.7.2. Anchovy in Division IXa. Anchovy in Sub-division IXa South(Algarve+Gulf of Cadiz). Trends in tuning indices (aggregated biomass) used in previous data explorations: Spanish purse-seiners standardised CPUE (upper panel) and Portuguese Acoustic Surveys estimates (bottom panel). This year the CPUE index series has been excluded from the exploratory assessment as a biomass tuning index.





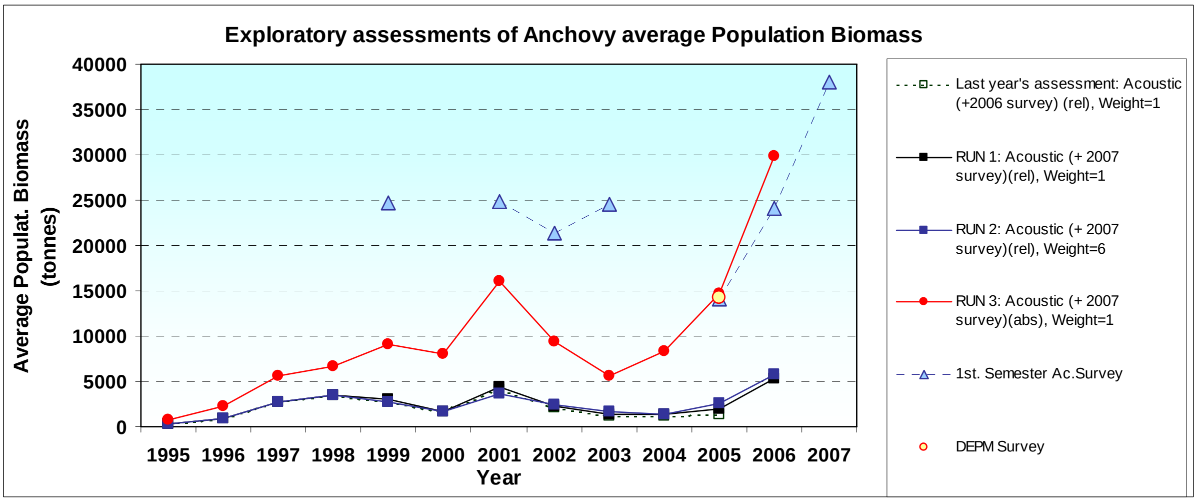
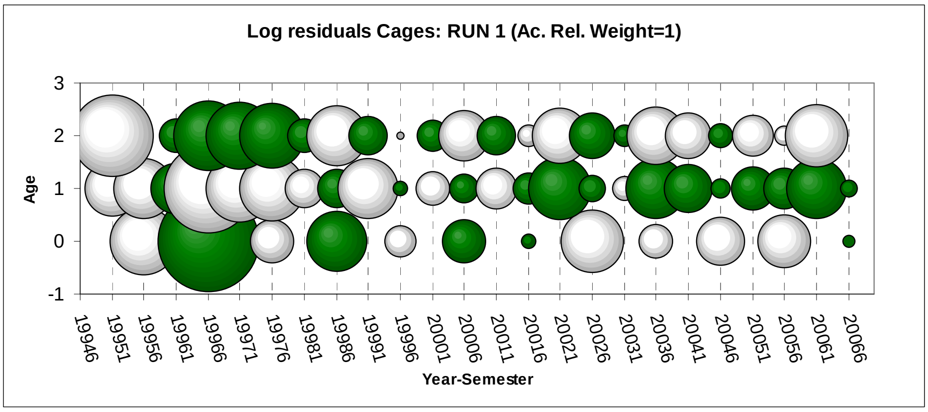
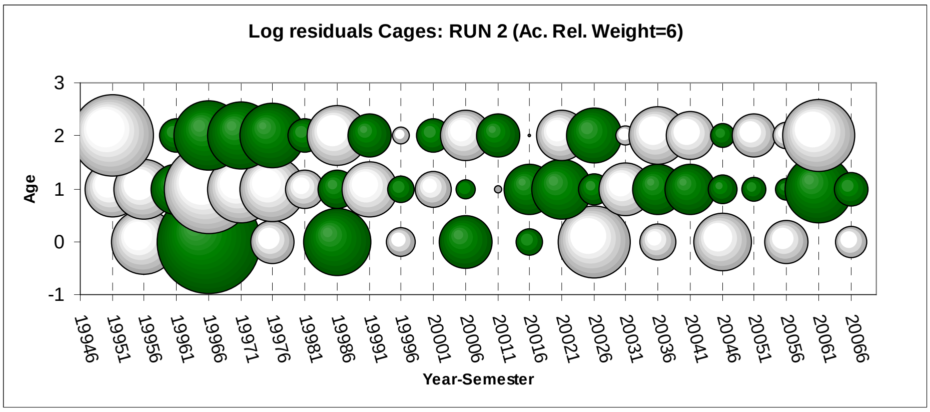


Figure 11.7.3. Anchovy in Division IXa. Anchovy in Sub-division IXa South(Algarve+Gulf of Cadiz). Comparison of last year's exploratory assessment with the new input data in 2007.





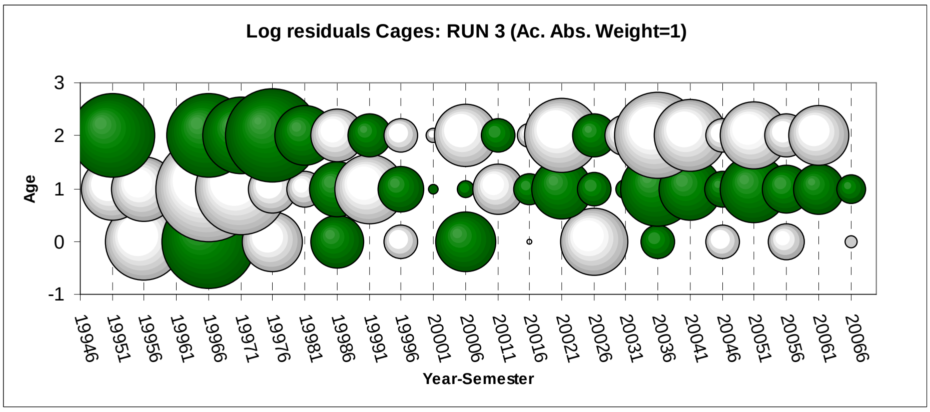


Figure 11.7.4. Anchovy in División IXa. Anchovy in Sub-division IXa South. Results from data exploration with the *ad-hoc* seasonal separable model. Log-residuals from catch-at-age data. Bubble size proportional to the log residual level. Negative values in white. Range of values by run are: RUN 1: -3.0 to 1.7; RUN 2: -3.1 to 1.7; RUN 3: -1.9 to 1.2.

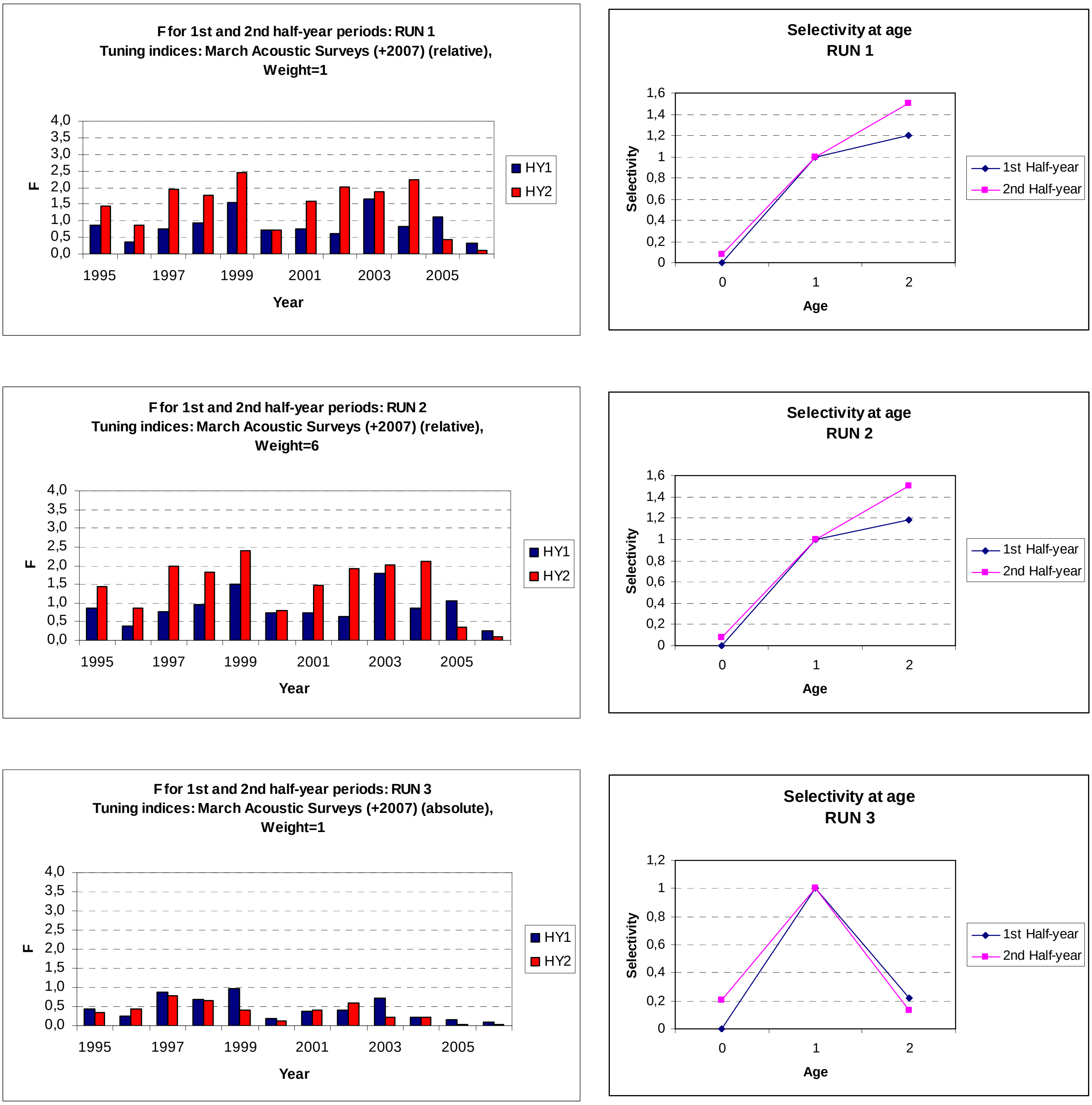
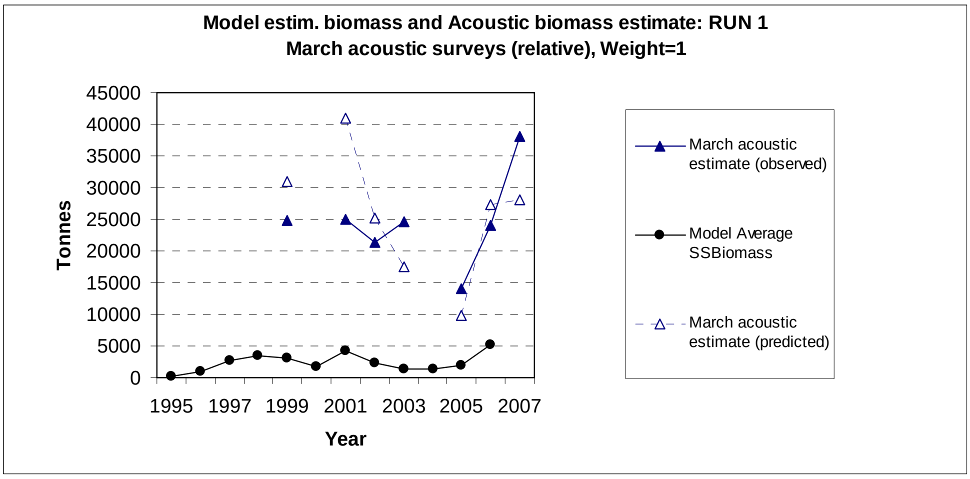
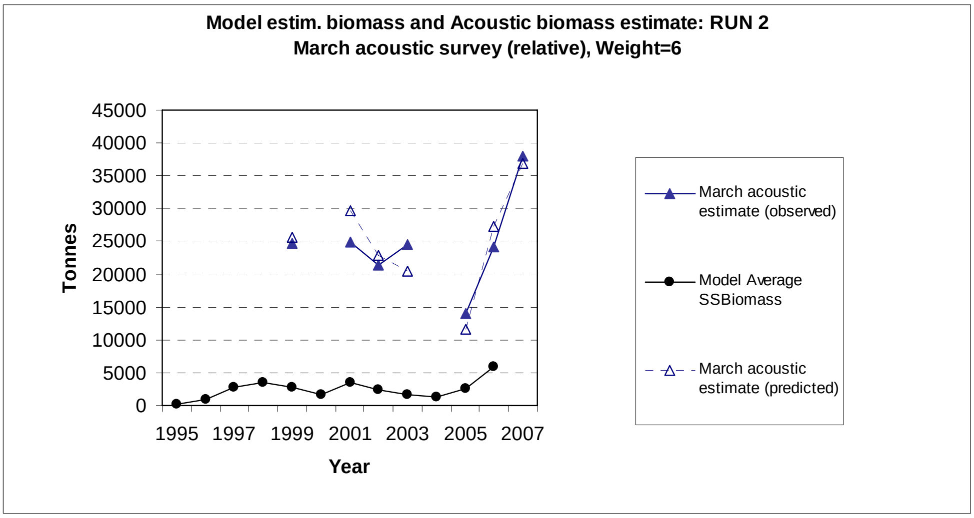


Figure 11.7.5. Anchovy in División IXa. Anchovy in Sub-division IXa South. Results from data exploration with the *ad-hoc* seasonal separable model. Estimated fishing mortalities (F) and fitted selection pattern by the separable model.





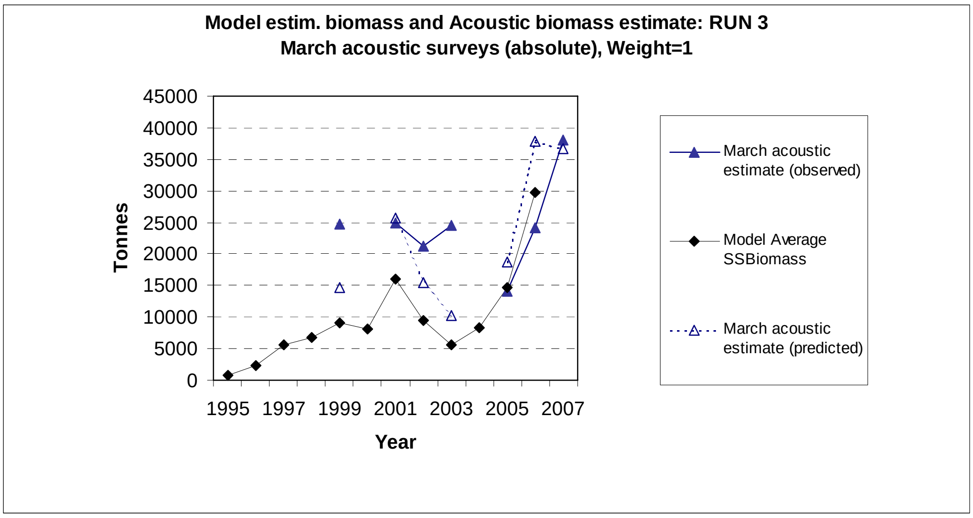


Figure 11.7.6. Anchovy in División IXa. Anchovy in Sub-division IXa South. Results from data exploration with the *ad-hoc* seasonal separable model. Model estimated biomass and acoustic biomass estimates.

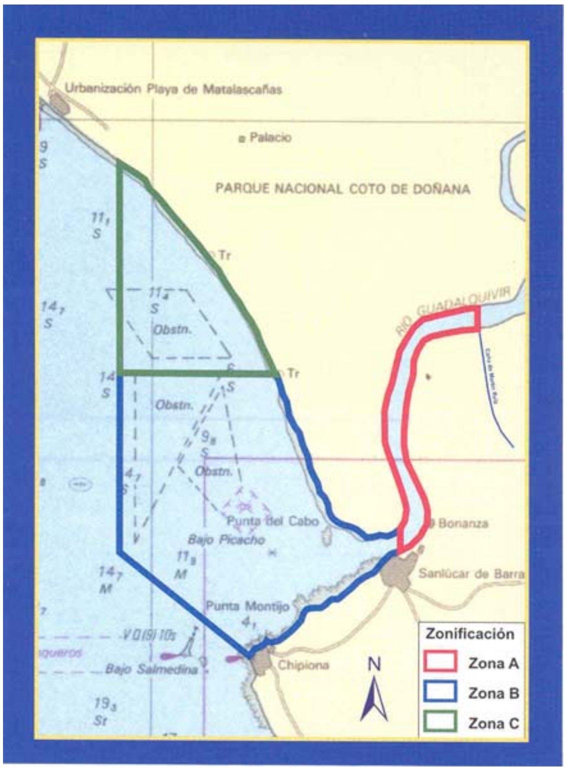


Figure 11.10.1. Anchovy in Division IXa. Limits of the Fishing Reserve off the Guadalquivir river mouth (Spanish Gulf of Cadiz. Sub-division IXa South).

12 Recommendations

The Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine, and Anchovy recommends for

1) improved communication and coordination between assessment scientists and the ecological/oceanographic scientists. In particular, with the objective of
    a) developing tools and the analysis for the detection and enumeration of environmental variability and changes in productivity;
    b) highlighting vulnerabilities of ecosystems to overexploitation and impact on trophic diversity.
2) The Working Group again recommends an observers programme to sample discards. The programme should include estimation of the age structure of the discards. Quantifying and recording slipping and coordination with other sampling programmes is also recommended. Existing observer programmes should be continued
3) Anchovy of the Bay and Biscay and Southern horse mackerel to be assessed as Benchmark in 2008;
4) In the light of the reorganising process taking place in ICES the WGMHSA recommends that it remains as a unit and continues performing the assessment and providing integrated advice for mackerel, horse mackerel, sardine and anchovy;

North East Atlantic Mackerel

5) A standardisation procedure for scrutinising acoustic data of NEA mackerel (ref WGFAST).
6) An age reading Workshop

Horse mackerel general

7) Further investigation to understand the stock fecundity.

Western horse mackerel

8) To examine all available survey data (other than the Egg survey) that could be used as tuning index for assessment.

Sardine

9) the continuation of the Portuguese November survey and support for its re-organization as a recruitment survey for both anchovy and sardine;
10) the performance of an inter-calibration exercise in 2008 to compare the catchability-at-age between the Spanish and Portuguese spring acoustic surveys;
11) the collection of samples from sardine fisheries in the northern areas of the species range, and especially in ICES Divisions VII;
12) continue the collection of fisheries and survey data from the Bay of Biscay;

Anchovy Bay of Biscay

13) The WG recommends that the spring acoustic and DEPM surveys should be maintained since they provide the main tuning indices to the current assessment.
14) The WG recommends the continuity of acoustic surveys on juveniles in autumn (JUVENA, PELACUS10) in order to get a significant series which could be correlated to estimates of recruitment at next spring and developing the understanding of the mechanism of recruitment. Coordination of these surveys should be enhanced
15) The WG recommends the continuity of the ecological studies and research surveys to understand the role of SSB, as well that of ecosystem community and the environment on the recruitment process.
16) The WG also recommends that further understanding of the catchability and observation error of surveys should be pursued within ICES WGACEGGS.

17) The WG recommends to collect data on top predators in pelagic community (mammals and birds) during all pelagic surveys and to coordinate data collection.

Anchovy IXa

The Working Group recommends:

- to provide all the information available on the anchovy fishery and biology (including, if available, information on fleets, length and age structure in landings and surveys by Sub-division) off Portuguese and Spanish waters;
- to analyse acoustic survey designs and estimation procedures by Portugal and Spain in the next WGACEGG in order to achieve a proper survey standardisation and reliable estimates for the whole population, due to the conflicting trends showed by their respective 2006-2007 acoustic estimates. The Working Group encourages the continuation of both the Portuguese and Spanish acoustic survey series;
- to continue the triennial Spanish DEPM surveys since they may provide a useful tuning indices to scale the current assessment;
- to provide to the next year meeting, if possible, previous and new age determinations of the Gulf of Cadiz anchovy according to the recommendations proposed in the 2002 Workshop on Anchovy otoliths and endorsed by this Working Group
- The Working Group encourages the provision of the information available on the influence of the environment on anchovy sapwning and recruitment in Division IXa and particularly in the Gulf of Cadiz area.

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14 Abstracts of Working Documents

Abaunza, P., Punzón, A., Patiño, B., Hernández, C.

A new CPUE at age time series for southern horse mackerel stock (ICES Division IXa): The bottom trawl fleet from Marin (Galicia, NW Spain).

Abstract:

A new CPUE at age series for southern horse mackerel stock is presented. This series corresponds to Marín bottom trawl fleet that operates mainly in Subdivision IXa North (Galicia, NW Spain). The effort series for this fleet showed a clear decreasing trend since 1997 until 2002, remaining at relatively low level since then. Length distributions of horse mackerel catches from this fleet by month are available from 1999 to 2005. The CPUE data was obtained dividing the catch at age data by the number of fishing trips. The CPUE at age by cohort showed that the trend in young adult ages (from 3 to age 8) is null or even slightly positive indicating a possible immigration of those ages from other areas or that the fishing fleet target those intermediate ages. For the older ages the slopes are negative, which allows to obtain some information on mortality for those ages.In any case, the time series is at the moment quite short and the analysis of the complete cohorts is not possible.

Paula Alvarez[1] and Finlay Burns[2]

Results of the 2007 Mackerel and Horse Mackerel Egg Surveys.

[1] AZTI Foundation, Pasal, Basque Country, Spain, e-mail: palvarez@pas.azti.es

[2] Fisheries Research Section, Aberdeen, Scotland

The triennial survey estimating egg production of mackerel and horse mackerel in the western and southern areas were carried out during 2 February-31 July 2007. During this period 315 survey days were carried out. The WD gives preliminary results of the egg production, realised fecundity and SSBs of western and southern mackerel, and egg production of western horse mackerel. The results are discussed and dealt with in sections 2.5.1 and 3.7 in the present Working Group report. Due to a miscalculation the SSB estimates of western and southern mackerel were corrected in an e-mail from the authors.

Corrected SSBs (tons)	Western mackerel	Southern mackerel
Pre-spawning	2389 814	293 830
SSB	2580 999	317 336

Combined SSB western and southern mackerel : 2898 335 tons

Maurice Clarke[1], Gerard van Balsfoort[2], Aukje Coers[3], Andrew Campbell[1], Mark Dickey-Collas[4], Afra Egan[1], Marc Ghiglia[5], Ingvild Harkes[3], Ciarán Kelly[1], Sean O' Donoghue[6], Christian Olesen[7], Beatriz Roel[8], Andrew Tait[9]and Andres Uriarte[10].

A new scientific initiative with the Pelagic RAC to develop a management

plan for western horse mackerel

The western horse mackerel stock is currently managed by annual TACs covering only part of its distribution area. No stock assessment has been accepted and recent ICES advice has consistently been for *status quo* catches. In 2006, the Pelagic Regional Advisory Committee asked scientists to help with developing a harvest control rule for the stock that would both meet conservation and stability objectives. An initial questionnaire was circulated to the industry, to elicit feedback on possible management options. A series of Harvest Control Rules were developed. These were tested by simulation and presented to the RAC at a number of meetings. Results will be presented within the ICES advisory process and elsewhere in the scientific literature. This is a developing approach involving scientists and stakeholders in an iterative process. The problems encountered and lessons learned, are discussed.

Keywords: Pelagic Regional Advisory Committee, western horse mackerel, harvest control rule

Dickey-Collas, M., van Helmond, E.

Discards by Dutch Flagged Freezer trawlers

Doc. available from Mark Dickey-Collas, Wageningen IMARES, P.O. Box 68, 1970 AB IJmuiden, the Netherlands, E-mail: Mark.dickeycollas@wur.nl

The first ever estimation of discarding by the Dutch pelagic freezer-trawler fleet was carried out based on data from observers on board commercial vessels. A total of 38 fishing trips of 2 to 5 weeks duration each were sampled between 2002 and 2006, covering the North Sea and western waters of the British Isles. Different methods to estimate discards were compared, and raising by number of trips or by total landings did not affect greatly the annual estimates of total discarding. A total of 26,000 tonnes (35% coefficient of variation) of fish were discarded annually by the fleet, made up of a range of species. However over the five years sampled there was a declining trend in the tonnes of fish discarded with half the amount of fish being discarded in 2006 compared to 2002. Of these discards, the commercial target species mackerel, herring and horse mackerel were the most discarded. The most commonly discarded non-commercial species was boarfish, accounting for 5% of total discards. Slippage accounts for 10% of all discards, and of these the most common species slipped is herring. The greatest between variability in discarding of a particular species was observed in mackerel and over all this was the most discarded species by weight. A suggestion of the occurrence of high grading of mackerel by this fishery has been disputed by those in the fishery. They point out that unlike the other species, mackerel are discarded in 2 fisheries; the mackerel fishery (where fish are discarded during processing like the other species) and in the horse mackerel fishery (where smaller mackerel are caught and discarded because they are below minimum landing size and the mackerel quota has already been taken earlier in the year). This suggestion is plausible. Preliminary investigations of the data show that the smaller mackerel are caught during the horse mackerel fishery and are not associated with the targeted mackerel fishery. The large between year variability in the catches of juvenile mackerel in the horse mackerel fishery have also been suggested as a possible index of recruitment in mackerel. A longer time series is required to fully assess this, and to further assess the discarding behaviour of the fleet by area, fishery and stock level.

Iglesias, M., Miquel, J., Oñate, D., Bernal, M., Porteiro, C., Peleteiro, E., Nogueira, E. and Santos, M.B.

Sardine (*Sardina pilchardus*) in IXa & VIIIc: results from the Spanish spring acoustic survey PELACUS0407

Document available from: Begoña Santos, Instituto Español de Oceanografía. Centro Oceanográfico de Vigo. PO Box 1552, Vigo, Spain.

E-mail: m.b.santos@vi.ieo.es

Results of the Spanish spring acoustic survey PELACUS0407, carried out from the 27th March to the 23rd April 2007, indicated a stock biomass of 96,390 tons of sardine (1482 million fish) in northwest and northern Spanish waters. The main bulk of the resource was found in Galician waters (ICES sub-areas IXa-N, VIIIc-W) and consisted of age 3 fish (fish born in 2004). Age 3 fish also predominated in ICES sub-area VIIIcE-w but not in the eastern part of the surveyed area, where older fish were more abundant (ICES sub-area VIIIcE-e). The abundance and biomass obtained from PELACUS0407 are similar to the values estimated from the last 2 surveys (with a slight increase in the biomass but not in the number of fish). These figures seem to indicate that the last strong sardine recruitment (2004) probably halted the downward trend in stock size apparent since 2001 in Spanish waters. However, there is also evidence that the 2004 recruitment in the surveyed area was not as strong as the previous recruitment peak in 2000, since both biomass and abundance values are at their lowest since 2001. In addition, the area occupied by the sardine stock in Spanish waters appears also to have diminished continuously since 2001, which could make the resource even more vulnerable to fishing and/or predation. PELACUS0407 also obtained data on the distribution of sardine eggs and their number in the surveyed area: eggs were found in larger quantities and over a wider area than previously recorded by CUFES in the PELACUS series (2000-2007).

Iversen, S. A. Skogen, M. and Svendsen, E.

A prediction of the Norwegian catch level of horse mackerel in 2007.

Document available from: Svein A. Iversen, Institute of Marine Research, P.O Box 1870

Nordnes, 5817 Bergen, Norway.

E-mail: svein.iversen@imr.no

Norway has in most years since 1987 been the major nation fishing for horse mackerel in the northern North Sea and Norwegian Sea, and the fishery is carried out by purse seiners in the Norwegian economical zone (NEZ). The fishery is usually carried out in October and is considered to exploit the western stock. The purse seine fleet adapts its effort in this fishery according to the actual availability of horse mackerel. This means that in years with low availability of horse mackerel the fleet will leave the fishery. The Norwegian fleet exploits mainly the 5+ group and the fishery started in 1987 when the 1982 year class was five years old. The modelled influx of Atlantic water to the North Sea during the first quarter correlates well with the Norwegian catches of horse mackerel in NEZ later in the year. An exception is 2000 when there was no obvious correlation. The correlation has been used locally to predict the catch levels in NEZ since 1997. The predicted and actual catch matched very well in 2006. The influx in 2007 indicates an increase in catch rate from 27 000 t in 2006 to more than 60 000 tons in 2007.

Jan Arge Jacobsen

Juvenile (2006 year-class) mackerel in the southwestern part of the Faroese area in late 2006 and early 2007

Abstract:

For the first time juvenile mackerel was observed in the southwestern part of the Faroese area in late 2006 and early 2007. The Faroese pelagic fleet usually fish for pre spawning blue whiting in the eastern part of the Faroese EEZ, when they are on their way south towards their spawning areas. These fish were caught as by-catch in the commercial fishery for blue whiting southwest of the Faroes in winter 2007/2007. The mean length was around 18-19 cm and

mean weight was 40-44 g. Examination of the otoliths showed that it was the 2006 year-class that was present in this area in the winter months. These observations could be an early indication of a strong 2006 year-class of mackerel coming up.

Jacques Massé[1], Pierre Beillois, Erwan Duhamel, Martin Huret, Benjamin Planque , Pierre Petitgas, Alain Biseau

Direct assessment of pelagic species by the PELGAS07 acoustic survey

An acoustic survey was carried out in the bay of Biscay from April 26st to May 26th on board the French research vessel Thalassa. The objective of PELGAS07 survey was to study the abundance and distribution of pelagic fish in the Bay of Biscay. The target species were mainly anchovy and sardine and were considered in a multi-specific context. To assess an optimum horizontal and vertical description of the area, two types of actions were combined : i) Continuous acquisition by storing **acoustic** data from five different frequencies and and counting the number of fish eggs using **CUFES** system, and discrete sampling at **stations.** According to EU agreement, a consort survey was organised this with commercial vessels. 6 vessels were permanently accompanying Thalassa during the survey, 2 French pair trawlers, 1 French coastal purse seiner and 3 Spanish purse seiners. This WD report acoustic assessments and length distributions of main species, age distribution for anchovy and sardine and some environmental data.

Ramos, F., Miquel J., Millán M, Iglesias M., Oñate D. and Díaz N.

Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCÁDIZ 0707* Spanish survey (July 2007).

Document available from: Fernando Ramos, Instituto Español de Oceanografía. Estación de Biología Pesquera de Cádiz. Centro Andaluz de Ciencia y Tecnología Marina, CACYTMAR. Campus Universitario Río San Pedro. 11510 Puerto Real, Cádiz, Spain

E-mail: fernando.ramos@cd.ieo.es

The working document reports the main results from a Spanish acoustic survey conducted by IEO between 3rd and 12th July 2007 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V "*Cornide de Saavedra*". The survey season was coincident with the anchovy (*Engraulis encrasicolus*) peak spawning to achieve an acoustic estimate of its SSB in the study area. Abundance and biomass estimates are given for all the mid-sized and small pelagic fish species susceptible of being acoustically assessed according to their occurrence and abundance levels in the study area. The distribution of these species is also shown from the mapping of their back-scattering energies. Anchovy was distributed all over the inner and middle shelf of the study area with the densest concentrations being recorded, as usual, in the Spanish waters. The total biomass estimated for anchovy was 12.6 thousand tonnes (805 million fish). Sardine (*Sardina pilchardus*) showed the highest densities in the westernmost coastal waters of the sampled area. The total biomass estimated for sardine was 62.5 thousand tonnes (1207 million fish). Chub mackerel was mainly concentrated in Algarvian waters as well. The Chub mackerel total biomass was estimated at 63.2 thousand tonnes (797 million fish). Acoustic estimates for round sardinella (*Sardinella aurita*), mackerel (*S. scombrus*), horse-mackerel species (*Trachurus spp*.), and bogue (*Boops boops*) are also given in the WD.

Silva, L., Castro J., Ramos, F. and Punzón A.

Identification of *métiers* in the Gulf of Cadiz Spanish purse-seine fishery (ICES Sub-division IXa South).

Document available from: Luis Silva, Instituto Español de Oceanografía. Estación de Biología Pesquera de Cádiz. Centro Andaluz de Ciencia y Tecnología Marina, CACYTMAR. Campus Universitario Río San Pedro. 11510 Puerto Real, Cádiz, Spain

E-mail: luis.silva@cd.ieo.es

The CLARA (Clustering LARge Applications) method, a non-hierarchical clustering data-mining technique was used to classify the fishing trips of the Spanish purse-seine fleet operating in the ICES Sub-division IXa South from 2003 to 2005. The classification of individual trips was only based on the species composition of landings from logbooks. Up to four clusters (catch profiles) were identified from each of the annual datasets according to the targeted species: 1) trips targeting anchovy, 2) trips targeting sardine; 3) trips targeting a mackerel species complex; and 4) trips targeting an anchovy and sardine mixing. The three first groupings were considered as clearly identifiable métiers according to our knowledge on the fishery. These métiers may be considered as a stratification criterion of market sampling protocols if they have to be reconsidered under the fishery/fleet-based approach .

John Simmonds,

Are reported catches sufficient to account for biomass in the NE Atlantic mackerel stock.

In 2004 the assessment method for mackerel was changed to reflect greater uncertainty in the size of the stock. Since then ICES has indicated in its management advice that reported catches may not reflect the full extent of removals by the fishery and have given advice based more on harvest rates than catch and biomass. The paper presents the results of an extensive MCMC modelling analysis of catch at age, egg survey and tagging mortality data. The errors in each method are dealt with independently in the model and there is extensive exploration of potential sources of uncertainty both in the data and in the model. The different possibilities examined in the model include selection in the fishery, by age and over time; age dependence, magnitude and trend in natural mortality; precision of the egg survey; and extent of missing catch, as a constant factor, with trend and by year. The results clearly reject the null hypothesis that reported catches explain the extent of removals due to fishing. The evidence presented shows that to reconcile tagging mortality, catch at age and biomass from the egg surveys there is additional biomass and unaccounted removals amounting in total to between 1.6 to 3.4 times the reported landings and reported discards.

Yorgos Stratoudakis, Alexandra Silva and Graça Pestana

Post-SARDYN research and monitoring suggestions for sardine

IPIMAR, Avenida de Brasilia, s/n, Lisboa, 1449-006, Portugal

With the completion of SARDYN in May 2006, the route of communication for scientists with interest to sardine assessment offered by the project came to an end. This document aims to re-establish some form of this dialogue, by providing an update of post-SARDYN initiatives and suggestions for future monitoring and research for sardine in the Atlanto-Iberian stock area and its neighbourhood. The list of topics considered is not exhaustive, but mainly develops on comments provided by the 2006 Review Group (RG06) of the WGMHSA report. It is merely based on the opinions of IPIMAR scientists due to the impossibility to discuss its contents with other colleagues prior to the assessment meeting. However, the intention of the document is to stimulate discussion among interested members of the assessment group to establish commonly accepted lines of research and monitoring both at national and international levels.

Ulleweit, J., Panten, K.:

Observing the German Pelagic Freezer Trawler Fleet 2002 to 2006 – Catch and Discards of Mackerel and Horse Mackerel

Doc. available from J. Ulleweit, Inst Sea Fisheries, Fed Res Centre Fisheries, Palmaille 9, D-22627 Hamburg, Germany, E-mail: jens.ulleweit@ish.bfa-fisch.de

Since the implementation of the EU-funded National Data Collection Programmes in 2002, 31 German pelagic freezer trawler trips directed towards mackerel, horse mackerel, herring, and blue whiting have been investigated by biological observers until the end of 2006. The data obtained were used for calculating discard rates of mackerel, horse mackerel and other species. 12 out of 31 trips were without discards at all. The average discard rate per trip was 3.3 % of the total catch, all species and years combined. Maximum discard rate observed on a single trip was 19 % of the total catch.

The discard rates per species depend on the target species: Mackerel discards in the mackerel fishery vary between 0 and 11 % of the catch. Higher discard rates were found in the North Sea herring fishery. Here, herring was discarded with rates up to 14 %.

Besides the disposal of unwanted by-catch like boar fish and the necessity of discarding because of minimum length restrictions the observed discarding practices can mostly be explained by high-grading, but in individual cases also with limited processing capacities.

Ecosystem survey in the Norwegian Sea

Summary

The major aim of this coordinated cruise was to map the large-scale oceanic distribution and quantify the abundance, aggregation and feeding ecology of Northeast Atlantic mackerel (*Scomber scombrus*), Norwegian spring-spawning herring (*Clupea harengus* L.) and blue whiting (*Micromesistius poutassou*) in relation to their experienced physical and biological environment during summer in the Norwegian Sea and surrounding waters. The fleet included two chartered commercial fishing vessels: M/V *Libas* and M/V *Eros*. These two vessels have adjustable drop keel and highly advanced acoustic instrumentation and sampling devices, making them excellent for large-scale scientific surveys. The vessels covered substantial areas (7395 nmi.) in the Norwegian Sea and surrounding waters between 62°30-75.00ºN and 18°W-22°E. The NEA mackerel was distributed over substantial areas in Coastal, Atlantic and Arctic water masses as well as frontal coastal and Arctic regions within shallow waters less than 50 meters depth. The dominant acoustic registrations and pelagic trawl catches were taken in the central and eastern part of the Norwegian Sea. The largest and oldest mackerel were typically caught in the western and northern part of the Norwegian Sea in the Jan Mayen area and 5 years old individuals dominated the catches (21%), together with 2 years old (20%). 1 year old mackerel contributed almost 10% of the catches. Mackerel was caught as far north as 73°30 N and weights ranging from 100-920 g. Most of the schools were quite small in size with shallow distribution (0-50 m) and the school biomass typically ranged from about 100 kg – 20 tons. Libas and Eros counted > 100 000 individual schools with multibeam sonars along the cruise tracks.

WORKING GROUP ON THE ASSESSMENT OF MACKEREL, HORSE MACKEREL, SARDINE AND ANCHOVY

ICES Headquarters, Copenhagen - 4-13 September 2007

Annex 1: LIST OF PARTICIPANTS

NAME	ADDRESS	TELEPHONE	FAX	E-MAIL
Beatriz Roel (Chair)	CEFAS Lowestoft Laboratory Pakefield Road Lowestoft, Suffolk NR33 0HT United Kingdom	+44 1502 52 4358	+44 1502 513865	b.a.roel@cefas.co.uk
Pablo Abaunza	Instituto Español de Oceanografía Apdo. 240 39080 Santander Spain	+34 942 29 10 60	+34 942 27 50 72	pablo.abaunza @st.ieo.es
Geert Aarts	IMARES, Wageningen UR P.O. Box 68 NL-1970 AB IJmuiden Netherlands			geert.aarts@wur.nl
Sergei Belikov	PINRO 6, Knipovich Street Murmansk, 183763 Russia	+7 8152 47 34 24	+7 8152 47 3331	belikov@pinro.ru
Jonathan Beecham	CEFAS Lowestoft Laboratory Pakefield Road Lowestoft, Suffolk NR33 0HT United Kingdom	+44 1502 562 244	+44 1502 513865	Jonathan.Beecham@cefas.co.uk
Andrew Campbell	The Marine Institute Rinville Oranmore Co. Galway Ireland	+353 91 367 200	+353 9173 0470	andrew.campbell@marine.ie
Sarah Clarke	Fisheries Research Services FRS Marine Laboratory P.O. Box 101 AB11 9DB Aberdeen United Kingdom			Clarkes@marlab.ac.uk
Erwan Duhamel	IFREMER 8, rue François Toullec F-56100 Lorient France	+33 297 873 837	+33 2 9797 3836	Erwan.Duhamel@ifremer.fr

NAME	ADDRESS	TELEPHONE	FAX	E-MAIL
Svein A. Iversen	Institute of Marine Research P.O. Box 1870 Nordnes 5817 Bergen Norway	+47 55 23 84 07	+47 55 23 86 87	Svein.iversen@imr.no
Jan Arge Jacobsen Arriving Sunday	Fiskirannsóknarstovan P.O. Box 3051, Noatún FO-110 Tórshavn Faroe Islands	+298 353900	+298 353901	janarge@frs.fo
Ciaran Kelly Arriving Sunday	The Marine Institute Rinville Oranmore Co. Galway Ireland	+353 91 387 200	+353 9173 0470	Ciaran.kelly@marine.ie
Jacques Massé	IFREMER rue de l'Ile d'Yeu B.P. 21105 F-44311 Nantes Cédex 03 France	+33 2 40 374 169	+33 2 40 374 075	Jacques.masse@ifremer.fr
Alberto Murta	IPIMAR – DRM Instituto de Investigaçao das Pescas e do Mar Av. Brasília 1449-006 Lisboa Portugal	+351 21 302 7120	+351 21 3015948	amurta@ipimar.pt
Leif Nøttestad	Institute of Marine Research P.O. Box 1870 Nordnes 5817 Bergen Norway	+4755236809	+47 55 23 86 87	leif.nottestad@imr.no
Fernando Ramos	Instituto Español de Oceanografía Apdo. 2609 11006 Cadiz Spain	+34 956 26 16 33	+34 956 26 35 56	fernando.ramos@ cd.ieo.es
Begoña Santos	Inst. Español de Oceanografía Centro Oceanográfico de Vigo Cabo Estay – Canido Apdo 1552 E-36280 Vigo Spain	+34 986492111	+34 986498626	m.b.santos@vi.ieo.es

NAME	ADDRESS	TELEPHONE	FAX	E-MAIL
Alexandra Silva	IPIMAR – DRM Instituto de Investigaçao das Pescas e do Mar Av. Brasília 1499-006 Lisboa Portugal	+351 21 302 7095	+351 1 3025948	asilva@ipimar.pt
John Simmonds	Fisheries Research Services Marine Laboratory P.O. Box 101 375 Victoria Road Aberdeen AB11 9DB United Kingdom	+44 1224 876 544	+44 1224 295511	j.simmonds@marlab.ac.uk
Dankert W. Skagen	Institute of Marine Research P.O. Box 1870 Nordnes 5817 Bergen Norway	+47 55 23 84 19	+47 55 23 86 87	Dankert.skagen@imr.no
Per Sparre	Danish Institute for Fishery Research Charlottenlund Slot DK-2920 Charlottenlund Denmark	+45 33 96 3455	+45 33 96 3333	pjs@dfu.min.dk
Jens Ulleweit	Institut für Seefischerei Palmaille 9 22757 Hamburg Germany	+49 40 3890 5217	+49 40 3890 5263	jens.ulleweit@ish.bfa-fisch.de
Andrés Uriarte	AZTI Herrera Kaia Portualde z/g 20110 Pasaia Gipuzkoa, Basque Country Spain	+34 943 00 48 00	+34 943 00 48 01	auriarte@pas.azti.es
Dmitri Vasilyev	VNIRO 17 Verkhne Krasnoselskaya 107140 Moscow Russia	007 499 264 8974	007499 264 9187	dvasilyev@vniro.ru
Begoña Villamor	Instituto Español de Oceanografía Apdo. 240 39080 Santander Spain	+34 942 29 10 60	+34 942 27 50 72	begona.villamor @st.ieo.es

Annex 2: DESCRIPTION OF THE TISVPA (version 2006.1)

D.A.Vasilyev <dvasilyev@vniro.ru>

01.03.2006

Introduction

The TISVPA (Triple Instantaneous Separable VPA) is an extension of the ISVPA model in its version 2004.3. The extension consists in possibility to estimates within the model an additional set of generation-dependent parameters in separable representation of exploitation rates. This set of parameters is intended to adapt traditional separable representation of fishing mortality (as a product of age-dependent and year-dependent factors) to situations when several year classes may have peculiarities in their interaction with fishing fleets caused by different spatial distribution, higher attractiveness of more abundant schools to fishermen, or by other reasons.

The above mentioned generation-dependent factors (g-factors) can be estimated and applied not to the whole interval of age groups used in the model, but to some age "window". The user can choose this window by setting the first and the last age for estimation of g-factors. He also can not use them at all – in such a case the TISVPA model is reduced to the "ordinary" ISVPA model.

Two sub-models with respect to these generation-dependent peculiarities are reserved in the model:

1 - model of "within-year effort redistribution by ages"

2- model of "gain (loss) in selection"

The first sub-model assumes that in each year more fishing-attractive cohorts borrow some amount of fishing effort from other cohorts by increasing its selection at the expense of diminished selections for other age groups in this year. The second one assumes that some cohorts has increased (or reduced) selections, but it does not cause direct change in selections for others.

The same way, as in ISVPA, the TISVPA parameter estimation procedures is based on some principles of robust statistics what helps to diminish the influence of error (noise) in catch-at-age data on the results if the assessment. Special parameterization of the model makes it unnecessary to use any preliminary assumptions about the age of unit selection and about the shape of selection pattern.

Brief description of the model is summarized in the table below.

Model	ISVPA (TISVPA)
Version	2006.1
Model type	A separable model is applied to one or two periods, determined by the user. The separable model covers the whole assessment period. It is possible to include the third, generation-dependent, factor into separable representation.
Selection	The selection at oldest age is equal to that of previous age; selections as function of age s(a) are normalized by their sum to 1. For the plus group the same mortality as for the oldest true age. If generation dependent factors are included, then s(a,y)=s(a)g(cohort). s(a,y) can be normalized for each year by their sum to 1 – sub-model of "within-year effort redistribution by ages, or not – sub-model of "gain (loss) in selection". The matrix of g-factors is normalized to give global average = 1.
Estimated parameters	
Catchabilities	The catchabilities by ages and fleets can be estimated or assumed equal to 1. Catchabilities are derived analytically as exponents of the average logarithmic residuals between the catch-derived and the survey-derived estimates of abundance.
Plus group	The plus group is not modelled, but the abundance is derived from the catch assuming the same mortality as for the oldest true age.
SSB surveys	Considered as absolute or relative. If considered as relative, coefficient of proportionality is derived analytically as exponent of the average logarithmic residuals between the catch-derived and the survey estimates of SSB.
Surveys in year (terminal + 1)	Can be taken into account (in assumption that fishing pattern in the year (terminal+1) is equal to that of terminal year)
Objective function	The objective function is a weighted sum of terms (weights may be given by user). For the catch-at-age part of the model, the respective term is: sum of squared residuals in logarithmic catches, or median of distribution of squared residuals in logarithmic catches MDN(M, fn), or absolute median deviation AMD(M, fn). For SSB surveys it is sum of squared residuals between logarithms of SSB from cohort part and from surveys. For age- structured surveys it is SS, or MDN, or AMD for logarithms of N(a,y) or for logarithms of proportions-at-age, or for logarithms of weighted (by abundance) proportions-at-age.
Variance estimates/ uncertainty	For estimation of uncertainty parametric conditional bootstrap with respect to catch-at-age, (assuming that errors in catch-at-age data are log-normally distributed, standard deviation is estimated in basic run), combined with adding noising to indexes (assuming that errors in indexes are log-normally distributed with specified values of standard deviation) is used.
Other issues	Three error models are available for the catch-at-age part of the model: errors attributed to the catch-at-age data. This is a strictly separable model ("effort-controlled version") errors attributed to the separable model of fishing mortality. This is effectively a VPA but uses the separable model to arrive at terminal fishing mortalities ("catch-controlled version") errors attributed to both ("mixed version"). For each age and year, F is calculated from the separable model and from the VPA type approach (using Pope's approximation). The final estimate is an average between the two where the weighting is decided by the user or by the squared residual in that point.

	Four options are available for constraining the residuals on the catches: Each row-sum and column-sum of the deviations between fishing mortalities derived from the separable model and derived from the VPA-type (effort controlled) model are forced to be zero. This is called "unbiased separabilization" As option 1, but applied to logarithmic catch residuals. As option 1, but the deviations are weighted by the selection-at-age. No constraints on column-sums or row-sums of residuals. If "triple-separable" version is used, then option 2 also produces cohort-sum equal to zero. For options 1 and 2, as well as for option 3 if not the whole age range is chosen for application of g-factors, the listed above conditions can be somewhat compromised, but the are still hold with respect to generation-independent "pure" s(a).
Program language	Visual Basic

The model

The Instantaneous Separable VPA (the ISVPA) group of models is designed for stock assessment when catch-at-age data are noisy; auxiliary information may be incorporated, or not used at all (if it is not available or considered as unreliable). The term "instantaneous" means that similarly to the cohort analysis introduced by Pope (1972) the catch is assumed to be taken "instantaneously", that is within a comparatively short period during the year. Approximation of instantaneous catch is absolutely correct for short fishing seasons, but it also can be regarded as being an approximate method for assessment of continuously exploited age-structured populations. In should be noted that the assumption of the constant fishing mortality coefficient during a year, that underlines conventional VPA, is also only a approximation. These two hypotheses are, in fact, the two opposite marginal simplifications in the frame of cohort models. The ISVPA acronym should not be confused with that of the Integrated Stochastic VPA by Lewy (1988).

Let us recall that Pope's Cohort Analysis is based on the observation equation (Baranov's catch equation):

$$C_{a,y} = F_{a,y}/(F_{a,y} + M)*N_{a,y}\,[1 - e^{-(F_{a,y} + M)}] \qquad (1)$$

($a = 1,\ldots, m;\ y = 1,\ldots,n$),

and the dynamic state equation:

$$N_{a,y} = (N_{a+1,y+1}e^{M/2} + C_{a,y})e^{M/2} \qquad (2)$$

($a = 1,\ldots, m-1;\ y = 1,\ldots n-1$), where a is the age index, m is the total number of age groups, y is the year index, n is the total number of years, $N_{a,y}$ is the abundance of age group a in year y,$C_{a,y}$ is the catch from age group a in year y, M is the instantaneous natural mortality coefficient (may be constant or represent a function of age). For simplicity, a=1 and y=1 are, respectively, the first age group and the first year in the available data.

Equation (1) expresses the total catch from age group a, accumulated in the y-th year if the dynamics of the group abundance N and the accumulated catch C (at time t) during the year are governed by the well known equations: $dN/dt=-(F+M)N$ and $dC/dt=FN$, where F and M do not depend on t (indices are omitted). Equation (2) is traditionally regarded as a discrete approximation of a continuous process; it becomes an exact one if the catch $C_{a,y}$ is taken instantaneously in the middle of the year y.

However, there are many exploited stocks with such short periods of fishing that the latter may be regarded as momentary. In such a case if the period of fishing falls on the middle of the year, equation (1) may be replaced by

$$C_{a,y}= \varphi_{a,y} N_{a,y} e^{-M/2}, \qquad (3)$$

where $\varphi_{a,y}$ plays the role similar to that of $F_{a,y}$ in equation (1) but cannot be called a fishing mortality coefficient. Strictly speaking, it is the fraction of the abundance of the a-th age group, taken as catch in the middle of the year y. The model (2)-(3) can be regarded as an "instantaneous" analogue of the VPA. The word "separable" shows that the hypothesis of separability (i.e. of age selectivity of the fishery) is accepted.

In terms of the TISVPA in its traditional separable case (ISVPA) it means that

$$\varphi_{a,y} = s_a \cdot f_y \qquad (4)$$

where f_y is proportional to the fishing effort (a year effect), while s_a is the selectivity of the fishery (an age effect). Further we will call them an effort factor and a selectivity factor.

If it is assumed that the assumption about selection pattern can be violated by some cohort-dependent effect, then the following representation can be used ("triple-separable" version):

$$\varphi_{a,y} = s_a \cdot f_y \cdot g_{cohort} \qquad (4.1)$$

Selectivity factors in the model are normalized:

$$\sum_{a=1}^{m} s_a = 1 \quad (5)$$

If triple-separable version is used, then g-factors are normalized to give global average for the whole matrix of g-factors equal to 1:

$$\sum_{y=1}^{n-1} \sum_{a=1}^{m-1} g_{a,y} = 1/[(n-1)(m-1)]$$

(n - number of years),

where

$$g_{a(j)1,\, y(j)1} = g_{a(j)1+1,\, y(j)1+1} = g_{a(j)1+2,\, y(j)1+2} = \ldots = g_{a(j)k, y(j)k} = g_j\,;$$

$a_{(j)1}$ - index of youngest age group, and $a_{(j)k}$ - index of oldest age group in the cohort j under consideration.

If triple-separable version is used, then an additional normalization allows to get sub-models of two kinds of "physical" process of changes in selection pattern (or two sub-versions with respect to g-factors):

1 – sub-model of "within-year effort redistribution by ages". Here the following additional normalization is used for each year:

$$\sum_{a=1}^{m} s_{a,y} = s_a g_{cohort} = 1 \qquad (5.1)$$

2- sub-model of "gain (loss) in selection" - this additional normalization is not used.

It is clear that in reality the fishing season does not necessarily fall on the middle of the calendar year. For the model it means that instead of factors $e^{M/2}$ и $e^{-M/2}$ the Equations (2) and (3) must contain factors $e^{\beta M}$, $e^{(1-\beta)M}$ and $e^{-\beta M}$, where β is the given constant (0 < β < 1). For simplicity in further explanations we will use β=1/2.

As can be seen, calculation of abundances in Equation (2) is undertaken directly via catch values. Catch values in this case are treated as true, the same way as in deterministic cohort models. But separabilization of the model makes it possible to look for unique values of $N_{a,y}$. . By this reason the version of the model determined by Equations (2)-(5) can be called catch controlled. In this version of the model the role of separabilization consists only in estimation of terminal populations and this version may be regarded simply as a method of tuning of ordinary cohort analysis, while the loss function of the model (e.g. the sum of squared residuals between logarithms of actual and theoretical catches) may be regarded as a measure of inseparability of the catch-at-age data (in logarithmic form).

The effort-controlled version of the ISVPA, which do not treat catch-at-age data as true, is based on another dynamic state equation, resulting from substitution of the expression for theoretical catch $\hat{C}_{a,y} = s_{a,y} f_y N_{a,y} e^{-M/2}$ instead of actual catch $C_{a,y}$ into Equation (2):

$$N_{a,y} = \frac{N_{a+1,y+1} e^{M}}{1 - s_{a,y} f_y} \qquad (2')$$

(Naturally, for ordinary separable representation (ISVPA) $s_{a,y}=s_a$ for every y.)

Thus, in the abundance estimation by this version of the model it is implied that separable representation of fishing mortality is true and residuals are attributed to errors in catch-at-age data. Here the value of loss function may be regarded as a measure of “precision” of catch-at-age data (if we assume that the fishery is fairly separable).

In practice in most cases both assumptions (that catch-at-age data are precise or fishery is well separable) are rather far from reality. If there are some ideas about their relative validity it is possible to use mixed version of the ISVPA in which the equation of the stock dynamics is a mixture (with the coefficient set up by the user) of equations (2) and (2’). In this version of the ISVPA the same weight (or the “level of relative confidence”) of the two assumptions is used for all points.

Since the user often has no preliminary perception about the relative validity of the above mentioned assumptions and since the relative weight of these assumptions could be highly different for different points (a,y), the 4-th version of the ISVPA called mixed with weighting by points is also available. In this version for every point (a,y) equations (2) and (2’) are weighted with reciprocal squared residuals between the given catch(a,y) value and its respective “theoretical” value $\hat{C}_{a,y} = s_{a,y} f_y N_{a,y} e^{-M/2}$ where $N_{a,y}$ is calculated by equation (2) or (2’). These weights are recalculated at every iteration within the iterative procedure of the model parameters estimation (see below).

Equation (2) or (2’) is treated as an exact one and serves for calculation of the matrix $\|N_{y,a}\|$ through M and $\|C_{y,a}\|$ (in the catch controlled version) or M and the vectors s_a , f_y and g_{cohort} (in the effort controlled version). Equations (3)-(4), postulating the separability, or age selectivity of fishing, are regarded as approximate ones, and the unknowns M, s_a , g_{cohort} and f_y are estimated so that to reduce the residual in Equation (3) to the minimum possible (as a rule, the squared logarithmic error is meant). Equation (5) is a normalizing condition and is treated as an exact one.

Estimated values of $\varphi_{a,y}$ can be recalculated into traditional instantaneous coefficients of fishing mortality $F_{a,y}$ by the formula: $F_{a,y} = -\ln(1-\varphi_{a,y})$, which becomes obvious if we rewrite the equation (2') as

$$\text{Ln}\,(N_{a,y} / N_{a+1,y+1}) = M - \ln(1-\varphi_{a,y})$$

and to compare it with traditional VPA equation:

$$\text{Ln}\,(N_{a,y} / N_{a+1,y+1}) = F_{a,y} + M.$$

Algorithm of the model

The algorithm of each version of the ISVPA generally consists of a 'core', in which all the model parameters are evaluated from the iterative procedure with the given natural mortality coefficient, M, and terminal fishing effort, f_n, and an the outward 'shell' (a loop in which the best M and f_n are fitted).

The 'core' is represented in the program by 4 iterative procedures. The three procedures which are described in details below are designed to ensure "unbiasness" of the solution, each in its own sense.

The 4-th procedure is intended to produce the best fit to catch-at-age data, but the solution will be free from any restriction on bias. The 4-th procedure is a rather time consuming derivative-free procedure, but experiments with very noisy data showed that if parameters are strongly interdependent and the minimum is flat this procedure works better (gives a better fit) compared to some tested algorithms, including Marquardt-Levenberg and Simplex ones.

Basic iterative procedure (procedure A) (marked as nonlog in the menu)

Within any ISVPA iterative procedure the given M and f_n are not changed. The calculations start with setting up of the initial values of the fishing effort, f_y at y=1,..., n-1 and selectivity, s_a; at a=1,..., m (the normalizing condition (5) must be followed). Each iteration consists of the following steps.

First, the terminal vectors $\{N_{a,n}\}$ and $\{N_{m,y}\}$ are evaluated by (3), then all other $N_{a,y}$ are determined from (2) or (2'). After that the matrix of fractions $||\varphi_{a,y}||$ is evaluated by the Equation

$$\varphi_{a,y} = \frac{C_{a,y}}{N_{a,y}} e^{M/2}, \qquad (6)$$

and $\{f_y\}$ and $\{s_a\}$ are determined as

$$f_y = \sum_{a=1}^{m} \varphi_{a,y} \qquad (7)$$

and $$s_a = \frac{\sum_{y=1}^{n} (\varphi_{a,y} / g_{a,y})}{\sum_{a=1}^{m} \sum_{y=1}^{n} (\varphi_{a,y} / g_{a,y})} \qquad (8)$$

To improve the convergence, s_m and s_{m-1} are replaced with their arithmetic mean:

$$s_m = s_{m-1} = \frac{\sum_{y=1}^{n}(\varphi_{m,y}/g_{m,y} + \varphi_{m-1,y}/g_{m-1,y})}{2\sum_{a=1}^{m}\sum_{y=1}^{n}(\varphi_{a,y}/g_{a,y})}. \qquad (8.1)$$

Note that the selectivity values remain normalized since the initial normalization.

Generation-dependent factors g_{cohort} = are estimated as follows:

$$g_j = (g_{a(j)1,\, y(j)1} + g_{a(j)1+1,y(j)1+1} + \ldots + g_{a(j)k,y(j)k}) / k\,, \qquad (9)$$

where $$g_{a(j),\, y(j)} = \frac{\varphi_{a,y}}{s_a f_y}$$

Strictly speaking, the symbol $\varphi_{a,y}$ is allotted to the estimate of the fraction given by formula (6) at each iteration IT. To avoid confusion, its separable analog, which also can be evaluated at each iteration, will be designated as $\varphi_{a,y}^{sp} = s_{a,y} \cdot f_y$.

Assume that the convergence is already achieved, and $\varphi_{a,y}$ and $\varphi_{a,y}^{sp}$ are limits of the corresponding fractions at IT$\rightarrow\infty$. When we deal with the 'pure', completely separable data, the convergence means that $\varphi_{y,a} = \varphi_{y,a}^{sp}$. However, in the general case, when the catch-at-age data do not correspond to completely separable fishing (and contain errors), the two fraction estimates, $\varphi_{a,y}$ and $\varphi_{a,y}^{sp}$ must differ. This difference could serve as a measure of non-separability in the data, thus appearing in the role of a random error, $\varepsilon_{a,y}$ in the fraction $\varphi_{a,y}$ with respect to the separable fraction $\varphi_{a,y}^{sp}$:

$$\varphi_{a,y} = s_a \cdot f_y + \varepsilon_{a,y}. \qquad (10)$$

Now let us clarify the question of whether our separable estimates of φ are unbiased or not. Such an analysis requires calculation of the mathematical expectation of the random values ε. It is reasonable to regard such errors within each age group at y=1,...,n-1 as being independent and equally distributed. When this is the case, the averaging of ε within the same age group furnishes the required estimation of the bias. At IT$\rightarrow\infty$ relationships (5), (7) and (10) yield:

$$f_y = \sum_{a=1}^{m}(s_a f_y + \varepsilon_{a,y}) = f_y + \sum_{a=1}^{m}\varepsilon_{a,y}$$

or

$$\sum_{a=1}^{m}\varepsilon_{a,y} = 0, \qquad (11)$$

for each year y. Similarly, at IT$\rightarrow\infty$, relationships (5), (8), (10) and (11) involve:

$$s_a = \frac{\sum_{y=1}^{n}(s_a f_y + \varepsilon_{a,y})}{\sum_{a=1}^{m}\sum_{y=1}^{n}(s_a f_y + \varepsilon_{a,y})} = s_a + \frac{\sum_{y=1}^{n}\varepsilon_{a,y}}{\sum_{y=1}^{n} f_y},$$

or

$$\sum_{y=1}^{n} \varepsilon_{a,y} = 0 \qquad (12)$$

for each age group a (certainly, transformation (9) does not break this result). Relationships (11) and (12) prove that the separable estimates of φ supplied by this iterative procedure are unbiased. This is valid for traditional "double-separable" representation. If $s_{a,y}$ is used instead of s_a , then this condition can be somewhat compromised.

Weighted arithmetical mean procedure (procedure B) (marked as nonlog w-d in the menu)

When the selectivity is strongly dependent on age, the errors corresponding to different age groups hardly can be regarded as equally distributed (although, relationship (10) shows that their mean over age also equals zero). In this case, a modified iterative procedure could be appropriate, in which inverse selectivity values serve as weights at the stage of calculating the efforts.

Within this, 'weighted' iterative procedure, relationship (7) is replaced with the following equation for calculating the efforts:

$$f_y = \frac{1}{m}\sum_{a=1}^{m} \frac{\varphi_{a,y}}{s_{a,y}}, \qquad (13)$$

(which is also an algebraic consequence of the separability hypothesis), and the efforts are calculated from (13) using the selectivity values from the previous iteration. Thereupon the current selectivity values are computed from (8) and g-factors – from (9).

Analysis of statistical sense of the solution for this procedure is similar to the previous one. At IT$\rightarrow \infty$ relationships (5), (13) and (10) result in:

$$f_y = \sum_{a=1}^{m}(s_a f_y / s_a + \varepsilon_{a,y} / s_a) = f_y + \sum_{a=1}^{m}(\varepsilon_{a,y} / s_a)$$

or

$$\sum_{a=1}^{m}(\varepsilon_{a,y} / s_a) = 0, \qquad (11')$$

for each year y. Similarly, at IT$\rightarrow \infty$, relationships (5), (8), (10) and (11') will give:

$$s_a = \frac{\sum_{y=1}^{n}(s_a f_y / s_a + \varepsilon_{a,y} / s_a)}{\sum_{a=1}^{m}\sum_{y=1}^{n}(s_a f_y / s_a + \varepsilon_{a,y} / s_a)} = s_a + \frac{\sum_{y=1}^{n}(\varepsilon_{a,y} / s_a)}{\sum_{y=1}^{n} f_y},$$

or

$$\sum_{y=1}^{n}(\varepsilon_{a,y} / s_a) = 0 \qquad (12')$$

for each age group a. Relationships (11') and (12') prove that the separable estimates of φ weighted by selectivity factor, supplied by this iterative procedure are unbiased. Again, this is valid for "double-separable" procedure. If $s_{a,y}$ is used instead of s_a , then this condition can be somewhat compromised.

"Logarithmic" (geometrical mean) procedure (procedure C)

Logarithmic transformation of the relationships (3) and (4) leads to the third iterative algorithm, similar to the basic and the weighed arithmetic mean ones but dealing with logarithms of C, φ, s, f, etc. Within this, logarithmic iterative procedure relationships (6) - (8), that are used at the IT-s iteration, must be replaced with:

$$\ln \varphi_{a,y} = \frac{M}{2} \ln \frac{C_{a,y}}{N_{a,y}}, \qquad (14)$$

$$\ln f_y = \frac{1}{m} \sum_{a=1}^{m} \ln(\frac{\varphi_{a,y}}{s_a g_j}), \qquad (15)$$

$$\ln s_a = \frac{1}{n} \sum_{y=1}^{n} \ln(\frac{\varphi_{a,y}}{f_y g_j}), \qquad (16)$$

$$\ln s_m = \ln s_{m-1} = \frac{1}{2n} \sum_{y=1}^{n} (\ln \frac{\varphi_{m,y}}{g_j f_y} + \ln \frac{\varphi_{m-1,y}}{g_j f_y})$$

and

$$\ln g_j = (\ln g_{a(j)1,\, y(j)1} + \ln g_{a(j)1+1, y(j)1+1} + \ldots + \ln g_{a(j)k, y(j)k}) / k , \qquad (17)$$

where $g_{a(j),\, y(j)} = \dfrac{\varphi_{a,y}}{s_a f_y}$

It is necessary to mention that in this and in all other procedures for "short" generations (less than 2 points in the catch-at-age data matrix), values of g_j are not recalculated within iterations and remains the same (their discrepancy from initial guess (equal to 1) is due only to normalization.

When evaluating f_y by (15), selection-at-age and g-factors are taken from the previous iteration. At the end of each iteration, selectivities must be re-normalized so that to satisfy condition (5). This procedure can also be called "weighed geometrical mean procedure", as from (15) and (16) it immediately follows that f_y, s_a and g-factors equal to the geometrical means of $\varphi_{a,y}$ weighed by s_a or f_y or generation factor respectively.

It is easy to show, that this iterative procedure stops when "estimated" logarithmic catches are unbiased (residuals have zero mean) simultaneously within years, age groups and generations (this will be illustrated below). In order to understand the statistical meaning of the convergence of the procedure, it is convenient to use the notion of estimated catch,

$\hat{C}_{a,y} = s_a f_y g_j N_{a,y} e^{-M/2}$, and present $\varphi_{y,a}$ in the form:

$$\varphi_{a,y} = g_j s_a f_y \frac{C_{a,y}}{\hat{C}_{a,y}} \qquad (18)$$

Let us consider the limits at IT $\rightarrow \infty$ of all the variables participating in the model. Therefore the fractions $\varphi_{a,y}$, which is determined by equation (4.25)-(4.28), can be replaced with that given by relationship (4.29), where $\hat{C}_{a,y}$ is substituted by $\hat{C}^*_{a,y}$, the catch estimates supplied by the iterative procedure at at $IT \rightarrow \infty$. This substitution implies:

$$\sum_{a=1}^{m}[\ln C_{a,y} - \ln \hat{C}^*_{a,y}] = 0 \quad , \qquad (19)$$

$$\sum_{y=1}^{n}[\ln C_{a,y} - \ln C'^*_{a,y}] = 0 \ , \qquad (20)$$

$$\sum_{j=1}^{k}[\ln C_{a,y}(j) - \ln C'^*_{a,y}(j)] = 0, \qquad (21)$$

Equation (21) is valid only for generations, participating in evaluation of g_j (see above). The meaning of (19)-(21) is that the log-transformed estimates of catches are unbiased for each age group, each year, and each generation. If not all available age groups, but some age window is chosen for application of g-factors, then equation (21) may be compromised, while (19) and (20) remain valid.

Loss functions

In accordance with the assumptions about the error structure in the data the solution of the model can be based on the standard minimization of sum of squared residuals or on the minimization of some more robust loss functions: the median of distribution of squared residuals or the absolute median deviation of residuals.

Minimization of the median, MDN, of squared residuals (that is, the use of the least median or the LMSQ principle) instead of their sum (the classical LSQ-principle) sometimes is referred to be more resistant to outliers, i.e. those elements of the data set which go far beyond the reasonable confidence limits and, hence, are suspicious of containing extremely high errors (O'Brien, 1997; Hampel et al., 1986).

According to this concept, an alternative ISVPA solution can be seeked as providing estimates of M and f_n, which secure the minimum of the median of the distribution of the squared logarithmic residuals,

$$SE_{a,y} = (\ln C_{a,y} - \ln \hat{C}^*_{a,y})^2$$

(a = 1,...,m; y=1,...,n). The corresponding loss function will be denoted as MDN(M, f_n).

In practice, the median of a random series is estimated by rearranging its elements in a descending or increasing order and taking the central element of the new series or the mean of two central elements (depending on whether the total number of the elements is odd or even). However, when used within the framework of ISVPA, this estimate sometimes may cause a certain roughness of the surface MDN(M, f_n). In order to make the loss function smoother, the median is estimated here as the mean of a number (for example, 10) of central elements of the ordered series of $SE_{a,y}$. So, in this version of ISVPA, the iterative procedures for estimating the vectors f and s remain the same as described above, the only difference being the use of the behavior of the median as an indicator of their convergence. Numerical experiments ascertain workability of the three versions of the ISVPA iterative procedures combined with the LMSQ principle.

As it was already noted, in order to smooth the median estimates, averaging over a number of central elements of the ordered series of squared residuals is suggested. Certainly, the number of central elements can vary from one or two to m·n, the total length of the series. However, in the latter case, the averaging results in estimation of the mathematical expectation rather than the true median of the squared residuals. Thus, in fact, the suggested approach (when averaging over a number of central squared residuals is applied) can actually be regarded as a compromise between the true median minimization and the conventional least squares criterion. The advantage of this compromise is that, according to our experience, the use of the least squares approach leads to a sufficiently smooth loss function, while the minima of MDN(M, f_n) are better pronounced.

One of the central issues in fitting a model to real data is the choice of the fitting criterion. Statistically, the use of the LSQ criterion is equivalent to accepting the hypothesis of normality of the distribution of the residuals (in the case when the sum of squared logarithmic residuals is minimized, the errors themselves are supposed to be logarithmically normal). What is the reason for using the median minimization approach? What kind of iterative procedure matches well the LMSQ criterion? To illuminate the nature of combining the LMSQ criterion with the ISVPA, let us consider the third, weighed logarithmic version of the iterative procedure.

It has been shown above that the logarithmically transformed theoretical estimates of catches are unbiased. Strictly speaking, it means only that the mathematical expectation of the corresponding residuals is zero. We, however, believe that in practice, the distributions of the logarithmic residuals are often almost symmetric. This is confirmed by our numerous computer tests with both simulated and real data. Clearly, if a random value □ is distributed symmetrically the median of its squares, □^{2}, indicates the compactness of the distribution of □: the higher the median of □^{2}, the greater the variance of □. Conversely, the lower the median of the distribution of □^{2}, the more compact is the distribution of □. Thus, by minimizing the median of the squared logarithms of the catches residuals resulting from estimation of catches by means of the weighed logarithmic iterative procedure, the maximal allowable compactness of the distribution of the errors themselves is reached, consequently, providing a reasonable fit of the model to the catch-at-age data in the sense of the conventional maximum likelihood concept.

Such a statistical justification cannot be given to the median minimization approach when the first (A) or the second (B) version of the TISVPA iterative procedure is used, as neither of them impose any reasonable condition on the errors in the logarithmically transformed catches. From this point of view for these versions the conventional least squares approach seems to be more appropriate.

On the other hand, the approach when the quality of fitting is measured by some “window” in the distribution of residuals which does not include the tails of the distribution, could be considered a means to suppress the influence of outliers on the solution (because the residuals corresponding to outliers are located near the margins of the distribution and will not affect the value of the median). From this point of view minimization of the median seems to be appropriate for procedures A and B also.

In addition to the two above mentioned TISVPA objective functions, the absolute median deviation AMD(M, f_n), i.e. the median of the absolute deviations of model residuals from their median value, known as one of the most robust measures of scale (Huber, 1981), also may be used. According to my experience in some cases (for example, when distribution of residuals, still having zero mean, has nonzero median) AMD gives more pronounced minimum with respect to MDN(SE) - minimization. However, if the data are not informative (for example, if historical changes in catches and in stock are not pronounced) the AMD may be not sufficiently sensitive and it may be better to use the MDN.

Now let us say a few word about the procedure of estimation of the "best" (in the sense of the loss function chosen) values of (f_n ,M). The choice of the procedure in the ISVPA is based on the following considerations:

- algorithmic simplicity, taking into account that in the outer loop only two (or even one, if M is considered as known) parameters are to be estimated;
- if the loss function surface has more than one minimum - to give possibility to start minimization in the vicinity of the required minimum and to arrive at it even if the surface is very flat (this implies that gradient methods may be ineffective).

Numerous simulation experiments have indicated that the method, which is not the fastest, but which allows us to reach precisely the minimum even if the error surface is very flat and the minimum is local, is the method of "lowering by coordinates" with successively diminishing steps. The step of the procedure (i.e. the increase in the tested parameter value) is fixed by the program and after the minimum is reached with this step, the latter is reduced by a factor of 10. When the minimum is attained again the step value is reduced by the same factor, and so on, till the minimum of the tested parameter value is reached with the required precision.

It is necessary to mention that while minimization of the sum of squared errors multiple minima are almost never encountered (here the problem is that for noisy data minimum of SSE is often reached at a marginally high or low value of the tasted parameter), for the median minimization the surface of the loss function (as a function of f_n and M) may have complex structure. That is why before the final run with precise estimation of the model parameters it is recommended to make preliminary point-by-point scanning of the (f_n ; M) area with sufficiently small step (e.g. 0.1 for f_n and 0.01 for M). The TISVPA program realization gives such a possibility.

Suppression of inter-iteration oscillations

When the level of noise in the initial data is high, the estimated effort and selectivity, as well as the sum of squared residuals, SSE, vs. the number of iteration, IT, contain a few explicit slowly decaying modes of oscillations superimposed on a certain rapidly stabilizing trends. These oscillations slow down the convergence of the SSE to its limit, SSE*, or of the MDN to MDN*, or the AMD to AMD* at $IT \to \infty$, thus becoming significant at the stage of searching for the minimum of SSE*(M, f_n) or MDN*(M, f_n), as in practice, at every M and f_n the iterative process is stopped at a finite IT. The most notable in this context are the saw-tooth type oscillations with a 2-year periodicity, i.e., those with the highest frequency. Conventional method for filtering oscillations and extraction of trends from numerical series is a moving averaging. We, however, are dealing with an iterative process, where at any iteration IT, the current selectivity, $s_{IT}(a)$, or the effort, f_{IT}, estimate is calculated after the previous value, $s_{IT-1}(a)$ or $f_{IT-1}(y)$, was found. That is why, by defining the corrected selectivity and effort estimates at IT-th iteration, $s'_{IT}(a)$ and $f'_{IT}(y)$, as

$$s'_{IT}(a) = \alpha s_{IT-1}(a) + (1-\alpha) s_{IT}(a) \qquad (22)$$

$$f'_{IT}(y) = \alpha f_{IT-1}(y) + (1-\alpha) f_{IT}(y) \qquad (23)$$

and by a proper choice of the coefficient $0<\alpha<1$, the desired filtration, similar to the moving averaging, can be achieved. According to (22), all the selectivity estimates, which were computed at the previous iterations, participate in the correction for the current, IT-th iteration. The same is valid for the effort (see (23)). So, the size of the averaging interval in this filtration procedure increases with the growth of IT. Nevertheless, as the weights of the last, IT-th, iterations remain constant, while the weights of the early iterations decay, the suggested filtering procedure can be regarded as an analog of a conventional moving averaging. The effective averaging interval is determined by the choice of α: the smaller α, the narrower the effective averaging interval. Experiments showed that the choice of α do es not affect the result: they are almost identical for tested range of α from 0 to 0.95.

Treatment of zero catches.

Existence of zero values in the catch-at-age matrix is known to be a rather complicated (and may be logically controversial when dealing with the logarithmic residuals) problem which is solved differently in different methods. In the ISVPA the following algorithm is applied:

1. If $C_{a,\,y}$=0, then the value of $\varphi_{a,y}$ is taken equal to its "theoretical" value, that is

$\varphi_{a,y}= s_{a,y}\, f_y$.

2. Residuals for points of zero catches are taken equal zero.

3. Stock abundance is computed as follows:

3.1. If $N_{a+1,y+1}$ >0 and $C_{a,y}$=0, than $N_{a,y}$ is computed by (2).

3.2. If $N_{a+1,y+1}$ =0 and $C_{a,y}$=0, than $N_{a,y}$ = 0.

3.3. If $N_{a+1,y+1}$ =0 and $C_{a,y}$>0, than $N_{a,y}$ is computed by (3), similar to the terminal points.

3.4. If $N_{a+1,y+1}$ >0 and $C_{a,y}$>0, than $N_{a,y}$ is computed by equation (2) or (2') or their mixture, according to the version chosen.

Estimation of ISVPA parameters without limitation on bias

To test experimentally the role of limitation on bias, imposed by the above described ISVPA procedures, an additional, free of such limitations parameter estimation procedure was developed.

For "direct" fitting of multi-parameter models the Marquardt-Levenberg and Gauss-Newton method are traditionally used (Bard, 1974), as it was done, for example, in the CAGEAN (Deriso et al., 1985) and the ICA (Patterson, 1994). But in our case the use of these methods is complicated by normalization equation (2.5): parameters are becoming inter-dependent. Attempt to use the Simplex-method (Schnute, 1982) was also unsuccessful: for the case of many parameters the procedure is very time-consuming and also requires very qualified initial guess for parameters (the result is extremely sensitive to its choice).

Therefore, the procedure of "direct" search for the ISVPA parameters free of limitations on bias was finally arranged as follows. The same was, as it was done with "iterative" inner ISVPA procedures, the procedure was designed as two concentric loops. In outer loop optimization by (f_n , M) is made, while the parameters $\{s_a\}$and $\{f_y\}$ (except of f_n) are estimated in the inner loop.

The inner loop is arranged as follows. Each parameter is optimized in succession, while the order of optimization appeared to be important. Starting with a set of initial guesses for all parameters $s_1,...,s_m$ и $f_1,...,f_{n-1}$, optimization begins from f_{n-1} ; after that the value of f_{n-2} is optimized, and so on till f_1 . Further, the best value (from point of view of the loss function) of s_1 is estimated, the other values of s_a being changed by means of normalization equation (5). The found value of s_1 is then "frozen up" and the "best" value of s_2 is searched for (here the normalization equation (5) is applied to the rest of selectivity factors: $s_3,...,s_m$,). Then the next, s_3 , selectivity factor is estimated, and so on till s_{m-2}. . The rest of selectivities, s_m=s_{m-1} , appears to be already estimated by the normalization equation. After that the procedure returns back to the estimation of f_1 , and the same sequence of calculations is repeated till convergence.

The above described procedure gives the solution free from restrictions on bias. For "clean" catch-at-age data (simulated data without noise) the procedure gives absolutely correct estimates of all parameters (as well as "iterative" procedures A, B and C). For noisy simulated data and for real data the solution based on this "unrestricted" fitting procedure as a rule is much worse, while the final value of the loss function may be lower than for "unbiased" solutions.

It should be noted that implementation of the above described procedure of "parameter-by-parameter" optimization for the median minimization could be problematic if one (or a group) of parameters $s_1,...,s_m$ and $f_1,...,f_{n-1}$ occasionally influences only those values of residuals which are located in tails of the distribution of residuals and, hence, do not influence the median value.

Dealing with auxiliary information

There is possibility to include up to three SSB indices and up to seven age structured stock abundance indices into the model. In such a case, the ISVPA loss function will include additional components representing measures of discrepancy:

- for each SSB index : between logarithms of the SSB from the cohort part of the model and from surveys;

-for each age-structured index: between logarithms of abundance (a,y) from the cohort part of the model and from surveys (whether corrected to the estimated age-dependent "fleet catchabilities" or not).

The model fitting could be done not only with the survey abundance-at-age data, but also with the survey age proportions and "weighted" survey age proportions (see below).

Thus, for each age-structured index the discrepancy may be measured as the traditional sum of squared residuals, or by the MDN, or the AMD. The measure can be stated independently for each of "fleet".

For the SSB indices the only available measure in the model is the sum of squared residuals (because, as a rule, available number of years of the SSB surveys is rather low).

The program

Current realization of the ISVPA is made in Visual Basic and can be run within any Windows environment. If Visual Basic is installed on your computer it will be enough to copy only executable file. If not, you should use the TISVPA set-up package.

Input files are blank-separated text files, including:

- "necessary" files: catch-at-age by years, weight-at-age by years in the stock and maturity-at-age by years;

-"optional" files (not obligatory): natural mortality by ages, up to three files with the SSB estimates by years and up to seven files with age-structured abundance indices by years.

All input files must be copied to the C:\vbisvpa directory or its subdirectories.

Output files include: the file with records of minimization (minim.out), the file with results (its name is given by the user) of initial ("basic") run, as well as bootstrap output files:

1) bootf.out - includes the effort factor estimates by years and bootstrap runs;
2) bootm.out - includes the natural mortality estimates by ages and bootstrap runs (if it were regarded as an unknown parameter);

3) boots1.out and boots2.out - include the estimates of selectivities (for the first and the second time intervals) by ages and bootstrap runs (the program permits fitting of two selectivity patterns for two different successive time intervals);

4) bootssb.out - includes the SSB estimates by years and runs;

5) boottsb.out - includes the estimates of total stock biomass by years and runs;

6) bootntrm.out - includes the terminal year abundance estimates by ages and runs.

The procedure of working with the program is the following.

Primary choice is to use “triple” or ordinary separability assumption. If triple version is chosen – choose the first and the last ages for estimation of g-factors and sub-model (first or second). If ordinary (“double”) separabilization is chosen, the model will be reduced to ISVPA (in version 2004.3)

1) The first thigh to do while running the program is to enter the names of catch-at-age and weight-at-age files. If they are located directly in the C:\vbisvpa directory one should simply print their names (with extension). If they are stored in some sub-directory of C:\vbisvpa one should print the name of this subdirectory prior to the name of the file.

2) After that one will be asked about the situation with natural mortality: 1) to find M as an age-independent value; 2) to find it as a simple quadratic function of age; or 3) to use known values of M(a). If you choose option 2, you will be asked to enter the age of the minimum M (as a rule it can be taken equal to the age of ‘mass’ maturity). If option 3 is chosen, you will be asked to enter the name of the file with known M(a) values.

3) Next you will have to choose the method of the parameter estimation. There are four options available. Option 1 will produce solution with “unbiased separabilization”; option 3 will lead to “unbiased weighted separabilization”; option 2 will ensure “unbiased” estimates of logarithms of all parameters; option 4 will produce solution corresponding to the best fit to logarithmic catches, not restricted by any condition on bias. While using option 4 one should be patient as it is time-consuming. In most cases option 1 or 2 is recommended. It is strongly recommended not to use option 4 when you minimize the median as the error surface can be too "broken".

4) The next choice is what to minimize. It is possible to minimize the sum of squared residuals in the logarithmic catches, or the median of distribution of squared residuals in the logarithmic catches MDN(M, f_n), or the absolute median deviation AMD(M, f_n). For noisy data it is recommended to minimize the MDN or AMD.

5) Selection of the first and the last year of analysis and the last year of first selectivity pattern (the program gives possibility to fit two different selectivity patterns for two different successive time intervals). After that it is required to input the first and the last age groups. Naturally, they should be within the range of the input data. After that you will be asked whether the oldest age in the data is a “normal” age group, or a +-group?

6) Next question is about the “version” of the program (1. Catch-controlled, 2. Effort-controlled, 3. Mixed, 4. Mixed, weighted by points). Version 1 is preferable if fishery is known to be extremely non-separable. It also can be useful as a part of “mixed” versions 3 and 4. Version 2 is preferable if M is considered as an unknown parameter and/or the data are very noisy.

7) If version 3 is chosen you should input relative weight of the catch-controlled routine.

8) You could (1) scan the error surface or (2) look for a precise solution. If scanning is chosen, you will be asked about minimum and maximum values of the parameter (f_{term} or (M and f_{term})) and of the "step". It is recommended to make scanning first as there could be several local minima of the loss function. Option 2 allows to find a precise solution. If there are several local minima, you could

look for a solution corresponding to the required minimum making a proper choice of an initial guess about the parameter and a sufficiently small initial step. Please note that if the “scan” mode was chosen, the output file will contain the result at the rough minimum of the loss function. To get the result at the precise minimum you have to start the program again and to choose the option called “precise solution”. If "precise solution” is looked for, you should input the value of initial guess for f_{term} or (M and f_{term}) as well as the value of the initial step in the searching procedure.

9) Next you will have to set the value of the “inter-iteration smoother”. In most cases any value within 0.5-0.9 will be OK. In case of very noisy data, to suppress possible oscillations you could take a higher value - up to 0.9. Don’t worry about the “precise” value of this parameter: if the procedure converges - it is OK. Experiments proved that the final result will be the same even at 0.95.

10) If you have chosen the median minimization, you should input the number of central elements of the ordered series of squared residuals (or residuals) to use as its measure. In most cases 10 points is OK. If the error surface contains too many local minima it could be useful to increase the number of central elements; if minimum is too flat - you may diminish the number of central elements. It is noteworthy that this setting will be used for the MDN or the AMD measures everywhere (for indices also, if one of these measures will be used for some of them).

11) Enter the part of the year for the peak of catches (since the model is based on Pope’s approximation of “instantaneous” catch). If the fishing is uniform all over the year - enter the traditional value of 0.5.

12) Enter the name of the output file. It will be in C:\vbisvpa directory.

13) You can display the currents results on the screen. This will slow down the calculations, however, you would be able to watch the process.

14) Input the maturity-at-age file name.

15) You will be asked whether to include SSB surveys or not. If you want to do it, you will have to input names of the SSB survey files by years (up to 3).

16) If you have age-structured abundance indices, you can use up to seven different indices. If you want to include these indices, input their names.

17) If any auxiliary information is used, you will be asked to input weight for the catch-at-age- derived component in the overall loss function (any value is possible, including 0).

18) If SSB surveys are included: for each of them input weights for components of the overall loss function which represents the measures of their closeness to the cohort part -derived estimates of the SSB (for the SSB indexes only one sort of measure is available - the sum of squared residuals between their logarithmic values).

19) Input part from the beginning of the year till the period when the surveys have been made (the same should be done for all SSB indices).

20) . If SSB surveys are included: for each of them, input values of the standard deviation from the lognormal distribution which will be used in the stochastic runs.

21) If SSB surveys are included: state whether to treat each of them as absolute or relative indices.

22) 22. If age-structured indices are included, input part from the beginning of the year till the period when the age-structured survey has been made (for each kind of survey).

23) . If age-structured indices are included, state the type of the index (e.g. the mature fish, the whole stock, or the immature fish).

24) If age-structured indices are included: for each of them, input weights for the components of the overall loss function which represent the measure of their closeness to the cohort part, derived estimates of abundance.

25) If age-structured indexes are included: for each of them answer whether: to estimate age-dependent catchabilities or not (if you choose not to do it it will be assumed that q(a)=1).

26) If age-structured indexes are included - choose for each of them what measure of closeness of fit will be used: the MDN, SSE, or AMD.

27) If age-structured indices are included – for each of them, choose the terms you want to compare at tuning : (1) logarithmic abundances(a,y) from the modeled cohort part or logarithmic abundances(a,y) from the survey; 2) a logarithmic abundance (a,y) (from the cohort part of the model) or a logarithmic age structure(a,y) from the surveys; 3) a logarithmic age structure of the stock (a,y) (from the cohort part) and a logarithmic age structure(a,y) from the surveys.

28) If age-structured indexes are included: for each of them, enter the values of the standard deviation of the lognormal distribution which will be used in stochastic runs.

29) When calculations are finished, you can make stochastic runs. Current version of the program gives possibility to run parametric conditional bootstrap with respect to catch-at-age, (assuming that errors in catch-at-age data are log-normally distributed, standard deviation is estimated in basic run), combined with adding noise to indexes (assuming that errors in indexes are log-normally distributed with specified values of standard deviation).

If something goes wrong or in an undesirable direction, it is always possible to stop the program by clicking the button “stop”. The program will return to the initial (input) screen and you can run it again. The only what is necessary to remember when using “stop by user” is that if the “direct search” option for inner parameters is used, you have to let the program to finish at least one inner cycle (that is to finish calculation of inner parameters for at least one f_{term}) and to stop it after that (otherwise interrupt will cause error and abortion of the program).

The current version of the program allows one to use surveys for the (terminal+1) year (that is for year without known catch-at-age data). Fishing pattern in this year is assumed equal to that of the “true” terminal year. In such a case all input files should be entailed to include data for this year which becomes terminal; the catch-at-age file should include zero values of the catch-at-age for this year.

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ICCAT WORKING DOCUMENT
SCRS/98/58

A Flexible Forward Age-Structured Assessment Program

Christopher M. Legault[1] and Victor R. Restrepo[2]

[1] U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
75 Virginia Beach Dr., Miami, Florida, 33149, USA

[2] University of Miami
Rosenstiel School of Marine and Atmospheric Science
Cooperative Unit for Fisheries Education and Research
4600 Rickenbacker Causeway, Miami, Florida 33149, USA

September 1998

Sustainable Fisheries Division Contribution SFD-98/99-16

Summary

This paper documents an age-structured assessment program (ASAP) which incorporates various modeling features that have been discussed by the SCRS in recent years, particularly during meetings of the bluefin tuna species group. The software was developed using the commercial package AD Model Builder, an efficient tool for optimization that uses an automatic differentiation algorithm in order to find a solution quickly using derivatives calculated to within machine precision, even when the number of parameters being estimated is rather large. The model is based on forward computations assuming separability of fishing mortality into year and age components. This assumption is relaxed by allowing for fleet-specific computations and by allowing the selectivity at age to change smoothly over time. The software can also allow the catchability associated with each abundance index to vary smoothly with time. The problem's dimensions (number of ages, years, fleets and abundance indices) are defined at input and limited by hardware only. We illustrate an application of ASAP using data for western Atlantic bluefin tuna.

Introduction

Stock assessment algorithms explain observed data through a statistical estimation procedure based on a number of assumptions. The number and severity of these assumptions are determined by the algorithm and reflect not only the user's paradigms but also the amount and quality of the available data. We present an age-structured assessment program (ASAP) which allows easy comparison of results when certain assumptions are made or relaxed. Specifically, ASAP is a flexible forward program that allows the assumption of separability of gear specific fishing mortality into year and age components to be relaxed and change over time. The assumption of constant catchability coefficients for scaling observed indices of abundance can also be relaxed to change over time. The advantage of this flexibility is an increased ability to fit models and less reliance on assumptions that are thought to be too strict. The disadvantage of such an approach is exactly this ability to explain the data in more (and possibly contradictory) ways through different choices in the amount of variability in the changing parameters. Explicit choices for relative weightings amongst the different parts of the objective function must be made. Slight changes in these parameter weightings in a complex model can produce vastly different results, while a simpler model will be more consistent (not necessarily more accurate) relative to changes in the parameter weightings.

Allowing flexibility in selectivity and catchability greatly increases the number of parameters to be estimated. We use the commercial software package AD Model Builder to estimate the relatively large number of parameters. The software package is based on a C++ library of automatic differentiation code (see Greiwank and Corliss 1991) which allows relatively fast convergence by calculating derivatives to machine precision accuracy. These derivatives are used in a quasi-Newton search routine to minimize the objective function. The array sizes for parameters are defined on input and limited only by hardware. Currently, ASAP is compiled to estimate a maximum of 5,000 parameters, but this can be increased by changing one line of code.

The AD Model Builder software package allows many matrix operations to be programmed easily in its template language and allows for the estimation of parameters to occur in phases. The phases work by estimating only some parameters initially and adding more parameters in a stepwise fashion until all parameters are estimated. When new parameters are added by incrementing the phase, the previously estimated parameters are still estimated, not fixed at the previous values. These phases also allow easy switching between simple and complex models by simply turning on or off phases through the input file. For example, index specific catchability coefficients can be allowed to change or have a constant value over time. An additional feature of the AD Model Builder software is easy likelihood profiling of specified variables, although this can be time consuming for models with large numbers of parameters. We first describe ASAP with all the features and then compare two analyses for bluefin tuna using different levels of complexity in the program.

The Model

Population dynamics

The model's population dynamics follow a standard form common to forward-projection methods such as those of Fournier and Archibald (1982), Deriso et al. (1985), Methot (1998), Ianelli and Fornier (1998), and Porch and Turner (In Press). Catches and fishing mortalities can be modeled as being fleet-specific.

Let a = age, 1…A,

y = year, 1…Y

g = fleet 1….G

u = abundance index series, 1….U

Selectivity (S) at age within a year by a fleet can be limited to a range of ages and averages one, as opposed to having a maximum of one,

$$\frac{\sum_{a(g_{start})}^{a(g_{end})} S_{a,y,g}}{a(g_{end}) - a(g_{start}) + 1} = 1.0 \tag{1}$$

where $a(g_{start})$ and $a(g_{end})$ denote the starting and ending ages for the gear's selectivity. The output of the program makes the simple conversion from averaging one to having a maximum of one in order to simplify comparisons with other models.

Fishing mortality is modeled as the product of the selectivity at age within a year by a fleet and a year and fleet specific fishing mortality multiplier ($Fmult_{y,g}$)

$$F_{a,y,g} = S_{a,y,g} Fmult_{y,g} \; . \tag{2}$$

Total fishing mortality at age and year is the sum of the fleet specific fishing mortality rates

$$Ftot_{a,y} = \sum_{g} F_{a,y,g} \tag{3}$$

and adding the natural mortality rate (M) produces the total mortality rate

$$Z_{a,y} = Ftot_{a,y} + M_{a,y} \; . \tag{4}$$

The catch by age, year and fleet is

$$C_{a,y,g} = \frac{N_{a,y} F_{a,y,g} (1 - e^{-Z_{a,y}})}{Z_{a,y}} \tag{5}$$

where N denotes population abundance at the start of the year.

The yield by age, year and fleet is

$$Y_{a,y,g} = C_{a,y,g} W_{a,y} \tag{6}$$

where $W_{a,y}$ denotes weight of an individual fish of age a in year y.

The proportion of catch at age within a year for a fleet is

$$P_{a,y,g} = \frac{C_{a,y,g}}{\sum_{a} C_{a,y,g}}. \tag{7}$$

The forward projections begin by computing recruitment as deviations from an average value

$$N_{1,y} = \overline{N}_1 e^{u_y} \tag{8}$$

where $?_y$~N(0,$s_{Ny}{}^2$) and the other numbers at age in the first year as deviations from equilibrium

$$\begin{aligned} N_{a,1} &= N_{1,1} e^{-\sum_{i=1}^{a-1} Z_{i,1}} e^{y_a} \qquad for\, a < A \\ N_{a,1} &= \frac{N_{1,1} e^{-\sum_{i=1}^{a-1} Z_{i,1}}}{1 - e^{-Z_{A,1}}} e^{y_a} \qquad for\, a = A \end{aligned} \tag{9}$$

where $?_a$~N(0,$s_{Na}{}^2$). The remaining population abundance at age and year is then computed

$$\begin{aligned} N_{a,y} &= N_{a-1,y-1} e^{-Z_{a-1,y-1}} && for\ a < A \\ N_{a,y} &= N_{a-1,y-1} e^{-Z_{a-1,y-1}} + N_{a,y-1} e^{-Z_{a,y-1}} && for\ a = A. \end{aligned} \tag{10}$$

Predicted indices of abundance ($\hat{I}$) are a measure of the population scaled by catchability coefficients (q) and selectivity at age (S)

$$\hat{I}_{u,y} = q_{u,y} \sum_{a(u_{start})}^{a(u_{end})} S_{u,a,y} N^*_{a,y} \tag{11}$$

where $a(u_{start})$ and $a(u_{end})$ are the index specific starting and ending ages, respectively, and N^* corresponds to the population abundance in either numbers or weight at a specific time during the year. The abundance index selectivity at age can either be input or linked to a specific fleet. If the latter is chosen, the age range can be smaller than that of the fleet and the annual selectivity patterns are rescaled to equal 1.0 for a specified age (a_{ref})such that the catchability coefficient is linked to this age

$$S_{u,a,y} = \frac{S_{a,y,g}}{S_{a_{ref},y,g}}. \tag{12}$$

Time-varying parameters

Fleet specific selectivity and catchability patterns are allowed to vary over time in the model. Changes in selectivity occur each t_g years through a random walk for every age in a given fleet

$$S_{a,y+t,g} = S_{a,y,g} e^{e_{a,y,g}} \tag{13}$$

where $e_{a,y,g}$~N(0,$s_{Sg}{}^2$) and are then rescaled to average one following equation (1). If t_g is greater than one, then the selectivity at age for the fleet is the same as previous values until t_g years elapse. The catchability coefficients also follow a random walk

$$q_{u,y+1} = q_{u,y} e^{w_{u,y}} \ , \tag{14}$$

as do the fleet specific fishing mortality rate multipliers

$$Fmult_{y+1,g} = Fmult_{y,g} e^{h_{y,g}} \tag{15}$$

where $?_{u,y}$~N(0,$s_{qu}{}^2$) and $?_{y,g}$~N(0,$s_{Fg}{}^2$).

<u>Parameter estimation</u>

The number of parameters estimated depends upon the values of t_g and whether or not changes in selectivity or catchability are considered. When time varying selectivity and catchability are not considered the following parameters are estimated: *Y* recruits, *A*-1 population abundance in first year, *YG* fishing mortality rate multipliers, *AG* selectivities (if all ages selected by all gears), *U* catchabilities, and 2 stock recruitment parameters. Inclusion of time varying selectivity and catchability can increase the number of parameters to be estimated by a maximum of (*Y*-1)*AG* + (*Y*-1)*U*. Sensitivity analyses can be conducted to determine the tradeoffs between number of parameters estimated and goodness of fit caused by changes in the t_g values.

The likelihood function to be minimized includes the following components (ignoring constants): total catch in weight by fleet (lognormally distributed)

$$L_1 = l_1[\ln(\sum_a Y_{a,y,g}) - \ln(\sum_a \hat{Y}_{a,y,g})]^2 \ ; \tag{16}$$

catch proportions in numbers of fish by fleet (multinomially distributed)

$$L_2 = -\sum_y \sum_g l_{2,y,g} \sum_a P_{a,y,g} \ln(\hat{P}_{a,y,g}) - P_{a,y,g} \ln(P_{a,y,g}) \ ; \tag{17}$$

and indices of abundance (lognormally distributed)

$$L_3 = \sum_g l_{3,g} \sum_y [\ln(I_{y,g}) - \ln(\hat{I}_{y,g})]^2 / 2s_{y,g}^2 + \ln(s_{y,g}) \ , \tag{18}$$

where variables with a hat are estimated by the model and variables without a hat are input as observations. The second term in the catch proportion summation causes the likelihood to equal zero for a perfect fit. The sigmas in equation 18 are input by the user and can optionally be set to all equal 1.0 for equal weighting of all index points. The weights (*?*) assigned to each component of the likelihood function correspond to the inverse of the variance assumed to be associated with that component. Note that the year and fleet subscripts for the catch proportion lambdas allow zero weights to be assigned to specific year and fleet combinations such that only the total catch in weight by that fleet and year would be incorporated in the objective function. Priors for the variances of the time varying parameters are also included in the likelihood by setting ? equal to the inverse of the assumed variance for each component

$$L_4 = \sum_g l_{4,g} \sum_a \sum_y e_{a,y,g}^2 \qquad (selectivity) \tag{19}$$

$$L_5 = \sum_u l_{5,u} \sum_y w_{u,y}^2 \qquad (catchability) \tag{20}$$

$$L_6 = \sum_g l_{6,g} \sum_y h_{y,g}^2 \qquad (F\ multipliers) \tag{21}$$

$$L_7 = l_7 \sum_y u_y^2 \qquad (recruitment) \tag{22}$$

$$L_8 = l_8 \sum_y y_y^2 \qquad (N\ year 1)\,. \tag{23}$$

Additionally, there is a prior for fitting a Beverton and Holt type stock-recruitment relationship

$$L_9 = l_9 \sum_y [\ln(N_{1,y}) - \ln\left(\frac{a\ SSB_{y-1}}{b + SSB_{y-1}}\right)]^2 \tag{24}$$

where *SSB* denotes the spawning stock biomass and *a* and *ß* are parameters to be estimated. Penalties are used to determine the amount of curvature allowed in the fleet selectivity patterns, both at age

$$r_1 = l_{r1} \sum_y \sum_g \sum_{a(g_{start})}^{a(g_{end})-2} (S_{a,y,g} - 2S_{a+1,y,g} + S_{a+2,y,g})^2 \tag{25}$$

and over time

$$r_2 = l_{r2} \sum_a \sum_g \sum_{y=1}^{Y-2} (S_{a,y,g} - 2S_{a,y+1,g} + S_{a,y+2,g})^2\,. \tag{26}$$

The function to be minimized is then the sum of the likelihoods and penalties

$$L = L_1 + L_2 + L_3 + L_4 + L_5 + L_6 + L_7 + L_8 + L_9 + r_1 + r_2\,. \tag{27}$$

An additional penalty is utilized in early phases of the minimization to keep the average total fishing mortality rate close to the natural morality rate. This penalty ensures the population abundance estimates do not get exceedingly large during early phases of the minimization. The final penalty added to the objective function forces the parameters for fleet selectivities in the first year to average 1.0. This penalty prevents multiple parameter sets from having the same objective function value, which would cause difficulty for the minimization routine. Each component of the objective function is reported in the output file along with the corresponding number of observations, weight assigned to that component, and residual sum of squared deviations (if appropriate).

Additional Features

The model optionally does some additional computations once the likelihood function has been minimized. These "extras" do not impact the solution, they are merely provided for reference. Each fleet can be designated as either directed or nondirected for the projections and F reference point calculations, with the option to modify the nondirected F in the future. The directed fleets are combined to form an overall selectivity pattern that is used to solve for common fishing mortality rate reference points ($F_{0.1}$, F_{max}, $F_{30\%SPR}$, $F_{40\%SPR}$ and F_{msy}) and compared to the terminal year F estimate. The inverse of the SPR for each of these points is also given so replacement lines corresponding to these reference values can be plotted on the spawner-recruit relationship. Projections are computed using either the stock-recruitment relationship or input values to generate future recruitment. The projections for each successive year can be made using either a total catch in weight or the application of a static $F_{X\%SPR}$, where X is input. A reference year is also input that allows comparison of the spawning stock biomass (SSB) in the terminal year and that in the final projection year as SSB_y/SSB_{ref}. Likelihood profiles for these SSB ratios can optionally be generated.

Example: Western Atlantic Bluefin Tuna

Two analyses of western Atlantic bluefin tuna data using ASAP are presented here. The first analysis (simple) did not allow selectivity and catchability to change over time (225 parameters estimated). The second analysis (complex) used the full complexity allowed by the model, with fleet selectivities allowed to change every two years and index catchabilities allowed to change every year (914 parameters estimated). In both analyses the model was structured for years 1970-1995, ages 1-10+, five fleets, and seven tuning indices (each point input with a variance) with all likelihood component weightings equal between the analyses. The natural mortality rate was set at 0.14 for all ages (for data details see Restrepo and Legault In Press). The number of observations associated with, and the weights given to, each part of the likelihood function are shown in Table 1. In this example, the weights assigned to each component were chosen arbitrarily. In an actual assessment, these weights will need to be selected by the assessment working group.

The overall fit of the complex analysis was better than the simple analysis (lower objective function value) as expected due to the greater number of parameters (Table 1). The complex analysis fits the indices better than the simple analysis, especially the US Rod and Reel Large, US Longline Gulf of Mexico, and the Japan Longline Gulf of Mexico indices. (Figure 1). Recruitment estimates from the two analyses are similar to the estimates from the 1996 SCRS assessment, which used virtual population analysis (VPA) with the main differences occurring in the early years of the time series (Figure 2). The estimates of spawning stock biomass (SSB) differ between the analyses, the complex one is similar in magnitude to the SCRS96 results, while the simple analysis estimates larger values (Figure 3). However, standardizing the SSB trends (dividing by the SSB in 1975) produces similar trends for all three analyses (Figure 3). The resulting stock-recruitment relationship is shown in figure 4. The total fishing mortality rates by year and age differ in both magnitude and pattern, with the complex analysis more closely matching the 1996 SCRS assessment (Figure 5). These differences in F are due to the assumptions about selectivity, fixed for the simple analysis and allowed to vary for the complex one (Figure 6). Note in particular the large change in selectivity of the purse seine fleet, mainly young fish in the early years and old fish in recent years. The catchability values also reflect the difference in assumptions, constant for the simple analysis and allowed to vary in the complex analysis (Figure 7). Note the large lambda given to the larval index causes the catchability coefficients to vary only slightly in the complex analysis. The catch at age proportions are fit relatively well in both analyses, the input and effective sample sizes are similar, even though this is the largest part of the total likelihood. The estimated effective sample size can be computed as

$$Effective\,N_g = \frac{\sum_a \sum_y \hat{p}_{a,y,g}(1-\hat{p}_{a,y,g})}{\sum_a \sum_y (p_{a,y,g}-\hat{p}_{a,y,g})^2} \tag{28}$$

(for details see McAllister and Ianelli, 1997 Appendix 2).

Discussion

The flexibility afforded by ASAP is a continuation of the trend in stock assessment programs from the relatively simple structure of Fournier and Archibald (1982) to the more flexible structure found in Methot (1998), Ianelli and Fournier (1998), and Porch and Turner (In Press). In fact, ASAP is based on the same logic as these more flexible programs, but combines the advantages of the AD Model Builder software with the more general input flexibility of stock synthesis and CATCHEM. J. Ianelli (NMFS, Seattle, pers. comm.) also provided guidance in the formulation of certain model components, specifically the logic of linking fleet specific indices with a specific age in the tuning process (see equation 12). The distinguishing feature between this approach and that found in virtual population analysis (VPA) (Gavaris 1988, Powers and Restrepo 1992) is that VPA assumes the catch at age is measured without error, while ASAP assumes the observed catch at age varies about its true value.

The flexibility of ASAP can also cause problems however. Slight changes in the weights assigned to each likelihood component can produce different results, both in magnitude and trend. The large number of parameters, in the complex model especially, required the solutions in each phase to progress towards a satisfactory region in the solution space. If any phase led the solution away from this region, the final result will not be believable (e.g. total F<1e-5). This problem was not found in multiple tests using simulated data that did not contain errors or only small observation errors. Thus, the ability to fit highly complex models depends upon the quality of the data available, especially the consistency between the catch at age and the tuning indices. Nevertheless, the flexible nature of ASAP allows for easy exploration of the data to determine what level of complexity can appropriately be modeled.

Acknowledgments

The conclusions presented here are entirely the authors' and are not necessarily endorsed by NMFS or UM. We are grateful to Jim Ianelli, Clay Porch, Joe Powers, Gerry Scott and Steve Turner for helpful discussions.

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Table 1. Likelihood function components for two ASAP analyses. nobs=number of observations in that component, ?=weight given to that component, RSS=residual sum of squared deviations, L=likelihood value

			Simple		**Complex**	
Component	nobs	?	RSS	L	RSS	L
Total Catch in Weight						
Rod and Reel	26	100.5	0.0005	0.0479	0.0001	0.0147
Japan Longline	26	100.5	0.0015	0.1558	0.0003	0.0322
Other Longline	26	100.5	0.0001	0.0069	0.0001	0.0070
Purse Seine	26	100.5	0.0002	0.0183	0.0039	0.3913
Other	26	100.5	0.0001	0.0065	0.0000	0.0026
Total	130	100.5	0.0023	0.2353	0.0045	0.4477
Catch at Age Proportions	1300	N/A	N/A	874.40	N/A	396.47
Index Fits						
Larval Index	16	1	5.26	11.95	5.29	11.61
US Rod and Reel Small	15	1	3.95	9.33	2.02	-1.02
Canadian Tended Line	15	1	2.08	3.05	0.64	-5.95
US Rod and Reel Large	13	1	1.76	1.22	0.39	-5.74
US Longline Gulf of Mexico	9	1	6.13	15.26	0.31	-3.79
Japan Longline Gulf of Mexico	8	1	0.74	1.10	0.58	1.05
Japan Longline NW Atlantic	20	1	3.22	9.51	0.58	-9.19
Total	96	7	23.15	51.43	9.80	-13.02
Selectivity Deviations						
Rod and Reel	12	0.1	0	0	2.52	0.25
Japan Longline	12	0.1	0	0	4.42	0.44
Other Longline	12	0.1	0	0	3.56	0.36
Purse Seine	12	0.1	0	0	8.74	0.87
Other	12	0.1	0	0	3.00	0.30
Total	60	0.5	0	0	22.25	2.22
Catchability Deviations						
Larval Index	16	1000	0	0	0.00	0.29
US Rod and Reel Small	15	6.7	0	0	0.51	3.43
Canadian Tended Line	15	6.7	0	0	0.37	2.45
US Rod and Reel Large	13	6.7	0	0	0.18	1.20
US Longline Gulf of Mexico	9	6.7	0	0	0.21	1.39
Japan Longline Gulf of Mexico	8	6.7	0	0	0.00	0.03
Japan Longline NW Atlantic	20	6.7	0	0	0.35	2.35
Total	96	1040.2	0	0	1.62	11.14
Fmult Deviations						
Rod and Reel	25	0.1	5.26	0.53	5.01	0.50
Japan Longline	25	0.1	21.44	2.14	19.67	1.97
Other Longline	25	0.1	24.30	2.43	23.97	2.40
Purse Seine	25	0.1	5.24	0.52	8.07	0.81
Other	25	0.1	5.60	0.56	6.84	0.68
Total	125	0.1	61.84	6.18	63.56	6.36
Recruitment	26	0.01	10.14	0.10	14.51	0.15
N in Year 1	9	1.44	3.34	4.82	3.08	4.43
Stock-Recruit Fit	25	0.001	9.47	0.01	3.94	0.00
Selectivity Curvature over Age	40	1.44	12.03	17.32	17.19	24.76
Selectivity Curvature over Time	1200	1.44	0	0	52.03	74.92
F penalty	260	0.001	3.0E-01	3.0E-4	2.3E-02	2.3E-02
Mean Sel Year 1 Penalty	50	1	4.5E-12	4.5E-12	4.7E-12	4.7E-12
Objective Function Value				**954.50**		**507.87**

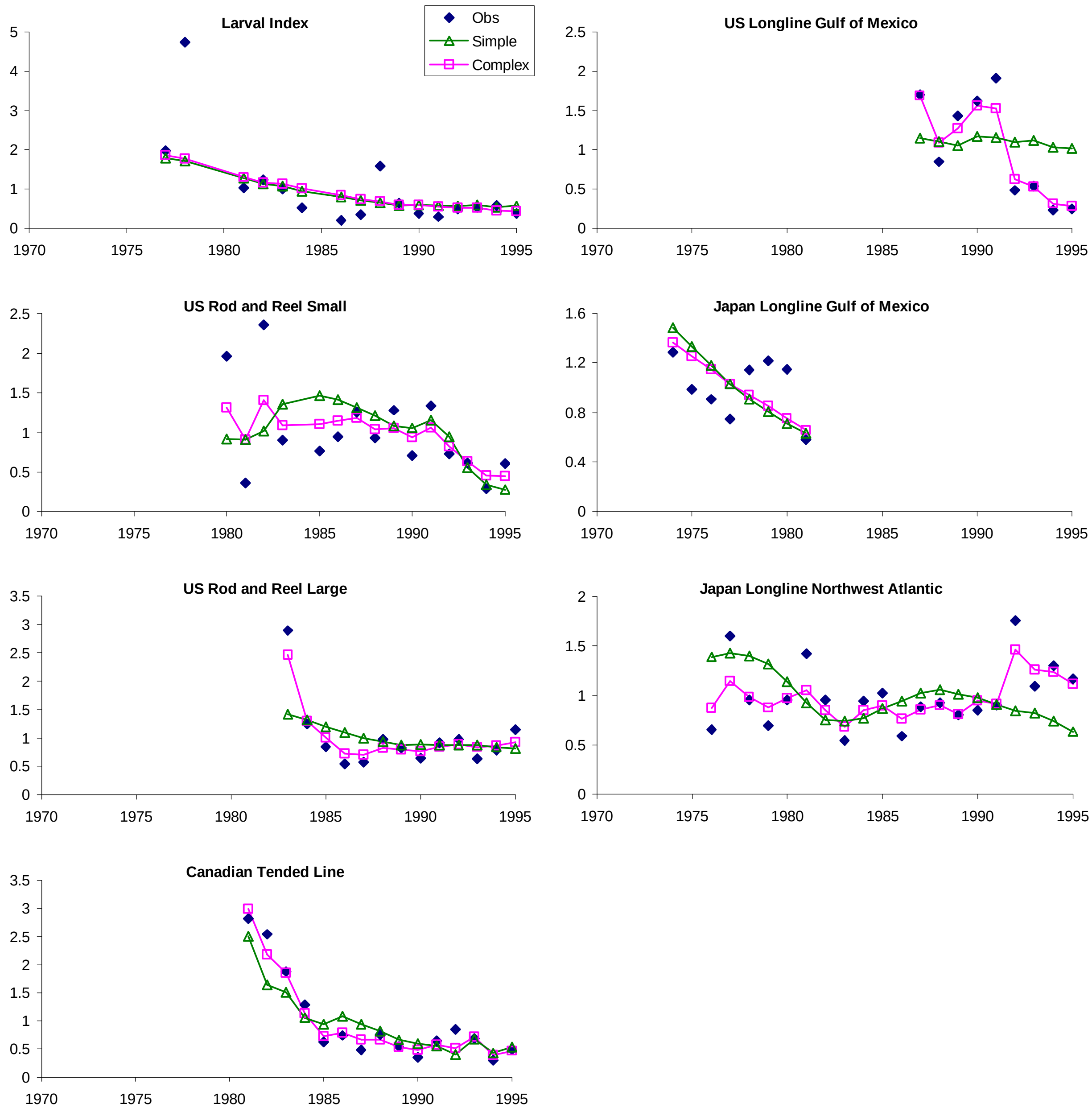

Figure 1. Observed and predicted indices for the simple and complex ASAP analyses.

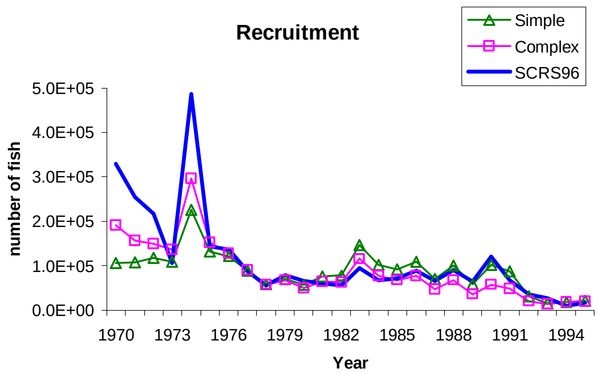

Figure 2. Estimated recruitment from two ASAP analyses and the SCRS 1996 assessment.

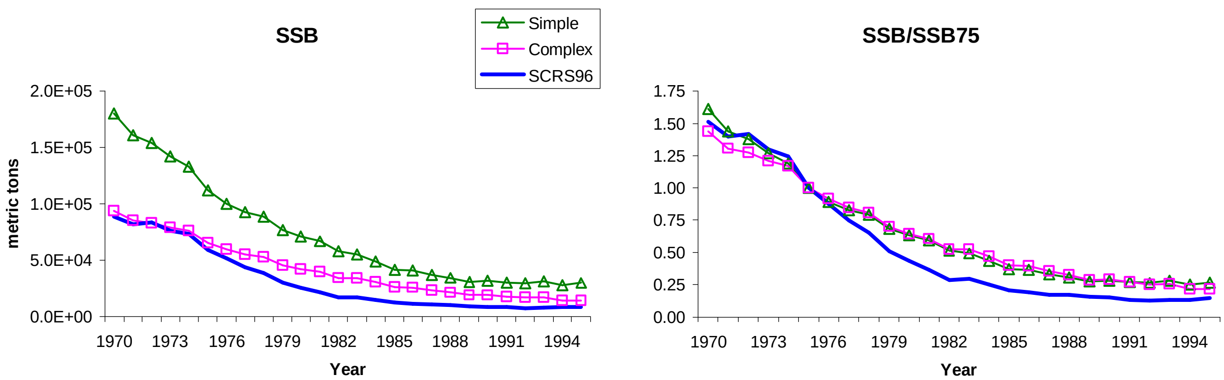

Figure 3. Spawning stock biomass (SSB) from two ASAP analyses and SCRS 1996.

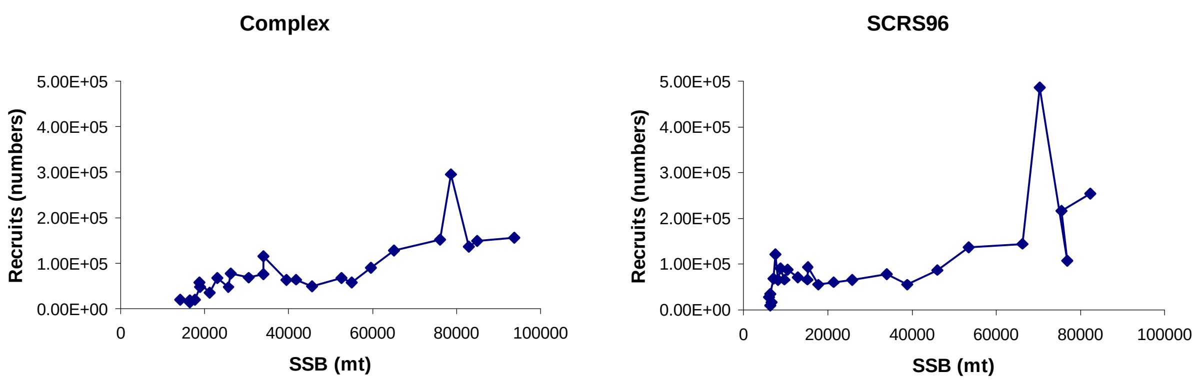

Figure 4. Complex ASAP analysis and SCRS 1996 stock-recruitment relationships.

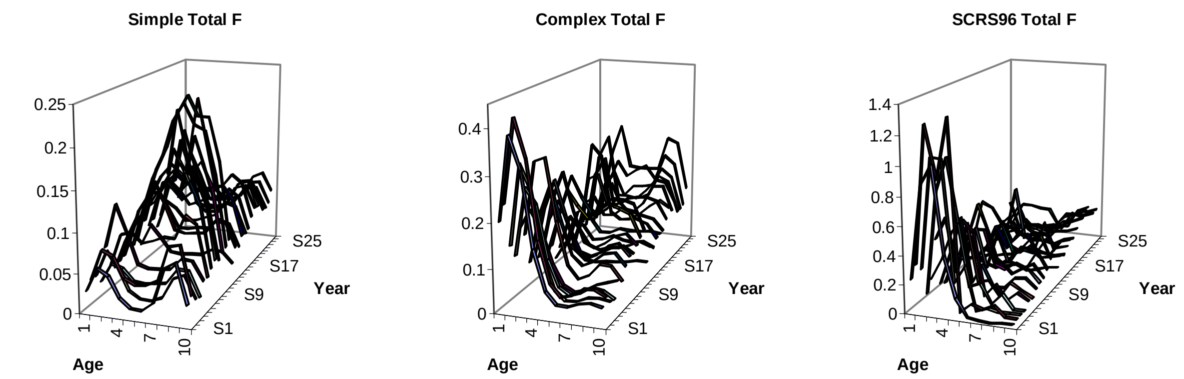

Figure 5. Estimated fishing mortality rates by age and year for two ASAP analyses and SCRS 1996.

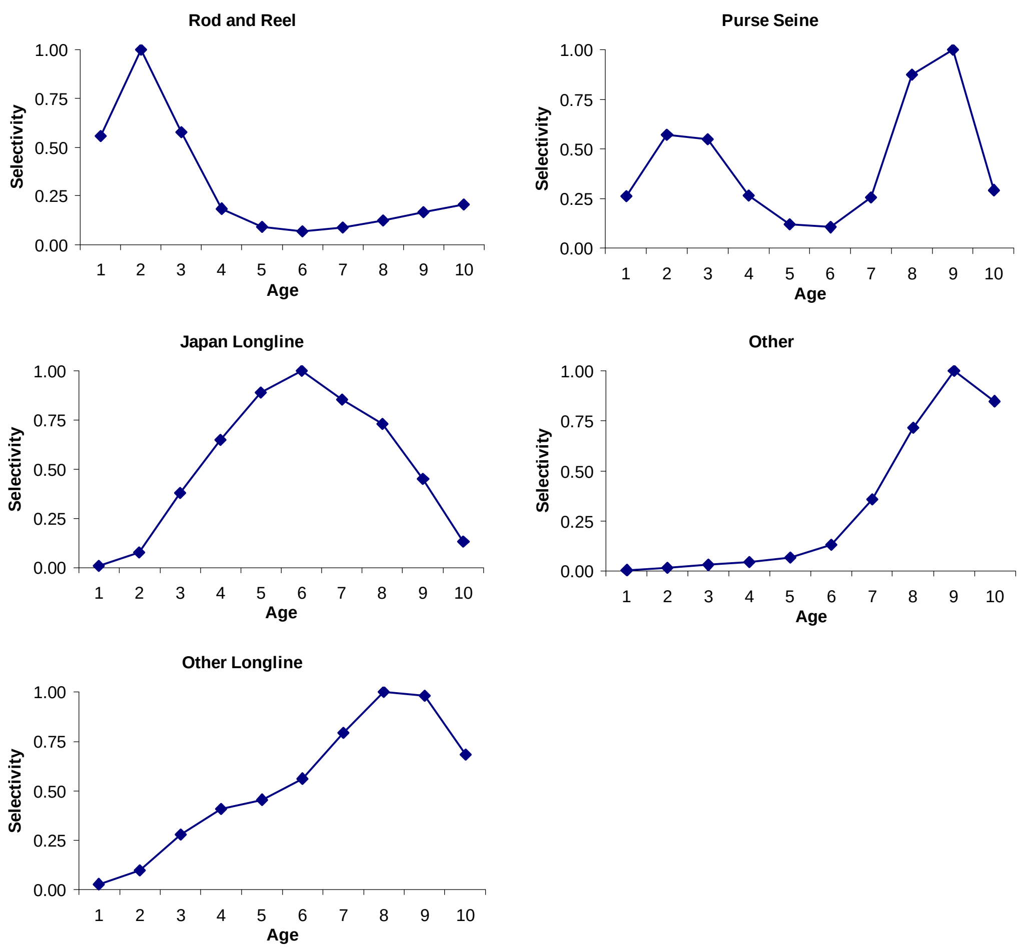

Figure 6a. Selectivity at age for the simple ASAP analysis, constant over all years for each fleet.

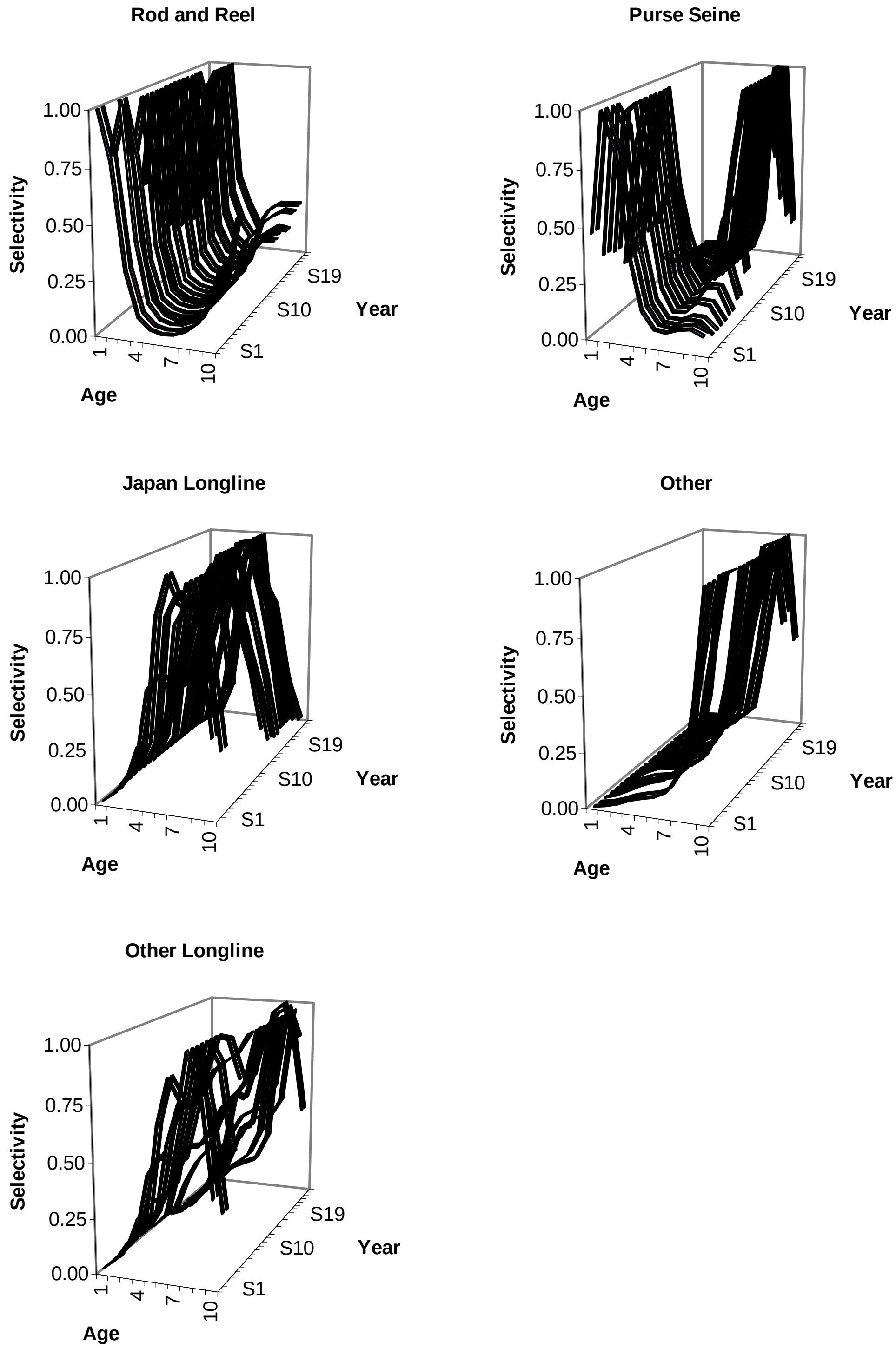

Figure 6b. Selectivity at age for the complex ASAP analysis.

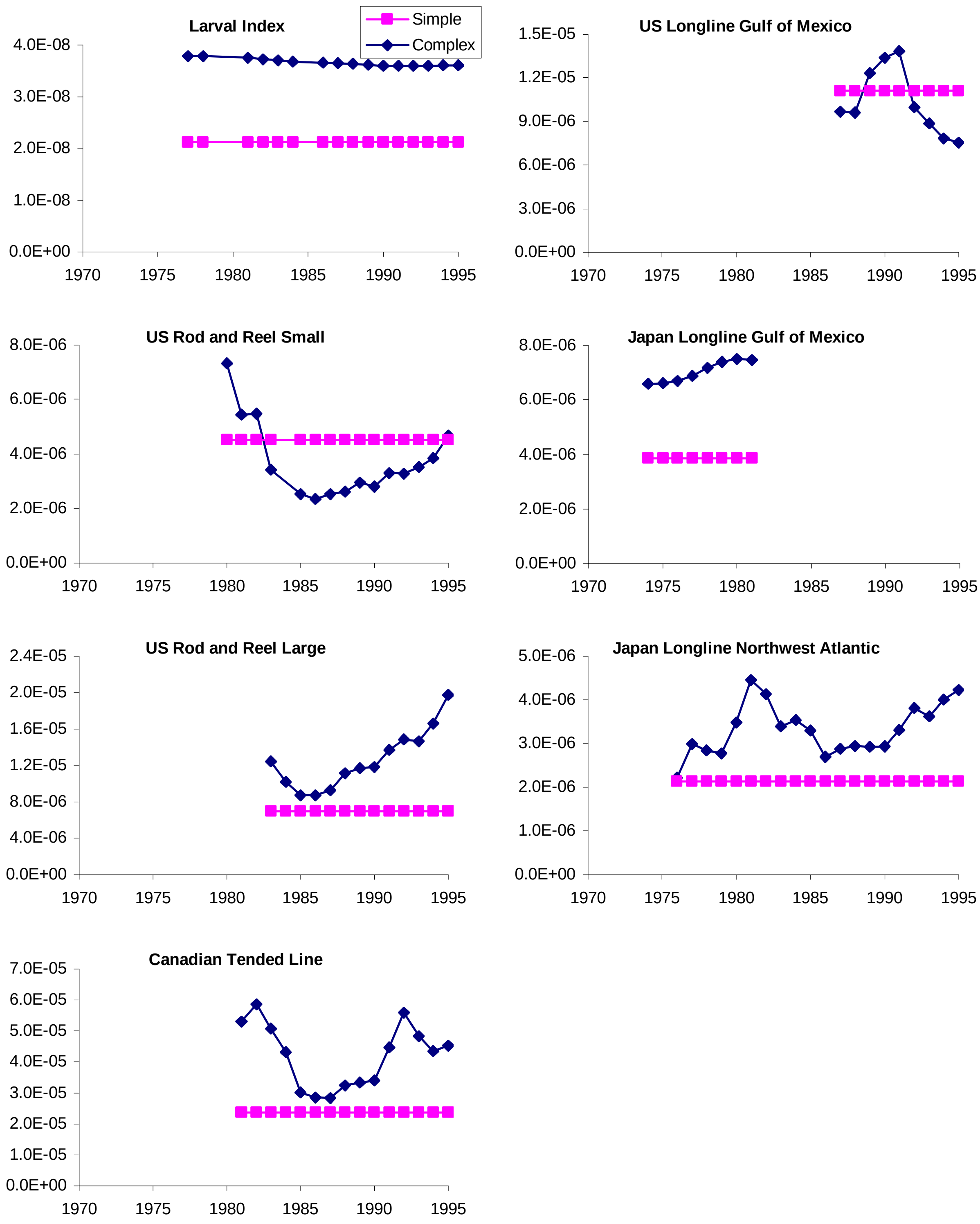

Figure 7. Catchability for each tuning index from the two ASAP analyses.

Pelagic RAC

European Commission
Directorate-General Fisheries
c/o Mr Fokion Fotiadis
Office: J-99 0/07
B-1049 BRUSSELS

Pelagic RAC
Treubstraat 17
PO Box 72
2280 AB Rijswijk
The Netherlands

Tel: +31 (0)70 336 9633
Fax: +31 (0)70 399 3004
E-mail: info@pelagic-rac.org
http://www.pelagic-rac.org

Date: 24 July 2007
Our reference: PRAC07.23/IH
Subject: Management plan for horse mackerel

Dear Mr Fotiadis,

The Pelagic RAC would like to present a management plan for horse mackerel for your consideration (attached) and with the request to ask ICES to evaluate this plan. We would appreciate it if this request could be forwarded to ICES in due time so that the ICES Working Group on mackerel, horse mackerel and anchovy can take it on board during their next meeting early September.

Could we also remind you to please forward the request to ICES to re-run the scenarios for North Sea herring so that we can work with reliable information that is supported by ICES.

The Pelagic RAC looks forward to your response.

Yours sincerely,

Ingvild Harkes

Pelagic RAC secretariat

c.c. Mr Kenneth Patterson, Mr Penas-Lado, Mr Emmanouil Papaioannou, Mr Poul Degnbol.

Management Plan for Western Horse Mackerel

Pelagic RAC

July 2007

This plan was discussed and agreed upon by the Executive Committee of the Pelagic RAC on 13 July 2007 for submission to the European Commission. The plan was developed in cooperation with an *ad hoc* group of scientists. It provides for an exploitation regime that is considered consistent with fishing at F_{MSY} and is presented as a means by which to manage the western horse mackerel stock.

This plan is divided into general provisions (Section 1) and a specific harvest control rule (Section 2). The normal harvest control rule may be adjusted in periods of elevated productivity (Section 3).

1. General provisions

The parties agree on a management plan for the western horse mackerel stock, with the following general provisions:

- The plan provides for conditions for sustainable long term yield for the stock.
- The plan provides for achievement of acceptable year to year stability in the TAC.
- A unified management regime across all areas where the stock is distributed
- That there are not additional catches to those covered by the TAC.
- The industry agrees to partake in studies to demonstrate that there are no additional catches above the level of the TAC.
- Productivity of the stock assumed to reflect the conditions for the period 1982 to 2005. However, the plan was tested under conditions where no strong year-classes of the magnitude of the 1982 year-class occur.
- That the TAC is set on a triennial basis based on egg abundance from the most recent three surveys
- Target fisheries will proceed with minimum ecological impact. The industry undertakes to partake in studies to quantify the levels of non-target by-catch.

2. Normal decision rule

For 2008 and subsequent years the TAC will be set according to the following rules:

1. *The TAC will be set for 3 years following the year of the most recent survey.*
2. *The TAC will be fixed at the set level for a period of 3 years.*
3. *In the event of the TAC being overshot in any year in the fixed period, the overshoot (as estimated by ICES) will be subtracted from the following years TAC. This needs to be tested by simulation.*

4. *In the event of a survey result not being available, ICES will be asked to advise on the state of the stock and on exploitation boundaries consistent with the Precautionary Approach.*
5. *The TAC will be set according to the following rule:*

$$TAC_{y-y+2} = 1.07\left[\frac{TAC_{ref}}{2} + \frac{TAC_{y-3}sl}{2}\right]$$

Where TAC_{ref}=150,000 t and sl is a function of the slope of the most recent egg abundance estimates from surveys (see annex)

Arrangements for reviewing the decision rules;

The plan will be reviewed and re-evaluated in 2009 and on three yearly intervals thereafter to ensure that:

1. SSB has been maintained above SSB_{1982}.
2. That the uncertainties and bias in the fishery and biological system remain within the bounds of those tested.
   and that the assumptions made in the simulation testing phase are still valid.

If either of the above has been violated the plan will be modified to adapt the decision rule to make it consistent with the precautionary approach.

3. Special conditions to apply in times of high stock productivity

If a recruitment event is the same or greater than that which occurred in 1982, as determined by ICES, the following will apply:

- The detection of the recruitment event will be established no sooner than 4 years after its occurrence.
- The level of the recruitment will be established based on ICES interpretation of the most valid assessment.
- After verification of such an event, by ICES, the decision rule will be adapted for as long as that year class contributes to the stock and the fishery .ICES is asked to develop a metric to determine the duration this period of elevated productivity. Such a metric would identify when the terms of the normal decision rule above will be reverted to.

Annex

Computations to estimate the f(slope) parameter (*sl*)

1) Divide the last three egg estimates from the triennial survey by 10^{15};
2) Compute the slope (b) for years 1, 2 and 3;
3) If

$$b \leq -1.5 \Rightarrow sl = 0$$
$$-1.5 < b < 0 \Rightarrow sl = 1 - (1/-1.5 * b)$$
$$0 \leq b \leq 0.5 \Rightarrow sl = 1 + (0.4/0.5 * b)$$
$$b > 0.5 \Rightarrow sl = 1.4$$