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Report of the Working Group on Widely Distributed Stocks (WGWIDE)

2-11 September 2008

ICES Headquarters Copenhagen

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Executive Summary

The Working Group (WG) on Widely Distributed Stocks (WGWIDE) met in ICES headquarters, Copenhagen 2 – 11 September 2008. Participants were scientists from Spain, Russia, UK (Scotland, England & Wales), Netherlands, Norway, Faroe Islands, Iceland, Ireland, Portugal and France. The WG reports on the status and considerations for management of NEA Mackerel, Sardine and Blue Whiting, Southern and Western Horse Mackerel stocks and Norwegian Spring Spawning Herring. The advice for North Sea horse mackerel was not updated this year.

Special requests from Norway/EC/Faroe Island and Ireland regarding

the management of mackerel in the North-East Atlantic which included a review of reference points;

long term management of Blue whiting which included references to the stock structure

were also addressed by WGWIDE and reported here.

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 an update. The 2007 SSB input for the analytical assessment was based on a revised estimate of Mackerel Egg abundance from the 2007 International Survey. Fishing mortality in 2007 is estimated to be above precautionary levels. Because of the unknown levels of underreporting in the catch, SSB in recent years cannot be accurately estimated, but indications are that SSB has increased by 40% since 2004. Variability in recruitment has increased in recent years.

Horse Mackerel. The WG performed an analytical assessment for western horse mackerel. The assessment indicates that the current level of SSB is above that in 1982 which produced the corresponding outstanding year class. The analyses confirms strong recruitment of the 2001 year class however this is not estimated to be of the same order of magnitude as the 1982 year class. The advice for this stock is based on an agreed management plan. An analytical assessment was also conducted for southern horse mackerel. The 2 surveys were combined and a clear cohort signal was evident. The assessment was performed using Flexible Forward Age-Structured Assessment program (ASAP). This estimated a recent increase in SSB and a quite stable overall fishing mortality. The assessment estimated above average 2004 recruitment.

Sardine. An update assessment using the single area AMCI model was conducted including some exploration of model settings. The assessment indicated that SSB in 2007 decreased 8% compared to 2006 due to successive low recruitments in the last three years (2005 – 2007). Fishing mortality increased by 18% from 2006 to 2007, reflecting the small increase of catches and the decrease in stock abundance although it is still near a historical low. In addition, the WG considered alternatives for management plan evaluation for this stock.

Norwegian spring spawning herring. It is the largest herring stock in the world. It is largely migratory and distributed throughout large parts of the NE Atlantic. The productivity of the stock has increased in the last 20 years as a result of strong year classes being produced more often. The WG undertook a bench-mark assessment of this stock. This was performed using recently developed assessment tools software (TASACS).The results from assessing the stock using a number of age-structured models were evaluated and the WG agreed on an assessment based on a VPA. This last model estimated spawning-stock biomass well above B_{pa} in 2008 and near the highest in the recent time series. Management advice was provided based on the agreed management plan.

Blue whiting. It is a pelagic gadoid that is widely distributed in the eastern part of the North Atlantic. Due to the large population size, its considerable migratory capabilities and wide spatial distribution, much remains to be understood regarding the stock composition and dynamics. The assessment this year was considered an update and was performed using the Stochastic Multi-species (SMS) model. Two alternative configurations of the 2007 WG options for SMS model were tested this year. In addition results were compared with XSA, TISVPA and ICA (FLICA). The four models estimated a steep decrease in recruitment in the most recent years with the age-1 abundance in 2007 at a historically low value. All the models estimate a large SSB reduction since 2004 and high mean F. To keep the SSB above precautionary reference points advised landings will require a reduction in F of 60% compared to F in 2008. A new draft management plan that takes into account recent low recruitment was put forward by the Coastal states in 2008 and was evaluated by the WG by means of simulation testing.

1 Introduction

1.1 Terms of Reference

Generic ToRs for Review and Advice Drafting Groups in 2008

The review process will have a different role compared to previous years. The new review process will aim to provide a review of the scientific finding and the development of a final advice that can be submitted to the Advisory Committee for approval. This shall be done in two distinct processes.

a) The first part is done by review groups that are constituted of independent experts and are not involved with the expert group report to be reviewed:

  i) The review groups shall ensure the quality of the analyses that is produced by the Expert Group(s). The Group shall review the quality of the assessment work carried out by the Expert Group(s) and write technical minutes of the main findings in the review. These Technical Minutes are part of the Expert group report. The review shall consider whether the analysis integrates all relevant knowledge;

b) The second step is advice drafting. The first draft advice is developed by the senior advisors supported by chairs from the expert groups and the Secretariat.

This draft is considered by an advice drafting group that review the draft advice and ascertain that the advice is

- in accordance with the advisory principles established by ACOM and as
- laid down in the MoUs with Clients
- relevant and answering the request
- understandable
- credible
- according to the standard form and format of advice

  ii) for fisheries advice, produce consolidated eco-region advice that, together with single stock summaries can be submitted to the Advisory Committee for adoption.

Generic ToRs for Fish Stock Assessment Working Groups

For AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBFAS, WGNSSK, WGNSDS, WGSSDS, WGHMM and WGANC ToRs (1)-(4):

1) Assemble national data on relevant fisheries and environmental data

  a) Input and quality check all input data and where possible input into the INTERCATCH database;

  b) Produce an overview of the sampling activities on a national basis (if possible derived from the INTERCATCH database);

  c) Recommend specific actions to be taken to improve the basis for the advice in future

  (including improvements in data collection);

d) When appropriate, conduct a Data Compilation Workshop as part of the expert group meeting where stakeholders are invited to contribute data including data from non-traditional sources. At these workshops stakeholders can also contribute to data preparation and evaluation of data quality. Data that are to be included in the analysis of the Expert Group shall satisfy quality criteria established by ACOM;

2) Update time-series of relevant fisheries and environmental data:

a) catches (landings, discards, bycatch)(−by fisheries/fleets). Where mis-reporting is considered significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information.

b) fishing effort (by fisheries/fleets)

c) surveys

d) environmental drivers

3) Update description of major regulatory changes (technical measures, TACs, effort control and management plans) and report on evaluations of their (potential) effects.

4) Produce a brief report of the work carried out by the Working Group. This report should summarise for the stocks and fisheries where the item is relevant:

a) Stock status and catch options

b) Mixed fisheries considerations

c) Ecosystem effects of fisheries

d) Regulatory changes in the fisheries which have consequences for the assessment or projections

e) Agreed or proposed management plans

f) Species interaction effects

For AFWG, HAWG, NWWG, NIPAG, WGWIDE in addition consider

5) Update the agreed analytical method for those stocks where a benchmark assessment is required to assess the state of the stocks and short term outlooks or update the agreed indicator(s) of stock trends

ToR for WGWIDE

2007/2/ACOM13 The **Working Group on Widely Distributed Stocks** [WGWIDE] (Chair: Beatriz Roel*, UK) will be established and will meet at ICES Headquarters, 2–11 September 2008 to:

a) compile, update, analyse and document time-series of relevant fisheries, environmental data and regulatory changes (see generic ToRs)

b) summarise the findings for the following stocks (see generic ToR 4):

i) NEA Mackerel

ii) Western and southern Horse mackerel

iii) Norwegian Spring Spawning herring

iv) Blue whiting

v) Sardine in Divisions VIIIc and IXa

WGWIDE will report by 12 September 2008 for the attention of ACOM. This Group continues work previously undertaken by WGMHSA and WGNPBW. Anchovy assessments are moved to WGANC.

FishStock	Name	Stock Coordinator	Assessment Coordinator 1	Assessment Coordinator 2
her-noss	Norwegian spring-spawning herring	IS	NO	RUS
hom-nsea	Horse mackerel in the North Sea Area (Areas IIa, IV and IIIa)	NO	DK	NL
hom-soth	Southern horse mackerel (Divisions VIIIc and IXa)	SP	SP	POR
hom-west	Western horse mackerel (IIa,IVa,Vb,VIa,VIIa-c,e-k,VIIIabde)	NO	UK	NL
mac-nea	Mackerel (combined Southern, Western & N.Sea spawn.comp.)	IRL	UK(FRS)	NL
sar-soth	Sardine in Divisions VIIIc and IXa	POR	POR	SP
whb-comb	Blue whiting combined stock (Sub-areas I-IX, XII & XIV)	IS	DK	RUS

1.2 List of Participants

Beatriz Roel (Chair)	United Kingdom
Pablo Abaunza	Spain
Esther Abad	Spain
Paula Alvarez	Spain
Frans van Beek	Netherlands
Sergei Belikov	Russian Federation
Thomas Brunel	Netherlands
Andrew Campbell	Ireland
Høgni Debes	Faroes
Erwan Duhamel	France
Afra Egan	Ireland
Pavel Gasyukov	Russian Federation
Asta Gudmundsdóttir	Iceland
Jens Christian Holst	Norway
Detlev Ingendahl	Germany
Svein A. Iversen	Norway
Teunis Jansen	Denmark
Igor Karpusheveskiyi	Russia
Alexander Krysov	Russian Federation
Charlotte Main	United Kingdom
Jacques Massé	France
Manolo Meixide	Spain
Eugene Mullins	Ireland
Alberto Murta	Portugal
Jose de Oliveira	United Kingdom
Are Salthaug	Norway
Sonia Sanchez	Spain
Begoña Santos	Spain
John Simmonds	United Kingdom
Dankert Skagen	Norway

Alexandra Silva	Portugal
Jens Ulleweit	Germany
Nikolay Timoshenko	Russian Federation
Morten Vinther	Denmark
Sytse Ybema	Netherlands

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 87%, exceeding the long-term average (82%). The proportion of the horse mackerel catch sampled has considerably decreased from 72% in 2006 to 62% in 2007 with divisions where sampling is considered inadequate. Sardines continue to be well sampled with samples provided by Portugal, Spain and France.

Information on long term trends in sampling effort were not given in the previous WGNPBW reports. However, tables with the total figures since 2000 were added at the beginning of the Norwegian spring spawning herring and the blue whiting sections. Overall, Norwegian spring spawning herring and blue whiting sampling covers 94% and 87% of the total catch, respectively.

It should be noted that the information on the percentage of catch sampled depends entirely on the accuracy of the sampled catch figure provided by the relevant countries.

In general, to facilitate age-structured assessment, samples should be obtained from all countries with catches of the relevant species.

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
2007	579,379	87	1,267	139,789	21,791

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

In 2007, 87% of the total catch was covered by national sampling programmes, a small increase on the figure for the previous year (85%). This is despite a significant fall in the number of samples compared with recent years. Denmark, Germany, Iceland, Norway, Portugal, Russia, Scotland and Spain all sampled over 95% of their catch with Ireland and the Netherlands achieving rates over 85%. As in previous years, England & Wales sample a small fraction (6%), corresponding to the handline fishery in area VIIe and VIIf. The remaining countries (of which France, the Faroes, 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	% CATCH COVERED BY SAMPLING PROGRAMME	NO. SAMPLES	NO. MEASURED	NO. AGED
Belgium	1	0	0	0	0
Denmark	25,223	99	34	2,875	2,875
Faroe Islands	13,430	0	0	0	0
France	20,038	0	0	0	0
Germany	18,221	97	54	15,090	1,765
Iceland	36,706	99	18	298	286
Ireland	49,259	94	40	7,436	2,443
Jersey	6	0	0	0	0
Lithuania	7	0	0	0	0
Netherlands	24,244	85	50	4,902	1,250
Norway	131,691	98	196	19,618	898
Poland	978	0	0	0	0
Portugal	2,605	100	273	21,732	1,497
Russia	35,408	100	87	23,105	1,288
Spain	62,946	100	379	26,162	4,888
Sweden	3,858	0	0	0	0
UK (England & Wales)	14,654	6	51	6,942	962
UK (Northern Ireland)	5,545	0	0	0	0
UK (Scotland)	113,490	97	85	11,629	3,639
Total	558,310	87	1,267	139,789	21,791

*** 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 IIIa (1,485t), VIIc (1,260t), VIIk (495t), VIIIa (5,444t), VIIId (674t). This was also the case with VIIIa,d in previous years. No sampling was carried out in areas IIIb,c,d and VIIa,g,h although the corresponding catches were minor.

AREA	OFFICIAL CATCH	WG CATCH	NO SAMPLES	NO AGED	NO MEASURED	NO AGED/ 1000 TONNES*	NO MEASURED/ 1000 TONNES*
IIa	65,002	64,992	99	1,362	23,084	20	360
IIIa	1,485	1,485	0	0	0	0	0
IIIb	2	2	0	0	0	0	0
IIIc	3	3	0	0	0	0	0
IIId	2	2	0	0	0	0	0
IVa	247,958	256,152	271	4,617	28,502	18	115
IVb	908	1423	14	1,265	1,345	1,390	1,480
IVc	233	132	1	25	64	110	270
Va	7,802	7,802	4	112	119	10	20
Vb	97	97	2	100	200	1,030	2,050
VIa	111,996	111,193	90	3,161	14,875	28	133
VIIa	9	71	0	0	0	0	0
VIIb	20,220	23,801	29	1,971	6,139	97	304
VIIc	1,359	1,260	0	0	0	0	0
VIId	3,358	7,407	6	150	685	40	200
VIIe	541	2,535	31	215	4,849	397	8,963
VIIf	805	805	25	872	2,635	1,083	3,273
VIIg	27	27	0	0	0	0	0
VIIh	33	20	0	0	0	0	0
VIIj	22,871	26,894	42	1,531	9,333	70	410
VIIk	495	495	0	0	0	0	0
VIIIa	5,710	5,444	0	0	0	0	0
VIIIb	3,827	3,827	23	1,057	1,410	280	370
VIIIcE	46,557	46,557	224	2,446	15,429	50	330
VIIIcW	6,899	6,899	62	827	4,281	120	620
VIIId	730	674	0	0	0	0	0
IXaN	6,773	6,773	71	583	5,107	90	750
IXaCN	2,605	2,605	273	1,497	21,732	570	8,340
Total	558,307	579,377	1,267	21,791	139,789	39	250

*** 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 (WG CATCH)	% CATCH COVERED BY SAMPLING PROGRAMME*	NO. SAMPLES	NO. MEASURED	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	72	1,623	231,344	12,009
2007	187,995	62	1,321	174,897	10,749

*** Percentage related to Working Group catch**

There was a considerable decrease in overall sampling for horse mackerel from 2006 to 2007. This is the lowest sampling level since 2000. As usual the large numbers of measured fish are due to intensive length measurement programs in the southern areas. In 2007, 76% of the horse mackerel measured were from Division IXa.

Countries that carried out sampling were Germany which covered 4% of the catches and Denmark, Ireland, the Netherlands, Norway, Portugal and Spain covered 501–00 of their catches. France, UK 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. Last year it was the first time Lithuania reported horse mackerel catches. Their main catches were taken in Division VIIb.

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

COUNTRY	OFFICIAL CATCH	% CATCH SAMPLED*	NO. SAMPLES	NO. MEASURED	NO. AGED
Belgium	6	0			
Denmark	7,872	86	12	445	445
Faroe Islands	478	0			
France	18,097	0			
Germany	5,871	3	16	2,480	742
Ireland	30,092	91	43	8,117	2,980
Lithuania	5,763	0			
Netherlands	60,237	68	57	8,651	1,425
Norway	5,425	74	15	574	166
Portugal	10,380	100	750	120,730	1,681
Spain	27,319	98	428	33,900	3,342
Sweden	129	0			
UK (England & Wales)	12,403	0			
UK (Scotland)	1,403	0			
Sum (WG catch)	187,994	62	1,321	174,897	10,749

*** 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 (areas) was as follows:

COUNTRY	OFFICIAL CATCH	% CATCH SAMPLED*	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	7,617	86	6	399	399
Faroe Islands	478				
France	12,748				
Germany	5,784	4	16	2,480	743
Ireland	30,091	91	43	8,117	2,948
Lithuania	5,467				
Netherlands	29,083	50	32	4,649	800
Norway	4,182	97	15	574	166
Spain	14,257	100	254	20,811	2,367
Sweden	76				
UK (England & Wales)	5,482				
UK (Scotland)	778				
Sum (WG catch)	123,408	57	366	37,030	7,423

*** 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	% CATCH SAMPLED*	NO. SAMPLES	NO. MEASURED	NO. AGED
Belgium	6				
Denmark	255	71	5	46	46
France	5,349				
Germany	87				
Ireland	1				
Lithuania	296				
Netherlands	31,154	92	25	4,002	625
Norway	1,243				
Sweden	53				
UK (Scotland)	625				
Sum (WG catch)	41,164	61	163	30	4,048

*** 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 takes 77% of the catches.

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

COUNTRY	OFFICIAL CATCH	% CATCH SAMPLED*	NO. SAMPLES	NO. MEASURED	NO. AGED
Portugal	13,043	95	174	13,089	975
Spain	103,380	100	750	120,730	1,681
Sum (WG catch)	23,323	97	924	133,819	2,656

*** Percentage based on Working Group catch**

The horse mackerel sampling intensity by division was as follows:

Area	Official catch	WG catch	No samples	No sampled	No measured	No aged/1000 tonnes	No measured/ 1000tonnes
IIa	0	0					
IIIa	148	148	0	0	0		
IIIb	4	4	0	0	0		
IIIc	22	22	0	0	0		
IVa	8198	6996	15	166	574	24	82
IVb	1126	1119	6	46	46	41	41
IVc	21333	8118	5	125	626	15	77
Va	0	0					
VB	366	366	0	0	0		
VIa	24474	25948	36	1954	5304	75	204
VIb	331	331	0	0	0		
VIIa	51	51	0	0	0		
VIIb	26608	29601	18	1120	3423	38	116
VIIc	1517	1159	0	0	0		
VIId	20529	29808	20	500	3376	17	113
VIIe	13248	18908	16	466	3138	25	166
VIIf	260	260	21	950	3381	3654	13004
VIIg	0.01	0.01	0	0	0		
VIIh	4295	4295	3	171	171	40	40
VIIj	10981	8866	0	0	0		
VIIk	185	185	0	0	0		
VIIIa	11251	11251	3	228	228	20	20
VIIIb	3174	3174	10	294	999	93	315
VIIIcE	4817	4817	148	1110	11660	230	2421
VIIIcW	9141	9141	96	963	8152	105	892
VIIId	3	3	0	0	0	0	0
IXaN	12046	12046	174	975	13089	81	1087
IXaCN	2700	2700	535	760	73701	281	27297
IXaCS	5580	5580	76	500	5716	90	1024
IXaS	2337	2337	139	421	41313	180	17678
SUM	184725	187995	1321	10749	174897	57	930

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	% CATCH COVERED BY SAMPLING PROGRAMME*	NO. SAMPLES	NO. MEASURED	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
2007	94,648	100	797	97,187	8,607

- Percentage related to Working Group catch

The sampling intensity for all sardine catching countries was as follows:

COUNTRY	OFFICIAL CATCH	% CATCH COVERED BY SAMPLING PROGRAMME	NO. SAMPLES	NO. MEASURED	NO. AGED
Portugal	64,500	100	447	59,611	4,908
Spain	31,968	100	350	37,576	3,699
France	24,009	67	42	2,878	1,194
Ireland	82	0	0	0	0
UK (England & Wales)	2,576	0	0	0	0
Total	123,135	91,4	839	100,065	9,801

*** Percentage based on Working Group catch**

Norwegian Spring Spawning Herring (NSSH)

YEAR	TOTAL CATCH	% CATCH COVERED BY SAMPLING PROGRAMME	NO. SAMPLES	NO. MEASURED	NO. AGED
2000	1,207,201	86	389	55956	10901
2001	766,136	86	442	70005	11234
2002	807,795	88	184	39332	5405
2003	789,510	71	380	34711	11352
2004	794,066	79	503	48784	13169
2005	1,003,243	86	459	49273	14112
2006	968,958	93	631	94574	9862
2007	1,266,993	94	476	56383	14661

94% of the total catch was covered by national sampling programmes. The following table gives a summary of the sampling activities of the NSSH catching countries. The sampling coverage by country is between 74 to 100%. No sampling were carried by Greenland, Ireland and Poland but catches of these countries are representing together only 1.2% of the total catch.

:

COUNTRY	OFFICIAL CATCH	% CATCH COVERED BY SAMPLING PROGRAMME	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	22,911	100	8	1038	1005
Faroe Islands	64,251	89	9	900	900
Germany	6,038	74	13	5271	895
Greenland	4,897	0	0	0	0
Iceland	173,621	80	66	2661	2493
Ireland	6,411	0	0	0	0
Norway	779,089	100	212	15897	7098
Poland	4,333	0	0	0	0
Russia	162,434	91	160	29600	2028
Scotland	13,244	100	1	143	67
The Netherlands	29,764	100	7	873	175
Total	1,266,993	94	476	56383	14661

*** Percentage based on Working Group catch**

Shown in the following table are the NSSH sampling levels by relating numbers measured and aged to the size of the catch in each ICES division.

AREA	OFFICIAL CATCH	WG CATCH	NO SAMPLES	NO AGED	NO MEASURED	NO AGED/ 1000 TONNES****	NO MEASURED/ 1000
IIa	1,205,106	1,205,106	417	12715	50454	11	42
IIb	8,291	8,291	23	313	4200	38	507
Va	46,743	46,743	29	933	1029	20	22
Vb	2,312	2,312	6	600	600	260	260
XIVa	4,541	4,541	1	100	100	22	22
Total	1,266,993	1,266,993	476	14661	56383	12	45

*** Based on official catches**

Blue Whiting

YEAR	TOTAL CATCH	% CATCH COVERED BY SAMPLING PROGRAMME	NO. SAMPLES	NO. MEASURED	NO. AGED
2000	1,412,928	*	1136	125162	13685
2001	1,780,170	*	985	173553	17995
2002	1,556,792	*	1037	116895	19202
2003	2,321,406	*	1596	188770	26207
2004	2,377,569	*	1774	181235	27835
2005	2,026,953	*	1833	217937	32184
2006	1,966,140	*	1715	190533	27014
2007	1,610,090	87	1399	167652	23495

*** no figures given**

87% of the total catch was covered by national sampling programmes. The sampling summary of the blue whiting catching countries is shown in the following table. No sampling were carried out by France, Lithuania and Sweden, representing together 1.7% of the total catch. All other countries are sampling for length and age with the exception of Germany which failed to provide age readings.

COUNTRY	OFFICIAL CATCH	% CATCH COVERED BY SAMPLING PROGRAMME	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	48,659	99	28	1381	1381
Faroe	317,859	99	29	5337	2892
France	16,639	0	0	0	0
Germany	34,404	*	45	10669	0
Iceland	236,538	97	94	9833	4015
Ireland	31,132	99	19	3595	1704
Lithuania	9,812	0	0	0	0
Norway	539,587	100	353	30223	5915
Portugal	3,897	50	241	32358	1559
Russia	236,369	48	218	27553	2029
Scotland	43,540	77	7	1242	310
Spain	13,557	100	283	26914	2020
Sweden	464	0	0	0	0
The Netherlands	77,634	101	82	18547	1670
Total	1,610,090	87	1399	167652	23495

*** no figure given**

The following table describes the blue whiting sampling levels by relating numbers measured and aged to the size of the catch in each ICES division.

AREA	OFFICIAL CATCH	WG CATCH	NO SAMPLES	NO AGED	NO MEASURED	NO AGED/ 1000 TONNES*	NO MEASURED/ 1000 TONNES*
IIa	119,570	119,478	247	3467	28232	29	236
IIb	2,624	2,624	46	810	5366	309	2045
IIIa	334	334	9	142	684	425	2048
IVa	60,590	60,590	62	1678	5408	28	89
IVb	182	182	34	659	2418	3622	13291
Va	34,077	34,077	9	529	933	16	27
Vb	289,513	290,146	85	2939	8736	10	30
VIa	307,092	305,579	117	3248	22299	11	73
VIb	281,288	281,709	96	2164	12934	8	46
VIIb	821	821	0	0	0	0	0
VIIc	434,563	437,273	97	2989	13745	7	32
VIId	0	120	0	0	0	0	0
VIIIabd	3	3	0	0	0	0	0
VIIIc+IXa	17,453	17,453	524	3579	59272	205	3396
VIIj	96	58	0	0	0	0	0
XII	40,506	40,506	65	1291	5998	32	148
XIIb	4,848	4,848	0	0	0	0	0
XIVb	16,529	16,529	8	0	1627	0	98
Total	1,610,090	1,612,331	1399	23495	167652	15	104

*** Based on official catches**

1.3.2 Importance of métier identification.

A métier is defined as a fishing activity which is characterised by one catching gear and a group of target species operating in a given area during a given season, within which the catches taken by any unit of fishing effort account for the same pattern of exploitation by species and size group (Tétard *et al.*, 1995). Later, the 'ICES Study group on the Development of Fishery-based forecast' (SGDFF, 2003) established 'métier' as:

- Fleet: a physical group of vessels sharing similar characteristics in terms of technical features.
- Fishery. Group of vessel voyages targeting the same (assemblage of) species using the same gear.
- Métier: homogeneous division of a fishery by vessel type.

The identification of métiers allows to have a more complete understanding (qualitatively and quantitatively) of the distribution of fishing effort between resources. The changes observed in effort may be due either to seasonal patterns of species distribution, fishing regulations and temporal restrictions, resource depletion, market forces or technical development. A case of resource depletion was described for purse seiners in the Galician area, when they were directed to horse mackerel during the scarcity of sardine (during 1996–1999); another example is the French purse seiners in the Bay of Biscay that due to the recent collapse of anchovy they are now incrementing the catches of sardine.

As it is has been presented in the WD-Abad *et al* (2008), focused on the purse seine Spanish fleet, the main objective of identifying métiers within a fleet, is to establish feasible fishing units to be used in effort-based management and to deepen the knowledge of the whole fishing system. Taking into account that the new European DCR (Data Collection Regulation) is based on métiers rather than stocks, defining métiers within a fleet is completely necessary.

In the working document, the methodology recommended is cluster multivariate analysis (CLARA and PAM methods). Six trips types with high consistency and a regular continuity along the time series were obtained for the Northern Coastal Spanish fleet operating in the ICES subdivision VIIIc and IXa North in the period analysed (20032–005). Also, the fleet analysis gave as results two homgeneous groups, one of big vessels and other of small ones. Before establishing métiers, it is necessary to follow the fishery behavior since the recent collapse of the anchovy stock. So, these six trips types have been defined instead of métiers for sampling and management purposes.

1) Purse seine trips targeting sardine.

2) Purse seine trips targeting anchovy.

3) Purse seine trips targeting mackerel.

4) Purse seine trips targeting horse-mackerel.

5) Purse seine trips targeting Sparidae.

6) Purse seine trips targeting mixed species (others)

All landings and onboard catches information from Purse seine fleet will be split in these 6 units for the Spanish Information and Sampling Programme but only units from 1 to 4 will be included in the length on market Sampling.

Although it is probable that no important changes will occur, some fleet adaptations could be adopted by the big vessels group. A new analysis including last years information is recommend to identify and define the métiers according with the fleet behavior since the anchovy depletion.

1.3.3 Catch Data

Recent working groups have on a number of occasions discussed the accuracy of the catch statistics and the possibility of large scale under reporting 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 underestimates.

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

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

1.3.4 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. The main reasons for ´slipping´ are daily or total quota limitations, illegal size and mixture with unmarketable by-catch. 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 & van Helmond 2007, Ulleweit & Panten 2007, Borges *et al*. 2008). Slipping estimates have 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 (Borges *et al*. 2008). 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.

Borges *et al*. (2008) show that for the Dutch freezer trawler fleet between 2002 and 2005, the most important commercial species discarded is mackerel, accounting for 40% of total pelagic discards. Other important discarded species are herring (18%), horse mackerel (15%) and blue whiting (8%). These discards are also the consequence of fisheries targeted at other species (e.g. mackerel in the horse mackerel and herring targeted fisheries). The most important non-commercial species is boarfish accounting for 5% of the discards. Dutch-owned freezer-trawlers also operate in European waters under German, UK, and French flags.

In 2008, discard estimates from the Netherlands and UK (Scotland) for mackerel, horse mackerel and blue whiting for 2007 were provided to the working group. No discarding on freezer trawlers targeting the above species was observed during three German observer trips carried out in 2007. Some of the provided discard 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 discarding 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 and Scotland provided discard data on mackerel to the working group. Age and length disaggregated data were available from the Scottish fishery in the first quarter in area VIa and VIIb and for the first and fourth quarter in area IVa (more than 90% of total catches were from these areas. The estimated mackerel landings of Scotland and the Netherlands represent approximately 27% of the total landings. Mackerel catches of Germany, which observed zero discards, represent 3% of the total catch. For 2007 the total mackerel discards estimated for the Dutch and Scottish fishery were approximately 5,738 and 2,875t, respectively. Discard percentages of the total catch varied between 2.5 and 13.5%.

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 and discarding of juveniles is now thought to be small. In 2007 the Netherlands estimated discards of 241t, accounting for less than 1% of the national landings. Horse mackerel catches of the Netherlands represent 38% 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.

Norwegian Spring Spawning Herring

No data were provided to estimate possible discards in the herring fishery. Although discarding may occur on this stock, it is considered to be a minor problem to the assessment.

Blue Whiting

In general, discards are assumed to be minor in the blue whiting directed fishery. Discard data to the working group were provided by the Netherlands. Blue whiting is also by-catch in several Spanish bottom trawl fisheries directed to a mixture of species. However, the catch rates of blue whiting in these fisheries are low.

1.3.5 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

An otolith exchange exercise on mackerel is scheduled for spring 2009. FRS (Scotland) has agreed on organizing and coordinating the exchange. Countries providing mackerel age data have already been contacted.

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 WGWIDE 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 was 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.

Sardine

The last workshop on sardine age reading took place in June 2005 to discuss the results of an otolith exchange carried outin 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.

Norwegian Spring Spawning Herring

A scale and otolith exchange of Norwegian spring spawning herring took place in 20072–008. Otolith and scale samples of Norwegian spring spawning herring (NSSH) from the ecosystem survey in the Nordic seas in May were provided by the Institute of Marine Research, Norway. Four countries were participating in the scale and otolith exchange; Norway, Faroe Islands, Iceland and Denmark. Norway and Iceland estimated the ages by reading scales, and Faroe Islands and Denmark estimated the ages by reading the otoliths.

Based on results from this scale and otolith exchange, the age estimate of NSSH between the four countries is very similar. High precision were obtained, and there were no relative bias between different countries. Precision of age estimates appears to be a little higher for the two countries reading scales compared to the two countries reading otoliths, but this is also influenced by technical aspect of the order the different readers are placed in the EFAN-spreadsheet. There is therefore no evidence for differences in the age estimates as a consequence of reading scales versus otoliths.

Another recent comparison (Couperus 2008) of age readings from scales and otoliths for Norwegian spring spawning herring from 2 samples taken at the ASH survey in 2008 demonstrates as well that there are no major differences between age readings from scales and otoliths. Scales were read by readers from Denmark, otoliths by readers from the Netherlands.

Blue Whiting

A workshop on blue whting age reading took place in June 2005. The objective of the workshop was to create the basis for a manual for age determination of blue whiting for future reference. The overall result of the workshop exercises was that there is a general high agreement between readers. An image analysis exercise clarified that lack of agreement can be referred to two reasons, the first being the position of the first ring where the Bower zone is clear. This is often seen in the younger individuals as the otolith is thinner and thus the structures more clear. The second reason to disagreement arose where some readers choose to leave out specific rings identified by other readers as true annual rings where the rings successive to the 2nd ring were split rings. The set of agreed age otoliths which is a product of the present report should be included in a future calibration.

1.3.6 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.

Horse Mackerel

No issues regarding biological data for horse mackerel were raised during the WG.

Sardine

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

Norwegian Spring Spawning Herring (NSSH)

The proportion mature at age used in assessment is based on various surveys and not always well documented. There is a potential problem of obtaining random samples of proportion mature at age from survey for NSSH due to the different catchability of mature and immature fish of the same age groups caused by spatial segregation. An alternative method for estimating proportion mature at age was presented to the Working Group (see 9.4.5). This method involves back-calculation of proportion mature at age from fully matured year classes. IMR (Norway) has agreed to put effort into updating estimates on proportion mature at age from recent years with this method and compare it with data on direct measurements on proportion mature at age from the Nordic ecosystem survey. Based on this, an evaluation will be done and the most reliable method will be adopted in future.

Blue Whiting

There are no critical issues with regard to biological data for blue whiting.

1.3.7 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.1.3.8 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 WGWIDE:

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.

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. Table 1.3.6.1 gives an overview on the availability and format of data provided to the species coordinators. Missing sampling data are regarded to be problematic for the Faroe Island, France, Northern Ireland, Poland and Sweden in the case of Mackerel; UK, France, Lithuania all with considerable catches in the case of Horse Mackerel; and England in the case of Sardine. Norwegian spring spawning herring and blue whiting are generally covered, countries not providing data constitute 1.2% and 1.7% of the total catch, respectively. 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.

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 the species sections.

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. 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 that archives folder should be given access only to designated members of the WGWIDE**, 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.

Table 1.3.7.1. Overview of the availability and format of data provided to the species coordinators Catch year 2007.

A. Mackerel

Stock Coordinator: Andrew Campbell

Country*	Data supplied	Data exchange sheet	Aged Samples
Denmark	YES	YES	YES
England&Wales	YES	YES	YES
Faroes	YES	YES	NO
France	YES	YES	NO
Germany	YES	YES	YES
Iceland	YES	YES	YES
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	YES	NO	NO

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

B. Horse Mackerel

Stock Coordinators: Svein Iversen (Western & North Sea), Pablo Abaunza (Southerr

Country*	Data supplied	Data exchange sheet	Aged Samples
Denmark	YES	YES	YES
England&Wales	YES	YES	NO
Faroes	YES	YES	NO
France	YES	YES	NO
Germany	YES	YES	YES
Ireland	YES	YES	YES
Lithuania	NO	-	-
Netherlands	YES	YES	YES
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

Stock Coordinator: Alexandra Silva

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

D. Norwegian Spring Spawning Herring

Stock Coordinators: Asta Gudmundsdottir, Alexander Krysov

Country	Data supplied	Data exchange sheet	Aged Samples
Denmark	YES	YES	YES
Faroe Islands	YES	YES	YES
Germany	YES	YES	YES
Greenland	NO	-	-
Iceland	YES	YES	YES
Ireland	YES	NO	NO
Norway	YES	YES	YES
Poland	YES	YES	NO
Russia	YES	YES	YES
Scotland	YES	YES	YES
The Netherlands	YES	YES	YES

E. Blue Whiting

Stock Coordinator: Manolo Meixide

Country	Data supplied	Data exchange sheet	Aged Samples
Denmark	YES	YES	YES
Faroe	YES	YES	YES
France	NO	-	-
Germany	YES	YES	NO
Iceland	YES	YES	YES
Ireland	YES	YES	YES
Lithuania	NO	-	-
Norway	YES	YES	YES
Portugal	YES	YES	YES
Russia	YES	YES	YES
Scotland	YES	YES	YES
Spain	YES	YES	YES
Sweden	NO	-	-
The Netherlands	YES	YES	YES

1.3.8 InterCatch

Prior to the working group, 5 WGWIDE stocks were targeted for entry to InterCatch and comparison with the output from the traditional software tool, sallocl. The average and maximum discrepancy for the catch in tonnes and catch and weight at age between InterCatch and sallocl for the North East Atlantic Mackerel, North Sea Horse Mackerel, Sardine, Southern Horse Mackerel and Norwegian Spring Spawning Herring stocks are given in the text table below:

	NEA-MAC		HOM-NSEA		SAR-SOTH		HOM-SOTH		HER-NOSS	
Parameter	Avg Disc.	Max Disc.	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	0.04%	N/A	0.00%	N/A	0.01%	N/A
Canum	0.09%	0.57%	0.02%	0.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%
Weca	0.03%	0.08%	0.01%	0.04%	0.02%	0.06%	0.02%	0.09%	0.09%	0.84%

Good agreement was obtained for the stocks examined and discrepancies are of the order reported last year. A proportion of the observed discrepancy can be attributed to the varying accuracy to which the different applications report the results. For stocks were no allocation in 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 contribute to the discrepancy when compared with the InterCatch results.

A number of issues with the InterCatch application were identified by the working group last year (ICES 2007c). In response to this, additional reporting has been implemented in InterCatch, as part of the data export functionality. Additional output files have been included to enable users to readily produce the data tables that are routinely included in working group reports. The following new outputs have been added:

- A description of the allocations and associated weight schemes and values
- Catch and sampling meta-data per country for each area/division
- Catch and sampling meta-data per country for each season (quarter)
- Catch numbers, mean weights and mean lengths at age for each seaon (quarter)
- All catch and sample data (including values derived from allocations) by country, area and age.

The new outputs are welcomed by the working group. Upon examination, the following issues have been identified

- InterCatch is rounding official catch values.
- In the report of catch number, weight and length at age the some information is missing e.g. for North East Atlantic Mackerel catches were input for area VIIj in all quarters yet the report only contains data for quarters 2 and 3. Other problematic areas are VIIId and VIIIcW.

The following general points were raised during the meeting (the first two are considered to be of a high priority and would be at the top of any 'wish-list' for the future development of the application)

- InterCatch identifies a stock as a collection of species-area combinations and selects the appropriate data from that uploaded when the stock coordinator requests the information for a particular stock in any year. There is, at present, no way to distinguish between stocks of the same species that may originate from the same area. 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 stock and catches in quarters 3 and 4 are assigned to the Western Horse Mackerel stock. This issue could be resolved by the introduction of a temporal element to the InterCatch stock definition. However, this does not solve the problem where stocks of the same species are reported from the same area at the same time of the year. While there is a workaround available (which involves transforming (mapping) data to alternative area and country codes), the method is not readily understandable and would benefit from detailed attention in the user manual and ultimately, improved functionality in InterCatch.
- The development of tools to aid formulation of the input files is a prority. This task would have to be undertaken at a national level since different nations maintain their catch and sampling data in different formats. It is a requirement that individual institute directors are made aware of this and that they assign appropriate resource to carry this out.
- It would be useful if the system could issue a warning to inputters if they attempt to upload data with a species/area combination for which there is no associated InterCatch stock.
- Performance of the InterCatch application can be poor when carrying out stock coordination tasks for larger stocks.
- Internet Explorer is not an appropriate browser for the larger stocks, due to a software bug. Mozilla Firefox is a suitable alternative.
- The current exchange format provides for catches to be reported by statistical rectangle (separately to the catches by area). This additional data provides a valuable source of information which can also be used for quality control.

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 added for horse mackerel and Sardine (Tables 1.4.11−.4.4)

1.5 Comment on update and benchmark assessments

For this year, ICES had scheduled a benchmark assessment for Norwegian Spring Spawning Herring, an update assessment for Sardine and Blue Whiting, 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: Update: Catch and survey data were fit using FLICA which corresponds to ICA run with FLR. Further exploration of the effect of under reported catches is provided in the report.

North Sea horse mackerel: As the advice for this stock is the same as last year's no data exploration was conducted.

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. An assessment is proposed by the WG.

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 (Legault and Restrepo, 1998).

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.

Norwegian Spring Spawning herring: Benchmark assessment: Most data exploration, as well as the final assessment was done with the recently developed toolbox TASACS. TASACS has multiple options for assessment, including 4 age structured assessment models, and also diagnostics that were used to analyse the role of individual data in the assessment. A detailed description is given in Annex 2. The WG agreed on a final assessment using a VPA. The assessment with most other models, as well as those resulting from applying the same procedure as last year, with SeaStar, appeared consistent with the VPA results.

Blue Whiting: Update. Data exploration conducted using FLICA, TSVPA and SMS. Final assessment presented using SMS.

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).
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: FLICA
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 /FLSTF

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	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 11−0 (except for selectivity at age 8 which is set to 1); (3) scaling parameter for fishing mortality at age 10 relative to the average for ages 79− (ignoring the 1982 year-class where applicable); (4) fishing mortality on the 1982 year-class at age 10 in 1992; (5) realised fecundity parameter, relating realised fecundity to potential fecundity, and therefore also relating estimated SSB to the egg production estimates; (6) potential fecundity parameters (intercept and slope), relating potential fecundity to fish weight.
	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.
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 2008 showed retrospective pattern.

4. Prediction model(s) – SHORT TERM

Step	Item	Considerations
4.1	Age, size, sex or fleet-structured prediction model	Catch advice based on agreed Management Plan.
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. Series of SSB estimates from triennial DEPM surveys (2002, 2005 and 2007).
	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. Catch at age is also privided by fishing fleet (available series: 19922−007) . Maturity ogive for the period 19922−006 is fixed. It was made in 2003 using data obtained with histological slides. New stimates for 2007. 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. Fishing fleets differ in their exploitation pattern. Spanish bottom trawl fleet is mainly directed to adult fish as is the case of Portuguese and Spanish artisanal fishing fleets, whreas catches of purse seiners and Portuguese bottom trawl fleet are mainly dominated by juveniles.

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: vectors of selectivities-at-age for 1992 for the three blocks in which the selectivity patterns are classified from the different fleets, kept fixed during the whole assessment period , F multiplier for the first year, deviations to the F multiplier for each year except the 1st one , a vector of catchabilities-at-age, kept fixed during the whole assessment period , a vector of the recruitment deviations from the mean for each year , a vector of deviations, for each age, from the number at age 0 in the 1st year , the virgin biomass for the stock-recruitment relationship
	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

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 1992 to 2006.
4.4	Recruitment	Was fixed as the geometric mean of the period 19922−006.
4.5	Evaluation of uncertainty	N/a
4.6	Evaluation of predictions	N/a
4.7	Major deficiencies	N/a

Table 1.4.4 Check List for the assessment of sardine in Area VIIIc and IXa

1. General

step	*Item*	*Considerations*
1.1	Stock definition	The stock is distributed in the Iberian Peninsula. Some mixing with adjacent populatons from French waters (Division VIIIb) and northern Morrocco is aknowledged, but it considered not to affect the assessment. The assessment is believed to reflect the dynamics of sardine in Iberian waters.
1.2	Stock structure	No subpopulations have been defined, although life-history properties indicate some heterogeneity across the stock area.
1.3	Single/multi-species	Single species assessment

2. Data

step	*Item*	*Considerations*
2.1	Removals: catch, discarding, fishery induced mortality	Discards are considered not relevant. The fishing statistics are considered accurate and landings are representative of catches. 99% of the landings are from purse-seiners.
2.2	Indices of abundance	Acooustic and DEPM (Daily Egg Production Method) surveys.
	Catch per unit effort	None.
	Gear surveys (trawl, longline, etc.)	Pelagic and bottom trawls. In some cases (opportunistically) purse seining.
	Acoustic surveys	Series of spring acoustic surveys covering the whole stock area since 1996 (gap in 2004). Two surveys, one covering the northern Spanish waters (Division VIIIc and IXaN) and another covering the Portuguese waers and Gulf of Cadiz (the remaining area of Division IXa) are carried out each year. Data (numbers-at-age) from the two surveys are combined (summed) in a single index of stock abundance.
	Egg surveys	SSB estimated from triennial DEPM surveys since 1997 covering the whole stock area.
	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 is generally good. Sampling levels improved across the time series. Calibration of age readings and maturity criteria between Portuguese and Spanish laboratories rsponsible for sampling. A revision of maturity and stock weights-at-age for 1996 – 2005 was presented in 2006.
2.4	Tagging information	None.
2.5	Environmental data	No environmental data is currently used in the assessment.
2.6	Fishery information	Sardine is mainly exploited by purse-seine fisheries in both Spanish and Portuguese waters. The fishery operates across the whole area and all year round but 60% of the landings occur in the second semester. Seasonal closures of 12−-months during winter are observed in some areas. A total of 531 vessels with lengths in the range of 83−8 m and 241−100 HP contributed to landings in 2007.

3. Assessment model

step	Item	Considerations
3.1	Age, size, length or sex-structured model	The stock is assessed using an age structured model (ACMI-Assessment Model Combining Information from various sources).
3.2	Spatially explicit or not	No
3.3	Key model parameters: natural mortality, vulnerability, fishing mortality, catchability	Natural mortality is 0.33 for all ages and years. Both the fishery selection and survey catchability are assumed equal for ages 4 and 5. Selection-at-age is allowed to change gradually across the period using the recursive updating algorithm in ACMI, with a gain factor of 0.2 for all ages and years, providing a fishery mortality model close to separable. Survey catchability-at-age assumed constant over time. Catchability of the DEPM survey assumed constant over time. 0-group catches downweighted (0.1). Equal weights for surveys and equivalent to catch data.
	Recruitment	No stock recruitment relationship is assumed.
3.4	Statistical formulation: - what process errors - what observation errors - what likelihood distr.	No process errors are assumed. Observation errors are not assumed to follow specific distributions. The objective function is a sum of squared log residuals for catch numbers-at-age, survey indices-at-age and DEPM indices of SSB (not likehood function).
3.5	Evaluation of uncertainty: - asymptotic estimates of variance, - likelihood profile – bootstrapping - bayes posteriors	Asymptotic estimates of variance and correlatons by the inverse of the Hessian matrix. Median and 90% limits of SSB, R and F trajectories estimated by non-parametric bootstrap of catch and survey residuals.
3.6	Retrospective evaluation	One year retrospective analysis.

4. Prediction model(s) – SHORT TERM

Step	Item	Considerations
4.1	Age, size, sex or fleet-structured prediction model	Age-structures deterministic short term prediction.
4.2	Spatially explicit or not	No
4.3	Key model (input) parameters	Weight-at-age in the stock and in the catches and selection-at-age were calculated as the arithmetic mean value of the last three years (20052−007). The maturity ogive corresponds to the 2007 values. Natural mortality was 0.33 and the proportion of F and M before spawning was 0.25. F_{sq} was the average F 20052−007, unscaled.
4.4	Recruitment	Recruitments for 2008 and 2009 were calculated as the geometric mean recruiment for 19982−007. This procedure is identical to previous years. Recruitment for 2007 was that estimated by the assessment model.
4.5	Evaluation of uncertainty	No.
4.6	Evaluation of predictions	No.
4.7	Major deficiencies	The outcome of deterministic predictions has a high uncertainty due to the use of assumed vlues of recruitment, the projection of current levels of fishing mortality and possible bias in the assessment.

5. Prediction model(s) – MEDIUM TERM

No medium term predictions are conducted.

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 WGWIDE

No revisions of the reference points have been considered at this meeting for blue whiting, Norwegian spring spawning herring, horse mackerel and sardine stocks. In the case of Northeast Atlantic mackerel there are indications from the management simulations that F values around 0.23 provide maximum sustainable yields that are compatible with precautionary biomass limits. This would mean an increment in the defined Fpa, and a revision of mackerel reference points are considered (see section 2.6).

1.8 Blue Whiting

1.8.1 Blue Whiting Management Plan Evaluation

1.8.1.1 EC/Faroe Islands/Iceland/Norway request on long-term management of blue whiting

Request

ARRANGEMENT FOR THE LONG-TERM MANAGEMENT OF THE BLUE WHITING STOCK

1) *The Parties agree to implement a long-telll1 management plan for the fisheries on the Blue Whiting stock, which is consistent with the precautionary approach, aiming at ensuring harvest within safe biological limits and designed to provide for fisheries consistent with maximum sustainable yield, in accordance with advice from ICES.*

2) *For the purpose of this long-term m anagement plan, in the following text, "TAC" means the sum of the coastal State TAC and the NEAFC allowable catches.*

3) *As a priority, the long-telll1plan shall ensure with high probability that the size of the stock is maintained above 1.5 million tonnes (Blim).*

4) *The Parties shall aim to exploit the stock with a fishing mortality of 0.18 on relevant age groups as defined by ICES.*

5) *While fishing mortality exceeds that specified in paragraph 4, the Parties agree to establish the TAC consistent with annual [x%] reductions in fishing mortality until the fishing mortality established in paragraph 4 has been reached.*

For the purposes of this calculation, the fishing percentage mortality reduction should be calculated with respect to the year before the year in which the TAC is to be established. For this year, it shall be assumed that the relevant TAC constrains catches.

6) *When the fishing mortality in paragraph 4 has been reached, the Parties agree to establish the TAC in each year in accordance with the following rules:*

- *In the case that the spawning biomass is forecast to reach or exceed 2.5 million tonnes (SSB trigger level) on 1 January of the year for which the TAC is to be set, the TAC shall be fixed at the level consistent with the specified fishing mortality.*
- *In the case that the spawning biomass is forecast to be less than 2.5 million tonnes on 1 January of the year for which the TAC is to be set (B), the TAC shall be fixed that is consistent with a fishing mortality given by:*
    - *F = 0.05 + [(B1−.5)(0.180−.05) / (2.51−.5)]*
- *In the case that spawning biomass is forecast to be less than 1.5 million tonnes on 1 January of the year for which the TAC is to be set, the TAC will be fixed that is consistent with a fishing mortality given by F = 0.05.*

7) When the fishing mortality rate on the stock is consistent with that established in paragraph 4 and the spawning stock size on 1 January of the year for which the TAC is to be set is forecast to exceed 2.5 million tonnes, the Parties agree to discuss the appropriateness of adopting constraints on TAC changes within the plan.

8) The Parties, on the basis of ICES advice, shall review this long-telll1 management plan at intervals not exceeding five years and when the condition specified in paragraph 4 is reached.

1) ICES are requested to assess whether the draft 1ong-term management plan is in accordance with the Precautionary Approach.

2) ICES are requested to assess the medium-term consequences of the application of this plan.

3) ICES are invited to suggest and to evaluate alternative values for the "trigger biomass" value of 2.5 million tonnes and the target fishing mortality rate.

4) ICES are requested to provide a range of options in accordance with paragraph 5 of Annex I for the reduction of fishing mortality to the target level identified in paragraph 4 of Annex I with a clear indication of the associated levels of risk and uncertainty.

ICES response

The plan includes two phases. First, the plan has a rule for a gradual reduction of the fishing mortality from the present high level down to a future lower target fishing mortality. Secondly, when that fishing mortality has been reached, the plan has rules for setting the TAC according to the level of SSB.

Simulations were done with 2008 as the starting year. The simulations account for uncertainty in the present and future assessments and in the future recruitments, assuming recruitments at the level experienced in the year classes 1981−1995. It was assumed that the TAC derived from the rule would be taken precisely in all years

A range of reduction rates for F ,trigger biomasses and target Fs was explored. In all these simulations, a high risk for SSB to fall below Blim was found from 2010 and some years onwards. In the longer term, this risk was reduced to well below 5% after 2020. Figure 1 shows as an example the risk year by year with a trigger biomass of 2.5 million tonnes and a reduction rate of 30% per year. The risk that SSB falls below Blim at least once in the first 7 years is around 23% in this example. The risk in the early period was reduced by a stronger reduction of the F-value, but even with a 50% annual reduction it was well over 10%. The choice of trigger biomass has little influence on these results. The long term yield with the assumed recruitment regime is between 300 and 470 thousand tonnes, with a mean at about 390 000 thousand tonnes. The log term yield is independent on both F reduction rate (unless the rate is very low) and trigger biomass.

Although the rule appears to ensure recovery when the SSB falls below Blim, the high risk in the early years implies that the proposed plan is not in accordance with the precautionary approach, unless the reduction is sufficiently fast to ensure full reduction in one year..

A more robust alternative would be to apply the long term harvest rule (Paragraph 6) immediately, with a target F of 0.18. That leads to a risk of falling below Blim at least once in the years 17– between 5 and 9%. The risk is lower with a higher trigger biomass. The time course of Risk and Yield for this option is shown in Figure 2.

Hence, ICES recommends to implement Paragraph 6 immediately, with a trigger biomass of at least 2.5 million tonnes, which is considered precautionary since the rule should ensure rapid recovery in that case. The long term catches with this alternative would be similar to those resulting from the proposed rule, but the early reduction in catches would be faster.

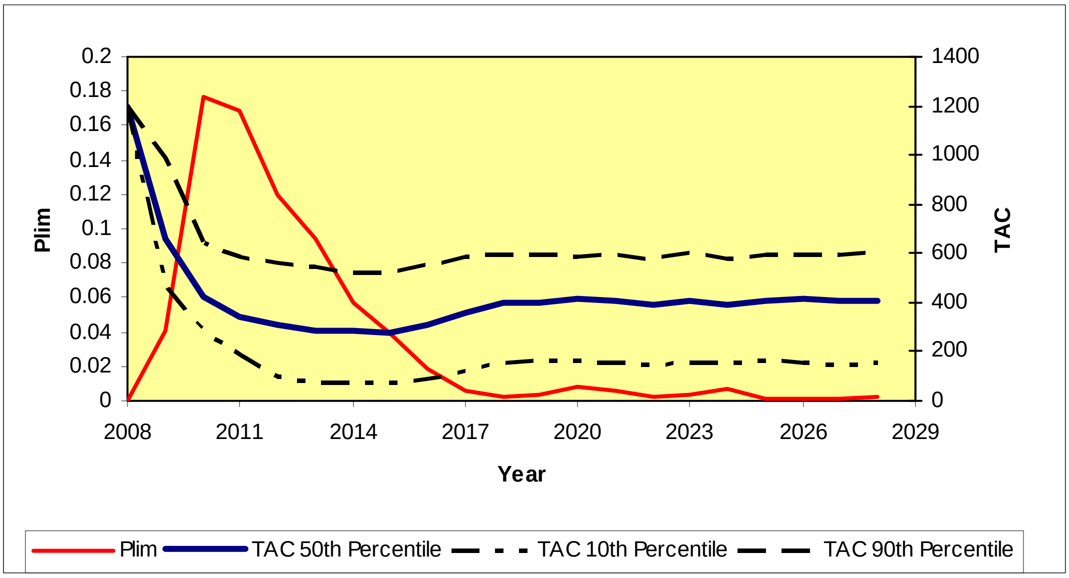

Figure 1.

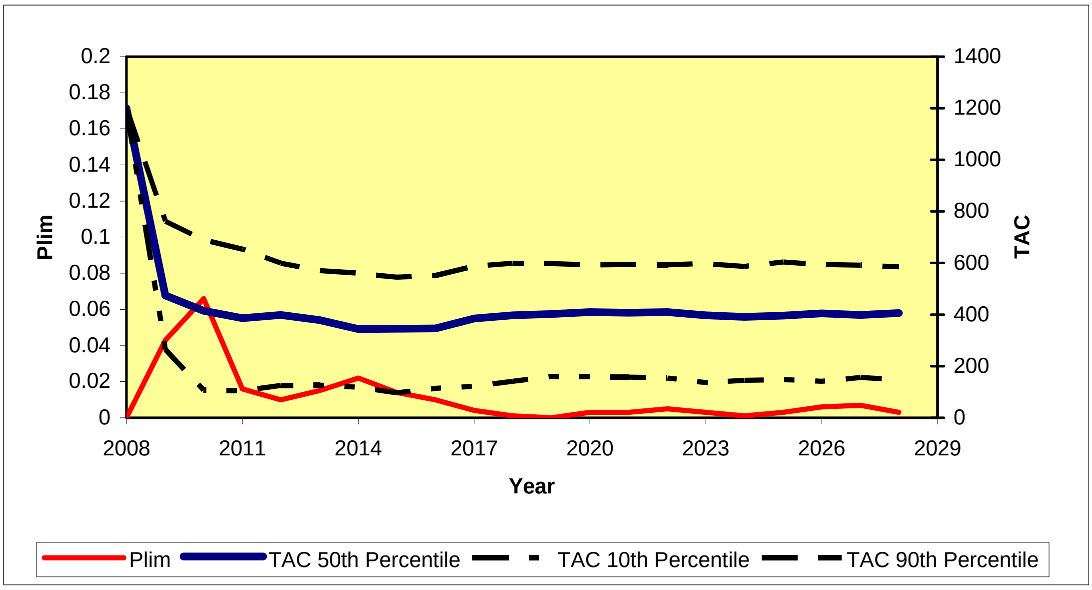

Figure 2

1.8.1.2 Irish request on management plan for blue whiting and stock structure

Request

Ireland requests ICES to consider the following two questions as part of its evaluation process Ireland takes the view that these questions are important considerations in the development of a blue whiting management plan.

> *1. Should such a management plan include provision for the separate management of juveniles, as is the case for North Sea herring?*
>
> *2. What is the latest scientific information on the stock structure of blue whiting? Any plan that is developed would have to be robust to possible changes to the assessment and management units.*

Question 1: In order to examine the impact of the juvenile fishery, the effects of applying three different exploitation patterns on ages 12− were explored. Three options for exploitation pattern were as follows (1) zero exploitation, (2) "high" exploitation and (3) the constant F selection pattern used in the assessment from 1999 onwards. The "high" exploitation pattern which gave the highest relative fishing mortality on ages 12− during the last 15 years was derived from the XSA assessment. The assessment exploitation pattern was used on ages older than 2 years. The results show that the difference between exploitation rates is marginal. The conclusion is that the effect on yield of protecting juveniles is likely to be very small. A separate clause for the protection of juveniles in the management plan is therefore not needed.

Question 2: There is growing evidence from the studies conducted that there may be several components in the North East Atlantic blue whiting stock. It is difficult to determine how many possible sub-populations may exist. In many of the studies carried out to date samples have not been sufficiently large to identify separate components. A more extended coordinated sampling programme across the stock area is required. Further investigation would then be needed if any changes were required regarding existing management units. In the event that there are several components management would need to be more precautionary, spreading exploitation evenly among units to avoid local depletion. Until further information becomes available ICES recommends that management of blue whiting follow the single stock unit advice.

1.8.2 Answer to special request on NEA mackerel

1.8.2.1 Request from EU, Norway and Faeroes coastal states.

1. In its 2007 advice, ICES presented analyses indicating that unreported catches are still a major uncertainty affecting the reliability of the assessment. The coastal States request ICES to:

> *i. Provide estimates of the magnitude in tonnes and precision of the unaccounted mortality in the fisheries on North-East Atlantic mackerel;*
>
> *ii. Indicate where possible the sources of this mortality;*
>
> *iii. Evaluate where possible any historical changes in this unaccounted mortality;*
>
> *iv. Provide estimates of historic Spawning Stock Biomass and Fishing Mortality thatwould be compatible with these estimates of unaccounted mortality.*

2. The coastal States request ICES to include the North-East Atlantic mackerel stock in their routine reviews of reference points.

The response to the individual questions is provided below. A brief description of the analyses carried out are included in section 2.5.2 and 2.7.2 for questions 1 and section 2.6 for question 2.

Question 1

i) Estimates of the magnitude (in tonnes) and precision of the unaccounted mortality in the NEA mackerel fisheries suggest that, on average (19752–007), total catch related removals are equivalent to between 1.6 and 3.4 times the catch, or an average removals (19752–007) of between 0.91 and 2.96 Mt per year with a long term mean of 1.92 Mt

ii) The additional sources of this mortality include:

- escapees from fishing that die, such as those that pass through the meshes and die
- discards, slippage and high-grading not included in the ICA assessment
- unreported catch throughout the timeseries

There is no basis for allocating the total quantities among these different sources. Because the additional catch cannot be partitioned amongst the various sources, the availability of this biomass to any fishery cannot be estimated. Currently the best estimates of availability of mackerel are given by the virtual population analysis provided by the ICA assessment.

iii) It has not been possible to evaluate where any significant historical changes in this unaccounted mortality. This is primarily because the only data source that can provide this information is the tag mortality data. These data show a great deal of variability and fit only weakly to the population, providing a good estimate of long term mean mortality but no evidence of changes with time. In particular, the absence of tag data after 2003 means that the four most recent years have no mortality data. In the absence of tag mortality estimates after 2003, mortality estimates are therefore based on the mean. The only signs of recent changes in unaccounted mortality, is a decline in the estimated factor for 2003.

iv) The spawning stock biomass may on average be between 1.7 and 2.7 times the ICA virtual population estimate, giving a long term mean SSB 1975 to 2007 of between 4.3 and 6.9Mt with a mean of 5.5Mt. Estimates of historic SSB and F are given in Figures 9.3.2.12.13–. The ICA assessment estimates long term mean F 48– as 0.25, this compares with the Bayesian estimate of 0.27 within an 95% interval of 0.19 to 0.35. Generally this good correspondence between methods supports the view that managing through the use of fishing mortalities or catch/biomass ratios is robust to uncertainties in unaccounted mortality.

Question 2

The WG has examined the reference points for NEA mackerel (See section 2.6) which were previously unchanged since 1998. A brief description of the analyses carried out is included as Annex II ICES has revised values for F_{lim}, B_{lim} and F_{pa} but B_{pa} remains unchanged because it has not been possible to select a value fully compatible with the precision of the assessment and the stock dynamics. Under these circumstances it is recommended to manage using criteria in the management plan rather than B_{pa}. The short term forecasts options (section 2.8) are provided for the current management plan, exploitation at revised F_{pa} and for a range of options under a revised management plan.

1.8.2.2 Irish request on long-term management for North East Atlantic mackerel

Request

In light of the scientific report on long term management for mackerel, Ireland requests ICES:

(1) to identify the appropriate Fpa for NEA mackerel;

(2) to comment on the appropriateness of the range of fishing mortalities specified in the existing TAC setting arrangement of the Coastal States, should any change in Fpa be identified.

ICES response

Question 1

ICES has examined the reference points for NEA mackerel which were previously unchanged since 1998. A brief description of the analyses carried out is included as Annex II to Coastal states request 9.3.2.12. ICES has concluded that revisions F_{lim}, B_{lim} and F_{pa} are required but B_{pa} remains unchanged, because it has not been possible to select a value fully compatible with the precision of the assessment and the stock dynamics. Under these circumstances it is recommended to manage using criteria in the proposed management plan rather than B_{pa}.

Revised Reference points

	Type	Value	Technical basis
Precautionary approach	Blim	1.67 Mt	Blim=Bloss, Biomass above which reduced recruitment has not been observed
	Bpa	2.3 million t.	Bloss in Western stock raised by 15%: = 2.3 million t.
	Flim	0.42 the fishing mortality estimated to lead to potential stock collapse	Flim =Floss
	Fpa	0.23	Flim * 0.55

Revised in 2008.(Bpa unchanged since 1998)

Question 2

Following the review of reference points for NEA mackerel and the revision of F_{pa} ICES considers that the existing range of mortalities specified in the existing TAC setting arrangement of the Coastal States for NEA mackerel (0.15 to 0.2) are precautionary and consistent with sustainable long term yield. ICES has provided advice (section 9.3.2.1 European Commission (EC) request on evaluation of management plan for NEA mackerel) in June 2008 regarding a range of appropriate management targets for this stock.

1.8.3 Irish request on long-term management for North East Atlantic mackerel

Request

In light of the scientific report on long term management for mackerel, Ireland requests ICES:

(1) to identify the appropriate Fpa for NEA mackerel;

(2) to comment on the appropriateness of the range of fishing mortalities specified in the existing TAC setting arrangement of the Coastal States, should any change in Fpa be identified.

ICES response

Question 1

ICES has examined the reference points for NEA mackerel which were previously unchanged since 1998. A brief description of the analyses carried out is included as Annex II to Coastal states request 9.3.2.12. ICES has concluded that revisions F_{lim}, B_{lim} and F_{pa} are required but B_{pa} remains unchanged, because it has not been possible to select a value fully compatible with the precision of the assessment and the stock dynamics. Under these circumstances it is recommended to manage using criteria in the proposed management plan rather than B_{pa}. The short term forecasts options (Section 2.8) are provided for the current management plan, exploitation at revised F_{pa} and for a range of options under a revised management plan.

Question 2

Following the review of reference points for NEA mackerel and the revision of F_{pa} ICES considers that the existing range of mortalities specified in the existing TAC setting arrangement of the Coastal States for NEA mackerel (0.15 to 0.2) are precautionary and consistent with sustainable long term yield. ICES has provided advice (section 9.3.2.1 European Commission (EC) request on evaluation of management plan for NEA mackerel) in June 2008 regarding a range of appropriate management targets for this stock.

1.9 Ecosystem considerations for widely distributed and migratory pelagic fish species

It has been known for more than a century that ecosystem factors have a determinant effect on the productivity of fish stocks, and may therefore be a source of variation as important as exploitation by fisheries (Hjort, 1914). Various biological aspects of fish stocks such as recruitment, growth or natural mortality, are influenced by ecosystem factors (Skjoldal *et al*. 2004). Geographical distribution of stocks and species migration patterns may also vary according to environmental conditions (Sherman and Skjoldal 2002). Ecosystem factors influencing fish stocks include:

- Physical (temperature, salinity) conditions
- Hydrographical (turbulence, stratification) conditions
- Large scale circulation patterns
- Inter-species and intra-species relationships
- Bottom-up effect of zooplankton on pelagic fishes
- Competition for food or space between pelagic species
- Top-down control of pelagic species by predator abundance

In a first attempt to integrate ecosystem considerations with fish stock assessment in WG WIDE, this section presents a short review of some recent changes which have taken place from the Bay of Biscay to the Barents Sea. Some of the possible implications of these changes are briefly reported in this section and then detailed in the sections specific to each stock.

An important challenge for the future meeting of this working group will be to take ecosystem considerations into account in stock assessment methods in order to reduce levels of uncertainty regarding the status and prediction of stocks. WGWIDE encourages further work to be carried out on ecosystem considerations linked to widely distributed fish stocks including NEA mackerel, Norwegian spring-spawning herring, blue whiting, horse mackerel and sardine. Emphasis should be on how ecosystem considerations from scientific studies and knowledge may be implemented and applied for management considerations. WGWIDE invite scientists working on ecosystem considerations to collaborate and present relevant working documents and publications for the next meeting in 2009.

Ecosystem Factors Affecting the Stocks Included in WGWIDE

Climate variability and climate change

Climate, in its wider sense, refers to the state of the atmosphere, for instance in terms of partitioned air masses (IPCC 2001). Climate variability, caused by the variations of atmospheric characteristics around the average climatic state, occurs via recurrent and persistent large-scale patterns of pressure and circulation anomalies. The North Atlantic Oscillation (NAO) is the recurrent pattern of variability in circulation of air masses over the North Atlantic region, corresponding to the alternation of periods of strong and weak differences between Azores high and Icelandic low pressure centers. Variations in the NAO influence winter weather over the North Atlantic (storm track, precipitations, strength of westerly winds) and hence have a strong impact on oceanic conditions (sea temperature and salinity, Gulf Stream intensity, wave height). Since 1996 the Hurrell winter NAO index has been fairly weak but mainly positive, except for during 2001, 2004 and 2006 (ICES, 2007). The Iceland Low and the Azores High were both weaker than normal in 2007 and 2008, and the centre of the Iceland Low was displaced towards the southwest to the entrances to the Labrador Sea (ICES 2007, 2008).

Accumulation of anthropogenic greenhouse gases in the atmosphere is currently effecting climate change (IPCC 2001). The classical measure of global warming is the Northern Hemisphere Temperature anomaly (NHT) (Jones and Moberg, 2003) which is computed as the anomaly in the annual mean of sea water and land air surface temperature over the northern hemisphere. Since the early 1900s, a warming of the northern hemisphere is evident. A first period of increasing temperature occurred from the early 1920s to about 1945. The period from the 1950s to the middle of the 1970s, corresponded to a light decrease of the NHT. During the last three decades, NHT anomalies have exhibited a strong warming trend.

Circulation pattern

Large-scale circulation patterns set the stage for important processes influencing fish species and ecosystems covered by WG WIDE. The circulation of the North Atlantic Ocean is characterized by two large gyres: the *subpolar* (SPG) and *subtropical* gyres (Rossby, 1999). When the SPG is strong it extends far eastwards bringing cold and fresh subarctic water masses to the NE Atlantic, while a weaker SPG allows warmer and more saline subtropical water to penetrate further northwards and westwards over the Rockall plateau area. Changes in the oceanic environment in the Porcupine/Rockall/Hatton areas have been shown to be linked to the strength of the subpolar gyre (Hátún *et al.*, 2005). In recent years the area has been dominated by the warmer and saline Eastern North Atlantic Water (Hátún *et al.*, 2007). The large oceanographic anomalies in the Rockall region spread directly into the Nordic Seas, regulating the living conditions there as well as further south. Such changes are likely to have an impact on the spatial distribution of spawning and feeding grounds and on migration patterns of certain pelagic species.

Temperature

Temperature is well known to affect many aspects of fish biology, such as recruitment, growth, or mortality rates.. Temperature affects fish both directly – through its effect on metabolic rates affecting growth and energy requirements and indirectly – through its effect on the production of prey items and production and distribution of predators.

Feeding and spawning distributions and migration patterns of widely distributed species are also closely related to temperature: the timing of migration is triggered by temperature and migration routes are related to temperature gradients. A better understanding of these effects could provide valuable information for both assessment and management of widely distributed stocks.

Time-series of sea surface temperature (SST) and salinity for the North Atlantic show recent generally rising trends. The trend from 19962–008 has been warming and increasing salinity in the upper ocean (ICES 2008). In 2008 Atlantic Water surface temperatures were above the long term mean. The increase in SST at several of the stations in the NE Atlantic is up to 3°C since the early 1980s. This rate of warming is very high relative to the rate of global warming (ICES 2007, 2008). The upper layers of the North Atlantic and Nordic Seas remained exceptionally warm and saline in 2006 and 2007 compared with the long-term average (ICES WGOH 2007, 2008). The largest anomalies were observed at high latitudes. The North Sea, Baltic Sea and Bay of Biscay had an unusually warm winter and spring. This was due to a combination of stored heat from the warm autumn in 2006, and high solar radiation in 2007 (ICES WGOH 2008).

Phytoplankton

Phytoplankton abundance in the NE Atlantic has increased in cooler regions (north of 55°N) and decreased in warmer regions (south of 50°N). These changes in the primary production are likely to have impacts on zooplankton because of tight trophic coupling. Similar effects may be expected for other mid-latitude pelagic ecosystems, because the proposed mechanisms are general and the results for the NE Atlantic are consistent and based on very large scale, long-term sampling (Richardson and Schoeman, 2004).

Zooplankton

Indicators of zooplankton communities which have been developed over recent years reveal important changes in the pelagic ecosystems of the North East Atlantic (Beaugrand, 2005). A northwards shift of 10° of latitude of the biogeographical boundaries of copepod

species has, for instance, occurred during the past four decades (Beaugrand *et al*. 2002). One well-known example of these changes is the decline in the North Sea of the sub-arctic copepod *Calanus finmarchicus*, an important food item for a number of fish species, and its replacement by *Calanus helgolandicus*, a temperate water species. Progressive increases in aboundance of warm water/sub-tropical phytoplankton species into more temperate areas of the northeast Atlantic (Beaugrand *et al*. 2005) have in turn influenced zooplankton communities.

The average biomass of zooplankton in the Norwegian Sea has followed a decreasing trend since 2002, but increased in 2008 compared to 2007. Average biomass of zooplankton in May 2008 was lower than in 2006 and 2007, and was the lowest measured since 1997 (ICES 2008). Increased biomass was observed in the eastern region, while biomass in the western region decreased abruptly from 2007 to 2008. The overall distribution pattern of zooplankton biomass in 2008 resembles largely the distribution during previous years with the highest biomass in the cold water of the East Icelandic Current, where high aggregations of adult herring and mackerel were also observed.. The biomass in the western region was much lower than any previous recordings Higher concentrations along the Arctic front further north were not obvious as opposed to in previous years.

Species interactions

A central element in ecosystem considerations is how different species interact with each other (Rothschild 1986, Skjoldal *et al*. 2004). The distribution of species considered by WG WIDE can overlap to a large extend during some part of the year and according to life history stages Since these species are mainly planktivorous, concurence for food is likely to hapend. The larger species (mackerel and horse mackerel) are also potential predator of the juveniles of the other pelagic species. Canibalism of adults on the eggs, larvea and juvenils is also likely to happend. Consequently, interspecific interaction between pelagic species could play an important role in the dynamics of these stocks. .

Various pelagic species (e.g. mackerel, horse mackerel, sardine, blue whiting) also represent an important food source for many top predators such as marine mammals, seabirds and other species of pelagic fish. Many pelagic ecosystems (particularly those in upwelling areas) are characterised by a wasp-waist control, where a few, but highly abundant fish species effectively regulate the populations of their prey (top down control) but also of their predators (bottom up control). This type of regulatory mechanism makes pelagic fish have a key role in ecosystem functioning.

There is a large body of literature on the diet of predator species feeding on pelagic fish in the Northeast Atlantic: sardine, mackerel, horse mackerel, blue whiting and herring have all been found in the diet of several cetacean and seabirds species and are also part of the diet of other fish species (e.g. hake, tuna found with sardine and anchovy).

Because of the numbers involved, if we compare population estimates of pelagic fish and those of top predators, it would appear than predation on pelagic fish by other pelagic fish could have a much bigger impact in regulating populations than that of predation by marine mammals and seabirds (as already suggested by Furness (2002) in the context of the North Sea). Nevertheless, top predators could play a bigger role in pelagic fish dynamics at regional or local scales particularly when fish biomass is low.

Overview of the environmental conditions during the recent years in the North East Atlantic ecosystems

Bay of Biscay to west of the British Isles

Hydrological and oceanographical data from the ICES Ocean Climate Report 2007 showed a cold winter and low sea surface temperatures, followed by an unusually warm summer and autumn, and correspondingly high SST (ICES 2007). This situation has recently influenced migration patterns and distribution of juvenile and adult NEA mackerel. Possible mechanisms involved are: earlier onset of spawning and migration to higher latitudes due to generally higher temperatures triggering spawning, and earlier spring blooms in the region important for some species such as mackerel and horse mackerel.

North Sea

The warm conditions from 2006 remained high until autumn 2007. Model simulations combined with survey data show that inflow of Atlantic water into the North Sea was the lowest ever recorded and cooling in winter has been far weaker than usual. The spring bloom started approximately one month earlier than normal. Increased temperatures have influenced biomass, species composition, distribution area and seasonal cycles of several zooplankton species. The cold water copepod *Calanus finmarchicus* has been considerably reduced in biomass in the North Sea during the last decade and has also moved northwards. This species has been only partly replaced by the smaller, warmer water species *C. Helgolandicus*. This may provide less favourable feeding conditions and less biomass of preferred prey in this area, especially for NEA mackerel and horse mackerel at different life stages.

Norwegian Sea

During winter 2008 strong westerlies (high NAO index) resulted in an increased influence of Arctic water in the southern Norwegian Sea for 2008 compared to 2007. Also compared to the average 19952–006 an increased Arctic influence was observed, especially in the western and southwestern part. This situation has strongly influenced the migration pattern and distribution in spring and summer of both NSS herring and NEA mackerel. The volume of transport of Atlantic water into the Norwegian Sea increased considerably during 2005 and record-high transport values were observed during winter 2006 (ICES Advice 2008). At the surface, the temperature in 2008 was warmer than the average for most of the Norwegian Sea. Nevertheless, after some years with large westerly extension of Atlantic water and additional warm Atlantic water in the Norwegian Sea, especially in 2003 and 2004, a temperature reduction in the western Norwegian Sea is observed in the last years. This is due to a decreased extension in the Atlantic water and the occurrence of an increased transport of Arctic water to the area. Thus, the temperature in the western Norwegian Sea in 2008 is close to and in some areas less than the 19952–006 average. However, in the eastern part, near the Norwegian coast, the water is still warmer than the average because the inflow of Atlantic water through the Faroe-Shetland Channel is warmer than normal. At the surface, the air-sea heat flux during April-June 2008 was higher than normal causing the relatively warm surface water.

The Atlantic water in the Norwegian Sea has been anomalously warm and salty since 2002. In 2007, the Atlantic water in the southeastern Norwegian Sea was 0.8C° warmer than normal. After the record-high volume transport of Atlantic water into the Norwegian Sea during winter 2006 it fell to a record-low during summer 2007.

Barents Sea

The general circulation pattern in the Barents Sea is strongly influenced by topography. The coastal water is fresher than the Atlantic water, and has a stronger seasonal temperature signal. The inflow of Atlantic Water to the Barents Sea was higher and warmer than ever recorded and the ice cover was the lowest on record for the winter of 2006. This expanded the possible distribution area for widely distributed stocks. In 2007, the temperature in the inflowing water was colder and less saline than in the previous year and at about the same level as 2005, but still above the long-term average (ICES Advice 2008). Compared with the two previous years, less zooplankton was observed in the Barents Sea in 2007, probably related to a lower amount of Atlantic water being transported into the area, and grazing by pelagic planktivorous species.

Subsurface temperature and salinity were lower in 2008 than normal in the west indicating a stronger influence of Arctic water. The midwater section was warmer and saltier than average, partly due to a deeper Atlantic layer there compared to the long-term-mean. A body of relatively cold and fresh water extends eastward from the Iceland Sea. Arctic waters are separated from the Atlantic by the Arctic Front, which is indicated by closely spaced isotherms. The temperature distribution in 2008 resembles in general that of 2007. Below the upper layer (>1 00 m) the water in the southern part is colder in 2008 than 2007. At some location the differences can be up to 1°C. This difference can be explained by increased intrusion of Arctic water there. In the Barents Sea highest zooplankton biomass was observed in the eastern part of the survey area. Average biomass was higher than 2007 but lower than in 2005. The Barents Sea component now consists of an abundant 2004 year class and weak 2005 and 2006 year classes of Norwegian spring spawning herring. Results from the Barents Sea bottom trawl survey in January-March also indicate that the 20052–007 year classes of blue whiting are poor, which is in line with the observations from the International Ecosystem Survey in the Nordic Seas.

Stock specific ecosystem considerations

North East Atlantic Mackerel

The NEA mackerel stock is distributed in the whole ICES area and currently supports one of the most valuable European fisheries. The distribution of the NEA mackerel stock in 2008 was between the Iberian Peninsula and the northernmost part of the Norwegian Sea (75°N). Distribution changes with life history stage and migration patterns. Geographical changes in the centre of spawning areas along the western shelf have been observed recently with peak spawning shifting west and northwards (Reid, 2001, Beare and Reid, 2002). This trend has continued and the northernmost observed spawning of mackerel was documented in the international egg survey in 2007 (ICES WGMHSA 2007). Mackerel has now the largest spatial expansion and distribution pattern in summer recorded in the Northeast Atlantic (see section 2.13).

NEA mackerel is dependent on zooplankton for growth and survival (Prokopchuk and Sentyabov 2006). The zooplankton *C. finmarchicus* is a key prey species for mackerel and most pelagic stocks in the North East Atlantic (Melle *et al*. 2004). Locally higher biomass was observed in the waters dominated by the East Icelandic current of the western Norwegian Sea. The distribution and biomass of *C. finmarchicus* likely influenced the feeding migration and distribution of adult mackerel from spring to autumn. Increased biomass of zooplankton was observed in the northeastern Norwegian Sea in 2008 compared to earlier periods, and coincided with increased presence of mackerel in these areas, including in coastal waters where mackerel was caught for the first time in decades.

Mackerel migrations in the southern and western part of the distribution area are closely associated with the slope current, and mackerel migration is modulated by temperature (Reid *et al*., 2001). The continued rapid warming of the slope current strongly suggests effects on both the timing and the spatial extent of this migration. The southward migration of mackerel from the wintering and pre-spawning areas in the Norwegian Sea and North Sea to the spawning grounds west of Ireland generally commences when the temperature falls below about a threshold of 9C°. During warmer oceanographic conditions, migration is only initiated once the threshold is reached and southwards movements may likely be delayed (Reid *et al*. 2001). In 2006 and 2007 we observed a later southward movement, and this influenced the timing of the fishery, where large proportions of mackerel in recent years in the North Sea have been caught later in the season compared to previous periods (ICES 2007). Furthermore, the post-spawning migration northwards to the Norwegian Sea has undergone considerable changes in the last few decades with an earlier migration occurring in recent years (Reid *et al* 2006). A pronounced length and age dependent migration pattern with the largest individuals moving to the northernmost areas has been found for mackerel (Nøttestad *et al*. 1999). This size selective migration pattern has remained strong the last decade, but also with a more pronounced western distribution of large mackerel in summer (Nøttestad *et al*. 2007). Catch data on mackerel also show the same pattern (ICES 2007, 2008). Furthermore, juvenile mackerel from the 2006 year class where present for the first time in relatively large quantities up to 66ºN and constituted about 10% of the sampled specimen (ICES, 2007c). They were also mostly feeding on *C. finmarchicus*, further showing the importance of this prey in the ecosystem. The 2006 year class was also sampled in similar areas in 2008 based on national surveys, suggesting that immature mackerel are distributed over considerable areas, although we do not know yet how strong this year class is within the stock.

Norwegian spring spawning herring

Norwegian spring spawning herring are a highly migratory and straddling stock carrying out extensive migrations in the NE Atlantic. This applies to the wintering, spawning and feeding area. Juveniles and adults of this stock form an important part of the ecosystems in the Barents Sea, the Norwegian Sea, and the Norwegian coast. Herring has an important role as food resource to higher trophic levels (e.g. cod, seabirds, and marine mammals). Recent changes in the herring migration have led to an increased proportion of the population feeding in Faroese and Icelandic waters. The growth of these herring is faster than those feeding further east and north. The size of the feeding area is influenced by the stock size. Additionally, ocean climate and current systems are obvious candidates affecting the feeding area with more northerly migrations in warming periods. Other factors could be the entrance of large year classes of young herring from the Barents Sea into the Norwegian Sea and asymmetrical plankton concentrations throughout the potential feeding area. Herring (as with previous years) had a somewhat more southerly distribution in 2008 than in 2007. This south-westward shift in feeding migration and distribution continued in 2004 through 2006, and especially in 2007 the fishery continued in the south-western areas throughout the summer, leading to some speculations of a change in their late autumn migrations of parts of the adult stock (see Fernö *et al*. 1998; Nøttestad *et al*. 2004).

The inflow of Atlantic water into the Norwegian Sea and Barents Sea seems to influence the condition and hence fecundity of adult fish as well as the survival of larvae (Toresen and Østvedt , 2000, Fiksen and Slotte, 2002, Sætre *et al.*, 2002). Environmental conditions may also affect fish, which may result in reduced fecundity (Oskarson *et al.*, 2002). The strong year classes have occurred in periods of good condition and high temperatures.

Two main features of the circulation in the Norwegian Sea, where the herring stock is grazing, are the Norwegian Atlantic Current (NWAC) and the East Icelandic Current (EIC). The highest concentrations of herring in 2007 recorded at the eastern edge of the cold waters of the East Icelandic Current but slightly farther to the northeast compared to 2006 and 2007. The increased concentrations are reflected both in the surveys and through a significant fishery in the southwestern area during 2007. Most of the oldest herring fed in the southwestern area during 2008. About 40% of the abundant 2002 year class was found in this area. The plankton concentration during the May survey in the southwestern part of the ocean was consistently higher than further north and east. The herring feeding in this region have previously been shown to have a higher condition factor than the rest of the stock. It was mainly older herring that appeared in the southwestern areas (1998, 1999 and 2002 year classes now at ages 10, 9 and 6). As in previous years the smallest fish are found in the northeastern area. Size and age were found to increase to the west and south.

Herring overlapped spatially in distribution with mackerel in several parts of its distribution area in 2008, including the south-western and northern part of the distribution area, but was not present in the warmer southern part of the Atlantic water masses. This could have considerable consequences for fishing because of considerable spatiotemporal overlap and bycatch issues involved when fishing for herring as well as mackerel.

Blue whiting

Blue whiting has an important role in the pelagic ecosystems of the NE Atlantic, both by consuming zooplankton and small fish, and by providing a food resource for larger fish and marine mammals.

In the last 15 years large changes have occurred in stock size, and during the last few years the stock has decreased rapidly; not only in terms of spawning stock biomass: recruitment has also been weak and lower than expected. This signal is reflected in changes in large-scale hydrographic systems in the north Atlantic (the subpolar gyre, SPG). Changes in the strength of the SPG have been shown to coincide with the recent large changes observed in the blue whiting recruitment (Hátún *et al*., 2005). The strength of the SPG might affect the spawning distribution of the blue whiting as well as the main migration pattern into feeding areas in the north (see section 10.15.1 for a detailed discussion). In addition it might also influence the relative amounts of eggs and larvae drifting to northern and southern nursery areas; a certain spawning area may seed northern areas in one year and southern areas in another (Skogen *et al*., 1999).

The recent large inflow of warm Atlantic water to the Barents Sea had a positive effect on abundance of blue whiting in the Barents Sea one year later (Heino *et al*., 2003). The strength of year classes as 0-group in the North Sea is only weakly coupled to the strength of year classes in the main Atlantic stock. This suggests either local recruitment or variation in transportation of larvae into the North Sea.

Blue whiting condition has decreased quite substantially the last 15 years. There are several possible explanations for this overall negative trend.

- Lower plankton concentrations in general.
- Lower plankton concentrations in particular areas and times occupied by blue whiting – an unfortunate match in time and space.
- Intra- or interspecific competition – too many fish competing for the same food resource.

For a detailed discussion on these different hypotheses see section 10.15.2.

Horse Mackerel.

Horse mackerel is widely distributed on the continental shelf in the Northeast Atlantic and Mediterranean Sea. Horse mackerel is a schooling and migratory species that are adapted to swimming at a low but a very constant speed (Enders, 1998). Migration (spawning, feeding, over-wintering) is probably driven by water temperature and availability of prey. Their prey are mainly the different components of the zooplankton. Horse mackerel is a serial spawner probably with indeterminate fecundity. Apparently, the water temperature of 8º C is the lower limit for horse mackerel, which they avoid during over-wintering, and they stop feeding at water temperatures below 9ºC. Migrations are closely associated with the slope current, and horse mackerel migration is known to be modulated by temperature (Reid *et al*., 2001). Continued warming of the slope current is likely to affect the timing and the spatial extent of this migration. For North Sea horse mackerel 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.

Horse mackerel are a fairly long-lived species, reaching a maximum age of well over 30 years. Therefore, an occasional strong year class can lead to high abundance of horse mackerel (Abaunza *et al*., 2003). 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 in 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). A very deep distribution of horse mackerel from hydro-acoustic recordings and trawl data in the northern North Sea in October-December, partly resulted in reduced availability of horse mackerel to the fishing fleet, and catches within NEZ remained low in 2007.

The recruitment seems to be more dependant on environmental factors than on the size of the parental stock (at least when it is not depleted). The recruitment of horse mackerel in the southern areas (Iberian coasts) seems to be related to temperature variables and/or upwelling phenomena (Santos *et al*., 2001; Lavin *et al*., 2007). In this sense cooler waters seems to favour horse mackerel recruitment in southern areas (Lavin *et al*., 2007). More research is needed on how horse mackerel respond to environmental and ecosystem changes and variation within its distributional area.

Sardine

European sardine (*Sardina pilchardus*) is found from Mauritania and Senegal to the North Sea, being also present in the Black Sea. This wide geographical range implies that the species is able to sustain wide ranges of both temperature and salinity. Recent studies by Bernal (1998) have also shown a wide temperature tolerance (121–7C°) for sardine spawning habitat and distribution.

Sardine in the western Iberia area seem to have a more coastal distribution than sardine in the Bay of Biscay probably due to the narrower shelf found in the area. In the Bay of Biscay juveniles are found mainly concentrated all along the French coast mixed with anchovy and sprat in areas influenced by river plumes while adult sardine tend to be seen offshore in big schools at the surface.

Several studies have tried to find a relationship between selected environmental variables and sardine dynamics and in particular to try to explain its high recruitment variability (see section 8.6). As with any other pelagic species, recruitment is highly dependent on favourable environmental conditions (concentrations of egg/larvae in suitable areas) and several local and large scale variables that could be affecting this process have been explored (i.e. upwelling index and NAO). In general, environmental effects on the models tend to be weak and sometimes give contradictory results.

Sardine is a passive filter-feeder that is able to feed on a wide variety of prey (both by particle-feeding and filter-feeding) (e,g, Bode *et al*., 2004) which could buffer it against changes in prey supply.

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*) 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).

French and UK fleets fishing for sardine operate mainly in the Channel during winter. Data from the position of the fishing vessels indicate a progressive movement of the fleet southwards from the Channel at the beginning of the year towards southern Brittany and SW Cornwall. This movement could be related to sardine movement but more data are needed to confirm this pattern.

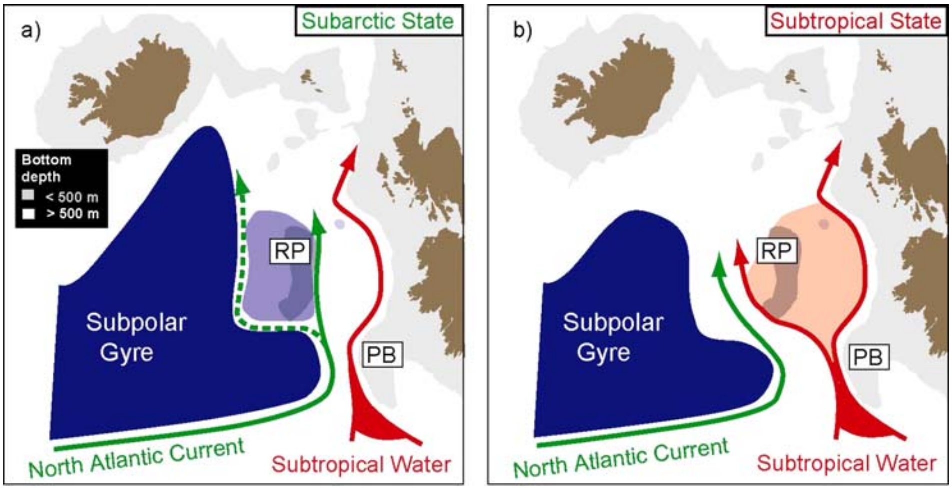

Figure 3 Outline of the source flows to the blue whiting spawning grounds in the Rockall Region. (a) A strong subpolar gyre (SPG) results in strong influence of cold subarctic water near the Rockall Plateau. (b) A weak gyre results in warm subtropical dominance near the plateau (based on Hátún et al., 2005). AbbreviationsR–P: Rockall Plateau and PB: Porcupine Bank.

2 Northeast Atlantic Mackerel

2.1 ICES advice applicable to 2007 and 2008

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, Va, 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 2007 and 2008, as well as the WG catch estimate for 2007 are given in the text table below.

Agreement	Areas and Divisions	TAC in 2007	TAC in 2008	Stock compo-nents	ACFM advice 2007	ACFM advice 2008	Areas used for allocations	Prediction basis	WG catch in 2007
Coastal states agreement (EU, Faroes, Norway)	IIa, IIIa, IV, Vb, VI, VII, VIII, XII, XIV	422,551	385,366	North Sea	Lowest possible level	Lowest possible level	IIa, IIIa, IV, Va, b, VI, VII, VIIIa,b,d,e, XII, XIV	Northern	518,645
NEAFC agreement	International waters of IIa, IV, Va, b, VI, VII, XII, XIV	47,838	43,629	Western	Reduce F in the range 0.15 – 0.20	Reduce F in the range 0.15 – 0.20			
EU-NO agreement[1)]	IIIa, IVa,b	1,865	1,865						
EU autono-mous[2)]	VIIIc, IXa	29,611	27,005	Southern			VIIIc, IXa	Southern[3)]	62,834
Total		501,865	457,865		390–509	349–456			581,479

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 2008 this figure was 14,043.5 tonnes and this amount of mackerel should be withdrawn from their national quotas in 2008. Thus, to arrive at an expected amount of mackerel in 2008 it is necessary to take the total TAC (457,865 tonnes) adding the estimated discards (8,616 tonnes, Table 2.2.1.1.) and subtracting the UK/Ireland payback (14,043.5 tonnes), giving an expected catch in 2007 of 448,259 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 (3,000 t) 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 20 cm 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 2007

2.2.1 Catch Estimates

The total estimated working group catch for NEA Mackerel in 2007 was 579,379t, an increase of 106,727t over the 2006 figure and the largest catch since 2004. The TAC for 2007 was set at 501,865t resulting in an overshoot of approximately 77,500t. The combined fishable TAC as best ascertained by the Working Group (section 2.1) agreed for 2008 amounts to 457,865t. Of this TAC, the UK and Ireland have agreed not to fish 18,222t.

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 sections 1.3.4 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]
Denmark	Y (landings)	Y (sale slips)	
Faroe[1]	Y (catches)	Y (coast guard)	
France	Y (landings)		
Germany	Y (landings)		Y
Iceland	Y (landings)		
Ireland	Y (landings)		
Netherlands	Y (landings)	Y	Y
Norway[1]	Y (catches)		
Portugal		Y (sale slips)	
Russia[1]	Y (catches)		
Spain		Y	
Sweden	Y (landings)		
UK	Y (landings)	Y	Y

[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 landings 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 recorded landings 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 landings 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.

Catches in the Norwegian Sea and area V were 72,882t (see Table 2.2.1.2) and were higher than the previous year (46,716t). The catches from area Va, first noted in last years report, have increased further, as have those taken in area IIa, primarily due to increased exploitation of the stock by Icelandic vessels. Norwegian catches have declined to a minimal level and Russian catches remain at a similar level.

The time series of catches by country recorded from the North Sea, Skagerrak and Kattegat (Subarea IV and Division IIIa) is given in Table 2.2.1.3. Catches in 2007 amounted to 259,199t, a substantial increase (52,888t) over the 2006 figure. This reverses the trend of reducing catches in this area since 2002. Previous to this, the trend had been for increasing catches (since 1996). No misreporting of catches taken in this area into VIa (or any other area) is reported. In previous years substantial but decreasing misreporting from this area had been reported to the Working Group. The reported discards are similar to previous years.

The catch taken in the western area (Subarea VI, VII and Divisions VIIIa,b,d,e) is given in table 2.2.1.4 and increased by 17,579t to 184,452t. The trend is similar to that reported for the North Sea where a recent decline in catches since 2000 has been reversed.

Catches in divisions VIIIc and IXa (Table 2.2.1.5) have continued to increase and are now over 62,000t, the highest presented in the table. 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. Catches in VIIIc and IXa continue to substantially exceed 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
2007	34	5	21	40

These catches are shown per statistical rectangle in Figures 2.4.1.1 to 2.4.1.4. and are discussed in more detail in Section 2.4.1. 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, 34% was taken during the 1st quarter as the shoals migrated 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 increased slightly to 21% (from 18% in 2005). A further 5% drop for quarter 1, means that there is a further increase in the proportion of the total catch taken in the fourth quarter such that it is now the quarter with the largest proportion of the total catch. This was last the case in the early 1990s.

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. These estimates are not necessarily identical with the official landings statistics because they may include estimates of unreported landings and corrections for misallocation of catches by area and species.

The main mackerel catching countries (more than 25,000t) in recent years continue to be Scotland, Norway, Spain, Ireland, the Netherlands, Denmark and Russia. Icelandic catches now also contribute a significant amount to the total. England & Wales, the Faroe Islands, France, Germany, Northern Ireland, Portugal and Sweden all have catches over 1,000t (combined catch 78,000t).

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 Subarea IV, mainly because of the very high prices paid for larger mackerel (>600g) 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. Anecdotal evidence from the fleet suggests that since 1994, discarding/slipping 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. Data provided for discarding by the Dutch fleet operating in this fishery has been included in the WG catch estimates (see table 2.2.1.1).

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 2007 discard data for mackerel were provided by three nations: Scotland, the Netherlands and Germany. Total discards amount to approximately 8,000t from the three nations, a drop on the previously reported figure (18,000t).

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 from the fishery in divisions IVa in the first and fourth quarters, VIa in the first quarter and VIIb in the first quarter. For the samples taken from areas VIa and VIIb (Q1) , 80% of the discarded fish were accounted for by 4–7 year olds. For area IVa in the fourth quarter 80% of the discards were 5 years old or younger. Discards in the first quarter for area IVa are more evenly distributed throughout the ages range (80% by age 9). It should be noted that these results are from a limited (1–2) number of samples for each area/quarter. The percentage length compositions of the Scottish discards for all areas with samples are shown in Table 2.4.4.2.

2.2.3 Fleet Composition in 2007

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

In the Norwegian Sea (Subarea II) catches are taken by Russian freezer trawlers (55–80 m) that target mackerel, blue whiting and herring at the same time and Icelandic vessels targeting herring.

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

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

2.3 Stock description and management units NS, Western Southern

ICES currently uses the term North East Atlantic Mackerel to define the mackerel present in the area extending from ICES Division IXa in the south to Division IIa in the north, including mackerel in the North Sea and Division IIIa. The spawning areas of mackerel are widely spread, and only the stock in the North Sea is sufficiently distinct to be clearly identified as a separate spawning component. Tagging experiments have demonstrated that after spawning, fish from Southern and Western areas migrate to feed in the Norwegian Sea and the North Sea during the second half of the year. In the North Sea they mix with the North Sea component. Since it is currently impossible to allocate catches to the stocks previously considered by ICES, they are at present, for practical reasons, considered as one stock: the North East Atlantic Mackerel Stock. Catches cannot be allocated specifically to spawning area components on biological grounds, but by convention the catches from the Southern and Western components are separated according to the area in which they are taken. In order to be able to keep track of the development of the spawning biomasses in the different spawning areas, the North East Atlantic mackerel stock is divided into three area components: the Western Spawning Component, the North Sea Spawning Component, and the Southern Spawning Component:

Northeast Atlantic Mackerel			
Distributed and fished in ICES Subareas and Divisions IIa, IIIa, IV, Vb, VI, VII, VIII, and IXa.			
Spawning component	Western	Southern	North Sea
Spawning Areas	**VI, VII, VIIIa,b,d,e.**	**VIIIc, IXa.**	**IV, IIIa.**

The Western Component is defined as mackerel spawning in the western area (ICES Divisions and Subareas VI, VII, and VIII a,b,d,e). This component currently comprises 76% of the entire North East Atlantic stock. Similarly, the Southern Component is defined as mackerel spawning in the southern area (ICES Divisions VIIIc and IXa). Although the North Sea component has been at an extremely low level since the early 1970s, ACFM regards the North Sea Component as still existing. This component spawns in the North Sea and Skagerrak (ICES Subarea IV and Division IIIa). Current knowledge of the state of the spawning components is summarized below.

Western Component: The catches of this component were low in the 1960s, but increased to more than 800 000 t in 1993. The main catches are taken in directed fisheries by purse-seiners and mid-water trawlers. Large catches of the western component are taken in the northern North Sea and in the Norwegian Sea. The 1996 catch was reduced by about 200 000 t compared with 1995, because of a reduction in the TAC. The catches since 1998 have been stable. The SSB of the Western Component declined in the 1970s from above 3.0 million t to 2.2 million t in 1994, but was estimated to have increased to 2.7 million t in 1999. A separate assessment for this stock component is no longer required, as a recent extension of the time-series of NEA mackerel data now allows the estimation of the mean recruitment from 1972 onwards. Estimates of the spawning-stock biomass, derived from egg surveys, indicate a decrease of 14% between 1998 and 2001 and a 6% decrease from 2001 to the 2004 survey and a 5% increase from 2004 to 2007.

North Sea Component: Very large catches were taken in the 1960s in the purse-seine fishery, reaching a maximum of about 1 million t in 1967. The component subsequently collapsed and catches declined to less than 100 000 t in the late 1970s. Catches during the last five years have been assumed to be about 10 000 t. The 2002, 2005 and 2008 egg surveys in the North Sea with limited spatial and temporal coverage indicate a higher egg production in the North Sea area than in 1999. Though the North Sea spawning component has increased since 1999, it is still small.

Southern Component: Mackerel is a target species for the hand line fleet during the spawning season in Division VIIIc, during which about one-third of the total catches are taken. It is taken as a bycatch in other fleets. The highest catches (87%) from the Southern Component are taken in the first half of the year, mainly from Division VIIIc, and consist of adult fish. In the second half of the year catches consist of juveniles and are mainly taken in Division IXa. Catches from the Southern Component increased from about 20 000 t in the early 1990s to 44 000 t in 1998, and were close to 50 000 t in 2002. Estimates of the spawning-stock biomass, derived from egg surveys, indicate a decrease of about 50% between 1998 and 2001. However, the SSB estimated in 2001 is similar to the survey estimates in 1995. The SSB estimated in 2004 showed a decrease of 36% over the 2001 survey, and the results from the 2007 survey indicate a 137% increase in biomass compared to 2004.

2.4 Data available

In this section the data available to the assessment are outlined. An overview is given in sections 2.4.1. – 2.4.3. This includes catch data (section 2.4.1) catch per unit effort data (section 2.4.2) and survey data, including the most recent egg survey data (sections 2.4.3.1 and 2.4.3.2). A brief description of recent analysis of and conclusions relating to mackerel recruit series is given in section 2.4.3.4.

Sections 2.4.3.5. and 2.4.3.6. cover data and analysis relating to acoustic surveys to do with NEA mackerel. The ecosystem survey in the Norwegian Sea is described in section 2.4.3.6.

Length composition of catch is outlined in section 2.4.4. Available data on weights at age and maturity at age are indicated in sections 2.4.5. and 2.4.6 respectively. A description of tagging mortality estimates and available data is given in section 2.4.7.

2.4.1 Catch data

The 2007 catches in number-at-age by quarter and area are given in table 2.4.1.1. This catch in numbers relates to a tonnage of 579,379t which is the working group estimate for total catches from the stock in 2007. These figures have been added to the catch-at-age assessment input table (see table 2.7.1.1).

Age distributions of commercial catches were provided by Denmark, England and Wales, Germany, Iceland, Ireland, the Netherlands, Norway, Portugal, Russia, Scotland and Spain. There remain gaps in the age sampling of catches, notably France (20,038t), Northern Ireland (5,545t) and Sweden (3,858t) who, in 2007, have a combined catch of over 29,000t. In addition, England and Wales sampled the handline fishery in areas VIIe and VIIf (which accounted for 6% of their reported catches). Areas with low sampling include IIIa, VIIc, VIIk, VIIIa and VIIId and account for a catch of almost 10,000t. Catches for which there were no sampling data were converted into numbers-at-age using data from the most appropriate fleets. The sampling coverage is further discussed in section 1.3.

The percentage catch numbers-at-age by area are given in table 2.4.1.2. The strong 2002 year class continues to contribute the most of any single year class to the catches (35%-45%) in the most heavily exploited areas. In total, it represents 29% of the total catch by age (reduced from 34% as 4 year olds in 2006). Areas where this is not the case include VIId,e,f and g where young mackerel (1 and 2 year olds), taken as a by-catch in the directed juvenile horse mackerel fishery and account for over 50% of the percentage by numbers.

In areas VIIIc W and IXa, the catch is also dominated by juvenile fish, although the very high proportion of age 0 fish (69% in area IXaN) seen in 2006 data is reduced in 2007 with similar percentages for ages 0,1 and 2.

Distribution of Commercial Catches in 2007

The distribution of the NEA Mackerel catches taken in 2007 is shown by quarter and statistical rectangle in Figures 2.4.1.1 – 4. These data are based on catches reported by Denmark, the Faroe Islands, Germany, Ireland, Iceland, the Netherlands, Norway, Poland, Portugal, Russia, Spain, Sweden and the UK countries. The Spanish data are not based on official data and not all catches included in these data are official. The total catches reported by rectangle were approximately 541,000t including Spanish WG data. The total working group catches were 579,377t. This year, the bulk of the catch not recorded by statistical rectangle was from France.

First Quarter 2007 (196,623t–34%)

The distribution of catches in quarter 1 is shown in Figure 2.4.1.1. The tonnage and distrubution remains close to that reported last year with the majority of catches taken along the shelf edge from the Celtic Sea up to the Shetland Isles.

Second Quarter 2007 (30,000t–5%)

The distribution of catches in the second quarter is shown in Figure 2.4.1.2. Catches in this quarter remain at 5% of the total catch. Most of the catches in this quarter continue to be taken along the North Iberian coast although there are some increases evident in Divisions VIIj and VIa.

Third Quarter 2007 (122,658t–21%)

The third quarter distribution of catches is shown in Figure 2.4.1.3. While catch levels in this quarter have increased slightly (from 18%), there has been a significant change in their distribution with large catches taken in Icelandic waters and increased catches north of 70º and in the Skagerrak and Kattegat .

Fourth Quarter 2007 (230,096t–40%)

The fourth quarter distribution of catches is shown in Figure 2.4.1.4. Catches in this quarter have continued to increase significantly with the 2007 figure 50,000t greater than that for 2006. Quarter 4 now accounts for 40% of the total catch, the first time this quarter has recorded the largest catch since 1994. The distribution remains similar with the great majority of the catch taken between the Shetland Isles and Southern Norway. Icelandic catches and others north of 62º seen in quarter 3 are not seen in this quarter. Continuing the trend reported last year, Norwegian catches in Division IVa have further increased and were reported as approximately 108,000t (up from 84,000t), while quarter 3 catches decreased from 27,000t to 21,000t. Although still significant, catches on the west coast of Ireland and north of Scotland are reduced as have those from the north-eastern Iberian coast.

2.4.2 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. They are not considered as indicative of trends of the population as a whole and therefore are not used in the assessment.

Table 2.4.2.1 and Figure 2.4.2.1 show the fishing effort data from Spanish and Portuguese commercial fleets. The table includes, among other fleets, the Spanish effort of the hand-line fleets from Santoña and Santander (Subdivision VIIIc East) for which mackerel is the target species from March to May. The effort of the Avilés 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 (Subdivision IXa North) 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 due to the catastrophe of the *Prestige* oil spill. The effort series of the hand-line fleet showed an increasing effort 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 fishing effort from the trawl fleet (Subdivision IXa Central-North, Central-South and South) during 1988–2001 is also included and, as occurs in Spain, mackerel is a by catch. The effort for this fleet varied between the lowest value, 38,719 fishing hours (1994), and the highest one, 86,020 fishing hours in 1998. Since 2002 the effort data has not been available.

Figure 2.4.2.2 and Table 2.4.2.2 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. Since 2005, the CPUEs of the handline fleets show the highest values of the two series. The CPUE of the trawl fleets also presents an increasing general trend. The CPUE series for the Avilés trawl fleet is not very 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 but decreasing greatly in 2007. 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 whereas from 1996 to 2002 an increasing trend is observed. 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 handline and trawl fleets is shown in Table 2.4.2.3.

2.4.3 Survey Data

2.4.3.1 Results form the 2008 mackerel egg survey in the North Sea

During the period 2 June-4 July 2008 Netherlands and Norway carried out an egg survey in the North Sea to estimate the mackerel egg production and SSB. During this period the spawning area was covered four times. The last time the North Sea was surveyed was in 2005. The data were collected and handled according to ICES (2005 d). R/V "Tridens" and R/V "Håkon Mosby" carried out the survey with a Gulf 7 working in double oblique hauls from the surface to 5 m above the bottom or 20 m below the thermocline. The timing and the results of the surveys are given in Table 2.4.3.1. 1. Due to technical problems and bad weather "Håkon Mosby" did not operate during period two.

The eggs were sorted from each of the sampled stations. The age of stage 1A and 1B mackerel eggs were estimated according to the observed temperature in 5 m and the formula given in Lockwood et.al.(1981) and the number of eggs produced/day/m^2 was calculated for each statistical rectangle of 0.5 ^{o} latitude * 0.5^{o} longitude (Figures 2.4.3.1.1–4). The samples were obtained in the middle of each of the rectangles. The egg production was calculated for the total investigated area for each of the periods (Table 2.4.3.1.1).

The surveys did not cover the total spawning area and period. The standard interpolation rules were applied and interpolated rectangles are shadowed in Figures 2.4.3.1.1–4. The interpolated egg production values accounted for 18%, 13% and 20% for periods one, three and four respectively. The main spawning still takes place in the south western area but the production is more abundant further north and east than in 2002 and 2005. Based on the three successful coverages the spawning curve was drawn (Figure 2.4.3.1.5). During the third period "Tridens" covered the same area as during period two. During the third period this area produced 48% of the egg production. The estimated egg production in the "Tridens" area during period two is raised accordingly the estimated production hits almost the straight line between period one and three (Figure 2.4.3.1.5). The four estimates are considered minimum estimates since the sampling was not carried until zero values were obtained in all directions. Particularly there are uncovered areas in the south western part of the area where the production values are quite high.

By integrating the egg production curve over the "standard spawning time", 17 May-27 July, the total egg production was estimated at $91*10^{12}$ eggs compared with $155*10^{12}$ in 2005. By applying the weight fecundity relationship, 1401 eggs/g/female (Adoff and Iversen, 1983) the SSB was estimated at 130,000 tons (Table 2.4.3.1.2). During the survey female mackerel were collected for fecundity purposes. Particularly "Håkon Mosby" had problems catching mackerel. Mainly small fish were caught and therefore probably do not reflect the length distribution in the SSB. Only 15 ovaries were in the right maturity stage. These ovaries have been analysed for potential fecundity but still not for atresia. The potential fecundity was about 50% lower than the standard one. Due to few data and that the caught mackerel might not reflect the actual composition of the SSB, the WG decided for the time being to apply the standard fecundity for estimating the SSB.

2.4.3.2 Western and Southern egg surveys.

The ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS) (ICES 2008) met in Ijmuiden on April 7–11, to analyse the data from the 2007 Mackerel and Horse Mackerel Egg Survey. This survey takes place triennially with the participation of Portugal, Spain, Scotland, Ireland, The Netherlands, Norway and Germany. The basis of the survey is to relate the number of freshly spawned eggs found in the water with the number of females having produced these eggs. Knowing the fecundity of the females provides an estimate for the spawning stock biomass. WGMEGS provided an estimate of SSB for the 2007 WGMHSA (ICES 2007c). This was based on an incomplete set of samples as the analysis could not be completed by the time of the working group. Since the large number of samples have now been analysed, the group met again to evaluate the results and to assess the size of the mackerel population in the Northeast Atlantic, the southern horse mackerel stock and the egg production of horse mackerel in the western stock. The results presented below are the revised estimates.

The analyses show that the **NEA mackerel stock** has increased by 504 700 t to a total of 3.26 mill. t (+18% relative to 2004). The spawning stock biomass estimate by components was:

a) 2,590 million tonnes (±787, 510 tonnes) for the western component. This can be compared to 2,468 million tonnes in 2004;

b) 667, 909 tonnes (±414,852 tonnes) for the southern component. This can be compared to 281,427 tonnes in 2004.

The increase in the SSB estimate for **NEA mackerel stock** was due to an increase in mackerel egg production coupled with only a small decrease in mackerel fecundity. The estimate of total egg production was $1.52*10^{15}$ which is an increase of $0.19*10^{15}$ (+14%) with respect to 2004. The total egg production estimate by component was:

a) $1.208*10^{15}$ (se = $0.105*10^{15}$) for the western component. This can be compared to $1.202*10^{15}$ in 2004;

b) $0.3119*10^{15}$ (se = $0.1709*10^{15}$) for the southern component. This can be compared to $0.126*10^{15}$ in 2004;

The analyses of potential fecundity gave a value of 1098 eggs/gr female for mackerel for the western and southern components combined. This represents a reduction of 29 eggs /g female when compared to the 2004 western component and an increase of 82 eggs /gr female when compared to the 2004 southern component. The overall prevalence of atresia as a percentage of the population was 38% and the relative intensity was 30 eggs per gram. This reduced the potential fecundity by 9% giving a realised fecundity of 1009 egg per g female.

In general the quality and reliability of the surveys were good. There was an increase in survey effort in 2007 compared to 2004, in spite of the lack of participation by England. This absence was mainly compensated by an additional survey carried out by Scotland and specific modifications in coverage carried out by several other countries. The adult sampling methodology was extended to all participants and the replication of the samples and its distribution between all the laboratories improved the reliability of the estimate.

As in 2003 the WG held egg identification and staging workshop prior to the surveys. This permitted a harmonisation of egg identification and realised fecundity in mackerel as well as spawning rate in horse mackerel across the participating institutes. Both activities led to an improvement in the quality of the estimate.

Even when the survey coverage was good the WG concluded that while the starting of the spawning event was fully covered for mackerel and horse mackerel, the surveys ended too early to adequately cover the end of spawning in the north for both mackerel and horse mackerel and in the southern area (south of 47°N) for horse mackerel.

2.4.3.3 Combined survey recruitment indices

The program RCT3 (Shepherd, 1997) which was available from ICES, was used to predict year class strength using four recruitment indices from NEA mackerel surveys 1985–2007. The program uses calibration regression to provide an estimate of predicted year class strength by using multiple time series of recruitment indices. The recruitment indices used from surveys carried out by from France, Ireland, Portugal, Scotland and Spain (quarter 4 surveys) and by Scotland (quarter 1 surveys). Data were available from Norway from the North Sea but were not used in this analysis. The recruitment indices were constructed from:

4th Quarter, age 0 mackerel from surveys 1985–2007

1st Quarter, age 1 mackerel from surveys 1985–2008

4th Quarter age 1 mackerel from surveys1985–2007

A combined index using data from 4th quarter, age 0 mackerel and 1st quarter, age 1 mackerel from surveys 1985–2007.

Various approaches were considered when using RCT3. These consisted of: a) allowing shrinkage of the estimates of year class strength towards the mean value for the time series; b) changing the range of the taper used by the program to estimate recruitment and c) not allowing shrinkage of year class strength estimates towards the mean.

All predicted recruitment values were compared graphically (Figure 2.4.3.3.1) with the calculated values from the VPA assessment (2008) and with the geometric mean of the recruitment time series from VPA (1972-two years before the assessment year).

Mackerel is a pelagic species, but the surveys used in this exercise were carried out with demersal trawl. The result is that recruitment data for NEA mackerel are noisy Hence, the conclusion of this exercise must unfortunately be that calibration regression may not, at present, provide a more sensible prediction of recruitment than the approach of using the geometric mean of the recruitment series from VPA.

2.4.3.4 Acoustic surveys in the North Sea

NEA mackerel has been measured acoustically by Norway in October-November in the Northern North Sea annually since 1999. The main commercial fishery is concentrated in this area during this season. The results of these surveys have been summarized in a Working Document by Korneliussen *et al*. presented to the PGAAM in May 2005 but were revised late 2005 (ICES 2006–MHSAWG report 2006) and 2007 (ICES 2007 – SGMAS report 2007).

The multi-frequency acoustic surveys combined with pelagic trawl sampling of mackerel have been applicable to collect data on the identification, regional distribution and aggregation of mackerel in the pre-spawning phase. However, based on data from 1999–2006 the uncertainty and variance in the calculated abundance estimation has unfortunately been too large to be able to implement these quantitative results into the assessment of the NEA mackerel. Acoustic surveys have not been used in the assessment primarily because 1) they do not cover the entire geographic range, 2) there are difficulties with the estimation of fish density, and 3) there could be species identification issues in some areas. The Institute of Marine Research (IMR) in Norway decided to end this time series on acoustic surveys on NEA mackerel in the North Sea from 2007, due to lack of reliable annual abundance estimates. IMR will put priority on further developing and improving the quantitative abundance estimation of mackerel, and aim to achieve reliable results from multi-frequency acoustic field experiments and mapping of mackerel. Future dedicated work on regional abundance estimation of mackerel as well as studies on distribution, migration, schooling dynamics and ecology will be concentrated during the extensive mackerel feeding period in summer in the Norwegian Sea.

2.4.3.5 Ecosystem survey in the Norwegian Sea

This is the sixth survey in the Norwegian Sea in summer concentrating on mackerel among other species. The cruise in 2008 was a joint effort, merging a pelagic ecosystem survey, concentrating on salmon, herring and mackerel and observations of whales (Holm et al. Cruise report 2008). One of the aims was to survey the distribution of the northerly range of mackerel distribution by acoustic recordings and biological sampling. The targeted area covers the southeast Greenland and the northeast Norwegian Sea. It covers the northernmost range of the NEA mackerel. Acoustic data were recorded with the ER60 software. Frequencies at 18, 38, 70, 120 and 200 kHz were logged. Only data at 38 kHz has so far been examined using the Large Scale Survey System (LSSS). The target species were mackerel, herring and blue whiting. All species caught were registered according to the IMR sampling protocol (number of fish, length, weight, total weight). Samples of mackerel otholiths were taken for age determinations. Sex and stomach fullness of mackerel were registered and stomachs of mackerel preserved for later analyses of content. Hydrographic data (temperature, depth, and conductivity/salinity) were collected at every station with a SAIV CTD sonde cast down to 500 m depth, and a thermosalinograph recording temperature, salinity and conductivity at 5 m depth every second along the cruise track. In July to early August, the sun remains above the horizon during the whole diurnal cycle at the latitudes surveyed.

The temperature (°C) distribution at 20 m depth shows a range from 6–11°C, providing feeding and migrating mackerel with relatively warm waters at these high latitudes (Figure 2.4.3.5.1). Mackerel were caught in 77% of the tows north to 75.18°N, but never in large quantities (Figure 2.4.3.5.2). The mean length of collected specimen was 37 cm (30–45 cm range) and mean weight was 482 grams. The migration and distribution of NEA mackerel during summer feeding in July-August have in recent years been documented to expand further to the north (Table 2.4.3.5.1). Within the last 5 years mackerel has moved 5 degrees latitude to the north, representing a distance of 550 km.

A take home message from this survey concerning mackerel is that the species expand further north in summer. We also see this pattern along the coast of Norway with a pronounced northern expansion. Relatively warm Atlantic water masses with favourable feeding conditions in high northern latitudes increase the possibilities for mackerel to rapidly distribute and adapt to new and formerly unknown territories for this species.

2.4.3.6 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.*, WD 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 echo sounder 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 echo traces 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 2008 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 2.4.3.6.1), and the highest concentrations are found in Division VIIIc (Table 2.4.3.6.1), coinciding with the main spawning ground in the Southern Area (ICES 2005). Mackerel abundance has varied considerably from 2001 to 2008, with higher values in 2002 and 2003 coinciding with a high abundance of juveniles (Table 2.4.3.6.2). 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 biomass estimated in 2008 (369,681 t) has increased at same level that in 2005. The fall in abundance and biomass registered in the last years (2005–2008), as Figure 2.4.3.7.2

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, the timing of the peak of catches has shifted forward in recent years (WD Punzón and Villamor, 2008) and this results pointing to the possibility that this shift may be due to a change in the timing of the spawning migration to the southern area of the NEA mackerel population. A forward shift in the timing of mackerel migration would mean that changes in the estimated abundance of this species by acoustic surveys would not be due to changes in its biomass, rather to changes in its migratory behaviour. This factor must be taken into account in future survey designs, in the use of indices deriving from them in the evaluation, and in the evaluation itself.

Also, as we see in biomass by length class distribution (Figure 2.4.3.6.3), years 2005–2008 show extremely low values. Biomass by age class (Figure 2.4.7.6.4) 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 could be examined if it fits as an independent index of the fishery. On the other hand, it may also be a 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.

2.4.4 Length Composition of Catch

The mean lengths-at-age in the catch per quarter and area for 2007 are given in Table 2.4.4.1. Sizes are similar to those presented for 2006 except for age 0 fish for which the mean length has increased by approximately 2 cm, reversing the decline in size noted in the 2006 dataset over previous years.

Length distributions of the 2007 catches were provided by Denmark, England and Wales, Iceland, Ireland, Germany, the Netherlands, Norway, Portugal, Russia, Scotland and Spain. The length distributions were available from most of the fishing fleets and account for approximately 90% of the catches. These distributions are only intended to give an indication of the size of mackerel caught by the various fleets and do not reflect seasonal variations, which occur in many of the landings. More detailed information on a quarterly basis is available for most of the fleets in the working group files. The length distributions by country and fleet for 2007 catches and discards are given in Table 2.4.4.2.

2.4.5 Weights at age in the catch and stock

The mean weights-at-age in the catch by quarter and area are given in Table 2.4.5.1. Weights have shown a slight increase for juvenile fish, especially for age 0 which has doubled, in accord with the increased mean length, noted in section 2.4.4.

The working group used stock weights based on mean weights-at-age from Dutch and Spanish commercial catch data collected in Divisions,VIa VIIj and VIIIb over the period March to May. For the 2007 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. Mean weights-at-age for the North Sea component are based on the sample catches collected by the Dutch from area IVa during 2nd quarter 2007. For the southern component, stock weights are based on samples taken in VIIIc and IXa in the 2nd 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	Catch	
0	-	-	-	0.000
1	0.083	0.060	0.077	0.064
2	0.172	0.179	0.129	0.169
3	0.229	0.228	0.210	0.224
4	0.262	0.271	0.308	0.278
5	0.313	0.301	0.338	0.309
6	0.369	0.355	0.393	0.363
7	-	0.438	0.443	0.439
8	0.510	0.447	0.439	0.448
9	-	0.500	0.491	0.498
10	-	0.525	0.483	0.517
11	-	0.545	0.528	0.542
12+	-	0.559	0.590	0.565
No of Samples	100	349	2028	
Weighting of stock	0.04	0.76	0.20	

2.4.6 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 components and the 2008 North Sea egg survey for the North Sea component. The weighting factors have changed from last year's working group due to the revision of the Western and Southern egg production estimates in 2008, and the new data from 2008 NS egg survey, 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	0.58
3	1.00	0.90	0.70	0.86
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	0.04	0.76	0.20	

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

2.4.7 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 deployed 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 2.4.7.1. The estimated for the late 1980s 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 1990s and a peak around 1999. For the years after 2000, the results are highly uncertain.

Data for one year mortalities *(y_j to y_i+1)* are presented here. No tags were deployed in 2005, therefore no estimates of the mortality for 2004 and 2005 could be provided. Estimates of mortality for 2006 to 2007 are still not possible, because of the requirement that tags are only included if they are recaptured at least one year after release (Skagen WD 2008).

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 not 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 Methods

In 2007 WGMHSA carried out a benchmark assessment and concluded that ICA (Patterson 1996) was a suitable assessment package for this stock. This model has been implemented in FLR and this was the formulation used in 2007. The assessment was also run in ICA to validate the new implementation. The model and setting are provided below in section 2.5.1.

The 2008 WG has received a request from NEAFC (see section 1.8.1). To answer this request a similar model formulation to that provided by ICA but with considerable additional flexibility was used. The model formulation is described in section 2.5.2.

2.5.1 FLICA assessment method

FLICA is an FLR (Kell 2007) implementation of the ICA program (Patterson 1996) and is separable method with tuning indices (See section 1.4). The final model fitted in 2008 was of the following form.

$$\sum_{a=0,y=1995}^{a=8,y=2007} \lambda_{ca} (\ln(\hat{C}_{a,y}) - \ln(C_{a,y}))^2 +$$
$$\sum_{y=1992}^{y=2007} \lambda_{mes} \cdot (\ln(q_{mes} . S\hat{S}B) - \ln(MES_y))^2$$

a,y	age (rings) and year
C	Catch at age (rings)
$\hat{C}$	Estimated catch at age (rings) in the separable model
$S\hat{S}B$	Estimated spawning stock size
MES	Mackerel Eggs Survey index (biomass index) triennialy
q_{mes}	catchability of mackerel egg survey.
λ ca	Weighting factor for catch independent of year
	$\lambda\ ca_0 = 0.01$
	$\lambda\ ca_1 = 0.1$
	$\lambda\ ca_{2-11} = 1.0$
λ mes	Weighting factor for MES $\lambda_{mes} = 10.0$

Implementation was using:

R2.4.1, FLICA 1.6. and R scripts developed to work with FLICA: FLICA v 5.30.r, FLICA diagnostics v 6.00.r, FLStock plot v 2.10.r, FLStocks plot v 2.20.r, Retro.func v 2.10.r, SSB v 2.00.r, Write.tbl v 6.10.r Write.FLstock v 3.08.r

2.5.2 Bayes method for evaluation of potential missing biomass and removals from the NEA mackerel population.

A WD (Simmonds WD2007) explored the potential magnitude of missing removals, this work was extended using updated data available to 2008 WGWIDE. The Bayes software WINBUGS (Spiegelhalter 2002 and 2003) was used to run a program (Table 2.5.2.1) written for this purpose. The model equations are similar to those used in ICA but with extensive additional flexibility. The data used were the assessment dataset as available at the beginning of the WG which differed negligible (<1%) from the final data set. Only the declared catches to for 2007 were very slightly amended. In addition tag data to 2007 giving estimated total mortality estimates was used to give total mortality up to 2003 (see section 2.4.7). Egg survey values were amended to take account of egg mortality using the values estimated by Portilla *et al* (2007). These values are used to back-calculate the number of eggs spawned using the durations at stage given in Mackerel Egg WG (ICES 2008). While the mean values of mortality and duration at stage are estimated, some uncertainty exists concerning the distributions of duration at stage 1. This parameter is required to estimate the correct mortality estimate and correction factor. Only the minimum values associated with the distribution are applied, so this method may still slightly underestimate the egg abundance.

Model formulation

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

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

σ_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

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

$\sigma_{MES,y}$ was estimated from bootstrap of survey estimates of egg abundance, egg mortality, fecundity and atresia, individually for each year (Simmonds *et al* 2003). Both value and variance are found to be different in different years and the variances were used as informative priors in the model.

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

$$\ln(C_{a,y}) = \ln(N_{a,y}F_{a,y} /(F_{a,y} + M\ )(1-\exp(-F_{a,y} - Q_m M)) / Q_c) + dnorm(0,\sigma_c)$$ σ_c is assumed to be independent of year and age and estimated in the model

3) Estimated total mortality at age from tags:-

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

σ_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, the value of σ_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 a reduced number of model variants chosen specifically to address NEAFC request. The following model variants and the equation changes are detailed below:

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

1) A constant catch multiplier Q_c

2) 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.

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

3) A damped random walk of Qc by year

$Q_{c,y} = \max(Q_{c,y-1}+\mathrm{Norm}(0,\sigma_r), 1)$ with σ_r constrained to 50% of a fitted free parameter

4) and a linear trend on M at age 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

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

The detailed results for the model convergence were presented in the working paper (WD 2007). Three chains were implemented to allow among and within chain comparisons and the same criteria described last year were used to ensure adequate convergence. 10000 samples were used for burn in and 25,000 per chain used to give numerical values for results.

2.5.3 Short term forecast and yield per recruit analysis

As in previous years the standard ICES method MFDP and MFYPR are used for short term forecast and yield per recruit analyses.

2.6 NEA Mackerel Reference points

2.7 Current Reference points from ICES advice 2007

	Type	Value	Technical basis
Precautionary approach	B_{lim}	no biological basis for defining Blim	
	B_{pa}	2.3 million t.	B_{loss} in Western stock raised by 15%: = 2.3 million t.
	F_{lim}	0.26, the fishing mortality estimated to lead to potential stock collapse 6	F_{loss} = 0.26.
	F_{pa}	0.17	F_{lim} * 0.65.

Unchanged since 1998.

An evaluation of reference points (Roel and Simmonds WD2008) was presented to the WG. The evaluation was carried out using the time-series of SSB and recruitment 1972–2003 from 2007 benchmark assessment The catch at older ages in 1972–1979 have a plus group that increases with age, and because of this ICES normally excludes SSB values from this period in its advice. However, the estimated recruitment time-series is not affected by catch at older ages in early years (Figure 2.6.1). Only the SSB estimate is affected and only for years 1972 to 1979. Bootstrap evaluation of estimates of recruitment and SSB (Figure 2.6.1) replacing the plusgroup with a plausible range of year-classes was carried out during the management plan review (ICES

2007). It can be seen in Figure 2.6.1 that the variability in SSB in the stock recruit relationship does not influence the evaluations of points of hockey-stick and as they are the only informative data for recruitment at higher biomass, to ignore this information would be inappropriate.

Limit points

Investigation using precautionary software (PaSoft, Cefas 1999) showed that there was no indications of reduced recruitment at biomasses above the lowest observed biomass of B_{loss} =1.67Mt. (Figure 2.6.2) and a segmented regression (Maxwell 2002) fits a point of inflection to the same biomass point (Figure 2.6.3). On this basis B_{lim} should take the value of B_{loss}.

Yield per recruit evaluations using B_{loss} and assuming historic mean recruitment give an estimate of F_{loss} = 0.42. (Figure 2.6.4). The value of F_{loss} is compatible with the proposed B_{lim} and on this basis F_{lim} should take the value of F_{loss} .

Precautionary reference points

Evaluations of precision of the assessment carried out during the management plan evaluations (ICES 2007) show that the precision of F estimated in the assessment has a CV of 36%. The ICES procedure for evaluating precautionary reference points from limit points uses a formula based on the CV (ICES 2001). This formula gives a factor of 0.55 and an estimate of Fpa =0.23.

A similar evaluation of precision of the SSB (29%) would result in Bpa = 2.69Mt, which exceeds the observed biomass during most of the period of the assessment of SSB (more reliable values since 1979). Due to the limited range of stock biomass and the precision of the assessment in the final year, it is therefore not possible to define both Blim and Bpa that lie within the observed range of biomass. Setting a Bpa outside the range of reliable observations is not thought to be appropriate. Given this situation it is proposed that Bpa should not be revised, until more information becomes available. Note that given Blim the existing Bpa = 2.3 Mt does not reflect the assessment uncertainty. Under these circumstances it is not recommended to use B_{pa} as a management target but rather to follow one of the precautionary options under the proposed management plan (See section 2.11),

Proposed Reference points

	Type	Value	Technical basis
Precautionary approach	Blim	1.67 Mt	Blim=Bloss, Biomass above which reduced recruitment has not been observed
	Bpa	2.3 million t.	Bloss in Western stock raised by 15%: = 2.3 million t.
	Flim	0.42 the fishing mortality estimated to lead to potential stock collapse	Flim =Floss
	Fpa	0.23	Flim * 0.55

Revised in 2008.(Bpa unchanged since 1998)

2.8 State of the stock

2.8.1 Final ICA Assessment

This is an update assessment with model and settings unchanged from the 2007 benchmark.

The assessment was carried out in FLR (Section 2.5.1) with ICA used for a quality check comparison. Table 2.7.1.1–6 shows the input data for the assessment. Control settings are the same as those used last year (Table 2.7.1.7–9), with the 12 year separable period moving one year forward to 1996–2007. The landings weights, maturities were updated by an additional year (2007). Note that detailed model selection was carried out in 2007; other aspects of uncertainty in the assessment of NEA mackerel are discussed in Section 2.9.1.

Table 2.7.1.10 summarises the assessment output.

Tables 2.7.1.11 and 2.7.1.12 show the estimated population numbers-at-age, and fishing mortality at age. Tables 2.7.1.13 gives the fitted selection pattern and Table 2.7.1.14, the predicted survey estimates. Diagnostics are shown in Table 2.7.1.15–17. The model estimated parameters are in Table 2.7.1.18. Figures 2.7.1.1 and 2.7.1.2 show fits to egg survey and catch respectively

Figure 2.7.1.3 shows the stock summary (catches from 1972 to 2007) the F(4–8) from 1977 to 2007, the recruitment from 1972–2007, and the SSB from 1980 to 2007), 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).

2.8.2 Bayesian analysis unaccounted mortality

2.8.3 Bayesian analysis unaccounted mortality

The flexible Bayes implementation of ICA described in Section 2.5.2 was used first in 2005 and again this year to estimate total biomass and multipliers on catch that would explain the estimated biomass. Three model options were used:

1) Fixed catch multiplier over all years

2) Simple linear trend in catch multiplier over all years

3) Annually varying catch multipliers based on a mean and a smoothed random walk, combined with natural mortality varying at age.

These models were first run with data from 2005. Since then

- Catches have been revised 2000 to 2004 by about +9% to account for estimated over quota taken by UK
- Catches have been extended with 3 years extra data 2005–2007
- A new egg survey value for 2007 has been included.
- Weights and maturities at age have been extended to 2007.
- Times for spawning and proportions of fishery have been updated according to the benchmark of 2007

The results for the three different assumptions are given in Figures 2.7.2.1–3. Estimated fishing mortality, SSB and catch multipliers are given for each model. The results for 2008 can be compared with those obtained 3 years earlier in 2005. There is a high level of consistency between results obtained now and in 2005. The F and SSB from the ICA assessment used for advice (Section 2.7.1) are also included in the plots.

Comparison between 2005 and 2008 estimates

Comparison of the estimates from the two analyses carried out three years apart suggest a robust estimate of biomass that is stable over the revision and addition of new data.

The mean and confidence intervals on the constant catch multiplier (Model 1) are indistinguishable with a mean of 2.4 and 95% intervals at 1.6 and 3.4.

Linear trends in unaccounted catch mortality from (Model 2), are largely unchanged between 2005 and 2008 (Figure 2.7.2.2c). There is no significant trend over the period.

The smoothed annual estimates (Model 3), are also very similar (Figure 2.7.2.3c). The absence of any significant longer term trends in the results from Model 3 indicate that the non significant results from Model 2 that indicate a positive trend may not be particularly applicable. Any important trend would also be shown by Model 3. There are only small differences between the estimates made using Model 3 in 2005 and those obtained now. Only Model 3 would be capable of showing difference in unaccounted mortality factors that are different in recent years. The new estimates only show major differences for 2003. Although data from 2000 have been revised (by +9%) to take account of underreporting in the UK. This might be expected to reduce the factor but only by 10%. It had been hoped that changes from 2001 would be picked up by the model. However, from 2004 and onwards there are no estimates of total mortality from tag data (see section 2.4.7), due to disruption to the data series. Loss of a single year of fish tagging results in loss of two years of mortality estimates (2004 and 2005) and results for 2006 are too preliminary to use. So the only possibility to pick up changes would be 2001 to 2003, of which only 2003 shows changes.

Comparison between ICA assessment and Bayesian estimates with unaccounted catch factors

The estimates of fishing mortality are largely unaffected by catch factors. The ICA assessment estimates long term mean F 4−8 as 0.25, this compares with the Bayesian estimate of 0.27 within an 95% interval of 0.19 to 0.35. Generally this good correspondence between methods supports the view that managing through the use of fishing mortalities or catch/biomass ratios is robust to uncertainties in unaccounted mortality.

Estimates of the magnitude (in tonnes) and precision of the unaccounted fishing mortality in the NEA mackerel fisheries suggest that, on average, total catch related removals are equivalent to between 1.6 and 3.4 times the catch, and the spawning stock biomass may on average be between 1.7 and 2.7 times the ICA virtual population estimate (mean = 2.1 times), giving a series mean SSB 1975 to 2007 of between 4.3 and 6.9Mt with an overall mean of 5.5Mt. Estimates of historic SSB and F are given in Figures 2 7.2.1−3. The additional sources of this mortality include:

- escapees from fishing that die, such as those that pass through the meshes and die
- discards, slippage and high-grading not included in the ICA assessment
- unreported catch throughout the timeseries

There is no basis for allocating the total quantities among these different sources. Because the additional catch cannot be partitioned amongst the various sources, the availability of this biomass to any fishery cannot be estimated. Currently the best estimates of availability of mackerel are given by the virtual population analysis provided by the ICA assessment in section 2.7.1.

It has not been possible to evaluate where any significant historical changes in this unaccounted mortality. This is primarily because the only data source that can provide this information is the tag mortality data. These data show a great deal of variability and fit only weakly to the population, providing a good estimate of long term mean mortality but no evidence of changes with time. In particular, the absence of tag data from 2004 onwards means that the four most recent years have no mortality data. In the absence of tag mortality estimates after 2003, mortality estimates are therefore based on the mean. The only signs of recent changes in unaccounted mortality, is a decline in the estimated factor for 2003.

2.9 NE Mackerel Catch predictions for 2008

Table 2.8.1 lists the input data for the short term predictions. With the exception of estimated catch for 2008 all procedures used this year follow those used in the benchmark of 2007. The ICA-estimated survivors ages 2 to 12+ in 1st of January 2008 in the assessment year are used as the starting populations in the prediction. The recruitment of age 0 (year class 2008) and the abundance at age 1 (year class 2007) are routinely revised.

Age 0–The geometric mean of the recruitments for the period 1972–2004, is used for the recruitment at age 0 for 2007 – 2009 in the predictions The value of 3836 million fish is used.

Age 1–As in previous years the WG has taken the abundance at age 1 to be the geometric mean recruitment at age 0 (3836 million fish) brought forward 1 year by the total mortality at age 0 in that year (see Table 2.7.12), this corresponds to 3281 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 is effectively the mean exploitation from 1995 to 2006 inclusive.

Maturity at age, weight at age in the catch and weight at age in the stock were all taken as 3 year average (years 2005–2007).

The catch in the intermediate year (2008) is taken as a TAC constraint, this is the standard practice for this stock, The catch is calculated from the agreed TAC modified by quota reduction due to EU COMMISSION REGULATION (EC) No 147/2007 plus an assumed amount of discards of 8,616 t (see Table 2.2.1.1), this part of the procedure conforms to that used last year (see Section 2.1). In addition two other sources of catch have been identified, an over catch of Coastal States agreement taken mostly in the southern area and additional catches taken by Iceland outside the Coastal States agreement. The detailed calculations for the short term forecast (STF) are provided in the text table below

	WG Estimates for STF 2007	Reported Catch for 2007	Estimated catch for STF 2008
Total of all areas TACs (NEAFC)	501,865		457,865
UK Ireland pay-back	-21,168.1		-18,222
Discards estimated from the preceding year	17,970	8,616	8,616
Estimated Catch assuming method used for STF in current year.	498,667		448,259
Icelandic catches*		36,706	108,484**
Catch reported by coastal states (EU Norway and Faeroes) over WG estimate for 2007		44,006# (8.8% of 498,667)	
WG estimates of total declared catch in 2007		579,379	
% Coastal states estimated over catch relative to WG estimated catch		8.8%##	8.8%##
Estimated over catch for 2008			43,088 (8.8% of 448,259)
Total Estimated Catch			599,831
Rounded catch used for STF			600,000

*** Icelandic catches have been zero or close to zero in preceding years.**

**** Preliminary catch for January to August 2008 reported from Icelandic Fisheries Directorate.**

 # Difference between reported catch in 2007 and WG estimate of 2007 catch (EU, Norway, Faeroes) + 2007 Icelandic catch

The percentage of the catch underestimated relative to forecast in 2007 and assumed as the underestimate in 2008.

Short Term Predictions were calculated by the MFDP program. A detailed single fleet management option table is presented: Table 2.8.2 with *catch constraint* fishing (Catch = 600kt) in 2008 Table 2.8.3 provides multi option for 2008 to give a range of F options from 0.0 up to 0.30. Given the uncertainty in the recorded historic catch (Section 2.7.1), the most appropriate advice may not be the exact level of TAC. Therefore, advice is given 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.

Table 2.8.4−2.8.6 give catch options for 2008 for the range of optimum management rules shown in Tables 2.11.1- 2.11.3 respectively.

Figure 2.8.1 shows the results of yield per recruit and short term forecast.

2.10 Uncertainties in assessment and forecast

2.10.1 Uncertainties in assessment

Analytical retrospective plots (Figure 2.9.1.) show fairly consistent stock trajectories. There is some revision associated with each new triennial egg survey, with periods of stability between surveys.

The validation check between FLICA and ICA indicated that there was no difference between model fit obtained by either FLR or ICA.

FLICA was used to investigate the precision of the assessment, using the parametric bootstrap (Figure 2.9.2). The 95% on SSB and F are estimated as 2.37 and 2.81 Mt and F=0.21 and 0.31 respectively.

Initial estimates of recruitment are uncertain for the 2006 and 2007 year-classes. Although the recruit surveys may give some information on recruitment, recent investigations (Section 2.4.3.4.) indicated that the recruitment indices for series 1985–2006 predict recruitment with no more certainty than by using the approach of calculating the geometric mean of the recruitment series.

Evaluations of unaccounted mortality (section 2.5.2 and 2.7.2) show substantial uncertainty in total biomass. It has not been possible to identify the separate sources of these differences or to determine historic changes (Section 2.7.2) and it is considered that the VPA type analysis used in the current assessment is the best method for establishing available biomass for the fishery.

- The main conclusions on the quality of assessments are:
- The terminal values of SSB and F are sensitive to the last egg survey value.
- Initial estimates of recent recruits are uncertain.

F estimates are thought to be less biased than SSB under the assumption of constant unaccounted mortality.

The WG considers the current use of the FLICA 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. FLR appears to be a useful tool for carrying out the assessment and forecast.

2.10.2 Uncertainties in forecast

Deterministic forecasts are presented in section 2.8. The uncertainty in the input parameters of the population at 1st January 2008 are discussed above. However, the forecast relies on estimation of catches in 2008. There is increased uncertainty in the prediction of these catches over previous years. There are additional catches of mackerel in Icelandic waters in 2008 that exceed previously observed catches (See section 2.1, 2.3 and 2.8). Preliminary estimates of catches from January to August 2008 reported from Icelandic waters contribute 16% of estimated total for 2008 and there may be further catches in the remainder of the year. In addition catches reported to the WG from the TAC area have exceeded agreed catches by 8.8% in 2007. These are taken into account in the short term forecast presented in section 2.8. However, the values of catch used for both Icelandic waters and TAC overshoot are subject to some uncertainty.

2.11 Comparison with previous assessment and forecast

The addition of a new year of catch data and the +12% revision of the egg survey index value for 2007 have revised the perception of the stock in 2006 from the 2007 to the new 2008 assessment presented in this report. Changes in the TSB, SSB and F4–8 for the year 2006 between theses two assessments are presented in the table below. Comparison of the perception of the stock in 2006 from assessments conducted either with ICA or with FLICA are also presented in this table as a verification of the model code.

Using FLICA instead of ICA results in a very small difference in the perception of TSB, SSB and F4−8 in 2006 (less than 1%, except for F4−8 from the 2007 assessment where the change in F4−8 is -1.7%).

The update of the egg survey index for 2007 changes the perception of the stock compared to the 2007 assessment using the previous survey index, with a 9.5% increase for TSB, 8.9% increase for SSB and a 10.2% decrease for the fishing mortality.

The perception of the stock from the 2008 assessment which includes a new year of catch data is also substantially revised compared to the 2007 assessment, with a 20.3% and a 16% increase in the 2006 TSB and SSB respectively, and a 18.7% decrease in fishing mortality.

	TSB (2006)	SSB (2006)	F 4−8 (2006)
2007 Assess (ICA)	2915510	2231941	0.258
2007 Assessment (FLICA)	2937010	2250514	0.254
2007 Assessment amended egg survey (FLICA)	3193289	2431515	0.232
2008 Assessment (FLICA)	3508577	2591238	0.208
2008 ICA	3508625	2589260	0.210

Comparison		Percentage difference	
FLICA (2007) with 2007 Assessment (ICA)	0.7%	0.8%	-1.7%
2008 Assessment (FLICA) with 2008 ICA	0.0%	0.1%	-0.9%
FLICA NEW EGG 2007 with ICA 2007	9.5%	8.9%	-10.2%
2008 Assessment (FLICA) and 2007 Assessment (ICA)	20.3%	16.0%	-18.7%

The estimate of SSB for 2007 from the new 2008 assessment is 16% higher than the value predicted in the short term forecast from the 2007 assessment (table below). The fishing mortality F 4−8 for 2007 estimated this year is 7.6% lower than the value predicted in the 2007 short term forecast.

	SSB (2007)	F 4−8 (2007)
Forecast from 2007 assessment	2231466	0.227
Estimate from 2008 assessment	2589260	0.210
% difference	16.0%	-7.6%

Comparison of the fit of the model to the catch data between the 2007 assessment and the 2008 assessment is shown on Figure 2.10.1. The log residuals of the catch for the separable period from the 2008 assessment are fairly similar to those from last year's assessment. Residuals values are slightly higher this year, but are still low values. The selection patterns are also very similar except for a slight increase in the selectivity for ages 7 and 8.

The fit of the model to the egg survey index from this year's assessment only shows small differences with last year's assessment (Figure 2.10.2). Changes in the egg survey change the terminal value of SSB in the assessment directly as the model fits very flexibly to the last value in the egg survey time-series. Relatively high residuals are observed for both the 1995 and 1998 survey values. For the other years, the 2008 assessment tends to show residuals of the same sign than the 2007 assessment but with low values.

2.12 Management plans and evaluations

During 2007 and 2008 ICES provided a report on NEA mackerel long-term management (ICES 2008). The content of the study was developed through a request from the European Commission and a series of meetings with representatives of Pelagic Regional Advisory Council (PRAC). The report was used by ICES to give advice in June 2008, which was presented to the PRAC in July 2008. Following this a request was made by the PRAC to provide information on tradeoffs between different management criteria, particularly concentrating on average catch, inter-annual change in catch and proportion of older fish. More runs were carried out with the software HCM with the same model conditioning and setting used to give ICES advice. These were used to give more detail in the region of greatest interest. The information on the methods used are given in (ICES 2008). The extended results are provided here.

2.12.1 Harvest Control Rules

2.12.1.1 F-rule proposed by the EU Commission

This rule sets the TAC according to an F-value that is derived as follows:

If SSB > B_{trig} (parameter B), F= F_{targ} (parameter A), but TAC in year y shall at most deviate by C% from the TAC in year y-1.

If SSB < B_{trig}, the F is set at F= F_{targ} *SSB/ B_{trig}, and the constraint on TAC change does not apply.

Points of interpretation.

4) The action below B_{trig} is a simplification of the request, which required rebuilding to above B_{trig} within an unspecified time.

5) The SSB that is used for decision was the SSB projected through the intermediate year and into the TAC year.

The rule was tested with and without the option to apply the TAC constraint only at SSB > B_{trig} or always.

Fixed TAC rule

This is a rule where the TAC is set as a function of the SSB and the TAC in the year before the TAC year. The rule has 3 parameters, C_{target}, B_{trig}, and $C_{constraint}$. It has the following form, where SSB always is the estimated SSB in the year before the TAC year:

If SSB > B_{trig}, TAC = C_{target}

If SSB < B_{trig}, TAC = C_{target}*SSB/ B_{trig}

If

abs{(TAC(y-1)-TAC(y))/TAC(y-1)} > $C_{constraint}$

and (optionally) SSB > B_{trig}

TAC(y)= TAC(y-1)*(1+$C_{constraint}$) if TAC(y)>TAC(y-1)

TAC(y)= TAC(y-1)*(1-$C_{constraint}$) if TAC(y)<TAC(y-1)

The rule was tested with and without the option to apply the TAC constraint only at SSB > B_{trig}.or always

Fixed Harvest Rate (HR) rule

This is another rule where the TAC is set as a function of the SSB and the TAC in the year before the TAC year. Basically, the TAC is set as a fraction (the HR) of the observed SSB. The rule has 3 parameters, HR_{target}, B_{trig}, and C constraint. It has the following form, where SSB always is the estimated SSB in the year before the TAC year:

If SSB > B_{trig}, TAC = HR_{target}*SSB

If SSB < B_{trig}, TAC = HR_{target}*SSB*SSB/B_{trig}

If

abs{(TAC(y-1)-TAC(y))/TAC(y-1)} > $C_{constraint}$

and (optionally) SSB > B_{trig}

then

TAC(y)= TAC(y-1)*(1+$C_{constraint}$) if TAC(y)>TAC(y-1)

TAC(y)= TAC(y-1)*(1-$C_{constraint}$) if TAC(y)<TAC(y-1)

The rule was tested with and without the option to apply the TAC constraint only at SSB > B_{trig}.or always.

2.12.2 Results of evaluations

Figure 2.11.1 compares the mean catch and mean inter-annual change in catch for all strategies tested. The upper panel shows the results for strategies with a constraint on inter-annual % change in TAC applied only above B_{trig}. The lower panel shows the results for strategies with a constraint on inter-annual % change in TAC applied always. The small dots show strategies that ICES considers are not precautionary. The optimal strategies are those with lowest inter-annual variability in catch and highest mean catch. These are found as the large dots to the right and lower part of the plots. These selected optimum strategies are shown as lines in Figure 2.11.2, and the details of these strategies are presented in Tables 2.11.1–3. The tables are organised to show only these optimal strategies with increasing mean catch and increasing inter-annual variability in catch down the table. Table 2.11.1 gives strategies with a constraint on inter-annual % change in TAC applied always. These strategies tend to use lower exploitation rates with than those in Table 2.11.2 where the constraint on inter-annual % change in TAC is applied only above B_{trig}. Only the very highest catch strategy in the last line of Table 2.11.2 gives a higher catch than those given in Table 2.11.1, which therefore contains the best options overall against these two main criteria. Table 2.11.3 contains strategies using the EU commissions F rule, which generally give higher variability for same mean catch than the strategies shown in Tables 2.11.1 and 2.11.2.

Figure 2.11.3 and 2.11.4 illustrate twenty 21year TAC trajectories of each of three possible options that could result from strategies given in Table 2.11.1 and 2.11.2 respectively. Figure 2.11.3 shows strategies with the constraint on inter-annual % change in TAC applied always. TAC trajectories chosen are for strategies that give mean catches of 575, 611 and 634kt. respectively. The first two are constant TAC strategies showing an upper level which is the constant TAC of 570 and 690 respectively, the TAC is reduced periodically as SSB falls below B_{trig}. The third panel of 2.11.3 shows an HR strategy with a constraint on inter-annual % change in TAC applied always. For comparison Figure 2.11.4 shows three similar options with TAC trajectories for strategies that give mean catches of similar amounts with a constraint on inter-annual % change in TAC applied only above B_{trig}. Again the first two are constant TAC strategies showing an upper level which is the constant TAC of 580 and 630 respectively. The third panel is an HR strategy. Note particularly for these strategies that periodically the TAC is reduced sharply as SSB falls below B_{trig}. The reductions in TAC are sometimes substantial.

The strategies that keep the % constraint on TAC always do so by reducing the target exploitation slightly keeping more stock in reserve reducing the need to make sever reductions in TAC and keeping the average exploitation rate lower, except when the stock declines below B_{trig}. However, these slightly lower exploitation regimes give similar overall mean catch. They work because the TAC is reduced more slowly, but exploitation rates are lower to start with and the risk of SSB falling below B_{lim} is the same as for the other strategies.

2.13 Management Considerations

The spawning stock biomass (SSB) has risen from a low of 1.7Mt in 2002 and is now estimated to be around 2.5 Mt in 2007, similar to the level seen in the 1990s. Short term projections assuming a catch of 600,000 t in 2008 (see section 2.8) will give an SSB of 2.8Mt in 2008, which is similar to levels seen in the late 1970s. This increase is due to the following: a) increased contributions to SSB from the relatively good 2004 and 2005 year classes; and b) increased survival of the large 2002 year class due to a general reduction in fishing mortality in recent years. The fishing mortality in 2007 was close to 0.25, having reduced substantially since 2002. Fishing mortality had reduced to 0.2 in 2006 and subsequently rose slightly in 2007, mostly due to increased catches in Icelandic waters and the southern part of the current TAC area.

Catches in 2008 are estimated to be about 600,000 t. Catches by coastal states are expected to be close to the agreement to fish at about 500,000 t including about 9% overquota. However, there is an additional 108,000 t of catch in Icelandic waters up to end of August (preliminary estimate from Directorate of Fisheries Iceland). This estimate must be considered a minimum as the total will be greater if this fishery continues. Therefore prediction of the fishery in 2008 is uncertain due to these unregulated catches.

There is increased uncertainty about the future productivity of the stock, there is some evidence, from survey data and catches, of distributional changes of both juveniles and adults, suggesting a north westerly movement of mackerel (see section 2.13). Currently the stock appears to be subject to increased variability in recruitment and changes in distribution.

An evaluation of unaccounted mortality in the mackerel fishery has been carried out following a request from NEAFC. This shows that both biomass and removals are significantly greater than those estimated using the standard assessment model (Section 2.7). These analyses also show that the historic estimates of F provided by the standard assessment are not affected by unaccounted mortality. The sources of the additional removals are thought to be:

- escapees from fishing that die, such as those that pass through the meshes and die

- discards, slippage and high-grading not included in the ICA assessment
- unreported catch throughout the time-series

As there is no basis for allocating the total quantities of unaccounted removals among these different potential sources, the availability of this biomass to any fishery cannot be estimated. Currently the best estimates of availability of mackerel are given by the virtual population analysis provided by the ICA assessment in section 2.7.1.

Following NEAFC and EU requests, options for a management plan have been developed (see section 2.11) and reference points have been re-evaluated (see section 2.6). There are new proposed values for F_{lim}, B_{lim} and F_{pa} but B_{pa} remains unchanged because it has not been possible to select a value fully compatible with the precision of the assessment and the stock dynamics. Under these circumstances it is recommended to manage using criteria in the management plan rather than to B_{pa}. The short term forecasts options (section 2.8) are provided for the current management plan, exploitation at revised F_{pa} and for a range of options under a revised management plan.

The short term forecast provides catch options for 2009. Options at the extremes of the management plan F_{mp}= 0.15−0.2 would give catches of between 443,000 to 578,000, with SSB rising to 3.11 or 2.95 Mt respectively. Exploitation at the revised F_{pa} =0.23 would give yields of 656,000 with SSB increasing very slightly to 2.86 Mt in 2010. Options for all of the optimal choices for a management plan (section 2.11) are given in section 2.8.

2.14 Ecosystem considerations

The ICES WGMHSA put forward in 2007 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 has occurred it is assumed this may have substantial consequences for future abundance, spawning, growth and recruitment of the NEA mackerel stock (ICES 2007c).

Ecosystem considerations have been included and evaluated at the ICES WG WIDE for NEA mackerel stock in 2008.

Changes in mackerel distribution and environmental influences

The NEA mackerel has now the largest spatial expansion and distribution pattern in summer recorded in the Northeast Atlantic (ICES 2008 d). The present situation with very high ocean temperatures over large areas in the North Atlantic (ICES 2007, 2008) seems to influence the extent of mackerel distribution and migration pattern from the spawning areas in the south to the northernmost summer feeding grounds in the Norwegian Sea. In 2008 NEA mackerel expanded its summer distribution further to the west, east, and north in the Norwegian Sea, compared to earlier periods based on data from targeted fishing, international scientific surveys and more anecdotal data. Partly due to high zooplankton concentrations in the western part of the Northeast Atlantic, adult mackerel has now a more pronounced westerly distribution and migration pattern (ICES 2008). The markedly warmer ocean temperatures seem to have triggered earlier mackerel spawning in the south, as well as earlier migration to northern waters from southern spawning grounds, most probably due to the timing of the spring bloom and availability of suitable prey. A general overview of ecosystem considerations is provided in Section 1.9.

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 three years when a sharp decline in biomass in April was observed. 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 (Punzon and Villamor, WD 2008).

French acoustic surveys in Divisions VIIIa and VIIIb in May showed both in 2006 and 2007 a 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. There was a light increase in 2008, and mackerel was mainly distributed along the shelf break and only represented by small sizes (about 20 cm).

A major finding from the ecosystem survey in the Norwegian Sea in July-August 2008, was that mackerel was caught as far north as 75.18°N between Bear island and Spitsbergen in quite warm Atlantic water masses. This is a new record for mackerel expansion and represents a distance >500 km further north as compared to the northernmost distribution in 2002 (Nøttestad, WD 2008).

In early July 2008 the central part of the Norwegian Sea was surveyed by the Faroese R/V Magnus Heinason. Mackerel was caught in every haul made in the area, and most of the mackerel were between 2 and 4 years of age. Spent mackerel was found in the southern part of the Faroese zone in early May 2008 (Jacobsen, WD 2008).

Interaction between species

NEA mackerel and NSS herring had a pronounced overlap in spatial distribution in the southwestern and northern parts of the Norwegian Sea in 2008. Mackerel were caught together with considerable amounts of herring in the same trawl hauls, both in several commercial fisheries and in international surveys, suggesting that bycatch issues can represent increased challenges in the performance of this fishery by pelagic trawling and purse seine. The distribution of chub mackerel (*Scomber colias*) overlaps with the mackerel distribution in the southern area, with some substantial catches in Division IXa (Table 2.13.1).

Future aspects of mackerel surveys

Due to the pronounced changes and dynamics in the distribution and migration pattern of both juvenile and adult mackerel observed in recent years (2006–2008), the ICES WG WIDE encourage future surveys to gain more information and to monitor these important changes. There is a general need for fishery-independent surveys on mackerel in order to increase our understanding of important mechanisms and processes underlying such observed changes in distribution and ecology and furthermore be able to improve our predictions for NEA mackerel. Currently the stock appears to be subject to increased variability in recruitment and changes in distribution. This adds to uncertainty about the future.

2.15 Regulations and their effects

An overview on the major existing technical measures, TACs, effort control and management plans is given in Table 2.14.1 Note that **not** all existing international and national regulations are listed.

TACs, effort control and management plans are based on annual agreements between the EU, Norway and the Faroe Islands. However, the increasing Icelandic catches observed since 2007 are taken unregulated in Icelandic waters.

In 2007 the EU introduced a new regulation scheduling payback until 2012 because of undeclared landings of mackerel in UK and Ireland 2001 to 2004.

Other 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.

2.16 Changes in fishing technology and fishing patterns

North East Atlantic mackerel as a wide distributed species is targeted by a number of different fishing metiers. Most of the fishing patterns of these metiers remained unchanged during the last years.

Recent changes can be noticed for two areas and metiers:

One part of the Northeast Atlantic mackerel population migrates towards the southern spawning area (Cantabrian Sea) at the end of winter. In this seasonal handline fishery, which is the most important fishery in this area that targets mackerel, the timing of the peak of catches has shifted forward since 2000 (WD Punzón and Villamor 2008). This approximately one month shift may be due to a change in the timing of the pre-spawning migration to the southern area of the Northeast Atlantic mackerel population. A shift on this scale has important consequences for the management of the resource, the fleets that exploit it and the resource evaluation survey designs. They will have to be adapted to this new scenario.

There has been a significant change in catch distribution in the 3rd quarter with large catches taken in Icelandic waters (Div. Va, see Sec. 2.4.1), due to increased effort by Icelandic vessels. Figures from Icelandic landings records show that the effort is still increasing from 4222t in 2006 to 36706t in 2007 to more than 100000t in 2008. Results of an observer trip carried out on an Icelandic pelagic trawler in 2008 demonstrate that the fishing grounds are mainly off the shelf at the East coast of Iceland and on and around the "Thorsbank" on the Faroe-Iceland Ridge (WD Sveinbjörnsson 2008). The fleet consists of about 20 vessels. In 2007 the pelagic trawling for mackerel was mainly a by-catch fishery for herring, whereas in 2008 the fishery was directed on mackerel.

This fishery can be seen as a result of the recently observed more north-westerly distribution of Northeast Atlantic mackerel (WD Nøttestad 2008, WD Jacobsen 2008, see 2.13).

2.17 Changes in the environment

The working group WG WIDE has decided to merge this section into section 2.13 Ecosystem considerations.

Table 2.2.1.1 NE Atlantic Mackerel catches by area (t). 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
2007	110,788	405	111,193	71,235	2,024	73,259	253,013	6,187	259,200	72,891	62,834	570,761	8,616	579,379

[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 NE Atlantic Mackerel catch (t) in the Norwegian Sea and Area V 1984–2007 (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	2007
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		278
France		270							2	1		
Germany	1											7
Iceland	92	925	357				53	122		363	4,222	36,706
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	493
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	35,408
Misreported (IVa)			-177	-40,011								
Misreported (VIa)				-100								
Misreported (unknown)							-570		-400			
Unallocated										-2,393		-10
Discards												
Total	103,376	103,598	134,219	72,848	92,557	67,097	73,929	53,701	62,486	54,129	46,716	72,882

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

2- includes small bycatches in subareas I and IIb

Table 2.2.1.3 NE Atlantic Mackerel catch (t) in the North Sea, Skagerrak and Kattegat (Sub-area IV and IIIa) 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	2007[1]
Belgium	146	97	22	2	4	1	3	1
Denmark	27,720	21,680	34,375	27,508	25,665	23,212	24,219	25,217
Estonia								
Faroe Islands	10,614	18,751	12,548	11,754	11,705	9,739	12,008	11,818
France	1,588	1,981	2,152	1,467	1,538	1,004	285	7,549
Germany, Fed. Rep.	78	4,514	3,902	4,859	4,514	4,442	2,389	5,383
Iceland								
Ireland	9,956	10,284	20,715	17,145	18,901	15,605	4,125	13,337
Latvia								
Netherlands	2,262	2,441	11,044	6,784	6,366	3,915	4,093	5,973
Norway	142,320	158,401	161,621	150,858	147,069	106,434	113,079	131,191
Poland						109		
Sweden	4,994	5,090	5,232	4,450	4,437	3,204	3,209	3,858
United Kingdom	58,282[3]	52,988[3]	61,781[3]	51,736	50,474	37,118	28,628	46,264
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	2,421
Discards	1,912	24	8,583	9,390	8,870	2,482	5,383	6,187
Total	304,896	339,970	394,878	357,765	316,620	252,223	206,311	259,199

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 NE Atlantic Mackerel catch (t) in the Western area (Sub-areas VI and VII and Divisions VIIIa,b,d,e) 1985–2007 (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	2007
Belgium								1			
Denmark			552	82	835		392				6
Estonia											
Faroe Islands	2,448[1]	3,681	4,239	4,863	2,161	2,490	2,260	674		59	1,333
France	19,114	15,927	14,311	17,857	18,975	19,726	21,213	18,549	15,182	14,625	12,434
Germany, Fed. Rep.	15,161	20,989	19,476	22,901	20,793	22,630	19,202	18,730	14,598	14,219	12,831
Guernsey										10	
Ireland	52,849	66,505	48,282	61,277	60,168	51,457	49,715	41,730	30,082	36,539	35,923
Jersey									9	8	6
Lithuania										95	7
Netherlands	22,749	28,790	25,141	30,123	33,654	21,831	23,640	21,132	18,819	20,064	18,261
Norway	223										7
Poland									461		978
Spain	7,842	3,340	4,120	4,500	4,063	3,483	735	2,081	4,795	4,048	2,772
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	87,424
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	10,042
Discards	16,057	3,277		1,920	1,164	15,191	91	2,102	17,278	12,587	2,428
Total	196,110	218,599	204,885	297,932	280,553	252,620	235,370	237,260	187,517	166,873	184,452

1 – Faroese catches revised from 2,158t

2 – catches revised for Northern Ireland

3 – catches revised for unallocated catches

Table 2.2.1.5 NE Atlantic Mackerel catch (t) in Divisions VIIIc and IXa, 1977–2007 (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	2007
France	VIIIc					226	177	151	43	55
Poland	IXa									
Portugal	IXa	2,002	2,253	3,119	2,934	2,749	2,289	1,509	2,620	2,605
Spain	VIIIc	37,631	30,061	38,205	38,703	17,381	28,428	42,851	43,063	53,401
Spain	IXa	4,164	3,760	1,874	7,938	5,646	3,946	5,107	7,025	6,773
USSR	IXa									
Total	IXa	6,165	6,013	4,993	10,873	8,395	6,234	6,616	9,645	9,378
Total		43,796	36,074	43,198	49,575	26,002	34,840	49,618	52,751	62,834

Table 2.2.3.1. NEA Mackerel. Pelagic fleet composition in 2007 of major mackerel catching nations.

Country	Details given	Length (metres)	Engine power (Horse Power)	Gear	Storage	Discard est	No vessels
Denmark	Y	39–57	1100–5200	Midwater Trawl	Tank	N	11
Denmark	Y	51–65	2400–5900	Purse Seine	Tank	N	6
Faroe Islands	Y	40–62	515–1540 kW	Trawl	219–906	N	1
Faroe Islands	Y	90	6468 kW	Trawl	1090	N	1
Faroe Islands	Y	53–76	2208–8000 kW	Purse Seine/Trawl	1480–2600	N	9
France	N			Pelagic Trawl	Dry Hold	N	9
France	N			Pelagic Trawl	Freezer	N	3
Germany	Y	85–125	3200–11000	Single Midwater Trawl	Freezer	Y	4
Iceland	Y	54–79	3003–11257	Purse Seine/Trawl	RSW/Freezer	N	20
Ireland	Y	>100	14400	Midwater Trawl	RSW/Freezer	N	1
Ireland	Y	60–80	2500–3000	Midwater Trawl	RSW	N	3
Ireland	Y	40–60	700–6000	Midwater Trawl	RSW	N	16
Ireland	Y	20–40	350–1201	Midwater Trawl	RSW	N	9
Ireland	Y	20–30	350–700	Pair Midwater Trawl	Tank	N	8
Ireland	Y	20–30	350–700	Dem/Pair Midwater Trawl	Dry Hold	N	6
Ireland	Y	10–20	350–700	Dem Trawl/Handline	Dry Hold	N	2
Netherlands	Y	55	2890	Pair Midwater Trawl	Freezer	Y	2
Netherlands	Y	88–140	4400–1045	Single Midwater Trawl	Freezer	Y	14
Norway	Y	≥27		Purse Seine		N	84
Norway	Y	21–27		Purse Seine		N	18
Norway	Y	<21		Purse Seine		N	137
Norway	Y			Trawler		N	30
Norway	Y			Handline/Gillnet		N	176
Russia	Y	55–80	1000–5000+	Single Midwater Trawl	Freezer	N	52
Spain	Y	10–32	110–800	Single Trawl	Dry hold, ice	N	247
Spain	Y	19.5–31.3	220–800	Pair Trawl	Dry hold, ice	N	74
Spain	Y	6.5–27	16–650	Purse Seine	Dry hold, ice	N	408
Spain	Y	4–27	5–750	Artisanal: Hook	Dry hold, ice	N	370
Spain	Y	7–29	40–450	Artisanal: Gillnet	Dry hold, ice	N	593
Spain	Y	2–34	4–900	Artisanal: Others	Dry hold,ice	N	4587
Sweden	N					N	
UK (E&W)	Y	92.05	5053.5	Pair Midwater Trawl	Freezer	N	2
UK (E&W)	Y	47.3	1992	Midwater Trawl	RSW	N	3
UK (NI)	N					N	
Scotland	Y	45–76	2149–10728	Trawl	RSW	Y	24

Table 2.4.1.1 NE Atlantic Mackerel. Catch numbers (000's) at age by area.

Quarters 1–4 for 2007

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0		30.42	0.69			36.15	185.04	0.82		
1	39.41	282.66	5.80	0.80	0.14	23186.47	2388.84	136.55	4.17	0.05
2	18258.39	111.70	0.80	2.30	0.38	93656.07	3096.42	292.87	2011.86	28.08
3	39991.04	245.35	0.39	1.99	0.63	89461.91	464.09	93.94	4863.25	60.23
4	15449.44	215.91	0.36	2.28	0.42	77164.19	257.76	32.97	1913.32	23.11
5	42035.70	935.47	1.00	1.20	1.58	162125.58	263.84	39.35	5072.06	62.98
6	21322.71	594.85	0.65	0.50	0.85	81427.90	191.81	27.77	2530.62	31.97
7	7998.68	263.23	0.28	0.05	0.38	32514.12	34.81	6.45	937.30	12.00
8	5451.37	262.78	0.28	0.04	0.32	26588.08	60.46	3.85	674.75	8.02
9	1863.80	158.15	0.17		0.15	11499.67	21.51		204.00	2.77
10	916.12	29.06	0.03		0.08	8204.27	13.71	0.45	115.47	1.36
11	796.02	73.76	0.08		0.08	7510.52	12.65	1.02	86.00	1.18
12	1080.28	27.57	0.03		0.03	2447.32	4.46		126.92	1.62
13	422.34	25.17	0.03		0.02	1368.24	2.02		53.10	0.62
14	230.72	0.55				1029.96	1.64	1.42	29.67	0.34
15	235.58	2.46			0.02	1705.21	0.75		27.08	0.36
SOP	64994.97	1484.70	2.48	3.41	2.28	256322.22	1423.39	130.94	7802.03	97.47
Catch	64992.03	1484.77	2.48	3.43	2.28	256152.17	1422.84	131.87	7802.00	97.47
SOP%	100.00	100.00	100.07	100.40	100.27	99.93	99.96	100.71	100.00	99.99

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0		0.13	38.15	0.07		1.59	0.86	0.49		1.91
1	5454.71	2.74	890.83	2.41	9373.78	4389.38	191.09	10.05		2864.52
2	25376.11	16.70	2858.87	26.54	8751.72	4099.56	1391.51	30.33	0.36	4624.57
3	36820.03	32.57	8043.95	272.09	7478.53	1709.30	935.33	22.99	3.76	19467.77
4	32923.25	20.56	11079.98	746.75	3014.39	1048.72	547.84	13.59	11.68	14061.36
5	99496.66	85.29	26019.89	1450.64	4205.61	712.68	595.08	15.26	22.26	30628.07
6	47584.74	57.05	9036.71	315.94	1323.93	155.31	304.24	3.73	4.94	6868.22
7	16364.98	8.52	4054.10	179.67	970.97	162.71	25.60	1.57	2.92	2711.16
8	15253.42	0.31	2093.47	80.14	242.48	16.99	21.64	0.60	1.25	1293.06
9	9540.15	0.19	979.98	38.81	155.30	238.17	10.98	0.33	0.65	442.00
10	3794.90	7.98	602.80	24.39	40.99	15.05	0.02	0.19	0.40	524.15
11	1843.91	0.03	417.29	13.24	20.38	0.02	0.02	0.11	0.22	203.42
12	1854.55		74.40			0.03				24.98
13	780.42		75.70	0.01	20.20	0.01	0.01			46.01
14	340.79		23.84							96.10
15	439.82		17.06		20.17	0.23	4.59			76.49
SOP	111161.72	71.84	23840.20	1259.72	7311.33	2546.13	828.76	27.10	19.76	26918.40
Catch	111193.27	71.06	23801.32	1259.87	7407.09	2535.24	805.27	27.12	19.76	26893.77
SOP%	100.03	98.92	99.84	100.01	101.31	99.57	97.16	100.09	99.99	99.91

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0			0.02	3074.01	1439.53	5.23	10413.58	144.90	15373.59
1		1591.55	118.60	1271.65	14233.28	106.55	11006.10	1846.06	79398.19
2	8.46	1555.00	175.10	3067.41	7749.12	323.18	9161.15	3090.65	189765.19
3	89.54	2564.28	795.55	7307.98	3051.74	442.10	2154.39	1483.96	227858.72
4	292.87	1775.67	2251.89	34581.86	2281.09	292.79	2783.50	1214.09	204001.64
5	558.99	7194.97	5095.75	54056.82	2725.04	686.79	3643.05	880.34	448611.91
6	121.66	2093.08	1439.03	21871.76	1457.59	159.07	1294.85	398.70	200620.17
7	72.98	379.08	602.25	6390.29	859.79	62.38	321.12	374.86	75312.28
8	31.41	377.12	384.76	4897.40	505.38	28.83	206.15	134.75	58619.13
9	16.21	98.63	145.63	2364.58	383.96		87.06	48.54	28301.38
10	10.17	16.55	143.90	1425.65	382.56		88.23	92.24	16450.71
11	5.53	3.43	32.26	511.03	167.02		28.59	68.40	11796.23
12		0.78	29.26	228.69	228.88		18.33		6148.14
13		1.33		11.47	130.86		9.37		2946.93
14		0.98	6.11	52.63	105.19		3.06		1923.03
15				0.03					2529.87
SOP	494.86	5432.18	3828.13	46526.03	6898.78	673.92	6773.07	2604.70	579476.52
Catch	494.90	5444.41	3827.00	46557.04	6899.16	673.62	6772.62	2605.13	579378.99
SOP%	100.01	100.23	99.97	100.07	100.01	99.96	99.99	100.02	99.98

Table 2.4.1.1 NE Atlantic Mackerel. Catch numbers (000's) at age by area (cont.).

Quarter 1

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0										
1	0.26				0.05	914.42	0.03	1.35		
2	0.80	0.01			0.15	1603.61	0.05	1.18		
3	1.35	0.01			0.26	962.07	0.02	0.91		
4	0.84	0.01			0.16	204.72		0.27		
5	2.92	0.02			0.56	1071.39		0.55		
6	1.39	0.01			0.27	435.86	0.01	0.13		
7	0.63				0.12	259.78		0.13		
8	0.45				0.09	356.21				
9	0.16				0.03	57.74				
10	0.19				0.04	349.20				
11	0.11				0.02	127.83				
12	0.04				0.01	36.69				
13	0.02					45.02				
14	0.01					0.41				
15	0.06				0.01					
SOP	4.01	0.02			0.77	1785.51	0.02	0.78		
Catch	4.00	0.03			0.77	1789.98	0.02	0.80		
SOP%	99.85	125.04			99.62	100.25	103.31	102.56		

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0										
1	821.54		113.92		7539.02	3.37	0.49			30.72
2	12572.50		273.54	20.24	6594.61	3.85	9.50	0.08	0.33	1719.96
3	27320.65		5670.99	267.71	5096.70	31.47	5.98	0.48	3.54	14130.18
4	28758.41		9962.36	744.79	1530.69	69.21	4.11	0.31	11.57	11340.31
5	97299.64		23127.89	1449.80	3045.73	63.87	6.36	0.56	22.08	27950.46
6	45267.40		7150.15	315.52	749.08	18.23	2.56	0.12	4.81	6159.99
7	15828.58		3785.32	179.57	749.22	6.11	0.58	0.04	2.88	2100.12
8	14566.87		2093.25	80.05	0.25	1.90	0.32	0.02	1.24	1150.18
9	9399.92		979.87	38.81		0.09	0.03	0.01	0.64	426.05
10	3501.67		346.31	24.34	0.36	0.32			0.40	509.05
11	1769.49		417.25	13.23	0.12	0.02			0.22	203.29
12	1844.61		74.40			0.02				24.95
13	713.59		75.70		0.02	0.01				45.95
14	338.58		23.84							96.07
15	422.74		17.06			0.01				76.49
SOP	101305.43		20479.48	1255.71	4396.26	56.34	7.22	0.50	19.55	22388.57
Catch	101339.55		20463.86	1255.87	4479.89	56.27	7.01	0.51	19.55	22404.86
SOP%	100.03		99.92	100.01	101.90	99.88	97.12	102.17	100.02	100.07

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0						5.23			5.23
1		344.54	0.04	784.66	9550.32	106.55	2028.83	10.36	22250.48
2	8.46	367.45	46.88	2474.55	2252.46	319.38	1803.80	251.72	30325.09
3	89.54	1609.95	565.91	5388.98	470.63	404.06	923.46	151.12	63095.96
4	292.87	1324.28	1970.34	23775.23	905.14	272.50	2122.86	106.25	83397.23
5	558.99	6333.02	4747.81	36141.05	1475.73	665.23	3029.53	67.95	207061.14
6	121.66	1272.76	1376.08	13848.37	941.97	154.00	1103.29	28.80	78952.44
7	72.98	211.22	565.51	3809.08	564.12	57.31	262.40	13.40	28469.10
8	31.41	350.49	377.62	2932.58	342.38	27.56	168.45	18.02	22499.33
9	16.21	10.60	136.09	1322.37	259.72		68.14	5.62	12722.11
10	10.17	3.24	141.62	808.55	264.19		68.99	8.16	6036.80
11	5.53	3.43	32.06	274.40	117.90		21.92	15.91	3002.74
12		0.78	29.07	105.72	163.79		13.43		2293.52
13		1.33		6.53	93.55		6.36		988.09
14		0.98	6.11	24.62	77.42		1.12		569.17
15				0.03					516.40
SOP	494.86	3961.49	3509.13	29983.36	3156.52	648.11	2819.80	167.33	196420.08
Catch	494.90	3970.41	3509.03	30035.07	3156.24	647.56	2819.81	167.33	196623.30
SOP%	100.01	100.22	100.00	100.17	99.99	99.92	100.00	100.00	100.10

Table 2.4.1.1 NE Atlantic Mackerel. Catch numbers (000's) at age by area (cont.).

Quarter 2

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0		8.28					117.13	0.82		
1	0.26	71.00		0.37	0.03	496.27	1335.74	85.50		
2	2594.73	13.09	0.01	0.66	0.05	884.21	753.15	116.07		4.75
3	2101.78	18.92	0.04	0.23	0.03	384.61	234.86	50.12		3.84
4	505.35	18.03	0.04	0.03	0.01	115.91	36.10	9.50		0.92
5	2288.18	77.23	0.20	0.04	0.06	461.55	57.85	16.84		4.17
6	1442.70	51.08	0.13	0.09	0.04	358.08	88.14	14.63		2.63
7	621.04	22.46	0.06		0.02	119.11	4.39	2.67		1.13
8	113.12	23.17	0.06	0.01	0.02	145.70	19.28	1.99		0.20
9	221.02	14.41	0.04		0.01	69.72	1.08			0.40
10	10.17	1.97	0.01			31.67	5.85			0.02
11	101.63	6.60	0.02			38.80	3.34	0.01		0.18
12	83.64	2.45	0.01			11.87	0.18			0.15
13	0.37	2.31	0.01			12.29	0.46			
14										
15	24.90									0.05
SOP	3842.17	132.23	0.32	0.26	0.10	958.79	411.10	52.15		7.00
Catch	3842.00	132.28	0.31	0.26	0.11	958.33	410.79	52.66		7.00
SOP%	100.00	100.03	96.07	100.16	109.18	99.95	99.93	100.97		99.98

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0										
1	48.04				81.96	48.97	43.86			0.05
2	36.37	0.31	0.06		96.68	97.54	846.89	0.17	0.02	399.32
3	413.17	2.32	0.61		836.09	160.74	415.19	1.75	0.17	3982.12
4	248.55	2.24	1.99		387.39	207.29	242.72	5.47	0.09	2125.52
5	649.29	3.85	3.80		606.57	122.59	224.89	10.39	0.10	2265.91
6	391.84	0.85	0.83		416.00	46.74	145.83	2.26	0.02	532.92
7	109.61	0.46	0.50		153.58	14.61	11.28	1.36	0.02	530.19
8	197.59	0.19	0.21		234.99	5.54	15.77	0.58	0.01	132.89
9	102.93	0.09	0.11		121.19		2.40	0.30		0.40
10	37.58	0.04	0.07		40.63	0.81	0.01	0.19		0.11
11	16.34	0.03	0.04		20.26		0.02	0.10		0.13
12	2.25									0.03
13	19.20				20.18		0.01			0.05
14	0.01									0.04
15	15.94				20.17					
SOP	842.16	3.56	3.37		953.93	157.13	364.13	9.21	0.12	2712.01
Catch	842.15	3.57	3.36		960.66	156.42	344.71	9.22	0.12	2733.48
SOP%	100.00	100.43	99.85		100.71	99.55	94.67	100.03	98.51	100.79

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0									126.23
1				185.05	19.14		1215.48	288.98	3920.70
2		53.29	15.92	102.40	1251.03	3.80	3856.92	383.41	11510.86
3		532.85	144.33	1658.20	1934.84	38.04	866.20	398.86	14179.92
4		284.19	210.23	10361.40	826.36	20.29	315.61	318.49	16243.73
5		301.95	289.41	17544.83	924.87	21.56	406.41	199.41	26481.92
6		71.05	30.21	7955.33	479.98	5.07	169.03	148.08	12353.57
7		71.05	23.71	2539.04	275.65	5.07	43.98	154.73	4705.72
8		17.76	3.70	1946.16	151.58	1.27	28.42	60.84	3101.06
9			0.46	1024.57	118.88		13.48	18.98	1710.46
10			1.59	611.32	113.02		13.73	45.63	914.42
11			0.11	235.68	47.13		4.49	6.97	481.89
12				121.91	64.07		3.65		290.23
13				4.93	36.83		2.55		99.19
14				28.00	27.51		1.66		57.23
15									61.05
SOP		362.13	194.45	15759.27	1689.76	25.85	1034.88	491.92	30007.36
Catch		365.00	194.81	15740.72	1689.72	26.06	1034.84	491.90	30000.47
SOP%		100.79	100.19	99.88	100.00	100.80	100.00	100.00	99.98

Table 2.4.1.1 NE Atlantic Mackerel. Catch numbers (000's) at age by area (cont.).

Quarter 3

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0		22.09	0.69				67.91			
1	38.62	200.41	5.79	0.39	0.01	8292.05	1034.39	30.42	4.17	0.05
2	15586.13	63.35	0.78	1.45	0.03	42138.85	2282.61	158.07	2011.86	23.33
3	37702.72	166.08	0.32	1.22	0.10	12165.04	142.75	26.19	4863.25	56.39
4	14870.24	158.79	0.30	1.48	0.09	9075.58	133.88	15.22	1913.32	22.19
5	39550.71	729.40	0.76	0.62	0.44	20187.11	45.26	14.27	5072.06	58.81
6	19781.92	482.96	0.50	0.27	0.29	12925.99	25.51	8.62	2530.62	29.34
7	7341.15	213.37	0.21	0.02	0.13	4903.28	7.59	1.47	937.30	10.87
8	5311.98	220.09	0.21	0.02	0.13	5056.86	10.41	1.43	674.75	7.82
9	1634.81	136.95	0.13		0.08	2865.09	5.17		204.00	2.37
10	901.29	18.77	0.02		0.01	398.54	1.89	0.02	115.47	1.34
11	690.96	62.29	0.07		0.04	1298.69	2.82	0.04	86.00	1.00
12	991.77	23.32	0.02		0.01	488.91	1.08		126.92	1.47
13	419.93	21.97	0.02		0.01	457.59	0.44		53.10	0.62
14	229.58					423.42	0.54	1.42	29.67	0.34
15	209.57					0.88	0.18		27.08	0.31
SOP	60851.93	1175.14	2.10	2.14	0.68	41841.65	761.72	58.71	7802.03	90.47
Catch	60848.03	1175.19	2.11	2.16	0.69	41846.54	761.49	58.85	7802.00	90.47
SOP%	99.99	100.00	100.28	101.08	101.56	100.01	99.97	100.25	100.00	100.00

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0		0.12	0.39					0.26		0.06
1	279.52	2.36	7.94		827.80	3003.57	129.77	5.20		1.21
2	3609.53	15.27	73.58		1265.41	2798.88	482.46	15.59	0.01	9.18
3	2499.57	29.48	165.68		790.76	1241.94	424.81	10.80	0.05	24.70
4	2.60	18.03	105.69		734.28	678.60	255.52	4.07	0.02	12.04
5	3.55	81.29	501.02		319.47	346.32	269.34	2.30	0.08	39.45
6	556.74	56.15	349.35		105.05	6.42	130.53	0.78	0.11	50.18
7	0.65	8.05	49.88		31.70	111.38	7.17	0.10	0.01	5.57
8	0.91	0.12			7.24	0.27	5.55			
9	0.36	0.10			34.11	222.29	5.04	0.02	0.01	5.55
10	0.25	7.94	49.76							
11	0.18									
12	0.08									
13	0.05									
14	0.03									
15	0.01					0.23	4.59			
SOP	1516.41	67.64	406.25		1232.45	1667.14	371.24	9.08	0.09	45.81
Catch	1514.86	66.84	401.37		1237.12	1664.59	372.97	9.09	0.09	45.69
SOP%	99.90	98.83	98.80		100.38	99.85	100.46	100.06	101.13	99.74

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0				8.54	308.68		3382.87	6.36	3797.96
1			67.17	122.37	3055.29		5471.28	1230.17	23809.95
2		79.16	65.92	204.67	2226.36		2426.51	1203.47	76742.46
3		316.65	48.28	69.43	261.49		235.69	697.71	61941.12
4		158.33	37.90	116.52	177.04		258.29	475.11	29225.13
5		555.56	33.33	110.45	110.27		157.95	407.63	68597.43
6		713.89	22.52	19.88	16.22		18.90	103.14	37935.89
7		79.16	7.83	13.62	10.22		12.26	88.43	13841.40
8			1.78	6.11	6.12		7.64	22.16	11341.61
9		79.16	7.87	5.56	2.87		4.50	16.56	5232.61
10			0.42	1.68	2.84		4.60	28.84	1533.68
11			0.09	0.64	1.24		1.75	15.83	2161.62
12			0.18	0.78	0.63		0.95		1636.13
13					0.33		0.43		954.49
14					0.16		0.28		685.43
15									242.85
SOP		623.70	71.00	172.98	1044.73		1729.23	1119.67	122657.32
Catch		622.00	70.55	172.47	1044.74		1728.89	1119.79	122658.57
SOP%		99.73	99.36	99.70	100.00		99.98	100.01	100.00

Table 2.4.1.1 NE Atlantic Mackerel. Catch numbers (000's) at age by area (cont.).

Quarter 4

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0		0.06				36.15				
1	0.29	11.25		0.04	0.05	13483.73	18.69	19.28		
2	76.73	35.25	0.01	0.19	0.14	49029.39	60.61	17.55		
3	185.18	60.34	0.02	0.54	0.24	75950.19	86.47	16.71		
4	73.01	39.08	0.01	0.77	0.15	67767.98	87.77	7.98		
5	193.89	128.82	0.05	0.53	0.52	140405.55	160.73	7.70		
6	96.70	60.80	0.02	0.14	0.25	67707.97	78.16	4.39		
7	35.87	27.40	0.01	0.02	0.11	27231.96	22.83	2.17		
8	25.82	19.51	0.01	0.01	0.08	21029.31	30.77	0.44		
9	7.82	6.79			0.03	8507.12	15.26			
10	4.48	8.31			0.03	7424.86	5.96	0.44		
11	3.32	4.87			0.02	6045.19	6.50	0.98		
12	4.84	1.80			0.01	1909.85	3.20			
13	2.02	0.89				853.35	1.13			
14	1.13	0.55				606.13	1.10			
15	1.06	2.46			0.01	1704.33	0.58			
SOP	297.99	177.26	0.06	1.01	0.71	211738.62	250.68	19.30		
Catch	298.00	177.27	0.06	1.01	0.71	211557.32	250.54	19.55		
SOP%	100.00	100.00	110.94	100.30	100.46	99.91	99.94	101.29		

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0		0.02	37.76	0.07		1.59	0.86	0.24		1.85
1	4305.61	0.38	768.97	2.41	925.01	1333.46	16.97	4.85		2832.54
2	9157.71	1.12	2511.70	6.29	795.03	1199.29	52.66	14.49		2496.11
3	6586.64	0.77	2206.68	4.39	754.99	275.15	89.35	9.96		1330.77
4	3913.68	0.29	1009.94	1.95	362.03	93.62	45.49	3.74		583.49
5	1544.19	0.16	2387.19	0.84	233.84	179.90	94.49	2.01		372.25
6	1368.75	0.04	1536.37	0.43	53.81	83.92	25.31	0.56		125.13
7	426.13	0.01	218.40	0.10	36.47	30.62	6.57	0.07		75.28
8	488.04			0.10		9.28	0.01			9.99
9	36.93					15.78	3.51			9.99
10	255.40		206.66	0.06		13.92	0.01			14.99
11	57.91			0.01						
12	7.60									
13	47.58			0.01						
14	2.18									
15	1.13									
SOP	7497.47	0.65	2952.24	3.98	729.07	665.84	86.19	8.30		1773.63
Catch	7496.72	0.64	2932.74	4.00	729.42	657.97	80.58	8.31		1709.75
SOP%	99.99	99.51	99.34	100.62	100.05	98.82	93.49	100.13		96.40

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0			0.02	3065.46	1130.85		7030.72	138.54	11444.17
1		1247.01	51.39	179.57	1608.53		2290.51	316.55	29417.08
2		1055.10	46.37	285.79	2019.27		1073.92	1252.06	71186.77
3		104.83	37.03	191.37	384.78		129.04	236.26	88641.71
4		8.87	33.43	328.72	372.56		86.74	314.24	75135.55
5		4.44	25.20	260.48	214.18		49.17	205.36	146471.47
6		35.39	10.22	48.19	19.41		3.63	118.68	71378.28
7		17.64	5.20	28.55	9.80		2.49	118.30	28296.01
8		8.87	1.65	12.55	5.30		1.65	33.74	21677.13
9		8.87	1.21	12.08	2.50		0.93	7.38	8636.21
10		13.31	0.26	4.10	2.51		0.90	9.61	7965.81
11				0.31	0.76		0.42	29.68	6149.98
12				0.28	0.38		0.29		1928.25
13					0.15		0.02		905.17
14					0.10				611.20
15									1709.56
SOP		484.67	53.75	615.04	1008.39		1188.83	826.12	230374.20
Catch		487.00	52.61	608.79	1008.45		1189.09	826.12	230096.65
SOP%		100.48	97.88	98.98	100.01		100.02	100.00	99.88

Table 2.4.1.2 NE Atlantic Mackerel. Percentage catch numbers at age by area. Zeros represent values <1%.

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0		0%	7%			0%	3%	0%		
1	0%	9%	55%	9%	3%	4%	34%	21%	0%	0%
2	12%	3%	8%	25%	7%	15%	44%	46%	11%	12%
3	26%	8%	4%	22%	12%	14%	7%	15%	26%	26%
4	10%	7%	3%	25%	8%	12%	4%	5%	10%	10%
5	27%	29%	9%	13%	31%	26%	4%	6%	27%	27%
6	14%	18%	6%	5%	17%	13%	3%	4%	14%	14%
7	5%	8%	3%	0%	7%	5%	0%	1%	5%	5%
8	3%	8%	3%	0%	6%	4%	0%	0%	4%	3%
9	1%	5%	2%		3%	2%	0%		1%	1%
10	0%	0%	0%		2%	1%	0%	0%	0%	0%
11	0%	2%	0%		2%	1%	0%	0%	0%	0%
12	0%	0%	0%		0%	0%	0%		0%	0%
13	0%	0%	0%		0%	0%	0%		0%	0%
14	0%	0%				0%	0%	0%	0%	0%
15	0%	0%			0%	0%	0%		0%	0%

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0		0%	0%	0%		0%	0%	0%		0%
1	2%	1%	1%	0%	26%	35%	5%	10%		3%
2	9%	7%	4%	0%	25%	33%	35%	31%	0%	6%
3	12%	14%	12%	9%	21%	14%	23%	23%	8%	23%
4	11%	9%	17%	24%	8%	8%	14%	14%	24%	17%
5	33%	37%	39%	46%	12%	6%	15%	15%	46%	36%
6	16%	25%	14%	10%	4%	1%	8%	4%	10%	8%
7	5%	4%	6%	6%	3%	1%	0%	2%	6%	3%
8	5%	0%	3%	3%	0%	0%	0%	0%	3%	2%
9	3%	0%	1%	1%	0%	2%	0%	0%	1%	0%
10	1%	3%	0%	0%	0%	0%	0%	0%	0%	0%
11	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
12	0%		0%			0%				0%
13	0%		0%	0%	0%	0%	0%			0%
14	0%		0%							0%
15	0%		0%		0%	0%	0%			0%

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0			0%	2%	4%	0%	25%	1%	0%
1		9%	1%	0%	40%	5%	27%	19%	5%
2	0%	9%	2%	2%	22%	15%	22%	32%	12%
3	7%	15%	7%	5%	9%	21%	5%	15%	15%
4	24%	10%	20%	25%	6%	14%	7%	12%	13%
5	46%	41%	45%	38%	8%	33%	9%	9%	29%
6	10%	12%	13%	15%	4%	8%	3%	4%	13%
7	6%	2%	5%	5%	2%	3%	0%	4%	5%
8	3%	2%	3%	3%	1%	1%	0%	1%	4%
9	1%	0%	1%	2%	1%		0%	0%	2%
10	0%	0%	1%	1%	1%		0%	0%	1%
11	0%	0%	0%	0%	0%		0%	0%	0%
12		0%	0%	0%	0%		0%		0%
13		0%		0%	0%		0%		0%
14		0%	0%	0%	0%		0%		0%
15				0%					0%

Table 2.4.2.1 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	-
2007	-	21202	1031	1895	337	-

- Not available

Table 2.4.2.2 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	-
2007	-	21.9	2675.6	2888.9	1.7	-

- Not available

Table 2.4.2.3 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
2007	1895	0	1	64	614	3562	6109	2878	896	687	327	201	72	44	2	11	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
2007	1031	0	0	0	223	1774	3221	1486	414	339	139	87	27	9	0	2	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	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2.4.2.3. (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
2007	21202	0	554	283	87	146	216	152	98	59	45	46	20	28	16	13	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 2.4.3.1.1. Mackerel egg surveys in the North Sea in 2008.

Coverage	1	2	3	4
”Tridens”	2–6.06	9–11.06	16–19.06	-
“Håkon Mosby”	-	No data	22–23.06	25.06–4.07
Midpoint of survey Julian day	4.06 156	10.06 162	18.06 170	30.06 182
Total daily egg prod. x 10^{-12}	1.88	1.22 (raised to 2.34)	2.75	1.16
Interpolated daily egg prod. x 10^{-12}	0.34	0.26	0.37	0.23

Table 2.4.3.1.2. Egg production estimates from egg surveys in the North Sea and corresponding SSB based on a standard fecundity of 1401 eggs/g/female.

Year	Egg prod $*10^{-12}$	SSB$*10^{-3}$ tons
1980	60	86
1981	40	57
1982	126	180
1983	160	228
1984	78	111
1986	30	43
1988	25	36
1990	53	76
1996	77	110
1999	48	68
2002	147	210
2005	155	220
2008	91	130

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Table 2.4.3.5.1. Annual changes from 2002–2008 in maximum spatial distribution measured in latitude and longitude for NEA mackerel in the Norwegian Sea in late summer.

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
2008	75.18	13,00

Table 2.4.3.6.1- Spanish acoustic surveys from 2001 to 2008. 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
2008	160	21,415	377	109,035	835	235,040	51	4,191	1423	369,681

Table 2.4.3.6.2. 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 2007 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 2.4.3.6.2. 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 2.4.3.6.2 continued

	2007			
	Number	**L**	**W**	**Biomass**
AGE	**(millions)**	**(cm)**	**(g)**	**t ('000)**
1	182.24	21.49	64.07	11.68
2	34.63	25.63	110.51	3.83
3	22.08	33.41	254.45	5.62
4	129.60	34.87	291.68	37.80
5	189.44	36.08	232.95	61.37
6	117.54	38.07	379.72	44.63
7	31.94	39.79	435.86	13.92
8	20.47	39.73	431.55	8.83
9	4.76	41.24	483.97	2.31
10	6.06	40.73	464.70	2.81
11	1.53	41.39	490.27	0.75
12	4.68	44.47	608.62	2.85
13	0.72	43.50	567.62	0.41
14	2.60	44.04	591.48	1.54
15+	0.65	46.50	697.93	0.46
TOTAL	748.94	32.51	265.44	198.80

Table 2.4.4.1 NE Atlantic Mackerel. Mean length (cm) at age by area.

Quarters 1–4

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0	20.5	22.0	22.0		20.5	20.5	22.0	22.0		
1	27.0	24.7	24.5	24.5	26.7	25.9	24.5	23.6	27.0	27.0
2	29.8	30.0	28.6	29.6	30.7	30.3	29.0	28.7	30.0	29.8
3	31.7	33.5	33.1	34.1	33.5	33.4	31.4	30.8	31.7	31.7
4	33.3	35.6	35.5	37.0	35.1	35.7	34.4	33.3	33.3	33.3
5	35.5	36.5	36.5	38.5	36.3	36.5	36.2	34.3	35.5	35.5
6	36.8	37.5	37.6	40.0	37.2	37.2	36.4	34.7	36.8	36.8
7	38.1	37.7	37.6	41.7	37.9	38.3	38.1	38.3	38.1	38.2
8	38.8	38.9	39.0	44.7	39.0	39.0	38.9	39.5	38.7	38.8
9	39.8	39.4	39.4	44.4	39.7	39.9	39.5		39.8	39.8
10	40.0	40.5	40.6	41.5	40.3	40.3	39.0	41.5	40.0	40.0
11	40.7	41.7	41.3	40.5	41.1	40.1	39.6	37.5	40.7	40.7
12	41.4	42.2	42.3	41.5	41.4	41.1	41.5		41.3	41.4
13	41.5	41.2	41.2	41.5	41.3	41.6	42.1		41.5	41.5
14	42.9	42.0	42.0	45.5	42.1	43.6	42.9	45.5	42.9	42.9
15	43.0	43.0	43.0		43.0	42.7	40.1		42.8	43.1

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0		20.1	20.1	20.1		21.5	21.5	20.1		20.1
1	25.1	25.8	24.9	25.7	24.0	26.6	26.2	25.8		27.5
2	28.5	28.8	29.8	31.3	28.8	29.1	28.1	30.0	31.7	29.1
3	31.5	30.9	32.1	33.1	30.6	31.0	29.9	32.1	33.4	31.9
4	35.1	33.3	35.1	35.8	33.9	31.6	31.3	34.7	35.9	34.7
5	35.9	34.5	35.4	36.3	34.9	34.3	32.3	35.9	36.5	35.6
6	36.6	36.6	36.7	37.7	34.6	34.4	33.0	36.8	37.9	37.2
7	38.2	37.5	37.7	38.8	39.2	34.9	33.8	38.4	38.9	39.2
8	38.6	39.5	38.7	40.4	39.8	38.9	34.7	40.6	40.6	38.7
9	39.7	40.4	39.7	41.2	41.0	36.5	33.7	41.2	41.2	40.1
10	40.5	38.5	39.7	40.8	43.4	41.1	41.1	40.8	40.8	39.5
11	40.6	41.4	39.8	41.1	41.5	40.4	42.0	41.1	41.1	41.5
12	40.1	42.5	39.9			39.8	42.5	42.5		42.3
13	41.8	41.5	40.7	41.5	41.5	41.9	41.5	41.5		41.9
14	41.2	45.5	41.5			41.1	45.5	45.5		43.3
15	41.8		42.3		40.5	37.2	37.1			42.4

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0			20.1	21.8	22.7	20.1	22.6	22.1	22.4
1		26.4	27.0	22.8	22.3	25.8	24.4	25.3	24.7
2	31.8	28.9	29.6	26.9	27.2	30.0	26.3	30.1	29.5
3	33.5	31.6	31.9	32.5	29.6	31.8	29.7	33.2	32.3
4	35.9	35.1	35.1	34.7	33.8	35.2	34.3	34.6	35.0
5	36.5	36.0	35.8	35.7	36.1	36.5	35.2	35.7	36.0
6	38.0	36.9	37.8	37.6	39.1	37.4	37.2	37.0	37.0
7	38.9	39.6	38.1	39.0	41.2	41.9	39.0	38.0	38.4
8	40.6	37.0	38.4	39.0	41.1	37.6	39.2	38.9	38.9
9	41.2	41.2	40.7	40.4	41.9		40.1	40.0	39.8
10	40.8	41.3	38.9	40.2	41.9		40.3	40.7	40.3
11	41.1	42.0	41.9	41.5	42.5		40.9	43.1	40.4
12		42.6	43.7	43.8	43.0		41.4		41.0
13		41.5		46.0	43.1		42.1		41.7
14		45.5	43.5	44.0	43.4		43.4		43.0
15				51.5					42.6

Table 2.4.4.1 NE Atlantic Mackerel. Mean length (cm) at age by area (cont.).

Quarter 1

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0	20.5	20.5			20.5					
1	28.0	28.0			28.0	22.6	22.4	23.2		
2	31.3	31.3			31.3	28.0	28.0	28.4		
3	33.6	33.6			33.6	31.2	30.9	29.7		
4	34.9	34.9			34.9	33.6	32.0	32.6		
5	36.2	36.2			36.2	35.3	34.5	34.6		
6	36.9	36.9			36.9	35.6	35.2	32.5		
7	38.1	38.1			38.1	37.1		39.5		
8	39.1	39.1			39.1	38.8	40.5			
9	40.1	40.1			40.1	39.2				
10	40.3	40.3			40.3	37.9				
11	40.4	40.4			40.4	38.9				
12	40.4	40.4			40.4	38.3				
13	41.6	41.6			41.6	41.4				
14	42.0	42.0			42.0	43.5				
15	43.0	43.0			43.0					

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0										
1	22.4		18.8		23.2	23.2	25.8	22.3		22.3
2	27.8		30.1	31.8	28.4	29.5	27.5	27.9	31.8	27.9
3	31.7		32.4	33.1	29.7	31.5	29.8	31.6	33.5	31.6
4	35.0		35.3	35.8	32.6	30.3	32.7	34.9	35.9	35.0
5	35.8		35.5	36.3	34.6	35.2	35.0	35.6	36.5	35.7
6	36.6		36.7	37.8	32.5	35.6	35.0	37.6	38.0	37.4
7	38.2		37.8	38.8	39.5	41.2	40.4	38.6	38.9	39.6
8	38.6		38.7	40.4	39.1	37.9	36.1	40.0	40.6	38.8
9	39.6		39.7	41.2		39.4	38.2	40.5	41.2	40.1
10	40.4		40.7	40.8	37.8	37.0		40.9	40.8	39.4
11	40.5		39.8	41.1	38.6	40.4		42.0	41.1	41.5
12	40.1		39.9			39.8		42.5		42.3
13	41.9		40.7		42.5	41.9		41.5		41.9
14	41.2		41.5			41.0		45.5		43.3
15	41.9		42.3			41.9				42.4

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0						20.1			20.1
1		23.2	25.5	21.5	20.4	25.8	21.6	21.0	21.7
2	31.8	28.3	29.5	26.3	25.1	30.0	25.2	27.9	27.5
3	33.5	31.2	31.8	32.2	29.7	31.8	30.7	32.4	31.6
4	35.9	35.6	35.3	34.5	35.0	35.4	34.5	33.6	34.9
5	36.5	36.4	36.0	35.6	36.9	36.5	35.3	34.2	35.8
6	38.0	37.2	37.9	37.4	39.3	37.4	37.1	36.1	36.9
7	38.9	41.4	38.1	38.9	41.3	42.3	38.9	37.4	38.4
8	40.6	36.9	38.4	38.9	41.3	37.6	39.2	38.8	38.7
9	41.2	40.5	40.8	40.2	42.0		40.1	39.5	39.8
10	40.8	40.7	38.9	40.1	42.0		40.3	40.5	40.2
11	41.1	42.0	41.9	41.4	42.6		40.8	42.8	40.6
12		42.6	43.7	43.9	43.1		41.2		40.5
13		41.5		46.4	43.1		41.9		41.9
14		45.5	43.5	44.3	43.5		43.8		42.0
15				51.5					42.0

Table 2.4.4.1 NE Atlantic Mackerel. Mean length (cm) at age by area (cont.).

Quarter 2

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0		22.0					22.0	22.0		
1	26.7	24.5	26.7	22.4	22.6	22.5	23.6	22.8		
2	28.7	29.0	30.2	28.0	28.1	28.0	28.0	28.1		28.7
3	31.7	33.4	33.5	30.9	32.0	31.4	31.0	30.5		31.7
4	35.0	35.7	35.8	32.0	35.2	34.6	32.7	32.2		35.0
5	35.9	36.5	36.5	34.5	36.4	36.2	34.9	34.5		35.8
6	36.9	37.6	37.6	35.2	37.2	36.8	35.3	34.4		36.9
7	38.7	37.6	37.6		37.6	37.5	36.9	39.5		38.8
8	39.1	38.9	38.9	40.5	39.0	39.1	40.1	40.5		39.1
9	40.0	39.4	39.4		39.4	39.4	39.4			40.0
10	42.9	40.6	40.6		40.6	38.6	37.9			43.0
11	40.6	41.7	41.8		41.8	41.2	37.8	34.5		40.6
12	42.4	42.3	42.3		42.3	42.3	42.3			42.4
13	41.2	41.2	41.2		41.2	41.3	42.0			
14										
15	45.0									45.0

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0										
1	22.2	22.3			22.4	22.4	25.8			22.3
2	28.8	29.0	31.8		29.3	29.4	27.5	31.7	30.8	30.8
3	32.1	32.1	33.5		32.0	31.7	29.3	33.4	32.2	32.2
4	35.4	35.1	35.9		34.9	29.8	31.0	35.9	33.6	33.6
5	36.7	36.0	36.5		36.1	33.7	32.4	36.5	34.9	34.9
6	37.9	37.5	38.0		37.0	34.3	33.4	38.0	35.5	35.5
7	39.0	38.6	38.9		38.8	37.8	32.8	38.9	38.0	38.0
8	40.1	40.0	40.6		39.5	38.6	34.7	40.6	37.5	37.5
9	42.3	40.9	41.2		42.3		38.2	41.2		40.5
10	43.3	40.8	40.8		43.5	36.5	40.9	40.8		40.9
11	41.5	41.4	41.1		41.5		42.0	41.1		42.0
12	43.4	42.5					42.5			42.5
13	41.5	41.5			41.5		41.5			41.5
14	40.9	45.5					45.5			45.5
15	40.5				40.5					

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0									22.0
1				22.1	25.0		22.1	22.1	22.8
2		30.8	30.5	26.7	27.4	30.8	25.6	27.8	27.4
3		32.2	32.1	33.3	29.0	32.2	28.1	32.4	31.4
4		33.6	33.6	35.1	33.0	33.6	33.7	33.5	34.6
5		34.9	33.8	36.0	35.6	34.9	35.3	34.7	35.8
6		35.5	35.2	37.8	39.1	35.5	37.6	36.5	37.5
7		38.0	36.8	39.3	41.3	38.0	39.6	37.5	39.0
8		37.5	37.9	39.2	41.1	37.5	39.6	38.3	39.2
9			40.8	40.6	41.8		40.9	39.5	40.8
10			37.3	40.3	41.8		40.8	40.1	40.7
11			41.1	41.6	42.3		41.6	42.6	41.4
12			43.8	43.8	42.9		42.4		43.1
13				45.5	42.8		42.7		42.2
14			43.5	43.9	43.3		43.3		43.6
15									42.3

Table 2.4.4.1 NE Atlantic Mackerel. Mean length (cm) at age by area (cont.).

Quarter 3

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0		22.0	22.0				22.0			
1	27.0	24.6	24.5	26.2	26.3	23.4	25.6	23.6	27.0	27.0
2	30.0	29.6	28.6	30.1	29.9	29.1	29.3	29.1	30.0	30.0
3	31.7	33.5	33.0	34.7	33.5	32.1	30.9	30.9	31.7	31.7
4	33.3	35.8	35.5	37.3	35.8	34.9	33.7	33.2	33.3	33.3
5	35.5	36.5	36.5	38.7	36.5	36.1	36.1	34.2	35.5	35.5
6	36.8	37.6	37.6	41.0	37.6	37.3	37.0	35.7	36.8	36.8
7	38.1	37.6	37.6	41.2	37.6	37.8	38.1	39.5	38.1	38.1
8	38.7	38.9	39.0	47.7	38.9	38.9	38.4	38.5	38.7	38.7
9	39.8	39.4	39.4		39.4	39.4	39.4		39.8	39.8
10	40.0	40.6	40.6		40.6	40.6	39.8	41.5	40.0	40.0
11	40.7	41.8	41.2		41.8	41.8	39.5	37.5	40.7	40.7
12	41.3	42.3	42.3		42.3	42.3	41.5		41.3	41.3
13	41.5	41.2	41.2		41.2	41.2	42.0		41.5	41.5
14	42.9			45.5	45.5	45.5	43.6	45.5	42.9	42.9
15	42.8					40.1	40.1		42.8	42.8

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0		20.1	20.1					20.1		20.1
1	25.5	25.8	25.8		27.0	26.3	26.3	25.8		25.8
2	28.4	28.7	28.3		30.1	29.2	28.8	30.0	29.5	29.7
3	30.3	30.8	30.6		33.2	30.4	30.3	32.0	31.0	31.1
4	35.6	33.1	33.0		35.7	32.2	31.3	33.9	34.5	34.4
5	36.2	34.4	34.4		37.3	34.7	31.9	34.6	32.9	33.0
6	33.5	36.6	36.6		40.7	32.6	32.6	35.0	36.5	36.5
7	38.6	37.5	37.5		38.3	33.5	31.6	34.9	36.5	36.5
8	38.2	38.8			49.5	34.7	34.7			
9	39.4	39.9			36.5	36.5	33.7	41.5	41.5	41.5
10	40.3	38.5	38.5							
11	41.0									
12	41.4									
13	41.9									
14	42.5									
15	40.1					37.1	37.1			

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0				24.3	24.7		23.5	23.5	23.6
1			26.4	27.7	26.2		25.5	25.5	25.0
2		29.5	29.4	29.8	28.0		27.7	30.4	29.2
3		31.0	31.2	32.5	30.6		31.9	33.6	31.7
4		34.5	33.6	33.1	33.6		33.5	35.1	33.9
5		32.9	34.7	34.1	34.3		33.9	36.2	35.6
6		36.5	36.5	38.6	36.8		37.2	37.5	36.9
7		36.5	36.6	39.6	38.1		38.5	38.3	37.9
8			38.3	39.0	38.4		38.6	39.5	38.8
9		41.5	38.0	39.5	39.2		39.0	40.5	39.4
10			41.0	41.2	39.3		39.1	41.5	40.1
11			42.5	43.5	40.4		40.5	43.7	41.4
12			42.5	42.5	41.3		41.3		41.6
13					42.1		42.3		41.3
14					42.7		42.7		44.5
15									42.6

Table 2.4.4.1 NE Atlantic Mackerel. Mean length (cm) at age by area (cont.).

Quarter 4

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0	20.5	20.5	20.5		20.5	20.5	20.5			
1	27.4	28.0	28.0	27.7	28.0	27.8	27.4	27.7		
2	30.0	31.3	31.3	31.4	31.3	31.5	31.0	30.1		
3	31.7	33.6	33.6	34.1	33.6	33.7	33.5	31.9		
4	33.3	35.0	34.9	36.7	34.9	35.8	36.0	34.6		
5	35.5	36.2	36.2	38.7	36.2	36.5	36.7	34.0		
6	36.8	36.9	36.9	41.1	36.9	37.2	37.5	34.3		
7	38.1	38.1	38.1	42.2	38.1	38.4	38.4	35.8		
8	38.7	39.1	39.1	43.6	39.1	39.0	38.4	38.5		
9	39.8	40.1	40.1	44.4	40.1	40.0	39.5			
10	40.0	40.3	40.3	41.5	40.3	40.4	39.8	41.5		
11	40.7	40.4	40.4	40.5	40.4	39.8	40.6	37.5		
12	41.3	40.4	40.4	41.5	40.4	40.8	41.4			
13	41.5	41.6	41.6	41.5	41.6	41.8	42.2			
14	42.9	42.0	42.0		42.0	42.2	42.5			
15	42.8	43.0	43.0		43.0	42.7	40.1			

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0		20.1	20.1	20.1		21.5	21.5	20.1		20.1
1	25.6	25.9	25.8	25.7	27.7	27.3	26.8	25.8		27.5
2	29.4	30.0	29.8	29.7	29.9	29.0	29.8	30.0		29.6
3	31.3	32.0	31.6	31.7	31.9	33.2	30.6	32.0		33.6
4	35.7	33.8	33.5	34.6	34.1	32.0	32.0	33.8		33.4
5	36.4	34.7	34.4	35.4	33.6	33.4	33.3	34.7		34.6
6	36.6	34.6	36.5	35.3	33.9	34.3	32.3	34.6		34.9
7	39.9	34.5	37.3	36.8	34.5	37.6	37.3	34.5		35.6
8	38.1	39.5		37.9		39.5	39.5	39.5		39.5
9	39.7	39.5				35.8	30.5	39.5		39.5
10	40.8	41.5	38.5	40.9		41.5	41.5	41.5		41.5
11	43.6			44.5		40.4				
12	41.4					40.4				
13	41.5			41.5		41.6				
14	42.5					42.0				
15	40.1					43.0				

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0			20.1	21.8	22.1		22.1	22.1	22.0
1		27.3	27.7	26.3	26.4		25.3	27.4	27.0
2		29.0	29.8	30.7	28.6		27.7	30.8	30.8
3		37.1	33.6	32.4	31.7		30.1	34.0	33.4
4		32.0	34.0	32.9	32.9		32.9	35.4	35.7
5		36.5	34.8	33.9	33.6		33.2	36.2	36.5
6		36.9	35.6	38.4	35.9		38.0	37.5	37.1
7		37.8	37.5	39.4	37.0		39.1	38.5	38.4
8		39.5	38.6	38.5	38.0		38.9	39.7	39.0
9		39.5	38.8	39.2	38.6		39.0	40.5	40.0
10		41.5	41.5	40.8	38.6		38.9	40.7	40.3
11				43.2	40.6		40.2	43.2	39.8
12				42.5	41.3		40.6		40.8
13					42.5		41.5		41.8
14					42.9				42.2
15									42.7

Table 2.4.4.2 NE Atlantic Mackerel. Percentage length composition in catches by country and gear, 2007. Zeros represent values <1%.

Len (cm)	DK – all IVa	NL – PTF	PT – ALL	RU – PT	IE – PTF	NO – PS	UKS – all IVa	UKS – all VIa	UKS – all VIIb	UKS – all VIIj	UKS – IVa Dis	UKS – VIa Dis	UKS – VIIb Dis	DE – PTF	ES – PS	ES – Trwl	ES – Artisanal	UKE – Lines	IC – All
10			0																
11																			
12																			
13																			
14																			
15																			
16																			
17														0					
18			0		0										0	0			
19			0		0			0						0	0	7		0	0
20		0	0		0	0		0						0	0	12	0		
21		0	2		0	0		0						0	6	2	0		
22	0	0	3		0	0		0						0	5	0	0		
23		0	2		0	0		0						0	3	2	0	0	
24		0	5	0	1	0	0	0						0	4	5	0	4	
25		0	6	0	2	0	0	0						0	6	5	0	9	
26	0	6	4	0	2	0	0	0			0	0		0	5	5	0	7	
27	0	10	4	0	2	0	0	1			3	0		1	3	1	0	8	
28	0	7	4	2	2	0	0	1	0		1			2	3	2	0	10	0
29	0	7	5	4	4	1	1	1	0		2	0		2	3	2	0	13	0
30	0	6	5	9	4	2	4	2	0	3	4	0		3	2	5	1	14	1
31	1	6	6	9	6	3	4	2	2	3	8	0	1	6	3	6	3	9	1
32	2	7	10	10	7	5	6	5	4	4	9	3	4	7	4	9	4	7	5
33	4	7	11	10	7	7	8	7	8	6	9	5	10	8	5	8	7	5	6
34	10	7	10	9	9	9	9	12	15	17	12	16	13	10	7	6	10	4	7
35	13	8	7	9	12	11	12	17	19	23	13	20	19	12	9	5	14	4	15
36	19	8	8	10	13	13	15	17	18	16	13	19	19	15	10	4	16	2	12
37	17	7	4	10	11	15	14	13	16	13	10	17	19	12	8	4	15	2	13
38	12	4	3	7	7	12	10	9	9	5	9	8	8	8	6	2	11	0	10
39	8	3	0	4	4	8	6	5	5	4	4	5	5	5	4	2	8	0	9
40	6	3	0	3	3	5	3	3	2	3	2	3	2	3	2	3	5	0	8
41	4	0	0	1	2	3	2	2	1	0	0	3	0	2	1	3	3	0	4
42	3	0	0	0	0	1	1	0	0	1	0	0	0	0	0	2	1	0	4
43	0	0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	2
44	0	0	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	0		
46			0		0	0		0							0		0		0
47			0											0					
48			0			0													
49						0													
50																			
51																	0		

Table 2.4.5.1 NE Atlantic Mackerel. Mean weight (kg) at age by area.

Quarters 1−4

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0	0.083	0.083	0.083		0.083	0.083	0.083	0.083		
1	0.172	0.118	0.112	0.110	0.165	0.149	0.114	0.099	0.175	0.175
2	0.268	0.233	0.199	0.219	0.252	0.243	0.206	0.192	0.273	0.266
3	0.322	0.346	0.330	0.363	0.343	0.340	0.262	0.235	0.323	0.322
4	0.379	0.438	0.409	0.476	0.410	0.424	0.366	0.303	0.378	0.379
5	0.459	0.479	0.477	0.534	0.463	0.459	0.431	0.321	0.460	0.458
6	0.508	0.524	0.523	0.602	0.497	0.489	0.439	0.359	0.509	0.507
7	0.549	0.505	0.504	0.691	0.516	0.530	0.524	0.464	0.549	0.549
8	0.583	0.571	0.575	0.903	0.569	0.560	0.532	0.464	0.583	0.583
9	0.630	0.600	0.599	0.777	0.603	0.607	0.589		0.632	0.631
10	0.665	0.612	0.617	0.702	0.594	0.587	0.549	0.528	0.665	0.665
11	0.643	0.680	0.661	0.643	0.635	0.584	0.588	0.434	0.643	0.642
12	0.698	0.729	0.734	0.702	0.671	0.654	0.690		0.698	0.697
13	0.701	0.649	0.649	0.702	0.652	0.670	0.717		0.702	0.702
14	0.753	0.780	0.780	0.729	0.779	0.753	0.750	0.729	0.753	0.753
15	0.769	0.743	0.743		0.743	0.746	0.782		0.759	0.771

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0		0.048	0.048	0.048		0.068	0.068	0.048		0.048
1	0.111	0.120	0.109	0.118	0.093	0.147	0.131	0.120		0.161
2	0.175	0.182	0.203	0.241	0.169	0.194	0.161	0.207	0.248	0.178
3	0.246	0.236	0.256	0.282	0.213	0.239	0.202	0.262	0.293	0.232
4	0.364	0.286	0.353	0.374	0.297	0.249	0.234	0.342	0.377	0.321
5	0.389	0.319	0.364	0.393	0.323	0.322	0.264	0.383	0.399	0.357
6	0.423	0.368	0.407	0.456	0.316	0.332	0.278	0.423	0.463	0.423
7	0.485	0.373	0.452	0.502	0.464	0.331	0.313	0.487	0.505	0.502
8	0.502	0.527	0.496	0.579	0.478	0.506	0.321	0.588	0.590	0.482
9	0.547	0.579	0.542	0.621	0.497	0.345	0.306	0.611	0.619	0.543
10	0.593	0.399	0.512	0.609	0.604	0.619	0.593	0.608	0.609	0.520
11	0.595	0.621	0.547	0.611	0.502	0.582	0.640	0.612	0.611	0.617
12	0.574	0.655	0.565			0.556	0.655	0.655		0.649
13	0.655	0.600	0.588	0.679	0.574	0.657	0.600	0.600		0.631
14	0.629	0.845	0.612			0.623	0.845	0.845		0.709
15	0.650		0.678		0.512	0.438	0.430			0.657

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IxaN	IXaCN	Total
0			0.048	0.086	0.097	0.048	0.095	0.076	0.093
1		0.140	0.154	0.093	0.089	0.120	0.117	0.122	0.121
2	0.253	0.180	0.195	0.144	0.158	0.207	0.140	0.220	0.218
3	0.297	0.227	0.234	0.249	0.194	0.241	0.197	0.289	0.295
4	0.378	0.325	0.314	0.303	0.289	0.346	0.294	0.336	0.369
5	0.400	0.352	0.337	0.331	0.347	0.383	0.317	0.375	0.408
6	0.466	0.391	0.403	0.384	0.432	0.447	0.371	0.414	0.453
7	0.506	0.522	0.408	0.432	0.502	0.629	0.428	0.452	0.505
8	0.591	0.412	0.429	0.430	0.499	0.445	0.433	0.479	0.529
9	0.621	0.499	0.499	0.480	0.524		0.466	0.526	0.569
10	0.609	0.623	0.436	0.472	0.526		0.470	0.548	0.575
11	0.611	0.638	0.546	0.520	0.547		0.491	0.710	0.587
12		0.652	0.621	0.611	0.568		0.510		0.632
13		0.600		0.715	0.569		0.535		0.663
14		0.842	0.614	0.621	0.583		0.588		0.713
15				0.969					0.726

Table 2.4.5.1 NE Atlantic Mackerel. Mean weight (kg) at age by area (cont.).

Quarter 1

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0	0.083	0.083			0.083					
1	0.192	0.192			0.192	0.082	0.083	0.078		
2	0.269	0.269			0.269	0.168	0.172	0.153		
3	0.346	0.346			0.346	0.234	0.229	0.188		
4	0.398	0.398			0.398	0.306	0.262	0.234		
5	0.455	0.455			0.455	0.362	0.313	0.310		
6	0.477	0.477			0.477	0.378	0.369	0.245		
7	0.524	0.524			0.524	0.435		0.475		
8	0.567	0.567			0.567	0.507	0.510			
9	0.609	0.609			0.609	0.532				
10	0.589	0.589			0.589	0.471				
11	0.579	0.579			0.579	0.514				
12	0.601	0.601			0.601	0.493				
13	0.659	0.659			0.659	0.633				
14	0.780	0.780			0.780	0.773				
15	0.743	0.743			0.743					

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0										
1	0.077		0.036		0.078	0.078	0.120	0.060		0.060
2	0.157		0.215	0.253	0.153	0.180	0.146	0.143	0.253	0.143
3	0.248		0.259	0.282	0.188	0.226	0.191	0.222	0.297	0.225
4	0.360		0.359	0.374	0.234	0.213	0.270	0.319	0.378	0.332
5	0.389		0.369	0.393	0.311	0.344	0.340	0.344	0.400	0.362
6	0.423		0.417	0.456	0.245	0.374	0.347	0.424	0.466	0.432
7	0.483		0.458	0.502	0.475	0.592	0.571	0.469	0.506	0.522
8	0.503		0.496	0.579	0.520	0.457	0.379	0.528	0.591	0.488
9	0.547		0.542	0.621		0.537	0.423	0.552	0.621	0.543
10	0.590		0.597	0.609	0.466	0.391		0.568	0.609	0.516
11	0.588		0.547	0.611	0.499	0.583		0.640	0.611	0.617
12	0.573		0.565			0.555		0.655		0.649
13	0.655		0.588		0.683	0.656		0.600		0.631
14	0.628		0.612			0.615		0.845		0.709
15	0.655		0.678			0.655				0.657

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IxaCN	Total
0						0.048			0.048
1		0.078	0.113	0.073	0.061	0.120	0.074	0.063	0.070
2	0.253	0.151	0.181	0.131	0.115	0.207	0.116	0.160	0.149
3	0.297	0.215	0.231	0.243	0.192	0.242	0.211	0.249	0.237
4	0.378	0.340	0.320	0.299	0.313	0.351	0.296	0.277	0.333
5	0.400	0.360	0.341	0.327	0.366	0.386	0.318	0.296	0.368
6	0.466	0.412	0.407	0.380	0.436	0.450	0.368	0.347	0.413
7	0.506	0.597	0.410	0.426	0.505	0.645	0.424	0.389	0.474
8	0.591	0.408	0.429	0.426	0.502	0.446	0.430	0.438	0.488
9	0.621	0.551	0.505	0.474	0.528		0.462	0.463	0.538
10	0.609	0.555	0.436	0.468	0.528		0.467	0.502	0.553
11	0.611	0.638	0.546	0.517	0.550		0.485	0.598	0.572
12		0.652	0.622	0.614	0.570		0.498		0.574
13		0.600		0.735	0.572		0.524		0.639
14		0.842	0.614	0.632	0.585		0.599		0.636
15				0.969					0.656

Table 2.4.5.1 NE Atlantic Mackerel. Mean weight (kg) at age by area (cont.).

Quarter 2

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0		0.083					0.083	0.083		
1	0.156	0.113	0.156	0.083	0.086	0.084	0.101	0.084		
2	0.232	0.207	0.231	0.172	0.175	0.173	0.175	0.166		0.232
3	0.307	0.343	0.347	0.229	0.278	0.254	0.233	0.216		0.307
4	0.393	0.440	0.449	0.262	0.420	0.388	0.284	0.254		0.392
5	0.438	0.482	0.483	0.313	0.473	0.453	0.340	0.312		0.438
6	0.484	0.528	0.529	0.369	0.505	0.479	0.377	0.331		0.484
7	0.552	0.503	0.502		0.502	0.495	0.448	0.475		0.552
8	0.574	0.572	0.571	0.510	0.567	0.558	0.518	0.510		0.574
9	0.626	0.599	0.599		0.599	0.599	0.599			0.626
10	0.699	0.621	0.621		0.621	0.513	0.470			0.701
11	0.637	0.685	0.688		0.688	0.653	0.474	0.321		0.636
12	0.688	0.737	0.737		0.737	0.737	0.737			0.688
13	0.648	0.648	0.648		0.648	0.652	0.670			
14										
15	0.851									0.851

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0										
1	0.060	0.060			0.065	0.083	0.120			0.060
2	0.152	0.163	0.253		0.158	0.179	0.146	0.249	0.181	0.181
3	0.226	0.235	0.297		0.217	0.230	0.182	0.293	0.229	0.229
4	0.328	0.337	0.378		0.285	0.195	0.219	0.377	0.269	0.269
5	0.378	0.368	0.400		0.318	0.282	0.253	0.400	0.301	0.301
6	0.415	0.435	0.466		0.370	0.312	0.277	0.465	0.340	0.341
7	0.448	0.484	0.506		0.432	0.431	0.266	0.505	0.443	0.443
8	0.470	0.550	0.591		0.451	0.450	0.312	0.590	0.422	0.423
9	0.547	0.597	0.621		0.541		0.425	0.621		0.552
10	0.619	0.601	0.609		0.605	0.364	0.568	0.609		0.568
11	0.507	0.621	0.611		0.502		0.640	0.611		0.640
12	0.748	0.655					0.655			0.655
13	0.585	0.600			0.574		0.600			0.600
14	0.609	0.845					0.845			0.845
15	0.512				0.512					

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0									0.083
1				0.076	0.112		0.079	0.068	0.087
2		0.181	0.186	0.135	0.149	0.181	0.121	0.153	0.163
3		0.229	0.230	0.267	0.176	0.229	0.161	0.239	0.233
4		0.269	0.271	0.314	0.262	0.269	0.278	0.268	0.302
5		0.301	0.276	0.339	0.331	0.301	0.318	0.302	0.344
6		0.340	0.322	0.392	0.430	0.340	0.384	0.355	0.402
7		0.443	0.385	0.441	0.502	0.443	0.448	0.388	0.458
8		0.422	0.429	0.435	0.496	0.422	0.445	0.416	0.453
9			0.505	0.488	0.520		0.490	0.460	0.521
10			0.378	0.476	0.522		0.487	0.485	0.498
11			0.515	0.523	0.540		0.514	0.593	0.561
12			0.627	0.608	0.563		0.544		0.628
13				0.689	0.560		0.554		0.588
14			0.614	0.612	0.578		0.579		0.595
15									0.651

Table 2.4.5.1 NE Atlantic Mackerel. Mean weight (kg) at age by area (cont.).

Quarter 3

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0		0.083	0.083				0.083			
1	0.172	0.115	0.112	0.130	0.149	0.099	0.130	0.102	0.175	0.175
2	0.273	0.218	0.198	0.234	0.226	0.209	0.215	0.209	0.273	0.273
3	0.323	0.346	0.327	0.388	0.346	0.298	0.259	0.257	0.323	0.323
4	0.378	0.446	0.404	0.487	0.448	0.392	0.340	0.312	0.378	0.378
5	0.460	0.483	0.476	0.546	0.483	0.456	0.439	0.343	0.460	0.460
6	0.510	0.529	0.524	0.655	0.529	0.514	0.478	0.437	0.509	0.509
7	0.549	0.502	0.504	0.691	0.502	0.511	0.526	0.587	0.549	0.549
8	0.583	0.571	0.576	1.195	0.571	0.561	0.538	0.415	0.583	0.583
9	0.631	0.599	0.599		0.599	0.599	0.587		0.632	0.632
10	0.664	0.621	0.621		0.621	0.620	0.608	0.528	0.665	0.665
11	0.644	0.687	0.656		0.688	0.688	0.585	0.435	0.643	0.643
12	0.699	0.737	0.737		0.737	0.737	0.692		0.698	0.698
13	0.701	0.648	0.648		0.648	0.649	0.717		0.702	0.702
14	0.753			0.729	0.729	0.729	0.744	0.729	0.753	0.753
15	0.759					0.782	0.782		0.759	0.759

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0		0.048	0.048					0.048		0.048
1	0.139	0.120	0.120		0.146	0.144	0.133	0.120		0.120
2	0.188	0.180	0.174		0.228	0.197	0.182	0.207	0.204	0.205
3	0.231	0.236	0.234		0.328	0.225	0.217	0.260	0.220	0.224
4	0.402	0.279	0.276		0.418	0.266	0.242	0.319	0.306	0.307
5	0.440	0.317	0.316		0.473	0.338	0.257	0.347	0.296	0.297
6	0.390	0.367	0.367		0.634	0.278	0.278	0.353	0.357	0.357
7	0.547	0.366	0.365		0.529	0.265	0.245	0.349	0.399	0.399
8	0.527	0.490			1.352	0.340	0.340			
9	0.585	0.564			0.340	0.340	0.305	0.487	0.487	0.487
10	0.623	0.397	0.397							
11	0.675									
12	0.687									
13	0.712									
14	0.753									
15	0.782					0.430	0.430			

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0				0.117	0.123		0.107	0.092	0.107
1			0.146	0.171	0.146		0.135	0.125	0.125
2		0.204	0.200	0.210	0.178		0.172	0.228	0.221
3		0.220	0.233	0.269	0.235		0.261	0.310	0.310
4		0.306	0.284	0.285	0.299		0.298	0.359	0.377
5		0.296	0.325	0.306	0.318		0.308	0.401	0.454
6		0.357	0.359	0.445	0.393		0.405	0.449	0.504
7		0.399	0.368	0.479	0.433		0.445	0.484	0.530
8			0.414	0.458	0.440		0.446	0.536	0.573
9		0.487	0.390	0.476	0.468		0.459	0.583	0.595
10			0.511	0.537	0.469		0.463	0.634	0.641
11			0.571	0.631	0.510		0.512	0.759	0.672
12			0.571	0.587	0.542		0.542		0.710
13					0.571		0.580		0.675
14					0.596		0.597		0.738
15									0.753

Table 2.4.5.1 NE Atlantic Mackerel. Mean weight (kg) at age by area (cont.).

Quarter 4

Ages	IIa	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	Va	Vb
0	0.083	0.083	0.083		0.083	0.083	0.083			
1	0.183	0.192	0.192	0.175	0.192	0.186	0.175	0.165		
2	0.273	0.269	0.269	0.270	0.269	0.276	0.264	0.213		
3	0.323	0.347	0.346	0.363	0.346	0.349	0.346	0.259		
4	0.378	0.401	0.398	0.463	0.398	0.428	0.438	0.348		
5	0.460	0.456	0.455	0.537	0.455	0.460	0.462	0.301		
6	0.509	0.479	0.477	0.640	0.477	0.485	0.498	0.301		
7	0.549	0.525	0.524	0.691	0.524	0.535	0.538	0.368		
8	0.583	0.568	0.567	0.743	0.567	0.561	0.540	0.415		
9	0.632	0.609	0.609	0.777	0.609	0.610	0.589			
10	0.663	0.589	0.589	0.702	0.589	0.591	0.607	0.528		
11	0.642	0.579	0.579	0.643	0.579	0.563	0.647	0.435		
12	0.698	0.601	0.601	0.702	0.601	0.635	0.687			
13	0.702	0.659	0.659	0.702	0.659	0.683	0.736			
14	0.753	0.780	0.780		0.780	0.769	0.753			
15	0.759	0.743	0.743		0.743	0.746	0.782			

Ages	VIa	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj
0		0.048	0.048	0.048		0.068	0.068	0.048		0.048
1	0.116	0.121	0.120	0.118	0.165	0.157	0.146	0.120		0.162
2	0.196	0.207	0.203	0.202	0.207	0.190	0.210	0.207		0.201
3	0.245	0.260	0.252	0.253	0.260	0.308	0.230	0.260		0.312
4	0.398	0.319	0.300	0.350	0.333	0.270	0.271	0.319		0.312
5	0.429	0.350	0.321	0.378	0.292	0.311	0.308	0.350		0.341
6	0.440	0.352	0.366	0.383	0.278	0.338	0.275	0.352		0.326
7	0.596	0.338	0.364	0.446	0.312	0.472	0.445	0.338		0.371
8	0.501	0.554		0.489		0.554	0.554	0.554		0.554
9	0.602	0.547				0.414	0.225	0.547		0.547
10	0.642	0.639	0.397	0.643		0.639	0.639	0.639		0.639
11	0.825			0.881		0.579				
12	0.690					0.601				
13	0.682			0.679		0.659				
14	0.753					0.780				
15	0.782					0.743				

Ages	VIIk	VIIIa	VIIIb	VIIIcE	VIIIcW	VIIId	IXaN	IXaCN	Total
0			0.048	0.086	0.089		0.089	0.076	0.088
1		0.157	0.165	0.147	0.150		0.133	0.164	0.162
2		0.188	0.204	0.215	0.189		0.172	0.244	0.252
3		0.425	0.298	0.255	0.256		0.221	0.338	0.336
4		0.269	0.298	0.272	0.283		0.281	0.388	0.421
5		0.438	0.316	0.298	0.299		0.290	0.419	0.456
6		0.417	0.334	0.436	0.365		0.428	0.473	0.480
7		0.489	0.398	0.466	0.398		0.465	0.518	0.533
8		0.554	0.432	0.433	0.427		0.457	0.577	0.559
9		0.547	0.440	0.463	0.446		0.460	0.617	0.609
10		0.639	0.639	0.517	0.448		0.458	0.630	0.588
11				0.601	0.517		0.502	0.772	0.567
12				0.571	0.541		0.514		0.635
13					0.587		0.548		0.683
14					0.604				0.769
15									0.746

Table 2.5.2.1 Bayesian model to estimate catch factors

```
# Mackerel assessment 2008 with added factor analysis for missing catch
model
{
for (i in 1:I3) {
FAV[i] ~ dunif(.001,2) # i1 number of years of catch
}
# selection function priors−alternative to current selection
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
QMstar~dgamma(1.5,0.5)
QM<-QMstar
QC~dunif(0.1,30)
#QCS~dnorm(0,25)
QCS<-2.4
MB~dunif(2,11)
for (i in 1:(I3−1)) {
Nstar[i] ~ dnorm(80000,.000000000000064)
}
for (i in 1:I2){
Nin[i]<-45000*pow(10,i/5)
Nvar[i]<-.00001/pow(Nin[i]/4,2)
Nstar2[i] ~ dnorm(Nin[i],Nvar[i])
}
# Define the observation priors
tauy ~ dgamma(0.001,0.001)
sigy <- pow(1/tauy,.5)
taum ~ dgamma(0.001,0.001)
sigm <- pow(1/taum,.5)
#taus ~ dgamma(0.001,0.001)
taus<-0.1225
sigs <- pow(1/taus,.5)
MJ~dunif(0,10)
MD<-round(MB)
for (j in 1:12){
flag[j]<-step(j-MD)
}
for (i in 1:33){
for (j in 1:12){
Mstar[j,i]<-QM*MS[j,i]*(1+(j-MB)*(1-MJ)/(MJ-12)*flag[j])
M[j,i]<-max(Mstar[j,i],0)
}
MP[i]<-M[1,i]
}
```

Table 2.5.2.1 (cont.) Bayesian model to estimate catch factors

```
################# main algorithm
## Selection curve
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]
}
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])))
}
# set up year based catch multiplier
QCSstar[1]~dnorm(0,QCS)
QCYstar[1]<-QC+QCSstar[1]
for (i in 2:33){
QCSstar[i]~dnorm(0,QCS)
QCYstar[i] <- QC+QCSstar[i] ### add in random component
}
for (i in 1:I1){
QCY[i] <- max(QCYstar[i],1) ### clip to a minimum of *1
}
######### population component of the likelihood
# Define the system process for the population data
# stop any negative population numbers
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)
}
### set op selection period first
# start with matrix of Fs
for (i in 1:I3){
for (j in 1:I2){
F[j,i]<-FA[j,i]*FAV[i] # fishing mortality
INTF[j,i]<-F[j,i]/FA[j,i]
}
FP[i]<-FAP[i]*FAV[i] # 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])
}
}
for (i in 1:I3){
NP[i]<-QCY[i]*CANUMP[i]*(FP[i]+QM*MP[i])/FP[i]/(1-exp(-FP[i]-QM*MP[i]))
}
```

Table 2.5.2.1 (cont.) Bayesian model to estimate catch factors

```
#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])+QCY[i]*CANUM[j,i]*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]
}
# 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,I3]
FP[i]<-FAV[i]*FAP[I3]
# then set Ns fopr oldest ages
N[1,i]<-QCY[i]*CANUM[1,i]*(F[1,i]+QM*M[1,i])/F[1,i]/(1-exp(-F[1,i]-QM*M[1,i]))
NP[i]<-QCY[i]*CANUMP[i]*(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
}
for (i in 1:MEST) {
ObsMESMod[i]<-log(SSB[i*3−2])
#ObsMESMod[i]<-log(SSB[i*3−2]*QMES)
ObsMES[i] ~ dnorm(ObsMESMod[i],tauM[i])
}
# 2 Catch ##### assuming 25 survey values !!!!
# dont bother with 0 group
for (i in 1:I3){
for (j in 1:(I2−1)){
ObsCatchMod[j,i]<-log((N[j,i]*F[j,i]/(F[j,i]+QM*M[j,i])*(1-exp(-F[j,i]-QM*M[j,i])))/QCY[i])
for (k in 1:CatchWT[j]){
ObsCatch[j,i] ~ dnorm(ObsCatchMod[j,i],tauy) # using tauy[j] as age dependent variance
}
}
}
# 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 2.7.1.1 CATCH IN NUMBER

Units : Thousands

year

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	10707	16997	29277	36171	62510	6077	34623	114529	33101	56682
1	34979	46267	108077	62908	282818	175220	34513	360698	411327	276229
2	51652	74544	47410	92385	249293	328732	560738	62909	393025	502365
3	194461	109015	155390	84509	374245	226560	449338	609522	64549	231814
4	650980	415015	148543	265129	176793	236116	279236	385578	328206	32814
5	0	814518	424462	164673	314261	67758	282158	250755	254172	184867
6	0	0	673317	251420	133822	186619	78877	248099	142978	173349
7	0	0	0	991632	379790	105004	172213	92655	145385	116328
8	0	0	0	0	478925	229803	73933	169605	54778	125548
9	0	0	0	0	0	236966	127975	73900	130771	41186
10	0	0	0	0	0	0	243333	102363	39920	146186
11	0	0	0	0	0	0	0	204291	56210	31639
12	0	0	0	0	0	0	0	0	104927	199615

year

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	11180	7333	287287	81799	49983	7403	57644	65400	24246	10007
1	213936	47914	31901	268960	58126	40126	152656	64263	140534	58459
2	432867	668909	86064	20893	424563	156670	137635	312739	209848	212521
3	472457	433744	682491	58346	38387	663378	190403	207689	410751	206421
4	184581	373262	387582	445357	76545	56680	538394	167588	208146	375451
5	26544	126533	251503	252217	364119	89003	72914	362469	156742	188623
6	138970	20175	98063	165219	208021	244570	87323	48696	254015	129145
7	112476	90151	22086	62363	126174	150588	201021	58116	42549	197888
8	89672	72031	61813	19562	42569	85863	122496	111251	49698	51077
9	88726	48668	47925	47560	13533	34795	55913	68240	85447	43415
10	27552	49252	37482	37607	32786	19658	20710	32228	33041	70839
11	91743	19745	30105	26965	22971	25747	13178	13904	16587	29743
12	156121	132040	69183	97652	81153	63146	57494	35814	27905	52986

year

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	43447	19354	25368	14759	37956	36012	61127	67003	36345	26034
1	83583	128144	147315	81529	119852	144390	99352	73597	102407	40315
2	156292	210319	221489	340898	168882	186481	229767	132994	142898	158943
3	356209	266677	306979	340215	333365	238426	264566	223639	275376	234186
4	266591	398240	267420	275031	279182	378881	323186	261778	390858	297206
5	306143	244285	301346	186855	177667	246781	361945	281041	295516	309937
6	156070	255472	184925	197856	96303	135059	207619	244212	241550	231804
7	113899	149932	189847	142342	119831	84378	118388	159019	175608	195250
8	138458	97746	106108	113413	55812	66504	72745	86739	106291	120241
9	51208	121400	80054	69191	59801	39450	47353	50613	52394	72205
10	36612	38794	57622	42441	25803	26735	24386	30363	31280	42529
11	40956	29067	20407	37960	18353	13950	16551	17048	18918	20546
12	68205	68217	57551	39753	30648	24974	22932	32446	34202	40706

year

age	2002	2003	2004	2005	2006	2007	2008
0	70409	14409	5168	5014	58294	15374	NA
1	222214	182121	24617	44235	69303	79398	NA
2	69728	265153	425834	131909	165134	189765	NA
3	366981	88950	499455	661629	156631	227859	NA
4	349853	290227	142792	289505	468403	204001	NA
5	262485	230568	244885	118453	194147	448612	NA
6	236927	180479	137998	119907	96817	200620	NA
7	151241	132355	83997	63297	73749	75312	NA
8	118814	93165	61426	38025	33234	58619	NA
9	79919	74779	37614	23744	18785	28301	NA
10	43776	45793	32816	18703	13951	16451	NA
11	21606	25691	15385	7863	8313	11796	NA
12	40260	30887	18151	10558	10071	13548	NA

Table 2.7.1.2 WEIGHTS AT AGE IN THE CATCH

Units : Kg

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.052	0.050	0.051	0.050	0.059	0.056	0.036	0.016	0.057	0.060	0.053
1	0.135	0.145	0.136	0.148	0.137	0.136	0.135	0.137	0.131	0.132	0.131
2	0.277	0.194	0.229	0.177	0.207	0.169	0.161	0.161	0.249	0.248	0.249
3	0.341	0.285	0.261	0.259	0.263	0.275	0.250	0.243	0.285	0.287	0.285
4	0.423	0.368	0.334	0.323	0.320	0.333	0.325	0.318	0.345	0.344	0.345
5	0.000	0.448	0.392	0.348	0.346	0.352	0.345	0.348	0.378	0.377	0.378
6	0.000	0.000	0.481	0.430	0.406	0.407	0.403	0.401	0.454	0.454	0.454
7	0.000	0.000	0.000	0.488	0.443	0.446	0.421	0.416	0.498	0.499	0.496
8	0.000	0.000	0.000	0.000	0.518	0.546	0.518	0.506	0.520	0.513	0.513
9	0.000	0.000	0.000	0.000	0.000	0.537	0.536	0.513	0.542	0.543	0.541
10	0.000	0.000	0.000	0.000	0.000	0.000	0.529	0.537	0.574	0.573	0.574
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.522	0.590	0.576	0.574
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.580	0.584	0.582

age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.050	0.031	0.055	0.039	0.076	0.055	0.049	0.085	0.068	0.051	0.061
1	0.168	0.102	0.144	0.146	0.179	0.133	0.136	0.156	0.156	0.167	0.134
2	0.219	0.184	0.262	0.245	0.223	0.259	0.237	0.233	0.253	0.239	0.240
3	0.276	0.295	0.357	0.335	0.318	0.323	0.320	0.336	0.327	0.333	0.317
4	0.310	0.326	0.418	0.423	0.399	0.388	0.377	0.379	0.394	0.397	0.376
5	0.386	0.344	0.417	0.471	0.474	0.456	0.433	0.423	0.423	0.460	0.436
6	0.425	0.431	0.436	0.444	0.512	0.524	0.456	0.467	0.469	0.495	0.483
7	0.435	0.542	0.521	0.457	0.493	0.555	0.543	0.528	0.506	0.532	0.527
8	0.498	0.480	0.555	0.543	0.498	0.555	0.592	0.552	0.554	0.555	0.548
9	0.545	0.569	0.564	0.591	0.580	0.562	0.578	0.606	0.609	0.597	0.583
10	0.606	0.628	0.629	0.552	0.634	0.613	0.581	0.606	0.630	0.651	0.595
11	0.608	0.636	0.679	0.694	0.635	0.624	0.648	0.591	0.649	0.663	0.647
12	0.614	0.663	0.710	0.688	0.718	0.697	0.739	0.713	0.708	0.669	0.679

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	0.046	0.072	0.058	0.076	0.065	0.062	0.063	0.069	0.052	0.081	0.086
1	0.136	0.143	0.143	0.143	0.157	0.176	0.135	0.172	0.160	0.171	0.160
2	0.255	0.234	0.226	0.230	0.227	0.235	0.227	0.224	0.256	0.271	0.267
3	0.339	0.333	0.313	0.295	0.310	0.306	0.306	0.305	0.307	0.338	0.326
4	0.390	0.390	0.377	0.359	0.354	0.361	0.363	0.376	0.367	0.387	0.402
5	0.448	0.452	0.425	0.415	0.408	0.404	0.427	0.424	0.425	0.439	0.422
6	0.512	0.501	0.484	0.453	0.452	0.452	0.463	0.474	0.460	0.477	0.488
7	0.543	0.539	0.518	0.481	0.462	0.500	0.501	0.496	0.512	0.523	0.523
8	0.590	0.577	0.551	0.524	0.518	0.536	0.534	0.540	0.537	0.572	0.557
9	0.583	0.594	0.576	0.553	0.550	0.569	0.567	0.577	0.580	0.612	0.575
10	0.627	0.606	0.596	0.577	0.573	0.586	0.586	0.603	0.601	0.631	0.598
11	0.678	0.631	0.603	0.591	0.591	0.607	0.594	0.611	0.629	0.648	0.633
12	0.713	0.672	0.670	0.636	0.631	0.687	0.644	0.666	0.665	0.715	0.686

age	2005	2006	2007	2008
0	0.067	0.042	0.093	NA
1	0.149	0.099	0.121	NA
2	0.270	0.196	0.218	NA
3	0.307	0.307	0.295	NA
4	0.366	0.357	0.369	NA
5	0.434	0.428	0.408	NA
6	0.440	0.480	0.453	NA
7	0.495	0.494	0.505	NA
8	0.539	0.543	0.529	NA
9	0.556	0.584	0.569	NA
10	0.582	0.625	0.575	NA
11	0.635	0.635	0.587	NA
12	0.657	0.690	0.668	NA

Table 2.7.1.3 WEIGHTS AT AGE IN THE STOCK

Units : Kg

	year										
age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
1	0.132	0.132	0.130	0.129	0.128	0.127	0.111	0.110	0.109	0.087	0.086
2	0.178	0.177	0.173	0.171	0.170	0.167	0.175	0.174	0.173	0.186	0.135
3	0.243	0.242	0.238	0.236	0.236	0.233	0.238	0.237	0.236	0.252	0.221
4	0.411	0.301	0.296	0.294	0.293	0.289	0.300	0.299	0.297	0.313	0.280
5	0.000	0.438	0.322	0.318	0.318	0.313	0.346	0.345	0.343	0.323	0.385
6	0.000	0.000	0.469	0.365	0.365	0.361	0.382	0.380	0.379	0.378	0.353
7	0.000	0.000	0.000	0.497	0.419	0.416	0.410	0.408	0.407	0.419	0.408
8	0.000	0.000	0.000	0.000	0.512	0.446	0.432	0.430	0.429	0.434	0.437
9	0.000	0.000	0.000	0.000	0.000	0.530	0.451	0.449	0.448	0.449	0.446
10	0.000	0.000	0.000	0.000	0.000	0.000	0.514	0.504	0.503	0.443	0.479
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.516	0.508	0.523	0.526
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.518	0.531	0.534

	year										
age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.086	0.081	0.085	0.077	0.078	0.072	0.076	0.074	0.075	0.078	0.078
2	0.172	0.194	0.165	0.179	0.148	0.156	0.177	0.138	0.155	0.212	0.197
3	0.235	0.253	0.293	0.267	0.240	0.237	0.244	0.222	0.230	0.259	0.268
4	0.280	0.295	0.306	0.304	0.286	0.301	0.306	0.287	0.307	0.310	0.315
5	0.339	0.324	0.341	0.356	0.374	0.329	0.352	0.339	0.357	0.362	0.360
6	0.377	0.393	0.384	0.351	0.386	0.423	0.380	0.373	0.409	0.402	0.416
7	0.404	0.436	0.430	0.416	0.411	0.445	0.429	0.414	0.432	0.424	0.454
8	0.439	0.441	0.459	0.473	0.429	0.432	0.474	0.409	0.502	0.462	0.465
9	0.503	0.479	0.468	0.443	0.482	0.455	0.457	0.437	0.541	0.487	0.484
10	0.473	0.520	0.559	0.468	0.499	0.522	0.466	0.514	0.566	0.522	0.511
11	0.555	0.510	0.579	0.497	0.470	0.589	0.510	0.523	0.566	0.552	0.585
12	0.563	0.550	0.607	0.575	0.549	0.632	0.595	0.529	0.594	0.583	0.577

	year										
age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.079	0.081	0.076	0.076	0.077	0.081	0.074	0.078	0.078	0.074	0.059
2	0.178	0.164	0.133	0.186	0.149	0.194	0.185	0.164	0.181	0.181	0.138
3	0.237	0.267	0.251	0.228	0.223	0.242	0.235	0.241	0.239	0.273	0.246
4	0.301	0.326	0.317	0.296	0.285	0.301	0.289	0.342	0.311	0.316	0.313
5	0.361	0.398	0.366	0.361	0.342	0.353	0.350	0.390	0.364	0.371	0.355
6	0.413	0.448	0.444	0.402	0.400	0.396	0.390	0.446	0.411	0.446	0.412
7	0.466	0.491	0.462	0.445	0.426	0.423	0.426	0.459	0.436	0.446	0.463
8	0.470	0.508	0.501	0.478	0.466	0.440	0.447	0.499	0.462	0.475	0.462
9	0.483	0.546	0.565	0.519	0.502	0.485	0.485	0.529	0.500	0.584	0.508
10	0.550	0.514	0.573	0.537	0.549	0.498	0.492	0.576	0.522	0.527	0.520
11	0.608	0.619	0.611	0.532	0.524	0.465	0.532	0.603	0.533	0.599	0.538
12	0.584	0.639	0.632	0.585	0.580	0.565	0.544	0.586	0.565	0.610	0.590

	year			
age	2005	2006	2007	2008
0	0.000	0.000	0.000	NA
1	0.074	0.076	0.064	NA
2	0.168	0.178	0.169	NA
3	0.238	0.228	0.224	NA
4	0.336	0.297	0.278	NA
5	0.381	0.345	0.309	NA
6	0.401	0.391	0.363	NA
7	0.481	0.436	0.439	NA
8	0.501	0.458	0.448	NA
9	0.550	0.517	0.498	NA
10	0.550	0.523	0.517	NA
11	0.576	0.578	0.542	NA
12	0.590	0.614	0.565	NA

Table 2.7.1.4 NATURAL MORTALITY

Units : NA

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
3	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
4	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
5	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
6	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
7	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
8	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
9	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
10	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
11	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
12	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

age \ year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
3	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
4	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
5	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
6	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
7	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
8	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
9	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
10	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
11	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
12	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

age \ year	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA
1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA
2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA
3	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA
4	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA
5	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA
6	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA
7	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA
8	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA
9	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA
10	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA
11	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA
12	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	NA

Table 2.7.1.5 PROPORTION MATURE

Units : NA

year

age	1972	1973	1974	1975	1976	1977	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	0.00	0.00	0.00	0.00	0.00	0.00
1	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07
2	0.53	0.54	0.54	0.55	0.55	0.55	0.56	0.56	0.57	0.57	0.57	0.58	0.58	0.58
3	0.90	0.90	0.90	0.89	0.89	0.89	0.89	0.89	0.89	0.88	0.88	0.88	0.88	0.88
4	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.97	0.97
5	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.97	0.97
6	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
2	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
3	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.86	0.86
4	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.98	0.98
5	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.98	0.98
6	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA
1	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	NA
2	0.58	0.59	0.59	0.59	0.59	0.58	0.57	0.58	NA
3	0.86	0.88	0.88	0.88	0.88	0.89	0.89	0.86	NA
4	0.98	0.97	0.97	0.97	0.97	0.98	0.98	0.98	NA
5	0.98	0.97	0.97	0.97	0.97	0.98	0.98	0.98	NA
6	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	NA
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA

Table 2.7.1.6 SURVEY INDICES

```
 – Index Value
Units :  NA
 year
age 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
 all 0 0 0 0 0 0 0 0 0 0 0 0 0
 year
age 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996
 all 0 0 0 0 0 0 0 3370000 0 0 2840000 0
 year
age 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
 all 0 3750000 0 0 2900000 0 0 2750000 0 0 3260000
 – Index Variance (Inverse Weights)
Units :  NA
 year
age 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
 all 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1
 year
age 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997
 all 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1
 year
age 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
 all 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1
```

Table 2.7.1.7 FLICA CONFIGURATION SETTINGS

```
Sep.2 : NA
sep.gradual : TRUE
sr : FALSE
sr.age : 0
lambda.age : 0.0033333 0.033333 0.33333 0.33333 0.33333 0.33333 0.33333 0.33333
0.33333 0.33333 0.33333 0.33333 0
lambda.yr : 1 1 1 1 1 1 1 1 1 1 1 1
lambda.sr : 0.01
index.model : linear
index.cor : -9.25596313493178e+61
sep.nyr : 12
sep.age : 5
sep.sel : 1.5
```

Table 2.7.1.8 STOCK OBJECT CONFIGURATION

```
 min max plusgroup minyear maxyear
 0 12 12 1972 2008
Table 2.7.1.9 INDEX OBJECTS CONFIGURATION
""
 min max plusgroup minyear maxyear startf endf
 NA NA NA 1972 2007 NA NA
```

Table 2.7.1.10 STOCK SUMMARY

Age 0 (Age 4 – 8) SOP
[Thousands] [Thousands] [Tonnes]

Year	Recruitment	TSB	SSB	Catches	Fbar	Landings
1972	2125661	5319231	3951000	361262	0.018	
1973	4770156	5215899	4017534	570719	0.184	
1974	4006591	5096511	3845017	607473	0.210	
1975	4926801	4913323	3575426	784329	0.216	
1976	4948046	4629193	3247101	828434	0.248	
1977	973253	4326013	3074447	620016	0.194	
1978	3239264	3975816	3030718	736519	0.190	
1979	5311747	3543248	2574710	842739	0.254	
1980	5576192	3221689	2155618	734950	0.246	
1981	7259058	3350903	2188786	754045	0.224	
1982	2047300	3281357	2106210	716987	0.220	
1983	1579830	3396171	2401891	672283	0.208	
1984	7411989	3166893	2416871	641928	0.220	
1985	3344031	3361115	2370376	614371	0.216	
1986	3453388	3362094	2385306	602201	0.230	
1987	5148832	3224616	2379490	654992	0.214	
1988	3585748	3304776	2391179	680491	0.236	
1989	4400475	3384739	2469100	585920	0.178	
1990	3206044	3168286	2331762	626107	0.182	
1991	3724106	3467394	2598927	675665	0.222	
1992	4733756	3578699	2614050	760690	0.250	
1993	5591156	3506003	2450526	824568	0.310	
1994	4759308	3377440	2269098	819087	0.346	
1995	4261347	3581131	2457544	756277	0.340	
1996	4042465	3407790	2482433	563472	0.250	
1997	3125055	3541565	2586616	573029	0.242	
1998	2986243	3376638	2505093	666316	0.282	
1999	3494438	3424727	2528340	640309	0.296	
2000	1844362	3143042	2259985	738606	0.348	
2001	5236954	3018661	2195525	737463	0.392	
2002	9368840	2690213	1785046	772905	0.438	
2003	3096612	3042584	1800065	669600	0.416	
2004	4214693	2928358	1983863	650221	0.358	
2005	4715282	3387432	2499364	543486	0.256	
2006	4774485	3505760	2592116	472652	0.208	
2007	3835910	3481608	2532654	579379	0.248	
2008	3835910	NA	NA	NA	NA	NA

Table 2.7.1.11 ESTIMATED POPULATION ABUNDANCE

Units : Thousands

year

age	1972	1973	1974	1975	1976	1977	1978	1979
0	2125661	4770156	4006591	4926801	4948046	973253	3239264	5311747
1	5237618	1819650	4089958	3421372	4207015	4200894	832055	2755974
2	2112699	4475641	1523318	3420122	2886509	3359120	3453429	684185
3	4164995	1770558	3783143	1267208	2858128	2253659	2586951	2453902
4	7841134	3404720	1422977	3112236	1012440	2113792	1730049	1811201
5	0	6146255	2546477	1087291	2433280	707974	1600857	1230865
6	0	0	4536621	1799317	783547	1803606	546641	1117029
7	0	0	0	3281978	1316125	550682	1379660	397543
8	0	0	0	0	1910171	782400	376929	1028151
9	0	0	0	0	0	1201925	461419	256101
10	0	0	0	0	0	0	815520	279051
11	0	0	0	0	0	0	0	477464
12	0	0	0	0	0	0	0	0

year

age	1980	1981	1982	1983	1984	1985	1986	1987
0	5576192	7259058	2047300	1579830	7411989	3344031	3453388	5148832
1	4465740	4768795	6195398	1751766	1352976	6113421	2802442	2926040
2	2038399	3462946	3848716	5134230	1463365	1134958	5012729	2358224
3	530651	1391234	2515940	2912052	3800245	1179825	957507	3921449
4	1549320	397011	983112	1728810	2105275	2640007	961442	788574
5	1202687	1030283	311331	675569	1143169	1453773	1860513	756652
6	827711	800331	715882	243392	464515	751604	1018101	1264858
7	732259	580234	528708	487732	190812	309211	494287	684073
8	256596	495910	391916	351149	336467	143796	208513	308955
9	728118	170246	310925	254502	235680	232464	105671	140134
10	152247	505812	108501	185751	174072	158567	156137	78431
11	145889	94191	300484	67951	114416	115198	101750	104097
12	272331	594266	511341	454409	262935	417181	359468	255303

year

age	1988	1989	1990	1991	1992	1993	1994	1995
0	3585748	4400475	3206044	3724106	4733756	5591156	4759308	4261347
1	4424779	3032865	3726918	2736997	3196093	4034116	4794414	4072863
2	2481281	3667017	2550865	3077599	2301587	2673459	3353474	3990106
3	1884663	2008186	2866709	2001272	2452123	1836269	2106344	2681259
4	2761891	1445918	1536243	2087478	1531465	1781100	1333838	1529020
5	626249	1879617	1089438	1129710	1449644	1071685	1165149	900928
6	568901	471548	1282809	792712	797952	964872	696777	724671
7	862644	408902	360797	869385	562880	542571	594666	429033
8	449679	556831	298191	271170	565509	379227	328634	336783
9	186686	273991	376463	210704	186189	358891	236170	185027
10	88488	109107	172821	245101	141240	112997	197005	129488
11	49357	57036	64179	118211	145604	87769	61505	116405
12	215338	146914	107971	210589	242478	205984	173453	121903

year

age	1996	1997	1998	1999	2000	2001	2002	2003
0	4042465	3125055	2986243	3494438	1844362	5236954	9368840	3096612
1	3654096	3457575	2673681	2552391	2985651	1573846	4463764	7976668
2	3429999	3074606	2912311	2244013	2139363	2491203	1307833	3694331
3	3118726	2789112	2506723	2353247	1807197	1703464	1963338	1020322
4	1993021	2400914	2158306	1905999	1777618	1335042	1233281	1393428
5	1061802	1441361	1750428	1531004	1338279	1205478	877302	785666
6	602788	739458	1013700	1190681	1028551	861823	747137	523588
7	441132	396723	492767	647570	748737	613023	489329	404395
8	238057	280112	255492	302504	390498	424883	329258	248948
9	185335	151217	180456	156907	182493	221705	228336	167616
10	95528	116142	96167	109167	93168	101703	116666	113546
11	72325	59176	73051	57434	63951	51108	52569	56868
12	120777	102504	82665	112042	103827	112014	101894	80922

year

age	2004	2005	2006	2007	2008
0	4214693	4715282	4774485	3835910	3835910
1	2637739	3595404	4032814	4087998	3281476
2	6613189	2198454	3024599	3406216	3441851
3	2894764	5251032	1786757	2483061	2774124
4	730368	2126758	4038355	1401545	1917456
5	899614	491069	1535654	3007238	1018489
6	476575	573325	341333	1108204	2106583
7	289288	280316	376415	235008	734787
8	210592	161722	177506	251550	150485
9	129719	117789	102446	118659	161135
10	85404	71172	73601	67715	75013
11	56761	46097	43957	48184	42329
12	53566	41287	46538	54684	65008

Table 2.7.1.12 ESTIMATED FISHING MORTALITY

Units : f

year

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.04	0.03
1	0.01	0.03	0.03	0.02	0.08	0.05	0.05	0.15	0.10	0.06	0.04	0.03	0.03	0.05
2	0.03	0.02	0.03	0.03	0.10	0.11	0.19	0.10	0.23	0.17	0.13	0.15	0.07	0.02
3	0.05	0.07	0.05	0.07	0.15	0.11	0.21	0.31	0.14	0.20	0.23	0.17	0.21	0.05
4	0.09	0.14	0.12	0.10	0.21	0.13	0.19	0.26	0.26	0.09	0.23	0.26	0.22	0.20
5	0.00	0.15	0.20	0.18	0.15	0.11	0.21	0.25	0.26	0.21	0.10	0.22	0.27	0.21
6	0.00	0.19	0.17	0.16	0.20	0.12	0.17	0.27	0.21	0.26	0.23	0.09	0.26	0.27
7	0.00	0.22	0.28	0.39	0.37	0.23	0.14	0.29	0.24	0.24	0.26	0.22	0.13	0.24
8	0.00	0.22	0.28	0.25	0.31	0.38	0.24	0.20	0.26	0.32	0.28	0.25	0.22	0.16
9	0.00	0.23	0.30	0.27	0.22	0.24	0.35	0.37	0.21	0.30	0.37	0.23	0.25	0.25
10	0.00	0.24	0.31	0.28	0.23	0.17	0.39	0.50	0.33	0.37	0.32	0.33	0.26	0.29
11	0.00	0.23	0.30	0.27	0.22	0.16	0.31	0.61	0.53	0.45	0.40	0.37	0.33	0.29
12	0.00	0.23	0.30	0.27	0.22	0.16	0.31	0.61	0.53	0.45	0.40	0.37	0.33	0.29

year

age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	0.02	0.00	0.02	0.02	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01
1	0.02	0.01	0.04	0.02	0.04	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.03
2	0.10	0.07	0.06	0.10	0.09	0.08	0.08	0.09	0.07	0.10	0.06	0.05	0.06	0.07
3	0.04	0.20	0.12	0.12	0.17	0.12	0.17	0.17	0.17	0.15	0.11	0.11	0.12	0.13
4	0.09	0.08	0.23	0.13	0.16	0.21	0.21	0.27	0.24	0.21	0.17	0.17	0.19	0.20
5	0.24	0.14	0.13	0.23	0.17	0.20	0.26	0.28	0.32	0.25	0.21	0.20	0.24	0.25
6	0.25	0.23	0.18	0.12	0.24	0.19	0.24	0.33	0.33	0.35	0.27	0.26	0.30	0.31
7	0.32	0.27	0.29	0.17	0.14	0.28	0.24	0.35	0.42	0.44	0.30	0.29	0.34	0.36
8	0.25	0.35	0.35	0.24	0.20	0.23	0.30	0.32	0.42	0.45	0.30	0.29	0.34	0.36
9	0.15	0.31	0.39	0.31	0.28	0.25	0.35	0.45	0.45	0.51	0.32	0.30	0.35	0.37
10	0.26	0.31	0.29	0.38	0.23	0.37	0.33	0.46	0.38	0.43	0.33	0.31	0.37	0.38
11	0.28	0.31	0.34	0.30	0.32	0.31	0.36	0.44	0.44	0.43	0.32	0.30	0.35	0.37
12	0.28	0.31	0.34	0.30	0.32	0.31	0.36	0.44	0.44	0.43	0.32	0.30	0.35	0.37

year

age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	NA
1	0.03	0.04	0.04	0.04	0.03	0.02	0.02	0.02	NA
2	0.08	0.09	0.10	0.09	0.08	0.06	0.05	0.06	NA
3	0.15	0.17	0.19	0.18	0.16	0.11	0.09	0.11	NA
4	0.24	0.27	0.30	0.29	0.25	0.18	0.14	0.17	NA
5	0.29	0.33	0.37	0.35	0.30	0.21	0.18	0.21	NA
6	0.37	0.42	0.46	0.44	0.38	0.27	0.22	0.26	NA
7	0.42	0.47	0.53	0.50	0.43	0.31	0.25	0.30	NA
8	0.42	0.47	0.53	0.50	0.43	0.31	0.25	0.30	NA
9	0.43	0.49	0.55	0.52	0.45	0.32	0.26	0.31	NA
10	0.45	0.51	0.57	0.54	0.47	0.33	0.27	0.32	NA
11	0.44	0.49	0.55	0.52	0.45	0.32	0.26	0.31	NA
12	0.44	0.49	0.55	0.52	0.45	0.32	0.26	0.31	NA

Table 2.7.1.13 FITTED SELECTION PATTERN

```
Units :  f
 year
age 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
 0 0.0297 0.0297 0.0297 0.0297 0.0297 0.0297 0.0297 0.0297 0.0297 0.0297
 1 0.1070 0.1070 0.1070 0.1070 0.1070 0.1070 0.1070 0.1070 0.1070 0.1070
 2 0.2683 0.2683 0.2683 0.2683 0.2683 0.2683 0.2683 0.2683 0.2683 0.2683
 3 0.5268 0.5268 0.5268 0.5268 0.5268 0.5268 0.5268 0.5268 0.5268 0.5268
 4 0.8218 0.8218 0.8218 0.8218 0.8218 0.8218 0.8218 0.8218 0.8218 0.8218
 5 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000
 6 1.2669 1.2669 1.2669 1.2669 1.2669 1.2669 1.2669 1.2669 1.2669 1.2669
 7 1.4360 1.4360 1.4360 1.4360 1.4360 1.4360 1.4360 1.4360 1.4360 1.4360
 8 1.4343 1.4343 1.4343 1.4343 1.4343 1.4343 1.4343 1.4343 1.4343 1.4343
 9 1.4983 1.4983 1.4983 1.4983 1.4983 1.4983 1.4983 1.4983 1.4983 1.4983
 10 1.5529 1.5529 1.5529 1.5529 1.5529 1.5529 1.5529 1.5529 1.5529 1.5529
 11 1.5000 1.5000 1.5000 1.5000 1.5000 1.5000 1.5000 1.5000 1.5000 1.5000
 12 1.5000 1.5000 1.5000 1.5000 1.5000 1.5000 1.5000 1.5000 1.5000 1.5000
 year
age 2006 2007
 0 0.0297 0.0297
 1 0.1070 0.1070
 2 0.2683 0.2683
 3 0.5268 0.5268
 4 0.8218 0.8218
 5 1.0000 1.0000
 6 1.2669 1.2669
 7 1.4360 1.4360
 8 1.4343 1.4343
 9 1.4983 1.4983
 10 1.5529 1.5529
 11 1.5000 1.5000
 12 1.5000 1.5000
```

Table 2.7.1.14 PREDICTED INDEX VALUES

```
character(0)
Units :  NA
 year
age 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
 all 1 1 1 1 1 1 1 1 1 1 1 1 1
 year
age 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996
 all 1 1 1 1 1 1 1 3447568 1 1 3240471 1
 year
age 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
 all 1 3301640 1 1 2894307 1 1 2615453 1 1 3341837
```

Table 2.7.1.15 INDEX RESIDUALS

```
character(0)
Units :  NA
 year
age 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
 all -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99
 year
age 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996
 all -99 -99 -99 -99 -99 -99 -99 -0.0228 -99 -99 -0.132 -99
 year
age 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
 all -99 0.127 -99 -99 0.00196 -99 -99 0.0502 -99 -99 -0.0248
```

Table 2.7.1.16 PREDICTED CATCH IN NUMBER

Units : NA

year										
age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	10707	16997	29277	36171	62510	6077	34623	114529	33101	56682
1	34979	46267	108077	62908	282818	175220	34513	360698	411327	276229
2	51652	74544	47410	92385	249293	328732	560738	62909	393025	502365
3	194461	109015	155390	84509	374245	226560	449338	609522	64549	231814
4	650980	415015	148543	265129	176793	236116	279236	385578	328206	32814
5	0	814518	424462	164673	314261	67758	282158	250755	254172	184867
6	0	0	673317	251420	133822	186619	78877	248099	142978	173349
7	0	0	0	991632	379790	105004	172213	92655	145385	116328
8	0	0	0	0	478925	229803	73933	169605	54778	125548
9	0	0	0	0	0	236966	127975	73900	130771	41186
10	0	0	0	0	0	0	243333	102363	39920	146186
11	0	0	0	0	0	0	0	204291	56210	31639
12	0	0	0	0	0	0	0	0	104927	199615

year										
age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	11180	7333	287287	81799	49983	7403	57644	65400	24246	10007
1	213936	47914	31901	268960	58126	40126	152656	64263	140534	58459
2	432867	668909	86064	20893	424563	156670	137635	312739	209848	212521
3	472457	433744	682491	58346	38387	663378	190403	207689	410751	206421
4	184581	373262	387582	445357	76545	56680	538394	167588	208146	375451
5	26544	126533	251503	252217	364119	89003	72914	362469	156742	188623
6	138970	20175	98063	165219	208021	244570	87323	48696	254015	129145
7	112476	90151	22086	62363	126174	150588	201021	58116	42549	197888
8	89672	72031	61813	19562	42569	85863	122496	111251	49698	51077
9	88726	48668	47925	47560	13533	34795	55913	68240	85447	43415
10	27552	49252	37482	37607	32786	19658	20710	32228	33041	70839
11	91743	19745	30105	26965	22971	25747	13178	13904	16587	29743
12	156121	132040	69183	97652	81153	63146	57494	35814	27905	52986

year										
age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	43447	19354	25368	14759	23529	17348	19306	23781	14686	47179
1	83583	128144	147315	81529	76088	68691	61782	62057	84802	50502
2	156292	210319	221489	340898	176110	150732	165636	134156	148927	195344
3	356209	266677	306979	340215	306184	261769	271824	267831	238271	251822
4	266591	398240	267420	275031	296312	341700	353290	326903	351179	294210
5	306143	244285	301346	186855	188705	245409	341853	312979	314062	314625
6	156070	255472	184925	197856	132176	155522	243579	299042	295086	273778
7	113899	149932	189847	142342	107838	93089	131774	180836	238114	215285
8	138458	97746	106108	113413	58135	65659	68254	84391	124066	149072
9	51208	121400	80054	69191	46986	36807	50014	45397	60062	80498
10	36612	38794	57622	42441	24966	29150	27461	32533	31554	37966
11	40956	29067	20407	37960	18353	14418	20265	16632	21066	18572
12	68205	68217	57551	39753	30648	24974	22932	32446	34202	40706

year						
age	2002	2003	2004	2005	2006	2007
0	94058	29716	34761	27693	23132	15374
1	159395	272433	77570	75537	69993	82797
2	113791	307820	476264	113873	129798	170187
3	320590	159861	394347	519949	147257	237392
4	298709	324528	148876	318825	506491	203079
5	250920	216347	217650	87985	230901	521117
6	258990	175062	140788	126713	63595	237105
7	187026	149249	94662	69059	78394	56080
8	125730	91793	68844	39801	36929	59966
9	90143	63923	43917	30093	22148	29370
10	47315	44500	29746	18744	16418	17280
11	20771	21706	19234	11788	9513	11937
12	40260	30887	18151	10558	10071	13548

Table 2.7.1.17 CATCH RESIDUALS

Units : Thousands

age \ year	1996	1997	1998	1999	2000	2001	2002
0	4.78e-01	0.73037	1.1526	1.04e+00	9.06e-01	-0.5945	-0.2896
1	4.54e-01	0.74290	0.4751	1.71e-01	1.89e-01	-0.2253	0.3323
2	-4.19e-02	0.21283	0.3273	-8.70e-03	-4.13e-02	-0.2062	-0.4898
3	8.51e-02	-0.09340	-0.0271	-1.80e-01	1.45e-01	-0.0726	0.1351
4	-5.95e-02	0.10329	-0.0891	-2.22e-01	1.07e-01	0.0101	0.1580
5	-6.03e-02	0.00557	0.0571	-1.08e-01	-6.09e-02	-0.0150	0.0451
6	-3.17e-01	-0.14108	-0.1597	-2.03e-01	-2.00e-01	-0.1664	-0.0890
7	1.05e-01	-0.09825	-0.1071	-1.29e-01	-3.04e-01	-0.0977	-0.2124
8	-4.08e-02	0.01279	0.0637	2.74e-02	-1.55e-01	-0.2149	-0.0566
9	2.41e-01	0.06934	-0.0547	1.09e-01	-1.37e-01	-0.1087	-0.1204
10	3.30e-02	-0.08647	-0.1188	-6.90e-02	-8.71e-03	0.1135	-0.0777
11	1.43e-08	-0.03297	-0.2025	2.47e-02	-1.08e-01	0.1010	0.0394
12	0.00e+00	0.00000	0.0000	2.22e-16	-2.22e-16	0.0000	0.0000

age \ year	2003	2004	2005	2006	2007
0	-7.24e-01	-1.9060	-1.71e+00	0.9243	-6.92e-10
1	-4.03e-01	-1.1477	-5.35e-01	-0.0099	-4.19e-02
2	-1.49e-01	-0.1119	1.47e-01	0.2408	1.09e-01
3	-5.86e-01	0.2363	2.41e-01	0.0617	-4.10e-02
4	-1.12e-01	-0.0417	-9.65e-02	-0.0782	4.53e-03
5	6.37e-02	0.1179	2.97e-01	-0.1734	-1.50e-01
6	3.05e-02	-0.0200	-5.52e-02	0.4203	-1.67e-01
7	-1.20e-01	-0.1195	-8.71e-02	-0.0611	2.95e-01
8	1.48e-02	-0.1140	-4.57e-02	-0.1054	-2.27e-02
9	1.57e-01	-0.1549	-2.37e-01	-0.1647	-3.71e-02
10	2.86e-02	0.0982	-2.18e-03	-0.1628	-4.92e-02
11	1.69e-01	-0.2233	-4.05e-01	-0.1348	-1.19e-02
12	-1.11e-16	0.0000	-2.22e-16	0.0000	-1.11e-16

Table 2.7.1.18 FIT PARAMETERS

	Value	CV.pct	Lower.95.pct.CL	Upper.95.pct.CL
F, 1996	2.12e-01	6.0	1.77e-01	2.54e-01
F, 1997	2.02e-01	5.6	1.69e-01	2.41e-01
F, 1998	2.35e-01	6.1	1.98e-01	2.80e-01
F, 1999	2.48e-01	6.2	2.09e-01	2.94e-01
F, 2000	2.90e-01	6.8	2.46e-01	3.42e-01
F, 2001	3.28e-01	7.6	2.78e-01	3.88e-01
F, 2002	3.66e-01	8.6	3.09e-01	4.33e-01
F, 2003	3.50e-01	8.3	2.95e-01	4.15e-01
F, 2004	3.01e-01	7.7	2.51e-01	3.60e-01
F, 2005	2.14e-01	6.3	1.77e-01	2.59e-01
F, 2006	1.76e-01	5.6	1.45e-01	2.13e-01
F, 2007	2.06e-01	6.4	1.69e-01	2.51e-01
Selectivity at age 0	2.97e-02	18.1	8.55e-03	1.03e-01
Selectivity at age 1	1.07e-01	9.3	7.12e-02	1.61e-01
Selectivity at age 2	2.68e-01	6.9	2.25e-01	3.20e-01
Selectivity at age 3	5.27e-01	13.8	4.43e-01	6.26e-01
Selectivity at age 4	8.22e-01	43.8	6.94e-01	9.73e-01
Selectivity at age 6	1.27e+00	34.8	1.08e+00	1.49e+00
Selectivity at age 7	1.44e+00	21.7	1.23e+00	1.67e+00
Selectivity at age 8	1.43e+00	20.8	1.24e+00	1.66e+00
Selectivity at age 9	1.50e+00	17.9	1.30e+00	1.73e+00
Selectivity at age 10	1.55e+00	16.7	1.35e+00	1.79e+00
Terminal year pop, age 0	2.72e+06	14.8	3.74e+04	1.97e+08
Terminal year pop, age 1	4.09e+06	4.3	1.13e+06	1.48e+07
Terminal year pop, age 2	3.41e+06	1.3	2.34e+06	4.96e+06
Terminal year pop, age 3	2.48e+06	0.9	1.90e+06	3.24e+06
Terminal year pop, age 4	1.40e+06	0.9	1.10e+06	1.78e+06
Terminal year pop, age 5	3.01e+06	0.6	2.53e+06	3.58e+06
Terminal year pop, age 6	1.11e+06	0.7	9.26e+05	1.33e+06
Terminal year pop, age 7	2.35e+05	0.8	1.92e+05	2.87e+05
Terminal year pop, age 8	2.52e+05	0.8	2.07e+05	3.06e+05
Terminal year pop, age 9	1.19e+05	0.9	9.69e+04	1.45e+05
Terminal year pop, age 10	6.77e+04	1.0	5.47e+04	8.38e+04
Terminal year pop, age 11	4.82e+04	1.1	3.82e+04	6.07e+04
Last true age pop, 1996	7.23e+04	2.0	4.67e+04	1.12e+05
Last true age pop, 1997	5.92e+04	1.5	4.25e+04	8.24e+04
Last true age pop, 1998	7.31e+04	1.3	5.52e+04	9.67e+04
Last true age pop, 1999	5.74e+04	1.2	4.45e+04	7.41e+04
Last true age pop, 2000	6.40e+04	1.1	5.05e+04	8.10e+04
Last true age pop, 2001	5.11e+04	1.1	4.08e+04	6.41e+04
Last true age pop, 2002	5.26e+04	1.1	4.18e+04	6.61e+04
Last true age pop, 2003	5.69e+04	1.1	4.50e+04	7.18e+04
Last true age pop, 2004	5.68e+04	1.1	4.49e+04	7.18e+04
Last true age pop, 2005	4.61e+04	1.1	3.64e+04	5.84e+04
Last true age pop, 2006	4.40e+04	1.1	3.48e+04	5.56e+04
Index 1, biomass, Q	1.32e+00	8.2	1.26e+00	1.38e+00

Table 2.8.1 North East Atlantic Mackerel. Short term prediction: INPUT DATA

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	3835910	0.15	0.00	0.421	0.35	0.000	0.006	0.067
1	3281476	0.15	0.07	0.421	0.35	0.071	0.022	0.123
2	3441851	0.15	0.58	0.421	0.35	0.172	0.055	0.228
3	2774124	0.15	0.88	0.421	0.35	0.230	0.108	0.303
4	1917456	0.15	0.98	0.421	0.35	0.304	0.169	0.364
5	1018489	0.15	0.98	0.421	0.35	0.345	0.206	0.423
6	2106583	0.15	0.99	0.421	0.35	0.385	0.261	0.458
7	734787	0.15	1.00	0.421	0.35	0.452	0.296	0.498
8	150485	0.15	1.00	0.421	0.35	0.469	0.295	0.537
9	161135	0.15	1.00	0.421	0.35	0.522	0.309	0.570
10	75013	0.15	1.00	0.421	0.35	0.530	0.320	0.594
11	42329	0.15	1.00	0.421	0.35	0.565	0.309	0.619
12	65008	0.15	1.00	0.421	0.35	0.590	0.309	0.672

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	3835910	0.15	0.00	0.421	0.35	0.000	0.006	0.067
1	-	0.15	0.07	0.421	0.35	0.071	0.022	0.123
2	-	0.15	0.58	0.421	0.35	0.172	0.055	0.228
3	-	0.15	0.88	0.421	0.35	0.230	0.108	0.303
4	-	0.15	0.98	0.421	0.35	0.304	0.169	0.364
5	-	0.15	0.98	0.421	0.35	0.345	0.206	0.423
6	-	0.15	0.99	0.421	0.35	0.385	0.261	0.458
7	-	0.15	1.00	0.421	0.35	0.452	0.296	0.498
8	-	0.15	1.00	0.421	0.35	0.469	0.295	0.537
9	-	0.15	1.00	0.421	0.35	0.522	0.309	0.570
10	-	0.15	1.00	0.421	0.35	0.530	0.320	0.594
11	-	0.15	1.00	0.421	0.35	0.565	0.309	0.619
12	-	0.15	1.00	0.421	0.35	0.590	0.309	0.672

2010 Age	Stock Size	Natural Mortality	Maturity Ogive	Prop. Of F bef. spaw.	Prop. Of M bef.spaw.	Stock weights	Exploitation pattern	Catch weights
0	3835910	0.15	0.00	0.421	0.35	0.000	0.006	0.067
1	-	0.15	0.07	0.421	0.35	0.071	0.022	0.123
2	-	0.15	0.58	0.421	0.35	0.172	0.055	0.228
3	-	0.15	0.88	0.421	0.35	0.230	0.108	0.303
4	-	0.15	0.98	0.421	0.35	0.304	0.169	0.364
5	-	0.15	0.98	0.421	0.35	0.345	0.206	0.423
6	-	0.15	0.99	0.421	0.35	0.385	0.261	0.458
7	-	0.15	1.00	0.421	0.35	0.452	0.296	0.498
8	-	0.15	1.00	0.421	0.35	0.469	0.295	0.537
9	-	0.15	1.00	0.421	0.35	0.522	0.309	0.570
10	-	0.15	1.00	0.421	0.35	0.530	0.320	0.594
11	-	0.15	1.00	0.421	0.35	0.565	0.309	0.619
12	-	0.15	1.00	0.421	0.35	0.590	0.309	0.672

Input units are thousands and kg−output in tonnes

Table 2.8.2 North East Atlantic Mackerel Short term prediction single option table. Catch constraint of 600 Kt in 2008 and F status quo for 2009 and 2010

Year: 2008		F multiplier: 0.8861	Fbar: 0.2175						
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.005	19246	1296	3835910	0	0	0	0	0
1	0.020	58966	7253	3281476	234079	229703	16386	216170	15420
2	0.049	152852	34850	3441851	590851	1984801	340724	1844855	316700
3	0.096	236417	71634	2774124	638049	2441229	561483	2224488	511632
4	0.150	248460	90440	1917456	582267	1879106	570622	1673895	508306
5	0.183	158135	66944	1018489	351379	998119	344351	877027	302574
6	0.231	404977	185344	2106583	811035	2085518	802924	1795311	691195
7	0.262	157827	78598	734787	332124	734787	332124	624371	282216
8	0.262	32289	17339	150485	70578	150485	70578	127889	59980
9	0.274	35922	20464	161135	84059	161135	84059	136267	71086
10	0.283	17252	10247	75013	39757	75013	39757	63171	33481
11	0.274	9446	5847	42329	23930	42329	23930	35792	20235
12	0.274	14507	9744	65008	38333	65008	38333	54969	32413
Total		1546296	600000	19604646	3796441	10847233	3225271	9674205	2845238

Year: 2009		F multiplier 1		Fbar: 0.2455					
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.006	21712	1462	3835910	0	0	0	0	0
1	0.022	66508	8180	3283760	234242	229863	16397	216092	15415
2	0.055	138387	31552	2769751	475474	1597223	274190	1480677	254183
3	0.109	269686	81715	2820841	648793	2482340	570938	2250216	517550
4	0.169	314259	114390	2168845	658606	2125468	645434	1878053	570302
5	0.206	246157	104206	1420509	490075	1392098	480274	1211192	417861
6	0.261	156269	71519	730384	281198	723080	278386	614724	236669
7	0.296	343358	170992	1438872	650370	1438872	650370	1205443	544860
8	0.295	116005	62294	486628	228229	486628	228229	407743	191232
9	0.309	24675	14057	99693	52007	99693	52007	83070	43335
10	0.320	26925	15994	105508	55919	105508	55919	87500	46375
11	0.309	12048	7458	48631	27493	48631	27493	40516	22905
12	0.309	17407	11692	70261	41431	70261	41431	58537	34517
Total		1753396	695511	19279593	3843837	10799665	3321068	9533763	2895204

Year: 2010		F multiplier 1		Fbar: 0.2455					
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0.006	21712	1462	3835910	0	0	0	0	0
1	0.022	66462	8175	3281476	234079	229703	16386	215941	15404
2	0.055	138136	31495	2764731	474612	1594328	273693	1477993	253722
3	0.109	215662	65346	2255768	518827	1985076	456567	1799451	413874
4	0.169	315628	114889	2178294	661475	2134728	648246	1886236	572787
5	0.206	273115	115619	1576078	543747	1544557	532872	1343838	463624
6	0.261	212900	97437	995072	383103	985122	379272	837499	322437
7	0.296	115563	57550	484276	218893	484276	218893	405712	183382
8	0.295	219640	117947	921369	432122	921369	432122	772010	362073
9	0.309	77155	43952	311719	162613	311719	162613	259741	135498
10	0.320	16083	9553	63023	33402	63023	33402	52267	27701
11	0.309	16340	10115	65955	37286	65955	37286	54949	31065
12	0.309	18615	12503	75135	44305	75135	44305	62598	36912
Total		1707011	686043	18808806	3744464	10394991	3235657	9168235	2818479

Input units are thousands and kg−output in tonnes

Table 2.8.3 North East Atlantic Mackerel. . Short term prediction; single area management option table. OPTION: Catch constraint 600 Kt in 2008.

2008				
Biomass	SSB	FMult	FBar	Landings
3796441	2845238	0.8861	0.2175	600000

2009					2010		% change in
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB	2009 landings
3843836	3151208	0.00	0.00	0	4361672	3642761	-100%
-	3140274	0.04	0.01	31388	4333771	3603729	-95%
-	3129384	0.08	0.02	62496	4306124	3565212	-90%
-	3118538	0.12	0.03	93328	4278726	3527202	-84%
-	3107735	0.16	0.04	123886	4251575	3489693	-79%
-	3096977	0.20	0.05	154173	4224668	3452676	-74%
-	3086262	0.24	0.06	184192	4198004	3416145	-69%
-	3075590	0.29	0.07	213946	4171580	3380093	-64%
-	3064962	0.33	0.08	243436	4145393	3344512	-59%
-	3054377	0.37	0.09	272667	4119440	3309396	-55%
-	3043834	0.41	0.10	301640	4093720	3274738	-50%
-	3033334	0.45	0.11	330358	4068230	3240532	-45%
-	3022876	0.49	0.12	358824	4042968	3206770	-40%
-	3012460	0.53	0.13	387040	4017931	3173447	-35%
-	3002087	0.57	0.14	415009	3993118	3140556	-31%
-	2991755	0.61	0.15	442732	3968525	3108091	-26%
-	2981465	0.65	0.16	470214	3944150	3076046	-22%
-	2971217	0.69	0.17	497455	3919993	3044415	-17%
-	2961009	0.73	0.18	524459	3896049	3013191	-13%
-	2950843	0.77	0.19	551227	3872317	2982369	-8%
-	2940718	0.81	0.20	577763	3848796	2951943	-4%
-	2930633	0.86	0.21	604068	3825482	2921907	1%
-	2920589	0.90	0.22	630145	3802374	2892257	5%
-	2910586	0.94	0.23	655996	3779469	2862985	9%
-	2900622	0.98	0.24	681624	3756766	2834088	14%
-	2890699	1.02	0.25	707029	3734263	2805559	18%
-	2880816	1.06	0.26	732216	3711957	2777393	22%
-	2870972	1.10	0.27	757186	3689846	2749586	26%
-	2861168	1.14	0.28	781940	3667929	2722131	30%
-	2851403	1.18	0.29	806482	3646204	2695024	34%
-	2841677	1.22	0.30	830813	3624669	2668260	38%

Input units are thousands and kg–output in tonnes

Table 2.8.4. North East Atlantic Mackerel. .Short term prediction; single area management option table. OPTION: Catch constraint 600 Kt in 2008. For optimal management options for all rules with % constraint on change in TAC implemented irrespective of level of SSB (see table 2.11.1).

Rule Parameters					2009 Options					2010	
Rule type	% constraint	Constraint	Target TAC	Trigger SSB	HR 2009	SSB 2009	Fmult 2009	Fbar 2009	Landings 2009	TSB 2010	SSB 2010
TargC	12.5	Always	550	2500	0.19	2951	0.77	0.19	550	3872	2982
TargC	15	Always	550	2400	0.19	2951	0.77	0.19	550	3872	2982
TargC	10	Always	560	2600	0.19	2951	0.77	0.19	551	3872	2982
TargC	10	Always	570	2600	0.19	2951	0.77	0.19	551	3872	2982
TargC	12.5	Always	570	2600	0.19	2946	0.79	0.20	564	3861	2967
TargC	15	Always	570	2600	0.19	2946	0.79	0.20	570	3861	2967
TargC	12.5	Always	590	2700	0.19	2946	0.79	0.20	564	3861	2967
TargC	10	Always	620	3100	0.19	2951	0.77	0.19	551	3872	2982
TargC	12.5	Always	610	2900	0.19	2946	0.79	0.20	564	3861	2967
TargC	10	Always	670	3500	0.19	2951	0.77	0.19	551	3872	2982
TargC	12.5	Always	640	3100	0.19	2946	0.79	0.20	564	3861	2967
TargC	10	Always	690	3500	0.19	2951	0.77	0.19	551	3872	2982
TargC	12.5	Always	700	3500	0.19	2946	0.79	0.20	564	3861	2967
TargC	15	Always	700	3400	0.19	2946	0.79	0.20	576	3861	2967
			TargHR								
TargHR	10	Always	0.20	2800	0.19	2951	0.77	0.19	551	3872	2982
TargHR	12.5	Always	0.20	2900	0.19	2946	0.79	0.20	564	3861	2967
TargHR	15	Always	0.20	2400	0.19	2946	0.79	0.20	576	3861	2967
TargHR	17.5	Always	0.20	2500	0.20	2941	0.81	0.20	588	3849	2952
TargHR	17.5	Always	0.21	2900	0.20	2941	0.81	0.20	589	3849	2952
TargHR	20	Always	0.21	2800	0.21	2931	0.86	0.21	601	3825	2922
TargHR	25	Always	0.21	2100	0.21	2931	0.86	0.21	615	3825	2922
TargHR	25	Always	0.21	2700	0.21	2931	0.86	0.21	615	3825	2922

Table 2.8.5. North East Atlantic Mackerel. .Short term prediction; single area management option table. OPTION: Catch constraint 600 Kt in 2008. For optimal management options for all rules with % constraint on change in TAC implemented when SSB > B_{trig} (see table 2.11.2).

Rule Parameters					2009 Options					2010	
Rule type	% constraint	Constraint	Target TAC	Trigger SSB	HR 2009	SSB 2009	Fmult 2009	Fbar 2009	Landings 2009	TSB 2010	SSB 2010
TargC	10	Only	550	2100	0.19	2951	0.77	0.19	550	3872	2982
TargC	12.5	Only	560	2200	0.19	2946	0.79	0.20	560	3861	2967
TargC	12.5	Only	570	2300	0.19	2946	0.79	0.20	564	3861	2967
TargC	15	Only	580	2300	0.19	2946	0.79	0.20	576	3861	2967
TargC	10	Only	600	2600	0.19	2951	0.77	0.19	551	3872	2982
TargC	12.5	Only	600	2500	0.19	2946	0.79	0.20	564	3861	2967
TargC	15	Only	610	2500	0.19	2946	0.79	0.20	576	3861	2967
TargC	12.5	Only	630	2600	0.19	2946	0.79	0.20	564	3861	2967
TargC	12.5	Only	650	2800	0.19	2946	0.79	0.20	564	3861	2967
TargC	10	Only	670	2900	0.19	2951	0.77	0.19	551	3872	2982
TargC	12.5	Only	690	3100	0.19	2946	0.79	0.20	564	3861	2967
			TargHR								
TargHR	10	Only	0.26	2300	0.19	2951	0.77	0.19	551	3872	2982
TargHR	15	Only	0.23	2100	0.19	2946	0.79	0.20	576	3861	2967
TargHR	15	Only	0.24	2300	0.19	2946	0.79	0.20	576	3861	2967
TargHR	20	Only	0.22	2100	0.21	2931	0.86	0.21	601	3825	2922
TargHR	20	Only	0.23	2100	0.21	2931	0.86	0.21	601	3825	2922
TargHR	25	Only	0.23	2100	0.21	2926	0.88	0.22	626	3814	2907

Table 2.8.6. North East Atlantic Mackerel. .Short term prediction; single area management option table. OPTION: Catch constraint 600 Kt in 2008. For optimal management options for European commission F rules with % constraint on change in TAC implemented when SSB > B_{trig} (see table 2.11.3).

Rule Parameters					2009 Options					2010	
Rule type	% constraint	Constraint	Target F	Trigger SSB	HR 2009	SSB 2009	Fmult 2009	Fbar 2009	Landings 2009	TSB 2010	SSB 2010
TargF	10	Only	0.18	2000	0.18	2961	0.73	0.18	533	3896	3013
TargF	10	Only	0.20	2000	0.19	2951	0.77	0.19	551	3872	2982
TargF	10	Only	0.24	2000	0.19	2951	0.77	0.19	551	3872	2982
TargF	10	Only	0.24	2000	0.19	2951	0.77	0.19	551	3872	2982
TargF	15	Only	0.22	2000	0.19	2946	0.79	0.20	576	3861	2967
TargF	15	Only	0.24	2300	0.19	2946	0.79	0.20	576	3861	2967
TargF	20	Only	0.22	2200	0.21	2931	0.86	0.21	601	3825	2922
TargF	20	Only	0.24	2400	0.21	2931	0.86	0.21	601	3825	2922
TargF	20	Only	0.26	2700	0.21	2931	0.86	0.21	601	3825	2922

Table 2.11.1 Optimal management options for all rules with % constraint on change in TAC implemented irrespective of level of SSB.

Rule Parameters					Outcomes			Other Information							
Rule type	Perc	Constraint	Targ	Trig	Cmean	IAV	7+	F	SSB	N Change	N up	N down	C up	C down	Risk
TargC	12.5	Always	550	2500	559	3.5	0.45	0.17	3385	4.3	2.6	1.7	38.4	-47.1	4.9
TargC	15	Always	550	2400	562	3.5	0.45	0.17	3369	3.9	2.3	1.6	43.1	-52.5	4.5
TargC	10	Always	560	2600	564	3.7	0.45	0.18	3318	5.3	3.2	2.1	34.4	-41.1	4.5
TargC	10	Always	570	2600	569	3.8	0.44	0.18	3285	5.5	3.3	2.2	33.9	-41.1	4.5
TargC	12.5	Always	570	2600	572	4.3	0.44	0.18	3286	5.2	3.1	2.1	40.7	-49.1	4.7
TargC	15	Always	570	2600	574	4.7	0.45	0.18	3336	4.9	2.9	2.0	46.6	-57.0	4.1
TargC	12.5	Always	590	2700	583	5.0	0.44	0.19	3239	6.0	3.5	2.5	42.6	-50.9	4.8
TargC	10	Always	620	3100	588	6.0	0.43	0.19	3205	8.1	4.7	3.4	39.4	-45.3	4.8
TargC	12.5	Always	610	2900	593	6.1	0.43	0.19	3206	7.0	4.1	3.0	45.1	-53.8	4.4
TargC	10	Always	670	3500	599	7.3	0.43	0.20	3166	9.6	5.5	4.1	42.4	-47.9	5
TargC	12.5	Always	640	3100	601	7.4	0.42	0.21	3133	8.2	4.7	3.5	48.2	-56.2	4.4
TargC	10	Always	690	3500	610	7.5	0.42	0.20	3122	9.8	5.6	4.1	43.7	-49.3	4.6
TargC	12.5	Always	700	3500	614	9.0	0.42	0.21	3087	9.7	5.5	4.2	52.3	-60.1	4.8
TargC	15	Always	700	3400	623	9.9	0.41	0.21	3029	9.5	5.4	4.1	59.4	-70.3	4.1
			TargHR												
TargHR	10	Always	0.20	2800	623	9.1	0.42	0.21	3089	11	6.4	4.6	50.4	-56.1	4.4
TargHR	12.5	Always	0.20	2900	624	11	0.42	0.21	3081	11	6.2	4.8	61.2	-69.2	4.8
TargHR	15	Always	0.20	2400	634	13	0.41	0.22	2970	11	6	5.0	71.2	-79.3	5
TargHR	17.5	Always	0.20	2500	635	15	0.41	0.21	3017	11	6.1	4.9	80.1	-92.0	3.9
TargHR	17.5	Always	0.21	2900	641	15	0.40	0.22	2988	11	6.1	4.9	82.8	-97.6	4.7
TargHR	20	Always	0.21	2800	642	17	0.40	0.22	2966	11	6.1	4.9	91.1	-107	4.5
TargHR	25	Always	0.21	2100	646	19	0.38	0.23	2829	11	6.0	5.0	104	-123	4.9
TargHR	25	Always	0.21	2700	647	20	0.40	0.22	2971	11	6.1	4.9	107	-128	4.2

Table 2.11.2 Optimal management options for all rules with % constraint on change in TAC implemented when SSB > B_{trig}.

Rule Parameters					Outcomes			Other Information							
Rule type	Perc	Constraint	Targ	Trig	Cmean	IAV	7+	F	SSB	N change	N up	N down	C up	C Down	Risk
TargC	10	Only	550	2100	562	3.5	0.44	0.18	3340	3.2	2.2	1.0	43.2	-77.2	4.8
TargC	12.5	Only	560	2200	571	4.2	0.44	0.18	3305	3.5	2.3	1.2	48.9	-81.2	3.9
TargC	12.5	Only	570	2300	577	4.8	0.43	0.18	3259	4.0	2.6	1.4	50.7	-84.7	4.6
TargC	15	Only	580	2300	583	5.6	0.42	0.19	3174	4.4	2.8	1.6	55.4	-84.2	4.9
TargC	10	Only	600	2600	589	7.1	0.43	0.19	3212	5.9	3.9	2.0	50.7	-90.9	4.8
TargC	12.5	Only	600	2500	591	7.4	0.42	0.19	3172	5.6	3.6	2.0	56.8	-95.1	4.6
TargC	15	Only	610	2500	600	7.9	0.41	0.20	3089	5.6	3.5	2.1	63	-96.4	4.9
TargC	12.5	Only	630	2600	611	8.7	0.41	0.21	3053	6.5	4.1	2.3	59.9	-99.5	4.7
TargC	12.5	Only	650	2800	615	10	0.41	0.21	3087	7.3	4.6	2.7	64.7	-103	4.5
TargC	10	Only	670	2900	618	12	0.4	0.21	3024	8.3	5.4	2.9	63.1	-111	4.7
TargC	12.5	Only	690	3100	624	14	0.4	0.21	3015	8.8	5.5	3.3	74.5	-117	3.7
			TargHR												
TargHR	10	Only	0.26	2300	613	15	0.41	0.21	3124	11	8.5	2.5	56.4	-178	4.8
TargHR	15	Only	0.23	2100	626	17	0.41	0.21	3011	11	7.5	3.5	72.9	-149	3.9
TargHR	15	Only	0.24	2300	629	19	0.41	0.21	3028	11	7.7	3.3	77.1	-175	3.6
TargHR	20	Only	0.22	2100	634	20	0.4	0.22	2977	11	7.0	4.0	90.7	-157	3.6
TargHR	20	Only	0.23	2100	639	20	0.39	0.23	2934	11	7.2	3.8	91.7	-164	4.2
TargHR	25	Only	0.23	2100	650	23	0.38	0.24	2852	11	6.9	4.1	110	-178	4.6

Table 2.11.3 Optimal management options for European commission F rules with % constraint on change in TAC implemented when SSB > B_{trig}.

Rule Parameters					Outcomes			Other Information							
Rule type	Perc	Constraint	Targ	Trig	Cmean	IAV	7+	F	SSB	N change	N up	N down	C up	C down	Risk
TargF	10	Only	0.18	2000	582	11	0.48	0.16	3548	11	7.8	3.2	46.9	-90.3	0.8
TargF	10	Only	0.20	2000	590	11	0.46	0.18	3416	11	8	3	47.5	-103	1.4
TargF	10	Only	0.24	2000	613	12	0.43	0.20	3214	11	8.3	2.7	50.9	-136	3.8
TargF	10	Only	0.24	2000	613	12	0.43	0.20	3214	11	8.3	2.7	50.9	-136	3.8
TargF	15	Only	0.22	2000	624	16	0.42	0.21	3078	11	7.4	3.6	71.1	-139	4.2
TargF	15	Only	0.24	2300	631	18	0.41	0.21	3046	11	7.9	3.1	76.8	-179	4.0
TargF	20	Only	0.22	2200	636	20	0.40	0.22	3021	11	7.2	3.8	92.7	-169	3.3
TargF	20	Only	0.24	2400	639	23	0.40	0.22	2969	11	7.4	3.6	98.9	-200	5.0
TargF	20	Only	0.26	2700	650	27	0.39	0.23	2906	11	7.4	3.6	113	-228	4.7

Table 2.13.1. Catches in tonnes of *Scomber colias* in Divisions VIIIb, VIIIc and IXa in the period 1982–2007.

Country	Sub-Divisions	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
	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													
Spain	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
	IXa Central-North	-	0	236	229	223	168	165	281	228	137	914	543	378
Portugal	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
	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
TOTAL	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	2007
	Division VIIIb	247	778	362	1218	632	344	426	99	157	40	222	262	744
	VIIIc East	2558	2633	4416	1753	414	1279	1442	1130	1200	1482	1237	853	4627
	VIIIc west		47	610	12	3	626	54	379	1325	1260	1913	3407	2526
Spain	Total	2558	2679	5026	1765	418	1905	1496	1509	2525	2741	3150	4260	7153
	IXa North	4705	5066	1727	412	104	531	1	54	33	6	504	2745	5689
	IXa South	364	370	613	969	879	470	552	1512	948	882	307	239	2550
	Total	5068	5437	2340	1381	983	1001	553	1566	981	888	812	2984	8239
	Total Spain	7872	8894	7729	4364	2033	3250	2475	3174	3663	3670	4184	7506	16136
	IXa Central-North	913	785	521	481	296	146	60	177	476	242	3033	2570	3847
Portugal	IXa Central-South	1544	2224	2109	3414	10407	7450	2202	1380	3405	5990	5743	6684	8693
	IXa South	1427	1749	2778	2796	3173	2924	1966	3744	4149	6193	6130	3777	7682
	Total Portugal	3884	4759	5408	6690	13877	10520	4228	5301	8030	12425	14905	13031	20222
	Division VIIIb	247	778	362	1218	632	344	426	99	157	40	222	262	744
	VIIIc East	2558	2633	4416	1753	414	1279	1442	1130	1200	1482	1237	853	4627
	VIIIc west		47	610	12	3	626	54	379	1325	1260	1913	3407	2526
	Division VIIIc	2558	2679	5026	1765	418	1905	1496	1509	2525	2741	3150	4260	7153
TOTAL	IXa North	4705	5066	1727	412	104	531	1	54	33	6	504	2745	5689
	IXa Central-North	913	785	521	481	296	146	60	177	476	242	3033	2570	3847
	IXa Central-South	1544	2224	2109	3414	10407	7450	2202	1380	3405	5990	5743	6684	8693
	IXa South	1790	2120	3391	3764	4052	3395	2518	5256	5097	7075	6438	4016	10232
	Division IXa	8952	10195	7748	8071	14860	11521	4781	6867	9011	13313	15717	16015	28461
	Total	11756	13653	13137	11054	15909	13770	6703	8475	11693	16094	19089	20537	36358

Table 2.14: Overview on major existing regulations on mackerel catches

Technical measure	National/European level	Specification	Note
Catch limitation	European (EU, Norway, Faroes)	TAC 2007: 501.000t all areas TAC 2008: 458.000t all areas	
Management plan	European (EU, Norway, Faroes)	F=0.15 to 0.20, SSB not under 2.300.000t	
Minimum size (North Sea)	European (EU, Norway, Faroes)	30cm in the North Sea	
Minimum size (all areas except North Sea)	European (EU, Faroes)	20cm in all areas except North Sea	10% undersized allowed
Minimum size	National (Nor)	30cm in all areas	
Catch limitation	European (EU, Norway, Faroes)	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.	
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 area
Quota adaptation	European (EU)	Reducing of UK and Irish mackerel quota with a scheduled payback until 2012 following the exceeding of fishing opportunities 2001 to 2004	
Discard prohibition	National (Nor)	All discarding is prohibited in Norwegian waters	

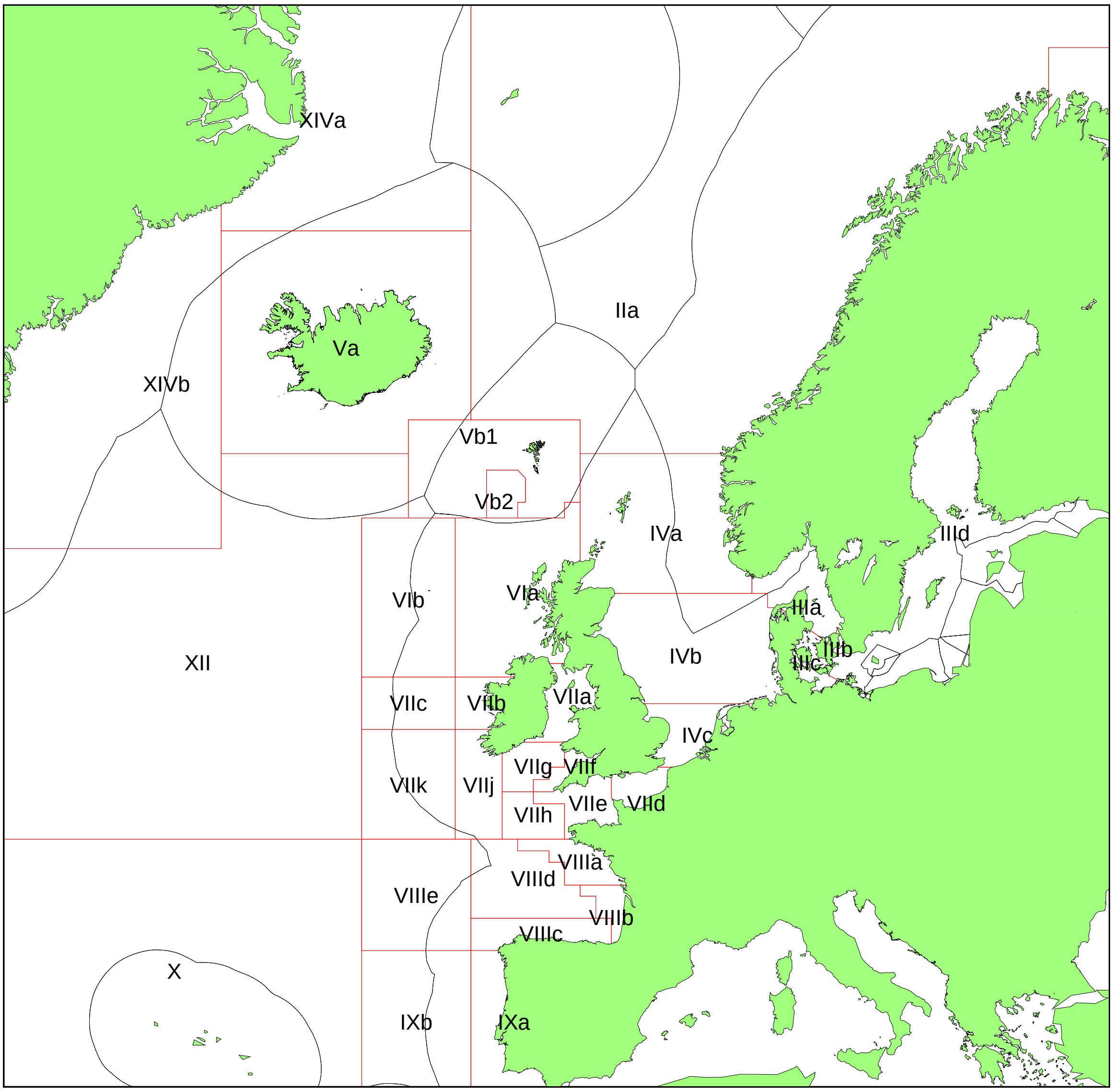


Figure 2.1.1. **Map of approximate national zones and ICES Divisions and Subareas. Note that EU region is considered as one zone in this map.**

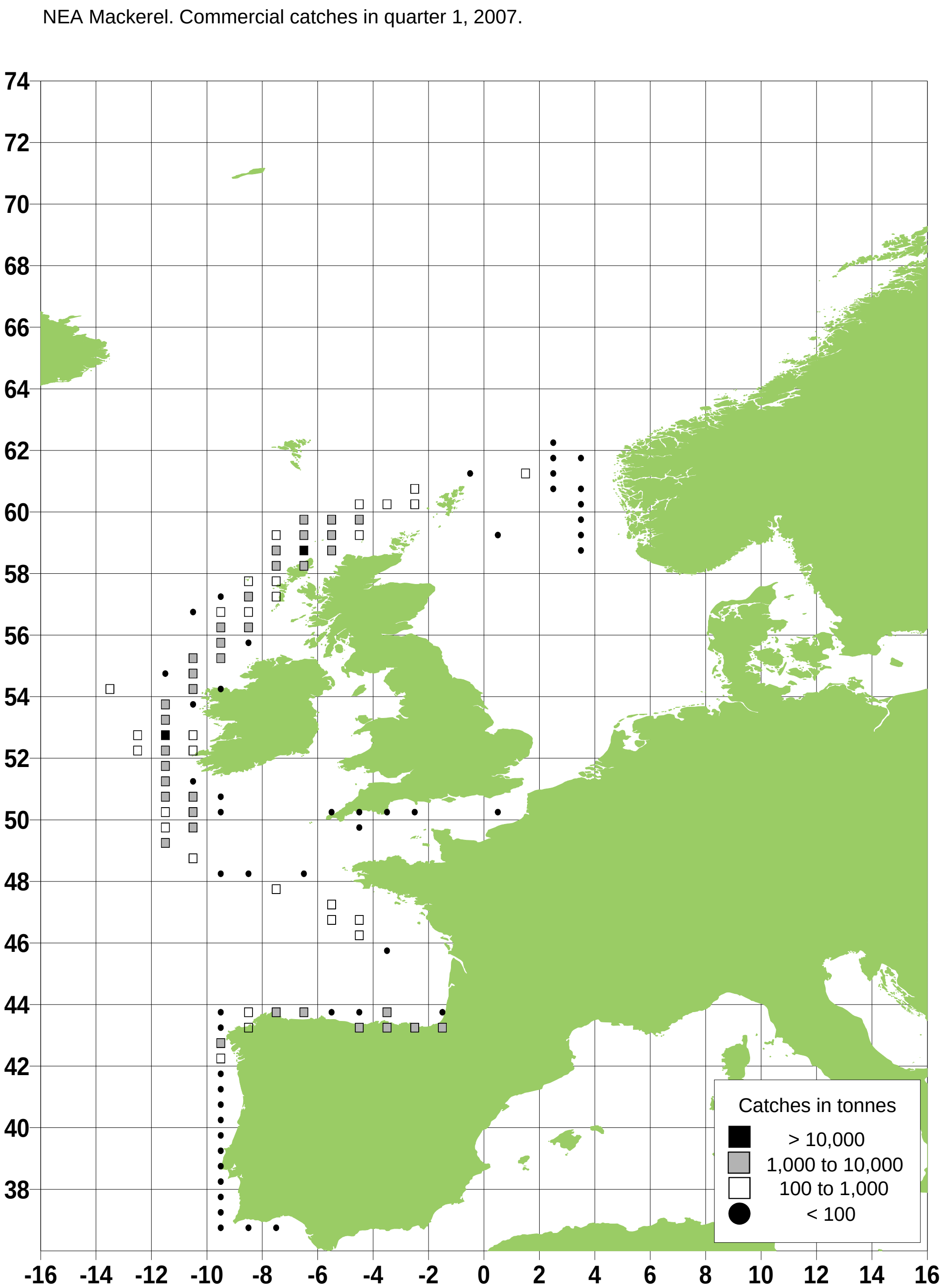


Figure 2.4.1.1 NEA Mackerel, commercial catches in quarter 1, 2007.

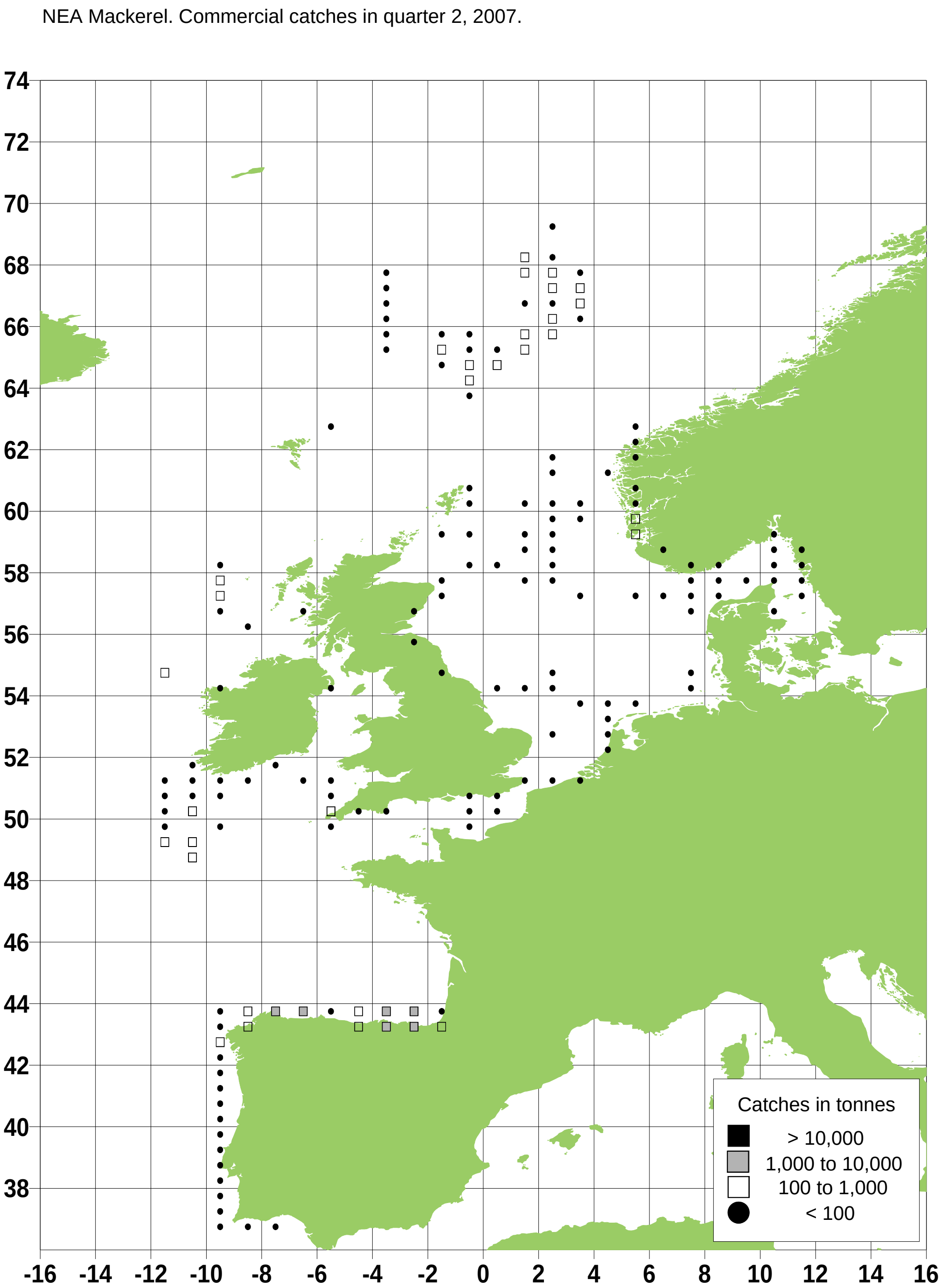


Figure 2.4.1.2 NEA Mackerel, commercial catches in quarter 2, 2007

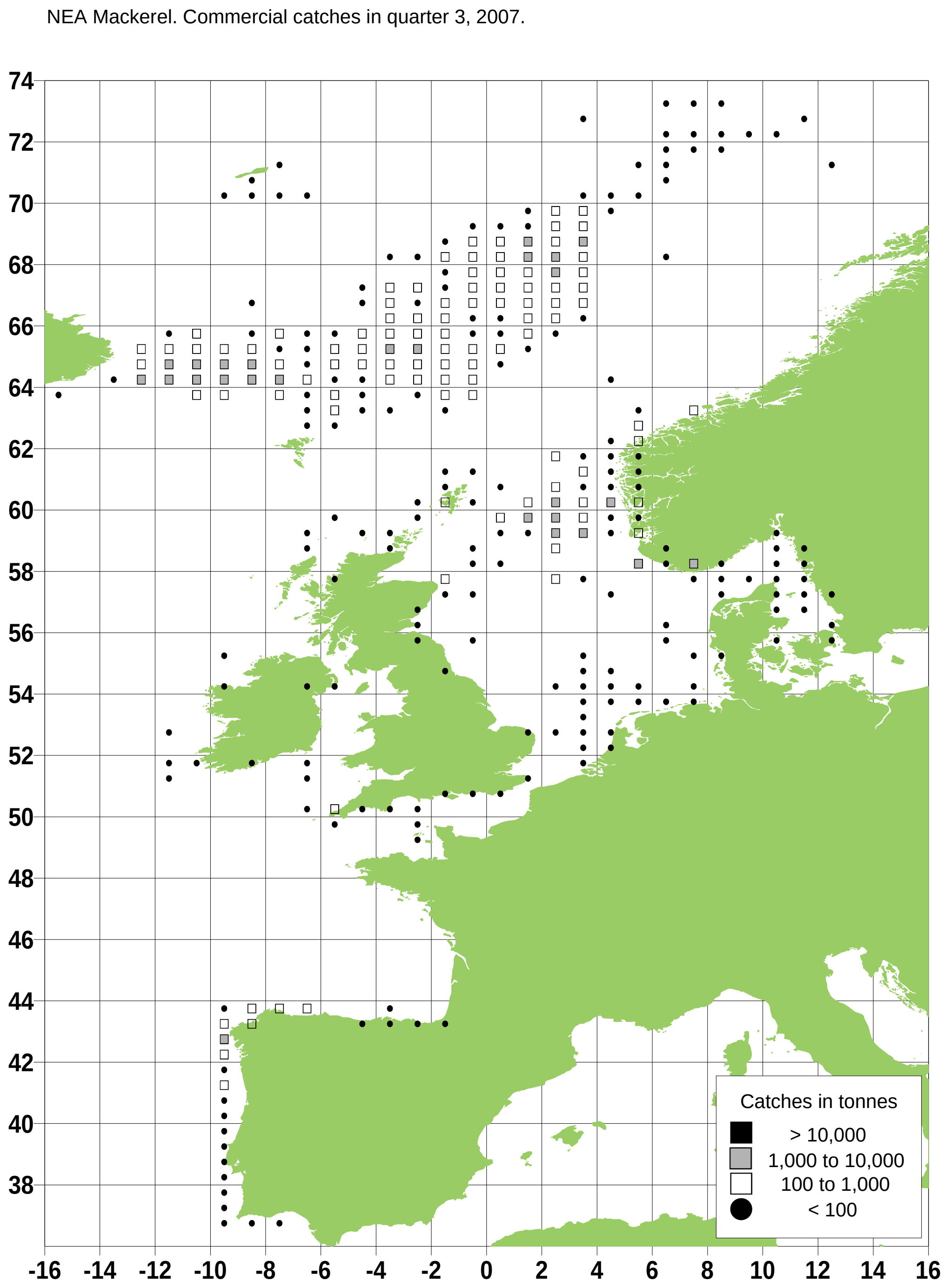


Figure 2.4.1.3 NEA Mackerel, commercial catches in quarter 3, 2007

NEA Mackerel. Commercial catches in quarter 4, 2007.

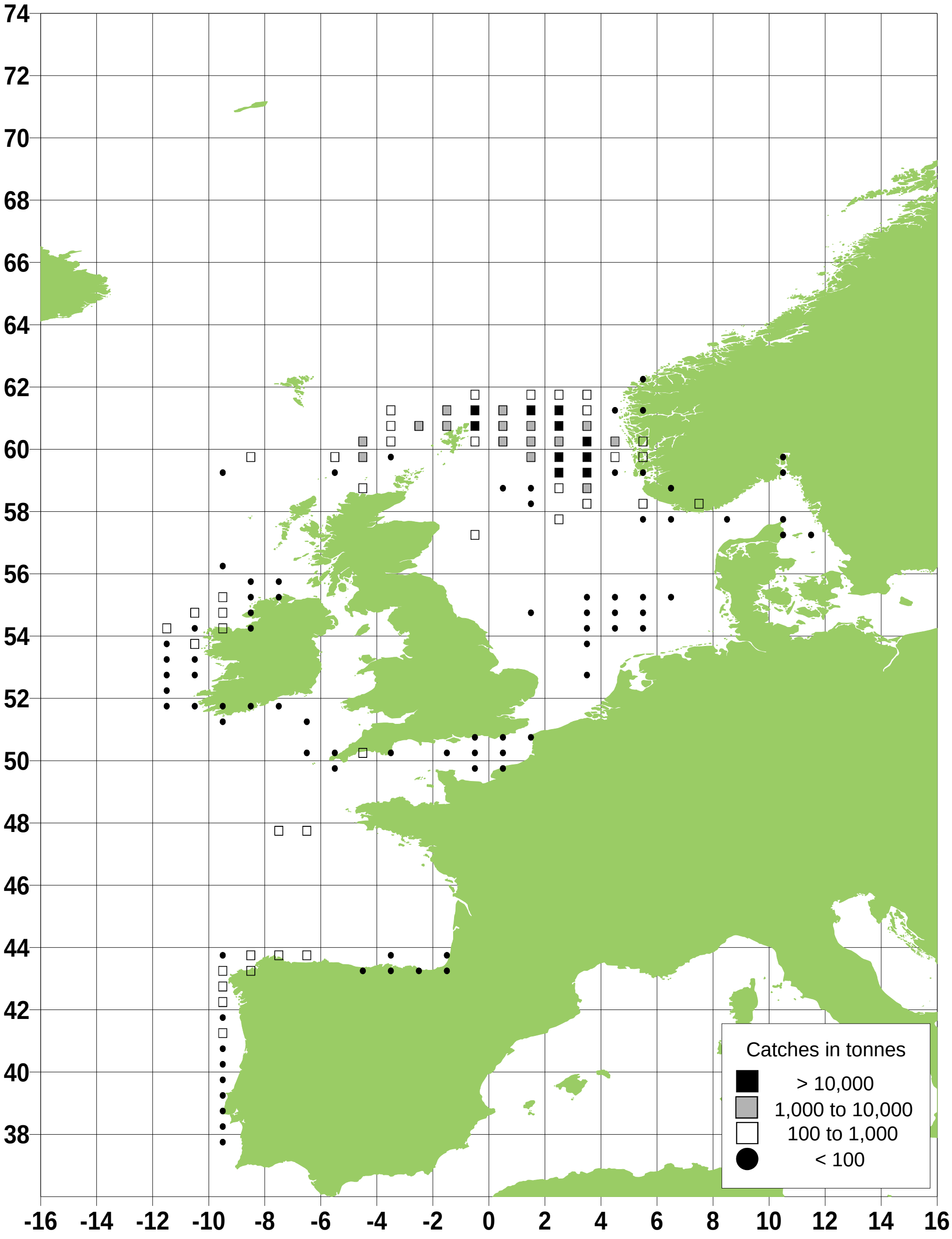


Figure 2.4.1.4 NEA Mackerel, commercial catches in quarter 4, 2007

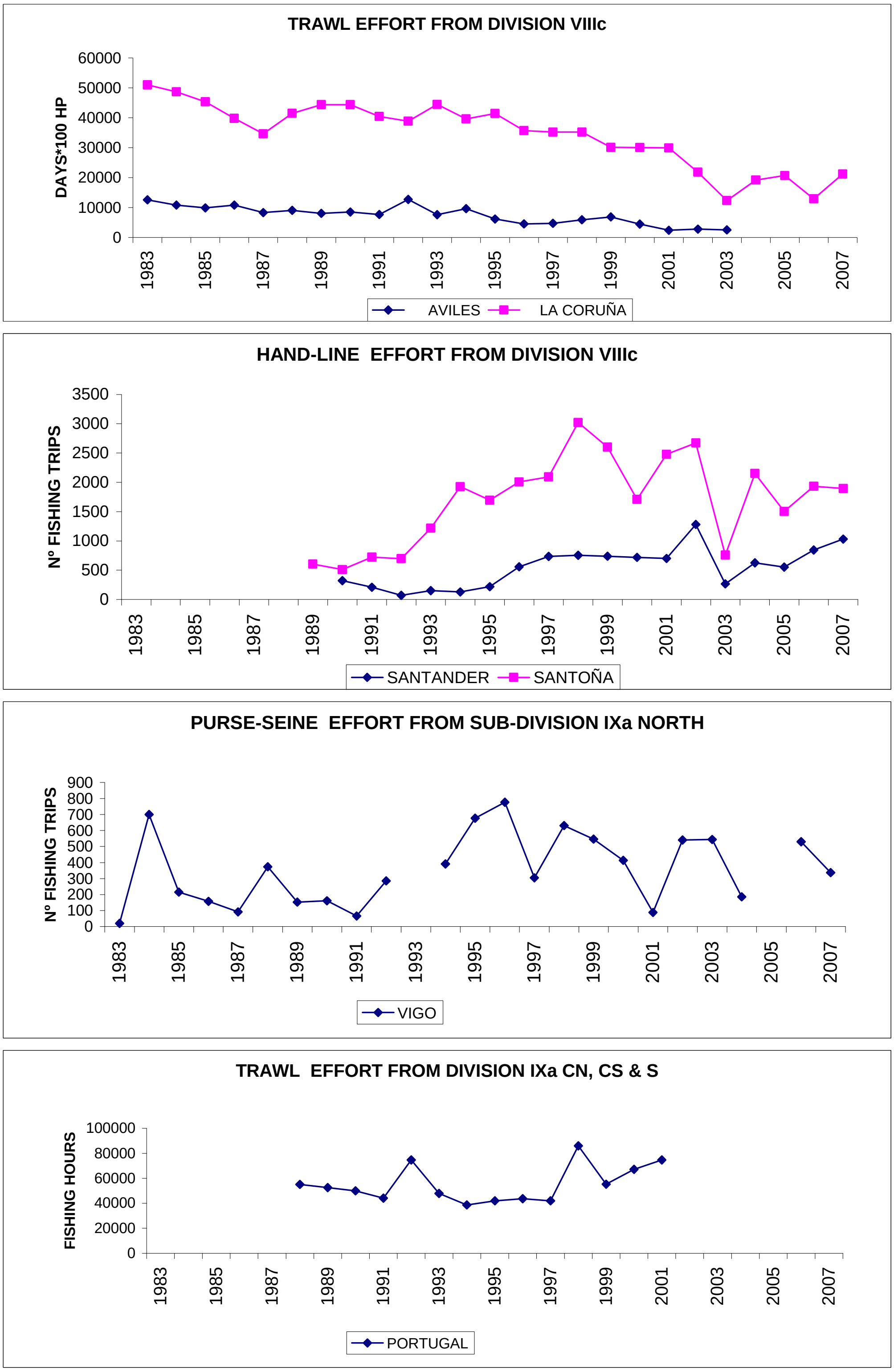


Figure 2.4.2.1. NEA mackerel (Southern component). Effort data by fleets and area .

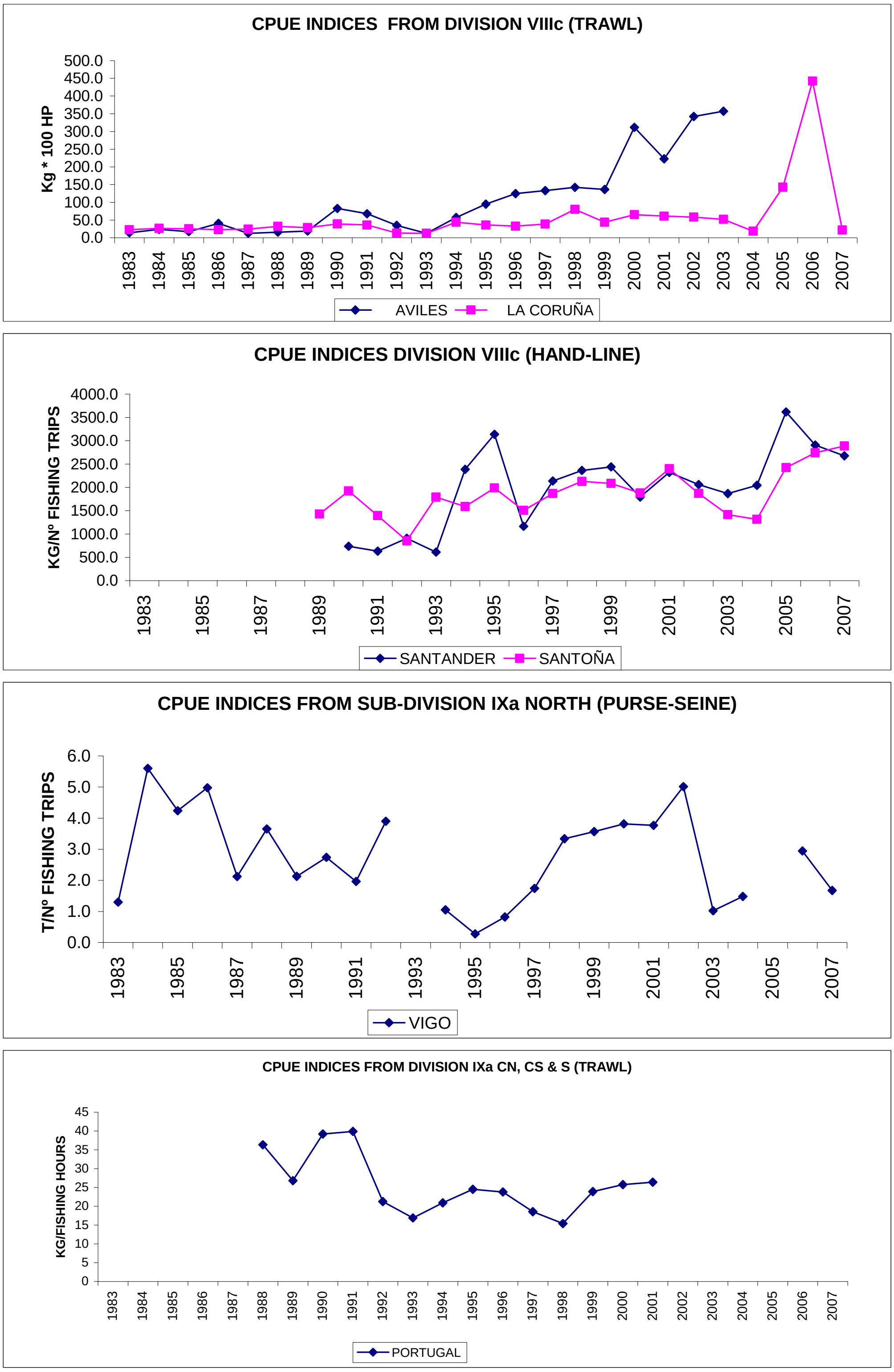


Figure 2.4.2.2. NEA mackerel (Southern component). CPUE indices by fleets and area

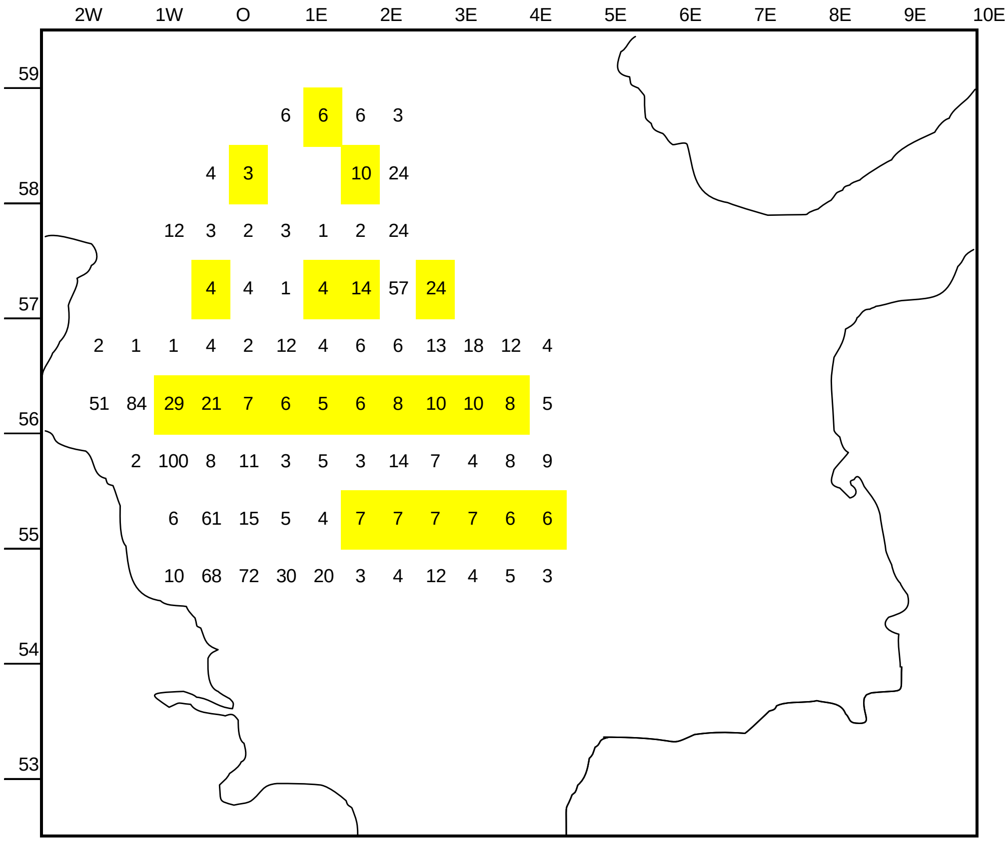


Figure 2.4.3.1.1 Daily egg production/m2 during period 1 (shadowed rectangles with intepolated values)

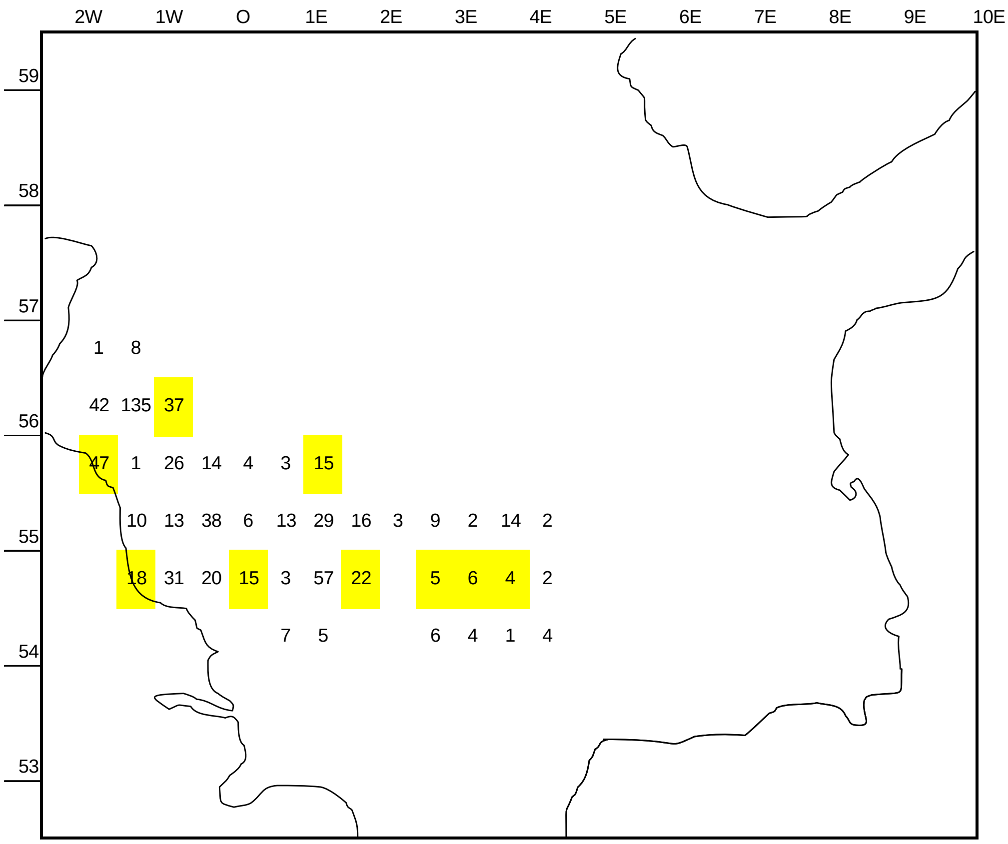


Figure 2.4.3.1.2 Daily egg production/m2 during period 2 (shadowed rectangles with intepolated values)

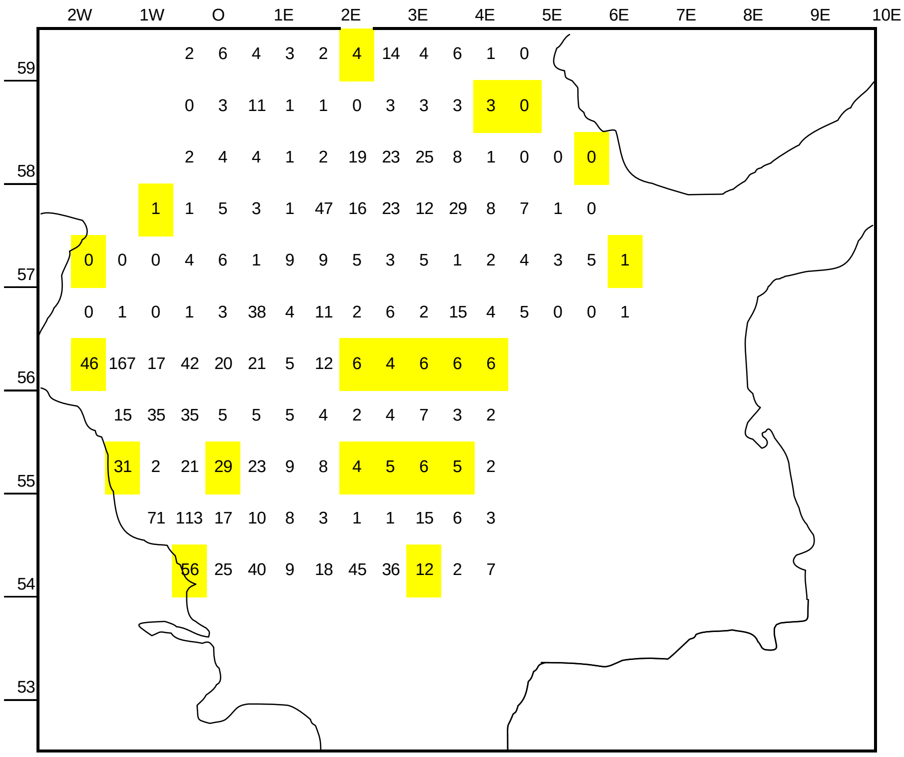


Figure 2.4.3.1.3 Daily egg production/m2 during period 3 (shadowed rectangles with intepolated values)

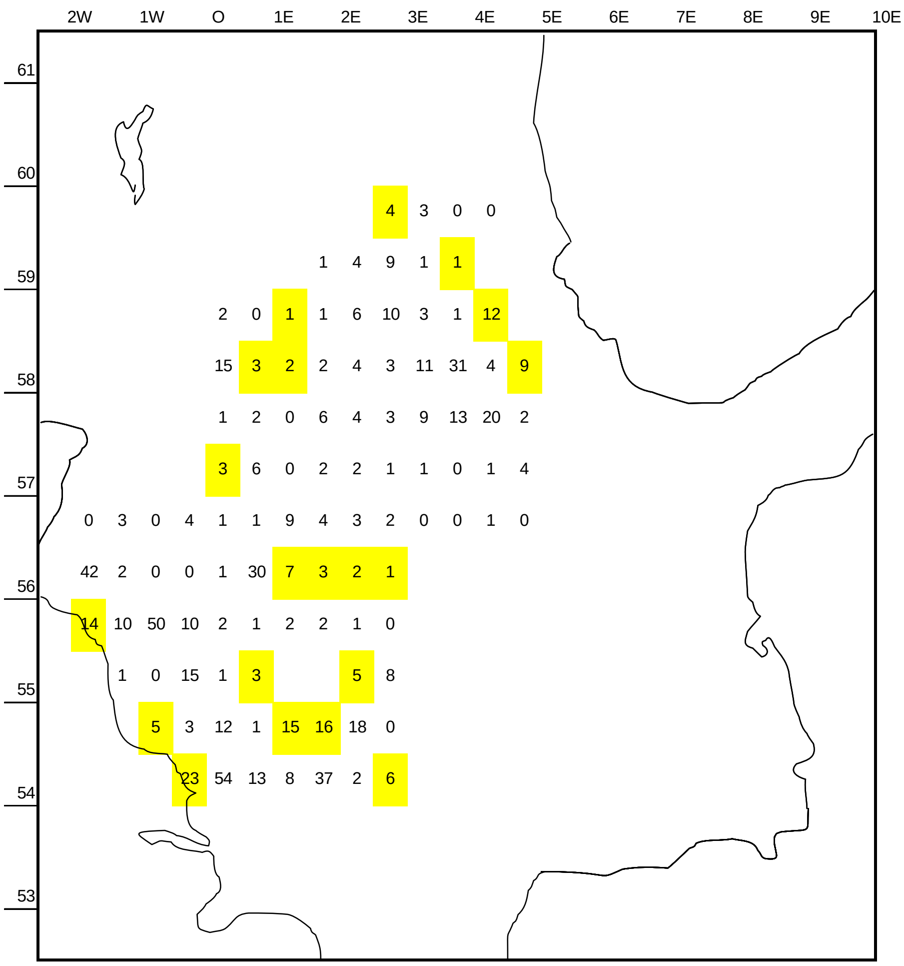


Figure 2.4.3.1.4 Daily egg production/m2 during period 4 (shadowed rectangles with intepolated values)

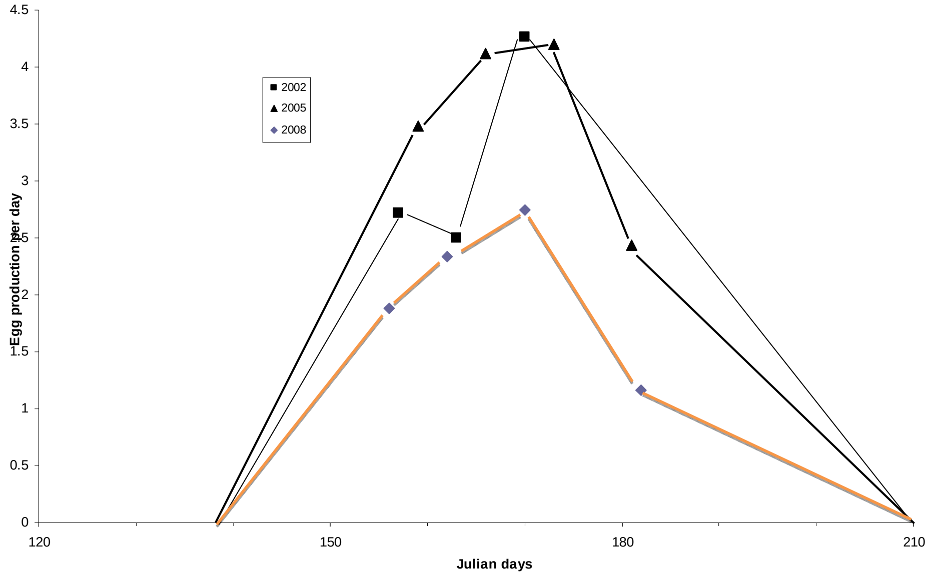


Figure 2.4.3.1.5. Egg production curve for North Sea mackerel in 2008, 2005 and 2002.

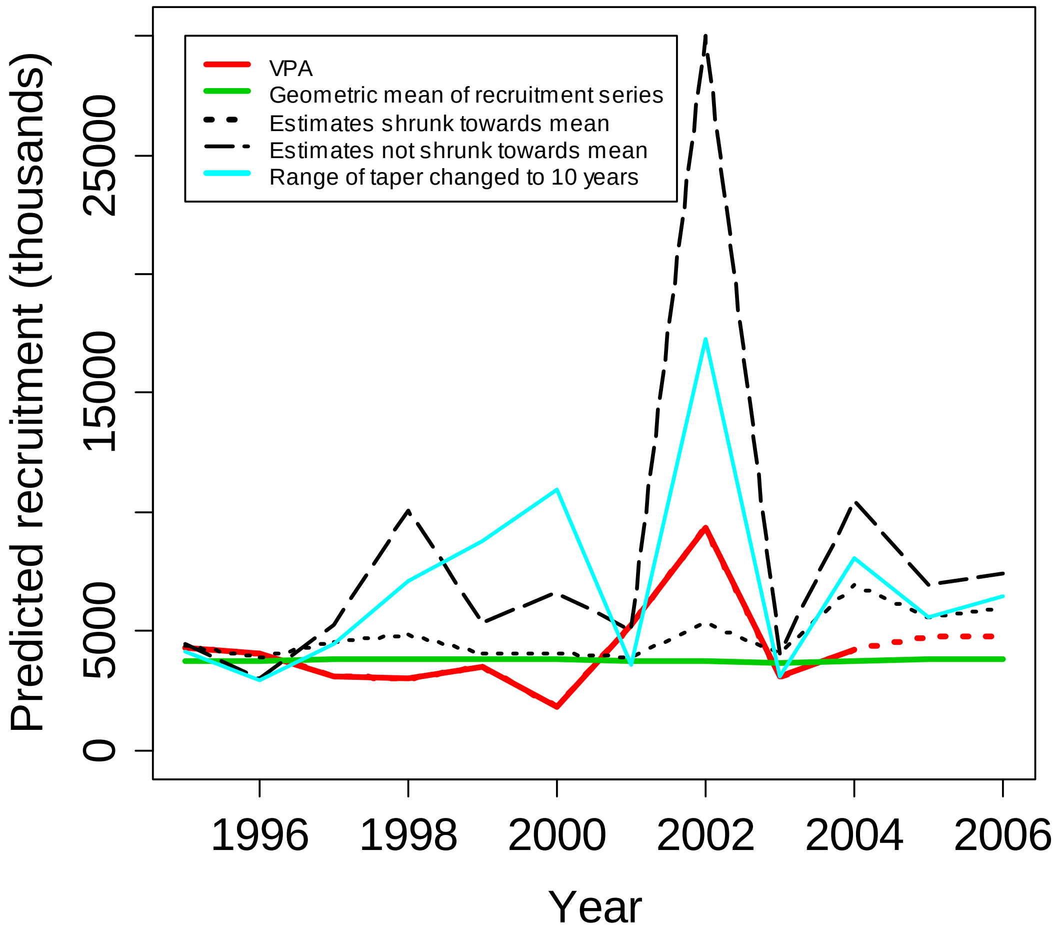


Figure. 2.4.3.3.1. A comparison of predicted recruitment (from various runs of the RCT3 program) with recruitment indicated by VPA analysis and with the geometric mean of the VPA series. The dashed line in the last two years of VPA-estimated recruitment indicates that the estimate is uncertain for these years.

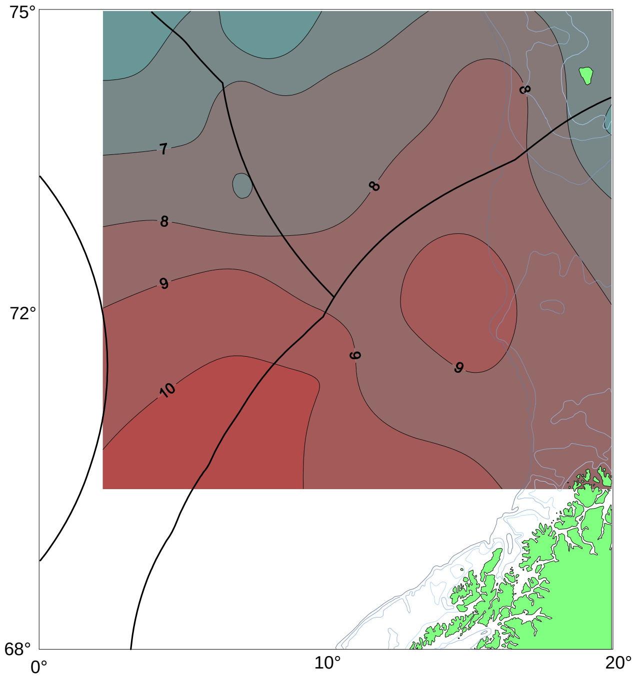


Figure 2.4.3.5.1. Temperature distribution at 20 m depth in the northern part of the Norwegian Sea, 26 July- 9 August 2008.

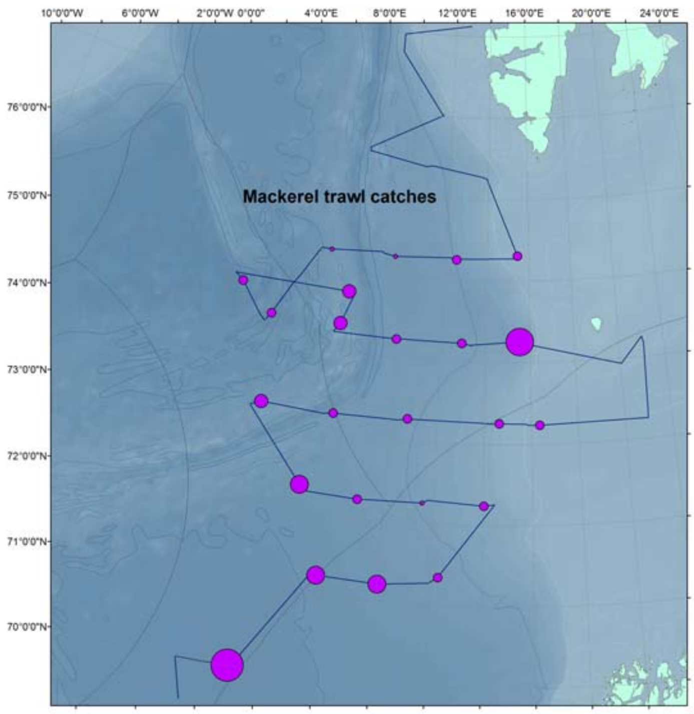


Figure 2.4.3.5.2. Distribution of NEA mackerel from pelagic trawl catches in the northern part of the Norwegian Sea, 26 July-9 August 2008.

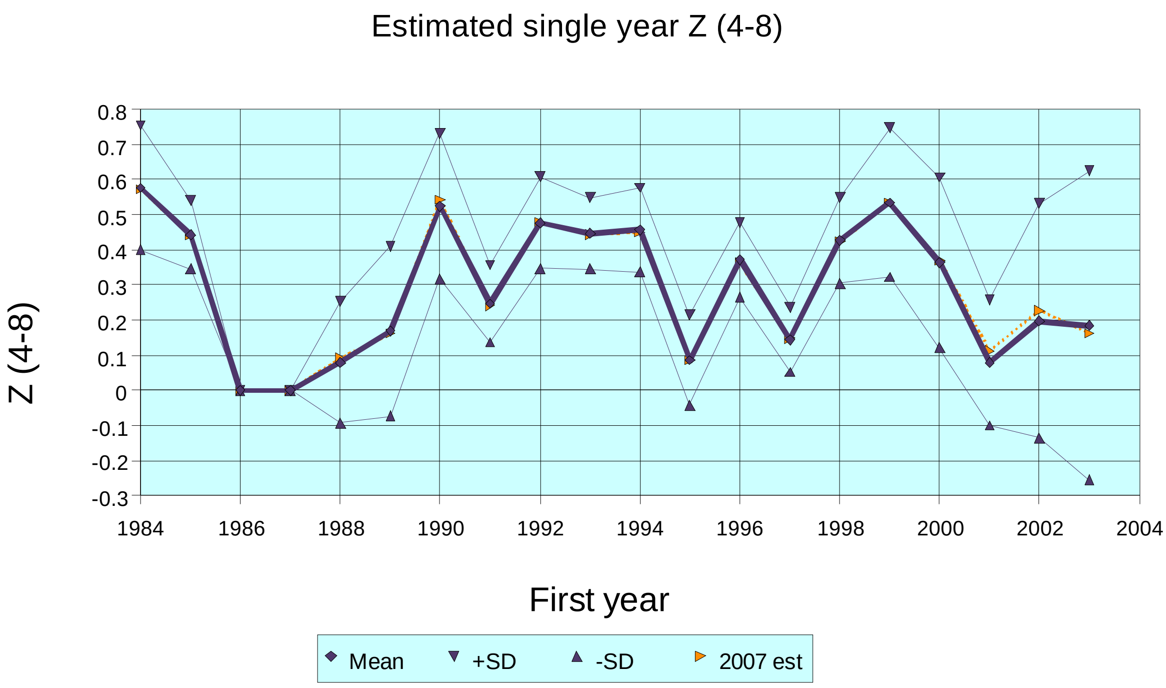


Figure 2.4.7.1 Mortality estimates (mean and SD) from bootstrapped tag return data, for pooled ages 4–8 years. The mean values from the analysis made in 2007 are included for comparison.

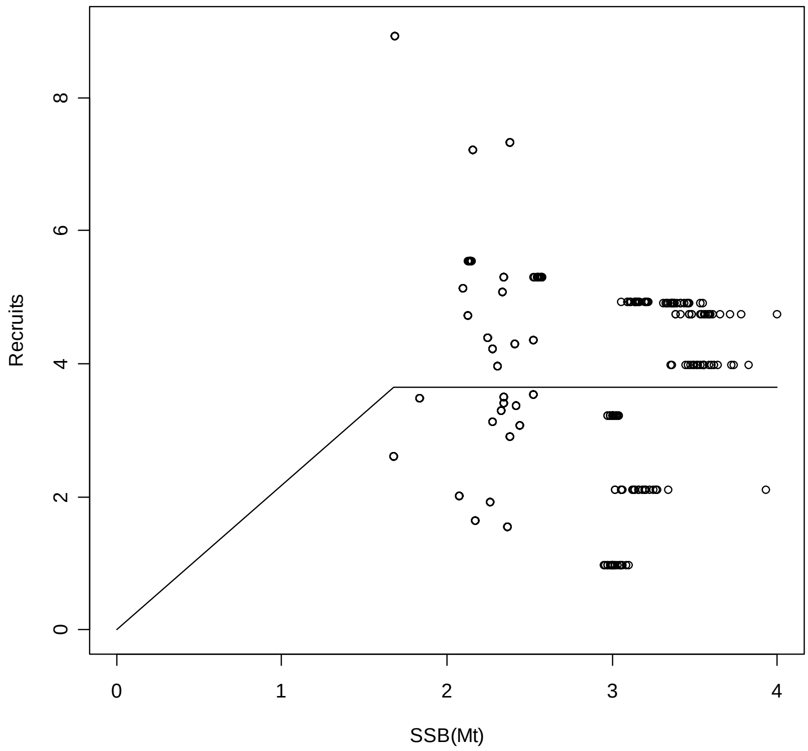


Figure 2.6.1 Estimated hockey-stick Stock Recruit relationships under different recruitment and exploitation conditions in years 1972–1979. Substituting bootstrap simulated age structure for catch at age 4–12+ in 1972 to 11 to 12+ in 1979. Shwing that the relatuionship is insensitive to variability in SSB in years 1972–1979

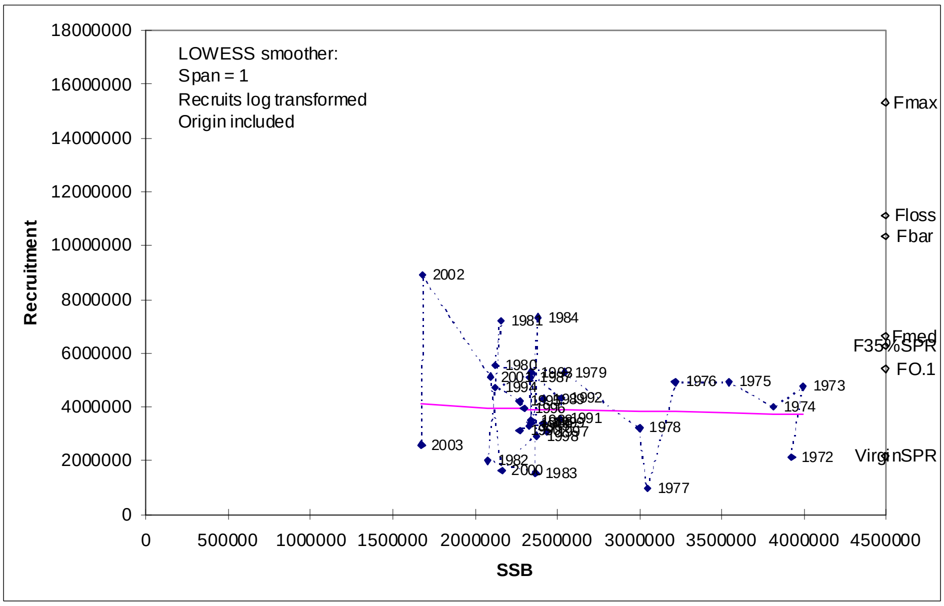


Figure 2.6.2. Recruitment against SSB. The solid line represents expected values estimated from the LOWESS smoothed stock recruitment relationship. A number of reference points are indicated on the *y*-axis.

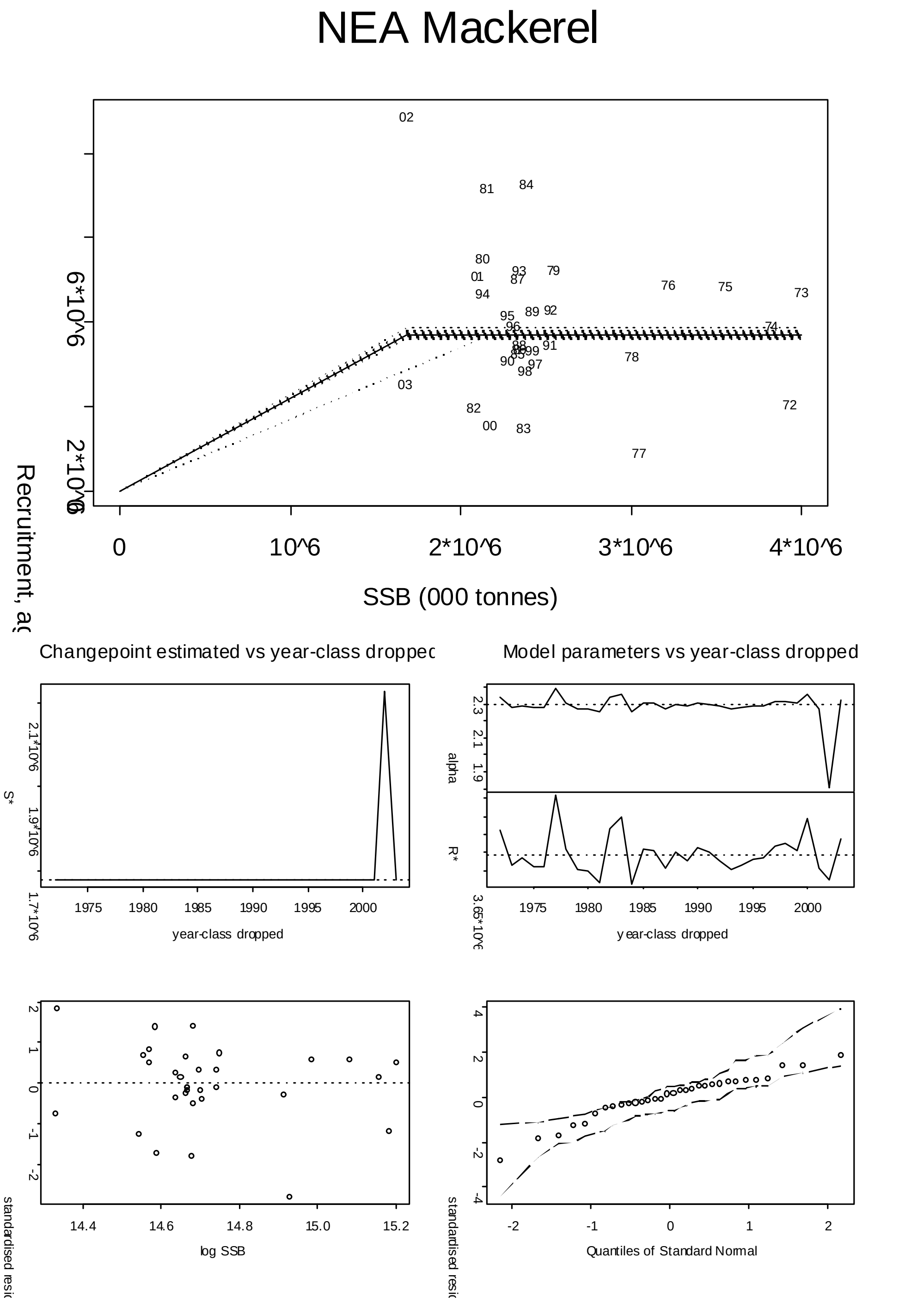


Figure 2.6.3. NEA mackerel. Segmented regression fit (Maxwell 2002). Estimated parameters are δ= 1.68 million, β1 = 2.199 and α2 = 3.69 billion.

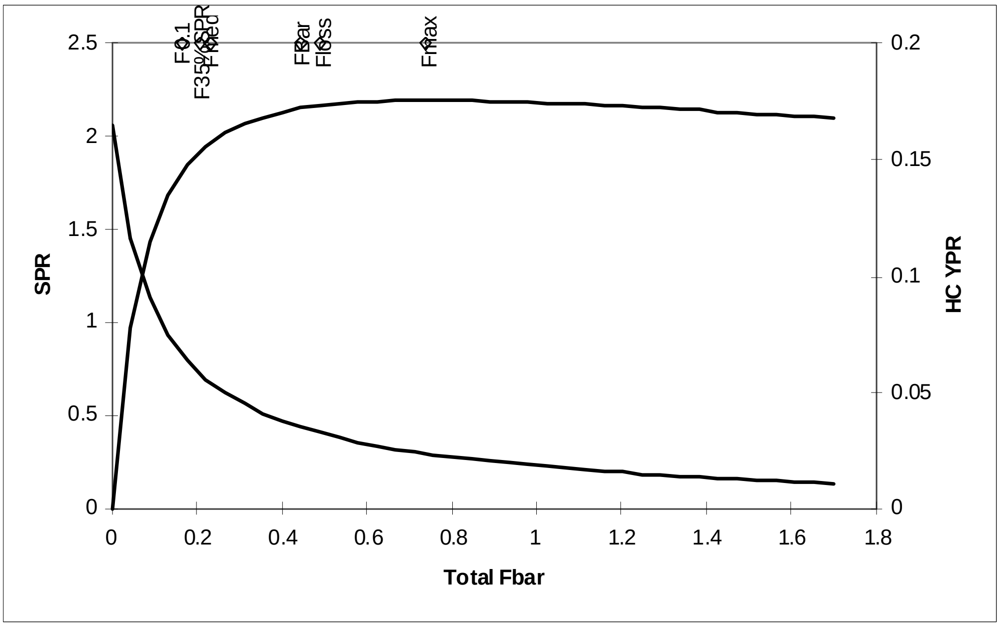


Figure 2.6.4. NEA mackerel. Spawner biomass per recruit and yield per recruit analysis, data 1972 – 2003.

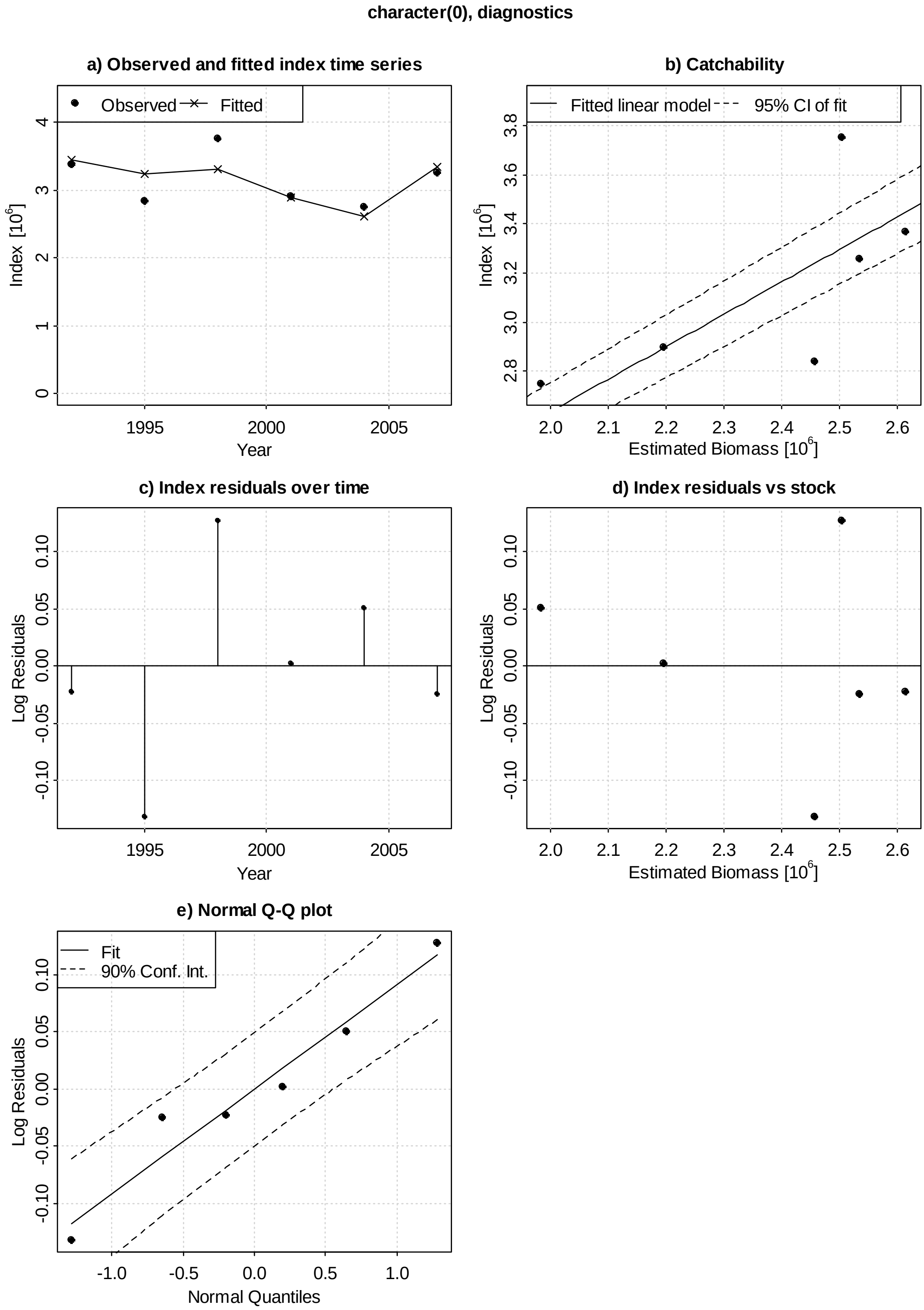


Figure 2.7.1.1. NE Atlantic mackerel final assessment FLICA diagnostics for fit to mackerel egg survey.

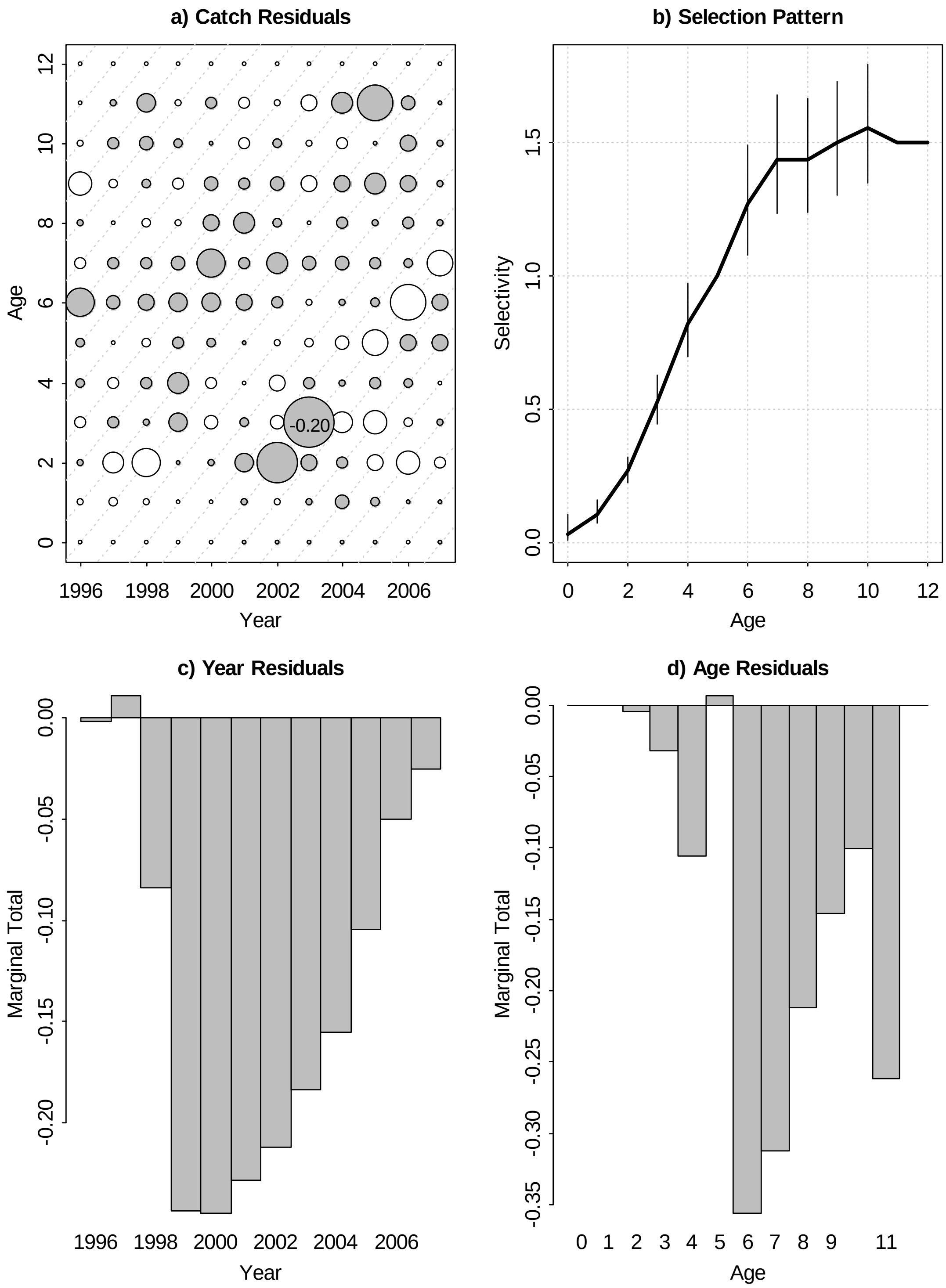


Figure 2.7.1.2. NE Atlantic mackerel final assessment FLICA diagnostics for fit of catch to the separable period, a) log residuals by year (age, 0 and 1 down weighted). b) fitted selection pattern, Average residuals c) by year, d) by age fitted selection pattern

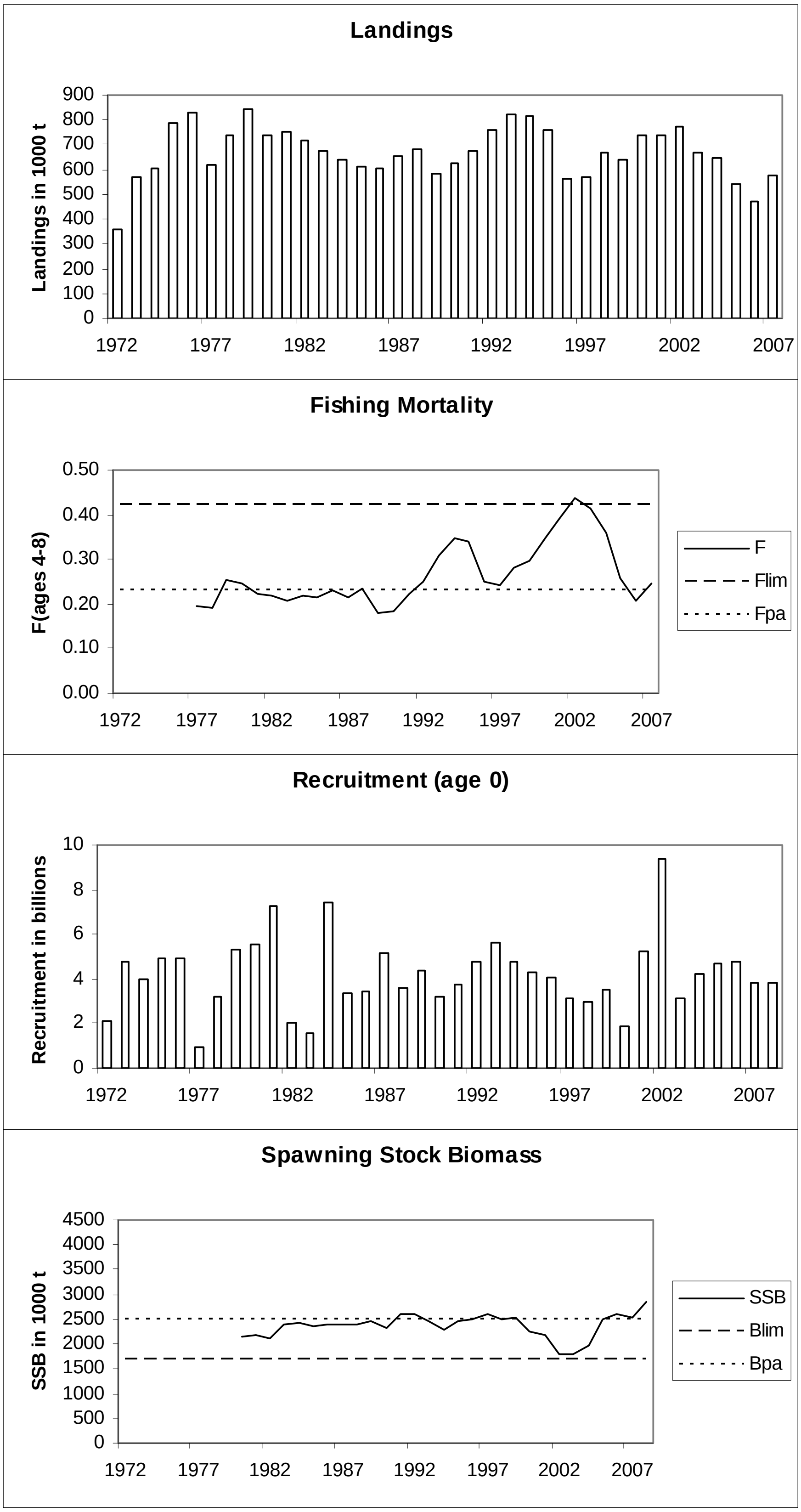
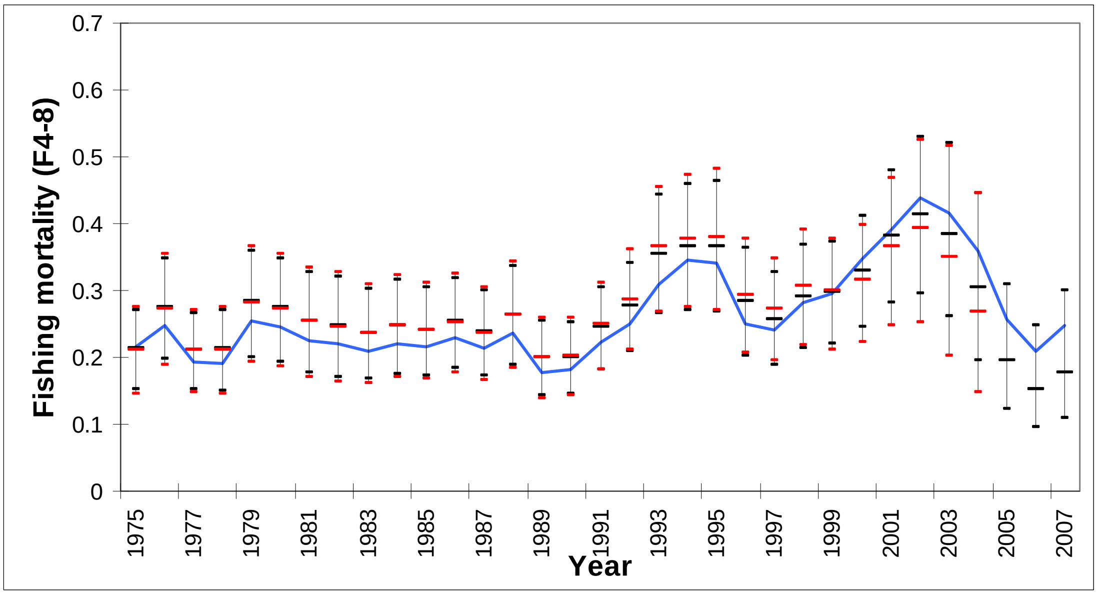
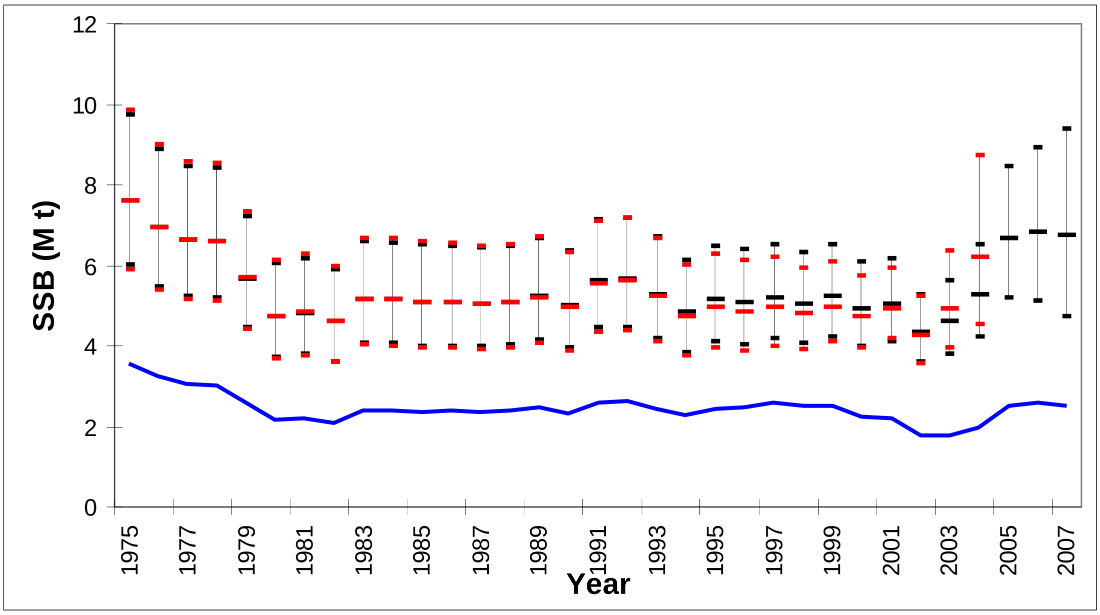


Figure 2.7.1.3 NE Atlantic Mackerel stock summary (biomass frp, 1980 to 2007, catches from 1972 to 2007, F(4-8) from 1977 to 2007, and recruitment from 1972-2007)





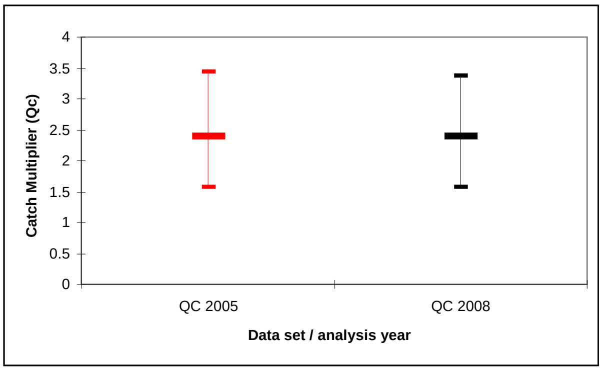
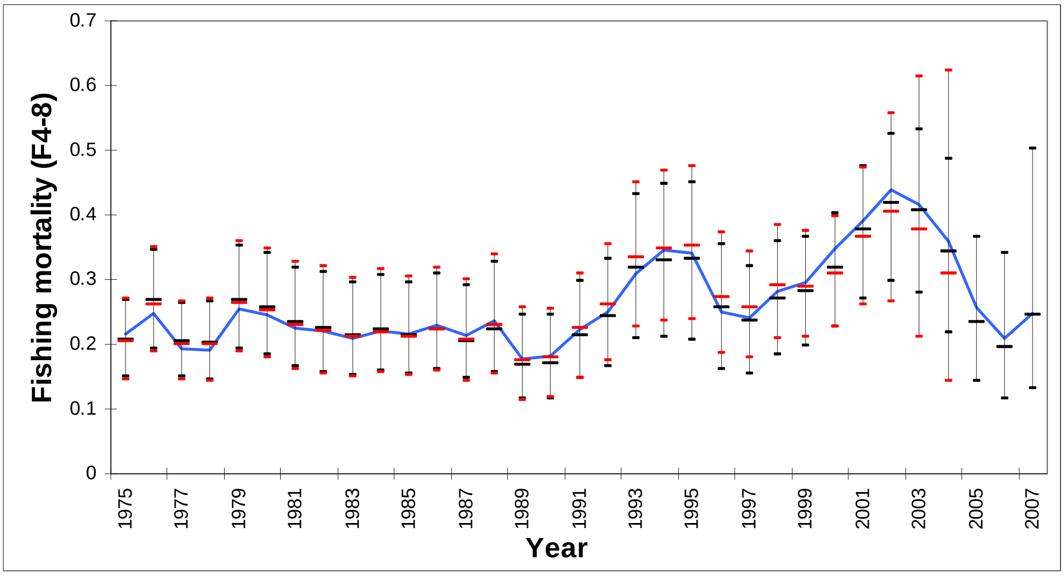
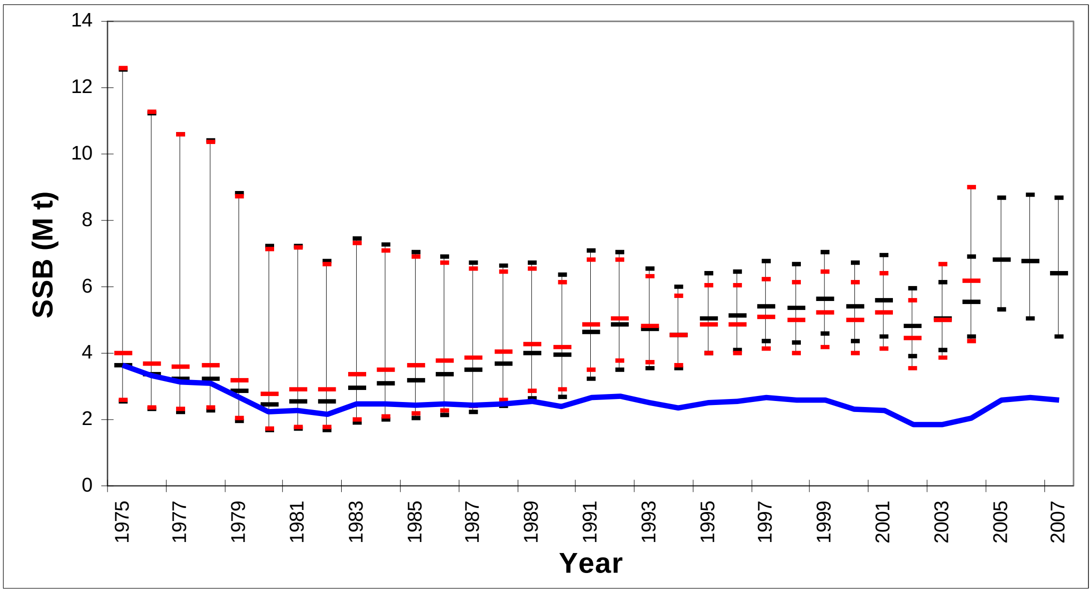


Figure 2.7.2.1 Estimates of F and SSB 1975 to 2007 from Bayesian analysis including constant catch and M multipliers. 2005 and 2008 analyses and ICA virtual population assessment (blue) based on reported catch and fixed M.



a)



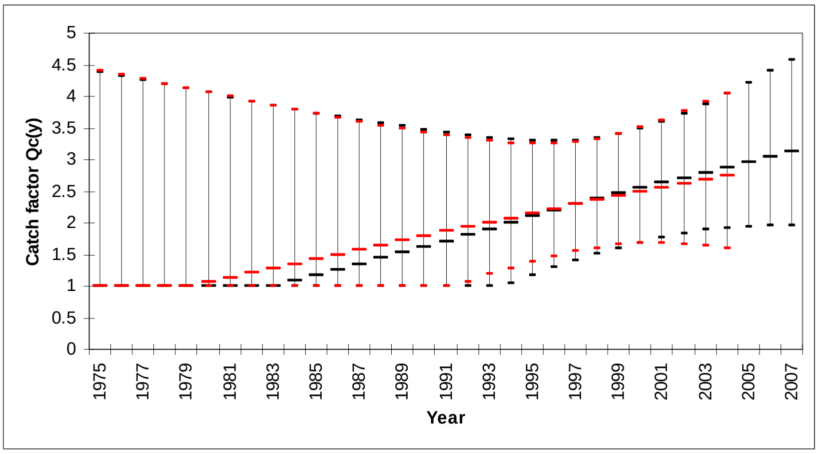


Figure 2.7.2.2 Estimates of F and SSB 1975 to 2007 and catch factors from Bayesian analysis including linear catch multiplier with time and fixed M multiplier. 2005 (red) and 2008 (black) analyses and ICA virtual population assessment (blue) based on reported catch and fixed M. Intervals are 95 percentiles

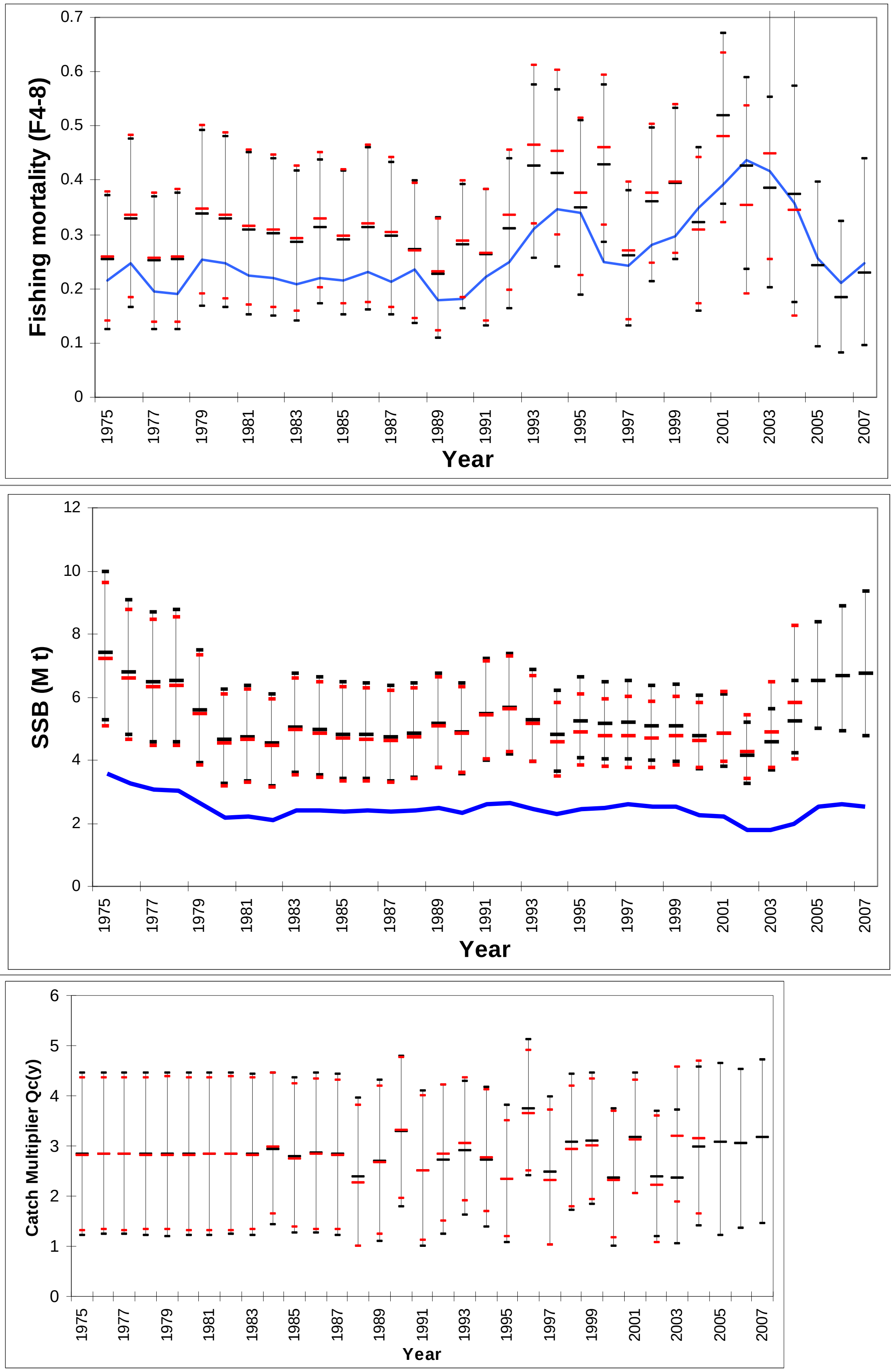
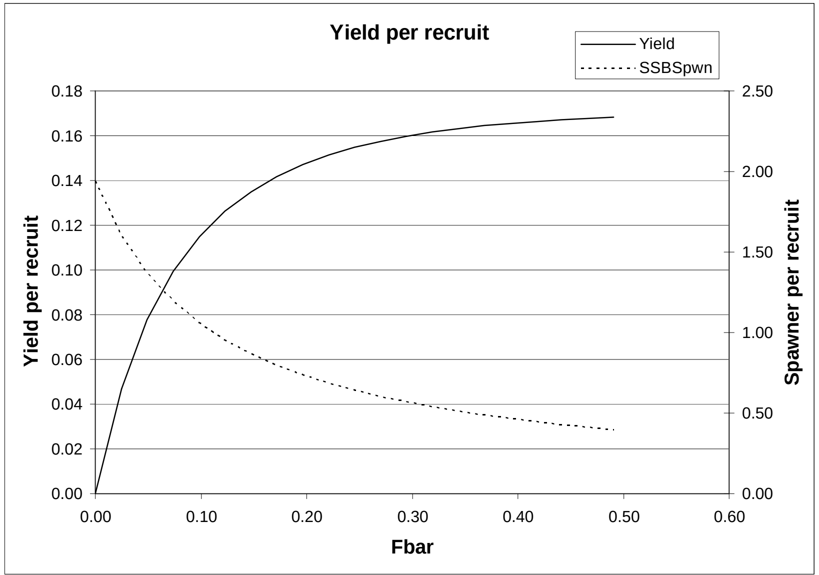
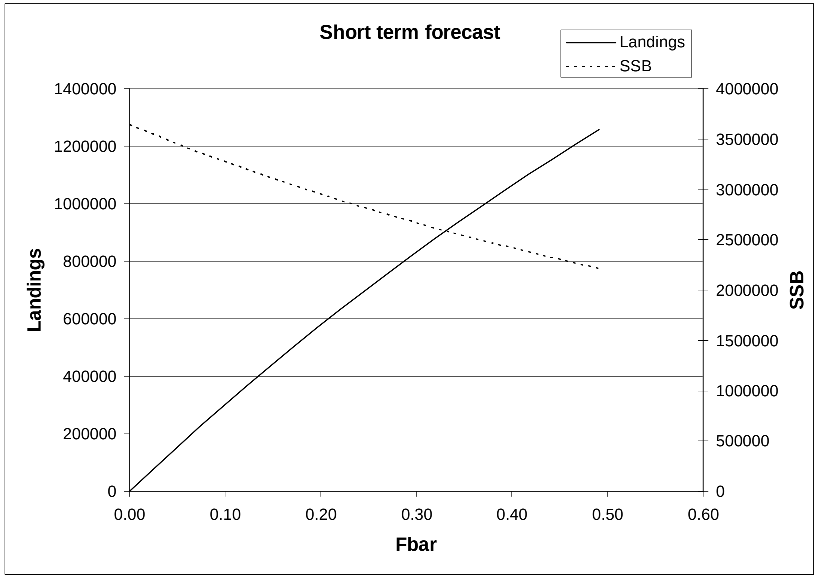


Figure 2.7.2.3 Estimates of F and SSB 1975 to 2007 and catch factors from Bayesian analysis including yearly varying catch multiplier with time and fixed M multiplier with time with variability at age. 2005 (red) and 2008 (black) analyses and ICA virtual population assessment (blue) based on reported catch and fixed M. Intervals are 95 percentiles





MFYPR version 2a
Run: Final2008
Time and date: 10:35 06/09/2008

Reference point	F multiplier	Absolute F
Fbar(4-8)	1.0000	0.2455
FMax	2.7707	0.6801
F0.1	0.7108	0.1745
F35%SPR	0.9139	0.2243

Weights in kilograms

MFDP version 1a
Run: final2008
Mackerel NE Atlantic WG2008
Time and date: 10:33 06/09/2008
Fbar age range: 4-8

Input units are thousands and kg - output in tonnes

Figure 2.8.1 NE Atlantic mackerel Yield Per Recruit and Short Term Forecast.

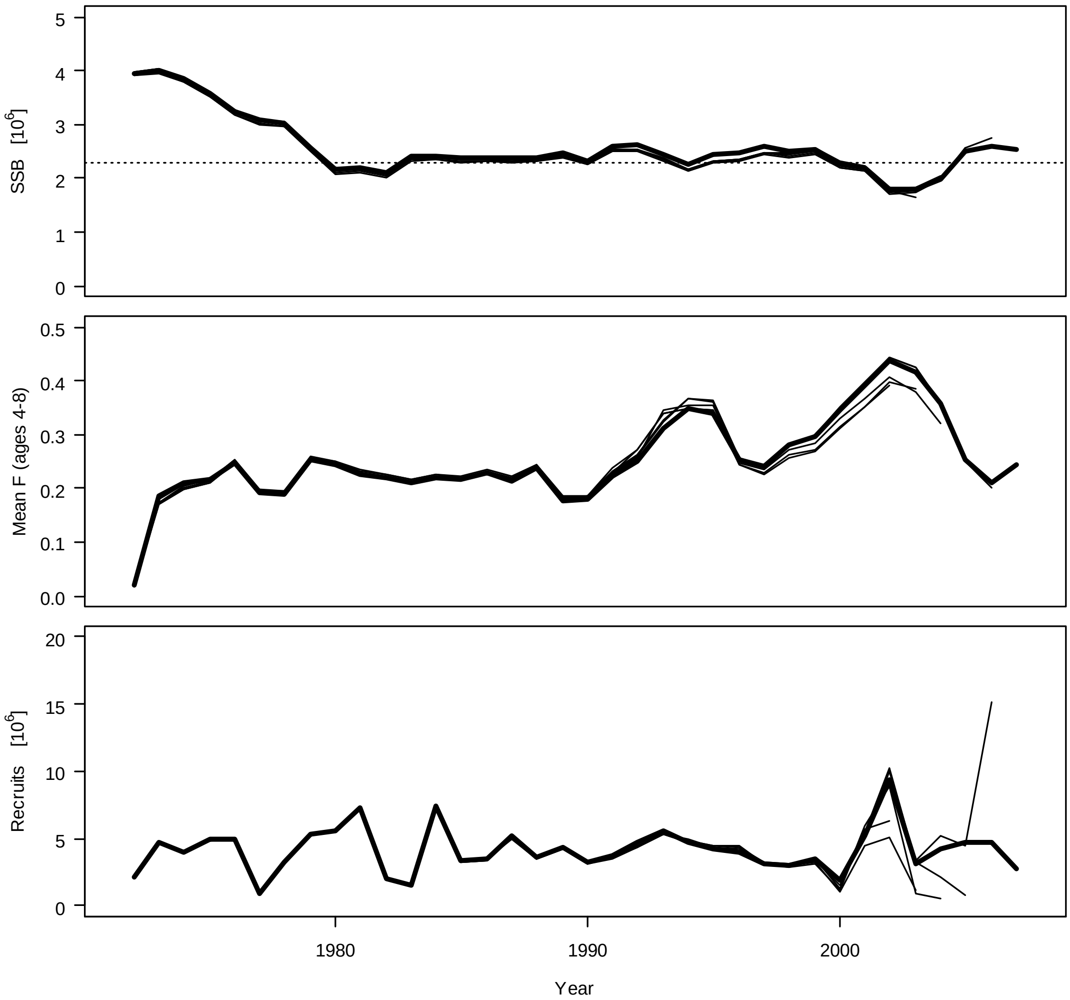


Figure 2.9.1 NE Atlantic mackerel final ICA assessment analytical retrospective of Spawning Stock Biomass (SSB), mean F ages 4–8, recruitment age 0.

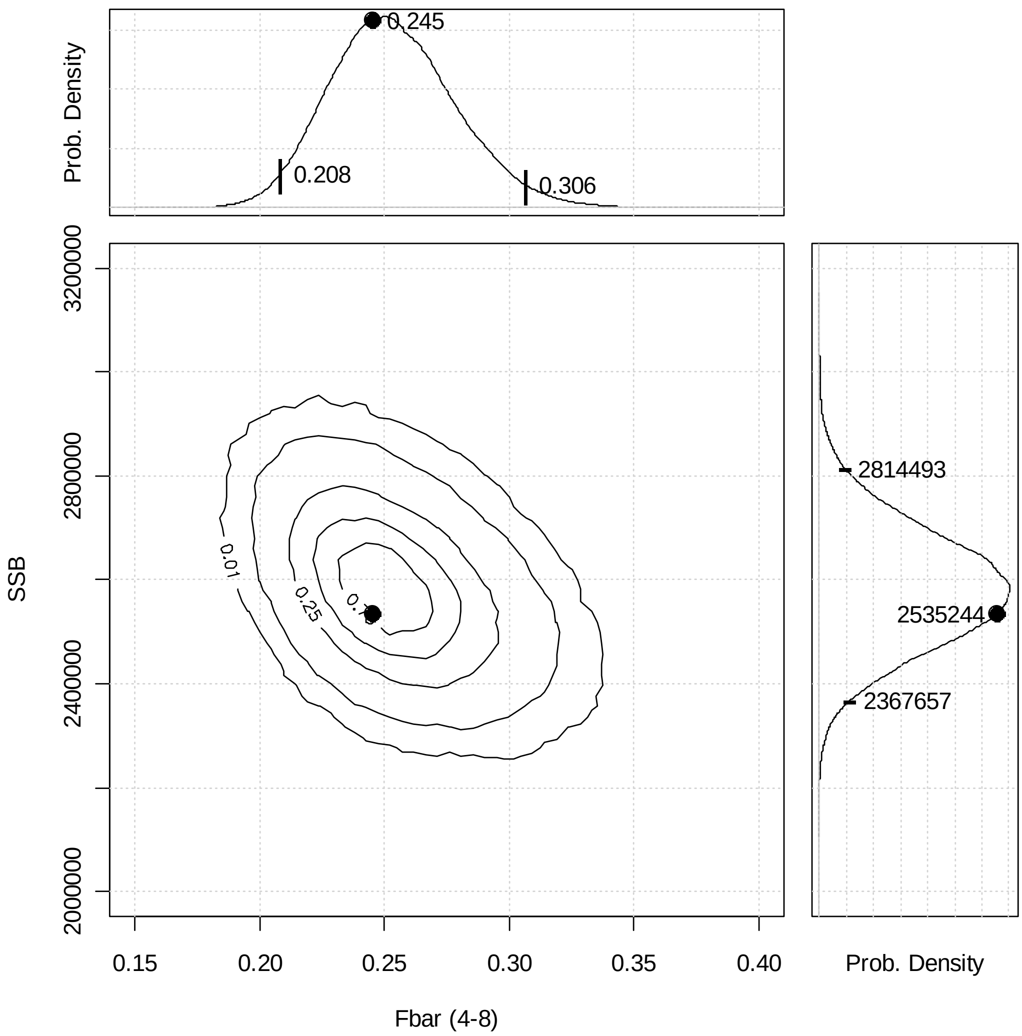
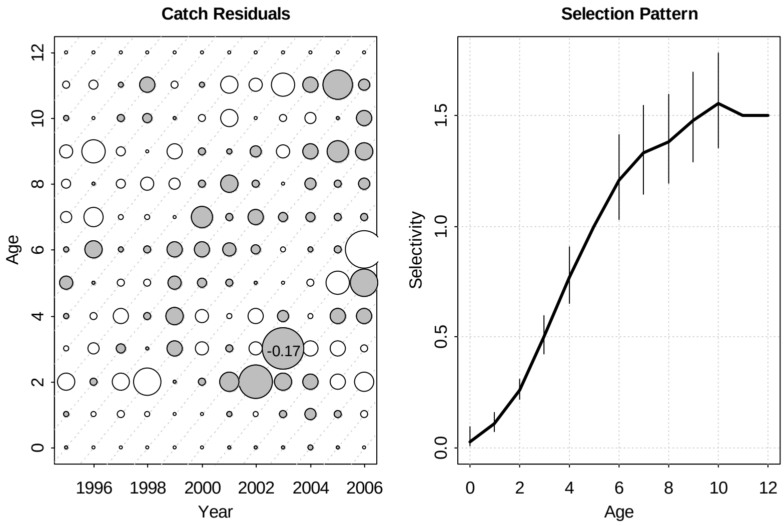


Figure 2.9.2.1 NE Atlantic mackerel, precision of ICA estimates of terminal SSB and F4–8 from bootstrap of parameter residuals in FLICA. Showing percentile contours from 1000 realisations and the point estimates.

FLICA 2007



FLICA 2008

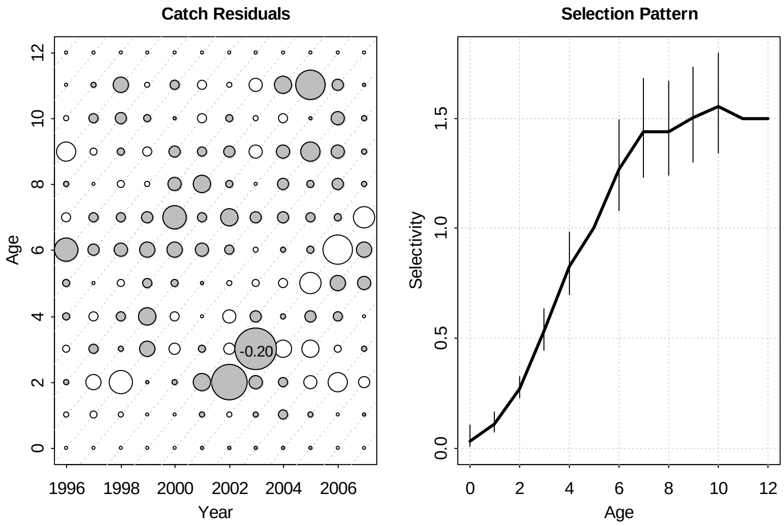


Figure 2.10.1. Comparison of the model fit to the catch data for the separable period between 2007 and 2008 assessments (left panels : log residuals; right panels : selection pattern).

FLICA 2007 FLICA 2008

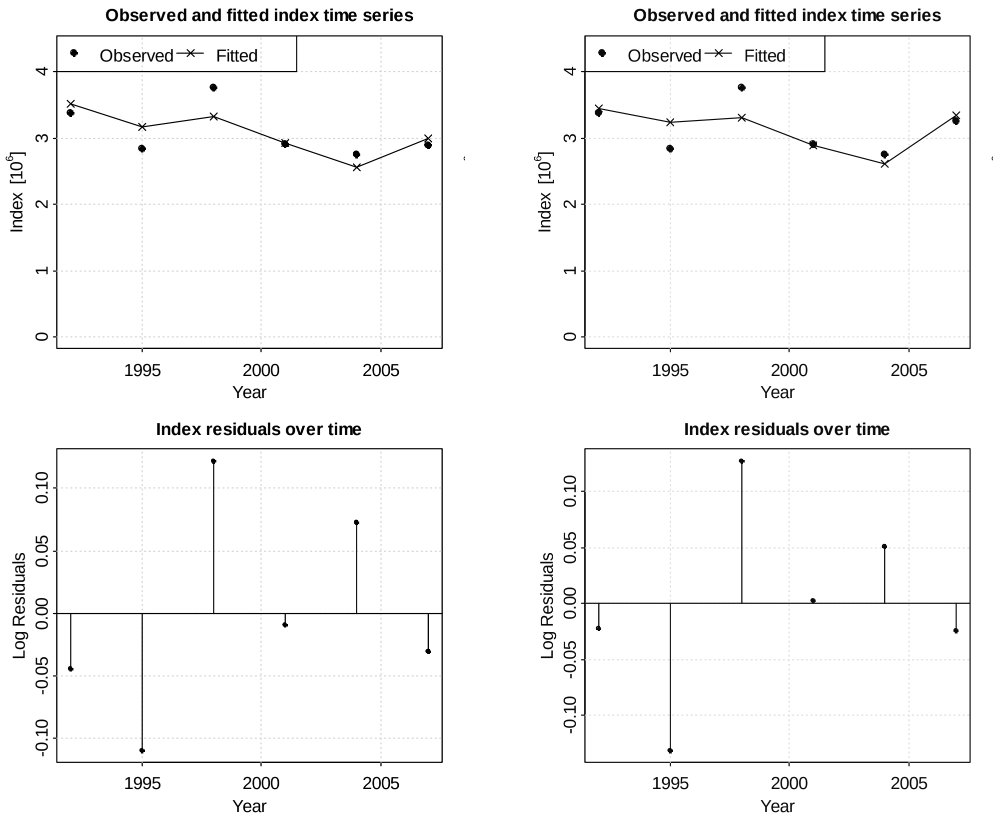
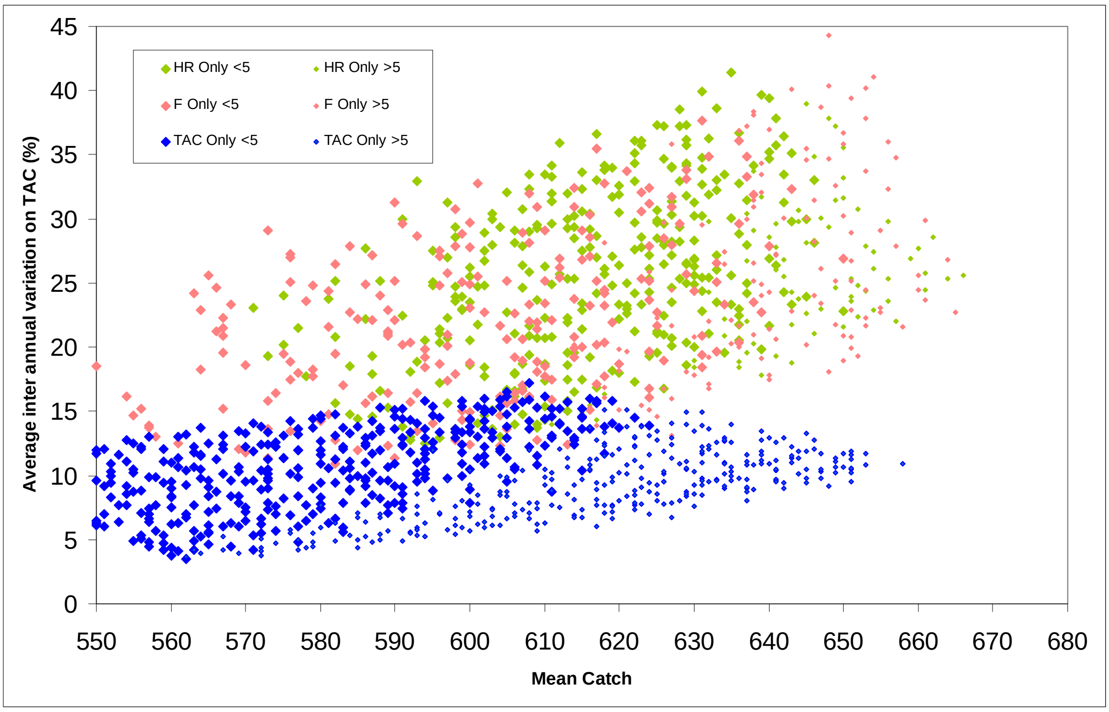


Figure 2.10.2 Comparison of model fit to the mackerel egg survey index for the 2007 and the 2008 assessments.



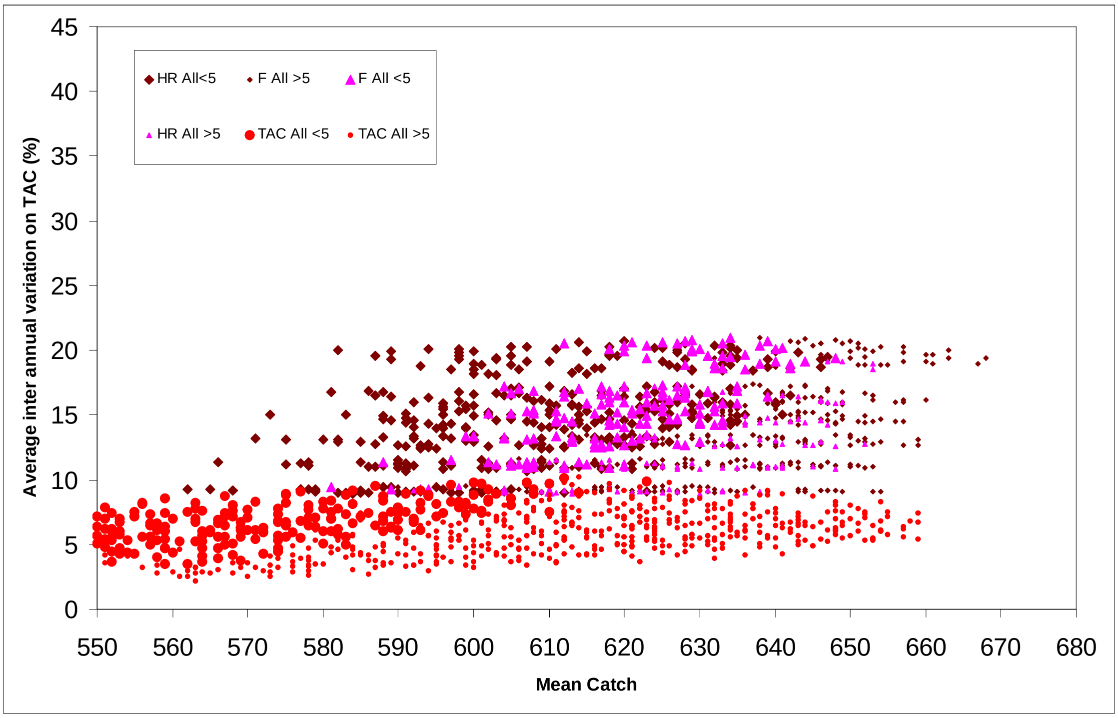


Figure 2.11.1 All Strategies tested. Mean catch (years 10–20) and average inter-annual variability in TAC for all strategies tested. Small dots show strategies with risk of SSB< Blim >5% during years 10–20. Top panel shows strategies where % constraint on inter-annual change in TAC is only applied when SSB > B_{trig}. Lower panel shows strategies where % constraint on inter-annual change in TAC is always applied.

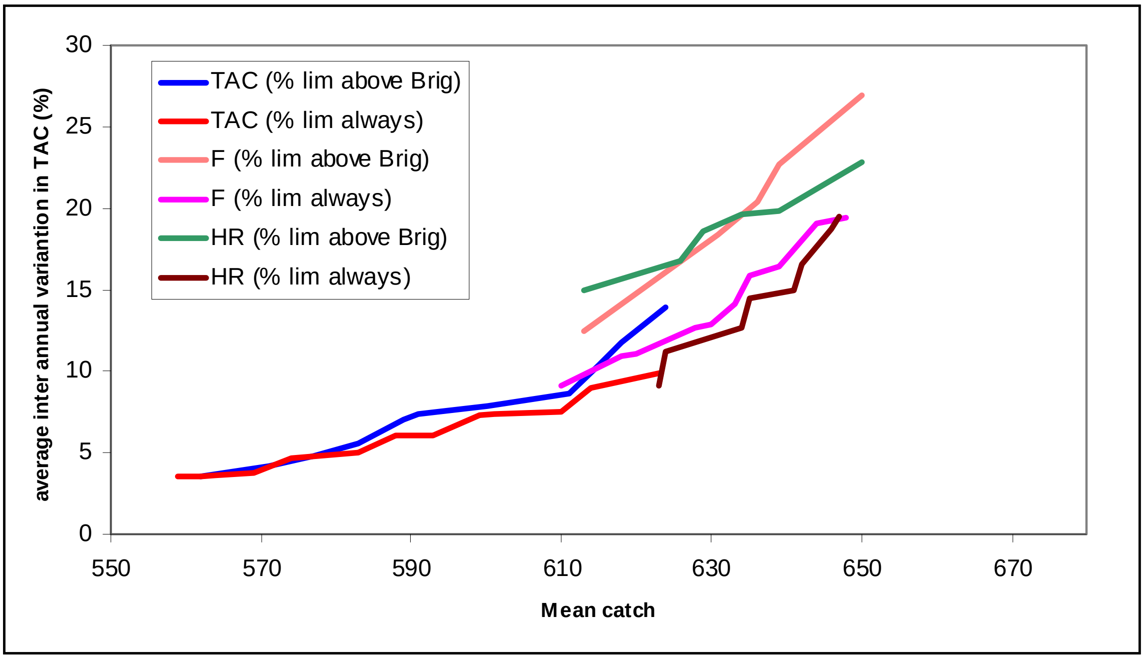


Figure 2.11.2 Optimal strategies. Mean catch (years 10–20) and average inter-annual variability in TAC for the strategies with minimum average inter-annual change in TAC for highest mean TAC. Lines connect lowest right strategies from figure 2.11.1.

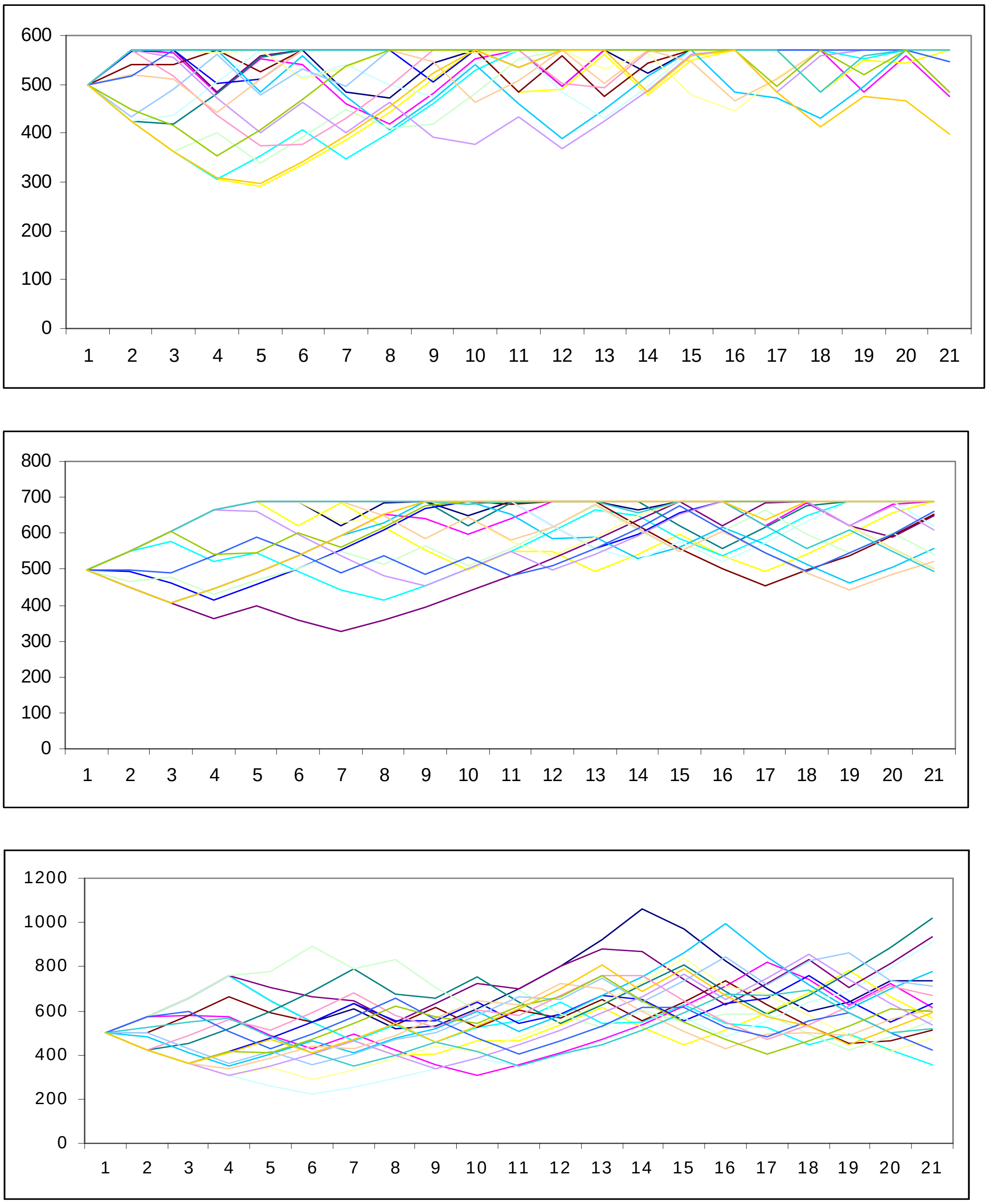


Figure 2.11.3 TAC trajectories by year over 21 years. Selection of 20 trajectories taken from optimal strategies that yield mean catch rates over years 10–20 of 580000, 610000 and 634,000 t. respectively when the inter-annual % change TAC is applied always, The top two panels are fixed TAC strategies where the TAC sometimes need to be reduced as SSB is below B_{trig}. The lower panel shows a HR strategy.

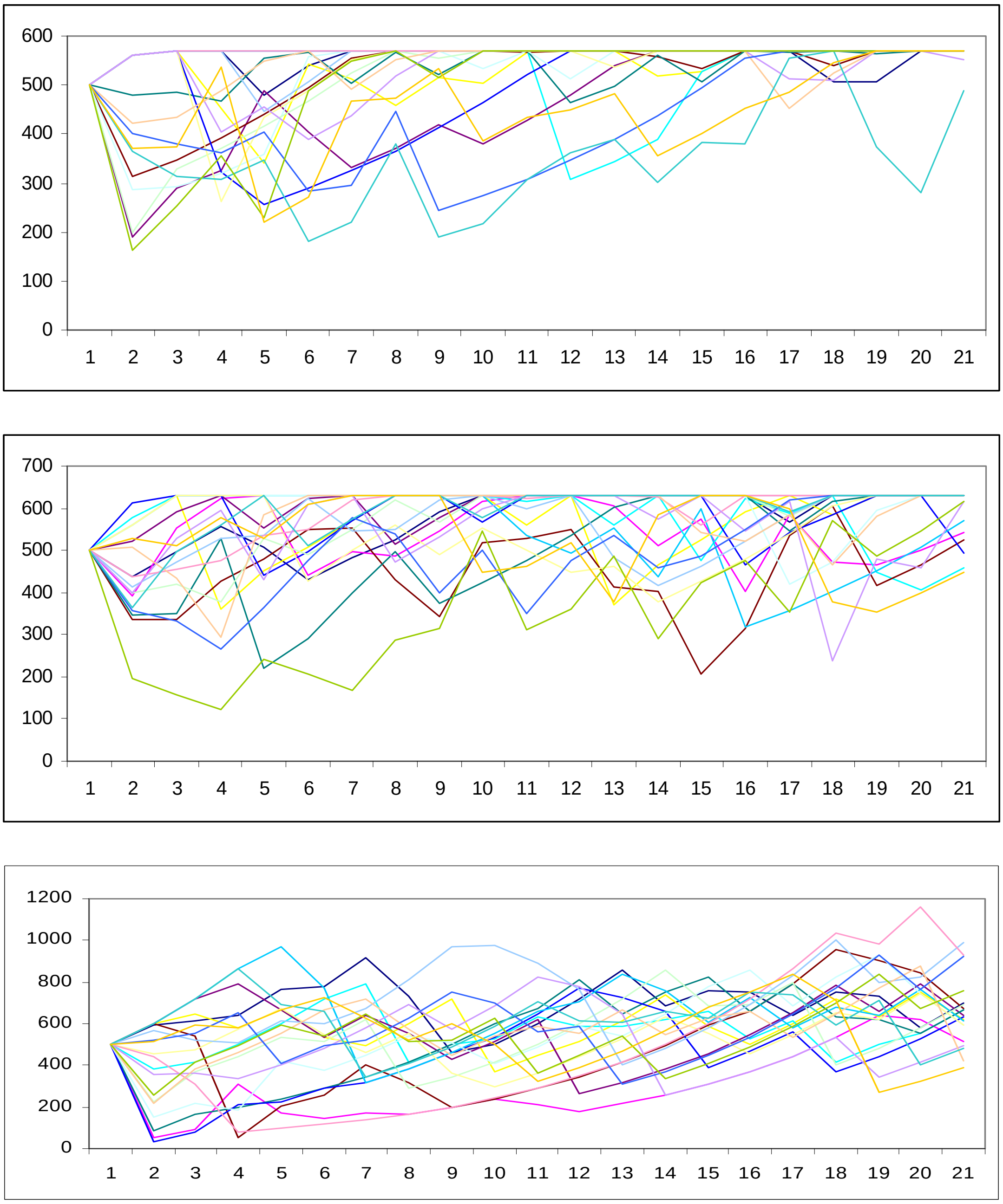


Figure 2.11.4 TAC trajectories by year over 21 years. Selection of 20 trajectories taken from optimal strategies that yield mean catch rates over years 10–20 of 580000, 610000 and 634,000 t. respectively when the inter-annual % change TAC is applied always, The top two panels are fixed TAC strategies where the TAC sometimes need to be reduced as SSB is below B_{trig}. The lower panel shows a HR strategy. Note the sharp drops required sometimes, particularly in the middle and lower panel.

3 Horse Mackerel

3.1 Fisheries in 2007

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 2007 was 187,994 tons which is 27,300 tons less than in 2006 and the lowest since 1986. 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 2007 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 Denmark, Faroe Islands, England and Wales, Germany, Ireland, Netherlands, Norway, Scotland, Portugal and Spain representing 83% of the total catches. The distribution of the fishery is similar to the later years.

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 second time Lithuania reported catches of horse mackerel, 5763 tons which is 3,400 less than they reported for 2006.

First quarter: 47,600 tons. This is 7,900 tons less than in 2006. 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 few catches were taken in the central part of the North Sea.

Second quarter: 18,700 tons. This is 2,500 tons more than in 2006. 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 Channel, 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: 20,600 tons. This is 4,400 tons less than in 2006. Most of the catches were taken in the Channel, and in Portuguese and Spanish waters. A few small catches were reported from the northern part of the North Sea (Figure 3.1.1.c).

Fourth quarter: 101,000 tons. This is 19,600 tons less than in 2006 and the catches were distributed in three main areas: Portuguese and Spanish waters, Irish waters, and in the Channel (Figure 3.1.1.d). Only few catches were reported from the North Sea.

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. 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 (see also Abaunza et al. 2008 for a comprehensive discussion of the results from the HOMSIR project). 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. In 2007 2,100 tons were caught during the two first quarters in Divisions IVa and IIIa and were allocated to the North Sea stock.

North Sea stock: Divisions IIIa (eastern part), IVa (first and second quarter), IVb,c and VIId. The catches 3−4 quarters of Divisions IVa and IIIa and 1−4 quartes from Divisions IVb,c and VIId from were allocated to the North Sea stock. In 2007 some small catches were reported from Divisions IIIb (4 tons) and IIIc (21.5 tons) which 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. 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 1.3.4).

3.5 *Trachurus* Species Mixing

Three species of genus Trachurus: *T. trachurus*, *T. mediterraneus* and *T. picturatus* are found together and are commercially exploited in NE Atlantic waters. Studies on genetic differentiation showed that the three species are very well identified excluding any doubt about the status of their category as species (Cárdenas et al., 2005).

Following the Working Group recommendation (ICES 2002/ACFM: 06), special care was again taken to ensure that catch and length distributions and numbers at age of *T. trachurus* supplied to the Working Group did not include *T. mediterraneus* and *T. picturatus*. Spain provided data on *T. mediterraneus* and Portugal on *T. picturatus*.

T. mediterraneus is almost only landed in ports of the Cantabrian Sea in the north of Spain. The fishery for *T. picturatus* takes place in the southern part of Division IXa and in Subarea X.

The time series of landings of *T. mediterraneus* show substantial variability, rangeing from about 500t to 7,000 tones. Since 2004 there has been a decrease in landings reaching the lowest level in 2007 (Table 3.5.1).

Landings of *T. picturatus* is also quite variable with a range from 1,400 to 7,000 tonnes. (Table 3.5.1)

Taking into account that the assessment is only made for *T. trachurus*, the Working Group recommends that the TACs and any other management regulations which might be established in the future should be related only to *T. trachurus* and not to *Trachurus spp*. More information is needed about the *Trachurus spp.* before the fishery and the stock can be evaluated.

3.6 Length Distribution by Fleet and by Country:

Denmark, Germany, Ireland, Netherlands, Norway, Portugal and Spain provided length distribution data for parts or for the total of their catches in 2007. These length distributions cover 76% of the total landings and are shown in Table 3.6.1.

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	2007[1]
II + Vb	176	30	366
IV + IIIa	40,564	38,911	16,407
VI	22,055	15,751	26,279
VII	107,475	101,912	93,132
VIII	41,495	34,122	28,387
IX	23,111	24,557	23,423
Total	234,876	215,283	187,994

[1]**Preliminary.**

Table 3.1.2 HORSE MACKEREL general. Quarterly catches (1000 t) by Division and Sub-division in 2007.

Division	1Q	2Q	3Q	4Q	TOTAL
IIa+Vb	0	0	0	0.4	0.4
III	+	+	+	0.1	0.1
IVa	0.9	1.2	0.2	4.7	7.0
IVbc	6.3	0.6	0.3	2.0	9.2
VIId	6.7	2.2	3.3	17.7	29.9
VIa,b	4.2	0.7	0.1	21.3	26.3
VIIa–c,e–k	13.4	2.3	5.0	42.6	63.3
VIIIa,b,d,e	9.0	1.6	1.0	2.7	14.3
VIIIc	2.3	3.7	3.8	4.2	14.0
IXa	4.8	6.4	6.9	5.3	23.4
Sum	47.6	18.7	20.6	101.0	187.9

+ 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 Vb	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]		-	400	3,600	8,020	412	14,878	-	24,881	36,926	2,643	25,580	-	90,442	48,733	147,195
1984	25,893[1]		-	930	3,585	29,478	23	2,725	94	31,716	38,782	2,510	23,119	500	96,744	23,178	149,400
1985	-		22,897	630	2,715	26,750	79	2,374	203	33,025	35,296	4,448	23,292	7,500	103,843	20,237	150,830
1986	-		19,496	30	4,756	24,648	214	850	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	2,492	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	128	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		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		63,869[2]	34,415	196,926	25,693	23,733	5,440	357,288	21,778	391,066
1992	112		13,955		688	15,043	13,457		101,752	40,881	180,937	29,329	24,243	1,820	394,793	26,713	436,548
1993			3,895		8,792	13,617	3,168		134,908	53,782	204,318	27,519	25,483	8,600	458,628	31,945	504,190
1994			2,496		2,503	5,689	759		106,911	69,546	194,188	11,044	24,147	3,935	413,022	28,442	447,153
1995			7,948		8,666	16,756	13,133		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	69	10,530	83	16,194	30,500	2,540[4]	2,095	17,011	35,043	232,451	15,662	22,906	830	326,443	41,574	398,523
1999	85	623	9,335	20	27,889	37,224	2,557[5]	1,105	47,316	40,381	158,715	22,824	24,188	305	298,076	27,733	363,033
2000	48	2,661	25,954	62	22,471	48,425	1,169[6]	72	4,524	20,657	115,245	32,227	21,984	701	196,911	27,160	272,496
2001	351	2,056	8,157	78	38,114	46,356	60	179	11,456	24,636	100,676	54,293	20,828	760	212,090	24,911	283,357
2002	357		12,636	139	10,723	23,379	1,324	1,974	36,855	14,190	86,878	32,450	22,110	99	194,292	23,665	241,336
2003	1,099		10,309		21,098	32,078	24	110	21,272	23,254	101,948	21,732	19,979	102	190,183	19,570	241,831
2004	63		18,348		16,455	35,154	47		11,841	21,929	98,984	8,353	15,772		157,627	23,581	216,361
2005			13,892		15,460	29,711	176		26,315	22,054	91,431	26,483	14,775		181,994	23,111	234,876
2006			7,998		23,790	35,626	30		27,152	15,722	77,970	20,651	13,470		155,094	24,557	215,277
2007			9,118		29,788	41,164	366[7]		4,940	26,279	63,223	14,428	13,960		123,408	23,423	187,994

[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.
[7] all fom Vb

Table 3.3.2 HORSE MACKEREL general. Catches by country and stock in 2007
(Data submitted by Working Group members)

Country	North Sea stock	Western stock	Southern stock	Total
Belgium	6			6
Denmark	255	7,617		7,872
Faroese Island		478		478
France	5,349	12,748		18,097
Germany	87	5,784		5,871
Ireland	1	30,091		30,092
Lithuania	296	5,467		5,763
Netherland	31,153	29,082		60,235
Norway	1,243	4,182		5,425
Portugal			10,380	10,380
Spain		14,257	13,043	
Sweden	53	76		129
UK E&W	6,921	5,482		12,403
UK Northern Ireland				
UK Scotland	635	778		1,403
Discard	139	102		241
Unallocated	-4,964	7,264		-10743
Tot	41,164	123,408	23,423	187,994

Table 3.5.1 Catches (t) of *Trachurus mediterraneus* in Divisions VIIIab, VIIIc and IXa and Sub-area VII in the period 1989-2007 and *Trachurus picturatus* in División IXa, Subarea X and in CECAF Division 34.1.1 in the period 1986-2005.

	Divisions	Sub-Divisions	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
T. mediterraneus	**VII**		-	-	-	0	0	0	0	0	0	0	0	0	0	0	59	1	1	0	0	1	1	0
	VIIIab		-	-	-	23	298	2122	1123	649	1573	2271	1175	557	740	1100	988	525	525	340	53	155	168	126
	VIIIc	VIIIc East	-	-	-	3903	2943	5020	4804	5576	3344	4585	3443	3264	3755	1592	808	1293	1198	1699	841	1005	777	326
		VIIIc west	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Total VIIIc	-	-	-	3903	2943	5020	4804	5576	3344	4585	3443	3264	3755	1592	808	1293	1198	1699	841	1005	777	326
	IXa	IXa North	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		IXa C, N & S	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Total IXa	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL All areas		**-**	**-**	**-**	**3926**	**3241**	**7142**	**5927**	**6225**	**4917**	**6856**	**4618**	**3821**	**4495**	**2692**	**1854**	**1820**	**1724**	**2039**	**894**	**1162**	**946**	**452**
T. picturatus	**IXa**		367	181	2370	2394	2012	1700	1035	1028	1045	728	1009	834	526	320	464	420	663	773	508	-	-	-
	X Azorean Area		3331	3020	3079	2866	2510	1274	1255	1732	1778	1822	1715	1920	1473	690	563	1089	5000	1509	1244	-	-	-
	34.1.1 Madeira's area		2006	1533	1687	1564	1863	1161	792	530	297	206	393	762	657	344	646	385	358	572	653	-	-	-
	TOTAL		**5704**	**4734**	**7136**	**6824**	**6385**	**4135**	**3082**	**3290**	**3120**	**2756**	**3117**	**3516**	**2657**	**1354**	**1672**	**1894**	**6021**	**2854**	**2405**	*****	*****	*****

(*) Under revision

Table 3.6.1 Horse mackerel general. Length distributions (%) catches by fleet and country in 2007. (0.0= <0.05%)

	Neth	Germany	Ireland	Norway	Denmark	Spain			Portugal
	P.trawl	**Trawl**	**Trawl**	**P.seine**	**Trawl**	**P.seine**	**Dem.trawl**	**Artisanal**	**All**
cm	All	VIIb	All	IVa	All	All	All	All	IXa
5									
6						0.0			
7			0.2						
8			1.3			0.0			
9			0.3			0.0			
10						0.0			
11						0.2	0.0		0.0
12						1.2	0.0		0.0
13						1.7	0.0		0.4
14						2.5	0.0		2.4
15						2.3	0.0		4.3
16	0.2					3.0	0.0	0.2	5.6
17	0.3					5.4	0.2	0.5	6.3
18	0.6		0.1			6.7	0.7	0.7	9.6
19	0.9		0.3			5.5	1.5	1.3	12.5
20	2.8		0.7			5.7	2.1	3.7	12.3
21	4.6		0.3			7.2	2.1	3.0	13.3
22	11.8		0.3			6.1	1.3	3.8	11.4
23	19.9	1.2	0.6			5.8	0.9	5.1	5.0
24	15.5	17.8	1.7			6.9	1.0	6.5	1.9
25	14.5	30.8	8.6			5.5	1.3	7.3	1.6
26	10.1	24.1	23.2			5.2	2.0	4.4	1.6
27	6.5	15.7	24.9	0.5		6.0	2.9	5.7	1.6
28	4.5	6.6	15.7	0.0		5.9	5.8	5.6	1.7
29	2.6	2.7	9.5	8.2	0.3	6.2	9.3	6.1	1.4
30	1.6	0.6	5.1	14.5	0.6	4.2	9.5	8.7	1.2
31	1.1	0.2	3.1	11.1	1.0	2.9	10.2	7.0	1.0
32	1.2	0.1	1.5	6.3	2.1	1.9	8.8	9.0	0.8
33	0.5	0.2	0.9	6.8	3.9	1.0	7.7	6.3	0.7
34	0.1		0.6	4.8	10.1	0.4	9.1	4.1	0.7
35	0.1		0.4	7.2	13.4	0.4	7.5	5.0	0.8
36	0.1		0.3	8.7	19.2	0.1	5.6	2.4	0.4
37	0.2		0.2	10.6	16.9	0.1	4.8	1.5	0.4
38	0.1		0.2	8.7	12.1	0.0	2.7	0.5	
39	0.1		0.1	8.2	7.6	0.0	1.5	0.5	
40			0.0	3.4	5.8	0.0	1.0	0.5	
41				0.5	3.6	0.0	0.3		
42+			0.0	0.5	2.7	0.0	0.1		

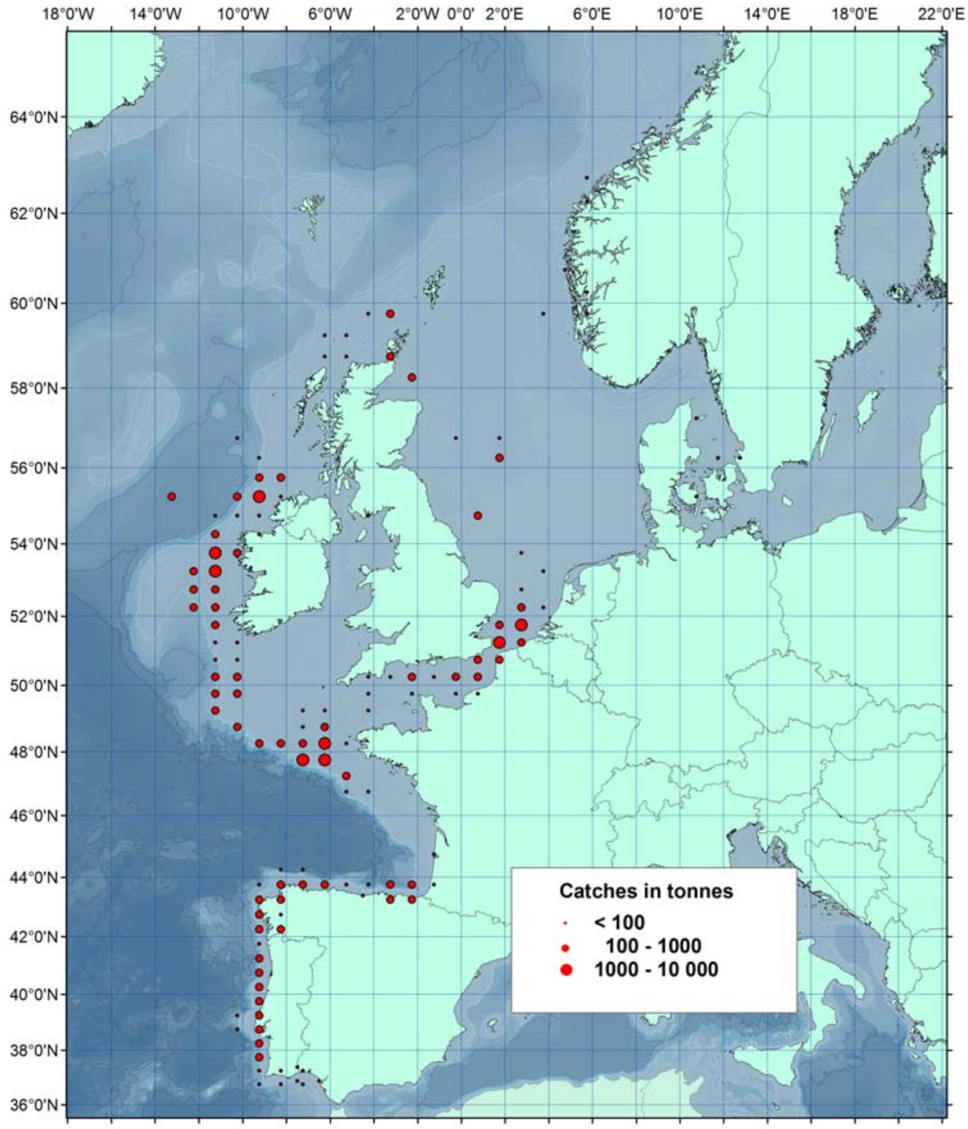


Figure 3.1.1a. Horese mackerel catches in 1. quarter 2007

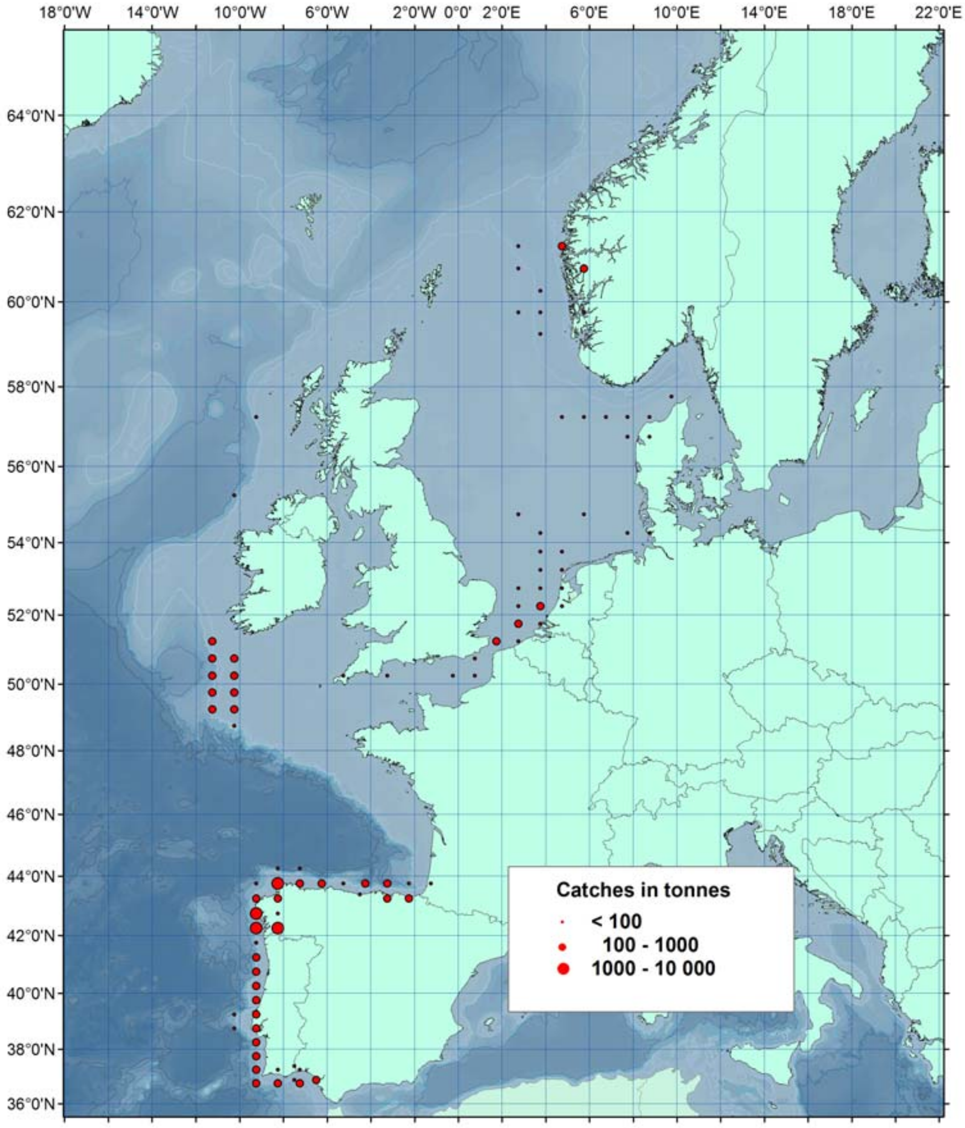


Figure 3.1.1b Horse mackerel catches in 2. quarter 2007

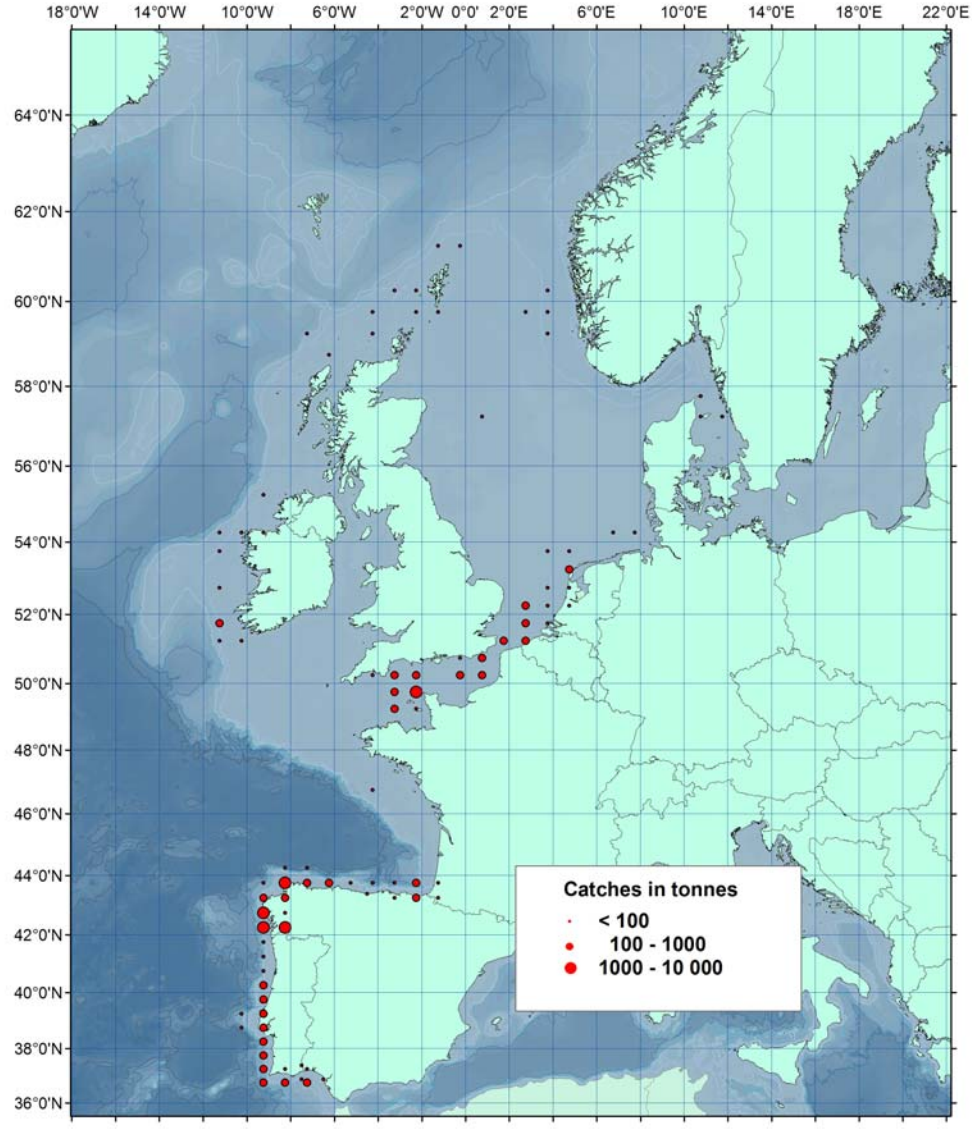


Figure 3.1.1.c Horse mackerel catches in 3. quarter 2007

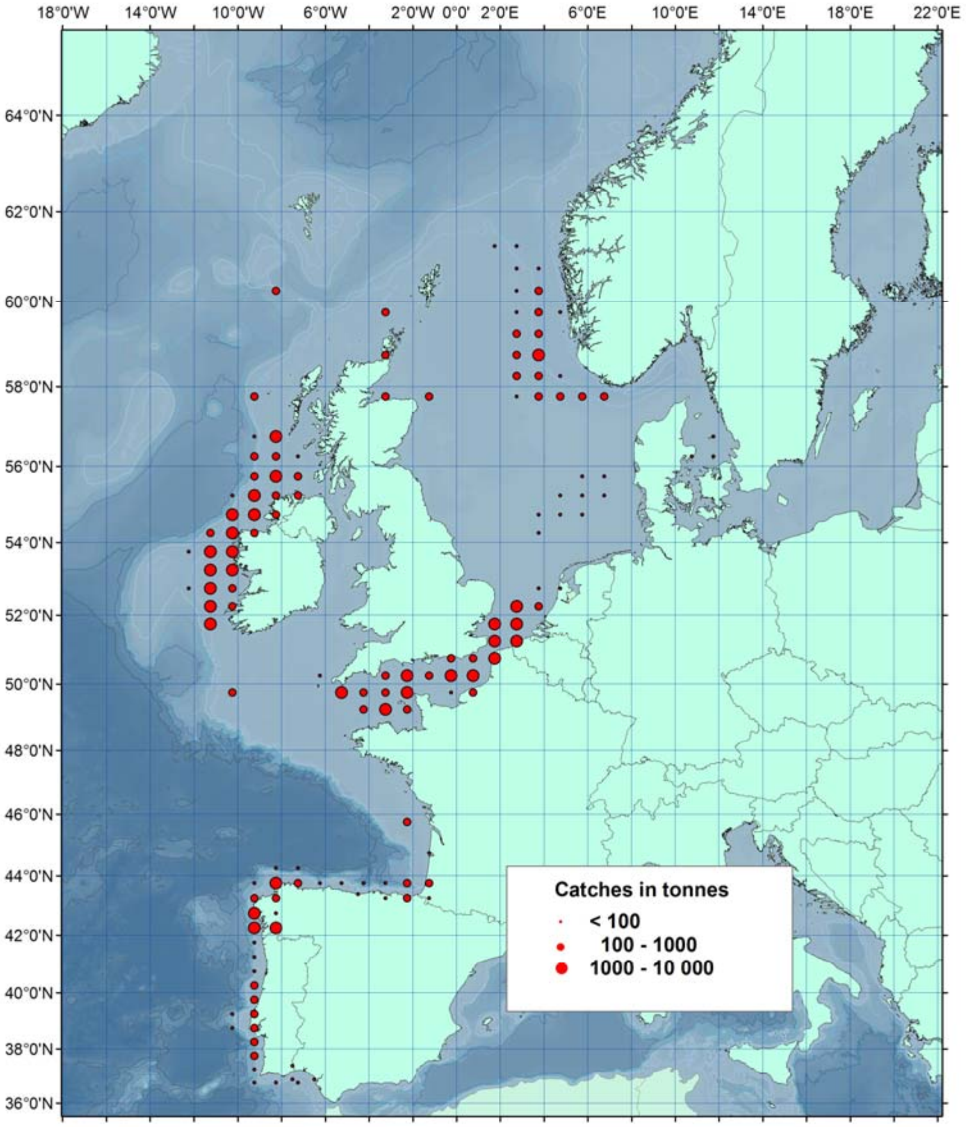


Figure 3.1.1.d Horse mackerel catches in 4. quarter 2007

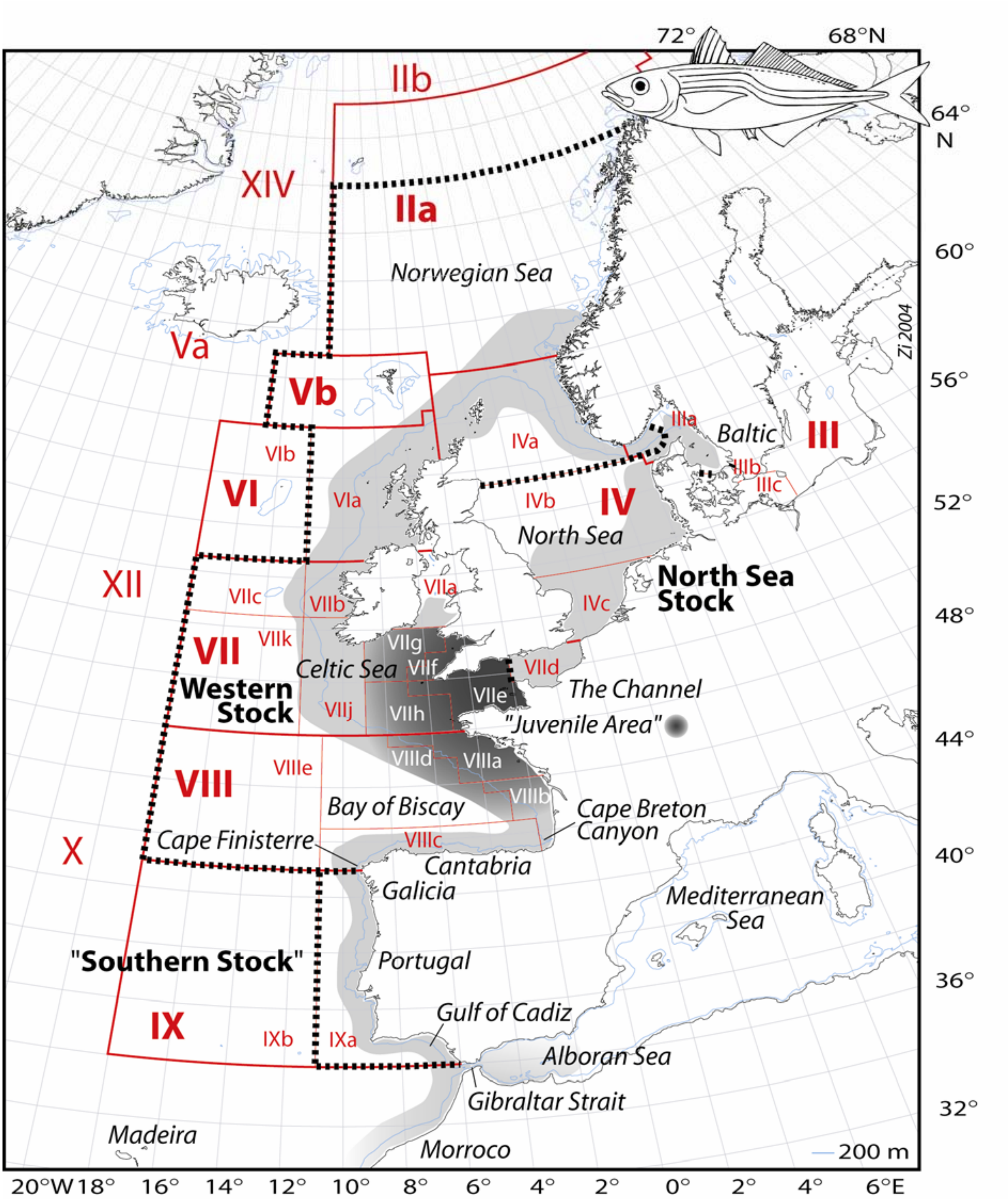


Figure 3.2.1: Distribution of Horse Mackerel in the Northeast-Atlantic: Stock definitions as used by the 2004 WG MHSA. Note that the "Juvenile Area" is currently only defined for the Western Stock distribution area – juveniles do also occur in other areas (like in Div. VIId). Map source: GEBCO, polar projection, 200 m depth contour drawn.

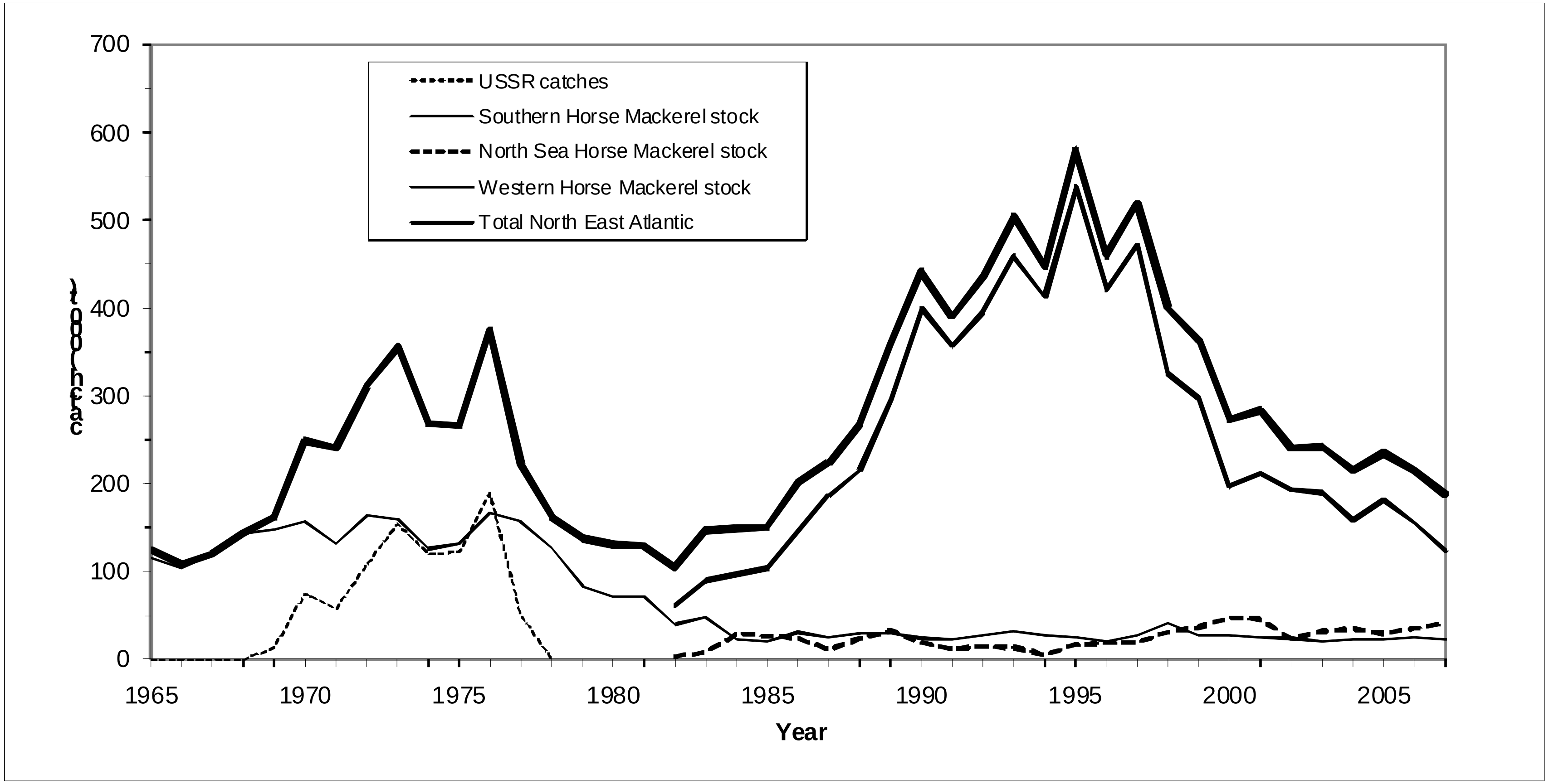


Figure 3.3.1 Horse mackerel general. Total catches in the northeast Atlantic during the period 1965 - 2007. The catches taken by the USSR and catches taken from the southern, western and North Sea horse mackerel stocks are shown in relation to the total catches in the northeast Atlantic. Caches from Div. VIIIc are transferred from southern stock to western stock from 1982 onwards.

4 North Sea Horse Mackerel (Divisions IVa,b,c, IIIa, and VIId)

4.1 ICES advice Applicable to 2007

The ICES advice has been the same since 2002. Also in 2007 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.

The 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 therefore do not correspond to the distribution areas of either the North Sea stock, or the western and southern stocks.

4.2 The Fishery in 2007 on the North Sea stock

Catches taken in Divisions IV a and IIIa during the two first quarters and all year in Divisions IVb, IVc and VIId are regarded as belonging to the North Sea horse mackerel. Catches from the eastern part of Division IIIa during the third and fourth quarters are regarded as belonging to the North Sea stock. Table 3.3.1 shows the reported catches of this stock from 1982–2007. 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 reaching a 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 and 41,100 tons in 2007.

In previous years most of the catches from the North Sea stock were taken as a bycatch 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. Horse mackerel is now considered to be an indeterminate spawner, where fecundity is not determined prior to spawning. 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 2007 were calculated according to Dutch samples from Division IVc, VIId, and according to Danish samples from Divison IVb. Table 4.4.1.1 shows catch number by quarter and by area in 2007. Annual catch numbers at age for 1995−2007 are given in Table 4.4.1.2. Age compositions from earlier years are presented in Figure 4.4.1.1. These age compositions are based on samples taken from smaller Dutch commercial catches and research vessel catches, are available for the period 1987–1995, and cover only a small proportion of the total catch. However, they give a rough indication of the age composition of the stock.

At present the sampling intensity is rather low (61%, Table 4.4.1.3) and the quality of the catch at age data may be questionable and involve large uncertainties. The sampling intensity has varied. The coverage was around 70% during 1998–2003. Since then the coverage has varied from 38% in 2004 to 70% in 2007 (Table 4.4.1.3). 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.

4.4.2 Mean weight at age and mean length at age

Tables 4.4.2.1–2 show weight and length by quarter and by area in 2007. The annual average values are shown in Table 4.4.1.2.

4.4.3 Maturity at age

No data have been made available for this Working Group.

4.4.4 Natural mortality

There is no specific information available about natural mortality of this stock.

Table 4.4.1.1 North Sea Horse Mackerel stock. Catch in numbers (1000) at age by quarter and area in 2007

Q 1

Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
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	1.56	0.34	0.43	74.29	74.84	469.55	687.45	1308.46
3	7.25	1.60	2.00	346.04	348.61	2187.23	3436.93	6329.66
4	24.21	5.35	6.69	1155.66	1164.23	7304.61	10102.14	19762.89
5	13.26	2.93	3.66	632.84	637.53	4000.03	8494.71	13784.96
6	27.54	6.09	7.61	1314.58	1324.33	8309.10	7060.18	18049.43
7	16.37	3.62	4.52	781.42	787.21	4939.12	4472.47	11004.73
8	11.92	2.63	3.29	568.90	573.12	3595.88	4372.42	9128.16
9	3.11	0.69	0.86	148.57	149.68	939.09	2627.81	3869.81
10	2.15	0.47	0.59	102.49	103.25	647.80	528.66	1385.42
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	184.94	184.94
13	0.00	0.00	0.00	0.00	0.00	0.00	343.73	343.73
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Q 2

Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
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	177.76	723.42	901.17
2	1.67	0.00	1.42	102.52	5.67	167.26	972.29	1250.83
3	7.77	0.00	6.61	477.54	26.41	139.22	1382.19	2039.75
4	25.95	0.00	22.07	1594.84	88.19	632.35	2769.43	5132.84
5	14.21	0.00	12.09	873.34	48.30	493.82	1958.48	3400.23
6	29.52	0.00	25.11	1814.15	100.32	648.06	1278.82	3895.99
7	17.55	0.00	14.92	1078.37	59.63	321.47	757.26	2249.21
8	12.78	0.00	10.87	785.10	43.42	185.50	706.64	1744.30
9	3.34	0.00	2.84	205.03	11.34	48.45	424.69	695.68
10	2.30	0.00	1.96	141.44	7.82	33.42	85.44	272.38
11	0.00	0.00	0.00	0.00	0.00	212.48	0.00	212.48
12	0.00	0.00	0.00	0.00	0.00	0.00	29.89	29.89
13	0.00	0.00	0.00	0.00	0.00	0.00	55.55	55.55
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Q 3

Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
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	4.60	200.16	2181.74	2386.50
2	0.00	0.00	0.00	0.00	3.70	161.07	2597.25	2762.02
3	0.00	0.00	0.00	0.00	0.68	29.71	2493.35	2523.74
4	0.00	0.00	0.00	0.00	6.61	287.74	3428.42	3722.76
5	0.00	0.00	0.00	0.00	7.43	323.70	1766.16	2097.29
6	0.00	0.00	0.00	0.00	5.67	247.08	415.58	668.34
7	0.00	0.00	0.00	0.00	1.72	75.08	103.90	180.70
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	5.50	239.26	0.00	244.75
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Q 4

Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
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	110.96	0.00	0.00	110.96
2	0.00	0.00	0.00	0.00	89.29	324.98	9723.25	10137.51
3	0.00	0.00	0.00	0.00	16.47	0.00	11917.05	11933.52
4	0.00	0.00	0.00	0.00	159.50	649.96	53216.09	54025.55
5	0.00	0.00	0.00	0.00	179.44	1950.32	49821.46	51951.23
6	0.00	0.00	0.00	0.00	136.96	1299.92	6464.92	7901.80
7	0.00	0.00	0.00	0.00	41.61	974.94	9480.00	10496.55
8	0.00	0.00	0.00	0.00	0.00	324.98	6075.10	6400.08
9	0.00	0.00	0.00	0.00	0.00	1625.34	1702.36	3327.70
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	132.63	0.00	0.00	132.63
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	324.98	0.00	324.98
14	0.00	0.00	0.00	0.00	0.00	649.96	0.00	649.96
15+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Q 1-4

Ages								
0	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
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	115.55	377.92	2905.16	3398.63
3	3.22	0.34	1.85	176.80	173.49	1122.86	13980.24	15458.81
4	15.02	1.60	8.61	823.59	392.17	2356.17	19229.52	22826.68
5	50.16	5.35	28.76	2750.50	1418.53	8874.66	69516.07	82644.04
6	27.47	2.93	15.75	1506.18	872.70	6767.87	62040.81	71233.72
7	57.06	6.09	32.72	3128.73	1567.29	10504.16	15219.51	30515.56
8	33.92	3.62	19.45	1859.79	890.18	6310.61	14813.63	23931.19
9	24.69	2.63	14.16	1354.00	616.54	4106.36	11154.16	17272.54
10	6.45	0.69	3.70	353.61	161.01	2612.88	4754.86	7893.19
11	4.45	0.47	2.55	243.93	111.07	681.22	614.10	1657.80
12	0.00	0.00	0.00	0.00	138.12	451.73	0.00	589.86
13	0.00	0.00	0.00	0.00	0.00	0.00	214.82	214.82
14	0.00	0.00	0.00	0.00	0.00	324.98	399.28	724.26
15+	0.00	0.00	0.00	0.00	0.00	649.96	0.00	649.96

Table 4.4.1.2 Catch in numbers at age (millions), w eight at age (kg) and length at age (cm) for the North Sea horse mackerel stock 1995-2007

millions	Catch number												
Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	1.76	4.58	12.56	2.30	12.42	70.23	12.81	60.42	13.81	15.65	52.4	5.0	3.4
2	3.12	13.78	27.24	22.13	31.45	77.98	36.36	16.82	56.15	17.54	29.8	23.7	15.5
3	7.19	11.04	14.07	36.69	23.13	28.41	174.34	19.27	23.44	34.38	27.8	61.5	22.8
4	10.32	11.87	14.93	38.82	17.59	21.42	87.81	11.90	33.21	14.51	12.6	40.9	82.6
5	12.08	9.64	14.58	20.79	23.12	31.27	18.51	5.61	26.93	27.77	16.7	72.9	71.2
6	13.16	12.49	12.38	12.10	26.19	19.64	11.49	5.83	10.59	20.17	5.2	23.4	30.5
7	11.43	7.96	10.12	13.99	20.64	19.47	18.25	5.54	6.33	10.58	2.9	13.7	23.9
8	12.64	6.60	8.64	10.79	21.75	9.00	14.70	10.48	9.56	3.82	2.4	5.9	17.3
9	7.25	1.48	2.45	8.26	12.91	11.50	10.22	6.33	10.90	5.37	3.8	1.6	7.9
10	5.87	5.31	0.75	4.01	8.21	8.96	9.98	6.75	1.51	10.95	5.8	1.4	1.7
11	0.01	0.29	0.34	2.72	2.14	6.98	9.58	5.12	3.43	6.22	2.3	0.2	0.6
12	8.84	1.28	0.25	0.71	0.43	3.07	5.35	3.02	3.29	4.47	4.1	1.7	0.2
13	0.20	8.92	0.00	1.81	1.40	1.61	3.73	2.17	2.25	6.16	2.5	0.6	0.7
14	4.37	8.01	1.38	0.31	3.78	0.00	1.95	1.29	3.40	2.25	9.9	1.0	0.6
15+	0.00	0.00	0.00	5.11	4.03	12.22	5.81	2.71	4.70	8.52	9.6	0.8	0.0

kg	w eight												
Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
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	0.073
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	0.082
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	0.105
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	0.115
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	0.130
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	0.164
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	0.191
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	0.197
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	0.256
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	0.258
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	0.517
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	0.279
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	0.338
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	0.414
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	2007
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	20.05
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	20.83
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	22.59
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	23.64
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	24.37
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	26.58
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	27.80
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	28.12
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	30.05
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	31.15
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	39.50
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	31.50
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	33.40
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	34.50
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 4.4.1.3. Percentage landings covered from research vessel and commercial fishing vessels from 1995–2007.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
% of landings covered	62	55	57	66	77	71	50	60	67	38	48	70	61
Samples from	RV	RV+FV	FV	FV	FV	FV	FV	FV	FV	FV	FV	FV	FV

(RV = Research Vessel, FV = Commercial fishing Vessels)

Table 4.4.2.1 North Sea Horse Mackerel stock. Weight (kg) in catch at age by quarter and area in 2007

Q 1 Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
0								
1								
2	0.075	0.075	0.075	0.075	0.075	0.075	0.082	0.079
3	0.092	0.092	0.092	0.092	0.092	0.092	0.091	0.092
4	0.122	0.122	0.122	0.122	0.122	0.122	0.116	0.119
5	0.153	0.153	0.153	0.153	0.153	0.153	0.136	0.142
6	0.168	0.168	0.168	0.168	0.168	0.168	0.161	0.165
7	0.212	0.212	0.212	0.212	0.212	0.212	0.217	0.214
8	0.240	0.240	0.240	0.240	0.240	0.240	0.216	0.229
9	0.245	0.245	0.245	0.245	0.245	0.245	0.255	0.252
10	0.278	0.278	0.278	0.278	0.278	0.278	0.223	0.257
11								
12							0.279	0.279
13							0.283	0.283
14								
15+								

Q 2 Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
0								
1						0.075	0.084	0.080
2	0.075		0.075	0.075	0.075	0.075	0.093	0.089
3	0.092		0.092	0.092	0.092	0.111	0.111	0.106
4	0.122		0.122	0.122	0.122	0.143	0.128	0.128
5	0.153		0.153	0.153	0.153	0.163	0.139	0.146
6	0.168		0.168	0.168	0.168	0.174	0.177	0.172
7	0.212		0.212	0.212	0.212	0.201	0.201	0.207
8	0.240		0.240	0.240	0.240	0.240	0.216	0.230
9	0.245		0.245	0.245	0.245	0.245	0.255	0.251
10	0.278		0.278	0.278	0.278	0.278	0.223	0.261
11						0.517		0.517
12							0.279	0.279
13							0.283	0.283
14								
15+								

Q 3 Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
0								
1					0.075	0.075	0.084	0.078
2					0.075	0.075	0.104	0.102
3					0.130	0.130	0.131	0.131
4					0.163	0.163	0.140	0.142
5					0.174	0.174	0.142	0.147
6					0.179	0.179	0.193	0.188
7					0.190	0.190	0.185	0.187
8								
9								
10								
11					0.517	0.517		0.517
12								
13								
14								
15+								

Q 4 Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
0								
1					0.075			0.075
2					0.075	0.088	0.075	0.076
3					0.130		0.106	0.106
4					0.163	0.142	0.110	0.110
5					0.174	0.149	0.123	0.124
6					0.179	0.185	0.146	0.153
7					0.190	0.220	0.158	0.164
8						0.148	0.144	0.144
9						0.284	0.239	0.261
10								
11					0.517			0.517
12								
13						0.405		0.405
14						0.414		0.414
15+								

Q 1-4 Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
0								
1					0.075	0.075	0.084	0.073
2	0.075	0.075	0.075	0.075	0.075	0.079	0.082	0.082
3	0.092	0.092	0.092	0.092	0.094	0.094	0.107	0.105
4	0.122	0.122	0.122	0.122	0.127	0.127	0.113	0.115
5	0.153	0.153	0.153	0.153	0.157	0.153	0.126	0.130
6	0.168	0.168	0.168	0.168	0.169	0.171	0.157	0.164
7	0.212	0.212	0.212	0.212	0.211	0.213	0.178	0.191
8	0.240	0.240	0.240	0.240	0.240	0.233	0.177	0.197
9	0.245	0.245	0.245	0.245	0.245	0.269	0.249	0.256
10	0.278	0.278	0.278	0.278	0.278	0.278	0.223	0.258
11					0.517	0.517	0.000	0.517
12						0.000	0.279	0.279
13						0.405	0.283	0.338
14						0.414		0.414
15+								

Table 4.4.2.2 North Sea Horse Mackerel stock. Length (cm) in catch at age by quarter and area in 2007

Q 1

Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
0								
1								
2	21.50	21.50	21.50	21.50	21.50	21.50	21.00	21.24
3	22.58	22.58	22.58	22.58	22.58	22.58	22.60	22.59
4	24.54	24.54	24.54	24.54	24.54	24.54	24.33	24.43
5	26.01	26.01	26.01	26.01	26.01	26.01	25.49	25.69
6	26.96	26.96	26.96	26.96	26.96	26.96	26.97	26.96
7	28.98	28.98	28.98	28.98	28.98	28.98	29.07	29.02
8	29.71	29.71	29.71	29.71	29.71	29.71	29.37	29.55
9	30.00	30.00	30.00	30.00	30.00	30.00	30.46	30.31
10	32.33	32.33	32.33	32.33	32.33	32.33	29.15	31.11
11								
12							31.50	31.50
13							32.50	32.50
14								
15+								

Q 2

Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
0								
1						19.10	20.21	19.99
2	21.50		21.50	21.50	21.50	20.40	21.37	21.25
3	22.58		22.58	22.58	22.58	23.04	23.24	23.06
4	24.54		24.54	24.54	24.54	24.87	24.50	24.56
5	26.01		26.01	26.01	26.01	26.01	25.17	25.53
6	26.96		26.96	26.96	26.96	26.78	26.99	26.94
7	28.98		28.98	28.98	28.98	27.79	27.79	28.41
8	29.71		29.71	29.71	29.71	29.71	29.37	29.57
9	30.00		30.00	30.00	30.00	30.00	30.46	30.28
10	32.33		32.33	32.33	32.33	32.33	29.15	31.33
11								39.50
12							31.50	31.50
13							32.50	32.50
14								
15+								

Q 3

Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
0								
1					19.10	19.10	20.21	20.11
2					19.30	19.30	21.74	21.59
3					23.50	23.50	23.88	23.88
4					25.20	25.20	24.68	24.72
5					26.00	26.00	24.85	25.03
6					26.60	26.60	27.00	26.85
7					26.60	26.60	26.50	26.54
8								
9								
10								
11					39.50	39.50	0.00	39.50
12								
13								
14								
15+								

Q 4

Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
0								
1					19.10			19.10
2					19.30	21.50	20.50	20.52
3					23.50		22.23	22.23
4					25.20	24.00	23.18	23.19
5					26.00	25.17	23.86	23.92
6					26.60	26.50	25.27	25.50
7					26.60	28.50	26.19	26.41
8						25.50	25.70	25.69
9						30.50	28.93	29.70
10								0.00
11					39.50			39.50
12								0.00
13						34.50		34.50
14						34.50		34.50
15+								0.00

Q 1-4

Ages	IIIa	IIIb	IIIc	IVa	IVb	IVc	VIId	Total
0								
1					19.10	19.10	20.21	20.05
2	21.50	21.50	21.50	21.50	20.32	21.02	20.82	20.83
3	22.58	22.58	22.58	22.58	22.62	22.62	22.58	22.59
4	24.54	24.54	24.54	24.54	24.62	24.55	23.47	23.64
5	26.01	26.01	26.01	26.01	26.01	25.77	24.15	24.37
6	26.96	26.96	26.96	26.96	26.93	26.88	26.25	26.58
7	28.98	28.98	28.98	28.98	28.86	28.82	27.15	27.80
8	29.71	29.71	29.71	29.71	29.71	29.38	27.37	28.12
9	30.00	30.00	30.00	30.00	30.00	30.31	29.91	30.05
10	32.33	32.33	32.33	32.33	32.33	32.33	29.15	31.15
11					39.50	39.50		39.50
12							31.50	31.50
13						34.50	32.50	33.40
14						34.50		34.50
15+								

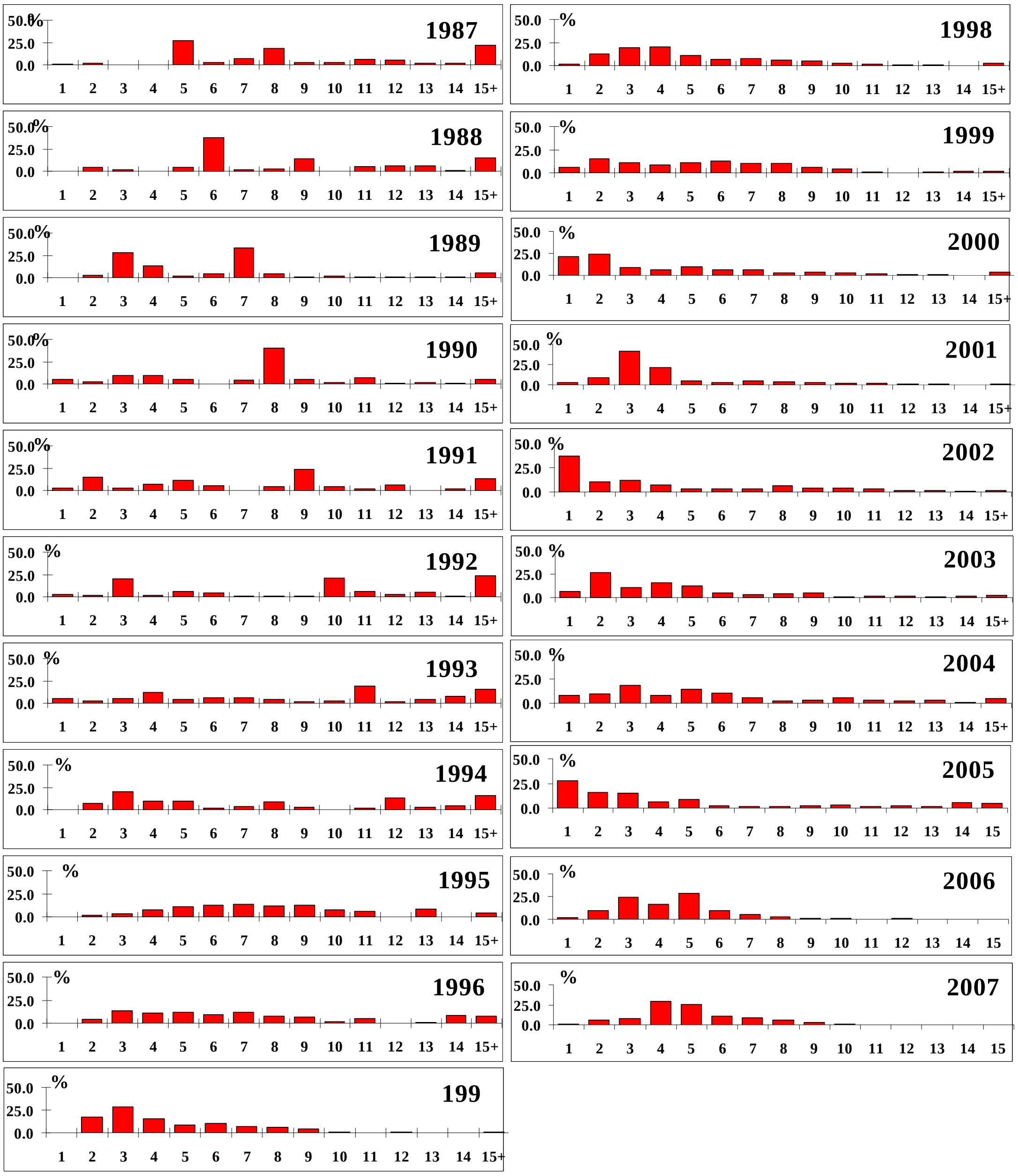


Figure 4.4.1.1 Age distribution in the catches of North Sea horse mackerel 1987-2007

5 Western Horse Mackerel (Divisions IIa, IIIa (Western Part), IVa, Vb, VIa, VIIa-c, VIIe-k, AND VIIIa-d

5.1 ICES advice Applicable to 2007 and 2008

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.

Last year ICES evaluated the proposed management plan for western horse mackerel to be in accordance with the precautionary approach and advised a TAC of 180,000 tons for each of the years 2008, 2009 and 2010. The TAC should apply to the total distribution area of this stock.

5.1.1 Stock description and management units

The western horse mackerel stock is spawning in the Bay of Biscay, in UK an Irish waters and after spawning parts of the stock is migrating northwards into the Norwegian Sea and north Sea where they are fished in the third and fourth quarter. The stock is distributed in Divisions IIa, Vb, IIIa, IVa, Via, VIIa-c, VIIe-k and VIIIa-d. The stock is caught in these areas in the total or parts of the year as described in section 3.3. The western stock is considered a management unit and advised accordingly. At present there are no international agreed management and TAC of western horse mackerel. EU regulates their fishery by TAC, but the TAC is not set in accordance with the distribution of the stock.

Based on various biological examinations undertaken in the last decade, an EU non-paper outlines the proposed updates to the management and assessment area. A summary of the existing structure is presented in the text table below

ICES-division concerned	Allocation to existing TAC-area	Biological observation as reviewed by ICES and ICES working groups	Allocation in the ICES-advice
VIIIc North and Northwest Spain	Southern area (VIIIc, IXa)	Inhabited by the Western stock, exchange between stocks not specified	Western stock (IIa, IVa, Vb, VI, VIIa-c, VIIe-k, VIIIa-e)
VIId Eastern English Channel	Western area (VI, VII, VIIIab, VIIIde, Vb, XII, XIV)	Inhabited by the North Sea stock for overwintering, overlap with the Western stock possible	North Sea stock (IIIa Eastern part, IVbc, VIId)
IIa Norwegian Sea and IVa Northern North Sea	Northern area (IIa, IV)	Inhabited by the Western stock in autumn, in first and second quarter presence of North Sea stock possible	Western stock (IIa, IVa, Vb, VIa, VIIa-c, VIIe-k, VIIIa-e)
IIIa Skagerrak and Kattegat	none	Presence of the Western stock in autumn; catches in winter/ spring in the Western part and catches in the Eastern part likely attributable to the North Sea stock	Eastern part to the North Sea stock, Western part to the Western stock

Based on the above results, the Commission is considering the following reallocations

Division VIIIc to the Western TAC area

Division VIId to the Northern TAC area

Divisions IIa and IVa to the Western TAC area

Division IIIa would not be included in the reallocation exercise, but will be subject to future work.

5.2 Scientific data

5.2.1 The fishery in 2007

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 2007 was approximately 123,400 t (Table 3.3.1) which is 31,700 tons less than in 2006 and the lowest reported catch since 1986. The catches of horse mackerel by country and area are shown in Tables 5.2.15−.

5.2.2 Egg survey estimates of spawning biomass

The ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS) met in Ijmuiden on April 71−1, to analyse the data from the 2007 Mackerel and Horse Mackerel Egg Survey (ICES 2008/LRC:09). This survey takes place triennially with the participation of Portugal, Spain, Scotland, Ireland, The Netherlands, Norway and Germany. It is not possible to convert the horse mackerel egg production to SSB since horse mackerel is considered an indeterminate spawner.

In 2004 a new definition of horse mackerel stock was accepted and as a result Triennial surveys were adopted to this change in 2007. The new western horse mackerel stock was found to have produced far more eggs in 2007 ($1.427*10^{15}$; se = $0.269*10^{14}$)

than in 2004 (0.889 $*10^{15}$). The increase in total egg production was 61%. The egg production reported by WGMEGS (ICES 2008/LRC:09) for the western stock is the same as reported by WGMHSA last year (ICES 2007c).

In general the quality and reliability of the surveys were good. There was an increase in survey effort in 2007 compared to 2004, in spite of the lack of participation by England. This absence was mainly compensated for by an additional survey carried out by Scotland and specific modifications in coverage carried out by several other countries.

As in 2003 the WGMEGS held a egg identification and staging workshop prior to the surveys. This permitted a harmonisation of egg identification and realised fecundity in mackerel as well as spawning rate in horse mackerel across the participating institutes. Both activities led to an improvement in the quality of the estimate.

Even when the survey coverage was good the WGMEGS concluded that while the starting of the spawning event was fully covered for mackerel and horse mackerel, the surveys ended too early to adequately cover the end of spawning in the northern areas for both mackerel and horse mackerel and in the southern area (south of 47°N) for horse mackerel.

5.2.2.1 Other surveys for western horse mackerel

Bottom trawl surveys:

Bottom trawl surveys are carried out in a systematic and standardized way through the Northeast Atlantic. They cover a significant part of the western horse mackerel distribution area and are carried out mainly during the autumn. These surveys are coordinated in the International Bottom Trawl Surveys Working Group (IBTSWG, ICES, 2008) with the main objective of obtaining an index of recruitment for the most important commercial fish species. Horse mackerel is a pelagic species but it shows to be closer to a demersal behavior than the rest of typical pelagic species. In this sense the IBTS could provide at least information on horse mackerel distribution, catch rates and length distributions. Taking in consideration the problems with the abundance index used in the western horse mackerel assessment (see sections 5.4 and 5.6) it is recommended to consider the surveys under IBTSWG, to analyze if they could provide an index of recruitment or of abundance for western horse mackerel.

Data from bottom trawl surveys carried out in autumn in the Cantabrian Sea and Galician coasts (North of Spain, Division VIIIc) are analysed in relation with horse mackerel (*Trachurus trachurus*). This survey is not used in the assessment because it covers only a small part of the western horse mackerel stock, but it provides valuable information on horse mackerel dynamics. In this sense, the length distributions show a gap in length range 182–3 cm which could be related with the particular exploitation pattern of this species. Juveniles are more abundant in the eastern part of the Cantabrian Sea although the depth strata <1 20 m, in which the young horse mackerel is also distributed, are very poor sampled in the Galician coasts. The recruitment in 1994 appeared to be strong in the data series (Table, 5.2.2.2.1). The evolution of the cohorts through the data matrix showed poor information on mortality (Figure, 5.2.2.2.1). This could be possibly due to migration to and from other areas, especially the French continental shelf (Murta *et al.*, 2008; Velasco *et al.*, 2008). Therefore the information provided from this survey will be completed with the results of other bottom trawl surveys carried out in adjacent areas. Traditionally age 0 has been adopted as the recruitment age for horse mackerel in this survey, nevertheless the use of age 1 as proxy for recruitment could be more adequate. On the other hand the years before

1997 have been revised to account for the change in the strata of the sampling design adopted in 1997 (Velasco *et al.*, 2008)

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 although it has not been possible to update the table at the time of the meeting (see last year report). 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).

Acoustic surveys

Horse mackerel data coming from the French acoustic PELGAS surveys are available as independent information about the western horse mackerel stock (ICES CM 2006/LRC:18). This multidisciplinary survey is covering Divisions VIIIa and VIIIb during spring, collecting information on spatial distribution and length distribution. Figure 5.2.2.2.2 shows the length distributions of horse mackerel (in numbers) from 2000 to 2008. Survey estimates have been revised and they are available in WD Massé et al (2008).

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 but the biomass estimates of the historical series were calculated considering the Subdivision IXa North (actually belonging to the Southern stock) and Division VIIIc (Western stock) until 2006 .The information will be split up by stock in the future.

5.2.3 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. This area represents a very small part of the western horse mackerel stock and therefore the fleet has not been used in the assessment.

The activity of this bottom trawl fleet is considered as mixed fisheries in which different métiers can be distinguished (see also section 6.3.1). Due to the assumption that CPUE is proportional to abundance, it is important that any other factors that may influence CPUE are removed from the index. The process of reducing the influence of these factors on CPUE is commonly referred to as standardizing the CPUE. Therefore it is considered to present in the future a new revised and standardized version of this CPUE series following the métiers classification, with the objective of obtaining a more reliable CPUE at age series.

5.2.4 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 2007 the Netherlands (VIa, VIIb,e,j,), Norway (IVa), Ireland (VIa and VIIb,j),Germany (VIIb,j) Spain (VIIIb,c) and Denmark (VIIIa) provided catch in numbers at age. The catch sampled for age readings in 2007 covered 57% of the total catch. This is the lowest sampling coverage for several years (see section 1.3).

Catches from other countries were converted to numbers at age using adequate samples from other countries. Catch at age data from the juvenile areas, The procedure has been carried out using the specific software for calculating international catch at age (Patterson, WD 1998). The catch in numbers by year class for each of the fishing Divison is showed in Figure 5.4.1.1.

The total annual and quarterly catches in numbers for western horse mackerel in 2005 are shown in Table 5.2.4.1. The sampling intensity is discussed in Section 1.3.

The catch at age matrix shows the dominance of the 1982 year class in the catches since 1984 until it entered the plus group in 1996 (Figures 5.2.4.1a-b). Since 2002 the 2001 year class of horse mackerel has been caught in considerable numbers.

5.2.5 Mean length at age and mean weight at age.

Mean length at age and mean weight at age in the catches

The mean weight and mean length at age in the catches by year, and by quarter in 2005 are shown in Tables 5.2.5.1 and 5.2.5.2.

Mean weight at age in the stock

As for previous years the mean weight at age for the two years old was given a constant weight while the weight for the older ages is based on all mature fish sampled from Dutch freezer trawlers the first and second quarter in Divisions VIIj,k , but in 2007 due to no catches in VIIk weights were only available from Division VIIj (Table 5.2.5.3). The mean weight by age groups in the stock and in the catches was lower than usual in 2001, but returned to normal since 2002.

5.2.6 Maturity ogive

Due to difficulties in estimating a maturity ogive (ICES, 2000/ACFM:05 and ICES, 2000/G:01) the working group has been unable to update the maturity ogive annually. Therefore the same maturity at age has been used since 1998 (Table 5.2.6.1).

5.2.7 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.

5.3 Methods

5.3.1 Data exploration

Catch-at-age data, expressed as proportions-at-age and standardized by age, is shown in Figure 5.4.1.1. Catches of the 1982 and 2001 year classes, and to a lesser extent the year classes in the early- to mid-90s19, show up clearly as well above average, indicating that these year classes were larger than average. Within-cohort consistency of the catch-at-age matrix is investigated in Figure 5.4.1.2, and demonstrates that the catch-at-age data contains information on year-class strength that could form the basis for an age-structured model.

Log-catch curves are shown in Figure 5.4.1.3, along with the negative of the gradients fitted to ages 13– (bottom left plot), and ages 48– (bottom right plot). The general pattern of log-catch ratios is increasing slopes for all ages for the earlier years, indicating cohorts are not fully selected until they have reached an advanced age, and the more usual decreasing slope for the most recent years, indicating selection has shifted towards younger fish over time. A requirement for interpreting the negative gradient as a proxy for total mortality is that catchability and selectivity-at-age remains stable within a cohort, so that any changes in the catch of a cohort are explained by changes in total mortality. The prevalence of negative values for the proxy (bottom plots of Figure 5.4.1.3) indicates that this requirement has not always been met for western horse mackerel catch data, and also indicates that a separable model with constant selectivity-at-age for the earliest data would not be appropriate.

5.3.2 Simulation testing of SAD

Simulation testing was performed on the SAD model used to present the final assessment for western horse mackerel this year (SAD08). The model is described in the following section and in Figure 5.4.3.1 and Table 5.4.3.1. The simulation testing was performed in two phases. The first phase used the SAD08 model fit to data up to 2006 (but including the 2007 egg production estimate; the additional year's data used in subsequent sections was not yet available when the simulation testing was conducted). This fit provided the "true" population values, which were then used to generate 120 sets of psuedo data with levels of observation error as estimated from the fit. The single set of true population values could then be compared to the 120 sets of estimated population values obtained by re-fitting the SAD08 model to the pseudo data sets. Relative error was calculated as $(\hat{x}_j - x)/x$, where x represents the true population estimate and $\hat{x}_j$ the estimate from a fit to pseudo data *j*. This first phase was a check to see if SAD08 could reproduce population estimates given the estimated levels of observation error. Figure 5.4.2.1 reveals that the performance of SAD08 in this regard was satisfactory (population estimates were reproduced without bias).

The second phase involved the construction of an operating model outside of SAD08, with some of the features of the western horse mackerel stock (such as the large recruitment in 1982), but not directly based on the data for this stock. Four operating models were constructed with the following features:

- low F scenario (=0.05)
- high F scenario (=0.4)
- positive trend in the realised fecundity parameter of 2% per year
- a realised fecundity parameter that varies randomly over time (CV=0.3)

Unlike the first phase, the operating models in the second phase produce 120 sets of "true" values, from each of which is produced a set of pseudo data, so that the relative error becomes $(\hat{x}_j - x_j)/x_j$ for the *j*th set of each operating model. Results for operating models (1) and (2) are shown in Figures 5.4.2.2 and 5.4.2.3 respectively, and demonstrate that under these operating models, SAD08 is able to reproduce population estimates without bias, and in the case of the high F scenario with lower spread of relative errors, confirming the established fact that VPA-based methods tend to perform better in high F situations (i.e. where F is larger than M). In the case of a trend in the realised fecundity parameter (Figure 5.4.2.4), the performance of SAD08 deteriorates markedly, producing positively biased SSB and recruitment estimates, and negatively biased F and realised fecundity estimates. This result is not surprising given that SAD08 does not account for trends in the realised fecundity parameter (assuming it to be constant over time), so that for this operating model, model misspecification is present. Performance is also poor for the case where the realised fecundity parameter varies randomly over time (Figure 5.4.2.5), producing large relative errors, but in this case the inter-quartile range still includes zero (where it did not for the previous operating model).

In conclusion, SAD08 returns unbiased population estimates in cases where there is no underlying trend in the realized fecundity parameter, and this includes scaling population size correctly. The model achieves improved performance when fishing mortality is high, confirming the established view that VPA-based methods perform better under high F than low F scenarios. The poorer performance under the scenario of positive trend in realized fecundity highlights the need to improve information on realized fecundity, and where this is not possible, to develop management plans that are robust to this source of uncertainty.

5.3.3 Preliminary modelling

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 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 5.4.3.1 presents an illustration of the model structure and the "free" parameters estimated by maximum likelihood (i.e. those estimated directly), and Table 5.4.3.1 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.

There is evidence that potential (i.e. 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.

The version of SAD used in 2007 (SADVF) assumed a linear relationship between realised fecundity and fish weight, which took into account the indications that fecundity changed with changing stock structure in the period considered in the assessment (WGMHSA 2005 report, WGMEGGS 2005 report). The slope of this linear relationship was derived externally to SADVF by fitting a linear relationship to potential fecundity vs. fish weight data and using the resultant slope in SADVF (assuming the slope of realised fecundity vs. weight was the same as potential fecundity vs. weight). The intercept of the realised fecundity vs. fish weight relationship was a free parameter in SADVF, but a penalty term was introduced in order to ensure that the realised fecundity in SADVF was consistent with that of Eltink (1991). The mean and variance of the penalty term were estimated (mean=1282 eggs per gram spawning female, CV=0.062), again externally to SADVF, by generating simulated data and combined it with actual potential fecundity data such that new "data"-set produced a population-average realised fecundity value consistent with the Eltink (1991) study.

The initial attempts to incorporate fecundity data in SADVF were problematic for two reasons. Firstly, the procedures used to estimate the fecundity parameters (externally to SADVF) were *ad-hoc* and could therefore be argued to be non-transparent. Secondly, the variance of the penalty term for the intercept of the realised fecundity vs. fish weight relationship was too small, having been empirically estimated (based on actual and simulated data), and does not account for the wide range of realised fecundity values reported in Abaunza *et al*. (2003). The SAD version proposed for 2008 (SAD08) attempts to rectify these problems. For the former, SAD08 explicitly incorporates and directly fits potential and realised fecundity data, with separate parameters for the two types of fecundity data, thus removing the *ad-hoc* procedures previously applied, and placing the estimation of fecundity parameters in a self-consistent framework. For the latter, the realised fecundity data point and associated CV (1847 eggs per gram spawning female, CV=0.287), is derived from a normal distribution, in log-space, which covers (with a 95% probability) the range of realised fecundity values reported by Abaunza *et al*. 2003 (10403−280 eggs per gram spawning female). This allows the incorporation of a more realistic level of uncertainty about realised fecundity than was previously the case.

The likelihood function used in SAD08 is as follows:

$$
\begin{aligned}
-\ln L = {} & \tfrac{1}{2}\sum_{y\in Y_{egg}}\left\{\frac{\left(\ln N_{egg,y}-\ln(\hat{N}_{egg,y})\right)^2}{\hat{\sigma}^2_{egg}}+\ln\left[2\pi\hat{\sigma}^2_{egg}\right]\right\} \\
& +\tfrac{1}{2}\sum_{y=2002}^{2006}\sum_{i=1}^{10}\left\{\frac{\left(\ln C_{y,i}-\ln\hat{C}_{y,i}\right)^2}{\hat{\sigma}^2_{sep}}+\ln\left[2\pi\hat{\sigma}^2_{sep}\right]\right\} \\
& +\tfrac{1}{2}\sum_{y=1983}^{2006}\left\{\frac{\left(\ln C_{y,11+}-\ln\hat{C}_{y,11+}\right)^2}{\hat{\sigma}^2_{11+}}+\ln\left[2\pi\hat{\sigma}^2_{11+}\right]\right\} \\
& +\tfrac{1}{2}\sum_{y\in Y_{pfec}}\sum_{j=1}^{J_y}\left\{\frac{\left(\ln f^p_{y,j}-\ln\hat{f}^p_{y,j}\right)^2}{\hat{\sigma}^2_{pfec}}+\ln\left[2\pi\hat{\sigma}^2_{pfec}\right]\right\} \\
& +\tfrac{1}{2}\left\{\frac{\left(\ln\bar{f}^r_{1989}-\ln\hat{\bar{f}}^r_{1989}\right)^2}{\sigma^2_{rfec}}+\ln\left[2\pi\sigma^2_{rfec}\right]\right\}
\end{aligned}
$$

where i represents age, $N_{egg,y}$ the egg production estimates, $C_{y,i}$ catch-at-age, $f^p_{y,j}$ potential fecundity for sample j in year y, and $\bar{f}^r_{1989}$ population-mean realised fecundity for 1989. Model estimates are shown with "^" and data without.

The model estimates egg production as follows:

$$\hat{N}_{egg,y} = \sum_i q_{fec}(a_{fec}+b_{fec}w_{y,i})\,B^{sp}_{y,i}\,s^f$$

where i represents age, q_{fec} the realised fecundity parameter, a_{fec} and b_{fec} the potential fecundity parameters, $w_{y,i}$ mean weights-at-age in the population, $B^{sp}_{y,i}$ SSB-at-age, and s^f the female sex ratio.

Potential fecundity is estimated as follows:

$$\hat{f}^{\,p}_{y,j} = a_{fec} + b_{fec} w_{y,j}$$

where $w_{y,j}$ are the sample weights for sample j of year y associated with the potential fecundity data $f^{\,p}_{y,j}$, and a_{fec} and b_{fec} are as before.

Population-mean realised fecundity is estimated as follows:

$$\hat{\bar{f}}^{\,r}_{y} = \frac{q_{fec}}{\sum_i N_{y,i} m_{y,i}} \sum_i N_{y,i} m_{y,i} (a_{fec} + b_{fec} w_{y,i})$$

where i represents age, $N_{y,i}$ population numbers-at-age, $w_{y,i}$ mean weights-at-age in the population, $m_{y,i}$ maturity-at-age, and q_{fec}, a_{fec} and b_{fec} as before.

The "free" parameters estimated directly in the model are:

1) Fishing mortality year effects (F_y) for the separable period;
2) Fishing mortality age effects (S_a, the selectivities) for ages 11−0 (excluding age 8, which is set at 1);
3) scaling parameter (F_{scal}) for fishing mortality at age 10 relative to the average for ages 79− (ignoring the 1982 year-class where applicable);
4) fishing mortality on the 1982 year-class at age 10 in 1992 ($F_{92,10}$);
5) realised fecundity parameter (q_{fec}), relating realised fecundity to potential fecundity, and therefore also relating SSB to egg production; and
6) potential fecundity parameters (a_{fec} and b_{fec}), relating potential fecundity to fish weight

Input data for the model were as presented in Tables 5.2.4.1, 5.2.5.1, 5.2.5.3 and 5.5.2.6.1 Natural mortality (constant at age and by year at 0.15), maturity-at-age, stock weights-at-age and the proportions of F and M before spawning (0.45), are assumed to be known precisely.

Results

Results are presented for a SPALY run (same procedure as last year, which is SADVF updated with 2007 data) in Figures 5.4.3.24−, and SAD08 in Figures 5.4.3.57−. Fits to the available data, and corresponding normalised residual plots are shown in Figures 5.4.3.2 and 5.4.3.5. Fits to the egg production estimates and plus-group catches are better for SAD08 than for the SPALY run. Figure 5.4.3.5 shows the additional fits to the fecundity data included in SAD08. Figures 5.4.3.3 and 5.4.3.6 indicate that precision is lower for the younger ages of the selectivity-at-age estimates (CVs of 304−5% for ages 13− compared with 153−0% for older ages) and for the most recent recruitments (CVs of 306−0% for the most recent five years compared to 41−4% for the first five years), reflecting poor representation of the younger ages in the catch, and the lack of survey information for these age groups.

In order to understand what is causing the difference between the SPALY run and SAD08, the CV of the penalty term for the intercept of the realised fecundity vs. fish weight relationship in the SPALY run was increased from 0.062 to 0.3, a value similar to the CV associated with the realised fecundity data point in SAD08. Figure 5.4.3.8 compares SSB, recruitment and F-trajectories for the three models (SPALY, SPALY with increased penalty-term CV, and SAD08). Although there is a difference between the SPALY run and SAD08, this difference is removed when the CV of the penalty term in the SPALY run is increased.

Sensitivity of SAD08 to the length of the separable window (base run = 20032−007, alternatives are 20022−007 and 20042−007) are shown in Figure 5.4.3.9, which indicates that SSB, recruitment and F trajectories are relatively insensitive to the length of the separable window.

Retrospective plots are shown for two cases. In the first case, 5-year retrospective plots were constructed for SSB, recruitment and F trajectories, and for selectivity-at-age, where the length of the separable window is kept at five years. For this case, Figure 5.4.3.10 indicates substantial retrospective bias both in the recent period and historically, with changes in the bias from one direction to the other and back again. This behaviour is likely due to the changes in selectivity-at-age for the separable period as the window is moved back in time, but the availability of egg production estimates may also have an effect. The changes in selectivity-at-age indicate increased selection of younger fish in recent years. For the second case, 3-year retrospective plots were constructed as before, but this time the starting year of the separable window (2003) was kept constant, thus resulting in the separable window reducing in length as years were dropped (allowing only 3 years for the analysis). Results for the second case (Figure 5.4.3.11) indicate a retrospective bias for the recent period, but negligible retrospective bias (in the opposite direction) for the historic period, again likely caused by changes in selectivity-at-age.

Conclusion

The Working Group supports the changes made to the SAD model (SAD08) to provide a consistent framework for estimating fecundity parameters, and to incorporate more realistic levels of uncertainty about realised fecundity, based on published information. The inclusion of fecundity data, particularly realised fecundity, helps scale the model. Simulations tests have shown that SAD08 provides unbiased population estimates under both high- and low-F scenarios, as long as there are no underlying trends in realised fecundity. However, the information available for western horse mackerel remains sparse, and concerns about the underlying data remain, particularly with regard to the reliability of age-determination for the catch-at-age data, and the interpretation of fecundity estimates (because horse mackerel are regarded as indeterminate spawners). Nevertheless, the Working Group considers that, given the available data, the current approach has been taken as far as it can, and that with recent improvements, it is comfortable in recommending SAD08 as a final analytical assessment for western horse mackerel.

5.4 Reference points

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}. Evaluation of precision of the assessment shows that the CV in SSB is 16%. The ICES procedure for evaluating precautionary reference points from limit points uses a formula based on the CV (ICES 2001). This formula gives a factor of 30% and an estimate of B_{pa} = 1.8Mt.

Fishing mortality reference points. The age range used in the calculation of mean F was changed in 2003 from F_{41-0} to F_{11-0} to include the ages exploited in both the adult and juvenile fisheries. No reliable estimate of total mortality is available for the stock, which could be used to judge the level of F although the management plan currently in place is not based on F (see section 5.10). There are indications that the assumed natural mortality (0.15) might be too high. However, there is insufficient data to estimate M.

5.5 State of the Stock

5.5.1 Stock assessment

SAD08 is presented as the final assessment model. Stock numbers-at-age and Fishing mortality-at-age are given in Tables 5.6.1.1 and 5.6.1.2, and a stock-summary is provided in Table 5.6.1.3, and illustrated in Figure 5.6.1.1. SSB peaked in 1988 following the very strong 1982 year-class and has since declined and shown two further smaller increases following moderate year-classes in the early- to mid-90s19 and the moderate-to-strong year-class of 2001 (a third the size of the 1982 year-class). Year-classes following 2001 have been weak, although these year-classes are estimated with poorer precision than previous ones. Fishing mortality on the older ages (48−) is low compared to levels in the 1990s.

5.5.2 Reliability of the assessment

Fishery-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 of the input data, and the extent to which model assumptions are violated. For example, simulation testing has shown that if there is an increasing trend in the realised fecundity parameter that is not accounted for, then the model over-estimates SSB and recruitment, and underestimates fishing mortality and realised fecundity.

The model relies on a single data point for realised fecundity, which it uses for scaling, and the inclusion of any additional information on realised fecundity would help improved the reliability of the assessment. Estimates of F 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. Nevertheless, total mortality appears to be low, given the persistence of the 1982 year-class in the catch data.

Shifting the separable window as new data is added induces retrospective bias, because any changes in selectivity-at-age violates the assumption of constant selectivity in the separable period.

Although estimates for the uncertainty of the egg input data are available, the assessment 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 precision of recruitment estimates for the most recent years is poor, with 95% lower confidence limit barely being positive. This result is 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 largest since 1982, with a CV of 25%.

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.

5.6 Short-term forecast

A short-term forecast is not conducted for western horse mackerel because a management plan is in place. The management plan provides for a constant TAC set for 3 years. This TAC (180kt) was last set in 2007 based on the egg survey estimate in that year. This value will remain unchanged for 2009 and 2010. The 2007 survey estimate has not been revised in 2008 so that the TAC should remain the same.

5.7 Uncertainties in the assessment and forecast

See section on reliability of assessment.

5.8 Comparison with previous assessment and forecast

There was not previously an accepted assessment and forecast.

5.9 Management plans and evaluations

In 2007 the Pelagic RAC put forward a management plan for the Western Horse Mackerel stock. Upon evaluation, ICES considered the plan to be precautionary in the short term, but not in the long term (ICES 2007d). The plan utilises the triennial egg survey results as a basis for setting a three-year TAC, based on the slope of the three previous egg production estimates. The TAC is set according to the following rule:

$$TAC_y = 1.07\left[\frac{TAC_{ref}}{2} + \frac{TAC_{y-3}\,sl}{2}\right]$$

where TAC_{ref} = 150,000t and *sl* is a function of the slope (*b*) of the most recent three egg abundance estimates from surveys such that

		b	≤	-1.5	sl =	0
-1.5	<	b	<	0	sl =	1-((1/-1.5)*b)
0	≤	b	≤	0.5	sl =	1+((0.4/0.5)*b)
0.5	<	b			sl =	1.4

The 2008 TAC was set at 180kt on the basis of the provisional egg production estimate in 2007 (ICES 2007c). The updated value (sec 5.3.1, this report) is unchanged at 1.43×10^{15} eggs (b remains at 0.31), such that the TAC does not require revision and will remain in place for 2009 and 2010.

5.10 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 is around a third the size of the 1982 year-class, but well above those in the early- to mid-90s19.

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 is consistent with the strong 2001 year class maturing. SSB in 2008 was estimated at 2.4Mt, which is well above the 1982 SSB of 1.4Mt and adopted as B_{lim}, Bpa = 1.8Mt was proposed. However, it is not recommended to use B_{pa} as a management target but rather follow the precautionary rule in the agreed management plan.

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 Division 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 mis-match between TAC and fishing areas has resulted in the catch prior 2007 exceeding those advised by ICES.

The management plan proposed by the Pelagic RAC in 2007 has been evaluated by ICES (and considered to be precautionary in the short term) and has been implemented to set the TAC for 20082−010. 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. It should be noted that the management plan assumes that all catches are taken against the TAC and, should the management and assessment areas be combined in the future, the TAC as set by the EU will not cover all fisheries.

5.11 Ecosystem considerations

Knowledge about the distribution of the western horse mackerel stock is gained from the egg surveys and the seasonal changes in the fishery. However, based on these observations it is not possible to infer a similar changing trend in the distribution of western horse mackerel as for NEA mackerel.

5.12 Regulations and their effects

Existing TACs are based on annual agreements between the EU, Norway and the Faroe Islands. The minimum landing size of horse mackerel is 15cm (10% undersized allowed in the catches).

The stock allocations were changed in 2005 following the results of the HOMSIR project (Abaunza *et al*. 2003b) and VIIIc is now belonging to the western stock. In frame of the front loading of the Fishing Opportunities Regulation for 2009 alterations according to the findings of the HOMSIR projects were applied to the TAC management areas.

In Norwegian waters there is no quota for horse mackerel but existing regulations on bycatch proportions as well as a general discard prohibition (for all species) apply to horse mackerel.

5.13 Changes in fishing technology and fishing patterns

The description of the fishery is given in sections 3.1 and 5.2.1 and no big changes in fishing areas or patterns have taken place. However, there has been a gradual shift from an industrial fishery for meal and oil towards a human consumption fishery.

5.14 Changes in the environment

Migrations are closely associated with the slope current, and horse mackerel migrations are known to be modulated by temperature. Continued warming of the slope current is likely to affect the timing and spatial extent of this migration.

Since the strong 1982 year class of the western stock started to appear in the North Sea in 1987 a good correspondence between the modelled influx of Atlantic water to the North Sea in the first quarter and the horse mackerel catches taken by Norwegian purse seiners in the Norwegian EEZ (NEZ) later (October-November) the same year (Iversen *et al.* 2002) has been noted in most years. An exception is 2000 when there was no obvious correlation between the influx and catch level. The catches in 2005 and 2007 were also lower than indicated by the influx. In 2005 the Norwegian horse mackerel fishery was stopped due to by-catches of mackerel. A more off-shore distribution of horse mackerel was observed during surveys in the Northern part of the North Sea in October-December 2007. This might have resulted in lower availability for the purse seine fleet. The modelled influx has been used locally to predict the catch level in NEZ. The modelled influx in 2008 was the same as in 2007, indicating a similar catch as in 2007. The predicted catch level for the Norwegian purse-seines in 2007 was 304−0,000 tons while the actual catch was considerably lower, 5,400 tons.

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	2007[1]
Faroe Islands	-	-	3	-
Denmark	-	-	-	-
France	-	-	-	-
Germany	-	-	-	-
Ireland	-	-	-	366[4]
Norway	42	176	27	-
Russia				
UK (England + Wales)	-	-	-	-
Estonia	-	-	-	-
Total	42	176	30	366

[1]Preliminary.

[2]Included in Subarea IV.

[3]Includes catches in Div. Vb.

[4]Taken in Div. 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	-	275	17	-	-
Faroe Islands	-	942	340	-	360	1,014	-	-	296
France	248	220	174	162	302	415	-	-	-
Germany, Fed.Rep.	506	2,469[5]	5,995	2,801	1,570	1,329	1,600	7	7,603
Ireland	-	687	2,657	2,600	4,086	94,000	220	1,100	8,152
Netherlands	14,172	1,970	3,852	3,000	2,470	-	5,285	6,205	37,778
Norway	84,161	117,903	50,000	96,000	126,800	2,087	84,747	14,639	45,314
Poland	-	-	-	-	-	389	-	-	-
Sweden	-	102	953	800	697	7,582	-	95	232
UK (Engl. + Wales)	10	10	132	4	115	1,511	478	40	242
UK (N. Ireland)	-	-	350	-	-		-	-	-
UK (Scotland)	2,093	458	7,309	996	1,059		3,650	2,442	10,511
USSR / Russia (1992 -)	-	-	-	-278[6]	-3,270		-28	136	-31,615
Unallocated + discards	12,482[4]	-317[4]	-750[4]						
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	-	-	-	699	809	174	35	2,380
Faroe Islands	28	908	24	48	-	392	4,905	3,876	965
France	379	60	49	230	2,671	3,048	379	1,811	2,077
Germany	4,620	4,071	3,115	375	72	93	21,418	753	2,354
Ireland	-	404	103	4,685	6,612	17,354	10,709	24,679	20,984
Lithuania	3,811	3,610	3,382	7,948	35,368	20,493	665	24,937	27,200
Netherlands	13,129	44,344	1,246	-	-	-	2,552	239	491
Norway	-	-	2	119	575	1,074	1	1,778	423
Russia	3,411	1,957	1,141	317	1,191	1,192	-19,103	22	314
Sweden	2	11	15	3,161	255	1		-21,830	-19,623
UK (Engl. + Wales)	3,041	1,658	3,465	649	-149	-14,009			
UK (Scotland)	737	-325	14613						
Unallocated+discards									
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 5.2.2 cont. 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	2007[1]
Belgium	5
Denmark	329
Faroe Islands	3
France	457
Germany, Fed.Rep.	93
Ireland	652
Netherlands	20,027
Lithuania	98
Norway	5.423
Sweden	130
UK (Engl. + Wales)	2,966
UK (Scotland)	626
Unallocated +discards	-14,403
Total	16,407

[1-]**Preliminary.**

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	-	-	-	996	83	75	41
Spain	-	-	-	-	-	-	-[2]	-[2]	-[2]
UK (Engl. + Wales)	9	5	+	38	+	1,427	198	404	475
UK (N. Ireland)	1	17	83	-	214	-	-	-	-
UK (Scotland)	-	-	-		-	-19,168	138	1,027	7,834
USSR							-	-	-
Unallocated + disc.							-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	-	-	-	-	-	-	-
Unallocated + disc.	6,493	143	-1,278	-1,940	-6,960[4]	-51	-41,326	-11,523	837
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
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	885	1,139	687	600	450	847	3,701	6,039	2,822
Netherlands	-	-	-	-	-	-	-	-	1,892
Spain	10	344	41	91	-	46	5	52	-
UK (Engl.+Wales)	1,132	-	-	3,111	1,192	453		210	-
UK (N.Ireland)	10,447	4,544	1,839	-21	3	-553	377	62	82
UK (Scotland)	98	1,507	2,038				559	1,298	43
Unallocated+disc.									-304
Total	34,815	65,308	20,657	24,636	14,190	23,254	21,929	22,055	15,751

Country	2007[1]
Denmark	-
France	-
Germany	1,835
Ireland	20,341
Lithuania	80
Netherlands	2,177
Norway	2
Russia	-
Spain	-
UK (Engl. + Wales)	232
UK (Scotland)	38
Unallocated+discards	1,474
Total	26,279

[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
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	91,946	56,223	50,120	46,196	37,605	48.222	41,123	31,156	3,569
Netherlands	-	-	50	7	0	1	27	12	35,467
Spain	12,832	8,885	2,972	8,901	5,525	4,186	7,178	4,752	60
UK (Engl. + Wales)	-	-	-	-	-	268	1,146	217	2,935
UK (N.Ireland)	5,095	4,994	5,152	1,757	1,461	24,897	18,485	59	142
UK (Scotland)	12,706	31,239	1,884	11,046	2,576			18,368	413
Unallocated+discards									19,379
Total	249,446	161,654	137,766	138,042	97,906	123,046	112,393	107,475	101,912

Country	2007[1]
Faroe Islands	475
Belgium	+
Denmark	4,806
France	6,844
Germany	3.943
Ireland	8,039
Lithuania	5,585
Netherlands	38,034
Spain	-
Sweden	55
UK (Engl. + Wales)	9,105
UK (Scotland)	738
Unallocated+discards	15,460
Total	93,084

[1]Preliminary

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
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

Country	2007[1]
Denmark	2,687
France	10,741
Germany	-
Ireland	694
Lithuania	-
Netherlands	-
Russia	-
Spain	13,853
UK (Engl. + Wales)	-
UK (Scotland)	-
Unallocated+discards	412
Total	28,387

[1]Preliminary.

[2]Included in Subarea VII.

Table 5.2.2.2.1. Western horse mackerel. CPUE at age series from Spanish bottom trawl surveys. It includes also the Subdivision IXa north (actually bolonging to southern horse mackerel stock)

Edad/Año	1984	1985	1986	1987	1988	1989*	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	1.68	70.70	36.12		69.22	69.50	7.83	0.36	27.12	83.85	725.31	18.02	26.54	6.65	22.70	2.38	45.98	6.88	1.22	38.81	59.13	724.74	15.62	9.04
1	136.89	60.18	22.79		6.26	2.48	7.65	0.15	30.12	29.62	52.63	80.89	21.11	11.10	7.36	33.26	4.20	4.54	2.39	20.12	11.43	78.19	47.62	4.85
2	200.17	205.18	6.17		4.45	0.91	1.69	0.03	0.68	2.91	18.82	9.91	21.20	4.82	20.45	12.16	2.94	19.29	2.87	68.04	3.22	20.02	38.16	4.95
3	4.00	289.94	5.14		2.83	16.28	1.38	0.03	0.89	0.63	1.36	6.62	25.92	8.65	26.25	3.44	8.47	10.48	2.70	9.05	11.15	8.39	10.24	4.26
4	21.51	3.32	22.73		1.67	3.50	8.91	0.45	0.30	1.98	1.62	5.62	48.95	7.56	54.15	18.07	18.43	6.00	6.38	7.73	3.47	30.98	5.29	4.76
5	17.72	2.98	2.00		2.68	14.01	3.23	0.63	1.87	4.15	2.65	4.00	25.88	6.26	28.34	16.29	28.61	3.65	3.14	5.46	3.64	1.56	7.45	2.81
6	8.69	2.07	1.90		19.11	12.71	4.27	0.24	4.06	12.75	5.12	6.51	9.49	3.85	19.39	9.95	47.08	1.28	4.38	8.17	2.85	3.20	7.93	5.86
7	37.37	1.58	4.02		1.73	47.35	3.23	0.20	3.94	15.95	10.12	9.69	15.49	4.07	11.05	13.73	20.51	27.89	9.67	7.65	1.43	2.97	4.93	6.40
8	3.52	1.61	1.35		2.28	6.01	37.28	0.66	5.26	4.36	12.00	14.96	3.74	12.49	4.55	12.26	6.94	17.31	12.77	8.35	3.33	4.62	2.54	5.53
9	15.21	1.76	2.11		2.98	7.71	1.48	8.43	4.69	4.32	2.51	12.61	30.14	4.11	2.62	9.05	7.45	3.50	8.07	16.50	2.69	5.87	1.39	3.98
10	0.11	1.17	2.92		2.17	17.86	2.15	1.32	43.87	3.78	1.45	3.97	9.24	10.68	0.90	4.56	1.43	5.68	4.32	7.21	1.91	1.23	1.24	2.57
11	0.82	0.27	0.88		1.14	0.34	0.45	0.92	4.72	21.50	0.85	2.12	1.53	8.05	2.13	1.07	0.48	3.39	2.43	2.85	0.02	3.60	3.05	1.33
12	0.36	0.27	0.35		3.28	0.23	0.28	0.63	1.53	0.24	4.35	0.35	2.46	0.50	2.24	1.33	0.94	0.51	0.70	1.30	0.55	5.83	5.91	2.07
13	2.91	0.07	0.21		0.76	2.22	0.18	0.38	0.63	0.04	0.33	9.29	0.03	0.34	0.49	0.08	0.93	0.62	1.09	0.07	0.07	1.20	3.77	1.61
14	0.92	0.21	0.26		1.11	0.16	0.23	0.84	0.21	0.24	0.18	0.11	4.73	0.10	0.26	0.06	4.32	0.21	1.74	0.18	0.16	0.61	0.95	1.00
15+	2.49	1.62	1.11		8.11	2.49	0.47	0.64	3.61	0.26	0.39	0.05	0.09	2.65	2.49	0.11	1.10	0.48	0.16	1.84	0.89	0.18	2.67	1.78
Total	**454.38**	**642.91**	**110.05**		**129.79**	**203.76**	**80.71**	**15.91**	**133.49**	**186.58**	**839.69**	**184.71**	**246.54**	**91.87**	**205.38**	**137.80**	**199.81**	**111.71**	**64.03**	**203.34**	**105.95**	**893.17**	**158.75**	**62.80**

Table 5.2.4.1 Western Horse Mackerel stock. Catch in numbers (1000) at age by quarter and area in 2007

Q 1

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	823.46	1117.12	7417.77	0.00	9358.35
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2146.40	201.15	0.00	544.61	0.00	0.00	0.00	2329.74	2382.14	1881.03	0.00	9485.08
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3531.18	330.92	0.00	1336.54	0.00	0.00	837.55	3016.88	827.72	904.47	0.00	10785.25
4	0.00	0.00	0.00	74.47	6.41	2.90	53.78	44.83	3046.53	285.50	0.00	4370.90	27.69	1.30	11167.31	2118.16	362.43	280.96	0.00	21843.18
5	0.00	0.00	0.00	108.63	9.35	5.52	264.73	85.28	1246.32	116.80	0.00	19223.54	202.11	26.89	34409.27	1047.92	284.26	102.48	0.00	57133.09
6	0.00	0.00	0.00	12969.49	1116.23	191.90	9570.04	2965.36	3323.44	311.45	0.00	13729.67	13456.34	764.51	21008.50	1827.86	380.65	50.23	0.00	81665.67
7	0.00	0.00	0.00	1090.00	93.81	27.65	2668.20	427.18	553.93	51.91	0.00	801.39	1130.85	71.95	2093.87	509.14	386.05	171.75	0.00	10077.68
8	0.00	0.00	0.00	1305.10	112.32	18.79	1876.50	290.36	0.00	0.00	0.00	0.00	1066.47	70.41	279.18	99.56	254.91	183.41	0.00	5557.00
9	0.00	0.00	0.00	759.84	65.40	20.98	2251.44	324.21	0.00	0.00	0.00	220.28	768.53	44.14	0.00	49.92	276.37	628.28	0.00	5409.40
10	0.00	0.00	0.00	380.30	32.73	4.35	260.94	67.22	0.00	0.00	0.00	0.00	459.15	28.76	0.00	44.43	179.28	469.88	0.00	1927.04
11	0.00	0.00	0.00	201.09	17.31	3.52	237.77	54.34	0.00	0.00	0.00	0.00	352.36	22.42	0.00	40.19	143.65	192.09	0.00	1264.74
12	0.00	0.00	0.00	302.98	26.08	1.55	34.46	24.02	0.00	0.00	0.00	0.00	263.98	17.75	0.00	30.50	175.84	421.67	0.00	1298.83
13	0.00	0.00	0.00	633.47	54.52	9.22	847.41	142.43	0.00	0.00	0.00	0.00	1142.60	74.64	0.00	69.05	326.30	820.83	0.00	4120.47
14	0.00	0.00	0.00	343.51	29.56	2.14	50.78	33.09	0.00	0.00	0.00	0.00	403.67	29.33	0.00	10.01	105.74	467.20	0.00	1475.05
15+	0.00	0.00	0.00	1167.94	100.52	6.28	321.02	96.97	0.00	0.00	0.00	0.00	539.07	37.46	0.00	15.94	130.82	460.08	0.00	2876.09

Q 2

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	53.57	1.58	2399.24	1.60	2455.99
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	377.27	21.15	0.00	0.00	0.00	0.00	0.00	704.73	119.78	2628.23	2.43	3853.59
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	620.67	34.79	0.00	1.13	0.00	0.00	122.87	1106.31	284.63	1939.75	2.45	4112.60
4	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.18	535.49	30.01	0.00	9.26	0.00	0.00	1638.21	922.94	488.53	1039.16	1.51	4665.46
5	0.00	0.00	0.00	27.22	0.00	0.00	0.33	0.34	219.07	12.28	0.00	48.67	1459.40	0.00	5047.73	389.37	753.32	556.78	1.10	8515.61
6	0.00	0.00	0.00	54.76	0.00	0.00	11.39	11.77	584.16	32.74	0.00	33.17	11258.32	0.00	3081.88	975.42	1032.89	442.17	1.15	17519.82
7	0.00	0.00	0.00	218.41	0.00	0.00	1.64	1.70	97.36	5.46	0.00	1.70	2293.49	0.00	307.16	175.88	1325.81	641.09	1.10	5070.79
8	0.00	0.00	0.00	218.82	0.00	0.00	1.12	1.15	0.00	0.00	0.00	0.00	416.87	0.00	40.96	6.48	897.43	498.74	0.66	2082.23
9	0.00	0.00	0.00	28.47	0.00	0.00	1.25	1.29	0.00	0.00	0.00	0.57	208.44	0.00	0.00	3.25	800.20	937.47	0.69	1981.61
10	0.00	0.00	0.00	110.34	0.00	0.00	0.26	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.89	494.44	685.22	0.47	1293.90
11	0.00	0.00	0.00	0.83	0.00	0.00	0.21	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.61	438.74	370.56	0.35	813.52
12	0.00	0.00	0.00	137.15	0.00	0.00	0.09	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.98	516.50	720.67	0.48	1376.98
13	0.00	0.00	0.00	82.29	0.00	0.00	0.55	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.49	926.71	1254.56	0.87	2270.03
14	0.00	0.00	0.00	137.36	0.00	0.00	0.13	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	239.46	657.65	0.31	1035.69
15+	0.00	0.00	0.00	1046.38	0.00	0.00	0.37	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	322.15	648.62	0.36	2019.29

Q 3

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0	0.00	0.00	0.00	7.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	379.34	41.26	594.16	0.48	1022.52
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	148.98	124.63	6221.23	0.96	6495.79
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4876.31	132.35	0.04	0.00	0.00	0.00	1060.87	2.34	182.51	2035.58	0.31	8290.31
3	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	8022.34	217.73	0.06	0.23	0.00	0.00	1745.31	0.00	499.20	2501.31	0.46	12986.84
4	0.22	1.19	0.00	5.04	0.00	0.00	0.00	0.00	6921.28	187.85	0.05	1.85	0.00	0.00	1505.77	0.10	1007.62	3352.79	0.72	12984.47
5	4.77	25.42	0.00	4.28	0.00	0.00	4227.08	0.00	2831.47	76.85	0.02	9.73	8.92	0.00	616.00	0.25	1023.81	1070.00	0.44	9899.05
6	16.90	89.98	0.00	195.19	0.00	0.00	3576.71	0.00	7550.39	204.92	0.06	6.63	54.03	0.00	1642.63	1.58	997.58	621.57	0.38	14958.54
7	9.67	51.48	0.00	22.65	0.00	0.00	325.12	0.00	1258.46	34.16	0.01	0.34	26.93	0.00	273.79	2.73	915.92	642.77	0.36	3564.38
8	2.76	14.72	0.00	21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	1.38	472.04	415.57	0.20	928.00
9	8.01	42.66	0.00	6.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	3.95	257.41	223.65	0.11	542.80
10	2.88	15.36	0.00	7.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.80	250.17	371.96	0.14	662.23
11	3.65	19.42	0.00	1.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.77	218.53	398.56	0.14	668.89
12	5.49	29.23	0.00	9.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.73	407.99	540.16	0.24	1040.37
13	1.31	6.99	0.00	6.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	128.12	230.43	677.51	0.29	1051.54
14	3.09	16.45	0.00	9.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.86	104.15	331.20	0.15	543.12
15+	32.89	175.16	0.00	61.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.46	0.00	0.00	421.21	154.70	1071.75	0.61	1922.52

Q 4

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIcØ C	VIIIc west	VIIId	Total
0	0.00	0.00	0.00	3330.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	136.81	92.91	0.00	0.00	3560.16
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8233.67	0.55	0.00	0.00	0.00	0.00	3007.52	6039.80	1613.15	2.77	0.00	18897.46
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5780.28	0.24	0.00	0.00	0.00	0.00	1307.03	8595.97	2413.61	16.86	0.00	18113.99
3	0.00	0.00	0.00	96.39	0.00	0.00	0.00	0.00	12528.18	0.47	0.00	0.00	0.00	0.00	2568.74	1738.03	1327.45	74.40	0.00	18333.65
4	0.43	28.15	2.18	2304.97	0.00	0.00	1529.30	22.97	16298.96	0.33	0.00	0.00	0.00	0.00	1788.64	187.39	1346.52	333.62	0.00	23843.46
5	9.22	601.69	46.51	1342.44	0.00	0.00	1363.72	20.48	20673.19	0.27	0.00	0.00	2261.81	0.00	1490.71	29.21	970.98	684.13	0.00	29494.36
6	32.63	2129.96	164.63	88011.95	0.00	0.00	95982.30	1441.77	17121.57	0.30	0.00	0.00	13696.51	0.00	1658.30	24.27	847.95	1369.38	0.00	222481.48
7	18.67	1218.63	94.19	5408.38	0.00	0.00	6541.59	98.26	6318.65	0.08	0.00	0.00	6827.31	0.00	424.95	27.36	760.85	1614.57	0.00	29353.49
8	5.34	348.35	26.92	4645.40	0.00	0.00	7083.92	106.41	4797.56	0.06	0.00	0.00	83.77	0.00	322.65	4.34	379.74	1264.96	0.00	19069.41
9	15.47	1009.85	78.05	2509.27	0.00	0.00	5955.37	89.46	1552.97	0.02	0.00	0.00	0.00	0.00	104.44	5.44	214.20	686.76	0.00	12221.31
10	5.57	363.59	28.10	1116.70	0.00	0.00	2190.26	32.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.74	217.54	958.69	0.00	4918.10
11	7.04	459.77	35.54	814.06	0.00	0.00	1477.60	22.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.64	186.39	962.19	0.00	3967.42
12	10.60	692.00	53.49	1247.30	0.00	0.00	1125.94	16.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.02	367.58	1489.33	0.00	5009.17
13	2.53	165.38	12.78	1288.78	0.00	0.00	1597.32	23.99	1295.80	0.02	0.00	0.00	0.00	0.00	87.15	3.23	241.39	1392.02	0.00	6110.41
14	5.96	389.40	30.10	1105.21	0.00	0.00	1269.57	19.07	1167.32	0.01	0.00	0.00	0.00	0.00	78.51	2.03	100.22	602.46	0.00	4769.86
15+	63.51	4146.15	320.47	4521.02	0.00	0.00	3888.84	58.42	0.00	0.00	0.00	0.00	1130.90	0.00	0.00	5.11	201.55	1298.35	0.00	15634.33

Q 1-4

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0	0.00	0.00	0.00	3337.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	516.16	134.16	594.16	0.48	4582.69
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8233.67	0.55	0.00	0.00	0.00	0.00	3007.52	7065.81	2856.48	16041.02	2.56	37207.60
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13180.26	354.88	0.04	544.61	0.00	0.00	2367.90	11632.78	5098.05	6561.70	2.74	39742.96
3	0.00	0.00	0.00	96.60	0.00	0.00	0.00	0.00	24702.37	583.91	0.06	1337.90	0.00	0.00	5274.46	5861.22	2939.00	5419.93	2.91	46218.34
4	0.65	29.34	2.18	2384.48	6.41	2.90	1583.25	67.98	26802.25	503.69	0.05	4382.02	27.69	1.30	16099.92	3228.59	3205.10	5006.54	2.23	63336.56
5	13.99	627.11	46.51	1482.58	9.35	5.52	5855.86	106.10	24970.05	206.20	0.02	19281.94	3932.24	26.89	41563.71	1466.75	3032.37	2413.39	1.54	105042.09
6	49.52	2219.94	164.63	101231.38	1116.23	191.90	109140.45	4418.90	28579.55	549.42	0.06	13769.47	38465.20	764.51	27391.31	2829.12	3259.07	2483.35	1.53	336625.63
7	28.33	1270.11	94.19	6739.44	93.81	27.65	9536.56	527.14	8228.41	91.60	0.01	803.43	10278.58	71.95	3099.77	715.11	3388.63	3070.17	1.46	48066.35
8	8.10	363.06	26.92	6190.31	112.32	18.79	8961.53	397.92	4797.56	0.06	0.00	0.00	1567.44	70.41	642.79	111.76	2004.12	2362.68	0.86	27636.64
9	23.48	1052.52	78.05	3304.48	65.40	20.98	8208.06	414.96	1552.97	0.02	0.00	220.96	976.97	44.14	104.44	62.57	1548.17	2476.16	0.80	20155.12
10	8.45	378.96	28.10	1615.25	32.73	4.35	2451.46	100.39	0.00	0.00	0.00	0.00	459.15	28.76	0.00	65.86	1141.43	2485.75	0.61	8801.27
11	10.69	479.19	35.54	1017.80	17.31	3.52	1715.58	76.75	0.00	0.00	0.00	0.00	352.36	22.42	0.00	72.21	987.31	1923.40	0.49	6714.57
12	16.09	721.24	53.49	1696.96	26.08	1.55	1160.49	41.02	0.00	0.00	0.00	0.00	263.98	17.75	0.00	86.23	1467.92	3171.84	0.72	8725.35
13	3.85	172.36	12.78	2011.44	54.52	9.22	2445.28	166.99	1295.80	0.02	0.00	0.00	1142.60	74.64	87.15	204.90	1724.84	4144.91	1.15	13552.45
14	9.05	405.85	30.10	1595.31	29.56	2.14	1320.48	52.30	1167.32	0.01	0.00	0.00	403.67	29.33	78.51	91.55	549.57	2058.51	0.47	7823.73
15+	96.40	4321.31	320.47	6797.08	100.52	6.28	4210.23	155.77	0.00	0.00	0.00	0.00	1674.44	37.46	0.00	443.30	809.22	3478.80	0.97	22452.24

Table 5.2.5.1 Western Horse Mackerel stock. Mean weight (kg) in catch at age by quarter and area in 2007

Q 1

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0																				
1																0.045	0.056	0.033		0.037
2									0.065	0.065		0.065				0.074	0.076	0.079		0.073
3									0.105	0.105		0.098			0.101	0.100	0.093	0.092		0.101
4				0.122	0.122	0.129	0.128	0.129	0.122	0.122		0.101	0.107	0.109	0.104	0.117	0.110	0.102		0.108
5				0.131	0.131	0.132	0.135	0.132	0.130	0.130		0.103	0.150	0.150	0.111	0.130	0.138	0.145		0.110
6				0.166	0.166	0.156	0.157	0.156	0.134	0.134		0.111	0.140	0.140	0.115	0.139	0.149	0.153		0.136
7				0.198	0.198	0.174	0.176	0.174	0.142	0.142		0.156	0.151	0.155	0.130	0.150	0.169	0.218		0.161
8				0.221	0.221	0.192	0.198	0.192				0.000	0.185	0.188	0.138	0.167	0.180	0.203		0.197
9				0.243	0.243	0.213	0.209	0.213				0.022	0.197	0.206		0.180	0.202	0.227		0.207
10				0.281	0.281	0.221	0.203	0.221					0.175	0.185		0.182	0.207	0.229		0.220
11				0.292	0.292	0.265	0.298	0.265					0.178	0.175		0.177	0.194	0.215		0.231
12				0.261	0.261	0.220	0.223	0.220					0.204	0.210		0.208	0.209	0.237		0.231
13				0.282	0.282	0.240	0.248	0.240					0.193	0.214		0.198	0.217	0.240		0.233
14				0.332	0.332	0.254	0.268	0.254					0.190	0.212		0.254	0.241	0.251		0.254
15+				0.381	0.381	0.322	0.328	0.322					0.210	0.265		0.241	0.232	0.251		0.311

Q 2

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0																				
1																0.045	0.060	0.057	0.054	0.056
2									0.065	0.065						0.067	0.087	0.081	0.084	0.077
3									0.105	0.105		0.084			0.101	0.104	0.104	0.097	0.099	0.101
4							0.129	0.129	0.122	0.122		0.096			0.104	0.121	0.123	0.110	0.115	0.113
5				0.147			0.132	0.132	0.130	0.130		0.103	0.118		0.111	0.130	0.141	0.133	0.135	0.118
6				0.197			0.156	0.156	0.134	0.134		0.109	0.130		0.115	0.134	0.151	0.149	0.148	0.130
7				0.221			0.174	0.174	0.142	0.142		0.159	0.138		0.130	0.144	0.169	0.186	0.171	0.156
8				0.258			0.192	0.192				0.000	0.124		0.138	0.167	0.179	0.188	0.178	0.178
9				0.270			0.213	0.213				0.022	0.150			0.180	0.195	0.219	0.198	0.203
10				0.290			0.221	0.221								0.182	0.200	0.227	0.203	0.222
11				0.293			0.265	0.265								0.177	0.192	0.212	0.194	0.201
12				0.268			0.220	0.220								0.208	0.201	0.233	0.214	0.224
13				0.369			0.240	0.240								0.198	0.211	0.238	0.216	0.232
14				0.387			0.254	0.254								0.254	0.238	0.252	0.248	0.267
15+				0.422			0.322	0.322								0.241	0.229	0.247	0.239	0.335

Q 3

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0																0.024	0.036	0.042	0.034	0.035
1																0.036	0.044	0.051	0.044	0.050
2									0.065	0.065	0.065				0.065	0.055	0.095	0.078	0.076	0.069
3				0.107					0.105	0.105	0.105	0.084			0.105	0.099	0.119	0.111	0.109	0.107
4	0.200	0.200	0.000	0.139					0.122	0.122	0.122	0.096			0.122	0.191	0.134	0.123	0.150	0.123
5	0.252	0.252	0.000	0.152			0.163		0.130	0.130	0.130	0.103	0.141		0.130	0.209	0.147	0.140	0.165	0.147
6	0.272	0.272	0.000	0.183			0.169		0.134	0.134	0.134	0.109	0.147		0.134	0.254	0.163	0.171	0.196	0.148
7	0.302	0.302	0.000	0.209			0.176		0.142	0.142	0.142	0.159	0.165		0.142	0.237	0.172	0.187	0.198	0.164
8	0.324	0.324	0.000	0.236									0.186			0.213	0.187	0.201	0.200	0.197
9	0.393	0.393	0.000	0.247								0.022				0.267	0.185	0.208	0.220	0.215
10	0.444	0.444	0.000	0.261												0.323	0.199	0.233	0.252	0.229
11	0.429	0.429	0.000	0.257												0.366	0.208	0.247	0.274	0.245
12	0.424	0.424	0.000	0.247												0.414	0.196	0.245	0.285	0.240
13	0.443	0.443	0.000	0.298												0.425	0.223	0.295	0.314	0.296
14	0.422	0.422	0.000	0.327												0.446	0.229	0.325	0.333	0.328
15+	0.539	0.539	0.000	0.353									0.288			0.432	0.267	0.369	0.356	0.393

Q 4

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIcØ C	VIIIc west	VIIId	Total
0				0.0050												0.0449	0.0334	0.0000		0.0073
1									0.0680	0.0680					0.0680	0.0592	0.0595	0.0713		0.0644
2									0.0720	0.0765					0.0765	0.0794	0.0811	0.0921		0.0771
3				0.1070					0.1039	0.1068					0.1068	0.0952	0.1078	0.1424		0.1040
4	0.200	0.2000	0.2000	0.1390			0.1360	0.1360	0.1275	0.1269					0.1269	0.1170	0.1290	0.1616		0.1297
5	0.252	0.2520	0.2520	0.1560			0.1600	0.1600	0.1451	0.1464			0.1410		0.1464	0.1418	0.1451	0.1682		0.1490
6	0.272	0.2717	0.2717	0.1709			0.1750	0.1750	0.1570	0.1510			0.1470		0.1510	0.1627	0.1632	0.1828		0.1711
7	0.302	0.3022	0.3022	0.2001			0.2090	0.2090	0.1670	0.1670			0.1650		0.1670	0.1624	0.1716	0.1920		0.1898
8	0.324	0.3237	0.3237	0.2193			0.2400	0.2400	0.2430	0.2430			0.1860		0.2430	0.1754	0.1897	0.1992		0.2335
9	0.393	0.3933	0.3933	0.2279			0.2390	0.2390	0.2320	0.2320					0.2320	0.1737	0.1861	0.2030		0.2467
10	0.444	0.4441	0.4441	0.2440			0.2510	0.2510								0.1994	0.2062	0.2287		0.2586
11	0.429	0.4291	0.4291	0.2251			0.2660	0.2660								0.2425	0.2153	0.2379		0.2690
12	0.424	0.4240	0.4240	0.2358			0.2570	0.2570								0.2228	0.2061	0.2210		0.2625
13	0.443	0.4431	0.4431	0.2512			0.2830	0.2830	0.3234	0.3234					0.3234	0.3162	0.2393	0.2401		0.2787
14	0.422	0.4221	0.4221	0.2978			0.2540	0.2540	0.3310	0.3310					0.3310	0.2483	0.2534	0.2572		0.2996
15+	0.539	0.5391	0.5391	0.3422			0.3190	0.3190					0.2880			0.3513	0.3118	0.2830		0.3842

Q 1-4

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0				0.005												0.030	0.034	0.042	0.034	0.013
1									0.068	0.068					0.068	0.057	0.058	0.044	0.050	0.055
2									0.068	0.065	0.065	0.065			0.071	0.078	0.080	0.079	0.083	0.074
3				0.107					0.105	0.105	0.105	0.098			0.105	0.100	0.105	0.103	0.101	0.104
4	0.200	0.200	0.200	0.139	0.122	0.129	0.136	0.131	0.125	0.122	0.122	0.101	0.107	0.109	0.108	0.118	0.128	0.122	0.126	0.120
5	0.252	0.252	0.252	0.154	0.131	0.132	0.161	0.137	0.143	0.130	0.130	0.103	0.133	0.150	0.113	0.130	0.144	0.147	0.143	0.125
6	0.272	0.272	0.272	0.170	0.166	0.156	0.173	0.162	0.148	0.134	0.134	0.111	0.140	0.140	0.118	0.138	0.158	0.173	0.160	0.159
7	0.302	0.302	0.302	0.201	0.198	0.174	0.199	0.180	0.161	0.142	0.142	0.156	0.157	0.155	0.136	0.149	0.170	0.191	0.178	0.178
8	0.324	0.324	0.324	0.221	0.221	0.192	0.231	0.205	0.243	0.243			0.169	0.188	0.191	0.168	0.183	0.198	0.183	0.221
9	0.393	0.393	0.393	0.232	0.243	0.213	0.231	0.219	0.232	0.232		0.022	0.187	0.206	0.232	0.185	0.193	0.216	0.201	0.231
10	0.444	0.444	0.444	0.256	0.281	0.221	0.246	0.231					0.175	0.185		0.212	0.202	0.229	0.214	0.242
11	0.429	0.429	0.429	0.238	0.292	0.265	0.270	0.265					0.178	0.175		0.250	0.200	0.232	0.217	0.251
12	0.424	0.424	0.424	0.243	0.261	0.220	0.256	0.235					0.204	0.210		0.323	0.202	0.230	0.238	0.249
13	0.443	0.443	0.443	0.266	0.282	0.240	0.271	0.247	0.323	0.323			0.193	0.214	0.323	0.341	0.218	0.249	0.240	0.258
14	0.422	0.422	0.422	0.313	0.332	0.254	0.255	0.254	0.331	0.331			0.190	0.212	0.331	0.419	0.240	0.265	0.276	0.289
15+	0.539	0.539	0.539	0.361	0.381	0.322	0.320	0.321					0.263	0.265		0.424	0.257	0.299	0.313	0.371

Table 5.2.5.2 Western Horse Mackerel stock. Mean length (Cm) in catch at age by quarter and area in 2007

Q 1

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0																				
1																17.10	18.78	15.37		15.93
2									18.82	18.82		18.82				20.15	20.93	21.12		20.13
3									22.46	22.46		22.47			23.50	22.55	22.41	22.33		22.55
4				25.50	25.50	25.66	25.54	25.66	23.89	23.89		23.65	24.50	24.50	23.80	23.92	23.72	23.16		23.80
5				26.03	26.03	26.01	26.32	26.01	24.67	24.67		24.21	27.12	27.08	24.50	24.94	25.69	26.05		24.45
6				27.88	27.88	27.90	27.57	27.90	25.33	25.33		24.83	26.63	26.54	24.80	25.73	26.49	26.65		26.15
7				29.41	29.41	28.87	28.50	28.87	26.12	26.12		26.93	27.27	27.39	25.80	26.55	27.65	30.14		27.55
8				30.32	30.32	28.85	29.24	28.85					29.16	29.24	26.50	27.53	28.27	29.48		29.27
9				31.21	31.21	29.99	29.87	29.99				30.50	30.06	30.64		28.26	29.41	30.68		30.20
10				32.63	32.63	30.41	30.03	30.41					28.61	28.92		28.24	29.63	30.78		30.35
11				32.95	32.95	31.91	33.07	31.91					29.46	28.89		28.00	28.98	30.07		30.83
12				31.79	31.79	30.33	30.44	30.33					30.52	30.66		29.62	29.75	31.09		30.90
13				32.50	32.50	30.92	31.03	30.92					30.05	30.60		29.05	30.08	31.18		30.91
14				34.24	34.24	31.66	32.22	31.66					30.14	30.73		31.83	31.24	31.71		31.89
15+				35.67	35.67	33.80	33.70	33.80					30.56	32.50		31.14	30.80	31.66		33.50

Q 2

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0																				
1																17.10	19.26	18.86	18.41	18.82
2									18.82	18.82						19.18	21.92	21.29	21.57	20.67
3									22.46	22.46		22.50			23.50	22.48	23.36	22.74	22.92	22.69
4							25.66	25.66	23.89	23.89		23.60			23.80	23.89	24.72	23.78	24.15	23.92
5				27.50			26.01	26.01	24.67	24.67		24.20	25.64		24.50	24.72	25.93	25.37	25.50	24.90
6				29.50			27.90	27.90	25.33	25.33		24.80	26.33		24.80	25.36	26.60	26.45	26.40	26.00
7				31.63			28.87	28.87	26.12	26.12		27.10	26.86		25.80	26.21	27.66	28.54	27.73	27.39
8				33.50			28.85	28.85					26.50		26.50	27.53	28.23	28.70	28.15	28.51
9				34.44			29.99	29.99				30.50	28.50			28.26	29.06	30.26	29.19	29.64
10				34.25			30.41	30.41								28.24	29.30	30.62	29.39	30.42
11				34.10			31.91	31.91								28.00	28.88	29.86	28.91	29.33
12				33.12			30.33	30.33								29.62	29.34	30.89	29.95	30.53
13				36.15			30.92	30.92								29.05	29.76	31.09	29.97	30.73
14				37.07			31.66	31.66								31.83	31.10	31.78	31.57	32.33
15+				37.91			33.80	33.80								31.14	30.62	31.54	31.10	34.70

Q 3

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0				8.56												13.88	16.14	16.90	15.64	15.69
1																16.10	17.19	18.09	17.13	18.03
2									18.82	18.82	18.82				18.82	18.62	22.57	20.92	20.70	19.42
3				23.53					22.46	22.46	22.46	22.50			22.46	22.70	24.39	23.85	23.65	22.80
4	27.00	27.00	0.00	25.71					23.89	23.89	23.89	23.60			23.89	28.90	25.50	24.75	26.38	24.24
5	29.30	29.30	0.00	27.12			27.35		24.67	24.67	24.67	24.20	25.00		24.67	29.78	26.31	25.86	27.32	26.13
6	30.00	30.00	0.00	28.44			27.95		25.33	25.33	25.33	24.80	26.83		25.33	31.81	27.30	27.68	28.93	26.27
7	31.20	31.20	0.00	30.22			28.50		26.12	26.12	26.12	27.10	27.83		26.12	31.11	27.78	28.55	29.15	27.33
8	32.00	32.00	0.00	31.55									28.50			29.98	28.68	29.38	29.34	29.12
9	33.70	33.70	0.00	32.28								30.50				32.44	28.52	29.66	30.21	29.55
10	34.70	34.70	0.00	32.35												34.60	29.22	30.88	31.57	30.46
11	34.60	34.60	0.00	32.00												36.12	29.66	31.45	32.41	31.16
12	34.20	34.20	0.00	31.62												37.71	29.09	31.20	32.67	30.78
13	35.40	35.40	0.00	33.20												38.09	30.41	33.21	33.90	33.21
14	34.60	34.60	0.00	34.48												38.72	30.65	34.30	34.55	34.25
15+	37.70	37.70	0.00	35.29									34.50			38.39	32.38	36.04	35.61	36.41

Q 4

Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIcØ C	VIIIc west	VIIId	Total
0				8.56												17.40	15.42			9.08
1									20.25	20.25					20.25	19.09	19.13	20.44		19.78
2									20.19	20.70					20.70	21.21	21.34	22.29		20.87
3				23.53					23.01	23.32					23.32	22.61	23.60	25.98		23.07
4	27.00	27.00	27.00	25.71			25.86	25.86	24.70	24.79					24.79	24.32	25.15	27.18		24.94
5	29.30	29.30	29.30	26.82			27.08	27.08	25.62	25.91			25.00		25.91	25.98	26.21	27.56		25.86
6	30.00	30.00	30.00	27.53			27.86	27.86	26.24	26.11			26.83		26.11	27.30	27.30	28.39		27.55
7	31.20	31.20	31.20	29.18			29.45	29.45	27.09	27.09			27.83		27.09	27.28	27.78	28.88		28.48
8	32.00	32.00	32.00	30.14			30.70	30.70	29.93	29.93			28.50		29.93	27.97	28.80	29.29		30.24
9	33.70	33.70	33.70	30.49			30.71	30.71	30.00	30.00					30.00	27.89	28.60	29.44		30.73
10	34.70	34.70	34.70	31.29			31.05	31.05	0.00	0.00						29.08	29.53	30.66		31.25
11	34.60	34.60	34.60	30.19			31.80	31.80	0.00	0.00						31.10	29.98	31.09		31.57
12	34.20	34.20	34.20	30.83			31.37	31.37	0.00	0.00						30.17	29.54	30.27		31.20
13	35.40	35.40	35.40	31.23			32.38	32.38	32.60	32.60					32.60	34.31	31.06	31.18		31.95
14	34.60	34.60	34.60	33.23			31.14	31.14	33.50	33.50					33.50	31.35	31.58	31.92		32.66
15+	37.70	37.70	37.70	34.88			33.48	33.48	0.00	0.00			34.50			35.59	34.05	33.01		35.15

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Ages	IIIa	IVa	Vb	VIa	VIb	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0				8.56												14.81	15.64	16.90	15.64	10.55
1									20.25	20.25					20.25	18.78	18.91	16.95	17.93	18.44
2									19.42	18.82	18.82	18.82			19.86	20.88	21.21	21.13	21.47	20.37
3				23.53					22.74	22.46	22.46	22.47			23.07	22.56	23.37	23.23	23.03	22.84
4	27.00	27.00	27.00	25.70	25.50	25.66	25.85	25.73	24.38	23.89	23.89	23.65	24.50	24.50	23.92	23.94	25.03	24.62	24.87	24.33
5	29.30	29.30	29.30	26.77	26.03	26.01	27.24	26.22	25.46	24.67	24.67	24.21	25.35	27.08	24.55	24.90	26.12	26.24	26.02	25.04
6	30.00	30.00	30.00	27.58	27.88	27.90	27.84	27.89	25.87	25.33	25.33	24.83	26.61	26.54	24.91	25.62	26.98	27.83	27.02	27.08
7	31.20	31.20	31.20	29.30	29.41	28.87	29.15	28.98	26.87	26.12	26.12	26.93	27.55	27.39	26.01	26.51	27.72	28.81	28.08	28.09
8	32.00	32.00	32.00	30.30	30.32	28.85	30.39	29.34	29.93	29.93			28.42	29.24	28.22	27.58	28.45	29.20	28.42	29.88
9	33.70	33.70	33.70	30.69	31.21	29.99	30.48	30.15	30.00	30.00		30.50	29.73	30.64	30.00	28.49	28.97	30.09	29.33	30.45
10	34.70	34.70	34.70	31.81	32.63	30.41	30.94	30.62	0.00	0.00			28.61	28.92		29.64	29.38	30.70	29.87	30.87
11	34.60	34.60	34.60	30.74	32.95	31.91	31.98	31.88	0.00	0.00			29.46	28.89		31.12	29.27	30.83	29.92	31.12
12	34.20	34.20	34.20	31.19	31.79	30.33	31.34	30.76	0.00	0.00			30.52	30.66		34.13	29.37	30.68	30.85	31.00
13	35.40	35.40	35.40	31.84	32.50	30.92	31.91	31.13	32.60	32.60			30.05	30.60	32.60	34.79	30.09	31.48	30.94	31.53
14	34.60	34.60	34.60	33.78	34.24	31.66	31.18	31.47	33.50	33.50			30.14	30.73	33.50	37.75	31.13	32.21	32.55	32.58
15+	37.70	37.70	37.70	35.49	35.67	33.80	33.50	33.68	0.00	0.00			33.23	32.50		38.08	31.84	33.49	33.95	35.01

Table 5.2.5.3 Western horse mackerel: stock weights-at-age.

age												
year	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
2007	0.000	0.000	0.085	0.098	0.100	0.118	0.128	0.137	0.157	0.180	0.173	0.181

Table 5.2.6.1. Western horse mackerel. Maturity-at-age.

Age												
year	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
2007	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 5.4.3.1 Western horse mackerel. A summary of the main features of the SAD model used for the assessment of western horse mackerel.

Model	SAD
Version	2008 Working Group (WGWIDE)
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 5 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 (79−, 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. Fecundity data are potential fecundity vs. fish weight data for the years 1987, 1992, 1995, 1998, 2000 and 2001, and a realised fecundity data point with associated CV for 1989. The realised fecundity value and associated CV (used as input data) are derived from a normal distribution in log-space, which covers (with a 95% probability) the range of realised fecundity values reported by Abaunza et al (2003).
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 11−0 and the final four years for which catch data are available. Selectivity at age 8 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 79− (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 11−0 (except for selectivity at age 8 which is set to 1); (3) scaling parameter for fishing mortality at age 10 relative to the average for ages 79− (ignoring the 1982 year-class where applicable); (4) fishing mortality on the 1982 year-class at age 10 in 1992; (5) realised fecundity parameter, relating realised fecundity to potential fecundity, and therefore also relating estimated SSB to the egg production estimates; (6) potential fecundity parameters (intercept and slope), relating potential fecundity to fish weight.
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 five components to the likelihood, corresponding to egg estimates, catches for the separable period, catches for the plus-group, potential fecundity vs. fish weight, and realised fecundity. The variance of each component is estimated, apart from that associated with realised fecundity for which a CV is input.
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.

Table 5.6.1.1 Western horse mackerel. Final assessment. Numbers-at-age (thousands).

	0	1	2	3	4	5	6	7	8	9	10	11+
1982	76278800	743982	1845940	3360430	484835	437522	348789	258580	40106.2	43289.4	47360.2	2334590
1983	509536	65653800	636907	1569260	2767340	406618	364336	289313	214353	32988.1	36875.4	1973240
1984	1478820	438562	56501400	546086	1320160	2332230	335743	272266	200147	167868	25339.9	1452590
1985	2733810	1272830	377474	48407300	465902	1102600	1868390	268242	198861	140706	130795	1050900
1986	3964450	2353010	1094020	320348	41105100	396865	910214	1515020	219148	156158	115355	939925
1987	5342580	3412240	2025260	941633	274290	34752200	333488	722988	1202170	164768	114757	779051
1988	2184090	4598400	2936850	1742700	810471	233347	29084200	285124	583721	950466	130925	700453
1989	2324820	1879050	3932490	2522100	1498010	693495	183246	24159300	234169	465384	755109	658313
1990	2181230	2001000	1617310	3384730	2151520	1272390	591972	144269	19609700	190376	345492	1072550
1991	4298570	1877410	1703340	1350250	2784370	1794830	1064260	499728	105055	15593400	129521	953102
1992	8391150	3680670	1584760	1382850	1140800	2203790	1412090	847615	406584	66686.6	12289900	746498
1993	12713400	7208520	2954880	1330310	1115500	929691	1659240	1097530	684071	332274	35643	10137000
1994	14456100	10942500	6103160	2455620	1129480	901933	712325	1133710	810492	523178	255660	7482560
1995	7250710	12439000	9361940	4407210	2006200	922861	734839	577136	769864	598781	412452	5476490
1996	3867840	6238240	10553000	7621390	3399430	1526850	739544	548213	463668	435117	404866	3756870
1997	3435840	3319130	5350960	8471880	5761010	2753070	1234850	588878	420613	349561	321506	3040440
1998	4735080	2952750	2754610	4173890	6609070	4577580	2142920	952383	388418	237254	198853	1841530
1999	5042250	4074830	2456560	2199800	3139140	5354390	3736180	1698400	705998	258705	140875	1277280
2000	4466390	4326160	3416730	2036710	1729250	2455270	4372440	3018870	1288110	470976	150592	889429
2001	24929200	3843670	3650400	2819170	1704110	1421790	1973310	3605310	2433230	985028	348244	780066
2002	6961040	21402300	3243860	2913220	2285730	1375400	1129720	1589940	2885260	1905210	751366	862966
2003	4056380	5978710	17993400	2680590	2354370	1850150	1124030	907579	1280870	2362490	1560670	1298340
2004	2205560	3489650	4900260	14847900	2187240	1927220	1497530	910093	736531	1043180	1941720	2375060
2005	2105880	1878630	2883440	4071940	12222800	1805350	1575870	1224850	745800	605367	863958	3607180
2006	1495290	1811380	1539150	2378560	3321070	10001100	1460550	1275310	993528	607129	497362	3713230
2007		1285240	1510910	1289420	1978310	2767910	8275390	1208770	1057020	825355	507322	3542610
2008			1071740	1265460	1072120	1648320	2289470	6846410	1001530	877816	689488	3406730

Table 5.6.1.2 Western horse mackerel. Final assessment. Fishing mortality-at-age.

	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.000	0.005	0.012	0.044	0.026	0.033	0.037	0.038	0.045	0.010	0.038	0.038
1983	0.000	0.000	0.004	0.023	0.021	0.042	0.141	0.218	0.094	0.114	0.175	0.175
1984	0.000	0.000	0.005	0.009	0.030	0.072	0.074	0.164	0.202	0.100	0.191	0.191
1985	0.000	0.001	0.014	0.014	0.010	0.042	0.060	0.052	0.092	0.049	0.079	0.079
1986	0.000	0.000	0.000	0.005	0.018	0.024	0.080	0.081	0.135	0.158	0.153	0.153
1987	0.000	0.000	0.000	0.000	0.012	0.028	0.007	0.064	0.085	0.080	0.094	0.094
1988	0.000	0.006	0.002	0.001	0.006	0.092	0.036	0.047	0.077	0.080	0.083	0.083
1989	0.000	0.000	0.000	0.009	0.013	0.008	0.089	0.059	0.057	0.148	0.126	0.126
1990	0.000	0.011	0.030	0.045	0.031	0.029	0.019	0.167	0.079	0.235	0.247	0.247
1991	0.005	0.019	0.058	0.019	0.084	0.090	0.078	0.056	0.304	0.088	0.222	0.222
1992	0.002	0.070	0.025	0.065	0.055	0.134	0.102	0.064	0.052	0.476	0.102	0.102
1993	0.000	0.016	0.035	0.014	0.063	0.116	0.231	0.153	0.118	0.112	0.157	0.157
1994	0.000	0.006	0.176	0.052	0.052	0.055	0.060	0.237	0.153	0.088	0.196	0.196
1995	0.000	0.014	0.056	0.110	0.123	0.071	0.143	0.069	0.421	0.241	0.299	0.299
1996	0.003	0.003	0.070	0.130	0.061	0.062	0.078	0.115	0.132	0.153	0.164	0.164
1997	0.002	0.036	0.098	0.098	0.080	0.101	0.110	0.266	0.423	0.414	0.452	0.452
1998	0.000	0.034	0.075	0.135	0.061	0.053	0.082	0.149	0.256	0.371	0.318	0.318
1999	0.003	0.026	0.037	0.091	0.096	0.053	0.063	0.127	0.255	0.391	0.317	0.317
2000	0.000	0.020	0.042	0.028	0.046	0.069	0.043	0.066	0.118	0.152	0.138	0.138
2001	0.003	0.020	0.076	0.060	0.064	0.080	0.066	0.073	0.095	0.121	0.118	0.118
2002	0.002	0.023	0.041	0.063	0.061	0.052	0.069	0.066	0.050	0.049	0.068	0.068
2003	0.000	0.049	0.042	0.053	0.050	0.061	0.061	0.059	0.055	0.046	0.035	0.035
2004	0.010	0.041	0.035	0.045	0.042	0.051	0.051	0.049	0.046	0.039	0.030	0.030
2005	0.001	0.049	0.042	0.054	0.051	0.062	0.062	0.059	0.056	0.047	0.036	0.036
2006	0.001	0.031	0.027	0.034	0.032	0.039	0.039	0.038	0.035	0.030	0.023	0.023
2007	0.000	0.032	0.027	0.035	0.032	0.040	0.040	0.038	0.036	0.030	0.023	0.023

Table 5.6.1.3 Western horse mackerel. Final assessment. Stock summary table.

	R (age 0) (thousands)	SSB (tons)	TSB (tons)	Catch (tons)	Yield/SSB	F (1-3)	F(4-8)
1982	76278800	1364480	1593390	61197	0.045	0.021	0.036
1983	509536	1364440	1590339	90442	0.066	0.009	0.103
1984	1478820	1299180	4035264	96744	0.074	0.004	0.109
1985	2733810	2430260	5029757	103843	0.043	0.010	0.051
1986	3964450	3258150	5349109	145999	0.045	0.002	0.068
1987	5342580	3969620	5340955	187338	0.047	0.000	0.039
1988	2184090	4560190	5225798	214729	0.047	0.003	0.051
1989	2324820	4229050	5031398	296037	0.070	0.003	0.045
1990	2181230	3583190	4357430	398645	0.111	0.029	0.065
1991	4298570	3461020	4195757	357288	0.103	0.032	0.122
1992	8391150	2880620	3469039	394793	0.137	0.053	0.081
1993	12713400	2736460	3410749	458628	0.168	0.022	0.136
1994	14456100	2312160	3137872	413022	0.179	0.078	0.111
1995	7250710	1830360	2900088	538131	0.294	0.060	0.165
1996	3867840	1840050	3194789	420942	0.229	0.068	0.090
1997	3435840	1833660	3165087	471700	0.257	0.078	0.196
1998	4735080	1891560	2803888	326449	0.173	0.081	0.120
1999	5042250	2096010	2813464	298076	0.142	0.051	0.119
2000	4466390	2177340	2777445	196911	0.090	0.030	0.068
2001	24929200	1606430	2235416	212090	0.132	0.052	0.076
2002	6961040	1973240	2650676	194292	0.098	0.042	0.060
2003	4056380	1925490	3294777	190183	0.099	0.048	0.057
2004	2205560	2120120	3787250	154929	0.073	0.040	0.048
2005	2105880	2822210	4024385	181994	0.064	0.049	0.058
2006	1495290	2798210	3488403	155094	0.055	0.031	0.037
2007		2540620	3049317	123408	0.049	0.031	0.037
2008		2380280					

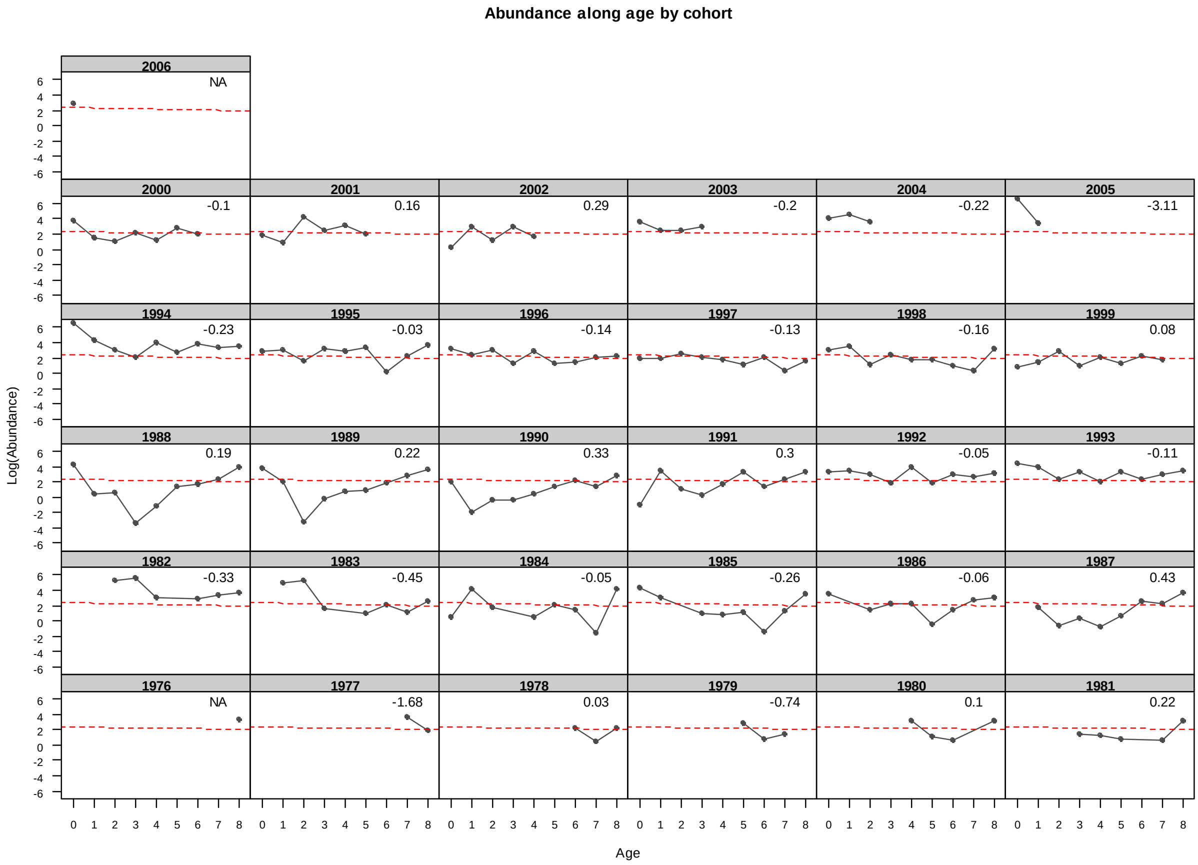

Figure 5.2.2.2.1 Western horse mackerel. Bottom trawl Spanish survey. Log catch curves by cohort with an estimate of the slope

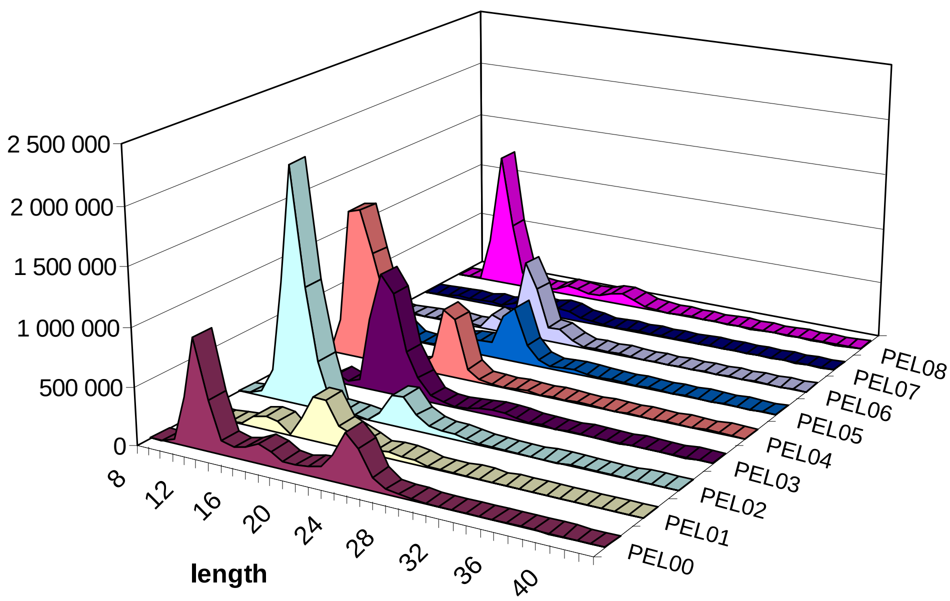

Figure 5.2.2.2.2 –Western horse mackerel. Length composition of Horse mackerel as estimated by acoustics during PELGAS surveys between 2000 and 2008.

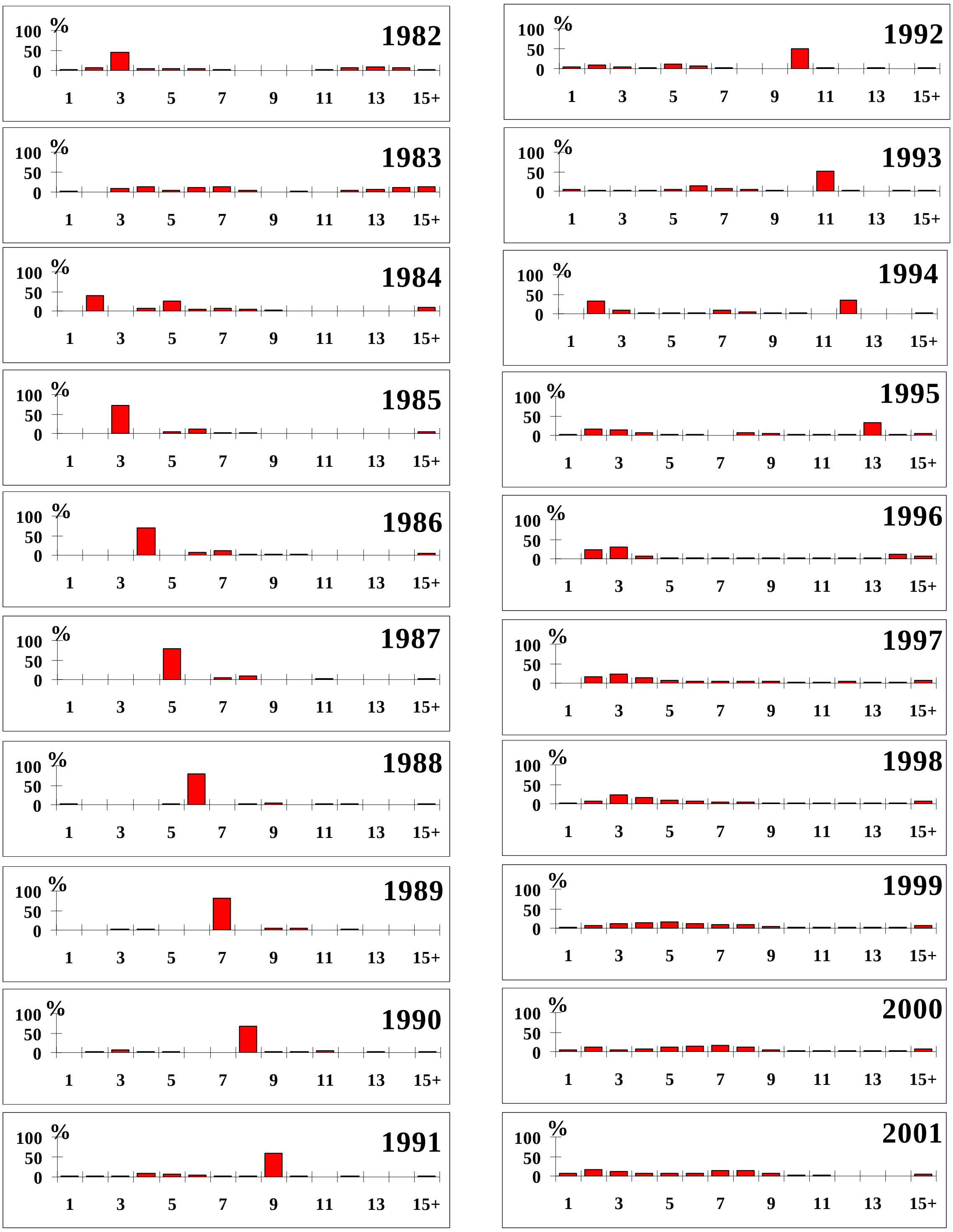

Figure 5.2.4.1a WESTERN HORSE MACKEREL. Age composition in the international catches during 1982-2001.

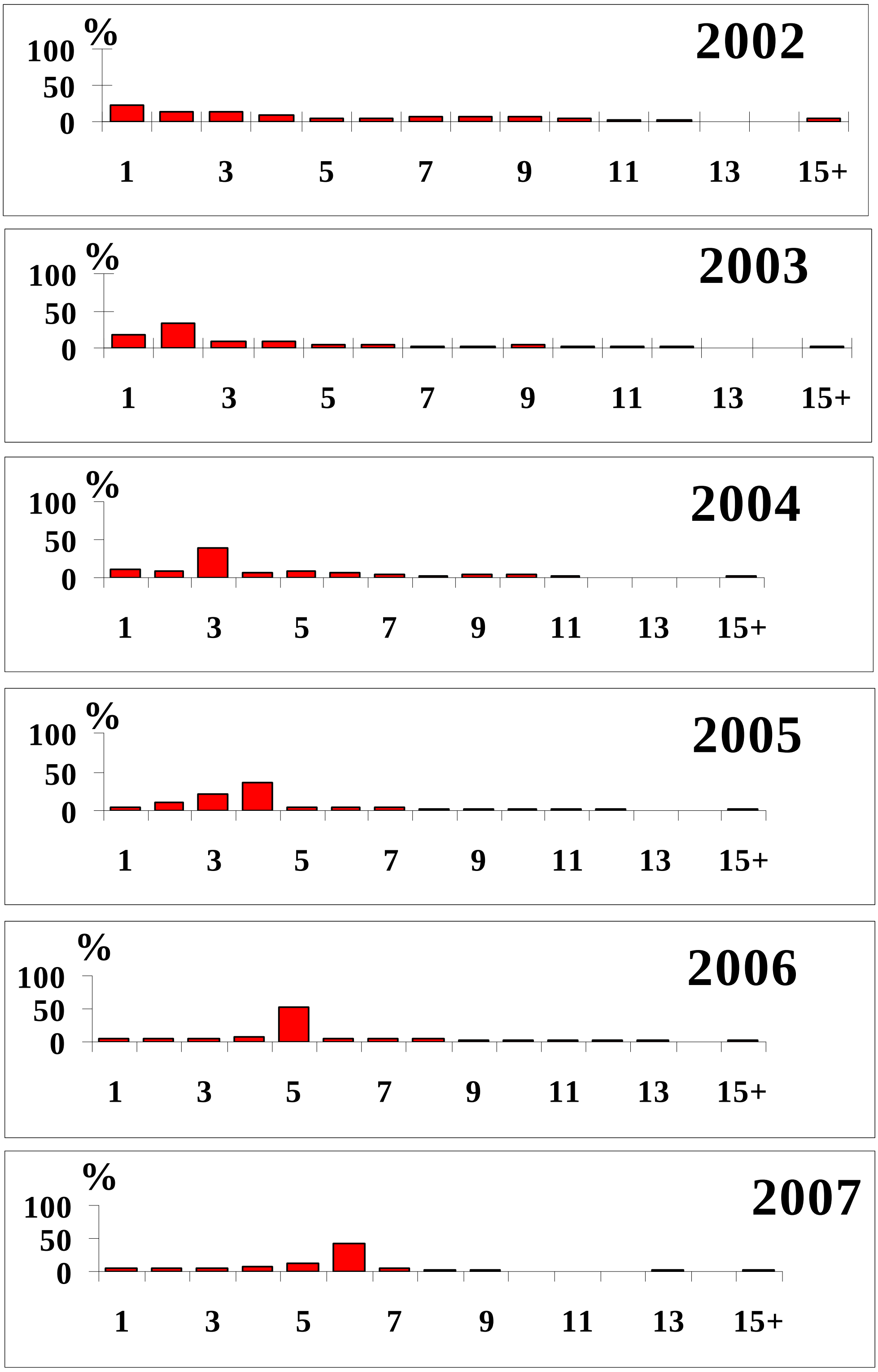

Figure 5.2.4.1 b WESTERN HORSE MACKEREL. Age composition in the international catches during 2002-2007

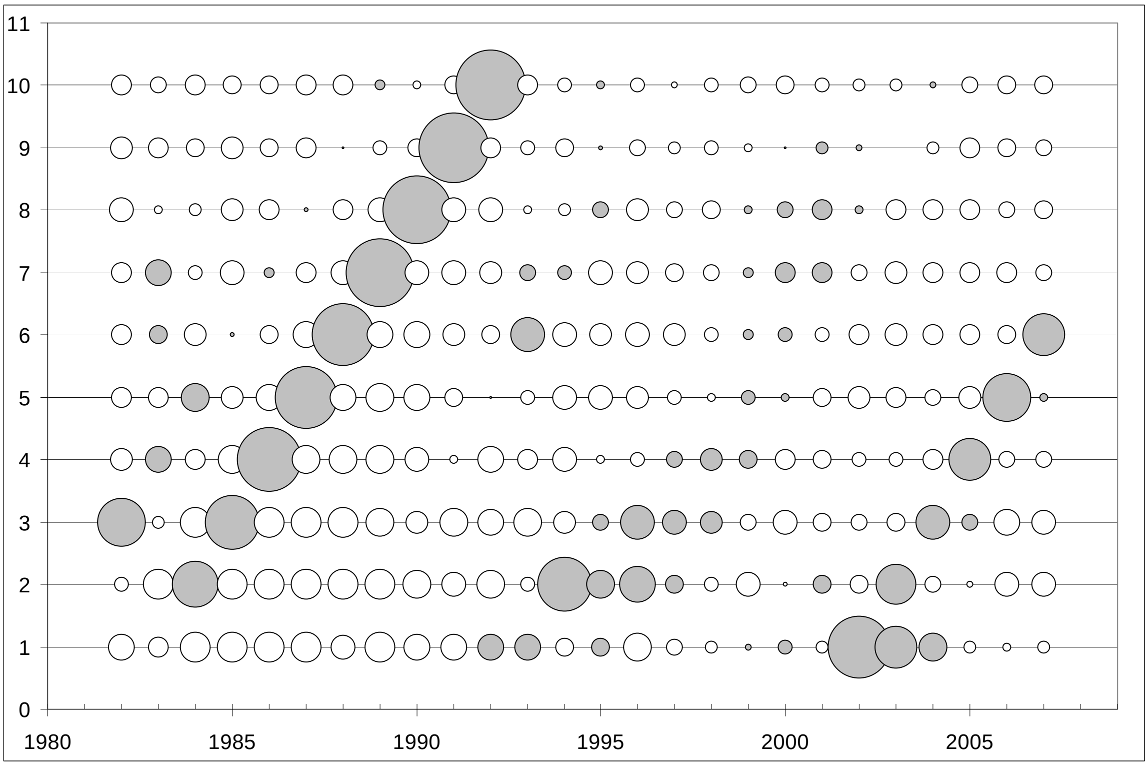

Figure 5.4.1.1. Western horse mackerel. Date exploration. Catch-at-age matrix, expressed as proportions-at-age, and then standardised for each age by subtracting the mean and dividing by the standard deviation over the time series for that age.

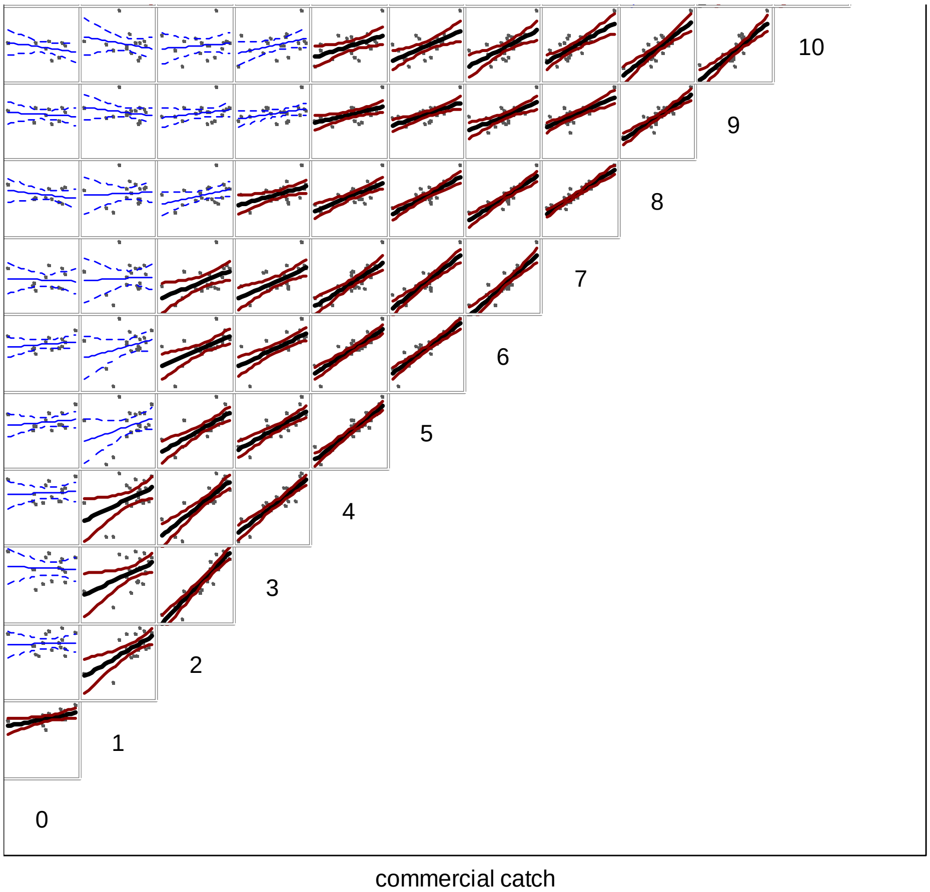

Figure 5.4.1.2. Western horse mackerel. Data exploration. Within-cohort consistency in the catch-at-age matrix, shown by plotting the log-catch of a cohort at a particular age against the log-catch of the same cohort at subsequent ages. Thick lines represent a significant (p<0.05) regression and the curved lines are approximate 95% confidence intervals.

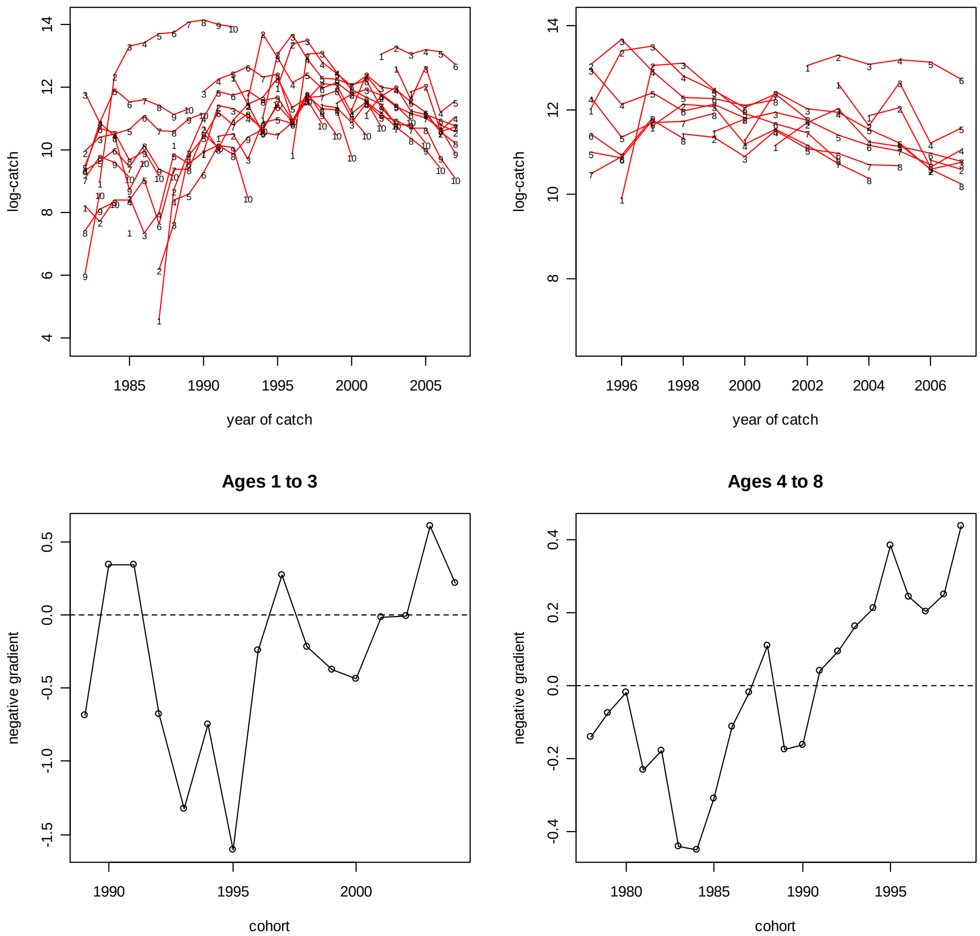

Figure 5.4.1.3. Western horse mackerel. Data exploration. Log-catch cohort curves (top row, shown the full time series on the left, and the most recent period on the right) and the associated negative gradients for each cohort across the reference fishing mortality of ages 13– (bottom left) and 48– (bottom right).

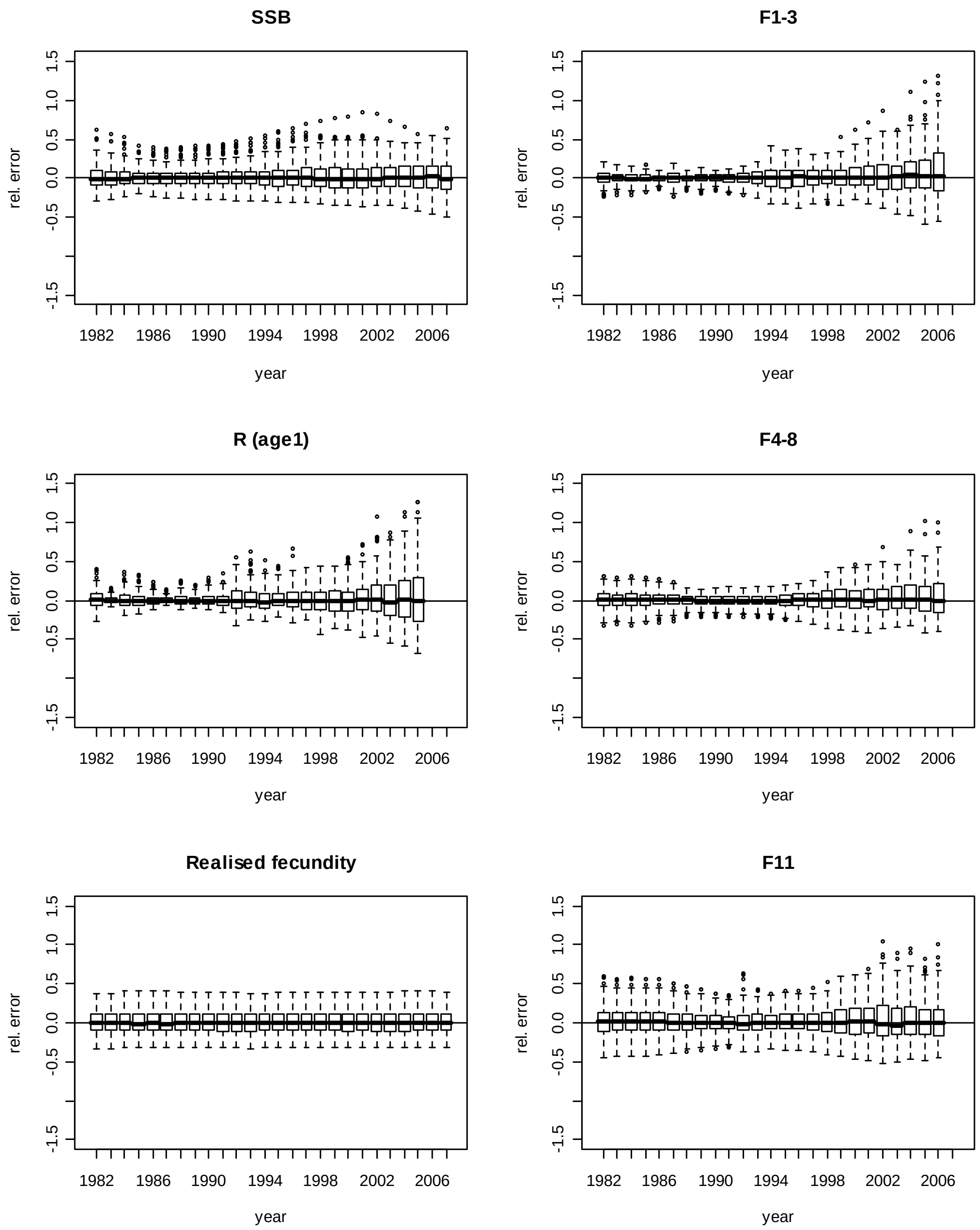

Figure 5.4.2.1. Western horse mackerel. Simulation testing of SAD08. Pseudo data generated by SAD08 based on fits to actual data up to 2006 (but including the 2007 egg production estimate). The pseudo-data are subsequently fitted with SAD08. Plots show relative error for the quantities indicated, which is calculated as $(\hat{x}-x)/x$ (with "^" indicating model estimates, and without "^" indicating the "true" values from which the pseudo data are generated).

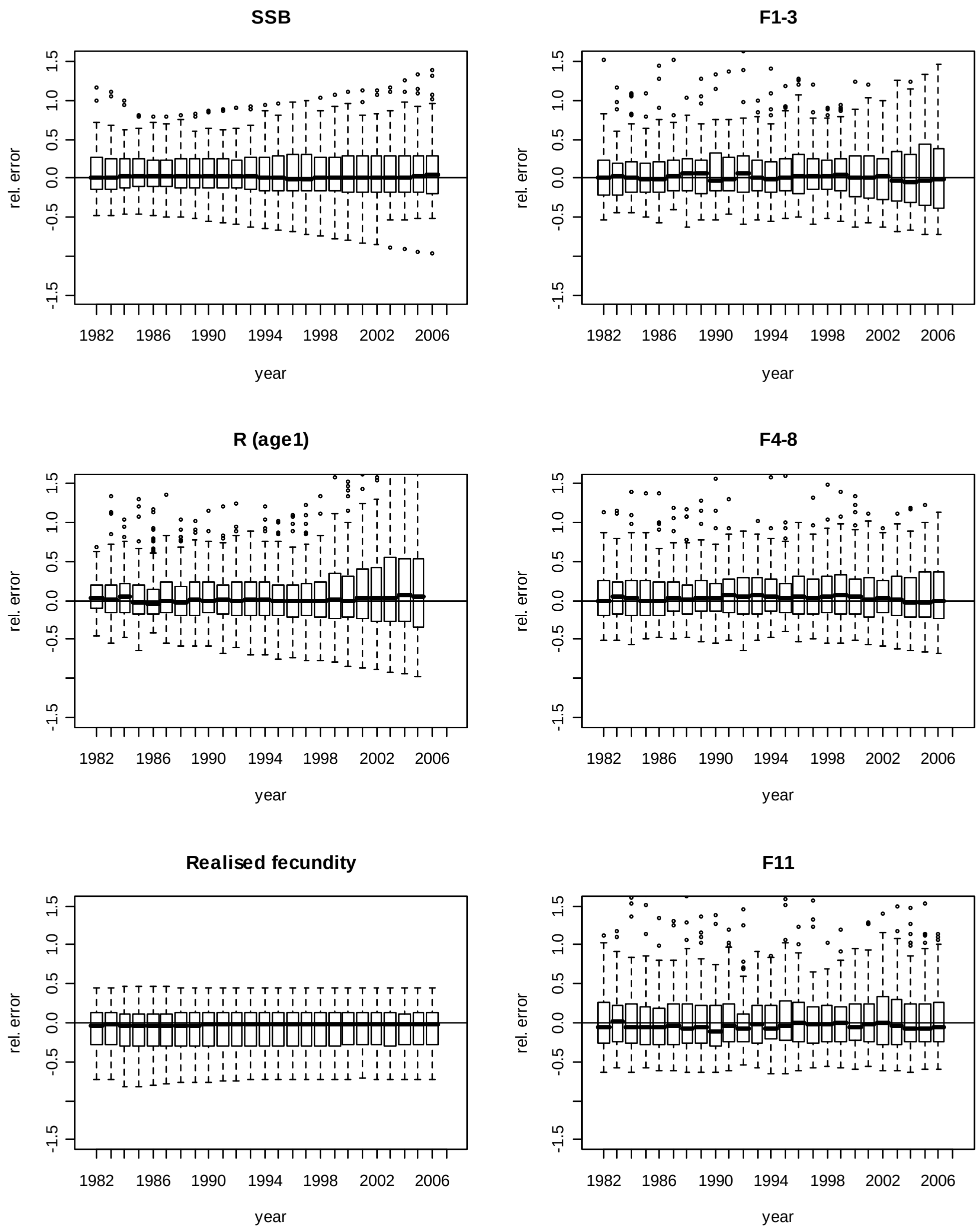

Figure 5.4.2.2. Western horse mackerel. Simulation testing of SAD08. Pseudo data generated by an operating model with low F (=0.05). The pseudo-data are subsequently fitted with SAD08. Plots show relative error for the quantities indicated, which is calculated as $(\hat{x}-x)/x$ (with "^" indicating model estimates, and without "^" indicating the "true" values).

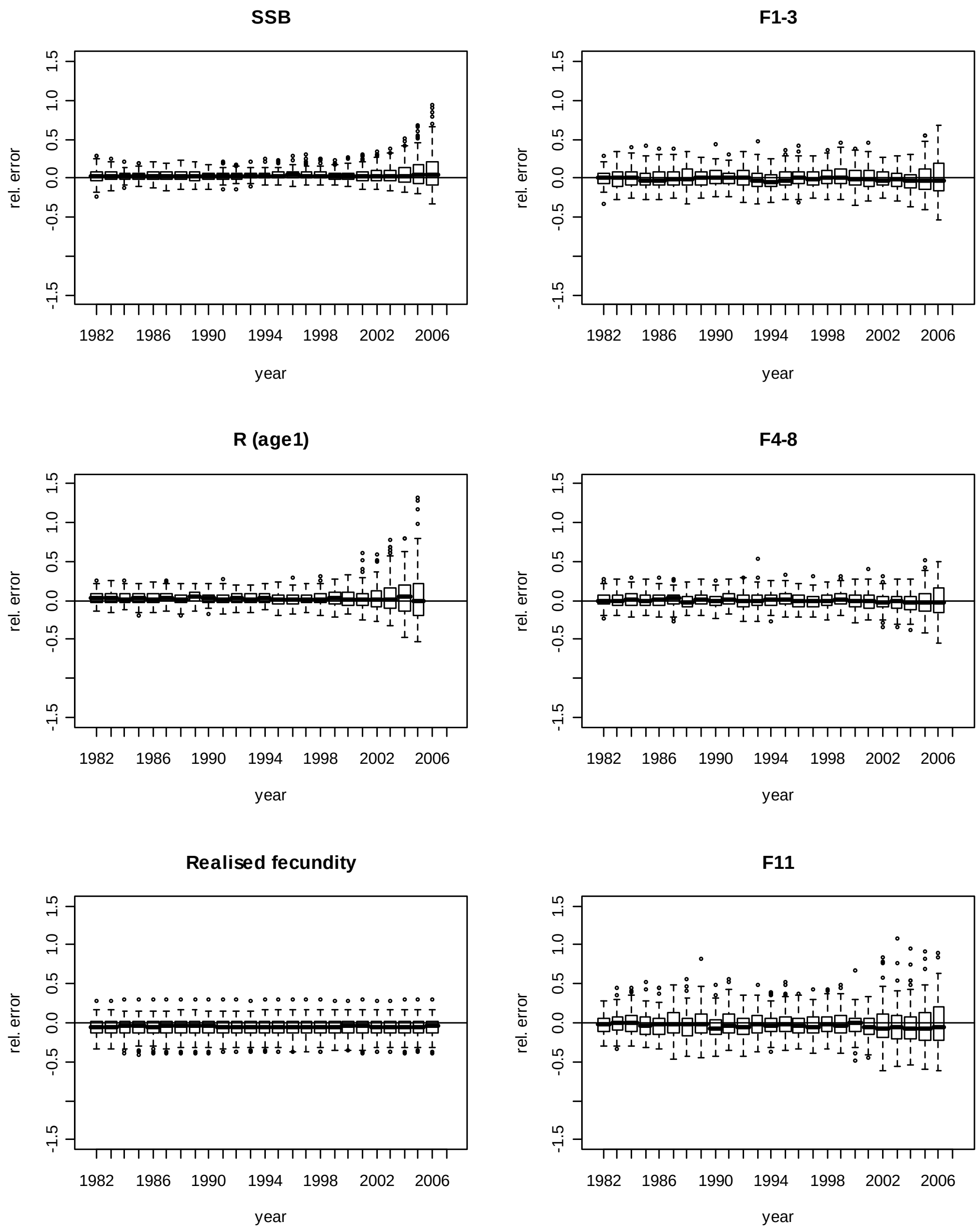

Figure 5.4.2.3. Western horse mackerel. Simulation testing of SAD08. Pseudo data generated by an operating model with high F (=0.05). The pseudo-data are subsequently fitted with SAD08. Plots show relative error for the quantities indicated, which is calculated as $(\hat{x}-x)/x$ (with "^" indicating model estimates, and without "^" indicating the "true" values).

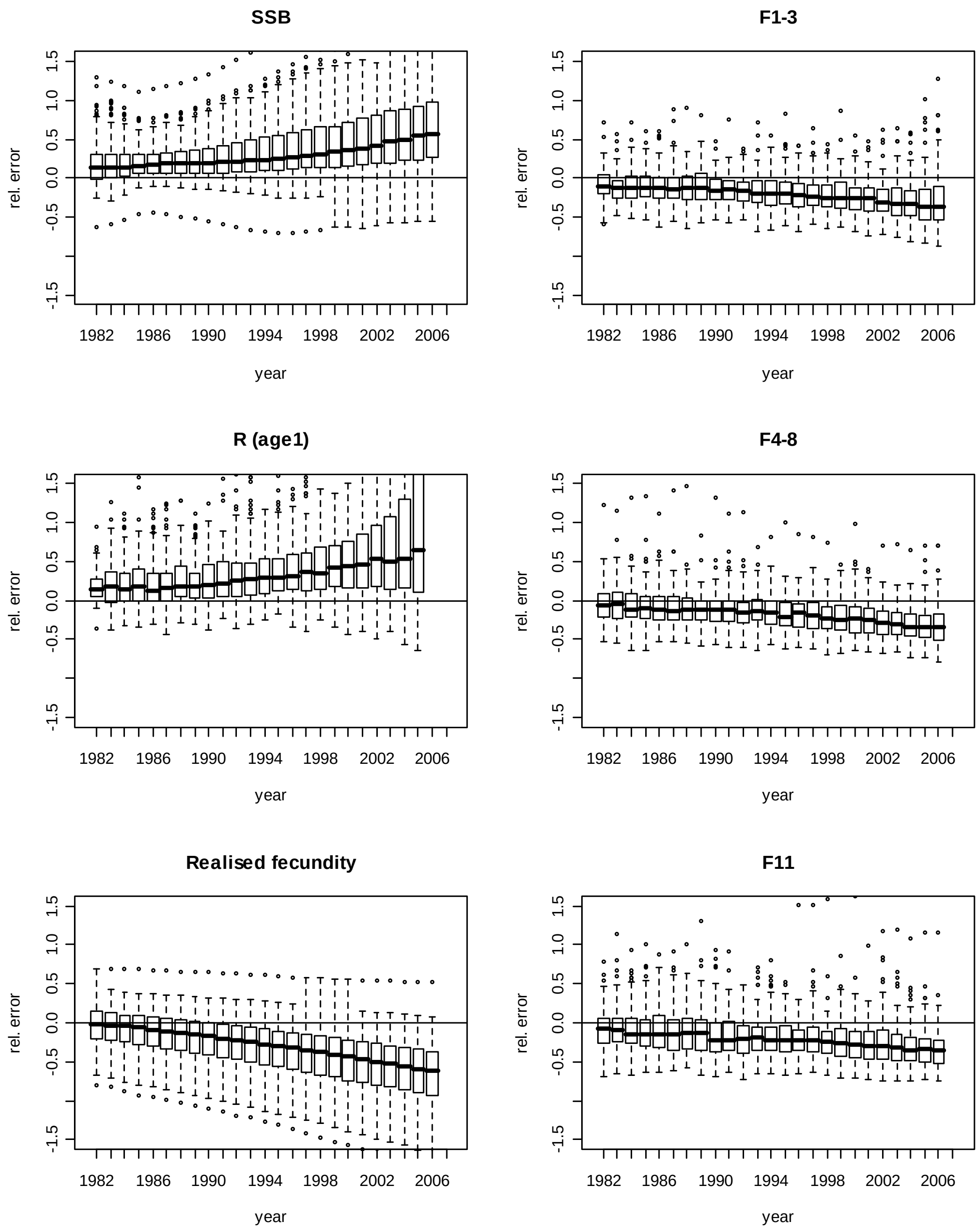

Figure 5.4.2.4. Western horse mackerel. Simulation testing of SAD08. Pseudo data generated by an operating model with a trend in realised fecundity, with the realised fecundity parameter increasing by 2% per year (F=0.1). The pseudo-data are subsequently fitted with SAD08. Plots show relative error for the quantities indicated, which is calculated as $(\hat{x}-x)/x$ (with "^" indicating model estimates, and without "^" indicating the "true" values).

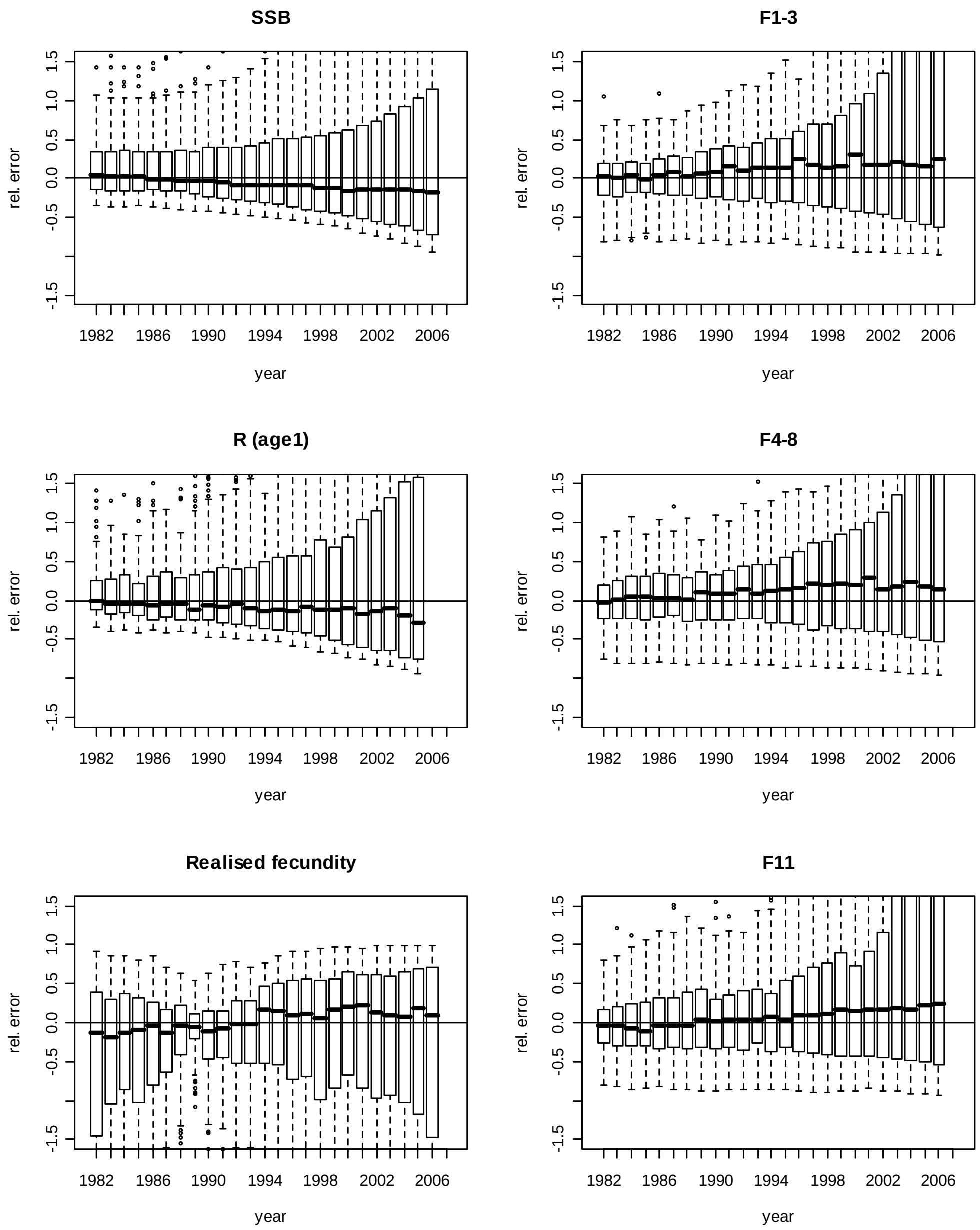

Figure 5.4.2.5. Western horse mackerel. Simulation testing of SAD08. Pseudo data generated by an operating model with the realised fecundity parameter varying randomly each year (CV=0.3). The pseudo-data are subsequently fitted with SAD08. Plots show relative error for the quantities indicated, which is calculated as $(\hat{x}-x)/x$ (with "^" indicating model estimates, and without "^" indicating the "true" values).

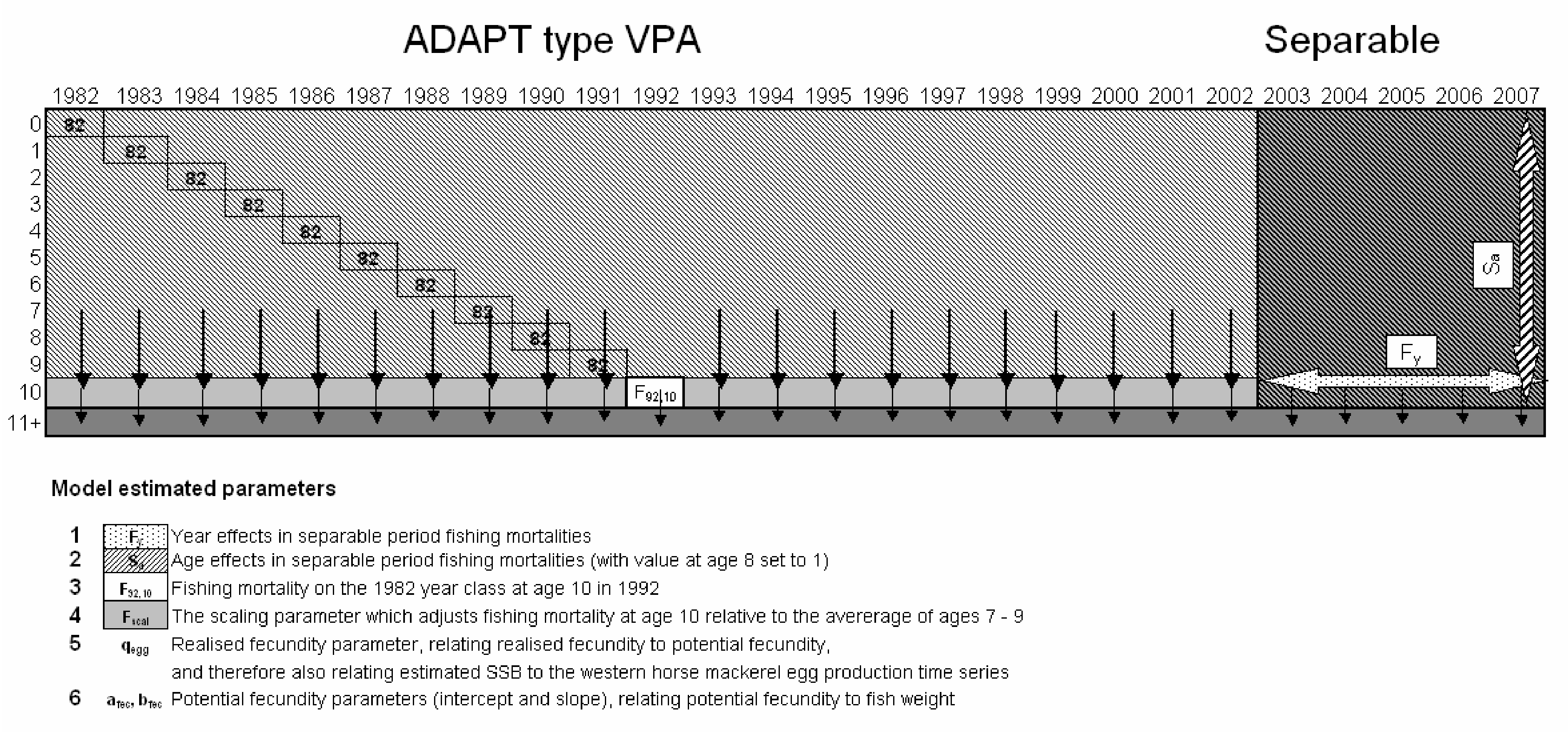

Figure 5.4.3.1 Western Horse Mackerel. An illustration of the SAD model structure used for the assessment of the Western horse mackerel stock and the "free" parameters estimated by maximum likelihood.

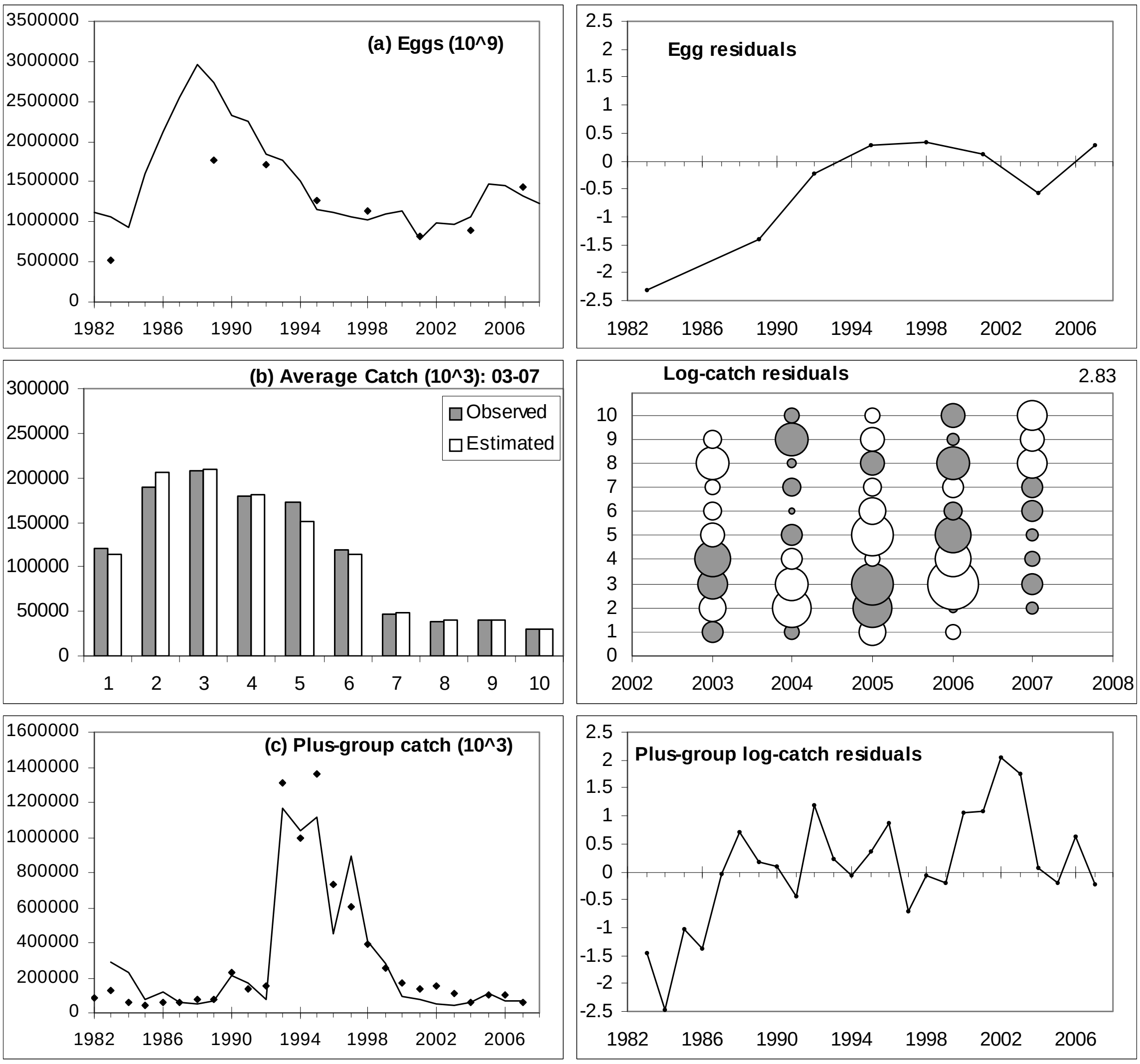

Figure 5.4.3.2. Western horse mackerel. SPALY run. Model fits to data for the three components of the likelihood, corresponding to (a) the egg estimates, (b) the catches in the separable period, and (c) to the catches in the plus-group. The left-hand column shows the actual fit to the data (average catches 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 maximum absolute size given in the top right of the plot.

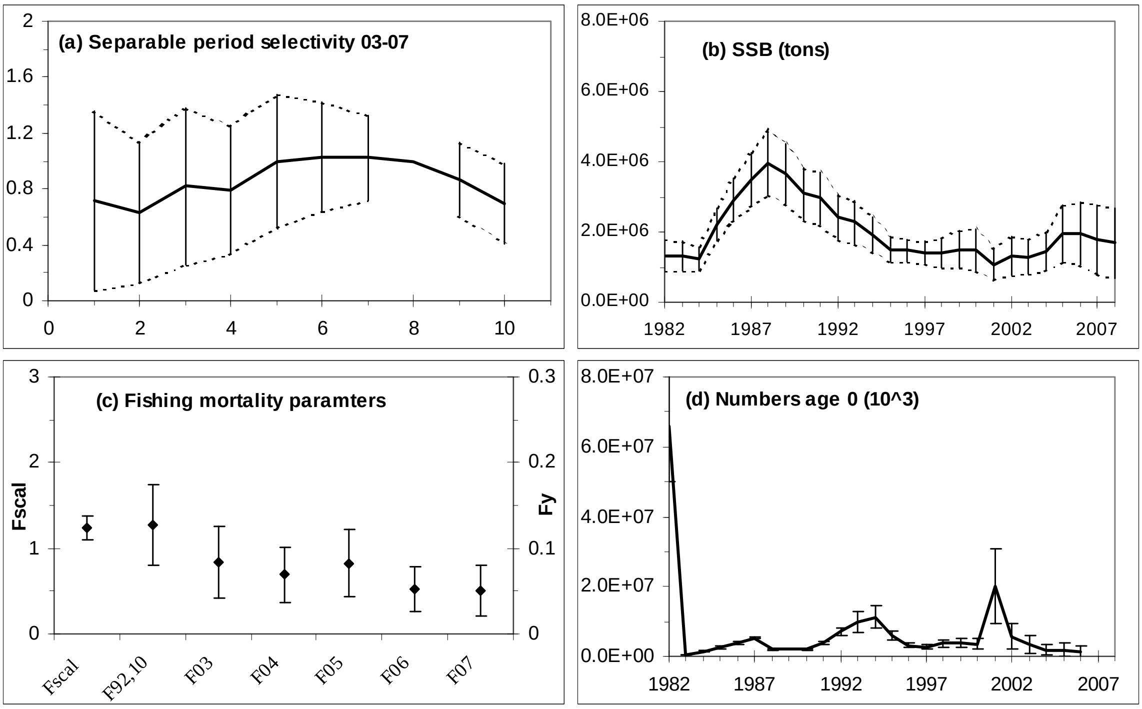

Figure 5.4.3.3. Western horse mackerel. SPALY run. Plots of (a) the selectivity pattern, (b) the SSB trajectory, (c) fishing mortality parameters (the scaling parameter F_{scal}, fishing mortality at age 10 in 1992, $F_{92,10}$, and the fishing mortality year effects for the separable period, F_y), and (d) numbers at age 0. The error bars are 2 standard deviations (indicating roughly 95% confidence bounds).

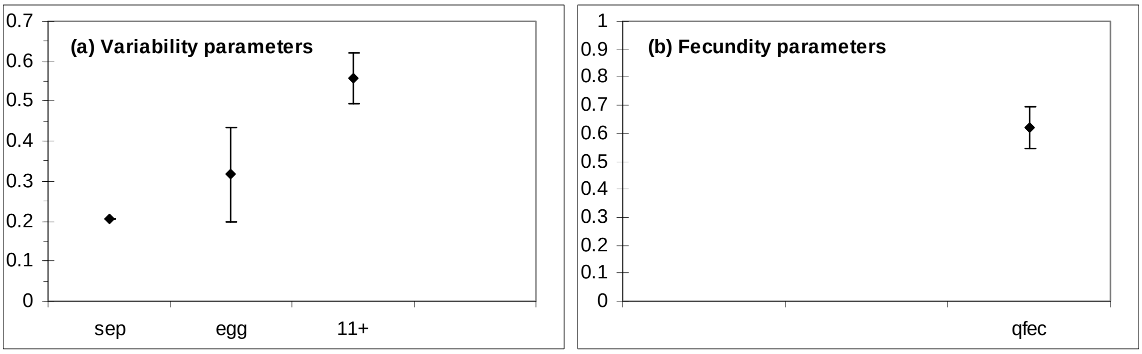

Figure 5.4.3.4. Western horse mackerel. SPALY run. Estimates for some key parameters, with (a) corresponding to variability parameters, plotted as standard deviations, for the three components of the likelihood (σ_{sep}, σ_{egg} and σ_{11+}), and (b) the fecundity parameter q_{fec}. The error bars are 2 standard deviations (indicating roughly 95% confidence bounds).

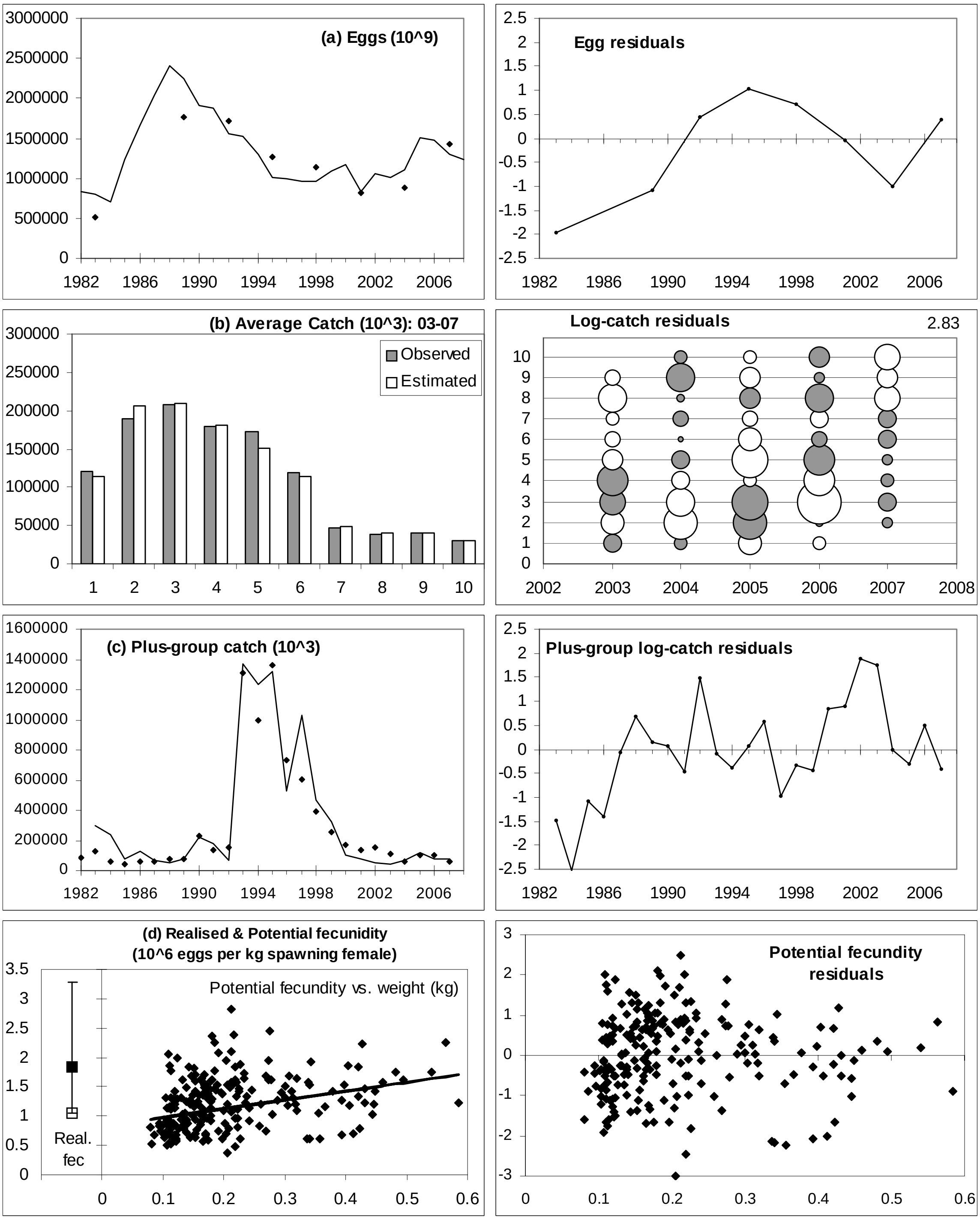

Figure 5.4.3.5. Western horse mackerel. SAD08 run. Model fits to data for the five components of the likelihood, corresponding to (a) the egg estimates, (b) the catches in the separable period, (c) to the catches in the plus-group, and (d) population-mean realised fecundity (left of y-axis) and potential fecundity (right of y-axis). The left-hand column of plots 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 maximum absolute size given in the top right of the plot. In the residual plot for (d), only the potential fecundity residuals are shown (there is only one residual for the population-mean realised fecundity).

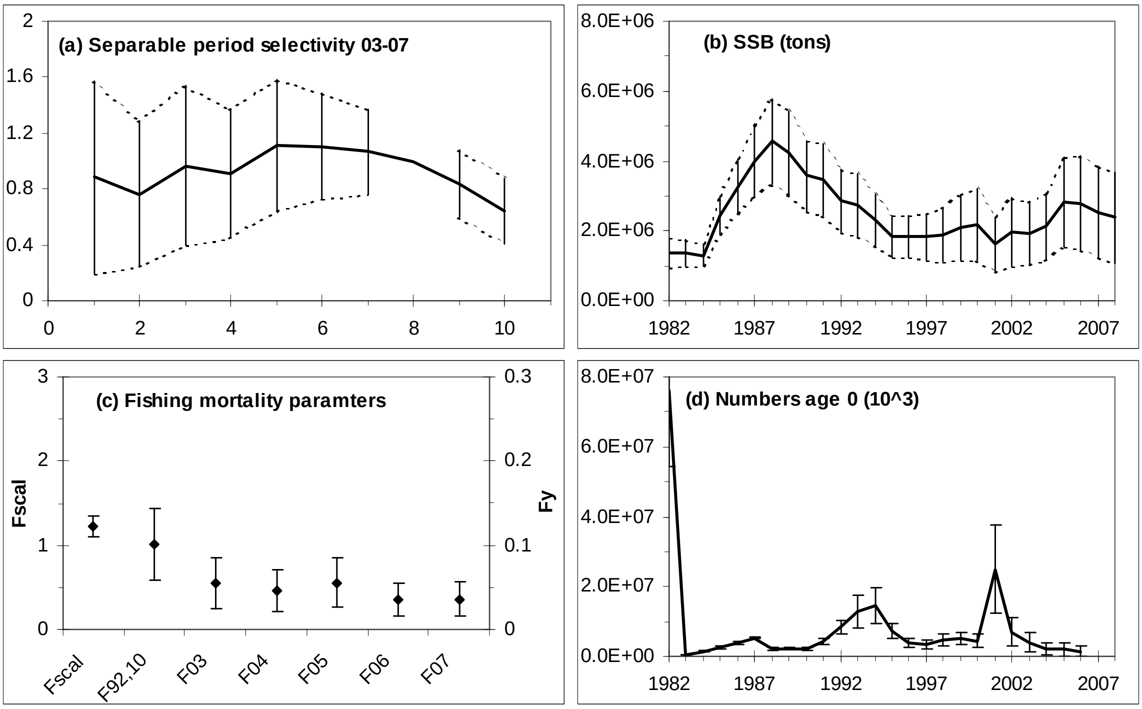

Figure 5.4.3.6. Western horse mackerel. SAD08 run. Plots of (a) the selectivity pattern, (b) the SSB trajectory, (c) fishing mortality parameters (the scaling parameter F_{scal}, fishing mortality at age 10 in 1992, $F_{92,10}$, and the fishing mortality year effects for the separable period, F_y), and (d) numbers at age 0. The error bars are 2 standard deviations (indicating roughly 95% confidence bounds).

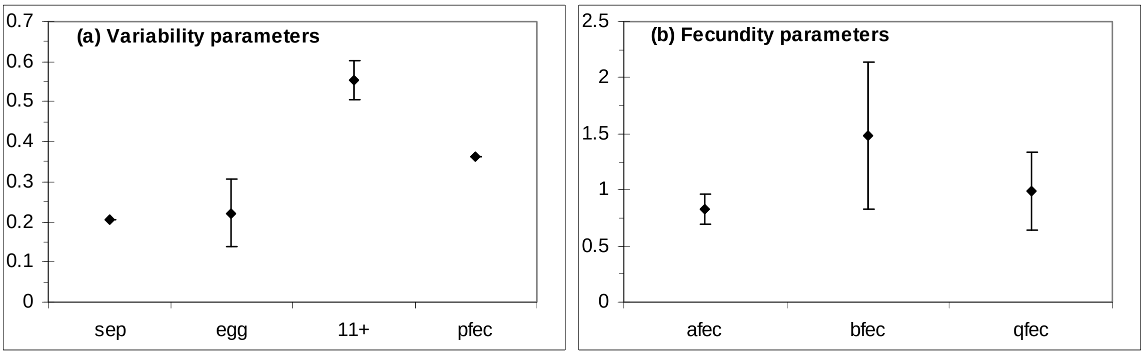

Figure 5.4.3.7. Western horse mackerel. SAD08 run. Estimates for some key parameters, with (a) corresponding to variability parameters, plotted as standard deviations, for four components of the likelihood (σ_{sep}, σ_{egg}, and σ_{11+} and σ_{pfec}), and (b) the fecundity parameters a_{fec}, b_{fec} and q_{fec}. The error bars are 2 standard deviations (indicating roughly 95% confidence bounds).

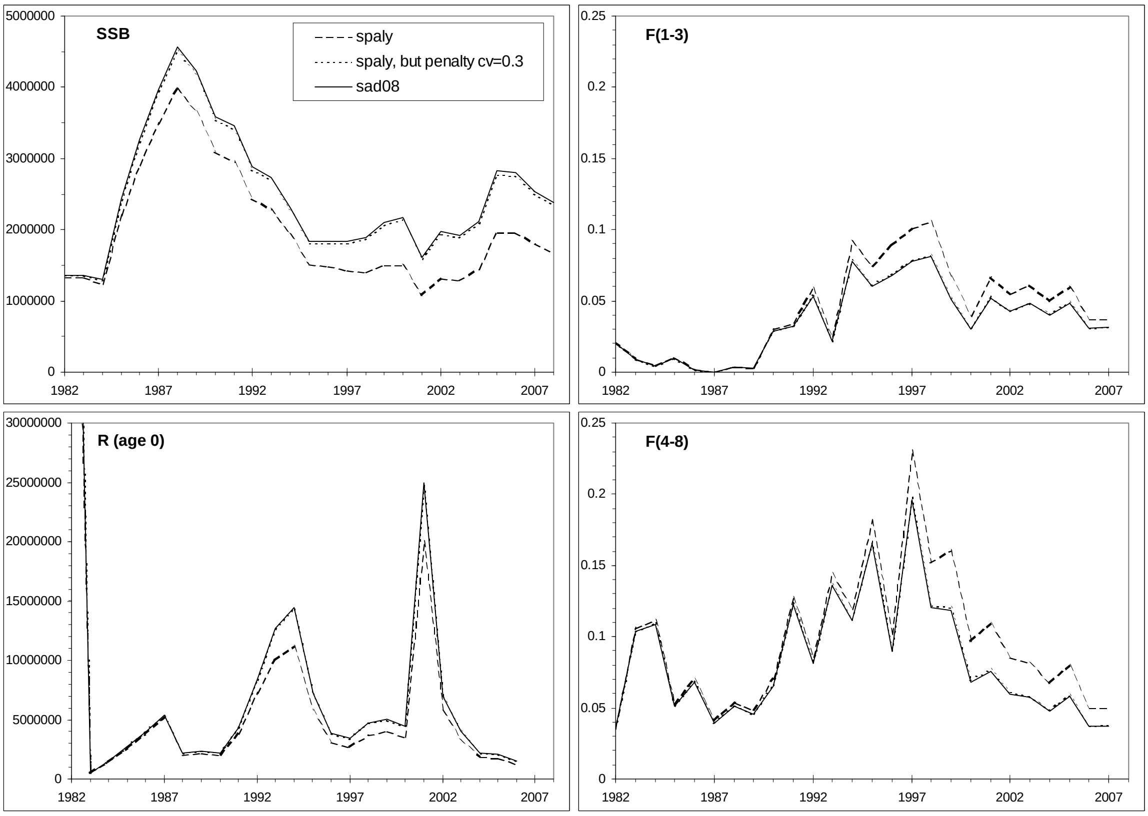

Figure 5.4.3.8. Western horse mackerel. Trajectories of SSB, recruitment (age 0), F (13–) and F (48–) for three model runs: SPALY, SPALY with penalty CV increased from 0.062 to 0.3, and SAD08.

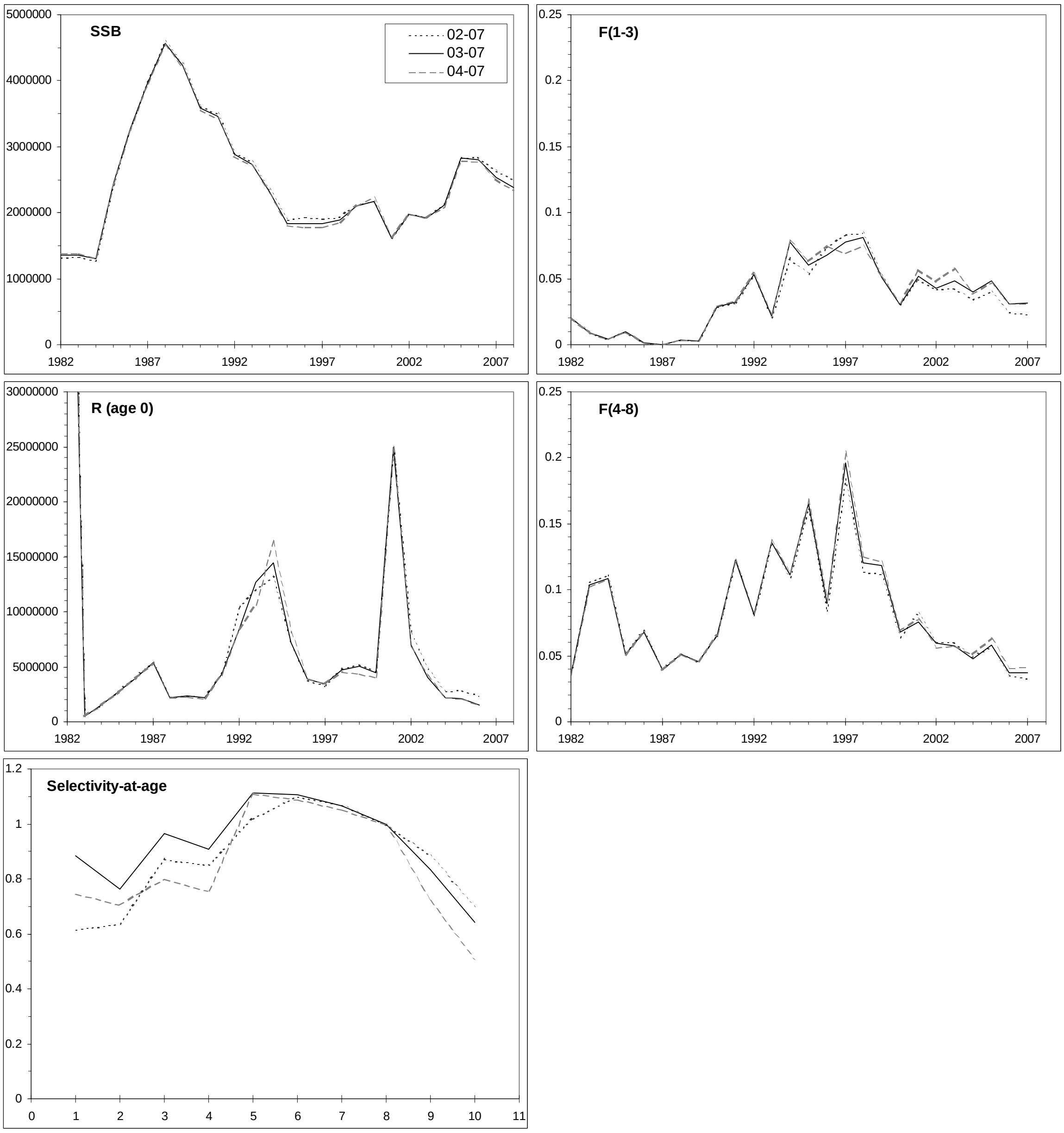

Figure 5.4.3.9. Western horse mackerel. Sensitivity of SAD08 to the length of the separable window. Trajectories of SSB, recruitment (age 0), F (13−) and F (48−) are shown in the top four plots, while the bottom plot shows selectivity-at-age.

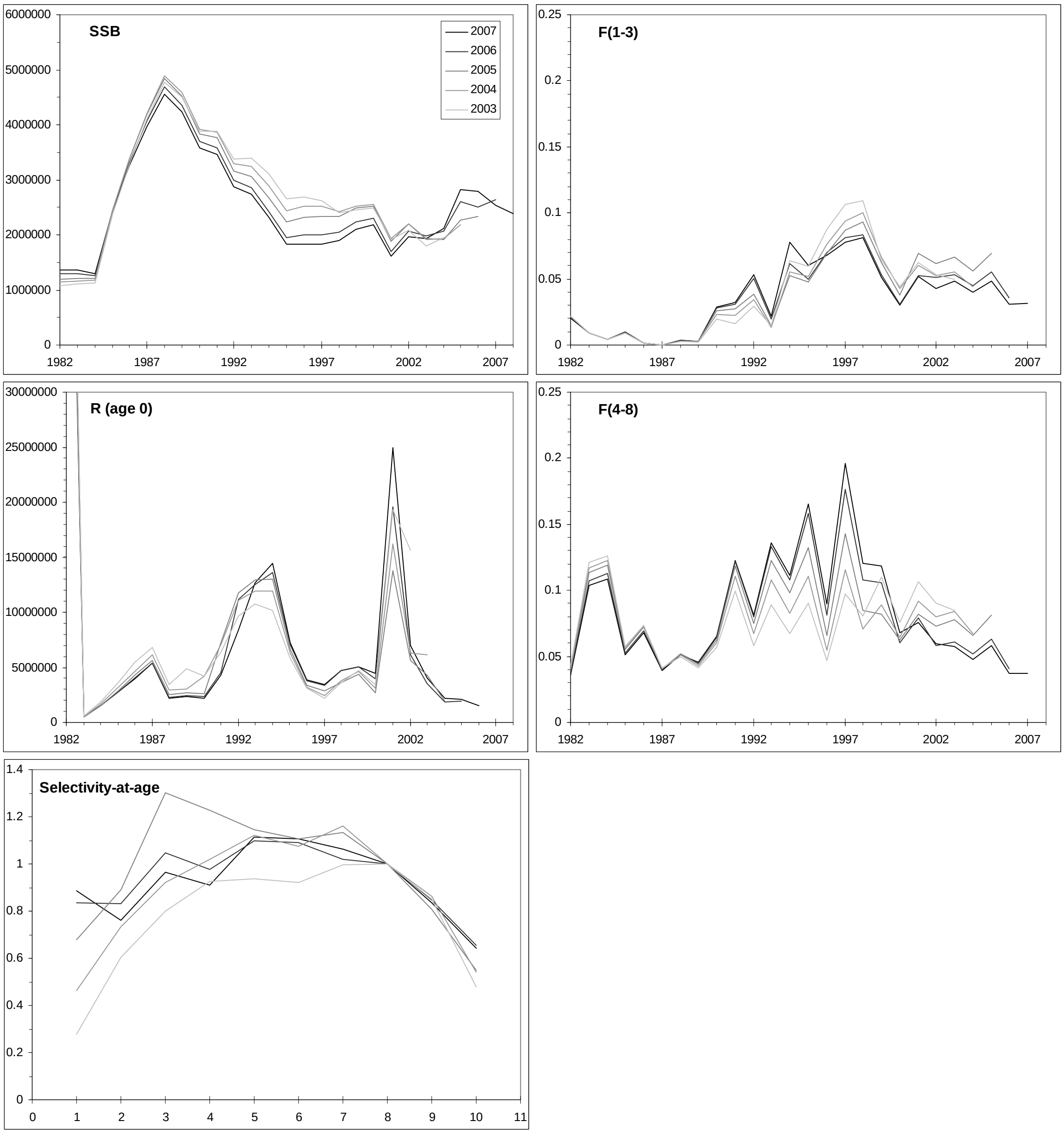

Figure 5.4.3.10. Western horse mackerel. 5-year retrospective bias for the case where the length of the separable window is kept at 5 years. Trajectories of SSB, recruitment (age 0), F (13−) and F (48−) are shown in the top four plots, while the bottom plot shows selectivity-at-age.

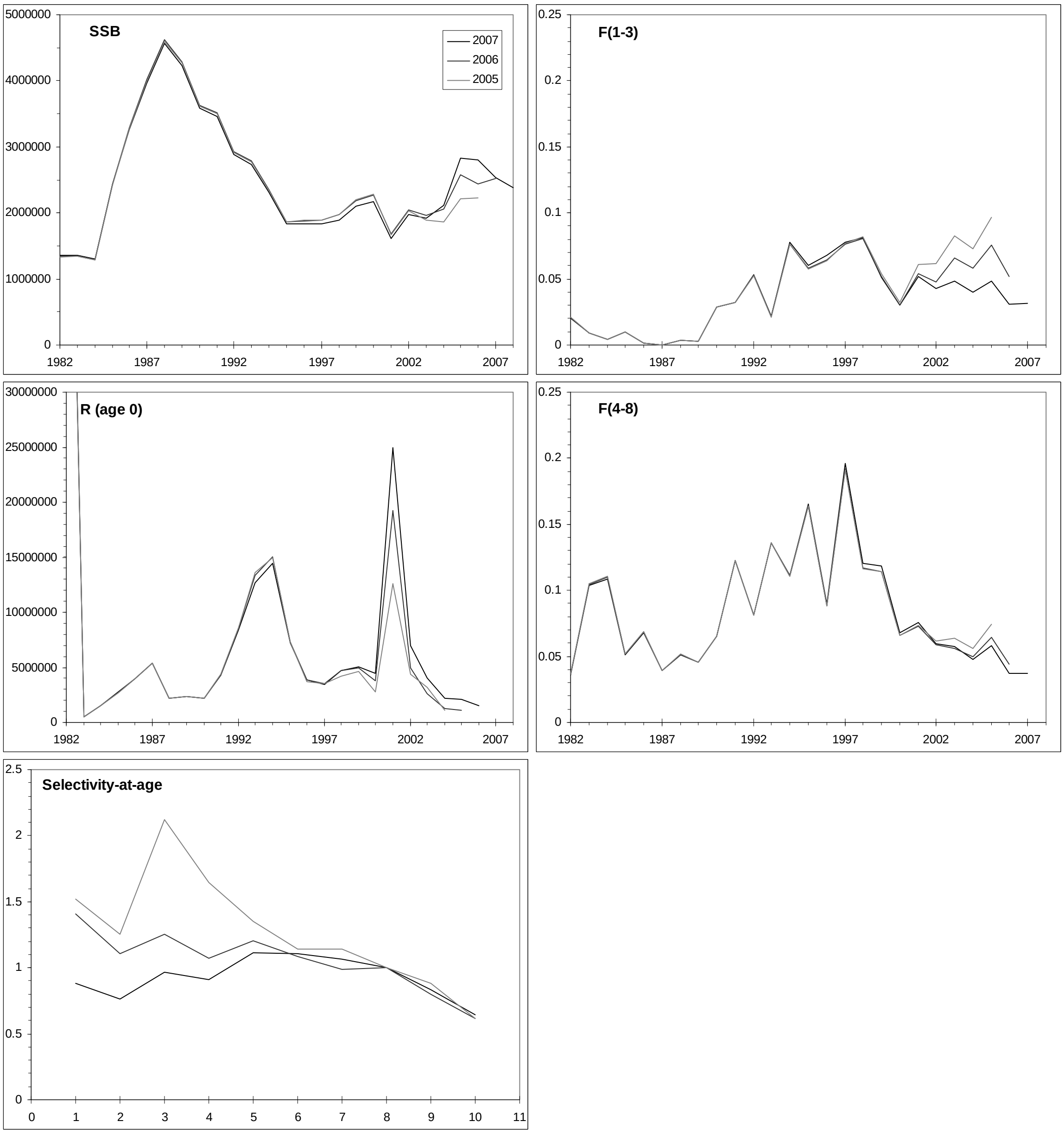

Figure 5.4.3.11. Western horse mackerel. 3-year retrospective bias for the case where the starting year of the separable window is kept at 2003, so that the window decreases in length as more years are dropped. Trajectories of SSB, recruitment (age 0), F (13–) and F (48–) are shown in the top four plots, while the bottom plot shows selectivity-at-age.

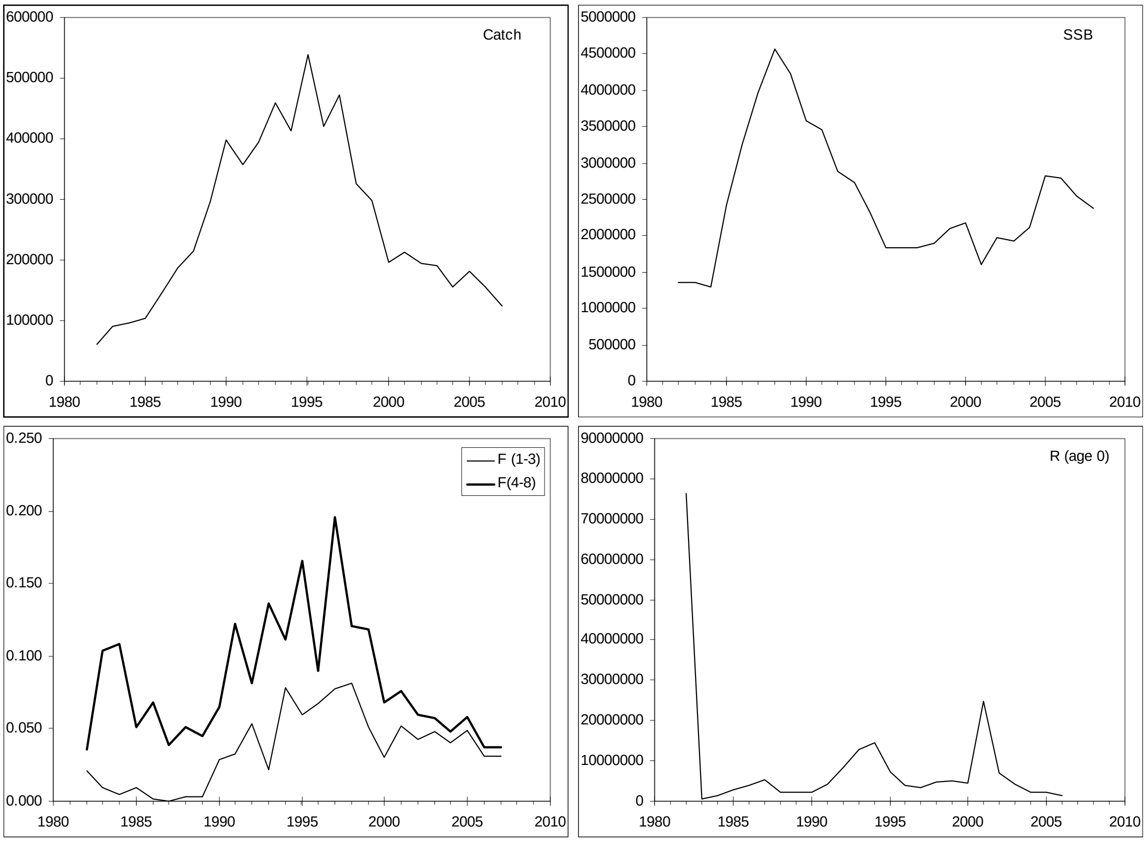

Figure 5.6.1.1. Western horse mackerel. Final assessment. Stock summary. Plots of catch, SSB, recruitment (age 0) and fishing mortality (average for ages 13– and 48–). SSB and catch are in tons, and recruitment in thousands.

6 Southern Horse Mackerel (Division IXa)

6.1 ICES advice applicable to 2007 and 2008

In 2007 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 could not be evaluated.

ICES further stated that the recent level of catches does not seem to be detrimental to the stock, therefore recommending that catches in 2008 should not exceed the 2000–2004 average of 25 000 t. The reference period of 2000–2004 excludes 2003 because of the reduced effort as an effect of the "Prestige" oil spill.

ICES also recommended that the TAC for this stock should only apply to *Trachurus trachurus*.

6.2 Stock description and management units

The definition of horse mackerel stocks and management units in the ICES area is discussed in sections 3.2 and 3.3.

6.3 Scientific data

6.3.1 The fishery in 2007

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 (Table 6.3.1.1 and Figure 6.3.1.1). 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. At the moment it has been collected the required information for the period 1991−2007, and it 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 (2.7% in 2007). Therefore, their exclusion should not affect the reliability of the assessment. The Portuguese catches range from 45% of the total catch of the stock in 2007 to 85% in 1992 (Table 6.3.1.1). Therefore in 2007 the Portuguese catches were the lowest of the time series with a decrease of more than 4,000 tonnes comparing with catches in 2006. On the contrary Spanish catches in 2007 increased in more than 3,100 t. 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 (Figure 6.3.1.1). 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 2007 showed a slight decrease of 4.7% compared with those obtained in 2006 mainly due to the significant drop in the Portuguese catches from Subdivision IXa Central North (-57%). 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 in Subdivisions IXa Central-North showed a decreasing trend whereas in Subdivision IXa North they increased markedly until 1998 (an outstanding catch = 20,000 t, Figure 6.3.1.1) and since then the catches were always higher than 7,000 t. The catches from bottom trawlers are the majority in both countries (usually more than 60% in recent years). The rest of the catches are taken by purse seiners, especially in the Spanish area and by the artisanal fleet which is much more important in the Portuguese area (Table 6.3.1.2 and Figure 6.3.1.2).

The descriptions of the Portuguese fishing fleets operating in Division IXa (data provided by the Portuguese Fisheries Directorate) and the Spanish fishing fleets operating in Division IXa (Southern stock) and Division VIIIc (Western stock) (Hernández, 2008) are shown in Tables 6.3.1.3 and 6.3.1.4, 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.

In the Portuguese area (Division IXa) Silva and Murta (2007) classified trawl fleet in two main types: those directed to fish and cephalopods species and those fishing crustaceans. Looking at the the fishing trips of those that catch fish and cephalopods, they identified three main clusters:

- Directed to horse mackerel,
- Directed to cephalopods
- The third cluster is a mixed cluster, not well defined.

In 2005, the landings of blue whiting increase, probably due to increased market demand and consequent reduction of discards, resulting in a fourth specific cluster. The Crustacean trawl clusters do not follow the same pattern every year, depending on the abundance of the two main target crustacean species, which are Norway lobster and deepwater rose shrimp. There can be one target species by cluster or mixed clusters with different percentages of these two species.

6.3.2 Fishery independent information

6.3.2.1 Bottom 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 Subdivisions 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 6.3.2.1.1 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 been confirmed at age 1 in 2006 (Table 6.3.2.1.1).

The two bottom-trawl surveys series, available to use as tuning data in the assessment, were joined as in the past, given that both vessels and gears have a similar catchability for horse mackerel. The weight given to each data set was proportional to the respective area covered, roughly 85% to the Portuguese data and 15% to the Spanish one (Table 6.3.2.1.2 and Figure 6.3.2.1.1.). 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.

Given that there is a high natural variability in the survey indices from year to year, each year-class was smoothed with a moving average, in which:

$N_i = 0.75N_i + 0.125N_{i-1} + 0.125N_{i+1}$

N_i is the number/hour at age i in the year-class. Figure 6.3.2.1.1 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.

6.3.2.2 Egg surveys

Recent work suggests that horse mackerel has indeterminate fecundity (Gordo et al., 2008), 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.

For this assessment, a total of three SSB estimates, for the years 2002, 2005 and 2007 were made available. The SSB estimate and variance for 2007 was obtained from a

DEPM egg survey directed at horse mackerel. Details of the sampling procedure, data obtained and methods followed are available from the 2008 report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (ICES, 2008–ICES CM 2008/LRC:09). However, some details were corrected after the WGMEGS report, namely the total egg distribution area (which was corrected from 1.7e11 sq.meter to 7.1e11 sq.meter) and the fitting of the mortality curve to the egg abundance data, which was done using a GLM with a log link and assuming a Poisson distribution for the variance, instead of the non-linear regression described in the WGMEGS report. This resulted in a change of egg production from 13 eggs/sq.meter to 17 eggs/sq.meter.

The 2002 and and 2005 estimates were obtained with egg abundance data collected during the surveys directed at sardine in 2002 and 2005 and from horse mackerel adult samples collected at the same time of those surveys. The methodology followed to estimate SSB was the same as the one for 2007, although the area covered in the egg sampling, which corresponded to the sampling grid for sardine, was smaller than in 2007.

There are different criteria that can be used to estimate the spawning fraction, such as the presence of migratory nucleus, hydrated oocytes or post-ovulatory follicles (POF). Estimates of SSB were obtained for the three years with all these criteria, and the obtained trends in SSB were parallel but with different levels. The POF criteria, assuming POF last for 2 days as in other species at similar temperatures (Ganias *et al.*, 2003; Hunter and Macewicz, 1985) was the one providing the lowest CV, being therefore adopted to use in the assessment. However, given the uncertainty in the absolute value of SSB, partly due to the choice of the criteria for the spawning fraction, the SSB index for the assessment must be treated as relative and a corresponding catchability parameter has to be estimated.

Still another source of uncertainty is the egg distribution area, which was roughly defined and kept fixed for the three years. In all these egg surveys, there are several transects with the presence of eggs in the most offshore station, which indicates that the area with egg presence must, in some cases, be extended further away from the coast. However, a good approximation of that area is impossible to obtain with the available data.

The SSB estimates and corresponding CV used in the stock assessment are showed below

Year	SSB (ton.)	CV
2002	172577	0.76
2005	284951	0.54
2007	346983	0.75

6.3.3 Effort and catch per unit of 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 6.3.3.1). 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 6.3.3.2 and 6.3.3.3). 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, 2007). This series is still too short to be used in the assessment. This series corresponds to Marín bottom trawl fleet, one of the fleets that operates mainly in Subdivision IXa North (Galicia, NW Spain). The effort series for this fleet is available from 1994 to 2006 and it has not been possible to update the information for the time of the 2008 meeting. Taking into 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 years 2006 and 2007 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 6.3.3.1). 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 6.3.3.4) (Murta *et al.*, 2008). 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 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.

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6.3.5 Mean length at age and mean weight at age

Table 6.3.5.1 and Table 6.3.5.2 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 (Figure 6.3.5.1). In 2007, the majority of the ages showed a significant increase in mean weigh at age.

In parallel with the previous paragraph, the mean length at age showed a smooth increase trend for those ages since 2002 with a decrease in 2005 and 2006 (table 6.3.5.2).

<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.

6.3.6 Maturity at ageCatch in numbers 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.*, 2008). 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 until 2006 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.

In 2007 a new estimate of maturity proportion by age is available for Division IXa. The proportion of maturity at age used in the assessment period is:

Age	0	1	2	3	4	5	6	7	8	9	10
Maturity (92–06)	0.04	0.31	0.83	0.98	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Maturity (2007)	0.04	0.54	0.77	0.9	0.96	0.99	1.0	1.0	1.0	1.0	1.0

6.3.7 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 for all horse mackerel stocks since 1992 (ICES 1992/Assess: 17).

6.4 Information from the fishing industry

There is no any information in relation with this subsection

6.5 Methods

6.5.1 The ASAP model

The ASAP model (Legault and Restrepo, 1998), here used in the version ASAP 2.0.18, is a flexible, forward computing algorithm, which minimises an objective function based on likelihoods using a quasi-Newton minimisation method, with partial derivatives calculated by automatic differentiation (Griewank and Corliss, 1991). The automatic differentiation and minimisation routines are those supplied by the software 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 standard, well tested, and widely used methodology.

ASAP differs from the virtual population analysis methods 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. 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.

6.5.2 Model and data exploration

The objective function in ASAP is the weighted sum of a number of negative log-likelihoods, such as:

$$obj\ fxn = \lambda * (-\ln(L))$$

There are two types of error distributions in the calculation of the objective function: lognormal and multinomial. The lognormal error distribution is assumed for:

(1) Total catch in weight
(2) Indices
(3) Stock recruitment relationship
(4) Selectivity parameters (relative to initial guesses)
(5) The two stock recruitment parameters (relative to their initial guesses)
(6) Fmult in year 1 by fleet (relative to initial guesses)
(7) Fmult deviations
(8) Catchability in year 1 by fleet (relative to initial guesses)
(9) Catchability deviations
(10) Numbers at age in year 1 (relative to a population in equilibrium)

and has the expression:

$$-\ln(L) = 0.5\ln(2\pi) + \sum \ln(obs_i) + \ln(\sigma) + 0.5\sum \frac{(\ln(obs_i) - \ln(pred_i))^2}{\sigma^2}$$

The lognormal model fits all contain a lambda weight that allows emphasis of that particular part of the objective function along with an input coefficient of variation (CV) that is used to measure how strong a particular deviation is.

The multinomial distribution is just assumed for the proportions of catch at age, with the expression:

$$-\ln(L) = -\ln(ESS!) + \sum_{i=1}^{k} \ln(n_i!) - ESS \sum_{i=1}^{k} p_i \ln(predp_i)$$

where *ESS* is the expected sample size (McAllister and Ianelli, 1997−appendix 2), $n_i = p_i \cdot ESS$, p_i is observed proportion of fish in age class *i*, and $predp_i$ is the fitted proportion of fish in age class *i*.

The assessment input data set was made of six matrices of catch in numbers at age, for the fleets of bottom-trawlers, purse seiners and artisanal fishing boats from Portugal and Spain (ICES subdivision IXa North); one abundance index for each age (mean number/hour by year) from the combined bottom-trawl survey, three SSB indices from the DEPM surveys, the CVs for landings and abundance indices data, and the ESS for the catch at age data. The CV for the landings was fixed at 0.15 (given that black landings and discards seem to be insignificant in this stock) and the ESS at 100. The biological data set was made of one matrix with the natural mortality rates (fixed and 0.15/year for all ages and years), the weight at age matrices in the catch and in the stock (assumed equal) and a maturiy at age by year matrix. All data sets covered the years 1992−2007 and the age range 0−11plus years.

The separability in the fishing mortality was assumed during the whole time series. 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, year and fleet resulted from the product of the F multipliers by the selectivity parameter at each age and fleet. Three selectivity vectors were estimated, corresponding to blocks of fleets sharing a similar selectivity at age. This is a useful feature of the model, that helps to avoid overparameterisation. By looking at the plots of catch at age by fleet (Figure 6.3.4.1), it was decided to have a common selectivity for the purse-seine fleets, together with the Portuguese bottom-trawl fleet, another one for the artisanal fleets and a third one just for the Spanish bottom-trawl fleet. Preliminary runs were made with a separate selectivity vector for each fleet but no significant improvement in the model fitting was achieved with that option. One catchability parameter was also estimated for each abundance index, and kept fixed along time.

The model fitting, given a set of weights (lambdas), is done by the minimisation of the objective function. However, different combinations of weights can influence the fitting of the model, by attributing a lower or higher importance to different data sources that contribute to the objective function. Therefore, an interactive procedure must take place, by trying to find a set of weights that allow to achieve a coherent fit of all objective function components. In this procedure we had as first priority to achieve a good fit to the lading data by year and fleet, given that is the data source considered most accurate, and also because the overall level of the estimated SSB was dependent on how good was the fitting to the total landings. A second priority was the fitting to the survey data, which is typically a much noisier data source.

The detailed parameterisation of the model can be seen in the final input file (Annex ???), and the parameter estimates and diagnostics are detailed in the output report file in Annex ???. The overall fitting of the model to the total catch data of every fleet is very good (log residuals ranging from -0.01 to 0.02). The fitting to the catch proportions at age by fleet also shows small residuals, ranging from -0.24 to 0.26, with higher negative residuals in the younger ages in some fleets (Portuguese bottom-trawl and purse-seiners), which are due to higher catches in those ages than would be expected by the fitted selectivity vector (Figure 6.5.2.1). The opposite (higher positive residuals) takes place in the 11-plus age class in the Spanish bottom-trawl fleet (Figure 6.5.2.1). The residuals of the fit to the survey data (Figure 6.5.2.2) show clear year-effects, which may be due to several causes (different availability of the fish in different years, fishing experience of the different skippers, etc). There are no clear patterns across ages, which means that the catchabilities vector shown in Figure 6.5.2.3 is well fitted. Figure 6.5.2.4 also shows the residuals of the fit to the survey data, by plotting the observed (dashed lines) and the fitted (solid lines) indices. Given the variability in the survey data, the fitted values behave as smoothers that describe the overall trends, but do not fit to the extreme fluctuations of the abundance indices. Regarding the three observations of the egg surveys, the fitting is also very good, with log residuals ranging from -0.09 to 0.08. The estimated catchability is of 3.97, which is related to the uncertainty around the absolute value of this index discussed in section 6.3.2.1.

6.6 Reference points

Reference points have not been defined for this stock

6.7 State of the stock

6.7.1 Stock assessment

The numbers at age in the stock, estimated in the assessment, are shown in Table 6.7.1.1. Figure 6.7.1.1 shows the SSB and recruitment estimates in each year, along with the respective retrospective pattern. Those figures show a strong recruitment in 1996, followed by another one in 2004. This recent strong recruitment is likely responsible for the increase in SSB that is shown in Figure 6.7.1.1 (upper panel). Estimates of SSB, recruitment, and the average fishing mortality from ages 1 to 11+ are shown in the stock summary table (Table 6.7.1.2).

Figure 6.7.1.2 shows the average fishing mortality rate from ages 1 to 11+, both total (dashed line) and by fleet (solid lines). The apparent overall stability in the exploitation rate is not reflected in the individual fleets exploitation rates, but rather due to an inverse trend in fishing mortality between the two most important fleets (the Portuguese and Spanish bottom-trawl fleets). The Portuguese purse-seine fleet also presents a decreasing trend in fishing mortality, while the Spanish purse-seiners show a stable rate, after an increase in the late 1990s due to a shortage in their main target species (sardine), which was followed by a decrease from 1998 to 2004. Both artisanal fleets have a stable exploitation rate at relatively low levels.

The three vectors of selectivity estimates are shown in Figure 6.7.1.3, along with the respective retrospective pattern. Block 1 corresponds to the selectivity of the Portuguese bottom-trawl fleet and both purse-seine fleets, Block 2 corresponds to the selectivity of both artisanal fleets, and Block 3 corresponds to the selectivity of the Spanish bottom-trawl fleet. Blocks 2 and 3 correspond to fleets mainly targeting older age classes, while Block 1 corresponds to fleets targeting mainly young fish, but also catching a wide range of age classes. This latter selectivity pattern has a hole in the middle age classes, roughly from 3 to 6 years old. This is a feature which has been known for a long time, and that is also present in the length distribution data from the surveys. Borges (1991) suggested it is due to age-dependent migrations that decrease the fish availability in those ages. Botsford *et al*. (1994) state that such a pattern is a common populational feature, produced by the joint effect of pulsed recruitment and asymptotic growth. In our case such pattern can only be seen in those fleets that catch a wide range of age classes.

6.8 Short term forecast

A short-term forecast was carried out by fixing a TAC for the whole period (2008–2010) corresponding to the catches of the year 2007 (23000 ton.), assuming a constant recruitment of 646 million individuals, which is the geometric mean of the estimated recruitments from 1992 to 2006, and assuming no changes in the selectivity pattern of all fleets. With these assumptions, the SSB would increase to 139,000 ton. in 2008, 149,000 ton. in 2009 and 162,000 ton. in 2010. In summary it would be an increment of about 17% in SSB at the end of the period. The forecast evolution of numbers at age, yield at age, and fishing mortality at age are shown in Figure 6.8.1.

Table 6.8.1 shows the forecast for different catch options. To find a decrease in the level of SSB at the end of the forecasting period one should go for more than an increment of 40% of *status quo* catch. However, it is considered a misleading concept for this stock since the forecast should be made taking into account the effects that the particular selection pattern of each fleet could have on the horse mackerel population (see also section 6.10). This analysis will be made in the next meeting with the appropriate software.

6.9 Uncertainties in assessment and forecast

There are typically several source of uncertainty in a fish stock assessment, e.g.:

(1) Unsatisfactory fitting of the assessment model;
(2) Inaccurate catch data (due to black landings or discards);
(3) Doubts in aging criteria;
(4) Noisy abundance indices;
(5) Ignorance on stock identity.

Regarding the first source of uncertainty, all diagnostics (residuals, retrospective patterns) indicate an appropriate fit of the model to the available data. Even the survey indices, which are the noisiest data source, could be fitted in a way that, although not adjusting for extreme variations, allowed to describe the main overall trends in the data

Although horse mackerel is usually labelled 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) 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 6.3.2.1.1.

The catch data used in the assessment 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). The aging data for this stock is produced by experienced technicians who have participated more than once on otolith exchange programmes and age reading workshops. Age reading criteria were validated by using an otolith reference collection from the 1982 year-class, which was preponderant for many years in the western horse mackerel stock and therefore allowed to know with little doubt the actual age of the sampled fish.

The stock identity of the north-east Atlantic horse mackerel has recently been the subject of an international research project, which defined the boundaries of several stocks (including the southern one), using a multidisciplinary approach. The main findings of that project are published in several papers in the special issue of *Fisheries Research* (2008, vol. 89, issue 2) on the stock identification of horse mackerel.

Finally, the main uncertainties in the forecast are related to the assumptions on the stability of catches, recruitment and exploitation patterns.

6.10 Management considerations

This stock has supported a stable exploitation level for a long time period. The assessment indicates an increase in biomass in recent years, linked to an above average recruitment in 2004. The fleet-disaggregated assessment carried out this year allows to evaluate the historical series of fishing mortality by fleet, and their corresponding exploitation pattern. It is clear that the apparent stability in the overall exploitation level is due to a decrease in fishing mortality in most fleets but a sharp rise in the Spanish bottom-trawl fleet operating in subdivision IXa North. This overall stability can change drastically if there is a change in the fishing mortality trend of any of the purse-seine fleets or the Portuguese bottom-trawl fleet. Such change in fishing mortality has been observed in the late 1990s due to a decrease in sardine abundance, which made many purse-seiners to start targeting horse mackerel. Such a drastic change, in the current conditions, could lead to a rapid decline of the stock.

Both artisanal fleets and the Spanish bottom-trawl fleet target adult fish, especially above 6 years old. There are studies on the migratory pattern of southern horse mackerel that suggest that age classes are not evenly distributed along the stock area, with old fish mostly present in the waters of Galicia and northern Portugal (Murta et al., 2008). Therefore, a high fishing mortality focused on those areas may deplete the spawning stock in a faster way than if the fish were homogeneously distributed. This would reduce the reproductive capacity of the stock.

The traditional exploitation pattern across fleets has been, for a long time, the targeting of juvenile age classes. This targeting of juveniles at a moderate level of exploitation does not seem to have been detrimental to the dynamics of this stock, which has been stable along the years.

A short-term forecast assuming status quo catch predicts an increase in SSB. However, this is conditional on the maintenance of the current exploitation pattern. In this context, the increasing trend in fishing mortality of the Spanish bottom-trawlers operating in subdivision IXa North is a matter of concern. Therefore, to keep the current catch level (or lower) in all fleets seems to be the most adequate option.

6.11 Comparison with previous assessment and forecast

Last year's exploratory assessment was made with a significantly different data set. Catch data was not disaggregated by fleet and the SSB indices from the egg surveys were not included in the assessment. Moreover, the work to disaggregate the fleet catch data lead to corrections in the landings data from some years and fleets. Still, both assessments agree on the pattern of stability in the fishing mortality and SSB across the years (although this year's assessment indicates that this apparent exploitation stability may be misleading).

6.12 Management plan evaluations

There is no management plan for this stock

6.13 Ecosystem considerations

See section 1.9 in relation with horse mackerel species.

6.14 Regulations and their effects

There is no specific regulations that can affect significantly to the fishery and/or dynamics of southern horse mackerel stock.

6.15 Changes in fishing technology and fishing patterns

Traditionally this fishery is characterized by the high proportion of juveniles in catches. Recently the importance of the Spanish bottom trawl fleet in the catches of the stock is increasing. This fleet is targeting mainly adult fish.

6.16 Changes in the environment

No information. See also section 1.9.

Table 6.3.1.1 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	4,059[1]	28,411[1]
1993	25,747	6,198	31,945
1994	19,061	9,380[1]	28,441[1]
1995	17,698	7,449	25,147
1996	14,053	6,347[1]	20,400[1]
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)*
2007	10,381	12,409 // (13,043)*	22,790 // (23,424)*

(*) 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.

([1]) These figures have been revised in 2008.

Table 6.3.1.2. Southern horse mackerel. Landings by gear and by country with and indication (in parenthesis) of the percentage that represent those landings in each country.

GEAR YEAR	BOTTOM TRAWL		PURSE SEINE		ARTISANAL	
	Portugal	Spain	Portugal	Spain	Portugal	Spain
1992	13,000 (54.7)	1,651 (40.7)	7,354 (30.9)	2,409 (59.3)	3,445 (14.5)	-
1993	16,783 (66.3)	3,877 (62.6)	4,683 (18.5)	2,321 (37.4)	3,841 (15.2)	-
1994	10,466 (55.0)	2,655 (28.3)	5,369 (28.2)	6,724 (71.7)	3,202 (16.8)	-
1995	12601 (71.3)	3,010 (40.4)	2,947 (16.7)	4,440 (59.6)	2,137 (12.1)	-
1996	10,674 (76.3)	2,705 (42.6)	2,085 (14.9)	3,642 (57.4)	1,228 (8.8)	-
1997	12,446 (66.8)	2,130 (19.5)	4,385 (23.5)	8,776 (80.5)	1,800 (9.7)	-
1998	13,170 (61.7)	3,773 (18.6)	5,901 (27.6)	16,458 (81.4)	2,287 (10.7)	-
1999	6,868 (47.6)	3,238 (24.3)	5,707 (39.5)	10,074 (75.7)	1,855 (12.9)	-
2000	7,970 (55.5)	4,727 (40.0)	4,210 (29.3)	7,027 (59.5)	2,169 (15.1)	58 (0.5)
2001	7,690 (55.9)	4,536 (40.7)	4,788 (34.8)	6,260 (56.1)	1,281 (9.3)	356 (3.2)
2002	8,126 (56.9)	4,181 (50.8)	4,271 (29.9)	3,959 (48.1)	1,873 (13.1)	96 (1.2)
2003	6,887 (61.3)	3,229 (42.2)	2,112 (18.8)	4,411 (57.7)	2,243 (20.0)	5 (0.1)
2004	8,625 (65.8)	7,501 (65.9)	2,042 (15.6)	3,658 (32.2)	2,441 (18.6)	217 (1.9)
2005	8,319 (62.5)	5,710 (60.9)	2,444 (18.4)	3,596 (38.3)	2,545 (19.1)	76 (0.8)
2006	9,485 (64.9)	5,534 (59.6)	1,754 (12.0)	3,676 (39.6)	3,368 (23.1)	77 (0.8)
2007	5,706 (55.0)	7,999 (64.5)	2,683 (25.8)	4,092 (33.0)	1,992 (19.2)	316 (2.5)

Table 6.3.1.3. 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 6.3.1.4. De… …ivision IXa including the G… …c (Western horse mackerel … …esis). Data from official ce… …a is mainly fished by bottom…

Gear	B… T…				… mesh size)		…Other artisanal
Number	282	410	100	67	35	57	5379
Construction year (mean)	1996	1992	1990	1995	1990	1993	1982
Length	9–35 (22.9)	8–38 (21)	6–28 (15.1)	18–38 (27.6)	4–28.6 (14)	12–27 (17.2)	3–27 (7)
Power	66–800 (322.3)	24–1100 (302.5)	12–476 (150.3)	175–780 (418.9)	10–500 (141.8)	50–408 (164.9)	2–450 (32.6)
Tonnage	6–228 (81.2)	4–221 (56.6)	2–118 (26)	37–206 (116)	1–110 (23.7)	10–99 (27.6)	0.3–83 (3.5)

Table 6.3.2.1.1. Southern horse mackerel. CPUE at age from bottom trawl surveys

Portuguese October Survey

	AGES															
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
1991	319.270	35.750	20.580	21.330	25.070	11.790	6.560	3.540	4.080	3.070	1.340	0.990	0.590	0.040	0.000	0.080
1992	522.240	568.290	182.260	63.540	28.300	11.010	7.420	7.750	4.120	3.460	4.720	0.770	1.000	0.300	0.160	0.120
1993	2065.440	277.910	279.050	171.660	40.690	5.350	3.110	1.940	1.110	1.270	0.780	1.870	0.520	0.360	0.080	0.090
1994	4.070	10.210	70.590	64.570	26.870	6.640	3.000	2.050	1.000	0.550	0.350	0.120	0.040	0.010	0.000	0.010
1995	22.900	90.500	129.630	78.560	34.980	6.640	1.370	1.600	0.500	0.240	0.240	0.370	0.310	0.570	0.150	0.210
1996*	1613.260	11.340	18.460	29.820	29.970	5.680	2.290	0.910	0.330	0.180	0.060	0.120	0.090	0.060	0.010	0.010
1997	1306.610	92.160	152.190	45.400	73.850	42.740	8.650	6.880	2.740	3.110	1.130	0.140	0.040	0.160	0.100	0.070
1998	115.750	48.910	137.450	19.900	7.390	4.100	2.200	2.190	0.340	0.070	0.030	0.010	0.030	0.000	0.000	0.010
1999*	147.220	31.310	58.860	69.360	5.820	2.000	1.050	0.250	0.060	0.100	0.030	0.000	0.010	0.010	0.000	0.000
2000	3.510	22.700	30.540	34.320	16.700	9.320	4.810	1.470	0.750	0.100	0.050	0.070	0.040	0.020	0.000	0.000
2001	726.800	1.150	4.710	3.700	5.110	7.260	8.800	13.960	7.610	2.470	1.370	0.400	0.180	0.230	0.050	0.000
2002 [1]	41.580	2.630	8.850	14.570	11.590	5.970	1.880	1.260	0.860	0.520	1.020	0.350	0.240	0.120	0.060	0.030
2003*	82.460	10.470	10.510	20.340	18.090	5.170	2.810	1.720	1.100	0.630	0.270	0.010	0.010	0.010	0.000	0.000
2004	63.080	39.330	140.660	55.220	11.570	4.980	2.360	5.900	7.710	1.220	0.250	0.030	0.000	0.000	0.000	0.000
2005	383.510	1475.200	237.210	81.050	39.830	17.230	20.270	20.600	15.780	8.200	5.000	5.990	5.440	1.020	1.270	0.350
2006	93.110	95.230	253.400	63.140	3.760	12.110	8.750	7.190	2.930	1.600	0.730	0.160	0.040	0.000	0.000	0.000
2007	40.790	0.870	28.190	45.660	34.270	8.580	2.880	1.700	0.170	0.570	1.620	1.470	0.660	0.330	0.330	0.59

Spanish October Survey (only Subdivision IXa North)

	AGES															
YEAR	**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
2007	1.388	0.000	0.000	0.007	0.091	0.210	0.965	1.256	1.634	0.756	0.618	0.641	0.177	0.239	0.190	0.162

***** 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 6.3.2.1.2. Time series of CPUE at age from Portuguese and Spanish combined bottom trawl survey. It is showed with the period and the age plus considered in the assessment.

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	392.788	425.955	138.299	47.025	20.884	10.037	6.29	5.89	3.32	2.87	4.36	2.61
1993	1329.247	240.474	245.718	132.097	33.436	6.735	3.51	2.73	2.26	2.32	2.17	4.8
1994	21.841	241.463	82.96	74.624	36.15	8.71	2.65	1.74	1.04	0.78	1.36	4.61
1995	17.017	60.09	86.895	60.774	29.766	7.334	1.68	1.39	0.65	0.31	0.55	3.43
1996	1051.822	25.835	26.206	40.634	31.997	8.263	2.95	1.08	0.84	0.61	0.28	1.42
1997	843.585	245.395	100.34	31.691	50.689	30.68	6.4	4.79	2	2.23	0.89	0.93
1998	80.557	176.298	104.783	29.474	9.745	10.576	5.99	2.44	1.08	0.45	0.61	0.36
1999	98.68	35.524	46.365	60.597	6.817	2.581	1.33	0.58	0.43	0.37	0.45	1.27
2000	2.644	30.617	23.191	28.679	18.792	7.502	4.86	2.26	1.26	0.65	0.34	0.49
2001	465.33	2.38	6.962	6.836	7.54	6.637	6.8	9.93	5.74	2.46	1.8	1.05
2002	28.752	80.258	7.981	11.711	8.333	4.645	2.23	2	2.98	2.06	2.03	3.4
2003	61.958	26.091	13.149	15.236	13.697	4.811	3.08	2.16	1	0.76	0.47	0.76
2004	363.816	59.338	99.678	42.384	11.982	7.776	4.44	5.9	6.06	1.46	1.85	0.18
2005	660.776	975.758	162.131	67.063	32.891	13.293	14.33	13.75	10.94	6.19	3.38	9.2
2006	62.74	170.47	323.138	69.108	11.929	12.289	7.62	6.8	4.14	2.9	1.75	1.29
2007	34.88	21.406	38.208	82.956	35.279	6.294	4.52	3.09	1.82	1.07	1.45	2.48

Table 6.3.3.1. 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 6.3.4.1. Southern horse mackerel. Time series of catch at age data

	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
2007	2881	13666	21668	41343	20290	8238	4868	4076	6483	5133	5243	4755	5636	2997	5772	11172

Table 6.3.4.2. Southern horse mackerel. Catch in number by gear and country (Pt = Portugal; Sp = Spain)

Pt. Bottom trawl

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11+
1992	4707	43326	72194	19567	7253	6331	3538	4288	3046	2495	6593	5676
1993	98	8737	40080	77980	28618	10722	9734	6540	3471	1342	1383	3356
1994	3413	16252	37679	55074	16278	3862	1945	900	1263	914	691	1136
1995	3917	12983	18291	22796	11429	5351	2395	2195	2036	2378	1691	17550
1996	30763	10329	10084	19186	23285	6293	4295	2813	2181	1779	1195	3638
1997	2819	180143	67538	14756	7630	4251	1825	779	296	175	172	806
1998	4444	36543	205035	32093	7077	3347	2155	2045	1844	1041	1225	2539
1999	28176	11489	16041	23580	8295	2527	2701	1581	863	932	767	1309
2000	1106	35946	13682	17867	9887	5749	5723	4046	2301	1568	950	769
2001	39825	25156	10755	9140	7377	4284	5419	5757	3687	1331	774	666
2002	3572	58462	49165	11953	4456	3560	3600	4563	2847	1891	775	821
2003	14581	2077	18044	12035	12655	7100	5807	4606	3117	1629	831	347
2004	1335	77202	44073	10862	3388	4640	3772	4340	2829	807	229	125
2005	2943	50534	30346	14960	10564	5227	5228	3751	2836	1720	1180	2200
2006	1223	55455	60260	14803	3643	9412	8894	3068	2630	1797	1218	624
2007	19	2374	14842	31466	10961	2909	1595	632	411	534	772	4181

Pt. Purse seine

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11+
1992	6188	36983	47773	12060	3322	2414	1344	1952	1278	1186	2537	2363
1993	2143	44611	72760	9606	2792	477	174	200	73	96	92	175
1994	2378	8351	21613	26189	7060	1706	816	466	580	440	392	452
1995	0	121	2649	15853	8111	1863	354	265	52	299	162	1223
1996	5933	210	1032	3839	3675	244	108	91	256	1522	560	2111
1997	132	80144	25732	5035	2512	920	242	70	44	22	65	0
1998	8511	10500	56107	23166	3661	994	225	69	179	0	0	0
1999	879	1757	5691	27514	19477	4308	1953	361	67	23	11	2
2000	1180	3147	3833	13482	14000	4449	1824	455	150	11	1	2
2001	49834	28340	2185	7538	10979	5726	2627	1048	269	39	17	7
2002	8107	14724	27433	11274	5473	3771	1833	876	291	58	125	0
2003	8945	1558	9762	13652	5428	1574	644	66	10	2	1	0
2004	432	11782	8860	3419	1648	1675	1543	1043	102	15	0	0
2005	9441	35137	12717	4993	1840	1193	863	381	214	76	29	8
2006	589	14848	22692	3355	78	17	0	0	0	0	0	0
2007	65	5327	8411	8935	6005	3106	111	0	0	0	0	2007

Pt. Artisanal

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11+
1992	0	0	1	5	45	76	93	553	731	935	4393	5818
1993	89	6135	13760	5902	2402	1668	2025	1501	886	766	511	3187
1994	1666	1549	3052	1939	1171	863	882	839	1039	943	1290	3511
1995	2	286	516	2193	1929	1410	608	415	258	252	175	3485
1996	0	11	97	692	1651	618	465	331	370	255	205	1330
1997	17	602	972	1384	2915	2575	1313	653	420	235	278	814
1998	180	181	2726	1051	1726	1861	1387	1684	740	647	728	2056
1999	2	67	731	1927	2836	2102	2420	1151	433	394	98	564
2000	73	1129	1028	998	1385	1081	2154	2137	1463	717	386	787
2001	420	1011	129	489	841	1194	1482	1557	888	359	228	382
2002	1212	3166	459	588	467	883	1330	1656	1580	1114	533	1095
2003	2537	143	1581	663	1434	1313	2145	2855	2031	1079	601	547
2004	491	7154	1551	431	877	1364	1328	2510	2606	986	357	265
2005	203	738	295	305	323	1306	1607	917	1138	1018	1170	3611
2006	26	5785	1859	590	777	1079	853	1009	1763	1931	1961	3753
2007	0	5	211	1458	1349	1395	415	250	287	307	382	4193

Table 6.3.4.2. (Cont.)

Sp. Bottom trawl

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	0	0	0	2	12	18	25	51	79	128	416	458
1993	0	2	14	37	42	182	667	1634	1695	2581	1936	6056
1994	0	0	0	5	44	65	193	658	1267	1286	1516	4087
1995	0	0	1	11	18	24	146	85	263	360	447	8060
1996	0	11	39	59	46	33	228	250	590	1466	1015	4973
1997	10	400	792	299	216	286	262	438	516	627	436	3555
1998	0	1	574	901	74	81	332	1518	1256	1377	1498	4686
1999	0	2	18	164	358	388	942	989	787	1000	846	4215
2000	0	0	3	219	876	2141	3457	3611	3245	2578	1594	1747
2001	47	89	106	261	915	2045	3267	4504	3957	1300	782	1940
2002	0	579	237	335	340	901	1500	2718	3220	3306	1896	2336
2003	0	0	35	521	370	426	1603	2334	2928	2337	1424	1179
2004	17	327	98	1787	1370	4474	4014	5276	4046	1559	3594	3834
2005	13	109	43	140	1682	1409	1768	2439	4211	3826	2530	4505
2006	443	4022	915	112	156	411	598	694	1242	2505	3690	9357
2007	0	70	11	4	6	23	388	829	2270	2110	2364	17195

Sp. Purse seine

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	790	14877	25764	9102	1538	263	18	21	20	18	35	39
1993	4150	6727	10476	6990	1564	317	339	619	472	766	575	1667
1994	5256	37078	24375	13047	4207	1133	563	570	1061	1251	2158	3079
1995	3311	41990	9807	11177	6712	2361	501	180	110	62	55	1024
1996	32956	3237	2769	4350	5279	2672	1514	1016	766	481	331	2190
1997	2079	34040	17176	4762	3895	4855	4138	5230	2663	2809	1473	3672
1998	9782	48725	56279	11227	6232	5034	5613	15313	8741	3621	2760	2041
1999	22602	16480	3749	13518	11994	6377	5824	3473	2025	2442	752	1326
2000	9888	32714	4999	9027	9779	5196	4066	1836	726	327	171	229
2001	15634	22765	18074	6626	3414	3294	2408	1959	901	251	210	637
2002	5553	17461	7083	2330	2421	2270	1971	2634	2145	1083	233	116
2003	13970	3051	7331	1686	2036	2370	4544	3719	2544	1446	674	260
2004	4826	30332	3471	1717	1025	1367	1057	1560	856	474	979	928
2005	8416	21553	5795	3889	3432	2172	1676	418	689	772	571	1018
2006	1048	12448	7154	3779	2024	2192	1506	1225	1638	1804	2037	1514
2007	2798	8476	4006	2296	2014	693	1801	1712	2799	1667	1323	2179

Sp. Artisanal

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992												
1993												
1994												
1995												
1996												
1997												
1998												
1999												
2000	0	0	2	26	40	27	30	33	31	25	22	22
2001	0	3	11	50	195	251	189	138	94	31	11	357
2002	0	10	3	3	3	12	29	55	74	73	45	66
2003	0	0	0	3	9	8	7	2	1	0	0	0
2004	0	0	1	25	20	66	121	149	103	35	98	167
2005	0	0	1	3	36	26	36	21	35	33	22	78
2006	0	5	16	27	60	64	41	32	30	33	41	73
2007	3	168	187	198	199	61	149	139	209	130	103	246

Table 6.3.5.1. Southern horse mackerel. Mean weight at age in the catch

YEAR	AGES 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
2007	0.028	0.048	0.057	0.070	0.093	0.113	0.162	0.193	0.232	0.223	0.237	0.260	0.294	0.266	0.323	0.363

Table 6.3.5.2. Southern horse mackerel mean length at age in the catch

YEAR	AGES 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
2007	14.60	17.49	18.53	20.02	22.09	23.64	26.90	28.72	30.64	30.33	30.92	31.83	33.42	32.16	34.49	35.74

Table 6.7.1.1. Southern horse mackerel. Numbers at age from ASAP assessment.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+
1992	7.66E+008	6.67E+008	3.36E+008	1.48E+008	9.10E+007	6.12E+007	2.45E+007	2.88E+007	3.27E+007	2.92E+007	5.13E+007	5.36E+007
1993	6.33E+008	5.86E+008	4.12E+008	2.07E+008	9.07E+007	6.40E+007	4.15E+007	1.67E+007	1.88E+007	1.89E+007	1.74E+007	7.13E+007
1994	4.49E+008	4.77E+008	3.46E+008	2.42E+008	1.20E+008	6.15E+007	4.14E+007	2.67E+007	1.01E+007	9.71E+006	9.88E+006	5.64E+007
1995	6.22E+008	3.45E+008	2.97E+008	2.14E+008	1.49E+008	8.43E+007	4.15E+007	2.78E+007	1.71E+007	5.65E+006	5.47E+006	4.45E+007
1996	1.40E+009	4.80E+008	2.18E+008	1.87E+008	1.34E+008	1.06E+008	5.78E+007	2.83E+007	1.80E+007	9.55E+006	3.14E+006	3.27E+007
1997	7.74E+008	1.12E+009	3.38E+008	1.53E+008	1.31E+008	1.02E+008	7.87E+007	4.27E+007	2.01E+007	1.15E+007	6.01E+006	2.50E+007
1998	3.82E+008	6.00E+008	7.18E+008	2.16E+008	9.72E+007	9.49E+007	7.19E+007	5.54E+007	2.89E+007	1.20E+007	6.95E+006	2.15E+007
1999	4.15E+008	2.78E+008	3.20E+008	3.81E+008	1.14E+008	6.37E+007	5.88E+007	4.45E+007	3.21E+007	1.35E+007	5.65E+006	1.66E+007
2000	3.52E+008	3.22E+008	1.78E+008	2.04E+008	2.42E+008	8.21E+007	4.42E+007	4.06E+007	2.93E+007	1.82E+007	7.54E+006	1.42E+007
2001	6.17E+008	2.71E+008	2.02E+008	1.11E+008	1.27E+008	1.72E+008	5.56E+007	2.95E+007	2.54E+007	1.51E+007	9.00E+006	1.23E+007
2002	5.10E+008	4.72E+008	1.68E+008	1.25E+008	6.80E+007	8.95E+007	1.15E+008	3.69E+007	1.83E+007	1.29E+007	7.36E+006	1.18E+007
2003	9.10E+008	3.92E+008	2.95E+008	1.04E+008	7.69E+007	4.80E+007	6.01E+007	7.63E+007	2.28E+007	9.29E+006	6.25E+006	1.06E+007
2004	1.36E+009	7.15E+008	2.62E+008	1.96E+008	6.88E+007	5.60E+007	3.36E+007	4.14E+007	4.96E+007	1.27E+007	5.00E+006	1.01E+007
2005	8.80E+008	1.10E+009	5.15E+008	1.87E+008	1.39E+008	5.15E+007	4.00E+007	2.31E+007	2.63E+007	2.58E+007	5.91E+006	7.68E+006
2006	5.03E+008	7.11E+008	7.93E+008	3.69E+008	1.33E+008	1.04E+008	3.71E+007	2.79E+007	1.50E+007	1.43E+007	1.28E+007	7.27E+006
2007	4.40E+008	4.07E+008	5.17E+008	5.74E+008	2.64E+008	9.92E+007	7.43E+007	2.54E+007	1.76E+007	7.82E+006	6.68E+006	9.99E+006

Table 6.7.1.2. Southern horse mackerel. Summary table from the ASAP assessment.

year	Recruits ('000)	Tot. Biomass (tonnes)	SSB (ton.)	Landings (tonnes)	Yield/SSB	Mean F (ages 1–11)	SOP
1992	7.66E+008	132363	94011	27858	0.30	0.29	100
1993	6.33E+008	123053	95672	31521	0.33	0.37	100
1994	4.49E+008	131809	97541	28451	0.29	0.31	100
1995	6.22E+008	126232	91837	25132	0.27	0.31	100
1996	1.40E+009	146008	99661	20360	0.20	0.21	100
1997	7.74E+008	153478	104893	29491	0.28	0.27	100
1998	3.82E+008	136197	107599	41661	0.39	0.44	100
1999	4.15E+008	126360	106852	27768	0.26	0.30	100
2000	3.52E+008	113059	97762	26161	0.27	0.35	100
2001	6.17E+008	106054	86001	24911	0.29	0.37	100
2002	5.10E+008	98100	72336	22506	0.31	0.37	100
2003	9.10E+008	97927	69722	18887	0.27	0.30	100
2004	1.36E+009	156022	86358	24485	0.28	0.33	100
2005	8.80E+008	135413	92005	22689	0.25	0.30	100
2006	5.03E+008	145400	109037	23895	0.22	0.33	100
2007	4.40E+008	166465	132222	22787	0.17	0.34	100

Table 6.8.1. Sourthern horse mackerel. Short-term forecast (2008–2010) for different catch options.

RATIONALE	LANDINGS (2008–2010)	BASIS	SSB (2008)	SSB (2010)	%SSB CHANGE 2008 TO 2010
Status quo catch	20,700	-10% *status quo* catch	139,000	167,000	20.5%
	23,000	*Status quo* catch	139,000	162,000	16.8%
	25,300	+ 10% *status quo* catch	139,000	157,000	13.0%
	27,600	+ 20% *status quo* catch	139,000	152,000	9.3%

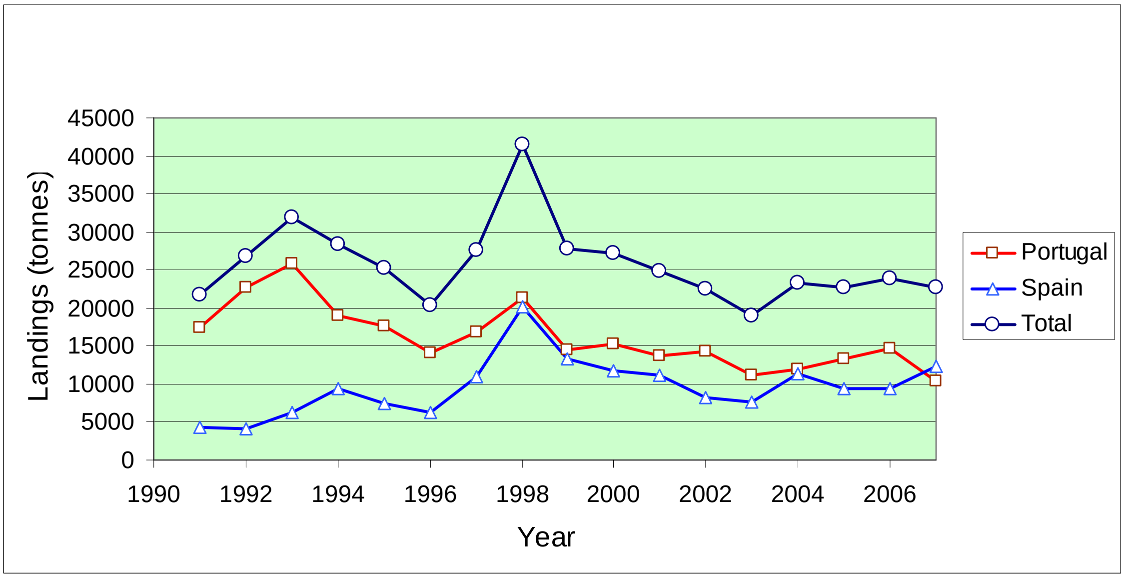


Figure 6.3.1.1. Southern horse mackerel. Historical series of the the stock landings including the landings by country.

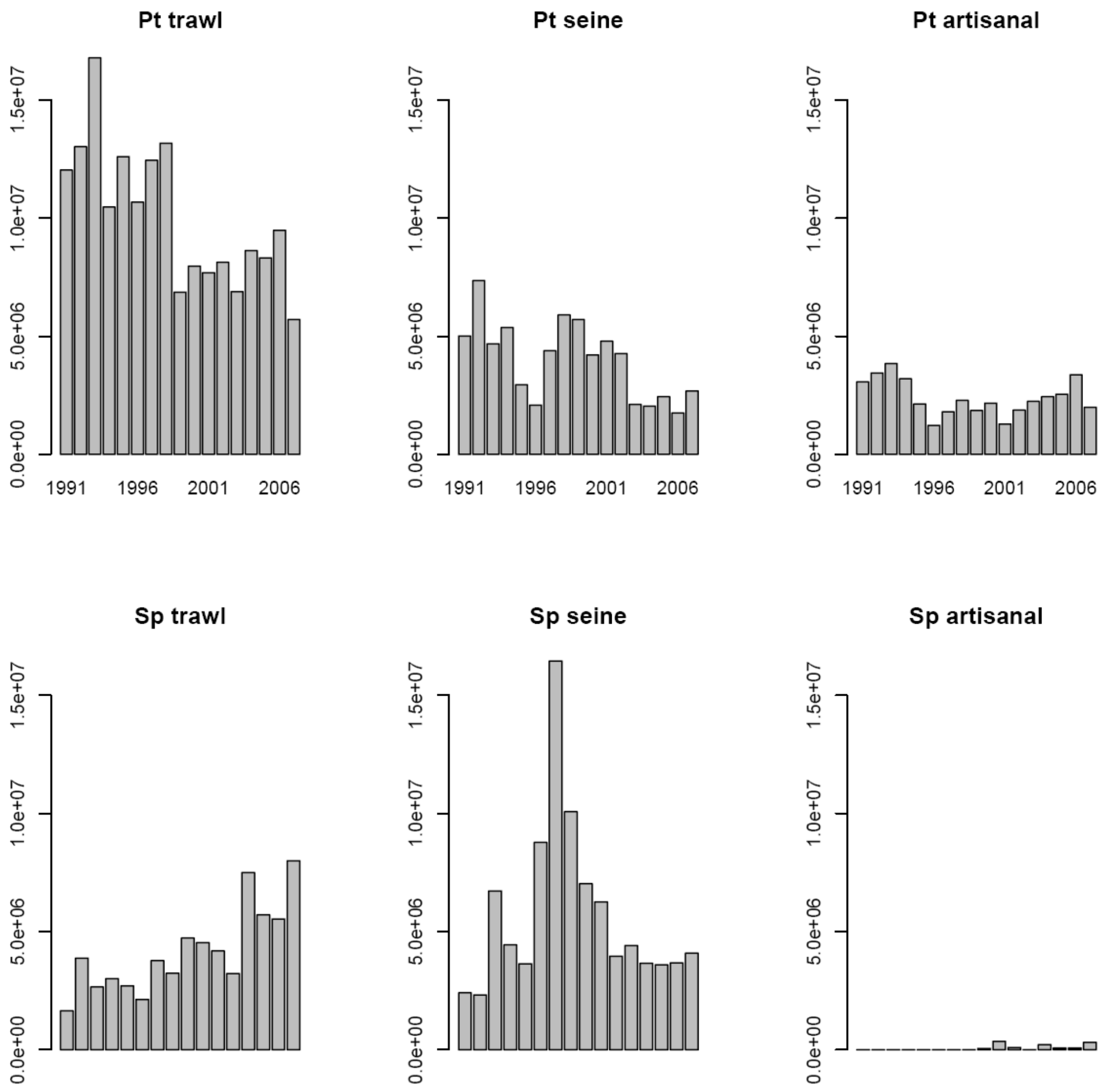


Figure 6.3.1.2. Southern horse mackerel. Historical series of catches by gear and country (Pt = Portugal; Sp = Spain)

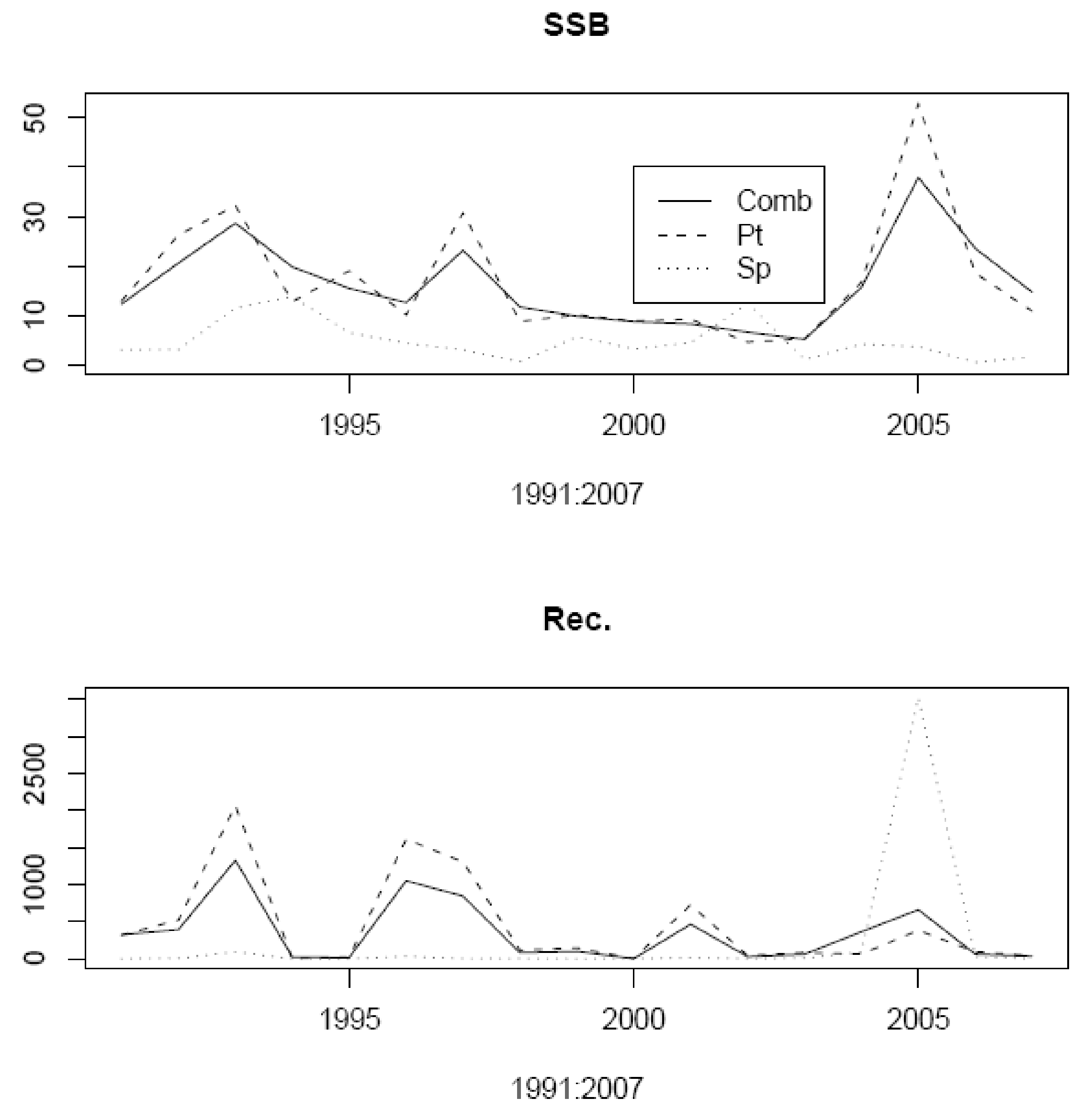


Figure 6.3.2.1.1. Southern horse mackerel. Historical series of biomass and recruitment index estimates from bottom trawl surveys (Pt = Portuguese, Sp = Spanish and combined).

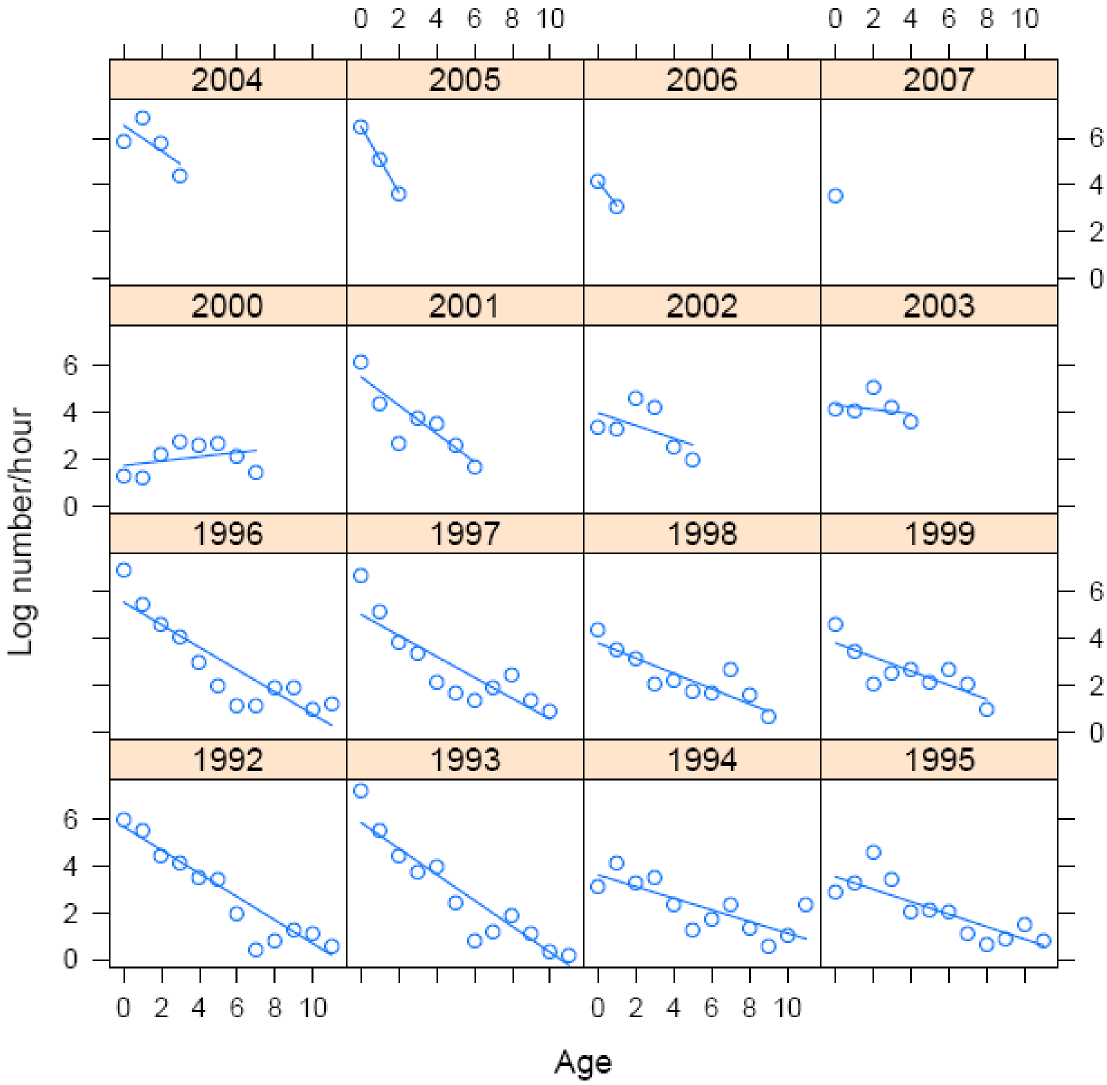


Figure 6.3.2.1.2. Southern horse mackerel. Evolution of several year-classes in the combined survey (Portuguese bottom trawl survey and Spanish bottom trawl survey)

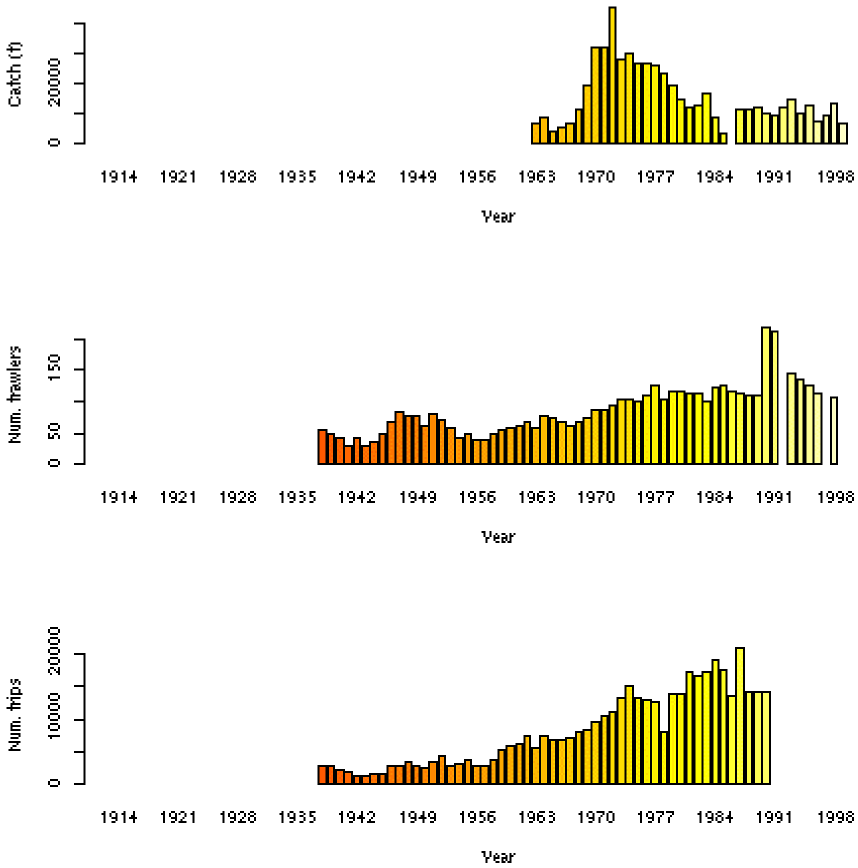


Figure 6.3.3.1. Southern horse mackerel. Time series of catch and effort from Portuguese bottom trawlers operating in Division IXa.

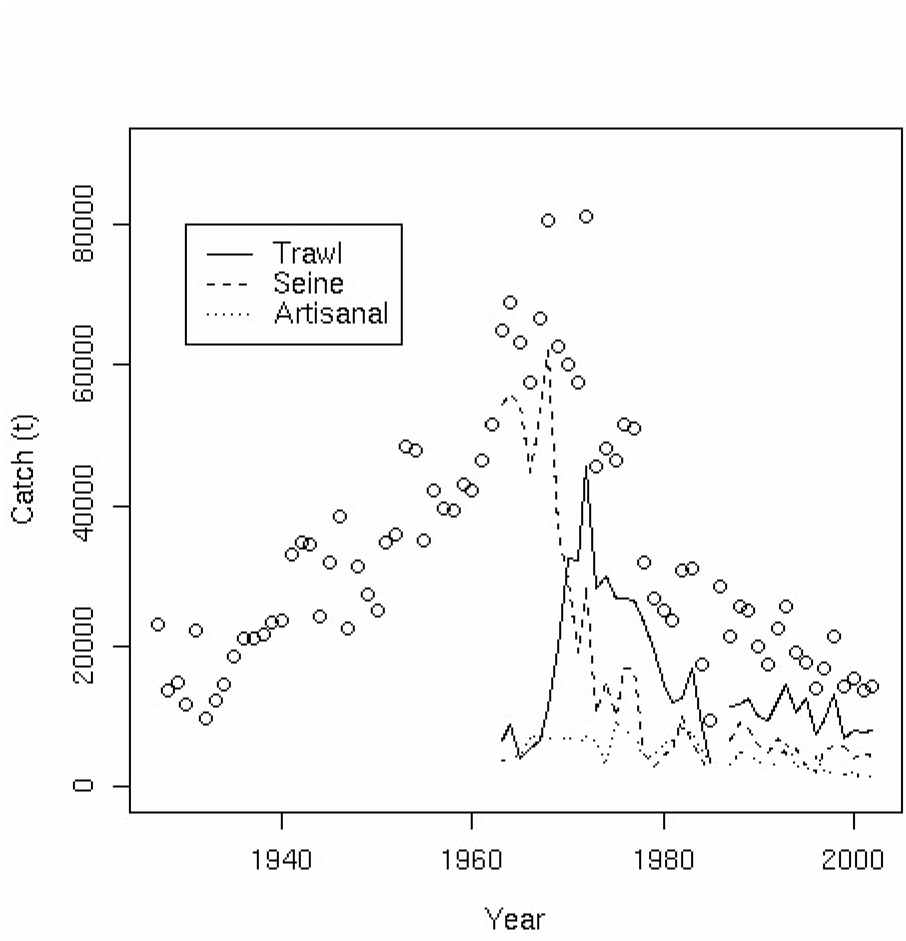


Figure 6.3.3.2. Southern horse mackerel. Time series of the Portuguese catches of horse mackerel in Division IXa: total and by fishing gear

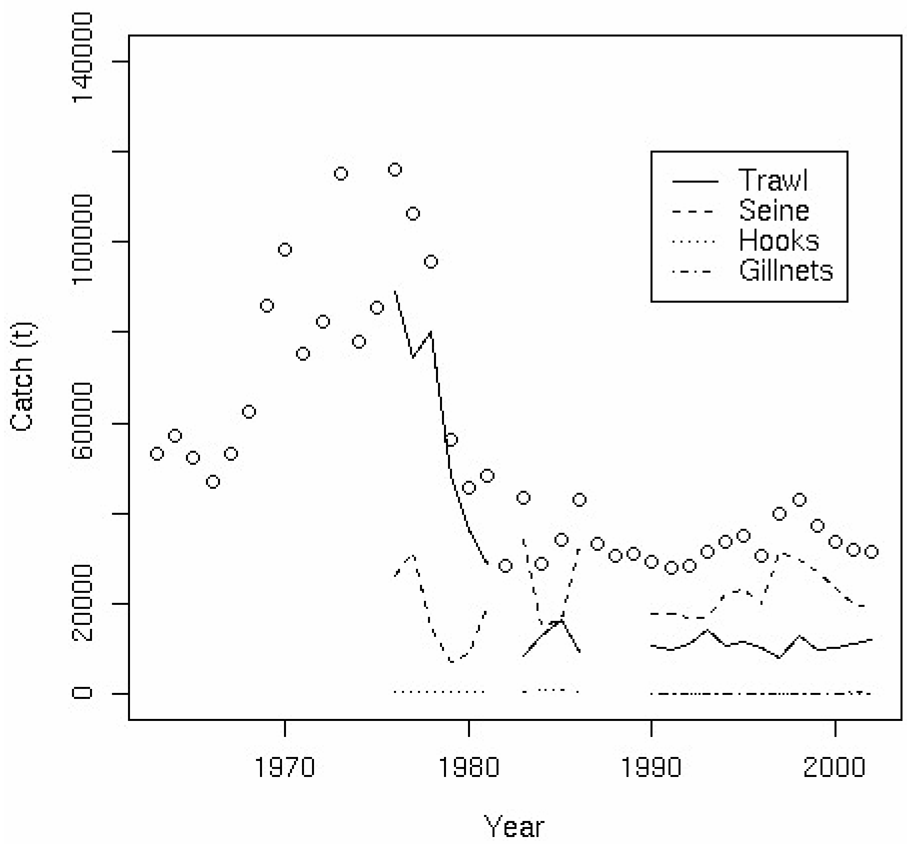


Figure 6.3.3.3. Southern horse mackerel. Time series of the Spanish catches of horse mackerel in Division IXa (Southern stock) and in Division VIIIc (Western stock): total and by fishing gear.

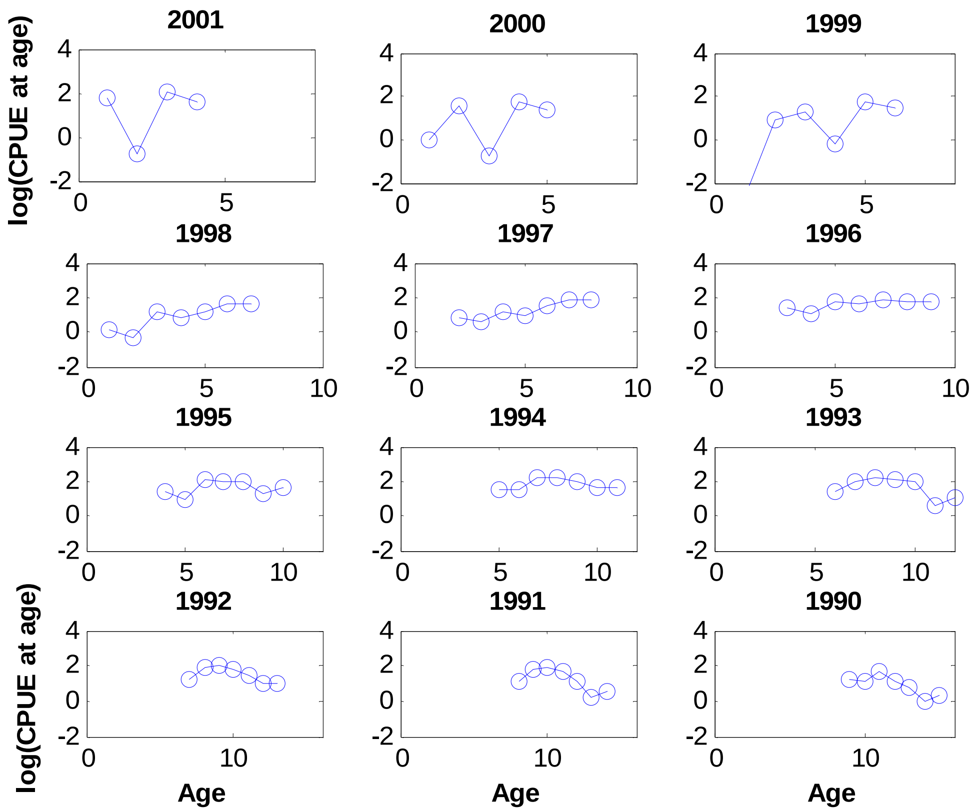


Figure 6.3.3.4. Southern horse mackerel. Marín bottom trawl fleet. Evolution of the index of abundance of several year classes (1990–2001).

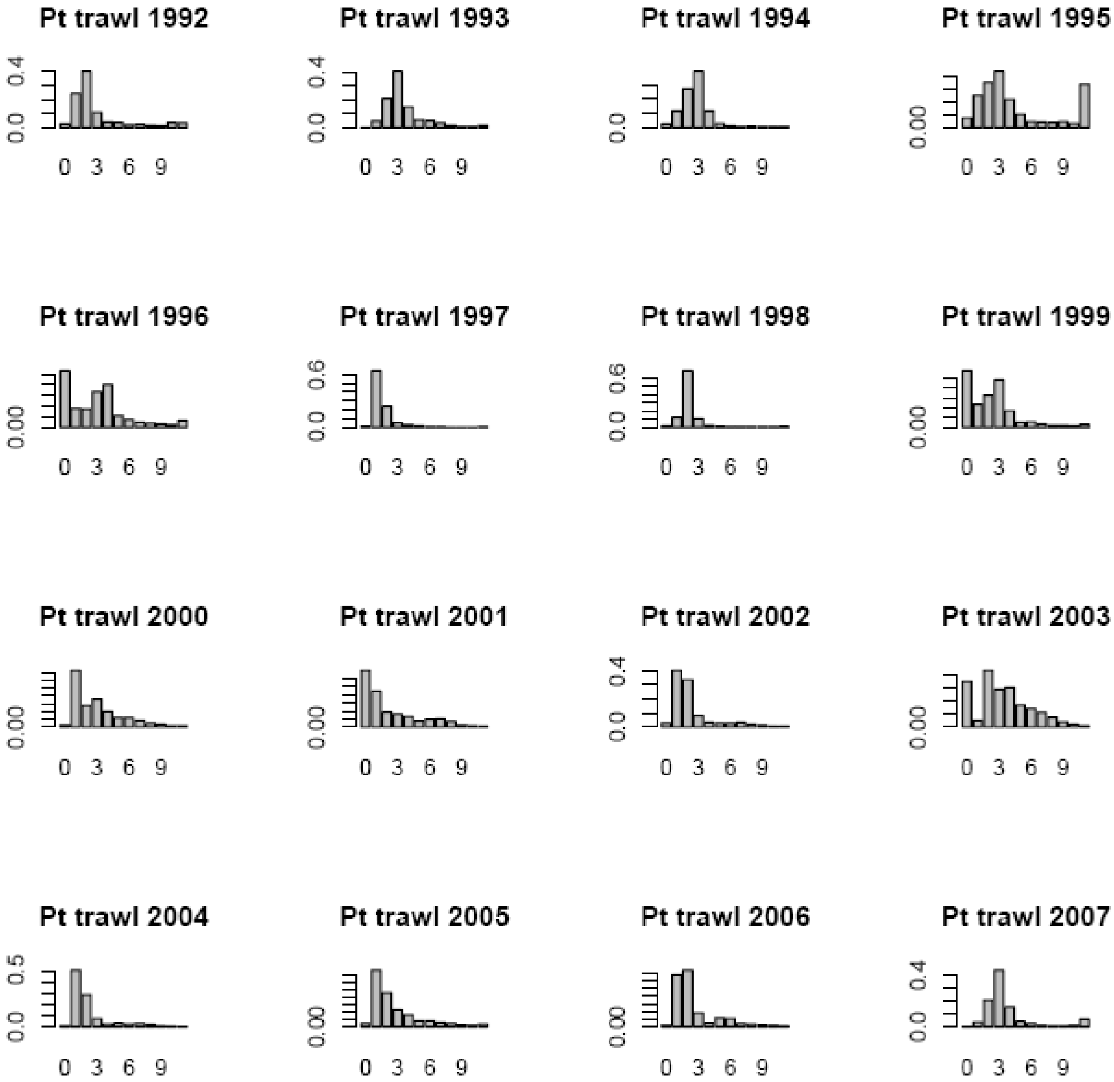


Figure 6.3.4.1. Southern horse mackerel. Historical series of proportions of catches at age by fishing fleet and country (Pt = Potugal; Sp = Spain; art. = artisanal)

Figure 6.3.4.1. (Cont.)

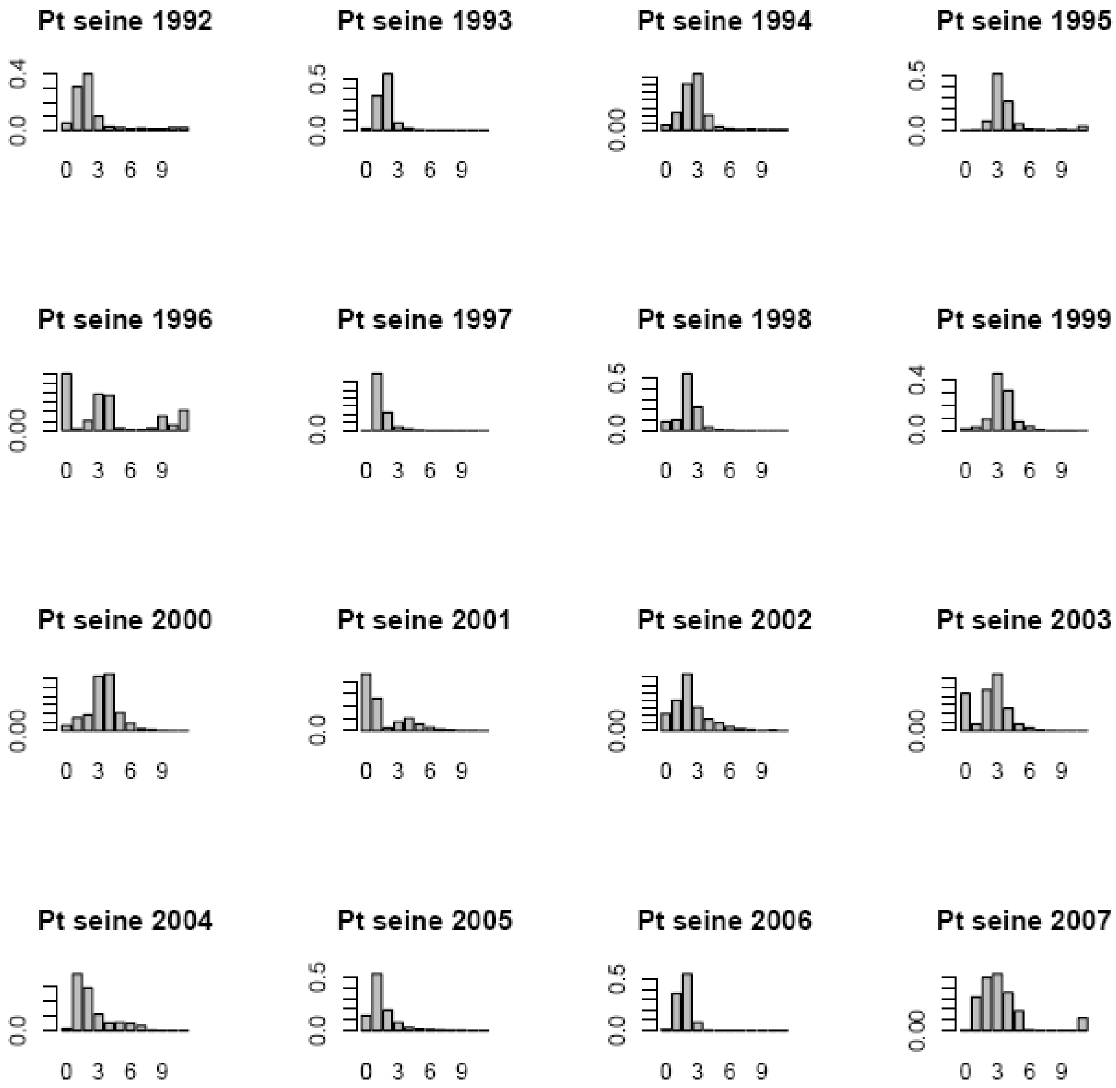


Figure 6.3.4.1. (Cont.)

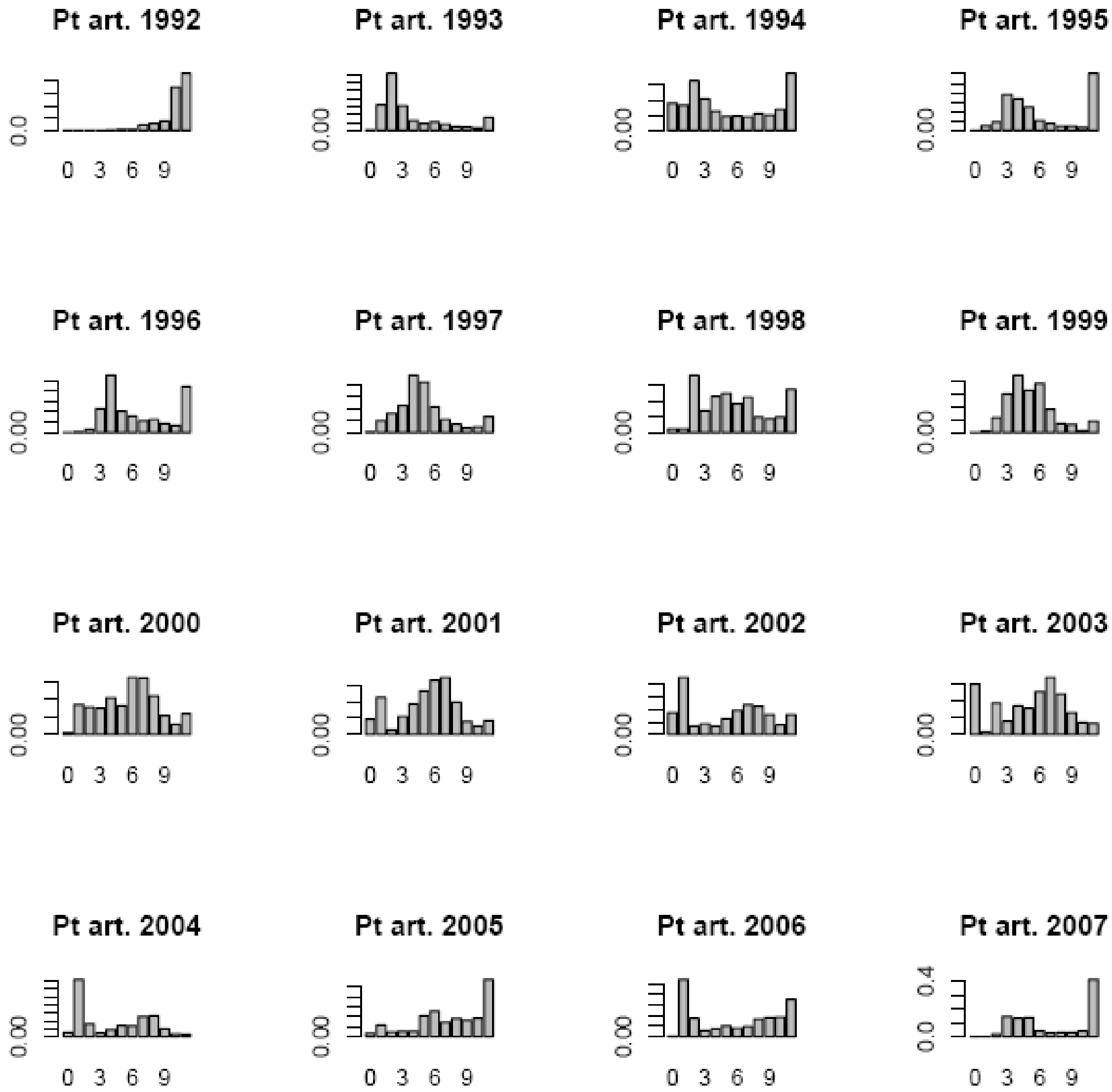


Figure 6.3.4.1. (Cont.)

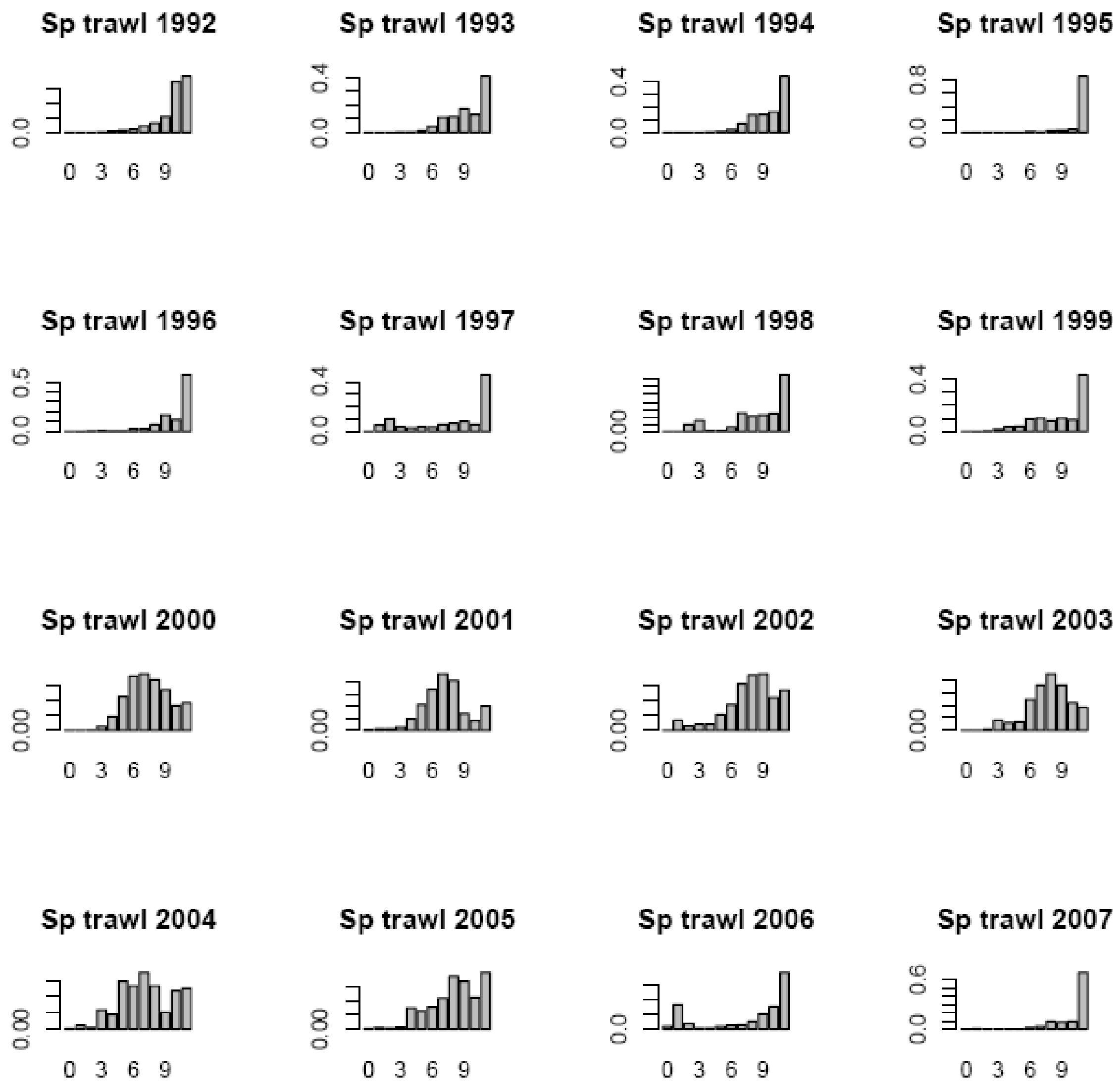


Figure 6.3.4.1. (Cont.)

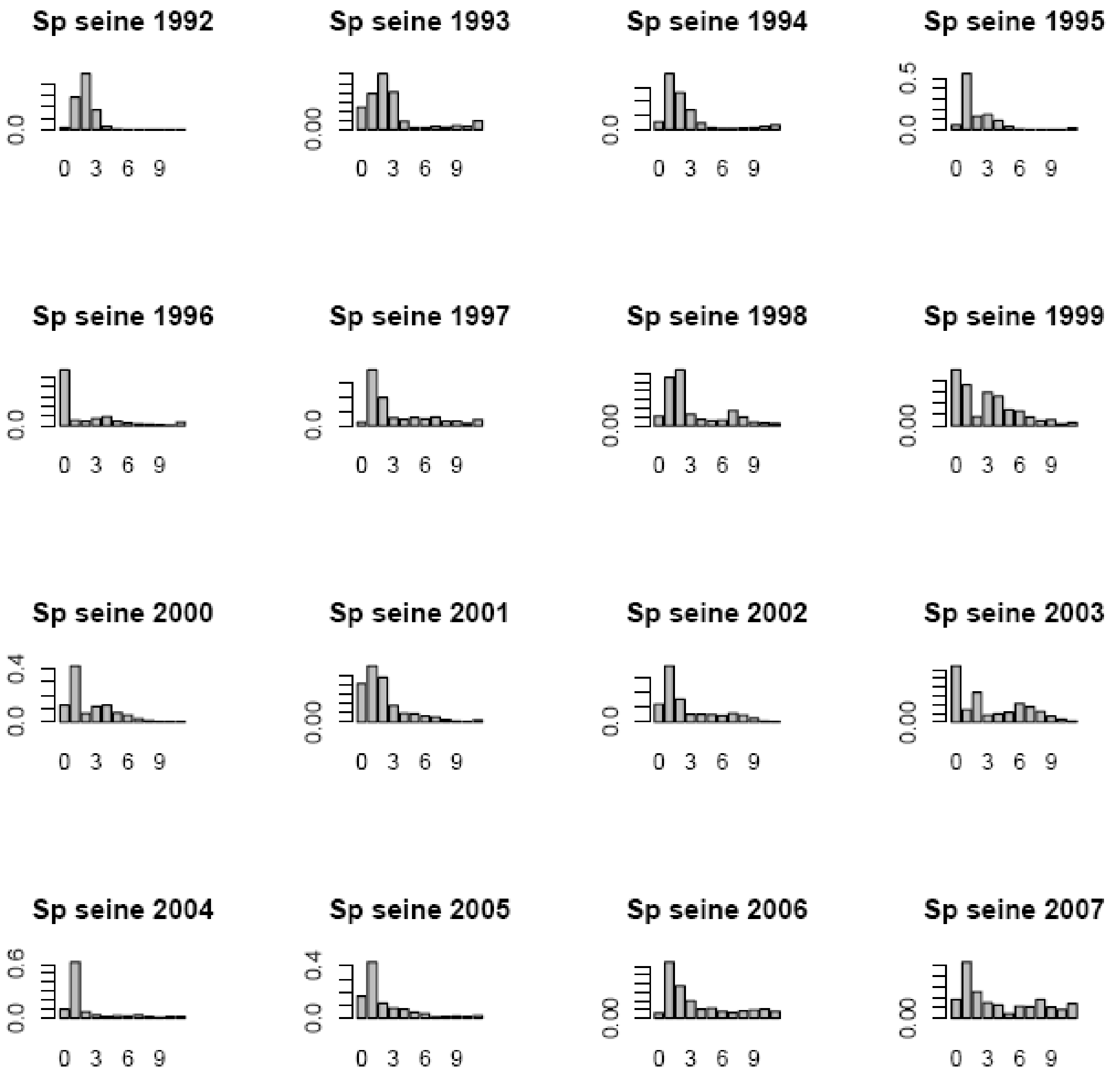
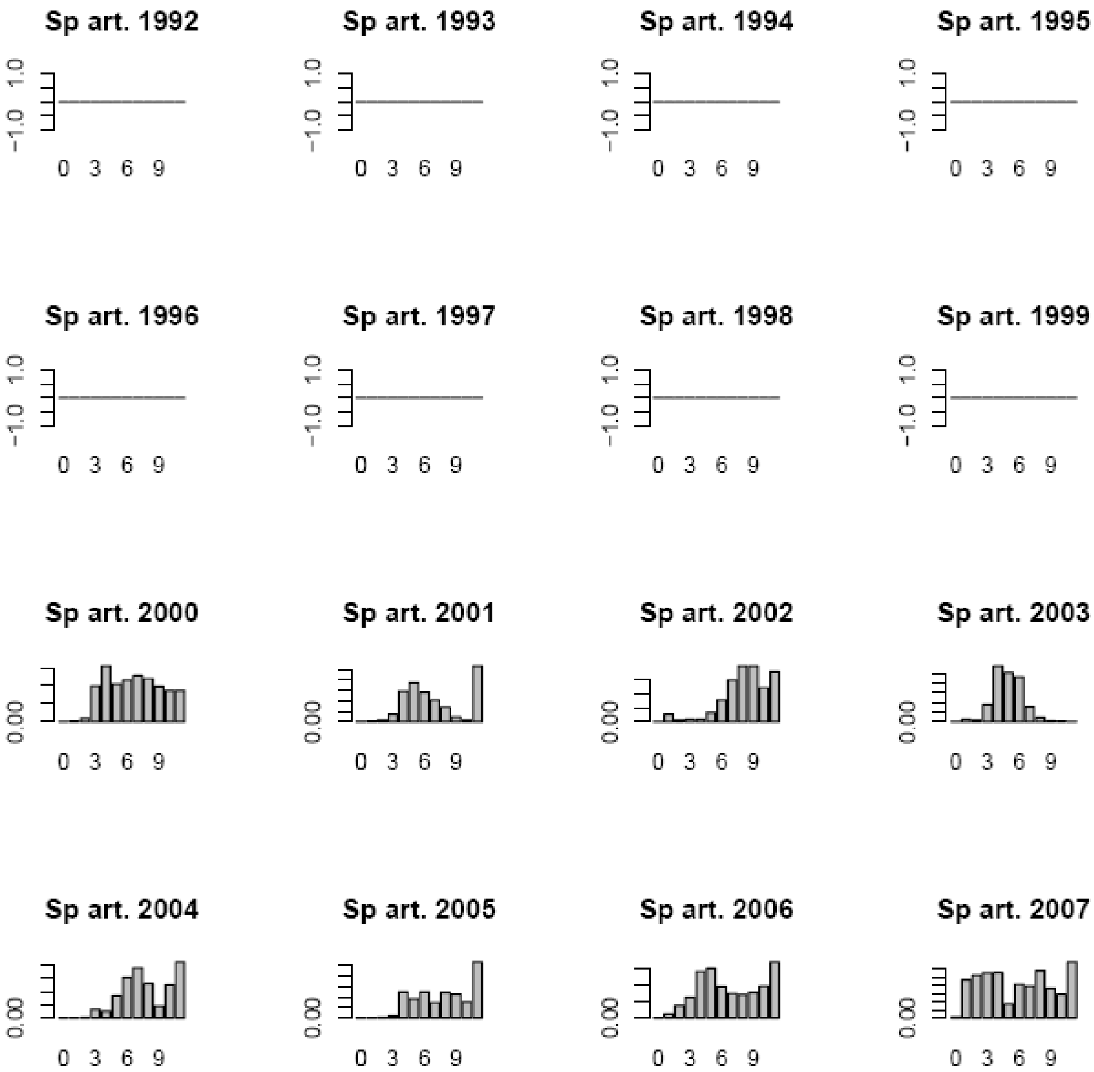


Figure 6.3.4.1. (Cont.)


Sp art. 1992
Sp art. 1993
Sp art. 1994
Sp art. 1995
Sp art. 1996
Sp art. 1997
Sp art. 1998
Sp art. 1999
Sp art. 2000
Sp art. 2001
Sp art. 2002
Sp art. 2003
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Sp art. 2005
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Sp art. 2007
-1.0 1.0
0.00
0 3 6 9

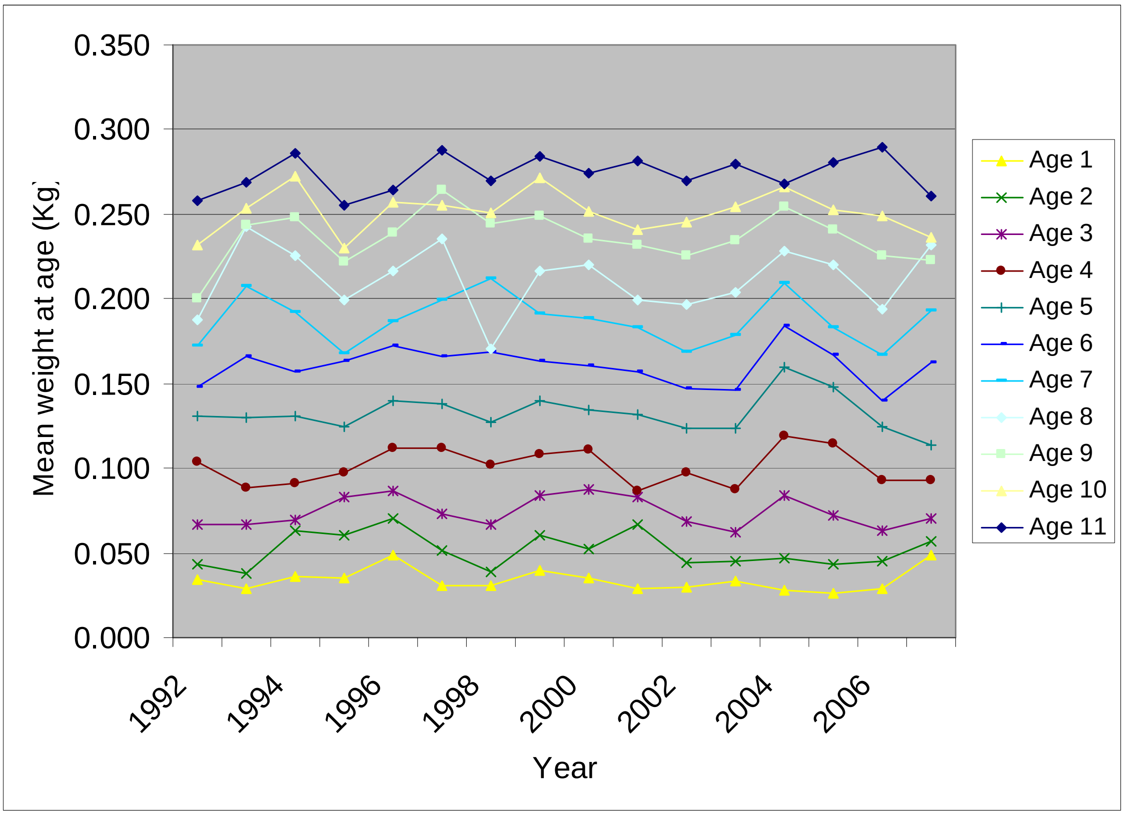


Figure 6.3.5.1. Southern horse mackerel. Time series of mean weight at age in the catch (from age 1 to 11)

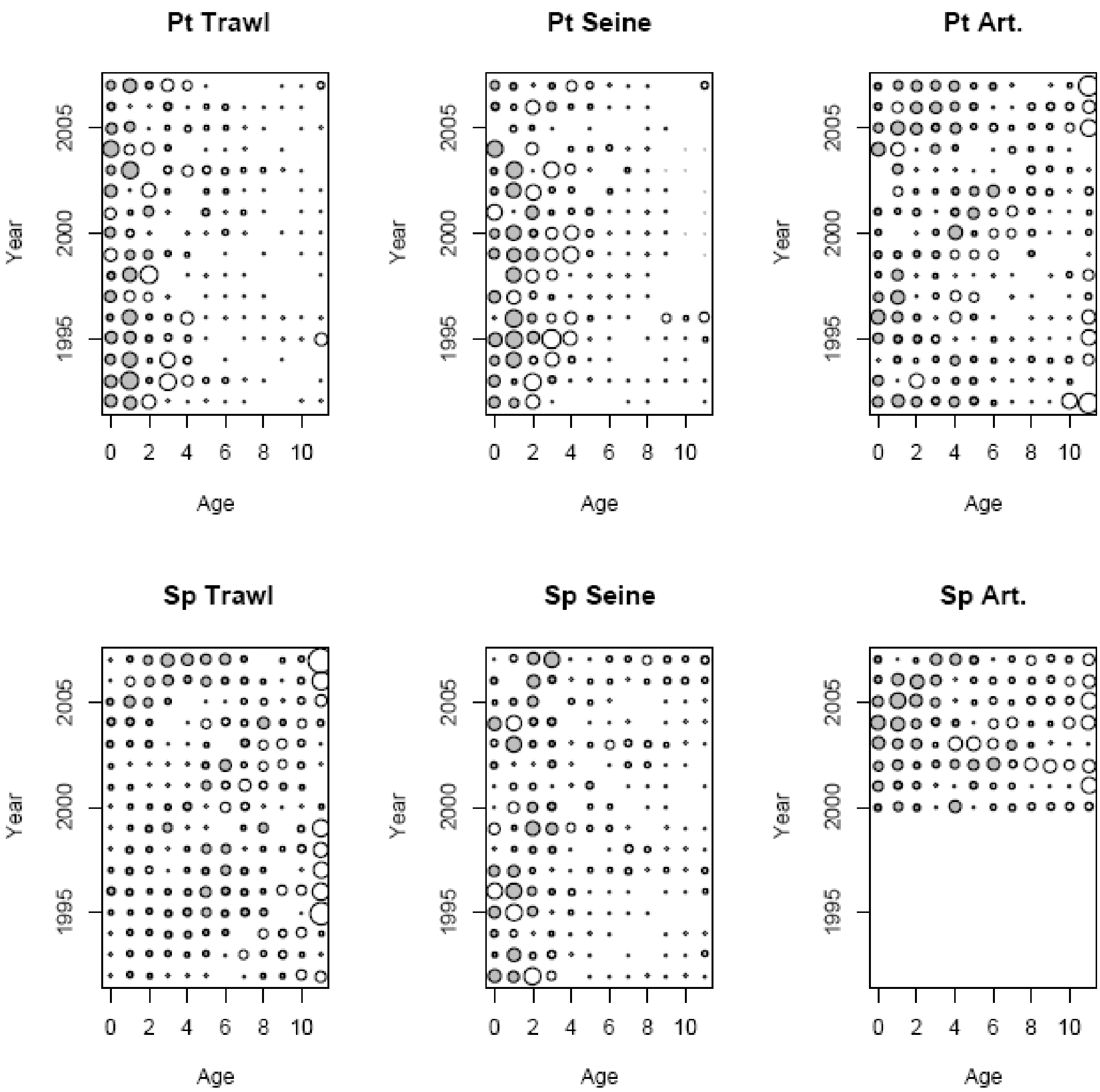


Figure 6.5.2.1. Southern horse mackerel. Catch proportion at age residuals from the ASAP assessment. In white = positive residuals; in grey = negative residuals. (Pt = Portuguese, Sp = Spainish)

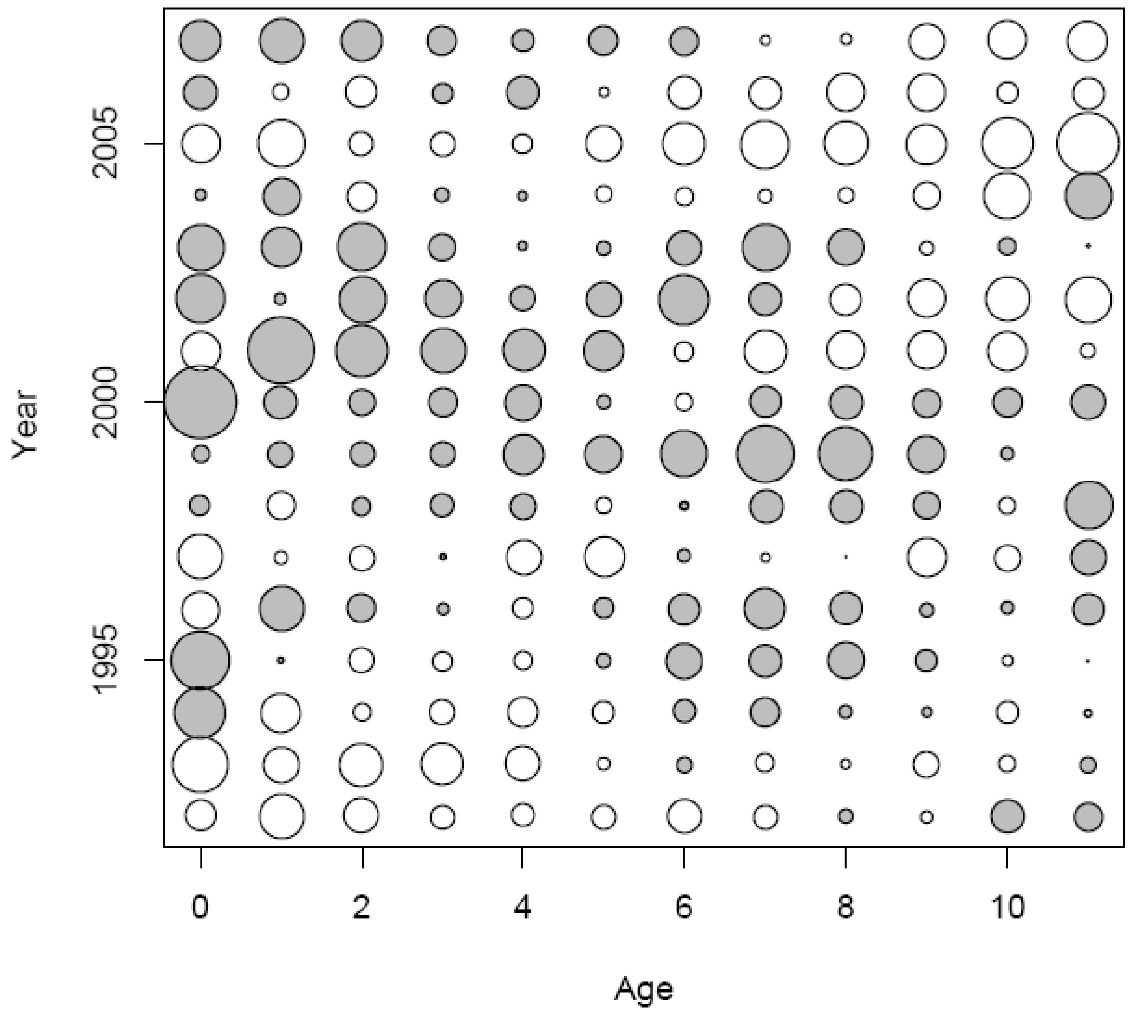


Figure 6.5.2.2. Southern horse mackerel. Bubble plot of bottom trawl survey residuals (raw) from the ASAP assessment. In white = positive residuals; in grey = negative residuals.

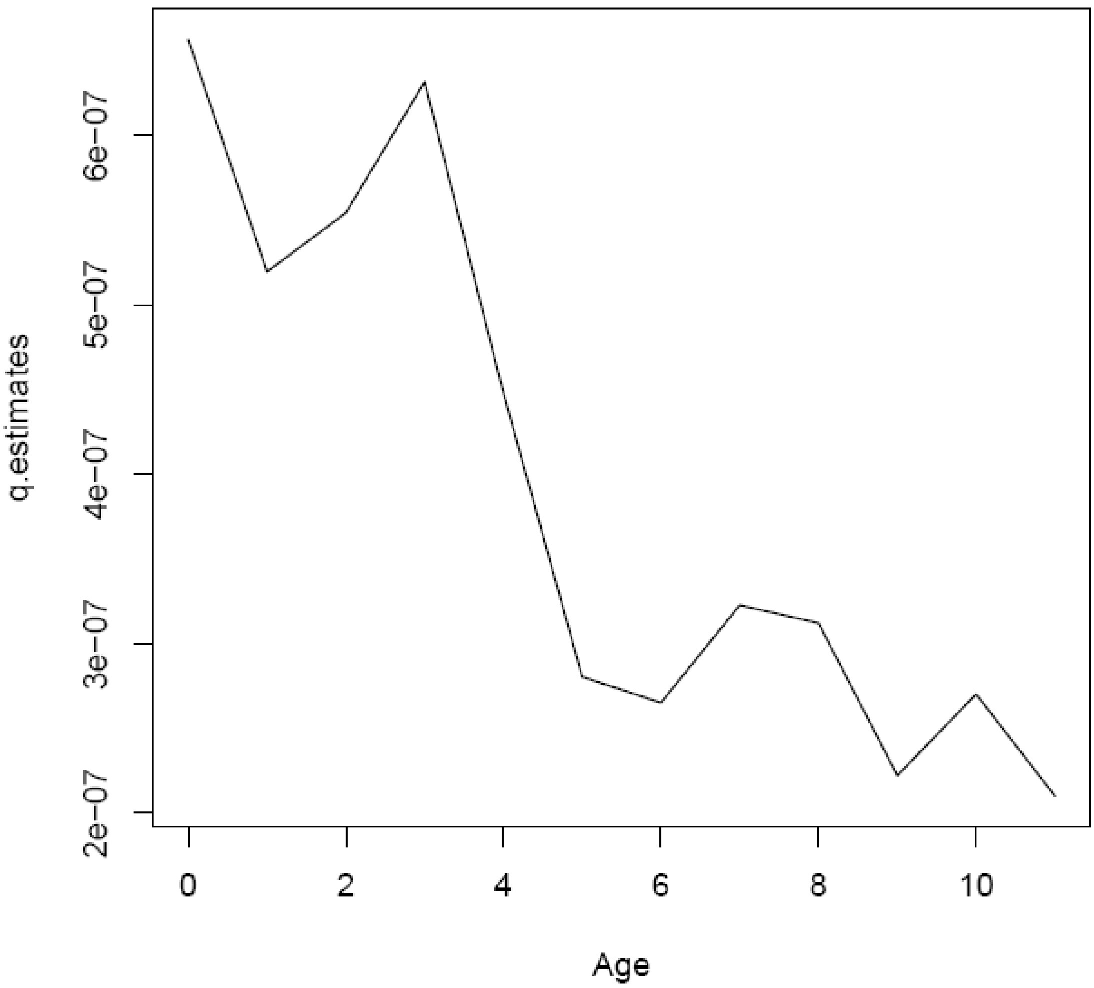


Figure 6.5.2.3. Southern horse mackerel. Catchability at age of bottom trawl survey

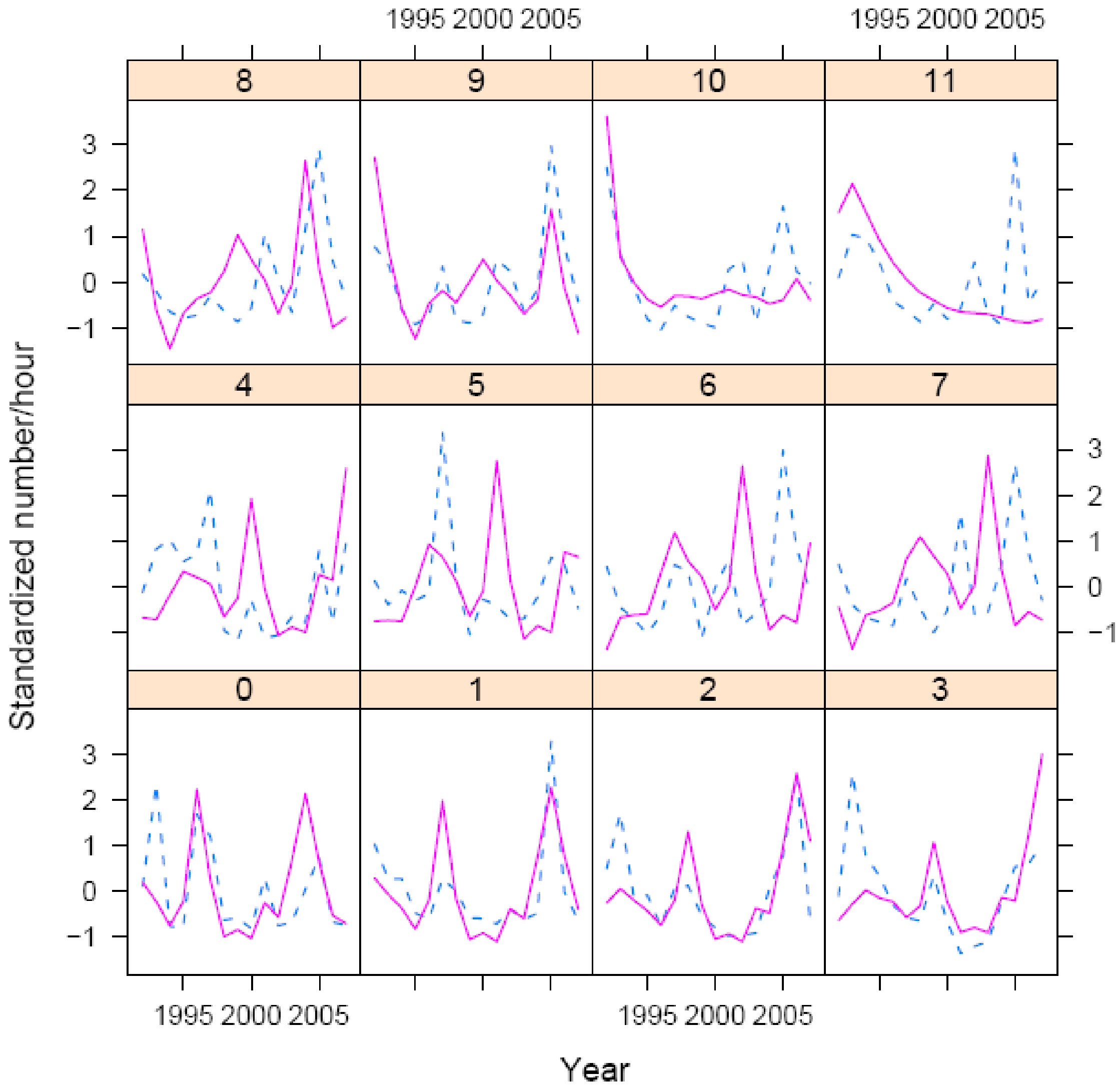


Figure 6.5.2.4. Southern horse mackerel. Comparison of observed bottom trawl survey values bay age and those fitted by the ASAP model. Observed values = dashed lines; fitted values = solid lines.

Figure 6.7.1.1. Southern horse mackerel. Retrospective analysis from the ASAP model. (four years backward were included).

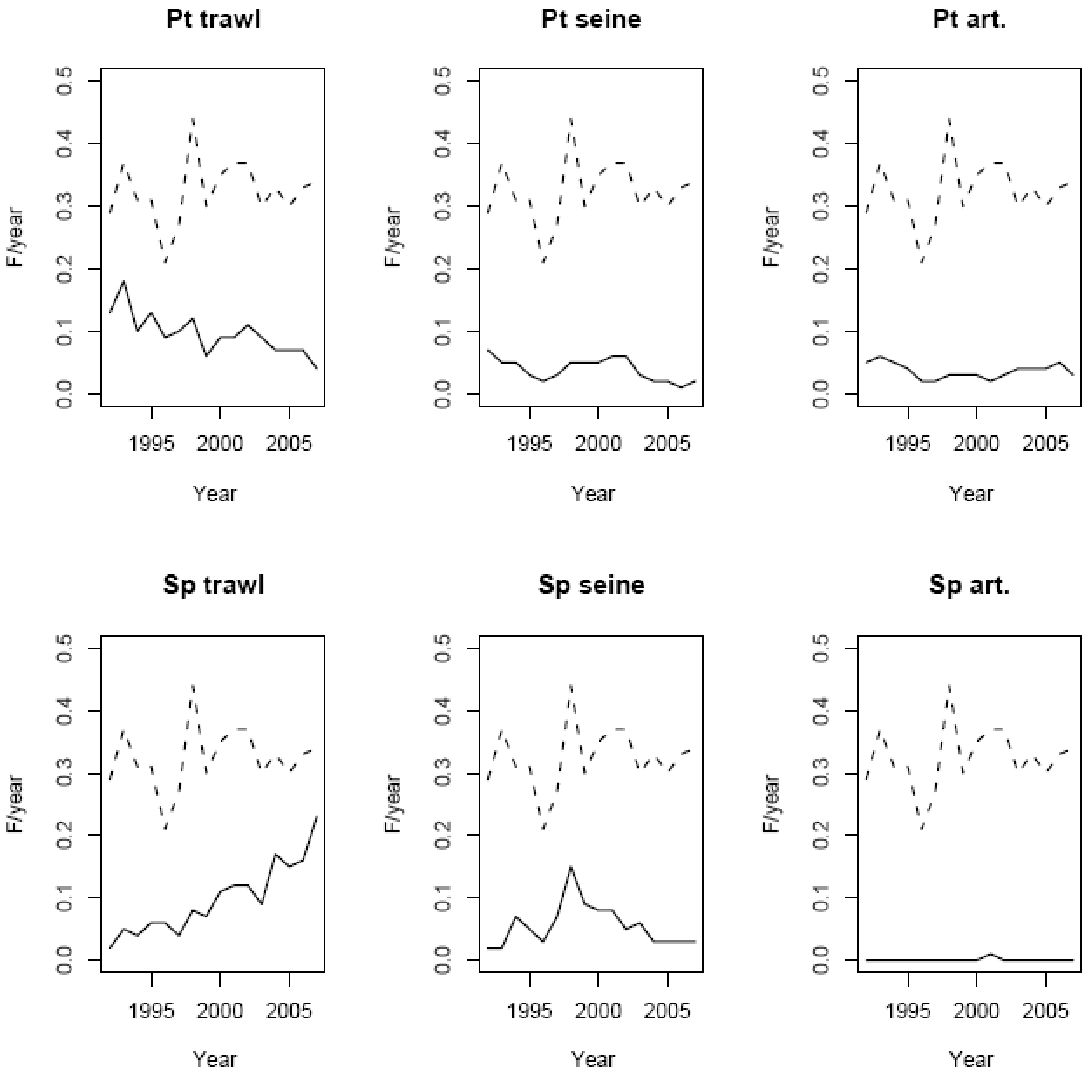


Figure 6.7.1.2. Southern horse mackerel. Mean Fishing mortality (1–11), overall (dashed line) and by fishing fleet (solid line), estimated by the ASAP model. (Pt = Portuguese; Sp = Spanish; art = artisanal).

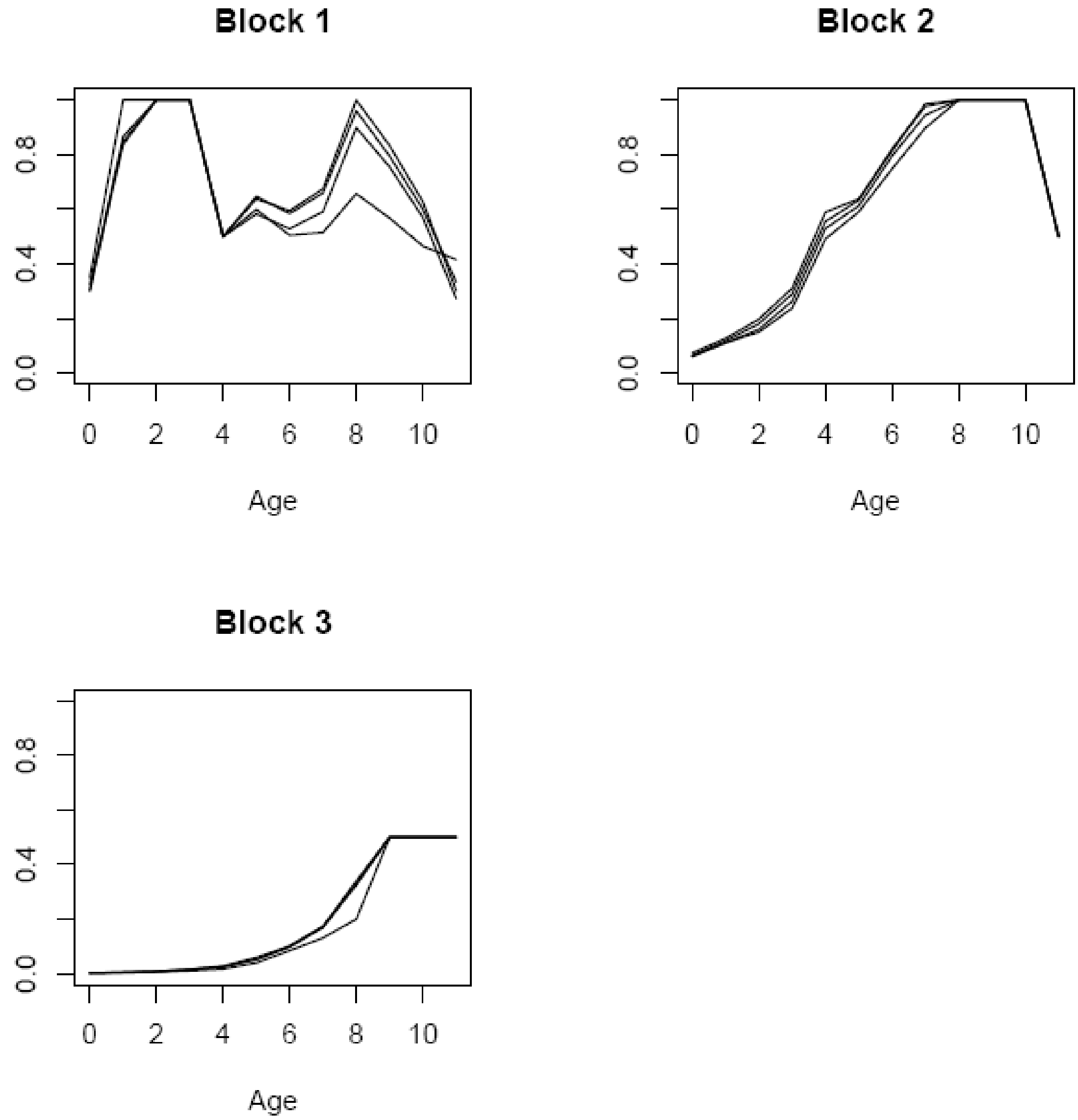


Figure 6.7.1.3. Southern horse mackerel. Retrospective analysis of the selectivity patterns from the ASAP model. Three blocks are defined: Block 1: Portuguese bottom trawl and purse seine fleets and Spanish purse seine fleet; Block 2: Portuguese and Spanish artisanal fleets; Block 3: Spanish bottom trawl fleet.

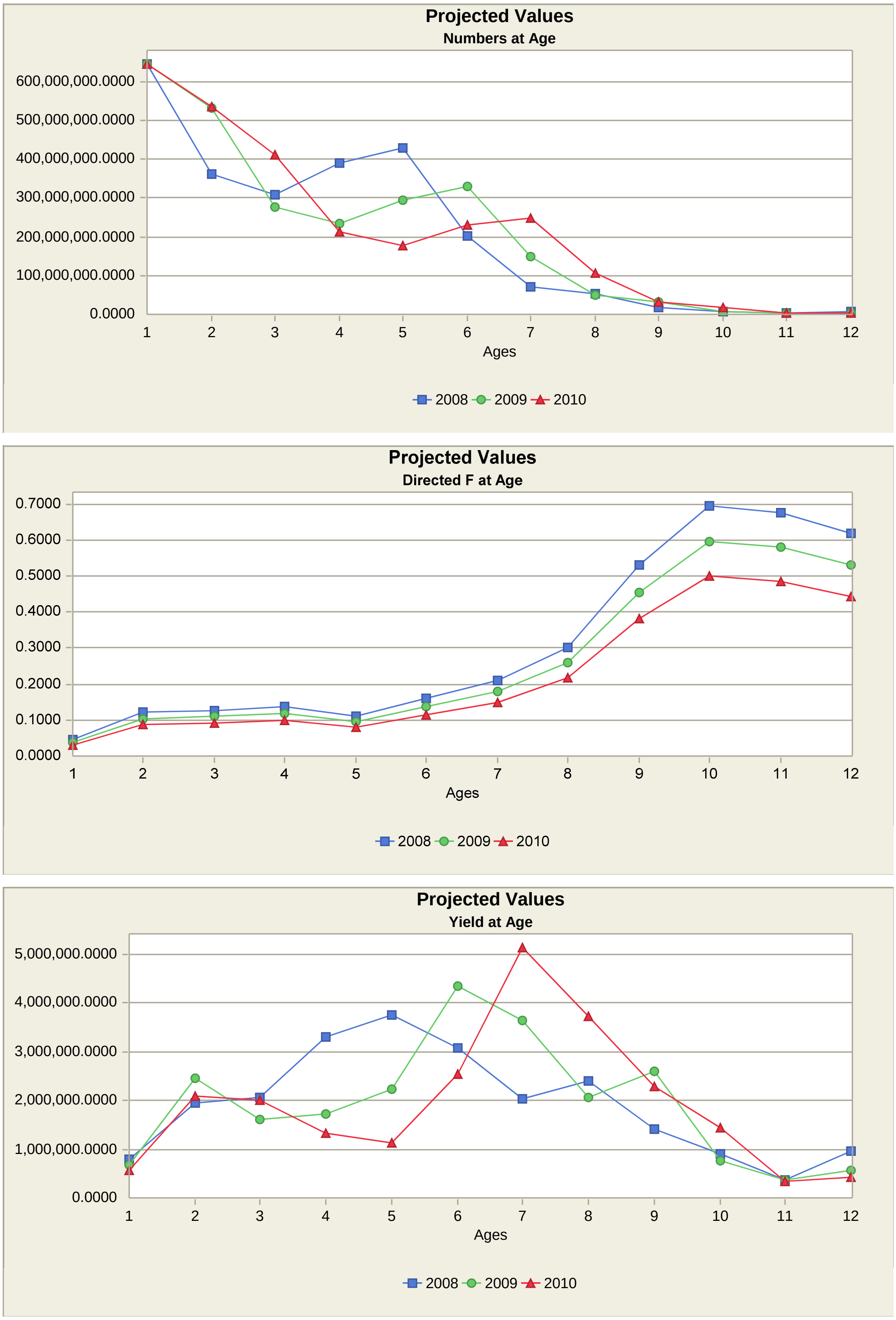


Figure 6.8.1. Southern horse mackerel short predictions. From top to down: Projected numbers at age; Projected fishing mortality at age; Projected yield at age. Note that the ages in x-axis should be from 0 to 11+.

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 (revised during WGACEGG in 2007), as well as catch data on age and length distribution for this species have been provided to the WG. The time series is now available since 2000 and a preliminary exploration of the data is presented in this section. 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 2007 were provided by Portugal, Spain, France, Ireland and UK (England and Wales) (Table 7.1.1.1). Data from Ireland are preliminary. Total reported catch was 124 398 tonnes, divided as follows: 52% of the catches by Portugal, 27% by Spain and 19% by France. The remaining 2% of catches are reported for divisions IVb and VIId-f by England and Wales and for divisions VIa and VIIj by Ireland. Catches in VIIIc and IXa amount to 78% 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 2007, there was a 6% decrease with respect to the total 2006 sardine catches in European waters (although it should be taken into account that not data were provided to the WG by Netherlands and Germany this year). Portugal and Spain showed a 15% and 1% increase in catches, respectively, with respect to 2006. Landings in France showed a 20% decrease while catches from England and Wales decreased by 9% in 2007. Figure 7.1.1.1 shows sardine catches by ICES statistical rectangle by the French and UK (England and Wales) fleet for the period 20030–7. The fishery tends to concentrate on the Channel and the south-west Brittany coast [the UK data by ICES rectangle have been made available to the WG this year for the first time].

There were also important landings (about 7 780 t) taken in division VIId in the eastern Channel, resulting from the catches of two single pelagic trawlers. However no biological data are collected on this fishery.

7.2 Catch and survey data for sardine in areas VIIIa and VIIIb

7.2.1 Catch data in areas VIIIa and VIIIb

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 2007 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 16 060 tonnes in 2007 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. In 2007 landings increased again reaching 1 200 tonnes. The Spanish fishery takes place mainly during March and April and in the fourth quarter of the year.

In France, the main fishery takes place in the north part of the Bay of Biscay (VIIIa – 15 725 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. Average vessel length is about 18 m. 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. The highest catches are taken in the summer months. Almost all the catches are taken in south-west Brittany. Due to the closure of the anchovy fishery in autumn 2005, 2006 and again in 2007, 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 20020–7 is shown in Figure 7.2.1.1. 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 7.2.1.2. shows French annual sardine landings by the different fleet components. Catches by purse seiners are increasing, while catches by pelagic trawlers remained stable for the last 6 years.

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. While most of the sardine taken by Spanish vessels in 2007 was bigger than 18 cm, catches in 2007 included a high proportion of smaller fish. French catches in divisions VIIIa and VIIIb are constituted by fish of a wider range of sizes.

7.2.2 Acoustic survey in areas VIIIa and VIIIb

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.-3. 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 proportions 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 biomass. Figures 7.2.2.1.-3 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 shows the influence of different pulses of recruitment from those of the northwestern Iberian areas.

7.2.2.1 French Spring Acoustic survey 2008

The French acoustic survey (PELGAS) takes place each spring in the Bay of Biscay on board the RV "Thalassa" with the main objective of studying the abundance and distribution of pelagic fish in the Bay of Biscay and to study the pelagic ecosystem as a whole. PELGAS08 took place from the 26th April to 26th May and detailed objectives, methodology and sampling strategy are described in the WD-Massé *et al* (2008) presented in this group.

Target species were anchovy and sardine but both species 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 frequencies: 18, 38, 70, 120 & 200 kHz) and pumping sea-water under the surface, in order to evaluate the distribution of fish eggs using the CUFES system, and ii) discrete sampling at stations (by trawls, plankton nets, CTD). Concurrently, a visual census of marine mammals and seabirds took place in order to characterise the top predators of the Bay of Biscay pelagic ecosystem.

Sardine was distributed close to the French coast, particularly in the southern part of the Bay of Biscay (Landes) mixed with anchovy. Along the southern Brittany coast pure sardine hauls were obtained (Figure 7.2.2.1.1). In the offshore area, sardine was generally found together with horse mackerel and mackerel, but while sardine was mainly detected at the surface the other species where found close to the bottom. As in previous years, young sardine (age 1 fish) were detected close to the coast, along southern Landes and Brittany.

Sardine ranged in length from 14.5 to 24.5 cm and showed a bimodal length distribution with modes at 17 cm (juvenile fish) and at 21 cm (adult fish) (Figure 7.2.2.1.2). Adult fish dominated the population in the offshore strata (depth >6. 0 m) while young fish were predominant in the inshore waters of division VIIIb and along the coast of Brittany.

The series of sardine biomass obtained in the PELGAS surveys (since 2000) has been revised and consolidated during the 2007 WGACEGG (see ICES, 2007e). With the exception of 2003 (an atypical year in terms of environmental conditions and therefore fish distributions), sardine biomass in the surveyed area (460 727 tons) in 2008 is one of the highest observed in the series.

Biomass (tonnes)	2000	2001	2002	2003[1]	2004	2005	2006	2007	2008
VIIIa	240 250	337 378	331 368	97 499	249 062	191 495	123 101	56 125	75 773
VIIIb	136 192	46 137	232 512	13 735	247 309	243 792	111 027	70 112	384 954
Total	376 442	383 515	563 880	111 234	496 371	435 287	234 128	126 237	460 727
CV	0.083	0.117	0.088	0.241	0.121	0.135	0.117	0.159	0.139

[1] the 2003 estimate has to be taken with caution since during the 2003 survey abnormally hot conditions induced an unusual behaviour in all pelagic species.

Sardine age distribution for the whole survey series shows poor recruitments in 2005 and 2006 while the 2007 year class (age 1 fish in 2008) appears to be one of the strongest of the series (Figure 7.2.2.1.3). Additional data provided to the WG shows that the strength of the 2007 year class was also apparent in the results of the Spanish acoustic survey PELACUS1007. [PELACUS1007 aims to obtain information on the abundance and distribution on juveniles and adults of anchovy and other small pelagics in the southern Bay of Biscay. The survey took place from the 17th of September to the 13th of October 2007]. During PELACUS1007 big concentrations of age 0 sardine were found close the coast in the inner part of the Bay of Biscay (Figure 7.2.2.1.4).

It should be taken into account that PELGAS takes place in spring and there is evidence that in some years an unknown part of the sardine population enters the surveyed area later in the year. Because of this, the figures obtained for the 2006 and 2007 year classes could be an underestimation since the 2006 year class (age 2 fish in 2008) is well represented in 2008.

7.2.2.2 Exploration of survey data

Data from French acoustic surveys 2002–2008 (excluding 2003) were explored to investigate the consistency of year-class signals and provide a first perspective of population trends in recent years. A year-class curve model (YCC, e.g. Cotter et al., 2007) was fitted to the log numbers-at-age for the whole survey area and all age groups (no plus group).

[The model is a linear regression (derived from the negative exponential equation describing year-class mortality) and has the general form:

$\log U_{a,c} = \log U_{0,c} + Zage + e_{a,c}$

where $U_{a,c}$ is the abundance of year-class *c* at age *a*, $U_{0,c}$ is the abundance of year-class *c* at age 0, *Z* is the average year class slope between ages 0 and *a*. Since surveys provide an index of abundance, the intercept of the YCC, $U_{0,c}$, estimates relative recruitment strength and the slope, *Z*, estimates the rate of decline of year class abundance due to combined effects of mortality (fishing and natural), migration and availability of the different age groups to the survey].

Figure 7.2.2.2.1 shows observed data and fitted regression lines for each year class. Despite substantial noise in the data, the mortality signal is clear for most year classes. An average Z = 0.65 year^{-1} was estimated by the model.

The plot of model residuals by age-group shows an increasing spread over age possibly due to higher uncertainty in age readings of older individuals (Figure 7.2.2.2.2). Residuals by year show strong year effects, particularly in the period 20052–008, which may reflect inter-annual changes in the spatial distribution of the population (Figure 7.2.2.2.3). The relative recruitment (at age 1) predicted by the model suggests a strong 2004 year class followed by 2 years of poor recruitment (also observed in the Atlanto-Iberian stock, see section 8). The 2007 year class seems to be strong but is still very uncertain. Estimated total biomasses show large discrepancies from observed values (up to 200 thousand t, Figure 7.2.2.2.4) but reflect the overall trend reasonably well. A decline of ca. 150 thousand tonnes across the period is indicated by the model.

Two variants of this model were explored, one assuming a linear trend in mortality over time (interaction between Age and Year) and the other, estimating separate Z's for each year class (interaction between Age and Year class). These models did not fit the data better as judged by the inspection of residuals and change in AIC.

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 with the exception on 2006 when age 2 were predominant and 2007 when age 1 and age 3 fish were predominant as a result of the strong 2004 year class (see figures 7.2.3.1.1 and 7.2.3.1.2). The 2004 year class can be followed in the catches of both countries.

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 and figure 7.2.3.2.1 for French landings and in Tables 7.2.3.2.3 and 7.2.3.2.4 for Spanish landings.

7.3 Future of assessment and management of sardine outside the stock area

The current perception of the sardine fishery is possibly influenced by the closure of the anchovy fishery. The French, and part of the Spanish pelagic fleet (both purse seiners and pelagic trawlers) are being subsidized not to fish. Catches on sardine are therefore possibly limited for this reason. The lack of anchovy could also shift the interest of the canning industry towards sardine.. A basic exploration of the French survey and catch data series has been carried out during this WG (see section 7.2.2.2.) with the aim of providing a first perspective of population trends in French waters.

For the above reasons, it is advisable to have a better knowledge of the dynamics of the Bay of Biscay sardine population and its seasonal migration in case of a future increase of the fishery. It is also desirable to collect survey data (e.g. Herring surveys in the Celtic Sea) and data from the fisheries (e.g. in the English Channel) in the northern areas to clarify the relationship between sardine from the Bay of Biscay and that distributed further north. For example, a survey carried out in spring, at the same time as PELGAS (at least one year), could provide an estimation of the part of this population that could be missed by the PELGAS survey in some years.

There is evidence of different recruitment pulses between French and Atlanto-Iberian stock waters at least in some years (for instance there was a strong 2007 year class in VIIIb which was not apparent in VIIIc or IXa). More detailed knowledge on sardine dynamics outside the Iberian stock area may help clarify the level of exchange between both.

Table 7.1.1.1: Sardine general: 2007 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								0
IVb					24			24
IVc			4		101			105
VIa				68				68
VIIa								0
VIIb								0
VIIc								0
VIId			356		7780			8136
VIIe			1223					1223
VIIf			993					993
VIIg								0
VIIh								0
VIIi								0
VIIj				14	44			58
VIIIa					15725			15725
VIIIb					335	1263		1598
VIIIc						13380		13380
VIIId								0
VIIIe								0
IXaN						12402		12402
IXaCN							41 090	41090
IXaCS							19 142	19142
IXaS-Alg							4 266	4266
IXaS-Cad						6188		6188
Total	0	0	2576	82	24009	33233	64498	124398

Table 7.2.1.1: Sardine general: Landings by France (1983-2007) and Spain (1996-2007) 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
2007	16,060	1,263

* 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 2007.

Length	1st quarter	2nd quarter	3rd quarter	4th quarter	Total
7					
7.5					
8					
8.5					
9					
9.5					
10					
10.5					
11	2	24			26
11.5			109	23	132
12	4	47	273	57	382
12.5	8	147	328	69	551
13	66	427	656	138	1 286
13.5	52	720	1 055	195	2 022
14	67	858	1 079	282	2 287
14.5	87	1 879	1 247	388	3 601
15	77	2 199	1 922	521	4 719
15.5	92	3 707	3 026	665	7 490
16	87	4 387	3 413	660	8 547
16.5	72	5 539	3 427	592	9 630
17	65	3 217	3 456	411	7 149
17.5	71	2 023	4 854	313	7 261
18	69	1 273	4 346	491	6 180
18.5	126	777	3 318	1 083	5 305
19	175	1 024	3 204	1 463	5 866
19.5	141	1 512	2 918	2 580	7 151
20	252	3 413	6 105	2 185	11 955
20.5	95	4 441	13 715	2 574	20 824
21	217	3 665	21 326	2 943	28 149
21.5	365	3 126	16 423	2 663	22 577
22	696	2 845	10 540	3 072	17 153
22.5	997	1 966	4 902	3 147	11 012
23	1 209	1 500	4 412	3 072	10 194
23.5	1 057	879	2 206	1 873	6 016
24	634	362	1 471	1 199	3 666
24.5	695	347	245	525	1 811
25	544		490	225	1 259
25.5	302			75	377
26	30	52			82
26.5	91				91
27	30				30
27.5					
28					
28.5					
29					
Total	8 474	52 352	120 469	33 484	214 780
Mean L	22.5	18.8	20.2	20.9	20.1
sd	2.75	2.86	2.47	2.55	2.74
Catch	**912**	**3197**	**9 121**	**2830**	**16 060**

Table 7.2.1.3: Sardine general: Spanish catch length composition (thousands) in ICES division VIIIb in 2007.

Length	1st quarter	2nd quarter	3rd quarter	4th quarter	Total
7					
7.5					
8					
8.5	1				1
9	1				1
9.5	1				1
10					
10.5					
11					
11.5					
12					
12.5					
13		7			7
13.5	15			71	86
14	9	7			16
14.5	23				23
15	79			6	85
15.5	74	7		344	425
16	141	7		241	389
16.5	217	72		444	733
17	367	65		783	1 215
17.5	471	50		1650	2 172
18	546	50		2343	2 939
18.5	317	29		2646	2 991
19	180			1540	1 720
19.5	168	14		967	1 150
20	97	7		413	517
20.5	29			228	257
21	9			46	55
21.5	14	14			28
22					
22.5					
23					
23.5					
24					
24.5					
25					
25.5					
26					
26.5					
27					
27.5					
28					
28.5					
29					
Total	2 759	331		11 722	14 813
Mean L	17.9	17.7		18.4	18.3
sd	1.33	1.50		1.11	1.18
Catch	**223**	**26**		**1014**	**1 263**

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**	**2007**
0					
1	6192	1765	2917	1586	949
2	1954	4075	492	1269	371
3	1507	1827	331	1124	1120
4	2077	712	516	1093	757
5	1393	572	707	1037	731
6	835	414	639	829	1511
7	706	167	511	669	1374
8	411	107	480	553	796
9	93	28	344	306	433
10			23	115	255
11			28	45	93
12				13	60
13				18	
14					25
Total	15169	9668	6988	8657	8474
Catch (Tons)	1157	722	540	792	912

					Second Quarter
Age	**2003**	**2004**	**2005**	**2006**	**2007**
0					
1	21560	45623	27723	17299	26903
2	10030	11971	9398	17308	4937
3	4312	8593	6247	7213	11367
4	3178	3517	7563	4065	2620
5	2058	1901	5952	2893	1921
6	1238	1182	4300	2114	2220
7	1377	458	2470	1266	1168
8	691	211	1135	1017	734
9	127	55	424	412	305
10			75	128	127
11				47	12
12				8	26
13				11	
14					12
Total	44572	73512	65285	53781	52352
Catch (Tons)	2959	3386	4307	3580	3197

					Third Quarter
Age	**2003**	**2004**	**2005**	**2006**	**2007**
0	4057	18991	3380	8360	19992
1	50623	21426	52448	15459	30120
2	35992	27906	28025	56617	15407
3	12960	20653	18698	16727	32647
4	6133	8136	11547	11545	5595
5	2614	4975	8777	7335	6968
6	1672	575	2653	3906	4930
7	431	388	1088	2744	2865
8	231	183	894	1012	1182
9	216	135	385	272	634
10			8	110	127
11				24	
12					
13					
14					
Total	114928	103368	127904	124112	120469
Catch (Tons)	8574	7312	9553	9413	9121

					Fourth Quarter
Age	**2003**	**2004**	**2005**	**2006**	**2007**
0	325	3078	734	536	4001
1	6531	18183	2042	753	7975
2	9559	5350	1531	7567	3359
3	5323	4219	1404	2818	7016
4	3152	1858	1518	2461	2175
5	2450	1313	1341	2217	3175
6	1716	322	949	1951	2515
7	484	186	781	1919	1673
8	201	64	584	744	829
9	233	31	340	630	617
10		23	63	192	150
11			31	277	
12				126	
13					
14					
Total	29975	34627	11316	22190	33484
Catch (Tons)	2805	2436	1062	2130	2830

					Whole Year
Age	**2003**	**2004**	**2005**	**2006**	**2007**
0	4382	22069	4114	8896	23994
1	84906	86997	85129	35097	65947
2	57535	49301	39446	82760	24075
3	24102	35292	26680	27882	52150
4	14541	14224	21144	19164	11147
5	8515	8762	16776	13482	12795
6	5461	2493	8541	8801	11176
7	2998	1200	4850	6597	7079
8	1534	565	3093	3325	3540
9	670	250	1493	1621	1989
10		23	169	545	659
11			59	393	105
12				147	86
13				29	
14					37
Total	204644	221174	211493	208740	214780
Catch (Tons)	15494	13856	15462	15916	16060

Table 7.2.3.1.2: Sardine general: Spanish landings in ICES division VIIIb: catch in numbers (thousands) at age by quarter and year.

						First Quarter
Age	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
0						
1	3375	3		3370	337	103
2	2857	45	363	591	585	312
3	1989	31	299	613	1159	1304
4	1011	25	515	633	973	356
5	422	18	481	486	825	249
6	222	7	228	266	328	242
7	89	7	97	110	212	147
8	49	1	53	43	77	23
9	36	1	25	40	33	18
10	1		8			6
11						
12				3		
13						
Total	10049	138	2069	6155	4530	2759
Catch (Tons)	555	10	150	298	370	223

						Second Quarter
Age	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
0						
1	20789	4349	1041	2113	154	16
2	2792	2551	59	435	556	49
3	1455	1477	91	286	613	171
4	824	882	85	317	497	34
5	290	520	40	253	391	18
6	107	225	16	155	169	18
7	40	236	8	70	122	15
8	19	40	3	28	57	4
9	18	17	1	29	15	4
10						3
11						
12				4		
13						
Total	26333	10298	1344	3690	2573	331
Catch (Tons)	979	582	44	189	208	26

						Third Quarter
Age	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
0			48			
1		2		1		
2		21		3	2	
3		20		5	1	
4		12		3	1	
5		6		2	1	
6		5		1		
7		1				
8		1				
9		1				
10						
11						
12						
13						
Total	0	69	48	14	5	0
Catch (Tons)	0	6	1	1	0	0

						Fourth Quarter
Age	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
0			166			24
1	5534	214	268	758		747
2	14222	1993	460	1005	853	1495
3	10636	1817	509	1522	682	5791
4	4578	1085	285	900	373	1558
5	2459	586	105	466	505	1124
6	1034	508	59	227	220	742
7	290	92	24	85	15	228
8	72	71	11	3	99	15
9	248	48		9	22	
10	72				1	
11						
12						
13						
Total	39146	6414	1888	4976	2770	11722
Catch (Tons)	2894	516	147	410	247	1014

						Whole Year
Age	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
0			214			24
1	29699	4569	1309	6242	491	866
2	19870	4610	883	2034	1995	1855
3	14080	3344	900	2425	2455	7266
4	6413	2004	886	1853	1844	1948
5	3172	1131	626	1207	1722	1390
6	1363	746	302	649	718	1001
7	418	336	129	265	349	389
8	140	112	67	75	233	42
9	301	67	26	77	70	22
10	73		8		1	8
11						
12				8		
13						
Total	75529	16919	5350	14834	9879	14813
Catch (Tons)	4428	1113	342	898	825	1263

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**	**2007**
0					
1	17.3	17.9	15.3	15.3	16.2
2	19.5	19.5	19.8	19.6	19.7
3	21.3	20.6	21.3	21.8	21.4
4	22.4	21.8	21.9	22.4	22.6
5	22.7	22.7	22.7	22.9	23.0
6	23.1	22.8	22.9	23.2	23.4
7	23.6	23.5	23.2	23.7	24.0
8	23.5	24.4	23.8	23.6	23.9
9	23.2	23.4	24.5	24.3	24.3
10			23.0	24.5	24.3
11			26.0	24.7	24.9
12				25.5	26.4
13				25.0	
14					24.5

					Second Quarter
Age	**2003**	**2004**	**2005**	**2006**	**2007**
0					
1	16.8	14.3	15.7	15.4	16.2
2	19.7	19.8	20.1	19.5	19.8
3	20.8	20.9	21.0	21.1	20.8
4	22.6	21.6	21.5	22.0	21.7
5	23.1	22.4	22.0	22.6	22.0
6	23.7	22.7	22.3	22.7	22.6
7	24.4	23.6	22.4	23.2	23.2
8	24.1	24.1	23.1	23.3	23.0
9	23.5	23.4	23.8	23.8	23.2
10			23.0	24.2	23.8
11				24.5	24.5
12				25.5	26.0
13				25.0	
14					24.5

					Third Quarter
Age	**2003**	**2004**	**2005**	**2006**	**2007**
0	13.3	13.5	13.5	14.3	15.7
1	18.9	18.6	18.6	17.7	19.3
2	21.0	21.1	20.9	20.4	21.0
3	21.7	21.6	21.4	21.3	21.3
4	22.0	21.8	21.7	21.5	22.0
5	22.8	22.0	21.7	21.9	22.2
6	23.1	23.2	22.4	22.5	22.5
7	23.6	23.3	22.9	22.5	23.1
8	24.6	23.9	23.0	22.7	23.4
9	23.9	23.7	23.2	23.5	23.5
10			24.5	23.0	24.1
11				24.5	
12					
13					
14					

					Fourth Quarter
Age	**2003**	**2004**	**2005**	**2006**	**2007**
0	13.2	13.2	12.0	13.3	15.4
1	19.9	19.0	19.3	19.0	19.5
2	21.2	21.0	21.2	20.4	20.9
3	22.2	22.0	22.0	21.6	21.5
4	22.6	22.1	22.4	22.3	22.5
5	23.2	22.5	22.8	22.8	22.7
6	23.5	23.7	23.0	23.3	22.9
7	24.3	23.5	23.4	23.6	23.4
8	24.5	24.1	23.6	23.5	23.7
9	23.9	23.8	23.9	23.9	23.8
10		24.9	26.2	24.3	24.2
11			33.0	24.7	
12				25.0	
13					
14					

					Whole Year
Age	**2003**	**2004**	**2005**	**2006**	**2007**
0	13.3	13.5	13.2	14.3	15.6
1	18.3	16.4	17.6	16.5	18.0
2	20.7	20.6	20.7	20.2	20.7
3	21.6	21.4	21.3	21.3	21.2
4	22.3	21.8	21.7	21.7	22.1
5	23.0	22.2	21.9	22.2	22.4
6	23.4	23.0	22.5	22.8	22.7
7	24.1	23.5	22.7	23.1	23.3
8	24.1	24.1	23.3	23.2	23.5
9	23.7	23.6	23.8	23.9	23.7
10		24.9	24.3	24.1	24.2
11			29.7	24.7	24.8
12				25.1	26.3
13				25.0	
14					24.5

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**	**2007**
0					
1	0.045	0.050	0.030	0.030	0.036
2	0.067	0.067	0.070	0.067	0.068
3	0.088	0.080	0.089	0.096	0.090
4	0.105	0.096	0.098	0.105	0.108
5	0.110	0.109	0.109	0.113	0.114
6	0.115	0.112	0.113	0.118	0.120
7	0.125	0.123	0.118	0.126	0.131
8	0.123	0.139	0.129	0.125	0.130
9	0.117	0.121	0.141	0.137	0.137
10			0.114	0.141	0.137
11			0.171	0.144	0.148
12				0.162	0.180
13				0.151	
14					0.141

	Second Quarter				
Age	**2003**	**2004**	**2005**	**2006**	**2007**
0					
1	0.041	0.024	0.032	0.031	0.036
2	0.069	0.070	0.073	0.066	0.070
3	0.082	0.083	0.085	0.086	0.082
4	0.108	0.093	0.092	0.098	0.095
5	0.116	0.105	0.098	0.107	0.098
6	0.126	0.109	0.103	0.109	0.107
7	0.138	0.124	0.104	0.117	0.117
8	0.134	0.133	0.117	0.119	0.114
9	0.122	0.121	0.128	0.129	0.118
10			0.114	0.135	0.128
11				0.140	0.141
12				0.161	0.171
13				0.151	
14					0.141

	Third Quarter				
Age	**2003**	**2004**	**2005**	**2006**	**2007**
0	0.019	0.020	0.019	0.024	0.032
1	0.060	0.056	0.057	0.048	0.064
2	0.084	0.086	0.084	0.076	0.084
3	0.095	0.093	0.090	0.088	0.088
4	0.099	0.096	0.094	0.091	0.099
5	0.111	0.099	0.095	0.097	0.102
6	0.116	0.118	0.105	0.106	0.106
7	0.125	0.119	0.113	0.107	0.116
8	0.143	0.129	0.114	0.109	0.121
9	0.129	0.127	0.118	0.122	0.122
10			0.141	0.114	0.134
11				0.141	
12					
13					
14					

	Fourth Quarter				
Age	**2003**	**2004**	**2005**	**2006**	**2007**
0	0.018	0.018	0.013	0.019	0.031
1	0.070	0.061	0.064	0.060	0.066
2	0.087	0.085	0.087	0.077	0.083
3	0.102	0.099	0.099	0.093	0.091
4	0.107	0.101	0.105	0.103	0.106
5	0.118	0.107	0.110	0.111	0.109
6	0.124	0.126	0.115	0.120	0.113
7	0.136	0.123	0.121	0.124	0.121
8	0.140	0.133	0.125	0.123	0.126
9	0.129	0.129	0.130	0.130	0.127
10		0.148	0.175	0.138	0.136
11			0.377	0.145	
12				0.151	
13					
14					

	Whole Year				
Age	**2003**	**2004**	**2005**	**2006**	**2007**
0	0.019	0.020	0.018	0.024	0.032
1	0.055	0.040	0.048	0.039	0.052
2	0.081	0.080	0.081	0.074	0.081
3	0.094	0.091	0.089	0.089	0.087
4	0.104	0.096	0.094	0.095	0.100
5	0.114	0.102	0.098	0.102	0.104
6	0.121	0.114	0.106	0.111	0.110
7	0.133	0.122	0.110	0.116	0.120
8	0.133	0.133	0.119	0.118	0.123
9	0.126	0.125	0.129	0.129	0.126
10		0.148	0.138	0.133	0.135
11			0.280	0.144	0.147
12				0.152	0.177
13				0.151	
14					0.141

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**	**2007**
0						
1	16.0	18.1		14.3	17.9	18.2
2	19.7	19.9	15.2	20.1	19.7	20.1
3	20.9	20.6	20.2	21.1	21.5	21.2
4	21.7	21.4	21.3	21.7	21.9	21.9
5	22.3	22.1	21.8	21.8	22.3	22.4
6	22.7	22.4	22.0	22.4	22.5	22.6
7	23.1	22.7	22.5	22.7	23.4	23.0
8	23.4	22.8	23.2	23.0	24.1	23.6
9	23.5	22.8	23.5	23.3	22.8	23.9
10	24.8		24.6			24.9
11						
12				24.3		
13						

						Second Quarter
Age	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
0						
1	15.8	16.9	13.5	15.8	19.5	17.5
2	19.5	19.7	20.1	19.6	19.9	20.4
3	20.9	20.4	21.2	21.0	21.3	20.9
4	21.6	21.1	21.8	21.8	21.8	21.6
5	22.1	21.9	21.9	21.9	22.4	22.2
6	22.6	22.3	22.4	22.6	22.6	22.5
7	23.0	22.6	23.0	22.8	23.5	23.7
8	23.4	23.8	23.5	23.1	24.2	24.7
9	23.6	22.8	25.3	23.4	22.8	24.8
10						25.3
11						
12				24.3		
13						

						Third Quarter
Age	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
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**	**2007**
0			17.0			17.3
1	19.9	20.6	20.1	19.9		19.6
2	21.0	20.9	21.4	21.2	21.5	21.2
3	21.6	21.3	21.8	21.8	22.3	21.8
4	22.2	21.7	22.0	22.0	22.3	22.4
5	22.6	22.0	22.4	22.6	22.5	22.9
6	23.3	22.1	22.5	22.9	22.4	23.1
7	22.9	23.4	23.0	23.1	24.4	23.9
8	25.1	23.8	23.7	24.3	23.5	24.8
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**	**2007**
0			16.4			17.3
1	16.6	17.0	14.8	15.5	18.4	19.4
2	20.6	20.2	18.8	20.5	20.5	21.0
3	21.4	20.9	21.2	21.6	21.7	21.7
4	22.1	21.5	21.5	21.9	21.9	22.3
5	22.5	21.9	21.9	22.2	22.4	22.8
6	23.1	22.2	22.1	22.6	22.5	23.0
7	22.9	22.8	22.6	22.9	23.5	23.5
8	24.3	23.7	23.3	23.1	23.9	24.1
9	24.0	23.5	23.6	23.3	23.1	24.1
10	25.1		24.6		25.3	25.0
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**	**2007**
0						
1	0.031	0.047		0.022	0.046	0.048
2	0.057	0.064	0.031	0.066	0.062	0.066
3	0.069	0.071	0.066	0.076	0.081	0.077
4	0.077	0.080	0.078	0.084	0.086	0.086
5	0.084	0.088	0.084	0.085	0.092	0.093
6	0.088	0.093	0.088	0.093	0.094	0.095
7	0.093	0.096	0.094	0.097	0.106	0.101
8	0.097	0.097	0.104	0.101	0.117	0.110
9	0.098	0.097	0.108	0.105	0.097	0.114
10	0.115		0.124			0.129
11						
12				0.119		
13						

						Second Quarter
Age	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
0						
1	0.030	0.037	0.019	0.030	0.059	0.042
2	0.056	0.061	0.065	0.061	0.063	0.068
3	0.069	0.069	0.077	0.076	0.078	0.075
4	0.076	0.077	0.084	0.085	0.085	0.083
5	0.082	0.086	0.087	0.087	0.093	0.090
6	0.087	0.091	0.092	0.095	0.095	0.093
7	0.091	0.095	0.101	0.098	0.107	0.112
8	0.097	0.112	0.109	0.102	0.118	0.127
9	0.099	0.097	0.135	0.106	0.097	0.128
10						0.135
11						
12				0.119		
13						

						Third Quarter
Age	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
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**	**2007**
0			0.039			0.040
1	0.059	0.070	0.066	0.063		0.061
2	0.070	0.073	0.079	0.077	0.081	0.077
3	0.076	0.079	0.084	0.085	0.091	0.085
4	0.083	0.084	0.088	0.087	0.091	0.092
5	0.088	0.088	0.093	0.095	0.093	0.100
6	0.096	0.089	0.094	0.099	0.092	0.103
7	0.093	0.107	0.101	0.102	0.122	0.113
8	0.125	0.111	0.110	0.119	0.108	0.127
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**	**2007**
0			0.035			0.040
1	0.035	0.039	0.028	0.030	0.050	0.059
2	0.066	0.067	0.058	0.070	0.070	0.075
3	0.075	0.074	0.077	0.082	0.083	0.083
4	0.081	0.081	0.082	0.086	0.087	0.091
5	0.086	0.087	0.086	0.089	0.092	0.098
6	0.094	0.090	0.089	0.095	0.094	0.101
7	0.093	0.099	0.096	0.099	0.107	0.109
8	0.111	0.111	0.105	0.102	0.113	0.118
9	0.107	0.107	0.109	0.105	0.101	0.116
10	0.125		0.124		0.135	0.131
11						
12				0.119		
13						

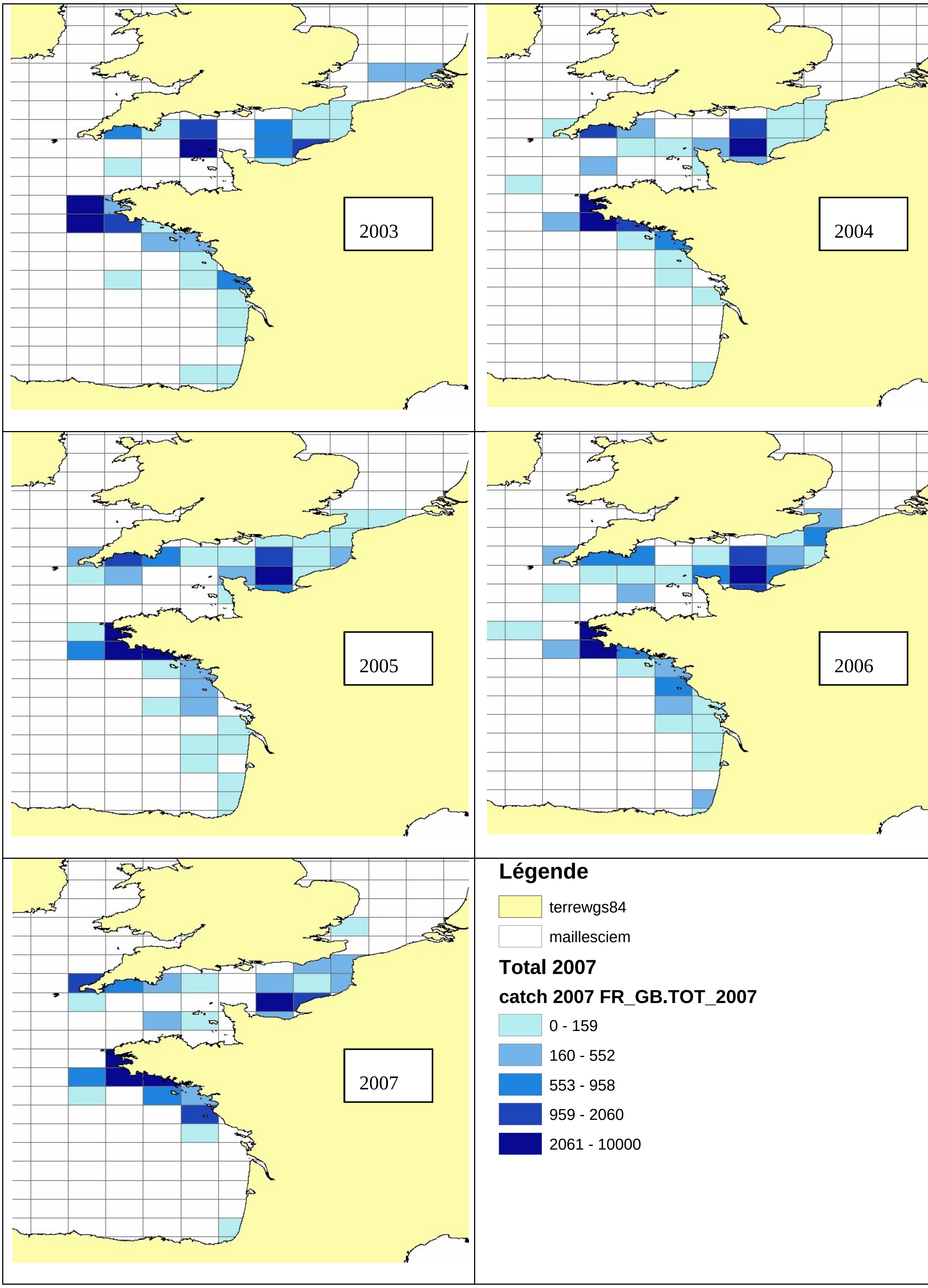


Figure 7.1.1.1: Sardine general: Geographical distribution of the sardine catches by the French and UK (England & Wales) fleets.

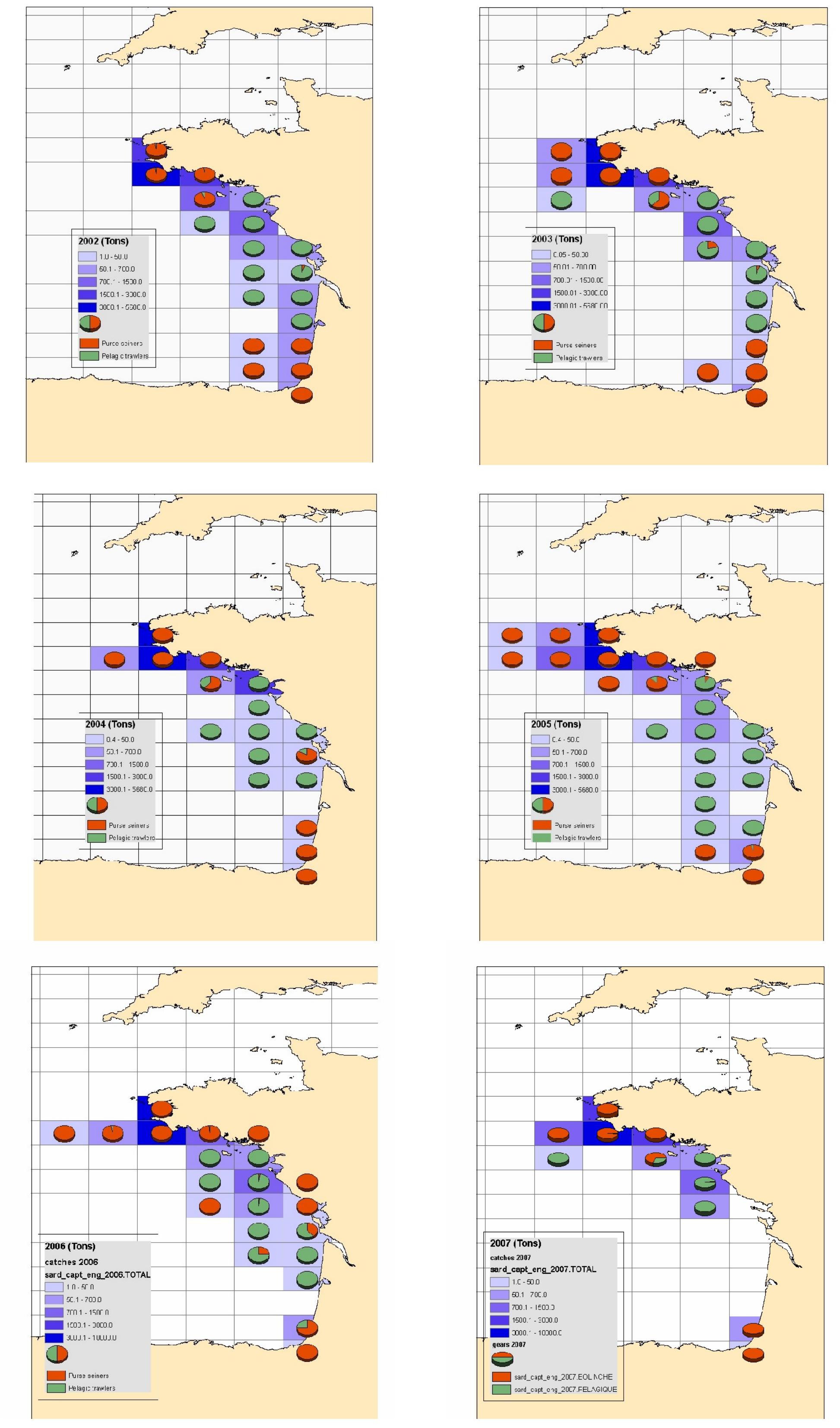


Figure 7.2.1.1: Sardine general: French landings in divisions VIIIa and VIIIb: Geographical distribution of sardine catches by the French fleet (purse seiners and pelagic trawls combined) during 20020–7. The colour of the square represents the amount of catches while the pies in each square indicate the proportion of those catches taken by purse seiners and trawlers.

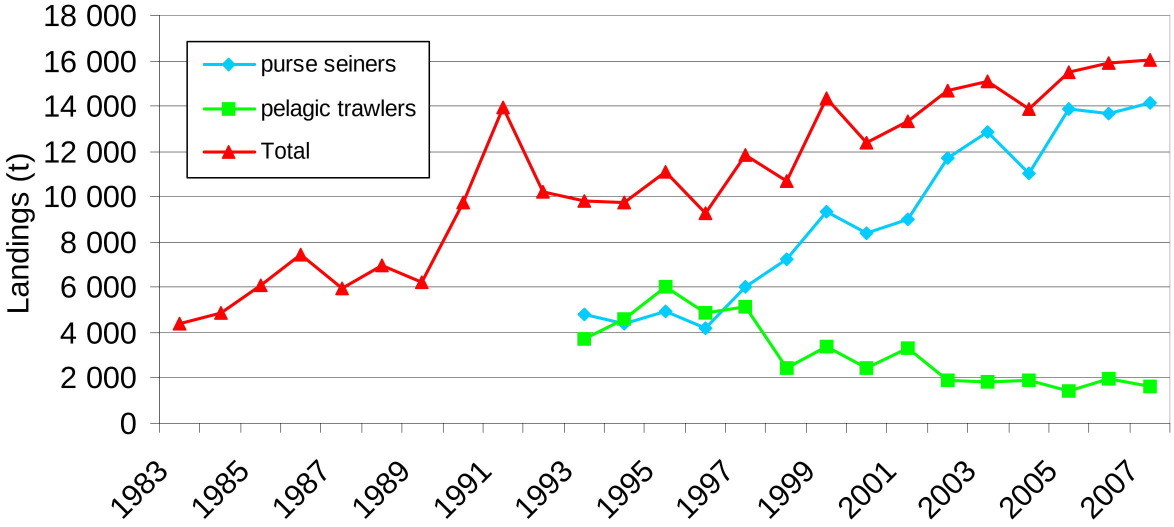


Figure 7.2.1.2: Sardine general: French landings in divisions VIIIa and VIIIb. Annual sardine landings (by different French fleet components since 1993).

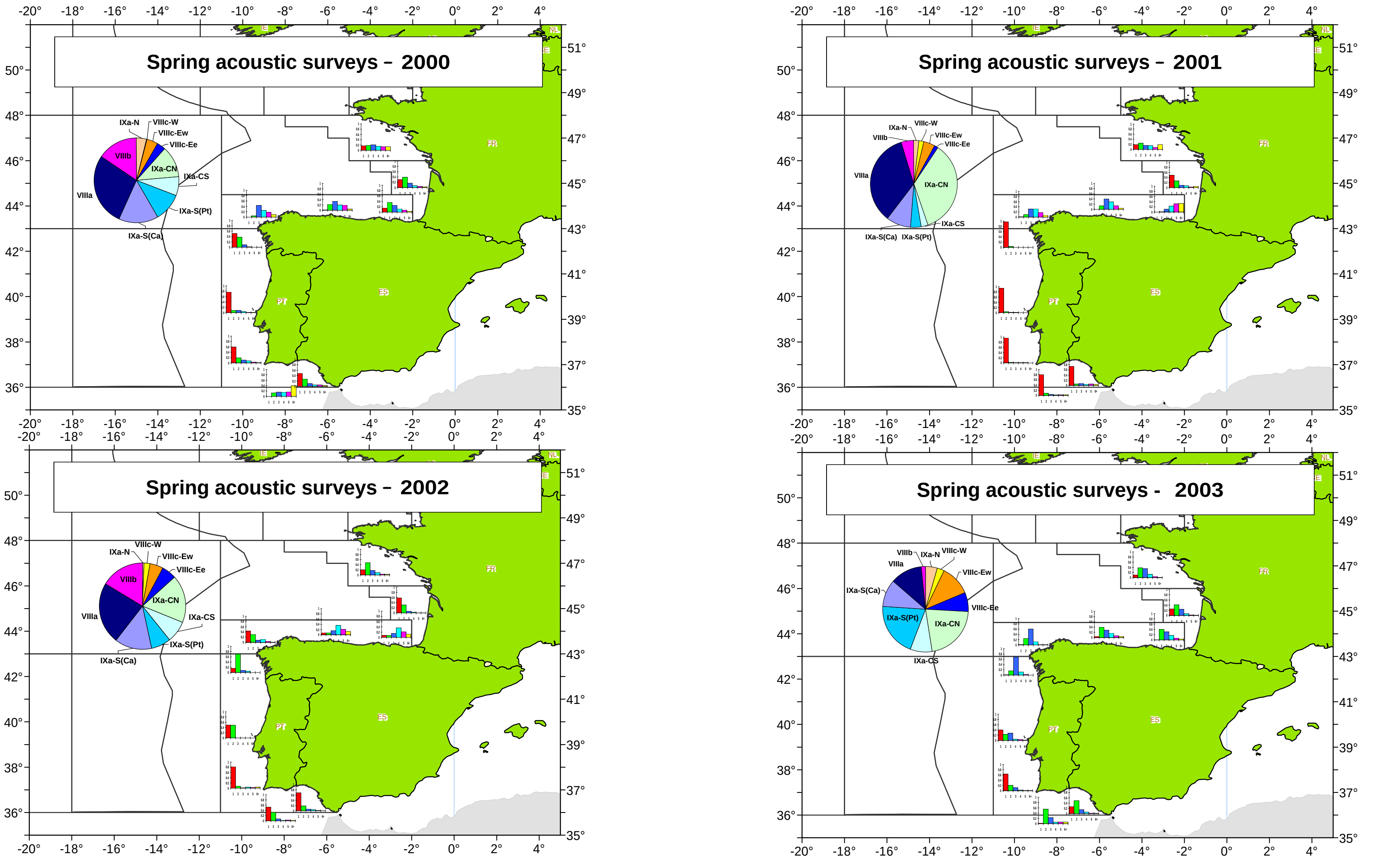


Figure 7.2.2.1: Sardine general: Sardine age frequency distribution by subarea showing the importance of each age class in each subarea in relation to the total sardine population in that subarea as estimated by the spring surveys carried out by France, Spain and Portugal (2000-2003). Age categories are: 1, 2, 3 and 6+. The pie chart represents the contribution of each subarea to the total biomass.

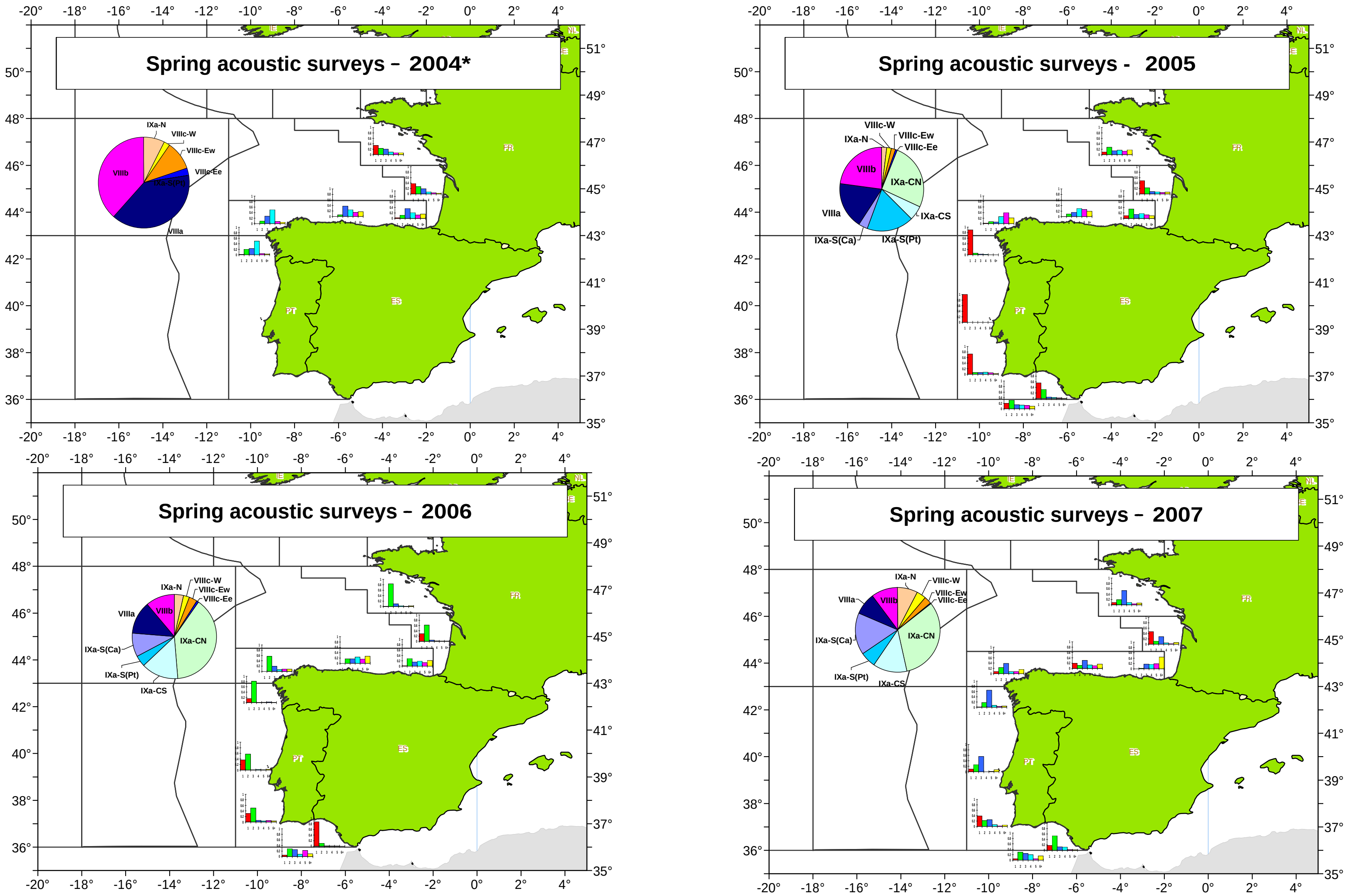


Figure 7.2.2.2: Sardine general: Sardine age frequency distribution by subarea showing the importance of each age class in each subarea in relation to the total sardine population in that subarea as estimated by the spring surveys carried out by France, Spain and Portugal (2004-2007). Age categories are: 1, 2, 3,…and 6+. The pie chart represents the contribution of each subarea to the total biomass.*No Portuguese survey was carried out in spring 2004.

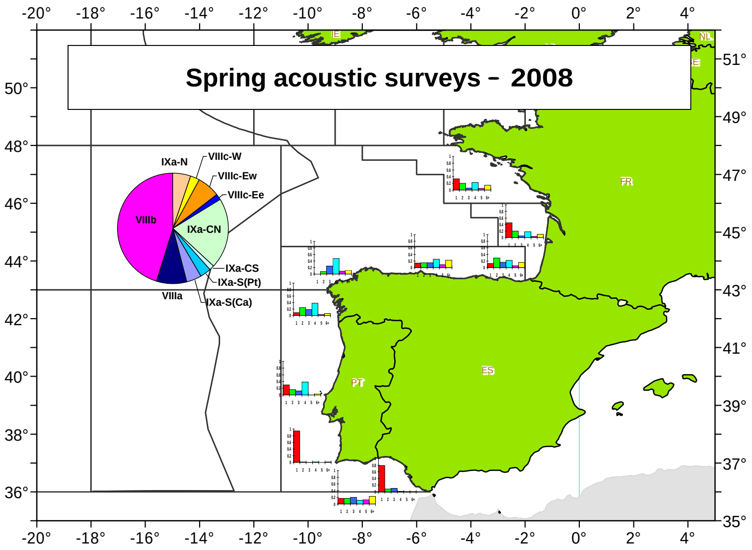


Figure 7.2.2.3: Sardine general: Sardine age frequency distribution by subarea showing the importance of each age class in each subarea in relation to the total sardine population in that subarea as estimated by the spring surveys carried out by France, Spain and Portugal (2008). Age categories are: 1, 2, 3 and 6+. The pie chart represents the contribution of each subarea to the total biomass.

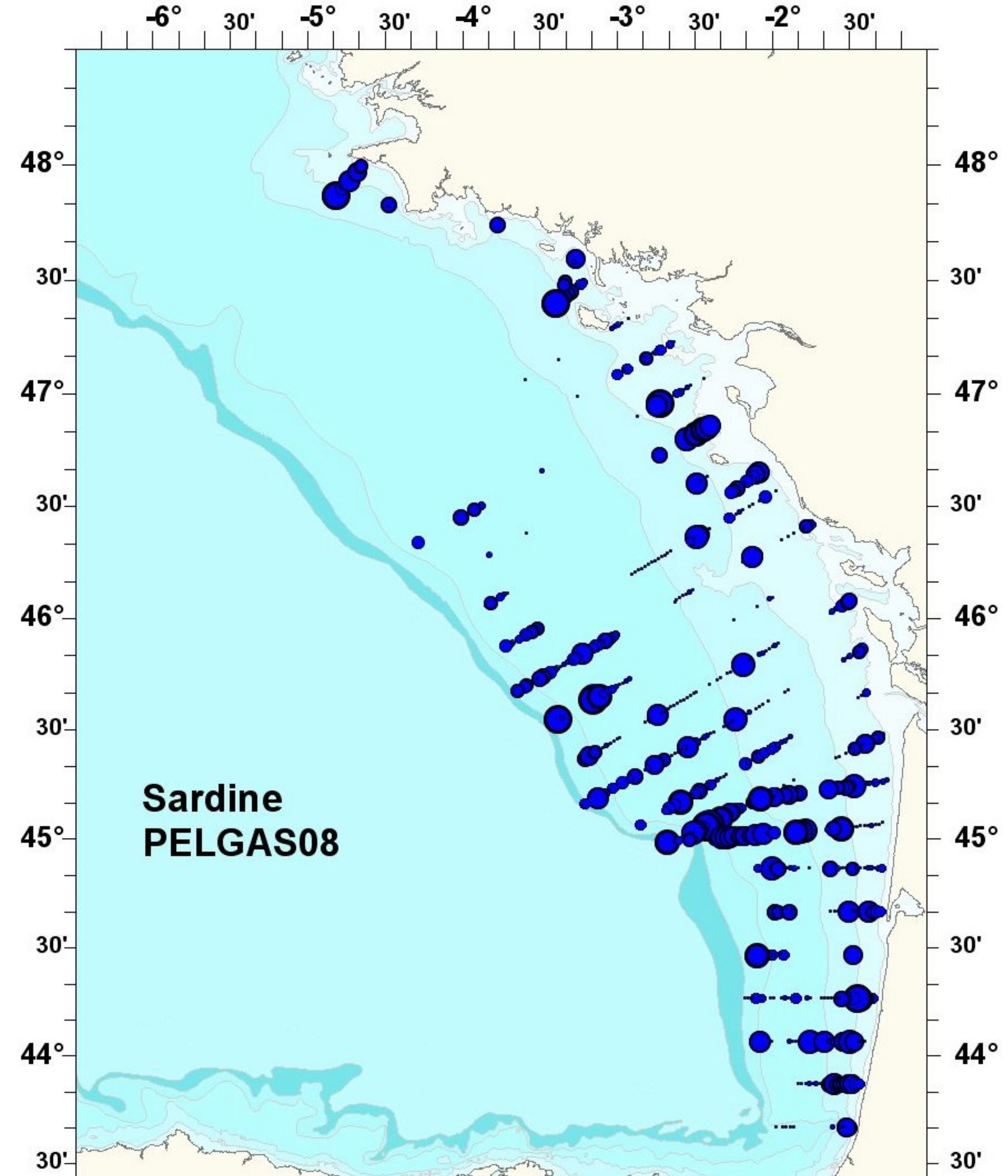


Figure 7.2.2.1.1: Sardine general: Distribution of sardine as observed during the French acoustic survey PELGAS08.

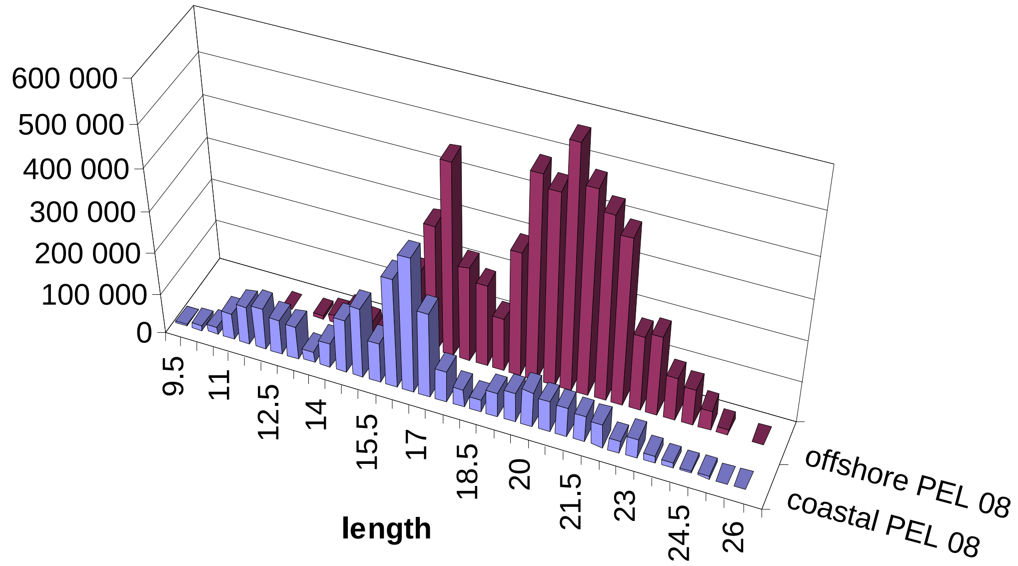


Figure 7.2.2.1.2: Sardine general: Sardine length distribution in numbers of fish for divisions VIIIa+VIIIb in the French acoustic survey PELGAS08.

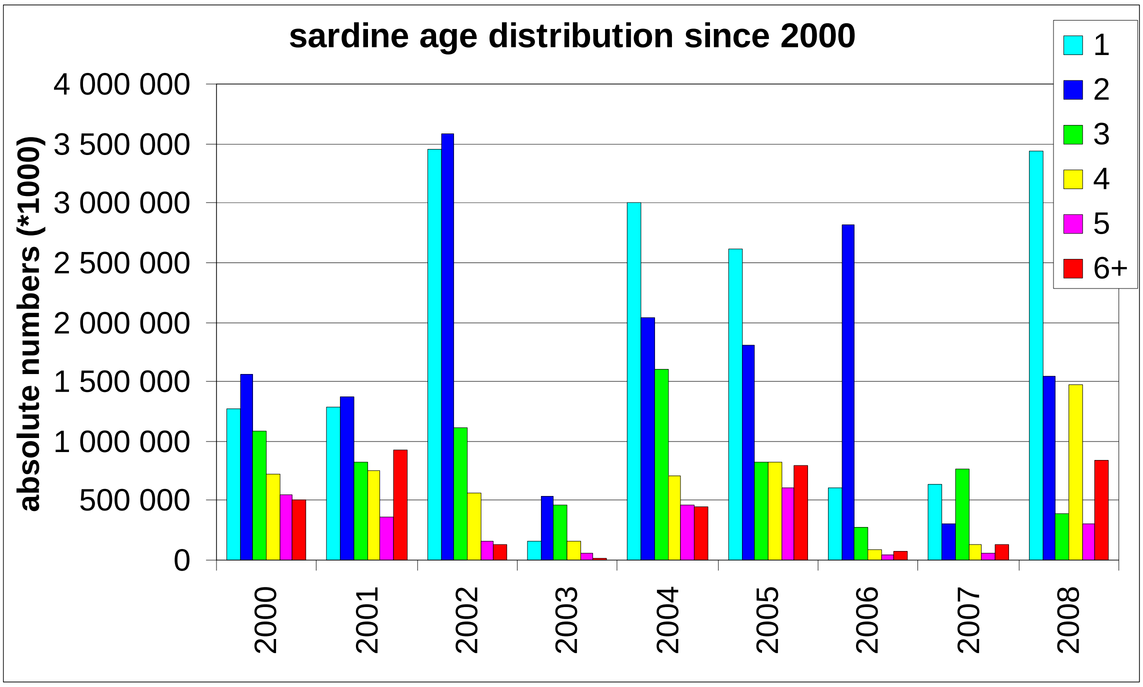


Figure 7.2.2.1.3: Sardine general: Sardine age distribution in numbers of fish for divisions VIIIa and VIIIb in the French acoustic surveys PELGAS 2000 – 2008.

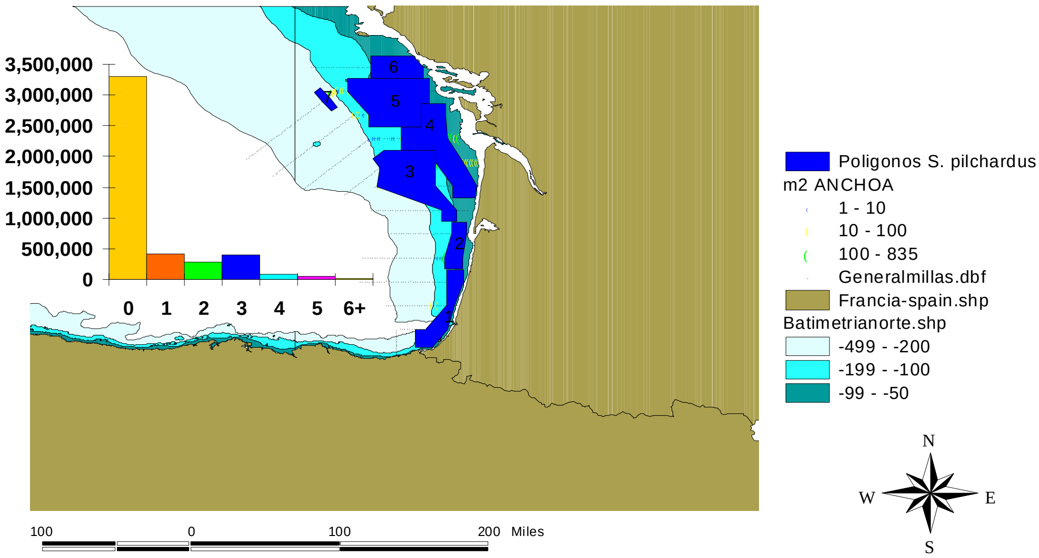


Figure 7.2.2.1.4: Sardine general: Spatial distribution of energy allocated to sardine during the PELACUS1007 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m² within each polygon. The histogram shows sardine age distribution in numbers of fish.

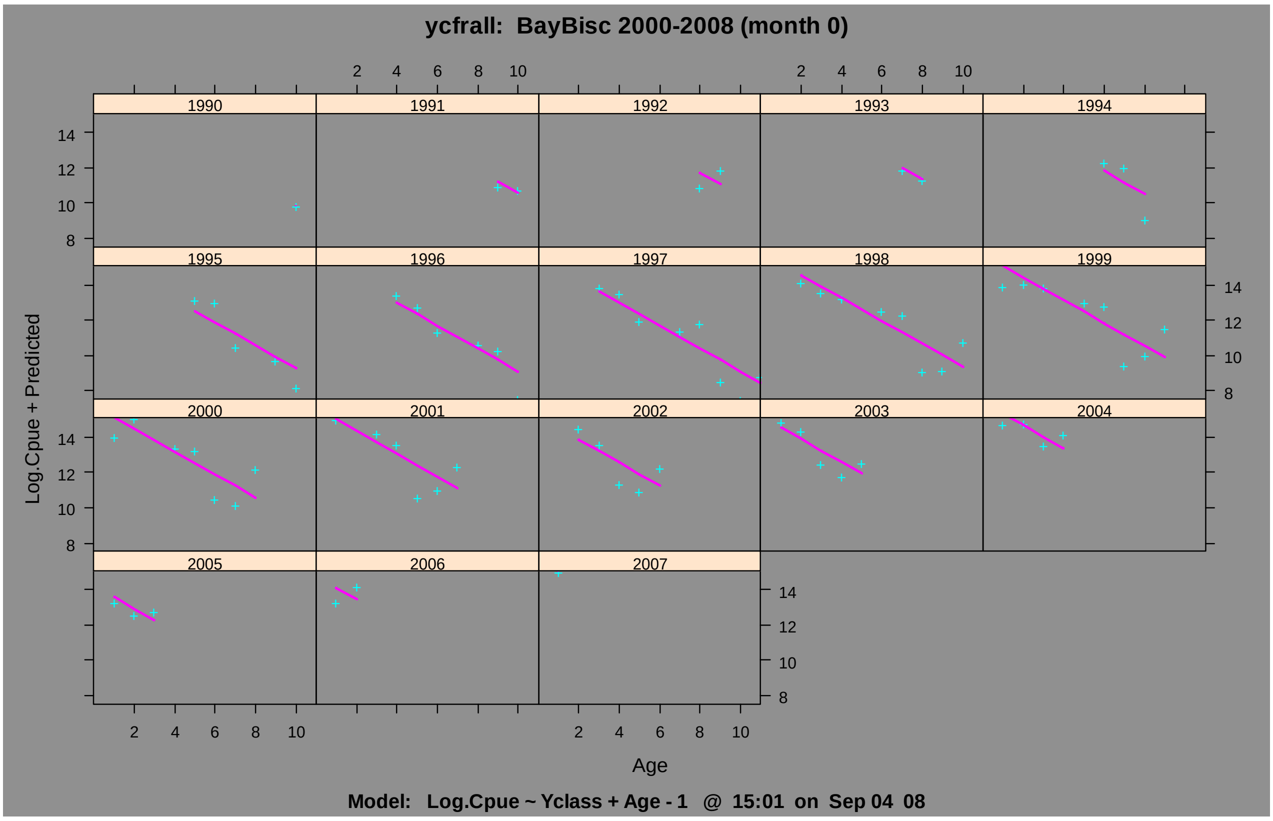


Figure 7.2.2.2.1: Sardine general: Year-class data obtained the French acoustic surveys 2000 – 2008. Points are observed values of log abundance-at-age, lines are values predicted from a linear regression model assuming a common slope for all year-classes.

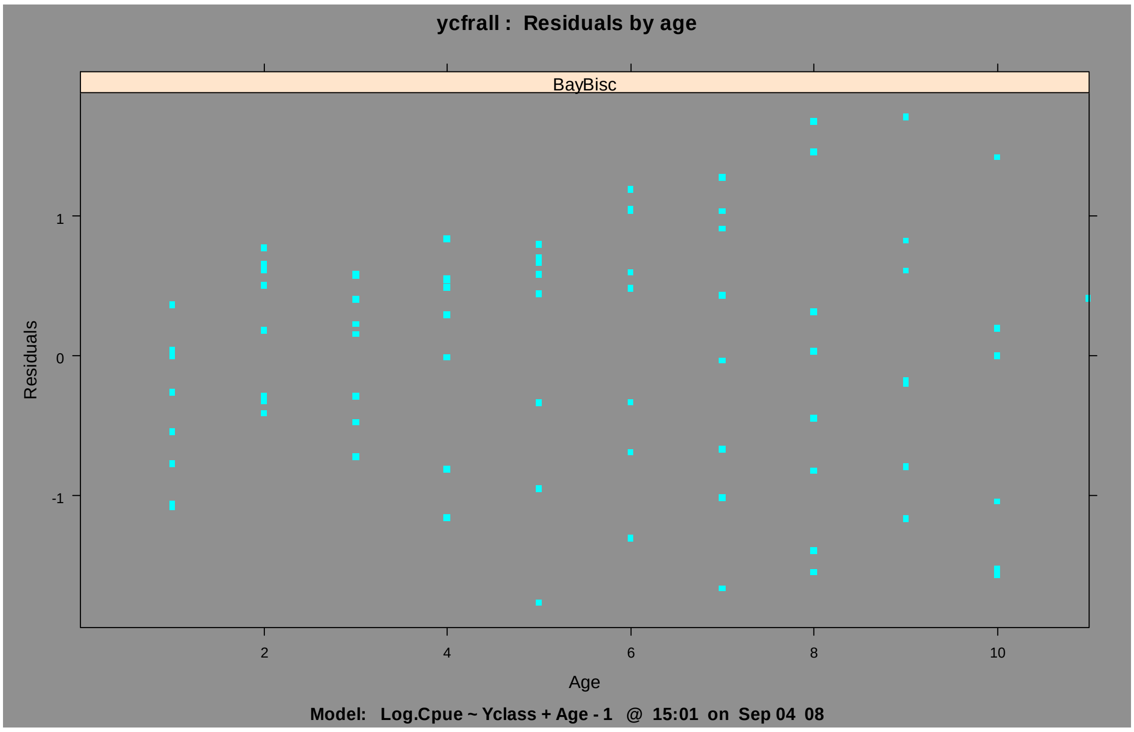


Figure 7.2.2.2.2: Sardine general: Residuals at age from a year-class model fitted to French acoustic surveys data 2000 – 2008.

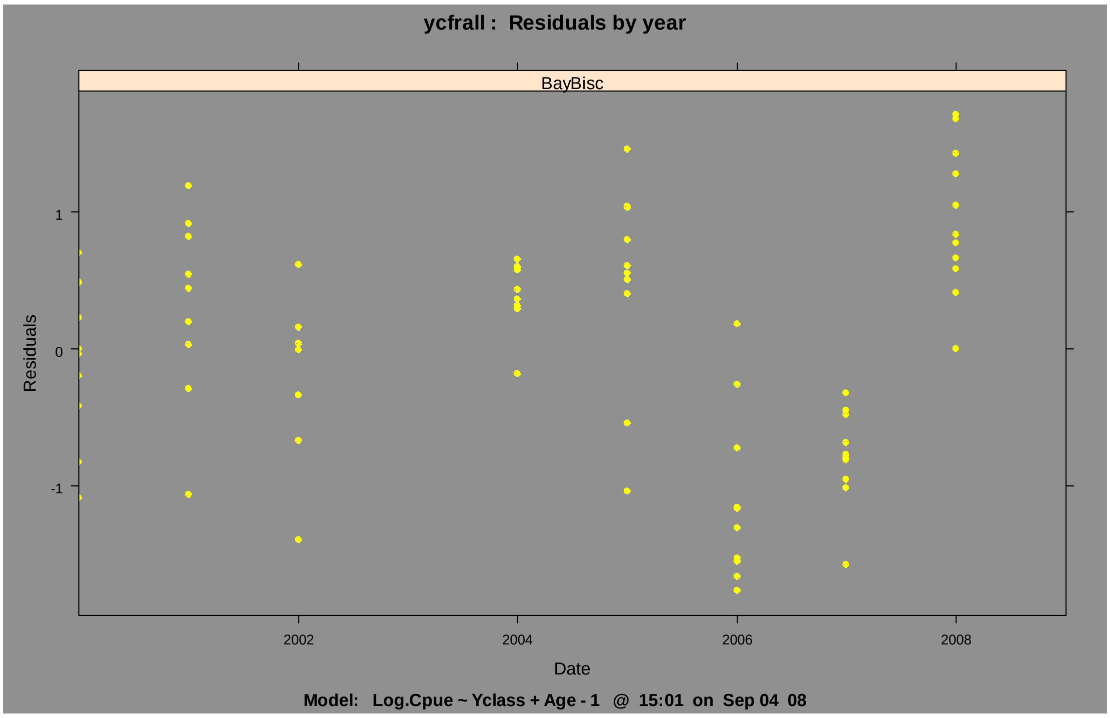


Figure 7.2.2.2.3: Sardine general: Residuals by year from a year-class model fitted to French acoustic surveys data 2000 – 2008.

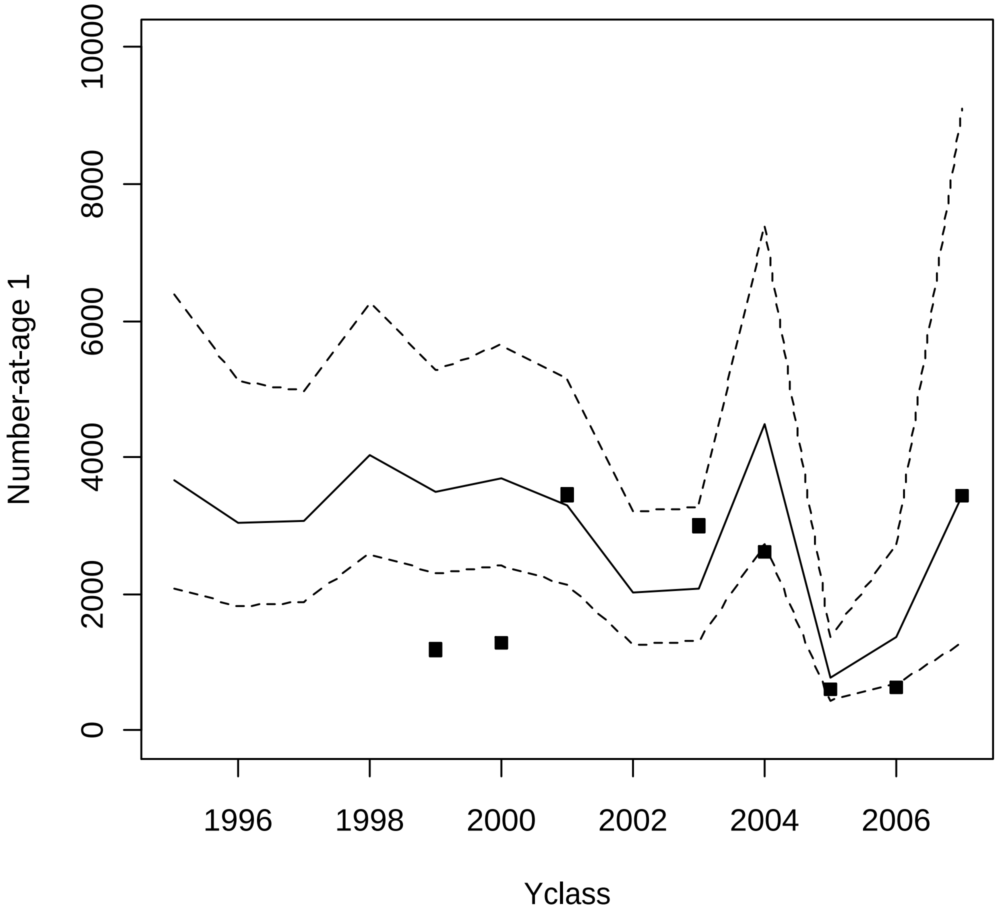


Figure 7.2.2.2.4: Sardine general: Predicted abundance-at-age 1 obtained from the year-class model fitted to French acoustic surveys data 2000 – 2008. Symbols show observed abundances-at-age 1, dashed lines show predicted values ± 1 standard error.

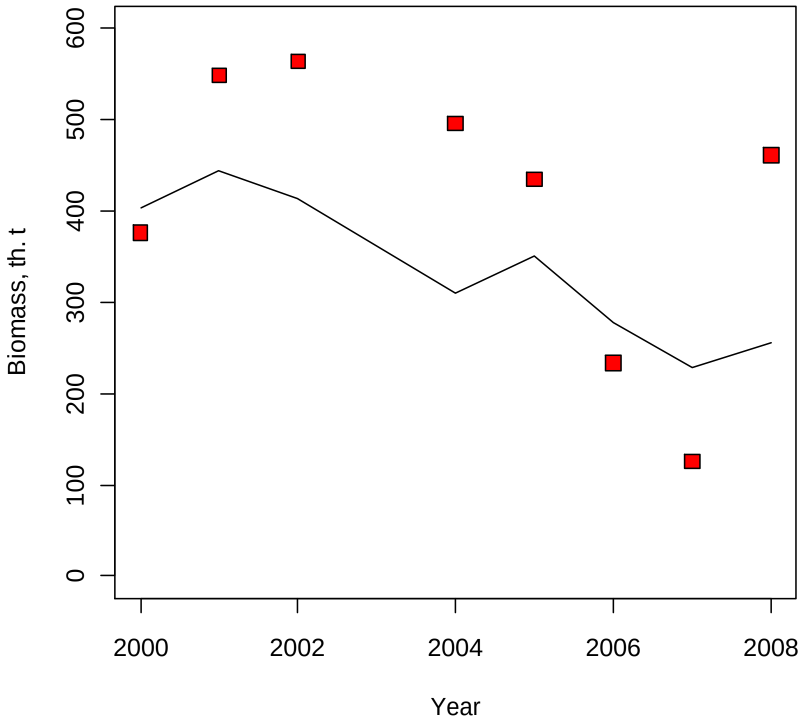


Figure 7.2.2.2.5: Sardine general: Predicted total biomass in French acoustic surveys 2000 – 2008. Symbols show observed values.

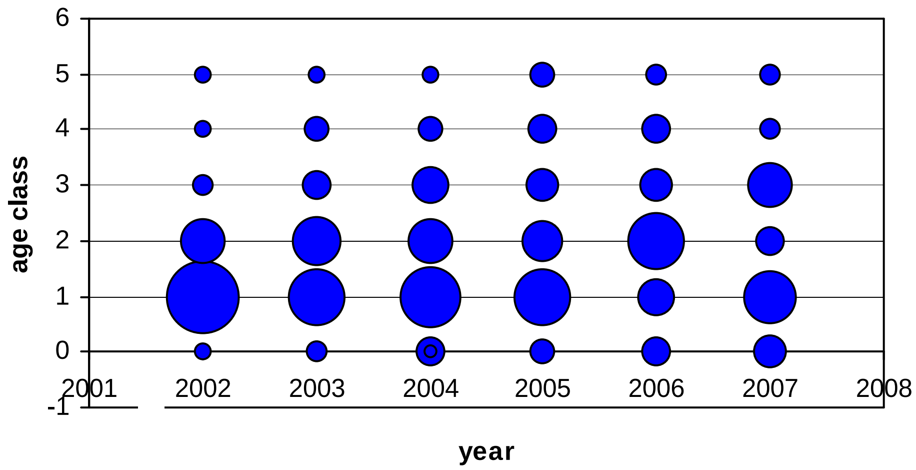


Figure 7.2.3.1.1: Sardine general: bubble plot of French catches at age from 2002 to 2007 for sardine in the Bay of Biscay (VIIIab).

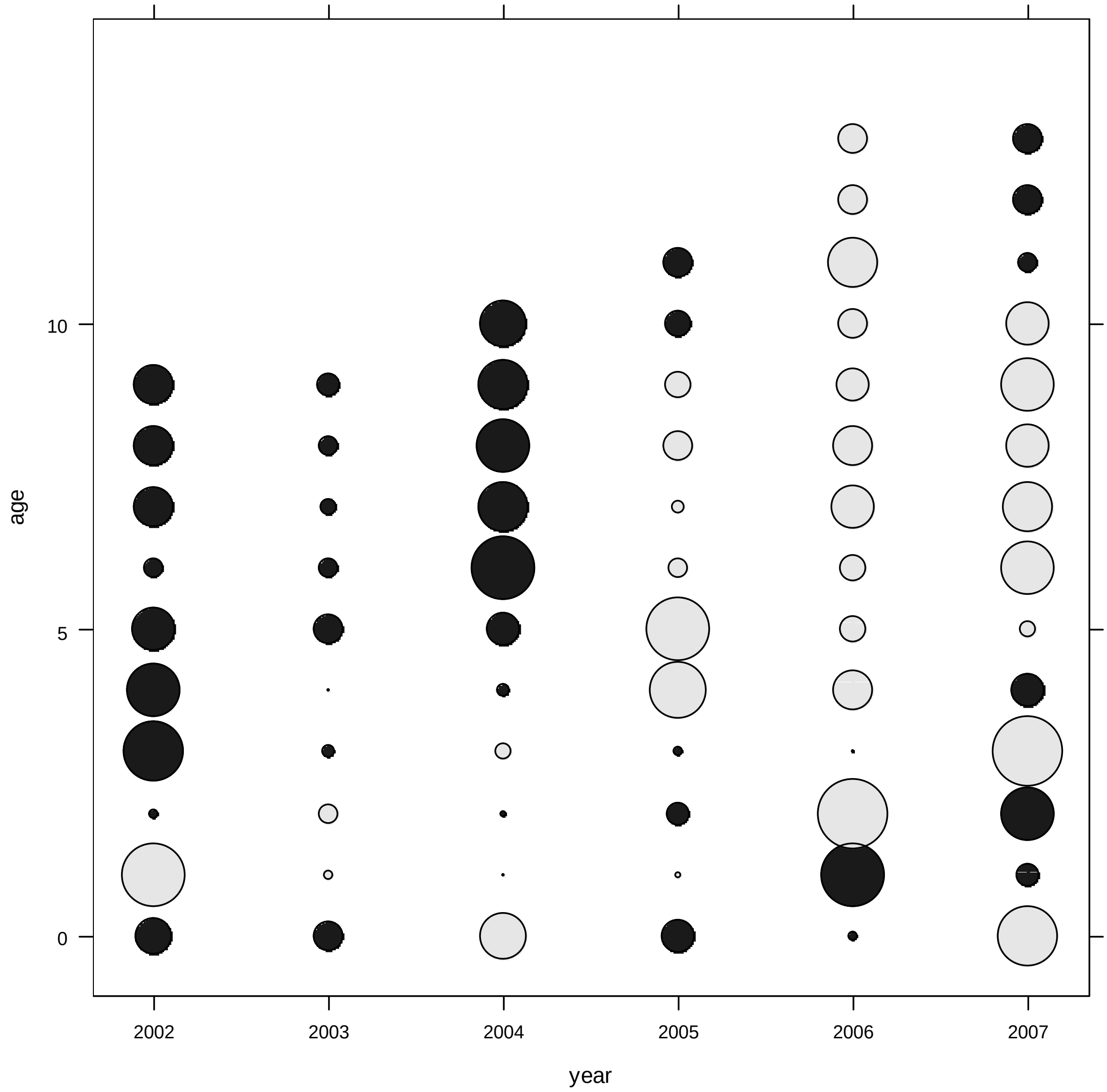


Figure 7.2.3.1.2: Sardine general: Standardized proportion at age (negative in black, positive in grey) in French sardine catches from 2002 to 2007 in the Bay of Biscay (VIIIab).

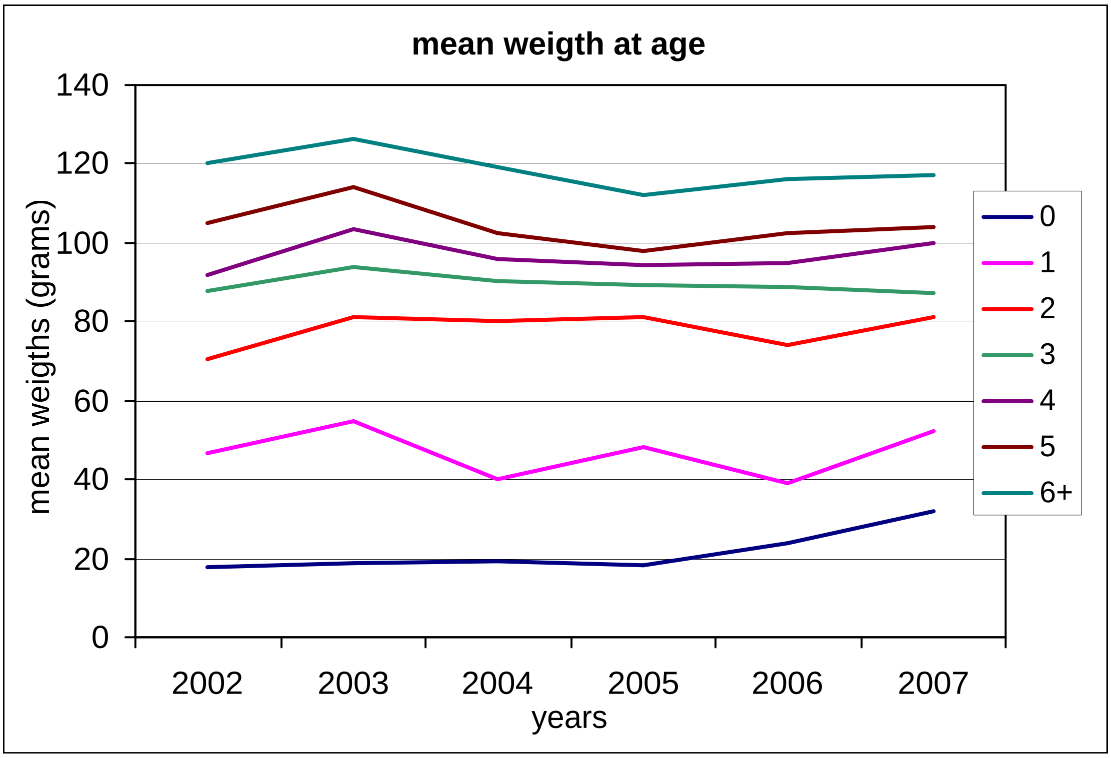


Figure 7.2.3.2.1: Sardine general: Mean weight at age of French sardine catches from 2002 to 2007 in the Bay of Biscay (VIIab).

8 Sardine in VIIIc and IXa

8.1 ACFM Advice Applicable to 2007

ICES recommended that fishing mortality should not increase above 2004–2006 level of 0.19, corresponding to a catch of less than 92 000 t in 2008.

In the absence of defined reference points, the state of this stock cannot be evaluated with regard to these. Based on the most recent assessment, SSB in 2006 and 2007 was high. Fishing mortality shows a decreasing trend since 1998. The 2004 year class is the second highest of the historical series, while the 2005 year class is confirmed to be low and the 2006 year class is estimated as the lowest in the historical series. Short-term predictions indicate that the SSB will decrease in 2008 and further in 2009 at the *status quo* fishing mortality. An extremely weak 2006 recruitment is also indicated. 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.

There are no management objectives for this stock and there is no TAC. The stock is managed by Portugal and Spain through minimum landing size, maximum daily catch, days fishing limitations, and closed areas.

8.2 The fishery in 2007

As estimated by the Working Group, sardine landings in 2007 shows a slight increase in comparison with those of 2006 (Tables 8.2.1 and 8.2.2, Figure 8.2.1). Total 2007 landings in divisions VIIIc and IXa were 96 469 t, i.e. an increase of 11% with respect to the 2006 values (87 023 tonnes). The bulk of the landings (99%) were made by purse-seiners. In Spain, landings of sardine (31 970 tonnes) showed no variation with respect to the values from 2006 (32 012 tonnes). Both ICES subdivisions IXaN and IXaS Cadiz showed an increase in catches (14% in subdivision IXaN and 7% in IXaS-Cadiz) while subdivision VIIIc showed a 13% decrease. In Portugal, landings in 2007 (64 449 tonnes) were 17% higher than the landings in 2006 (55 011 tonnes). This increase in landings originated in subdivision IXaCS (catches 36% higher than in 2006). Landings in subdivision IXaS-Algarve decreased by 26% with respect to the 2006 values while catches remained stable in subdivision IXaCN.

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 (1995–2007) (Table 8.2.2). Values for area VIIIc have been rather stable (between 15 000 to 20 000 tonnes) with the exception of catches in 1999, 2000 and 2007 (values around 12 000 and 13 000). Although landings in this area had been increasing before 2006, they have now been decreasing for two years (2006 and 2007). Values for IXa North also present a sharp decrease in 1998–2000, increasing slowly with some fluctuations afterwards. IXaCN values have been quite stable for the past few years with a decrease in landings in 2004 and 2005 followed by increases in 2006 and again in 2007. IXaCS landings have remained relatively stable, although there has been a decrease in 2006. The southern part of stock shows a decreasing trend in landings for both Algarve and Gulf of Cádiz since 2002 although Gulf of Cadiz caches have increase slightly in 2007. In the case of Algarve the landings in 2007 are at their lowest for this period (1995–2007).

Table 8.2.1 summarises the quarterly landings and their relative distribution by ICES Subdivision. Sixty-eight percent of the catches were landed in the second semester

(36% in the fourth quarter) while almost 43% 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) (27%) decreased slightly from last year. The southern areas accounts for 11% of the total values in 2007, again slightly reduced from the value in 2006.

8.2.1 Fleet Composition in 2007

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 seine. The total number of vessel with license for this gear in 2007 was 325, ranging in size from 7.7 to 38.3 m (mean vessel length = 22.2 m) and in power between 24 to 1100 (mean = 327.1 HP).

Since 2004, Spanish legislation orders that purse seiners must have at least, a length of 11 m in the Atlantic coast of Spain. Moreover the gear must have a maximum length of 600 m, a maximum height of 130 m and minimum mesh size of 14 mm.

Half of the purse seiners (53%) 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 (26% 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. According to the WD-Abad et al (2008) presented in this group, northern Spanish purse seine fleet from the period 2003–2005 can be split into two fleet segments. The mean values of technical features in that period were a bit smaller than 2006 values (21 m length and 296 HP). Most of the trips types targeting sardine (around 85%) during the period 2003–2005 were carried out by the small vessels segment. This group of vessels presented an average of 16 m length and 190 HP.

In the Gulf of Cadiz, purse seiners taking sardine are generally targeting anchovy (n = 85) and range in size from 10.5 to 25 m with a mean vessel length of 16.3 m (horse power between 30 to 510 with a mean of 208.6). In Portuguese waters, fleet data from 2006 indicate that 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 were carried out in 2008 by both Spain and Portugal. Results from these surveys are still preliminary and definitive results are expected to be available for the 2009 WGWIDE meeting.

8.3.1.1 Portuguese DEPM Survey

During 2008, the Portuguese DEPM survey was carried out on board the R/V “Noruega” from the 20th of January to the 15th of February. Preliminary results indicate that the positive (spawning) area has almost doubled with respect to the last DEPM survey (2005). There has been also an increase (values have doubled) of the total egg production. Large sardine predominated in the surveyed area which resulted in a high mean weight.

	DEPM 05	DEPM 08
Survey area (km^2)	46373	49887
Number CalVET stations	408	462
Percentage stations with eggs	36	46
Positive stratum (km^2)	16426	28398
Total sardine eggs (1 net)	3675	6731
Egg production (*10^{12}) (CV)	3.69(22)	10.67(19)

8.3.1.2 Spanish DEPM Survey

The Spanish DEPM survey took place from the 2th – 27th April on board R/V Cornide de Saavedra. Preliminary results are given in the WD Diaz et al (2008) presented in this group. As it was the case with the Portuguese survey, the positive (spawning) area has almost doubled with respect to the last DEPM survey (2005) and egg distribution has expanded beyond the 200 m depth contour, reaching up to the 1000 m depth contour in the eastern Cantabrian Sea. There has been also a 30% increase in estimated total egg production with respect to the 2005 values.

	DEPM05	DEPM08 Spanish waters	DEPM08 Spanish & French waters
Survey area (km^2)	41019	48672	10888
Number of sampled stations	375	429	101
Percentage stations with eggs	33	54	76
Positive stratum (km^2)	17917	31206	8567
Total eggs	3231	3749	1144
Egg production (*10^{12}) (CV)	2.10 (22.8)	3.07 (14.7)	4.23 (12.1)

8.3.2 Acoustic surveys

Portuguese and Spanish acoustic surveys are coordinated within WGACEGG (ICES, 2007e). Surveys are undertaken within the framework of the EU DG XIV project “Data Directive”.

Portuguese and Spanish spring surveys are used in the assessment as a single index of abundance of the stock. The merging of data from these surveys remains an outstanding issue in the current assessment and in order to address this issue a calibration exercise between the Spanish and Portuguese acoustic surveys took place in spring 2008 with the simultaneous coverage of several transects by the RVs Thalassa (Spanish survey) and Noruega (Portuguese survey) off northern Portugal. Results from this exercise will be presented at the 2008 WGACEGG meeting. The Portuguese November survey is used to support recruitment strength. Portuguese November 2007 and April 2008 Acoustic Surveys

During 2007/2008, two acoustic surveys were carried to estimate sardine and anchovy abundance in IXa. The November 2007 survey (SAR07NOV) aims to cover the early spawning and recruitment season while the April 2008 survey (PELAGOS08) aims to cover the late spawning season. Both surveys took place onboard the RV “Noruega”.

The November 2007 survey took place from the 24th of October to the 17th of November covering the Portuguese coast and the Gulf of Cádiz. Due to lack of time, the area between Cape Espichel and Cape S. Vicente was not prospected. A total of 33 trawl hauls were performed with sardine being present in 24 of those. Sardine was found in all the surveyed area, being predominant in the western part (between Figueira da Foz and Peniche) (Figure 8.3.2.1.1). Total sardine biomass estimated in the surveyed area was 517 thousand tonnes (74% of it being located in Portuguese waters) corresponding to 9 688 million individuals of which 72% were located in Portuguese waters (Table 8.3.2.1.1). These values represent an increase of 19% in biomass of 26% in numbers compared with the values estimated by last year autumn survey (Figures 8.3.1. and 8.3.2). Age 3 fish (2004 year class) dominated in subdivisions IXaCN and IXa-S Algarve. In the Gulf of Cadiz, age 2 fish (2005 year class) was predominant while in subdivision IXaCN both 2005 and 2006 cohorts were well represented.

Sardine eggs covered a smaller area during the 2007 survey in comparison with the 2006 survey (Figure 8.3.2.1.2). A reduction in the number of eggs detected in the area between Peniche and Figueira da Foz was also apparent in the 2007 survey.

The April 2008 survey (PELAGOS08) took place from the 31st of March to the 5th of May and covered the Portuguese and Gulf of Cádiz waters ranging from 20 to 200 m depth. A total of 49 fishing stations were carried out with sardine being present in 34 of those. Sardine was found throughout the surveyed area but in low numbers (Figure 8.3.2.1.3). The highest concentrations were found in subdivision IXaCN (from Caminha to Figueira da Foz). Total estimated sardine biomass in the surveyed area was 244 thousand tonnes corresponding to 7 031 million individuals (Table 8.3.2.1.2). These values represent a decrease of 46% in biomass of 26% in numbers compared with the values estimated by last year spring survey (Figures 8.3.1. and 8.3.2) and are similar to the lowest values recorded from last decade. Age 4 fish (2004 year class) dominated in subdivision IXaCN but not in the remaining areas. The apparent disappearance of the strong 2004 cohort in the subdivision IXaCS and the Algarve (and the signal of the 2005 cohort in the Gulf of Cadiz) is not consistent with the findings of the previous surveys and needs to be investigated further. The low number of age 1 fish in the survey confirms the indication of a poor 2007 recruitment obtained in the 2007 autumn survey (Table 8.3.2.1.2).

Sardine eggs were found widespread from Gibraltar to Lisbon with some areas of localized high concentrations (Figure 8.3.2.1.4). Few eggs were found north of Cape Carvoeiro and Aveiro. High concentrations were also found north of Aveiro. This reduced spawning areas and egg density north of Cape Carvoeiro was also apparent in the spring and autumn 2007 surveys.

8.3.2.1 Spanish April 2008 Acoustic Survey

The area of the continental shelf covered in 2008 (27th March to 23rd April) extended from 30 to 200 m depth, from northern Portuguese waters to southern French waters. The survey took place onboard the RV "Thalassa". Sardines were present in 38 of the 63 trawl hauls completed during the survey (54 in Spanish waters,). Sardine abundance was estimated as 1 762 million individuals, while biomass was estimated to be 137.5 thousand tonnes (Table 8.3.2.2.1). Half of the fish (53% by number and 49% of the biomass) were found in Galician waters (ICES subdivisions IXaN, VIIIcW) very close to the coast in high densities. In the Cantabrian and Basque Country areas sardine was found more widely distributed, throughout the whole shelf, (Figure 8.3.2.2.1).

Sardine ranged in length from 14.5 to 25.5 cm without two modes at 17.5 and 21.5 cm (Figure 8.3.2.2.2). Applying the ALK obtained from the fish sampled during the survey, most fish (33% by number and 35% of the biomass) in the entire surveyed area were assigned to age class 4 (2004 year class) (Table 8.3.2.2.1). Considering the age distribution by sub-area, the highest proportion of older fish (up to 9 years old although in very low numbers) was found in Cantabrian and Basque Country waters (ICES subdivision VIIIcE). No fish older than 7 years were found in Galician waters (ICES subdivisions IXaN and VIIIcW). Age 4 fish predominated in all areas with the exception of the Basque country, where both the 2006 and the 2004 year classes were noticeable (29% and 22% by number, respectively).

In 2008, sardine eggs were concentrated along the coast with low – zero values near the edge of the shelf (this was not the case in 2007, when an anomalous high presence of eggs was found throughout the whole shelf). In Galicia, sardine egg presence was larger than that usually found for the area (Figure 8.3.2.2.3).

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 and VIIIcE which showed bimodal distributions (modes at 14 and 18 cm and at 15.5 and 22 cm, respectively). The single modes for IXaN and VIIIcW were very similar at 22 and 21.5 cm respectively. For Portugal, single modes were observed for IXaCS at 20 cm while both IXaCN and IXaS-Algarve showed bimodal length distributions (at 13 and 20 cm for IXaS-Algarve and at 15 and 19.5 for IXaCN).

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. All northern Spanish waters (VIIIc and IXaN) and western Portugal catches are dominated by the strong 2004 year class (3-group in 2007). The 2004 year class however is as apparent as the 2005 year class in IXaS Algarve. Age 0 fish (2007 year class) dominates the catches in Cádiz.

0-group catches are concentrated in sub-division IXaS Cádiz. 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

The maturity ogive and stock weights for 2007 (see below) were calculated according to the procedure described in WD2006 Silva et al.. The maturity at age 1 was the second highest of the series (see Figure 8.7.1.5 for historical perspective).

AGE	0	1	2	3	4	5	6+
% mature fish	0	75.0	97.6	99.0	99.6	99.8	99.9

AGE	0	1	2	3	4	5	6+
Weight, kg	0	0.039	0.054	0.062	0.070	0.076	0.077

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

There are a number of studies investigating the role of sardine in the ecosystem both as predator and prey. Sardine is widely distributed all along the Atlantic Iberian shelf in waters ranging from 10 to 100 m (e.g. Porteiro *et al.*, 1996). Analysis of its stomach contents and stable isotope signature indicate an omnivorous feeding behaviour, related to its ability to feed by particle-feeding and filter-feeding (more common as fish grow older, Bode *et al.*, 2003) and its exploitation of a wide range of prey (both phytoplankton and zooplankton have been found in its diet, e.g. Bode et al., 2004). In addition, sardine have been found to ingest their own eggs (and probably those of other species) and this cannibalism would act as a density control mechanism (Garrido *et al.*, 2007).

Sardine is prey of a range of fish and marine mammal species which take advantage of its schooling behaviour and availability. Sardine has been found to be important in the diet of common dolphins (*Delphinus delphis*) in Galicia (NW Spain) (Santos *et al.*, 2004), Portugal (Silva, 2001) and the Atlantic French coast (Meynier, 2004). Also feeding on sardine but 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).

Habitat modelling studies aim to identify which environmental processes could be defining the habitat of a species and eventually to be able to predict fish distribution. Zwolinski *et al* (2008) analysed the relationship between data on sardine distribution obtained by the Portuguese acoustic surveys and 4 environmental variables (sub-surface salinity, temperature, chlorophyll concentration and plankton presence). Sardine showed a preference for waters with low temperature and salinity, high chlorophyll content and low planktonic backscattering energy.

8.6.2 Recruitment forecasting and Environmental effects

Large fluctuations in recruitment are a characteristic of many populations of small pelagic fish species. Periods of good recruitments have helped develop new industries and led to the social and economic changes while periods of continuous low recruitments have brought economic hardship in many areas. This was the case of the Iberian sardine at the end of the 1990s, when several successive poor recruitments led to an all time low of the stock biomass. Sardine is a batch spawner producing batches of eggs over an extended period of time (October to May) in Iberian waters with different peaks between southern and northern regions. Although the survival of offspring is highly dependent on favourable environmental conditions (concentrations of egg/larvae in suitable areas), sardine appears to show a wide range of temperature tolerance for both habitat and spawning distribution (Bernal, 1998).

Historical series of other environmental factors which could contribute/cause the dispersal of egg and larvae outside optimum areas (e.g. upwelling, turbulence, food availability, predation, etc.) have also been explored to try to explain recruitment variability. Cabanas et al. (2007) analysed the Portuguese and Spanish landing series between 1978 and 2005 and attempted to model the variability in recruitment as a function of several local and large scale environmental indices (e.g. 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 1980s but when the whole time series was considered the performance of the model was poor. Their results highlighted one of the most common occurrences of this kind of studies, i.e. correlations between environmental variables and recruitment which "work" well for several years, suddenly break down when the time series increase (see Solow, 2002). A similar study was carried out by Borges and Mendes (2008) looking also for correlations between sardine catches in Portugal with the NAO index, winter north wind and winter upwelling conditions.

Wind-induced transport has also been suggested as a potential predictor of sardine recruitment strength. However, the analysis by Oliveira and Stratoudakis (2008) showed that due to the large variability in the estimated particle movement no relationship could be established between advection/retention and sardine recruitment off western Iberia.

Porteiro *et al* (2008) reanalyzed the available series of Iberian sardine landings (1946–2005) and recruitment (1978–2005) together with series of local and large scale environmental factors to investigate common trends in both. Results from their study have recently been updated (unpublished) and indicated a strong temporal autocorrelation with one year lag in the landings data which presumably mainly reflects the underlying stock dynamics. Once the autocorrelation was taken into account, models indicated that individual landings series were related to SST and AMO and recruitment also appeared to be related to temperature.

8.7 Data and model exploration

This year, the assessment of sardine is an update and therefore no data and model exploration was carried out. Catch and survey data were updated. The Review Group 2007 (RG2007) suggested the exploration of partial effects of recent changes in biological parameters (maturity and weight-at-age), recruitment and fishing mortality, on the SSB. This exploration will be considered in the next benchmark assessment of the stock.

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 poor year-classes in the period 2005 – 2007 (with 2006 indicated as the lowest recruitment of the historical series). 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 and catches show an increasing trend since the late 1990s particularly in 2+ individuals. A substantial increase of weights at ages 1 and 2 was observed from 2005 to 2006 and this continued in 2007. Maturity-at-age 1 continued to be high in 2007 (75%). 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 2007, very low in 2006).

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: 1978–2007
- 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 2008.
- 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 2008. Recruitment in 2008 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 8.8.1.1 d-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 a decrease of about 43 thousand tonnes from 2006 (570 thousand tonnes) to 2007 (526 thousand tonnes) due to successive low recruitments since 2004. Fishing mortality (F_{2-5}) increased 18% from 2006 (0.18 year^{-1}) to 2007 (0.21 year^{-1}), reflecting the increase of catches and decline of stock abundance. However, F is still at a low historical level. The 2006 recruitment is confirmed to be extremely low and the 2007 recruitment is also estimated to be low (4433 billion individuals, CV=55%). A low 2007 recruitment is supported by the 2007 November Portuguese survey at age 0 (not included in the assessment, see Section 8.3.2.1 and Figures 8.3.1–2) and also corroborated in the 2008 Spring acoustic surveys (at age 1).

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 (Figure 8.8.1.1). This assessment is an update and therefore, comments reported in ICES (2006, 2007) are still applicable (namely, the abrupt decline of selection and catchability for the 6+ group and a weak retrospective pattern (Figure 8.8.2.1)).

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 with the following assumptions:

- the input value for the 2007 recruitment was that estimated in the assessment, R_{2007}=4433 million individuals;
- Input values for 2008, 2009 and 2010 recruitments were set equal to the geometric mean of the last 10 years of the times series, $R_{GM(98-07)}$ = 4529 million individuals;
- Weights-at-age in the stock and in the catch were calculated as the arithmetic mean value of the last three years (2005–2007);
- The maturity ogive corresponded to the 2007 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(2005–07) unscaled. F_{sq} = 0.20 year^{-1}

The assumption of recruitment for 2008 – 2010 is equal to that used in catch predictions performed last year. For 2007, the estimate from the assessment model is used, since it is supported by data from the April 2008 acoustic surveys (at age 1) and also from the November 2007 survey (see also section 8.3.2.1). The remaining assumptions are equal to those used in catch predictions performed last year.

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 (0.20) for 2008 are 78 thousand tonnes. Predicted SSB for 2008 is 402 thousand tonnes. If fishing mortality remains at the Fsq level (0.20), the predicted yield in 2009 (71 thousand tonnes) is 25% lower than the catch level in recent years (average of 95 thousand tonnes, 2003 – 2007). Predicted SSB for 2009 is 373 thousand tonnes, which means a decrease of 30% with respect to the estimated 2007 SSB.

According to catch predictions, the average catch level in the last five years (95 thousand tonnes, 2002–2006) will not be sustainable.

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 2008 and 2009.

8.10 Reference points for management purposes

No reference points are defined for this stock.

Last year, the WG considered that the establishment of reference points should be seen in the context of the management of the fishery for this stock. This view was reiterated this year. Some points worth considering in the development of a management strategy are outlines in section 8.12.

8.11 Management considerations

No TAC is set to manage the stock. Limitations to fishing effort and catch levels implemented in Portugal and Spain since 1997 continued to be in effect during 2007.

The Spawning Stock Biomass of this stock, 526 thousand tonnes in 2007, is above the average of the historical series (480 thousand tonnes) but decreased 8% compared to 2006 due to successive low recruitments in the last three years (2005 – 2007). Fishing mortality increased 18% from 2006 to 2007, reflecting the increase of catches and the decrease in stock abundance but is still at a low historical level. Short term predictions indicate a substantial decline in SSB in 2009 (30%) at the assumed fishing mortality level (average of last three years), if the 2007 recruitment is confirmed to be below average and no strong recruitment occurs in 2008. Therefore, recent catch levels will not be sustainable in 2009. 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. Hence, fishing mortality should not increase above the 2005 – 2007 level of 0.20, corresponding to a catch of less than 71 thousand tonnes in 2009.

The WG considers that the management of this stock would be facilitated if a management plan were developed.

8.12 Towards a management plan for sardine

The development of a management plan for sardine was discussed this year by the WG (see also WD Silva et al.). As recommended by SGMAS (2006), the development of this plan should be an interactive process involving stakeholders, managers and scientists interested in the fishery.

The exploration of data on sardine recruitment, SSB and fishing mortality illustrated the following points about the dynamics of the stock (WD Silva et al.):

- There is no clear relationship between spawning biomass and recruitment for the stock within the range of observed values (Figure 8.12.1); there is also no evidence of a breakpoint which could be used to set a Blim reference point
- Recruitment peaks once every 4–7 years leading to a peak in biomass 2 years later; the influence of a strong recruitment on stock biomass persists 4–5 years (Figure 8.12.2)
- In the past, regional problems in the fishery (crisis of the Galician fishery in the mid-1990s) were experienced after 7 years of consecutive low recruitments
- Fishing mortality varies inversely to stock biomass, in consistency with a constant catch regime (Figure 8.12.3); over an F=0.3 year -1, only low stock biomasses were observed in the past

The management of this stock should take into account that recruitment shows extensive inter-annual variability but some temporal pattern. The variability in stock biomass is dependent on strong recruitments and there is also a pattern in the way these recruitments influence stock biomass. In recent years, the advice for this stock has been generally to maintain the F level. Management based on a stable F allow to take advantage of regular increases in biomass due to strong incoming recruitments. However, market constraints represent an important control in recent years and the fishery aims at maintaining catches that satisfy the needs of a stable market (below those recommended in the advice). Portuguese stakeholders have expressed a stable catch as one of their objectives for the fishery. Management aiming at the stability of catches may thus be more consistent with the objectives of stakeholders.

With these points as a background, other management strategies than the common Fixed F –rules may be worth considering. In particular a strategy should be sufficiently flexible with respect to catch limitation to protect the stock under periods of poor recruitment, but also avoid unnecessary fluctuations in the catches.

In conditioning simulation tools, special attention should be given to the recruitment dynamics, as noted above. Also, variations in area distributions linked to the occurrence of strong and weak year classes may have to be considered.

Some commonly used Fixed_F rules have a clause limiting the year-to-year change in TACs. Such rules may be worth considering. However, the special dynamics should encourage thinking of less conventional rules. Some suggestions were outlined by SGMAS (ICES 2007). Another example of a simple rule is the following (assuming *i-1* as the last data year in the assessment):

If :

stock biomass year *i-1* < X

and/or

years since last high Recruitment >Y

and

Recruitment in year *i -1* < W

and

Recruitment in year i < Z

Then:

Change catch in year *i+1* by A

Data available to evaluate these rules includes (i) results from the most recent stock assessment, (ii) the most recent spring survey (year following the last in the assessment) and (iii) the Portuguese November survey in the year following the last year in the assessment. The latter survey could provide useful indication of recruitment strength in the interim year of the advice (there is a good relationship between the relative magnitude of recruitment estimated in this survey and that estimated in the assessment, Figure 8.12.4). Information that could provide some knowledge of the recruitment level in the interim year could also be collected from the fishery.

The WG agrees that future work towards a management plan for sardine should be carried out in a simulation framework. Assumptions about uncertainty and regularity in recruitment dynamics should be considered in the simulation design. Different scenarios of recruitment, stock biomass and catch levels and their influence on short- and long term dynamics of the stock and fishery need to be explored. The results from this work will help to define "threshold" points (or ranges) of biomass and recruitment and to test harvest rules. This work should be carried out interactively with stakeholders. One of the aspects to clarify in the near future regards their aims for the fishery, which aspects of stability are important to them and which quantities could be of interest to evaluate risks in the simulations.

Table 8.2.1: Sardine in VIIIc and IXa: Quaterly distribution of sardine landings (t) in 2007 by ICES Sub-Division. Above absolute values; below, relative numbers.

Sub-Div	**1st**	**2nd**	**3rd**	**4th**	**Total**
VIIIc-E	1120	742	1563	2285	**5710**
VIIIc-W	689	2491	3060	1429	**7670**
IXa-N	1865	2444	1993	6099	**12402**
IXa-CN	3838	6761	13731	16759	**41090**
IXa-CS	3137	4219	6373	5415	**19142**
IXa-S (A)	814	933	1315	1205	**4266**
IXa-S (C)	1605	535	2723	1325	**6188**
Total	**13068**	**18126**	**30757**	**34517**	**96469**

Sub-Div	**1st**	**2nd**	**3rd**	**4th**	**Total**
VIIIc-E	1.16	0.77	1.62	2.37	**5.92**
VIIIc-W	0.71	2.58	3.17	1.48	**7.95**
IXa-N	1.93	2.53	2.07	6.32	**12.86**
IXa-CN	3.98	7.01	14.23	17.37	**42.59**
IXa-CS	3.25	4.37	6.61	5.61	**19.84**
IXa-S (A)	0.84	0.97	1.36	1.25	**4.42**
IXa-S (C)	1.66	0.55	2.82	1.37	**6.41**
Total	**13.55**	**18.79**	**31.88**	**35.78**	

Table 8.2.1.1: Sardine in VIIIc and IXa: Spanish and Portuguese composition of the fleet catching sardine in 2007. Length category: range (average) in m, Engine power category: range (average) in HP.[Values from Portugal correspond to 2006 data].

Country	Details given	Length (metres)	Engine power (Horse Power)	Gear	Storage	Discard estimates	No vessels
Spain (northern)	yes	7.7 – 38.3 (22.2)	24 – 1100 (327.1)	Purse seine	Dry hold with ice	No	325
Spain (Gulf of Cadiz)	yes	10.5 – 25 (16.3)	30 – 510 (208.6)	Purse seine	Dry hold with ice	No	85
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 1940-2007.

	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**
2007	13380	12402	41090	19142	4266	6188	**96469**	**83088**	**64499**	**25782**	**31970**

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 2007 Portuguese autumn acoustic survey. Number in thousand fish and biomass in tonnes.

AREA		0	1	2	3	4	5	6+	Total
Oc. Norte	**Biomass**	**45470**	**9602**	**36683**	**117783**	**19110**	**15108**	**14510**	**258265**
	%	18	4	14	46	7	6	6	
	Mean Weight	22.8	50.3	65.6	77.1	124.3	133.4	151.6	
	No fish	**1993687**	**190864**	**559102**	**1527434**	**153772**	**113226**	**95716**	**4633801**
	%	43	4	12	33	3	2	2	
	Mean Length	14.4	18.9	19.9	20.2	21.0	21.0	21.1	
Oc. Sul	**Biomass**	**11522**	**4853**	**42292**	**38354**	**4993**	**3029**	**8899**	**113942**
	%	10	4	37	34	4	3	8	
	Mean Weight	15.8	58.6	68.1	75.1	79.6	86.9	89.5	
	No fish	**729627**	**82887**	**620899**	**510506**	**62763**	**34870**	**99391**	**2140943**
	%	34	4	29	24	3	2	5	
	Mean Length	12.0	18.5	19.4	20.0	20.3	20.9	21.1	
Algarve	**Biomass**	**1005**	**396**	**1978**	**3407**	**1916**	**1439**	**1226**	**11367**
	%	29	39	51	58	65	68	72	
	Mean Weight	31.0	50.1	64.3	70.1	70.9	78.6	80.5	
	No fish	**32388**	**7899**	**30766**	**48578**	**27034**	**18310**	**15229**	**180204**
	%	18	4	17	27	15	10	8	
	Mean Length	15.5	17.8	19.4	20.0	20.0	20.7	20.8	
Cadiz	**Biomass**	**31124**	**23963**	**41765**	**17873**	**10296**	**2327**	**5927**	**133275**
	%	29	39	51	58	65	68	72	
	Mean Weight	31.4	47.2	59.2	64.7	71.5	78.3	76.2	
	No fish	**992535**	**507613**	**704908**	**276112**	**144066**	**29702**	**77829**	**2732765**
	%	36	19	26	10	5	1	3	
	Mean Length	15.6	17.6	18.9	19.4	20.0	20.6	20.5	
Total	**Biomass**	**59614**	**15452**	**83268**	**142974**	**31797**	**24643**	**25826**	**383574**
Portugal	**%**	16	4	22	37	8	6	7	
	Mean Weight	21.9	58.0	71.3	77.5	81.3	88.7	91.5	
	No fish	**2755702**	**281650**	**1210767**	**2086518**	**243569**	**166406**	**210336**	**6954948**
	%	40	4	17	30	4	2	3	
	Mean Length	13.8	18.4	19.6	20.1	20.3	20.9	21.0	
Total	**Biomass**	**91684**	**34642**	**123813**	**157490**	**47012**	**27160**	**35049**	**516849**
	%	18	7	24	30	9	5	7	
	Mean Weight	23.8	9.0	161.5	231.5	33.9	273.4	143.1	
	No fish	**3748237**	**789263**	**1915675**	**2362630**	**387635**	**196108**	**288165**	**9687713**
	%	39	8	20	24	4	2	3	
	Mean Length	14.3	17.6	19.4	19.9	20.3	20.8	20.9	

Table 8.3.2.1.2: Sardine in VIIIc and IXa: Sardine Assessment from the 2008 Portuguese spring acoustic survey (PELAGOS08). Number in thousand fish and biomass in tonnes.

AREA		1	2	3	4	5	6+	Total
Oc. Norte	**Biomass**	60771	34352	42237	75257	9574	22994	**245185**
	%	25	14	17	31	4	9	
	Mean Weight	15.8	44.8	62.1	54.2	96.4	93.9	
	No fish	980810	519844	389222	1269745	21136	121999	**3302756**
	%	30	16	12	38	1	4	
	Mean Length	16.9	18.3	19.9	20.3	20.4	21.7	
Oc. Sul	**Biomass**	7567	955	710	2264	185	1163	**12844**
	%	59	7	6	18	1	9	
	Mean Weight	5.4	43.0	53.4	65.3	77.2	73.6	
	No fish	1404287	22175	13298	34672	2396	15816	**1492644**
	%	94	1	1	2	0	1	
	Mean Length	8.8	18.0	19.2	20.5	21.7	21.3	
Algarve	**Biomass**	3536	3893	5211	2915	3788	7133	**26476**
	%	13	15	20	11	14	27	
	Mean Weight	43.9	48.7	54.1	58.8	62.8	67.6	
	No fish	80621	79939	96343	49544	60278	105521	**472246**
	%	17	17	20	10	13	22	
	Mean Length	17.7	18.4	19.3	20.0	20.5	21.2	
Cadiz	**Biomass**	15133	6580	10593	2086	993	105	**35489**
	%	43	19	30	6	3	0	
	Mean Weight	10.9	45.4	58.4	61.4	63.9	68.8	
	No fish	1386148	144781	181487	33991	15522	1523	**1763453**
	%	79	8	10	2	1	0	
	Mean Length	10.7	18.0	19.6	20.0	20.2	20.8	
Total	**Biomass**	45102	28786	36535	68245	8840	22188	**209696**
Portugal	**%**	22	14	17	33	4	11	
	Mean Weight	18.3	46.3	73.2	50.4	105.5	91.2	
	No fish	2465719	621957	498864	1353961	83810	243336	**5267646**
	%	47	12	9	26	2	5	
	Mean Length	12.3	18.2	19.6	20.3	20.5	21.3	
Total	**Biomass**	60234	35366	47127	70331	9832	22293	**245185**
	%	25	14	19	29	4	9	
	Mean Weight	15.6	46.1	69.3	50.7	99.0	91.0	
	No fish	3851867	766738	680350	1387952	99332	244859	**7031099**
	%	55	11	10	20	1	3	
	Mean Length	11.7	18.2	19.7	20.3	20.5	21.3	

Table 8.3.2.2.1: Sardine in VIIIc and IXa: Sardine abundance in number (thousands of fish) and biomass (tons by age groups and ICES subdivision in PELACUS0408.

AREA VIIIcE east	AGE										
	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	1096	3688	2553	3644	989	1387	865	506	393	0	15120
% Biomass	7.2	24.4	16.9	24.1	6.5	9.2	5.7	3.3	2.6	0.0	100
Abundance (in '000)	23580	56887	31449	42041	10373	13978	8656	4710	3634	0	195308
% Abundance	12.1	29.1	16.1	21.5	5.3	7.2	4.4	2.4	1.9	0.0	100
Medium Weight (gr)	46.5	64.8	81.2	86.7	95.4	99.2	99.9	107.5	108.0	0.0	82.5
Medium Length (cm)	17.9	20.1	21.7	22.2	23.0	23.3	23.4	24.0	24.0	0.0	20.2
AREA VIIIcE west	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	4099	5884	8246	15177	5724	8551	4758	1381	385	0	54206
% Biomass	7.6	10.9	15.2	28.0	10.6	15.8	8.8	2.5	0.7	0.0	100
Abundance (in '000)	88865	91479	92631	164579	57852	84116	44799	12527	3275	0	640123
% Abundance	13.9	14.3	14.5	25.7	9.0	13.1	7.0	2.0	0.5	0.0	100
Medium Weight (gr)	46.1	64.3	89.0	92.2	98.9	101.7	106.2	110.3	117.7	0.0	91.8
Medium Length (cm)	17.9	20.0	22.5	22.7	23.3	23.5	23.9	24.2	24.7	0.0	22.5
AREA VIIIcW	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	0	1656	5671	11340	2124	1744	1410	0	0	0	23944
% Biomass	0.0	6.9	23.7	47.4	8.9	7.3	5.9	0.0	0.0	0.0	100
Abundance (in '000)	0	22784	69360	134659	23844	17958	14663	0	0	0	283267
% Abundance	0.0	8.0	24.5	47.5	8.4	6.3	5.2	0.0	0.0	0.0	100
Medium Weight (gr)	0.0	72.7	81.8	84.2	89.1	97.1	96.1	0.0	0.0	0.0	65.1
Medium Length (cm)	0.0	20.9	21.8	22.0	22.5	23.1	23.1	0.0	0.0	0.0	16.7
AREA IXaN	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	2444	10121	8793	17784	1616	1948	1527	0	0	0	44233
% Biomass	5.5	22.9	19.9	40.2	3.7	4.4	3.5	0.0	0.0	0.0	100
Abundance (in '000)	55433	160587	124159	243082	19305	23176	17549	0	0	0	643290
% Abundance	8.6	25.0	19.3	37.8	3.0	3.6	2.7	0.0	0.0	0.0	100
Medium Weight (gr)	44.1	63.0	70.8	73.2	83.7	84.1	87.0	0.0	0.0	0.0	69.8
Medium Length (cm)	17.6	19.9	20.7	21.0	22.0	22.0	22.3	0.0	0.0	0.0	20.5
TOTAL SPAIN	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	7640	21349	25262	47946	10452	13630	8560	1888	778	0	137504
% Biomass	5.6	15.5	18.4	34.9	7.6	9.9	6.2	1.4	0.6	0.0	100
Abundance (in '000)	167878	331737	317598	584361	111374	139228	85666	17237	6909	0	1761988
% Abundance	9.5	18.8	18.0	33.2	6.3	7.9	4.9	1.0	0.4	0.0	100
Medium Weight (gr)	45.5	64.4	79.5	82.0	93.9	97.9	99.9	109.5	112.6	0.0	78.5
Medium Length (cm)	17.8	20.0	21.6	21.8	22.9	23.2	23.4	24.1	24.4	0.0	19.9

Table 8.4.1.1: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in 2007.

Total								
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5								
8								
8.5								
9	2							2
9.5				10		10		20
10	49		2	241		17		309
10.5	92			291	25	83	175	666
11	301	1	2	446		299	1 867	2 916
11.5	228	12	45	243	16	736	3 093	4 372
12	528	70	274	238	8	1 591	4 070	6 778
12.5	260	165	248	596	32	1 726	7 557	10 584
13	376	323	558	1 870	54	1 903	12 664	17 748
13.5	441	462	974	2 703	4	1 186	18 092	23 864
14	596	584	1 721	5 783	33	667	20 000	29 384
14.5	772	789	2 071	14 380	33	286	17 418	35 750
15	1 349	1 069	2 254	21 555	88	80	9 841	36 236
15.5	1 718	1 098	2 128	14 179	25	59	7 582	26 789
16	1 625	1 274	2 147	6 893	55	147	6 274	18 416
16.5	1 040	882	1 968	4 189	168	86	5 767	14 100
17	832	801	3 730	5 888	769	284	6 967	19 272
17.5	466	780	4 614	15 607	1 860	712	10 435	34 475
18	282	806	8 038	34 625	4 553	3 064	15 410	66 779
18.5	285	798	8 558	47 305	10 428	6 242	11 956	85 572
19	613	1 320	9 244	79 281	26 409	9 975	10 226	137 067
19.5	1 092	2 061	8 803	114 582	46 813	10 523	4 565	188 438
20	2 233	4 565	10 263	97 508	56 172	11 101	2 936	184 778
20.5	3 299	9 905	13 862	60 631	48 391	7 361	1 198	144 647
21	5 655	16 532	16 034	30 691	33 369	4 624	330	107 235
21.5	8 222	17 422	16 256	20 511	19 323	2 034	236	84 005
22	10 488	12 989	18 424	10 340	8 735	987		61 964
22.5	8 995	7 154	9 183	6 954	3 634	268		36 188
23	7 182	3 484	6 188	3 005	973	24		20 857
23.5	4 174	1 552	3 530	873	334	23		10 487
24	1 825	756	675	226	22			3 504
24.5	604	123	124	87	33			970
25	160	29		59				249
25.5	33	8						42
26	8	6						14
26.5	1							1
27								
27.5	5		8					13
28								
28.5								
29								
Total	65 831	87 822	151 926	601 794	262 359	66 100	178 659	1 414 490
Mean L	21.1	21.0	20.3	19.3	20.4	19.0	15.8	19.3
sd	2.88	2.03	2.31	1.90	1.02	2.54	2.37	2.48
Catch	**5710**	**7670**	**12402**	**41090**	**19142**	**4266**	**6188**	**96468**

Table 8.4.1.1a: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the first quarter 2007.

				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			2					2
10.5								
11		1	2					3
11.5		4	28	46				78
12		27	91	13				131
12.5		26	82	29				137
13		65	94	57		1		217
13.5		144	599	76		2	125	946
14		289	1 268	103		5	125	1 789
14.5	1	469	1 882	93		4	876	2 450
15	11	452	1 860	165			1 234	2 488
15.5	58	306	1 587	52		6	988	2 009
16	70	267	1 408	330		28	1 436	2 103
16.5	77	176	855	985	90	12	2 199	2 194
17	94	185	1 167	3 799	273	117	4 331	5 635
17.5	24	279	2 436	11 948	882	160	5 490	15 730
18	25	458	3 042	22 116	2 249	772	7 954	28 662
18.5	48	586	3 937	19 586	4 970	1 100	4 573	30 228
19	205	498	3 818	10 542	8 383	2 030	3 827	25 476
19.5	493	663	3 579	4 399	9 548	2 225	1 840	20 907
20	1 032	623	2 505	2 887	8 647	2 883	1 000	18 576
20.5	1 214	805	2 107	2 389	7 048	1 904	871	15 466
21	1 855	1 250	1 606	1 237	5 243	1 171	202	12 362
21.5	2 248	1 479	1 504	707	3 359	529	161	9 826
22	2 361	1 076	1 040	343	1 260	256		6 336
22.5	1 494	659	419	142	589	45		3 348
23	1 290	257	217	64	132	9		1 968
23.5	753	184	89	2	40	1		1 068
24	315	49	16					379
24.5	71	4			24			99
25	29							29
25.5	14							14
26	8							8
26.5								
27								
27.5	5							
28								
28.5								
29								
Total	13 795	11 282	37 241	82 108	52 735	13 260	37 231	210 667
Mean L	21.8	19.7	18.4	18.6	20.1	20.0	18.0	19.3
sd	1.44	2.73	2.33	1.05	1.10	1.05	1.36	1.79
Catch	**1 120**	**689**	**1 865**	**3 838**	**3 137**	**814**	**1 605**	**13 068**

Table 8.4.1.1b: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the second quarter 2007.

				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								
10.5								
11								
11.5								
12								
12.5		3						3
13		1	8					9
13.5		2						2
14		1	8	17				26
14.5	57	1	20	17		2		97
15	183	10	64	5		2		264
15.5	208	12	209	84		2	16	531
16	352	10	301	72		37	54	826
16.5	152	11	561	428		22	362	1 536
17	230	9	1 815	1 032	190	108	1 022	4 407
17.5	123	32	1 658	3 312	300	321	1 940	7 686
18	158	11	3 741	10 018	804	1 272	2 058	18 063
18.5	102	19	3 197	16 282	2 173	2 400	1 210	25 384
19	94	575	3 377	25 428	5 001	2 990	1 522	38 986
19.5	135	976	3 475	24 889	8 065	2 412	1 096	41 049
20	335	2 171	4 448	13 851	10 291	2 112	297	33 505
20.5	432	5 623	4 815	8 501	11 014	980	244	31 610
21	688	6 740	3 926	3 385	9 811	521	113	25 185
21.5	1 012	6 353	1 865	1 405	6 691	184	75	17 584
22	1 459	3 336	1 318	423	3 618	129		10 284
22.5	1 076	1 657	157	142	1 446	13		4 491
23	1 052	1 110	133	29	328	3		2 656
23.5	524	306			135	1		965
24	233	125						358
24.5	76	32			9			117
25	22	8						31
25.5	10							10
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	8 713	29 134	35 100	109 318	59 877	13 513	10 010	265 665
Mean L	21.3	21.4	19.7	19.5	20.6	19.5	18.5	20.
sd	2.41	0.95	1.49	0.92	1.05	0.95	1.04	1.36
Catch	**742**	**2 491**	**2 444**	**6 761**	**4 219**	**933**	**535**	**18 125**

Table 8.4.1.1c: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the third quarter 2007.

Third 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	2							2
9.5				10		10		20
10	6			241		17		264
10.5	17			291		83	175	565
11	57			446		299	1 867	2 669
11.5	146	7	17	197		736	3 093	4 196
12	227	36	183	170		1 591	4 070	6 276
12.5	133	115	141	164		1 726	7 182	9 460
13	59	158	163	282		1 899	11 344	13 906
13.5	18	187	40	152		1 182	12 406	13 986
14	50	216	38	51		649	6 923	7 927
14.5	75	130	32	32		230	4 594	5 092
15	75	108	35	11		58	3 072	3 358
15.5	64	108	70				1 944	2 186
16	33	108	113			6	1 811	2 071
16.5	18	36	175			11	1 294	1 533
17	14	7	410	13		13	921	1 378
17.5	6		287	30	78	111	2 456	2 967
18	8		912	1 458	200	862	4 993	8 432
18.5	20	6	1 172	6 601	1 579	2 409	5 950	17 736
19	72	15	1 349	27 414	6 947	3 923	4 713	44 435
19.5	91	129	1 094	48 669	15 921	3 566	1 555	71 024
20	230	1 449	1 749	41 305	21 070	2 176	1 565	69 544
20.5	341	3 170	2 836	25 167	17 037	796	68	49 415
21	939	7 772	4 137	10 806	10 559	442		34 655
21.5	2 078	7 389	3 884	6 723	5 390	116		25 580
22	3 006	6 273	2 617	1 232	2 312	45		15 485
22.5	3 225	2 709	1 041	530	734	12		8 251
23	2 083	1 139	556	128	172	11		4 089
23.5	1 243	462	150	28	48	8		1 938
24	573	254						828
24.5	240	6						246
25	41	9						50
25.5	4							4
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	15 196	31 998	23 200	172 151	82 045	22 986	81 995	429 570
Mean L	21.9	21.5	20.6	20.0	20.5	17.1	15.0	19.2
sd	2.52	1.63	1.94	1.17	0.82	3.30	2.52	2.82
Catch	**1 563**	**3 060**	**1 993**	**13 731**	**6 373**	**1 315**	**2 723**	**30 758**

Table 8.4.1.1d: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the fourth quarter 2007.

				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	43							43
10.5	75				25			100
11	244							244
11.5	82				16			98
12	301	7		55	8			371
12.5	127	21	26	403	32		376	983
13	317	98	292	1 531	54	3	1 320	3 615
13.5	423	130	335	2 475	4	2	5 561	8 929
14	546	78	407	5 613	33	12	12 953	19 642
14.5	638	189	137	14 238	33	51	11 949	27 234
15	1 080	499	295	21 375	88	20	5 536	28 893
15.5	1 388	672	261	14 044	25	51	4 634	21 075
16	1 170	890	325	6 491	55	76	2 973	11 980
16.5	793	658	377	2 777	79	41	1 913	6 638
17	494	600	338	1 044	307	46	692	3 520
17.5	314	470	233	317	599	121	548	2 602
18	91	337	343	1 034	1 301	158	405	3 668
18.5	115	187	252	4 836	1 706	334	223	7 652
19	242	232	700	15 898	6 077	1 031	164	24 344
19.5	373	292	655	36 625	13 279	2 320	74	53 618
20	636	322	1 561	39 465	16 165	3 929	74	62 154
20.5	1 312	308	4 105	24 574	13 292	3 680	15	47 285
21	2 172	770	6 364	15 264	7 757	2 490	15	34 831
21.5	2 883	2 201	9 004	11 677	3 883	1 205		30 854
22	3 661	2 304	13 448	8 342	1 545	558		29 859
22.5	3 199	2 129	7 565	6 140	864	199		20 098
23	2 757	979	5 282	2 784	341	1		12 144
23.5	1 655	601	3 291	843	112	14		6 515
24	704	328	659	226	22			1 939
24.5	217	80	124	87				509
25	67	12		59				138
25.5	5	8						14
26		6						6
26.5	1							1
27								
27.5			8					8
28								
28.5								
29								
Total	28 126	15 408	56 385	238 217	67 702	16 341	49 424	471 604
Mean L	20.2	20.4	21.7	19.	20.3	20.4	14.9	19.2
sd	3.44	2.92	1.84	2.61	1.06	1.07	1.09	2.86
Catch	**2 285**	**1 429**	**6 099**	**16 759**	**5 415**	**1 205**	**1 325**	**34 517**

Table 8.4.1.2: Sardine in VIIIc and IXa: Catch in numbers (thousands) at age by quarter and by subdivision in 2007

							First Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	435	2 228	9 208	2 927	794	1 850	7 257	24 699
2	990	1 820	9 764	17 419	12 206	2 730	20 766	65 694
3	5 488	5 392	15 236	54 128	17 663	3 341	6 607	107 856
4	1 920	458	1 202	1 197	6 680	2 833	1 042	15 333
5	1 816	515	939	2 218	6 846	2 230	1 197	15 761
6	1 726	568	679	1 773	4 671	166	255	9 836
7	1 029	227	213	2 333	3 284	68	106	7 261
8	199	73		82	286	42		683
9	149				306			455
10	43			32				75
11								
12								
Total	13 795	11 282	37 241	82 108	52 735	13 260	37 231	247 652
Catch (Tons)	582	689	1 865	3 838	3 137	814	1 605	12 530

							Second Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	1 452	50	1 405	1 852		93	832	5 685
2	505	4 079	11 352	18 080	1 122	3 092	6 033	44 263
3	2 338	18 350	18 483	74 653	17 578	3 595	2 295	137 292
4	1 086	1 815	1 561	3 003	4 803	2 620	335	15 222
5	1 189	1 997	1 287	3 003	11 211	1 033	368	20 087
6	1 135	1 912	926	3 753	11 921	1 858	94	21 598
7	718	753	86	4 616	10 023	618	52	16 865
8	144	178		117	2 308	281		3 029
9	115					288		403
10	32			241	687	36		995
11								
12					226			
Total	8 713	29 134	35 100	109 318	59 877	13 513	10 010	265 439
Catch (Tons)	630	2 491	2 444	6 761	4 219	933	535	18 013

							Third Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	967	1 194	1 802	2 059		8 504	56 841	71 368
1	418	1 410	5 010	12 064	2 150	1 286	8 780	31 118
2	1 444	9 067	4 784	79 765	22 667	6 487	10 507	134 722
3	5 595	12 066	5 642	63 045	23 401	4 198	4 531	118 478
4	1 746	2 826	2 628	5 402	10 241	710	667	24 220
5	1 870	3 027	2 157	3 509	9 626	1 039	667	21 895
6	2 059	2 028	959	5 746	10 961	694		22 447
7	1 003	308	150	561	1 345			3 367
8	95	72	68		729	68		1 032
9					473			473
10					451			451
11								
12								
Total	15 196	31 998	23 200	172 151	82 045	22 986	81 995	429 570
Catch (Tons)	1 554	3 060	1 993	13 731	6 373	1 315	2 723	30 748

							Fourth Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	6 746	3 616	2 336	70 363	2 658	346	41 931	127 997
1	2 635	1 954	4 011	3 529	2 626	291	5 538	20 583
2	2 790	2 266	9 396	36 227	13 590	2 822	1 683	68 774
3	7 482	3 734	16 761	106 023	33 575	4 310	194	172 080
4	2 261	1 167	8 890	5 483	4 294	3 441	38	25 574
5	2 272	1 380	7 296	7 011	4 850	2 123	38	24 970
6	2 568	906	5 682	6 425	4 202	2 463		22 246
7	1 276	249	1 157	3 156	1 246	336		7 419
8	97	136	857		194	211		1 495
9					467			467
10								
11								
12								
Total	28 126	15 408	56 385	238 217	67 702	16 341	49 424	471 603
Catch (Tons)	1 119	1 429	6 099	16 759	5 415	1 205	1 325	33 350

							Whole Year	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	7 713	4 811	4 138	72 423	2 658	8 851	98 772	199 364
1	4 940	5 642	19 634	20 372	5 569	3 520	22 408	82 084
2	5 729	17 232	35 296	151 491	49 585	15 130	38 990	313 453
3	20 903	39 542	56 122	297 850	92 217	15 444	13 627	535 706
4	7 013	6 266	14 281	15 084	26 018	9 603	2 083	80 348
5	7 146	6 919	11 678	15 740	32 533	6 425	2 272	82 713
6	7 487	5 414	8 246	17 696	31 754	5 181	350	76 128
7	4 026	1 537	1 606	10 666	15 898	1 021	157	34 912
8	535	459	925	199	3 518	602		6 238
9	263				1 245	288		1 797
10	74			273	1 137	36		1 520
11								
12					226			
Total	65 831	87 822	151 926	601 794	262 359	66 100	178 659	1 414 264
Catch (Tons)	3 886	7 670	12 402	41 090	19 142	4 266	6 188	94 644

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	12%	5%	3%	12%	1%	13%	55%	14%
1	8%	6%	13%	3%	2%	5%	13%	6%
2	9%	20%	23%	25%	19%	23%	22%	22%
3	32%	45%	37%	49%	35%	23%	8%	38%
4	11%	7%	9%	3%	10%	15%	1%	6%
5	11%	8%	8%	3%	12%	10%	1%	6%
6+	19%	8%	7%	5%	20%	11%	0%	9%
	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	4%	2%	2%	36%	1%	4%	50%	100%
1	6%	7%	24%	25%	7%	4%	27%	100%
2	2%	5%	11%	48%	16%	5%	12%	100%
3	4%	7%	10%	56%	17%	3%	3%	100%
4	9%	8%	18%	19%	32%	12%	3%	100%
5	9%	8%	14%	19%	39%	8%	3%	100%
6+	10%	6%	9%	24%	45%	6%	0%	100%

Table 8.4.2.1: Sardine VIIIc and IXa: Sardine Mean length (cm) at age by quarter and by subdivision in 2007.

								First Quarter
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	17.2	15.1	15.2	16.7	18.3	18.5	16.3	16.1
2	20.5	19.7	19.2	18.1	19.3	19.5	18.1	18.6
3	21.3	20.8	19.3	18.7	19.7	20.0	19.0	19.2
4	22.1	21.9	20.3	19.6	20.5	20.4	19.0	20.5
5	22.6	22.1	21.4	20.2	20.7	20.9	19.3	20.9
6	22.7	22.4	22.0	20.8	20.9	21.0	21.0	21.4
7	23.1	22.6	23.3	20.8	21.4	21.6	21.6	21.6
8	23.6	23.5		22.3	21.9	21.9		22.6
9	23.9				21.1			22.0
10	25.0			21.4				23.5
11								
12								

								Second Quarter
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	16.6	15.6	16.9	17.3		17.3	17.6	17.1
2	20.0	20.9	19.6	19.1	18.8	18.8	18.3	19.3
3	21.5	21.3	19.7	19.4	19.8	19.2	19.1	19.8
4	22.3	21.7	20.5	20.1	20.6	19.5	19.1	20.5
5	22.7	22.0	21.3	20.3	20.8	20.1	19.4	20.9
6	22.8	22.2	21.5	20.6	21.1	20.1	21.1	21.1
7	23.3	22.4	23.1	20.5	21.2	20.6	21.6	21.2
8	23.6	23.5		22.0	21.6	20.7		21.7
9	23.8					20.6		21.5
10	24.8			22.5	22.2	20.8		22.3
11								
12					23.6			23.6

								Third Quarter
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	13.2	14.3	16.1	12.0		12.9	13.5	13.5
1	19.8	20.8	19.4	19.6	19.7	18.9	17.7	19.1
2	21.5	21.5	20.9	20.1	20.0	19.3	18.6	20.0
3	22.2	21.7	21.4	20.0	20.2	19.6	19.2	20.4
4	22.5	22.1	21.6	20.7	20.7	20.0	20.1	21.1
5	22.9	22.2	21.7	20.6	20.9	20.4	20.1	21.2
6	23.4	22.1	22.1	21.0	21.0	20.2		21.4
7	24.0	22.7	22.5	21.6	21.7			22.5
8	24.8	24.2	23.2		21.2	22.1		22.0
9					21.9			21.9
10					21.8			21.8
11								
12								

								Fourth Quarter
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	14.9	16.0	15.2	15.2	17.4	16.2	14.6	15.1
1	18.4	18.5	19.3	20.0	19.6	19.2	16.3	18.5
2	21.3	21.9	21.8	20.0	20.2	20.0	17.3	20.4
3	22.0	22.3	22.0	20.5	20.3	20.3	19.2	20.7
4	22.5	22.5	22.3	21.1	20.8	20.6	20.2	21.6
5	23.0	22.7	22.3	21.1	21.1	21.2	20.2	21.7
6	23.4	22.7	22.9	21.4	21.3	21.0		22.0
7	24.0	23.5	23.1	22.5	21.3	20.9		22.6
8	24.9	24.4	23.5		21.8	21.4		23.1
9					21.6			21.6
10								
11								
12								

								Whole Year
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	14.7	15.6	15.6	15.2	17.4	13.1	14.0	14.5
1	17.9	17.7	17.2	19.1	19.4	18.7	16.9	17.9
2	21.1	21.2	20.3	19.7	19.8	19.4	18.2	19.7
3	21.8	21.4	20.5	19.8	20.1	19.8	19.1	20.1
4	22.4	22.0	21.8	20.6	20.7	20.2	19.4	21.0
5	22.8	22.2	22.0	20.7	20.9	20.8	19.5	21.2
6	23.1	22.3	22.6	21.0	21.1	20.6	21.0	21.5
7	23.6	22.7	23.1	21.2	21.3	20.8	21.6	21.7
8	24.0	23.9	23.5	22.1	21.5	21.2		22.2
9	23.9				21.6	20.6		21.8
10	24.9			22.4	22.0	20.8		22.2
11								0.0
12					23.6			23.6

Table 8.4.2.2: Sardine VIIIc and IXa: Sardine Mean weight (kg) at age by quarter and by subdivision in 2007.

							First Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	0.040	0.027	0.028	0.034	0.046	0.049	0.033	0.032
2	0.068	0.059	0.055	0.042	0.053	0.057	0.043	0.048
3	0.076	0.068	0.056	0.046	0.057	0.062	0.050	0.052
4	0.084	0.079	0.064	0.053	0.063	0.065	0.050	0.065
5	0.090	0.081	0.074	0.058	0.065	0.069	0.052	0.068
6	0.091	0.085	0.080	0.062	0.067	0.071	0.066	0.072
7	0.096	0.087	0.094	0.063	0.072	0.076	0.071	0.073
8	0.101	0.096		0.076	0.076	0.080		0.086
9	0.105				0.069			0.081
10	0.118			0.068				0.096
11								
12								

							Second Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	0.045	0.038	0.047	0.042		0.050	0.046	0.045
2	0.071	0.080	0.069	0.058	0.054	0.063	0.052	0.062
3	0.085	0.084	0.069	0.061	0.062	0.066	0.058	0.066
4	0.094	0.089	0.077	0.068	0.070	0.069	0.058	0.074
5	0.099	0.091	0.085	0.071	0.072	0.075	0.060	0.076
6	0.100	0.094	0.086	0.074	0.075	0.075	0.074	0.078
7	0.106	0.096	0.104	0.073	0.076	0.080	0.079	0.078
8	0.110	0.108		0.090	0.080	0.081		0.083
9	0.112					0.080		0.089
10	0.124			0.098	0.086	0.082		0.090
11								
12					0.102			0.102

							Third Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	0.021	0.031	0.045	0.018		0.027	0.021	0.023
1	0.076	0.087	0.072	0.075	0.070	0.069	0.052	0.068
2	0.096	0.095	0.088	0.080	0.073	0.073	0.061	0.079
3	0.104	0.098	0.094	0.080	0.075	0.076	0.068	0.082
4	0.108	0.102	0.097	0.088	0.081	0.080	0.079	0.089
5	0.114	0.104	0.098	0.087	0.083	0.084	0.079	0.090
6	0.120	0.103	0.103	0.092	0.084	0.081		0.092
7	0.129	0.111	0.108	0.099	0.091			0.106
8	0.142	0.132	0.117		0.087	0.103		0.098
9					0.094			0.094
10					0.093			0.093
11								
12								

							Fourth Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	0.029	0.042	0.037	0.033	0.050	0.038	0.025	0.031
1	0.057	0.065	0.076	0.079	0.071	0.060	0.035	0.061
2	0.085	0.109	0.109	0.079	0.078	0.068	0.043	0.083
3	0.096	0.115	0.110	0.086	0.079	0.071	0.059	0.088
4	0.104	0.119	0.116	0.093	0.086	0.075	0.068	0.099
5	0.113	0.122	0.116	0.095	0.089	0.081	0.068	0.102
6	0.122	0.123	0.125	0.099	0.093	0.079		0.106
7	0.133	0.136	0.130	0.117	0.092	0.077		0.116
8	0.157	0.153	0.136		0.098	0.084		0.127
9					0.098			0.098
10								
11								
12								

							Whole Year	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	0.028	0.039	0.040	0.032	0.050	0.027	0.023	0.028
1	0.053	0.055	0.050	0.067	0.067	0.057	0.041	0.054
2	0.083	0.090	0.078	0.073	0.069	0.067	0.049	0.071
3	0.091	0.089	0.080	0.071	0.071	0.069	0.057	0.074
4	0.098	0.100	0.104	0.083	0.075	0.071	0.061	0.085
5	0.105	0.102	0.106	0.083	0.076	0.076	0.062	0.086
6	0.111	0.101	0.115	0.088	0.079	0.078	0.068	0.090
7	0.118	0.104	0.122	0.085	0.078	0.079	0.074	0.088
8	0.121	0.123	0.135	0.084	0.082	0.084		0.096
9	0.108				0.089	0.080		0.090
10	0.121			0.094	0.089	0.082		0.091
11								0.000
12					0.102			0.102

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	0.028	0.054	0.071	0.074	0.085	0.086	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	0.039	0.054	0.062	0.070	0.076	0.077

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	0.000	0.650	0.950	1.000	1.000	1.000	1.000
1979	0.000	0.650	0.950	1.000	1.000	1.000	1.000
1980	0.000	0.650	0.950	1.000	1.000	1.000	1.000
1981	0.000	0.650	0.950	1.000	1.000	1.000	1.000
1982	0.000	0.650	0.950	1.000	1.000	1.000	1.000
1983	0.000	0.650	0.950	1.000	1.000	1.000	1.000
1984	0.000	0.650	0.950	1.000	1.000	1.000	1.000
1985	0.000	0.650	0.950	1.000	1.000	1.000	1.000
1986	0.000	0.650	0.950	1.000	1.000	1.000	1.000
1987	0.000	0.650	0.950	1.000	1.000	1.000	1.000
1988	0.000	0.650	0.950	1.000	1.000	1.000	1.000
1989	0.000	0.230	0.830	0.910	0.920	0.940	0.977
1990	0.000	0.600	0.810	0.880	0.890	0.940	0.987
1991	0.000	0.740	0.910	0.960	0.970	1.000	1.000
1992	0.000	0.790	0.910	0.950	0.980	1.000	1.000
1993	0.000	0.470	0.930	0.940	0.970	0.990	1.000
1994	0.000	0.800	0.890	0.960	0.960	0.970	1.000
1995	0.000	0.730	0.980	0.970	0.990	1.000	1.000
1996	0.000	0.542	0.934	0.986	0.994	0.996	0.998
1997	0.000	0.638	0.939	1.000	1.000	1.000	0.987
1998	0.000	0.686	0.851	0.964	0.983	0.989	0.994
1999	0.000	0.838	0.991	0.999	1.000	1.000	1.000
2000	0.000	0.465	0.915	0.960	0.972	0.980	0.984
2001	0.000	0.430	0.816	0.942	0.971	0.971	0.978
2002	0.000	0.586	0.932	0.981	0.993	0.997	0.997
2003	0.000	0.500	0.936	0.973	0.985	0.990	0.987
2004	0.000	0.489	0.936	0.974	0.983	0.985	1.000
2005	0.000	0.193	0.854	0.968	0.986	0.992	1.000
2006	0.000	0.885	0.985	0.997	0.999	0.999	0.999
2007	0.000	0.750	0.976	0.990	0.996	0.998	0.999

Table 8.8.1.1.d

Run id 20080905 093224.369
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	11745.9	13799.1	15000.3	9525.7	6951.7	20105.7	8559.7	6542.8
1	7610.8	9324.5	11004.4	12149.1	7554.5	5609.3	16302.3	7010.1
2	3715.8	4176.2	5163.9	6500.9	6919.3	4449.9	3421.1	9848.4
3	1251.7	1800.1	2048.7	2747.9	3233.3	3514.2	2386.1	1910.7
4	632.9	624.9	902.4	1142.4	1440.4	1734.5	1938.5	1334.8
5	191.9	330.6	319.1	510.2	621.0	788.6	982.3	1123.3
6	83.4	145.9	247.6	327.1	460.2	594.7	781.6	1021.1

	1986	1987	1988	1989	1990	1991	1992	1993
0	5456.3	9153.9	5888.1	5854.8	5540.5	12806.1	10674.4	4769.9
1	5368.6	4434.4	7253.5	4643.6	4637.1	4386.7	10185.2	8580.4
2	4349.8	3226.0	2681.1	4370.4	2785.7	2738.1	2745.2	6480.0
3	5531.2	2306.0	1723.1	1432.2	2307.9	1441.1	1567.2	1610.8
4	1073.1	2990.6	1236.6	908.9	734.1	1121.3	768.4	861.6
5	775.0	575.8	1626.4	661.8	475.9	353.1	602.4	421.8
6	1262.5	1148.5	983.6	1437.4	1165.8	871.4	712.3	768.7

	1994	1995	1996	1997	1998	1999	2000	2001
0	4653.9	3947.5	5014.3	3895.8	3987.0	3874.0	10909.1	7403.2
1	3848.3	3835.9	3267.9	4130.7	3176.6	3185.2	3112.4	8800.8
2	5439.8	2590.7	2582.7	2213.6	2706.1	2035.2	2033.6	1984.0
3	3721.2	3422.4	1626.1	1614.6	1309.3	1545.6	1188.0	1195.7
4	834.1	2120.7	1910.1	882.1	814.7	627.6	786.4	616.5
5	448.9	472.8	1184.7	1029.8	423.9	370.8	301.8	386.6
6	681.6	692.5	708.2	1096.4	1190.5	938.2	778.6	649.4

	2002	2003	2004	2005	2006	2007	2008
0	3942.1	2765.5	12393.2	4286.5	1133.7	4432.6	9000.0
1	6049.5	3242.4	2253.2	10061.6	3499.6	932.3	3625.0
2	5668.1	3937.4	2097.5	1450.8	6535.5	2293.7	600.9
3	1214.7	3528.7	2446.1	1288.8	891.9	4061.9	1388.6
4	669.3	707.6	2057.0	1409.9	762.1	534.8	2357.1
5	329.4	375.7	398.5	1142.5	817.7	450.7	305.3
6	633.6	606.7	612.8	622.4	1074.2	1196.3	1039.6

Table 8.8.1.1.e

Total yearly fishing mortalities at age

	1978	1979	1980	1981	1982	1983	1984	1985
0	0.0659	0.0613	0.0458	0.0669	0.0496	0.0447	0.0347	0.0328
1	0.2702	0.2610	0.1964	0.2329	0.1993	0.1645	0.1740	0.1472
2	0.3947	0.3822	0.3009	0.3684	0.3475	0.2932	0.2525	0.2469
3	0.3647	0.3605	0.2541	0.3159	0.2928	0.2649	0.2509	0.2469
4	0.3194	0.3421	0.2402	0.2795	0.2725	0.2386	0.2156	0.2136
5	0.3194	0.3421	0.2402	0.2795	0.2725	0.2386	0.2156	0.2136
6	0.2724	0.2863	0.1938	0.2518	0.2614	0.2439	0.2179	0.1847
Fref	0.3496	0.3567	0.2588	0.3108	0.2963	0.2588	0.2337	0.2303

	1986	1987	1988	1989	1990	1991	1992	1993
0	0.0424	0.0677	0.0724	0.0682	0.0685	0.0640	0.0534	0.0497
1	0.1793	0.1732	0.1766	0.1810	0.1968	0.1388	0.1222	0.1257
2	0.3046	0.2971	0.2970	0.3085	0.3291	0.2280	0.2031	0.2247
3	0.2849	0.2931	0.3097	0.3383	0.3918	0.2989	0.2682	0.3282
4	0.2925	0.2791	0.2952	0.3171	0.4018	0.2913	0.2698	0.3221
5	0.2925	0.2791	0.2952	0.3171	0.4018	0.2913	0.2698	0.3221
6	0.2143	0.2082	0.2208	0.2320	0.2659	0.1813	0.1563	0.1793
Fref	0.2936	0.2871	0.2993	0.3202	0.3811	0.2773	0.2528	0.2993

Table 8.8.1.1.e. cont.

```
 1994 1995 1996 1997 1998 1999 2000 2001
 0 0.0283 0.0239 0.0289 0.0391 0.0595 0.0539 0.0498 0.0370
 1 0.0657 0.0655 0.0595 0.0929 0.1152 0.1187 0.1203 0.1100
 2 0.1334 0.1357 0.1398 0.1951 0.2301 0.2083 0.2010 0.1607
 3 0.2323 0.2532 0.2817 0.3541 0.4054 0.3458 0.3261 0.2504
 4 0.2377 0.2523 0.2878 0.4028 0.4571 0.4021 0.3799 0.2968
 5 0.2377 0.2523 0.2878 0.4028 0.4571 0.4021 0.3799 0.2968
 6 0.1121 0.1143 0.1065 0.1250 0.1383 0.1166 0.1107 0.0892

Fref 0.2103 0.2234 0.2493 0.3387 0.3874 0.3396 0.3217 0.2511


 2002 2003 2004 2005 2006 2007 2008
 0 0.0304 0.0399 0.0434 0.0378 0.0306 0.0361 0.0361
 1 0.0995 0.1056 0.1102 0.1015 0.0925 0.1092 0.1092
 2 0.1439 0.1460 0.1570 0.1565 0.1456 0.1718 0.1718
 3 0.2104 0.2097 0.2210 0.1954 0.1815 0.2142 0.2142
 4 0.2475 0.2442 0.2580 0.2147 0.1953 0.2305 0.2305
 5 0.2475 0.2442 0.2580 0.2147 0.1953 0.2305 0.2305
 6 0.0767 0.0835 0.0939 0.0836 0.0803 0.0947 0.0947

Fref 0.2123 0.2110 0.2235 0.1953 0.1794 0.2117 0.2117
```

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 690712.2 757426.6 619942.9 568522.6 310416.8 811392.3 269655.3 194925.7
 1 1546079.5 1839620.1 1681716.0 2167133.3 1172539.7 730586.5 2230978.4 823475.2
 2 1043397.8 1142525.9 1151286.8 1721701.8 1744654.7 970357.4 654688.9 1847723.4
 3 329027.4 468913.7 394577.5 639524.1 704971.3 701542.7 453731.2 358221.3
 4 148689.9 155553.3 165220.4 239209.4 294935.8 315755.7 322304.4 220072.1
 5 45091.8 82290.1 58424.0 106842.3 127159.0 143555.4 163319.9 185204.8
 6 17061.7 31180.8 37399.0 62461.5 90765.2 110254.5 131047.6 147643.3

 1986 1987 1988 1989 1990 1991 1992 1993
 0 209022.7 552816.4 379728.5 356242.3 338907.9 732727.3 512201.6 213610.5
 1 757387.7 605745.3 1009367.2 661162.8 713881.5 488950.8 1007557.3 873445.3
 2 981342.0 712178.4 592128.1 997639.9 673442.6 480024.0 433603.4 1122044.0
 3 1178225.6 503023.4 394110.4 353152.0 644104.4 319439.3 316230.8 386933.9
 4 233528.3 625001.0 271376.0 212135.9 208924.5 243034.7 155771.2 203704.2
 5 168656.3 120343.1 356908.1 154462.5 135423.4 76540.7 122131.6 99711.5
 6 209205.9 185437.9 167411.9 255836.4 234356.3 124226.9 88578.6 108495.5

 1994 1995 1996 1997 1998 1999 2000 2001
 0 120027.6 86342.5 131758.4 138006.6 212784.7 187684.2 489004.2 248012.7
 1 211242.8 209967.0 163228.6 316037.9 297646.7 306222.3 302804.9 785123.7
 2 584060.1 282727.4 289855.5 337866.0 478997.7 329244.8 318418.1 252762.3
 3 660679.4 656004.6 342361.4 414288.9 375970.4 388822.0 284295.6 227327.2
 4 151086.3 405123.9 409609.9 251461.6 257413.0 178680.7 213630.2 135759.4
 5 81307.4 90314.1 254052.5 293562.4 133939.0 105568.9 81984.8 85148.8
 6 62123.0 64294.8 61591.7 111211.9 132833.1 89148.9 70373.9 47725.0

 2002 2003 2004 2005 2006 2007 2008
 0 108916.4 99802.6 486040.9 146850.1 31543.2 145160.9 294737.9
 1 490072.1 277933.3 201269.0 830586.3 264483.0 82517.5 320842.5
 2 651208.0 458353.6 261218.9 179795.8 757450.4 309977.3 81215.6
 3 197566.1 572200.7 415855.7 196001.0 126744.9 671114.3 229431.1
 4 125700.4 131317.2 400936.9 233383.5 115740.4 94341.2 415799.1
 5 61862.8 69716.0 77671.8 189121.1 124196.7 79499.9 53863.3
 6 40230.1 41713.6 47105.5 42754.2 70943.7 92618.9 80487.9
```

Table 8.8.1.1.f cont

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	2008
0	106882.0	198412.0	589910.0	169229.0	18347.0	199364.0	0.0
1	587354.0	318695.0	180522.0	1005530.0	250200.0	82084.0	0.0
2	753897.0	446285.0	263521.0	266213.0	777315.0	313453.0	0.0
3	181381.0	518289.0	386715.0	206657.0	128695.0	535706.0	0.0
4	112166.0	114035.0	377848.0	191013.0	108244.0	80348.0	0.0
5	55650.0	61276.0	78396.0	116628.0	121043.0	82713.0	0.0
6	40219.0	51172.0	55312.0	46087.0	81149.0	120821.0	0.0

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	0.14	-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	0.96	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	-0.07	-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	0.35	-0.16	0.11	0.04	0.35	0.09	0.18	0.23
5	0.15	0.25	-0.20	0.26	0.11	-0.02	-0.10	0.13
6	-0.23	-0.08	0.12	-0.04	0.06	-0.17	-0.09	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	0.75	0.27	0.00	-0.12
1	-1.26	-0.10	-0.48	0.55	0.21	0.44	0.16	0.40
2	-0.07	-0.01	0.18	0.29	0.05	0.09	-0.01	0.01
3	0.50	0.23	0.41	-0.06	-0.06	-0.14	-0.11	-0.15
4	0.59	0.15	0.47	0.29	-0.10	-0.01	-0.10	-0.07
5	0.33	-0.25	-0.25	-0.27	0.29	0.00	0.18	-0.12
6	0.15	0.00	-0.28	-0.46	-0.23	-0.21	-0.09	0.04

Residuals: log (Obs/mod), fleet 1 area 1

	2002	2003	2004	2005	2006	2007	2008
0	-0.02	0.69	0.19	0.14	-0.54	0.32	0.00
1	0.18	0.14	-0.11	0.19	-0.06	-0.01	0.00
2	0.15	-0.03	0.01	0.39	0.03	0.01	0.00
3	-0.09	-0.10	-0.07	0.05	0.02	-0.23	0.00
4	-0.11	-0.14	-0.06	-0.20	-0.07	-0.16	0.00
5	-0.11	-0.13	0.01	-0.48	-0.03	0.04	0.00
6	0.00	0.20	0.16	0.08	0.13	0.27	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 5045307.8 6350175.4 4869818.7 4883401.2 4771755.713516267.7
2 -1.0 -1.0 3038638.7 2585830.3 3147414.4 2374481.2 2375139.2 2329684.5
3 -1.0 -1.0 1545903.3 1520398.5 1225303.8 1456738.6 1122416.2 1140227.2
4 -1.0 -1.0 2165783.3 986821.5 905434.9 702080.3 882009.2 698284.7
5 -1.0 -1.0 1343284.6 1152039.8 471122.5 414806.0 338488.5 437966.5
6 -1.0 -1.0 320093.3 494079.3 535451.0 423285.1 351600.0 294237.0

2002 2003 2004 2005 2006 2007 2008
0 -1.0 -1.0 -1.0 -1.0 -1.0 -1.0 -1.0
1 9304221.8 4983587.0 3460737.915472346.4 5387392.1 1432239.6 5568801.6
2 6671661.1 4633663.4 2465121.6 1705976.2 7695196.6 2691967.9 705309.2
3 1164019.6 3382112.3 2341235.5 1237552.9 858001.0 3891644.3 1330420.5
4 762504.6 806442.1 2340438.4 1612213.9 873443.5 610355.6 2690078.1
5 375262.5 428138.2 453403.5 1306449.3 937259.4 514337.1 348477.5
6 287604.2 275232.7 277652.2 282397.9 487660.6 542076.1 471076.7
```

Table 8.8.1.1.g cont

```
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 6673110.019659943.0
 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 2008
 0 -1.0 -1.0 -1.0 -1.0 -1.0 -1.0 -1.0
 113040557.0 5884533.0 -1.022921588.0 7454560.0 1645060.0 4019746.0
 2 6998075.0 4584129.0 -1.0 1302100.0 8309214.0 3084732.0 1098475.0
 3 1164108.0 3567936.0 -1.0 685187.0 577248.0 4000502.0 997949.0
 4 1130977.0 1008979.0 -1.0 763181.0 443151.0 636829.0 1972313.0
 5 565547.0 570302.0 -1.0 652746.0 577657.0 283416.0 210706.0
 6 442031.0 338076.0 -1.0 369282.0 606933.0 704458.0 493898.0

 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 -1.13 0.01 -0.82 0.19 0.34 0.37
 2 0.00 0.00 -0.35 0.30 0.27 0.13 0.03 -0.81
 3 0.00 0.00 0.48 0.10 0.62 0.09 0.39 -0.49
 4 0.00 0.00 0.41 0.34 0.48 0.32 0.12 -0.37
 5 0.00 0.00 -0.81 0.21 0.94 0.41 0.76 -0.16
 6 0.00 0.00 -2.16 -0.63 0.63 0.23 0.66 -0.16

 2002 2003 2004 2005 2006 2007 2008
 0 0.00 0.00 0.00 0.00 0.00 0.00 0.00
 1 0.34 0.17 0.00 0.39 0.32 0.14 -0.33
 2 0.05 -0.01 0.00 -0.27 0.08 0.14 0.44
 3 0.00 0.05 0.00 -0.59 -0.40 0.03 -0.29
 4 0.39 0.22 0.00 -0.75 -0.68 0.04 -0.31
 5 0.41 0.29 0.00 -0.69 -0.48 -0.60 -0.50
 6 0.43 0.21 0.00 0.27 0.22 0.26 0.05
```

Table 8.8.1.1.h

SPAWNING STOCK BIOMASS

Year	Modelled Total		Expected By fleet	Observed/q By fleet
1997	380653.53	1	380653.53	358255.78
1998	329668.61	1	329668.61	-1.00
1999	330992.84	1	330992.84	281292.48
2000	266393.77	1	266393.77	-1.00
2001	309472.23	1	309472.23	-1.00
2002	450215.10	1	450215.10	474328.14
2003	458374.29	1	458374.29	-1.00
2004	455387.48	1	455387.48	-1.00
2005	368859.28	1	368859.28	437728.75
2006	570171.05	1	570171.05	-1.00
2007	526457.35	1	526457.35	-1.00
2008	460632.10	1	460632.10	-1.00

Table 8.8.1.1.i

SUMMARY TABLE

Year	Recruits age 0	SSB	F 2 – 5	Catch SOP
1978	11745859	306044	0.3496	173761
1979	13799091	375897	0.3567	162454
1980	15000263	465247	0.2588	204861
1981	9525742	582716	0.3108	242574
1982	6951714	615482	0.2963	214148
1983	20105684	571591	0.2588	176636
1984	8559694	625827	0.2337	215114
1985	6542813	730443	0.2303	219928
1986	5456257	680143	0.2936	192838
1987	9153861	575805	0.2871	176283
1988	5888071	501497	0.2993	157273
1989	5854789	421146	0.3202	146539
1990	5540503	383244	0.3811	142966
1991	12806072	389119	0.2773	132785
1992	10674372	507376	0.2528	131196
1993	4769882	565728	0.2993	144949
1994	4653889	573179	0.2103	138725
1995	3947481	629469	0.2234	126755
1996	5014323	428119	0.2493	115179
1997	3895783	380653	0.3387	117250
1998	3986960	329668	0.3874	112033
1999	3874038	330992	0.3396	95793
2000	10909137	266393	0.3217	87272
2001	7403242	309472	0.2511	102903
2002	3942062	450215	0.2123	101741
2003	2765507	458374	0.2110	99113
2004	12393208	455387	0.2235	98464
2005	4286502	368859	0.1953	97282
2006	1133743	570171	0.1794	88816
2007	4432576	526457	0.2117	97937
2008	9000000	460632	0.2117	0

Table 8.8.1.2. Sardine in VIIIc and IXa: Coefficient of variation of estimated parameters from the inverse Hessian

```
Run id 20080905 093224.369
 Coeff. of variation and correlations from inverse Hessian
 Parameter Param. value CV
 1 Initial number 1978 age1 7610779.1914 0.0636
 2 Initial number 1978 age2 3715785.6961 0.0779
 3 Initial number 1978 age3 1251688.5738 0.0982
 4 Initial number 1978 age4 632883.3684 0.0514
 5 Initial number 1978 age5 191928.4823 0.2193
 6 Initial number 1978 age6 83374.0802 0.0733
 7 Recruitment age0 1978 11745859.2545 0.1034
 8 Recruitment age0 1979 13799091.7572 0.1015
 9 Recruitment age0 1980 15000263.2750 0.0591
 10 Recruitment age0 1981 9525742.0696 0.0315
 11 Recruitment age0 1982 6951714.1851 0.0474
 12 Recruitment age0 1983 20105684.1708 0.0865
 13 Recruitment age0 1984 8559694.5937 0.1062
 14 Recruitment age0 1985 6542813.2994 0.0359
 15 Recruitment age0 1986 5456257.8317 0.1071
 16 Recruitment age0 1987 9153861.0208 0.0677
 17 Recruitment age0 1988 5888071.7814 0.1059
 18 Recruitment age0 1989 5854789.9162 0.0613
 19 Recruitment age0 1990 5540503.8114 0.1058
 20 Recruitment age0 1991 12806072.2274 0.0607
 21 Recruitment age0 1992 10674372.4641 0.0595
 22 Recruitment age0 1993 4769882.3980 0.0402
 23 Recruitment age0 1994 4653889.9205 0.0780
 24 Recruitment age0 1995 3947481.9987 0.0369
 25 Recruitment age0 1996 5014323.7761 0.0494
 26 Recruitment age0 1997 3895783.9423 0.0363
 27 Recruitment age0 1998 3986960.9722 0.0412
 28 Recruitment age0 1999 3874038.3760 0.0505
 29 Recruitment age0 2000 10909137.4898 0.0357
 30 Recruitment age0 2001 7403242.8009 0.0301
 31 Recruitment age0 2002 3942062.8379 0.0504
 32 Recruitment age0 2003 2765507.4241 0.0496
 33 Recruitment age0 2004 12393208.5797 0.1002
 34 Recruitment age0 2005 4286502.4779 0.1602
 35 Recruitment age0 2006 1133743.2942 0.1121
 36 Recruitment age0 2007 4432576.0403 0.5457
 37 F-select year 1978 age 0 0.3710 0.2117
 38 F-select year 1978 age 1 0.7611 0.1601
 39 F-select year 1978 age 2 1.1121 0.1141
 40 F-select year 1978 age 3 1.0273 0.0526
 41 F-select year 1978 age 4 0.8999 0.1513
 42 F-select year 1978 age 6 0.7675 0.0674
 43 F year 1978 0.3496 0.0727
 44 F year 1979 0.3567 0.0589
 45 F year 1980 0.2588 0.0787
 46 F year 1981 0.3108 0.0790
 47 F year 1982 0.2963 0.0315
 48 F year 1983 0.2588 0.0537
 49 F year 1984 0.2337 0.1038
 50 F year 1985 0.2303 0.0331
 51 F year 1986 0.2936 0.0309
 52 F year 1987 0.2871 0.0401
 53 F year 1988 0.2993 0.0368
 54 F year 1989 0.3202 0.0357
 55 F year 1990 0.3811 0.0411
 56 F year 1991 0.2773 0.0321
 57 F year 1992 0.2528 0.0647
 58 F year 1993 0.2993 0.0718
 59 F year 1994 0.2103 0.0470
 60 F year 1995 0.2234 0.0493
 61 F year 1996 0.2493 0.0985
 62 F year 1997 0.3387 0.0333
 63 F year 1998 0.3874 0.1020
 64 F year 1999 0.3396 0.0711
 65 F year 2000 0.3217 0.0331
 66 F year 2001 0.2511 0.0554
 67 F year 2002 0.2123 0.1054
 68 F year 2003 0.2110 0.0517
 69 F year 2004 0.2235 0.0622
 70 F year 2005 0.1953 0.0582
 71 F year 2006 0.1794 0.0581
 72 F year 2007 0.2117 0.0533
 73 Joint Spring Acoustic age 1 1.6227 0.1955
 74 Joint Spring Acoustic age 2 1.2489 0.2215
 75 Joint Spring Acoustic age 3 1.0248 0.0895
 76 Joint Spring Acoustic age 4 1.2230 0.1054
 77 Joint Spring Acoustic age 6 0.4778 0.1490
 78 Q for ssb year 1988 0.9563 0.0897
```

Table 8.9.1.1: Sardine in VIIIc and IXa: Input data for short term catch predictions.

MFDP version 1a
Run: sar-soth
Time and date: 16:24 06-09-2008
Fbar age range: 2-5

2008

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4528949	0.33	0.00	0.25	0.25	0.000	0.035	0.027
1	3625017	0.33	0.75	0.25	0.25	0.029	0.101	0.044
2	600948	0.33	0.98	0.25	0.25	0.047	0.158	0.061
3	1388613	0.33	0.99	0.25	0.25	0.060	0.197	0.070
4	2357125	0.33	1.00	0.25	0.25	0.069	0.214	0.077
5	305346	0.33	1.00	0.25	0.25	0.072	0.214	0.080
6	1039640	0.33	1.00	0.25	0.25	0.077	0.086	0.100

2009

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4528949	0.33	0.00	0.25	0.25	0.000	0.035	0.027
1	.	0.33	0.75	0.25	0.25	0.029	0.101	0.044
2	.	0.33	0.98	0.25	0.25	0.047	0.158	0.061
3	.	0.33	0.99	0.25	0.25	0.060	0.197	0.070
4	.	0.33	1.00	0.25	0.25	0.069	0.214	0.077
5	.	0.33	1.00	0.25	0.25	0.072	0.214	0.080
6	.	0.33	1.00	0.25	0.25	0.077	0.086	0.100

2010

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4528949	0.33	0.00	0.25	0.25	0.000	0.035	0.027
1	.	0.33	0.75	0.25	0.25	0.029	0.101	0.044
2	.	0.33	0.98	0.25	0.25	0.047	0.158	0.061
3	.	0.33	0.99	0.25	0.25	0.060	0.197	0.070
4	.	0.33	1.00	0.25	0.25	0.069	0.214	0.077
5	.	0.33	1.00	0.25	0.25	0.072	0.214	0.080
6	.	0.33	1.00	0.25	0.25	0.077	0.086	0.100

Input units are thousands and kg - output in tonnes

Table 8.9.1.2: Sardine in VIIIc and IXa: Results for short term catch predictions.

MFDP version 1a
Run: sar-soth
Sardine (VIIIc+IXa), 2006 WG
Time and date: 16:24 06-09-2008
Fbar age range: 2-5

2008				
Biomass	SSB	FMult	FBar	Landings
482353	401506	1	0.196	77705

2009					2010	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
446886	388024	0	0.000	0	488253	424705
.	386475	0.1	0.020	7646	481975	417511
.	384933	0.2	0.039	15175	475797	410457
.	383397	0.3	0.059	22591	469719	403541
.	381869	0.4	0.078	29894	463737	396760
.	380346	0.5	0.098	37087	457851	390111
.	378831	0.6	0.117	44172	452058	383591
.	377322	0.7	0.137	51150	446357	377198
.	375820	0.8	0.157	58024	440746	370928
.	374325	0.9	0.176	64795	435224	364780
.	372836	1	0.196	71466	429790	358750
.	371353	1.1	0.215	78036	424440	352836
.	369877	1.2	0.235	84510	419175	347036
.	368408	1.3	0.254	90887	413992	341348
.	366945	1.4	0.274	97170	408891	335768
.	365488	1.5	0.294	103361	403869	330295
.	364038	1.6	0.313	109460	398926	324927
.	362594	1.7	0.333	115470	394059	319660
.	361156	1.8	0.352	121392	389268	314494
.	359725	1.9	0.372	127227	384551	309426
.	358299	2	0.391	132978	379907	304454

Input units are thousands and kg - output in tonnes

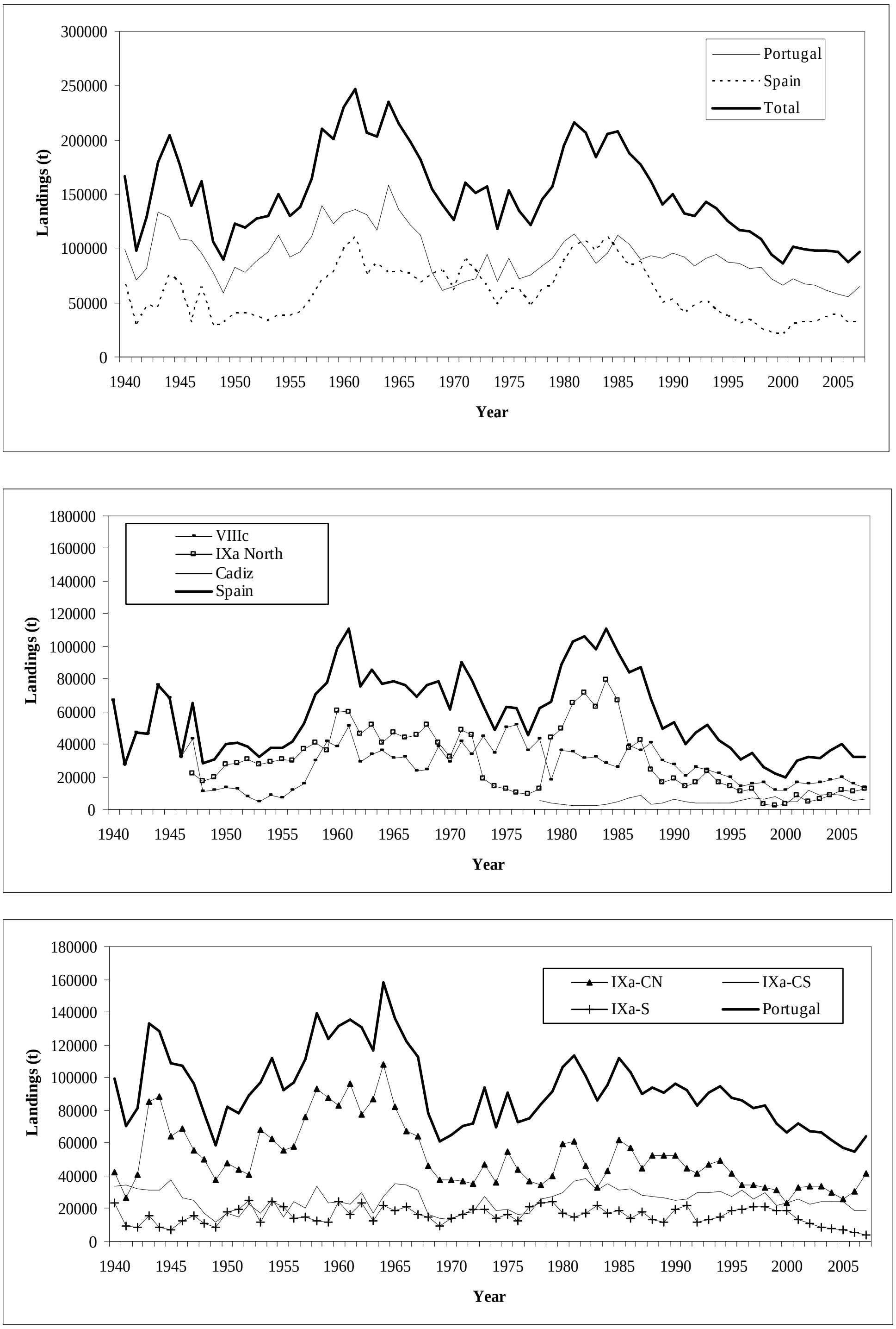


Figure 8.2.1: Sardine in VIIIc and IXa: Annual landings of sardine, by country (upper pannel) and by ICES subdivision and country

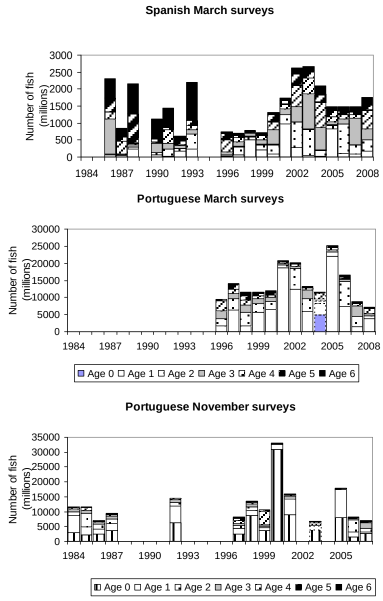


Figure 8.3.1: Sardine in VIIIc and IXa: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish Spring survey series covers area VIIIc and IXa-N (Galicia), the Portuguese Spring surveys covers the Portuguese area and the Gulf of Cadiz (Sub-divisions IXa-CN, IXa-CS, IXa-S-Algarve and IXa-S-Cadiz) and the Portuguese November survey covers only the Portuguese waters. Estimates from Portuguese acoustic survey in 2004 (June) are considered as indications of the population abundance and are not included in assessment.

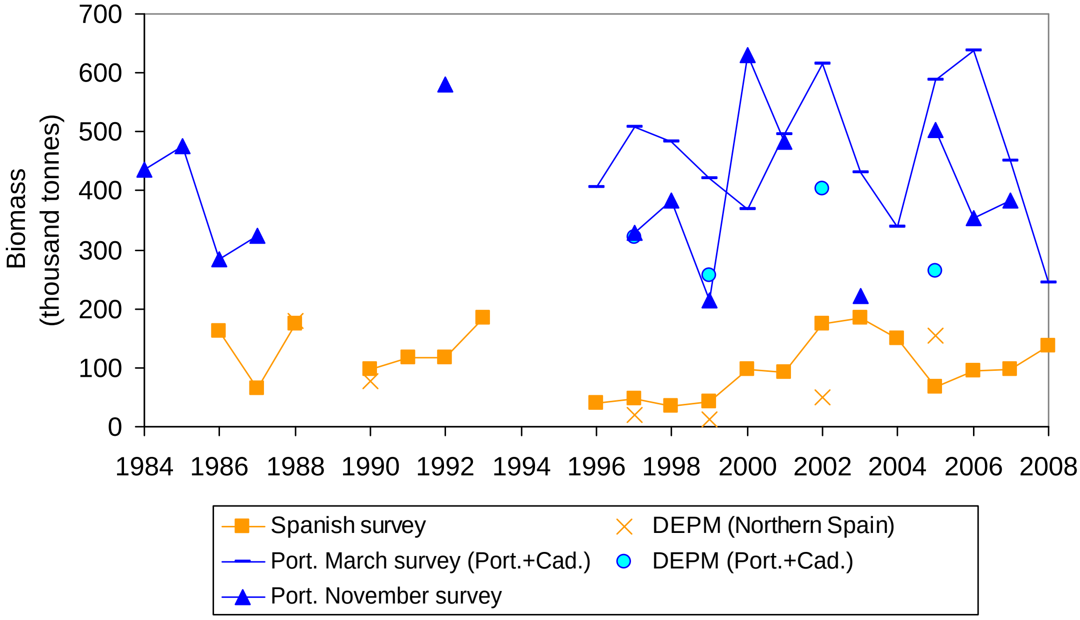


Figure 8.3.2: Sardine in VIIIc and IXa: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.

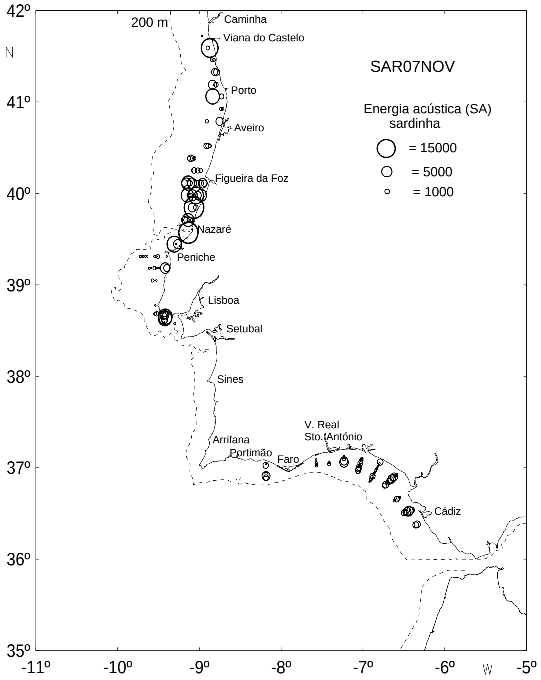


Figure 8.3.2.1.1: Sardine in VIIIc and IXa: Portuguese autumn acoustic survey in 2008. Acoustic energy by nautical mile and abundance and length structure by area. Circle area is proportional to the acoustic energy (S_A m²/nm²).

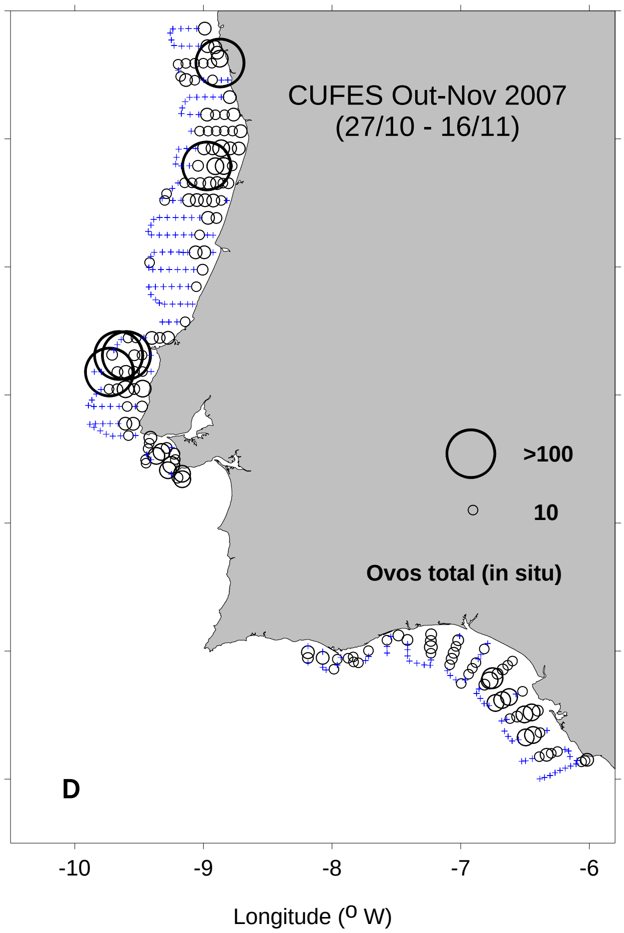


Figure 8.3.2.1.2: Sardine in VIIIc and IXa: Portuguese autumn acoustic survey in 2007. Total number of sardine eggs obtained during the survey.

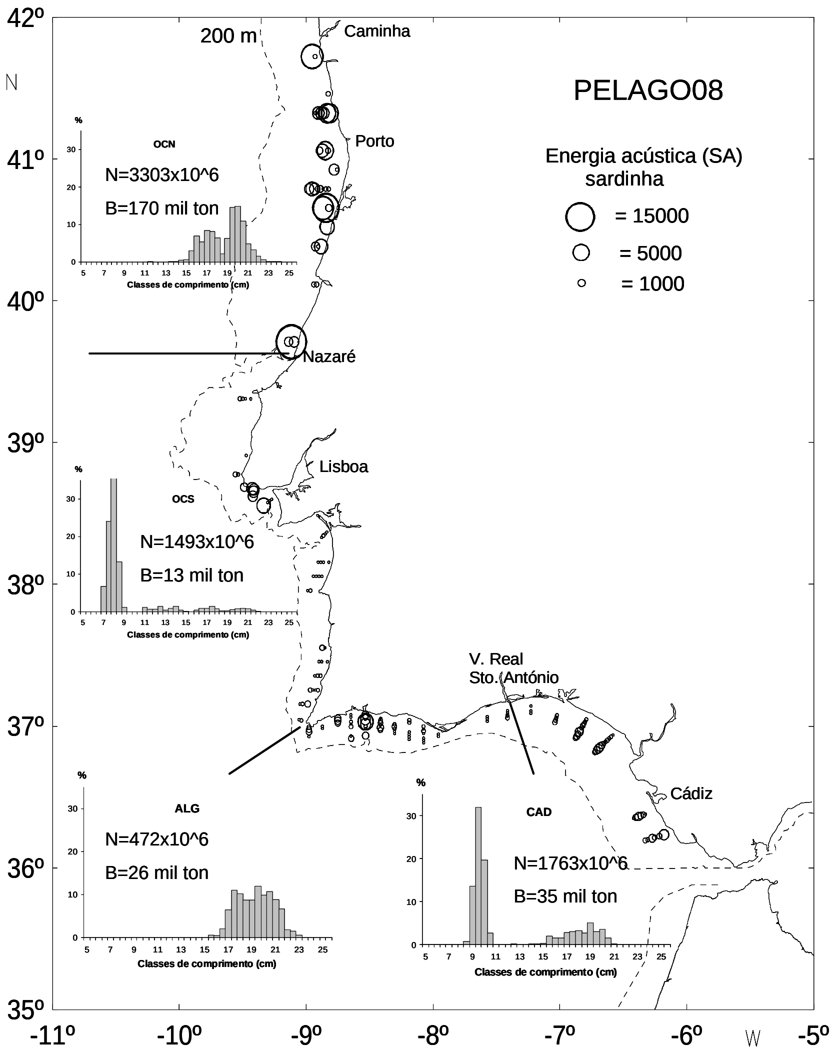


Figure 8.3.2.1.3: Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2008. Acoustic energy by nautical mile and abundance and length structure by area. Circle area is proportional to the acoustic energy (S_A m²/nm²).

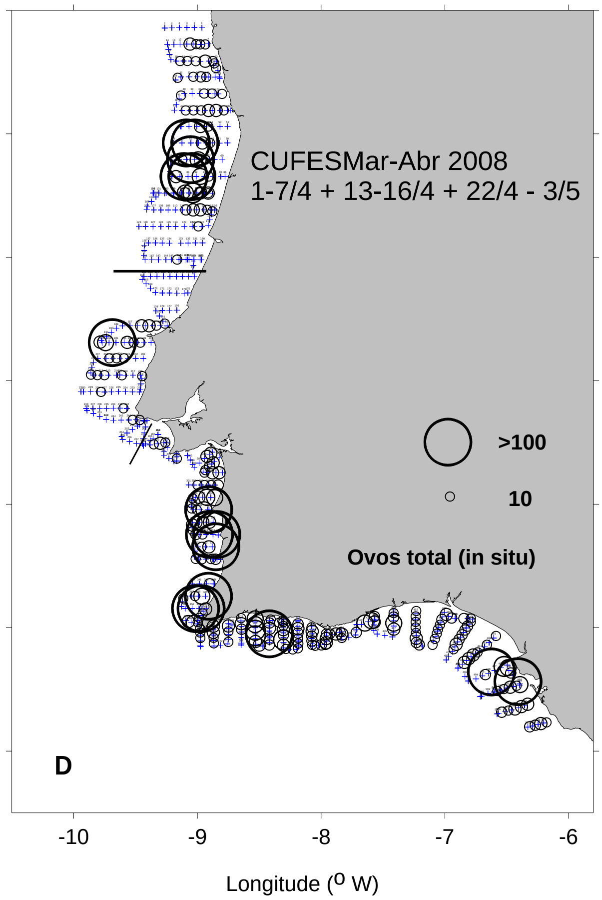


Figure 8.3.2.1.4: Sardine in VIIIc and IXa: Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2008. Total number of sardine eggs obtained during the survey.

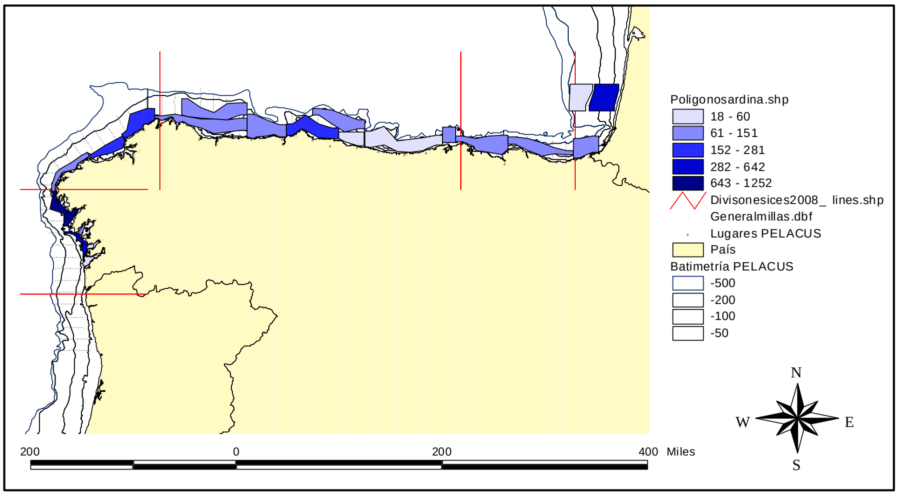
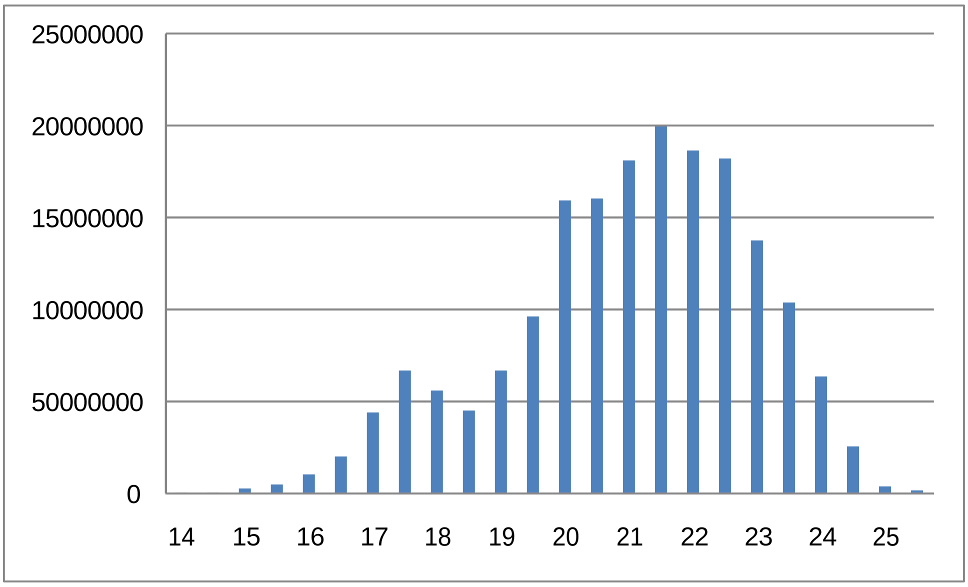


Figure 8.3.2.2.1: Sardine in VIIIc and IXa: Spatial distribution of energy allocated to sardine during the PELACUS0408 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m² within each polygon.



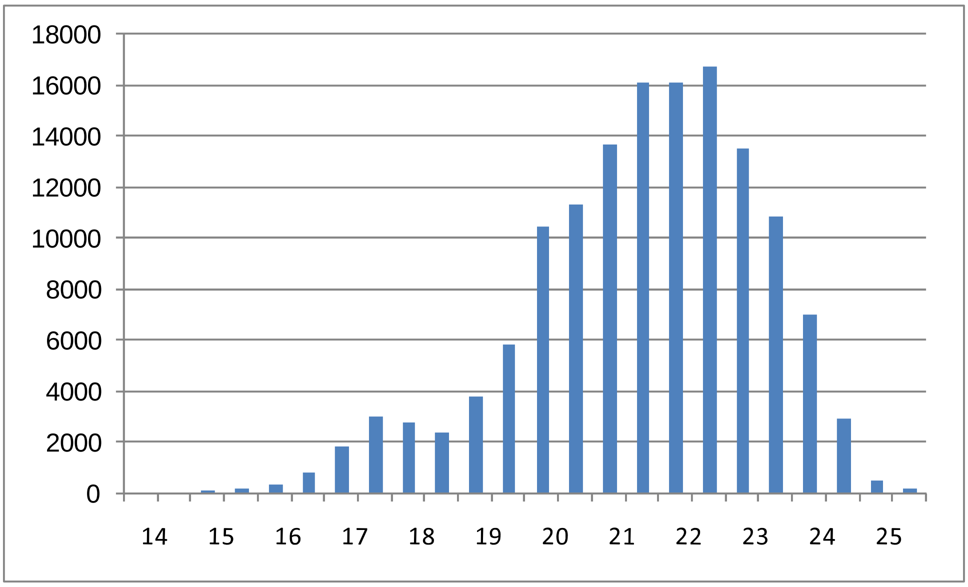


Figure 8.3.2.2.2: Sardine in VIIIc and IXa: Sardine length distribution (cm) in numbers (top) and biomass in tonnes (bottom) during the PELACUS0408 survey.

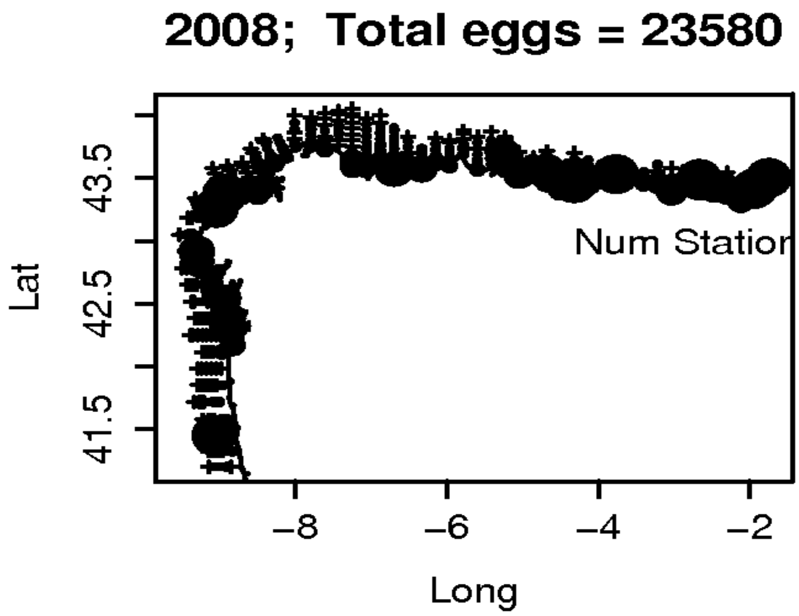


Figure 8.3.2.2.3: Sardine in VIIIc and IXa: Total number of sardine eggs obtained during the PELACUS0408 survey.

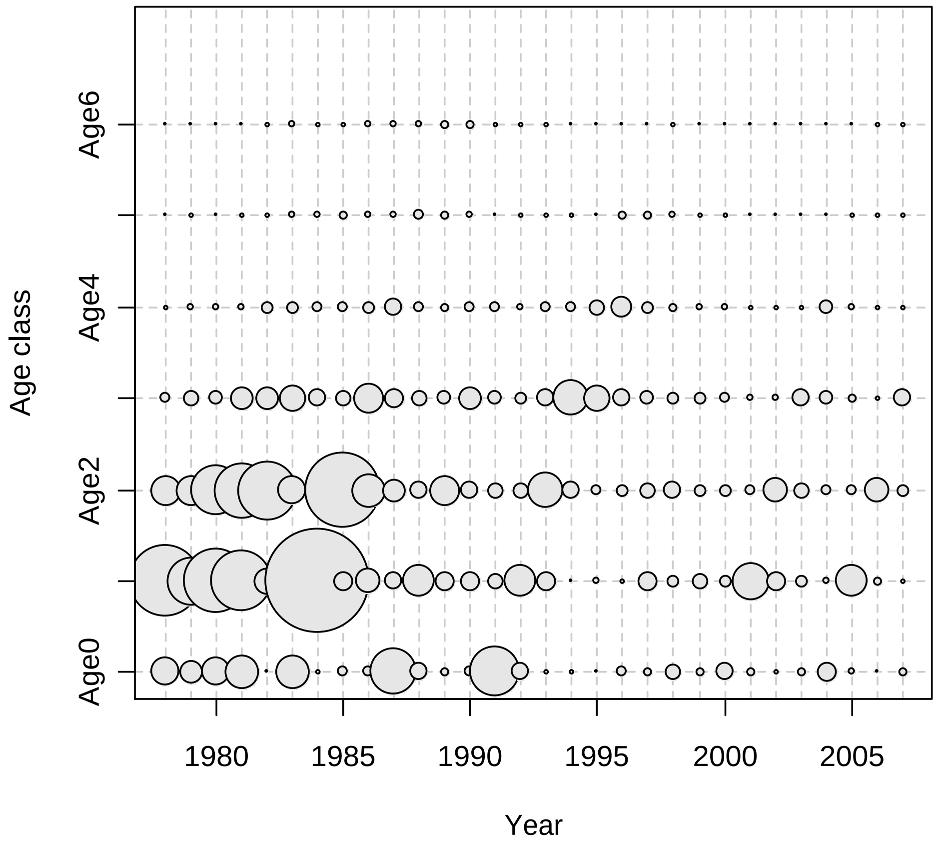


Figure 8.7.1.1: Sardine in VIIIc and IXa: Catches-at-age for 1978–2007.

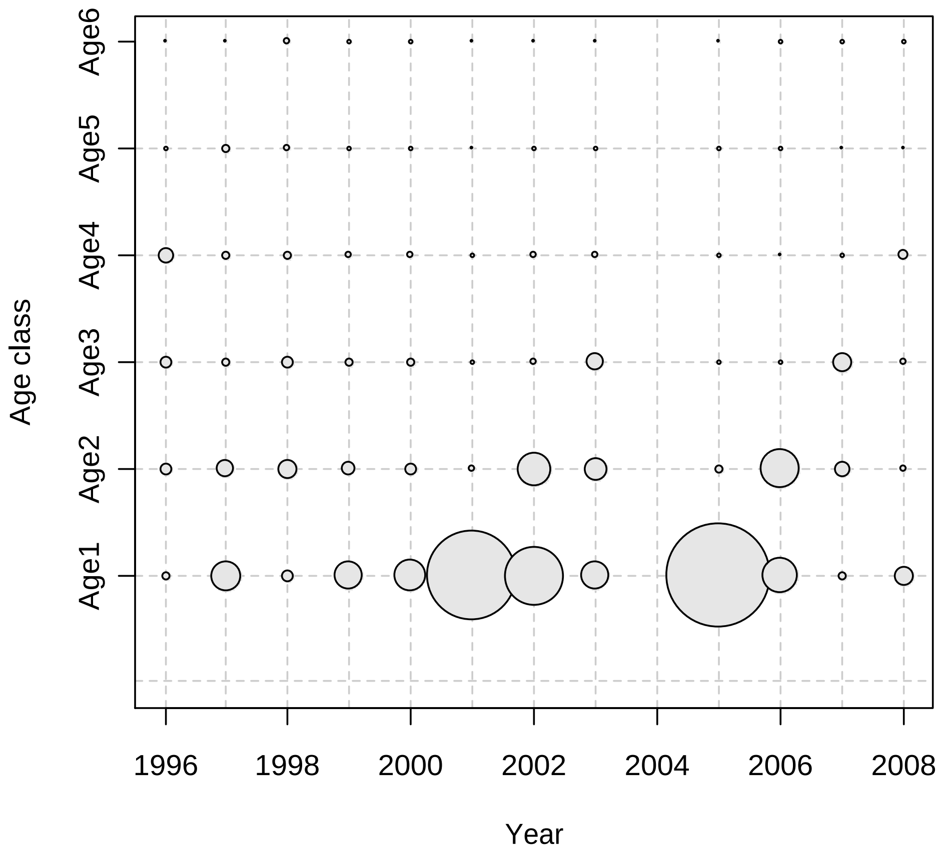


Figure 8.7.1.2: Sardine in VIIIc and IXa: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996–2008.

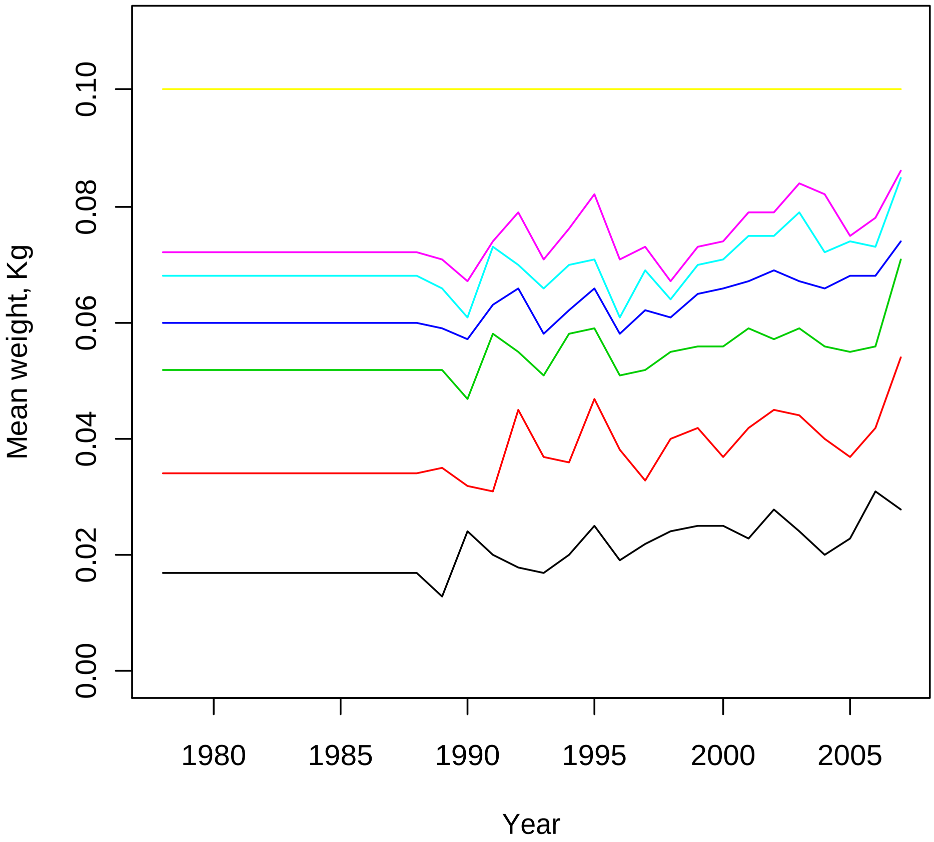


Figure 8.7.1.3: Sardine VIIIc and IXa: Mean weight-at-age in the catches 1978 – 2007.

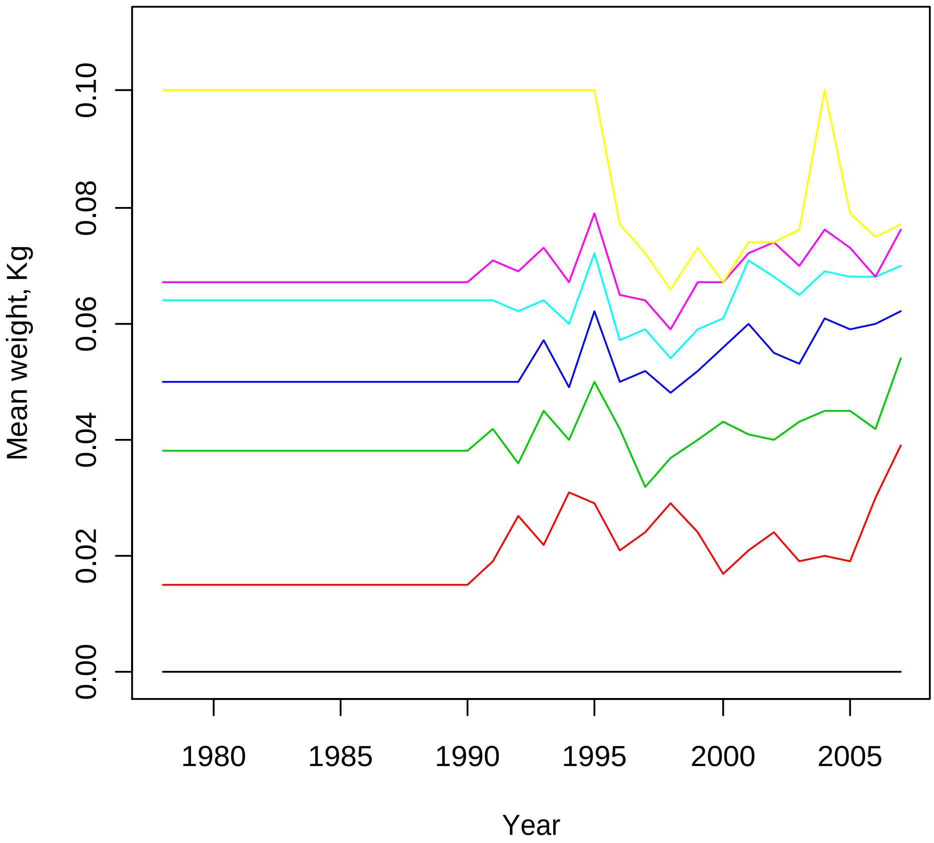


Figure 8.7.1.4: Sardine VIIIc and IXa: Mean weight-at-age in the stock 1978 – 2007.

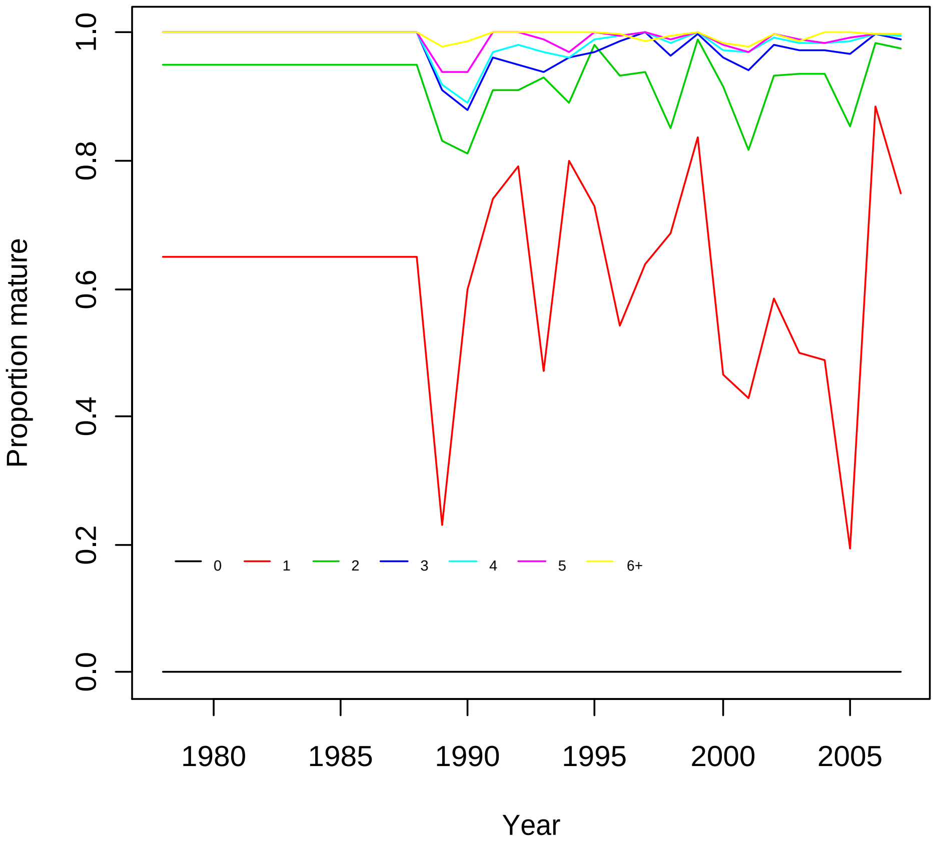


Figure 8.7.1.5: Sardine VIIIc and IXa: Maturity ogives 1978 – 2007.

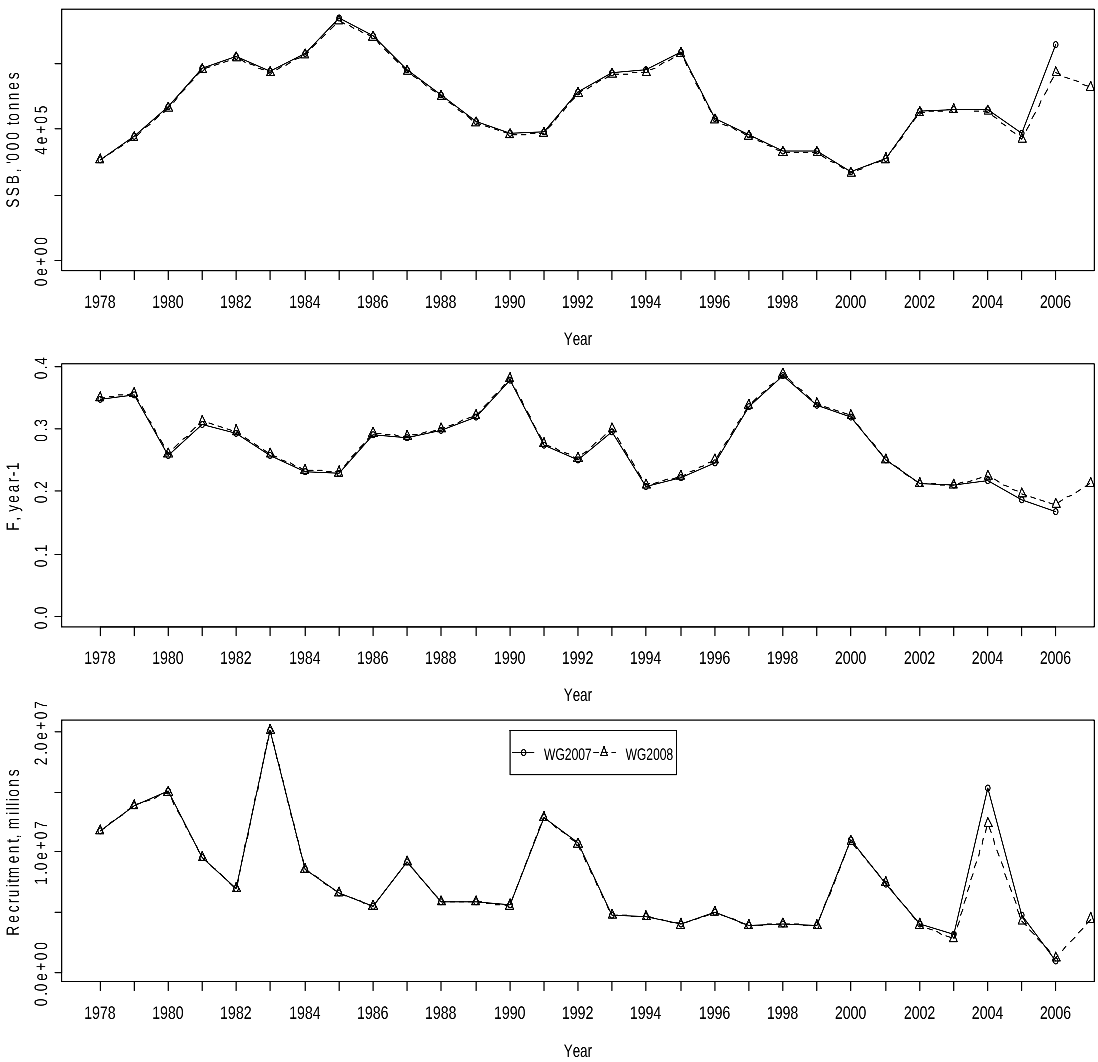


Figure 8.8.1.1: Sardine VIIIc and IXa: SSB (top), F (middle) and recruitment (bottom) trajectories in the period 1978 – 2007 from the sardine AMCI final assessment (WG2008). The WG2007 assessment is shown for comparison.

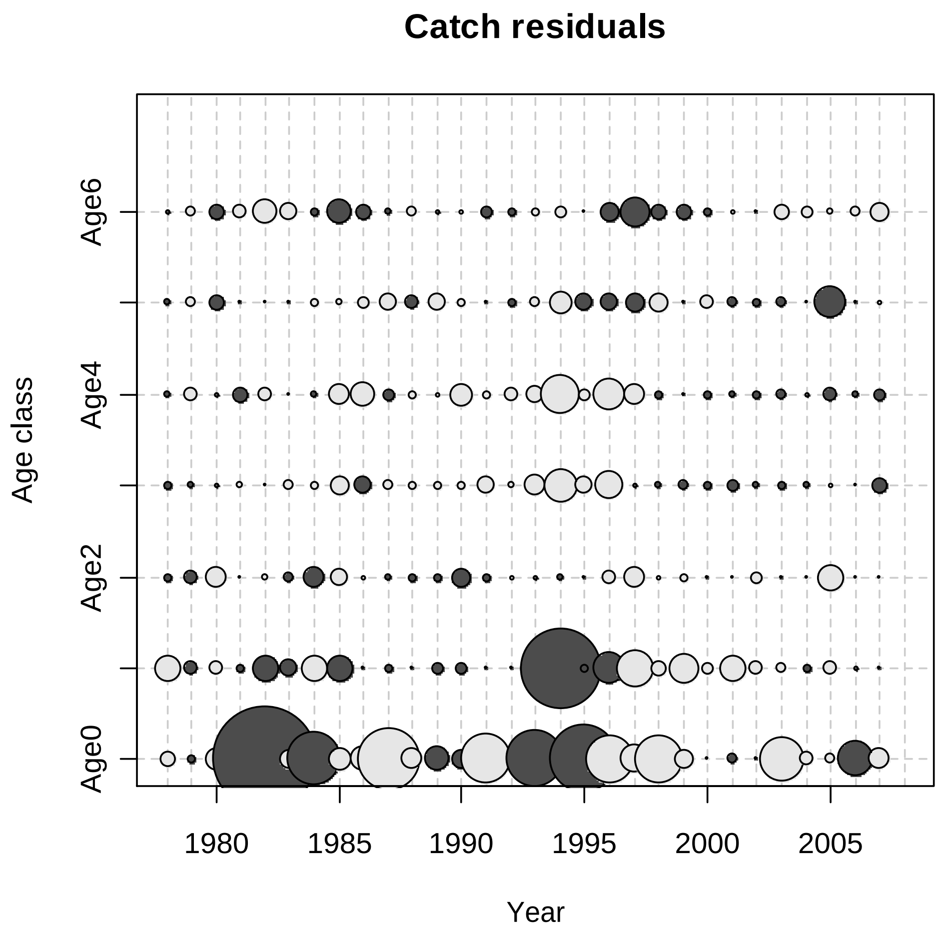


Figure 8.8.1.2: Sardine VIIIc and IXa: Catch residuals 1978 – 2007 (unweighted, negative in black, positive in grey) for the final AMCI assessment. Values are in the range [-1.6, 0.96].

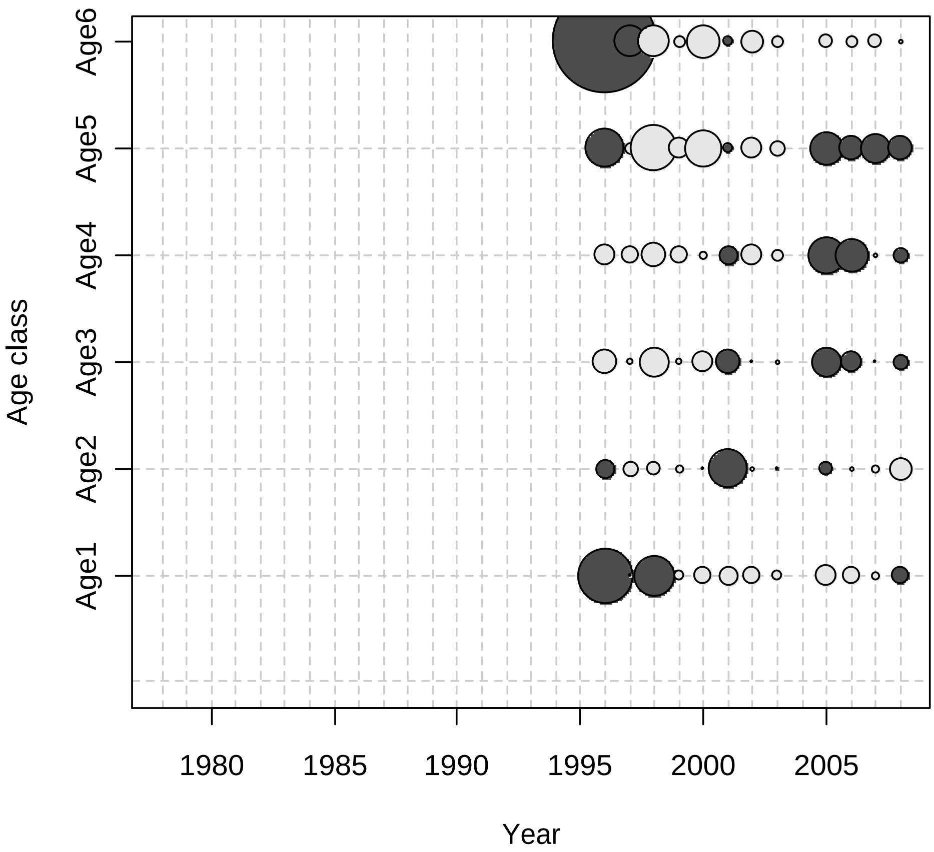


Figure 8.8.1.3: Sardine VIIIc and IXa: Survey residuals (for the combined Iberian spring acoustic survey 1996–2008) for the final assessment. Negative residuals in black, positive in grey, values in the range [-2.2, 0.93].

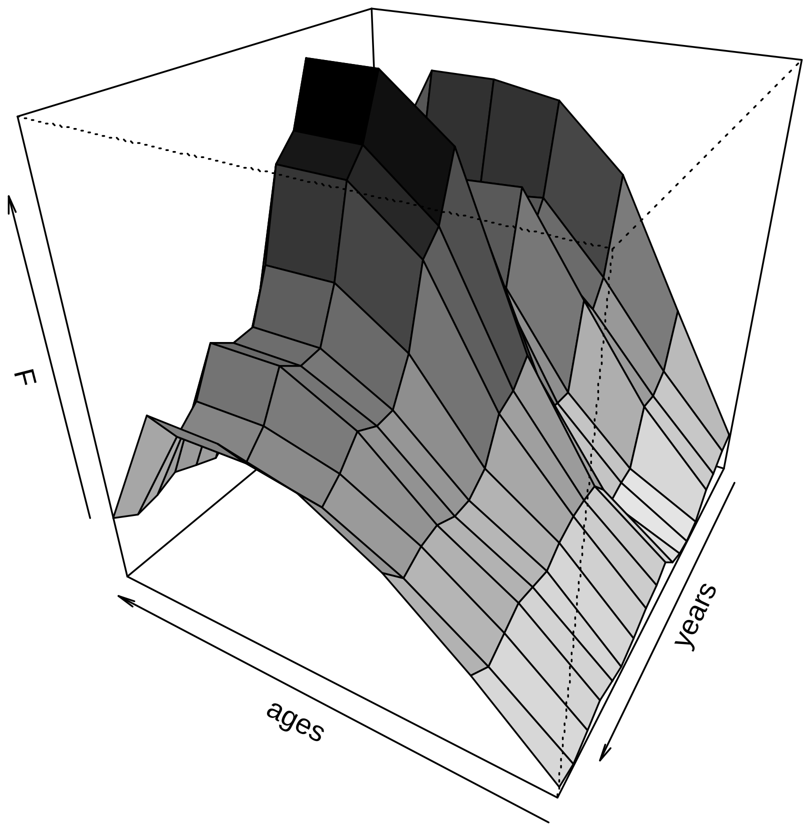


Figure 8.8.1.4: Sardine VIIIc and IXa: Year and age specific fishing mortalities estimated by the final assessment model for the period 1978 – 2007 and age groups 0−6+.

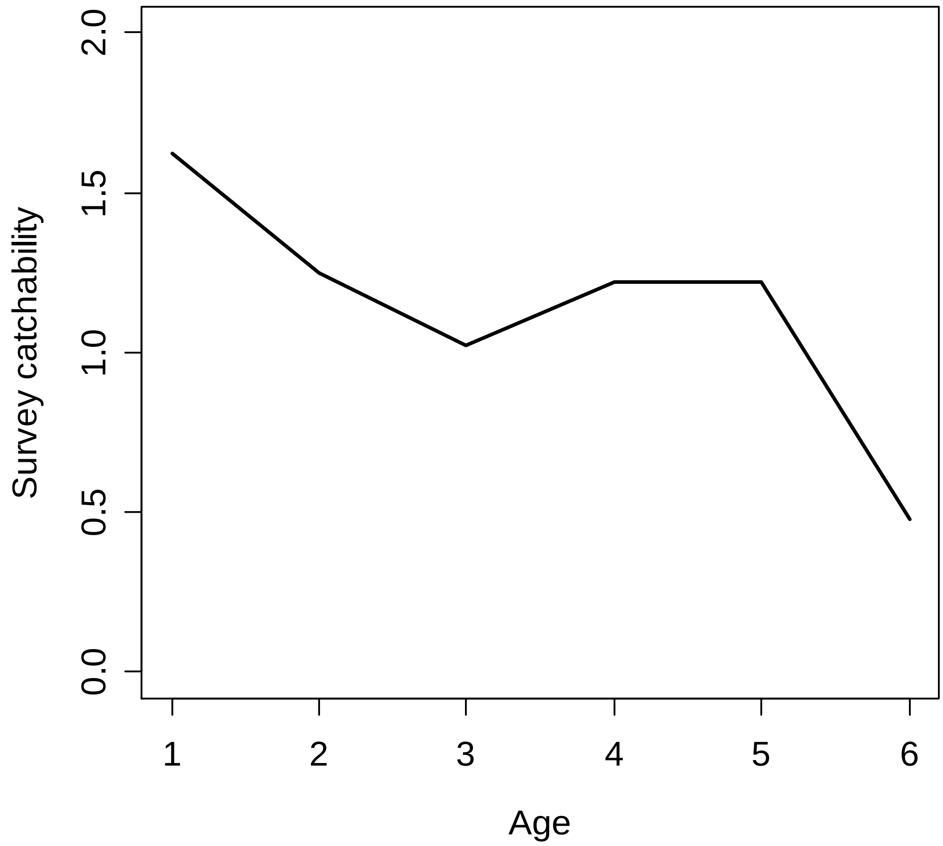


Figure 8.8.1.5: Sardine VIIIc and IXa: Survey catchability for ages 1 to 6+ in the final assessment model.

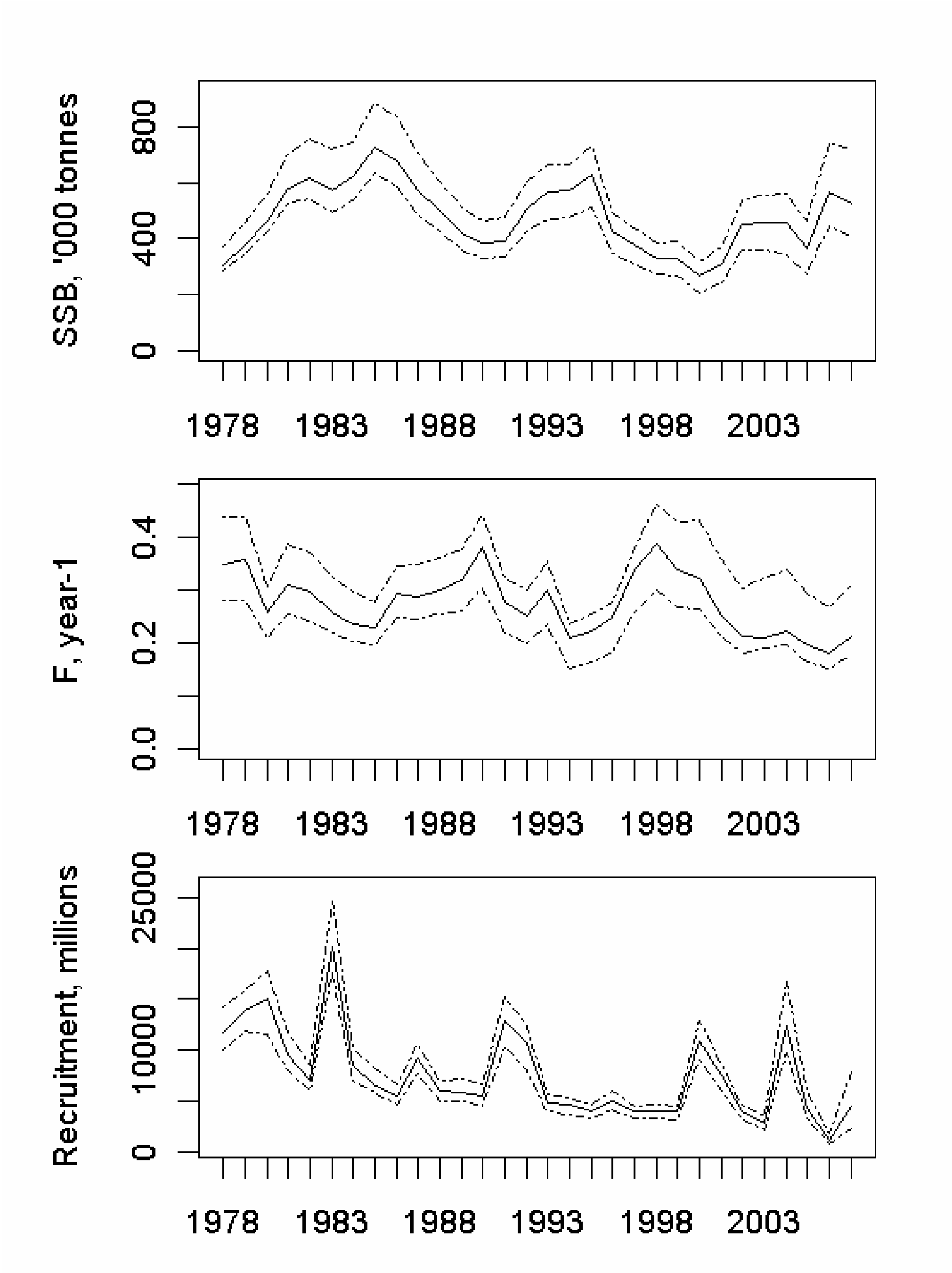


Figure 8.8.1.6: Sardine VIIIc and IXa: Bootstrap trajectories of SSB, recruitment and F for the final assessment model. Dotted lines represent the 90% limits

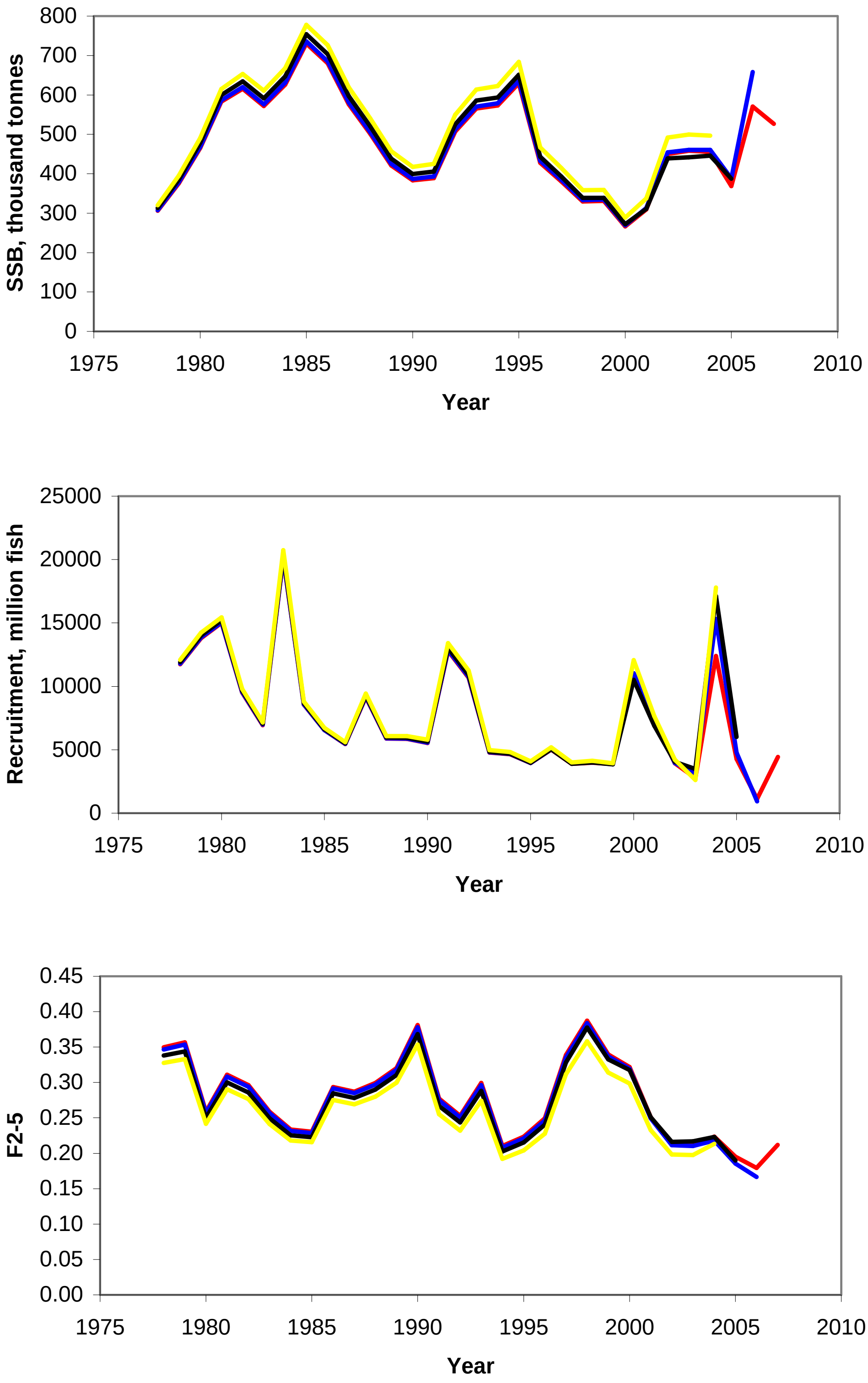


Figure 8.8.2.1: Sardine VIIIc and IXa: Retrospective plots for the sardine final assessment.

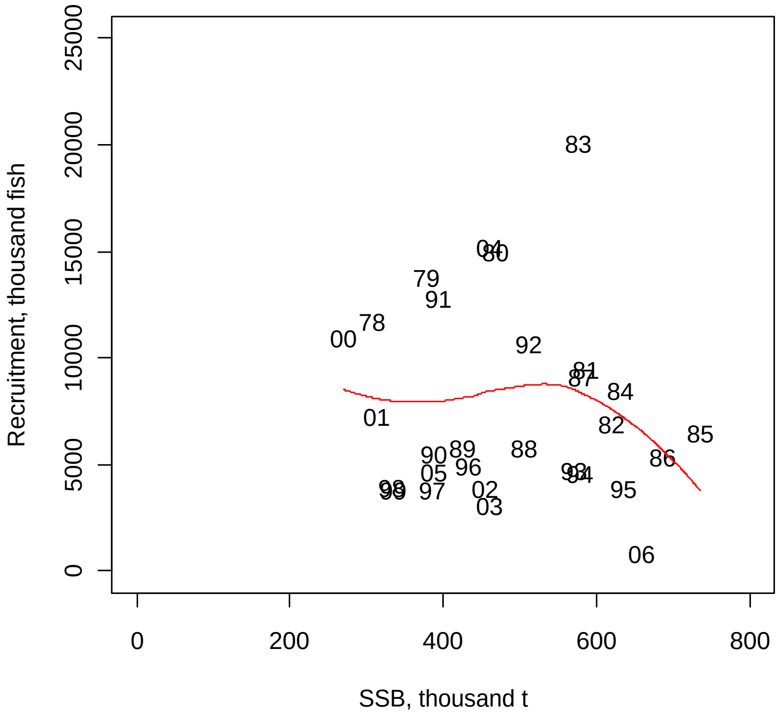


Figure 8.12.1: Sardine in VIIIc and IXa: Relationship between SSB and recruitment. Red line: loess smoother with span 1.

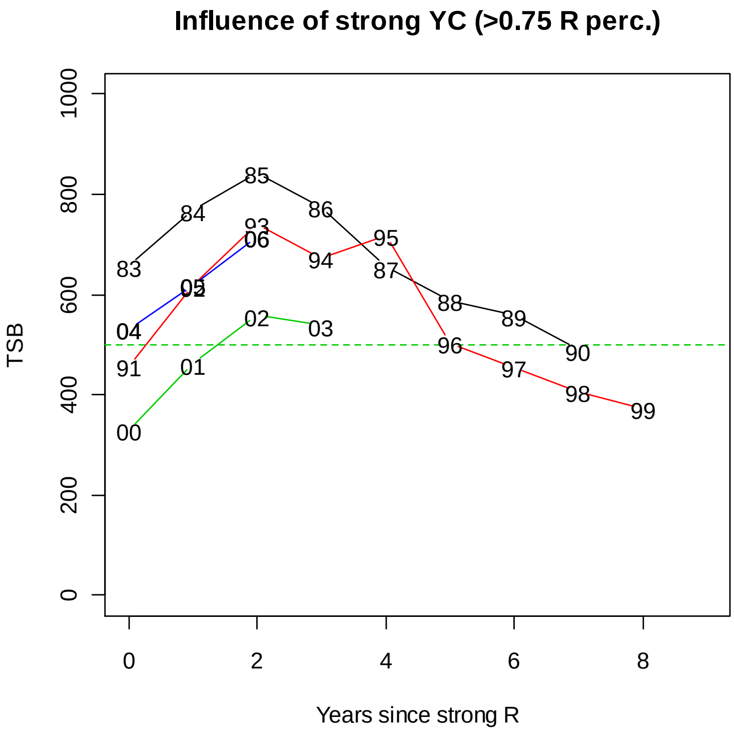


Figure 8.12.2: Sardine in VIIIc and IXa: Influence of strong recruitments on the total stock biomass, TSB. Strong recruitments were considered those above the 75% percentile of the historical series, 1983, 1991, 2000 and 2004. Note that TSB peaks two years after a strong recruitment and that it takes 4–5 years for TSB to return to the level observed prior to the strong recruitment.

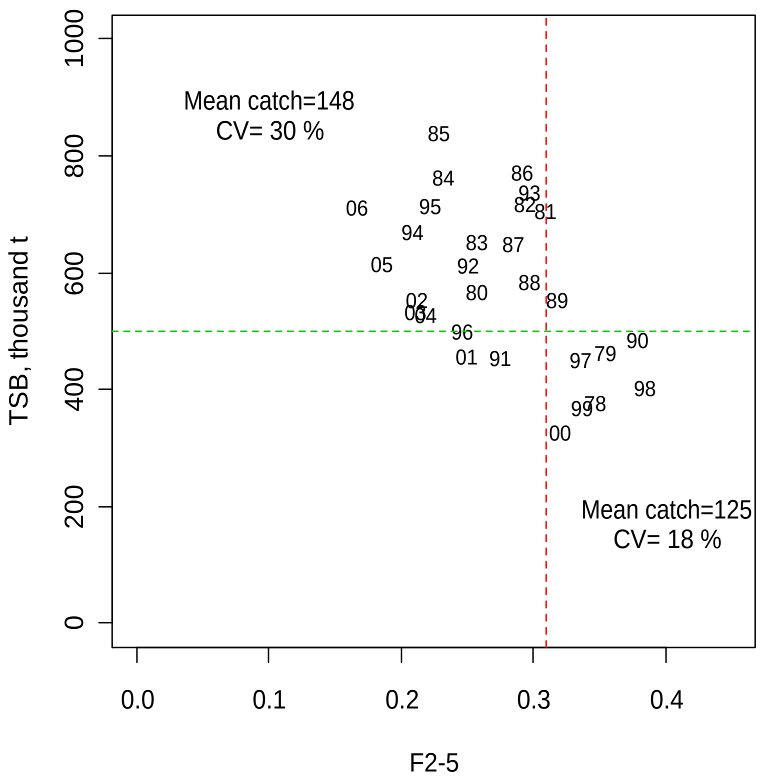


Figure 8.12.3: Sardine in VIIIc and IXa: Relationship between total stock biomass and fishing mortality. Note that an F level of around 0.3, (red line) seems to separate years of only low TSB from years of both low and high TSB. An arbitrary TSB boundary (around 500 thousand t., green line) may also be defined. Mean catches and CVs are presented for periods of TSB above and below 500 thousand t.

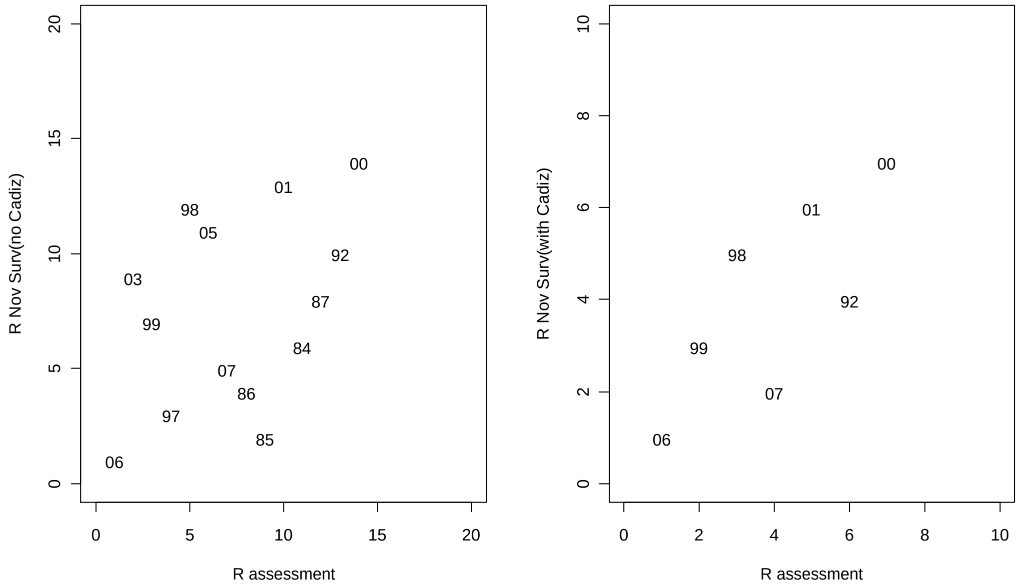


Figure 8.12.4: Sardine in VIIIc and IXa: Relationship between the abundance of recruits (age 0) estimated by the Portuguese November acoustic survey (not included in the assessment) and that estimated in the assessment in corresponding years, expressed as ranks. Left panel: excluding the Cadiz area; right panel: including the Cadiz area).

9 Norwegian spring spawning herring

9.1 ICES advice in 2007

In October 2007 ACFM stated that "Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as having full reproductive capacity and being harvested sustainably. The estimate of the spawning stock biomass, although uncertain, is well above Bpa in 2007. Fishing mortality is well below Fpa. The spawning stock is now dominated by the strong 1998, 1999 and 2002 year class. Surveys indicate that the 2003 year class is moderate, while the 2004 year class is also strong (comparable to the 1998 year class)". The management plan implies maximum catches of 1 266 000 t in 2008, which is expected to leave a spawning stock of 12.2 million tonnes in 2009. The target defined in the management plan is consistent with high long-term yield and has a low risk of depleting the production potential. The current long-term management plan is considered to be consistent with the precautionary approach.

The advice on Norwegian spring spawning herring that was released in October 2007 contained an error in the short term forecast. The error has been corrected in November 2007 and a corrected forecast was presented which implies maximum catches of 1 518 000 t in 2008 expecting to leave a spawning stock of 12.4 million tonnes in 2009.

The fishing mortality, on which the ICES advice for Norwegian spring spawning herring is based in recent years, is the average fishing mortality is the average over age groups 5−14 weighted over the population numbers in the relevant year. The history of calculation of the average fishing mortality is given in Table 9.1.1.

9.2 The fishery in 2007

9.2.1 Description and development of the fisheries

Like in earlier years the fishing pattern in 2007 followed the clockwise migration pattern of the herring, now also including the catches in the Jan Mayen area in the Norwegian Sea. Last year the Jan Mayen zone was closed for non-Norwegian vessels. As last year, the westerly trend in the southwest area continued with high catches taken in the Icelandic-Faroe zone during the summer fishery targeting the largest and oldest fish. The rich 2002 year class was now fully recruited to the adults stock in the feeding areas in 2007.

The distribution of the fisheries of Norwegian spring-spawning herring by all countries in 2007 by ICES rectangles is shown in Figure 9.2.1.1 (total whole year) and in Figure 9.2.1.2 (by quarter). In 2007 the data provided as catch by rectangle represented more than 99.8% of the total WG catch.

Due to limitations by some countries to enter the EEZs of other countries in 2007 the fisheries do not necessarily depict the distribution of herring in the Norwegian Sea and the preferred fishing pattern of the fleets given free access to any zone.

A special feature of the summer fishery in 2005 and 2006 was the prolonged fishery in the Icelandic and Faroese zones during summer, where the oldest age groups were present (second and third quarter), but in 2007 this fishery was hampered by the high concentrations of mackerel in the area, this was especially the case for the Faroese fleet, which usually targets the mackerel later in the year (October-November). The usual pattern previously has been that the fishery moved gradually northwards towards the Jan Mayen zone in June.

The migration pattern, together with environmental factors, was mapped in 2008 during the ICES PGNAPES (Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys) investigations (ICES 2008/RMC:05).

9.2.2 Information on bycatches in the fisheries

With the exception of the Faroes and Iceland, no information was provided to the Working Group on bycatches in the fishery for herring. In 2006, the Faroese summer fishery for Norwegian spring spawning herring north of the Faroes was hampered by large amounts of mackerel present in the same area and often mixed within the herring schools in the upper layers. This was again the case in 2007 where the Faroese vessels had to move northwards out of the Faroese area in late July and August due to large quantities of mackerel northeast of the Iceland-Faroe Ridge. The reason they avoided the bycatch was the low marketing value of mackerel in the summer months, the mackerel is too soft in the early phase of its "fattening" season. The bycatch of mackerel was subtracted from the individual vessel quotas, and was thus a result of legal activity.

Bycatch of mackerel in the Icelandic fishery for herring was also reported. Considerable quantities of mackerel were caught in July-August as by–catch in Icelandic waters off the east coast of Iceland and was the reported by-catch of mackerel over 33 thous. tonnes.

9.2.3 Denmark

The Danish fishery of Norwegian spring spawning herring in 2007 carried out by purse seiners and trawlers was 22 912 t. The fishery took place in the first quarter (4 484 t), the third quarter (4 922 t) and fourth quarter (13 505 t). Two thirds of the landings were landed in Denmark (15 765 t.) and the rest in Norway (7 147 t).

9.2.4 Germany

Germany reported 6 038 tonnes of herring caught in 2007. Catches were exclusively taken by one large freezer trawler (95 m) using pelagic gear.

9.2.5 Greenland

Greenland reported 4 897 tonnes of herring caught in 2007. No description of the fishery was given.

9.2.6 Faroe Islands

The Faroese quota for herring was set at 78 329 tonnes for 2007. As in summer 2006 the summer fishery in 2007 lasted for an extended period (late April to August) in the Faroese zone as well as in the Icelandic zone (Vb, Va and IIa). The catches mostly consisted of large (old) herring, however with varying proportions of the abundant 2002 year class in the catches. The general pattern was that the fishery gradually moved northwards towards the Jan Mayen zone in June, but in July and August a large fishery was also in the Faroese zone north of the Faroes. Thus they seem to use the southern area more extensively during their oceanic feeding phase.

The Faroese fishery (8 large vessels and 1 smaller vessel) started in late April in the area north of the Faroes in the Faroese EEZ (Vb and IIa) and continued in May north of the Faroes and extended north into the eastern part of the Icelandic zone in June. In July the fishery continued north and northeast of the Faroes, as well as further north close to Jan Mayen. Due to by catches of mackerel several of the fishing vessels decided to move north towards Jan Mayen. The fisheries continued in the northern area as well as north of the Faroes in August. In September and October the fisheries moved further north and eastwards into the International zone and Norwegian zone, and the rest of the quota was taken in the Norwegian zone in November and December.

There has been a change the last years towards using pair trawling instead of single trawling; about 50% of the catch was taken with pelagic pair trawling while the rest was split between single pelagic trawl and purse-seine.

9.2.7 Iceland

The Icelandic catch quota for Norwegian spring-spawning herring in 2007 was set at 186 000 tonnes. The Icelandic fishery started in May in the Icelandic and Faroes zone and lasted there until the end of August. The fishery gradually moved to the international zone and also to the Norwegian EEZ in autumn. In May-August almost the entire fishery took place in the Icelandic waters (107 000 t). So much has not been caught in the Icelandic EEZ since the 1960s. About 8 000 t were taken in Faroes waters, 24 000 t in the International zone, 1 500 t in the Jan Mayen zone and about 33 000 t in the Norwegian zone.

In the autumns of 2004–2005 the Norwegian spring-spawning herring was mixed with the Icelandic summer-spawners in the autumn fishery east of Iceland. In 2006 the fishery of the Icelandic summer-spawning herring had much more westerly distribution and therefore much less was caught of Norwegian spring-spawning herring. In 2007 the entire fishery of the Icelandic summer-spawning herring was west off Iceland and therefore nothing was caught of Norwegian spring-spawning herring in that fishery.

The total catch was 173 620 tonnes of which 164 311 were caught in mid-water trawl and about 9 310 tonnes in purse-seine. A total of 22 trawlers/purse-seiners participated in the herring fishery, as compared to 25 vessels in 2006. The length range of the vessels was 54–79 meters with a mean length of 69 meters. The engine power range of the fleet was 2 399–11 257 HP with a mean of 5 317 HP.

9.2.8 Ireland

The Irish fishery for Norwegian spring spawning herring took place in February off the Norwegian coast. A total of 7 vessels participated in the fishery and recorded landings in the region of 6 400 tonnes.

The fleet is comprised of 7 pelagic licensed trawlers with RSW tanks. Norwegian spring spawning herring from the Irish fleet is landed primarily for reduction to fishmeal and processed for human consumption. Landings were made into Norwegian ports for reduction to fishmeal and a UK port for processing. Fishing took place on spawning aggregations in ICES Area IIa and was concentrated on the shelf.

9.2.9 Netherlands

The fishery for Norwegian spring spawning herring in 2007 was conducted by 6 freezer trawlers using large pelagic trawls. Only a few trips were made to fill up the quota in the third and fourth quarter in ICES Division IIa. The total catch was 29 764 tonnes

9.2.10 Norway

The Norwegian quota is shared with 50% to the large oceanic purse seiners, 10% to trawlers and 40% to smaller coastal purse seiners.

The change from a fjordic to an oceanic wintering area of the Norwegian spring spawning herring has now been completed. Last winter (2007/2008) no NSSH wintered in the fjords and only small amounts of mainly autumn spawning herring were caught here. The change in winter area led to large consequences for the fishing pattern of the Norwegian fleet. For the larger vessels the new distribution means longer trips in terms of distance and lower availability because of strongly reduced concentrations in the oceanic as compared to fjordic wintering areas. Weather has also become a more important factor to the fishery in the wintering areas. For the smaller vessels the availability of herring has been grossly reduced and many vessels find difficulties in taking their quotas. This has led to a shift in the fisheries towards the Norwegian coastal/fjordic herring stocks, which are herring of smaller size and lower lengths at maturity. This herring is often found in mixed concentrations with immature Norwegian spring spawning herring and there is a new and clear challenge to science and management in how to deal with this new situation. Due to the reduced availability of herring to the coastal fleet in the wintering area, the fisheries on the spawning migration and in the spawning areas has increased. This is reflected in a strong increase in the fisheries during the first quarter from 2006 to 2007 with catches up from 202 649 tonnes to 296 762 tonnes.

The Norwegian fleet hardly fish herring in the oceanic feeding area during the second quarter. There are some catches reported from the coastal areas during this period, amounting to 1 305 tonnes. This herring mainly consists of local fjordic herring stocks which have so far been allocated to the Norwegian spring spawning herring quota for practical reasons.

The Norwegian fisheries after the feeding period in Quarter 3 started in the areas west of Lofoten, about 100–200 nautical miles from land, and then moved towards the new oceanic wintering area north of Vesterålen. A total of 92 124 tonnes were caught in this quarter.

9.2.11 Poland

Poland reported 4 333 tonnes of herring caught in 2007. No description of the fishery was given.

9.2.12 Russia

The Russian fishery started within the wintering area of Norwegian spring spawning herring (approximately 12–15° E) in the Vesteralen (Norwegian EEZ) at the end of January, then progressed in the south-western direction along the Norwegian coast in February and finished in the area of Buagrunnen Bank (approximately 63° N) at the middle of March. In January-March the catch was 14 140 t.

In May-June, the commercial vessels conducted fishing in the southern part of the international area in the Norwegian Sea and landed 4 277 t.

In July, the vessels caught herring in the northern part of the international water. In August, the fishery expanded into the Norwegian EEZ and Jan-Mayen. In September, the main fishery focused in the Norwegian EEZ to the north from Lofoten. 103 705 t of the herring was taken in the III quarter.

In October, the fishery was continued on the same area and was finished in the beginning of November. 40 304 t was taken in that period.

The Russian fishery is carried out by many types of trawl vessels. Total Russian catch of Norwegian spring spawning herring was 162 434 t. The entire Russian catch was utilized for human consumption.

9.2.13 UK (Scotland)

In 2007 Scottish vessels landed around 13 200 tonnes of herring into ports in Denmark, Norway and Scotland. All of the landings were reported in quarter 1 and were from ICES area IIa. A total of 13 boats participated in this fishery and used single and pair pelagic trawls.

9.3 Stock description and management units

9.3.1 Stock description

The Norwegian spring spawning herring (*Clupea harengus*) is the largest herring stock in the world. It is highly migratory and distributed throughout large parts of the NE Atlantic during its lifespan. It is a herring type with high number of vertebrae, large size at age, large maximum size, different scale characteristics from other herring stocks and large variation in year class strength. The herring spawns along the Norwegian west coast in February-March. Large variations in the north-south distribution of the spawning areas have been observed through the centuries. The larvae drift north and northeast and distribute as 0–group in fjords along the Norwegian coast and in the Barents Sea. The Barents Sea is by far the most important juvenile area for the large year classes, which form the basis for the large production-potential of the stock. Some year classes are in addition distributed into the Norwegian Sea basin as 0–group. Examples of this are the 1950 and 2002 year classes. Most of the young herring leave the Barents Sea as 3 years old and feed in the north-eastern Norwegian Sea for 1–2 years before recruiting to the spawning stock. Large year classes typically mature at a higher mean age due to density dependent distribution and growth. However, exceptions occur and the 2002 year class is a large year class, which has shown quick growth and a relatively early maturation. Juveniles growing up in the Norwegian Sea grow faster than those in the Barents Sea and mature one year earlier. With maturation the young herring start joining the adult feeding migration in the Norwegian Sea. The feeding migration starts just after spawning with the maximum feeding intensity and condition increase occurring from late May until early July. The feeding migration is in general length dependent, meaning that the largest and oldest fish perform longer and typically more western migrations than the younger ones. After the dispersed feeding migration the herring concentrate in one or more wintering areas in September-October. These areas are unstable and since 1950 the stock has used at least 6 different wintering areas in different periods. During the 1950s and 1960s they were situated east of Iceland and since around 1970 in Norwegian fjords. In 2001–2002 a new wintering area was established off the Norwegian coast between 69º30'N and 72ºN and in 2007\2008 no herring was observed in the fiords in winter. After wintering, the spawning migration starts around mid January.

Norwegian spring spawning herring is one the few stocks for which data have been collected over a very long period. Figure 9.3.1.1 shows the dynamics of the stock in the past century indicated by assessments which go back to 1907.

9.3.2 Changes in migration

A characteristic feature of this herring stock is a very flexible and varying migration pattern. The migration is characterised as relatively stable periods and periods characterised by large changes occurring at varying time intervals. The changes may or may not be correlated between the major distribution areas: Spawning, feeding and wintering. At present we see a period of large changes in both the wintering and feeding area. Until about 2002 the bulk of the adult herring wintered in fjords in northern Norway. The 1998 and 1999 year classes were expected to enter the fjords around 2002, but were instead observed wintering off the coast in the ocean off Vesterålen/Troms, between 69º30'N–72ºN. This continued in the years to come and in 2005 also the 2002 year class was observed wintering in the same area. During these years, the amount of older herring wintering in the fjords has decreased rapidly and during the winter 2007 and 2008 no herring was observed in the fiords. The survey covering the oceanic wintering area in November 2003–2007 have shown a strong decrease in the biomass in the wintering stock in the area, indicating that may be a third and so for unknown wintering area could be under establishment somewhere else. Such a development is supported by the western feeding distribution in recent years, and the fact that the return migration of the smaller herring feeding in the west could be too long compared with comparable return migration distances observed in earlier periods. It is also supported by the fact that the international survey in May did not show any such negative trend in the stock.

With regard to the feeding area there has been a western trend, where the oldest and largest herring has been migrating further west in recent years. The plasticity of the herring migration could be regarded an adaptive trait enabling the stock to optimally exploiting the ever varying climate and planktonic resources of its potential range in the NE Atlantic.

During the autumn in the period 2004–2006 Norwegian spring spawning herring has been caught as bycatch in smaller concentrations in catches of Icelandic summer spawning herring off the Icelandic east coast. This feature is probably linked to the western movement of the south-western summer feeding area. It is not known whether Norwegian spring spawning herring are wintering in this area.

9.3.3 Management in 2008

EU, Faroe Islands, Iceland, Norway, and Russia agreed in 1996 to implement a long-term management plan for Norwegian spring-spawning herring. The management plan was part of the international agreement on total quota setting and sharing of the quota during the years 1997–2002. The plan in use now consists of the following elements:

1) Every effort shall be made to maintain a level of Spawning Stock Biomass (SSB) greater than the critical level (Blim) of 2 500 000 t.
2) For the year 2001 and subsequent years, the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality rate of less than 0.125 for appropriate age groups as defined by ICES, unless future scientific advice requires modification of this fishing mortality rate.
3) Should the SSB fall below a reference point of 5 000 000 t (Bpa), the fishing mortality rate, referred under Paragraph 2, shall be adapted in the light of scientific estimates of the conditions to ensure a safe and rapid recovery of the SSB to a level in excess of 5 000 000 t. The basis for such an adaptation

should be at least a linear reduction in the fishing mortality rate from 0.125 at Bpa (5 000 000 t) to 0.05 Blim (2 500 000 t).

4) The Parties shall, as appropriate, review and revise these management measures and strategies on the basis of any new advice provided by ICES.

ICES considers that the objectives of this agreement are consistent with the precautionary approach.

As in years 2003–2005, there was also no agreement in 2006 between the Coastal States regarding the allocation of the quota. Quotas in 2006 were set unilaterally and in some countries quota were raised during the year. The sum of the total national quotas for 2006 amounts to about 967 000 t.

In 2007 and 2008 the Coastal States have agreed to set a TAC in accordance with the Management Plan. The agreed TAC for 2008 was 1 518 000 tonnes. The agreed shares of the Parties are 98,822 tonnes for the European Community, 78,329 tonnes for Faroe Islands, 220,262 tonnes for Iceland, 925,980 tonnes for Norway and 194,607 tonnes for the Russian Federation.

9.4 Data available

9.4.1 Catch data

Landings

The total annual catches of Norwegian spring-spawning herring for the period 1972–2007 (2007 preliminary) are presented in Table 9.4.1.1 (by country). The reported catch in 2007 was 1 266 993 tonnes

Discards

The Working Group noted that in this fishery an unaccounted mortality caused by fishing operations and underreporting probably exists. Now it was not possible to assess the magnitude of these extra removals from the stock, and taking into account the large catches taken in recent years, the relative importance of such additional mortality is probably low. Therefore, no extra amount to account for these factors has been added in 1994 and later years. In previous years, when the stock and the quotas were much smaller, an estimated amount of fish was added to the catches.

The Working Group has no accessible data to estimate possible discards of the herring. Although discarding may occur on this stock, it is considered to be very low and a minor problem to the assessment.

Length and age compositions

To derive the age composition of the total international catches of Norwegian spring spawning herring in 2007 the program SALLOC (ICES 1998/ACFM:18) was used. Samples were provided by Denmark, Faroe Islands, Germany, Iceland, Norway, The Netherlands, Russia and Scotland (Table 9.4.1.2). Sampled catches accounted for 94% of the total catches (Table 3). In each area sampled catches accounted over 90% of the catches taken in that area except area XIVa where it was only 15% (Table 9.4.1.3).

Unsampled catches were allocated to samples ones with the knowledge of where and when the catches were taken. The allocations and the results from the SALLOC program are shown in Table 9.4.1.2.

The catches in numbers and weight by age are also shown in Table 9.4.1.4 and Table 9.4.1.5. The year class 2002 accounts for 42% in numbers and 39% in weight, whereas year class 1999 accounts for 17% in numbers and 20% in weight and year class 1998 accounts for 12% in numbers and 14% in weight. Together these 3 year classes account for 71% of the catches in numbers and 73% in weight.

Length-at-age data are available from several countries. They are not used in the assessment.

Sampling levels in 2007

The sampling levels of the catch in 2007 are presented in section 1.3.1.

9.4.2 Information from the fishery

No information was available from the fishery,

9.4.3 Weight at age

The weight-at-age in the catches in 2007 was taken from the total international weight-at-age (Table 9.4.1.5), which were produced using the computer programme SALLOC, standard ICES software. Trends in weight-at-age are presented in Figure 9.4.3.1. Since 1995, the weight-at-age has been relatively stable but with a slight increasing trend. For the youngest ages, however, there has been a slight decrease during the last 1–2 years.

A similar pattern is observed in weight-at-age in the stock which is presented in Figure 9.4.3.2. These data are taken from the survey in the wintering area. The general pattern is also here a slight increase since 1996 for all age groups with a slight decrease for the younger ages during the last 2–3 years.

Weight-at-age in the stock by year classes is shown in Figure 9.4.3.3 and Table 9.4.3.1. The strong year classes 1991 and 1992 had a low growth which is normal for strong year classes due to density dependent effects in the nursery areas. On the other hand, the even stronger 2002 year class had a relatively higher growth. This emphasises what has been previously assumed that a large part of this year class used the Norwegian Sea as a nursery area favouring higher growth compared to year classes using the Barents Sea as nursery area. This also explains the slight decrease in weight-at-age both in the stock and in the catch for the young ages during the last years. The year classes following the 2002 year class have used the Barents Sea as nursery area and have therefore had a comparably slower growth.

9.4.4 Natural Mortality

By scanning through the Working Group reports from 1990 to 2007 it was noticed that different values had been used for natural mortality at age through the years. In some years an additional mortality at age had been applied because of a disease. But taken directly from the 1997 WGNPBW-report (ICES 1997): "Values of natural mortality assumed by the Working Group previously (ICES 1996/ASSESS:14) for ages 3 and older were 0.16 for the years 1950 to 1970 and 0.13 for the years 1971 and subsequently. In the previous assessment of this stock it was assumed (on the basis of observations of many diseased and dying fish in catches) that the fish of the 1987 cohorts and older had suffered a higher natural mortality in the years 1991 to 1994. An additional disease-induced natural mortality of 0.1 was assumed. However, interim studies (Patterson, WD 1997; Tjelmeland WD 1997) directed at estimating disease-induced mortality have failed to provide compelling evidence for values above zero. Attempts to estimate natural mortality from tagging information (Hamre, WD 1997; Patterson, WD 1997a; Tjelmeland, WD 1997) were highly consistent with values in the range 0.13 to 0.16, but the Working Group did not consider that this parameter could be estimated with sufficient precision to justify a discrimination between levels of 0.13 and 0.16. Consequently it was decided to predicate the assessment model estimates on an arbitrarily-chosen M=0.15 for ages 3 and older, and no attempt was made to include additional disease-induced mortality in the maximum likelihood assessment model."

This value M=0.15 has been used for ages 3 and older since the assessment in 1997 (for all years) until the assessment made in 2005 (ICES 2005). Then a value of 0.5 was used for the plus group (16+) and was used until 2007. This increase of M was done in order to get the SSB at low values in the collapsed phase in the 1970s. It caused only a slight decrease of the SSB in the newest years (ICES 2005).

In this year's (2008) assessment age 15 is used as a plus group and a value of M=0.15 is used.

In the Working Group report from 1992 (ICES 1992) a comparison of acoustic estimates for year classes 1983–1985 and 1988, and the same year classes as 3 year old (VPA) gave an average annual M=0.88, so M=0.9 was used for ages 0–2.

For ages 0–2 then the following is stated in the report from 1997 (ICES 1997): "Values of natural mortality for juvenile fish (ages 0–2) used by the Working Group in 1996 were 0.9 for all years in historic VPA, but for forecasting purposes values of 1.56 for age 1 and 0.54 for age 2 were used for the 1993–1995 year classes. These values were based on an unpublished Ph.D. Thesis by de Barros (1995); this work was not available for evaluation by the Working Group, and hence it was decided to retain the assumption of M=0.9 for ages 0 to 2 in all years. This value is consistent with the mean of de Barros' estimates." This value of M=0.9 is still used in the present assessments for ages 0–2.

9.4.5 Maturity at age

Except for the year class 2002, the proportion mature at age used in assessment has generally been the same during the last ten years (Table 9.4.5.1).

The growth rate of the 2002 year class has been higher than usually seen in large year classes of this stock. One reason for this is that a large part of the juveniles stayed in the Norwegian Sea as juveniles, favouring quicker growth than in the Barents Sea, which is the area where juveniles normally are distributed.

The proportion mature of this year class was calculated from samples collected during the surveys in the wintering area in November (before spawning) and in the Norwegian Sea in May (after spawning). The proportion of fishes in maturation stage 3 or larger (fish to spawn) in November 2005 was used as a first proxy to the proportion maturing. The proportion maturing according to these data was 0.85. The proportion in stages >5 (spent) in May was used as a proxy for the proportion having spawned. The proportion having spawned according to these data was 0.92. Based on these observations and calculations 0.9 was adopted as proportion mature of the 2002 year class at age 4. Based on this 1.0 instead of 0.9 was adopted as proportion mature of the 2002 year class at age 5. All other year classes in the later years were set at the standard 0.3 at age 4, 0.9 at age 5 and 1.0 at age 6 both in the assessment and predictions.

The Working Group accepts the present values for the use in the assessment but considers that there is a need to validate the presently assumed values in particular for the most recent years. The proportion mature at age used in assessment is based on various surveys carried out many years ago and is not always well documented. The Working Group acknowledges the potential problem of obtaining random samples of proportion mature at age from survey for this stock due to the different catchability of mature and immature fish of the same age groups caused by spatial segregation. An alternative method for estimating proportion mature at age was proposed to the Working Group. This method involves back-calculation of proportion mature at age from fully matured year classes and is based on work done by Engelhard *et al.* (2003) and Engelhard and Heino (2004). The Working Group found this approach interesting, but decided to explore it further before any decision should be taken regarding using it in assessment. The Working Group recommends that effort should be put into updating estimates on proportion mature at age from recent years with this method and compare it with data on direct measurements on proportion mature at age from the May survey during the period since 1997 when this survey was assumed to cover the entire stock. This work will be done by IMR. Based on this, an evaluation will be done and the most reliable method will be adopted in the assessment in 2009.

The maturity at age values used in the assessment are given in Table 9.4.5.1.

9.4.6 Fisheries independent information

A number of surveys on this stock have been carried out in the Norwegian Sea and Barents Sea to estimate the size of the stock, its age composition or the recruitment to the stock. The surveys and its potential use is described in the sections below

9.4.6.1 Survey 1 Norwegian acoustic survey on spawning grounds in February/March

Background and status

In 2008 a Norwegian acoustic survey was undertaken to estimate the abundance of herring in the spawning areas in February. The survey has been carried out since 1988 but not in every year. The survey will not be carried out after 2008.

Use of this survey in stock assessment

The age groups 5–15+ have been used in the assessment for the years 1994 to 2005. After this year the survey has not been used in the assessment. This applies also to 2008. The reason for this being that the survey was carried out very earlier and before the herring had reached the spawning grounds, with the possibilities of herring emerging the spawning grounds also through other routes than those covered in the survey.

Results

Results can be found in Table 9.4.6.1.1 and Figure 9.4.6.1.1.

9.4.6.2 Survey 2 Norwegian acoustic survey in November/December

Background and status

The survey has been carried out by Norway since 1992 in the Norwegian fjords where the adult herring winter. Since 2003 also the oceanic areas north of Lofoten/Vesterålen has been included in the survey to take account of changes in the wintering area. The fjordic coverage was ceased during the winter 2007/2008 because theherring had totally left the fjords.

Use of this survey in stock assessment

Given the large changes in the wintering pattern of herring and the possibility of a third and undescribed wintering area, it was decided not to use this survey for the period following the new wintering pattern of the herring in the assessment. The survey will not be continued by Norway and will not be carried out in 2008.

Results

In 2007 the RV Johan Hjort carried out an acoustic survey in the oceanic wintering area in northern Norway (Figure 9.4.6.2.1). The results of this survey are shown in Table 9.4.6.2.1. This survey covers the known wintering area of the mature part of the stock. The survey gave a very low biomass estimate due to unknown reasons. One possible explanation is that a new wintering area is building up somewhere else. This has so far not been confirmed and remains an open question.

9.4.6.3 Survey 3 Norwegian acoustic survey in January

Background and status

This survey was carried out by Norway in the fjords in the period 1991–1999.

Use of this survey in stock assessment

Although the survey series has ended, the data are still used in the assessment. The age groups 5–15+ from 1991 to 1999 are currently used.

Results

The results of the survey in the wintering area in January can be found in Table 9.4.6.3.1.

9.4.6.4 Survey 4 and 5 International ecosystem survey in the Nordic Seas and Barents Sea

Background and status

The international ecosystem survey in the Nordic Seas and the Barents Sea is aimed at observing the pelagic ecosystem, focusing herring, blue whiting, zooplankton and hydrography. The survey, run since 1995, is coordinated by the ICES PGNAPES (ICES CM 2008/RMC:15) and is a cooperative effort by Faroes, Iceland, Norway, Russia, and the EU (Denmark, Germany, Ireland, The Netherlands, Sweden and UK). This trawl-acoustic survey supplies the most important time series for the assessment of NSSH and also a time series on young blue whiting in the juvenile areas.

The area covered has been somewhat varying between years and in 2008 only a small part of the Barents Sea was covered.

Use of this survey in stock assessment

From the area west of 20°E the age groups 4 and older are used for the assessment, whereas the Barents Sea area east of 20°E supplies the recruitment age groups 1 and 2 for the assessment. The part of the survey covering the Barents Sea has been used in the final assessment from 2005 onwards, but for this year assessment it could not be used because of incomplete coverage.

Results for herring

Survey coverage was considered adequate in 2008, except for the areas east of 20 degrees east. Herring were recorded throughout most of the surveyed area as shown in Figure 9.4.6.4.1.

The herring concentrations (Figure 9.4.6.4.1) and size by area (Figure 9.4.6.4.2) in 2008 were comparable to what has been seen in later years with the largest concentrations and largest herring in the western areas.

Recruitment surveys in the Barents Sea have been conducted in the Norwegian and Russian Sea in May-June since 1991. In 2005 this survey became part of the ecosystem survey. No surveys were carried out in the years 2003–2004. The plan was to cover all of the relevant parts of the Barents Sea, as was done in 2005 and to include all of the immature part of the stock. Unfortunately, due to technical and administrative difficulties, the Russian EEZ could not be surveyed in May 2006 and the Norwegian zone east of 20 degrees east could not be covered in 2008. Although this series could act as a very important recruitment series for age 1–3 it is too unstable today. This has to been given high priority in the future planning of survey strategies related to this stock assessment.

The age-disaggregated time-series of abundance for the Norwegian Sea is presented in Table 9.4.6.4.2 and for the Barents Sea in Table 9.4.6.4.1. Age and length distributions from the three last years in the Norwegian Sea and Barents Sea are shown in Figure 9.4.6.4.3.

9.4.6.5 Survey 6 and 7 Joined Russian-Norwegian ecosystem autumn survey in the Barents Sea

Background and status

The survey consists of a trawl survey catching 0–group herring amongst other species and an acoustic survey estimating one and two year old herring. In 2001, the Working Group decided to include data on immature herring obtained during the Russian-Norwegian survey in August-October in estimating the younger year classes in the Barents Sea.

Use of this survey in stock assessment

The age groups 1 and 2 are used in the assessment. The log index of 0–group herring has been used in the assessment up to 2004 and then replaced by a new abundance index, which was included in the assessment since 2006.

Results

The results from these surveys on 0–group herring are given in Table 9.4.6.5.2; those of the 1 to 3 age groups are given in Table 9.4.6.5.1. The youngest age groups (0+ to 3+) of the Norwegian spring spawning herring stock are found in the Barents Sea at irregular intervals. It is difficult to access the stock size during autumn, due to various reasons. The age groups 1 to 3 are found mixed with 0–group herring and are difficult to catch in the sampling trawl used in this survey. The stock size estimates of herring are therefore considered less reliable than those for capelin and polar cod.

The distribution of young herring is shown in Figure 9.4.6.5.1. Distribution of 0–group herring is presented in Figure 9.4.6.5.2.

9.4.6.6 Survey 8 Norwegian herring larvae survey on the Norwegian shelf

Background and status

A Norwegian herring larvae survey has been carried out on the Norwegian shelf since 1981 during March-April. The objectives of the survey are to map the distribution of herring larvae and other fish larvae on the Norwegian shelf and to collect data on hydrography, nutrients, chlorophyll and zooplankton. The larval indices are used as indicator of the size of the spawning stock. Two indices are available from this survey (Table 9.4.6.6.1).

Use of this survey in stock assessment

The "Index 1" is used in the assessment as representative for the size of the spawning stock.

Results

In 2008 the survey was carried out from 5−19 April. The weather conditions were generally favourable and the coverage was considered to be adequate. The number of herring larvae found this year was very high and the total number was estimated to be $107.9*10^{12}$. This is the highest number of larvae recorded since the time-series started in 1981. The mean size of the larvae was 11.9 mm which is similar to the last four years but somewhat lower than preceding years. Most of the larvae were in early first feeding stages (stages 1 d and 2a) and a few older larvae were found. The fraction of yolk sac larvae was the second lowest found in the time series. Herring larvae were observed throughout the sampling area (Figure 9.4.6.6.1). However, zero values were found both on the northernmost and on the southernmost section. Also, the western extent of the larval distribution were found on all transects. Since there has been very limited spawning activity on the traditional spawning grounds south of Møre (i.e. Karmøy) in recent years, it was concluded that the survey covered the total distributional area of herring larvae.

9.4.6.7 Norwegian tagging data

With the exception of 1999, 2001 and 2005, tagging has been carried out annually between 1975 and 2007. In 2007 Norway has decided to discontinue the tagging programme in 2008 and in future years.

The use of the tagging data in the assessment was discontinued since 2006 due to a low number of recaptures. This comes as a result of too low tag density in the stock given the high stock size and amount of fish screened for tags.

9.5 Data exploration and prelimary assessment

9.5.1 Methods

The present assessment is a benchmark assessment. The benchmark process applied includes both an evaluation of the information used in the assessment and of the assessment model itself. The information used in the assessment is catch and survey data. Several assessments models and data exploration tools have been applied in evaluating the data.

The benchmark process was done in two stages: First, an extensive exploration of the data and the signals in the data was carried out to select data that appeared informative, and to resolve conflicts between different sources of data. Then, a range of assessment methods were used on the selected data, to select an adequate assessment method to infer stock abundance and mortalities from the data.

9.5.1.1 Catch curve analyses

Figures 9.5.1.1.1 and 9.5.1.1.2 show the catch in weight and in numbers by age in the years 1984−2007. It is clear that only few year classes dominate the catches in each year. In 1985 and 1986 some older year classes than the 1983 year class were in the fishery together with the 1983 year class, but they were not seen in the years thereafter. The 1983 year class contributed 50−90% of the catches by weight by year in the years 1987−1994 and the year classes from 1991 and 1992 dominated in the catches in the years 1996−2002, being 42−67% of the catches by weight by year. The year classes 1998 and 1999 were 33−50% of the catches in weight in the years 2003−2007. In 2007 the 2002 year class dominated the catches, being almost 39% of the catch by weight and 42% by numbers. The number of 5 years old caught was greater in 2007 than all the intervening years since the 1992 year class was caught as 5 year old in 1997. In 2007 the ratio between the catch of 1998 and 1999 year classes reversed (both in numbers and in weight) from that observed earlier. The 2007 values for catch at age were derived by using SALLOC with input data from all countries by exchanging data using the data delivery sheets format (WD, Gudmundsdottir).

In Figure 9.5.1.1.3 we can see the catch by year classes 1950−2003 in the years 1950−2007 both in weight (upper figure) and by numbers (lower figure). The 1950 year class has given the most yield, 5 million tonnes, and then the 1959 year class, 3.4 million tonnes. In numbers then most was caught of the 1959 year class, 46 billions, but thereof around 30 billions were caught as 0 and 1 year, old weighting very little. The year classes from 1983, 1990, 1991 and 1992 are all now fully utilized, the total catch from each of them is above 1 million tonnes. The total catch from the 1998 year class is already 1.3 million tonnes and with the exploitation used on this stock it is expected that more will be caught from the 1998, 1999 and 2002 year classes. From figure 4 we can also see that some year classes have given very little catch like the year classes from 1984, 1986, 1987 and 1995.

Figures 9.5.1.1.4 and 9.5.1.1.5 show the disaggregated catch in numbers plotted on a log scale. On Figure 9.5.1.1.4 age is on the x-axis, but in Figure 9.5.1.1.5 year is on the x-axis. For comparison lines corresponding to Z=0.3 are drawn in the background. For interpretation of these curves, some knowledge on the fishery throughout the years is required. If the fishing effort can be assumed to be relative constant through the years the slope of the decline of the cohorts can be interpreted as an estimate of total mortality. But if the effort has not been constant, say that the fishing effort has been gradually increasing then the slopes will be lower than the real value of Z. A first glance at the pictures gives the impression of a very different pattern of the year classes 1992 and older and the pattern seen in year classes 1993 and younger. The pattern in the 1992 and older year classes is more pronounced, the year classes are fully recruited at age 6 or 7 and then the curves decline at a suggested rate close to 0.3. The curves for the younger year classes are more flat, indicating either that they are still recruiting in the fishery or that they are exploited at a much lower rate than 0.3 at older ages. These assumptions are made on a relatively constant effort. We know however that the fishery has changed, from being a two nation fishery in the 1980s and early 1990s to a multinational fishery since mid 1990s, with the landings increasing about 100% each year from 1992 to 1995 and about 35% per year from 1995 to 1996. In the last years there has also been a change in the effort. So the assumption of a relatively constant effort hardly holds for the whole period but could hold for shorter period at a time. It is tempting to draw the conclusion that the catch curves shows the exploitation of the big year classes in the periods of relatively constant effort, but the poor year classes exhibit just noise. For the most recent year classes these curves provide hardly any information.

9.5.1.2 Survey curve analyses

Survey 1 (spawning area in Feb-March)

The age distribution in this survey is shown in Figure 9.5.1.2.1. The 1983 year class appears there as 11–13 years old in the first years. The 1991,1992 1998 and 1999 year classes are abundant. The 2002 year class is now seen as abundant. In this survey the 1992 year class is always larger than the 1991 year class. The 1999 year class is at a similar magnitude as the 1998 since 2006. Other year classes are very small in this survey. Only a few points are available for each year class in the survey, but the series is continuous the last 4 years. From Figures 9.5.1.2.2 and 9.5.1.2.3 one can say that the 1998 and 1999 year classes have been disappearing at a rate close to 0.3. The 2002 year class seems still to be recruiting to the survey.

Survey 2 (wintering area in Nov.-Dec.)

The age distribution in this survey is dominated by some few year classes at a time. These are the 1983, 1991, 1992, 1996, 1998, 1999 and 2002 year classes (Figure 9.5.1.2.4). Other year classes are sparce. This is the only survey in which the 1996 year class has been seen in some magnitude, and then only as 4 and 5 years old. From the catch curves (Figures 9.5.1.2.5 and 9.5.1.2.6) the conclusion can be drawn that the big year classes from 1991 and 1992 have disappeared at a rate higher than 0.3. There are "drops" in 2002, 2005 and also in 2007 for the 1998 and 1999 year classes. The first drop is due to the fact that in 2002 these year classes did not winter in the Fjord system as the older part of the stock did, but resided outside in the ocean and were not covered by this survey. It has been difficult to locate the overwintering areas of the stock since 2002 and the drops are a consequence of that. This pattern of drops is not seen in the survey on the feeding grounds, supporting the fact that the wintering grounds have not been located.

Survey 3 (wintering area in Jan.)

This survey was discontinued in 1999, and the time series is short, only from 1991. The age distribution in this survey is dominated by the 1983, 1991 and 1992 year classes, like in the other surveys during the same time (Figure 9.5.1.2.7). The catch curves for this survey were plotted (Figures 9.5.1.2.8 and 9.5.1.2.9) but don't tell anything new.

Survey 4 (juveniles in Barents Sea, May/June)

There are only two age groups used from this survey, 1 and 2 year old, Figure 9.5.1.2.10. It looks like that when a year class is big at age 1 then the survey picks it up and it is also big at age 2. This can be seen for the big year classes seen in the other surveys, the 1990, 1991, 1992, 1998, 1999 and the 2004 year class. The value for the 1999 year class as 1 year old is considered unrealistic.

Survey 5 (feeding area, May)

The age distribution in this survey is shown in Figure 9.5.1.2.11. The same year classes are prominent in this survey as in the other surveys, namely the 1991, 1992, 1998, 1999 and the 2002 year classes. The 1992 year class has been bigger than the 1991 year class through the survey. Since the 1998 and 1999 year classes were both fully recruited to the survey in 2003 they have been at a similar magnitude, in alternation, but not as in survey 2, where the 1999 year class is always smaller than the 1998 year class. The 2002 year class is a special case, as it grew up both in the Norwegian Sea and in the Barents Sea. As 5 and 6 year old (in 2007 and 2008) it was of the same order as the big 1992 year class as 5 and 6 years old in 1996 and 1997 respectively. The survey conducted in 2008 is considered to be an underestimate, as the whole feeding area was not surveyed as in the years before. The catch curves are shown in Figures 9.5.1.2.12 and 9.5.1.2.13. They tell a similar story to that drawn from the catches; that the older year classes (1992 and older) are disappearing at a different rate than the younger ones.

9.5.1.3 Analyses of the consistency within and between the surveys

The analyses aims to identify whether the information provided by a survey for the abundance of different year classes is internally consistent, If this is not the case it gives contradictive information and the use of the survey indices in the tuning of the assessment will cause problems. In order to investigate the correlation between the estimates of a year class at different ages, the numbers at age were plotted versus the numbers at age a+1 in the same survey. The points are marked as the year classes so it is possible to follow the year classes through the survey. A linear regression was made where the line is forced through the origin. The fitted line is plotted as a straight line and the correlation coefficient is printed above the plots, Figures 9.5.1.3.1–5.

The same was done by investigating the consistency in the information for different surveys by comparing the year class indices at the same age given by the surveys. The correlation between survey indices was investigated by plotting the numbers at age a in one survey against age a in the other survey.

This procedure was done for surveys 1, 2, 3 4 (only within) and 5, see Figures 9.5.1.3.6–11. Not only a high correlation number was used in determining the ages that could be used in the tuning, but also a look given to what caused the high correlation, e.g. many points in a cluster close to the origin and one point determining the regression line.

The results were that one could use ages 5–10 in survey 1; ages 4 and older in survey 2; ages 5 and older in survey 3; ages 1 and 2 in survey 4; and ages 4 and older in survey 5.

Some of the surveys have been dismissed and in some years surveys have not been conducted, so only few surveys can be compared.

There is a good consistency for ages 5–10 between survey 1 and survey 2. There is also a good consistency for age 4 and older between the surveys 5 and 2, but the magnitude of the year classes is higher in survey 5 than in survey 2. Good consistency is also between the surveys 1 and 5 for ages 5–11. There seems to be a inconsistency between survey 3 and 2, but survey 3 is though considered to give an information for the big year classes.

9.5.1.4 Assessment models used for exploration

For the evaluation of the data, a new toolbox, TASACS, was available for the first time. The toolbox was developed by Norwegian and Russian scientists in response on a request by NEAFC and includes essential elements and experiences from several methods. The toolbox allows exploration of data using and combining various model assumptions previously available in separate frameworks, as well as tools for comparing the signals in various sources of data. TASACS was developed with the intention to replace the various model programmes used in previous Working Groups.

TASACS has 4 alternative population models, a VPA, a Separable population model, and two variants of the ISVPA−the catch controlled and the effort controlled versions. The free parameters of each model are estimated by minimizing an objective function that compares modelled values with observations. There is a range of objective functions available, but the analyses were carried out minimising log SSQs. The optimisation is done with a search routine, which is slow, but by experience has proven to be very robust.

With respect to the ISVPA, there are some discrepancies between the original ISVPA and the implementation in TASACS.

1. The TASACS implementation uses ordinary fishing mortalities while ISVPA uses instantaneous fishing mortalities. It has been verified that this does not make a difference to the performance.
2. In ISVPA in general, an objective function (e.g. sum or the median of squared log residuals) expressing the fit of the modelled catches to the observed catches under the separable assumption is minimized. In an inner loop, this is done by fixing the fishing mortality in the last year. In an outer loop, this terminal fishing mortality is estimated together with parameters in other observation models if there are any, by minimizing the measure of fit to other data together with the objective function from the inner loop. In the catch controlled version, the N-values are derived directly from the catches, except for the terminal N-values, which are taken from the separable model. In the effort control version, the N-values are those derived from the separable model.

   In the TASACS implementation as it stands at present, the fit is done in two stages. First a separable model is fitted with a given terminal fishing mortality. In the next step, the terminal fishing mortality is determined by the fit of modelled survey data, derived from the N-values from ISVPA, to the survey observations, disregarding the fit to the separable model. Hence, the TASACS implementation regards the ISVPA population model as a 'black box', which gives a set of N-values for each terminal fishing mortality, while the ISVPA fits all data in one objective function, but in an inner and outer loop.

   The profile of the objective function in the inner loop is commonly used as a valuable diagnostic when using ISVPA, to reveal problems with local minima and help in deciding the final conditioning of the model. This facility is not available in the TASACS package at the moment. In the future, the plan is to include a facility to compute probability profiles as a generic tool.

Hence, to bring TASACS in line with the standard ISVPA, including the sum of squares from the separable model in the overall objective function is needed. Likewise, a diagnostic facility based on the objective function for the catches as a function of the terminal F should be provided.

Previous years assessments on Norwegian spring-spawning herring have been carried out with SeaStar which is a VPA and a family of ISVPA models. SeaStar will no longer be available for exploration of data. This year only a SPALY run for SeaStar was available which has been used for comparison only. A number of the ISVPA assumptions (catch constrained, effort constrained) are available in TASACS and data have been explored with these. The Triple-separable version of ISVPA, which can take into account possible year class dependent systematic violations of the stability of the selection pattern, is not available in TASACS but was available as a separate programme.

9.5.2 Results of data analyses and exploration

9.5.2.1 Exploration of survey data with TASACS

The exploration of the survey data is carried out in order to investigate whether the survey contributes information to the assessment or whether there is no or little information in the survey data. In the case where the survey contributes mostly noise to the assessment it is not included in further exploration and in the final assessment. In addition, when conflicting information appeared between different surveys, it was attempted, as far as possible, to use expert knowledge about the performance and known problems of the different surveys, to resolve conflicts by excluding the data that were considered the least reliable.

Within TASACS, the development of the individual cohorts (year classes) were explored for each survey separately. This was done cohort by cohort by translating each survey index into population numbers. This allows comparing what each survey indicates that the population numbers should be, and thus identify conflicting signals between surveys and outliers in the survey data. This was done year class by year class. Included in this analysis was also catch data at age, translated into N-values assuming a separable model for the fishing mortalities.

Such comparisons allows identification of outliers in the surveys, contradicting signals, or may indicate that the survey provides mostly noise. Figure 9.5.2.1.1 shows an example of the N values based on all information compared with those based on the information selected by this process, see Figure 9.5.2.1.2, and used in further exploration of data and final assessment.

The comparison provided some general observations. The information in most surveys deteriorates in the older age groups because of low (or zero) numbers in the survey catches. Also there were ageing problems identified for older fish, especially for poor year classes in years adjacent to large year classes.

Rather than excluding information from the survey on a subjective basis, it was decided to set criteria for exclusion. These were set based on the general observations and the analysis of comparisons of the consistency within and between the surveys. The following criteria were set for exclusion of data:

1) Data outside the range of years and age windows selected by previous WG have also been excluded in this assessment. Such as incomplete survey coverage of the stock of survey not completed due to other reasons.
2) Survey data of poor year classes with mostly noise are excluded. This is for instance the case for year class 1995 in all surveys.

3) Reject ages where the analysis of consistency between and within surveys indicate severe problems. For instance for survey 1, the conclusion from the correlation analyses is not to use information at ages older than age 11.

4) If there is a conflict between data from different surveys, discard the data where known problems with the survey indicates that these are the least reliable. This applied in particular to conflicts between survey 2 and survey 5, where survey 2 indicated a rapid decline in the stock and survey 5 a more gentle decline. Since representative sampling of old fish in survey 2 is a known problem, caused by vertical segregation in the wintering areas in the Ofoten fjord, the survey 2 data were ignored and the survey 5 data used. at ages above 10 years.

5) If there are internal inconsistencies in the old ages in a survey (mismatch between abundance at young and old age), the old ages were ignored.

6) No zero values were used.

The data finally used in further exploration with TASACS are shown in Figure 9.5.2.1.3. Data not used still remain on the input files. Exclusion of data is done by giving them zero weight in the analysis.

In previous SeaStar assessments, which were the basis for the ICES advice, *a priori* assumptions had been made on the noise in the data. It was assumed that poor year classes were not estimated well because of low numbers or age reading problems and they were excluded from the final assessment. The present analyses has kept some of the information of poor year classes previously ignored in the assessment but has excluded some data used previously on the basis of the criteria outlined above.

9.5.3 Exploratory assessment runs

Exploratory assessment runs were carried out with TASACS with the selected data. The four population models used for the main explorations are a VPA, a separable model and the ISVPA model both catch and effort constrained. For these model configurations base line assessments were done with the selected data using SSQ as the objective function. In addition, retrospective and bootstrap analyses were carried out as well.

Settings in the exploratory runs:

The observations used, as well as weights and maturities were as described above. Spawning at the start of the year was assumed.

Natural mortality was assumed at 0.9 for ages 0, 1 and 2 and 0.15 for older ages.

The analysis was restricted to the years 1988–2008, which is regarded as the period representative of the present production and exploitation regimes, and is presumed to be of main interest for the management.

On some occasions, the WG has run the assessment further back to 1950. Data exist that allow VPAs back to 1907. Such analyses have been published (Toresen and Østvedt, Fish and Fisheries, 2000, 1: 231 – 256) . There is no survey information before 1980, and only the 0-group survey and the Larval survey have data that can be used before 1990. The long collapse period will cause problems in deriving terminal fishing mortalities back in time both because the catches were very small and because only the very youngest ages were represented. The assessment, also for the period before the collapse, will be sensitive to how these problems are handled. The

WGWIDE could not prioritize going in depth on these problems as part of the benchmark, but refers to earlier studies.

The age range was 0 15+. In previous runs with SeaStar the 15+ group was split internally in the program in an age 15 group and a 16+ group to improve the model fit. This was not done here.

The assumed fraction of fishing mortality and natural mortality realized before each of the age-structured surveys is given in the text table below:

Fleet 1	Fleet 2	Fleet 3	Fleet 4	Fleet 5	Fleet 6	Fleet 7
0.17	0.91	0.17	0.41	0.41	0.70	0.70

All observations still included were given equal weight, except for the catches at the youngest ages, where the following weightings, relative to the standard weighting of 1.0 were used:

Age 0	0.001
Age 1	0.001
Age 2	0.01
Age 3	0.1

In all models, catchabilities at age for the age structured surveys were set independent of age from age 5 onwards. Trial runs had indicated no age trend in the catchabilities above this age.

In the Separable model, all annual fishing mortalities and terminal survivor numbers were free parameters. Selection at age was assumed constant over all years, and independent of age up to 12 and constant between 12 and 15+.

In the present implementation of ISVPA, the only free parameters are catchablities and the fishing mortality year factor in the last catch year.

In the VPA, there were no data to support the estimate of the terminal stock numbers for some small year classes (before 1982, 1984−1988, 1995 and 2000−2001). For those of these year classes that had reached oldest true age, terminal fishing mortalities were derived from the terminal F the year before and fishing mortalities at younger ages, with the standard procedure in TASACS. For the year classes that still are younger than the oldest true age, survivor numbers were fixed at arbitrarily selected small values.

The model was run with catch data 1988−2007, and projected forwards through 2008 assuming Fs in 2008 equal to those in 2007, to include survey data from 2008.

Residuals and sums of squares

Figure 9.5.3.1 shows the residual SSQ of the different model configurations for the surveys separately. Fleet 5 contributes most to the SSQ, but this fleet also contributes most of the survey data to the assessment. In Figures 9.5.3.2−5 weighted residuals for the surveys for different model configurations are shown. The effort controlled version of ISVPA has some strong cohort effect in the Survey 5 residuals. Some year class effects are seen in the separable models which is not seen in the VPA. With exception of the effort controlled ISVPA, the SSQ in the different models are at the same level. The effort controlled ISVPA shows higher SSQ. The lowest SSQ is in the VPA run.

Separability

The changes in the migration of the herring in recent years have affected the exploitation of the stock. The exploitation in the overwintering areas in the Norwegian fjords has ceased, and it is exploited now in other areas in open sea. Also the different migration and consequently the different distribution of the stock in the area has changed the accessibility to the different fleets and nations. These changes may have affected the catchability and the selection pattern. The diagnostics of the separable models, assuming constant selection over the whole time period of the assessment, do not give strong indications that this has been the case. However, there some are patterns in the catch residuals with clusters that may indicated some deviations from the separable hypothesis, but no marked shift at any time.

Although there are no clear indications of violating the separable assumption, the violations may well be concealed by the noise in the data.

Bootstrap

The uncertainty of the assessments was examined by bootstrap. Due to time constraints, a large number of bootstrap replicas (1000) could only be made for the proposed final run with the VPA. For the other models, 25–50 bootstrap replicas were made, which only give a coarse impression of the uncertainty.

For the data where residuals are generated by the modelling, the bootstrap was made by adding randomly drawn residuals from the same source of data to the modelled observations. For catches at age in the VPA, log-normally distributed random noise with a CV of 0.1 was added to the observations. The results are shown in Figures 9.5.3.6–9. The difference in precision of estimates between the methods is not large. The VPA appears to perform slightly better than the others, which may be due to the moderate noise put on the catch data.

Retrospective analyses rearrange to the end of this section

The retrospective analyses for different models are shown in Figures 9.5.3.10–13. These show underestimation of SSB and overestimation of fishing mortality. These retrospective trends are the same in all model configurations. This suggests that the trends are not caused by the model but by the data used in the assessment. The main reason for the retrospective trends is the data on the 2002 year class. Estimates of this large year class have increased considerably in successive years as more information (from surveys and catches) became available, leading to higher estimates of the stock in successive years in all models. Thus the retrospective performance of the different assessment models is not considered to be an important criterion for selection of the model for the final assessment.

Conclusion

All the available population models, with a possible exception of the effort controlled ISVPA, seem to perform well, and there is little to select one over the other. However, the performance of the VPA with respect to fit to the survey data, retrospective pattern and uncertainty in the bootstrap is marginally better than with the other models. Also by using a VPA, possible violations of the separable hypothesis are avoided. While there are no clear indications of such violations in the model fit, the way the fishery has developed may cause some concern, and violations of the separable hypothesis would be difficult to detect with the present level of noise in the catch data. Therefore it was decided to bring the VPA forward as the final run.

9.5.4 Comparison TASACS with Seastar and TISVPA

The SSB, Fishing Mortality and Recruitment estimated by the different explorations in TASACS and those of TISVPA and the SPALY Seastar run are presented in Figure 9.5.4.1. The relative exploitation pattern in 2007 between the different explorations and the final SeaStar assessment of last year are shown in Figure 9.5.4.2. The results of most models are in good agreement and the choice between them would have only little effect on the advice. An exception is the effort controlled ISVPA run which is out of line with the other models. However, the results of this model are considered less reliable because it showed strong cohort effects in the diagnostics of survey 5. It had also the highest SSQ with respect to the other survey data. The results of the SPALY Seastar run are consistent with last year's assessment and the explorations carried out with the other model configurations examined, but no diagnostics are available for this model.

9.6 Final assessment

The VPA assessment from the TASACS framework was selected as the final assessment. As discussed above the main reasons for this choice were that the fit of the survey data to the catch data in the most important survey was better than in the other models. Additionally there was no need to make the separable assumption.

The results of the assessment are presented in Tables 9.6.1 (stock in numbers) and 9.6.2 (fishing mortality) and Figure 9.6.1. Table 9.6.3 is the summary table of the assessment.

The assessment indicates that the fishing mortality ($F_{5\text{–}14\text{weighted}}$ weighted by stock numbers) in recent years has fluctuated between 0.10 and 0.15. and is estimated in 2007 at 0.101. A number of large year classes have appeared in recent years of which two year classes 2002 and 2004 are the most recent ones. The 2002 year class is now fully recruited in the spawning stock. The estimate of the 2004 year class by this year's assessment is close to the one used by the Working Group in the forecast last year. The available information indicates this is a strong year class. As a result of these large year classes and the high survival due to low fishing mortality, the SSB has increased in recent years and is estimated near 11.5 million tonnes in 2008.

9.7 Reference points

9.7.1 Precautionary and limit reference points:

The reference points for herring were considered by the Workshop on Limit and Target Reference Points (WKREF) held in Gdynia in 2007. Although it was the intention to review and update the biological basis of limit reference point taking into account the possible effects of species interactions and regime shifts, this has not been done because of lack of data. Instead, the breakpoint of a segmented regression applied to the stock recruitment plot was investigated. This breakpoint gives an indication at which SSB recruitment starts to decline and is a candidate for B_{lim}. The breakpoint in the stock recruit data varied between 2 to 4 million tonnes and seemed to be very sensitive to small changes in the estimates of the poor year classes (points near the origin of the S/R plot) in assessments carried out in different years

WKREF could not explain the sensitivity and considered this behaviour of the model highly undesirable. WKREF decided to ask the Methods Working Group to investigate this observation further. Given this, the use of segmented regression technique to establish a limit biomass reference point for Norwegian spring spawning herring was not considered appropriate until the observed methodological issue has been resolved.

The presently used values originate from an analysis carried out in 1998.

	ICES CONSIDERS THAT:	ICES PROPOSED THAT:
Precautionary Approach reference points	$\mathbf{B}_{lim}$ is 2.5 million t	$\mathbf{B}_{pa}$ be set at 5.0 million t
	$\mathbf{F}_{lim}$ is not considered relevant for this stock	$\mathbf{F}_{pa}$ be set at F = 0.15

Technical basis:

$\mathbf{B}_{lim}$: MBAL	$\mathbf{B}_{pa}$: $=\mathbf{B}_{lim}$ * exp(0.4*1.645) (ICES Study Group 1998)
$\mathbf{F}_{lim}$: not relevant for this stock	$\mathbf{F}_{pa}$: based on medium term simulations (ICES Study Group 1998)

The new assessment did not give a different perceptions of the dynamics and levels of SSB and Fishing Mortality compared to the assessment which was the basis for establishing the reference points. Therefore there was no need to reconsider the reference points because of the new assessment method.

9.7.2 Target reference points

The Coastal States have agreed a target reference point defined at F=0.125. (Note that the average fishing mortality is calculated as a weighted mean over the age groups 5–14 (weighted over abundance).

9.8 State of the stock

The stock is considered to be within safe biological limits. Fishing mortality is lower than the defined limit and target reference points. SSB is well above all reference points and is estimated near the highest in the time-series. The stock contains a number of good year classes. The productivity of the stock presently is high. In the last 10 years, four large year classes have been produced (1998, 1999, 2002 and 2004).

9.9 Short term forecast

9.9.1 Input data for the forecast

Input stock numbers in 2008 at age 4 and older are taken from the final assessment. Stock numbers at age 0 to 3 were estimated separately. In 2007, the review group critisized the procedure applied by WGNPBW to estimates these age groups and recomended the use of RCT3 to derive suitable estimates of recruits for projections. In the absence of external information on the year classes 2007 and later, the Working Group decided to use geometric mean over the years 1988−2004 for these year classes. To derive estimates for ages 2 and 3 in 2008 (year classess 2006 and 2005) the RCT3 program was used. Input data for the RCT3 program (Table 9.9.1.) were VPA values at age 2 and available survey indices. Results from the RCT3 are shown in

Table 9.9.2. The year classes estimates used in the prediction are indicated (underlined) in the text table below:

year class	age	VPA	RCT	GM
2005	3	3 037	4 870	5 000
2006	2	10 693	13 000	13 700
2007	1	-		35 000
2008	0	-		105 000
2009	0	-		105 000
2010	0	-		105 000

The estimates of RCT3 for the 2005 and 2006 are close to the GM. The Working Group adopted the RCT3 values to be used in the forecast.

The catch weight-at-age, used in the forecast, is the average of the observed catch weights over the last 3 years (2005–2007). For the weight-at-age in the stock, the values for 2008 were obtained from the winter surveys (Table 9.4.3.1). For the other years the average of the last 3 years (2006–2008) was used.

Standard values of maturity at age and natural mortality were used.

The exploitation pattern used in the forecast was taken as the average of the last 3 years (2005–2007). The average fishing mortality is the average over the ages 5 to 14 and is weighted over the population numbers in the relevant year.

$$\overline{F}_y = \sum_{a=5}^{a=14} F_{y,a} N_{y,a} / \sum_{a=5}^{a=14} N_{y,a}$$

Where $F_{y,a}$ and $N_{y,a}$ are fishing mortalities and numbers by year and age

This procedure is the same as applied in previous years for this stock.

Input data for the short term forecast are given in Table 9.9.3.

9.9.2 Results of the short term forecast

The Management Options Table with the results of the forecast is presented in Table 9.9.4. Detailed output of the forecast, corresponding to the management plan is given in Table 9.9.5. Assuming that the TAC of 1 518 000 tonnes is taken in 2008, it is expected that the SSB will remain about 12.6 million tonnes in 2009. The TAC in 2009, corresponding with the fishing mortality of 0.125 in the agreed Management Plan ($F_{management\ plan} = F_{(5-14)weighted} = 0.125$), is 1 643 000 tonnes. The expected SSB in 2010 is about 11.5 million tonnes.

9.10 Medium term forecasts

No medium term forecasts were carried out by the Working Group

9.11 Uncertainties in the assessment and forecast

The assessment appears to be more sensitive to the choice of the data used than to the choice of the model. This is particularly the case because there has been an apparent shift in wintering areas for this stock since 2003. These distributional changes have affected the usefulness of winter surveys because the surveys do not cover the whole distribution area of the stock anymore. These surveys show a lower abundance of the 1998 and 1999 year classes since 2003, because these year classes did not enter the area covered by the survey. The decrease of these year classes is not observed in other surveys carried out later in the year on the feeding grounds. Because of the large change in wintering patterns of the herring, the results of the winter surveys from 2003–2007 were not used in the assessment. Some of these surveys will not be continued in the future.

Recruitment estimates of the most recent year classes are uncertain and based on surveys in the Barents Sea. In 2008, the most important of these surveys for the assessment did not fully cover the Barents Sea. However, the estimates of the most recent year classes have little impact on the short term prediction of landings and SSB because of the late recruitment of these year classes in the catches and spawning stock.

9.12 Comparison with previous assessment and forecast

The assessments for Norwegian spring spawning herring in 2005−2007 were carried out with the Seastar model which is a VPA type model. The final assessment in 2008 was a made with a VPA type of model carried out in the TASACS framework. In principle, the same sources of information have been used in all these assessments, but the weight of this information given in the assessment this year was changed in some cases, following an evaluation of this information (section 9.5).

The results of the present assessment are consistent with the assessments carried out in 2006 and 2007 (Figure 9.12.1.) The SSB and Fishing mortalities estimated by WG 2008 are almost the same as those estimated by WG 2006. The estimate of the very strong 2002 year class has been increased in successive years and also in the present assessment. For the also abundant 2004 year class, little information is available to estimate it accurately. The estimate this year class has been reduced by the present assessment with respect to last years assessment, but it remains a strong year class.

9.13 Management plans and evaluations

The present management plan dates from 1996 and is described in section 9.3.3. It aims for exploitation at a target fishing mortality below Fpa and is considered by ICES in accordance with the precautionary approach. In general, management has achieved to manage to stock in compliance with the management plan. The Working Group did not consider new evaluation of the existing management plan and there were also no requests to do so.

9.13.1 History of the management plan

In brief there have been three management plans under two management regimes. After the collapse of the stock in the late 1960s and beginning of the 1970s the stock spent the whole year in Norwegian waters and so became under Norwegian jurisdiction, and the Norwegians managed the stock in the rebuilding phase. Since autumn 1996 an international agreement on the management has existed and the management authorities are the Coastal States (EU, Faroes Islands, Iceland, Norway, Russia).

A short versions of the management plans are:

1) <u>Fish at F=0.05.</u>
This rule was in force during the rebuilding phase. The aim by using so low F was to get the SSB over the 2.5 million t threshold. ICES recommended a cautious re-opening of the fishery in 1984 at this level of F (ICES 1992). This plan was last used for advice by ICES in 1992 in the TAC advice for 1993.

2) <u>Fish at F=0.15 with a catch ceiling of 1.5 million t.</u>
The aim with this rule was to keep the SSB > 2.5 million t. The Coastal States

adopted this rule as their management plan in autumn 1996. During 1996–1999 this rule was the basis for the advice ICES gave for the TAC in 1997–2000. The Coastal States however also used it for setting the TAC for 2001.

3) Fish at F=0.125.
   There are also requirements in this rule to keep the SSB > 2.5 million t (B_{lim}) and take some actions if the SSB falls below 5 million t (B_{pa}) to ensure rapid recovery of the SSB. This rule was agreed by the Coastal States in October 1999. In October 2001 the Coastal States agreed on a recovery plan, namely a linear reduction in the fishing mortality from 0.125 at B_{pa} to 0.05 at B_{lim}.

   This plan, fishing at F=0.125 has been the basis for the advice given by ICES since 2000 (advice for 2001) and is still in use.

   It should be noted that there is presently no catch ceiling in this plan. In the medium term projections done by the NPBWWG in 2000, 2001 and 2002 however a catch ceiling of 1.5 million t was included (for technical performance reasons) (ICES 2000, 2001, 2002).

For the evaluation of the rules 2 and 3 weighted F (by stock numbers) was used (ICES 1997, 1998, 1999, 2000, 2001, 2002).

9.14 Management considerations

This stock has shown a large dependency on the irregular occurence of very strong year classes. In recent years, the stock has tended to produce strong year classes more regularly.

In recent years, the migration behaviour of the stock has changed significantly, particularly in geographical locations of the wintering and feeding areas. These, in turn, affect the distribution of the fisheries.

The perception of the situation of the stock and its exploitation is similar to last year and has not changed because of the new assessment applied in 2008.

Catches, taken from the stock in recent years, have been taken with a low fishing mortality close to the agreed target fishing mortality in the Management Plan. This has contributed to a rapid recovery of the stock.

9.15 Ecosystem considerations

Norwegian spring spawning herring is a straddling stock. Juveniles and adults of this stock form an important part of the ecosystems in the Barents Sea, the Norwegian Sea, and the Norwegian coast. Herring has an important role as food resource to higher trophic levels (e.g. large fish, seabirds, and marine mammals), but also as a consumer of zooplankton in the Norwegian Sea and capelin larvae in the Barents Sea. The present high stock size will therefore have positive effects on its predators, but the effects on other pelagic fish stocks feeding in the Norwegian Sea such as blue whiting and mackerel may be negative due to competition for food.

Recent changes in the herring migration have led to an increased proportion of the population feeding in Faroese and Icelandic waters. The growth of these herring is faster than those feeding further east and north.

Not much information is available on the impact of the herring fishery on the ecosystem. The fishery is entirely pelagic. There is little quantitative information on the by-catches in the fisheries for herring but these are thought to be small. Therefore unintended effects of the fishery on the ecosystem are probably small or absent. Since herring is a major source of food for some populations of other species, overfishing of the herring stock could affect these populations. This is presently not the case since the herring stock is very abundant and is exploited at a low rate.

9.16 Regulations and their effects

In the rebuilding phase of the stock in the 1980s and beginning of the 1990s (SSB < MBAL = 2.5 million t), the objective was to keep the fishing mortality below 0.05. With the exception of a few years, this objective was achieved. A minimum landing size regulation of 25 cm has been in place since 1977. This has prevented the exploitation of young herring. These regulations have contributed to a rebuilding of the stock to levels well above precautionary limits. When the fishery expanded in the mid-1990s, a long-term management plan was agreed; this plan is cited above.

For 2006, the Parties exploiting the resources (European Union, Faroe Islands, Iceland, Norway, and Russia) did not reach agreement regarding the allocation of the quota and no TAC was agreed. However, the fishing mortality resulting from the sum of the coastal states quotas has not exceeded F_{pa}. For 2007 the parties did reach agreement on a TAC in accordance with the Management Plan and agreed on the allocation of the quota.

9.17 Changes in fishing patterns

A gradual change from a fjordic to an oceanic wintering area of the Norwegian spring spawning herring has observed over time. Last winter (2007/2008) no NSSH wintered in the fjords and only small amounts of mainly autumn spawning herring were caught here. The change in winter area led to large consequences for the fishing pattern of the Norwegian fleet. For the larger vessels the new distribution means longer trips in terms of distance and lower availability because of strongly reduced concentrations in the oceanic as compared to fjordic wintering areas. Weather has also become a more important factor to the fishery in the wintering areas. For the smaller vessels the availability of herring has been grossly reduced and many vessels find difficulties in taking their quotas. This has led to a shift in the fisheries towards the Norwegian coastal/fjordic herring stocks, which are herring of smaller size and lower lengths at maturity. This herring is often found in mixed concentrations with immature Norwegian spring spawning herring and there is a new and clear challenge to science and management in how to deal with this new situation. Due to the reduced availability of herring to the coastal fleet in the wintering area, the fisheries on the spawning migration and in the spawning areas has increased. This is reflected in a strong increase in the fisheries during the first quarter from 2006 to 2007 with catches up from 202 649 tonnes to 296 762 tonnes.

9.18 Changes in the environment

Two main features of the circulation in the Norwegian Sea, where the herring stock is grazing, are the Norwegian Atlantic Current (NWAC) and the East Icelandic Current (EIC). The NWAC with its offshoots forms the northern limb of the North Atlantic current system and carries relatively warm and salty water from the North Atlantic into the Nordic Seas. The EIC, on the other hand, carries Arctic waters.

It has been shown that atmospheric forcing largely controls the distribution of the water masses in the Nordic Seas. Hence, the lateral extent of the NWAC, and consequently the position of the Arctic Front in the Norwegian Basin, is correlated with the large-scale distribution of the atmospheric sea level pressure. This is clearly indicated for example by the correlation with the winter index of the North Atlantic Oscillation (NAO). Current measurements south in the Norwegian Sea have also shown that high NAO index gives larger Atlantic inflow, along the shelf edge, in the eastern part of the Norwegian Sea.

During winter 2008 strong westerlies (high NAO index) resulted in an increased influence of Arctic water in the southern Norwegian Sea for 2008 compared to 2007. Also compared to the average 1995−2006 an increased Arctic influence is observed, especially in the western part. After some years with large westerly extension of Atlantic water and additional warm Atlantic water in the Norwegian Sea, especially in 2003 and 2004, a temperature reduction in the western Norwegian Sea is observed the last years. This is due to a less extension of Atlantic water and the occurrence of an increased transport of Arctic water to the area. Thus, the temperature in the western Norwegian Sea in 2008 is close to and in some areas less than the 1995−2006 average. However, in the eastern part, near the Norwegian coast, the water is still warmer than the average due to that the inflow of Atlantic water through the Faroe-Shetland Channel is warmer than normal. At the surface, the air-sea heat flux during April-June 2008 was higher than normal causing the relatively warm surface water.

It has been shown that the Arctic front is a central feeding area for NSSH (Nøttestad *et al*., 2007) and during periods when the Arctic front is shifted eastwards due to high NAO index it is likely that the part of the NSSH stock feeding in the western Norwegian Sea will also be shifted eastward compared to years with high NAO index.

The average biomass of zooplankton in the Norwegian Sea in May has been on a decreasing trend since 2002, and reached in 2008 a record low level since the measurements started in 1997.

The overall distribution pattern of the zooplankton biomass in May 2008 resembles largely the distribution during previous years with the highest biomass in the cold water of the East Icelandic Current. However, further north along the Arctic front the biomass was markedly lower in 2008 compared to previous years and especially compared to 2007.

ICES has shown that there was a weak relationship between zooplankton biomass in May and herring condition in the autumn during the years 1995–2005. The March–April NAO index for 2004 and 2005 has been shown to predict the herring condition index in the winters of 2005 and 2006. There was no expertise available at the 2008 Working Group meeting to update this data set.

9.19 References

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Table 9.1.1. Norwegian spring-spawning herring. Overview of reference F used in assessments and predictions in 1990-2007.

YEAR	VPA	PREDICTIONS
1990	$F_{4\text{-}9,w}$	$F_{4\text{-}9,u}$
1991	$F_{4\text{-}9,w}$	F_{8}
1992	$F_{5\text{-}9,u}$	$F_{5\text{-}12,w}$
1993	$F_{5\text{-}9,u}$	$F_{5\text{-}11,u}$
1994	$F_{5\text{-}10,u}$	$F_{5\text{-}10,u}$
1995	$F_{5\text{-}10,w}$	$F_{5\text{-}10,u}$
1996	$F_{5\text{-}12,w}$	$F_{5\text{-}12,w}$
1997	$F_{5\text{-}13,w}$	$F_{5\text{-}13,u}$
1998	$F_{5\text{-}14,w}$	$F_{5\text{-}14,u}$
1999	$F_{5\text{-}14,w}$	$F_{5\text{-}14,u}$
2000	$F_{5\text{-}14,w}$	$F_{5\text{-}14,u}$
2001	$F_{5\text{-}14,w}$	$F_{5\text{-}14,u}$
2002	$F_{5\text{-}14,w}$	$F_{5\text{-}14,u}$
2003	$F_{5\text{-}14,w}$	$F_{5\text{-}14,w}$
2004	$F_{5\text{-}14,w}$	$F_{5\text{-}14,w}$
2005	$F_{5\text{-}14,w}$	$F_{5\text{-}14,w}$
2006	$F_{5\text{-}14,w}$	$F_{5\text{-}14,w}$
2007	$F_{5\text{-}14,w}$	$F_{5\text{-}14,w}$

$F_{5\text{-}14,u}$ means average F over ages 5-10

$F_{5\text{-}14,w}$ means F weighted with stock numbers over ages 5-14

Table 9.4.1.1 Total catch of Norwegian spring-spawning herring (tons) since 1972. Data provided by Working Group members.

YEAR	NORWAY	USSR/ RUSSIA	DENMARK	FAROES	ICELAND	IRELAND	NETHERLANDS	GREENLAND	UK (SCOTLAND)	GERMANY	FRANCE	POLAND	SWEDEN	TOTAL
1972	13161	-	-	-	-	-	-	-	-	-	-	-	-	13161
1973	7017	-	-	-	-	-	-	-	-	-	-	-	-	7017
1974	7619	-	-	-	-	-	-	-	-	-	-	-	-	7619
1975	13713	-	-	-	-	-	-	-	-	-	-	-	-	13713
1976	10436	-	-	-	-	-	-	-	-	-	-	-	-	10436
1977	22706	-	-	-	-	-	-	-	-	-	-	-	-	22706
1978	19824	-	-	-	-	-	-	-	-	-	-	-	-	19824
1979	12864	-	-	-	-	-	-	-	-	-	-	-	-	12864
1980	18577	-	-	-	-	-	-	-	-	-	-	-	-	18577
1981	13736	-	-	-	-	-	-	-	-	-	-	-	-	13736
1982	16655	-	-	-	-	-	-	-	-	-	-	-	-	16655
1983	23054	-	-	-	-	-	-	-	-	-	-	-	-	23054
1984	53532	-	-	-	-	-	-	-	-	-	-	-	-	53532
1985	167272	2600	-	-	-	-	-	-	-	-	-	-	-	169872
1986	199256	26000	-	-	-	-	-	-	-	-	-	-	-	225256
1987	108417	18889	-	-	-	-	-	-	-	-	-	-	-	127306
1988	115076	20225	-	-	-	-	-	-	-	-	-	-	-	135301
1989	88707	15123	-	-	-	-	-	-	-	-	-	-	-	103830
1990	74604	11807	-	-	-	-	-	-	-	-	-	-	-	86411
1991	73683	11000	-	-	-	-	-	-	-	-	-	-	-	84683
1992	91111	13337	-	-	-	-	-	-	-	-	-	-	-	104448
1993	199771	32645	-	-	-	-	-	-	-	-	-	-	-	232457
1994	380771	74400	-	2911	21146	-	-	-	-	-	-	-	-	479228
1995	529838	101987	30577	57084	174109	-	7969	2500	881	556	-	-	-	905501
1996	699161	119290	60681	52788	164957	19541	19664	-	46131	11978	-	-	22424	1220283
1997	860963	168900	44292	59987	220154	11179	8694	-	25149	6190	1500	-	19499	1426507
1998	743925	124049	35519	68136	197789	2437	12827	-	15971	7003	605	-	14863	1223131
1999	740640	157328	37010	55527	203381	2412	5871	-	19207	-	-	-	14057	1235433
2000	713500	163261	34968	68625	186035	8939	-	-	14096	3298	-	-	14749	1207201
2001	495036	109054	24038	34170	77693	6070	6439	-	12230	1588	-	-	9818	766136
2002	487233	113763	18998	32302	127197	1699	9392	-	3482	3017	-	1226	9486	807795
2003*	477573	122846	14144	27943	117910	1400	8678	-	9214	3371	-	-	6431	789510

***In 2003 the Norwegian catches were raised of 39433 to account for changes in percentages of water content.**

Table 9.4.1.1, cont. Total catch of Norwegian spring-spawning herring (tons) since 1972. Data provided by Working Group members.

YEAR	NORWAY	USSR/ RUSSIA	DENMARK	FAROES	ICELAND	IRELAND	NETHERLANDS	GREENLAND	UK (SCOTLAND)	GERMANY	FRANCE	POLAND	SWEDEN	TOTAL
2004	477076	115876	23111	42771	102787	11	17369	-	1869	4810	400	-	7986	794066
2005**	580804	132099	28368	65071	156467	-	21517	-	-	17676	0	561	680	1003243
2006***	567237	120836	18449	63137	157474	4693	11625	-	12523	9958	80	-	2946	968958
2007	779089	162434	22911	64251	173621	6411	29764	4897	13244	6038	0	4333	0	1266993

Preliminary, as provided by Working Group members.

*****Scotland and Northern Irland combined.**

Table 9.4.1.2 Norwegian spring spawning herring. Output from SALLOC for 2007 data. Run 2.

Summary of Sampling by Country

AREA : IIa

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Denmark	22911.00	22911.00	8	1038	1005	100.13
Faroe Islands	54639.00	57579.00	5	500	500	100.02
Germany	4462.00	6038.00	13	5271	895	96.86
Greenland	0.00	3345.00	0	0	0	0.00
Iceland	95919.00	128334.00	37	1632	1560	99.94
Ireland	0.00	6411.00	0	0	0	0.00
Norway	777784.00	779089.00	212	15897	7098	99.95
Poland	0.00	4333.00	0	0	0	0.00
Russia	139918.00	154058.00	134	25100	1415	100.01
Scotland	13244.00	13244.00	1	143	67	100.05
The Netherlands	29764.00	29764.00	7	873	175	96.34
Total IIa	1138641.00	1205106.00	417	50454	12715	99.86

Sum of Offical Catches : 1205106.00
Unallocated Catch : 0.00
Discards : 0.00
Working Group Catch : 1205106.00

AREA : IIb

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Russia	8282.00	8291.00	23	4200	313	100.08
Total IIb	8282.00	8291.00	23	4200	313	100.08

Sum of Offical Catches : 8291.00
Unallocated Catch : 0.00
Discards : 0.00
Working Group Catch : 8291.00

AREA : Va

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Faroe Islands	0.00	3762.00	0	0	0	0.00
Iceland	42981.00	42981.00	29	1029	933	99.96
Total Va	42981.00	46743.00	29	1029	933	99.96

Sum of Offical Catches : 46743.00
Unallocated Catch : 0.00
Discards : 0.00
Working Group Catch : 46743.00

AREA : Vb

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Faroe Islands	2227.00	2227.00	3	300	300	100.04
Russia	60.00	85.00	3	300	300	100.43
Total Vb	2287.00	2312.00	6	600	600	100.05

Sum of Offical Catches : 2312.00
Unallocated Catch : 0.00
Discards : 0.00
Working Group Catch : 2312.00

AREA : XIVa

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Faroe Islands	683.00	683.00	1	100	100	99.92
Greenland	0.00	1552.00	0	0	0	0.00
Iceland	0.00	2306.00	0	0	0	0.00
Total XIVa	683.00	4541.00	1	100	100	99.92

Sum of Offical Catches : 4541.00
Unallocated Catch : 0.00
Discards : 0.00
Working Group Catch : 4541.00

PERIOD : 1

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Denmark	4484.00	4484.00	2	284	274	100.14
Ireland	0.00	6411.00	0	0	0	0.00
Norway	296762.00	296762.00	81	6137	2793	99.99
Poland	0.00	99.00	0	0	0	0.00
Russia	0.00	14140.00	0	0	0	0.00
Scotland	13244.00	13244.00	1	143	67	100.05
Period Total	314490.00	335140.00	84	6564	3134	99.99

Sum of Offical Catches : 335140.00
Unallocated Catch : 0.00
Discards : 0.00
Working Group Catch : 335140.00

PERIOD : 2

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Faroe Islands	38.00	5217.00	1	100	100	98.50
Iceland	37056.00	37196.00	22	687	619	99.96
Norway	0.00	1305.00	0	0	0	0.00
Russia	4271.00	4277.00	16	2024	712	100.00
Period Total	41365.00	47995.00	39	2811	1431	99.96

Sum of Offical Catches : 47995.00
Unallocated Catch : 0.00
Discards : 0.00
Working Group Catch : 47995.00

PERIOD : 3

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Denmark	4922.00	4922.00	1	116	108	99.95
Faroe Islands	33306.00	34829.00	6	600	600	100.06
Germany	0.00	1576.00	0	0	0	0.00
Greenland	0.00	4897.00	0	0	0	0.00
Iceland	101844.00	104010.00	44	1974	1874	99.94
Norway	91209.00	91209.00	32	1928	1101	99.95
Poland	0.00	1080.00	0	0	0	0.00
Russia	103685.00	103705.00	141	27300	1040	100.03
The Netherlands	7139.00	7139.00	1	79	25	100.05
Period Total	342105.00	353367.00	225	31997	4748	99.98

Sum of Offical Catches : 353367.00
Unallocated Catch : 0.00
Discards : 0.00
Working Group Catch : 353367.00

PERIOD : 4

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Denmark	13505.00	13505.00	5	638	623	100.20
Faroe Islands	24205.00	24205.00	2	200	200	99.97
Germany	4462.00	4462.00	13	5271	895	96.86
Iceland	0.00	32415.00	0	0	0	0.00
Norway	389813.00	389813.00	99	7832	3204	99.92
Poland	0.00	3154.00	0	0	0	0.00
Russia	40304.00	40312.00	3	276	276	100.02
The Netherlands	22625.00	22625.00	6	794	150	95.17
Period Total	494914.00	530491.00	128	15011	5348	99.69

Sum of Offical Catches : 530491.00
Unallocated Catch : 0.00
Discards : 0.00
Working Group Catch : 530491.00

Total over all Areas and Periods

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Denmark	22911.00	22911.00	8	1038	1005	100.13
Faroe Islands	57549.00	64251.00	9	900	900	100.02
Germany	4462.00	6038.00	13	5271	895	96.86
Greenland	0.00	4897.00	0	0	0	0.00
Iceland	138900.00	173621.00	66	2661	2493	99.95
Ireland	0.00	6411.00	0	0	0	0.00
Norway	777784.00	779089.00	212	15897	7098	99.95
Poland	0.00	4333.00	0	0	0	0.00
Russia	148260.00	162434.00	160	29600	2028	100.02
Scotland	13244.00	13244.00	1	143	67	100.05
The Netherlands	29764.00	29764.00	7	873	175	96.34
Total for Stock	1192874.00	1266993.00	476	56383	14661	99.86

Sum of Offical Catches : 1266993.00
Unallocated Catch : 0.00
Discards : 0.00
Working Group Catch : 1266993.00

DETAILS OF DATA FILLING-IN

Filling-in for record : (2) Norway 2 IIa
Using Only
>> (6) Russia 2 IIa

Filling-in for record : (5) Russia 1 IIa
Using Only
>> (1) Norway 1 IIa

Filling-in for record : (9) Russia 2 IIb
Using Only
>> (6) Russia 2 IIa

Filling-in for record : (11) Russia 4 IIb
Using Only
>> (8) Russia 4 IIa

Filling-in for record : (13) Russia 3 Vb
Using Only
>> (38) Faroe Islands 3 Vb

Filling-in for record : (14) Russia 4 Vb
Using Only
>> (8) Russia 4 IIa

Filling-in for record : (20) Iceland 4 IIa
Using Only
>> (4) Norway 4 IIa

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  Filling-in for record : ( 23)   Iceland                2 XIVa
Using Only
  >>  ( 21)  Iceland                2 Va

  Filling-in for record : ( 24)   Iceland                3 XIVa
Using Only
  >>  ( 41)  Faroe Islands          3 XIVa

  Filling-in for record : ( 25)   Ireland                1 IIa
Using Only
  >>  (  1)  Norway                 1 IIa

  Filling-in for record : ( 29)   Germany                3 IIa
Using Only
  >>  ( 35)  Faroe Islands          3 IIa

  Filling-in for record : ( 31)   Poland                 1 IIa
Using Only
  >>  (  1)  Norway                 1 IIa

  Filling-in for record : ( 32)   Poland                 3 IIa
Using Only
  >>  (  7)  Russia                 3 IIa

  Filling-in for record : ( 33)   Poland                 4 IIa
Using Only
  >>  (  4)  Norway                 4 IIa

  Filling-in for record : ( 34)   Faroe Islands          2 IIa
Mean Weighted by Number of Samples of:
  >>  ( 18)  Iceland                2 IIa
  >>  (  6)  Russia                 2 IIa

  Filling-in for record : ( 39)   Faroe Islands          2 Va
Using Only
  >>  ( 21)  Iceland                2 Va

  Filling-in for record : ( 40)   Faroe Islands          3 Va
Using Only
  >>  ( 22)  Iceland                3 Va

  Filling-in for record : ( 42)   Greenland              3 XIVa
Using Only
  >>  ( 41)  Faroe Islands          3 XIVa

  Filling-in for record : ( 43)   Greenland              3 IIa
Using Only
  >>  ( 19)  Iceland                3 IIa
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Catch Numbers at Age by Area

For Periods 1 to 4

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	0.00	0.00	0.00	0.00	0.00	0.00
1	4474.71	0.00	0.00	0.00	0.00	4474.71
2	8408.71	41.28	0.00	0.47	0.00	8450.46
3	223451.84	1091.08	87.98	4.85	0.22	224635.95
4	360674.19	3234.76	2187.78	261.58	624.53	366982.88
5	1762945.13	18226.54	19230.39	2306.46	1786.09	1804494.63
6	143529.03	1557.45	6051.27	522.83	1254.95	152915.53
7	217375.25	1140.21	19317.73	1268.56	3821.40	242923.19
8	673856.75	2241.76	47818.44	1421.26	3498.08	728836.31
9	484086.00	1257.96	24789.84	544.38	985.47	511663.66
10	43130.43	84.15	3745.52	120.11	134.62	47214.83
11	23742.29	78.17	1405.02	31.37	127.08	25383.93
12	13427.25	38.18	1486.50	68.74	295.29	15315.96
13	21626.39	15.04	2685.18	29.29	131.91	24487.81
14	57408.02	19.20	7148.29	30.51	148.52	64754.54
15	52958.27	0.08	5486.09	0.11	19.97	58464.52

Mean Weight at Age by Area (Kg)

For Periods 1 to 4

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0744	0.0000	0.0000	0.0000	0.0000	0.0744
2	0.1370	0.1620	0.0000	0.1610	0.0000	0.1372
3	0.1621	0.1751	0.2697	0.1960	0.2530	0.1622
4	0.2277	0.2360	0.2823	0.3181	0.3156	0.2284
5	0.2710	0.2820	0.2891	0.3217	0.3090	0.2714
6	0.3153	0.3140	0.3101	0.3531	0.3562	0.3155
7	0.3323	0.3200	0.3241	0.3565	0.3524	0.3321
8	0.3429	0.3440	0.3323	0.3727	0.3660	0.3424
9	0.3593	0.3759	0.3362	0.3814	0.3766	0.3583
10	0.3616	0.4129	0.3548	0.4035	0.4214	0.3614
11	0.3824	0.4259	0.3589	0.3906	0.3895	0.3813
12	0.3912	0.4329	0.3749	0.3900	0.3876	0.3897
13	0.4039	0.4418	0.3715	0.3970	0.3936	0.4003
14	0.4077	0.4396	0.3776	0.4381	0.4275	0.4045
15	0.4009	0.4113	0.3783	0.4070	0.3700	0.3988

Mean Length at Age by Area (cm)

For Periods 1 to 4

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	21.5577	0.0000	0.0000	0.0000	0.0000	21.5577
2	25.5653	26.5986	0.0000	26.4000	0.0000	25.5704
3	27.2829	27.2043	30.6540	28.8000	30.6000	27.2839
4	29.8426	29.8008	31.3017	31.7504	31.6971	29.8555
5	31.1568	31.4003	31.7026	31.8939	31.4118	31.1663
6	32.5496	32.2006	32.7549	33.1686	33.3915	32.5632
7	33.0982	33.4009	33.4565	33.2966	33.2046	33.1308
8	33.6513	33.4016	33.8577	33.9762	33.8042	33.6655
9	34.0431	34.5006	34.0580	34.2884	34.2844	34.0456
10	34.5273	35.7008	34.9217	35.2069	36.0004	34.5666
11	35.2896	36.8985	35.0856	34.6541	34.7183	35.2797
12	36.0802	37.4986	35.9340	34.6385	34.6252	36.0350
13	36.0537	38.3978	35.6982	34.9027	34.9647	36.0089
14	35.9850	39.6832	36.0365	36.5073	36.4297	35.9930
15	36.0064	39.2155	36.0362	39.4000	36.1000	36.0092

Catch Numbers at Age by Area

For Period 1

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	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
2	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
4	23123.14	0.00	0.00	0.00	0.00	23123.14
5	547039.88	0.00	0.00	0.00	0.00	547039.88
6	39762.25	0.00	0.00	0.00	0.00	39762.25
7	56297.88	0.00	0.00	0.00	0.00	56297.88
8	244441.80	0.00	0.00	0.00	0.00	244441.80
9	207199.58	0.00	0.00	0.00	0.00	207199.58
10	19942.80	0.00	0.00	0.00	0.00	19942.80
11	10733.28	0.00	0.00	0.00	0.00	10733.28
12	4694.76	0.00	0.00	0.00	0.00	4694.76
13	6291.93	0.00	0.00	0.00	0.00	6291.93
14	18282.80	0.00	0.00	0.00	0.00	18282.80
15	29814.66	0.00	0.00	0.00	0.00	29814.66

Mean Weight at Age by Area (Kg)

For Period 1

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.1546	0.0000	0.0000	0.0000	0.0000	0.1546
5	0.2279	0.0000	0.0000	0.0000	0.0000	0.2279
6	0.2692	0.0000	0.0000	0.0000	0.0000	0.2692
7	0.2910	0.0000	0.0000	0.0000	0.0000	0.2910
8	0.3127	0.0000	0.0000	0.0000	0.0000	0.3127
9	0.3391	0.0000	0.0000	0.0000	0.0000	0.3391
10	0.3324	0.0000	0.0000	0.0000	0.0000	0.3324
11	0.3730	0.0000	0.0000	0.0000	0.0000	0.3730
12	0.3720	0.0000	0.0000	0.0000	0.0000	0.3720
13	0.3727	0.0000	0.0000	0.0000	0.0000	0.3727
14	0.3834	0.0000	0.0000	0.0000	0.0000	0.3834
15	0.3800	0.0000	0.0000	0.0000	0.0000	0.3800

Mean Length at Age by Area (cm)

For Period 1

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	27.3399	0.0000	0.0000	0.0000	0.0000	27.3399
5	30.3355	0.0000	0.0000	0.0000	0.0000	30.3355
6	31.7368	0.0000	0.0000	0.0000	0.0000	31.7368
7	32.2203	0.0000	0.0000	0.0000	0.0000	32.2203
8	33.1790	0.0000	0.0000	0.0000	0.0000	33.1790
9	33.8449	0.0000	0.0000	0.0000	0.0000	33.8449
10	33.9854	0.0000	0.0000	0.0000	0.0000	33.9854
11	35.3000	0.0000	0.0000	0.0000	0.0000	35.3000
12	35.9428	0.0000	0.0000	0.0000	0.0000	35.9428
13	35.7837	0.0000	0.0000	0.0000	0.0000	35.7837
14	35.5172	0.0000	0.0000	0.0000	0.0000	35.5172
15	35.6000	0.0000	0.0000	0.0000	0.0000	35.6000

Catch Numbers at Age by Area

For Period 2

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	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
2	0.00	0.00	0.00	0.00	0.00	0.00
3	295.49	0.17	40.46	0.00	0.22	336.34
4	3979.97	1.96	1112.08	7.00	5.94	5106.96
5	30455.50	14.49	9868.71	161.00	52.76	40552.46
6	3831.93	1.29	3324.20	20.00	17.77	7195.19
7	7287.54	1.01	10909.71	28.00	58.32	18284.58
8	16134.00	2.23	27571.17	54.00	147.39	43908.79
9	8639.39	1.51	14388.09	33.00	76.92	23138.91
10	1042.18	0.12	2279.92	3.00	12.19	3337.41
11	458.62	0.11	869.32	2.00	4.65	1334.71
12	411.72	0.10	996.17	2.00	5.33	1415.31
13	582.75	0.03	1773.64	0.00	9.48	2365.89
14	1407.25	0.05	4880.23	1.00	26.09	6314.61
15	1126.07	0.02	3736.44	0.00	19.97	4882.50

Mean Weight at Age by Area (Kg)

For Period 2

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.1918	0.1670	0.2530	0.0000	0.2530	0.1992
4	0.2288	0.2130	0.2690	0.2686	0.2690	0.2376
5	0.2519	0.2460	0.2760	0.2921	0.2760	0.2580
6	0.2872	0.2810	0.2970	0.3060	0.2970	0.2918
7	0.3062	0.3070	0.3110	0.3357	0.3110	0.3091
8	0.3130	0.3090	0.3200	0.3407	0.3200	0.3175
9	0.3163	0.3140	0.3240	0.3573	0.3240	0.3212
10	0.3368	0.3260	0.3450	0.3847	0.3450	0.3425
11	0.3499	0.3700	0.3490	0.3720	0.3490	0.3494
12	0.3718	0.3860	0.3660	0.3860	0.3660	0.3677
13	0.3591	0.3600	0.3630	0.0000	0.3630	0.3620
14	0.3709	0.3820	0.3690	0.3930	0.3690	0.3694
15	0.3730	0.4280	0.3700	0.0000	0.3700	0.3707

Mean Length at Age by Area (cm)

For Period 2

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	28.5539	27.7000	30.6000	0.0000	30.6000	28.8010
4	30.2628	30.0000	31.4000	31.2143	31.4000	30.5130
5	31.3018	31.5000	31.8000	31.7783	31.8000	31.4256
6	32.6873	32.8000	32.8000	32.3750	32.8000	32.7388
7	33.4591	34.1000	33.5000	33.1286	33.5000	33.4832
8	33.7784	34.5000	33.9000	33.3463	33.9000	33.8547
9	33.9938	34.6000	34.1000	34.0758	34.1000	34.0604
10	35.0411	36.2000	35.0000	35.4667	35.0000	35.0133
11	35.2633	36.2000	35.2000	33.9000	35.2000	35.2199
12	36.1587	36.7000	36.0000	35.7000	36.0000	36.0458
13	35.7416	37.2000	35.8000	0.0000	35.8000	35.7856
14	36.2093	37.6000	36.1000	36.3000	36.1000	36.1244
15	36.2224	38.5000	36.1000	0.0000	36.1000	36.1282

Catch Numbers at Age by Area

For Period 3

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	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
2	0.00	41.00	0.00	0.00	0.00	41.00
3	18657.48	1088.00	47.52	0.00	0.00	19793.00
4	75697.35	3229.00	1075.71	248.25	618.59	80868.90
5	470715.56	18209.00	9361.68	2140.38	1733.34	502159.97
6	53415.86	1556.00	2727.07	502.55	1237.18	59438.66
7	83551.01	1139.00	8408.01	1240.23	3763.08	98101.33
8	167908.47	2239.00	20247.27	1366.37	3350.69	195111.80
9	95987.52	1256.00	10401.74	510.62	908.55	109064.45
10	8828.82	84.00	1465.60	117.06	122.43	10617.90
11	3536.87	78.00	535.69	29.26	122.43	4302.26
12	4424.57	38.00	490.33	66.60	289.96	5309.47
13	3628.08	15.00	911.54	29.26	122.43	4706.32
14	5829.19	19.00	2268.06	29.26	122.43	8267.94
15	4826.59	0.00	1749.64	0.00	0.00	6576.24

Mean Weight at Age by Area (Kg)

For Period 3

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.1620	0.0000	0.0000	0.0000	0.1620
3	0.1794	0.1750	0.2840	0.0000	0.0000	0.1794
4	0.2580	0.2360	0.2960	0.3220	0.3160	0.2583
5	0.3026	0.2820	0.3030	0.3240	0.3100	0.3020
6	0.3278	0.3140	0.3260	0.3550	0.3570	0.3282
7	0.3452	0.3200	0.3410	0.3570	0.3530	0.3450
8	0.3524	0.3440	0.3490	0.3740	0.3680	0.3523
9	0.3629	0.3760	0.3530	0.3830	0.3810	0.3623
10	0.3822	0.4130	0.3700	0.4040	0.4290	0.3815
11	0.3752	0.4260	0.3750	0.3920	0.3910	0.3767
12	0.4041	0.4330	0.3930	0.3900	0.3880	0.4023
13	0.3960	0.4420	0.3880	0.3970	0.3960	0.3946
14	0.3963	0.4400	0.3960	0.4400	0.4400	0.3971
15	0.4039	0.0000	0.3960	0.0000	0.0000	0.4018

Mean Length at Age by Area (cm)

For Period 3

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	26.6000	0.0000	0.0000	0.0000	26.6000
3	27.4892	27.2000	30.7000	0.0000	0.0000	27.4810
4	30.3618	29.8000	31.2000	31.8000	31.7000	30.3652
5	31.6481	31.4000	31.6000	31.9000	31.4000	31.6384
6	32.5314	32.2000	32.7000	33.2000	33.4000	32.5541
7	33.3190	33.4000	33.4000	33.3000	33.2000	33.3221
8	33.6940	33.4000	33.8000	34.0000	33.8000	33.7056
9	33.9109	34.5000	34.0000	34.3000	34.3000	33.9312
10	34.7125	35.7000	34.8000	35.2000	36.1000	34.7538
11	34.9976	36.9000	34.9000	34.7000	34.7000	35.0094
12	36.4444	37.5000	35.8000	34.6000	34.6000	36.2686
13	35.6941	38.4000	35.5000	34.9000	34.9000	35.6395
14	36.0465	39.7000	35.9000	36.5000	36.5000	36.0231
15	36.1726	0.0000	35.9000	0.0000	0.0000	36.1001

Catch Numbers at Age by Area

For Period 4

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	0.00	0.00	0.00	0.00	0.00	0.00
1	4474.71	0.00	0.00	0.00	0.00	4474.71
2	8408.71	0.28	0.00	0.47	0.00	8409.46
3	204498.88	2.91	0.00	4.85	0.00	204506.63
4	257873.75	3.80	0.00	6.33	0.00	257883.88
5	714734.25	3.05	0.00	5.08	0.00	714742.38
6	46518.98	0.17	0.00	0.28	0.00	46519.42
7	70238.81	0.20	0.00	0.33	0.00	70239.34
8	245372.45	0.53	0.00	0.89	0.00	245373.88
9	172259.52	0.46	0.00	0.76	0.00	172260.73
10	13316.63	0.03	0.00	0.05	0.00	13316.71
11	9013.52	0.06	0.00	0.10	0.00	9013.68
12	3896.20	0.08	0.00	0.14	0.00	3896.43
13	11123.63	0.01	0.00	0.02	0.00	11123.67
14	31888.78	0.15	0.00	0.25	0.00	31889.18
15	17190.95	0.07	0.00	0.11	0.00	17191.12

Mean Weight at Age by Area (Kg)

For Period 4

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0744	0.0000	0.0000	0.0000	0.0000	0.0744
2	0.1370	0.1610	0.0000	0.1610	0.0000	0.1370
3	0.1604	0.1960	0.0000	0.1960	0.0000	0.1604
4	0.2254	0.2210	0.0000	0.2210	0.0000	0.2254
5	0.2840	0.2950	0.0000	0.2950	0.0000	0.2840
6	0.3425	0.3090	0.0000	0.3090	0.0000	0.3425
7	0.3529	0.3500	0.0000	0.3500	0.0000	0.3529
8	0.3685	0.3720	0.0000	0.3720	0.0000	0.3685
9	0.3840	0.3620	0.0000	0.3620	0.0000	0.3840
10	0.3935	0.3790	0.0000	0.3790	0.0000	0.3935
11	0.3980	0.3470	0.0000	0.3470	0.0000	0.3980
12	0.4018	0.4290	0.0000	0.4290	0.0000	0.4018
13	0.4265	0.4360	0.0000	0.4360	0.0000	0.4265
14	0.4254	0.4020	0.0000	0.4020	0.0000	0.4254
15	0.4383	0.4070	0.0000	0.4070	0.0000	0.4383

Mean Length at Age by Area (cm)

For Period 4

Ages	IIa	IIb	Va	Vb	XIVa	Total
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	21.5577	0.0000	0.0000	0.0000	0.0000	21.5577
2	25.5653	26.4000	0.0000	26.4000	0.0000	25.5654
3	27.2623	28.8000	0.0000	28.8000	0.0000	27.2623
4	29.9081	30.4000	0.0000	30.4000	0.0000	29.9081
5	31.4556	33.0000	0.0000	33.0000	0.0000	31.4556
6	33.2539	33.5000	0.0000	33.5000	0.0000	33.2539
7	33.5017	34.9000	0.0000	34.9000	0.0000	33.5017
8	34.0844	35.6000	0.0000	35.6000	0.0000	34.0844
9	34.3576	35.7000	0.0000	35.7000	0.0000	34.3576
10	35.1759	35.8000	0.0000	35.8000	0.0000	35.1759
11	35.3932	36.3000	0.0000	36.3000	0.0000	35.3933
12	35.8238	37.8000	0.0000	37.8000	0.0000	35.8239
13	36.3401	38.3000	0.0000	38.3000	0.0000	36.3401
14	36.2320	38.2000	0.0000	38.2000	0.0000	36.2321
15	36.6503	39.4000	0.0000	39.4000	0.0000	36.6503

Table 9.4.1.3. Norwegian Spring Spawning Herring; summary of sampling data of the catches in 2007.

Total over all Areas and Periods 2007						
Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Denmark	22911	22911	8	1038	1005	100.13
Faroe Islands	57549	64251	9	900	900	100.02
Germany	4462	6038	13	5271	895	96.86
Greenland	0	4897	0	0	0	0
Iceland	138900	173621	66	2661	2493	99.95
Ireland	0	6411	0	0	0	0
Norway	777784	779089	212	15897	7098	99.95
Poland	0	4333	0	0	0	0
Russia	148260	162434	160	29600	2028	100.02
Scotland	13244	13244	1	143	67	100.05
The Netherlands	29764	29764	7	873	175	96.34
Total for stock	1192874	1266993	476	56383	14661	99.86

Table 9.4.1.4. Norwegian spring spawning herring. Catch in numbers (thousands).

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	5112600	2000000	600000	276200	184800	185500	547000	628600	79500	88600	109500	86900	194500	368300	66400	344300
1951	1635500	7607700	400000	6600	383800	172400	164400	515600	602000	77100	82700	103100	107600	253500	348000	352500
1952	13721600	9149700	1232900	39300	60500	602300	136300	204500	380200	377900	79200	85700	107700	106800	186500	564400
1953	5697200	5055000	581300	740100	46600	100900	355600	81900	110900	314100	394900	61700	91200	94100	98800	730400
1954	10675990	7071090	855400	266300	1435500	142900	236000	490300	128100	199800	440400	460700	88400	100600	133000	803200
1955	5175600	2871100	510100	93000	276400	2045100	114300	189600	274700	85300	193400	295600	203200	58700	84600	580600
1956	5363900	2023700	627100	116500	251600	314200	2555100	110000	203900	264200	130700	198300	272800	163300	63000	565100
1957	5001900	3290800	219500	23300	373300	153800	228500	1985300	72000	127300	182500	88400	121200	149300	131600	281400
1958	9666990	2798100	666400	17500	17900	110900	89300	194400	973500	70700	123000	200900	98700	77400	70900	255600
1959	17896280	198530	325500	15100	26800	25900	146600	114800	240700	1103800	88600	124300	198000	88500	77400	235900
1960	12884310	13580790	392500	121700	18200	28100	24400	96200	73300	203900	1163000	85200	129700	153500	56700	168900
1961	6207500	16075600	2884800	31200	8100	4100	15000	19400	61600	49200	136100	728100	49700	45000	63000	60100
1962	3693200	4081100	1041300	1843800	8000	3100	7200	20200	11900	59100	52600	117000	813500	44200	54700	152300
1963	4807000	2119200	2045300	760400	835800	5300	1800	3600	18300	9300	107700	92500	174100	923700	79600	185300
1964	3613000	2728300	220300	114600	399000	2045800	13700	1500	3000	24900	29300	95600	82400	153000	772800	336800
1965	2303000	3780900	2853600	89900	256200	571100	2199700	19500	14900	7400	19100	40000	100500	107800	138700	883100
1966	3926500	662800	1678000	2048700	26900	466600	1306000	2884500	37900	14300	17400	26200	11000	69100	72100	556700
1967	426800	9877100	70400	1392300	3254000	26600	421300	1132000	1720800	8900	5700	3500	8500	8900	17500	104400
1968	1783600	437000	388300	99100	1880500	1387400	14220	94000	134100	345100	2000	1100	830	2500	2600	17000
1969	561200	507100	141900	188200	800	8800	4700	700	11700	33600	36000	300	200	200	200	2400
1970	119300	529400	33200	6300	18600	600	3300	3300	1000	13400	26200	28100	300	100	200	2000
1971	30500	42900	85100	1820	1020	1240	360	1110	1130	360	4410	6910	5450	0	20	120
1972	347100	41000	20400	35376	3476	3583	2481	694	1486	198	0	494	593	593	0	0
1973	29300	3500	1700	2389	25200	651	1506	278	178	0	0	0	0	0	180	0
1974	65900	7800	3900	100	241	24505	257	196	0	0	0	0	0	0	0	0
1975	30600	3600	1800	3268	132	910	30667	5	2	0	0	0	0	0	0	0
1976	20100	2400	1200	23248	5436	0	0	13086	0	0	0	0	0	0	0	0
1977	43000	6200	3100	22103	23595	336	0	419	10766	0	0	0	0	0	0	0
1978	20100	2400	1200	3019	12164	20315	870	0	620	5027	0	0	0	0	0	0
1979	32600	3800	1900	6352	1866	6865	11216	326	0	0	2534	0	0	0	0	0
1980	6900	800	400	6407	5814	2278	8165	15838	441	8	0	2688	0	0	0	0
1981	8300	1100	11900	4166	4591	8596	2200	4512	8280	345	103	114	964	0	0	0
1982	22600	1100	200	13817	7892	4507	6258	1960	5075	6047	121	37	37	121	0	0

Table 9.4.1.4. cont. Norwegian spring spawning herring. Catch in numbers (thousands).

	Age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	127000	4680	1670	3183	21191	9521	6181	6823	1293	4598	7329	143	40	143	860	0
1984	33860	1700	2490	4483	5388	61543	18202	12638	15608	7215	16338	6478	0	0	0	1650
1985	28570	13150	207220	21500	15500	16500	130000	59000	55000	63000	10000	31000	50000	0	0	2640
1986	13810	1380	3090	539785	17594	14500	15500	105000	75000	42000	77000	19469	66000	80000	0	2470
1987	13850	6330	35770	19776	501393	18672	3502	7058	28000	12000	9500	4500	7834	6500	7000	450
1988	15490	2790	9110	62923	25059	550367	9452	3679	5964	14583	8872	2818	3356	2682	1560	540
1989	7120	1930	25200	2890	3623	5650	324290	3469	800	679	3297	1375	679	321	260	0
1990	1020	400	15540	18633	2658	11875	10854	226280	1289	1519	2036	2415	646	179	590	480
1991	100	3370	3330	8438	2780	1410	14698	8867	218851	2499	461	87	690	103	260	540
1992	1630	150	1340	12586	33100	4980	1193	11981	5748	225677	2483	639	247	1236	0	0
1993	6570	130	7240	28408	106866	87269	8625	3648	29603	18631	410110	0	0	0	0	0
1994	430	20	8100	32500	110090	363920	164800	15580	8140	37330	35660	645410	2830	460	100	2070
1995	0	0	1130	57590	346460	622810	637840	231090	15510	15850	69750	83740	911880	4070	250	450
1996	0	0	30140	34360	713620	1571000	940580	406280	103410	5680	7370	66090	17570	836550	0	0
1997	0	0	21820	130450	270950	1795780	1993620	761210	326490	60870	20020	32400	90520	19120	370330	300
1998	0	0	82891	70323	242365	368310	1760319	1263750	381482	129971	42502	25343	3478	112604	5633	108514
1999	0	0	5029	137626	35820	134813	429433	1604959	1164263	291394	106005	14524	40040	7202	88598	63983
2000	0	0	14395	84016	560379	34933	110719	404460	1299253	1045001	216980	71589	16260	22701	23321	71811
2001	0	0	2076	102293	160678	426822	38749	95991	296460	839136	507106	73673	23722	3505	3356	22164
2002	0	0	62031	198360	643161	255516	326495	29843	93530	264675	663059	339326	52922	12437	7000	10087
2003	0	3461	4524	75243	323958	730468	175878	167776	22866	74494	217108	567253	219097	38555	8111	6192
2004	125	1846	43800	24299	92300	429510	714433	111022	137940	26656	52467	169196	401564	210547	28028	11883
2005	0	442	20411	447788	94206	170547	643600	930309	121856	123291	37967	65289	139331	344822	126879	15697
2006	0	1968	45438	75824	729898	82107	171370	726041	772217	88701	77115	30339	57882	133665	142240	49128
2007	0	4475	8450	224636	366983	1804495	152916	242923	728836	511664	47215	25384	15316	24488	64755	58465

Table 9.4.1.5. Norwegian spring spawning herring. Weight at age in the catch (kg).

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	0.007	0.025	0.058	0.110	0.188	0.211	0.234	0.253	0.266	0.280	0.294	0.303	0.312	0.32	0.323	0.334
1951	0.009	0.029	0.068	0.130	0.222	0.249	0.276	0.298	0.314	0.330	0.346	0.357	0.368	0.377	0.381	0.394
1952	0.008	0.026	0.061	0.115	0.197	0.221	0.245	0.265	0.279	0.293	0.308	0.317	0.327	0.335	0.339	0.349
1953	0.008	0.027	0.063	0.120	0.205	0.230	0.255	0.275	0.290	0.305	0.320	0.330	0.34	0.347	0.351	0.363
1954	0.008	0.026	0.062	0.117	0.201	0.225	0.250	0.269	0.284	0.299	0.313	0.323	0.333	0.341	0.345	0.356
1955	0.008	0.027	0.063	0.119	0.204	0.229	0.254	0.274	0.289	0.304	0.318	0.328	0.338	0.346	0.350	0.362
1956	0.008	0.028	0.066	0.126	0.215	0.241	0.268	0.289	0.304	0.320	0.336	0.346	0.357	0.365	0.369	0.382
1957	0.008	0.028	0.066	0.127	0.216	0.243	0.269	0.290	0.306	0.322	0.338	0.348	0.359	0.367	0.371	0.384
1958	0.009	0.030	0.070	0.133	0.227	0.255	0.283	0.305	0.321	0.338	0.355	0.366	0.377	0.386	0.390	0.403
1959	0.009	0.030	0.071	0.135	0.231	0.259	0.287	0.310	0.327	0.344	0.360	0.372	0.383	0.392	0.397	0.409
1960	0.006	0.011	0.074	0.119	0.188	0.277	0.337	0.318	0.363	0.379	0.360	0.420	0.411	0.439	0.450	0.447
1961	0.006	0.010	0.045	0.087	0.159	0.276	0.322	0.372	0.363	0.393	0.407	0.397	0.422	0.447	0.465	0.452
1962	0.009	0.023	0.055	0.085	0.148	0.288	0.333	0.360	0.352	0.350	0.374	0.384	0.374	0.394	0.399	0.414
1963	0.008	0.026	0.047	0.098	0.171	0.275	0.268	0.323	0.329	0.336	0.341	0.358	0.385	0.353	0.381	0.386
1964	0.009	0.024	0.059	0.139	0.219	0.239	0.298	0.295	0.339	0.350	0.358	0.351	0.367	0.375	0.372	0.433
1965	0.009	0.016	0.048	0.089	0.217	0.234	0.262	0.331	0.360	0.367	0.386	0.395	0.393	0.404	0.401	0.431
1966	0.008	0.017	0.040	0.063	0.246	0.260	0.265	0.301	0.410	0.425	0.456	0.460	0.467	0.446	0.459	0.472
1967	0.009	0.015	0.036	0.066	0.093	0.305	0.305	0.310	0.333	0.359	0.413	0.446	0.401	0.408	0.439	0.430
1968	0.010	0.027	0.049	0.075	0.108	0.158	0.375	0.383	0.364	0.382	0.441	0.410		0.517	0.491	0.485
1969	0.009	0.021	0.047	0.072		0.152	0.296		0.329	0.329	0.341					0.429
1970	0.008	0.058	0.085	0.105	0.171		0.216	0.277	0.298	0.304	0.305	0.309				0.376
1971	0.011	0.053	0.121	0.177	0.216	0.250		0.305	0.333		0.366	0.377	0.388			
1972	0.011	0.029	0.062	0.103	0.154	0.215	0.258		0.322							
1973	0.006	0.053	0.106	0.161	0.213		0.255									
1974	0.006	0.055	0.117			0.249										
1975	0.009	0.079	0.169	0.241			0.381									
1976	0.007	0.062	0.132	0.189	0.250			0.323								
1977	0.011	0.091	0.193	0.316	0.350				0.511							
1978	0.012	0.100	0.210	0.274	0.424	0.454				0.613						
1979	0.010	0.088	0.181	0.293	0.359	0.416	0.436				0.553					
1980	0.012			0.266	0.399	0.449	0.460	0.485				0.608				
1981	0.010	0.082	0.163	0.196	0.291	0.341	0.368	0.380	0.397							
1982	0.010	0.087	0.159	0.256	0.312	0.378	0.415	0.435	0.449	0.448						

Table 9.4.1.5. cont. Norwegian spring spawning herring. Weight at age in the catch (kg).

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	0.011	0.090	0.165	0.217	0.265	0.337	0.378	0.410	0.426	0.435	0.444					
1984	0.009	0.047	0.145	0.218	0.262	0.325	0.346	0.381	0.400	0.413	0.405	0.426				0.415
1985	0.009	0.022	0.022	0.214	0.277	0.295	0.338	0.360	0.381	0.397	0.409	0.417	0.435			0.435
1986	0.007	0.077	0.097	0.055	0.249	0.294	0.312	0.352	0.374	0.398	0.402	0.401	0.410	0.410		0.410
1987	0.010	0.075	0.091	0.124	0.173	0.253	0.232	0.312	0.328	0.349	0.353	0.370	0.385	0.385	0.385	
1988	0.008	0.062	0.075	0.124	0.154	0.194	0.241	0.265	0.304	0.305	0.317	0.308	0.334	0.334	0.334	
1989	0.010	0.060	0.204	0.188	0.264	0.260	0.282	0.306			0.422	0.364				
1990	0.007		0.102	0.230	0.239	0.266	0.305	0.308	0.376	0.407	0.412	0.424				
1991		0.015	0.104	0.208	0.250	0.288	0.312	0.316	0.330	0.344						
1992	0.007		0.103	0.191	0.233	0.304	0.337	0.365	0.361	0.371	0.403			0.404		
1993	0.007		0.106	0.153	0.243	0.282	0.320	0.330	0.365	0.373	0.379					
1994			0.102	0.194	0.239	0.280	0.317	0.328	0.356	0.372	0.390	0.379	0.399	0.403		
1995			0.102	0.153	0.192	0.234	0.283	0.328	0.349	0.356	0.374	0.366	0.393	0.387		
1996			0.136	0.136	0.168	0.206	0.262	0.309	0.337	0.366	0.360	0.361	0.367	0.379		
1997			0.089	0.167	0.184	0.207	0.232	0.277	0.305	0.331	0.328	0.344	0.343	0.397	0.357	
1998			0.111	0.150	0.216	0.221	0.249	0.277	0.316	0.338	0.374	0.372	0.366	0.396	0.377	0.406
1999			0.096	0.173	0.228	0.262	0.274	0.292	0.307	0.335	0.362	0.371	0.399	0.396	0.400	0.404
2000			0.124	0.175	0.222	0.242	0.289	0.303	0.310	0.328	0.349	0.383	0.411	0.410	0.419	0.409
2001			0.105	0.166	0.214	0.252	0.268	0.305	0.308	0.322	0.337	0.363	0.353	0.378	0.400	0.427
2002			0.056	0.128	0.198	0.255	0.281	0.303	0.322	0.323	0.334	0.345	0.369	0.407	0.410	0.435
2003		0.062	0.068	0.169	0.218	0.257	0.288	0.316	0.323	0.348	0.354	0.351	0.363	0.372	0.376	0.429
2004	0.022	0.066	0.143	0.18	0.227	0.26	0.29	0.323	0.355	0.375	0.383	0.399	0.395	0.405	0.429	0.439
2005		0.092	0.106	0.181	0.235	0.266	0.290	0.315	0.344	0.367	0.384	0.372	0.384	0.398	0.402	0.413
2006		0.055	0.102	0.171	0.238	0.268	0.292	0.311	0.330	0.365	0.374	0.376	0.388	0.396	0.398	0.407
2007	0.000	0.074	0.137	0.162	0.228	0.271	0.316	0.332	0.342	0.358	0.361	0.381	0.390	0.400	0.405	0.399

Table 9.4.3.1. Norwegian spring spawning herring. Weight at age in the stock (kg).

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1951	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1952	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1953	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1954	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1955	0.001	0.008	0.047	0.100	0.195	0.213	0.260	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1956	0.001	0.008	0.047	0.100	0.205	0.230	0.249	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1957	0.001	0.008	0.047	0.100	0.136	0.228	0.255	0.262	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1958	0.001	0.008	0.047	0.100	0.204	0.242	0.292	0.295	0.293	0.305	0.315	0.330	0.340	0.345	0.352	0.363
1959	0.001	0.008	0.047	0.100	0.204	0.252	0.260	0.290	0.300	0.305	0.315	0.325	0.330	0.340	0.345	0.358
1960	0.001	0.008	0.047	0.100	0.204	0.270	0.291	0.293	0.321	0.318	0.320	0.344	0.349	0.370	0.379	0.378
1961	0.001	0.008	0.047	0.100	0.232	0.250	0.292	0.302	0.304	0.323	0.322	0.321	0.344	0.357	0.363	0.368
1962	0.001	0.008	0.047	0.100	0.219	0.291	0.300	0.316	0.324	0.326	0.335	0.338	0.334	0.347	0.354	0.358
1963	0.001	0.008	0.047	0.100	0.185	0.253	0.294	0.312	0.329	0.327	0.334	0.341	0.349	0.341	0.358	0.375
1964	0.001	0.008	0.047	0.100	0.194	0.213	0.264	0.317	0.363	0.353	0.349	0.354	0.357	0.359	0.365	0.402
1965	0.001	0.008	0.047	0.100	0.186	0.199	0.236	0.260	0.363	0.350	0.370	0.360	0.378	0.387	0.390	0.394
1966	0.001	0.008	0.047	0.100	0.185	0.219	0.222	0.249	0.306	0.354	0.377	0.391	0.379	0.378	0.361	0.383
1967	0.001	0.008	0.047	0.100	0.180	0.228	0.269	0.270	0.294	0.324	0.420	0.430	0.366	0.368	0.433	0.414
1968	0.001	0.008	0.047	0.100	0.115	0.206	0.266	0.275	0.274	0.285	0.350	0.325	0.363	0.408	0.388	0.378
1969	0.001	0.008	0.047	0.100	0.115	0.145	0.270	0.300	0.306	0.308	0.318	0.340	0.368	0.360	0.393	0.397
1970	0.001	0.008	0.047	0.100	0.209	0.272	0.230	0.295	0.317	0.323	0.325	0.329	0.380	0.370	0.380	0.391
1971	0.001	0.015	0.080	0.100	0.190	0.225	0.250	0.275	0.290	0.310	0.325	0.335	0.345	0.355	0.365	0.390
1972	0.001	0.010	0.070	0.150	0.150	0.140	0.210	0.240	0.270	0.300	0.325	0.335	0.345	0.355	0.365	0.390
1973	0.001	0.010	0.085	0.170	0.259	0.342	0.384	0.409	0.404	0.461	0.520	0.534	0.500	0.500	0.500	0.500
1974	0.001	0.010	0.085	0.170	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1975	0.001	0.010	0.085	0.181	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1976	0.001	0.010	0.085	0.181	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1977	0.001	0.010	0.085	0.181	0.259	0.343	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1978	0.001	0.010	0.085	0.180	0.294	0.326	0.371	0.409	0.461	0.476	0.520	0.543	0.500	0.500	0.500	0.500
1979	0.001	0.010	0.085	0.178	0.232	0.359	0.385	0.420	0.444	0.505	0.520	0.551	0.500	0.500	0.500	0.500
1980	0.001	0.010	0.085	0.175	0.283	0.347	0.402	0.421	0.465	0.465	0.520	0.534	0.500	0.500	0.500	0.500
1981	0.001	0.010	0.085	0.170	0.224	0.336	0.378	0.387	0.408	0.397	0.520	0.543	0.512	0.512	0.512	0.512
1982	0.001	0.010	0.085	0.170	0.204	0.303	0.355	0.383	0.395	0.413	0.453	0.468	0.506	0.506	0.506	0.506

Table 9.4.3.1. cont. Norwegian spring spawning herring. Weight at age in the stock (kg).

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	0.001	0.010	0.085	0.155	0.249	0.304	0.368	0.404	0.424	0.437	0.436	0.493	0.495	0.495	0.495	0.495
1984	0.001	0.010	0.085	0.140	0.204	0.295	0.338	0.376	0.395	0.407	0.413	0.422	0.437	0.437	0.437	0.437
1985	0.001	0.010	0.085	0.148	0.234	0.265	0.312	0.346	0.370	0.395	0.397	0.428	0.428	0.428	0.428	0.428
1986	0.001	0.010	0.085	0.054	0.206	0.265	0.289	0.339	0.368	0.391	0.382	0.388	0.395	0.395	0.395	0.395
1987	0.001	0.010	0.055	0.090	0.143	0.241	0.279	0.299	0.316	0.342	0.343	0.362	0.376	0.376	0.376	0.376
1988	0.001	0.015	0.050	0.098	0.135	0.197	0.277	0.315	0.339	0.343	0.359	0.365	0.376	0.376	0.376	0.376
1989	0.001	0.015	0.100	0.154	0.175	0.209	0.252	0.305	0.367	0.377	0.359	0.395	0.396	0.396	0.396	0.396
1990	0.001	0.008	0.048	0.219	0.198	0.258	0.288	0.309	0.428	0.370	0.403	0.387	0.440	0.440	0.440	0.44
1991	0.001	0.011	0.037	0.147	0.210	0.244	0.300	0.324	0.336	0.343	0.382	0.366	0.425	0.425	0.425	0.425
1992	0.001	0.007	0.030	0.128	0.224	0.296	0.327	0.355	0.345	0.367	0.341	0.361	0.430	0.470	0.470	0.46
1993	0.001	0.008	0.025	0.081	0.201	0.265	0.323	0.354	0.358	0.381	0.369	0.396	0.393	0.374	0.403	0.4
1994	0.001	0.010	0.025	0.075	0.151	0.254	0.318	0.371	0.347	0.412	0.382	0.407	0.410	0.410	0.410	0.41
1995	0.001	0.018	0.025	0.066	0.138	0.230	0.296	0.346	0.388	0.363	0.409	0.414	0.422	0.410	0.410	0.426
1996	0.001	0.018	0.025	0.076	0.118	0.188	0.261	0.316	0.346	0.374	0.390	0.390	0.384	0.398	0.398	0.398
1997	0.001	0.018	0.025	0.096	0.118	0.174	0.229	0.286	0.323	0.370	0.378	0.386	0.360	0.393	0.391	0.391
1998	0.001	0.018	0.025	0.074	0.147	0.174	0.217	0.242	0.278	0.304	0.310	0.359	0.340	0.344	0.385	0.369
1999	0.001	0.018	0.025	0.102	0.150	0.223	0.240	0.264	0.283	0.315	0.345	0.386	0.386	0.386	0.382	0.395
2000*	0.001	0.018	0.025	0.119	0.178	0.225	0.271	0.285	0.298	0.311	0.339	0.390	0.398	0.406	0.414	0.427
2001	0.001	0.018	0.025	0.075	0.178	0.238	0.247	0.296	0.307	0.314	0.328	0.351	0.376	0.406	0.414	0.425
2002	0.001	0.010	0.023	0.057	0.177	0.241	0.275	0.302	0.311	0.314	0.328	0.341	0.372	0.405	0.415	0.438
2003	0.001	0.010	0.055	0.098	0.159	0.211	0.272	0.305	0.292	0.331	0.337	0.347	0.356	0.381	0.414	0.433
2004	0.001	0.010	0.055	0.106	0.149	0.212	0.241	0.279	0.302	0.337	0.354	0.355	0.360	0.371	0.400	0.429
2005	0.001	0.010	0.046	0.112	0.156	0.234	0.267	0.295	0.330	0.363	0.377	0.414	0.406	0.308	0.420	0.452
2006	0.001	0.010	0.042	0.107	0.179	0.232	0.272	0.297	0.318	0.371	0.365	0.393	0.395	0.399	0.415	0.428
2007	0.001	0.010	0.036	0.086	0.155	0.226	0.265	0.312	0.310	0.364	0.384	0.352	0.386	0.304	0.420	0.412
2008**	0.001	0.010	0.044	0.077	0.146	0.212	0.269	0.289	0.327	0.351	0.358	0.372	0.411	0.353	0.389	0.393

***values in 2000 changed to values in the report from 2000.**

**** mean weight at ages 11 and 13 are mean of 5 previous years at the same age. These age groups were not existent in the wintering survey from which the stock weight are derived.**

Table 9.4.5.1. Norwegian spring spawning herring. Proportion mature at age.

	AGE																
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1950	0	0	0	0	0.1	0.3	0.6	0.9	1	1	1	1	1	1	1	1	1
1951	0	0	0	0	0.1	0.3	0.6	0.9	1	1	1	1	1	1	1	1	1
1952	0	0	0	0	0.1	0.3	0.6	0.9	1	1	1	1	1	1	1	1	1
1953	0	0	0	0	0.1	0.3	0.6	0.9	1	1	1	1	1	1	1	1	1
1954	0	0	0	0	0.1	0.3	0.6	0.9	1	1	1	1	1	1	1	1	1
1955	0	0	0	0.08	0.22	0.37	0.85	1	1	1	1	1	1	1	1	1	1
1956	0	0	0	0.08	0.22	0.37	0.85	1	1	1	1	1	1	1	1	1	1
1957	0	0	0	0	0	0.5	0.6	1	1	1	1	1	1	1	1	1	1
1958	0	0	0	0.08	0.22	0.37	0.85	1	1	1	1	1	1	1	1	1	1
1959	0	0	0	0.08	0.22	0.37	0.85	1	1	1	1	1	1	1	1	1	1
1960	0	0	0	0.08	0.22	0.37	0.85	1	1	1	1	1	1	1	1	1	1
1961	0	0	0	0.04	0.35	0.68	0.94	1	1	1	1	1	1	1	1	1	1
1962	0	0	0	0	0.11	0.67	1	1	1	1	1	1	1	1	1	1	1
1963	0	0	0	0.04	0.03	0.32	0.9	1	1	1	1	1	1	1	1	1	1
1964	0	0	0	0.02	0.06	0.28	0.32	1	1	1	1	1	1	1	1	1	1
1965	0	0	0	0	0.34	0.35	0.76	1	1	1	1	1	1	1	1	1	1
1966	0	0	0	0.01	0.15	1	0.96	1	1	1	1	1	1	1	1	1	1
1967	0	0	0	0	0.01	0.23	1	1	1	1	1	1	1	1	1	1	1
1968	0	0	0	0	0	0.01	0.76	1	1	1	1	1	1	1	1	1	1
1969	0	0	0	0.62	0.89	0.95	1	1	1	1	1	1	1	1	1	1	1
1970	0	0	0	0.06	0.13	0.31	0.17	1	1	1	1	1	1	1	1	1	1
1971	0	0	0	0.1	0.25	0.6	0.9	1	1	1	1	1	1	1	1	1	1
1972	0	0	0	0	0.1	0.25	0.6	0.9	1	1	1	1	1	1	1	1	1
1973	0	0	0	0.5	0.9	1	1	1	1	1	1	1	1	1	1	1	1
1974	0	0	0	0.5	0.9	1	1	1	1	1	1	1	1	1	1	1	1
1975	0	0	0	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1
1976	0	0	0	0.5	0.9	1	1	1	1	1	1	1	1	1	1	1	1
1977	0	0	0	0.73	0.89	1	1	1	1	1	1	1	1	1	1	1	1
1978	0	0	0	0.13	0.9	1	1	1	1	1	1	1	1	1	1	1	1
1979	0	0	0	0.1	0.62	0.95	1	1	1	1	1	1	1	1	1	1	1
1980	0	0	0	0.25	0.5	0.97	1	1	1	1	1	1	1	1	1	1	1
1981	0	0	0	0.3	0.5	0.9	1	1	1	1	1	1	1	1	1	1	1
1982	0	0	0	0.1	0.48	0.7	1	1	1	1	1	1	1	1	1	1	1
1983	0	0	0	0.1	0.5	0.69	0.71	1	1	1	1	1	1	1	1	1	1
1984	0	0	0	0.1	0.5	0.9	0.95	1	1	1	1	1	1	1	1	1	1
1985	0	0	0	0.1	0.5	0.9	1	1	1	1	1	1	1	1	1	1	1
1986	0	0	0	0.1	0.2	0.9	1	1	1	1	1	1	1	1	1	1	1
1987	0	0	0	0.1	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
1988	0	0	0	0.1	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
1989	0	0	0	0.1	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
1990	0	0	0	0.4	0.8	0.9	0.9	0.9	1	1	1	1	1	1	1	1	1
1991	0	0	0	0.1	0.7	1	1	1	1	1	1	1	1	1	1	1	1
1992	0	0	0	0.1	0.2	0.8	1	1	1	1	1	1	1	1	1	1	1
1993	0	0	0	0.01	0.3	0.8	1	1	1	1	1	1	1	1	1	1	1
1994	0	0	0	0.01	0.3	0.8	1	1	1	1	1	1	1	1	1	1	1
1995	0	0	0	0	0.3	0.8	1	1	1	1	1	1	1	1	1	1	1
1996	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
1997	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
1998	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
1999	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1

Table 9.4.5.1. cont. Norwegian spring spawning herring. Proportion mature at age.

	AGE																
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2000	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2001	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2002	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2003	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2004	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2005	0	0	0	0.1	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2006	0	0	0	0	0.9	0.9	1	1	1	1	1	1	1	1	1	1	1
2007	0	0	0	0	0.3	1	1	1	1	1	1	1	1	1	1	1	1
2008	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1

Table 9.4.6.1.1. Norwegian Spring-spawning herring. Estimates from the acoustic surveys on the spawning stock in February-March. Numbers in millions. Biomass in thousands. Data in black box are used in assessment. There have been corrections due to age readings. *Survey 1.*

	SURVEY 1						age									Total
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
1988		255	146	6805	202										7408	
1989	101	5	373	103	5402	182									6166	
1990	183	187	0	345	112	4489	146								5462	
1991	44	59	54	12	354	122	4148	102							4895	
1992*																
1993*																
1994	16	128	676	1375	476	63	13	140	35	1820					4742	
1995		1792	7621	3807	2151	322	20	1	124	63	2573				18474	3514
1996	407	231	7638	11243	2586	957	471	0	0	165	0	2024			25722	4824
1997*																
1998			381	1905	10640	6708	1280	434	130	39	0	64	0	915	22496	5360
1999	106	1366	337	1286	2979	11791	7534	1912	568	132	0	0	392	437	28840	7213
2000	1516	690	1996	164	592	1997	7714	4240	553	71	3	0	6	24	19566	4913
2001**																
2002**																
2003**																
2004**																
2005	103	281	811	3310	7545	10453	887	563	159	122	610	1100	686		26649	6501
2006	13	75	10167	684	1103	4540	4407	133	47	11	113	120	323	135	21871	4858
2007	109	534	2097	14575	952	592	3270	3092	263	276	20	285	189	628	26882	6004
2008	10	145	3517	3749	15066	972	612	2410	2374	426	136	121	90	171	29798	7244

*** No estimate due to poor weather conditions.**

**** No surveys.**

Table 9.4.6.2.1 Norwegian Spring-spawning herring. Estimates obtained on the acoustic surveys in the wintering areas in November-December. Numbers in millions. Data in black box are used in assessment. There have been corrections due to age readings. *Survey 2.*

	SURVEY 2						age								Total
year	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	total	biomass
1992		36	1247	1317	173	16	208	139	3742	69					6947	
1993	72	1518	2389	3287	1267	13	13	158	26	4435					13178	
1994		16	3708	4124	2593	1096	34	25	196	29	3239				15209	
1995	380	183	5133	5274	1839	1040	308	19	13	111	39	907			15246	
1996		1465	3008	13180	5637	994	552	92	0	7	41	15	393		25384	
1997	9	73	661	1480	6110	4458	1843	743	66	0	0	64	0	904	16411	
1998	65	1207	441	1833	3869	12052	8242	2068	629	111	14	0	40	573	31144	
1999	74	159	2425	296	837	2066	6601	4168	755	212	0	15	0	146	17754	
2000	56	322	1522	5260	165	497	1869	4785	3635	668	205	0	0	11	18995	
2001	362	522	3916	1528	2615	82	338	864	3160	2216	384	127	0	1	16115	
2002*	7	50	276	1659	624	1029	32	188	516	1831	911	184	0	0	7307	
2003**	586	406	2167	10670	13237	1047	678	41	134	301	1214	502	10	37	31030	
2004**	257	6814	1123	1596	5334	6731	363	280	37	42	187	761	392	83	24000	
2005	61	352	7173	465	685	2030	3101	177	190	57	46	184	476	327	15325	
2006	940	7785	3712	21320	1153	340	2879	4851	4	23	713	4	150	58	43778	
2007	1233	343	4161	2407	6213	226	288	695	694	0	43	0	126	188	16617	3660

*** Much of the youngest yearclasses (-98,-99) wintered outside the fjords this winter and are not included in the estimate**

**** In 2003-2004 a combined estimate from the Tysfjord, Ofotfjord and oceanic areas off Vesterålen/Troms.**

Table 9.4.6.3.1 Norwegian spring spawning herring. Estimates obtained on the acoustic surveys in the wintering areas in January. Numbers in millions. Data in the black box are used in the assessment. There have been corrections due to age readings. *Survey 3.*

	SURVEY 3							age						
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1991	90	220	70	20	180	150	5500	440							6670
1992		410	820	260	60	510	120	4690	30						6900
1993		61	1905	2048	256	27	269	182	5691	128					10567
1994	73	642	3431	4847	1503	102	29	161	131	3679					14598
1995		47	3781	4013	2445	1215	42	24	267	29	4326				16189
1996		315	10442	13557	4312	1271	290	22	25	200	58	1146			31638
1997*															-
1998	214	267	1938	4162	9647	6974	1518	743	16	4	0	33	7	462	25985
1999**	0	1358	199	1455	4452	12971	7226	1876	499	16	16	0	156	220	30444

*** No estimate due to poor weather conditions.**

**** No surveys since 1999.**

Table 9.4.6.4.1. Norwegian spring-spawning herring. Acoustic estimates (billion individuals) of immature herring in the Barents Sea in May/June. No survey in 2003, 1990-2002. See footnotes. Data in black box used in the assessment except the yellow highlighted cell. ***Survey 4.***

	SURVEY 4		AGE		
YEAR	1	2	3	4	5
1991	24.3	5.2			
1992	32.6	14	5.7		
1993	102.7	25.8	1.5		
1994	6.6	59.2	18	1.7	
1995	0.5	7.7	8	1.1	
1996[1]	0.1	0.25	1.8	0.6	0.03
1997[2]	2.6	0.04	0.4	0.35	0.05
1998	9.5	4.7	0.01	0.01	0
1999	49.5	4.9	0	0	0
2000	105.4	27.9	0	0	0
2001	0.3	7.6	8.8	0	0
2002	0.5	3.9	0	0	0
2003[3]					
2004[3]					
2005	23.3	4.5	2.5	0.4	0.3
2006	3.7	35.0	5.3	0.87	0
2007	2.1	3.7	12.5	1.9	0
2008[4]	0.043	0.38	0.2	0.28	0

[1] Average of Norwegian and Russian estimates

[2] Combination of Norwegian and Russian estimates as described in 1998 WG report, since then only Russian estimates

[3] No surveys

[4] Not a full survey

Table 9.4.6.4.2. Norwegian spring spawning herring. Estimates from the international acoustic surveys on the feeding areas in the Norwegian Sea in May. Numbers in millions. Biomass in thousands. Biomass in thousands. Data in black box are used in assessment. There have been corrections due to age readings. *Survey 5.*

	SURVEY 5						AGE										TOTAL
YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	TOTAL	BIOMASS
1996	0	0	4114	22461	13244	4916	2045	424	14	7	155	0	3134			50514	8532
1997	0	0	1169	3599	18867	13546	2473	1771	178	77	288	190	60	2697		44915	9435
1998	24	1404	367	1099	4410	16378	10160	2059	804	183	0	0	35	0	492	37415	8004
1999	0	215	2191	322	965	3067	11763	6077	853	258	5	14	0	158	128	26016	6299
2000	0	157	1353	2783	92	384	1302	7194	5344	1689	271	0	114	0	75	20758	6001
2001	0	1540	8312	1430	1463	179	204	3215	5433	1220	94	178	0	0	6	23274	3937
2002	0	677	6343	9619	1418	779	375	847	1941	2500	1423	61	78	28	0	26089	4628
2003	32073	8115	6561	9985	9961	1499	732	146	228	1865	2359	1769		287	0	75580	6653
2004	0	13735	1543	5227	12571	10710	1075	580	76	313	362	1294	1120	10	88	48704	7687
2005	0	1293	19679	1353	1765	6205	5371	651	388	139	262	526	1003	364	115	39114	5109
2006	0	19	306	14560	1396	2011	6521	6978	679	713	173	407	921	618	243	35545	9100
2007	0	411	2889	5877	20292	1260	1992	6780	5582	647	488	372	403	1048	1010	49051	12161
2008	0	1193	587	8332	8270	16345	1381	1920	3958	2500	416	242	159	217	408	45928	9996

Table 9.4.6.5.1. Norwegian spring-spawning herring. Acoustic estimates (billion individuals) of immature herring in the Barents Sea in August-October. Data in black boxes used in the assessment. ***Survey 6.***

SURVEY 6			
	AGE		
YEAR	1	2	3
2000	14.7	11.5	0
2001	0.5	10.5	1.7
2002	1.3	0	0
2003	99.9	4.3	2.5
2004	14.3	36.5	0.9
2005	46.4	16.1	7.0
2006	1.6	5.5	1.3
2007	3.9	2.6	6.3

Table 9.4.6.5.2.. Norwegian spring-spawning herring. Abundance indices for 0-group herring 1980-2007 in the Barents Sea, August-October. ***This index has been recalculated since 2006, these are the new values. Survey 7.***

SURVEY 7	
YEAR	ABUNDANCE INDEX
1980	4
1981	3
1982	202
1983	40557
1984	6313
1985	7237
1986	7
1987	2
1988	8686
1989	4196
1990	9508
1991	81175
1992	37183
1993	61508
1994	14884
1995	1308
1996	57169
1997	45808
1998	79492
1999	15931
2000	49614
2001	844
2002	23354
2003	28579
2004	133350
2005	26332
2006	66819
2007	22481

Table 9.4.6.6.1.. Norwegian Spring-spawning herring. The indices for herring larvae on the Norwegian shelf for the period 1981-2007 ($N*10^{-12}$). Data in black box are used in the assessment. *Survey 8.*

Survey 8		
Year	Index1	Index 2
1981	0.3	
1982	0.7	
1983	2.5	
1984	1.4	
1985	2.3	
1986	1	
1987	1.3	4
1988	9.2	25.5
1989	13.4	28.7
1990	18.3	29.2
1991	8.6	23.5
1992	6.3	27.8
1993	24.7	78
1994	19.5	48.6
1995	18.2	36.3
1996	27.7	81.7
1997	66.6	147.5
1998	42.4	138.6
1999	19.9	73
2000	19.8	89.4
2001	40.7	135.9
2002	27.1	138.6
2003*	3.7	18.8
2004	56.4	215.1
2005	73.91	196.7
2006	98.9	389.0
2007**	90.6	
2008	107.9	393.3

Index 1. The total number of herring larvae found during the cruise.

Index 2. Back-calculated number of newly hatched larvae with 10% daily moratlity. The larval age is estimated from the duration of the yolksac stages and the size of the larvae.

*** Poor weather conditions and survey was late in April**

**** only representative for the area 62-66°N**

Table 9.6.1. Norwegian spring spawning herring. Stock in numbers (billions).

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1988	26.279	3.988	2.033	3.381	0.712	14.869	0.046	0.014	0.014	0.027	0.012	0.013	0.014	0.007	0.004	0.002
1989	73.703	10.674	1.619	0.821	2.852	0.589	12.288	0.030	0.009	0.006	0.010	0.002	0.009	0.009	0.003	0.003
1990	109.506	29.961	4.339	0.642	0.704	2.451	0.502	10.275	0.023	0.007	0.005	0.005	0.001	0.007	0.007	0.005
1991	320.295	44.521	12.181	1.754	0.536	0.603	2.099	0.422	8.634	0.019	0.005	0.002	0.002	0.000	0.006	0.010
1992	386.480	130.222	18.099	4.950	1.502	0.458	0.518	1.793	0.355	7.228	0.014	0.003	0.002	0.001	0.000	0.012
1993	125.101	157.130	52.944	7.358	4.249	1.262	0.390	0.445	1.532	0.300	6.012	0.010	0.002	0.001	0.000	0.010
1994	42.323	50.858	63.884	21.521	6.306	3.558	1.005	0.328	0.379	1.291	0.241	4.794	0.008	0.002	0.001	0.009
1995	17.405	17.207	20.677	25.968	18.493	5.326	2.725	0.712	0.268	0.319	1.077	0.175	3.528	0.004	0.001	0.008
1996	57.924	7.077	6.996	8.406	22.298	15.596	4.006	1.754	0.399	0.216	0.260	0.862	0.073	2.190	0.000	0.006
1997	53.859	23.550	2.877	2.825	7.203	18.530	11.966	2.576	1.132	0.247	0.181	0.217	0.681	0.046	1.109	0.004
1998	315.607	21.898	9.575	1.156	2.311	5.949	14.283	8.450	1.511	0.672	0.156	0.137	0.157	0.502	0.022	0.613
1999	220.861	128.316	8.903	3.840	0.930	1.764	4.778	10.660	6.100	0.946	0.458	0.095	0.094	0.132	0.327	0.396
2000	50.118	89.795	52.170	3.616	3.177	0.767	1.393	3.714	7.686	4.170	0.544	0.296	0.068	0.044	0.107	0.442
2001	34.925	20.376	36.508	21.201	3.035	2.215	0.628	1.096	2.822	5.410	2.620	0.267	0.188	0.044	0.017	0.361
2002	531.678	14.199	8.284	14.842	18.153	2.463	1.510	0.504	0.855	2.154	3.878	1.785	0.162	0.140	0.034	0.255
2003	156.742	216.164	5.773	3.329	12.590	15.028	1.883	0.997	0.406	0.649	1.608	2.723	1.221	0.090	0.109	0.195
2004	308.241	63.726	87.884	2.344	2.795	10.536	12.257	1.457	0.703	0.329	0.489	1.183	1.817	0.848	0.042	0.240
2005	45.278	125.322	25.908	35.703	1.995	2.320	8.670	9.887	1.151	0.477	0.258	0.372	0.861	1.192	0.534	0.066
2006	64.706	18.409	50.952	10.520	30.314	1.630	1.839	6.865	7.647	0.878	0.296	0.187	0.260	0.612	0.706	0.385
2007	0.000	26.308	7.483	20.686	8.985	25.415	1.327	1.424	5.235	5.865	0.673	0.183	0.133	0.170	0.403	0.735
2008	0.000	0.000	10.693	3.037	17.597	7.393	20.201	1.000	1.000	3.830	4.574	0.536	0.134	0.100	0.124	0.809

Table 9.6.2. Norwegian spring spawning herring. Fishing mortality.

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1988	0.001	0.001	0.007	0.020	0.039	0.041	0.253	0.328	0.634	0.875	1.475	0.267	0.304	0.584	0.500	0.500
1989	0.000	0.000	0.025	0.004	0.001	0.010	0.029	0.131	0.103	0.124	0.458	0.934	0.090	0.040	0.094	0.094
1990	0.000	0.000	0.006	0.032	0.004	0.005	0.024	0.024	0.062	0.274	0.619	0.682	1.856	0.029	0.092	0.092
1991	0.000	0.000	0.000	0.005	0.006	0.003	0.008	0.023	0.028	0.157	0.118	0.044	0.392	-1.000	0.051	0.051
1992	0.000	0.000	0.000	0.003	0.024	0.012	0.003	0.007	0.018	0.034	0.218	0.225	0.159	-1.000	0.017	0.017
1993	0.000	0.000	0.000	0.004	0.028	0.078	0.024	0.009	0.021	0.069	0.076	0.000	0.000	0.000	0.047	0.047
1994	0.000	0.000	0.000	0.002	0.019	0.117	0.194	0.053	0.023	0.032	0.174	0.157	0.469	0.282	0.098	0.098
1995	0.000	0.000	0.000	0.002	0.020	0.135	0.291	0.430	0.065	0.055	0.072	0.728	0.327	-1.000	0.229	0.229
1996	0.000	0.000	0.007	0.004	0.035	0.115	0.292	0.287	0.328	0.029	0.031	0.086	0.303	0.531	0.247	0.247
1997	0.000	0.000	0.012	0.051	0.041	0.110	0.198	0.384	0.372	0.308	0.127	0.176	0.155	0.593	0.446	0.446
1998	0.000	0.000	0.014	0.068	0.120	0.069	0.143	0.176	0.318	0.234	0.347	0.223	0.024	0.277	0.322	0.322
1999	0.000	0.000	0.001	0.039	0.042	0.086	0.102	0.177	0.230	0.403	0.287	0.180	0.612	0.061	0.343	0.343
2000	0.000	0.000	0.000	0.025	0.211	0.050	0.090	0.125	0.201	0.315	0.562	0.303	0.296	0.813	0.268	0.268
2001	0.000	0.000	0.000	0.005	0.059	0.233	0.069	0.099	0.120	0.183	0.234	0.353	0.146	0.090	0.242	0.242
2002	0.000	0.000	0.012	0.015	0.039	0.119	0.265	0.066	0.126	0.142	0.204	0.229	0.436	0.101	0.246	0.246
2003	0.000	0.000	0.001	0.025	0.028	0.054	0.106	0.200	0.063	0.132	0.157	0.254	0.215	0.621	0.084	0.084
2004	0.000	0.000	0.001	0.011	0.036	0.045	0.065	0.086	0.238	0.092	0.123	0.168	0.272	0.312	1.297	1.297
2005	0.000	0.000	0.001	0.014	0.052	0.083	0.083	0.107	0.121	0.327	0.173	0.209	0.192	0.374	0.296	0.296
2006	0.000	0.000	0.001	0.008	0.026	0.056	0.106	0.121	0.115	0.115	0.330	0.192	0.274	0.269	0.245	0.245
2007	-1.000	0.000	0.002	0.012	0.045	0.080	0.133	0.203	0.163	0.099	0.079	0.162	0.133	0.169	0.190	0.190

Negative fishing mortality -1 means that the fishing mortality was not defined, see TASACS manual

Table 9.6.3. Norwegian spring spawning herring. Stock summary table.

	RECRUITMENT AGE 0 IN YEAR	TOTAL BIOMASS	SPAWNING STOCK BIOMASS	LANDINGS	WEIGHTED F
YEAR	BILLIONS	MILLION TONS	MILLION TONS	TONS	5-14
1988	26.279	3.594	2.748	135301	0.046
1989	73.703	4.269	3.398	103830	0.029
1990	109.506	4.814	3.749	86411	0.021
1991	320.295	5.462	3.935	84683	0.023
1992	386.480	6.540	3.832	104448	0.027
1993	125.101	7.664	3.704	232457	0.063
1994	42.323	8.774	4.181	479228	0.127
1995	17.405	9.612	5.023	905501	0.227
1996	57.924	9.720	6.586	1220283	0.192
1997	53.859	9.679	7.941	1426507	0.180
1998	315.607	8.736	7.360	1223131	0.151
1999	220.861	10.226	6.944	1235433	0.183
2000	50.118	9.740	5.926	1207201	0.211
2001	34.925	8.218	4.883	766136	0.179
2002	531.678	9.150	5.131	807795	0.180
2003	156.742	11.370	6.689	789510	0.105
2004	308.241	14.043	7.500	794066	0.090
2005*	45.278	14.350	7.989	1003243	0.123
2006**	64.706	15.601	11.506	968958	0.126
2007***	105.000	14.899	11.613	1266993	0.101
2008***		14.528	11.869		

*** Recruitment value has been replaced in the forecast by RCT estimate: 72.606**

**** Recruitment value has been replaced in the forecast by RCT estimae: 79.066**

***** GM mean 1988-2004**

Table 9.9.1. Norwegian spring-spawning herring. Input file for RCT3.

NSSH: VPA and acoustic survey data

5 22 2

'Yearcl'	'VPAage2'		'Sur70'	'Sur41'	'Sur42'	'sur61'	'sur62'
1986	2.0326	7	-11	-11	-11	-11	
1987	1.6194	2	-11	-11	-11	-11	
1988	4.3386	8686	-11	-11	-11	-11	
1989	12.1808	4196	-11	5.2	-11	-11	
1990	18.0987	9508	24.3	14	-11	-11	
1991	52.9442	81175	32.6	25.8	-11	-11	
1992	63.8842	37183	102.7	59.2	-11	-11	
1993	20.6774	61508	6.6	7.7	-11	-11	
1994	6.9958	14884	0.5	0.25	-11	-11	
1995	2.8771	1308	0.1	0.04	-11	-11	
1996	9.5747	57169	2.6	4.7	-11	-11	
1997	8.9029	45808	9.5	4.9	-11	-11	
1998	52.1695	79492	49.5	27.9	-11	11.5	
1999	36.508	15931	-11	7.6	14.7	10.5	
2000	8.2844	49614	0.3	3.9	0.5	-11	
2001	5.773	844	0.5	-11	-11	4.3	
2002	87.8836	23354	-11	-11	99.9	36.5	
2003	25.908	28579	-11	4.5	14.3	16.1	
2004	50.9516	133350	23.3	35	46.4	5.5	
2005	7.4831	26332	3.7	3.7	1.6	2.6	
2006	-11	66819	2.1	-11	3.9	-11	
2007	-11	22481	-11	-11	-11	-11	

Table 9.9.2.. Norwegian spring-spapwning herring. Output from RCT3.

```
Analysis by RCT3 ver3.1 of data from file :

 nssh08.txt

 NSSH: VPA and acoustic survey data

 Data for    5 surveys over   22 years :  1986 - 2007

 Regression type = C
 Tapered time weighting not applied
 Survey weighting not applied
 Final estimates not shrunk towards mean
 Estimates with S.E.'S greater than that of mean
+                                                   included
 Minimum S.E. for any survey taken as    .20
 Minimum of   3 points used for regression

 Forecast/Hindcast variance correction used.

 Yearclass =   2004

          I-----------Regression----------I  I-----------Prediction---------I

 Survey/  Slope  Inter-   Std  Rsquare  No.  Index Predicted   Std     WAP
 Series           cept   Error           Pts  Value   Value    Error   Weights

 Sur70      .52  -1.94   1.13   .496     18  11.80    4.19    1.260     .028
 Sur41      .62   1.51    .41   .856     11   3.19    3.50     .483     .187
 Sur42      .84   1.20    .44   .805     13   3.58    4.20     .534     .153
 sur61      .55   1.97    .16   .980      4   3.86    4.08     .272     .588
 sur62     1.58   -.67    .63   .757      5   1.87    2.28     .997     .044

                                        VPA Mean =    2.67    1.084     .000
```

Yearclass = 2005

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
	I-----------Regression----------I					I-----------Prediction---------I			
Sur70	.51	-1.89	1.08	.521	19	10.18	3.32	1.175	.026
Sur41	.65	1.48	.43	.847	12	1.55	2.49	.492	.148
Sur42	.82	1.23	.42	.824	14	1.55	2.49	.474	.159
sur61	.54	1.98	.14	.979	5	.96	2.49	.233	.657
sur62	1.90	-1.21	1.12	.443	6	1.28	1.23	1.817	.011
					VPA Mean =		2.74	1.093	.000

Yearclass = 2006

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
	I-----------Regression----------I					I-----------Prediction---------I			
Sur70	.53	-2.10	1.12	.493	20	11.11	3.78	1.222	.036
Sur41	.67	1.42	.43	.840	13	1.13	2.18	.493	.221
Sur42									
sur61	.59	1.78	.20	.966	6	1.59	2.72	.268	.744
sur62									
					VPA Mean =		2.71	1.073	.000

Yearclass = 2007

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
	I-----------Regression----------I					I-----------Prediction---------I			
Sur70	.53	-2.10	1.12	.493	20	10.02	3.20	1.211	1.000
Sur41									
Sur42									
sur61									
sur62									
					VPA Mean =		2.71	1.073	.000

Year Class	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2004	50	3.92	.21	.21	1.04	51	3.95
2005	12	2.50	.19	.09	.25	8	2.14
2006	13	2.64	.23	.22	.91		
2007	24	3.20	1.21	.00	.00		

Table 9.9.3. Norwegian Spring-spawning herring. Input to short-term prediction.

2008

Age	Stock size	Natural mortality	Maturity ogive	Prop.of F bef. spawn.	Prop. of M bef. spawn.	Weight in stock	Exploit. pattern	Weight in catch
0	105000	0.9	0.00	0	0	0.001	0.000	0.000
1	35000	0.9	0.00	0	0	0.010	0.0001	0.074
2	13000	0.9	0.00	0	0	0.044	0.0009	0.115
3	4870	0.15	0.00	0	0	0.077	0.0065	0.171
4	17597	0.15	0.30	0	0	0.146	0.0240	0.234
5	7393	0.15	0.90	0	0	0.212	0.0424	0.268
6	20201	0.15	1.00	0	0	0.269	0.0626	0.299
7	1000	0.15	1.00	0	0	0.289	0.0838	0.319
8	1000	0.15	1.00	0	0	0.327	0.0776	0.339
9	3830	0.15	1.00	0	0	0.351	0.1052	0.363
10	4574	0.15	1.00	0	0	0.358	0.1130	0.373
11	536	0.15	1.00	0	0	0.372	0.1096	0.376
12	134	0.15	1.00	0	0	0.411	0.1165	0.387
13	100	0.15	1.00	0	0	0.353	0.1577	0.398
14	124	0.15	1.00	0	0	0.389	0.1421	0.402
15	809	0.15	1.00	0	0	0.393	0.1421	0.406

2009 and 20010

Age	Stock size	Natural mortality	Maturity ogive	Prop.of F bef. spawn.	Prop. of M bef. spawn.	Weight in stock	Exploit. pattern	Weight in catch
0	105000	0.9	0.00	0	0	0.001	0.000	0.000
1		0.9	0.00	0	0	0.010	0.000	0.074
2		0.9	0.00	0	0	0.041	0.001	0.115
3		0.15	0.00	0	0	0.090	0.006	0.171
4		0.15	0.30	0	0	0.160	0.024	0.234
5		0.15	0.90	0	0	0.223	0.042	0.268
6		0.15	1.00	0	0	0.269	0.063	0.299
7		0.15	1.00	0	0	0.299	0.084	0.319
8		0.15	1.00	0	0	0.318	0.078	0.339
9		0.15	1.00	0	0	0.362	0.105	0.363
10		0.15	1.00	0	0	0.369	0.113	0.373
11		0.15	1.00	0	0	0.372	0.110	0.376
12		0.15	1.00	0	0	0.397	0.116	0.387
13		0.15	1.00	0	0	0.352	0.158	0.398
14		0.15	1.00	0	0	0.408	0.142	0.402
15		0.15	1.00	0	0	0.411	0.142	0.406

Table 9.9.4. Norwegian spring spawning herring. Short term prediction.

Basis: Landings (2008) = 1518 (=TAC); $\mathbf{F}_w$(2008)[1)] = 0.118; SSB(2008) = 11.9 million t.; SSB(2009)= 12.6 million t.
The fishing mortality applied according to the agreed management plan (F(management plan)) is 0.125.

Rationale	Landings (2009)	Fmult	Basis	F(2009)	SSB(2010)
Zero catch	0	0	F=0	0.000	13.0
Status quo	1339	1.00	F(2007)	0.101	11.8
Agreed management plan	175	0.12	F(management plan)*0.1	0.013	12.8
	433	0.31	F(management plan)*0.25	0.031	12.6
	859	0.62	F(management plan)*0.50	0.063	12.2
	1258	0.93	F(management plan)*0.75	0.094	11.8
	1492	1.12	F(management plan)*0.90	0.113	11.6
	1643	1.24	F(management plan)	0.125	11.5
	1800	1.37	F(management plan)*1.1	0.138	11.3
	2014	1.54	F(management plan)*1.25	0.156	11.1
Precautionary limits	1946	1.49	F_{pa}	0.150	11.2

Landings weights in thousand tonnes, stock biomass weights in million tonnes.

1) F_w = Fishing mortality weighted by population numbers (age groups 5–14).

Shaded scenarios are not considered consistent with the precautionary approach.

Table 9.9.5. Norwegian spring-spawning herring. Short term prediction at age for F=0.125

2008									
Age	stockno	stockno at	Biomass	Biomass at	ssb	ssb at spawntime	F	catch in number	catch in weight
	1-jan	spawntime	1-jan	spawntime	1-jan				
0	105000	105000	105	105	0	0	0.000	0.000	0
1	35000	35000	350	350	0	0	0.000	3.726	0
2	13000	13000	572	572	0	0	0.001	12.172	1
3	4870	4870	375	375	0	0	0.011	48.231	8
4	17597	17597	2569	2569	771	771	0.040	639.160	149
5	7393	7393	1567	1567	1411	1411	0.070	466.854	125
6	20201	20201	5434	5434	5434	5434	0.104	1854.929	555
7	1000	1000	289	289	289	289	0.139	120.888	39
8	1000	1000	327	327	327	327	0.129	112.414	38
9	3830	3830	1344	1344	1344	1344	0.175	571.235	208
10	4574	4574	1637	1637	1637	1637	0.188	728.227	272
11	536	536	199	199	199	199	0.182	82.979	31
12	134	134	55	55	55	55	0.193	21.954	9
13	100	100	35	35	35	35	0.262	21.468	9
14	124	124	48	48	48	48	0.236	24.224	10
15	809	809	318	318	318	318	0.236	158.444	64
	215166	215166	15226	15226	11869	11869	0.118	4866.9	1518.0
	(millions)	(millions)	(thousands)	(thousands)	(thousands)	(thousands)	(WF 5-14)	(millions)	(thousands)

Table 9.9.5 (cont'd)

				2009					
Age	stockno 1-jan	stockno at spawntime	Biomass 1-jan	Biomass at spawntime	ssb 1-jan	ssb at spawntime	F	catch in number	catch in weight
0	105000	105000	105	105	0	0	0.000	0	0
1	42690	42690	427	427	0	0	0.000	5	0
2	14228	14228	579	579	0	0	0.001	14	2
3	5278	5278	475	475	0	0	0.011	55	9
4	4147	4147	664	664	199	199	0.042	158	37
5	14553	14553	3250	3250	2925	2925	0.074	961	258
6	5931	5931	1593	1593	1593	1593	0.109	569	170
7	15670	15670	4690	4690	4690	4690	0.146	1978	632
8	749	749	238	238	238	238	0.135	88	30
9	757	757	274	274	274	274	0.183	118	43
10	2768	2768	1021	1021	1021	1021	0.197	460	172
11	3263	3263	1215	1215	1215	1215	0.191	527	198
12	384	384	153	153	153	153	0.203	66	25
13	95	95	33	33	33	33	0.274	21	8
14	66	66	27	27	27	27	0.247	14	5
15	634	634	261	261	261	261	0.247	129	53
	216213	216213	15006	15006	12631	12631	0.125	5162	1643
	(millions)	(millions)	(thousands)	(thousands)	(thousands)	(thousands)	(WF 5-14)	(millions)	(thousands)

Table 9.9.5 (Cont'd)

2010									
Age	stockno	stockno at	Biomass	Biomass at	ssb	ssb at spawntime	F	catch in number	catch in weight
	1-jan	spawntime	1-jan	spawntime	1-jan				
0	105000	105000	105	105	0	0	0.000	0	0
1	42690	42690	427	427	0	0	0.000	4	0
2	17353	17353	706	706	0	0	0.001	16	2
3	5776	5776	520	520	0	0	0.011	56	10
4	4492	4492	719	719	216	216	0.039	161	38
5	3423	3423	765	765	688	688	0.069	214	57
6	11636	11636	3126	3126	3126	3126	0.103	1056	316
7	4578	4578	1370	1370	1370	1370	0.137	547	175
8	11657	11657	3711	3711	3711	3711	0.127	1295	439
9	563	563	204	204	204	204	0.172	83	30
10	542	542	200	200	200	200	0.185	85	32
11	1957	1957	729	729	729	729	0.180	300	113
12	2321	2321	922	922	922	922	0.191	376	145
13	270	270	95	95	95	95	0.259	57	23
14	62	62	25	25	25	25	0.233	12	5
15	471	471	193	193	193	193	0.233	91	37
	212792	212792	13817	13817	11480	11480	0.125	4353	1421
	(millions)	(millions)	(thousands)	(thousands)	(thousands)	(thousands)	(WF 5-14)	(millions)	(thousands)

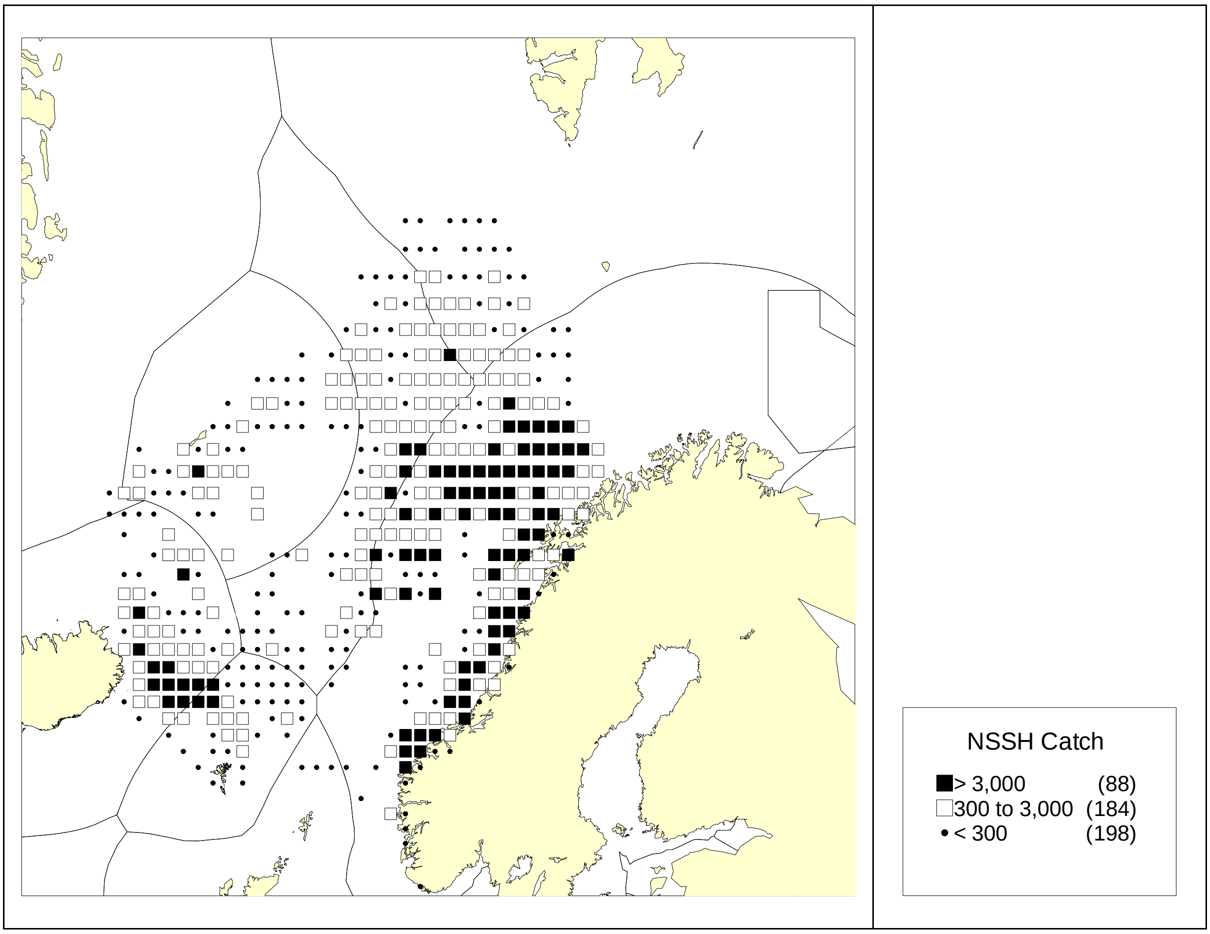


Figure 9.2.1.1. Total reported catches of Norwegian spring-spawning herring in 2007 by ICES rectangle. Grading of the symbols: black dots less than 300 t, open squares 300–3000 t, and black squares > 3000 t.

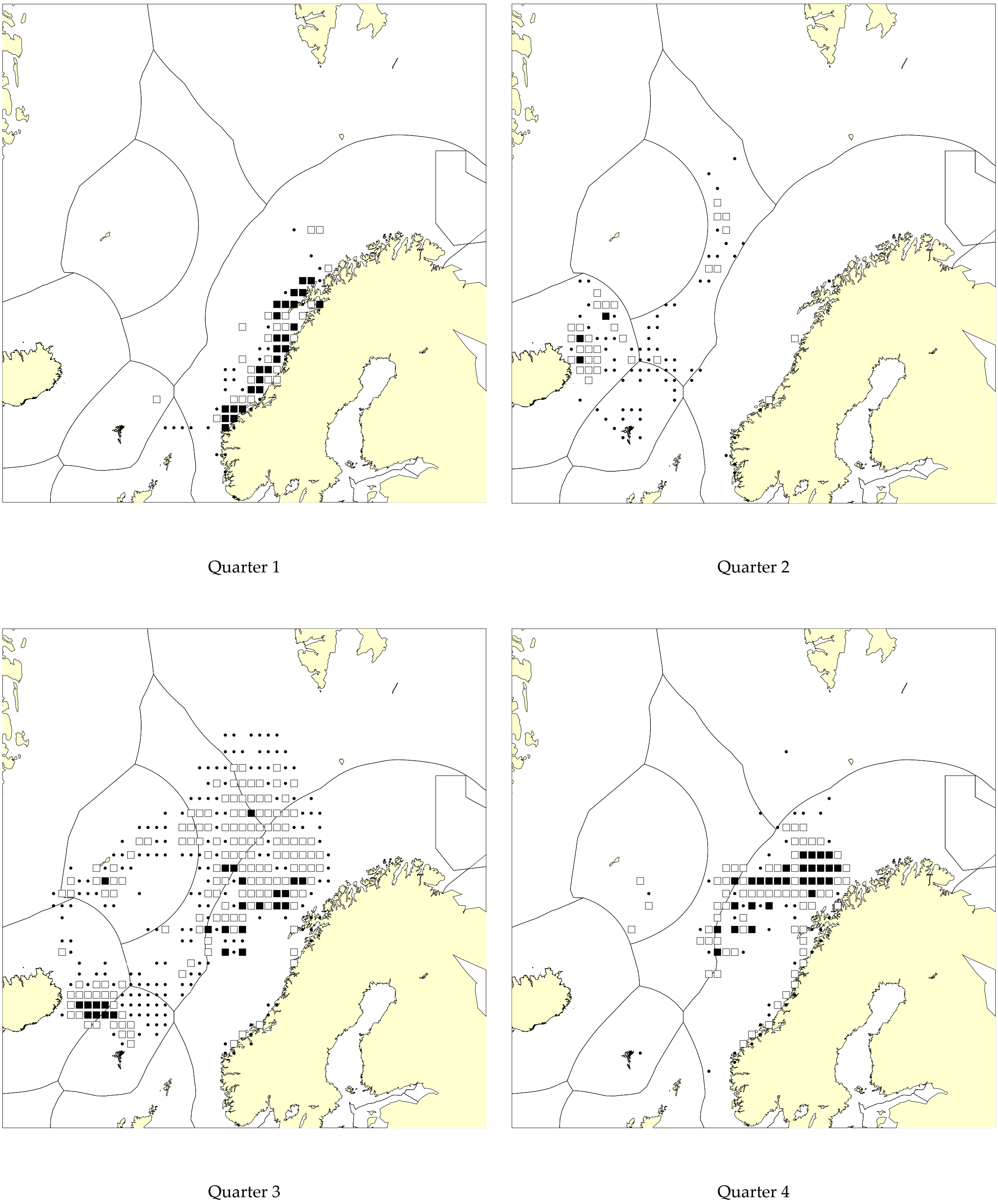


Figure 9.2.1.2. Total reported catches of Norwegian spring-spawning herring in 2007 by quarter and ICES rectangle. Grading of the symbols: black dots less than 300 t, open squares 300–3000 t, and black squares > 3000 t.

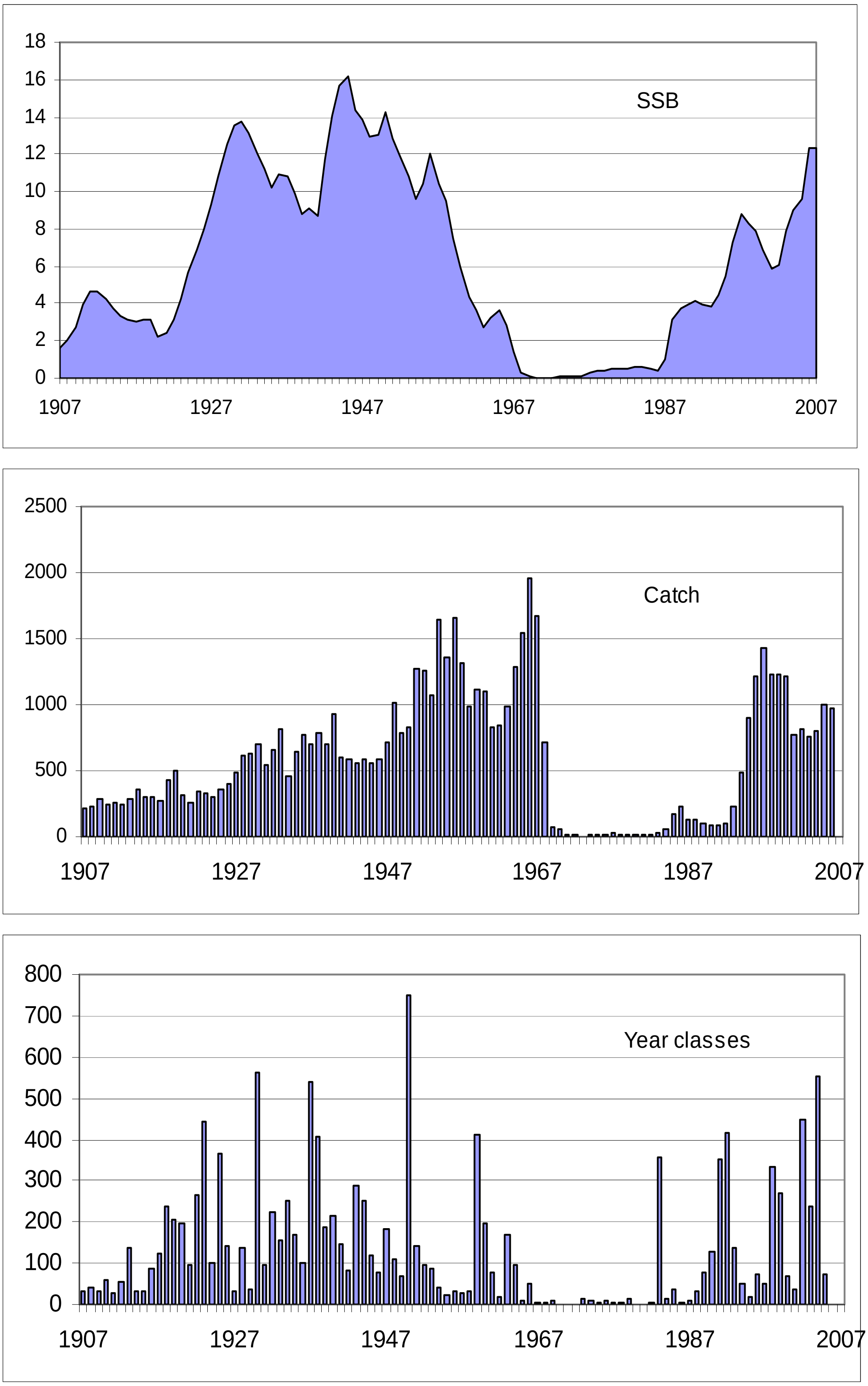


Figure 9.3.1.1. Norwegian spring spawning herring. Long term trends in spawning stock, catches and recruits (1907-1988 from Toresen and Østvedt; 1989-2007 from WGNPBW 2007).

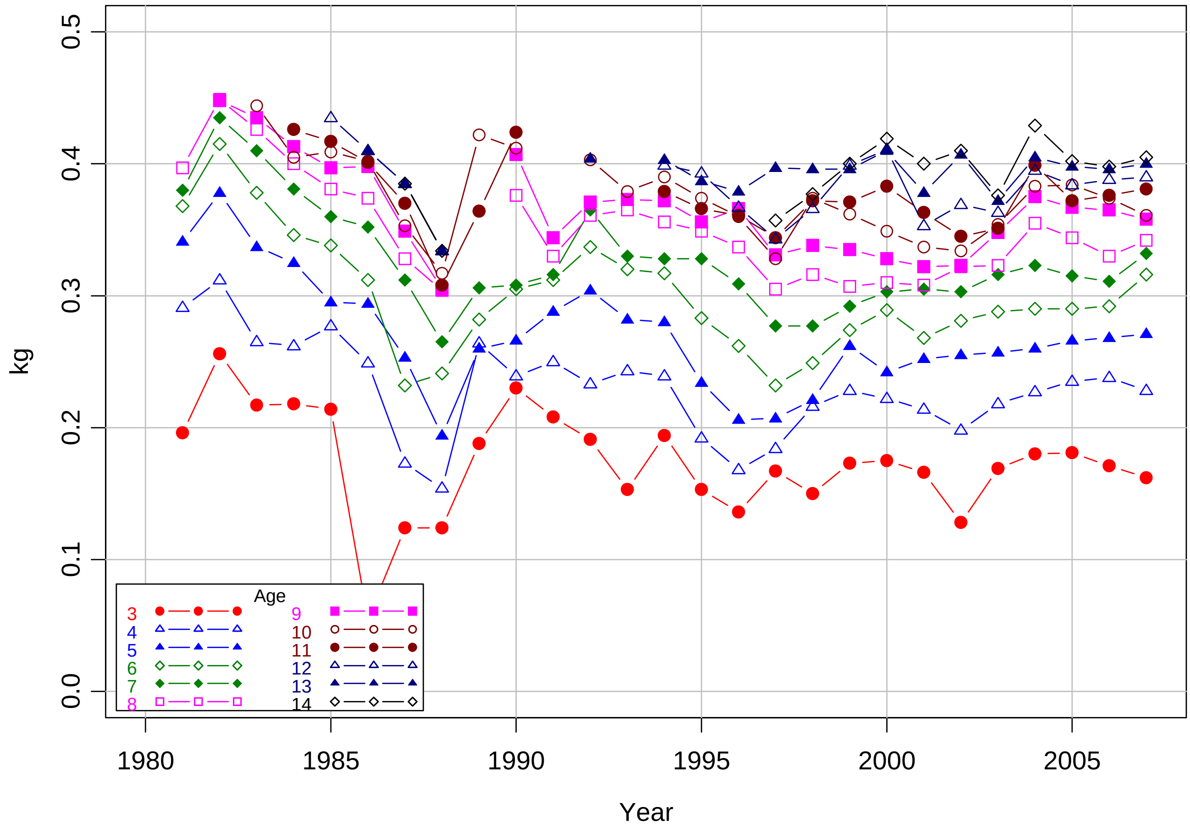


Figure 9.4.3.1. Norwegian spring spawning herring. Mean weight at age by age groups 3-14 in the years 1980-2007 (weight at age for zero catch numbers were omitted).

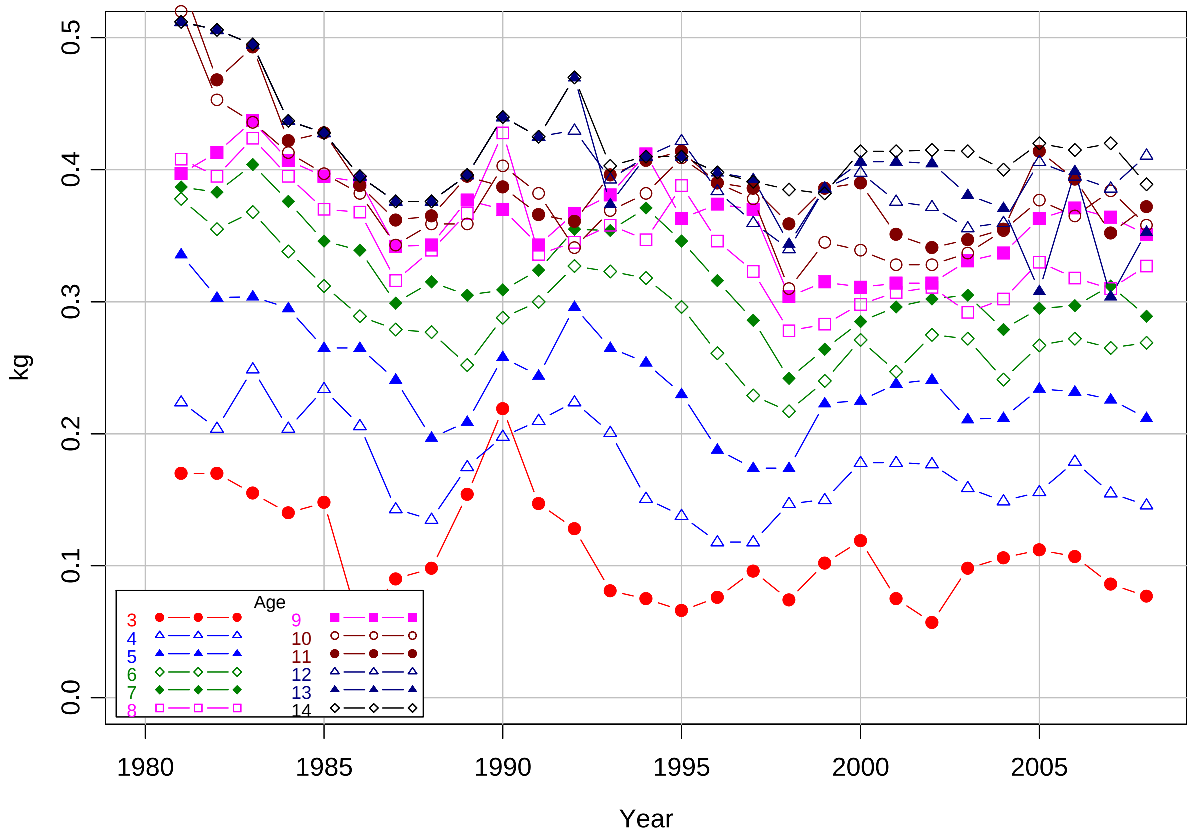
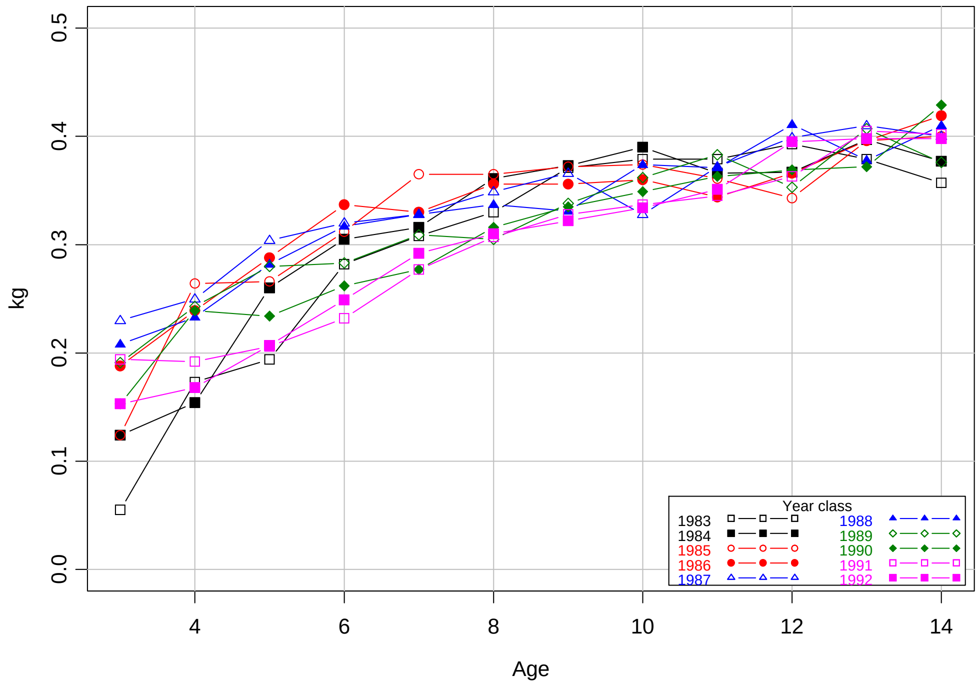


Figure 9.4.3.2. Norwegian spring-spawning herring. Mean weight at age in the stock 1981-2008.



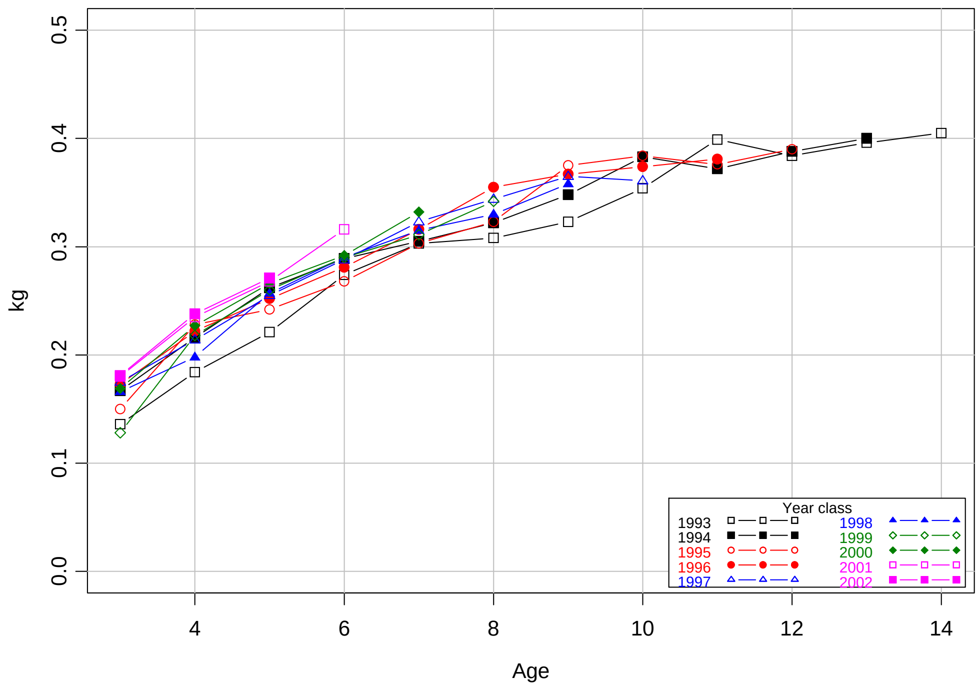


Figure 9.4.3.3. Norwegian spring-spawning herring. Mean weight at age by year classes 1983-1992 (upper) and 1993-2002 lower.

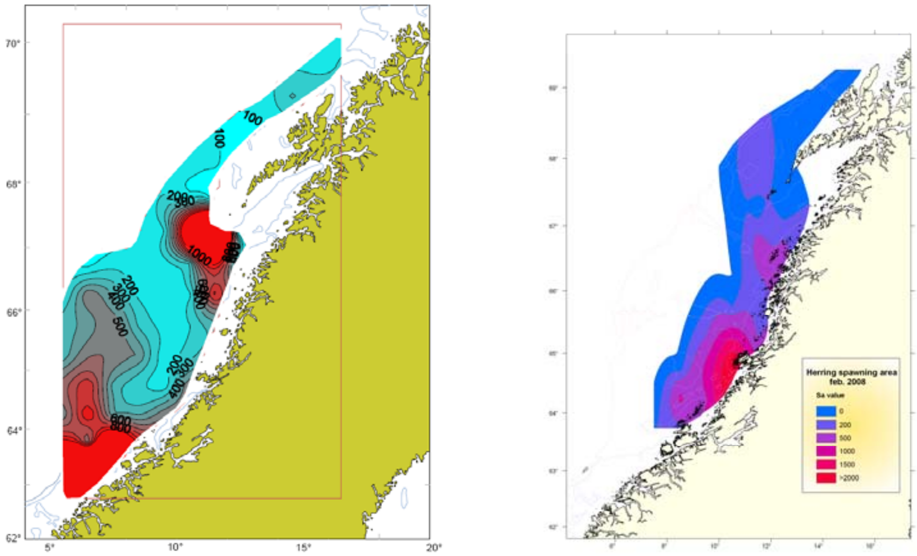


Figure 9.4.6.1.1. NSSH Acoustic survey on spawning grounds in February March, 2007 (left) and 2008 (right).

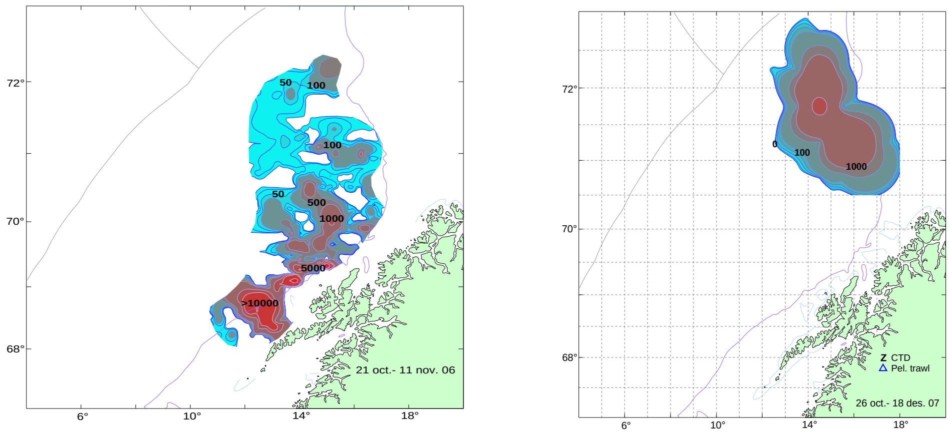
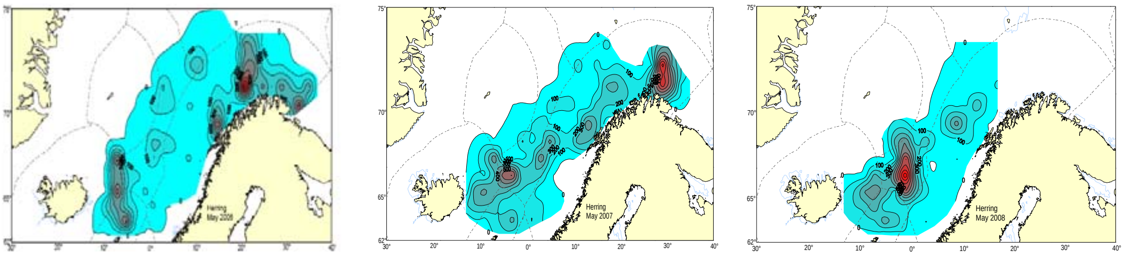


Figure 9.4.6.2.1. NSSH Acoustic survey in November/December 2006 (left panel here) and 2007 (right panel).



2006 2007 2008

Figure 9.4.6.4.1. Schematic map of herring acoustic density (sA, m2/nm2) found during the survey in May 2006, 2007 and 2008. Note the incomplete coverage of the Barents Sea in 2008.

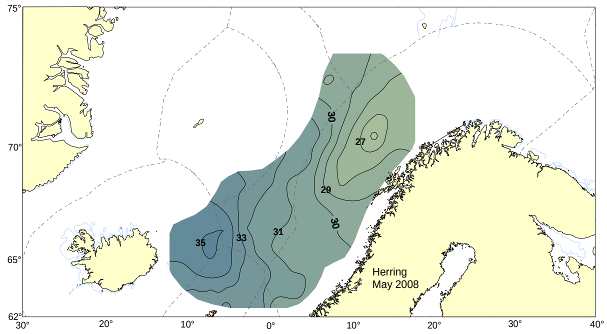


Figure 9.4.6.4.2. Isolines of mean lengths in cm of Norwegian spring spawning herring derived from trawl samples in April-June 2008.

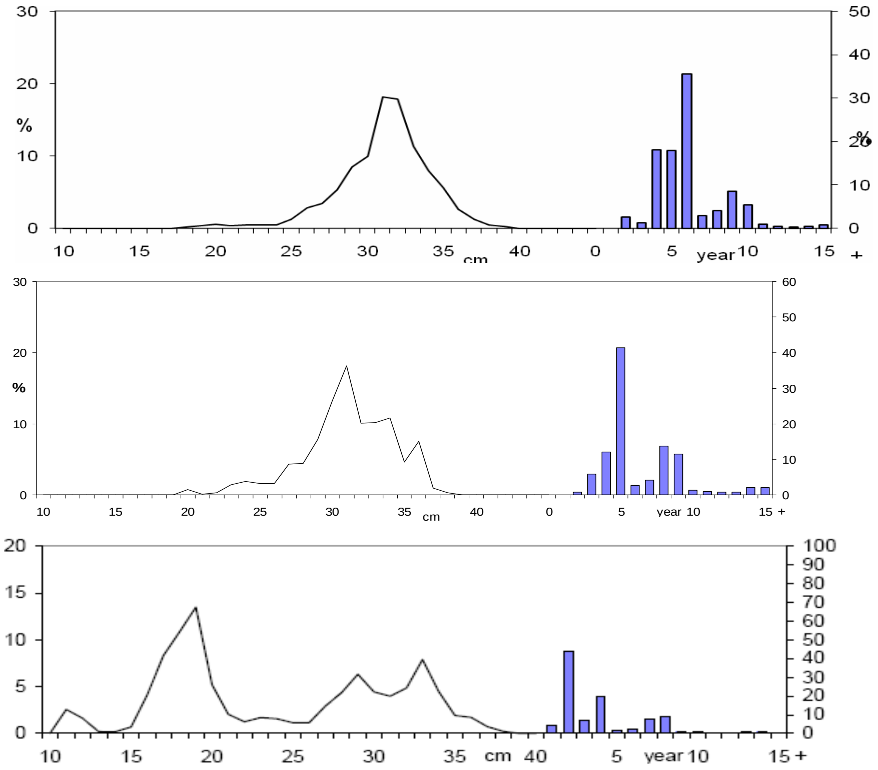


Figure 9.4.6.4.3. Length and age distribution of Norwegian spring spawning herring in the area in the Norwegian Sea, spring 2008 (upper panel), 2007 (middle panel) and 2006 (lower panel).

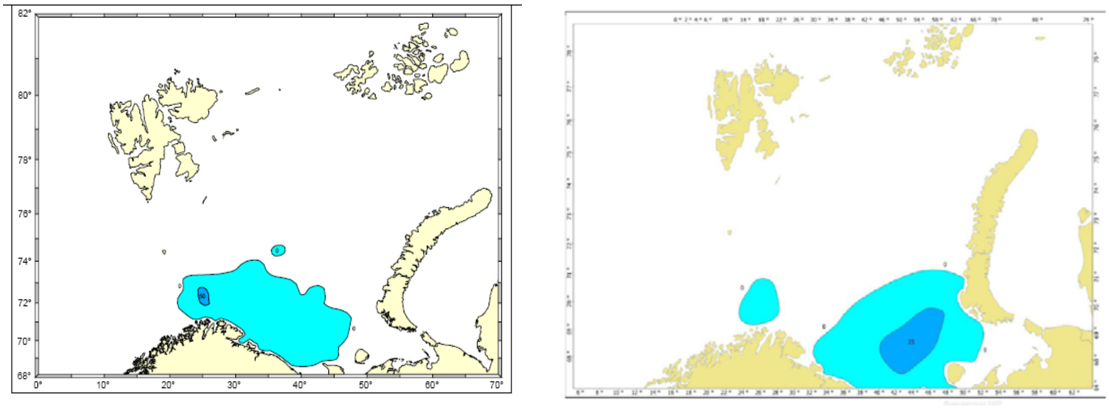


Figure 9.4.6.5.1. Estimated total density of herring (tonnes/nautical mile²) in August-September 2006 (left panel) and 2007 (right panel).

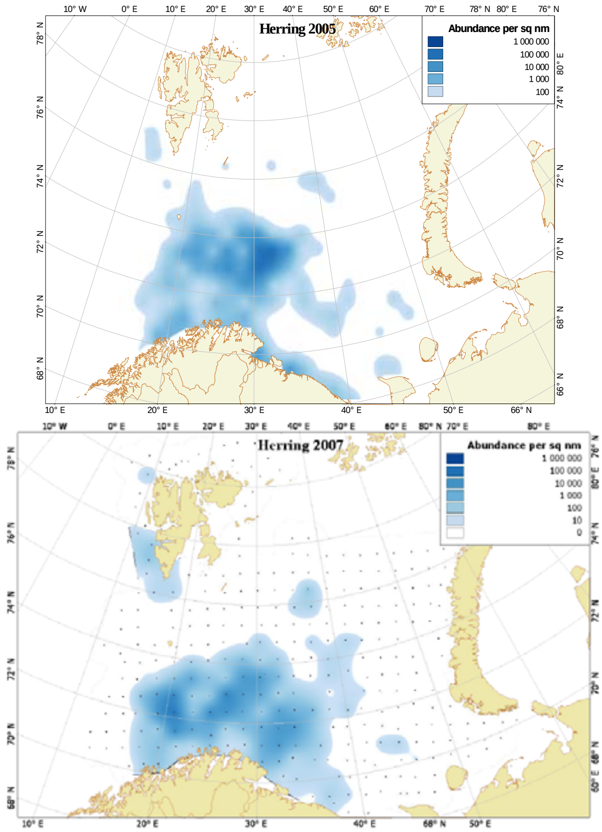


Figure 9.4.6.5.2. NSSH O–group surveys in August/September in the Barents Sea in 2006 (left panel) and 2007 (right panel).

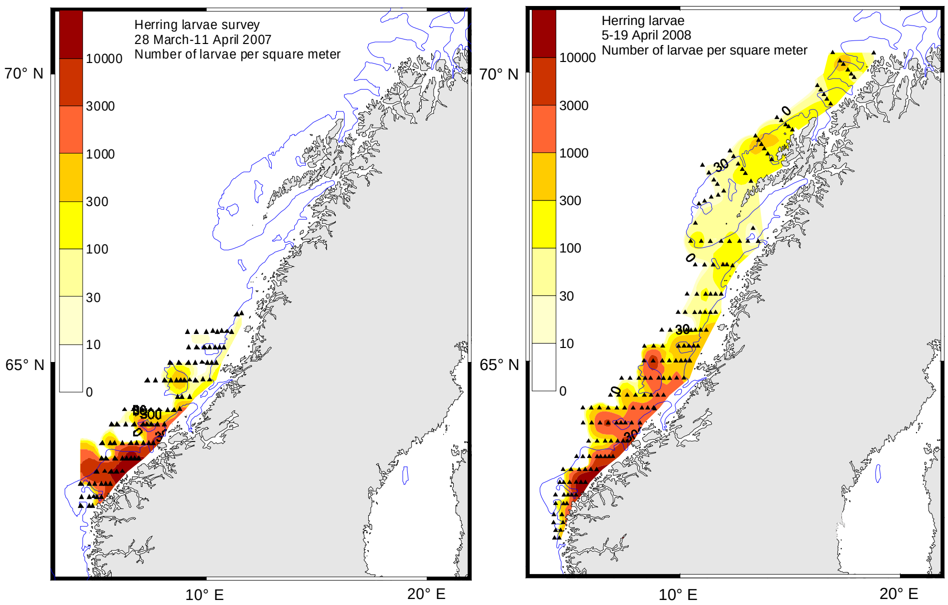


Figure 9.4.6.6.1. NSSH. Distribution of herring larvae on the Norwegian shelf in 2007 (left panel) and 2008 (right panel). The 200 m depth line is also shown.

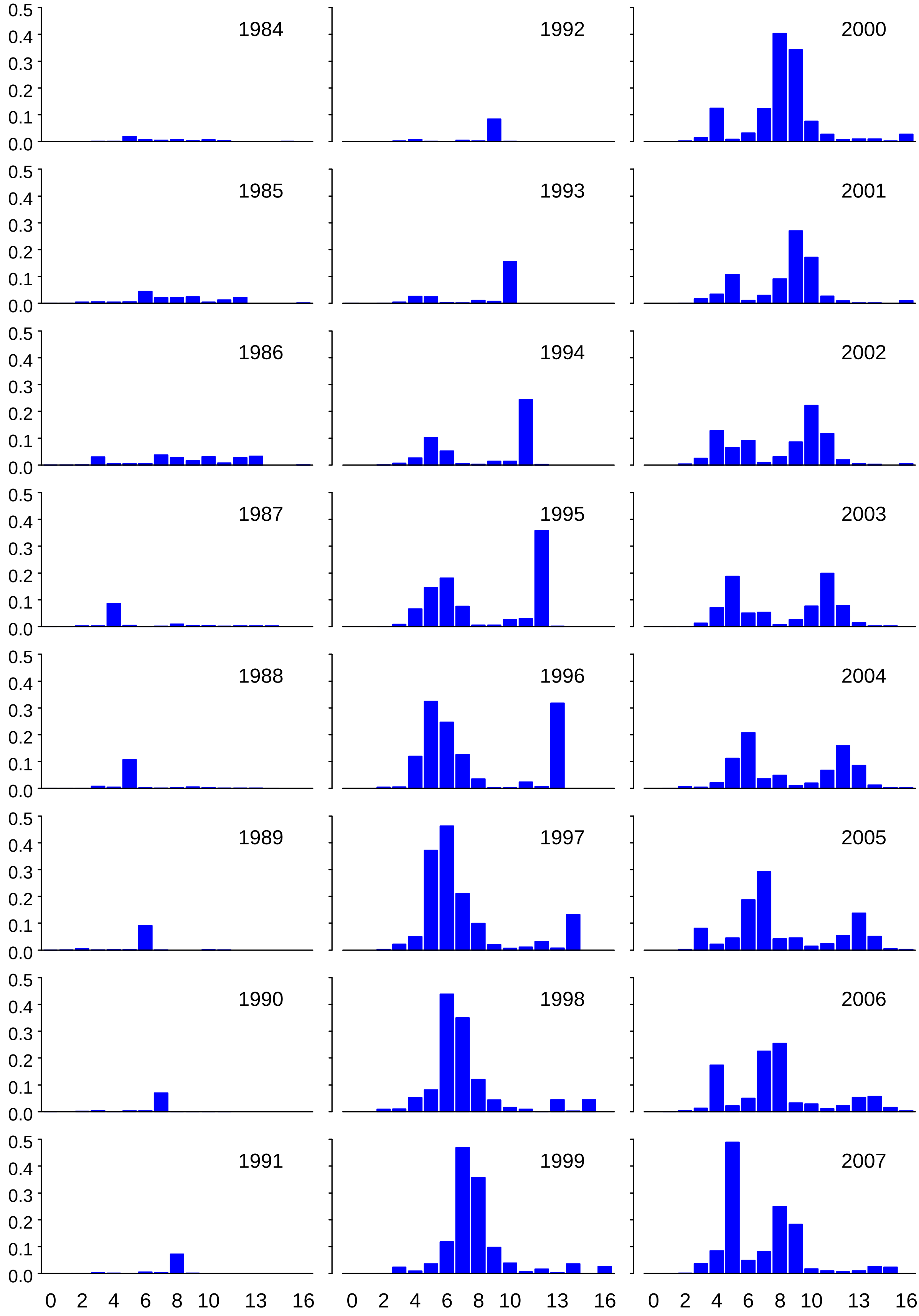


Figure 9.5.1.1.1. Norwegian spring spawning herring. Catch in weight (million tonnes) by age in the years 1984-2007.

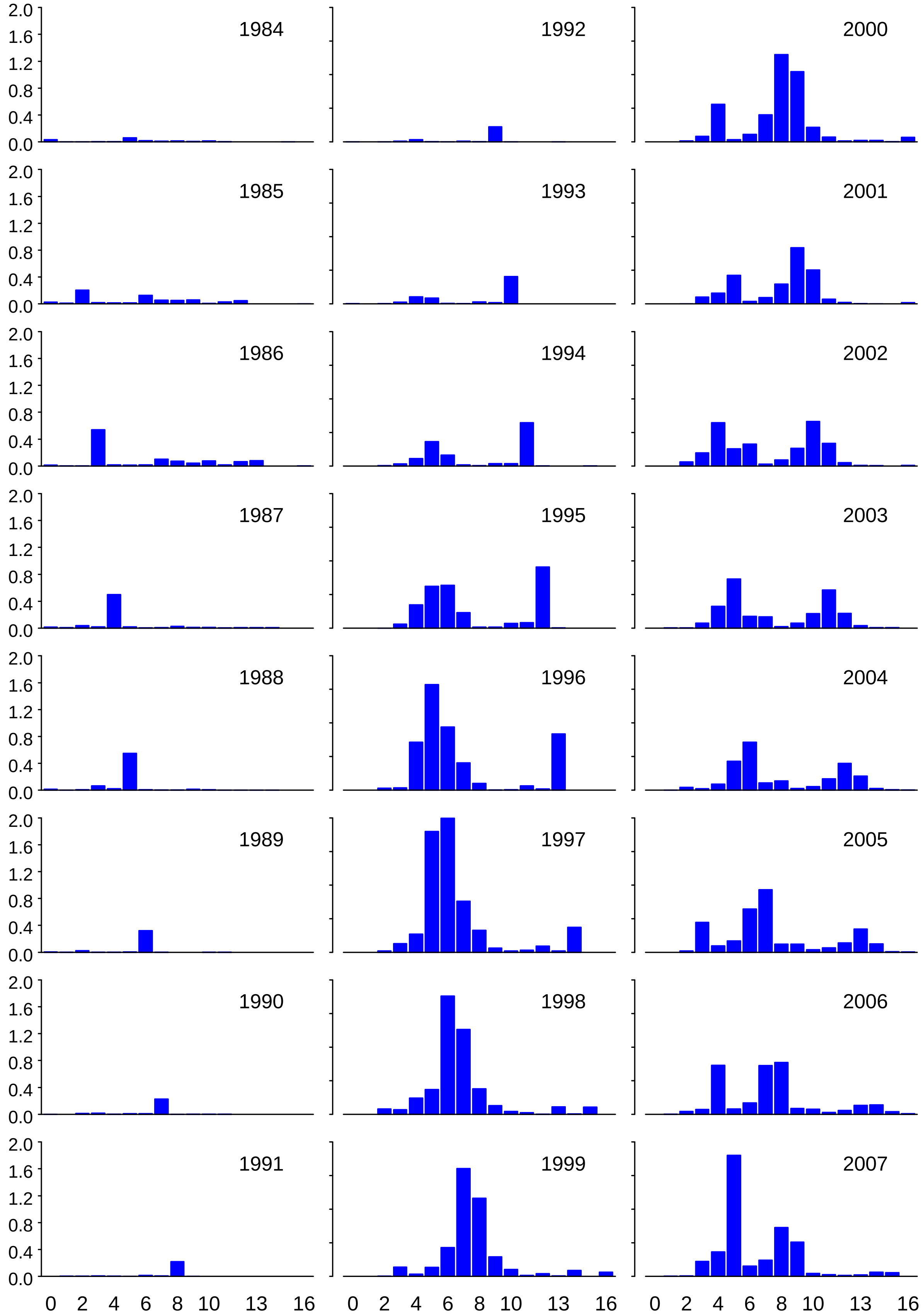


Figure 9.5.1.1.2. Norwegian spring spawning herring. Catch in numbers (billions) by age in the years 1984-2007.

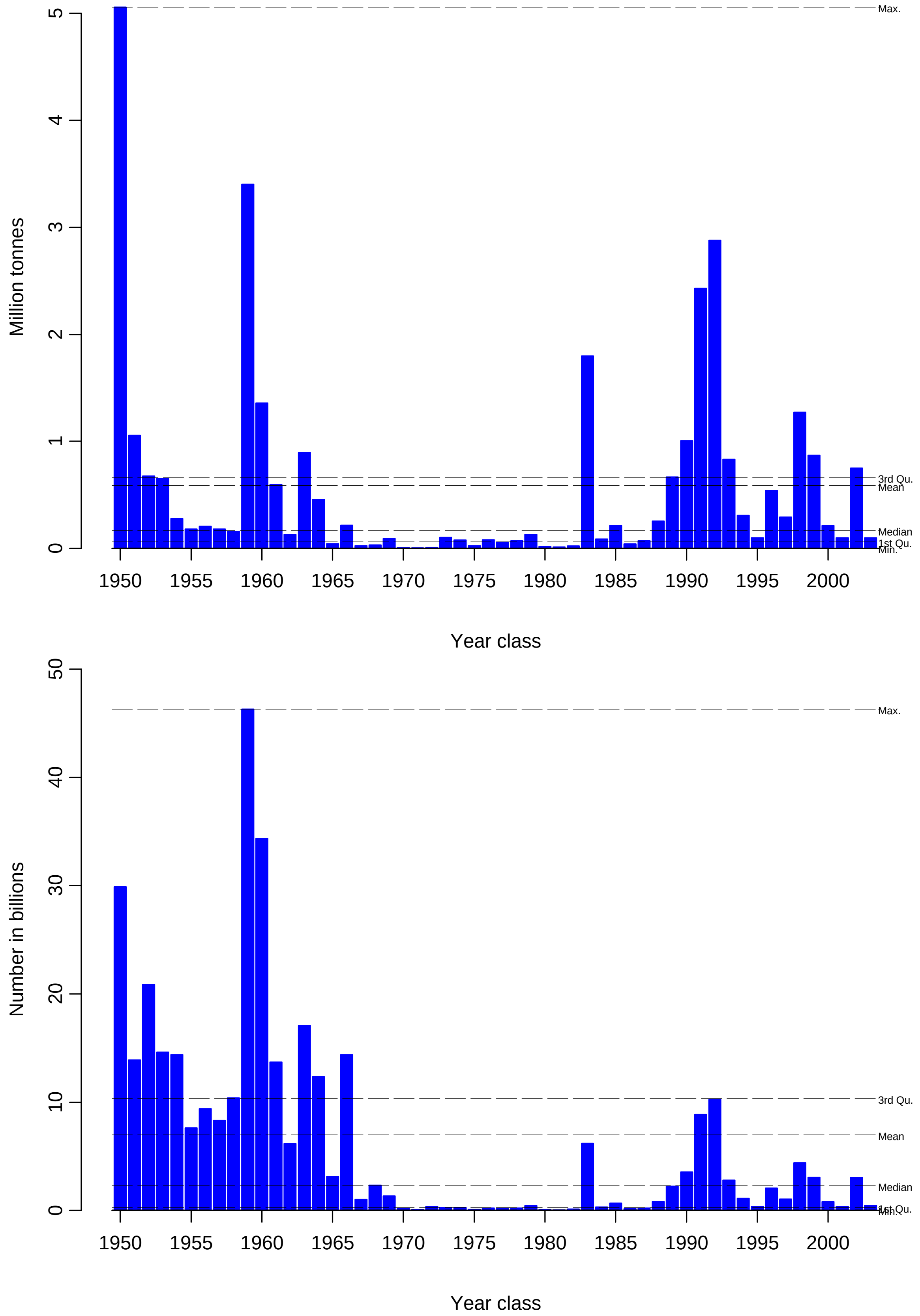


Figure 9.5.1.1.3. Norwegian spring spawning herring. Catches in weight (million tonnes, upper figure) and catches in numbers (billions, lower figure) by year classes in the years 1950-2007. Year classes 1950-1995 are used in the summary statistic.

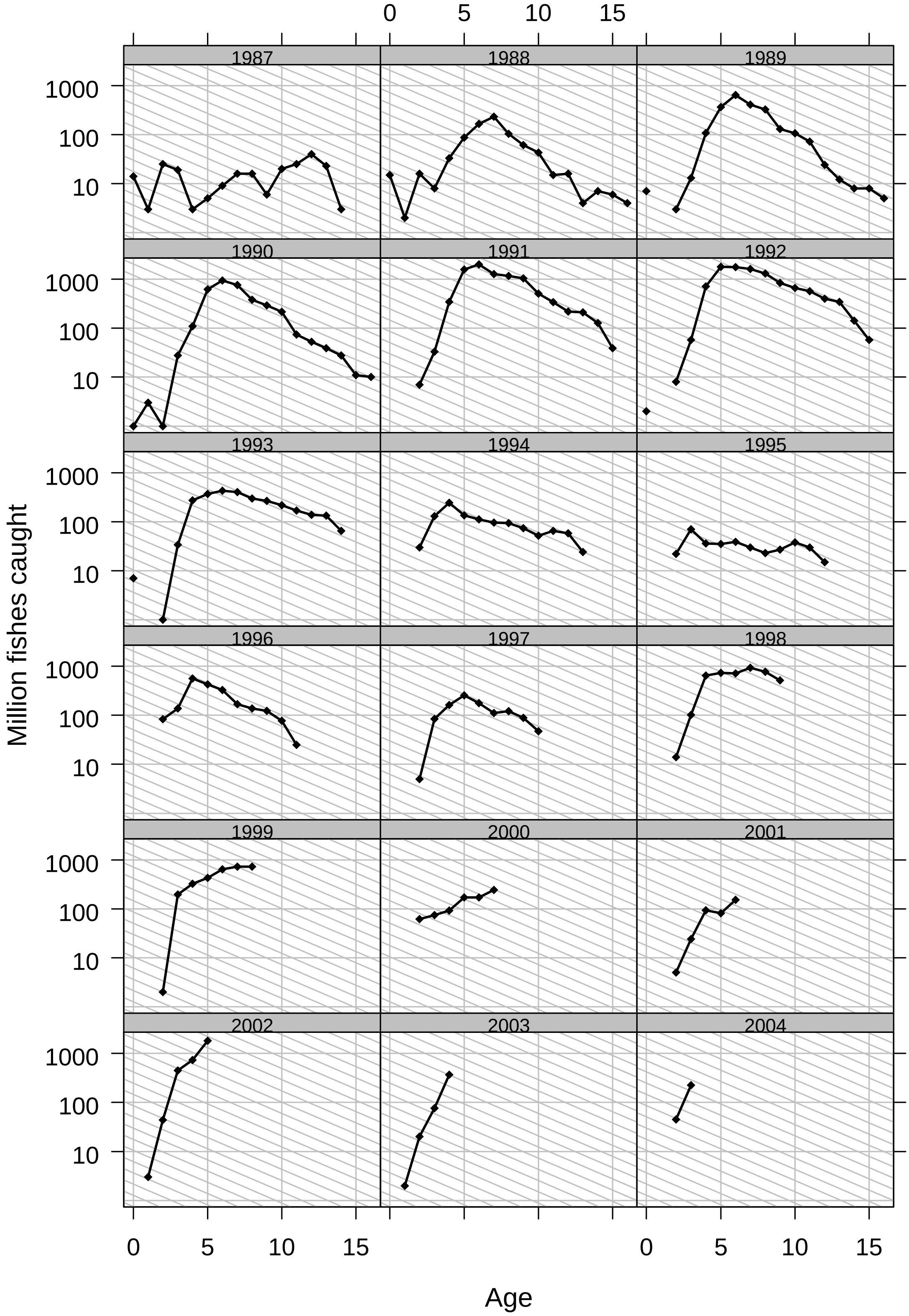


Figure 9.5.1.1.4. Norwegian spring spawning herring. Age disaggregated catch in numbers plotted on a log scale. Age is on x-axis. The labels above each figure indicate year classes. They grey lines correspond to Z=0.3.

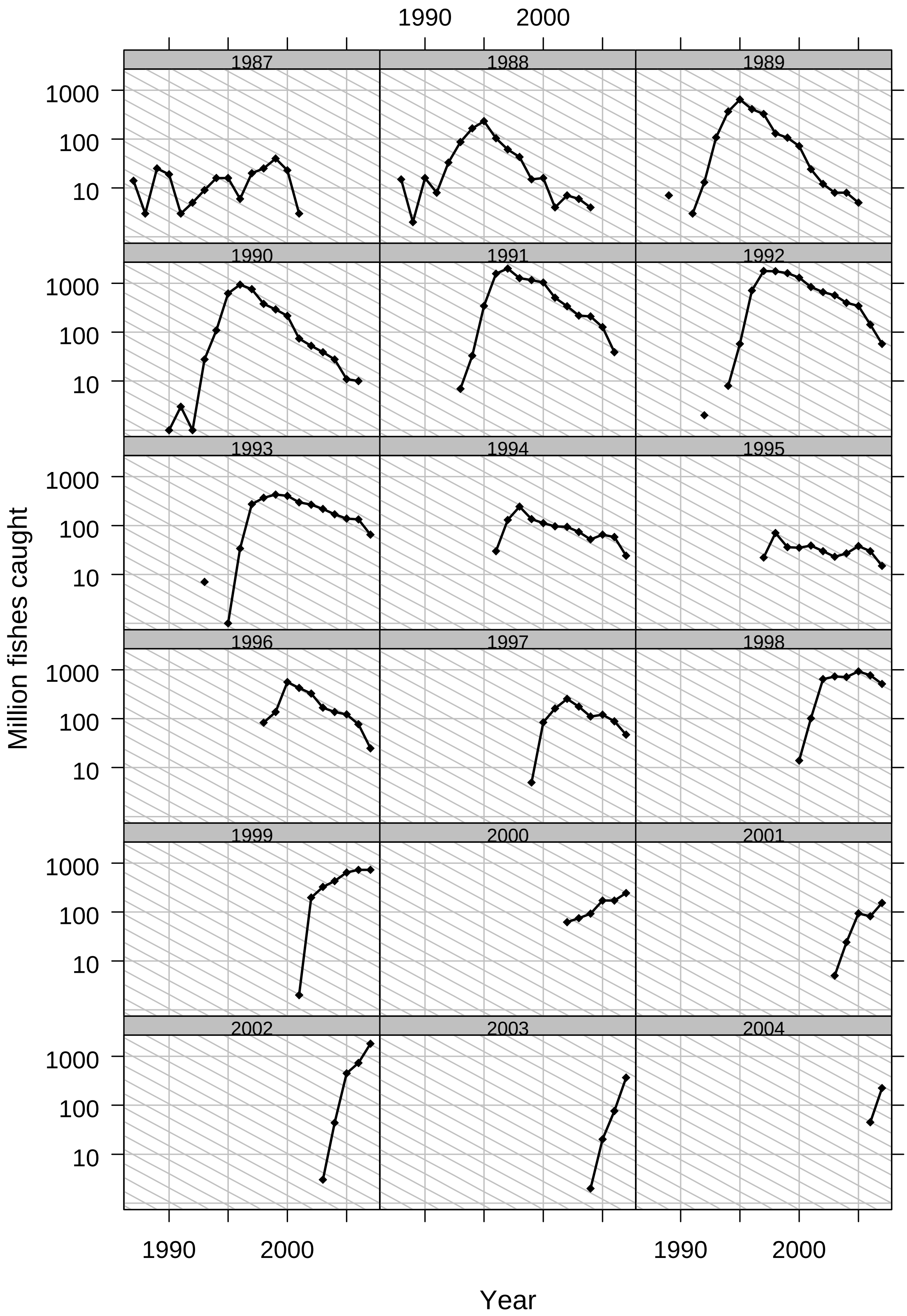


Figure 9.5.1.1.5. Norwegian spring spawning herring. Age disaggregated catch in numbers plotted on a log scale. Year is on the x-axis. The labels above each figure indicate year classes. They grey lines correspond to Z=0.3.

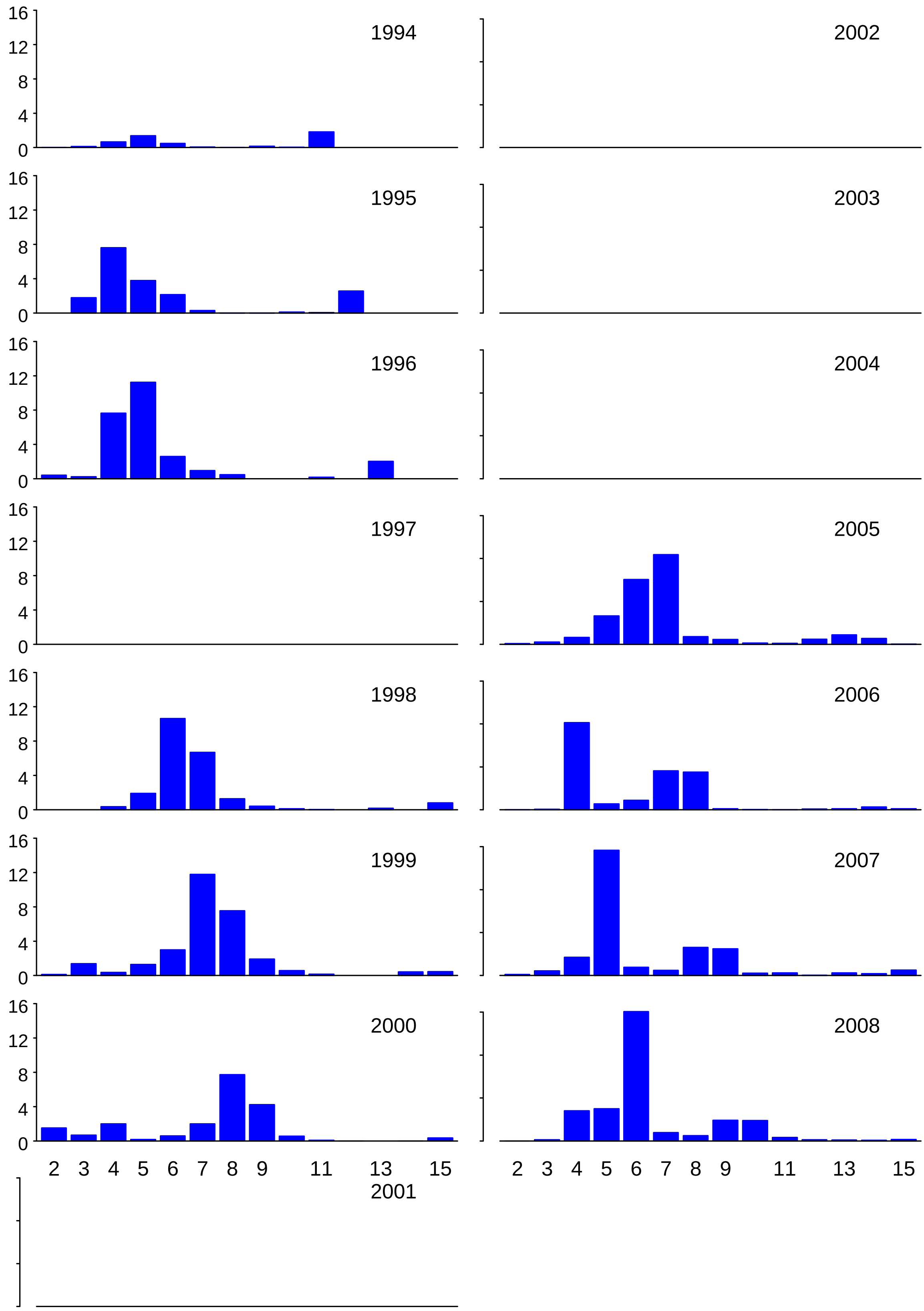


Figure 9.5.1.2.1. Norwegian spring spawning herring. Age disaggregated abundance indices (billions) from the acoustic survey on the spawning stock in February-March (survey 1) in the years 1994-2008.

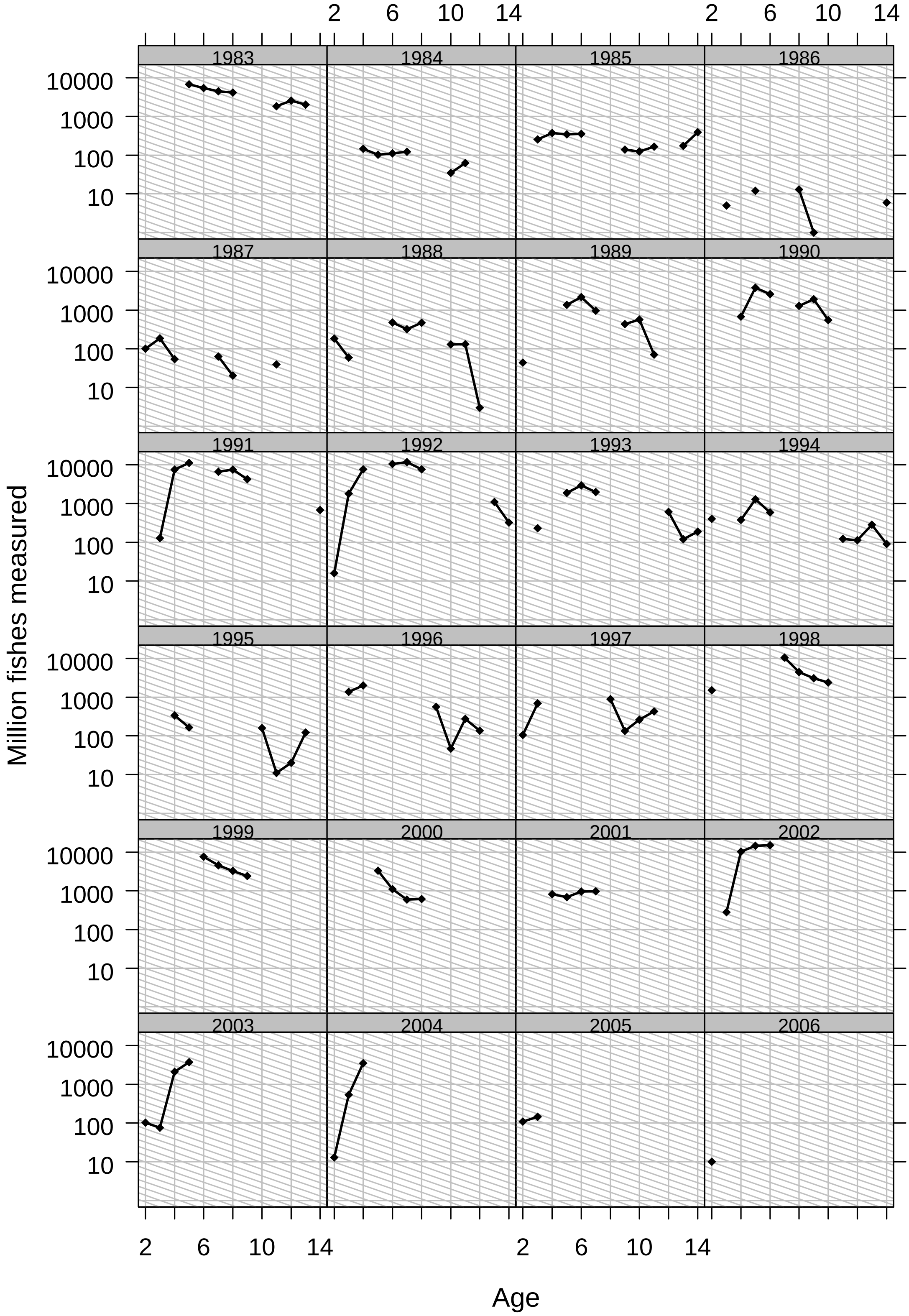


Figure 9.5.1.2.2. Norwegian spring spawning herring. Age disaggregated abundance indices from the acoustic survey on the spawning area in February-March (survey 1) plotted on a log scale. The labels above each figure indicate year classes. The grey lines correspond to Z=0.3.

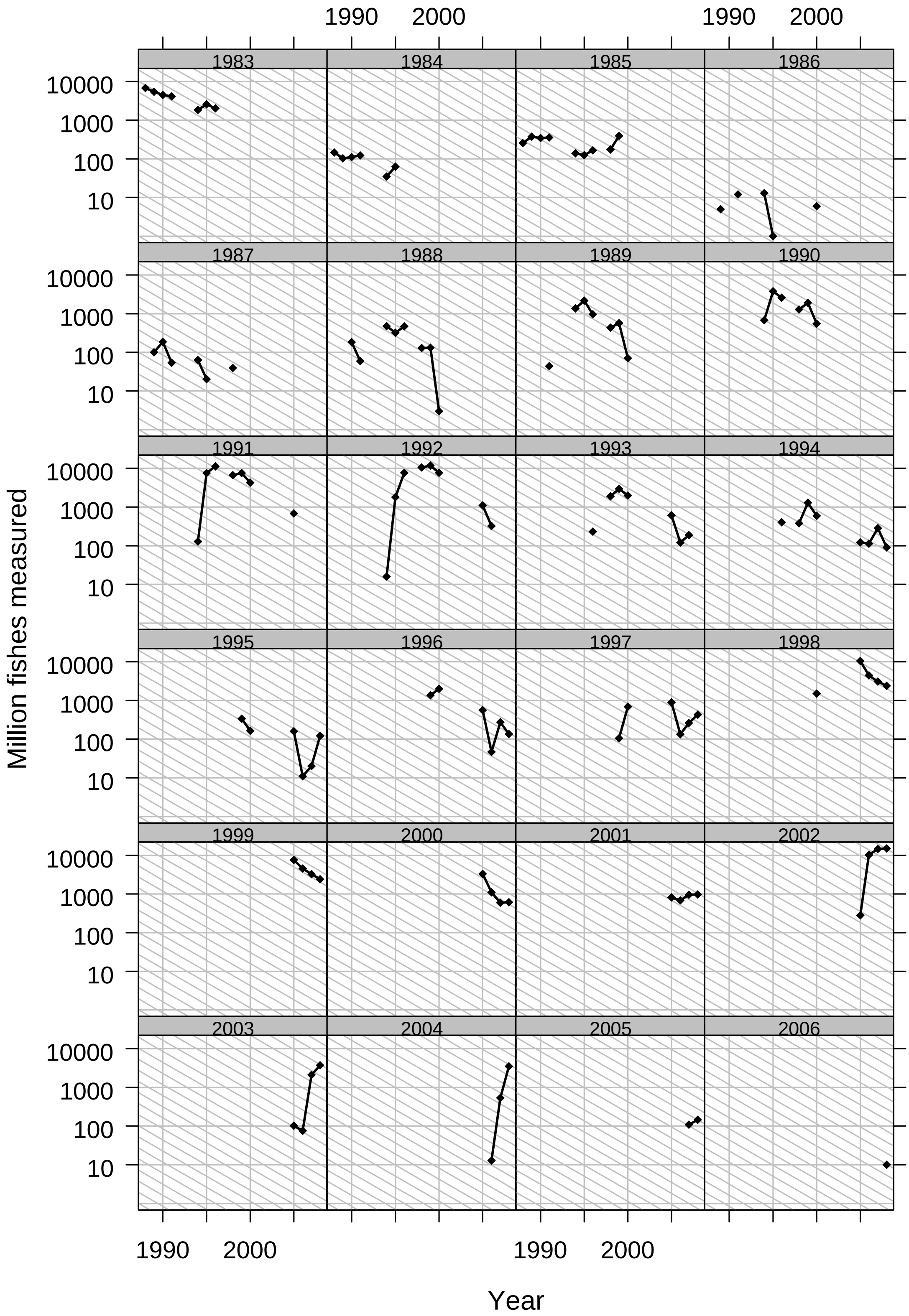


Figure 9.5.1.2.3. Norwegian spring spawning herring. Age disaggregated abundance indices from the acoustic survey on the spawning area in February-March (survey 1) plotted on a log scale. The labels above each figure indicate year classes. The grey lines correspond to Z=0.3.

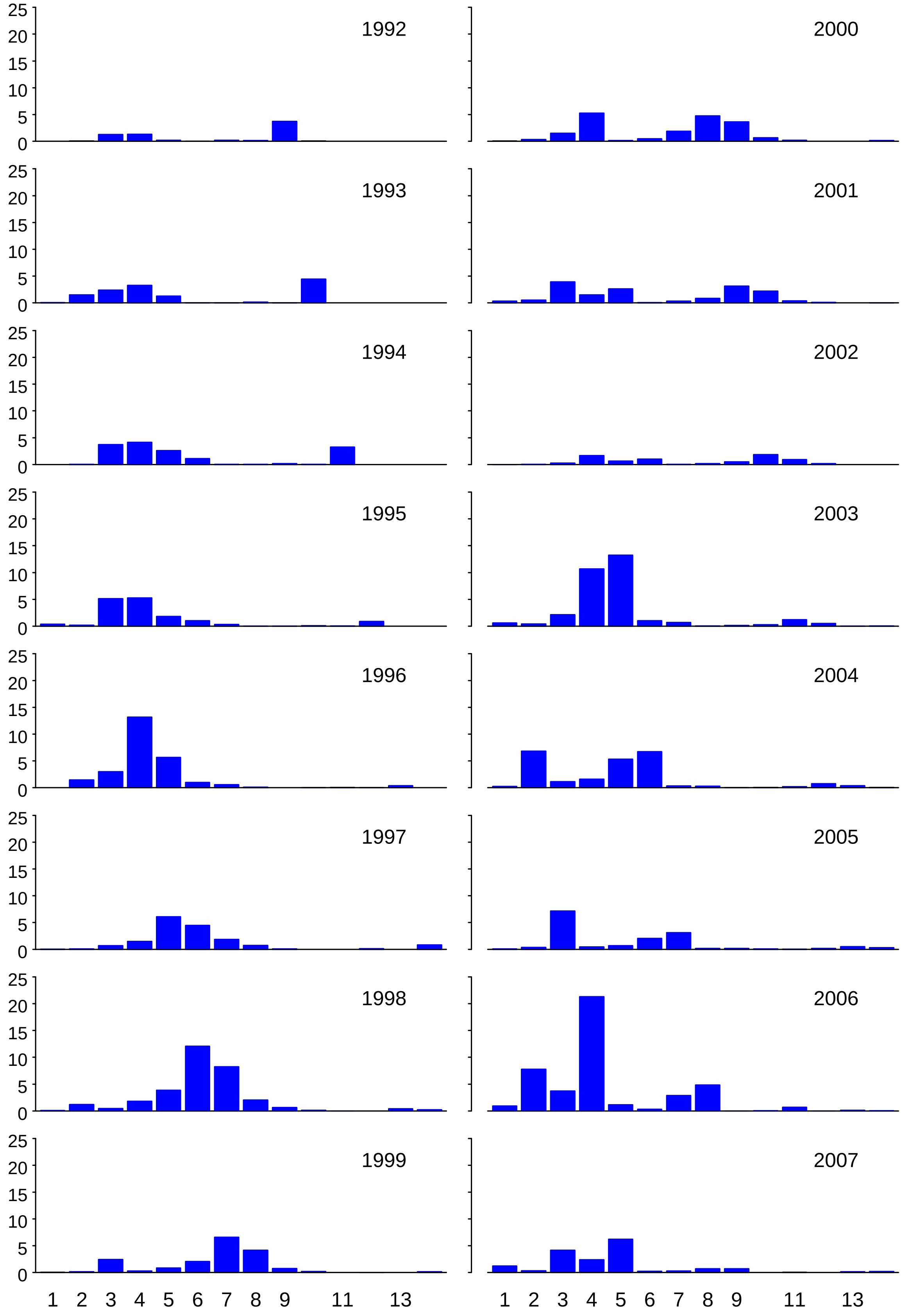


Figure 9.5.1.2.4. Norwegian spring spawning herring. Age disaggregated abundance indices (billions) from the acoustic surveys in the wintering areas in November-December (survey 2) in the years 1992-2007.

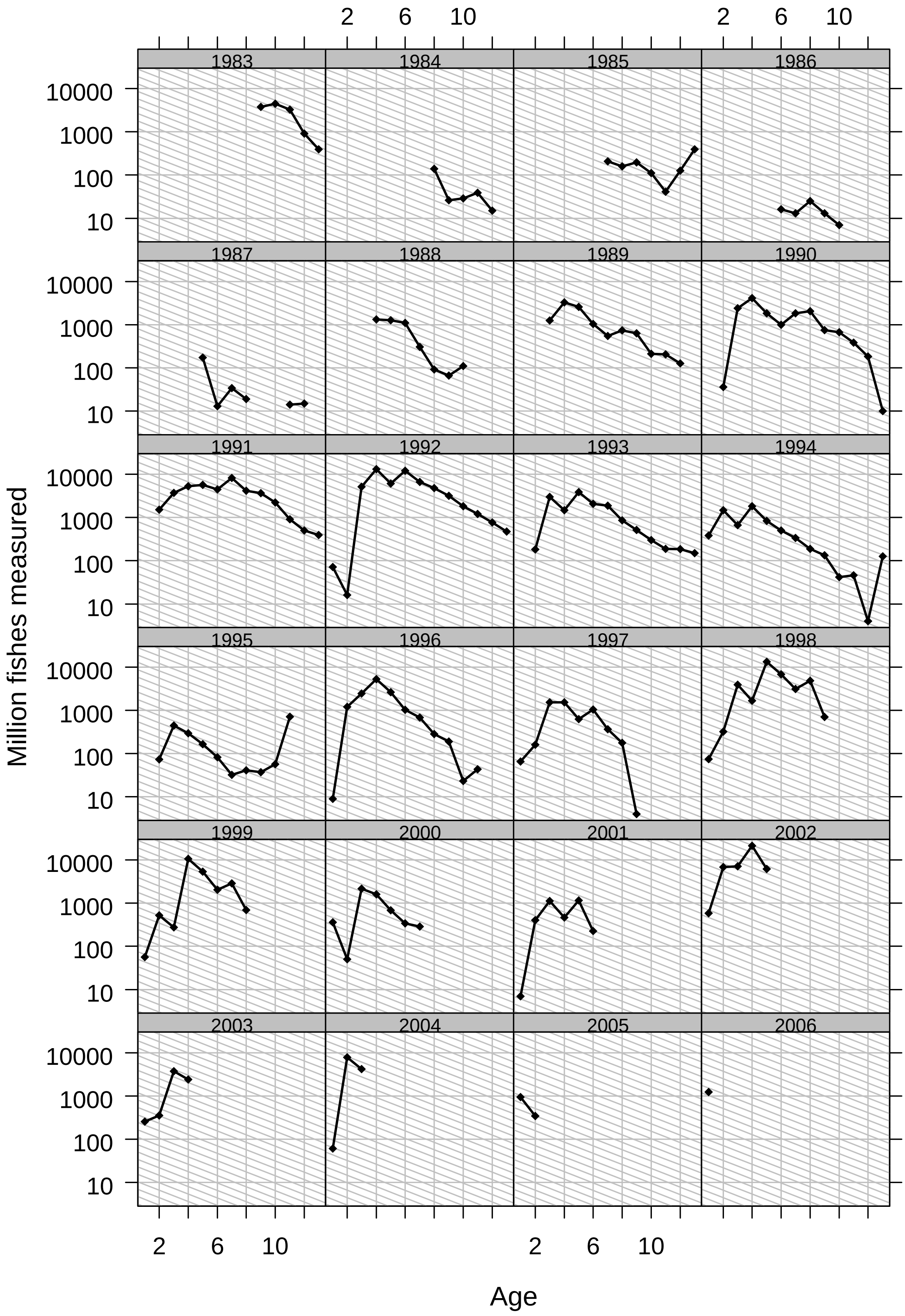


Figure 9.5.1.2.5. Norwegian spring spawning herring. Age disaggregated abundance indices from the acoustic surveys in the wintering areas in November-December (survey 2) plotted on a log scale. The labels above each figure indicate year classes. The grey lines correspond to Z=0.3.

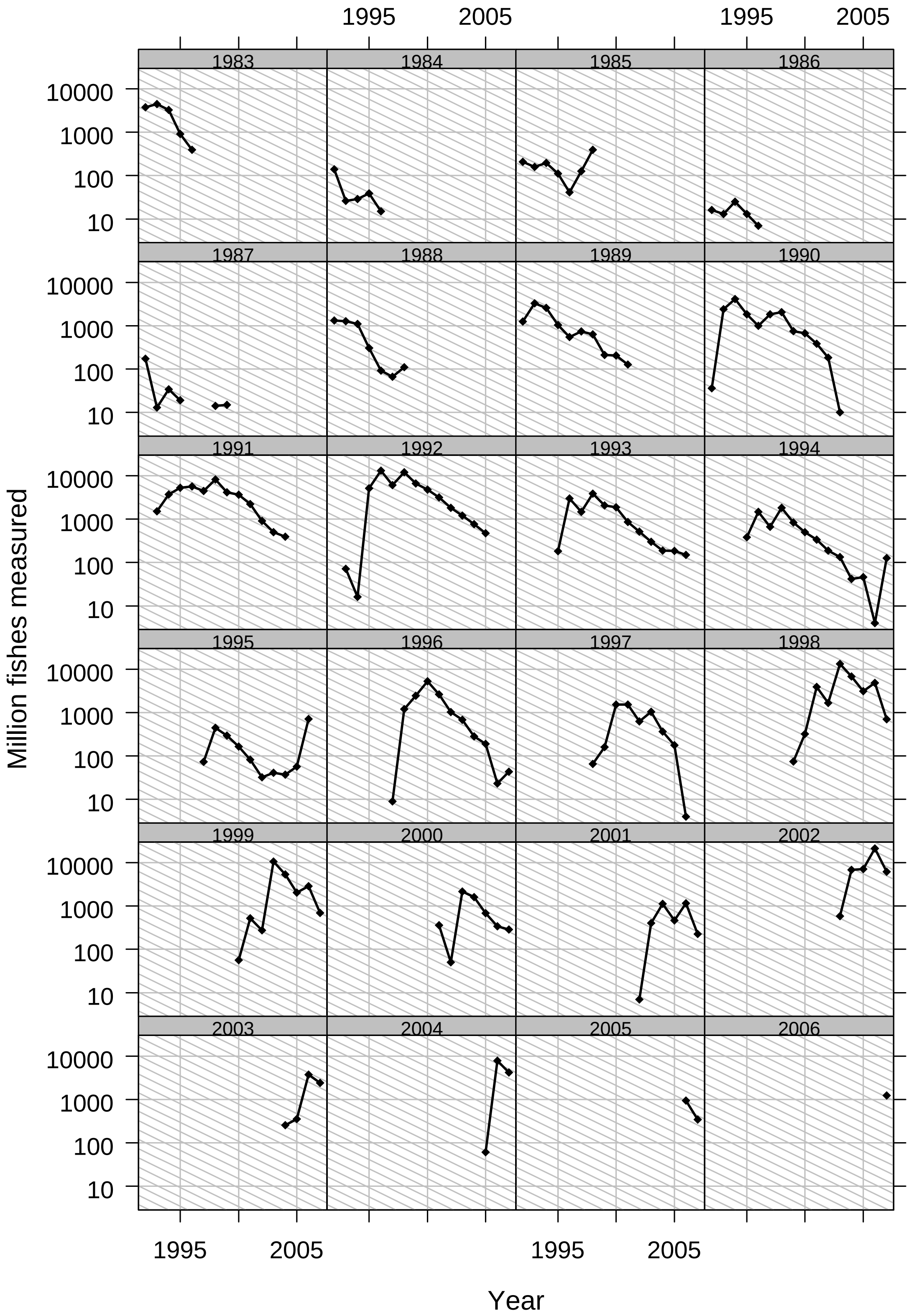


Figure 9.5.1.2.6. Norwegian spring spawning herring. Age disaggregated abundance indices from the acoustic surveys in the wintering areas in November-December (survey 2) plotted on a log scale. The labels above each figure indicate year classes. The grey lines correspond to Z=0.3.

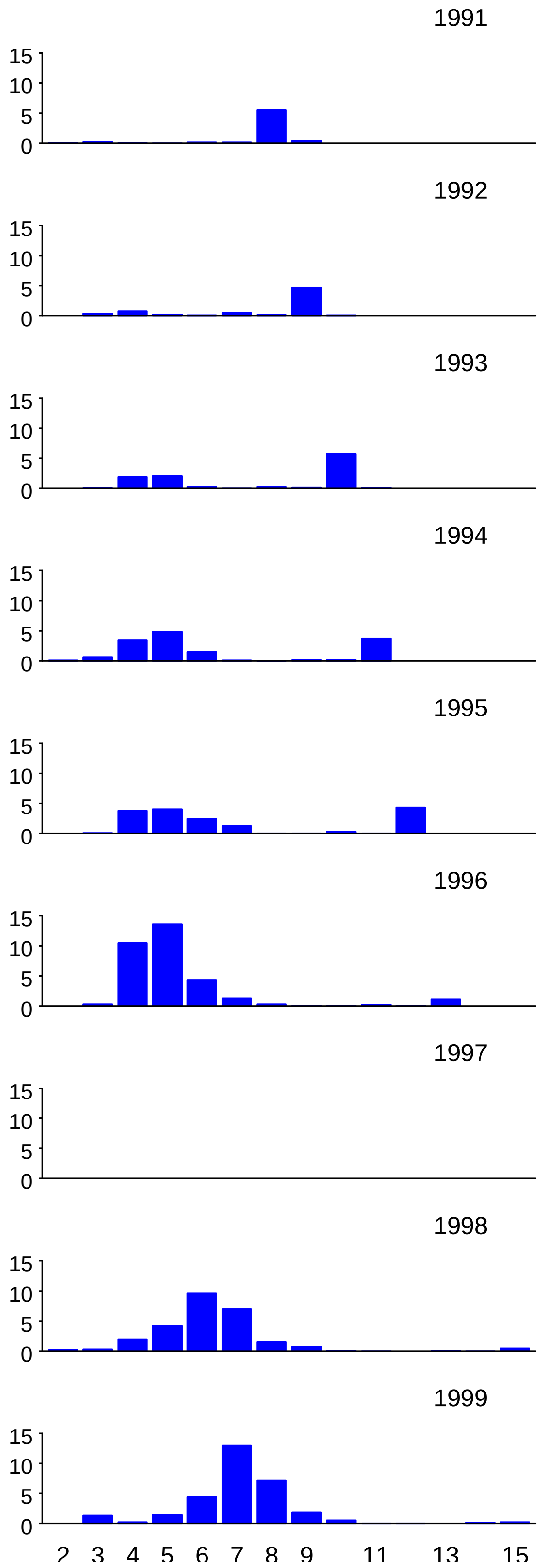


Figure 9.5.1.2.7. Norwegian spring spawning herring. Age disaggregated abundance indices (billions) from the acoustic surveys in the wintering areas in January (survey 3) in the years 1991-1999.

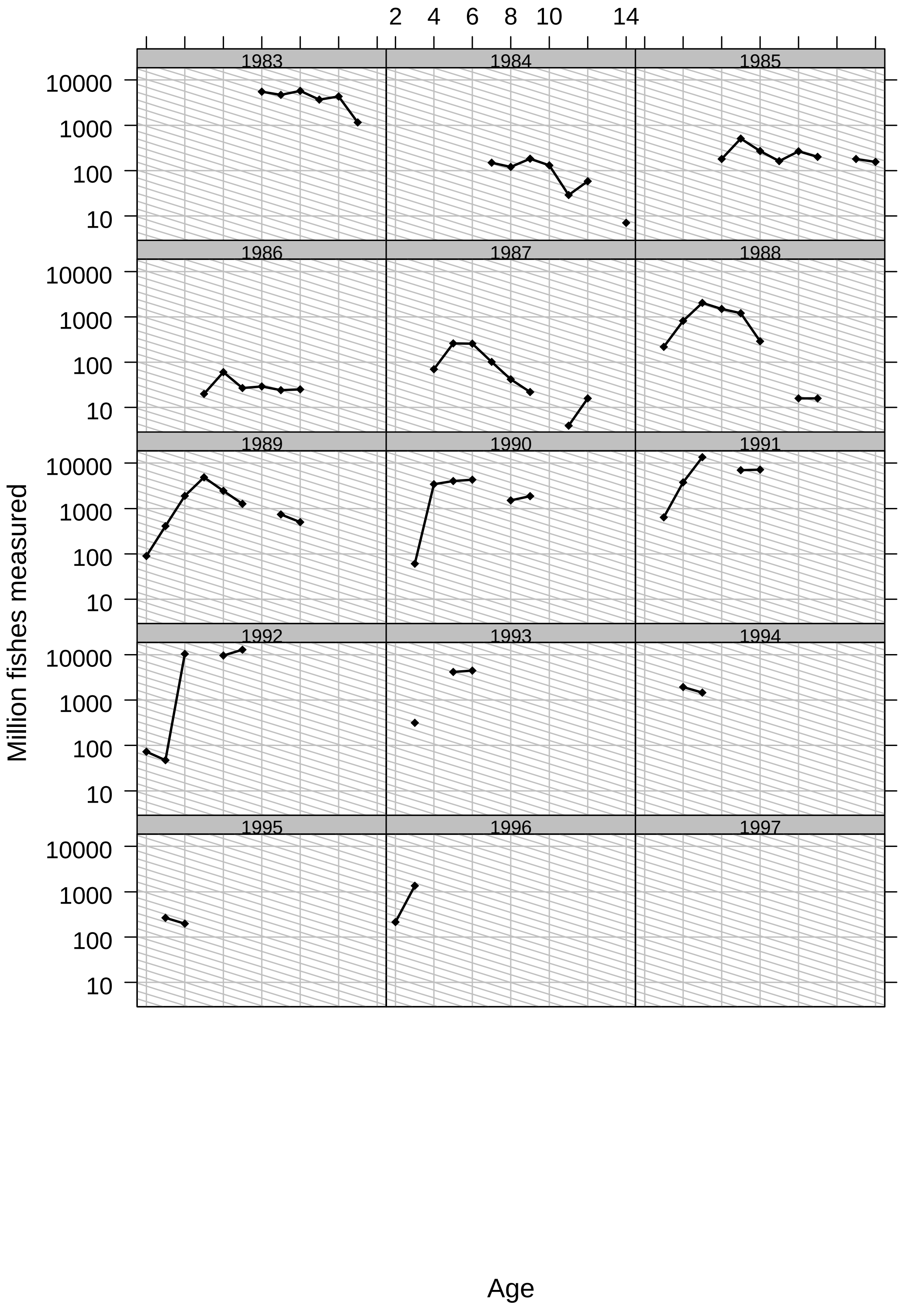


Figure 9.5.1.2.8. Norwegian spring spawning herring. Age disaggregated abundance indices from the acoustic surveys in the wintering areas in January (survey 3) plotted on a log scale. The labels above each figure indicate year classes. The grey lines correspond to Z=0.3.

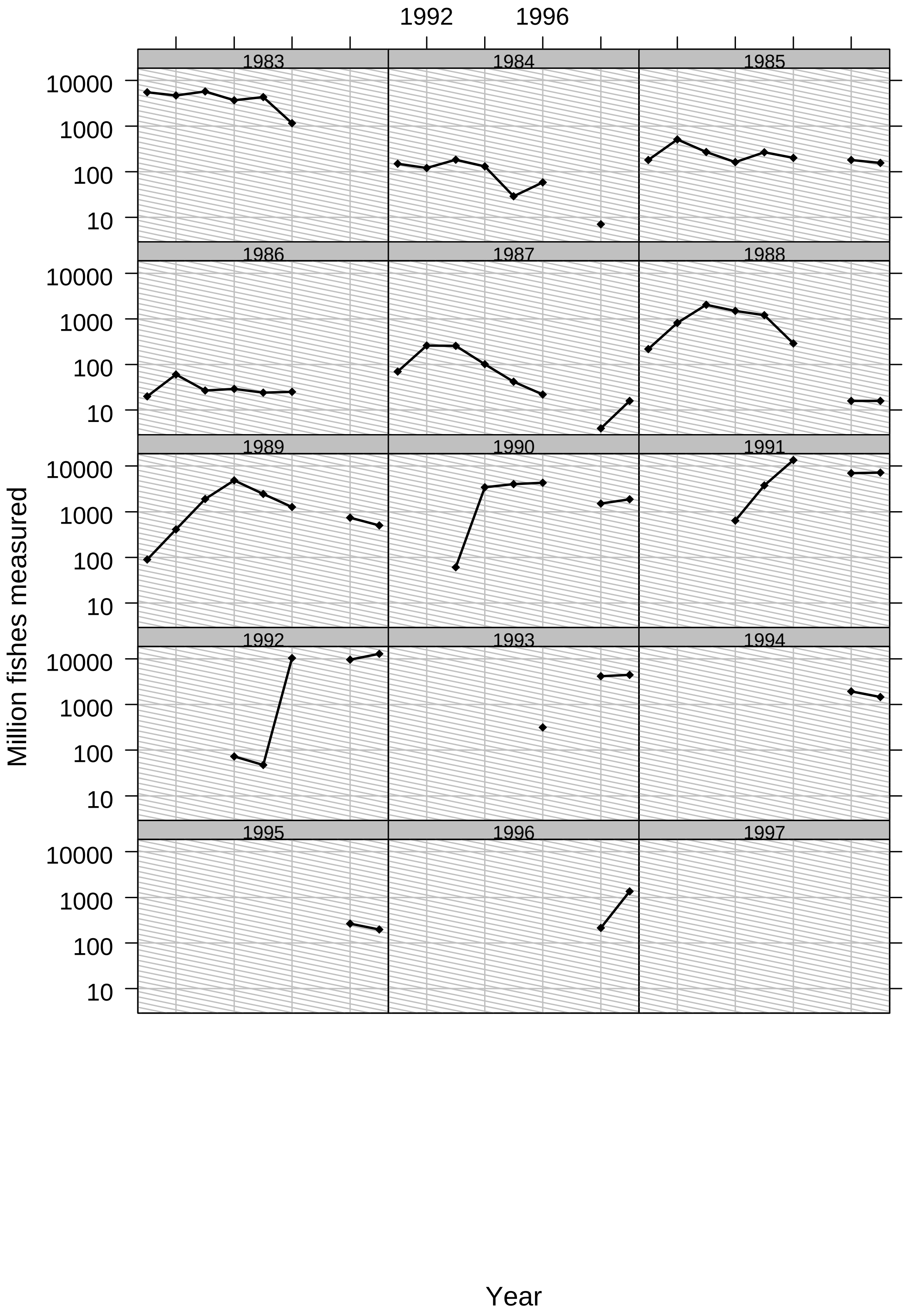


Figure 9.5.1.2.9. Norwegian spring spawning herring. Age disaggregated abundance indices from the acoustic surveys in the wintering areas in January (survey 3) plotted on a log scale. The labels above each figure indicate year classes. The grey lines correspond to Z=0.3.

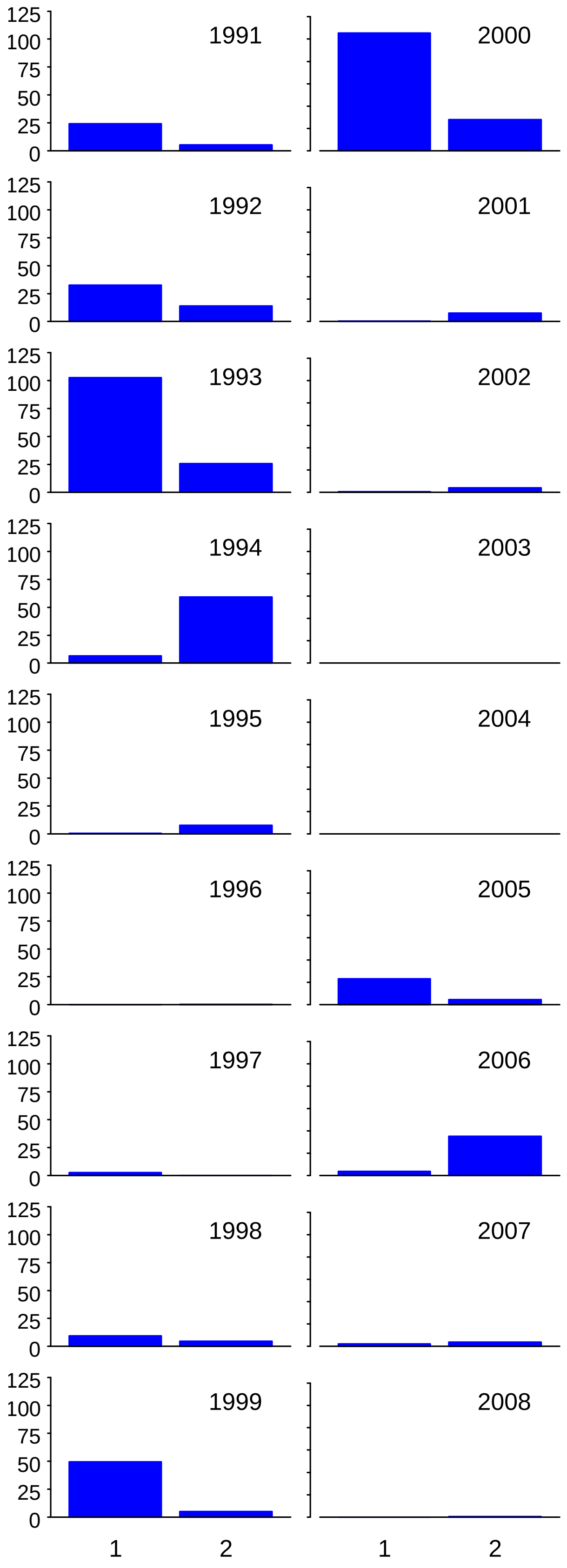


Figure 9.5.1.2.10. Survey 4.

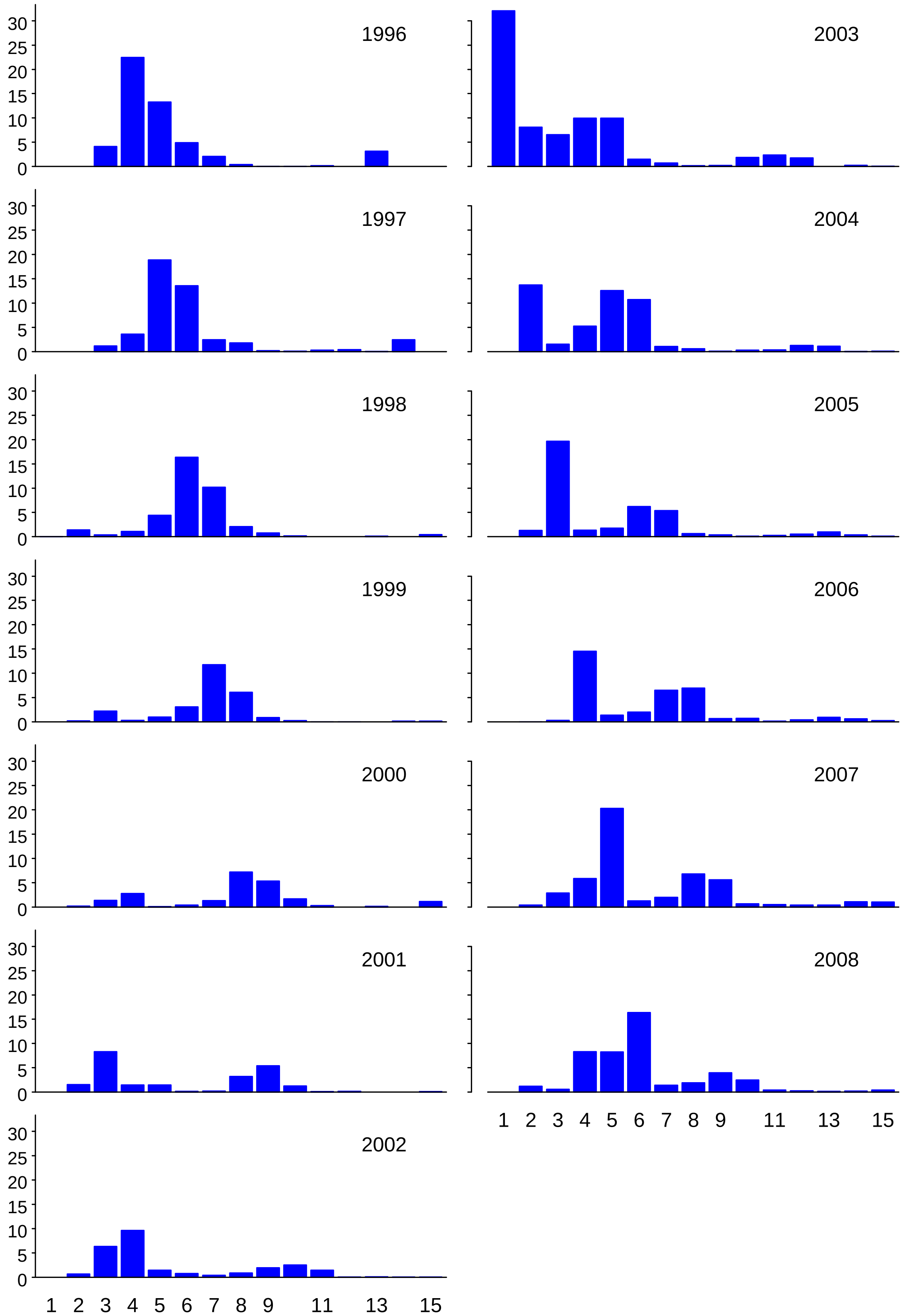


Figure 9.5.1.2.11. Norwegian spring spawning herring. Age disaggregated abundance indices (billions) from the acoustic survey on the feeding area in the Norwegian Sea in May (survey 5) in the years 1996-2008.

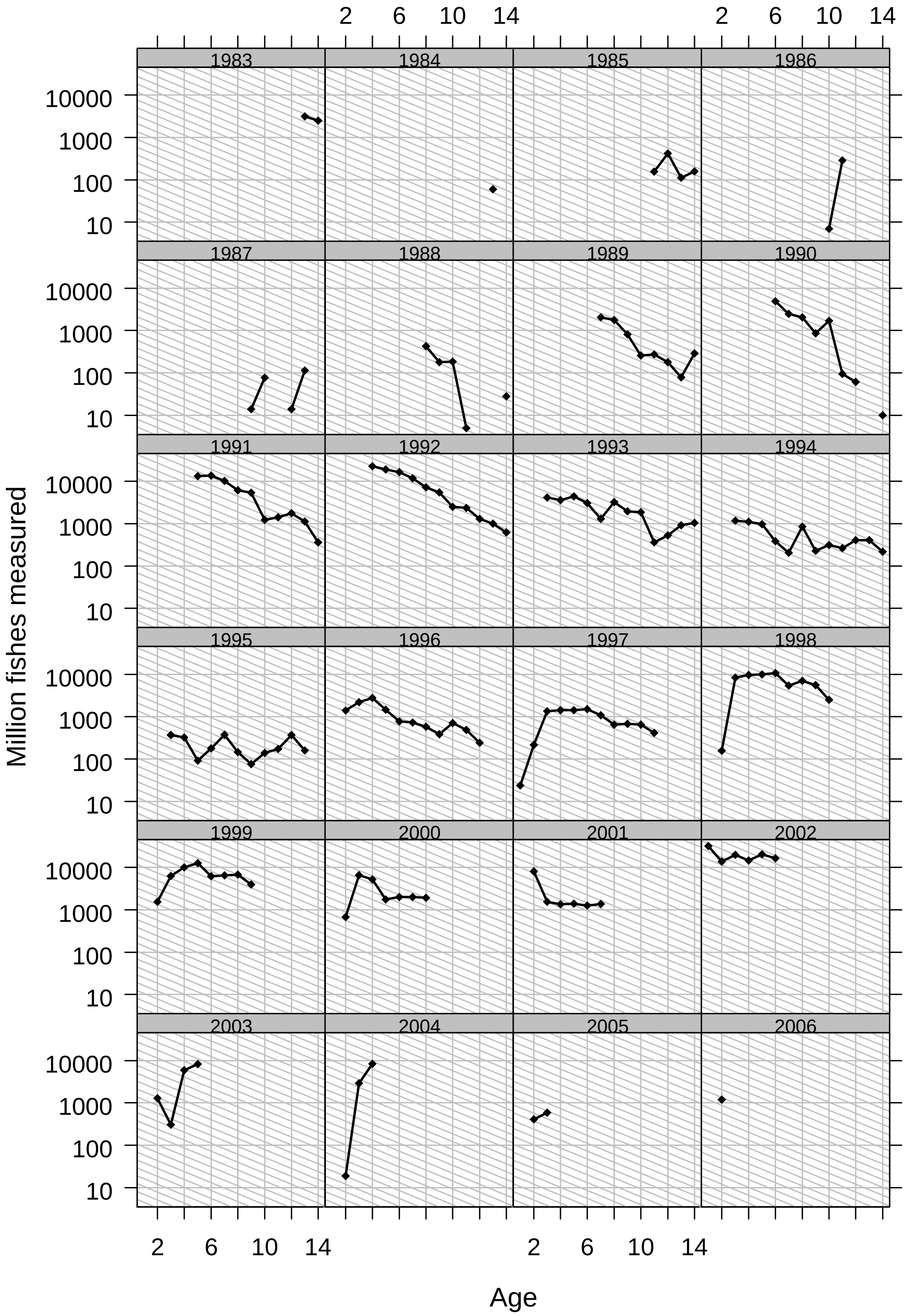


Figure 9.5.1.2.12. Norwegian spring spawning herring. Age disaggregated abundance indices (billions) from the acoustic survey on the feeding area in the Norwegian Sea in May (survey 5) plotted on a log scale. The labels above each figure indicate year classes. The grey lines correspond to Z=0.3.

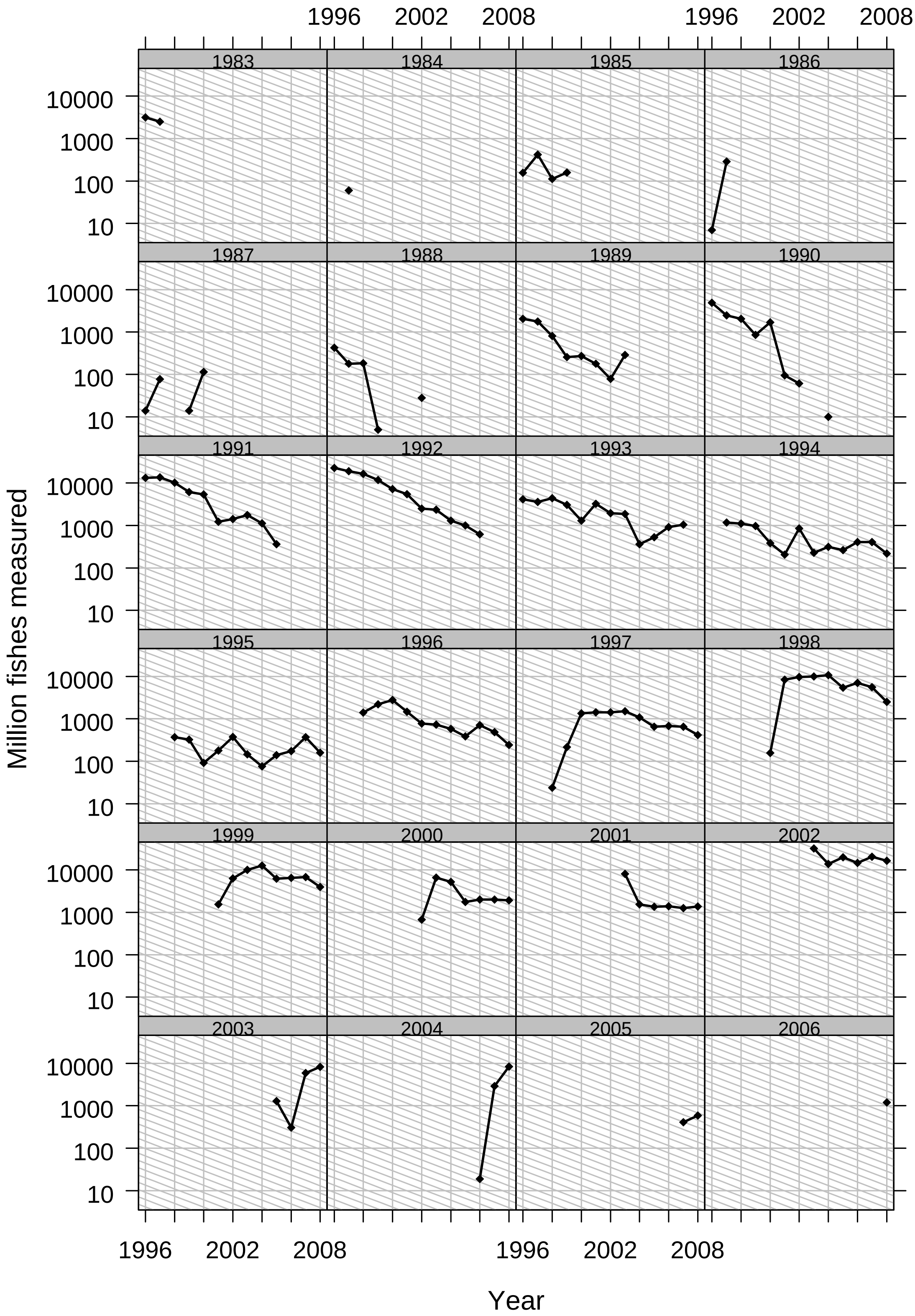


Figure 9.5.1.2.13. Norwegian spring spawning herring. Age disaggregated abundance indices (billions) from the acoustic survey on the feeding area in the Norwegian Sea in May (survey 5) plotted on a log scale. The labels above each figure indicate year classes. The grey lines correspond to Z=0.3.

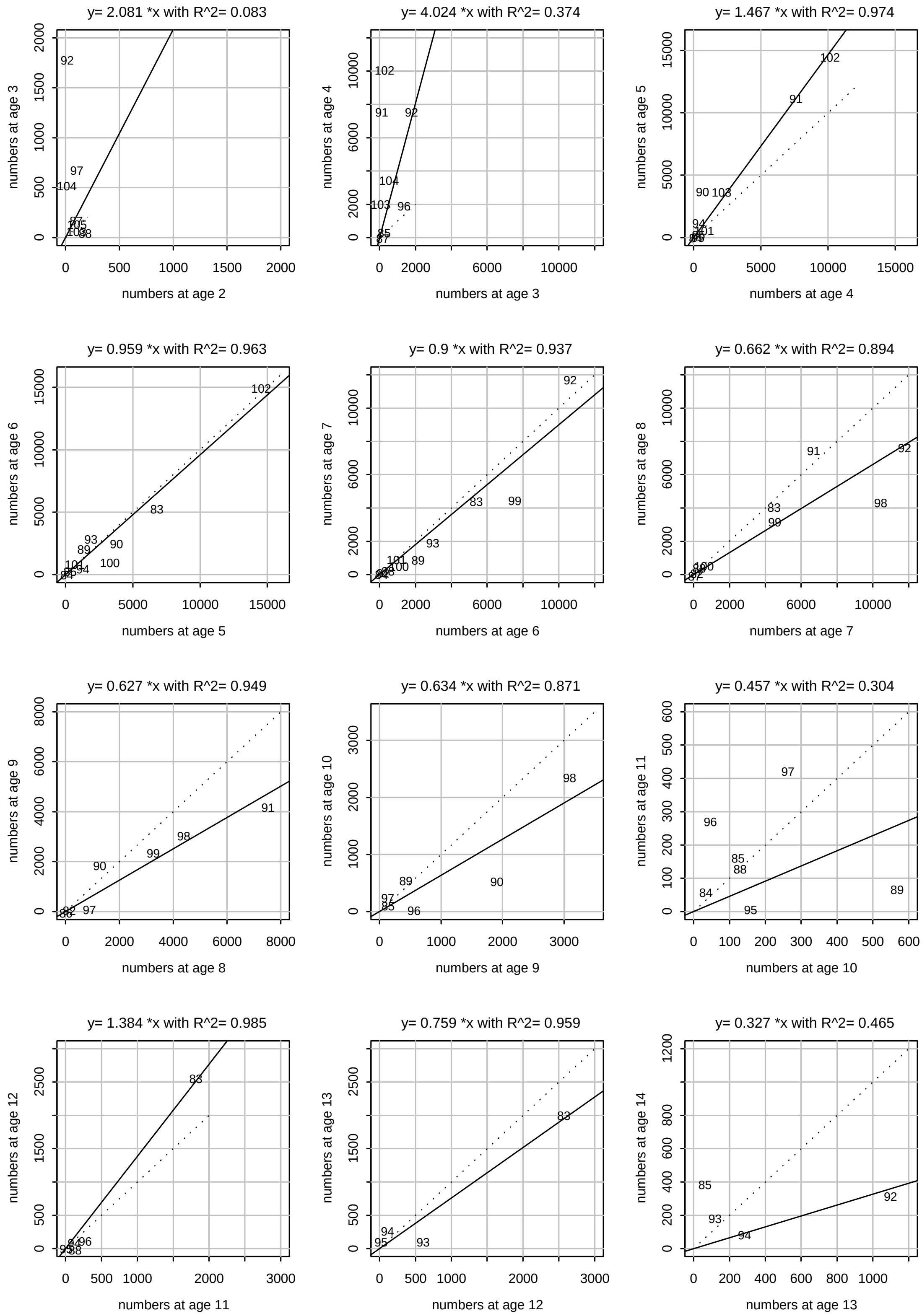


Figure 9.5.1.3.1. Survey 1 with survey 1.

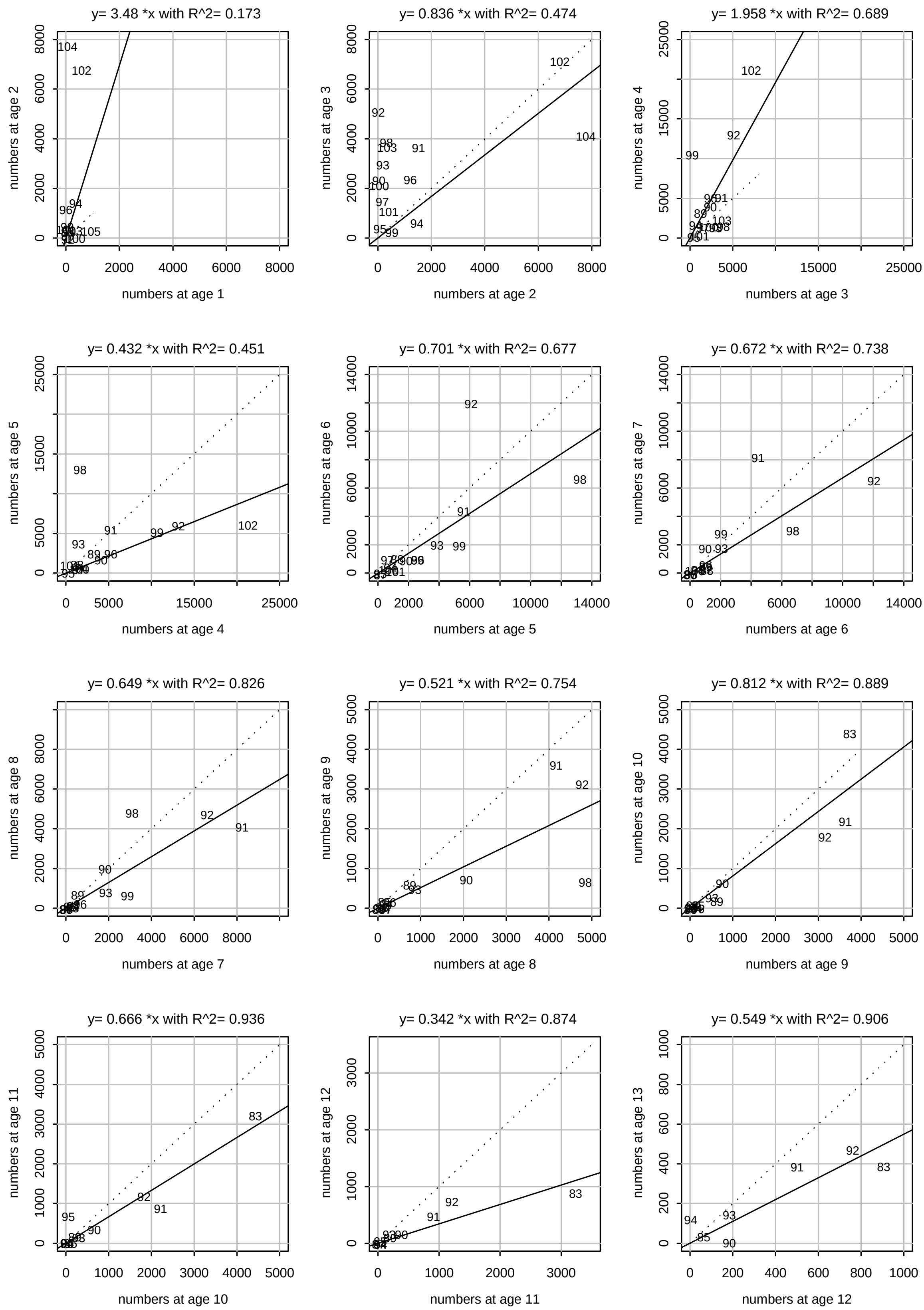


Figure 9.5.1.3.2. Survey 2 with survey 2.

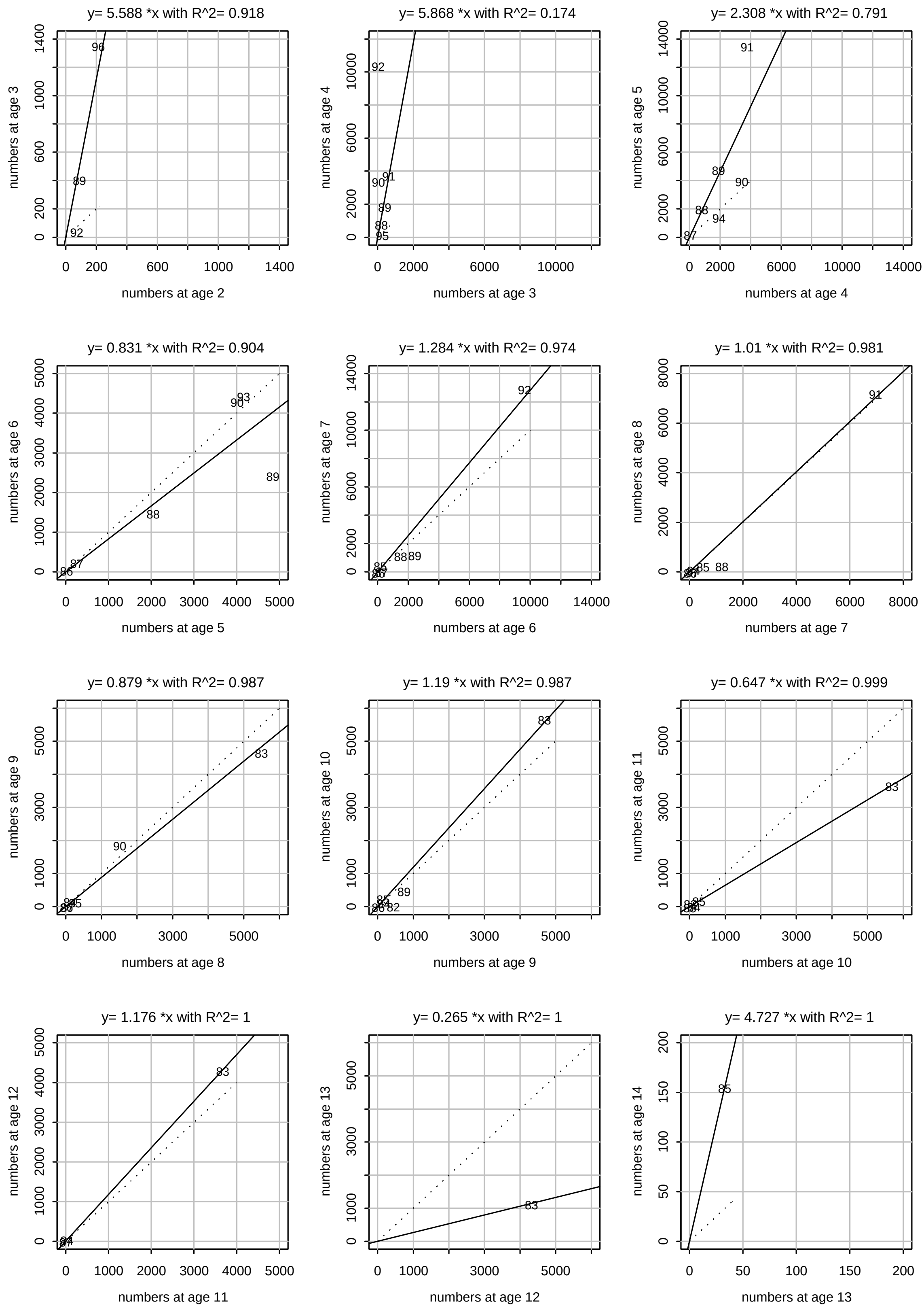


Figure 9.5.1.3.3. Survey 3 with survey 3.

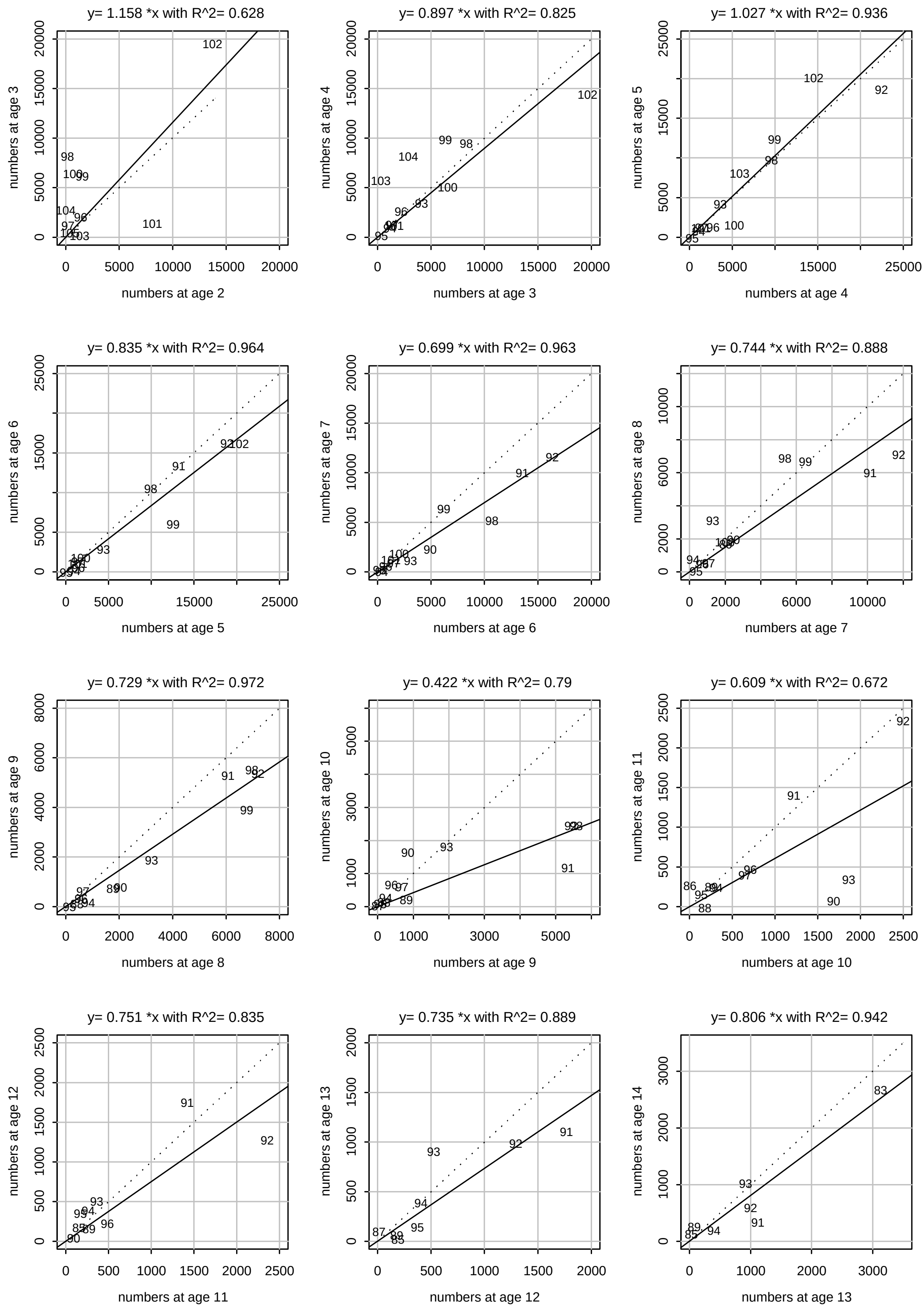


Figure 9.5.1.3.4. Survey 5 with survey 5.

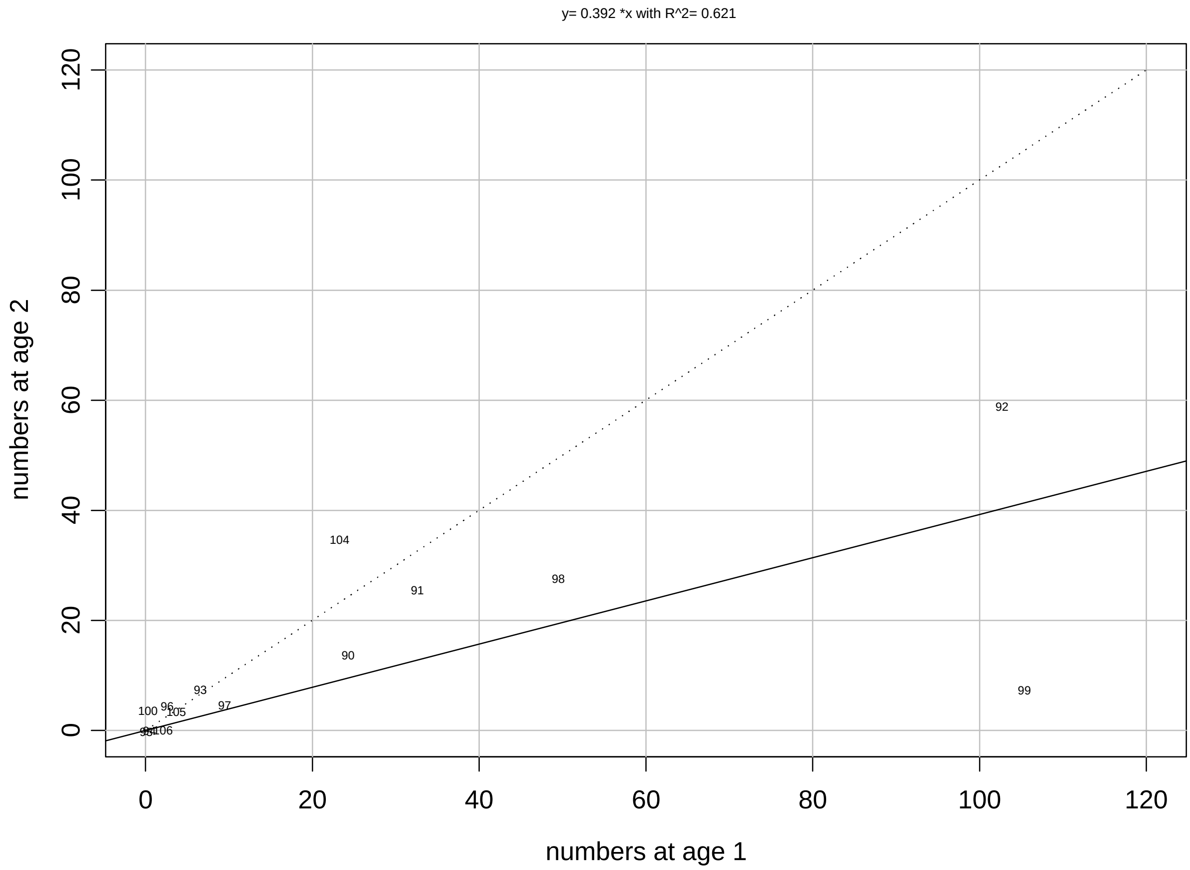


Figure 9.5.1.3.5. Survey 4 with survey 4.

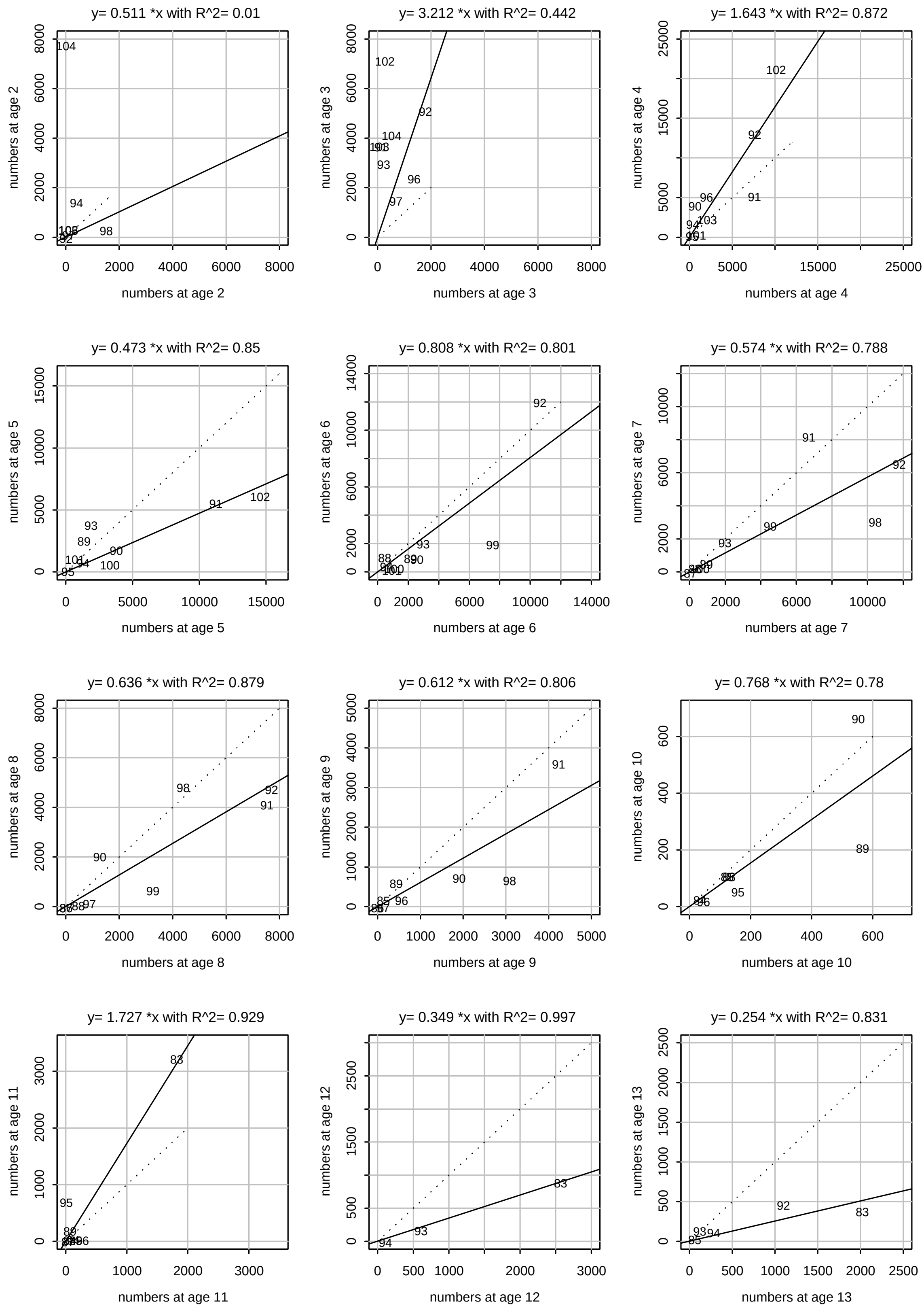


Figure 9.5.1.3.6. Survey 1 (x-axis) vs. survey 2 (y-axis).

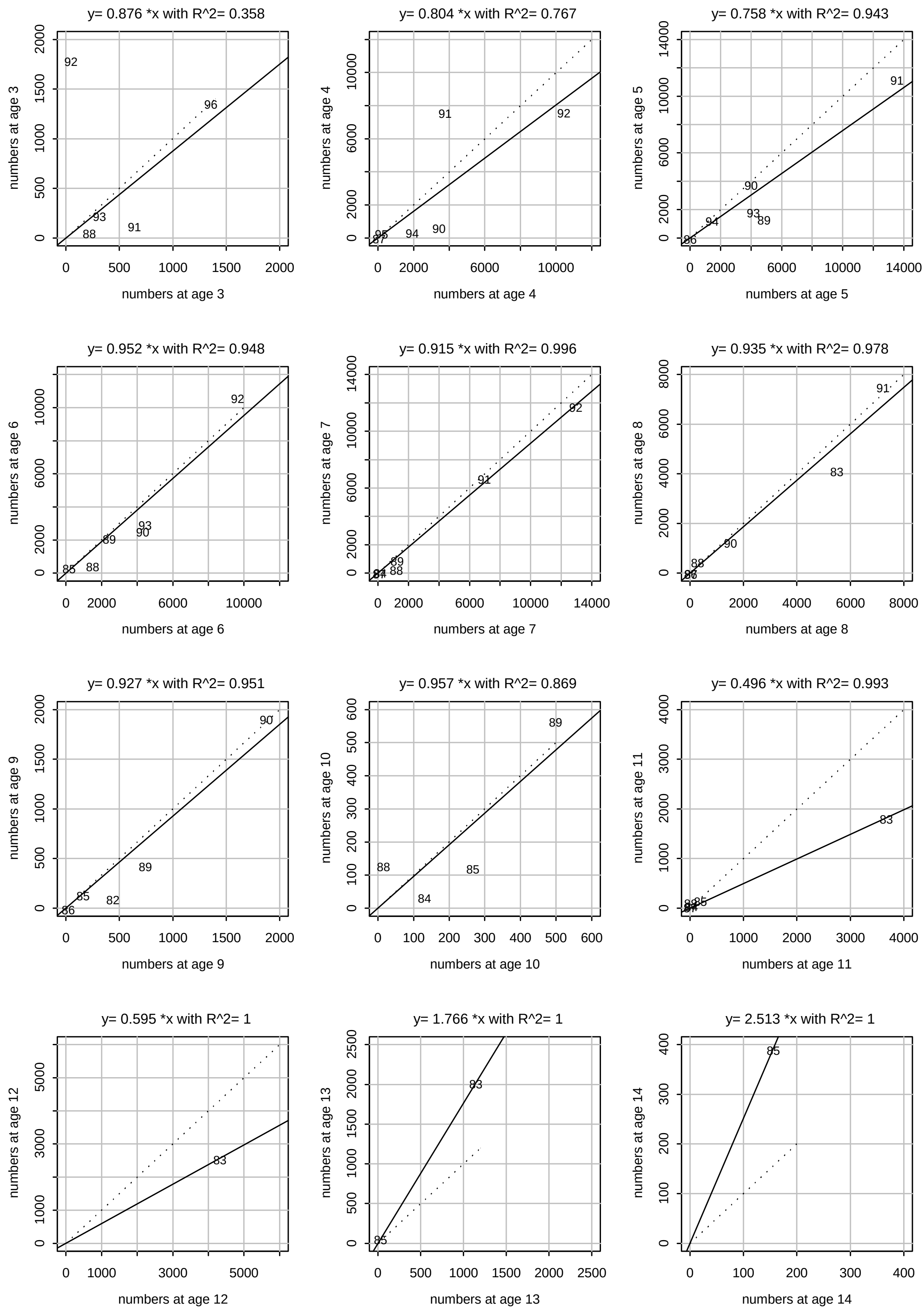


Figure 9.5.1.3.7. Survey 3 vs. survey 1

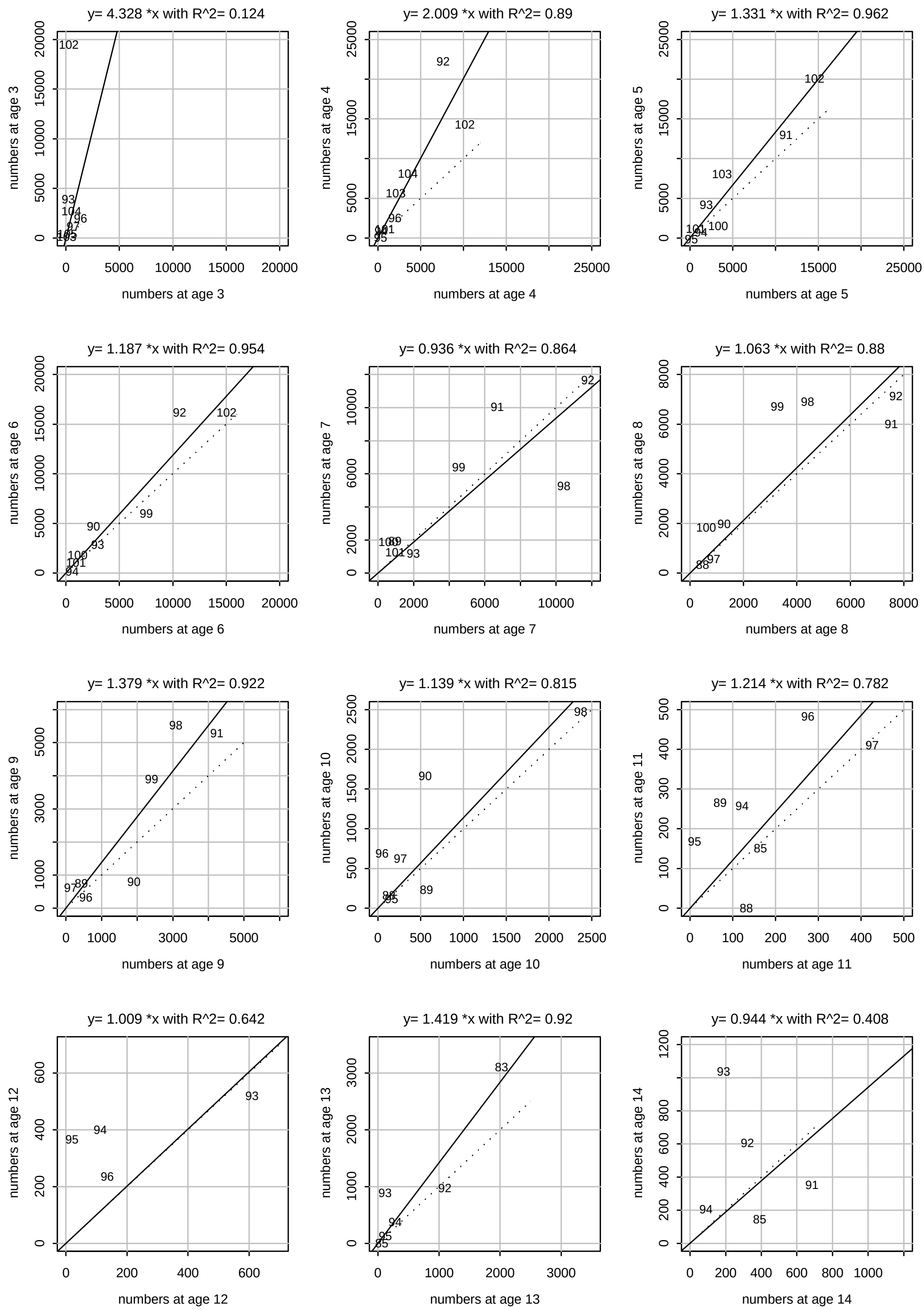


Figure 9.5.1.3.8. Survey 1 vs. survey 5.

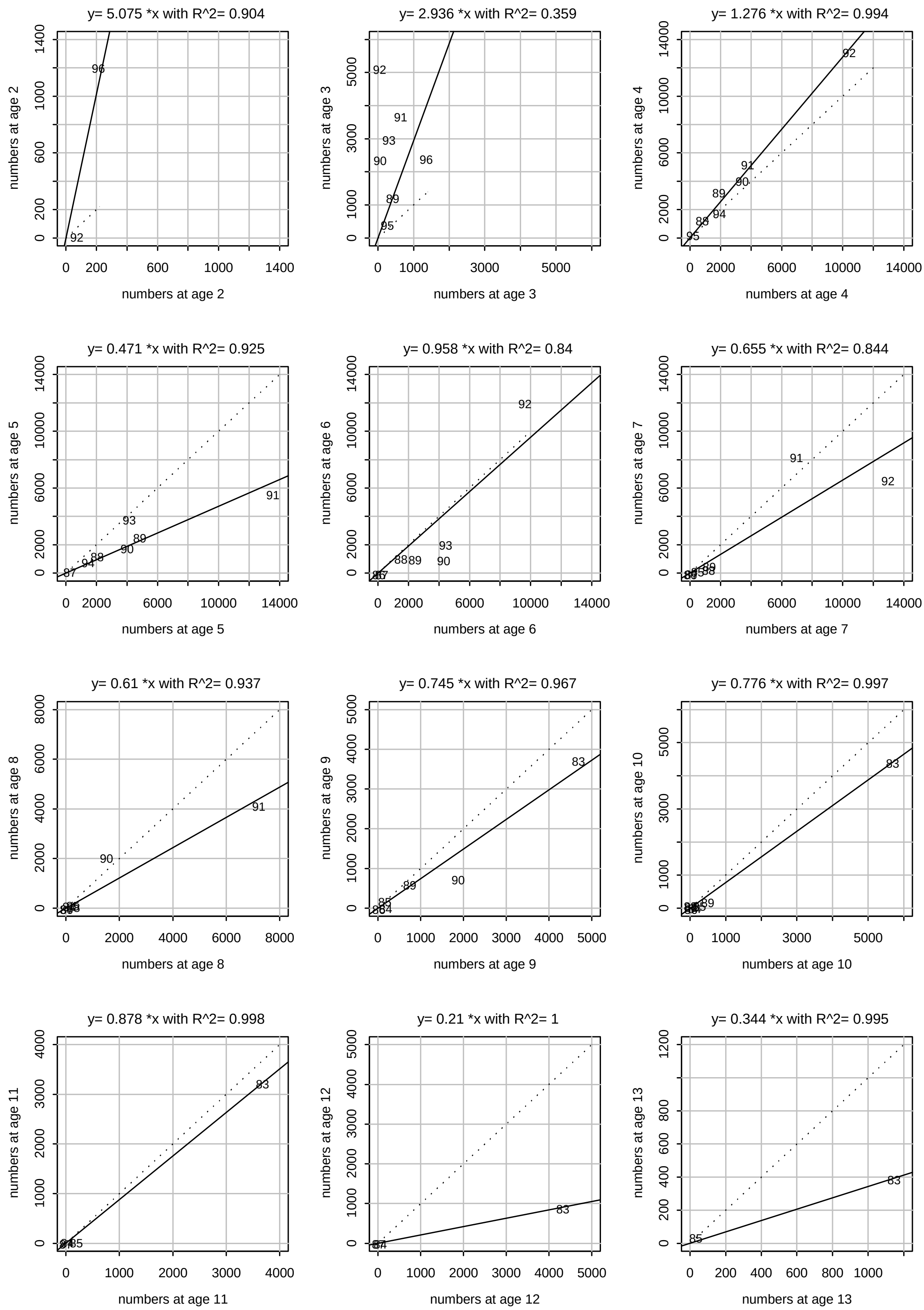


Figure 9.5.1.3.9. Survey 3 vs. survey 2

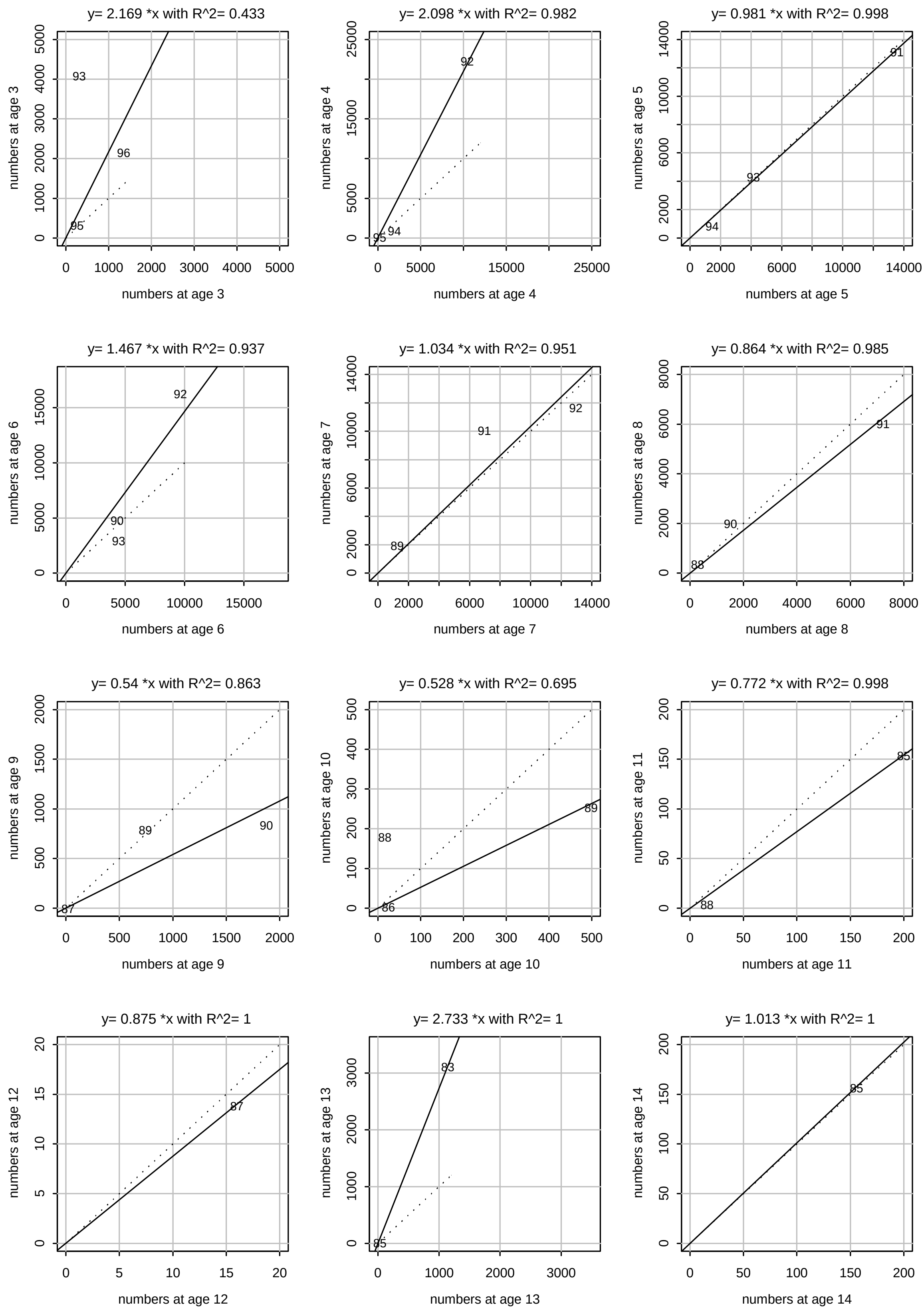


Figure 9.5.1.3.10. Survey 3 vs. survey 5

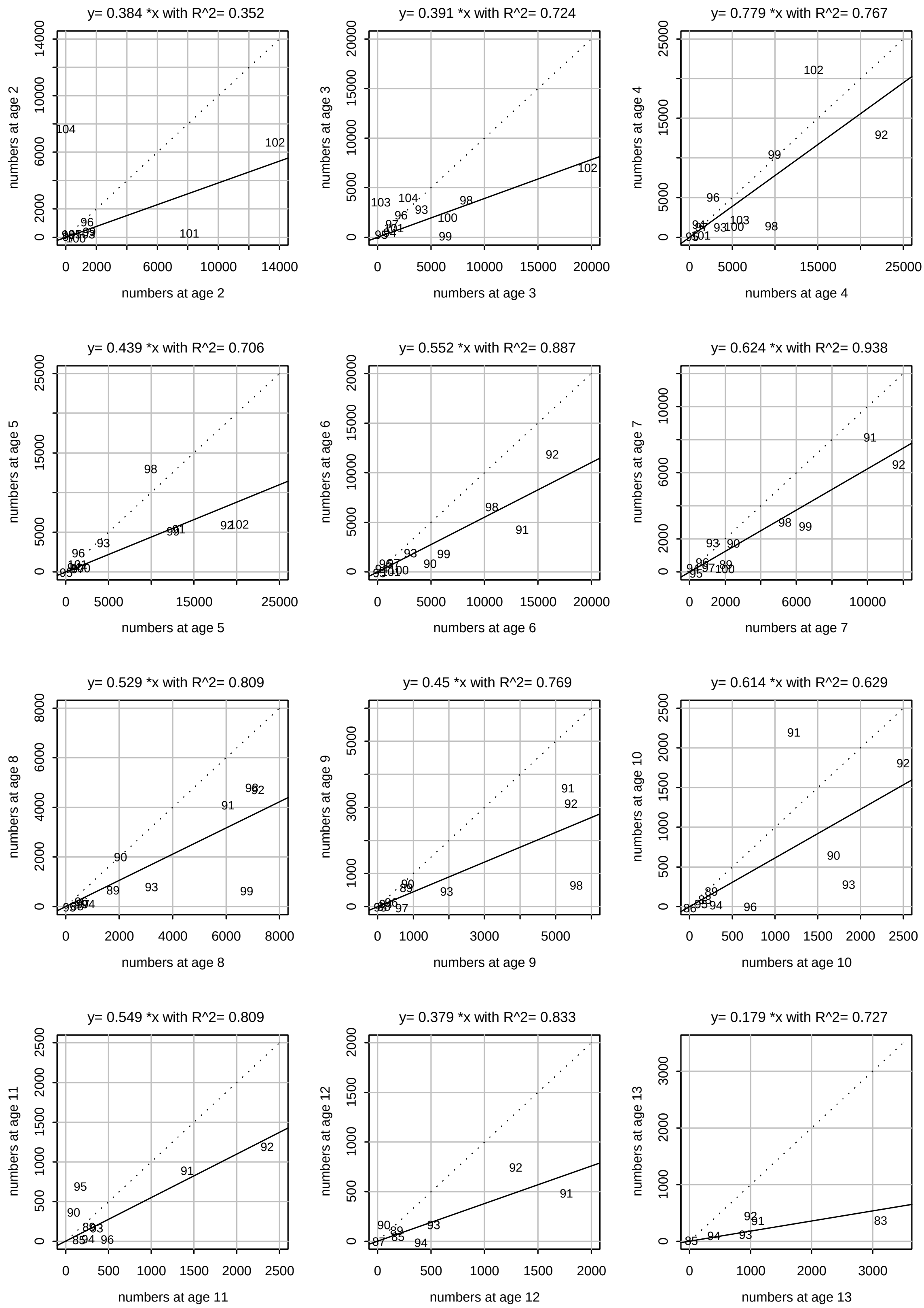


Figure 9.5.1.3.10. Survey 5 vs. survey 2.

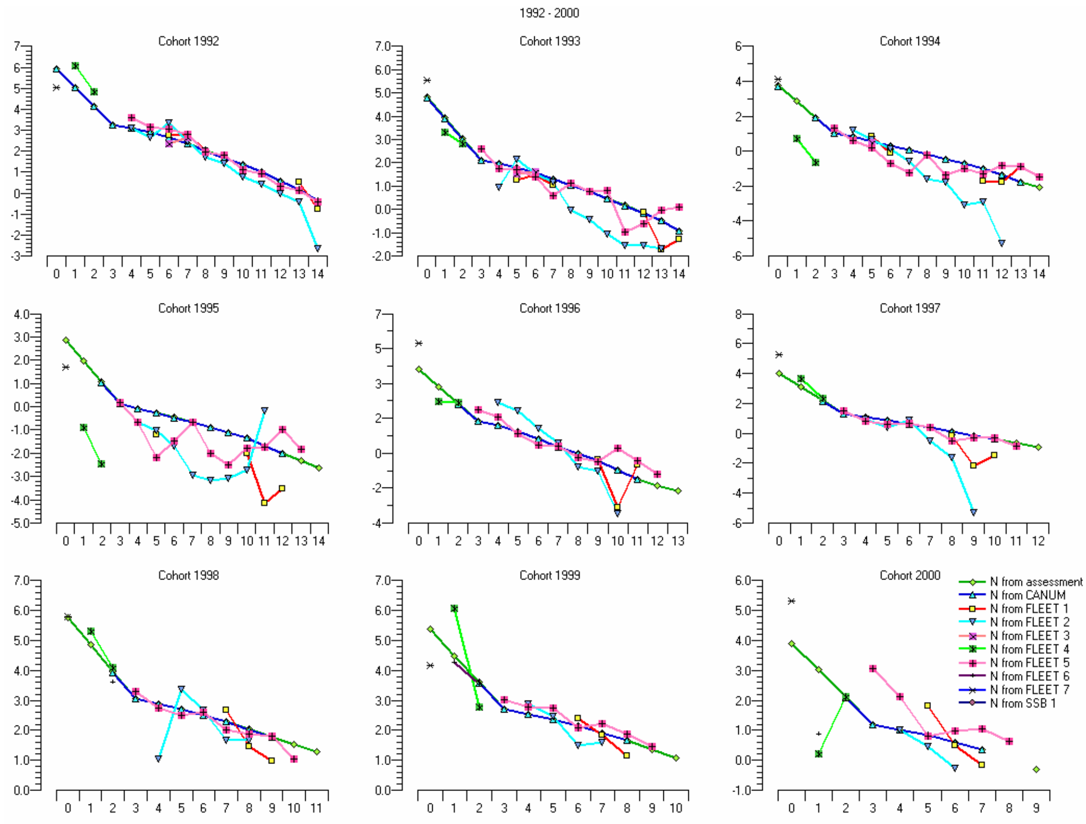


Figure 9.5.2.1.1 Norwegian spring spawning herring. Year class Ns, including values with zero weight.

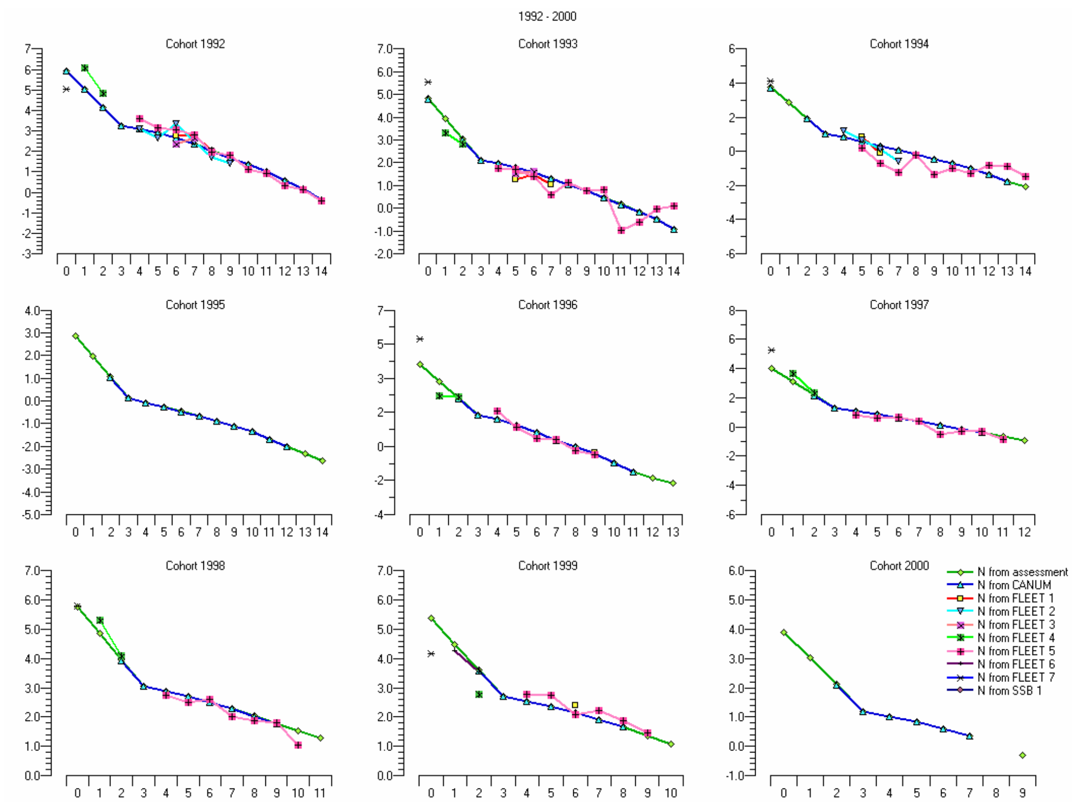


Figure 9.5.2.1.2 Norwegian spring spawning herring. Year class Ns, excluding values with zero weight.

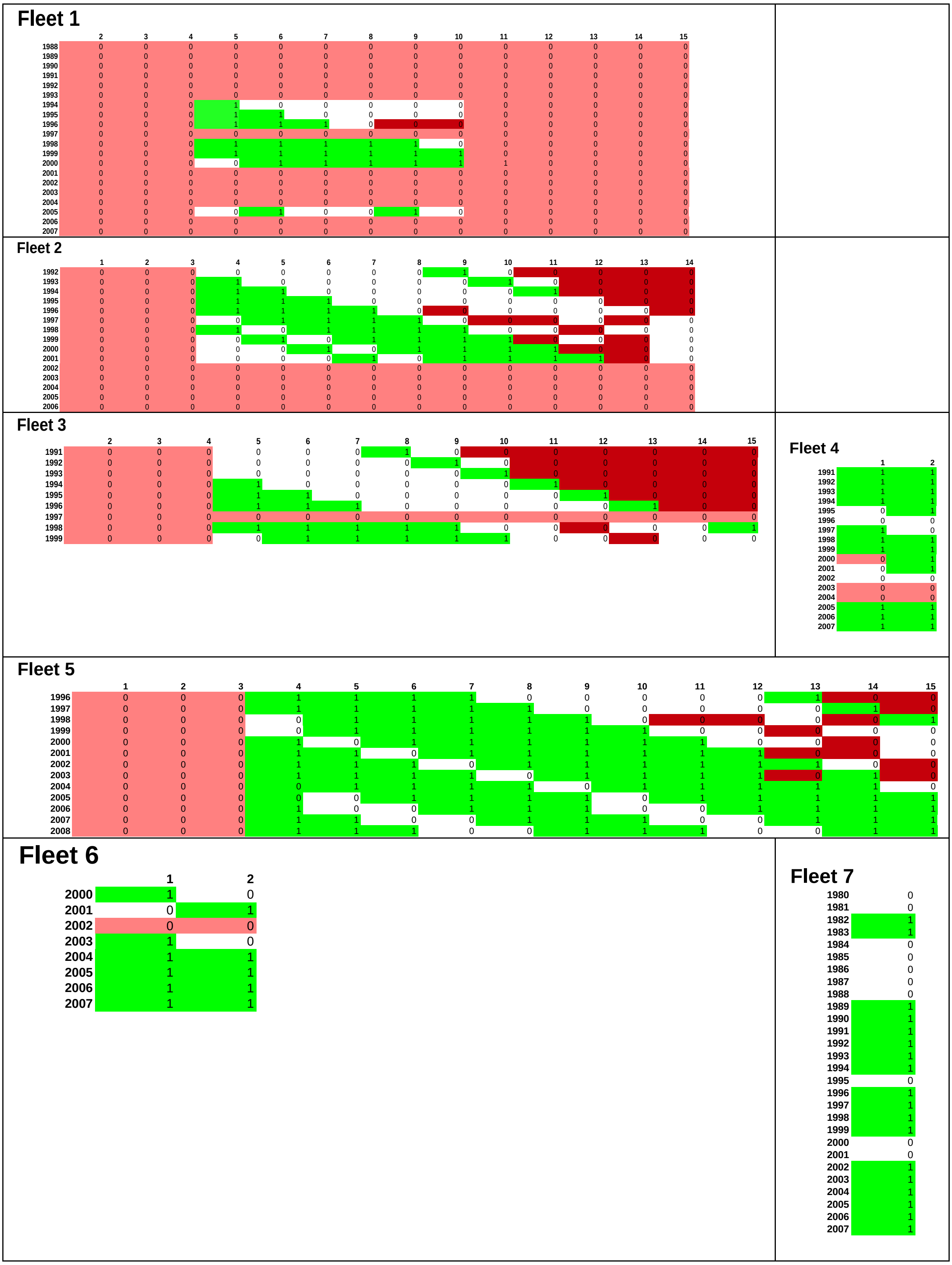


Figure 9.5.2.1.3. Norwegian spring-spawning herring. Colors description: pink=data is outside age and year range, dark red=zero catches in surveys, white=little information about year classes, mostly noise, green=data used. (see 9.5.2.1)

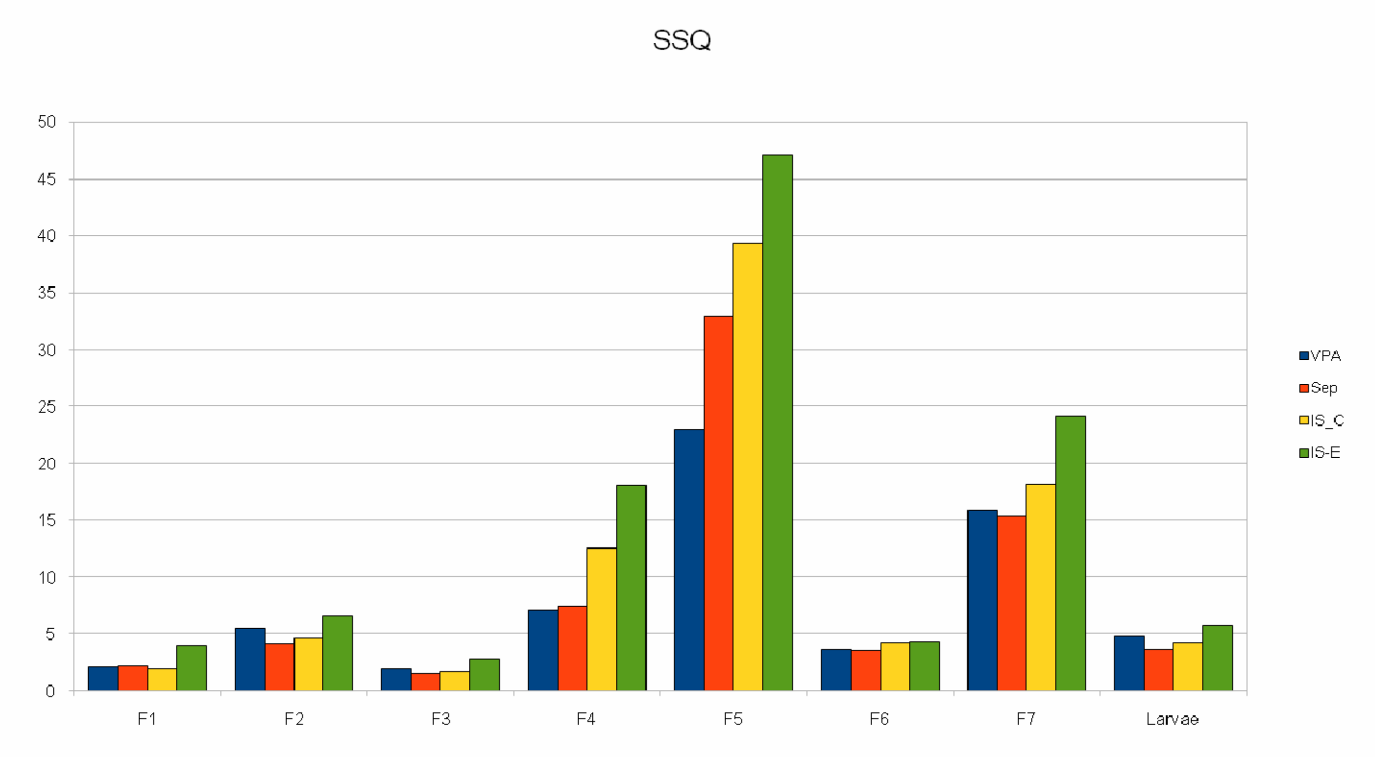


Figure 9.5.3.1. Norwegian spring-spawning herring. Residual sum of squares of different model configurations for the surveys separately.

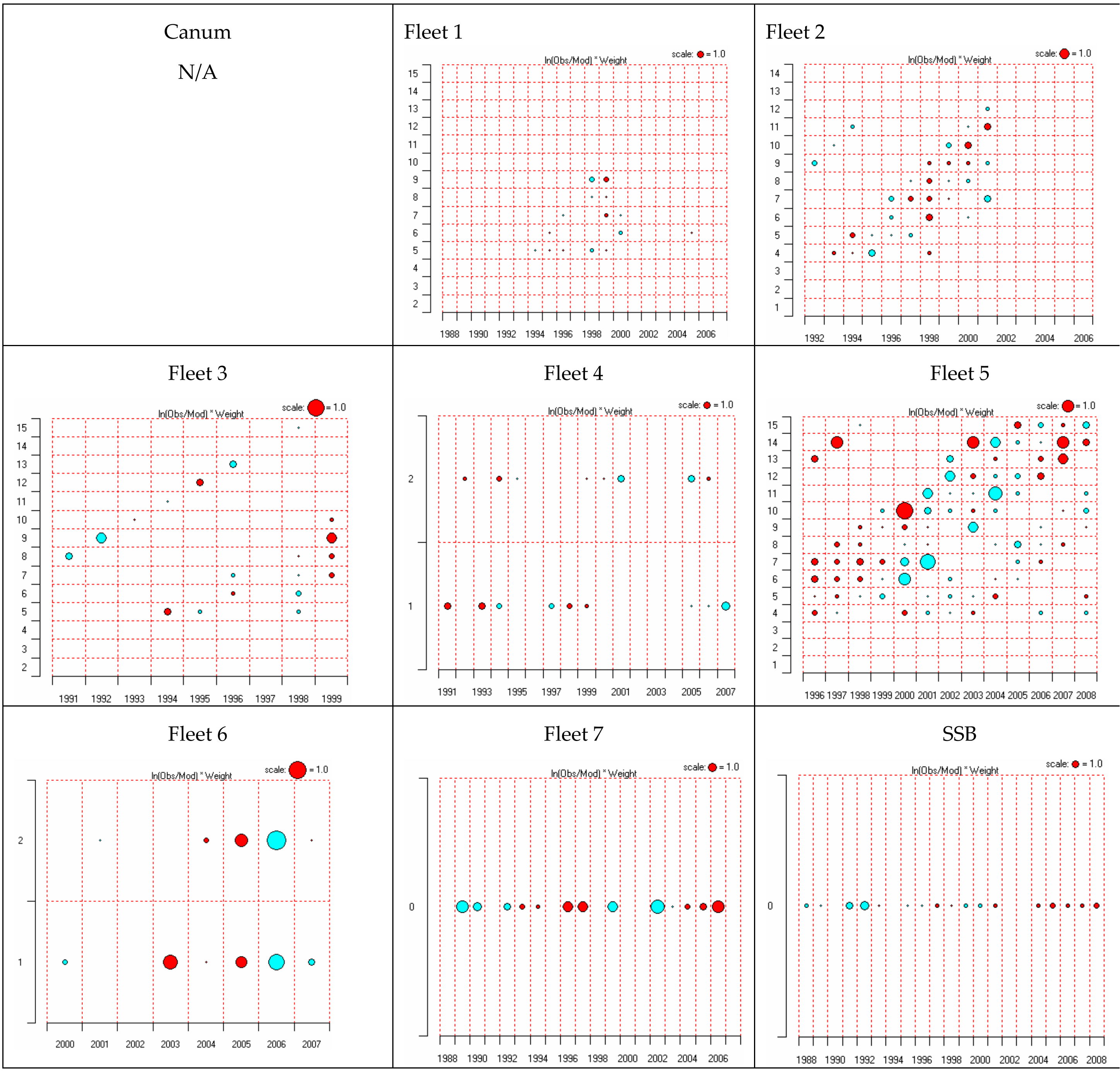


Figure 9.5.3.2. Norwegian spring-spawning herring. VPA weighted residuals.

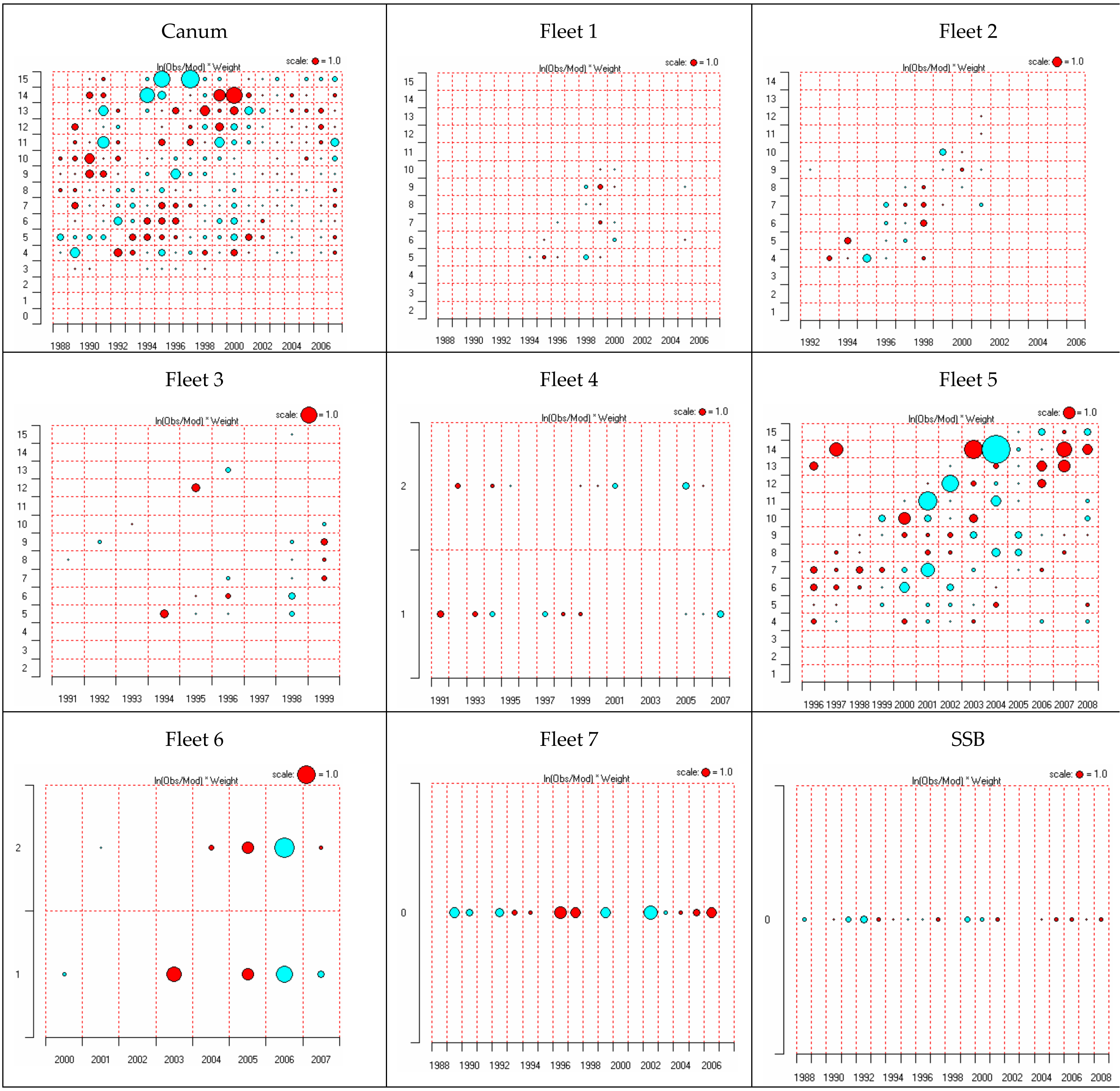


Figure 9.5.3.3. Norwegian spring-spawning herring. Separable weighted residuals.

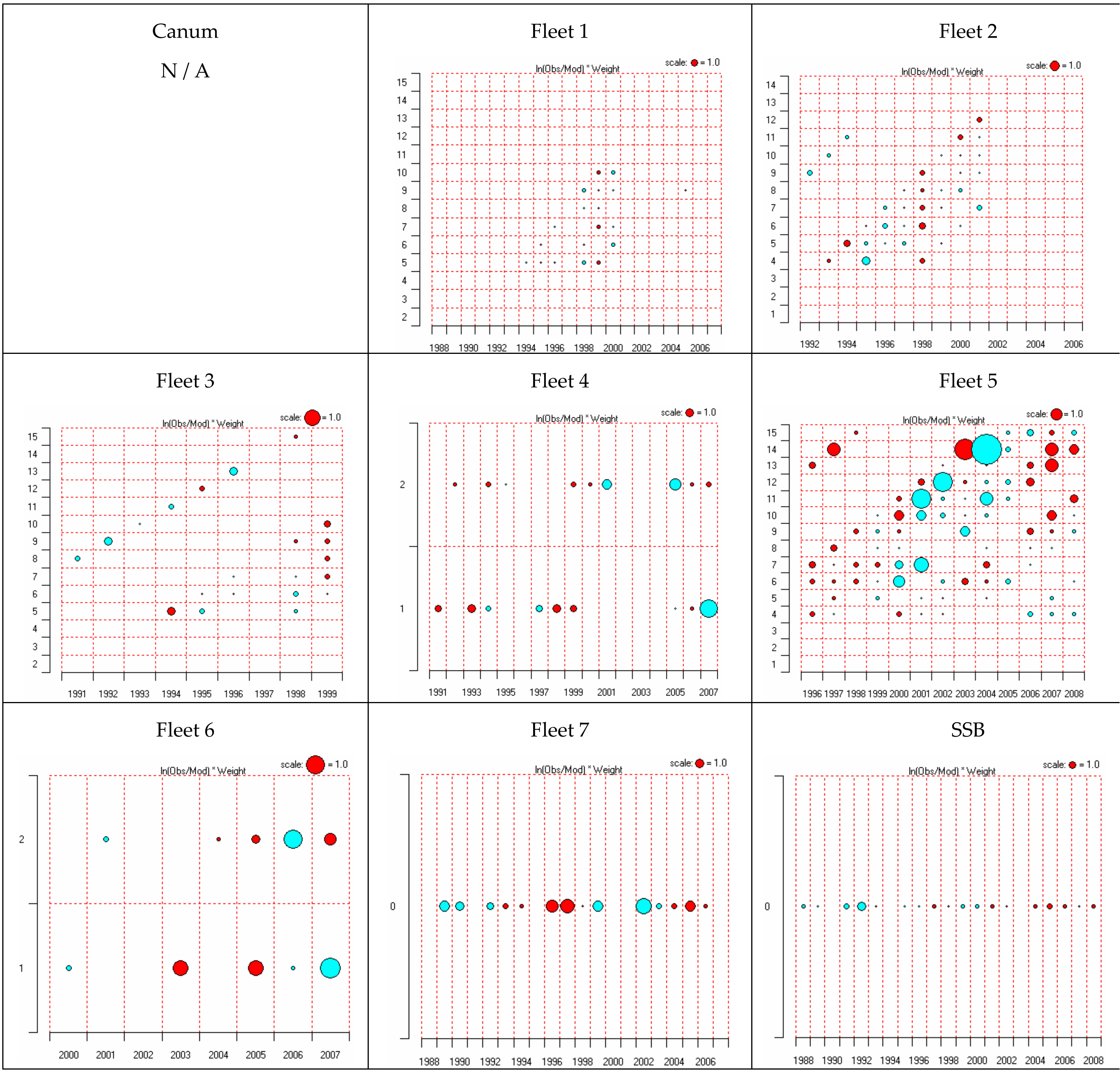


Figure 9.5.3.4. Norwegian spring-spawning herring. ISVPA-C weighted residuals.

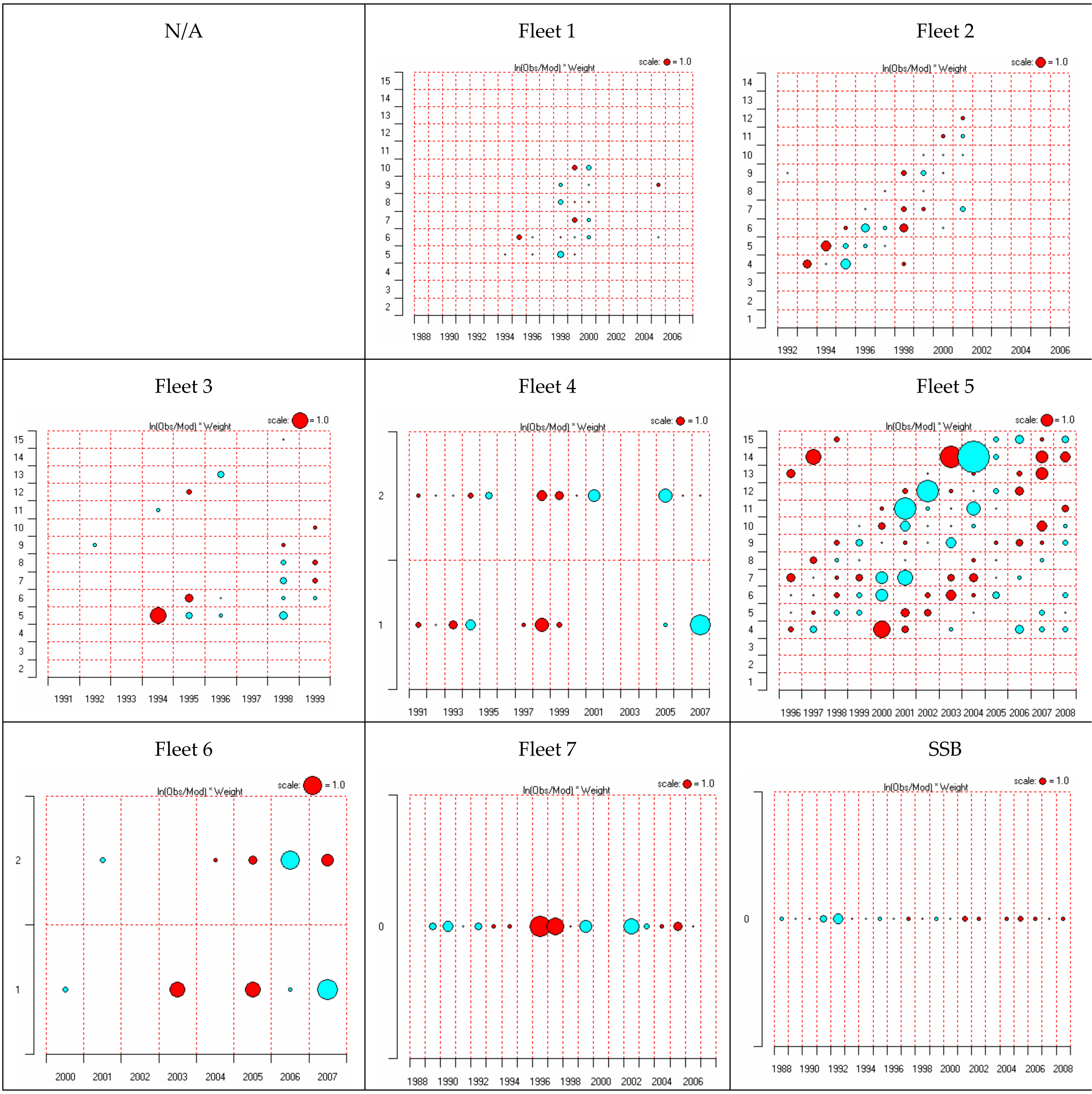


Figure 9.5.3.5 Norwegian spring spawning herring. ISVPA-E weighted residuals.

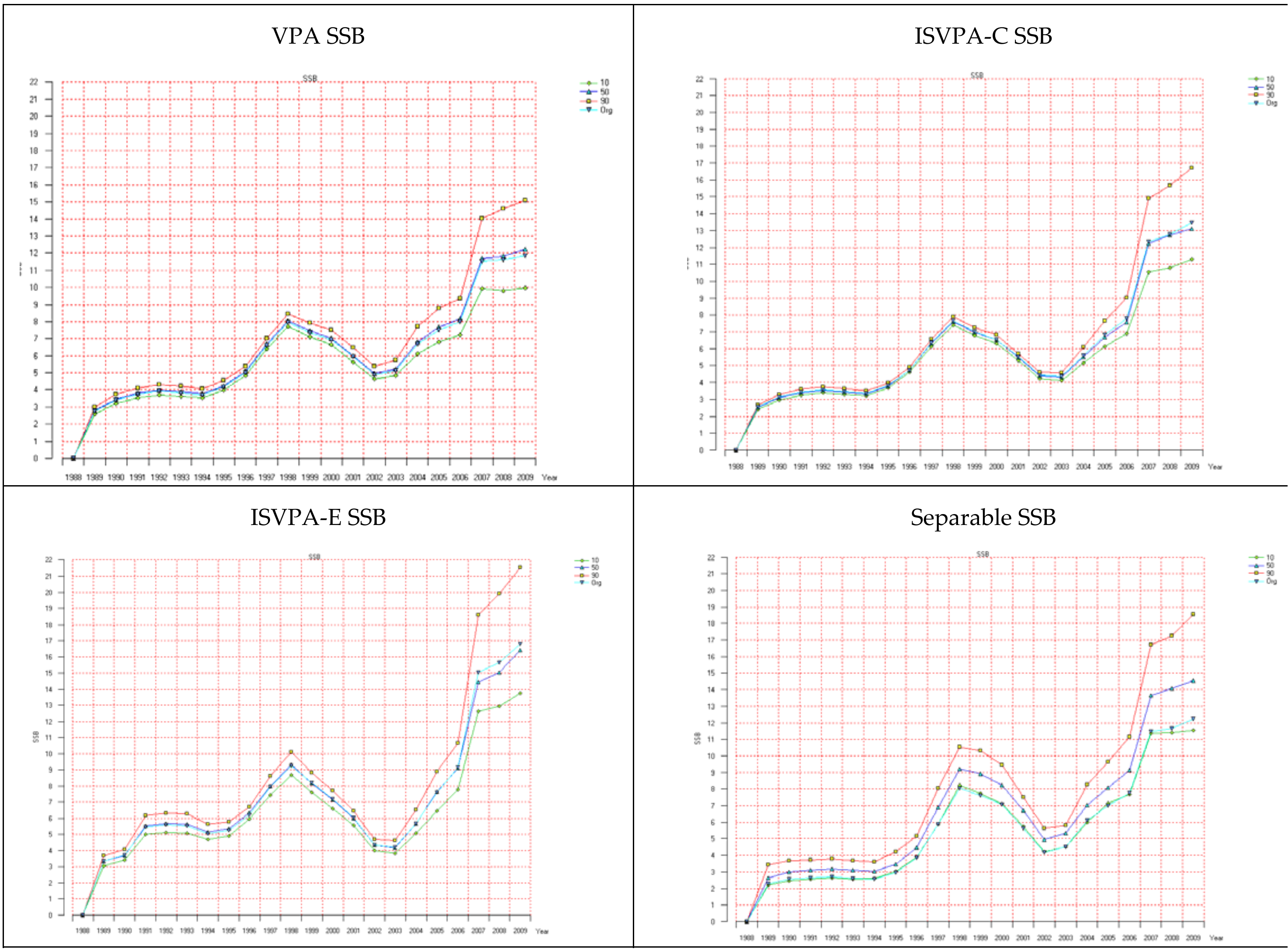


Figure 9.5.3.6 Norwegian spring-spawning herring. Percentiles for spawning stock biomass from bootstrap results for different models. (VPA 1000 runs, ISVPA-C, ISVPA-E and Separable 50 each).

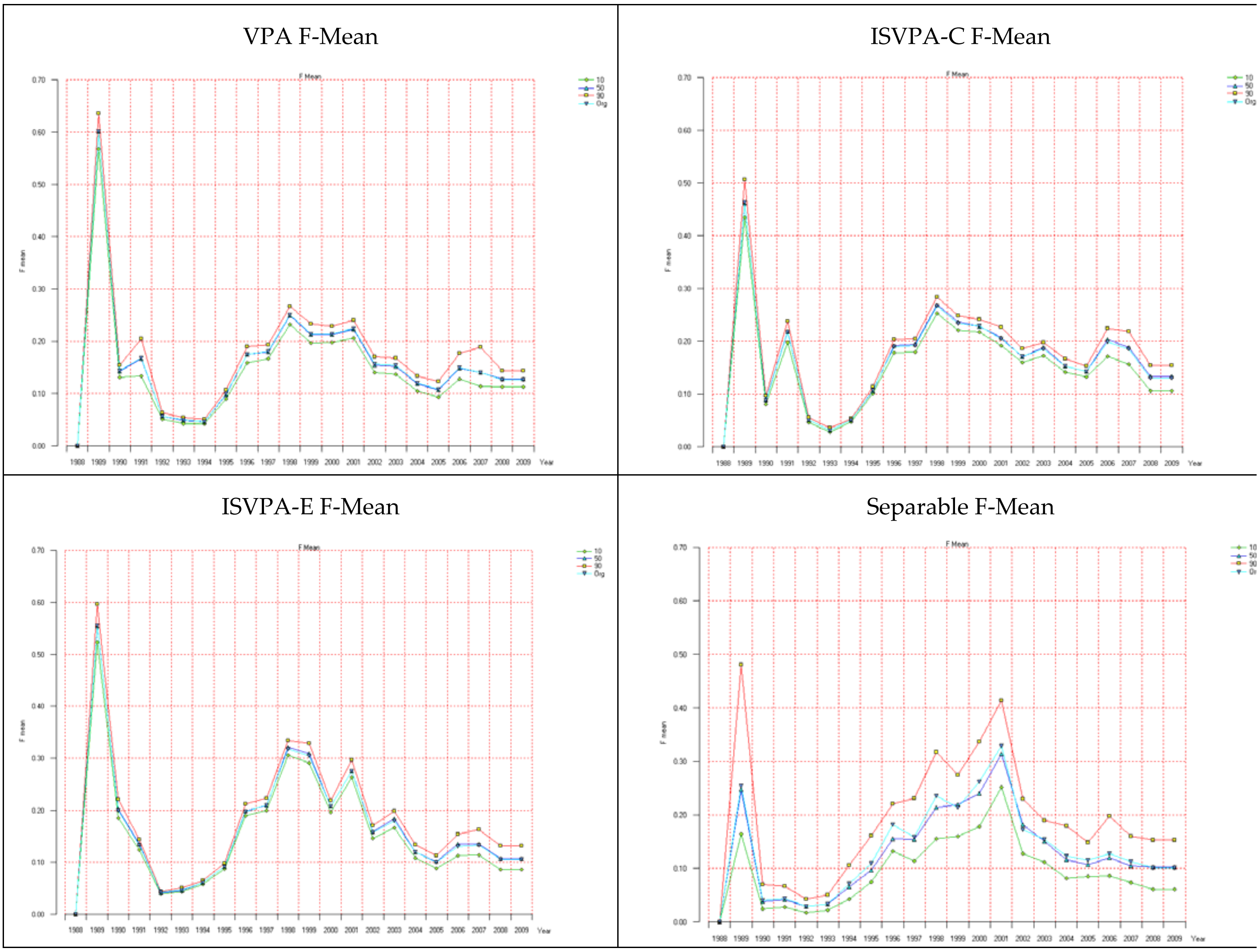


Figure 9.5.3.7. Norwegian spring-spawning herring. Percentiles for mean F 5-10 from bootstrap results for different models. (VPA 1000 runs, ISVPA-C, ISVPA-E and Separable 50 each).

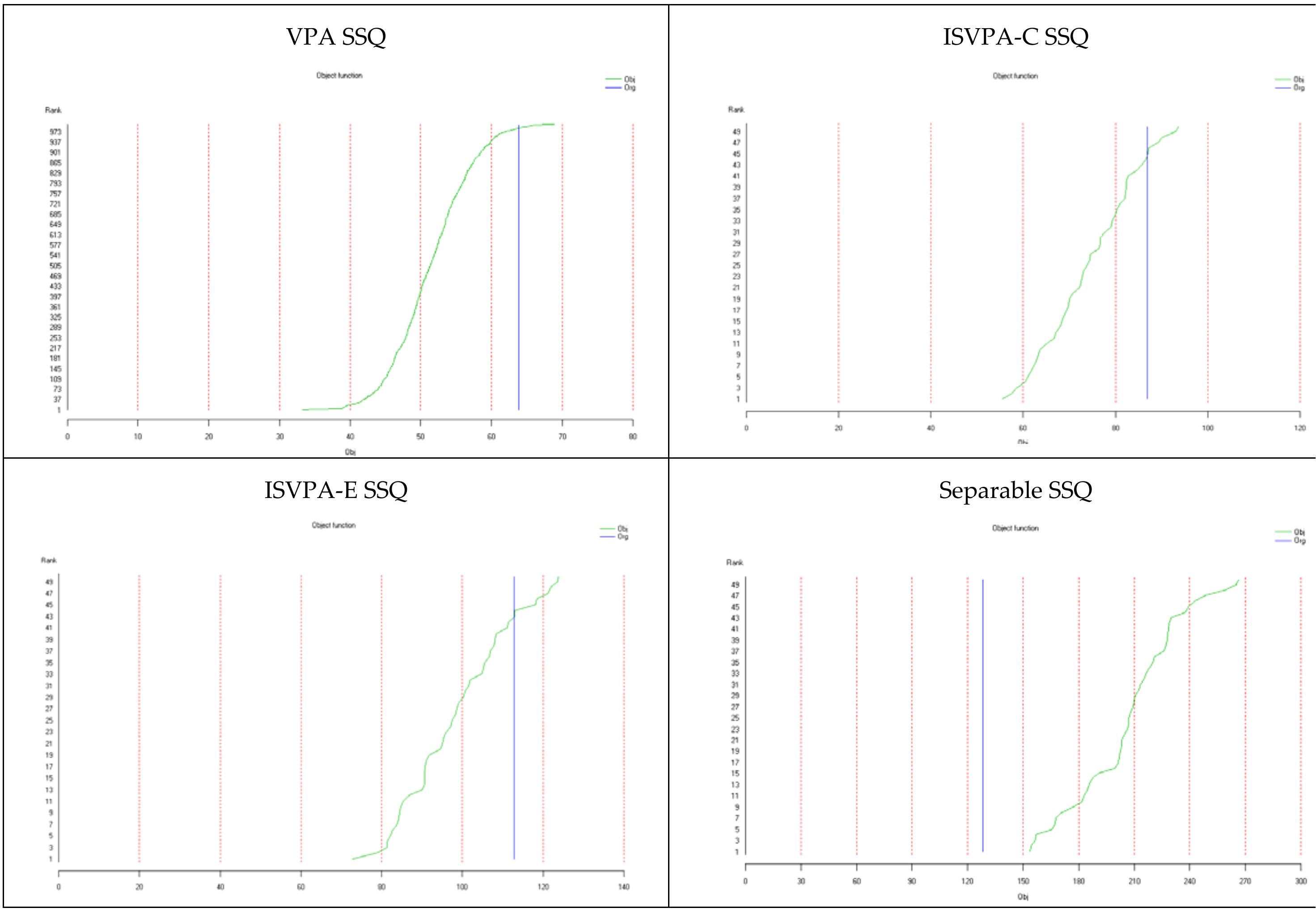


Figure 9.5.3.8 Norwegian spring-spawning herring. SSQ for different models from bootstrap runs for different models. (VPA 1000 runs, ISVPA-C, ISVPA-E and Separable 50 each).

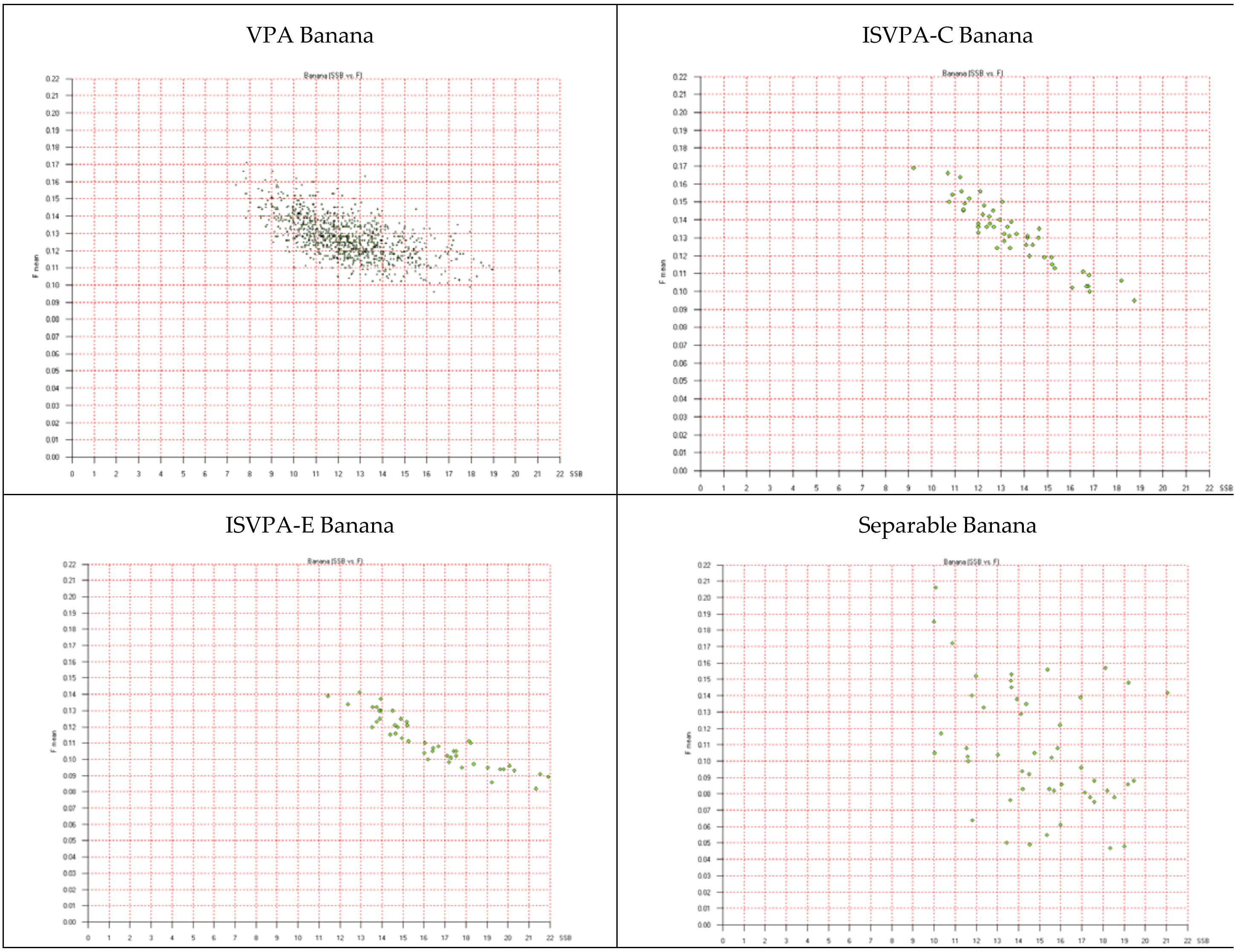


Figure 9.5.3.9 Norwegian spring-spawning herring. "Banana"-plot made from bootstrap runs for different models. (VPA 1000 runs, ISVPA-C, ISVPA-E and Separable 50 each).

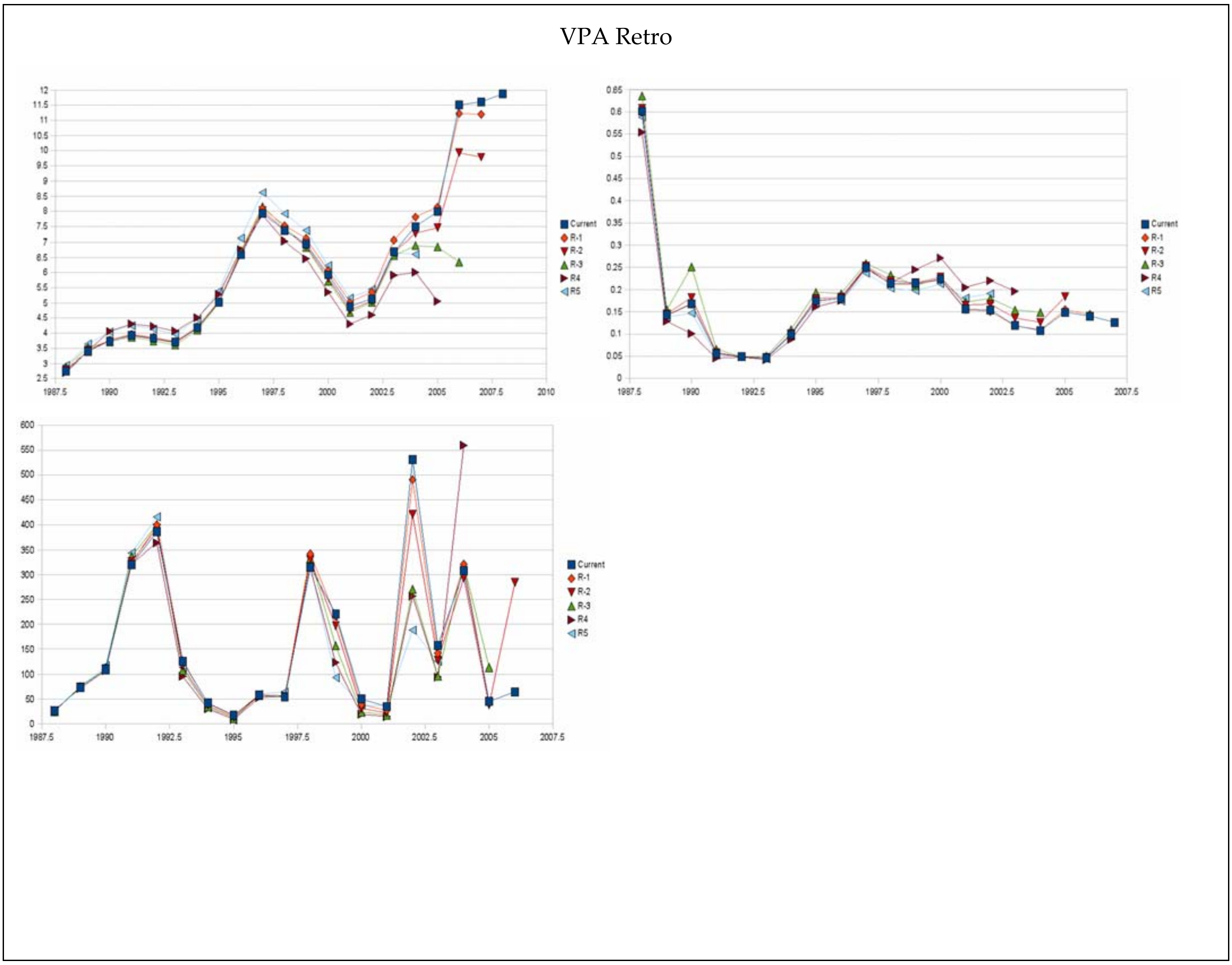


Figure 9.5.3.10 Norwegian spring-spawning herring. Retrospective run for VPA. SSB, F-Mean (F5-10) and recruits.

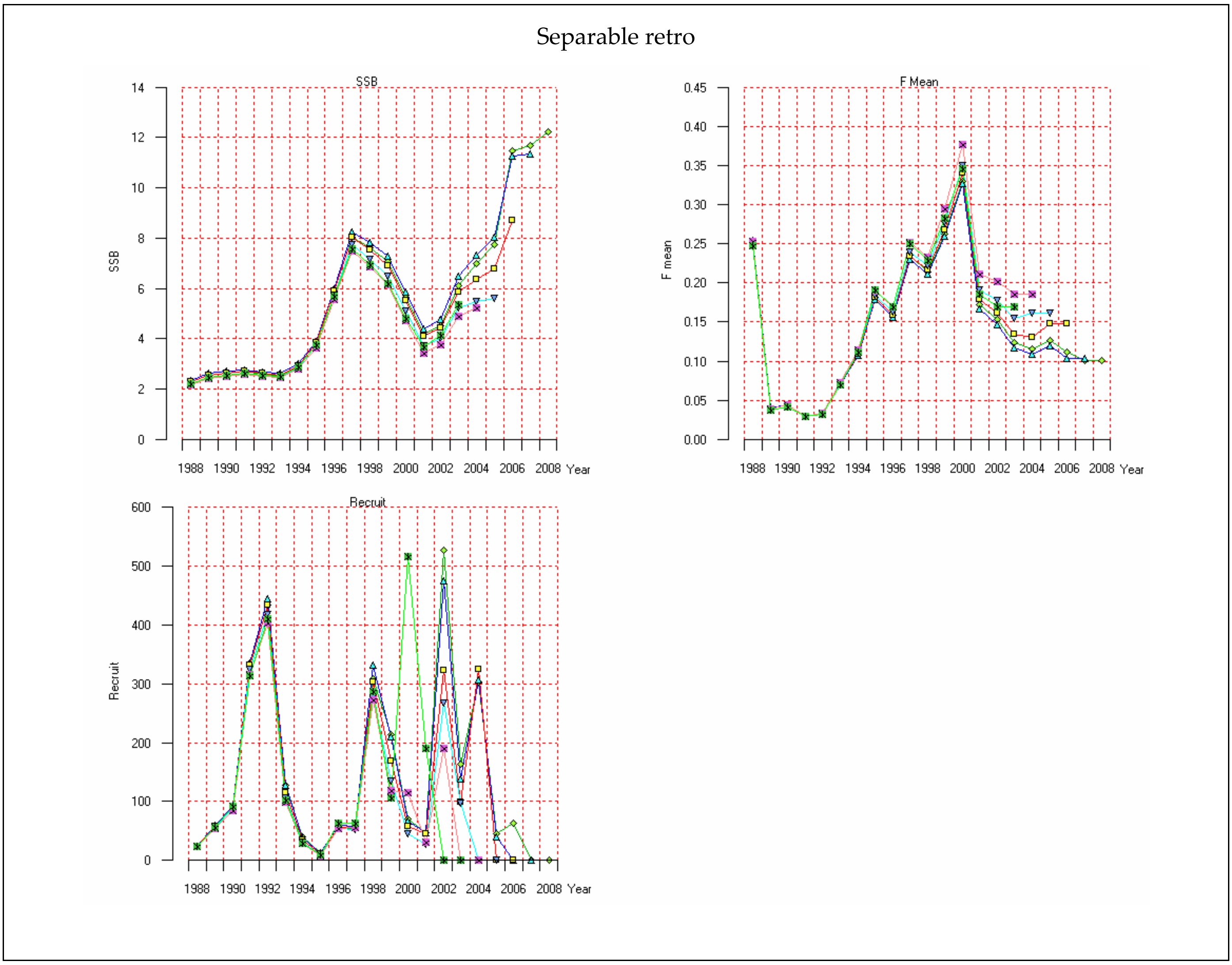


Figure 9.5.3.11 Norwegian spring-spawning herring. Retrospective run for separable model. SSB, F-Mean (F5-10) and recruits.

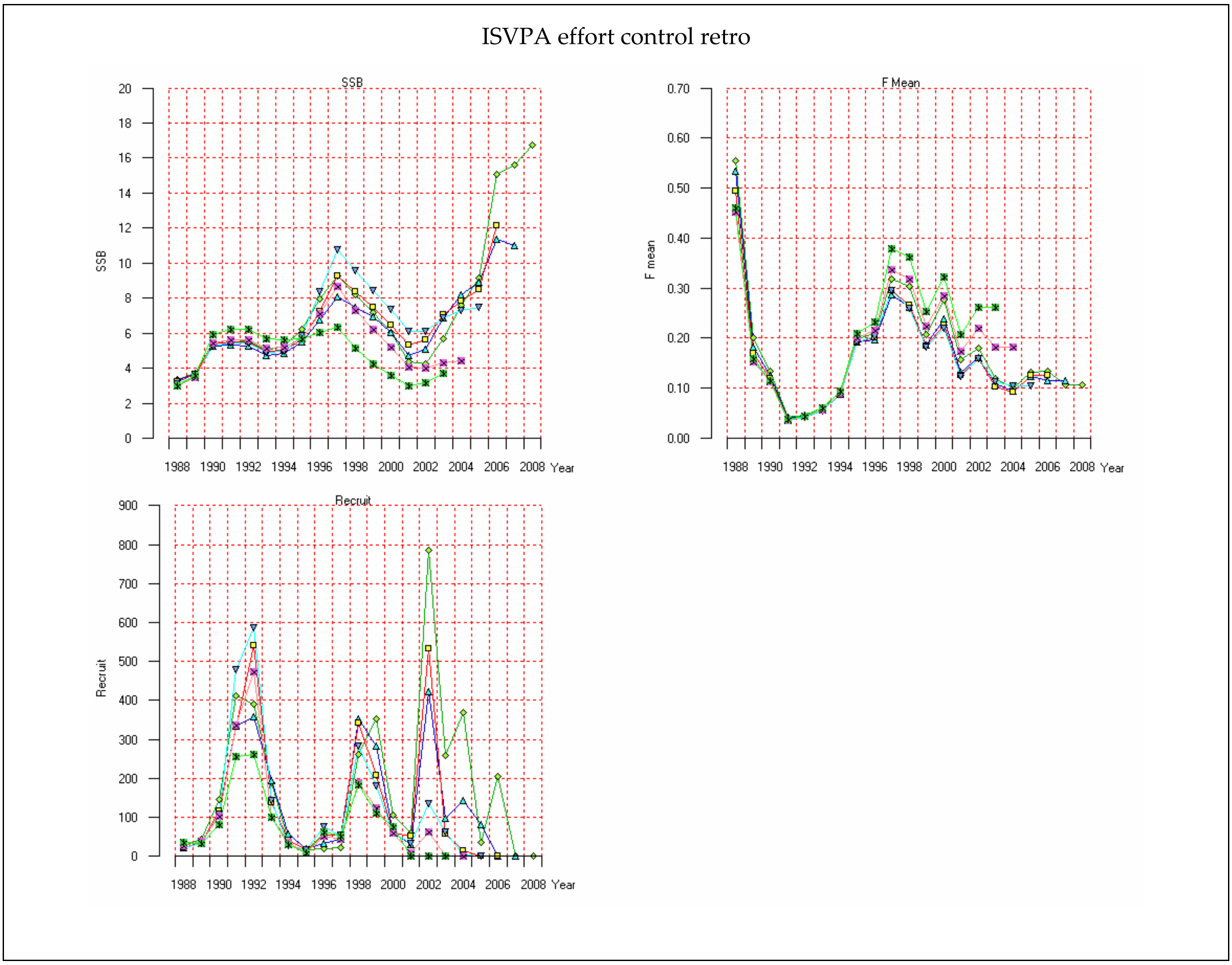


Figure 9.5.3.12 Norwegian spring-spawning herring. Retrospective run for ISVPA effort control. SSB, F-Mean (F5-10) and recruits.

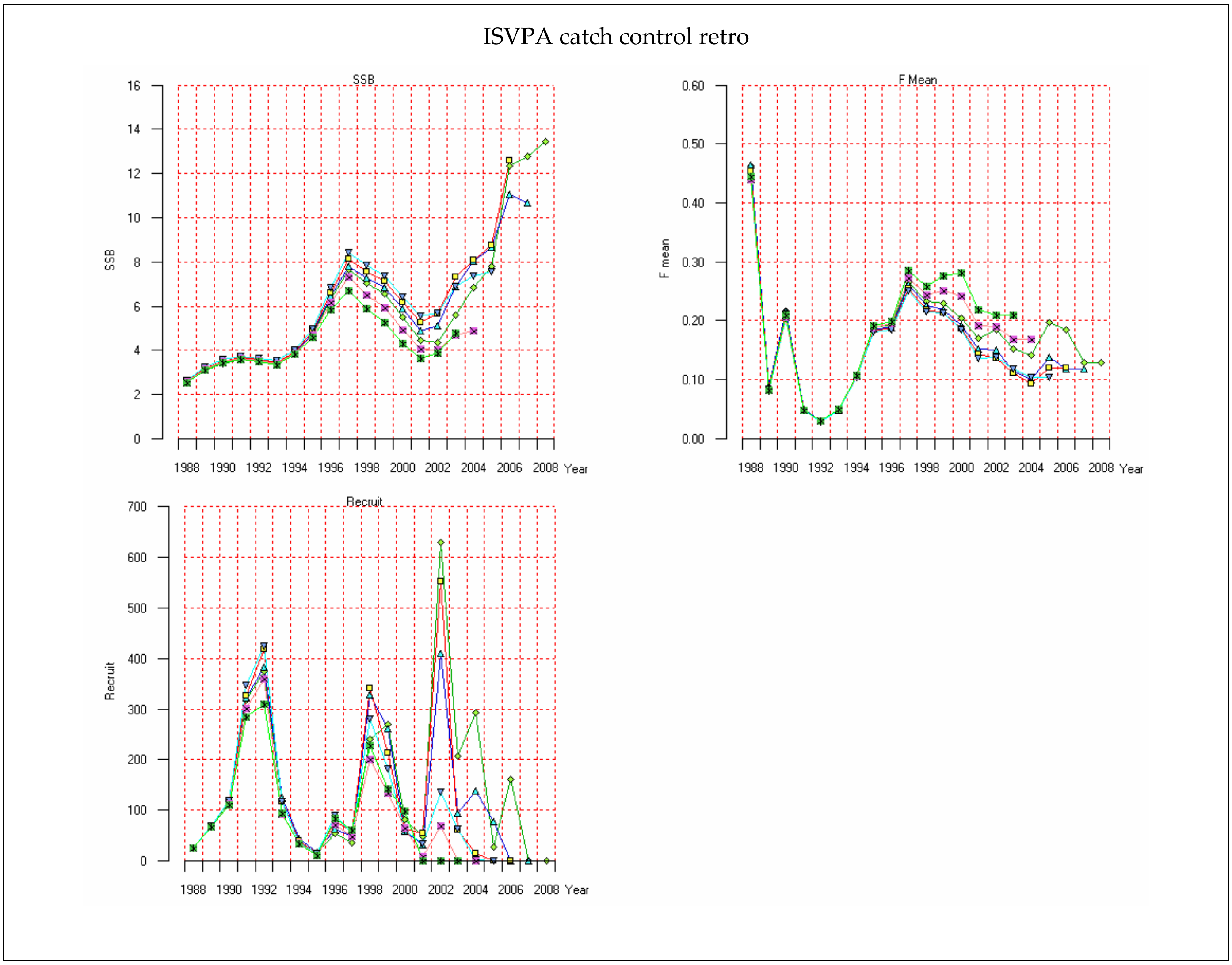
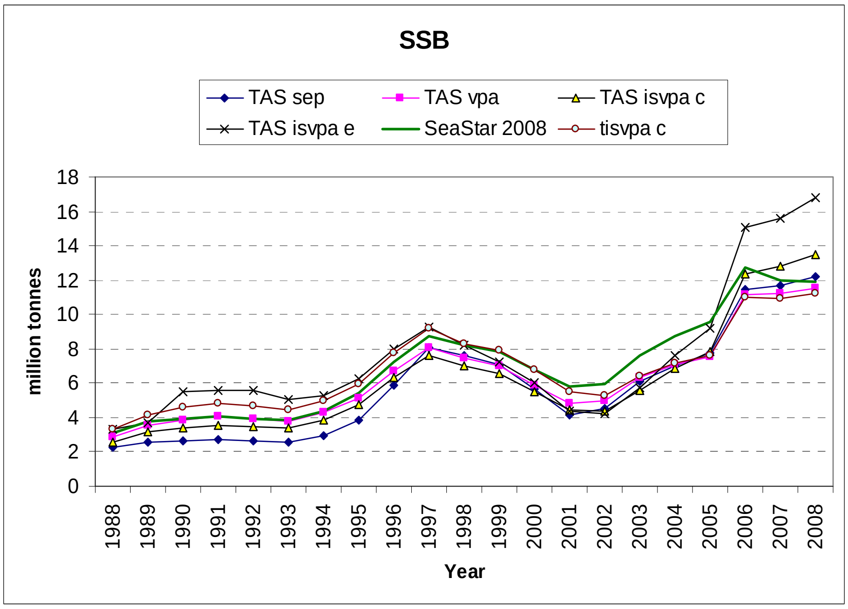
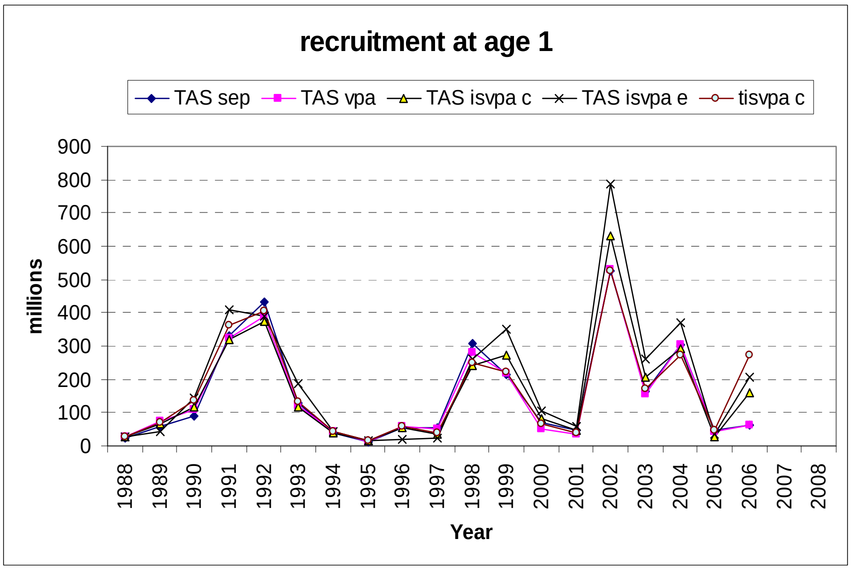


Figure 9.5.3.13 Norwegian spring-spawning herring. Retrospective run for ISVPA catch control. SSB, F-Mean (F5-10) and recruits.





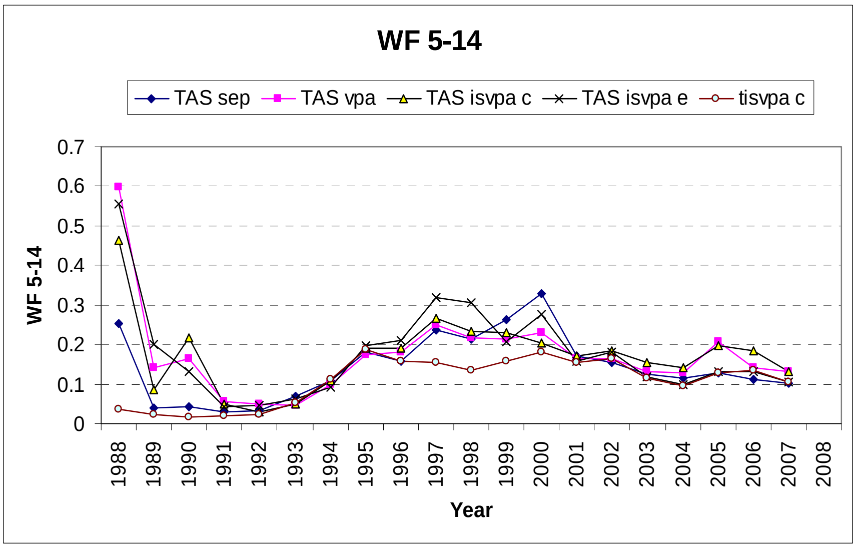


Figure 9.5.4.1. Norwegian spring-spawning herring. Comparisons of spawning stock biomass, fishing mortality and recruitment estimated by different models TASACS, SeaStar and TISVPA.

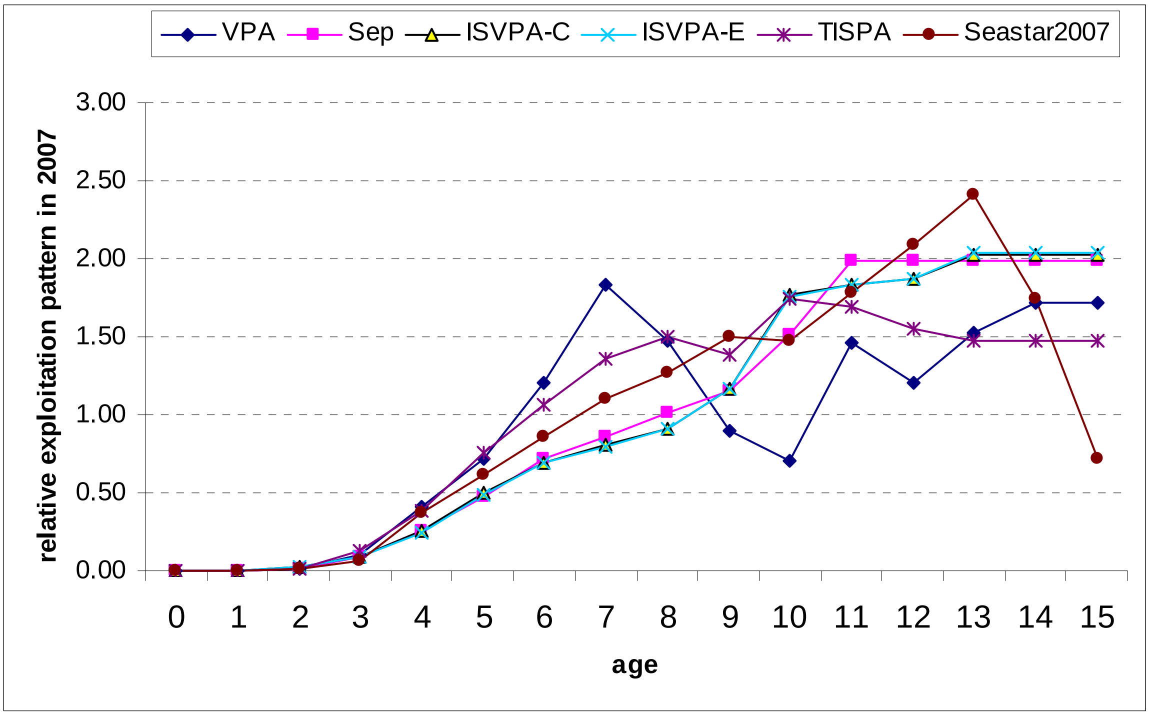


Figure 9.5.4.2. Norwegian spring-spawning herring. Comparison of relative exploitation pattern in 2007 between the different explorations and the final Seastar assessment of last year.

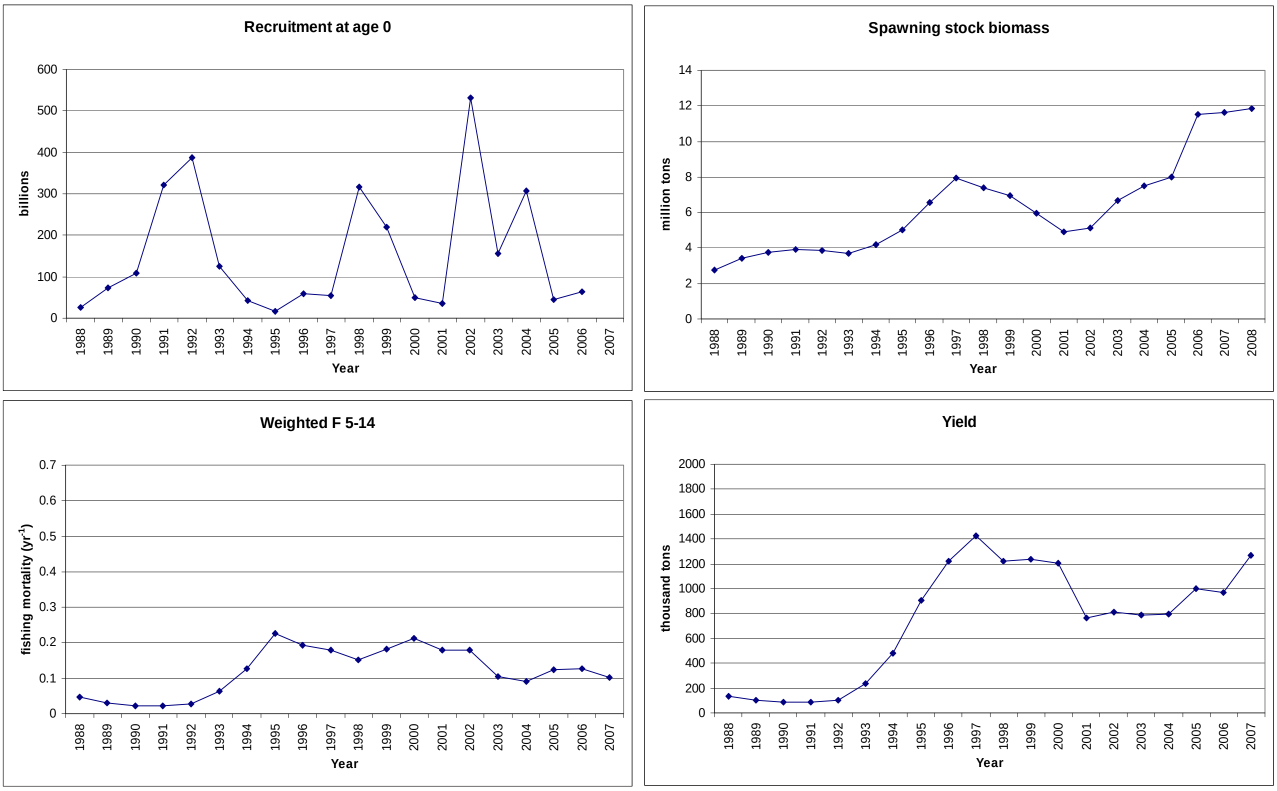


Figure 9.6.1. Norwegian spring-spawning herring. Standard plots from final assessment (VPA) in 2008.

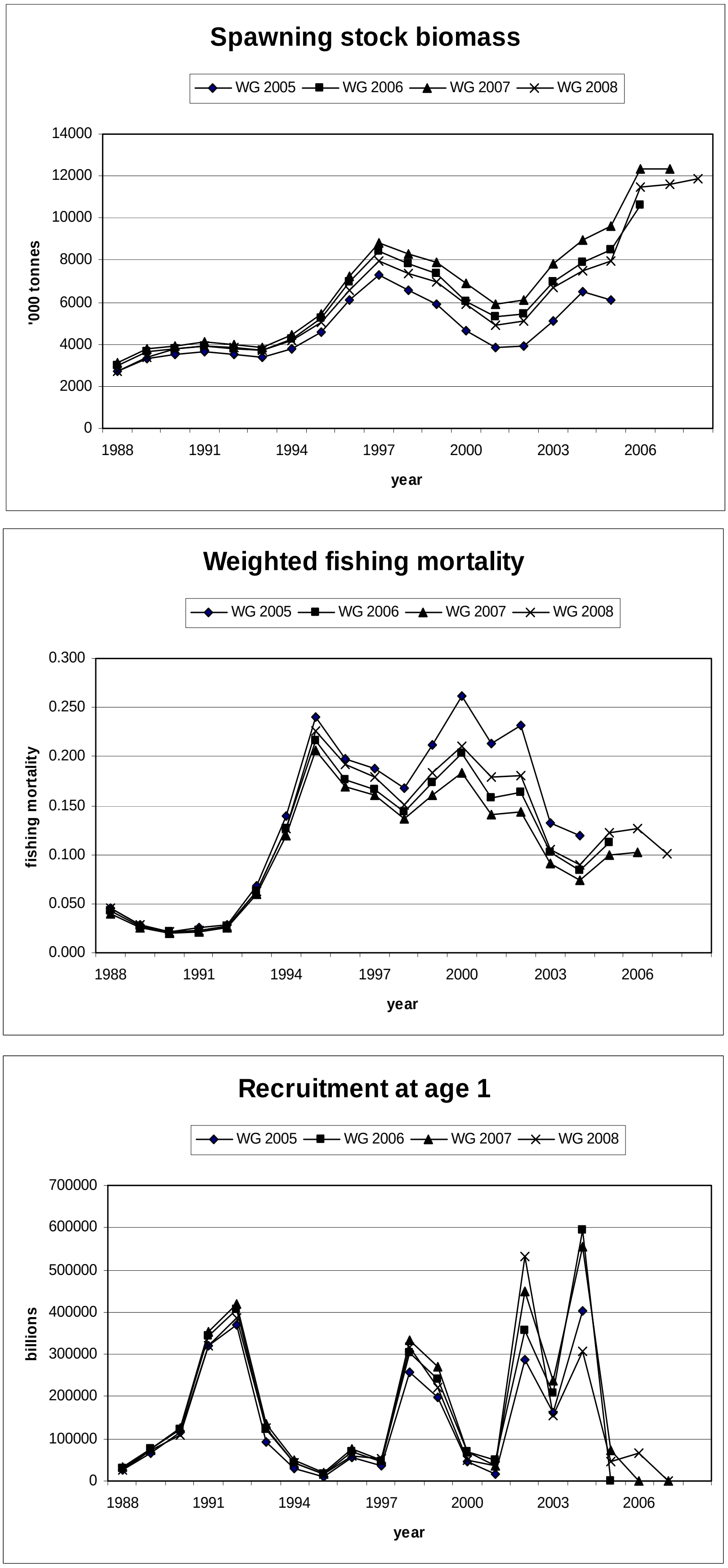


Figure 9.12.1. Norwegian spring spawning herring. Comparisons of spawning stock, weighted fishing mortality and recruitment at age 1 with previous assessments.

10 Blue Whiting

10.1 ICES advice in 2007

In 2007 ICES classifies the stock as having full reproductive capacity, but being harvested at increased risk. SSB increased to a historical high in 2003, but has decreased since then. The estimated fishing mortality is well above Fpa. Recruitment in the last decade appears to be at a much higher level than prior to 1996. The 2005 and 2006 year classes are estimated at the pre-1996 level.

ICES has evaluated the present management plan in 2006 and found it not to be in accordance with the precautionary approach. ICES concludes that the exploitation boundaries for this stock should be based on the precautionary limits. The advice for 2008 is a maximum TAC at 835 000 t based on an F at Fpa.

10.2 The fishery in 2007 and 2008

This main fisheries on blue whiting take place in the Faroes region, west of Scotland and around the Porcupine Bank (Figure 10.2.1). The fleet targeting blue whiting consists of several types of vessels but the bulk of the catch is caught with large pelagic trawlers (Table 10.2.1).

10.2.1 Denmark

The Danish directed fishery for blue whiting is mainly conducted by trawlers using a minimum mesh size of 40 mm. The directed fishery in the western and northern areas constituted 86% of the total Danish blue whiting fishery (52 500 tonnes) and this fishery was conducted mainly in March and April. The landings from the North Sea and Skagerrak were 7 000 tonnes. All landing were for production of fish meal and oil.

10.2.2 Germany

The vessels targeting blue whiting are owned by a Dutch company and operating under the German flag. They consist of three large pelagic freezer-trawlers of lengths between 90 m and 120 m with power ratings between 4200 and 11 000 hp. The crew consists of about 35 to 40 men. The vessels are purpose built for pelagic fisheries. The catch is pumped into large storage tanks filled with cool water to keep the catch fresh until it is processed.

10.2.3 Faroe Islands

The Faroese quota for blue whiting was set at 300 572 tonnes for 2007. The Faroese fleet targeting blue whiting consists of nine large vessels.

In January the Faroese vessels followed the pre-spawning blue whiting on their migration southwards in the eastern part of the Faroees zone. Later in January a fishery developed in the spawning area on the Porcupine Bank (VIIc). This fishery continued in February. Later in February and March a large fishery for spawning blue whiting developed west of the Hatton-Rockall Plateau in International waters (VIIc and VIb). In April the fishery had moved north and eastwards to the south of the banks on the border between EU and Faroes targeting spawning and post-spawning fish (VIb and a and Vb). In May the post-spawning fishery continued in the southern and northern part of the Faroese EEZ (Vb). As in 2006 the post-spawning blue whiting migrated northwards past the Faroes in the Faroe Bank channel (west of the isles). In June the fishery continued north of the Faroes (Vb and and IIa). During the period from July to November there were only scattered catches in the Icelandic, Faroese and International zone. The catches started to increase again in December on the north-eastern Faroe shelf slope targeting the beginning of the southward migration of blue whiting.

In general the fishery was less in 2007 compared to 2006 especially from May onwards. Almost the entire blue whiting catch in 2007 was taken with pelagic trawl.

10.2.4 Iceland

Iceland and Faroes have a bilateral agreement of mutual fishing rights for Blue whiting in each other's EEZs. The Icelandic directed fishery started late in February in International waters west of the British Isles and continued there through March. In April to June, the fishery was mainly in Faroese waters, but also in the Icelandic zone. In July and August the fishery mainly took place on the Dorhnbank. About 46 000 .tonnes were taken in Icelandic EEZ; 130 000 tonnes in the Faroes EEZ; 60 000 tonnes in the International zone; 716 tonnes in the Greenland EEZ and 202 tonnes in the Jan Mayen EEZ. The total Icelandic catch in 2007 was 237 854 tonnes. Iceland has set size limitations on landings of blue whiting. If the catch consists of 30% or more of fish smaller than 25 cm, a temporary area closure is imposed.

10.2.5 Ireland

The Irish fishery for blue whiting began in late January 2007 with the majority of landings reported from quarter 1 and a very small amount from quarter 4. A total of 20 boats took part and reported landings of 31 131 t. This is a decline from 2006 when the Irish landings were 54 900 t.

Fishing took place to the west and north of the Porcupine Bank as well as the Rockall trough to the north west of Ireland on spawning and post spawning aggregations. The main landings are reported from ICES area VIIc with lesser amounts reported from areas VIa, VIb and VIIb. Fishing was concentrated along the shelf-edge and in deeper waters between 300 m and 600 m. Samples from catches show that the proportion of small and young fish has decreased significantly the last years, with a very low proportion of small/young fish in 2008 (Fig. 10.2.7).

10.2.6 Netherlands

The Dutch fleet fishing for pelagic species in European waters consists of 9 freezer trawlers. In addition, a number of flag vessels are operating from the Netherlands. The fishery for blue whiting is carried out with large pelagic trawls and is a directed fishery with almost no bycatch of other species. Catches decreased in 2007 by almost 20% compared to 2006. Most of the catches in 2007 originated from ICES Division VIa and VIIc and were taken in the first half of the year. All catches are landed frozen for human consumption.

10.2.7 Norway

After the coastal states agreement in 2006 and quota transfers in other international agreements, the Norwegian TAC for 2007 was set to 550 670 t (of which 352 000 t could be taken in the EU zone and 61 000 t in the Faroese EEZ). The majority (approximately 80%) of the Norwegian catches were taken in a directed pelagic trawl fishery west of the British Isles and in the Norwegian Sea during the first half of the year. The remaining catches were mainly taken by the industrial trawl fleet (which uses both pelagic and demersal trawls) in the Norwegian deeps and Tampen area (east of 4ºW). This fishery is mainly a directed blue whiting fishery but the bycatch of saithe can be significant (the maximum bycatch proportion of other species is 30% by weight during a trip). Samples from catches in the directed pelagic trawl fishery west of the British Isles show that the proportion of small and young fish has decreased significantly the last years, with a very low proportion of small/young fish in 2008 (Fig. 10.2.7).

10.2.8 Russia

The Russian fishery started at the beginning of year within the Faroese EEZ. A Small part of the fleet relocated to the Porcupine region on the end of January, a couple of days earlier than in 2006. The fishery in the international waters had shifted to the Rockall area by the end of February, where number of trawlers amounted to 20. One year ago there were 29. The fleet crossed over to the Faroese waters during April and partly left to the international area of the Norwegian Sea in June. Almost all trawlers were in the Norwegian Sea in July, where they began to catch herring and mackerel together with the blue whiting. Several vessels only fished blue whiting directly in the southern part of the Norwegian Sea. The rest of trawlers had it only as bycatch until November. Then the blue whiting directed fishery moved to the Faroese waters.

In 2008 the movement from the Faroese EEZ to the Porcupine region started one week earlier, than in 2007. By March again 20 trawlers operated there, shifting to the Faroese EEZ in late April and to Norwegian EEZ in May. International waters of Norwegian Sea were included in the fishing area in the 2nd half of June. The rest of the fishery in 2008 followed the pattern from 2007.

10.2.9 Spain

The Spanish blue whiting fishery was carried out mainly by bottom pair trawlers in a directed fishery and by single bottom trawlers in a bycatch fishery. Small quantities were also caught by longliners. These coastal fisheries have trip durations of 1 or 2 days and catches are for human consumption. Thus, coastal landings are driven mainly by market forces, and are rather stable.

This fleet has decreased from 279 vessels in the early 1990s to 135 vessels in 2007 with an average of 28 m length, 444 HP and 141 GRT. 64% of these vessels are operating the whole year as bottom otter trawlers, 28% as pair bottom trawlers and 8% alternate between bottom otter trawls and pair bottom trawls throughout the year. The fleet operates only in Spanish waters year round and does not follow any blue whiting migration.

Spanish landings increased slightly in 2007 having a total landing of 13 557 tonnes.

10.2.10 Portugal

Around one hundred small vessels up to 30 m in length used for bottom trawling for both fish and crustaceans together with some artisanal vessels (37) had blue whiting as a bycatch.

10.3 Blue Whiting Stock description and management units

Blue whiting (*Micromesistius poutassou*) is a pelagic gadoid that is widely distributed in the eastern part of the North Atlantic. The highest concentrations are found along the edge of the continental shelf in areas west of the British Isles and on the Rockall Bank plateau where it occurs in large schools at depths ranging between 300 and 600 meters but is also present in almost all other management areas between the Barents Sea and the Strait of Gibraltar and west to the Irminger Sea. Adults reach maturation at 2–7 years old and undertake long annual migrations from the feeding grounds to the spawning grounds (Bailey, 1982). Most of the spawning takes place between March and April, along the shelf edge and banks west of the British Isles. Juveniles are abundant in many areas, with the main nursery area believed to be the Norwegian Sea. Morphological, physiological, and genetic research has suggested that there may be several components of the stock which mix in the spawning area west of the British Isles. Due to the large population size, its considerable migratory capabilities and wide spatial distribution, much remains to be understood regarding the stock composition and dynamics. Accurate estimates of the stock size are difficult to obtain and the management of this species therefore provides a challenge.

10.3.1 Blue Whiting Stock Identity

Prior to 1993, for the purposes of assessment, it was assumed that blue whiting had two components, a northern and a southern component. The Northern stock was known to feed in the Norwegian Sea and spawn to the west of the British Isles. The Southern stock was found along the continental shelf off the coast of Spain and Portugal with the main spawning areas towards the Porcupine Bank. The Porcupine Bank is considered a transitional area between the two main stocks (ICES, 1990). In 1993 it was argued that there was no strong evidence to maintain this division between the two stocks. Results from an otolith age reading workshop at that time showed no significant difference in mean annual ring diameter between northern and southern stocks. It was agreed by ACFM in 1993 that the two stocks should be combined for assessment purposes (ICES, 1995). Since then this stock has been assessed as one unit.

Several approaches have been employed to investigate the stock structure of blue whiting. The details of studies relating to genetics, larval otolith growth patterns and the movements of eggs and larvae have been published in recent years.

Blue Whiting have a wide geographic distribution and large population size, which is generally advantageous for the accumulation and preservation of genetic variability (Mork and Giaever, 1995). The first genetic work was carried out in the early 1990s. A study was carried out by Mork and Giaever, 1995 included samples from most of the eastern Atlantic but the amount of samples from the southern part of this area was generally low. Further work revealed significant geographic heterogeneity with reproductive units found at the fringes of the distribution range. A genetically distinct population was found in the Barents Sea and potential populations identified in the Mediterranean and Romsdalsfjord area of Norway. Samples taken from the area west of the British Isles and from the Norwegian Sea were genetically similar, which suggests a single blue whiting stock throughout the area (Giaever and Stein, 1998). Genetically distinct populations were also found in the Barents Sea and Mediterranean by Ryan *et al* 2005 by using one minisatellite and five microsatellite loci. Temporal variation was also seen between samples collected on the main spawning area. In this case there was insufficient data to identify explicitly the geographic range of these possible stocks. The most recent study conducted by Was *et al*, 2008 used a landscape genetics approach which combines spatial and genetic information to detect barriers to gene flow. This microsatellite analysis found that samples collected and analysed from along the south flowing current from the Porcupine Bank i.e. the Celtic Sea and Bay of Biscay were genetically different from those in the northward flowing current.

Temporal variation was seen in samples collected in the Rockall Bank area and the reasons for this are inconclusive.

Oceanographic modelling has been used to examine movements of blue whiting eggs and larvae. Larval drift is an important factor in recruitment. A hypothesis put forward by Skogen *et al*, 1999, was that the southern stock will spawn in an area where the eggs and larvae are likely to drift southwards and the northern stock where the eggs and larvae will drift northwards. Based on modelled drift patterns they found that a possible separation line was located at 54.5ºN but this was subject to significant interannual variability over the twenty years studied. Work conducted by Bartsch and Coombs (1997) used a three dimensional baroclinic model suggests that particles released on the Porcupine Bank drifted southwards with a separation at about 53–54ºN. This work gave some additional information about stock separation but suggested that the division might be more southerly. Additional testing of the use of this type of model was recommended.

An investigation of larval growth histories was carried out in 2007 (Brophy and King, 2007). Groups that are spatially or temporally distinct after hatching show measurable differences in the larval portion of the otolith. This study has shown that larvae from the Bay of Biscay grow faster than those from more northerly spawning areas. It also confirmed that fish spawning to the west of Ireland and Scotland, do not form a randomly mixing unit and that subunits within this aggregation have experienced difference during the larval phase. The dispersal of larvae influences the subsequent dispersal of spawning adults. The fish that are found in the feeding assemblages throughout the distribution do not contribute equally to the spawning assemblages in the north and south of the spawning grounds.

There is growing evidence from the studies conducted that there may be several components in the North East Atlantic blue whiting stock. It is difficult to determine how many possible sub-populations may exist. In many of the studies carried out to date samples have not been sufficiently large to identify separate components. A more extended coordinated sampling programme across the stock area is required. Further investigation would then be needed if any changes were required regarding existing management units. In the event that there are several components management would need to be more precautionary, spreading exploitation evenly among units to avoid local depletion. Until further information becomes available ICES recommends that management of blue whiting follow the single stock unit advice.

10.4 Data available

10.4.1 Catch data

Total catches in 2007 were provided by members of the WG. They were estimated to be about 1.61 million tonnes, 360 thousand tonnes less than in 2006. Time series with catches by nations and area are given in Tables 10.4.1.1.1–10.4.1.1.7.

The spatial and temporal distribution of the catches of blue whiting in 2007 is given by ICES rectangle for the whole year (Figure 10.4.1.1.1) and by quarter (Figure 10.4.1.1.2). In 2007 the data provided as catch by rectangle represented approximately 84% of the total WG catch.

Some details about vessels operated by different nations targeting blue whiting are given in Table 10.2.1 in section 10.2..

Most of the catches are taken in the directed pelagic trawl fishery in the spawning and post-spawning areas (Divisions Vb, VIa,b, and VIIb,c). Catches are also taken in the directed and mixed fishery in Subarea IV and Division IIIa, and in the pelagic trawl fishery in the Subareas I and II, in Divisions Va, and XIVa,b. These fisheries in the northern areas have taken 340 000–2 300 000 t per year in the last decade, while catches in the southern areas (Subarea VIII, IX, Divisions VIId,e and g-k) have been stable in the range of 20 000–85 000 t. In Division IXa blue whiting is mainly taken as bycatch in mixed trawl fisheries.

The proportion of landings originating from the Norwegian Sea has increased from 5% in the mid-1990 to around 30% in 2003−2004, after which the proportion has decreased again to around 11% (Figure 10.4.1.1.3). This might have implications for the stock assessment as much larger proportions of juvenile fish occur in catches from the Norwegian Sea, thus probably changing the exploitation pattern of the fishery as whole. Figures 10.4.1.1.4 and 10.4.1.1.5 show the spatial and temporal variation in the period 2000−2007.

Discards

Discards of blue whiting are thought to be small. Most of the blue whiting is caught in directed fisheries for reduction purposes. However, some discarding occurs in the fisheries for human consumption and as bycatch in fisheries directed to other species. Discarding in 2007 is not included in the assessment.

Reports on discarding from blue whiting fisheries were available from the Netherlands for the years 2002−2007. A discard sampling programme of the pelagic fleet is carried out in the framework of the EU Data Collection Regulation. On average about 3% (1%-5%) of the Dutch catch (in numbers) of blue whiting is estimated to be discarded. About 2/3 of the discards comes from the directed fishery and mainly originate from cod-end damage or cleaning of the fish tanks. The other 1/3 is bycatch in fisheries targeting other species. Blue whiting is a bycatch in several bottom trawl fisheries directed to a mixture of species but no bycatch was reported for 2007.

Sampling intensity

In total 1,399 samples were collected from the fisheries in 2007. 167,652 fish were measured and 23,495 were aged. Sampled fish were not evenly distributed throughout the fisheries (Table 10.4.1.2.1).

Considering the proportion between catches and sampling, the most intensive sampling took place in the southern fishery of Spain and Portugal. Here one sample was taken for every 34 tonnes, followed by the mixed fishery with one sample for every 582 tonnes, and lastly the directed fishery where there was one sample for every 1992 tonnes caught. In this context it should be noted that implementation of the EU Collection of Fisheries Data, Fisheries Regulation 1639/2001, requires EU Member States to take a minimum of one sample to be taken for every 1000 t landed in their country. Detailed information on the number of samples, number of fish measured, and number of fish aged by country and quarter is given in Table 10.4.1.2.1 and 10.4.1.2.2 As can be seen, no sampling was carried out by Germany, Sweden, France, and Lithuania, all with relatively small landings.

Sampling intensity for age and weight of herring and blue whiting are made in proportion to landings according to CR 1639/2001 and apply to EU member states. For other countries there are no guidelines. Current precision levels of the sampling intensity are unknown and the group recommends reviewing the sampling frequency and intensity on a scientific basis and provide guidelines for sampling intensity.

10.4.1.1 Length and age compositions

Data on the combined length composition of the 2007 commercial catch by quarter of the year from the directed fisheries in the Norwegian Sea and from the stock's main spawning area were provided by the Faroes, Iceland, Ireland, Germany the Netherlands, Norway, Russia and Scotland. Length composition of blue whiting varied from 12 to 48 cm, with 96% of fish ranging from 23–32 cm in length. The mean length in the fishery was 27.3 cm (Table 10.4.1.3.1) which is 4 mm larger than the mean length last year, and 11 mm larger than the mean length the year before.

The difference might be due to a decrease in recruitment in the most recent years lowering the proportion of young fish in the population. Length compositions of the blue whiting catch and bycatch from "other fisheries" in the Norwegian Sea and the North Sea and Skagerrak were presented by Norway (Table 10.4.1.3.2). The catches of blue whiting from the mixed industrial fisheries consisted of fish with lengths of 15–41 cm and a mean of 26 cm. Spain and Portugal caught blue whiting in the Southern area, together with very small quantities taken by the Netherlands, France and Scotland. The Spanish and Portuguese data used for length distribution of catches showed a length range from 11–43 cm with a mean length of 23.1 cm (Table 10.4.1.3.3).

For the directed fisheries in the northern area in 2007, age compositions were provided by Denmark, the Faroe Islands, Iceland, Ireland, Norway, the Netherlands, Russia and Scotland and the sampled catch accounted for 87% of the total catch. Estimates of catch in numbers for unsampled catches were raised according to the knowledge of how, where, and when the catches were taken. The age compositions in the directed fisheries are given in Table 10.4.1.3.4.

Age compositions for blue whiting bycatches from "other fisheries" in the North Sea and Skagerrak were provided by Norway, Denmark, Faroe Islands and Russia and sampled catch accounted for 96% of catches. These data were used for allocation of the remaining part of the total in that area. The age compositions are given in Table 10.4.1.3.5.

For the fisheries in the Southern area; age composition representing 89% of the catch were presented by Spain and Portugal. The age compositions in the southern fishery data are given in Table 10.4.1.3.6.

The combined age composition for the directed fisheries in the Northern area, i.e. the spawning area and the Norwegian Sea, as well as for the bycatch of blue whiting in "other fisheries" and for landings in the Southern area, were assumed to represent the overall age composition of the total landings for the blue whiting stock. The catch numbers-at-age used in the stock assessment are given in Table 10.4.1.3.7.The SALLOC program (ICES 1998/ACFM:18) was used to calculate the total international catch-at-age, and to document how it was done.

Catch curves made on the basis of the international catch-at-age (Figure 10.4.1.3.1) indicate a consistent stock-decline and thereby reasonably good quality catch-at-age data, especially for year-classes since 1995.

10.4.2 Information from the fishing industry

No comprehensive information has been received from the fishing industry this year.

10.4.3 Weight at age

Mean weight-at-age in the catch data were available from Denmark, the Faroes, Iceland, Ireland, the Netherlands, Norway, Portugal, Russia, Scotland and Spain. Mean weight-at-age for other countries was based on the allocations shown in the Annex II ("ALLOC" files) and was estimated by the SALLOC program for the total international catch. Table 10.4.3.1.1 shows the mean weight-at-age for the total catch during 1983–2007 used in the stock assessment.

The weight-at-age for the stock was assumed to be the same as the weight-at-age for the catch.

10.4.3.1 Analysis of the change in mean weight at age

The weight at age and growth rate in the catches has been decreasing since the early nineties (Figure 10.4.3.1.1). The same trend is seen in the spawning stock survey (Figure 10.4.3.1.2), showing that the overall trend is not an effect of changes in fisheries patterns – it is reflecting a real change in the population. This negative trend stopped around 2003 in survey data, but continued in the catches, the reason for this difference is the shift in fishing pattern from 2003−2007, where fishery in the Norwegian sea in the third quarter was replaced by the fishery on the spawning grounds (Rockall and Porcupine) in the first quarter (figure 10.4.1.1.4 and 10.4.1.1.5). The fish caught on the spawning grounds have lower weights at age than fish caught in the Norwegian Sea (10.4.3.1.3), therefore the overall mean weight decreased from 2003−7.

Since the main fishery is now taking place on the spawning grounds, it can be expected that the trend and size of mean weights at age in the fishery and in the spawning survey will converge given the present fishing pattern.

There are several possible explanations for the overall negative trend through the last 16 years. Since the main growth is taking place during the northern feeding migration it is most likely here, the explanation is to be found.

Suggested reasons for the change in growth and mean weight are:

- Ecosystem aspects, such as changes in feeding opportunities due to:
- Intra- and interspeciffic density dependant competition
- Zooplankton concentration, distribution and condition.
- External environmental factors, such as temperature and salinity have direct effect on the blue whiting physiology as well as on the physiology of the food.

Possible causal relations are considered in chapter 10.15 "Ecosystem considerations". In depth analysis of the causes, which would be needed for any kind of forecast is outside the scope of this working group.

10.4.4 Maturity and natural mortality

Maturity-at-age used in the assessment was obtained by combining maturity ogives from the southern and northern areas, weighted by catch in numbers-at-age (ICES 1995/Assess:7). These are the same as those used since 1994. Although the values of maturity-at-age probably are too low, sufficient information for estimating new ogives is not available.

The possible need for revising the current estimate of instantaneous natural mortality rate M for blue whiting was discussed in detail by the 2002 WG. Although it was admitted that the current estimate *M*>=0.2 yr^{-1} might be too low, the factual basis for revision was ambiguous. More recent methodological work by WGMG (ICES 2003/D:03) emphasizes that natural mortality rate cannot be estimated reliably with information normally available for stock assessment models. The working group therefore considers that there is no new information that would justify a revision of the current estimate of *M*.

In table 10.4.4.1, blue whiting natural mortality and proportion of maturation-at-age is shown.

10.4.5 Fisheries independent data

10.4.5.1 International Blue Whiting spawning stock survey

Background and status

The International Blue Whiting Spawning Stock Survey (IBWSS) is carried out on the spawning grounds west of the British Isles in March-April. The survey started in 2004 and is carried out by Norway, Russia, the Faroe Islands and the EU. This international survey, allowed for broad spatial coverage of the stock as well as a relatively dense net of trawl and hydrographical stations. The survey is coordinated by PGNAPES (ICES CM 2008xx, in press).

The International survey directly incorporates both the Norwegian and Russian spawning stock surveys that started in the early 1990s; details of these surveys can be found in previous working group documents (e.g. ICES CM 2006/ACFM:34). The integrity of the Norwegian time-series has been maintained from 1991–2006, and it was used as the major source of survey information in previous assessments. However, in 2007 the Norwegian contribution to the international survey changed, resulting in coverage of a non-standard area, and therefore a break in the time-series. The index from the Norwegian spawning stock survey time-series could therefore not be used from this year onwards.

Use of this survey in stock assessment

Indices of age 2−8 from the IBWSS survey were used as tuning time series in the assessment this year.

Quality of the survey

Uncertainties in spawning stock estimates have been assessed again in 2008. At present, only one source of uncertainty is considered namely the spatio-temporal variability in acoustic recordings. In 2008 mean acoustic density is similar to that observed in 2004–2006 over the entire survey area, and much less as observed in 2007 (Figure 10.4.5.1.1 left panel). This was caused by a few very high density observations in 2007. Relating these data to the stock estimate results show that the observed decline in biomass between 2006–2007 and 2008 is more than could be expected from uncertainty arising from spatial heterogeneity alone. In other words, within the considered domain of uncertainty, the decline is statistically significant.

The International spawning stock survey shows moderately good internal consistency for certain age groups (Figure 10.4.5.1.1 right panel). The international time-series clearly lacks sufficient data points to make a firm conclusion regarding internal consistency, but the available data appears more consistent with the low numbers from 2008.

Results

The spawning stock biomass appears to be maintained largely by growth of individuals in the spawning stock and to a lesser extent recruitment to the spawning stock.

The distribution of acoustic backscattering densities for blue whiting for the last 4 years is shown in Figure 10.4.5.1.2 (below). The main concentrations were generally recorded in the area between the Hebrides (>50%) and the banks southwest of the Faroes and the area north of Porcupine Bank. The blue whiting spawning stock estimates based on the international survey are given in Table 10.4.5.1.1.

The estimated total abundance of blue whiting for the 2008 international survey was 8 million tonnes, representing an abundance of $68x10^9$ individuals. The spawning stock was estimated at 7.9 million tonnes and $67x10^9$ individuals. In comparison to the results in 2007, there is a significant decrease (30%) in the observed stock biomass and a related decrease in stock numbers whereas the survey area was not more than 6% lower than the previous year (see table below). This decrease in stock estimate has been clearly observed in all sub-areas.

The stock in the survey area is dominated by age 4 and 5, of the 2003 and 2004 year classes respectively, contributing half of the spawning stock biomass. Immature individuals were observed in all sub areas but the total proportion of immature fish follows a similar declining pattern to that observed in 2007 and represents less than 1.5% of the total stock biomass.

Age and length distributions from the 4 last years are shown in Figure 10.4.5.1.3.

10.4.5.2 International ecosystem survey in the Nordic Seas

Background and status

The international ecosystem survey in the Nordic Seas (Figure 10.4.5.2.1 below) is aimed at observing the pelagic ecosystem with particular focus on Norwegian spring-spawning herring and blue whiting in the Norwegian Sea. Estimates in 2000–2008 are available both for the total survey area and for a “standardized” survey area. The latter is more meaningful as the survey coverage has been rather variable in the non-standard areas.

The survey is carried out in May since 1995 by the Faroes, Iceland, Norway, and Russia, and since 1997 (except 2002 and 2003) the EU. The high effort in this survey with such a broad international participation allowed for broad spatial coverage as well as a relatively dense net of trawl and hydrographic stations.

Since 2005 this survey has extended into the Barents Sea where the main focus of investigations has been young herring and capelin larvae. In 2008 the Russian vessel could not enter the Norwegian EEZ due to missing permissions from Russian authorities, so a large area in the Barents Sea was not covered. Low numbers of blue whiting found in the Norwegian bottom trawl survey in this area suggest that this gap would not significantly change the estimate for blue whiting. The survey is coordinated by PGNAPES (ICES CM 2008xx, in press).

Use of this survey in stock assessment

Indices of age 1 and 2 (from the standard area) is used as tuning time series in the assessment. Moreover, the age 1 indices are used in the recruitment prediction.

Quality of the survey

Internal consistency within the survey's age composition shows good correlation for the early age groups 1 to 4 year olds (Figure 10.4.5.2.2).

Results for blue whiting

The total biomass of blue whiting reported during the May 2008 survey was 1.1 million tonnes, which is very low (the corresponding estimates from 2006 and 2007 were 6.2 and 2.4 mill. tonnes, respectively). The stock estimate in number for 2008 is 8.2 billion, which is about 35% of the 2007 estimate. The reduction in estimated abundance is most severe for ages 1–3, but estimates of ages 4–5 are also significantly lower in 2008 than in previous years.

An estimate was also made from a subset of the data; namely the "standard survey area" between 8°W-20°E and north of 63°N (Figure 10.4.5.2.1). This area has been used as an indicator of the abundance of blue whiting in the Norwegian Sea because the spatial coverage in this area provides a coherent time series with adequate spatial coverage – this estimate is used as an abundance index in the assessment. The age-disaggregated total stock estimate in the "standard area" is presented in Table 10.4.5.2.1, showing that the part of the stock in this index area is dominated by 4 year old blue whiting.

Blue whiting were observed in most of the survey area with the highest concentrations northwest of the Faroe Islands (Figure 10.4.5.2.3). The mean length of blue whiting is shown in Figure 3.2.4.3. It should be noted that the spatial survey design was not intended to cover the whole blue whiting stock during this period.

The blue whiting stock estimates based on the international survey in both the standard and total survey area are given in Table 10.4.5.2.1. Age and length distributions from the 4 last years are shown in Figure 10.4.5.2.4.

10.4.5.3 Norwegian bottom trawl survey in the Barents Sea

Background and status

Norway has conducted bottom trawl surveys targeting cod and other demersal fish in the Barents Sea since late 1970s. From 1981 onwards there have been systematically designed surveys carried out during the winter months (usually late January-early March) by at least two Norwegian vessels; in some years the survey has been conducted in co-operation with Russia. Blue whiting is a regular bycatch species in these surveys, and has in some years been among the numerically dominant species (Heino et al., 2003). This survey is presently giving the first reliable indication of year class strength of blue whiting.

Most of the blue whiting catches (or samples thereof) have been measured for body length, but very few age readings are available (from 2004 onwards otoliths are systematically collected). The existing age readings suggest that virtually all blue whiting less than 19 cm in length belong to 1–group and that while some 1–group blue whiting are larger, the resulting underestimation is not significant. An abundance index of all blue whiting and putative 1–group blue whiting from 1981 onwards is given in Table 10.4.5.3.1 and follows methods described in Heino *et al*. (2003).

1–group index for 2008 is very weak in the historic perspective (the lowest observed since 1994 and only four years in the time series have lower values).

Use of this survey in blue whiting assessment

The survey is not used in the assessments, but it is used for recruitment predictions.

10.4.5.4Spanish bottom trawl survey

Background and status

Bottom trawl surveys have been conducted off the Galician (NW Spain) coast since 1980, following a stratified random sampling design and covering depths down to 500 m. The survey directed to a mixture of species. Since 1983, the area covered in the Spanish survey was extended to completely cover Spanish waters in Division VIIIc. A new stratification has been established since 1997.

Use of this survey in blue whiting assessment

The survey is not used in the assessments as it is only representative for a small part of the stock area.

Results

Stratified mean catches and standard errors are shown in Table 10.4.5.6.1. Larger mean catch rates are observed in the 100–500 m depth range. Since 1988 the highest catch rates in the Spanish survey were observed in 1999 (124 kg/haul). The 2007 estimate is 27 kg/haul (Figure 10.4.5.6.1.).

10.4.5.5 Portuguese bottom trawl survey

Background and status

Bottom trawl surveys have been conducted off the Portuguese coast since 1979, following a stratified random sampling design and covering depths down to 500 m. The area covered in the Portuguese survey was extended in 1989 to the 750 m contour.

Use of this survey in blue whiting assessment:

The survey is not used in the assessments as it is only representative for a small part of the stock area.

Results

Stratified mean catches and standard errors from the Portuguese survey are shown in Table 10.4.5.5.1. Larger mean catch rates were observed in the 100–500 m depth range. The Portuguese autumn surveys generally give higher values than in the summer surveys, and a better correlation with the Spanish surveys (Figure 10.4.5.7.1).

10.4.5.6 Surveys not providing any data to the Working Group

It was decided not to present any surveys which have been terminated or do not deliver any new data to the Working Group. Historical results can be found in earlier Working Group documents.

- Norwegian Sea summer survey, executed in 1981 – 2001, 2005–2007. The stock estimates in numbers at age are given in the 2007 report.
- Faroes plateau spring bottom trawl survey, executed during spring (March 1996–2008). The survey is aimed at cod, haddock and saithe, but varying amounts of blue whiting are caught as bycatch each year.
- Faroes plateau autumn bottom trawl survey, executed in autumn (August-September 1994–2008). The survey is aimed at cod, haddock and saithe, but varying amounts of blue whiting are caught as bycatch each year.

10.5 Methods

In previous years, the NPBWWG used an array of models for the assessment and made a comprehensive presentation and comparison of the various model output. Based on this evaluation, the SMS assessment has been chosen as the final assessment for the last three years. This year we have done the same exercise, but with a fewer models tested and a less comprehensive presentation of the model results.

A comprehensive analysis was made last year to examine the impact of adding and removing the available surveys (ICES, 2007/ACFM:29). This year, we have used the final configuration of survey data used last year without further explorations. The applied survey data area presented in table 10.5.1.

10.5.1 Data exploration in SMS

Two alternative configurations of the 2007 WG options for Stochastic Multi-species (SMS) model (Lewy and Vinther, 2004) were tested this year. Firstly the effect of the year range for the constant selection pattern in the fishery was tested, and secondly the effect of confining the estimated variance for the very short time series (5 years) from the IBSSS.

Year range for constant selectivity: SMS operates with two periods where the selection pattern for the catches. The first year in the second period has been kept constant (at 1993) in the last four year's assessments. Originally this year was chosen such that the period of constant selection was 10 years (arbitrarily chosen). However the relevance of the actually choice has not been investigated further before. Figure 10.5.1.1 shows the –log likelihoods from configurations using a different starting year for the period of constant selection. The likelihoods are quite similar for the years 1993–1999, however with a minimum (best model fit) at year 1999. The catch residual plots from the models using 1993 and 1999 are quite similar, but using the year range 1993–2007 gave a less clustered pattern for the ages 3–5, which dominates the catches. A retrospective analysis (2006–2007) revealed a more consistent estimate of F using 1999 as the first year.

Landings increased by 77% from 1997 to 1998 and have been maintained at the high level since. This may indicate a change in selection pattern in the late 1990s as indicated by the log-likelihood analysis.

Estimated SSB, F and recruitments from the various configurations are very similar. The model output results using the default first year (1993) and 1999 are shown in Figure 10.5.1.2. F in 2007 is slightly lower and SSB slightly higher when 1999 is used as the first year.

Due to the better overall model fit, the less clustered catch residuals, and more a more consistent retrospective estimate of F, the year range for the period with constant selection was changed from 1993–2007 to 1999–2007.

Minimum CV of the IBSSS: The International Blue Whiting Spawning Stock Survey (IBSSS) was included in the assessment last year, even though the time series was only 4 years. One more year has been added this year, but the time series is still very short. SMS uses maximum likelihood to weight the various data sources, giving a higher weight to observations associated with a low uncertainty. The results from last year's assessment and model runs this year showed that the model is fitting the IBSSS with a low standard deviation (0.2) for most ages, and thereby placing a high weight upon it. However, this may be scientifically unwise, due to the very short time-series and lack of contrast in the data. Reducing the weight given to this survey would produce a more robust assessment.

Last year the lower bound on the standard deviation from IBWSS observation was set to 0.4 to avoid “over fitting” of this very short time series. The effect of down-weighting all surveys was first examined by varying the *a priori* weights applied to all survey information in the SMS model (Figure 10.5.1.3). In contrast to last year’s results, the *a priori* weight on surveys has almost no effect on the estimated SSB, F and recruitment. This indicates that the addition of one more year to the IBWSS has stabilized the assessment considerably, and that catch data and survey indices show the same signal. The effect of a lower bound on standard deviation for only the IBWSS is presented in Figure 10.5.1.4. The difference in output from the two runs using a minimum CV at 0.4 or 0.3 is very small. It was decided to maintain the default value used last year at 0.4 since the length of the IBWSS time series is still very short.

Final configuration of SMS: The final SMS configuration (see section 10.6) is the same as last year except for change in the period for constant selection was changed from 1993–2006 to 1999–2007.

Examination of the catch residuals from the final SMS run (Figure 10.5.1.5) showed no appreciable patterns. The residuals from the survey observations (Figure 10.5.1.6) showed significant year effects in the IBWSS and Norwegian spawning stock survey, a well-known phenomenon with acoustic surveys. Compared with the residual from last year, the residuals from IBSSS are generally slightly higher, but more evenly distributed between years. The residuals from the International Ecosystem Survey in Nordic Seas (IESNS) are much higher this year. This is due to the indices for 2007–2008, which are a factor 2000 for age 1 and 40 to 300 for age 2 lower than the mean indices for the period 2000–2005. Catch data indicate a steep reduction in the recruitment, however not at that magnitude as indicated by the survey data. Fitting those two times data series with the same trend, but with a very different decrease is impossible leading to the very large residuals for the survey.

Examination of the diagnostic output from the final SMS run (Table 10.5.1.1) does not show any major causes for concern, although there is an unusual effect in the values of the survey catchabilities-at-age. The catchability in the Norwegian Spawning Stock Survey increases with age, and reaches at maximum at age 4. This is an unusual result, and tends to contradict the trend seen in the IBSSS, where the catchability increases monotonically with age, even though these two surveys are quite similar in setup. A similar phenomenon was observed Norwegian spawning stock survey in the final SMS run in the 2006–2007 working group. There is no good explanation for the result, but could simply be due to a lower (trawl) catchability of the oldest fish on the Norwegian spawning stock survey.

Comparison of the observed and fitted catches from the SMS run (Figure 10.5.1.7) did not provide strong evidence that the separability assumption has been violated; there is close agreement between the two time-series.

Due to the very short IBWSS time series the retrospective run can only be run for the last two years (Figure 10.5.1.8). The most recent F estimates are decreased and the SSB increased by addition of the 2007 data.

The comparison of the final assessment results in 2007 and the final SMS this year (Figur 10.5.1.9) shows that this year’s assessment estimate a lower F and a higher SSB in the most recent year, similarly to what is seen by the retrospective analysis.

The final SMS run (Figure 10.5.1.10, Tables 10.5.1.1–10.5.1.3) shows a small increase in fishing mortality in the terminal year. SSB is very rapidly decreasing associated with a strong decreasing recruitment from 2001 onwards and a limited decrease in landings in the same period. The 2005 year-class is at historic low levels and the 2004 year class is in the low end of the recruitments estimated for the "low recruitment" period in the 1980s.

The uncertainties on SSB and mean F are large (Figure 10.5.1.11), and at the same level as in last years' assessment. The CV of SSB increases from 5% in 2002 to 15% in 2007. CV on F increases from 8% to 20% in the same period. Uncertainties on stock numbers (1. January 2007) varies between 17% and 52% with the largest values on the youngest and oldest ages. Uncertainties on the stock numbers going in the short term forecast (N 1. January 2008) are in the range 30% to 50%.

10.5.2 Data exploration in FLICA

The ICA (Integrated Catch at Age Analysis) model implemented in FLR framework was used to explore blue whiting data. In previous years, various FLICA settings were investigated. In 2008 the use of the IESNS as a tuning fleet was examined. The same settings as the final ICA run in 2007 were used for each run in 2008.

As in previous years the available tuning fleets are the Norwegian spawning stock survey, ages 3–8 from 1991 – 2003. The IESNS, ages 1 and 2 from 2000 – 2008 and the IBSSS, ages 3–8 from 2004 – 2008.

The IESNS is the main recruitment index used in the assessment. The indices for 2007 and 2008 are very low with the 2008 index the lowest in the current time series.

Four Runs were carried out with the following variations

- SPALY (same procedure as last year) run including the IESNS
- The IESNS down-weighted
- The 2007 and 2008 values from the IESNS omitted
- IESNS excluded

The stock summaries for each run are presented in figure 10.5.2.1

FLICA shows a clear downward trend in recruitment since 2003. From 2003 SSB also shows a declining trend with the lowest value obtained in 2007. Mean F values have fluctuated over time with 2007 showing a slight increase. FLICA estimates F to be in the region of 0.36.

The final run chosen omits the very low values for 1 and 2 year olds found in the 2007 and 2008 IESNS. FLICA is very sensitive to these low values and when they are included result in very high F values and lower SSB values. Overall this run excluding these low values shows an improved residual pattern and a better model fit.

FLICA is compared to other models, SMS, TISVPA and XSA and produces a comparable low value for recruitment and similar trends in SSB as the other models. Each model shows the same pattern in mean F, with FLICA showing lower levels over the time series.

10.5.3 Data exploration in TISVPA

The result of the TISVPA exploratory run is somewhat more optimistic in comparison to expectations from the last year runs (see figure 10.5.4.5 and tables 10.5.4.1–10.5.4.3) and generally supports the results of present assessment made by the SMS model.

As in the previous assessments (2006 and 2007), the "triple-separable version of the ISVPA model (TISVPA) was used for exploratory runs. This version takes into account possible cohort-dependent peculiarities in selection pattern. These may originate from possible interactions of different cohorts with fishing fleets, or by possible errors in aging of some cohort or by some other unknown reasons.

The model settings were chosen to minimize non-contradicting signals from all available data (catch-at-age and 3 surveys: Norwegian spawning stock survey (survey 1); IESNS (survey 2), and the IBSSS (survey 3)) in order to retain the meaningful input into the model from all of them.

Similarly to last year, the following setting was used:

- the "catch-controlled" version (catch-at-age is assumed as true and all residuals in catch-at-age are attributed to violations of selection pattern stability) with the assumption of unbiased separable representation of fishing mortalities (more correctly−of exploitation rates);
- the window for estimation of cohort-factors−from age 1 to age 8; the measure of closeness of fit for catch-at-age−sum of squared residuals in logarithmic catch-at-age;
- catchability-at-age were estimated for all surveys.

The year of the change in selection pattern was chosen as 1994 (first year of the second selection pattern in the model) (see fig.10.5.3.1) as corresponding to the best fit to catch-at-age data.

When the components of the model objective function were chosen as traditional sums of squared logarithmic residuals, all data sources showed similar positions of respective minima, except for survey 2, the IESNS (Figure 10.5.3.2 A). In order to achieve similar results as from other surveys,, a more robust measure of closeness of fit the absolute median deviation (AMD) should be used. (Figure 10.5.3.2 B)

The selection pattern, estimated by the TISVPA model is shown on figure 10.5.3.3.

Figure 10.5.3.4 represents the model residuals by sources of data.

10.5.4 Data exploration in XSA

The main results (figure 10.5.5.1) are similar to the results from the other models.

XSA was run with the three surveys (Table 10.5.1) and the used following configuration:

- q plateau set at age 7
- catchability depends on stock size for ages less than 3
- SE at survey estimates set as 0.3
- Regression type P

10.5.5 Comparison of results of different assessments

The four models estimate a steep decrease in recruitment in the most recent years with the age 1 abundance in 2007 at a historically low value. All the models also estimate a large SSB reduction since 2004 with SSB in the range 2.9- 3.6 million tons in the start of 2008. Mean F in 2007 is estimated in the close range 0.37−0.44 with the highest F estimated by XSA.

The explorative runs showed that the very low indices for age 1 and age 2 in 2007-2008 from the IESNS caused some problems. For fitting all the data sources simultaneously, SMS increased the variance considerably for the survey compared to last year and thereby down-weighted its influence on the final population estimate. TISVPA uses fixed weight on the individual survey and had to shift to the more robust measure of closeness of fit−the absolute median deviation (AMD), to avoid contradicting signals about the stock from all the data sources. The population estimate from FLICA, with a configuration of fixed weighting of surveys and thus a relatively high weight on the survey with only two ages (1 and 2), was relativity low when the full time series was included, but gave similar results as SMS and TISVPA when the last two year's observation was removed from the survey. Figure 10.5.5.1 presents output from the various models.

XSA does not use survey data from 2008. Therefore, the very low indices for juveniles in 2008 were not included in the assessment and the IBSSS includes only the very short time series 2004−2007.

The WG decided to bring the SMS assessments into the forecast. SMS has been used for the last three years as the final assessment method and SMS in its final configuration gave results similar to the FLICA and TISVPA methods.

10.6 Final assessment

Input data are catch-at-age numbers (Table 10.4.1.3.7), mean weight-at-age in the sea and in the catch (Table 10.4.3.1.1) and natural mortality and proportion mature in Section 10.4.4. Applied survey data are presented in Table 10.5.1. The International Blue Whiting spawning stock survey" and the "International ecosystem survey in the Nordic Seas" are described further in section 10.4.5.1−10.4.5.2. The *Norwegian spawning ground survey* (described in ICES 2006) has been included in The International Blue Whiting spawning stock survey for the period since 2003.

The key settings and data for the final blue whiting assessment in 2006, 2007 and 2008 are shown in the table below. The changes from 2007 and 2008 are the addition of one more year to the time series and a change of the period where the catch selection pattern is assumed constant.

Settings/options for the final assessment	2006	2007	2008
Software	SMS	SMS	SMS
Age range for the analysis	1–10+	1–10+	1–10+
Last age a plus-group?	Yes	Yes	Yes
Catch data			
Constant selection pattern for the catch	2 periods: 1981–1992,1993–2005	2 periods: 1981–1992,1993–2006	2 periods: 1981–1999,1999–2006
First age with age independent catchability	8	8	8
Age groups with the same variance	1, 2, 3–6, 7–10	1, 2, 3–6, 7–10	1, 2, 3–6, 7–10
Age-structured tuning time-series			
Norwegian spawning ground survey, ages 3–8,	1993–2006	1993–2003	1993–2003
First age with age independent catchability	7	5	5

Settings/options for the final assessment	2006	2007	2008
Age groups with the same variance	3–4, 5–6, 7–8	3–4, 5–6, 7–8	3–4, 5–6, 7–8
International ecosystem survey in the Nordic Seas, ages 1–2	2000–2006	2000–2007	2000–2008
First age with age independent catchability	2	2	2
ages 1–2	2000–2006	2000–2007	2000–2008
Age groups with the same variance	1, 2	1, 2	1, 2
International blue whiting spawning stock ground survey *, ages 3–8*	Not used	2004–2007	2004–2008
First age with age independent catchability		5	5
Age groups with the same variance		3–8, min std 0.4	3–8, min std 0.4

The model was run until 2007. The SSB January 1st in 2008 is estimated from survivors without taking the contribution from recruits into account. With the very low recruitment this omission has practically no implications. The key results are presented in Tables 10.5.1.2−10.5.13 and summarized in Table 10.5.1.4 and Figure 10.5.1.10. Residuals of the model fit are shown in Figure 10.5.1.5 and Figure 10.5.1.6 and discussed in Section 10.5.1. Uncertainties of mean F and SSB are shown in figure 10.5.1.11.

10.7 Biological reference points

The present precautionary reference points have been introduced in the advice of ACFM in 1998. The values and their technical basis are:

REFERENCE POINT	B_{IM}	B_{PA}	F_{LIM}	F_{PA}
Value	1.5 mill t	2.25 mill. t	0.51 yr^{-1}	0.32 yr^{-1}
Basis	$\mathbf{B}_{loss}$	$\mathbf{B}_{lim}$* exp(1.645* σ), with σ= 0.25.	$\mathbf{F}_{loss}$	$\mathbf{F}_{med}$

Although problems have been identified with these reference points they have remained unchanged since then. A major problem is that fishing at $\mathbf{F}_{pa}$ implies a high probability of bringing the stock below $\mathbf{B}_{pa}$, in other words the present combination of $\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$ is inconsistent.

The Workshop on Limit and Target Reference Points (WKREF) considered the biological reference points for Blue Whiting at a meeting in Gdynia, Poland in January last year (ICES CM 2007/ACFM:05). The original reference points for this stock were set in 1998, before the era of high productivity became apparent. The group examined the consequences of these new observations on the reference points by first splitting the time-series into two productivity regimes (low productivity from 1981–1994, and high productivity from 1995–2005). Standard methods (i.e. using the guidelines from the Study Group on Precautionary Reference points, SGPRP (ICES CM 2003/ACFM:15)) were then used to re-estimate the reference points, which were found to be comparable to the current values. A new probabilistic approach for estimating B_{lim} was also employed, but again, the result was found to be comparable with the current values. The group concluded that there was no basis for revising the current reference points. WKREF also noted that there may be no need for different B_{lim} values in different productivity regimes.

A stochastic equilibrium analysis made during the Working Group established by the Blue Whiting Coastal States on Blue Whiting management strategies (*Anon.*, 2008) indicates a high risk of stock collapse with an F from approximately 0.3 and upwards given the "low recruitment" regime as observed in 1981–1996. F_{max} is poorly defined and a very limited increase in yield is obtained for F in the range 0.18 to 0.30. $F_{0.1}$ was estimated at 0.18. Sensitivity analysis of a change in exploitation pattern showed that these conclusions are robust with respect to the choice of exploitation pattern.

A yield per recruit analysis was conducted using MFYPR. $F_{0.1}$ is calculated as 0.18. The results are presented in Figure 10.7.1.

10.8 State of the Stock

Based on the most recent estimates of fishing mortality and SSB, ICES classifies the stock as having full reproductive capacity, but being harvested unsustainably.

It is confirmed from several time series that the 2005 and 2006 year classes are in the very low end of the historical recruitments. This is probably also the case for the 2007 year class. It is not possible to say if this is a more permanent shift towards the low recruitment regime, as observed in the period before the mid 1990s. Fishing mortality has declined from 2004 to 2006, but has increased slightly to 0.41 in 2007. SSB has declined since its historical peak in 2003 at around 7 million tonnes to 3.5 million tonnes at the beginning of 2008. A TAC of 1.25 million t in 2008 in combination with the small 2005–2007 year class will reduce SSB further to just above Bpa 1st January 2009.

10.9 Short term forecast

10.9.1 Recruitment estimates

In the previous two years recruitment at age 1 in the assessment year was predicted based on three different survey time series (1) the Norwegian bottom trawl survey in the Barents Sea, (2) the International Ecosystem survey in the Nordic Seas total area and (3) the International Ecosystem survey in the Nordic Seas standard area. (A more detailed description of these surveys is given in Section 10.4.5.). These time series was chosen based on exploration of recruitment signals in different data sources in 2006 (ICES 2006 d). The recruitment indices all indicate that both the 2006 and 2007 year classes are very weak (Figure 10.9.1.1 and Tables 10.4.5.2.1–10.4.5.3.1); around 3 orders of magnitude weaker than the average (index) from earlier years. The working group considers this large difference as unrealistic. Based on the available information it can only be inferred that the 2006 and 2007 year classes are very weak, but it is not known how weak. The working group therefore decided to assume that recruitment at age 1 in 2007 and 2008 is equal to the lowest observed pre-2007 value from the final SMS assessment which is **3.28 billion** (the 1980 year class).

For comparison, it was decided to also conduct a survey-based estimate of recruitment using the standard ICES software, RCT3. The trend in the standard area and total area index from the International ecosystem survey are quite similar (Fig. 10.9.1.1). Based on this, and the fact that these two time series are derived from the same survey and that the total area estimate is more influenced by between-year variation in spatial coverage (see Section 10.4.5), only the standard area index series was used. The Barents Sea bottom trawl time series extends back to 1981 and has previously provided good indications of year class strength, thus this series was also used. Figure 10.9.1.2 shows how age 1 estimates from the final SMS assessment relates to age 1 indices from the two surveys. Input to the RCT3 model is given in Table 10.9.1.1, and output in Table 10.9.1.2.

Since the stock now appears to have entered a "low" recruitment regime, geometric mean of the recruitments from 1981–1996 (8.82 billion at age 1) was assumed for the 2008 and 2009 year classes.

The text table below shows alternative recruitment assumptions (number of age 1 in billions). Values used in the short term prediction are in bold.

Year class	Age in 2008	SMS	RCT3	GM 81–96	SMS 81	GM 81–07
2006	2	1.78	1.80	8.82	3.28	13.42
2007	1	-	1.70	8.82	3.28	13.42
2008–2009	0	-	-	8.82	3.28	13.42

10.9.2 Short term forecast

Short term forecasts were conducted with the ICES standard software MFDP (Multi Fleet Deterministic Projection) version 1a.

Input

Table 10.9.2.1 lists the input data for the short term predictions. Mean weight at age in the stock and mean weight in the catch are the same and are calculated as three year averages (2005–2007). Selection (exploitation pattern) is based on F in 2007 from the most recent assessment, which assumes a fixed selection in the period 1999–2007. Natural mortality is assumed to be 0.2 across all ages. The proportion mature for this stock is assumed constant over the years and values are copied from the assessment input. The expected landings in 2008 is 1.2 million tonnes, which is 50 000 t lower than the TAC. This reduction is based on the best guess on the likelihood that the individual nations will take their full quota this year. .

Output

The predicted catch and SSB from the short term forecast are presented in Table 10.9.2.2 and figure 10.9.2.1.

Fishing at F_{pa} = 0.32 in 2009, will give landings of 711 thousand tonnes and an SSB of 1.93 million tonnes in 2010. This is below the precautionary limit, B_{pa} = 2.25 million tonnes. Landings at 384 thousand tonnes will leave a SSB in 2010 just above B_{pa}

Reducing the TAC according to the management plan agreed in 2005 with at least 100 thousand tonnes to 1.15 million tonnes in 2009 will lead to a SSB in 2010 of 1.50 million tonnes, which is equal to B_{lim}. If clause 6 of the management plan is interpreted as a requirement to keep SSB above Bpa in 2010 a maximum catch of 384 000 t can be taken in 2009.

The ICES evaluation of the draft 2008 management plan concludes that the plan is precautionary, if applied directly without a gradual F-reduction This implies application of the equation in clause 6 and with a SSB at 242 000 t in 2009, F in 2009 should be 0.17 resulting in a maximum catch of 408 thousands t in 2009.

Due to the low recruitment since 2005, the main part of the SSB and Catch in 2009–2010 come from the last strong year classes 2002–2004. Figure 10.9.2.1 shows the contribution by age SSB and catch using F_{2009}=0.2.

10.10 Medium term forecasts

Medium forecasts are presented as part of the evaluation of the 2008 management plan. See section 10.13.

10.11 Uncertainties in assessment and forecast

The assessments presented this year should be considered as fairly certain with respect to the absolute estimates of stock metrics, and certain in the conclusion on a strong decline in both SSB and recruitment in the most recent years.

There is only one survey that covers the spawning stock (IBWSS), but this survey consists of only 5 years, which is a very short period for assessment purpose. Being a acoustic survey taking place in a large area often during rough weather these circumstances are believed to have a negative effect on the quality of this survey. This problem was acknowledged by the planning group (PGNAPES) and improved international coordination has been given first priority.

Recruitment is mainly determined from surveys, which show that the abundance of 1 year old blue whiting has decreased to a very low level in the period 2006–2008. Very low age-2 abundance observed the following year for the same year class confirms the very low abundance of juveniles in the survey area. Catch data and information from the survey on the spawning grounds (IBWSS) confirms a very steep decrease in recruitment as well. It is not possible to estimate the exact level of recruitment, but there is no doubt that recruitment is very low. For forecast it is assumed that the age-1 abundance in 2007 and 2008 are at the same level as the lowest recruitment in the full assessment period. This assumption gives a slightly higher recruitment compared to the estimates from the surveys alone.

Last year the 2005 year classes was estimated to 2.9 billion by the assessment, but later raised to 11.7 billion for the use in forecast on the basis of a simple mean of survey estimates. This year the, the 2005 year-class is estimated twice as high (6.2 billions) as estimated by the assessment (catch and survey data) last year but lower than the estimate from surveys alone. Last years estimate of the 2006 year class was 4.84 billion based on a simple average of survey estimates. This year the assessment (catch and survey data) estimate the year class at 1.78 billion. The revision of the recruitment estimates illustrate the uncertainties in the recruitment estimate, but does not give a signal of the potential bias.

The four assessment models applied this year gave a consistent picture of the state of the stock. That means that the choice of the final assessment model has a very limited influence on the forecast results. Statistical uncertainties of the estimated SSB and fishing mortality from the final assessment (Figure 10.5.1.11) are however relatively large compared to most other stocks, such that the uncertainty of the predicted SSB becomes relatively high as well.

10.12 Comparison with previous assessment and forecast

The assessment is consistent with the results presented last year, however with a small upwards revision of SSB and a downward revision of F in the most recent years (Figure 10.5.1.9). Year classes 2001–2003 and 2005 are revised upwards while year-class 2004 is revised downwards. The retrospective analysis give the same result indicating that it is the addition of the 2007 data that makes the difference and not the small change in the model options.

The small revision of the stock has not changed the overall impression of the state of the stock. In 2007 ICES stated that an F at 0.51 corresponds to a landings at 1.25 million (the final TAC) in 2008. Due to the upwards revision of the stock, an F in 2008 at around 0.4 is however estimated to be sufficient for the TAC in 2008. Last year, SSB in the start of 2009 was estimated to 2.25 million t. This year the estimate has been raised to 2.42 million; a change of less than 8%

10.13 Management plans and evaluations

In October 2006, the coastal states (EU, Norway, Iceland and Faroe Islands) agreed on a management plan presented below:

ANNEX II. ARRANGEMENT FOR THE MULTI-ANNUAL MANAGEMENT OF THE BLUE WHITING STOCK

The Parties agree to implement a multi-annual management arrangement for the fisheries on the blue whiting stock which is consistent with the precautionary approach, aiming at constraining harvest within safe biological limits, protecting juveniles, and designed to provide for sustainable fisheries and a greater potential yield, in accordance with advice from ICES.

1) *The management targets are to maintain the Spawning Stock Biomass (SSB) of the blue whiting stock at levels above 1.5 million tonnes (Blim) and the fishing mortality rates at levels of no more than 0.32 (Fpa) for appropriate age groups as defined by ICES.*

2) *For 2006, the Parties agree to limit their fisheries of blue whiting to a total allowable catch of no more than 2 million tonnes.*

3) *The Parties recognise that a total outtake by the Parties of 2 million tonnes in 2006 will result in a fishing mortality rate above the target level as defined in Paragraph 2. Until the fishing mortality has reached a level of no more than 0.32, the Parties agree to reduce their total allowable catch of blue whiting by at least 100 000 tonnes annually.*

4) *When the target fishing mortality rate has been reached, the Parties shall limit their allowable catches to levels consistent with a fishing mortality rate of no more than 0.32 for appropriate age groups as defined by ICES.*

5) *Should the SSB fall below a reference point of 2.25 million tonnes (Bpa), either the fishing mortality rate referred to in Paragraph 5 or the tonnage referred to in Paragraph 4 shall be adapted in the light of scientific estimates of the conditions then prevailing. Such adaptation shall ensure a safe and rapid recovery of the SSB to a level in excess of 2.25 million tonnes.*

6) *This multi-annual management arrangement shall be reviewed by the Parties on the basis of ICES advice.*

The ICES review of the management plan concluded that that the plan is not precautionary in a situation with a (continued) low recruitment, as observed before 1995. A new draft management plan has been suggested by the Coastal states. This plan is evaluated in the following section.

10.13.1 Evaluation of the MP proposal by the blue whiting Coastal states

ICES has been requested by the coastal states Norway, EC, The Faroe Islands and Iceland, to evaluate a proposed management plan for Blue whiting. The proposed plan was selected by the coastal states after a meeting of scientists from the coastal states in May, (“the May meeting”–Anon 2008), at which the performance of a wide range of potential management strategies was studied by simulation.

The **request** was as follows:

ARRANGEMENT FOR THE LONG-TERM MANAGEMENT OF THE BLUE WHITING STOCK

1. The Parties agree to implement a long-term management plan for the fisheries on the Blue Whiting stock, which is consistent with the precautionary approach, aiming at ensuring harvest within safe biological limits and designed to provide for fisheries consistent with maximum sustainable yield, in accordance with advice from ICES.

2. For the purpose of this long-term management plan, in the following text, "TAC" means the sum of the coastal State TAC and the NEAFC allowable catches.

3. As a priority, the long-telll1plan shall ensure with high probability that the size of the stock is maintained above 1.5 million tonnes (Blim).

4. The Parties shall aim to exploit the stock with a fishing mortality of 0.18 on relevant age groups as defined by ICES.

5. While fishing mortality exceeds that specified in paragraph 4, the Parties agree to establish the TAC consistent with annual [x%] reductions in fishing mortality until the fishing mortality established in paragraph 4 has been reached.

For the purposes of this calculation, the fishing percentage mortality reduction should be calculated with respect to the year before the year in which the TAC is to be established. For this year, it shall be assumed that the relevant TAC constrains catches.

6. When the fishing mortality in paragraph 4 has been reached, the Parties agree to establish the TAC in each year in accordance with the following rules:

- *In the case that the spawning biomass is forecast to reach or exceed 2.5 million tonnes (SSB trigger level) on 1 January of the year for which the TAC is to be set, the TAC shall be fixed at the level consistent with the specified fishing mortality.*
- *In the case that the spawning biomass is forecast to be less than 2.5 million tonnes on 1 January of the year for which the TAC is to be set (B), the TAC shall be fixed that is consistent with a fishing mortality given by:*
  - $F = 0.05 + [(B-1.5)(0.18-0.05) / (2.5-1.5)]$
- *In the case that spawning biomass is forecast to be less than 1.5 million tonnes on 1 January of the year for which the TAC is to be set, the TAC will be fixed that is consistent with a fishing mortality given by F = 0.05.*

7. When the fishing mortality rate on the stock is consistent with that established in paragraph 4 and the spawning stock size on 1 January of the year for which the TAC is to be set is forecast to exceed 2.5 million tonnes, the Parties agree to discuss the appropriateness of adopting constraints on TAC changes within the plan.

8. The Parties, on the basis of ICES advice, shall review this long-telll1 management plan at intervals not exceeding five years and when the condition specified in paragraph 4 is reached

> *1) ICES are requested to assess whether the draft 1ong-term management plan is in accordance with the Precautionary Approach.*
>
> *2) ICES are requested to assess the medium-term consequences of the application of this plan.*
>
> *3) ICES are invited to suggest and to evaluate alternative values for the "trigger biomass" value of 2.5 million tonnes and the target fishing mortality rate.*
>
> *4) ICES are requested to provide a range of options in accordance with paragraph 5 of Annex I for the reduction of fishing mortality to the target level identified in para-*

graph 4 of Annex I with a clear indication of the associated levels of risk and uncertainty.

The plan that ICES now is requested to evaluate includes two phases. First, the plan has a rule for a gradual reduction of the fishing mortality from the present high level down to a future low target fishing mortality. When that fishing mortality has been reached, the plan has rules for setting the TAC according to the level of SSB. In the evaluation it is assumed the value of "2.5" should be substituted by the actual value of B-trigger in the formula for calculating F.

The present evaluation builds on the work by the May meeting. In particular, the same software has been used with addition of new code for the specified F-reduction algorithm. Input data is based on this years assessment in line with the data used in the present short term prediction (Table 10.9.2.1).

The main simulation tool was HCS (Skagen, 2008), which is the same that was used for evaluation the management plan for NEA mackerel and for Western Baltic spring spawning herring. Some minor modifications were made to cover the needs for the blue whiting simulations, in particular to simulate the rule to reduce the F in the early phase.

As a control, some simulations were repeated with the SMS software which is also used to assess the stock of blue whiting and was used for evaluation of the management plan presently in use. These simulations were done with option close to, but not quite identical to those in HCR, for practical reasons. The main difference is that SMS has a different algorithm for generating observation uncertainty. In particular, SMS includes variability in the selection at age, while this was kept constant in the HCS runs. In general, SMS indicated a somewhat higher risk than HCR. When the selection was fixed in SMS, the results were by the two programs were rather close to each other. This is shown in figures 10.13.3 and 10.13.5, which show the probability that SSB will be below Blim for a range of reduction rates, target fishing mortalities and trigger biomasses, as obtained with HCS and SMS (with fixed selection) respectively.

A detailed description of the HCS simulation framework is given in the report from the May meeting. Here, a brief outline is presented.

10.13.1.1 Simulation algorithm in HCS, as implemented for the blue whiting

For each year Y, set the TAC for year Y and get the true stock at the start of year Y using information from year Y-1.

Start with the true stock year Y-1 and the decided TAC for year Y-1.

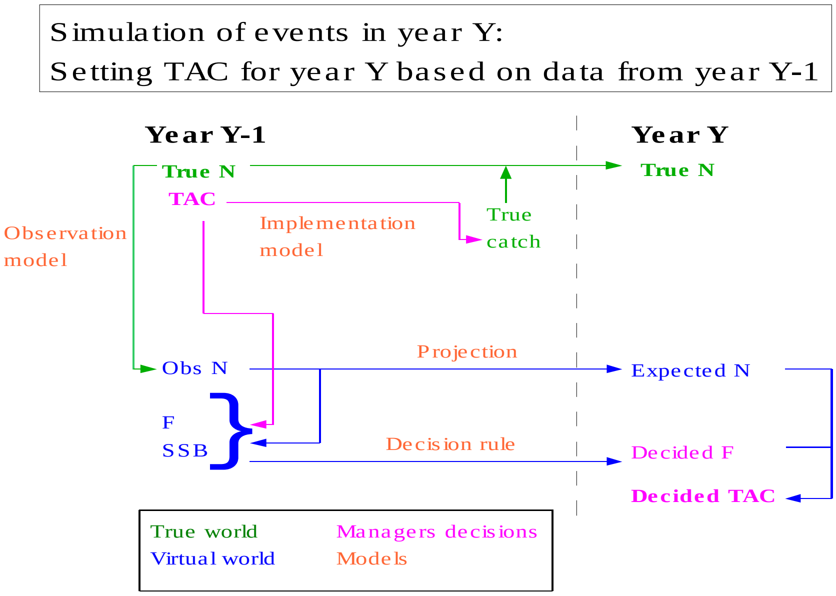
- Derive assessed stock numbers for year Y-1 from the true stock with the observation model
- Using the assessed stock in year Y-1, derive the expected SSB and expected F according to the decided TAC in year Y-1 .
- Project the assessed stock in year Y-1 from forwards, assuming the expected F from to get the expected stock in year Y
- Decide F for year Y according to the managers decision rule.
- Derive catch in year Y according to decided F for year Y and expected stock in year Y. Take this catch as the decided TAC for year Y

The following processes run in the background, to update the true stock.

- Apply the implementation model to the decided TAC for year Y-1, to get the true catch in year Y-1.

- Project the true stock forwards from year Y-1 to year Y with the true catches in year Y-1

The chart below shows the program flow graphically:



The decision rule for deciding the F for year Y (pts. 5–6 in the request) is interpreted as the following pseudocode:

Initially, a 'reduction flag' is set, indicating that we are in the reduction phase for F.

For each year Y, decide F for year Y, using the observed fishing mortality $Fobs_{Y-1}$ in year Y-1 and the observed spawning biomass $SSBobs_{Y-1}$ from (3).

If $Fobs_{Y-1} > F_{target}$ and reduction flag then:

Alternative 1: $FY = Fobs_{Y-1}*(100-x)/100$

Alternative 2: $FY = \max(Fobs_{Y-1}*(100-x)/100, 0.18)$

else

If reduction flag then turn off reduction flag

If $SSBobs_{Y-1} > SSBtrigger$ then

$FY = 0.18$

else if $SSBtrigger > SSBobs_{Y-1} > Blim$:

$$FY = 0.05 + \frac{(SSBobs_{Y-1} - 1.5)(F_{target} - 0.05)}{(SSBtrigger - 1.5)}$$

else

$FY = 0.05$

endif

endif

Some points of interpretation of the rule in the request:

1. It may happen that $Fobs_{Y-1} > F_{target}$, but the reduction rule leads to an F below F_{target}. for year Y. In this case, it is assumed that an $F = F_{target}$ will be used for year Y

2. It has been assumed that in the reduction phase, the F is set irrespective of the SSB. The rule to set $F < F_{target}$ when SSB<Btrig thus only applies after the reduction phase is over. Hence, in the reduction phase, the derived F is applied as it is, and not treated as a target in the long term harvest rule, and there is nothing in the proposed plan to respond to a rapid decline in the stock by reducing the F below F_{target} before the reduction phase is over.

Conditioning of the simulation model

Apart from the initial numbers, and the weights at age, the conditioning of the model was similar to that used at the May meeting.

Unless stated otherwise, a target fishing mortality of 0.18 was assumed, as stated in Paragraph 4 in the proposed arrangement.

Initial numbers (start of 2008): As the input to the short term prediction. A plausible range of initial numbers was generated by applying the observation model to these numbers.

Observation model: Nobs(a,y) = Ntrue(a,y) *yearfactor(y)*random_noise(a,y). The year factor was drawn from a log-normal distribution with CV = 0.16. The random noise was drawn from a lognormal distribution with CV according to the text table below:

Age	CV
1	0.50
2	0.50
3	0.31
4	0.25
5	0.25
6	0.25
7	0.26
8	0.29
9	0.33
10	0.37

No bias or autocorrelation was included. Applying this observation model to the initial stock numbers led to a CV of the SSB of 20%, in line with estimates of the uncertainty of the assessment obtained by SMS.

No implementation noise or bias was assumed. In HCS, implementation noise will generate variations in the realized selection at age. Without noise, the selection remains constant.

Recruitment model: A hockey-stick model was used, with breakpoint at 1500, a plateau at 8792, and a log-normally random multiplies for each year with a CV = 0.58, truncated at 0.2 and 2.85. This model was also used at the May meeting.

Weights and maturities at age were as the input to the short term prediction, and were regarded as deterministic numbers.

Changes from previous runs (May 2008 vs Sept 2008):

Apart from the interpretation of the HCR described above, the input data were updated to conform with the input to the short term predictions in WGWIDE 2008:

- Intermediate year (year 0): 2008.
- Minor reductions of weights at age at most ages.
- Numbers at start of the intermediate year 2008, as in short term prediction. Some numbers at age are smaller than last year, because of incoming small year classes.
- Assumed catches in 2008: 1.20 million tonnes

The simulations were limited to those needed to address the request. Hence, a range of trigger SSBs and a range of F reduction rates were explored. A set of runs which also included scanning over a range of target F-values was made to compare results with those from the May meeting on equal grounds, and to address the request to consider other target Fs than the 0.18 in the proposed plan.

Results

Three measures of were calculated.

1. The probability year by year that SSB will be below Blim.
2. The probability that the stock will fall below Blim at least once in the period 2009−2016 (years 1−7)
3. The probability that the stock will fall below Blim at least once in the period 2018−2020 (years 10−20)

The first is a measure of the risk in the transition phase, the second is the risk in the longer term, which includes the ability of the rule to respond to a low SSB to ensure rebuilding the stock.

Figure 10.13.1 shows for each year, the probability that the stock in that year is below Blim,. This is shown for a scenario with Target F = 0.18, trigger biomass 2500 thousand tonnes and F-reduction rate = 30%. The figure also shows the 10, 50 and 90 percentiles for the TACs resulting from the rule. The mean TACs were virtually independent of the F-reduction rate if this rate is above 20.

Figure 10.13.2 shows the probabilities of falling below Blim at least once in years 1−7 and 10−20, as functions of the reduction rate, for trigger SSBs 2250, 2500 and 2750 thousand tonnes. The risk is clearly higher for lower reduction rates, but the risk in years 1−7 in no cases comes below 10%. The risks do not depend on the trigger SSB.

Figure 10.13.3 shows the probability of being below Blim in some selected years for a range of trigger SSBs and also target Fs. The risk increases with increasing target F. Figure 10.13.4 shows the mean TAC for the same options. A higher target F gives higher mean catches in the short term (linked to a higher risk), while the catches in the medium term hardly depends on the target F.

The simulations show a large risk peaking around year 23 (2010−2011), which is reduced with a fast reduction of F in the initial phase, but remains well over 10% with a 50% per year reduction rate. In the later phase, the risk is low (well under 5%), except with very slow reduction rates for F. Therefore, the rule leads to a high initial risk, but apparently has elements that ensure recovery in the medium term. The likelihood of recovery will depend on the assumed stock-recruit relationship, which in this case is a hockey-stick function with breakpoint at Blim. This is generally assumed to be a conservative option, but the dynamics of the blue whiting recruitment at low SSBs is not known.

Because of the high risk to Blim in the short medium term, an alternative arrangement, the alternative to apply the long term harvest rule with a target F at 0.18 immediately was explored. The results in terms of risks and TACs is shown in figure 10.13.6. Now the risk of being below Blim in 2010 is about 4%, and it is rapidly reduced. The risk of falling below Blim at least once in the years 1–7 is 9%. The TACs are reduced faster, but will stabilize at the same level as found in the simulations above. It should be noted, however, that in the cases where SSB is estimated below Blim, TACs will be reduced to very low levels.

Comparison with results at the May meeting.

None of the results presented here are directly comparable with the run done at the May meeting, because the options requested now was not included in those studied at that meeting. The risk to Blim may be larger in the short medium term now than in those simulations. The initial stock numbers, according to the most recent assessment, are mostly are below those used at the May meeting, because another poor year class has entered the stock and previous poor year classes are propagated one year forward. In the long term, most scenarios led to an average catch just below 400 000 tonnes, which is in line with the results now.

Comparison between simulation tools.

The risk to Blim is highly sensitive to the uncertainties of the input values to the simulation. In SMS the uncertainties from the assessment period are brought into the simulation by used of the build in (in the Ad Model Builder software) MCMC (Markov Chain Monte Carlo) functionality. For the use in forecast, the MCMC routine creates a number of sets of likely model parameters from the assessment model where the correlation between parameters has maintained. Each of these parameter set is then used as input to the assessment model which calculate the stock numbers in 2008 and selection pattern used in the forecast. The size of the 2007 year-class and the applied SSB-recruitment is kept fixed. For a more direct comparison with HCS the selection pattern was kept constant in some simulations. In HCS, observation noise is generated with a combination of noise term at each stock number at age and a year factor, both log-normally distributed. The variances assumed at the May meeting were used in the present simulations, and it is likely that these lead to a somewhat lower overall observation noise.

The risk to Blim is highly sensitive to the uncertainties of the input values to the simulation. Therefore, the exact levels of risk should be treated with some care. Although the variation that is included have been carefully selected, the calculated risks vary considerably within a plausible range of noise levels.

Skagen, D. W. 2008. HCS program for simulating harvest rules: Outline of program and instructions for users. Available from the author.

10.13.2 Possible effects of protecting juvenile blue whiting

The modern blue whiting fishery developed during the second half of the 1970s when the landings increased from around 100 000 tonnes to above 1 million tonnes. The majority of the catches have since been taken on the spawning grounds west of the British Isles. A small but fairly constant fraction of the catches are taken in the southern areas and in the North Sea (Norwegian trench) and a variable fraction in the Norwegian Sea (Figure 10.4.1.1.3). The proportion of landings taken in the Norwegian Sea increased after the strong year classes from 1995 onwards led to increased densities of (young) blue whiting in this area, but is now decreasing and was in 2007 around the pre-2000 level.

Landings from the Norwegian Sea and the North Sea are generally comprised of a higher proportion of juvenile fish compared to landings from the spawning area, though this proportion varies between years. A measure to reduce the exploitation of juveniles could therefore, in theory, be to close the fishery in these areas (or a temporal closure of the fishery outside the spawning season). However, it is impossible to estimate the resulting reduction in juvenile fishing mortality of such measures since juveniles are also exploited in the spawning ground fishery.

The effects on the yield per recruit curve of applying three different exploitation patterns on ages 1–2 were explored using the standard ICES software MFYPR; (1) zero exploitation, (2) "high" exploitation and (3) the constant F selection pattern used in SMS from 1999 onwards. The "high" exploitation pattern which gave the highest relative fishing mortality on ages 1–2 during the last 15 years was derived from the XSA assessment. The SMS exploitation pattern was used on ages older than 2 years. Figure 10.13.2.1 shows the three F selection patterns used and the resulting yield per recruit curves. The difference between the curves is marginal with similar values for $F_{0.1}$ derived. The conclusion is that the effect on yield of protecting juveniles is likely to be very small. A separate clause for the protection of juveniles in the management plan is not needed.

10.14 Management considerations

The ICES review of the management plan agreed in 2005 pointed out that that the plan is not precautionary in a situation with a (continued) low recruitment, as observed before 1995. Presently there are strong indications that recruitment has remained at a very low level for the last three years. Information from the catch and surveys show consistently very small 2005 and 2006 year classes, and the limited available information indicates that the 2007 year class is small as well. Three years with a very low recruitment, in combination with a fishing mortality above Fpa in the most recent years, have given an extended decline in SSB, which is predicted to be just above Bpa in the beginning of 2009. Due to the low recruitment SSB will decline further. Even with no fishery in 2009 the SSB will increase by just 9%. To keep the SSB above Bpa in 2010, landings should be below 384 000 t in 2009. Such landings will require a reduction in F of 60% compared to F in 2008.

Last year ICES pointed out that a sustainable fishery and continued low recruitment will lead to average landings of around 400 000 t. This years evaluation of the management plan gives a similar conclusion.

The evaluation of the proposed management plan shows that there is a considerable risk, if a gradual reduction, over 2–3 years, of the present TAC from 1.25 million t to around 0.4 million t is applied. ICES concludes that the management plan is precautionary, if applied directly without a gradual F-reduction This implies that F in 2009 should be 0.17 resulting in a maximum catch of 408 thousands t in 2009.

Understanding of the factors which drive blue whiting recruitment has improved, but is still too limited for providing forecasts. High level of recruitment seems to be linked to a relatively narrow temperature and salinity range in the spawning region. Model experiments have revealed a potential for predicting the spawning environment. This may eventually help in recognizing periods of possible good or bad recruitment conditions for blue whiting and thus reveal future conditions for the blue whiting stock. This gives hope for identifying clearer bio-physical linkages than hitherto found. The actual forecast of the environmental conditions on the spawning grounds is, however, not available.

10.15 Ecosystem considerations

Irrespective of the direct economic and social implications of ups and downs of the blue whiting fishery, large changes in the abundance of blue whiting are bound to have wide-ranging ecosystem effects. Blue whiting is an important prey to a large range of opportunistic predators including fish, cephalopods, and marine mammals. Blue whiting itself preys upon larger crustaceans and small fish, including smaller blue whiting.

<u>Possible causal relations for reduced mean weight at age</u>

There are several possible explanations for the overall negative trend in mean weight at age, and hence growth, through the last 1½-decade. Possible causal relations are considered. In depth analysis of the causes, which would be needed for any kind of forecast is outside the scope of this working group.

Since the main growth is taking place during the northern feeding migration it is most likely here, the explanation is to be found.

Suggested reasons for the change in growth and mean weight are:

- Ecosystem aspects, such as changes in feeding opportunities due to:
    - Intra- and interspeciffic density dependant competition– too many fish competing for the same food resource.
    - Zooplankton concentration, distribution and condition.
        - Lower plankton concentrations in general.
        - Lower plankton concentrations in the particular area and time where the blue whiting are – an unfortunate match in time and space.
- External environmental factors, such as temperature and salinity have direct effect on the blue whiting physiology as well as on the physiology of the food.

Intra- or interspecific competition

Blue whiting condition and growth started to decrease in the early 1990'ies 4 to 5 years prior to the increase in stock size. This indicates that density dependence is not likely to be the main cause to the decrease in condition. In addition a dramatic decrease in blue whiting stock size was observed during the period 2006−2008 and at the same time the growth rates did not improve. This is in contrast with the functional response we would expect linked to density dependent feeding opportunities.

Like blue whiting, many other species share the pelagic ocean often in each others vicinity. Like blue whiting, also Norwegian spring spawning herring and Northeast Atlantic mackerel have shown large variations in both stock size and spatial distribution in the last decades.

A first analysis shows no strong relation between the total biomass of the main pelagic stocks feeding in the Norwegian Sea and the blue whiting mean weight or growth 10.15.1 and 10.15.2. The decrease began 2−3 years prior to the marked increase in the NSSH stock size and the successive change in the NSSH migration pattern. NSSH, NEA mackerel and blue whiting may also partly compete for the same food at different life stages, which complicates the relations further.

Even though there is no clearly visible overall relation between growth and density, the density dependency could still be an important factor. Because density dependency is working on a small spatial scale, it should also be analysed on a small scale. It is known that the growth differs between areas (Figure 10.15.3), the stocks are highly migratory and the migration patterns changes between years.

Plankton concentration and growth

There have been large scale changes in the plankton geography and abundance during the last several decades as described in chapter 1.9. An increasing mean water temperature in the feeding area shifted the southern distribution edge of an important prey item for adult blue whiting *(Calanus finmarchicus)* northwards (ICES 2008). In addition the average biomass of zooplankton in the Norwegian Sea has been on a decreasing trend since 2002. Thus large changes in the plankton abundance and species composition have occurred the last several years in the main feeding area for blue whiting (see section 1.9 for a more thorough description). More detailed studies are needed to quantify these effects.

Shnar (2007) presented anecdotal evidence of inter-annual blue whiting variation in the length-weight relations and feeding state, this corresponded to temperature differences.

Environmental factors effect on blue whiting physiology

The timing of spawning is affected by water temperature. Shnar (2007) presented anecdotal evidence of inter-annual blue whiting variation in the length-weight relations and maturity (i.e. spawning time), this corresponded to temperature differences. When the spawning survey measure the mean weight at the same time each year, a change in spawning timing is expected to have effect.

Impact of the fisheries on meso-pelagic ecosystem

Still too little is known of the consequences of a highly fluctuating blue whiting stock size on the dynamics of the meso-pelagic community, as well as the by-catches of deeper living organisms in the blue whiting fishery.

Since meso-pelagic communities form diverse communities which composition is sometimes particularly linked to the physical characteristics of the surrounding water masses, they could be utilized to describe the status as well as the changes in the pelagic ecosystem due to anthropogenic (e.g. by-catch in fisheries) and non-anthropogenic (e.g. climate change) impacts. Since investigation in those species is in compliance with the Marine Strategy Directive (Directive 2008/56/EC, in particular rationales 22, 40, and articles 5 and 8) of the European Union adopted on 17 June, 2008 the planning group for blue whiting surveys, PGNAPES, has initiated to standardize and expand deep sea species sampling during blue whiting surveys.

10.16 Regulations and their effects

Existing TAC are based on annual agreement between the EU, Norway, Iceland and the Faroe Island. No minimum landing size is associated with blue whiting.

10.17 Changes in fishing technology and fishing patterns

The proportion of landings originating from the Norwegian Sea has increased from 5% in the mid-1990 to around 30% in 2003–2004, after which the proportion has decreased again to around 11% (Figure 10.4.1.1.3). The change in relative distribution of the fishery in time and space can be seen on figure 10.4.1.1.4 and 10.4.1.1.5.

10.18 Changes in the environment

The large fluctuations observed in the blue whiting spawning stock since 1980 has raised a series of questions on the biology of blue whiting, possible effects of the environment on the productive capacity of the stock and the impact of fisheries on the blue whiting ecosystem.

Understanding the processes in the marine environment that drives the blue whiting recruitment is essential for the ability to predict the future stock development. Relations between variation in environment parameters and the recruitment are best studied using long time series, but the available time series of blue whiting recruitment however is relatively short. There is only information on the most recent 25 years (Figure 10.5.1.10). In this period large environmental changes have occurred in the blue whiting spawning area west of the British Isles. The driving force behind these changes, the Subpolar Gyre (described in chapter 1.9) suggests a causal relation (Figure 10.18.2).

The standard modelled Gyre index did not follow the recruitment trend well, so a relatively new dataset obtained from satellite images (Updated from Hakkinen and Rhines, 2004) was set back 4 years in time to make a good fit with recruitment (Figure 10.18.2). In depth analysis of the methodology or causes is outside the scope of this working group.

The hypothesis

Since blue whiting is known to spawn in water masses with a relatively narrow temperature and salinity range, it is believed that strong Subpolar Gyre influence 'pushes' spawning blue whiting aggregations to the European continental slope. After spawning has taken place, the majority of the stock will then take an eastern migration route through the Faroe-Shetland Channel to the feeding areas in the Norwegian Sea. In years when the SPG is weak, the opposite is believed to take place: spawning activity is more wide spread and reaches western areas such as the Rockall Plateau, more off the continental slope. In this situation the fish will take a more western migration route towards the Norwegian Sea feeding grounds (Hatun *et al.*, 2007).

This variability in the spawning distribution possibly influences the direction of drifting eggs and larvae (Skogen *et al.*, 1999) which then again might affect the survival of blue whiting recruits. Still too little is known in order to quantify these effects. However, model experiments have revealed a predictability potential of the Subpolar Gyre giving expectations of the near-future states of the marine climate in the spawning region. This may eventually help us in predicting recruitment conditions on a short term scale. On a longer time-scale however, global warming and uncertainties about the future state of the Subpolar Gyre make such predictions more complicated and unreliable. It is not possible to state to what extent or in which way global warming will affect the Subpolar Gyre.

Table 10.2.1. Blue whiting. Some details about the number, length and capacity of vessels prosecuting blue whiting fishery by country.

Blue whiting fishery

Country	Vessel length range (m)	Engine power (HP)	Gear Type	Storage	Discard estimates	Number of vessels
Germany	95-125	4200-11000 hp	Single Midwater	Freezer	Yes (some)	3
France						
Iceland	50-59	3000-5027 HP (av.=3692)	Single midw. trawl		Yes	5
	60-69	3000-6690 HP (av.=4476)	Single midw. trawl		Yes	10
	70-79	4080-11257 HP (av.=7131	Single midw. trawl		Yes	8
	>80	8050 HP	Single midw. trawl		Yes	1
Ireland	146	14400/19303	Single midw. trawl	RSW	No	1
	65	2710/3638	Single midw. trawl	RSW	No	1
	71	2984/4000	Single midw. trawl	RSW	No	1
	65	2710/3638	Single midw. trawl	RSW	No	1
	64	1319/1770	Single midw. trawl	RSW	No	1
	58	2100/2853	Single midw. trawl	RSW	No	1
	60	5520/7500	Single midw. trawl	RSW	No	1
	32	3300/4425	Single midw. trawl	RSW	No	1
	59	3460/4701	Single midw. trawl	RSW	No	1
	53	917/1231	Single midw. trawl	RSW	No	1
	53	1007/1352	Single midw. trawl	RSW	No	1
	49	1070/1436	Single midw. trawl	RSW	No	1
	51	1544/2072	Single midw. trawl	RSW	No	1
	49	1103/1479	Single midw. trawl	RSW	No	1
	40	708/950	Single midw. trawl	RSW	No	1
	40	634/851	Single midw. trawl	RSW	No	1
	45	1082/1452	Single midw. trawl	RSW	No	1
	37	1119/1596	Single midw. trawl	RSW	No	1
	37	1118/1500	Single midw. trawl	RSW	No	1
	45	700/940	Single midw. trawl	RSW	No	1
	35	708/949	Single midw. trawl	RSW	No	1
Netherlands	55	2890 hp	Pair midwater	Freezer	Yes	2
	88-140	4400-10455hp	Single Midwater	Freezer	Yes (some)	14
Norway	14-62	236-5400	Industrial trawl			50
	60-94	2640-9000	Directed pelagic trawl			45
Spain	28	477	Pair bottom trawl fishery			38
	27	404	Bottom trawl mixed fishery			86
			alterning bottom trawl and pair bottom trawl			11
Portugal	27	705	Bottom trawl (fish)			68
	25	563	Bottom trawl (crustaceans)			30
	16	213	Artisanal			377

Table 10.4.1.1.1 Blue whiting. Landings (tonnes) from the directed fisheries (Sub-areas I and II, Division Va, XIVa and XIVb) 1988–2007, as estimated by the Working Group.

Country	1988	1989 [3]	1990	1991	1992	1993	1994 [2]	1995 [3]	1996	1997
Denmark	-	-	-	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-	-	377	161
Faroes	-	1 047	-	-	-	-	-	-	345	-
France	-	-	-	-	-	-	-	-	-	-
Germany	3	1 341	-	-	-	-	2	3	32	-
Greenland	-	-	-	-	-	-	-	-	-	-
Iceland	-	4 977	-	-	-	-	-	369	302	10 464
Latvia	-	-	-	-	-	-	422	-	-	-
Netherlands	-	-	-	-	-	-	-	72	25	-
Norway [5]	-	-	-	-	-	-	-	-	-	-
Norway [6]	-	-	566	100	912	240	-	-	58	1 386
Poland	10	-	-	-	-	-	-	-	-	-
Scotland										
Sweden	-	-	-	-	-	-	-	-	-	-
USSR/ Russia [1]	55 816	35 250	1 540	78 603	61 400	43 000	22 250	23 289	22 308	50 559
Total	55 829	42 615	2 106	78 703	62 312	43 240	22 674	23 733	23 447	62 570

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Denmark	-	15	7 721	5 723	13 608	38 226	23 437	365	338	182
Estonia	904	-	-	-	-	-	-	-	-	-
Faroes	44 594	11 507	17 980	64 496	82 977	115 755	109 380	64 639	70 650	35 478
France	-	-	-	-	-	-	-	-	2 315	1 504
Germany	78	-	-	3117	1 072	813	488	569	1 772	125
Greenland	-	-	-	-	-	-	-	-	-	-
Iceland	68,681 [4]	96 295	155 024	245 814	195 483	312 334	279 811	145 640	152 155	66 126
Latvia	-	-	-	-	-	-	-	-	-	-
Netherlands	63	435	-	5180	906	592	1 365	-	1 279	-
Norway [5]	-	-	-	64 581	100 922	215 075	302 166	9 778	10 442	4 883
Norway [6]	12 132	5 455	-	28 812	-	-	22167	6 793	6 041	1648
Poland	-	-	-	-	-	-	-	-	-	-
Scotland							64	-	-	-
Sweden	-	-	-	-	850	57 206	15 794	785	-	-
USSR/ Russia [1]	51 042	65 932	103 941	173 860	145 649	191 507	166 677	177 008	159 370	62 762
Total	177 494	179 639	284 666	591 583	541 467	931 508	921 349	405 577	404 362	172 709

[1]) From 1992 only Russia
[2]) Includes Vb for Russia.
[3]) Icelandic mixed fishery in Va.
[4]) include mixed in Va and directed in Vb.
[5]) Directed fishery
[6]) By-catches of blue whiting in other fisheries.

Table 10.4.1.1.2 Blue whitings. Landings (tonnes) from directed fisheries (Division Vb,VIa,b, VIIa,b,c and Sub-area XII) 1988–2007, as estimated by the Working Group.

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998 1)	1999	2000	2001	2002	2003	2004	2005	2006	2007
Denmark	797	25	-	-	3 167	-	770	-	269	-	5051	19 625	11 856	18 110	2 141	17 813	44 992	24 731	52 009	45 181
Estonia	-	-	-	-	6 156	1 033	4 342	7754	10 605	5 517	5 416	-	-	-	-	-	4)			
Faroes	79 339	70 711	43 405	10 208	12 731	14 984	22 548	26 009	18 258	22 480	26 328	93 234	129 969	188 464	115 127	208 427	206 078	197 134	244 387	281 770
France	-	2 190	-	-	-	1 195	-	720	6 442	12 446	7 984	6 662	13 481	13 480	14 688	13 365	-	8 046	14 264	15 130
Germany	5 263	4 073	1 699	349	1 307	91	-	6 310	6 844	4 724	17 891	3 170	12 655	15 862	15 378	21 866	13 813	22 089	33 756	34 274
Iceland	-	-	-	-	-	-	-	-	-	-	-	64 135	105 833	119 287	91 853	189 159	99 832	119 569	157 353	170 412
Ireland	4 646	2 014	-	-	781	-	3	222	1 709	25 785	45635	35 240	25 200	29 854	17 723	22 484	62 730	73 174	54 910	31 097
Japan	-	-	-	-	918	1 742	2 574	-	-	-	-	-	-	-	-	-	-			
Latvia	-	-	-	-	10 742	10 626	2 160	-	-	-	-	-	-	-	-	-	-			
Lithuania	-	-	-	-	-	2 046	-	-	-	-	-	-	-	-	-	-	-		2 314	9 812
Netherlands 2)	800	2 078	7 280	17 359	11 034	18 436	21 076	26 703	17 644	23 676	27 884	35 408	46 128	68 415	33 365	45 239	82 520	143 470	101 349	79 755
Norway	208 416	258 386	281 036	114 866	148 733	198 916	226 235	261 272	337 434	318 531	519 622	475 004	460 274	399 932	385 495	502 320	486 843	622 981	527 172	477 934
UK (Scotland)	5 071	8 020	6 006	3 541	6 849	2 032	4 465	10 583	14 325	33 398	92 383	98 853	42 478	50 147	26 403	27 136	56 326	104 526	72 030	43 406
Sweden	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-			
USSR/ Russia 3)	121 705	127 682	124 069	72 623	115 600	96 000	94 531	83 931	64 547	68 097	79 000	112 247	141 257	141 549	144 419	163 812	179 400	150 014	168 664	172 111
Total	426 037	475 179	463 495	218 946	318 018	347 101	378 704	423 504	478 077	514 654	827 194	943 578	989 131	1 045 100	846 602	1 211 621	1 232 534	1 465 735	1 428 208	1 360 882

1) Including some directed fishery also in Division IVa.

2) Revised for the years 1987, 1988, 1989, 1992, 1995,1996,1997

3) From 1992 only Russia

4) Reported to the EU but not to the ICES WGNPBW. (Landings of 19,467 tonnes)

Table 10.4.1.1.3 Blue whiting. Landings (tonnes) from directed fisheries and by-catches caught in other fisheries (Divisions IIIa, IV) 1988–2007, as estimated by the Working Group.

Country	1988	1989	1990	1991	1992	1993 3)	1994	1995	1996	1997	1998 2)	1999	2000	2001	2002	2003	2004	2005	2006	2007
Denmark 4)	18 144	3 632	10 972	5 961	4 438	25 003	5 108	4 848	29 137	9 552	40 143	36 492	30 360	21 995						
Denmark 5)		22 973	16 080	9 577	26 751	16 050	14 578	7 591	22 695	16 718	16 329	8 521	7 749	7 505	35 530	26 896	21 071	16 354	2 316	3 296
Faroes 4) 6)	492	3 325	5 281	355	705	1 522	1 794	-	6 068	6 066	-	-	-	60	7 317	5 712	6 864	1 437	1 969	611
Faroes 5) 6)											296	265	42	6 741				3 589	391	
Germany 1)	280	3	-	-	25	9	-	-	-	-			-	81	-	36	19	17	909	4
Iceland																		307		
Ireland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4		4	9		35
Lithuania																			2 321	
Netherlands	-	-	20	-	2	46	-	-	-	793			-	-	50	0	0	0	83	
Norway 4)	24 898	42 956	29 336	22 644	31 977	12 333	3 408	78 565	57 458	27 394	28 814	48 338	73 006	21 804	85 062	117 145	107 311	98 938	96 007	
Norway 5)														58 182						55 122
Russia	-	-	-	-	-	-	-	-	-	-	-	-	-	69	-	-		5 204	1 066	1 496
Scotland																	35	3	76	77
Sweden	1 229	3 062	1 503	1 000	2 058	2 867	3 675	13 000	4 000	4 568	9 299	12 993	3 319	2 086	17 689	8 326	3 289	2 175	101	464
UK	100	7	-	335	18	252	-	-	1	-	-	-	-	-	-	65				
Total	45 143	75 958	63 192	39 872	65 974	58 082	28 563	104 004	119 359	65 091	94 881	106 609	114 476	118 523	145 652	158 180	138 593	128 033	105 239	61 105

1) Including directed fishery also in Division IVa.

2) Including mixed industrial fishery in the Norwegian Sea

3) Imprecise estimates for Sweden: reported catch of 34265 t in 1993 is replaced by the mean of 1992 and 1994, i.e. 2,867 t, and used in the assessment.

4) Directed fishery

5) By-catches of blue whiting in other fisheries.

6) For the periode 1987-2000 landings figures also include landings from mixed fisheries in Division Vb.

7) Some corrections done in the total amount.

Table 10.4.1.1.4 Blue whiting. Landings (tonnes) from the Southern areas (Sub-areas VIII and IX and Divisions VIIg-k and VIId,e) 1988–2007, as estimated by the Working Group.

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Faroes																			3 616	
Germany	-	-	-	-	-	-	-	-	-	-	-	-	-	-	600 2)	88 2)	973	148		
Ireland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	98 2)	96 2)	12 659	305		
Netherlands	-	-	450	10	-	-	-	-	-	-	10 1)	-	-	-	3208 2)	2471,8 2)	11 426	4 313		120
Norway	-	-	-	-	-	-	-	-	-	-			-	-	-	-	39 197		2 789	
Portugal	5 979	3 557	2 864	2 813	4 928	1 236	1 350	2 285	3 561	2 439	1 900	2 625	2 032	1 746	1 659	2 651	3 937	5 190	5 323	3 897
Russia																	685			
Scotland																	603	10		58
Spain	24 847	30 108	29 490	29 180	23 794	31 020	28 118	25 379	21 538	27 683	27 490	23 777	22 622	23 218	17 506	13 825	15 612	17 643	15 173	13 557
UK	12	29	13	-	-	-	5	-	-	-	-	-	-	-	-	181				
France	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	784			1 430	4
Total	30 838	33 695	32 817	32 003	28 722	32 256	29 473	27 664	25 099	30 122	29 400	26 402	24 654	24 964	23 071	20 097	85 093	27 608	28 331	17 634

1) Directed fisheries in VIIIa

2) Landings reported as Directed fisheries and included in the Catch-at-Age calculations of that fisheries

Table 10.4.1.1.5 Blue whiting. Total landings by country and area for 2007 in tonnes.

Area	Denmark	Faroe Islands	France	Germany	Iceland	Lithuania	Ireland	Norway	Portugal	Russia	Scotland	Spain	Sweden	Netherlands	Grand Total
IIa	182	17 373	1 504	125	33 624			6 531		60 138					119 478
IIb										2 624					2 624
IIIa	313							1					20		334
IVa	2 975	611	1				35	54 958		1 496	77		437		60 590
IVb	8			4				163					7		182
Va		16 308			17 769										34 077
Vb	3 668	109 664	762	665	80 964			7 143		82 874	2 813			1 593	290 146
VIa	4 776	31 552	5 928	15 970	34 605		1 658	155 090		5 609	11 388			39 003	305 579
VIb		65 159		4 695	49 197	540	167	99 935		50 369	6 727			4 920	281 709
VIIb			441				380								821
VIIc	36 737	62 512	7 999	12 944	798	9 272	28 892	211 745		9 656	22 478			34 240	437 273
VIId														120	120
VIIIabd		3													3
VIIIcIXa									3 897			13 557			17 453
VIIj											58				58
VIIk															0
XII		12 882			4 848			4 021		23 603					45 354
XIVb		1 796			14 733										16 529
Grand Total	48 659	317 863	16 636	34 404	236 538	9 812	31 132	539 587	3 897	236 369	43 540	13 557	464	79 875	1 612 331

Table 10.4.1.1.6 Blue whiting. Landings (tonnes) from the main fisheries, 1988–2007, as estimated by the Working Group.

Area	Norwegian Sea fishery (Sub-areas 1+2 and Divisions Va, XIVa-b)	Fishery in the spawning area (Divisions Vb, VIa, VIb and VIIb-c)	Directed- and mixed fisheries (Divisions IIIa and IV)	**Total northern areas**	Total southern areas (Subareas VIII and IX and Divisions VIId, e, g-k)	**Grand total**
1988	55 829	426 037	45 143	**527 009**	30 838	**557 847**
1989	42 615	475 179	75 958	**593 752**	33 695	**627 447**
1990	2 106	463 495	63 192	**528 793**	32 817	**561 610**
1991	78 703	218 946	39 872	**337 521**	32 003	**369 524**
1992	62 312	318 081	65 974	**446 367**	28 722	**475 089**
1993	43 240	347 101	58 082	**448 423**	32 256	**480 679**
1994	22 674	378 704	28 563	**429 941**	29 473	**459 414**
1995	23 733	423 504	104 004	**551 241**	27 664	**578 905**
1996	23 447	478 077	119 359	**620 883**	25 099	**645 982**
1997	62 570	514 654	65 091	**642 315**	30 122	**672 437**
1998	177 494	827 194	94 881	**1 099 569**	29 400	**1 128 969**
1999	179 639	943 578	106 609	**1 229 826**	26 402	**1 256 228**
2000	284 666	989 131	114 477	**1 388 274**	24 654	**1 412 928**
2001	591 583	1 045 100	118 523	**1 755 206**	24 964	**1 780 170**
2002	541 467	846 602	145 652	**1 533 721**	23 071	**1 556 792**
2003	931 508	1 211 621	158 180	**2 301 309**	20 097	**2 321 406**
2004	921 349	1 232 534	138 593	**2 292 476**	85 093	**2 377 569**
2005	405 577	1 465 735	128 033	**1 999 345**	27 608	**2 026 953**
2006	404 362	1 428 208	105 239	**1 937 809**	28 331	**1 966 140**
2007	172 709	1 360 882	61 105	**1 594 695**	17 634	**1 612 330**

Table 10.4.1.1.7 Blue whiting. Total landings of by quarter and area for 2007 in tonnes. Landing figures provided by Working Group members.

Area	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Grand Total
I					-
IIa	2 801	72 650	25 029	18 998	119 478
IIb			457	2 167	2 624
IIIa	11	8	314	2	334
IVa	6 023	29 436	17 943	7 188	60 590
IVb	4	6	165	6	182
Va		32 907	1 170		34 077
Vb	42 398	235 155	747	11 846	290 146
VIa	88 189	216 832	195	362	305 579
VIb	267 631	14 046	18	14	281 709
VIIb	629	166	15	12	821
VIIc	429 758	6 495	568	453	437 273
VIId	0	0	120	0	120
VIIIabd	2	1	0	0	3
VIIIc+IXa	4 080	3 951	4 795	4 627	17 453
VIIj	58				58
XII	38 259	2 248			40 506
XIIb	3 424	1 424			4 848
XIVb			16 529		16 529
Total	883 265	615 326	68 065	45 675	1 612 331

Table 10.4.1.2.1. Sampling intensity for blue whiting from commercial catches.

Quarter	Fisheries	Directed	Mixed	Southern	Total
1	No. of samples	364	26	132	522
	WG Catch	873089	6038	4139	883266
2	No. of samples	165	33	145	343
	WG Catch	581923	29450	3953	615326
3	No. of samples	84	18	131	233
	WG Catch	44727	18422	4915	68065
4	No. of samples	157	28	116	301
	WG Catch	33852	7196	4627	45675
Total No. of samples		770	105	524	1399
Total WG Catch		1533591	61106	17634	1612331

Table 10.4.1.2.2 Blue whiting. Total landings, No. of samples, No. of fish measured and No. of fish aged by country and quarter for 2007.

Country	Quarter	Landings (t)	No. Samples	No. Fish aged	No. Fish measured
Denmark	1	41393	23	1102	1102
	2	6844	5	279	279
	3	406	0	0	0
	4	16	0	0	0
	Total	48659	28	1381	1381
Faroe Islands	1	169216	13	1297	2492
	2	143335	9	897	1581
	3	3860	4	398	701
	4	1449	3	300	563
	Total	317859	29	2892	5337
France	1	9399	0	0	0
	2	6257	0	0	0
	3	547	0	0	0
	4	436	0	0	0
	Total	16639	0	0	0
Germany	1	22144	45	0	10669
	2	11465	0	0	0
	3	758	0	0	0
	4	36	0	0	0
	Total	34404	45	0	10669
Iceland	1	47756	16	744	1467
	2	172950	70	3271	6739
	3	15371	8	0	1627
	4	461	0	0	0
	Total	236538	94	4015	9833
Ireland	1	31097	19	1704	3595
	2	0	0	0	0
	3	0	0	0	0
	4	35	0	0	0
	Total	31132	19	1704	3595
Lithuania	1	5542	0	0	0
	2	3690	0	0	0
	3	323	0	0	0
	4	257	0	0	0
	Total	9812	0	0	0
Norway	1	377504	186	2877	17008
	2	136200	86	1720	7059
	3	19070	36	588	2736
	4	6813	45	730	3420
	Total	539587	353	5915	30223
Portugal	1	427	62	532	7868
	2	540	70	244	9945
	3	1816	57	237	7728
	4	1113	52	546	6817
	Total	3897	241	1559	32358
Russia	1	93381	9	205	814
	2	88732	18	400	1483
	3	22800	54	464	6502
	4	31456	137	960	18754
	Total	236369	218	2029	27553
Scotland	1	37564	6	257	1044
	2	5899	1	53	198
	3	0	0	0	0
	4	77	0	0	0
	Total	43540	7	310	1242
Spain	1	3652	70	250	6784
	2	3411	75	522	6987
	3	2979	74	418	7083
	4	3514	64	830	6060
	Total	13557	283	2020	26914
Sweden	1	262	0	0	0
	2	174	0	0	0
	3	15	0	0	0
	4	12	0	0	0
	Total	464	0	0	0
The Netherlands	1	43928	73	1478	16496
	2	35828	9	192	2051
	3	120	0	0	0
	4	0	0	0	0
	Total	79875	82	1670	18547
Grand Total		1612331	1399	23495	167652

Table 10.4.1.2.3 Blue Whiting. Sampling levels in 2007 per area.

Area	Landings	Nos samples	Nos fish aged	Nos fish measured
I				
IIa	119478	247	3467	28232
IIb	2624	46	810	5366
IIIa	334	9	142	684
IVa	60590	62	1678	5408
IVb	182	34	659	2418
Va	34077	9	529	933
Vb	290146	85	2939	8736
VIa	305579	117	3248	22299
VIb	281709	96	2164	12934
VIIb	821	0	0	0
VIIc	437273	97	2989	13745
VIIg	120	0	0	0
VIIIabd	4	0	0	0
VIIIcIXa	17453	524	3579	59272
VIIj	58	0	0	0
VIIk				
XII	45354	65	1291	5998
XIVb	16530	8	0	1627
Total general	1612331	1399	23495	167652

Table 10.4.1.3.1. Blue whiting. Landings in numbers ('000) by length group (cm) and quarter for the Northern area in 2007.

Length (cm)	Q1	Q2	Q3	Q4	All year
5					
6					
7					
8					
9					
10					
11					
12			85		85
13			43		43
14			2 552		2 552
15			3 913	36	3 949
16			6 465	24	6 489
17	79	133	3 466	24	3 703
18	157	266	702	12	1 137
19			234	24	258
20	7 074	1 695		109	8 879
21	23 081	5 645	27	48	28 802
22	52 955	12 082	352	133	65 523
23	76 386	31 959	711	705	109 762
24	183 980	99 246	2 411	4 244	289 881
25	501 375	273 123	14 161	19 113	807 772
26	928 494	418 231	34 083	47 531	1428 339
27	904 980	445 869	46 174	71 560	1468 583
28	769 130	350 975	31 115	52 473	1203 694
29	444 624	264 016	15 770	29 742	754 152
30	293 412	126 685	9 241	15 509	444 846
31	170 102	82 376	4 700	6 831	264 009
32	84 866	56 711	2 983	4 095	148 655
33	69 693	18 254	1 239	1 774	90 960
34	26 327	8 305	680	1 191	36 504
35	35 935	3 538	425	656	40 554
36	9 797	1 783	64	280	11 923
37	7 990	2 275	43	158	10 465
38	1 384	79	85	36	1 584
39	3 446	26		24	3 497
40	1 859	522		49	2 429
41	282	26	21	12	341
42	110				110
43	40		21		61
44			43		43
45					
46					
47					
48		517			517
49					
50					
51					
52					
53					
54					
55					
56					
57					
58					
59					
60					
TOTAL numbers	4597 559	2204 336	181 809	256 396	7240 099

Table 10.4.1.3.2. Blue whiting. Landings in numbers ('000) by length group (cm) and quarter for the North Sea and Skagerrak in 2007.

Length (cm)	Q1	Q2	Q3	Q4	All year
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15	10	302			312
16	50				50
17	155	614			769
18	249	4 550			4 799
19	30	12 381			12 411
20	40	20 232			20 272
21	20	7 851	254	81	8 206
22	120	5 436	509	162	6 227
23	942	16 486	1 274	405	19 107
24	1 719	31 906	8 153	2 590	44 368
25	3 234	53 083	27 004	8 581	91 902
26	5 015	53 073	42 544	13 521	114 153
27	4 288	40 372	49 169	15 626	109 455
28	3 456	26 129	25 476	8 096	63 157
29	2 530	22 767	12 738	4 048	42 083
30	1 689	9 109	4 840	1 538	17 176
31	962	6 069	1 784	567	9 382
32	493	6 069	254	81	6 897
33	319	906	254	81	1 560
34	90	604			694
35	110	302			412
36	65	10			75
37	20	302			322
38	30				30
39	10				10
40					
41	10				10
42					
43					
44					
45					
46					
47					
48					
49					
50					
51					
52					
53					
54					
55					
56					
57					
58					
59					
60					
TOTAL numbers	25 656	318 553	174 253	55 377	573 839

Table 10.4.1.3.3. Blue whiting. Landings in numbers ('000) by length group (cm) and quarter for the Southern area in 2007.

Length (cm)	Q1	Q2	Q3	Q4	All year
5					
6					
7					
8					
9					
10					
11		5			5
12					
13	7	1	5		12
14	50		38		88
15	348		73	14	436
16	1 819	93	236	79	2 227
17	3 012	944	165	583	4 705
18	2 941	2 849	290	1 537	7 616
19	1 427	4 490	1 175	3 028	10 120
20	1 266	4 155	7 437	3 652	16 510
21	1 744	3 305	14 864	5 779	25 693
22	4 604	3 708	10 496	6 461	25 269
23	7 090	5 141	6 248	5 590	24 069
24	6 646	6 872	5 276	4 888	23 683
25	6 159	6 389	5 351	3 918	21 817
26	3 842	4 610	3 719	3 535	15 707
27	2 847	3 142	2 389	2 795	11 174
28	1 730	2 060	1 546	2 052	7 389
29	1 130	658	763	1 977	4 527
30	591	345	358	1 347	2 641
31	472	199	197	786	1 654
32	217	99	60	453	829
33	223	30	38	226	517
34	91	39	16	46	191
35	31	10	15	44	99
36	15	4	2	3	24
37	11	3			14
38	1	1	1		3
39	3	2			5
40		1			1
41		2			2
42		1			1
43		1			1
44					
45					
46					
47					
48					
49					
50					
51					
52					
53					
54					
55					
56					
57					
58					
59					
60					
TOTAL numbers	48 316	49 161	60 759	48 796	207 032

Table 10.4.1.3.4 BLUE WHITING. Catch in number (millions) by age group in the directed fisheries (Sub-areas I and II, Divisions Va, and XIVa+b, Vb, VIa+b, VIIbc and VIIg-k) in 1993–2007.

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0	0	1	4	167	15	61	41	119	16	58	6	24	3	1
1	37	44	99	497	1352	984	544	912	3459	1111	2464	1132	856	114	13
2	130	31	143	327	1079	3535	1180	752	3924	2439	3626	3481	996	616	173
3	335	190	338	451	751	3211	5257	3119	2728	2939	7964	6220	4614	3670	1585
4	1348	362	416	425	526	929	3235	4834	3644	2114	4726	6524	5655	5692	4025
5	376	1242	566	248	268	346	362	1517	2474	1804	2006	2972	4304	3615	3747
6	196	294	769	430	238	311	186	500	555	1602	1090	1252	1391	1621	2292
7	108	201	246	619	270	298	143	210	160	336	398	633	506	475	904
8	60	103	154	214	391	257	146	144	91	165	119	246	244	167	312
9	38	88	58	88	101	209	66	57	69	100	18	74	97	64	126
10+	14	32	40	70	164	85	138	139	55	142	27	36	54	35	86
Total	2 641	2 588	2 829	3 373	5 307	10 180	11 318	12 225	17 281	12 768	22 495	22 575	18742	16 072	13 263

Table 10.4.1.3.5 BLUE WHITING. Catch in number (million) by age group in the directed fishery and by-catches from mixed fisheries (Divisions IIIa and IV) for 1993–2007.

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	132	95	3303	812	29	11	60	56	9	190	222	52	46	4	0
1	167	33	101	1334	621	576	188	822	770	621	1191	925	496	258	53
2	39	21	88	71	269	524	286	317	416	685	369	784	389	272	69
3	91	18	29	58	50	259	434	253	174	274	368	405	408	346	163
4	97	37	11	71	14	47	168	143	149	105	73	116	196	195	162
5	15	6	6	39	14	6	16	22	109	17	18	46	138	63	109
6	7	3	11	45	5	4	5	3	29	45	23	12	26	23	58
7	8	1	2	33	4	3	5	0	9	8	1	11	11	11	30
8	0	1	2	14	6	4	6	7	6	3	1	1	5	8	9
9	-	0	1	9	1	4	1	1	8	2	1	1	3	1	4
10+	-	-	1	11	2	12	3	1	11	1	1	1	1	1	3
Total	556	214	3 555	2 499	1 015	1 450	1 172	1 627	1 689	1 951	2 269	2 355	1 720	1 181	660

Table 10.4.1.3.6 BLUE WHITING. Catch in number (millions) by age group in the Southern area, 1993–2007.

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	25	13	3	9	11	18	18	32	33	17	7	4	16	4	15
1	41	12	96	43	118	97	57	80	134	88	88	84	85	39	101
2	146	56	123	131	143	122	82	123	146	108	79	130	141	39	65
3	181	149	55	117	86	71	130	93	60	79	47	50	70	55	47
4	62	72	38	36	26	69	57	35	14	24	26	10	26	37	23
5	12	27	44	33	8	32	35	9	10	4	12	5	12	15	12
6	7	9	20	17	4	7	15	10	1	1	4	3	3	8	4
7	2	5	6	5	3	2	3	3	0	0	1	1	1	2	1
8+	1	4	5	3	3	4	2	0	0	0	1	0	1	1	0
Total	477	347	390	394	402	422	399	384	398	321	264	286	355	200	268

Table 10.4.1.3.7. Blue Whiting: Catch in numbers (thousands) of the total stock in 1984–2007.

Age	1984	1985	1986	1987	1988	1989	1990	1991
0								
1	2 291 000	1 305 000	650 000	838 000	425 000	865 000	1 611 000	266 686
2	2 331 000	2 044 000	816 000	578 000	721 000	718 000	703 000	1 024 468
3	455 000	1 933 000	1 862 000	728 000	614 000	1 340 000	672 000	513 959
4	260 000	303 000	1 717 000	1 897 000	683 000	791 000	753 000	301 627
5	285 000	188 000	393 000	726 000	1 303 000	837 000	520 000	363 204
6	445 000	321 000	187 000	137 000	618 000	708 000	577 000	258 038
7	262 000	257 000	201 000	105 000	84 000	139 000	299 000	159 153
8	193 000	174 000	198 000	123 000	53 000	50 000	78 000	49 431
9	154 000	93 000	174 000	103 000	33 000	25 000	27 000	5 060
10+	255 000	259 000	398 000	195 000	50 000	38 000	95 000	9 570

Age	1992	1993	1994	1995	1996	1997	1998	1999
0		157 000	108 000	3 307 000	825 000	207 000	44 000	139 000
1	407 730	263 184	306 951	296 100	1 893 453	2 131 494	1 656 926	788 200
2	653 838	305 180	107 935	353 949	534 221	1 519 327	4 181 175	1 549 100
3	1 641 714	621 085	367 962	421 560	632 361	904 074	3 541 231	5 820 800
4	569 094	1 571 236	389 264	465 358	537 280	577 676	1 044 897	3 460 600
5	217 386	411 367	1 221 919	615 994	323 324	295 671	383 658	412 800
6	154 044	191 241	281 120	800 201	497 458	251 642	322 777	207 200
7	109 580	107 005	174 256	253 818	663 133	282 056	303 058	151 200
8	79 663	64 769	90 429	159 797	232 420	406 910	264 105	153 100
9	31 987	38 118	79 014	59 670	98 415	104 320	212 452	68 800
10+	11 706	17 476	30 614	41 811	82 521	169 235	85 513	140 500

Age	2000	2001	2002	2003	2004	2005	2006	2007
0	129 000	161 000	223 000	287 000	62 606	85 329	18 510	15 796
1	1 814 851	4 363 690	1 821 053	3 742 841	2 156 261	1 427 277	412 961	167 027
2	1 192 657	4 486 315	3 232 244	4 073 497	4 426 323	1 518 938	939 865	306 898
3	3 465 739	2 962 163	3 291 844	8 378 955	6 723 748	5 083 550	4 206 005	1 795 021
4	5 014 862	3 806 520	2 242 722	4 824 590	6 697 923	5 871 414	6 150 696	4 210 891
5	1 550 063	2 592 933	1 824 047	2 035 096	3 044 943	4 450 171	3 833 536	3 867 367
6	513 663	585 666	1 647 122	1 117 179	1 276 412	1 419 089	1 718 775	2 353 478
7	213 057	170 020	344 403	400 022	649 885	518 304	506 198	935 541
8	151 429	97 032	168 848	121 280	249 097	249 443	181 181	320 529
9	58 277	76 624	102 576	19 701	75 415	100 374	67 573	130 199
10+	139 791	66 410	142 743	27 493	36 805	55 226	36 688	88 573

Table 10.4.3.1.1. Individual mean weight (Kg) at age by year in the catches.

Year \ Age	1	2	3	4	5	6	7	8	9	10+
1981	0.052	0.065	0.103	0.125	0.141	0.155	0.170	0.178	0.187	0.213
1982	0.045	0.072	0.111	0.143	0.156	0.177	0.195	0.200	0.204	0.231
1983	0.046	0.074	0.118	0.140	0.153	0.176	0.195	0.200	0.204	0.228
1984	0.035	0.078	0.089	0.132	0.153	0.161	0.175	0.189	0.186	0.206
1985	0.038	0.074	0.097	0.114	0.157	0.177	0.199	0.208	0.218	0.237
1986	0.040	0.073	0.108	0.130	0.165	0.199	0.209	0.243	0.246	0.257
1987	0.048	0.086	0.106	0.124	0.147	0.177	0.208	0.221	0.222	0.254
1988	0.053	0.076	0.097	0.128	0.142	0.157	0.179	0.199	0.222	0.260
1989	0.059	0.079	0.103	0.126	0.148	0.158	0.171	0.203	0.224	0.253
1990	0.045	0.070	0.106	0.123	0.147	0.168	0.175	0.214	0.217	0.256
1991	0.055	0.091	0.107	0.136	0.174	0.190	0.206	0.230	0.232	0.266
1992	0.057	0.083	0.119	0.140	0.167	0.193	0.226	0.235	0.284	0.294
1993	0.066	0.082	0.109	0.137	0.163	0.177	0.200	0.217	0.225	0.281
1994	0.061	0.087	0.108	0.137	0.164	0.189	0.207	0.217	0.247	0.254
1995	0.064	0.091	0.118	0.143	0.154	0.167	0.203	0.206	0.236	0.256
1996	0.041	0.080	0.102	0.116	0.147	0.170	0.214	0.230	0.238	0.279
1997	0.047	0.072	0.102	0.121	0.140	0.166	0.177	0.183	0.203	0.232
1998	0.048	0.072	0.094	0.125	0.149	0.178	0.183	0.188	0.221	0.248
1999	0.063	0.078	0.088	0.109	0.142	0.170	0.199	0.193	0.192	0.245
2000	0.057	0.075	0.086	0.104	0.133	0.156	0.179	0.187	0.232	0.241
2001	0.050	0.078	0.094	0.108	0.129	0.163	0.186	0.193	0.231	0.243
2002	0.054	0.074	0.093	0.115	0.132	0.155	0.173	0.233	0.224	0.262
2003	0.049	0.075	0.098	0.108	0.131	0.148	0.168	0.193	0.232	0.258
2004	0.042	0.066	0.089	0.102	0.123	0.146	0.160	0.173	0.209	0.347
2005	0.039	0.068	0.084	0.099	0.113	0.137	0.156	0.166	0.195	0.217
2006	0.049	0.072	0.089	0.105	0.122	0.138	0.163	0.190	0.212	0.328
2007	0.050	0.064	0.091	0.103	0.115	0.130	0.146	0.169	0.182	0.249

Table 10.4.4.1. blue whiting natural mortality and proportion of maturation-at-age

AGE	0	1	2	3	4	5	6	7-10+
Proportion mature	0.00	0.11	0.40	0.82	0.86	0.91	0.94	1.00
Natural mortality	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Table 10.4.5.1.1 Stock composition of the IBSSS 2004–2008 in numbers (millions).

Year\Age	1	2	3	4	5	6	7	8	9	10	11	Total
2004	4886	17603	34350	44397	16775	5521	3111	1962	1131	127		129863
2005	3631	4320	18774	25579	26660	8298	2016	728	323	2	4	90335
2006	3162	5540	32201	38942	16608	7972	2459	791	293	7		107975
2007	1723	2654	16343	32851	24794	13952	7282	2509	951	420	235	103714
2008	956	1672	4443	17814	20144	11710	6418	3093	791	908		67948

Table 10.4.5.2.1. Estimated blue whiting stock numbers and biomass from the International Norwegian Sea ecosystem survey, 2000–2007. The estimates are for the standard area, north of 63°N and between 8°W–20°E.

Year\Age	1	2	3	4	5	6	7	8	9	10	11	Total
2000	48927	3133	3580	1668	201	5						57514
2001	85772	25110	7533	3020	2066							123501
2002	15251	46656	14672	4357	513	445		15		6		81915
2003	35688	21487	35372	4354	639	201	43	3				97787
2004	49254	22086	13292	8290	1495	533	83	39				95072
2005	54660	19904	13828	4714	1886	326	103	43	8	3	11	95486
2006	570	18300	15324	6550	1566	384	246	80	47	2	8	43077
2007	21	552	5846	3639	1674	531	178	49	19			12509
2008	29	75	534	2151	715	287	116	44				3951

Table 10.4.5.3.1 1-group indices of blue whiting from the Norwegian winter survey (late January-early March) in the Barents Sea. (Blue whiting <19 cm in total body length which most likely belong to 1-group.)

Year		1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Catch rate	All	0.13	0.17	4.46	6.97	32.51	17.51	8.32	6.38	1.65	17.81	48.87	30.05	5.80	3.02
(ind./nm)	<19cm	0.00	0.01	0.46	2.47	0.77	0.89	0.02	0.97	0.18	16.37	2.11	0.06	0.01	0.00

Year		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Catch rate	All	1.65	9.88	187.24	7.14	5.98	129.23	329.04	102.63	75.25	124.01	206.18	269.20	80.38	16.72
(ind./nm)	<19cm	0.10	5.81	175.26	0.21	0.71	120.90	233.76	9.69	15.15	36.74	90.23	3.52	0.16	0.01

Table 10.4.5.5.1 BLUE WHITING. Stratified mean catch (Kg/haul) and standard error of bottom trawl surveys in Portuguese waters (Division IXa).

		20-100 m		100-200 m		200-500 m		500-750 m		TOTAL	
Year	Month	**y**	sy	**y**	sy	**y**	sy	**y**	sy	**y**	sy
1990	July	**2**	2	**153**	103	**242**	42	**50**	5	**96**	35
	October	**11**	5	**90**	28	**762**	234	**42**	10	**153**	35
1991	July	**1**	1	**140**	40	**268**	38	**64**	18	**98**	15
	October	**8**	5	**83**	18	**259**	53	**121**	27	**91**	11
1992	February	**7**	7	**43**	35	**249**	21	**73**	3	**68**	12
	July	**1**	1	**29**	18	**216**	43	**27**	5	**47**	9
	October	**1**	1	**22**	7	**208**	44	**80**	3	**54**	7
1993	February	**0**	0	**19**	14	**105**	31	**36**	0	**42**	10
	July	**0**	0	**3**	3	**151**	28	**55**	5	**34**	4
	November	**0**	0	**90**	0	**189**	43	**6**	1	**86**	9
1994	October	**0**	0	**374**	30	**283**	32	**49**	7	**174**	11
1995	July	**0**	0	**18**	14	**130**	20	**52**	3	**35**	5
	October	**18**	15	**103**	21	**328**	91	**31**	12	**94**	16
1996	October	**25**	24	**12**	2	**36**	6	**25**	7	**22**	8
1997	June	**0**	0	**3**	3	**116**	42	**45**	12	**27**	7
	October	**2**	1	**54**	20	**77**	13	**7**	2	**32**	8
1998	July	**0**	0	**8**	5	**105**	17	**38**	3	**25**	3
	October	**1**	1	**384**	87	**427**	101	**20**	2	**212**	36
1999	July	**1**	0	**60**	21	**66**	19	**25**	2	**37**	9
	October	**0**	0	**69**	16	**80**	20	**18**	8	**41**	7
2000	July	**23**	13	**109**	34	**116**	10	**63**	6	**75**	13
	October	**11**	4	**155**	53	**196**	22	**54**	4	**99**	19
2001	July	**18**	7	**238**	37	**305**	116	**57**	14	**152**	23
	October	**106**	6	**474**	224	**294**	66		0	**295**	97
2002	October	**19**	12	**176**	81	**180**	24		0	**116**	34
2003	October	**24**	10	**114**	14	**119**	30	**34**	6	**76**	8
2004	October	**0**	0	**44**	10	**380**	27			**84**	15
2005	October	**0**	0	**25**	7	**407**	239			**81**	42
2006	October	**1**	1	**154**	59	**196**	32			**95**	26
2007	October	**1**	1	**136**	66	**141**	25			**91**	32

Table 10.4.5.6.1. Stratified mean catch (Kg/haul and Number/haul) and standard error of BLUE WHITING in bottom trawl surveys in Spanish waters (Divisions VIIIc and IXa north). All surveys in September-October.

Kg/haul	30-100 m		101-200 m		201-500 m		TOTAL 30-500 m	
Year	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1985	9.50	5.87	119.75	45.99	68.18	13.79	92.83	28.24
1986	9.74	7.13	45.41	12.37	29.54	8.70	36.93	7.95
1987	-	-	-	-	-	-	-	-
1988	2.90	2.59	154.12	38.69	183.07	141.94	143.30	45.84
1989	14.17	12.03	76.92	17.08	18.79	6.23	59.00	11.68
1990	6.25	3.29	52.54	9.00	18.80	4.99	43.60	6.60
1991	64.59	34.65	126.41	26.06	46.07	18.99	97.10	17.16
1992	6.37	2.59	44.12	6.64	29.50	6.16	34.60	4.23
1993	1.06	0.63	14.07	3.73	51.08	22.02	22.59	6.44
1994	8.04	5.28	37.18	8.45	25.42	5.27	29.70	5.19
1995	19.97	13.87	36.43	4.82	15.97	4.10	28.52	3.66
1996	7.27	3.95	49.23	7.19	92.54	17.76	54.52	6.36
Kg/haul	70-120 m		121-200 m		201-500 m		TOTAL 70-500 m	
Year	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1997	17.87	7.35	44.68	10.52	57.14	16.60	42.62	7.29
1998	14.13	4.17	42.78	8.13	78.88	22.01	47.14	7.58
1999	93.01	14.60	112.39	19.92	169.21	50.26	124.66	17.85
2000	62.39	12.00	91.99	14.75	58.72	24.94	76.19	10.61
2001	8.35	3.31	50.18	10.09	52.41	16.71	42.02	7.02
2002	31.40	5.02	69.00	13.41	36.75	12.07	51.80	7.64
2003	42.52	12.22	71.40	11.01	46.43	11.42	58.13	6.92
2004	2.80	2.11	14.05	7.79	59.51	21.41	24.76	7.31
2005	50.63	16.15	95.17	19.28	40.06	8.88	69.94	10.57
2006	14.28	7.01	70.79	12.60	115.08	39.88	71.64	13.18
2007	4.76	3.75	39.10	23.21	21.69	4.41	26.86	11.74

Table 10.5.1 . Blue Whiting. Survey indices used in the assessment.

```
# Survey indices at age, BLUE WHITING-COMBINED, 2008 WG, 3 fleets
# Norwegian spawning ground survey, 1991 2003
# Effort and catch numbers age 3 – 8
 1 6340 8497 7407 4558 2019 545 #1991
 1 26123 4719 1574 1386 810 616 #1992
 1 3321 26771 2643 1270 557 426 #1993
 1 2950 4476 11354 1742 1687 908 #1994
 1 9874 7906 6861 9467 1795 1083 #1995
 1 7433 8371 2399 4455 4111 1202 #1996
 1 -1 -1 -1 -1 -1 -1 #1997
 1 34991 4697 1674 279 407 381 #1998
 1 60309 26103 1481 316 72 153 #1999
 1 31011 41382 6843 898 427 228 #2000
 1 12843 13805 8292 718 175 51 #2001
 1 54740 12757 5266 8404 1450 305 #2002
 1 70303 28756 5735 2430 1708 260 #2003
# International ecosystem survey in the Nordic Seas, 2000 – 2008
# Effort and catch numbers age 1 – 2
 1 48927 3133 #2000
 1 85772 25110 #2001
 1 15251 46656 #2002
 1 35688 21487 #2003
 1 49254 22086 #2004
 1 54660 19904 #2005
 1 570 18300 #2006
 1 21 552 #2007
 1 29 75 #2008
# International blue whiting spawning stock ground survey, IBWSS, 2004 – 2008
# Effort and catch numbers age 3 – 8
 1 34350 44397 16775 5521 3111 1962 #2004
 1 18774 25579 26660 8298 2016 728 #2005
 1 32201 38942 16608 7972 2459 791 #2006
 1 16343 32851 24794 13952 7282 2509 #2007
 1 4443 17814 20144 11710 6418 3093 #2008
```

Table 10.5.1.1. Blue whiting SMS data exploration. SMS diagnostics output from the final run.

```
objective function (negative log likelihood): -197.138
Number of parameters: 94
Maximum gradient: 7.31372e-005
objective function weight:
 Catch CPUE S/R
 1 1 0.01
unweighted objective function contributions (total):
 Catch CPUE S/R Sum
 -186.9 -10.3 10.7 -186.5
unweighted objective function contributions (per observation):
 Catch CPUE S/R
 -0.69 -0.09 0.40
F, Year effect:
---------------

1981: 1.000
1982: 0.809
1983: 0.943
1984: 1.228
1985: 1.374
1986: 1.815
1987: 1.396
1988: 1.364
1989: 1.791
1990: 1.740
1991: 0.842
1992: 0.751
1993: 0.770
1994: 0.677
1995: 0.894
1996: 1.202
1997: 1.198
1998: 1.660
1999: 1.000
2000: 1.277
2001: 1.140
2002: 1.062
2003: 1.176
2004: 1.278
2005: 1.071
2006: 0.926
2007: 0.998
F, age effect:
--------------
 1 2 3 4 5 6 7 8 – 10
1981 – 1998: 0.068 0.100 0.173 0.225 0.264 0.333 0.393 0.414
1999 – 2007: 0.058 0.080 0.217 0.394 0.452 0.521 0.481 0.564
Exploitation pattern (scaled to mean F=1)
-----------------------------------------
 1 2 3 4 5 6 7 8 – 10
1981 – 1998: 0.245 0.361 0.625 0.810 0.950 1.199 1.416 1.493
1999 – 2007: 0.141 0.194 0.527 0.954 1.094 1.261 1.165 1.365
sqrt(catch variance) ~ CV:
--------------------------
Age
 1 0.404
 2 0.355
 3 – 6 0.175
 7 – 10 0.470
Survey catchability:
-------------------- age 1 age 2 age 3 age 4 age 5 – 8
 Norw. Spawning Stock Surv. 1.709 2.200 1.246
 Intl. Surv. in Nord. Seas. 0.427 0.383
 IBWSSS 1.091 1.891 2.115
sqrt(Survey variance) ~ CV:
--------------------------- age 1 age 2 age 3 age 4 age 5 – 6 age 7 – 8
 Norw. Spawning Stock Surv. 0.45 0.45 0.67 0.72
 Intl. Surv. in Nord. Seas. 1.41 1.01

 IBWSSS 0.40 0.40 0.40 0.40
```

Table 10.5.1.2 . Blue Whiting. Fishing mortality estimated by the final SMS run.

Age	1981	1982	1983	1984	1985	1986	1987	1988
1	0.0681	0.0550	0.0641	0.0836	0.0935	0.1235	0.0950	0.0928
2	0.1001	0.0809	0.0943	0.1229	0.1375	0.1817	0.1397	0.1365
3	0.1733	0.1401	0.1633	0.2128	0.2381	0.3146	0.2419	0.2363
4	0.2248	0.1817	0.2119	0.2761	0.3088	0.4081	0.3138	0.3065
5	0.2636	0.2131	0.2485	0.3237	0.3621	0.4785	0.3679	0.3594
6	0.3326	0.2689	0.3135	0.4085	0.4569	0.6038	0.4642	0.4535
7	0.3930	0.3177	0.3704	0.4826	0.5398	0.7134	0.5485	0.5358
8	0.4143	0.3350	0.3906	0.5089	0.5692	0.7522	0.5783	0.5650
9	0.4143	0.3350	0.3906	0.5089	0.5692	0.7522	0.5783	0.5650
10	0.4143	0.3350	0.3906	0.5089	0.5692	0.7522	0.5783	0.5650
Avg. F 3 – 7	0.277	0.224	0.262	0.341	0.381	0.504	0.387	0.378

Age	1989	1990	1991	1992	1993	1994	1995	1996
1	0.1219	0.1184	0.0573	0.0511	0.0524	0.0461	0.0609	0.0818
2	0.1793	0.1741	0.0843	0.0751	0.0771	0.0678	0.0895	0.1203
3	0.3105	0.3015	0.1459	0.1301	0.1334	0.1173	0.1550	0.2084
4	0.4027	0.3910	0.1893	0.1688	0.1731	0.1522	0.2010	0.2703
5	0.4722	0.4586	0.2220	0.1979	0.2029	0.1785	0.2357	0.3169
6	0.5959	0.5786	0.2801	0.2497	0.2561	0.2252	0.2974	0.3999
7	0.7040	0.6836	0.3309	0.2950	0.3025	0.2661	0.3514	0.4725
8	0.7423	0.7208	0.3489	0.3111	0.3190	0.2806	0.3705	0.4982
9	0.7423	0.7208	0.3489	0.3111	0.3190	0.2806	0.3705	0.4982
10	0.7423	0.7208	0.3489	0.3111	0.3190	0.2806	0.3705	0.4982
Avg. F 3 – 7	0.497	0.483	0.234	0.208	0.214	0.188	0.248	0.334

Age	1997	1998	1999	2000	2001	2002	2003	2004
1	0.0815	0.1130	0.0583	0.0745	0.0665	0.0619	0.0686	0.0746
2	0.1199	0.1662	0.0802	0.1024	0.0914	0.0852	0.0943	0.1025
3	0.2076	0.2877	0.2175	0.2777	0.2480	0.2309	0.2558	0.2780
4	0.2693	0.3732	0.3941	0.5033	0.4493	0.4185	0.4635	0.5038
5	0.3158	0.4377	0.4518	0.5769	0.5150	0.4797	0.5313	0.5774
6	0.3984	0.5523	0.5206	0.6648	0.5935	0.5528	0.6123	0.6654
7	0.4707	0.6525	0.4810	0.6143	0.5484	0.5108	0.5657	0.6149
8	0.4964	0.6880	0.5637	0.7199	0.6427	0.5985	0.6630	0.7206
9	0.4964	0.6880	0.5637	0.7199	0.6427	0.5985	0.6630	0.7206
10	0.4964	0.6880	0.5637	0.7199	0.6427	0.5985	0.6630	0.7206
Avg. F 3 – 7	0.332	0.461	0.413	0.527	0.471	0.439	0.486	0.528

Age	2005	2006	2007
1	0.0625	0.0540	0.0582
2	0.0859	0.0743	0.0800
3	0.2329	0.2014	0.2171
4	0.4220	0.3649	0.3934
5	0.4837	0.4183	0.4509
6	0.5574	0.4820	0.5196
7	0.5150	0.4454	0.4801
8	0.6036	0.5219	0.5626
9	0.6036	0.5219	0.5626
10	0.6036	0.5219	0.5626
Avg. F 3 – 7	0.442	0.382	0.412

Table 10.5.1.3 . Blue Whiting. Stock Numbers in thousands estimated by the final SMS run.

Age	1981	1982	1983	1984	1985	1986	1987	1988
1	3278990	4094484	14706165	18242121	10504953	8542822	8979598	6671710
2	3757663	2507997	3172820	11292320	13737906	7833110	6181463	6685715
3	4515108	2783519	1893766	2363835	8176070	9802810	5347756	4401154
4	2454035	3108484	1981008	1316824	1564335	5275869	5859590	3437698
5	2335683	1604706	2122060	1312218	818036	940488	2872162	3505471
6	2196838	1469174	1061639	1355157	777231	466273	477166	1627654
7	1838948	1289702	919232	635274	737445	402948	208715	245581
8	1773722	1016360	768507	519639	321003	351899	161651	98740
9	1504103	959576	595250	425768	255768	148745	135797	74226
10	3044675	2460869	2003246	1439618	918150	543965	267316	185100
TSB	3414534	2847667	2834724	2907566	3140087	3252183	2939927	2610184
SSB	2939507	2419359	1972298	1717480	1987313	2298847	1990531	1792030

Age	1989	1990	1991	1992	1993	1994	1995	1996
1	9351131	24611756	8662138	5696819	5346685	5783770	8315249	23730323
2	4978277	6777346	17900821	6697027	4431863	4154056	4522091	6405993
3	4775530	3406858	4662211	13471543	5086193	3359422	3178198	3385403
4	2845013	2866388	2063364	3298865	9684072	3644112	2445920	2228525
5	2071515	1557148	1587269	1398031	2281469	6668648	2562267	1637862
6	2003471	1057639	805981	1040877	939103	1524817	4567269	1657241
7	846711	903952	485514	498702	663892	595174	996651	2777269
8	117659	342877	373604	285527	303991	401650	373439	574200
9	45948	45856	136538	215794	171276	180910	248391	211075
10	120675	64939	44120	104348	192040	216215	245593	279209
TSB	2627980	2960362	3543545	3651656	3426752	3268085	3226544	3466276
SSB	1715672	1544389	1979023	2642861	2565666	2486320	2308252	2155949

Age	1997	1998	1999	2000	2001	2002	2003	2004
1	45230547	28866036	24019593	39379700	61797514	55627178	54056252	40335237
2	17902375	34132607	21108483	18551058	29926628	47339605	42808057	41322581
3	4650163	13001231	23666955	15950281	13709875	22360940	35594696	31893632
4	2250415	3093521	7982962	15589226	9892112	8759587	14532476	22564988
5	1392446	1407522	1743801	4406903	7715892	5167499	4719366	7484609
6	976725	831342	743897	908742	2026460	3774382	2618841	2271332
7	909597	536876	391813	361874	382706	916454	1777993	1162367
8	1417635	465104	228902	198291	160295	181061	450232	826740
9	285658	706551	191386	106650	79033	69014	81474	189950
10	243911	263937	399346	275234	152208	99559	75855	66376
TSB	5053504	6216915	6743348	7549788	9264255	11103335	12347044	11205491
SSB	2237356	3207358	3882114	4182112	4622760	5716171	7136770	7125470

Age	2005	2006	2007	2008
1	20413372	6228163	1781338*	3278990**
2	30650551	15701032	4831050	2532752***
3	30535754	23029770	11934980	3651100
4	19774543	19807027	15416108	7864800
5	11163038	10616620	11258462	8516800
6	3439759	5634673	5721047	5872300
7	955923	1612887	2848892	2785900
8	514571	467619	845898	1443100
9	329281	230391	227173	394560
10	102092	193140	205754	201930
TSB	9456619	8101795	5760998	
SSB	6619950	6328575	4917671	

* replaced by 3278990 (lowest recruitment in time series) for forecast
** from lowest recruitment in time series
*** derived from the age 1 number in 2007 (lowest recruitment in time series)

Table 10.5.1.4. Blue whiting. Stock summary 1981–2007 estimated by final SMS run. SSB in 2008 does not include contributions from age 1.

Year	Recruits	SSB	TSB	SOP	mean-F
	(1000)	(tonnes)	(tonnes)	(tonnes)	age 3 – 7
1981	3278990	2939507	3414534	922980	0.277
1982	4094484	2419359	2847667	550643	0.224
1983	14706165	1972298	2834724	553344	0.262
1984	18242121	1717480	2907566	615569	0.341
1985	10504953	1987313	3140087	678214	0.381
1986	8542822	2298847	3252183	847145	0.504
1987	8979598	1990531	2939927	654718	0.387
1988	6671710	1792030	2610184	552264	0.378
1989	9351131	1715672	2627980	630316	0.497
1990	24611756	1544389	2960362	558128	0.483
1991	8662138	1979023	3543545	364008	0.234
1992	5696819	2642861	3651656	474592	0.208
1993	5346685	2565666	3426752	475198	0.214
1994	5783770	2486320	3268085	457696	0.188
1995	8315249	2308252	3226544	505176	0.248
1996	23730323	2155949	3466276	621104	0.334
1997	45230547	2237356	5053504	639681	0.332
1998	28866036	3207358	6216915	1131955	0.461
1999	24019593	3882114	6743348	1261033	0.413
2000	39379700	4182112	7549788	1412449	0.527
2001	61797514	4622760	9264255	1771805	0.471
2002	55627178	5716171	11103335	1556955	0.439
2003	54056252	7136770	12347044	2365319	0.486
2004	40335237	7125470	11205491	2400795	0.528
2005	20413372	6619950	9456619	2018344	0.442
2006	6228163	6328575	8101795	1956239	0.382
2007	1781338	4917671	5760998	1612269	0.412
2008	3386585				

Recruitment: Arith mean (1981 – 2006): 20157542

Geo mean (1981 – 2006): 13419875

Table 10.9.1.1. Blue whiting. RCT3 Input.

```
2 28 2
'YEAR' 'VPA' 'Barents_idx' 'IES_idx'
1981 3278.990 -11 -11
1982 4094.484 0.010144928 -11
1983 14706.165 0.456467662 -11
1984 18242.121 2.473336705 -11
1985 10504.953 0.772955488 -11
1986 8542.822 0.893334361 -11
1987 8979.598 0.020615577 -11
1988 6671.710 0.96928982 -11
1989 9351.131 0.175609756 -11
1990 24611.756 16.37007012 -11
1991 8662.138 2.105831953 -11
1992 5696.819 0.056229538 -11
1993 5346.685 0.005464481 -11
1994 5783.770 -11 -11
1995 8315.249 0.100640739 -11
1996 23730.323 5.812809481 -11
1997 45230.547 175.2618555 -11
1998 28866.036 0.209994558 -11
1999 24019.593 0.70887144 -11
2000 39379.700 120.9015612 48927
2001 61797.514 233.7569233 85772
2002 55627.178 9.6862936 15251
2003 54056.252 15.1463275 35688
2004 40335.237 36.73747791 49254
2005 20413.372 90.23164366 54660
2006 6228.163 3.524569802 570
2007 1781.338 0.160115526 21
2008 -11 0.013165266 29
```

Table 10.9.1.2. Blue whiting. RCT3 output. Year class abundance is number of age 1.

```
Analysis by RCT3 ver3.1 of data from file :
 c:\mv\sms\rct3\data\rct3in.txt
 BLUE WHITING DATA
 Data for 2 surveys over 28 years : 1981 – 2008
 Regression type = C
 Tapered time weighting applied
 power = 3 over 20 years
 Survey weighting not applied
 Final estimates not shrunk towards mean
 Estimates with S.E.'S greater than that of mean
+ included
 Minimum S.E. for any survey taken as .20
 Minimum of 3 points used for regression
 Forecast/Hindcast variance correction used.
 Yearclass = 2007
 I-----------Regression----------I I-----------Prediction---------I
 Survey/ Slope Inter- Std Rsquare No. Index Predicted Std WAP
 Series cept Error Pts Value Value Error Weights
 Barent .68 8.34 1.10 .381 24 .15 8.45 1.352 .549
 IES_id .58 4.55 .64 .669 7 3.09 6.35 1.491 .451
 VPA Mean = 10.09 .862 .000
 Yearclass = 2008
 I-----------Regression----------I I-----------Prediction---------I
 Survey/ Slope Inter- Std Rsquare No. Index Predicted Std WAP
 Series cept Error Pts Value Value Error Weights
 Barent .85 7.82 1.35 .426 25 .01 7.84 1.643 .178
 IES_id .46 5.78 .51 .883 8 3.40 7.35 .765 .822
 VPA Mean = 9.92 1.111 .000
 Year Weighted Log Int Ext Var VPA Log
 Class Average WAP Std Std Ratio VPA
 Prediction Error Error
 2000 160740 11.99 1.13 .00 .00 39380 10.58
 2001 135300 11.82 .99 .00 .00 61798 11.03
 2002 22675 10.03 .76 .00 .00 55628 10.93
 2003 31342 10.35 .90 .02 .00 54057 10.90
 2004 54415 10.90 .95 .16 .03 40336 10.61
 2005 77212 11.25 .91 .36 .16 20414 9.92
 2006 17999 9.80 1.06 1.79 2.85 6229 8.74
 2007 1804 7.50 1.00 1.04 1.09 1782 7.49
 2008 1700 7.44 .69 .18 .07
```

Table 10.9.2.1. Blue Whiting. Input to short term projection.

Age	Weight in the stock (kg)	Weight in the catch (kg)	Proportion Mature	Exploitation Pattern	Stock Numbers 2008 (1000)
1	0.046	0.046	0.11	0.058	3278990
2	0.068	0.068	0.4	0.080	2532752
3	0.088	0.088	0.82	0.217	3651080
4	0.102	0.102	0.86	0.393	7864820
5	0.117	0.117	0.91	0.451	8516850
6	0.135	0.135	0.94	0.520	5872270
7	0.155	0.155	1	0.480	2785880
8	0.175	0.175	1	0.563	1443140
9	0.196	0.196	1	0.563	394556
10+	0.265	0.265	1	0.563	201932

Table 10.9.2.2. Blue Whiting. Short term projection

2008				
Biomass	SSB	FMult	FBar	Landings
4051220	3505990	0.9599	0.3957	1200000

2009					2010	
Biomass (tonnes)	SSB (tonnes)	FMult	FBar	Landings (tonnes)	Biomass (tonnes)	SSB (tonnes)
3037446	2423903	0.000	0.000	0	3395753	2633936
.	.	0.050	0.021	53717	3339545	2580018
.	.	0.100	0.041	106218	3284647	2527381
.	.	0.150	0.062	157531	3231027	2475995
.	.	0.200	0.082	207684	3178653	2425828
.	.	0.250	0.103	256707	3127495	2376850
.	.	0.300	0.124	304626	3077523	2329032
.	.	0.350	0.144	351467	3028708	2282346
.	.	0.385	0.159	383628	2995211	2250324
.	.	0.400	0.165	397256	2981022	2236764
		0.412	0.170	408092	2969742	2225985
		0.436	0.180	429588	2947372	2204613
.	.	0.450	0.186	442019	2934438	2192258
.	.	0.500	0.206	485781	2888928	2148803
.	.	0.550	0.227	528564	2844466	2106372
.	.	0.600	0.247	570393	2801027	2064940
.	.	0.650	0.268	611291	2758586	2024483
.	.	0.700	0.289	651279	2717119	1984977
.	.	0.750	0.309	690379	2676601	1946399
.	.	0.777	0.320	711132	2655108	1925945
.	.	0.800	0.330	728613	2637010	1908726
.	.	0.850	0.350	766002	2598324	1871936
.	.	0.900	0.371	802565	2560519	1836007
.	.	0.950	0.392	838321	2523576	1800918
.	.	1.000	0.412	873291	2487472	1766649

.	.	1.440	0.594	1149875	2202964	1497464

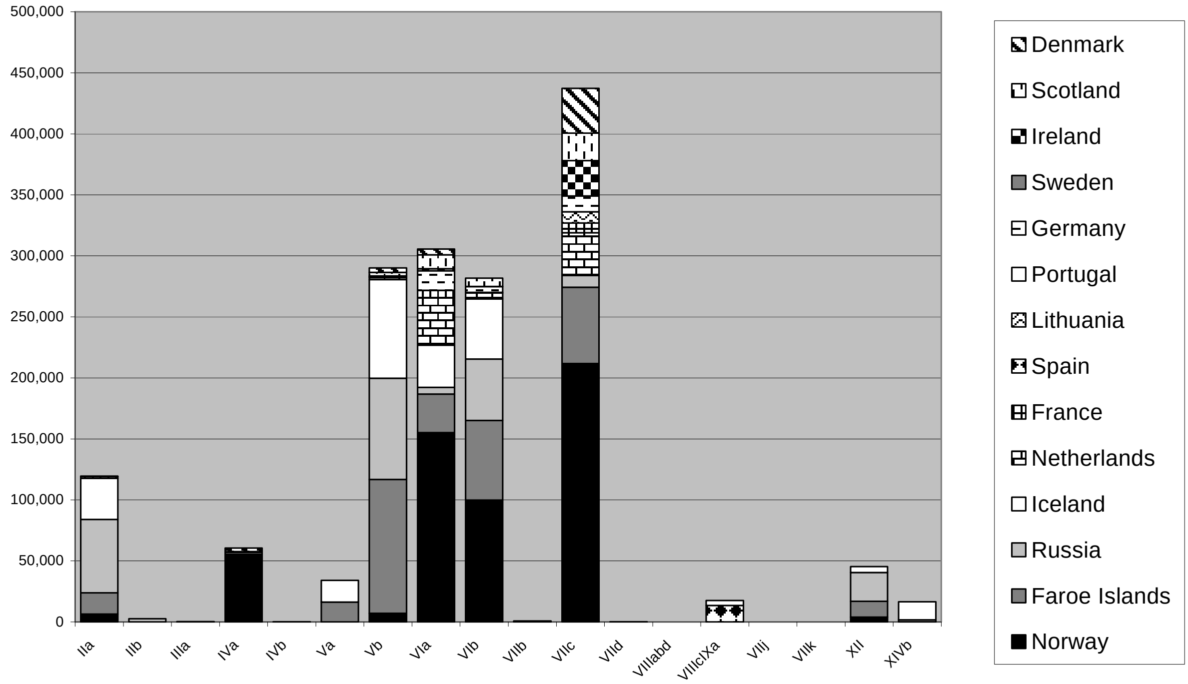


Figure 10.2.1. Blue whiting landings (tonnes) in 2007 presented by ICES area and country.

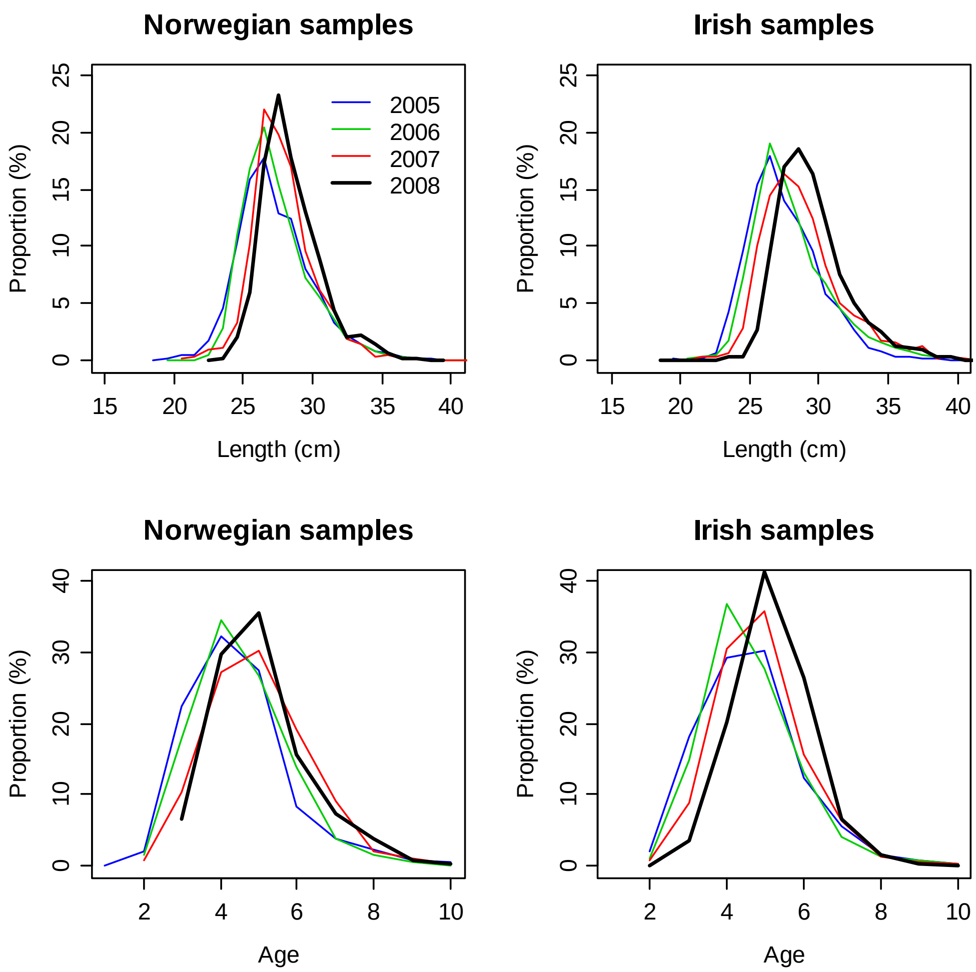


Figure 10.2.7. Blue whiting. Length and age distributions from sampled Norwegian and Irish commercial trawl catches taken on the blue whiting spawning grounds.

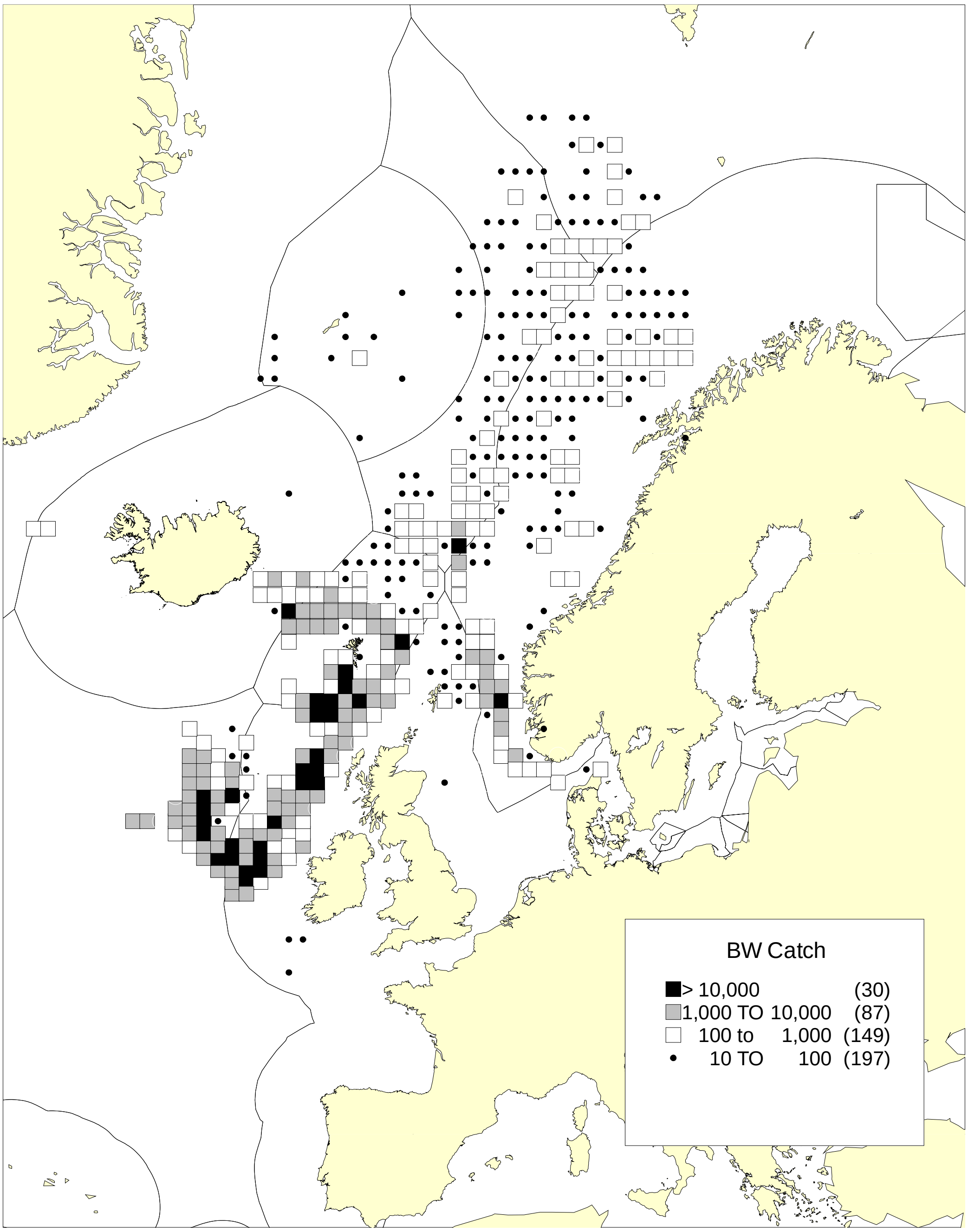
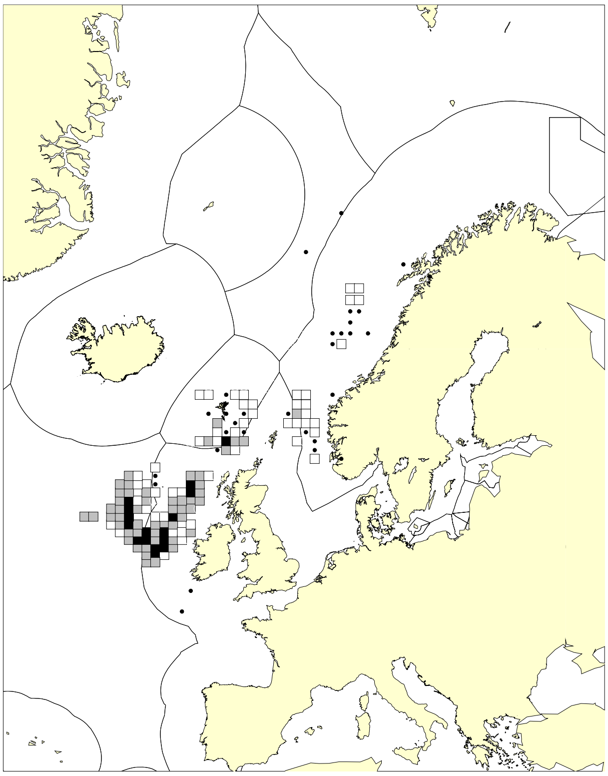
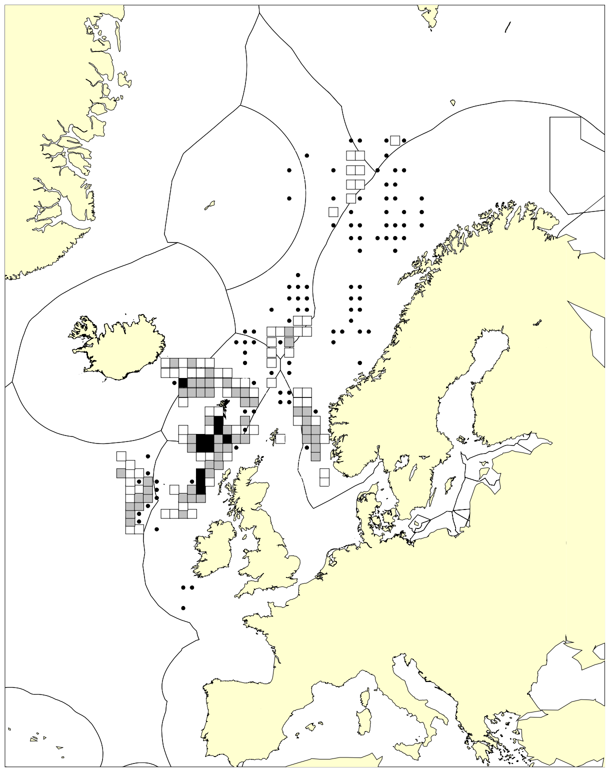


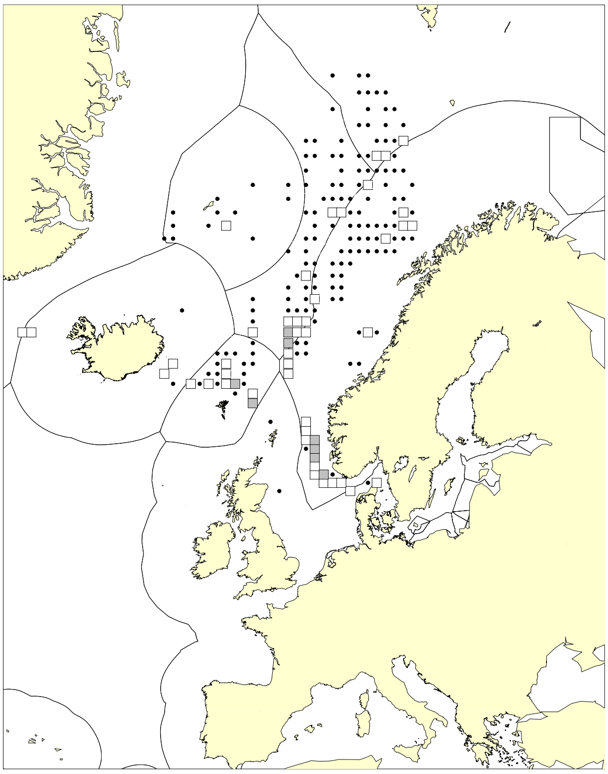
Figure 10.4.1.1.1. Blue whiting. Total catches (t) in 2007 by ICES rectangle. Grading of the symbols: small dots 10–100 t, white squares 100–1000 t, grey squares 1000–10 000 t, and black squares > 10 000 t. Catches below 10 t are not shown on the map.



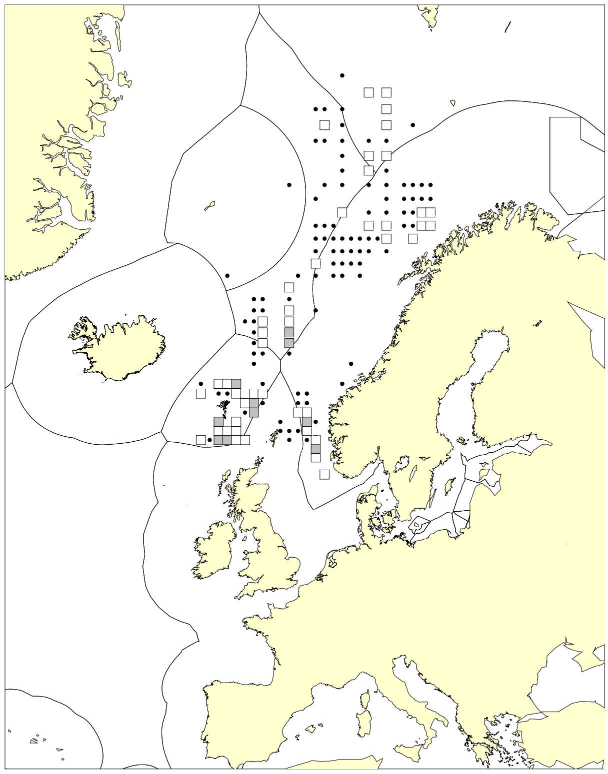
Quarter 1



Quarter 2

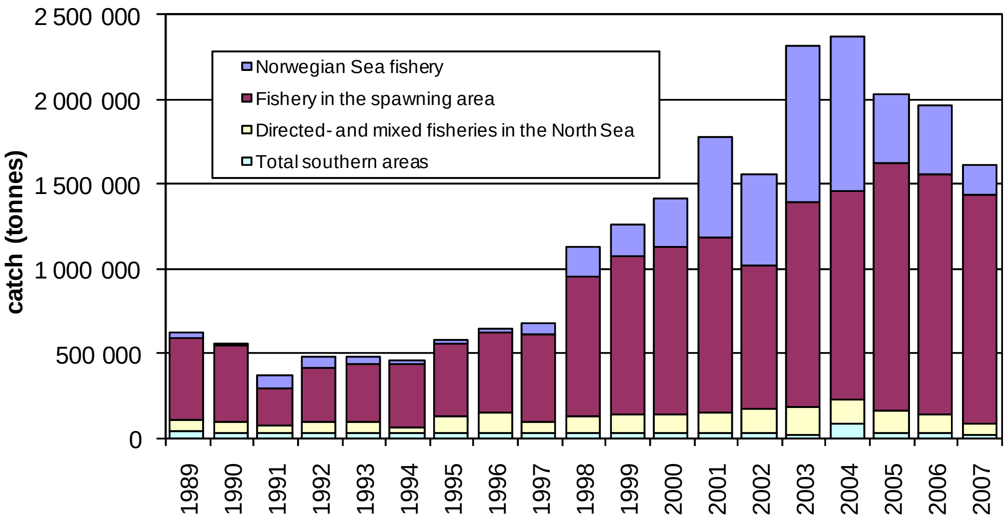


Quarter 3



Quarter 4

Figure 10.4.1.1.2. Blue whiting. Total catches (t) in 2007 by quarter and ICES rectangle. Grading of the symbols: small dots 10–100 t, white squares 100–1000 t, grey squares 1000–10 000 t, and black squares > 10 000 t. Catches below 10 t are not shown on the map.



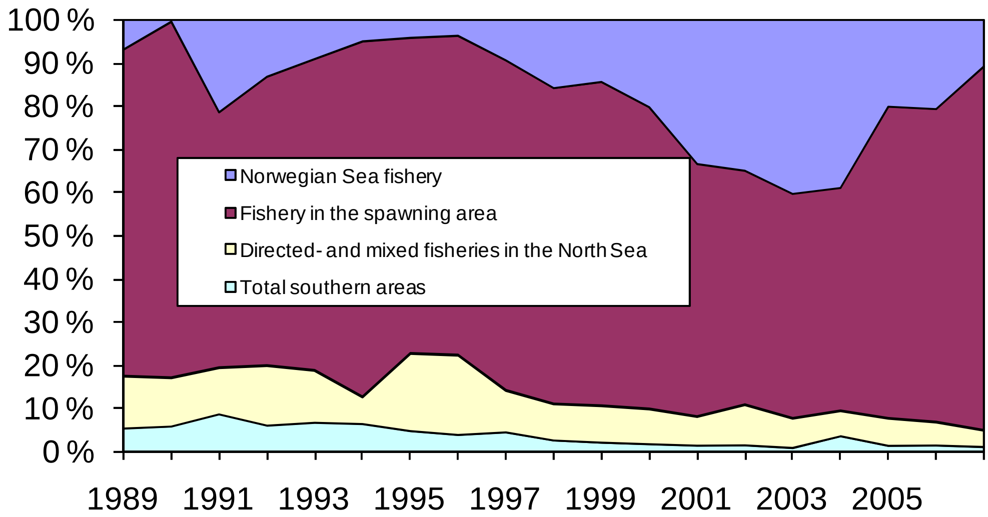


Figure 10.4.1.1.3. Blue whiting. Development of blue whiting fisheries in different sub-areas

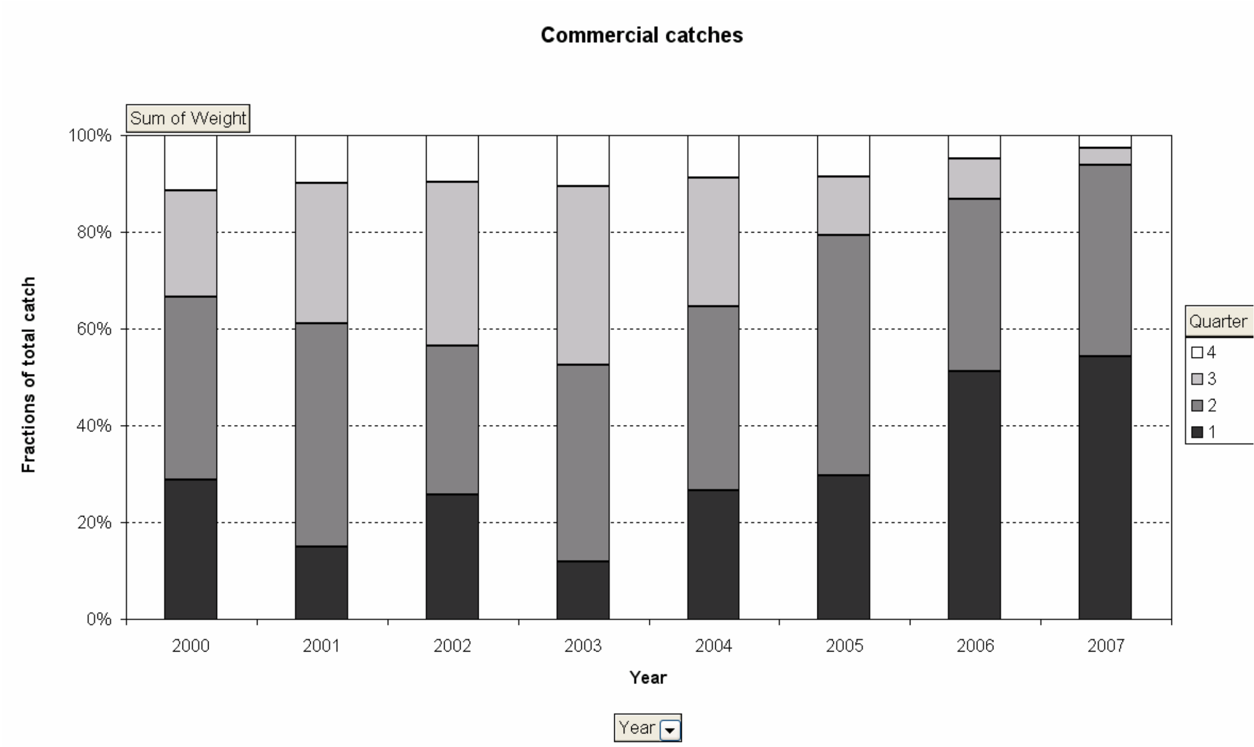


Figure 10.4.1.1.4. Blue whiting. Distribution of total landings by quarter.

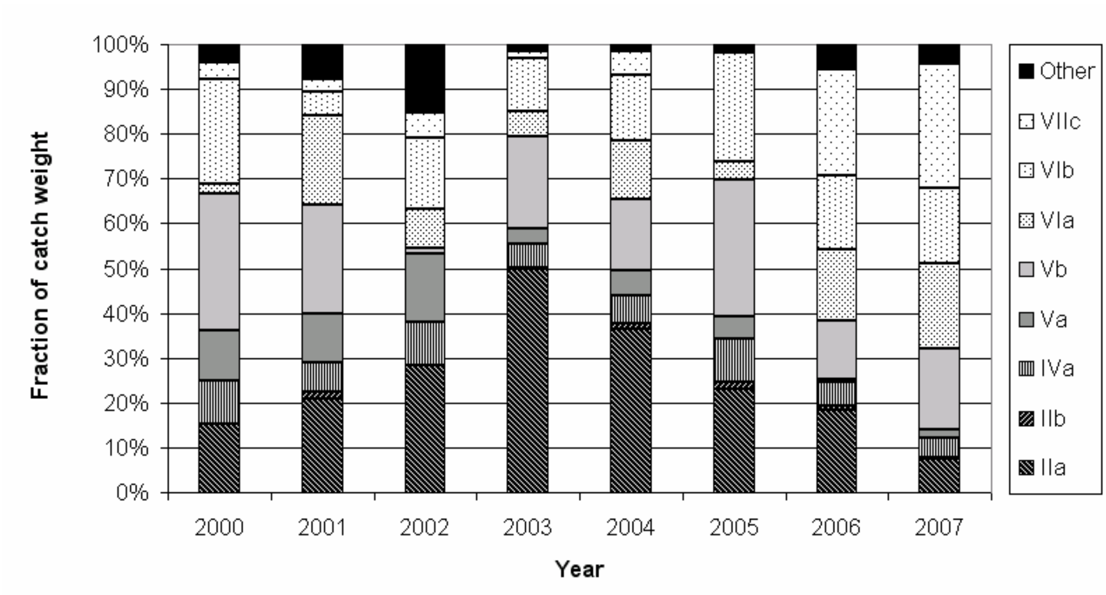


Figure 10.4.1.1.5. Blue whiting. Distribution of total landings by ICES sub-area.

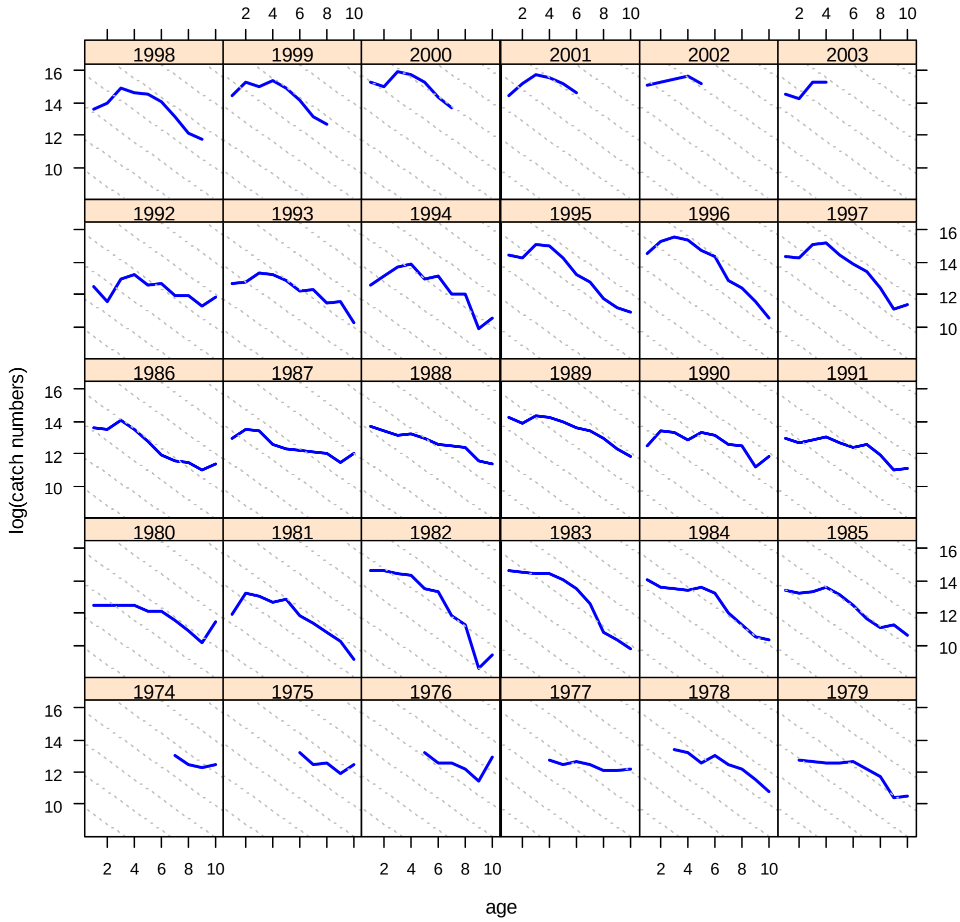


Figure 10.4.1.3.1. Blue whiting. Age disaggregated catch in numbers plottedon log scale. The labels behind each panel indicate year classes. The grey lines correspond to Z=0.6.

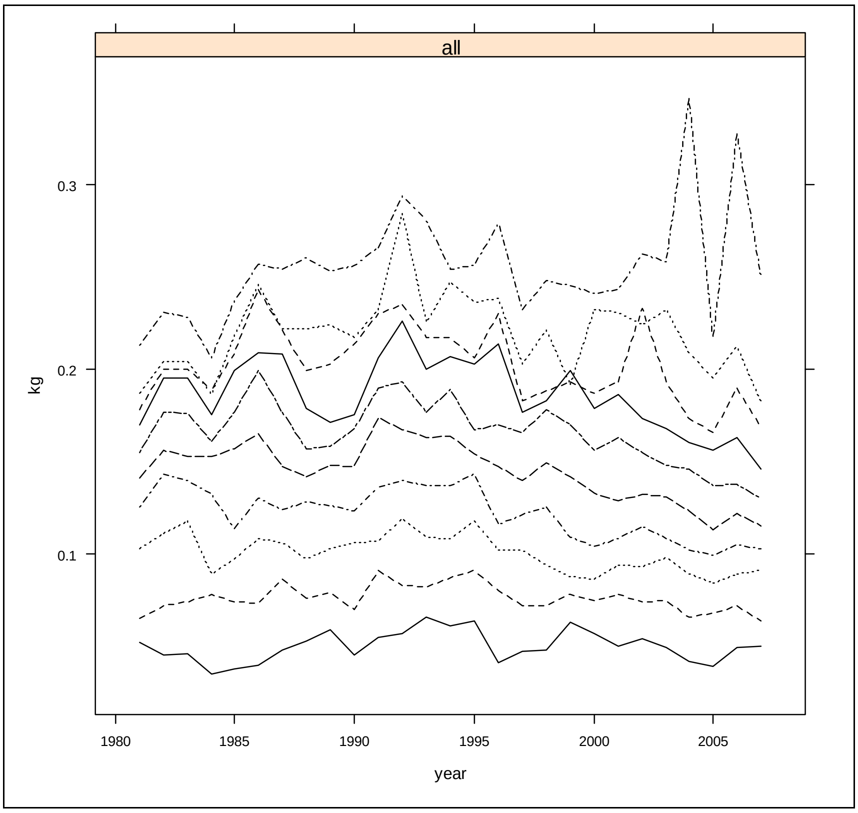


Figure 10.4.3.1.1. Weight (Kg) at age by year in the catches.

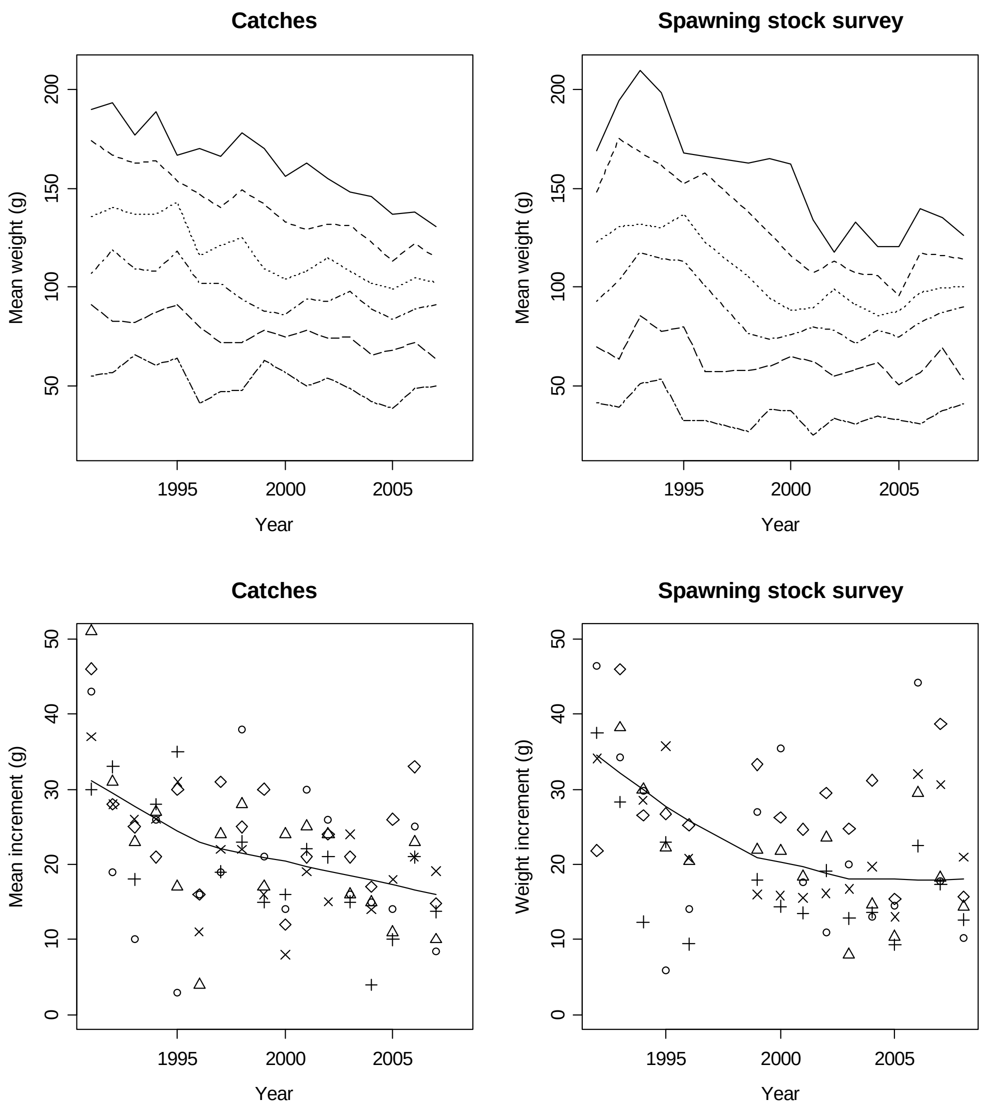


Figure 10.4.3.1.2. Weight at age by year in the catches (top left) and in the spawning stock survey (top right). Yearly growth rate by cohort in the catches (bottom left) and in the spawning stock survey (bottom right). Applied smoothed lines are done with lowess method. Spawning stock survey; Norwegian data are used from 1991–2005 and data from the international survey are used from 2006–2008.

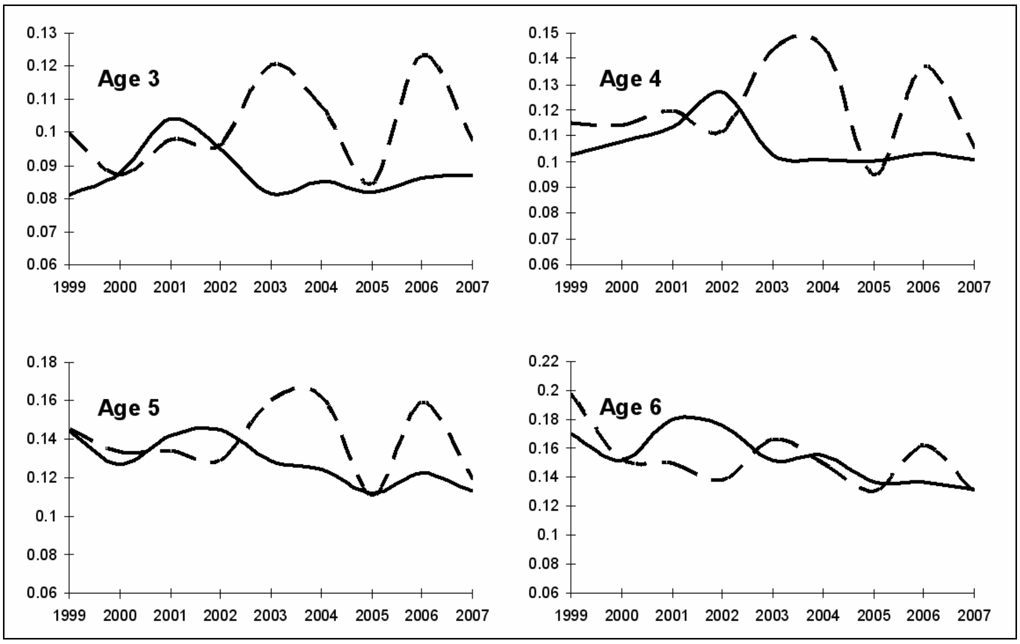


Figure. 10.4.3.1.3. Smoothed plots of the mean weight at age in the feeding area (Norwegian Sea IIa: spotted line) and in the spawning area (Rockall + Porcupine (VIb+VIIc): filled line).

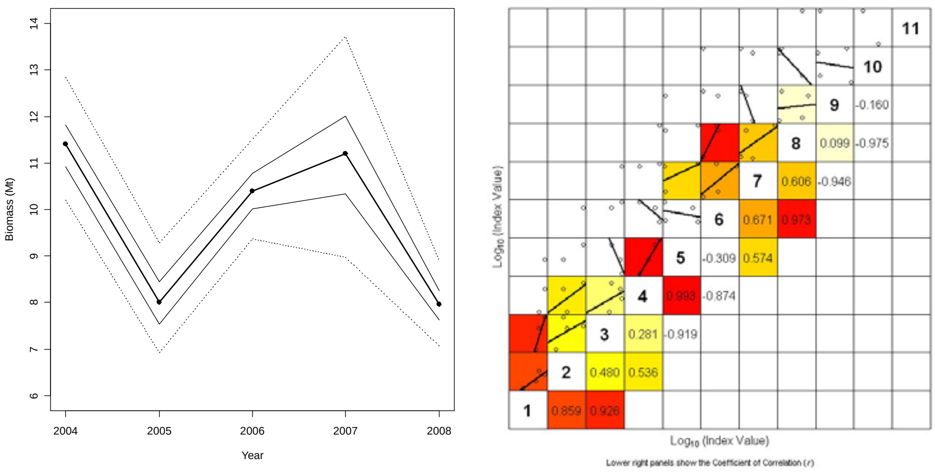


Figure 10.4.5.1.1. Left panel: Approximate 50% and 95% confidence limits for blue whiting biomass estimates. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations from the mean values. These confidence limits only account for spatio-temporal variability in acoustic observations. Right panel: Blue whiting. Internal consistency within the International blue whiting spawning stock survey (bottom panel). The upper left part of the plots shows the relationship between log index-at-age within a cohort. Linear regression line shows the best fit to the log-transformed indices. The ages plotted on the x- and y- axes of each panel can be found by moving either vertically (for the x-axis) or horizontally (y-axis) to the main diagonal. The lower-right part of the plots shows the correlation coefficient (r) for the two ages plotted in that panel. The background colour of each panel is determined by the r value, where red equates to r=1 and white to r=-1.

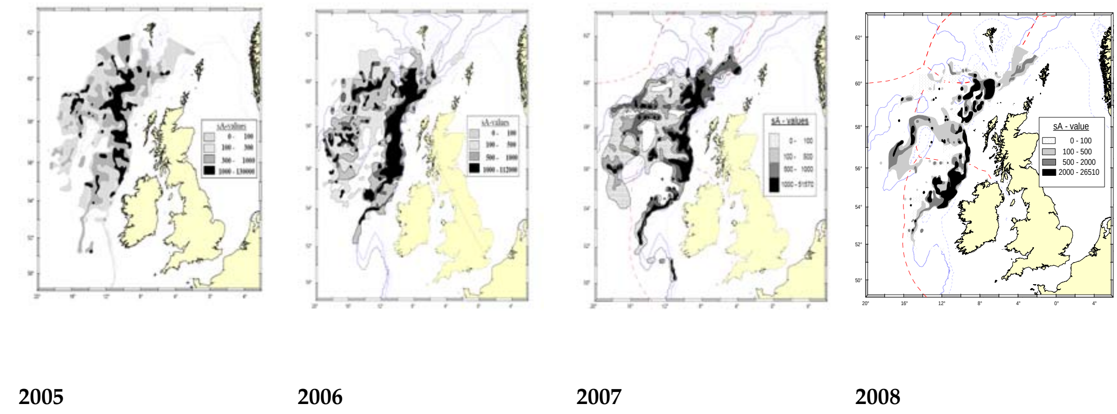


Figure 10.4.5.1.2. Blue whiting. Schematic map of blue whiting acoustic density (sA, m2/nm2) found during the spawning survey in spring 2005, 2006, 2007 and 2008.

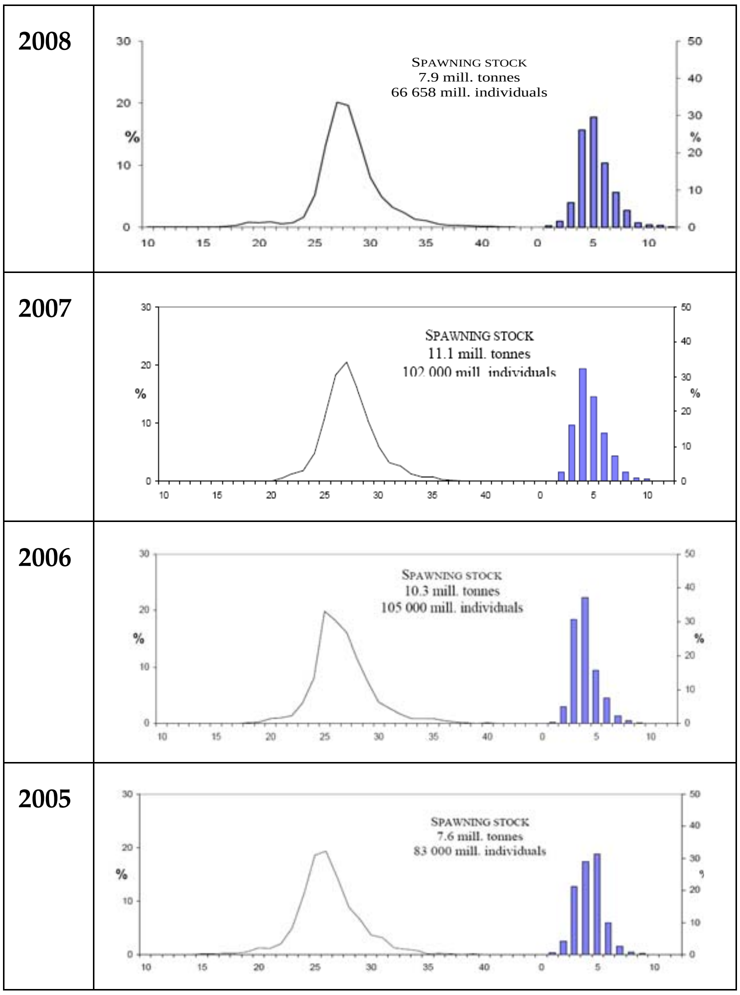


Figure 10.4.5.1.3. Blue whiting. Length and age distribution in the total and spawning stock of blue whiting in the area to the west of the British Isles, spring 2005 (lower panel to 2008 (upper panel).

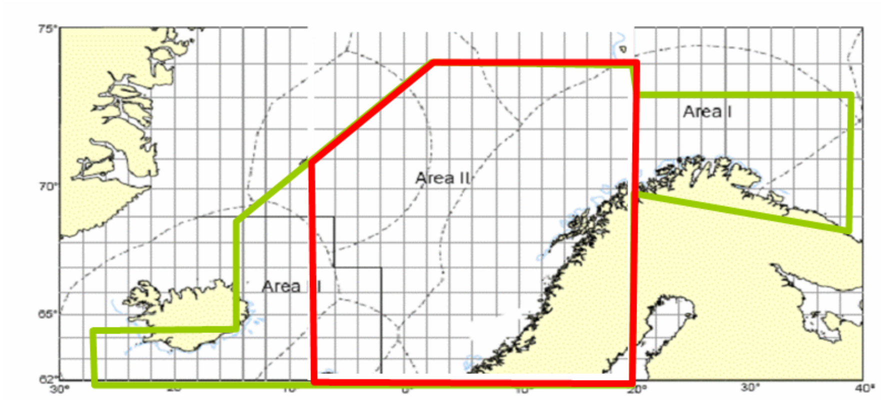


Figure 10.4.5.2.1. Blue whiting. Areas defined for acoustic estimation of blue whiting and Norwegian spring spawning herring. The dark red box in the middle represents the standard area (8°W–20°E and north of 62°N) of which blue whiting data is used for assessment. The outer green box represents the total survey area.

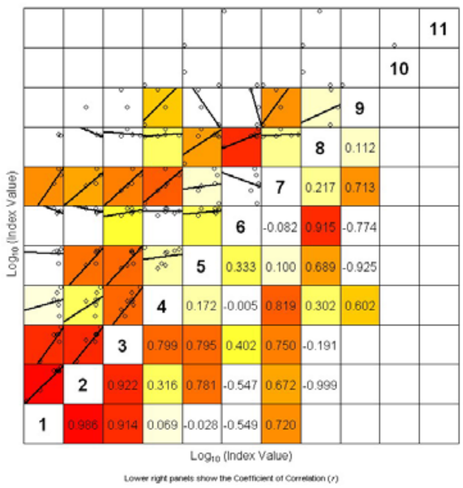
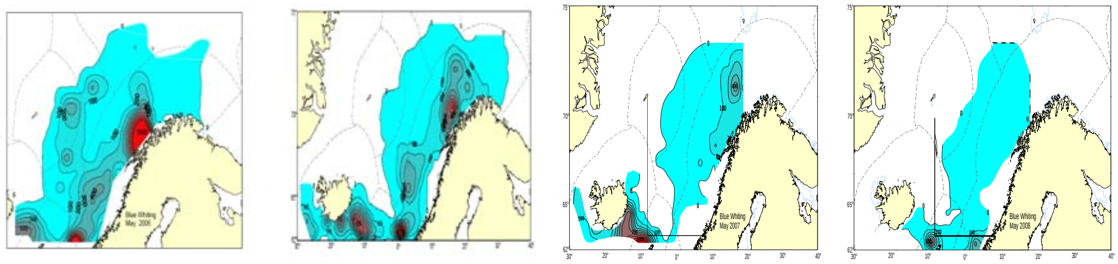


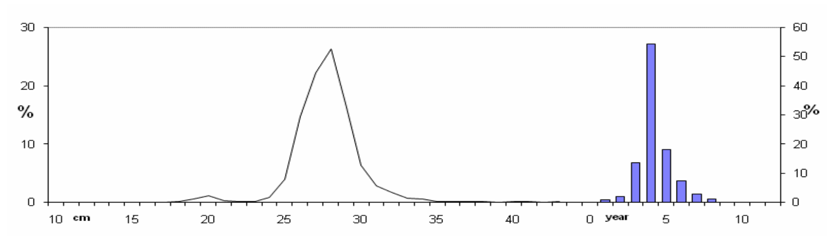
Figure 10.4.5.2.2 Blue whiting. Internal consistency within the International Ecosystem survey in the Nordic Seas. The upper left part of the plots shows the relationship between log index-at-age within a cohort. Linear regression line shows the best fit to the log-transformed indices. The ages plotted on the x- and y- axes of each panel can be found by moving either vertically (for the x-axis) or horizontally (y-axis) to the main diagonal. The lower-right part of the plots shows the regression coefficient (r) for the two ages plotted in that panel. The background colour of each panel is determined by the r value, where red equates to r=1 and white to r=-1.



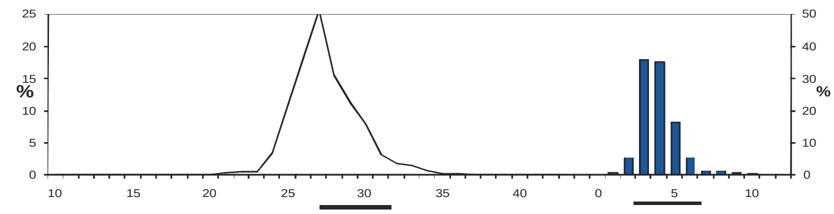
2005 2006 2007 2008

Figure 10.4.5.2.3. Blue whiting. Schematic map of blue whiting acoustic density (sA, m2/nm2) found during the survey in spring 2005–2008.

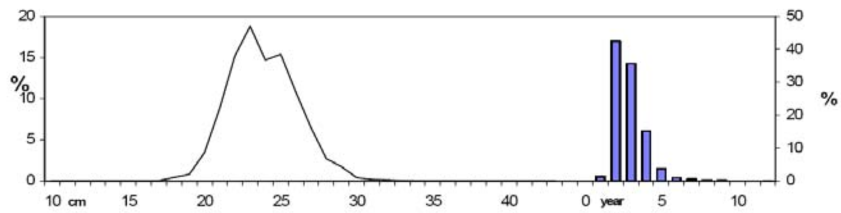
2008



2007



2006



2005

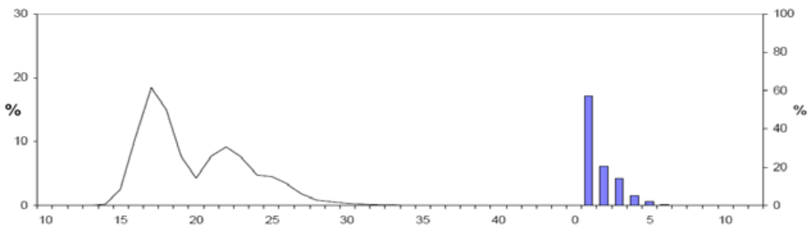


Figure 10.4.5.2.4. Estimated length and age distributions of blue whiting in the International Ecosystem Survey in the Nordic Seas in May–June 2008 based on the "standard survey area" between 8°W-20°E and north of 63°N.

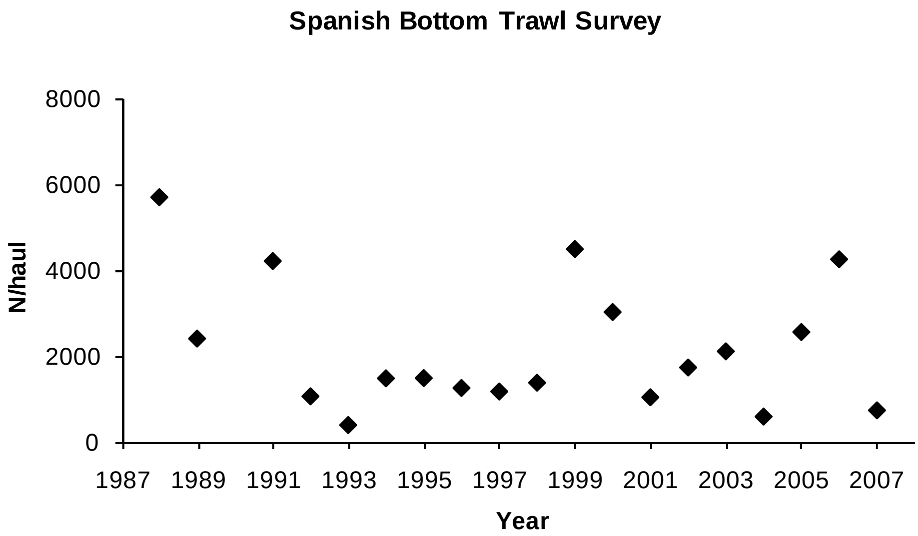


Figure 10.4.5.6.1 Blue whiting. Mean catch rates (Kg/haul and Number/haul) in Spanish bottom trawl survey.

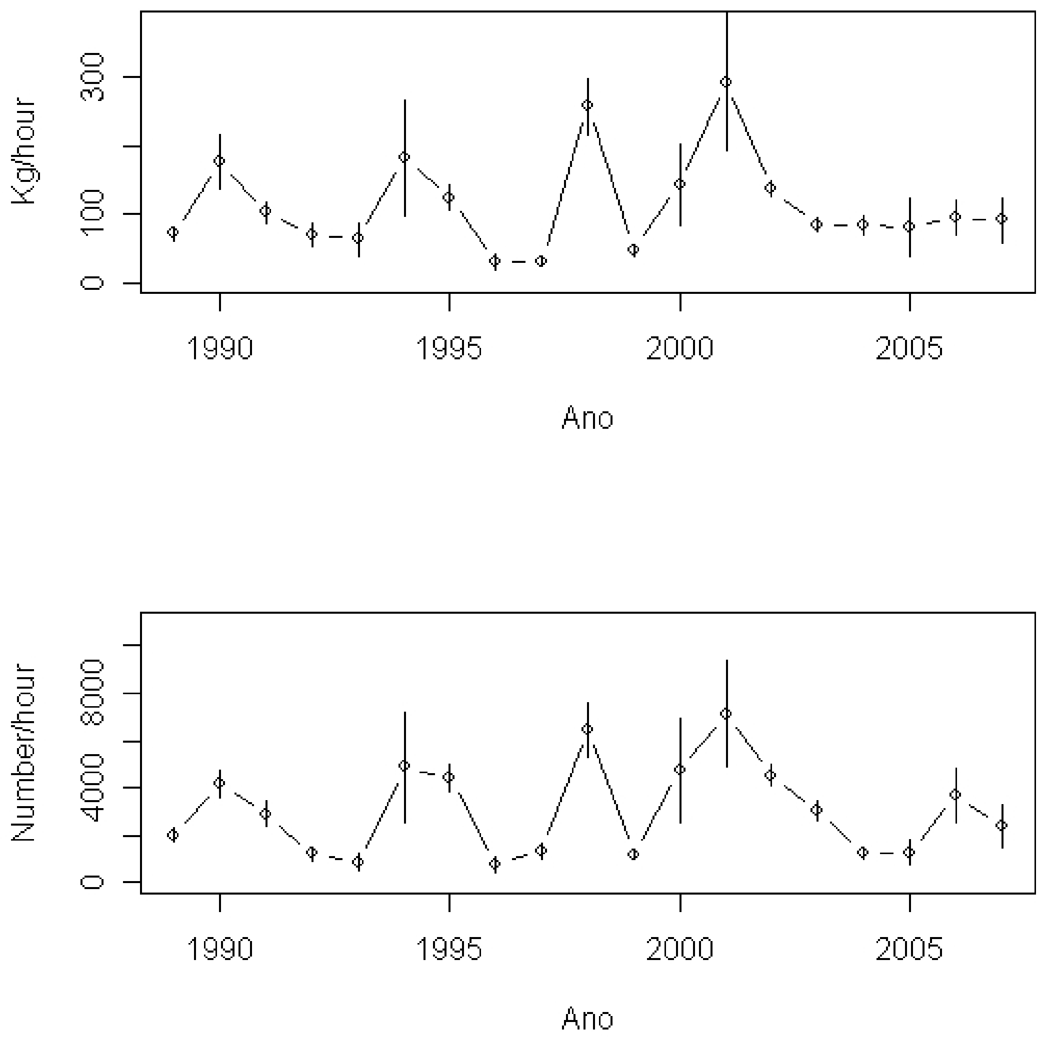


Figure 10.4.5.7.1 Stratified mean catch (Kg/haul and Number/haul) and standard error of BLUE WHITING in bottom trawl surveys in Spanish waters (Divisions VIIIc and IXa north). All surveys in September –October

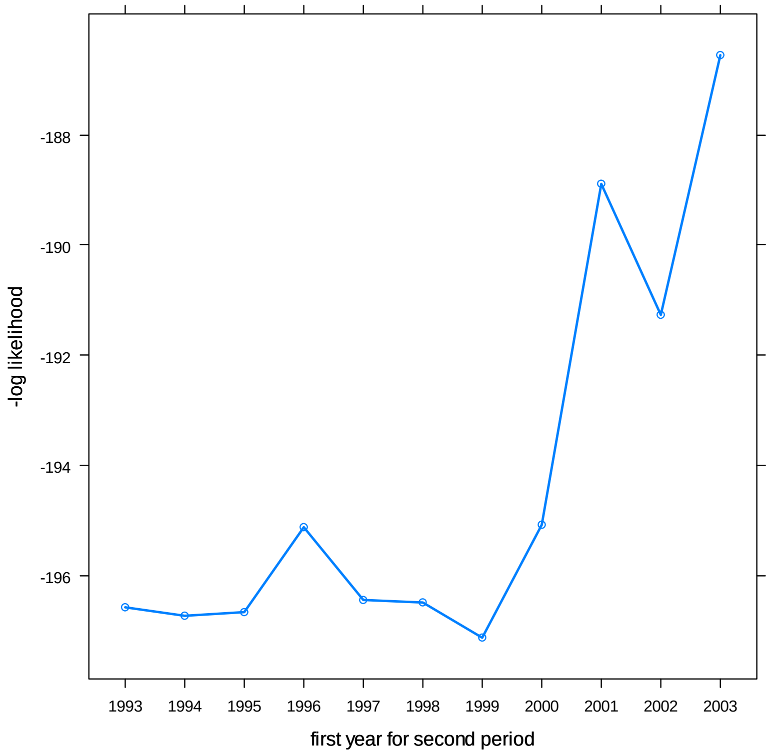


Figure 10.5.1.1. Blue Whiting SMS data exploration. Objective function value (negative log – likelihood) from SMS configurations where years in the range 1993–2003 were chosen as the first year in the last period where constant selectively is assumed.

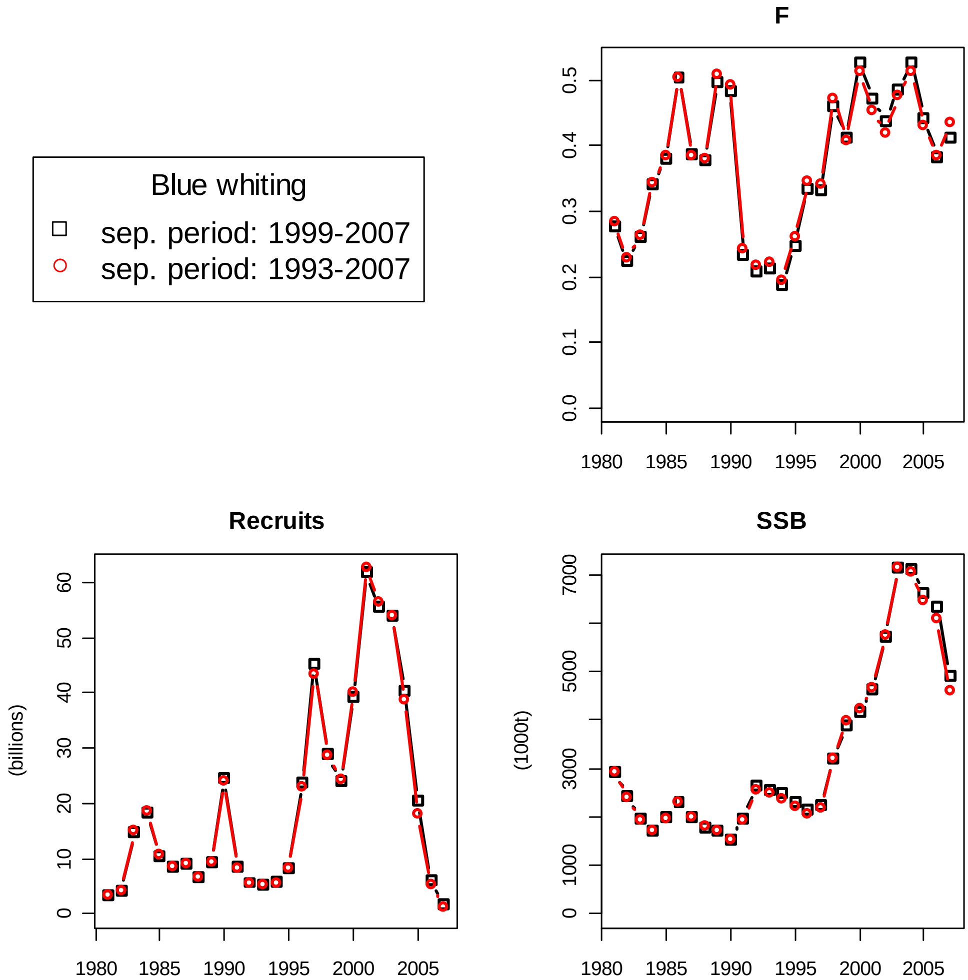


Figure 10.5.1.2. Blue Whiting SMS data exploration. Results using the year range 1993–2007 or 1999–2007 as the periods where constant selection is assumed.

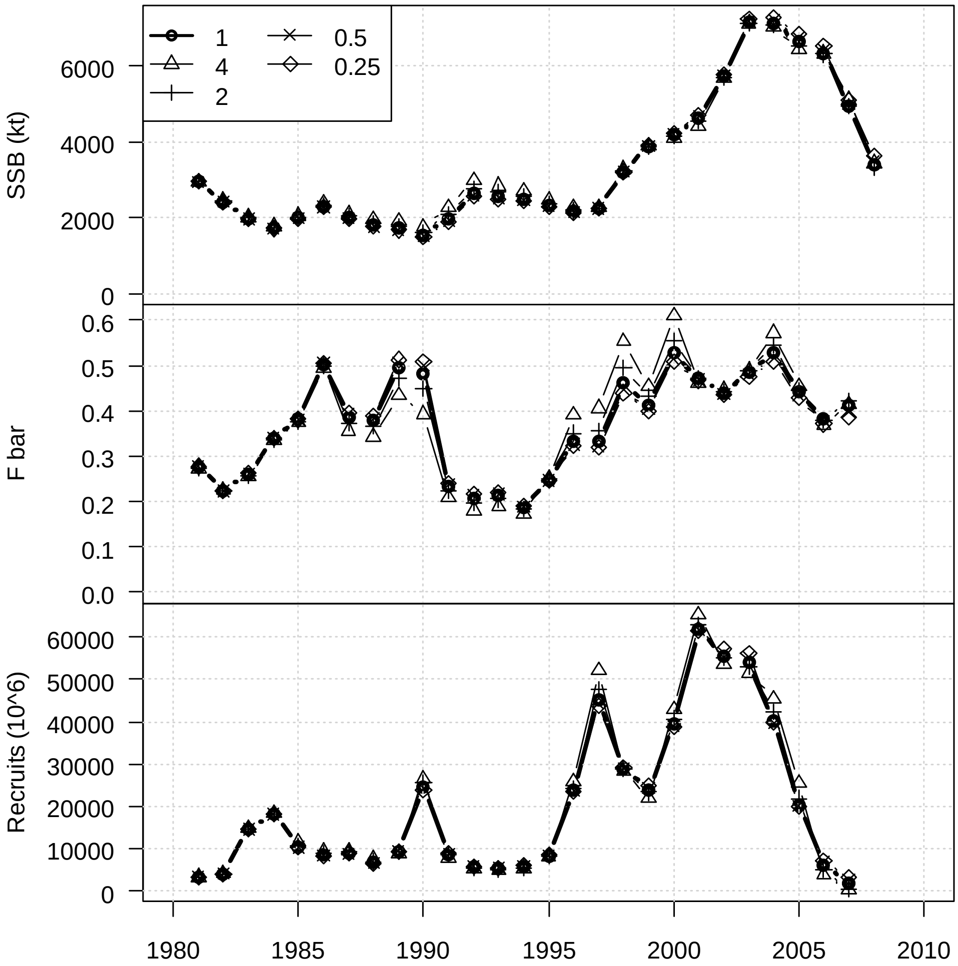


Figure 10.5.1.3. Blue Whiting SMS data exploration. Effect on SSB (top panel), mean fishing mortality F bar (ages 3–7; middle panel) and estimated recruitment (bottom panel) of changing the a priori weighting on the survey observations. The *a priori* weight on catch observations is kept constant at 1.0, and thus a weighting factor of, for example, 2 represents a relative weight on the survey twice that of the catches.

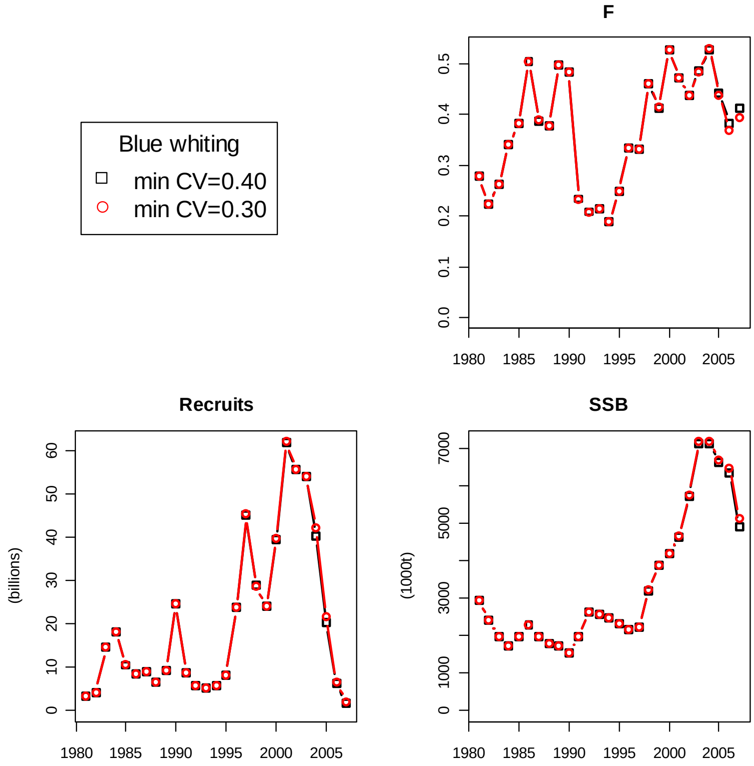


Figure 10.5.1.4. Blue Whiting SMS data exploration. Effect of using a "minimum CV [~standard deviation in log-normal distribution] on survey observations" constraint.

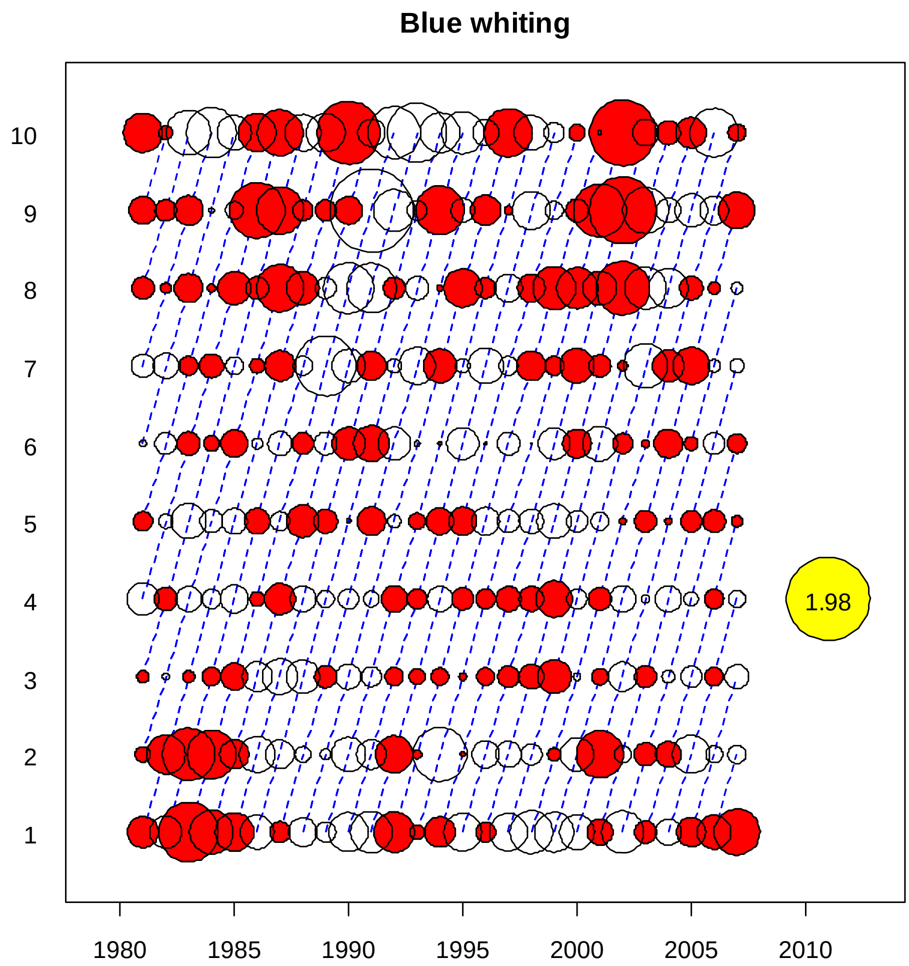


Figure 10.5.1.5. Blue Whiting SMS data exploration. Residuals for catch observations. Red (dark) bubbles show that the observed value is larger than the expected value. The bubble at right is the size of the largest residual.

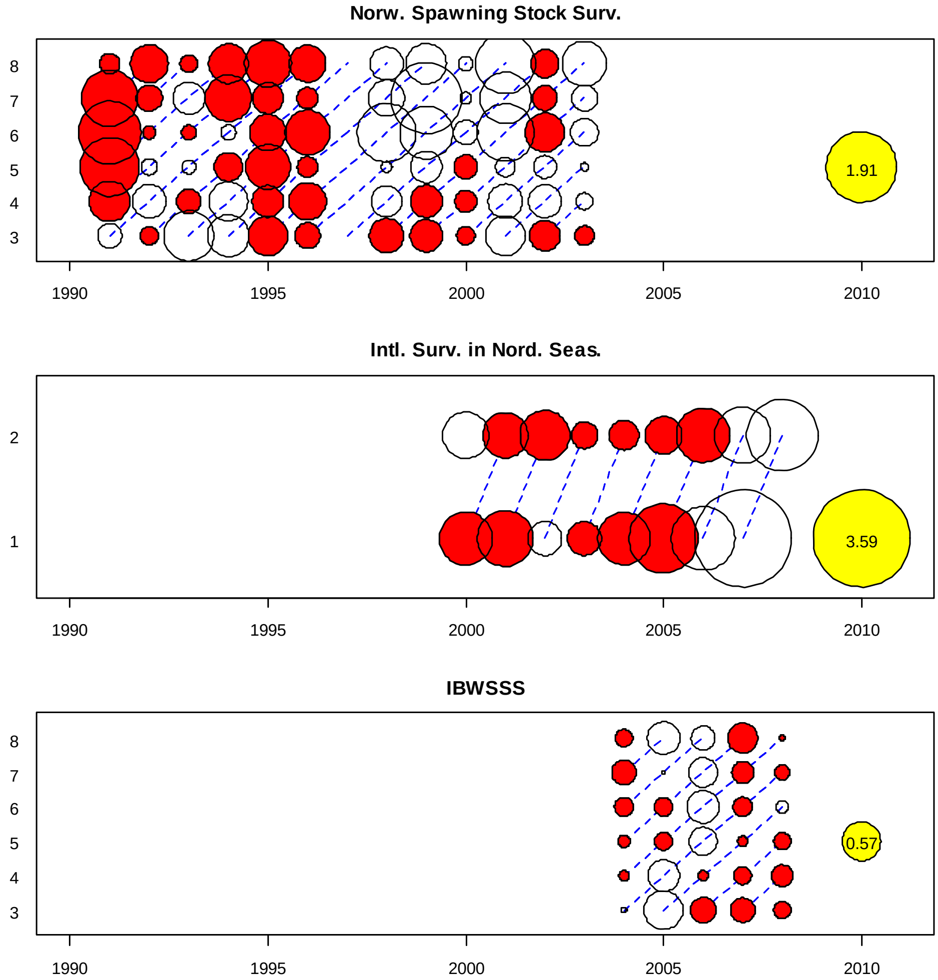


Figure 10.5.1.6. Blue Whiting SMS data exploration. Residuals for survey observations for the Norwegian spawning stock survey (top panel), the International ecosystem survey in the Nordic seas (middle panel) and the International Blue Whiting Spawning Stock Survey (IBWSSS; bottom panel). Red (dark) bubbles show that the observed value is larger than the expected value. The bubble at right is the size of the largest residual. The bubble-size scale is constant between the individual surveys. The minimum standard deviation of the survey observations was set to be 0.4 which affects only the IBWSSS.

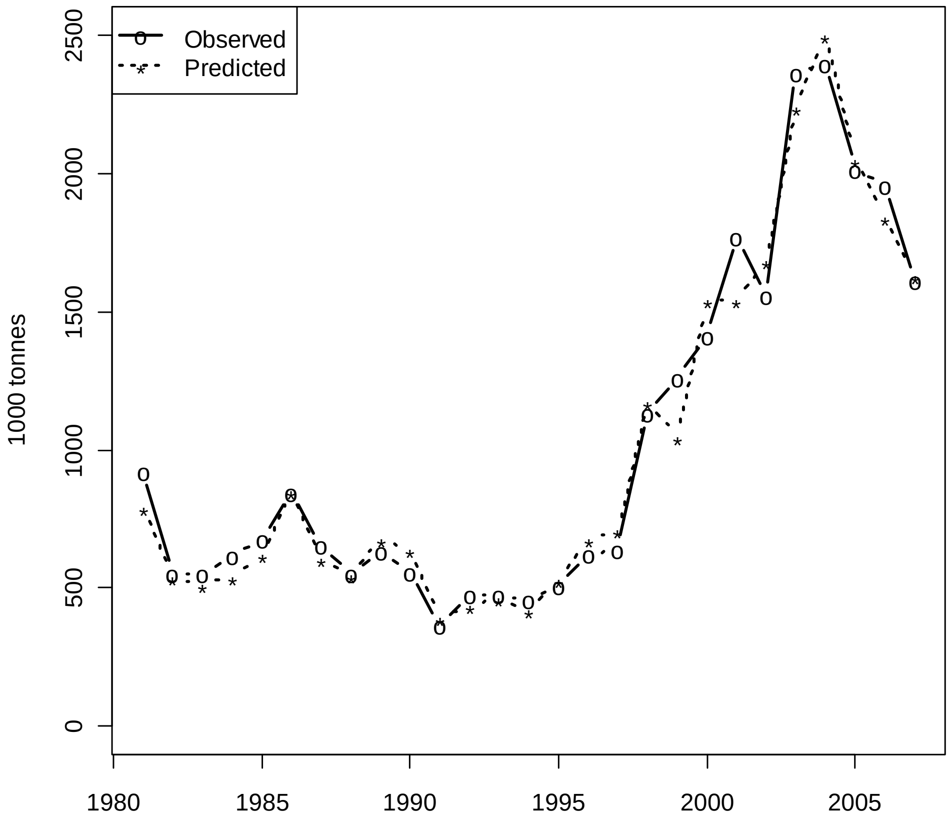


Figure 10.5.1.7. Blue whiting SMS data exploration. Comparison of observed and predicted catch weight from the final SMS run.

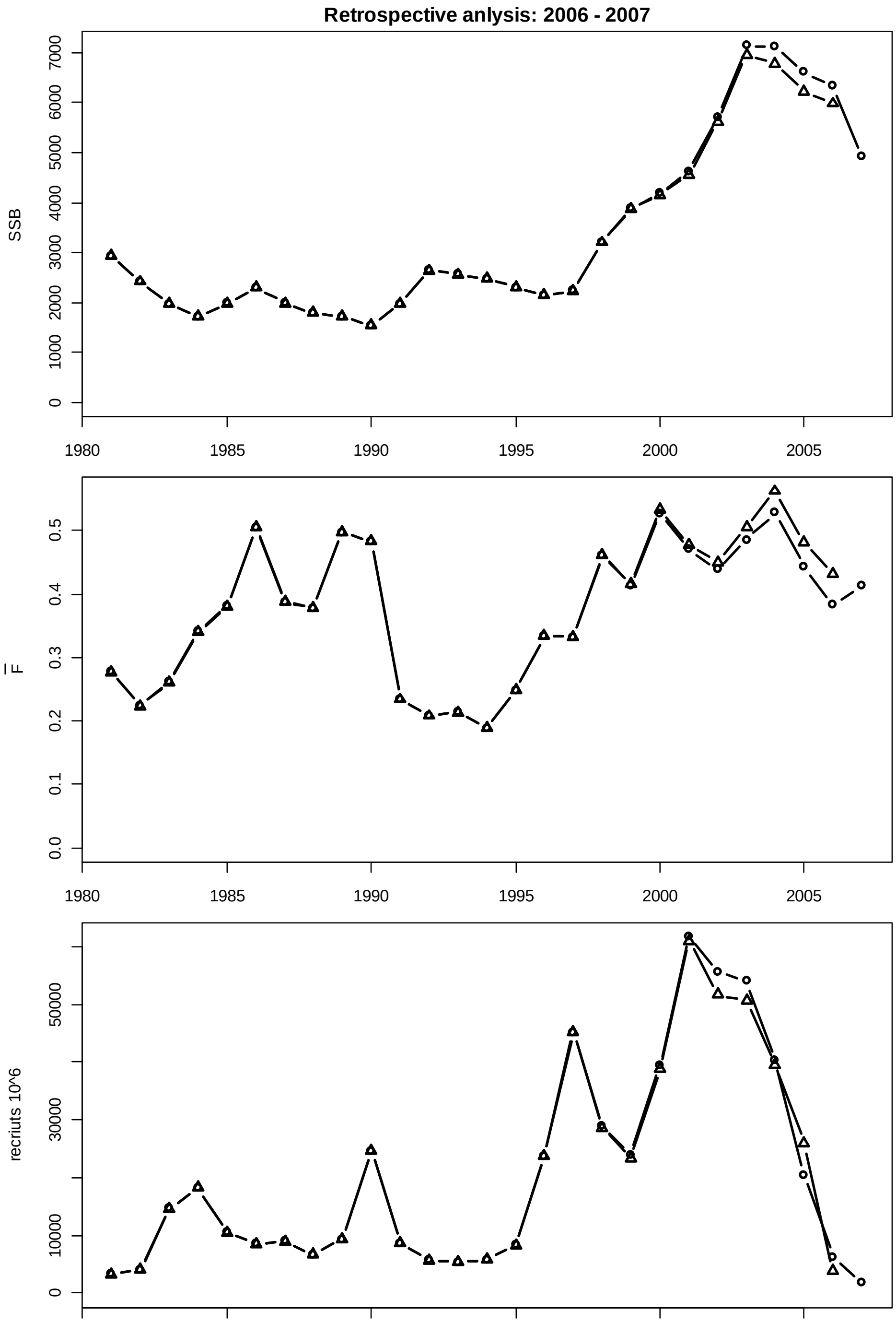


Figure 10.5.1.8. **Blue Whiting SMS data exploration. Retrospective analysis.**

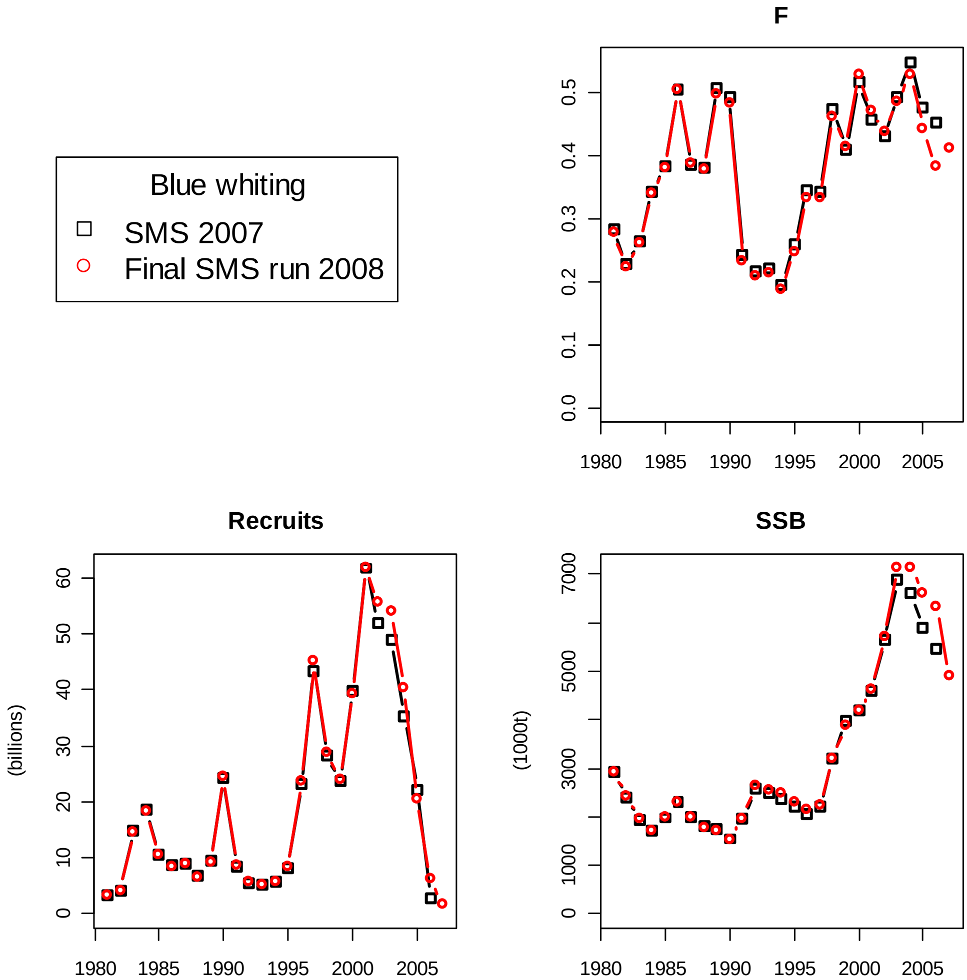


Figure 10.5.1.9. Blue whiting. Comparison of the SMS final assessment from last year and the updated SMS.

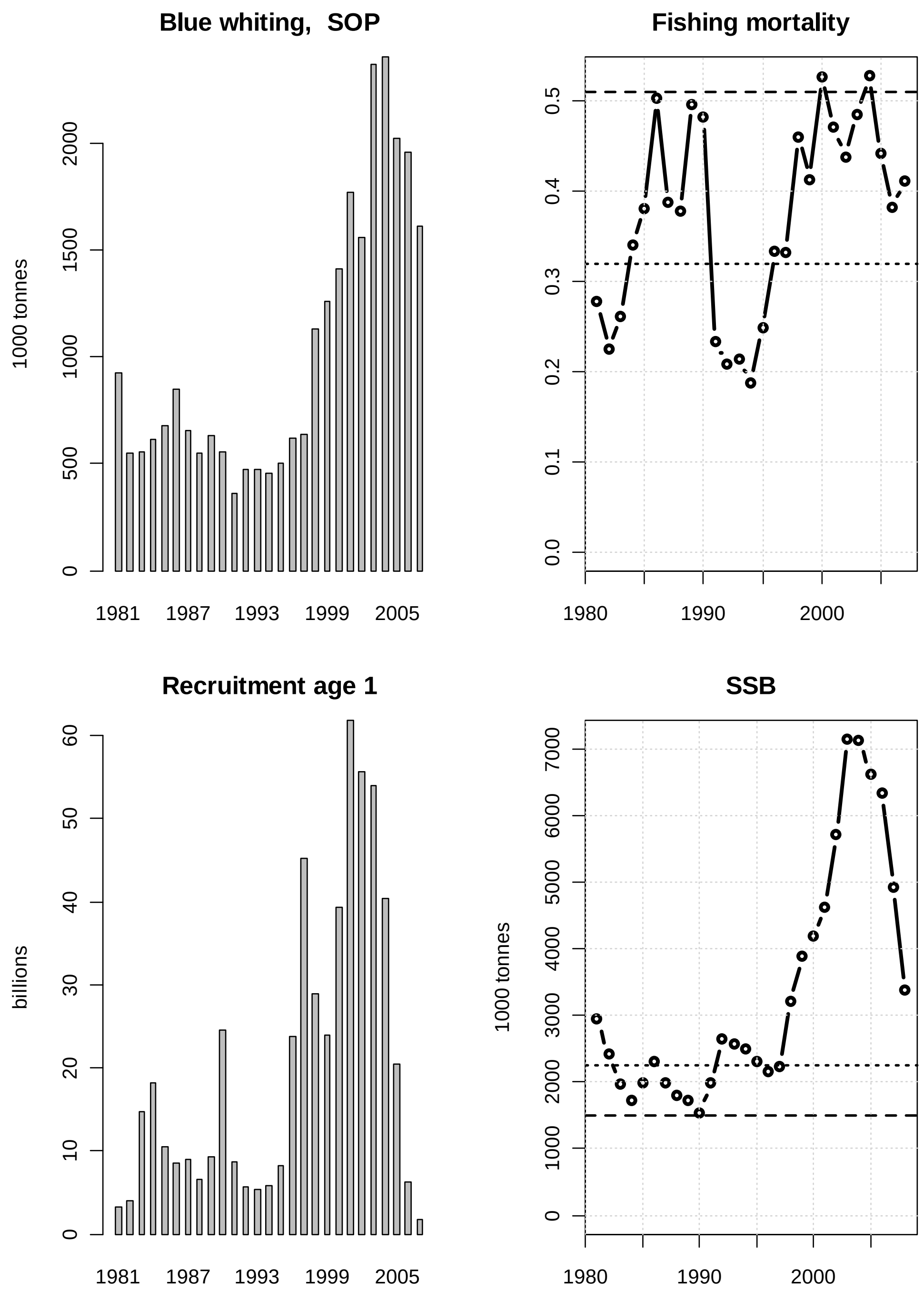


Figure 10.5.1.10. Blue whiting SMS data exploration. Stock summary. SSB at 1st January 2008 does not include age 1.

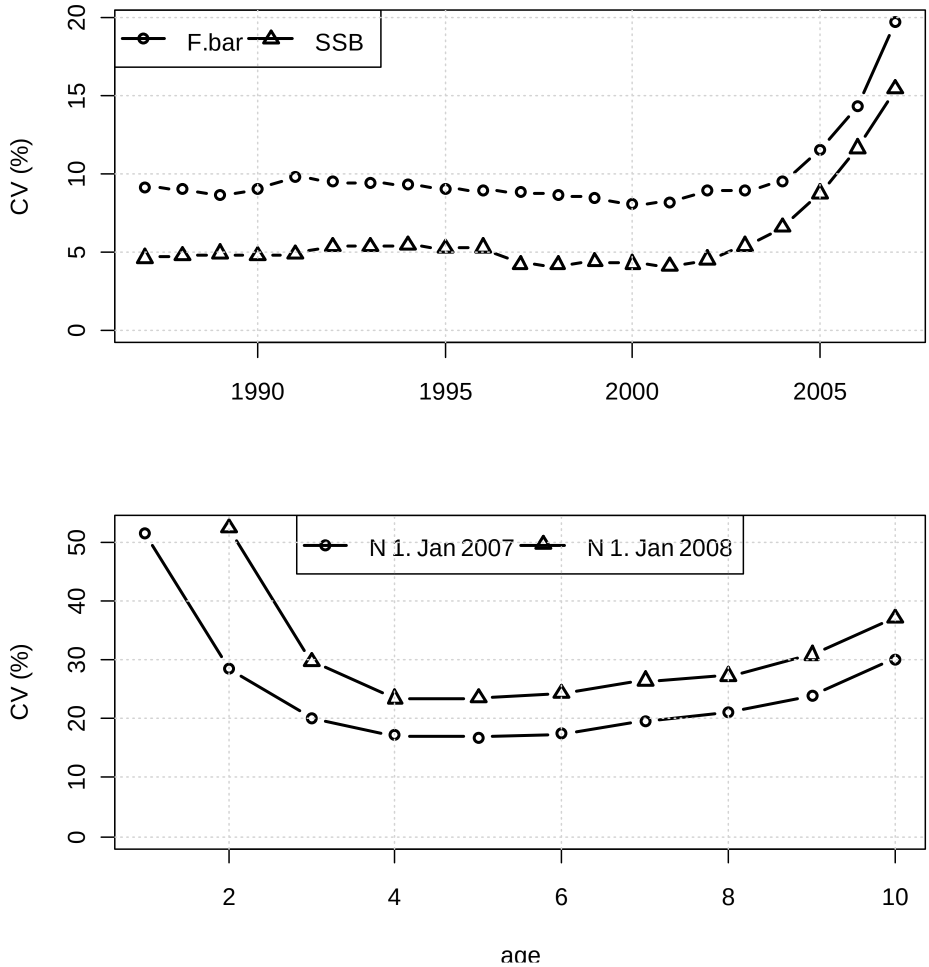


Figure 10.5.1.11. Blue whiting SMS data exploration. Estimates of CV of SSB and F-bar (3–7) (top panel) and CV of stock number-at-age in the terminal assessment year and the following. CVs are estimated by SMS from the Hessian matrix.

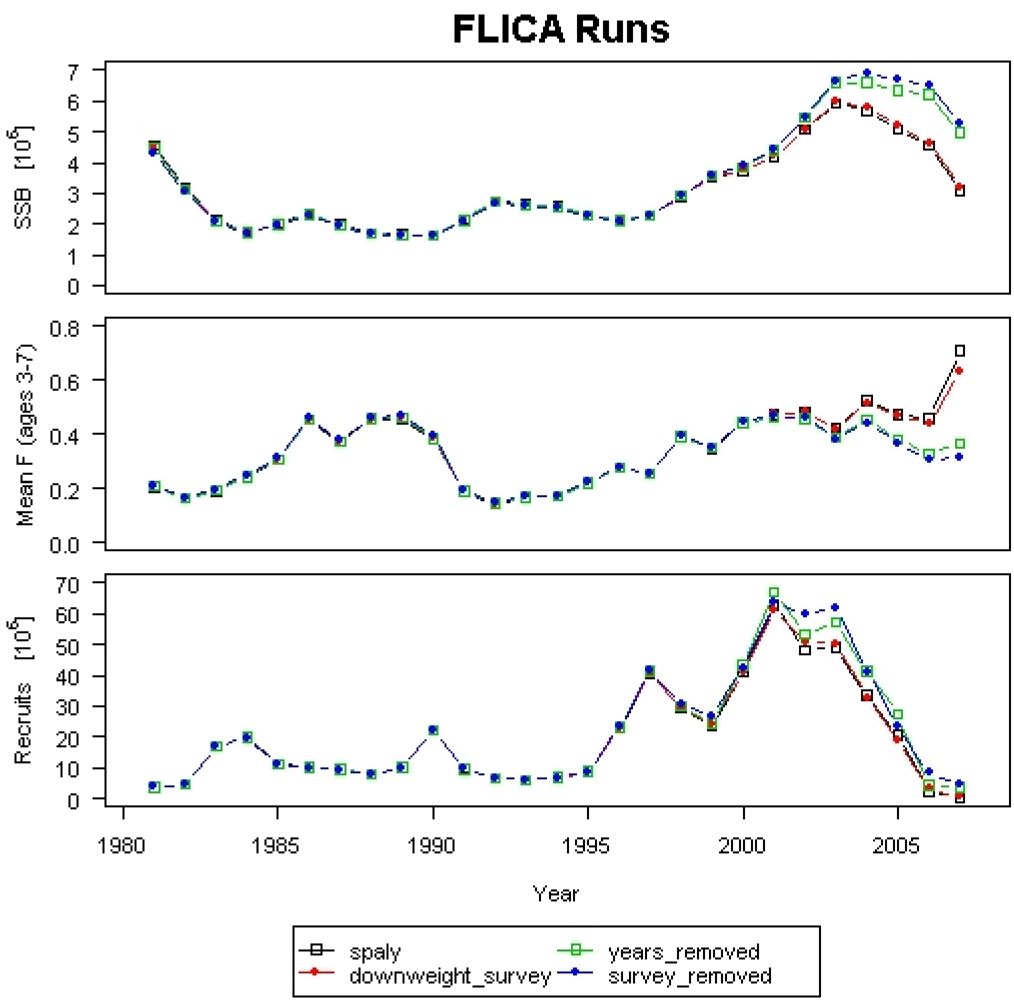


Figure 10.5.2.1: Blue Whiting. Comparison of the assessment runs using FLICA.

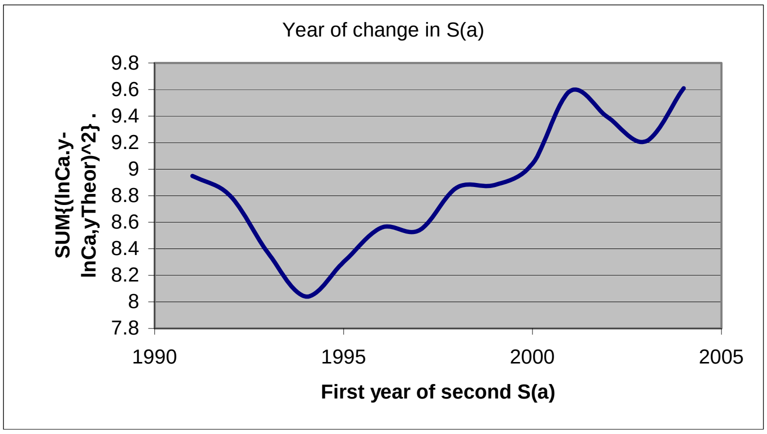


Figure 10.5.3.1. Blue Whiting TISVPA data exploration. Closeness of fit to catch-at-age for different choices of the year of change in selection-at-age.

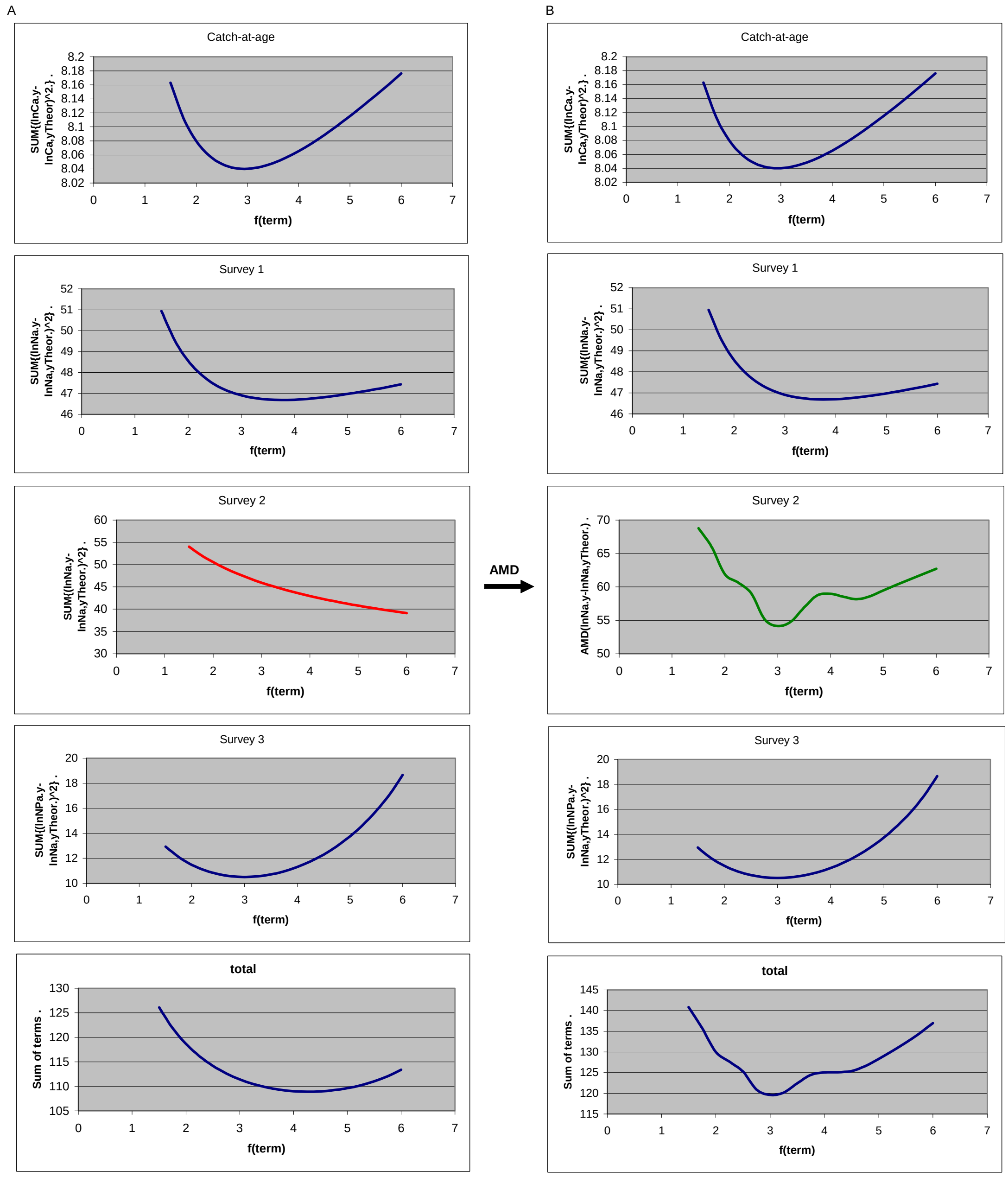


Figure 10.5.3.2. Blue Whiting TISVPA data exploration Profiles of components of the TISVPA loss function

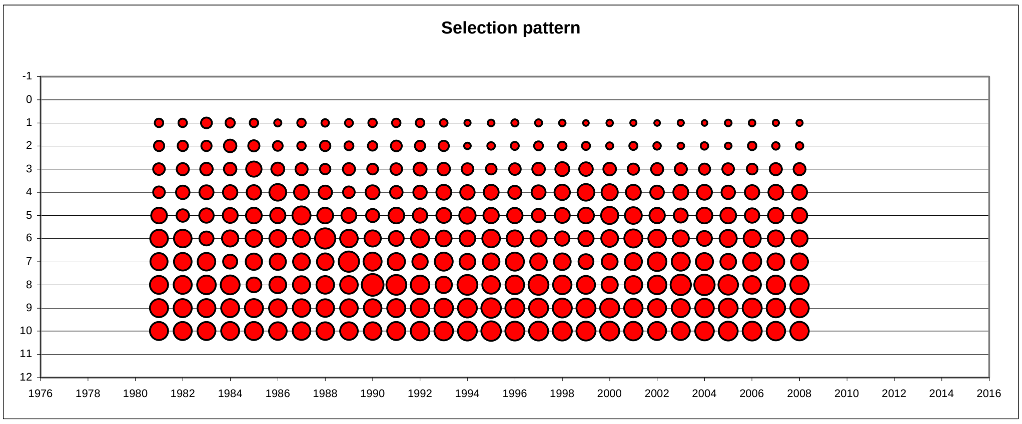


Figure 10.5.3.3. Blue Whiting TISVPA data exploration. Estimated selection pattern

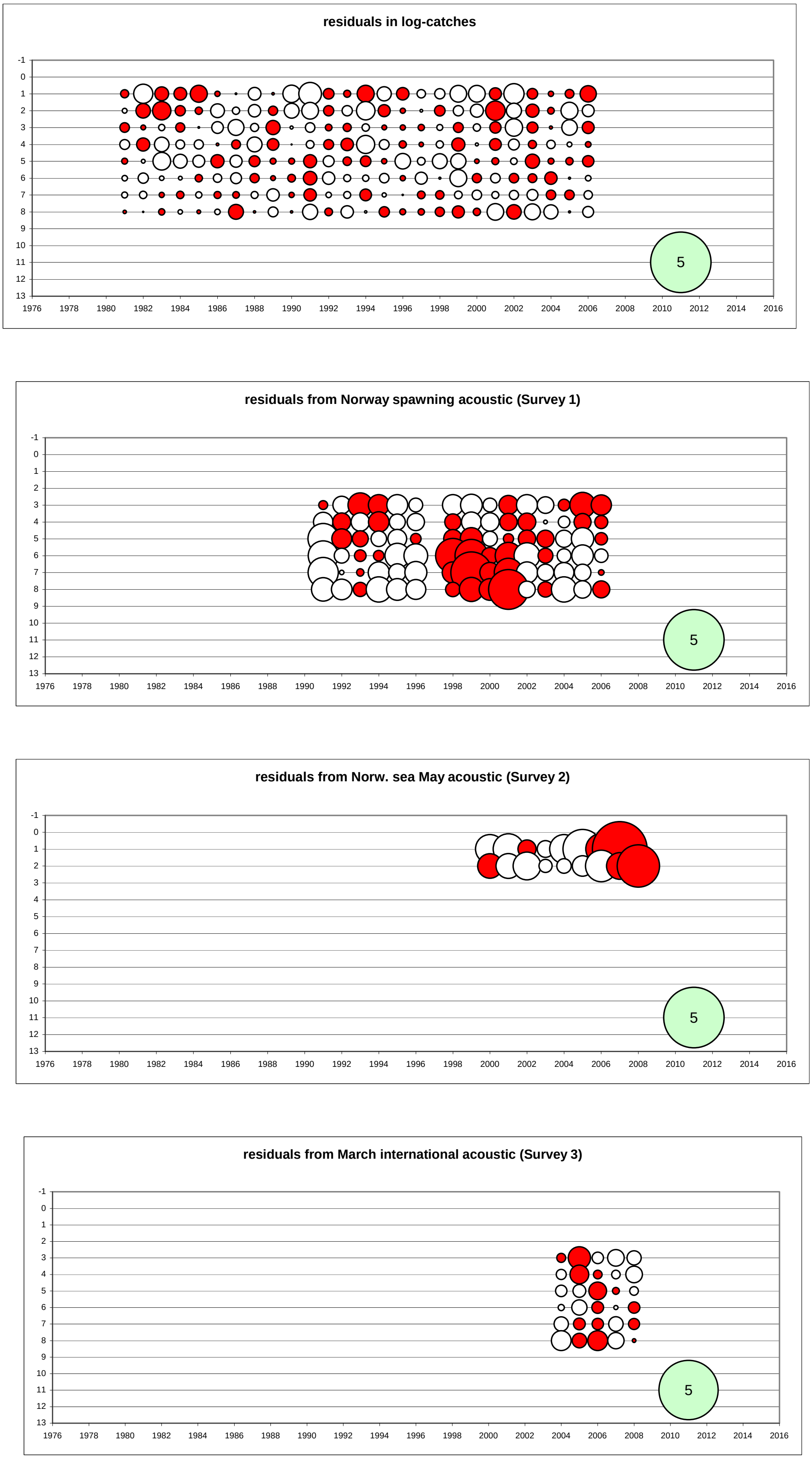


Figure 10.5.3.3. Blue Whiting TISVPA data exploration. Residuals

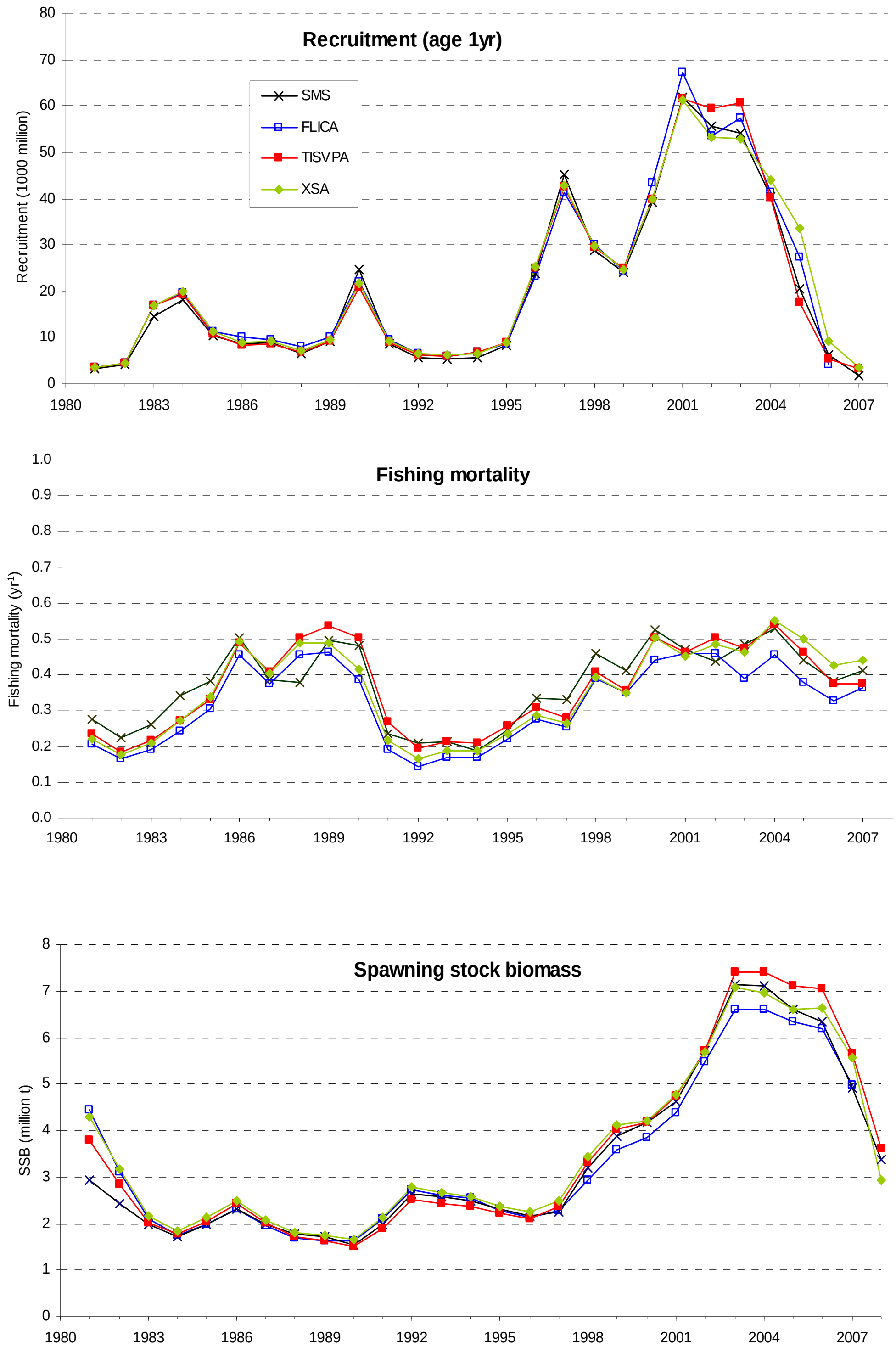
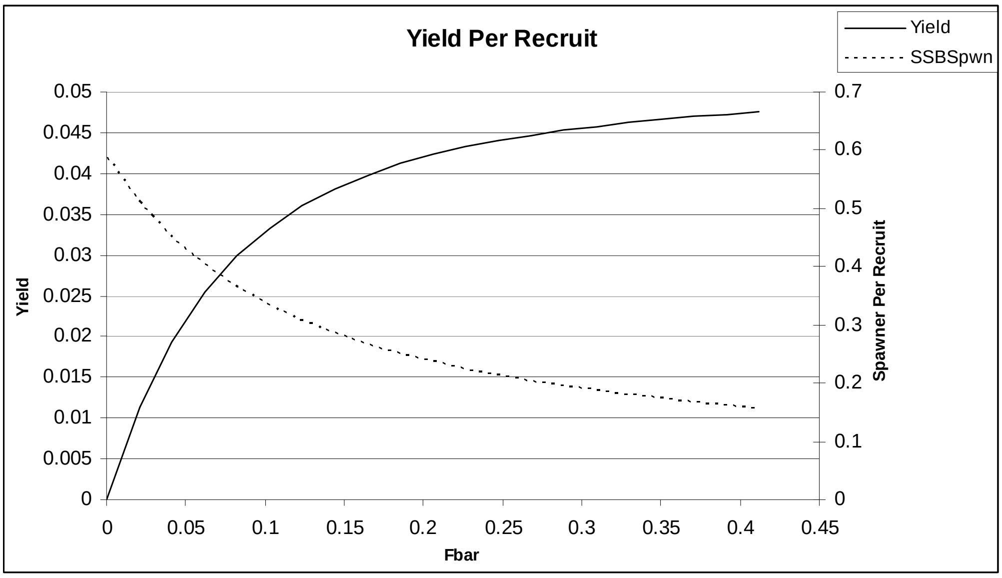


Figure 10.5.5.1 Blue whiting. Comparison between final exploratory SMS, FLICA, TISVPA and XSA assessments.



Reference point	F multi-plier	Absolute F
Fbar(3 – 7)	1	0.4122
FMax	3.2411	1.336
F0.1	0.4317	0.178

Figure 10.7.1: Blue Whiting. Yield Per Recruit curve calculated using MFYPR.

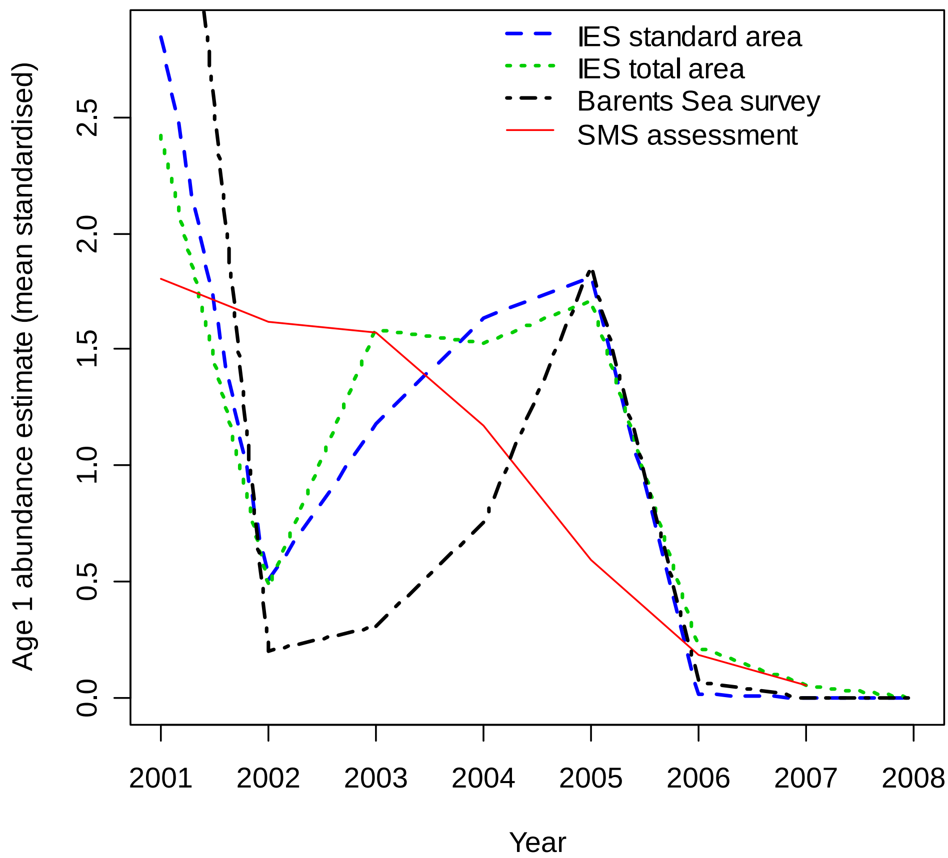


Figure 10.9.1.1. Relative trend in age 1 estimates from the Barents Sea bottom trawl survey, the International ecosystem survey in the Nordic Seas (IES) standard area, IES total area and the final SMS assessment.

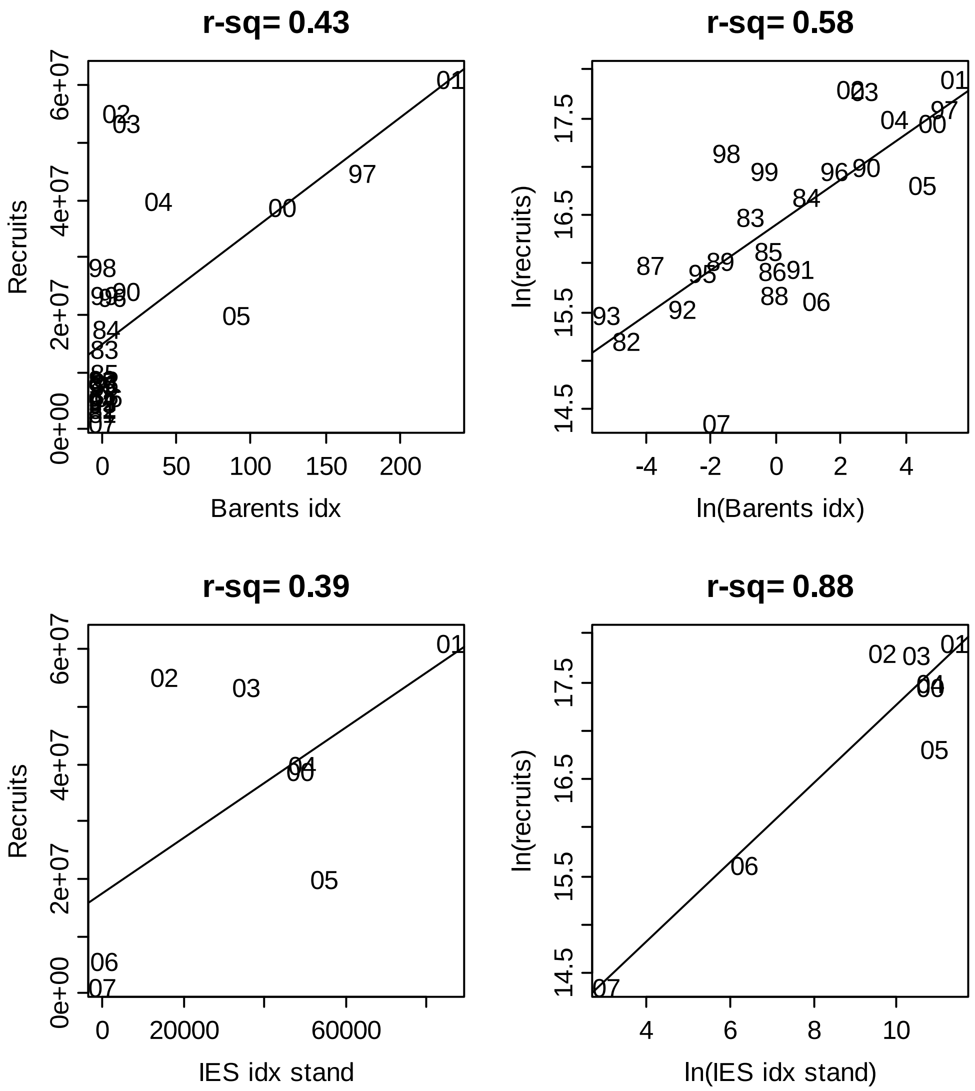
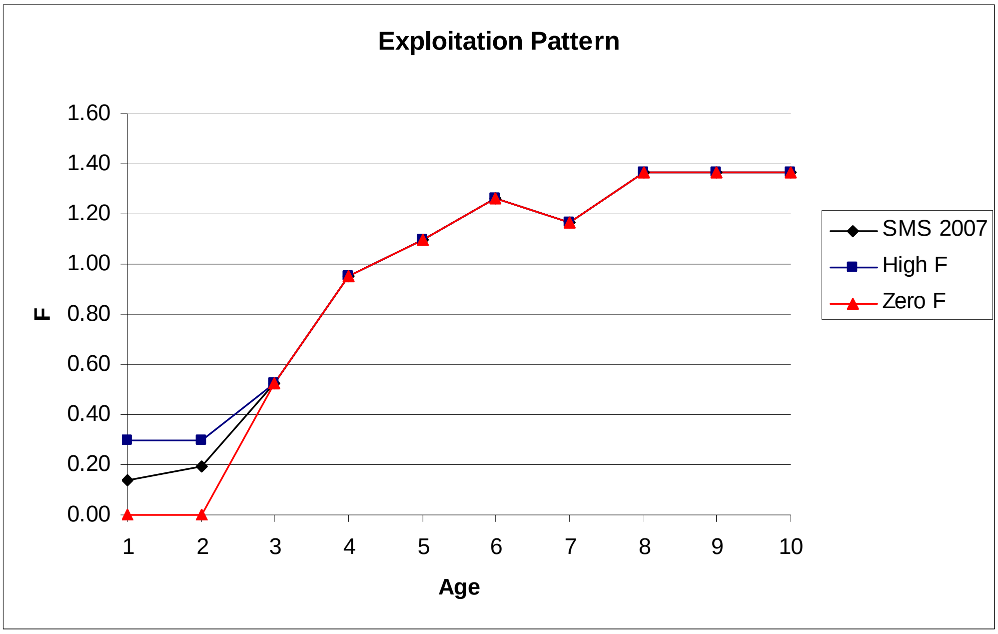


Figure 10.9.1.2.. Recruitment (age 1) from the final SMS assessment and age 1 indices from the Barents Sea bottom trawl survey (upper panels) and the International ecosystem survey in the Nordic Seas (IES) standard area (lower panels), both on natural scale (left panels) and log-scale (right panel).

Figure 10.9.2.1. Forecasted age distribution in SSB and in the catch.



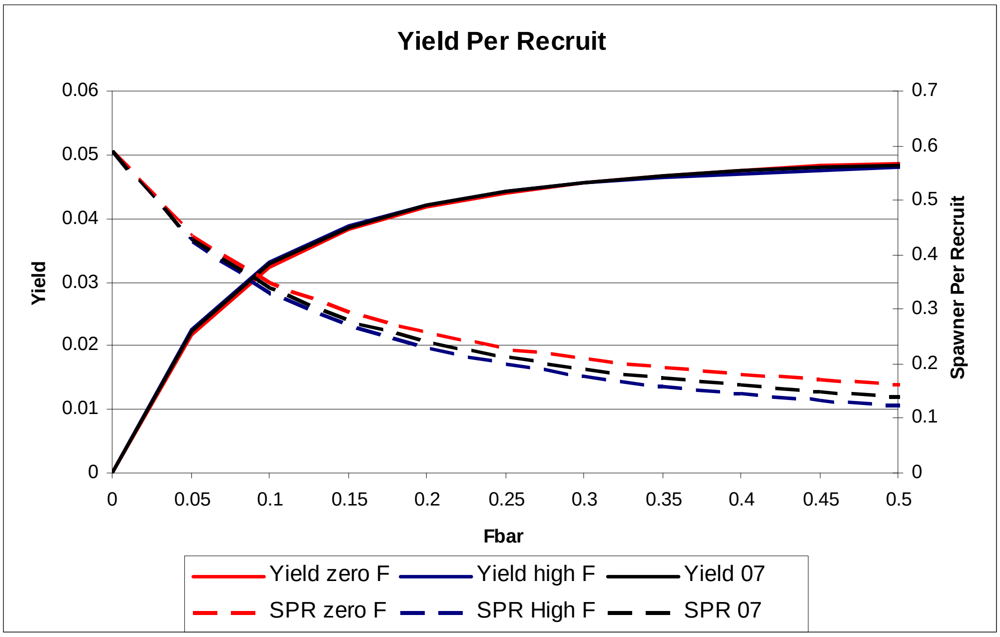


Figure 10.13.2.1: Blue Whiting, exploitation pattern (upper) and yield per recruit curves (lower)

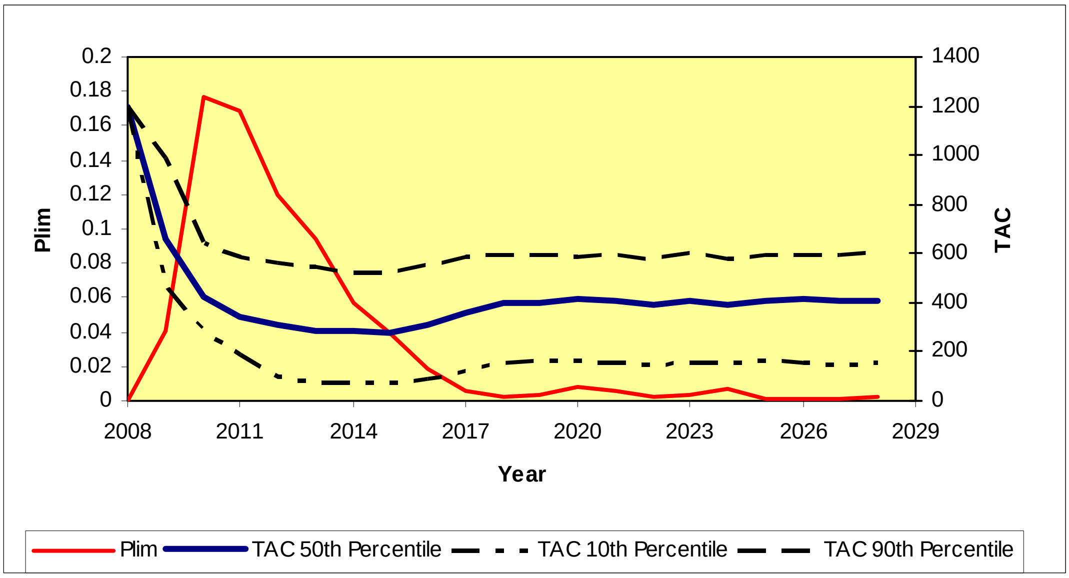
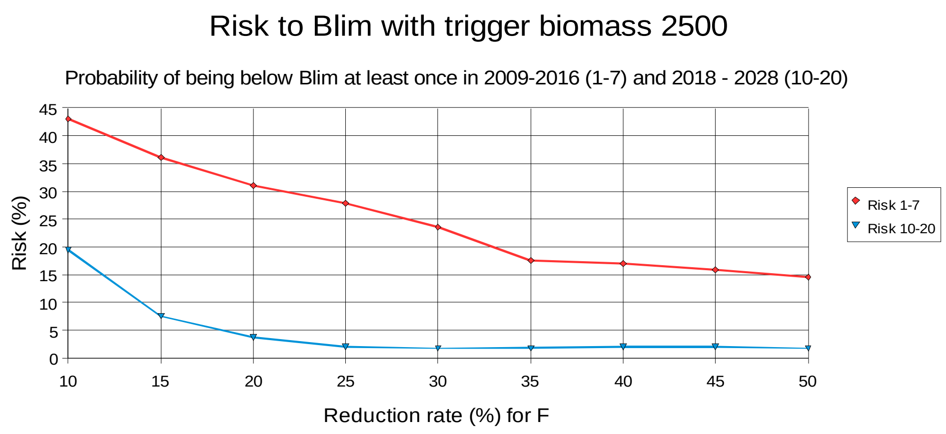
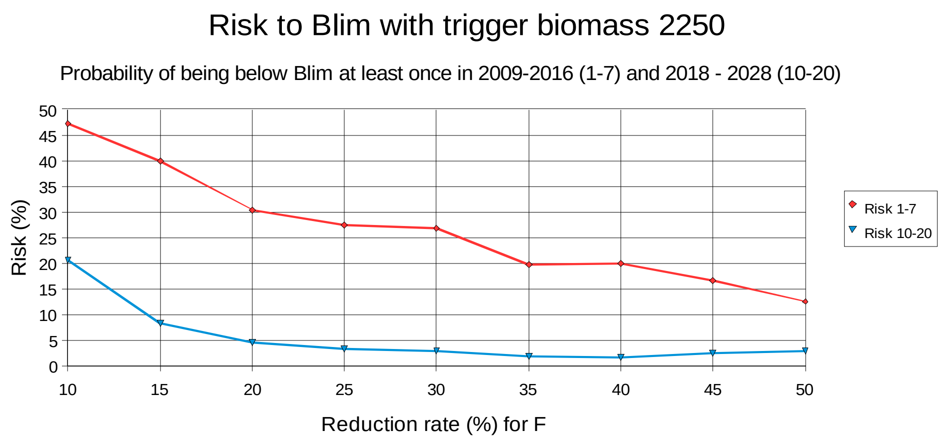


Figure 10.13.1 Example of risk to Blim and TAC (10, 50 and 90 percentiles) with Trigger biomass = 2500 thousand tonnes and reduction rate 30%.


Risk to Blim with trigger biomass 2500
Probability of being below Blim at least once in 2009-2016 (1-7) and 2018 - 2028 (10-20)
Risk (%)
Reduction rate (%) for F
Risk 1-7
Risk 10-20


Risk to Blim with trigger biomass 2250
Probability of being below Blim at least once in 2009-2016 (1-7) and 2018 - 2028 (10-20)
Risk (%)
Reduction rate (%) for F
Risk 1-7
Risk 10-20

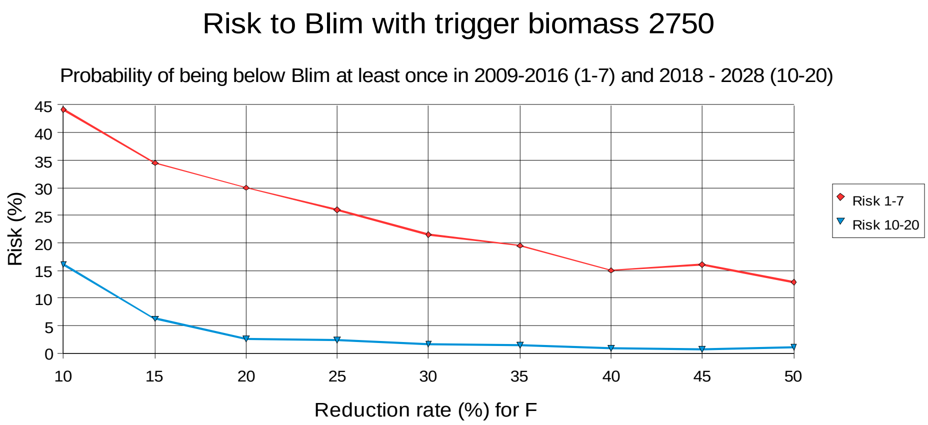


Figure 10.13.2. Risk to Blim in the early and late period, as function of the F- reduction rate for Btrigger = 2250 thousand tonnes (upper), 2500 thousand tonnes (middle) and 2750 thousand tonnes (lower)

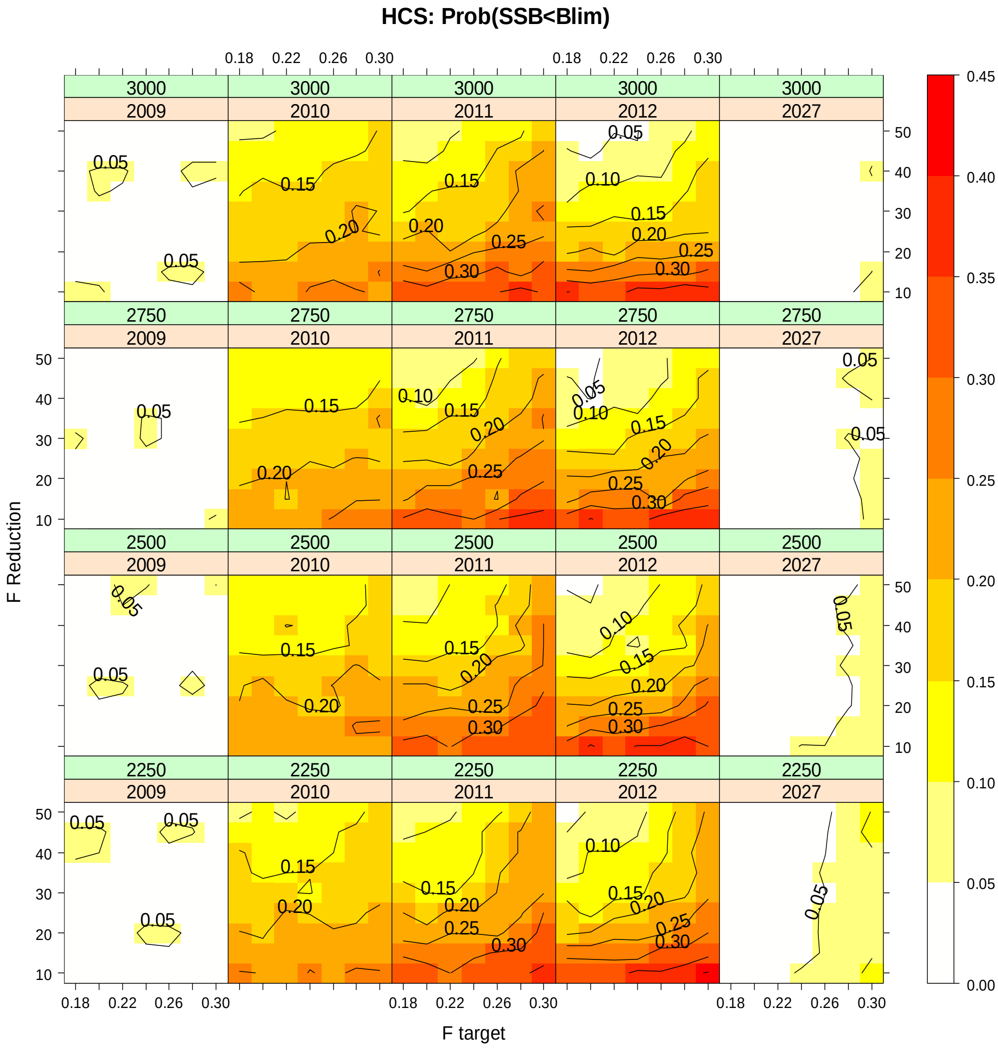


Figure 10.13.3 . Contour plot of the probability that SSB is below Blim. The x-axis shows the target F, the y-axis the F-reduction. For each plot the lower light-red line show the year, the upper light-green line the trigger SSB.

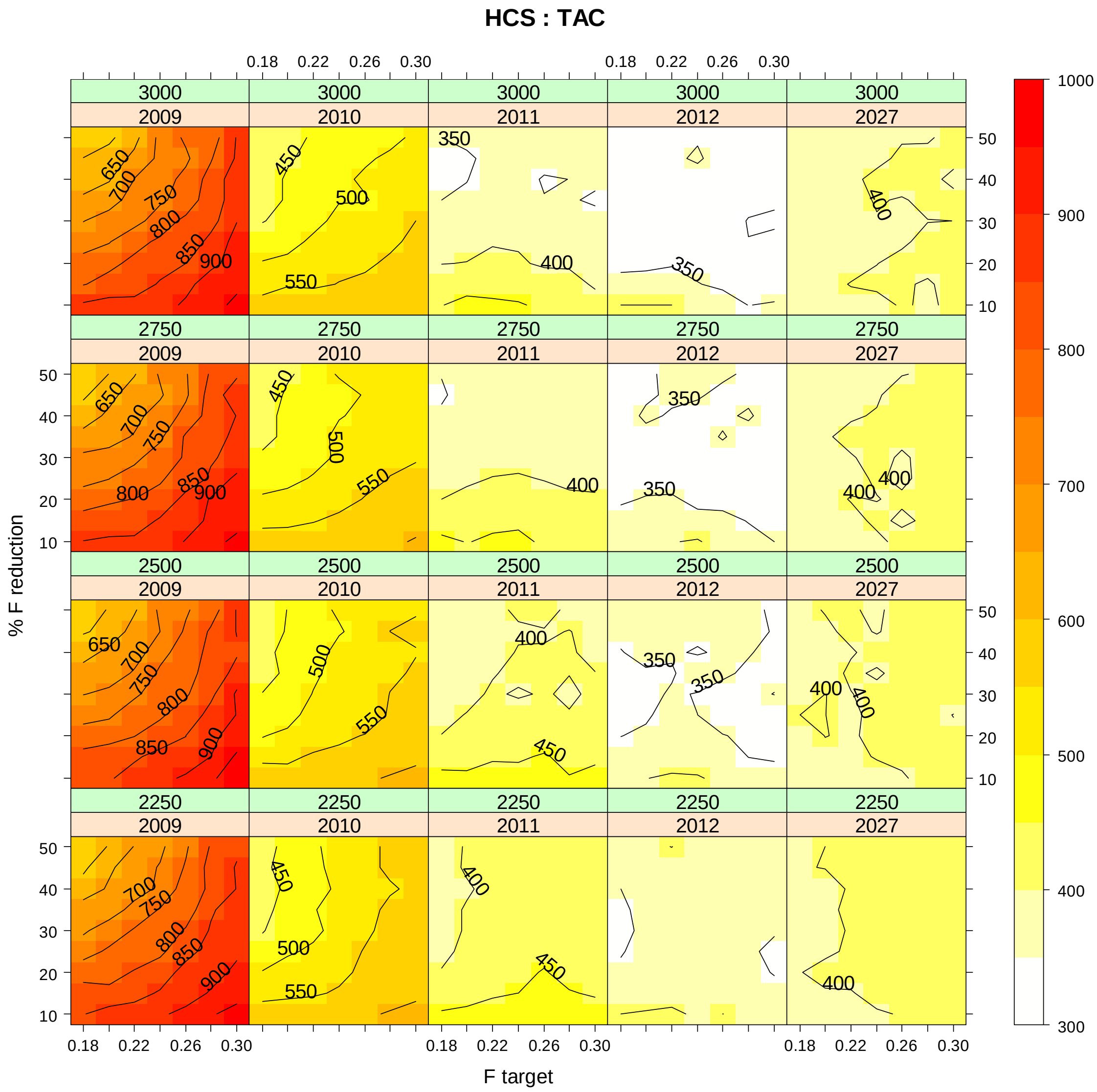


Figure 10.13.4. Contour plot TAC. The x-axis shows the target F, the y-axis the F-reduction. For each plot the lower light-red line show the year, the upper light-green line the trigger SSB.

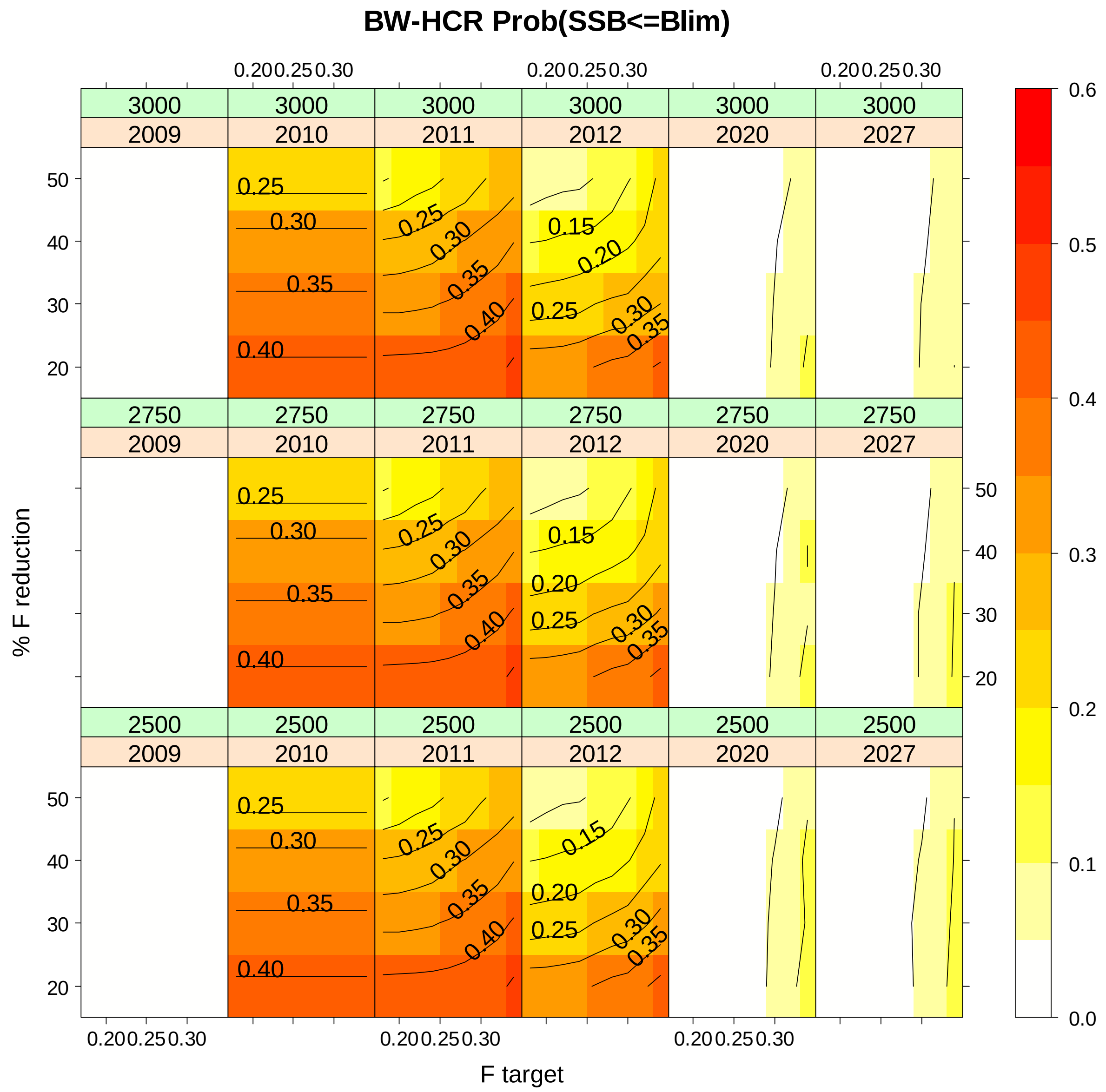


Figure 10.13.5 . Contour plot of the probability that SSB is below Blim using the SMS software. The x-axis shows the target F, the y-axis the F-reduction. For each plot the lower light-red line show the year, the upper light-green line the trigger SSB.

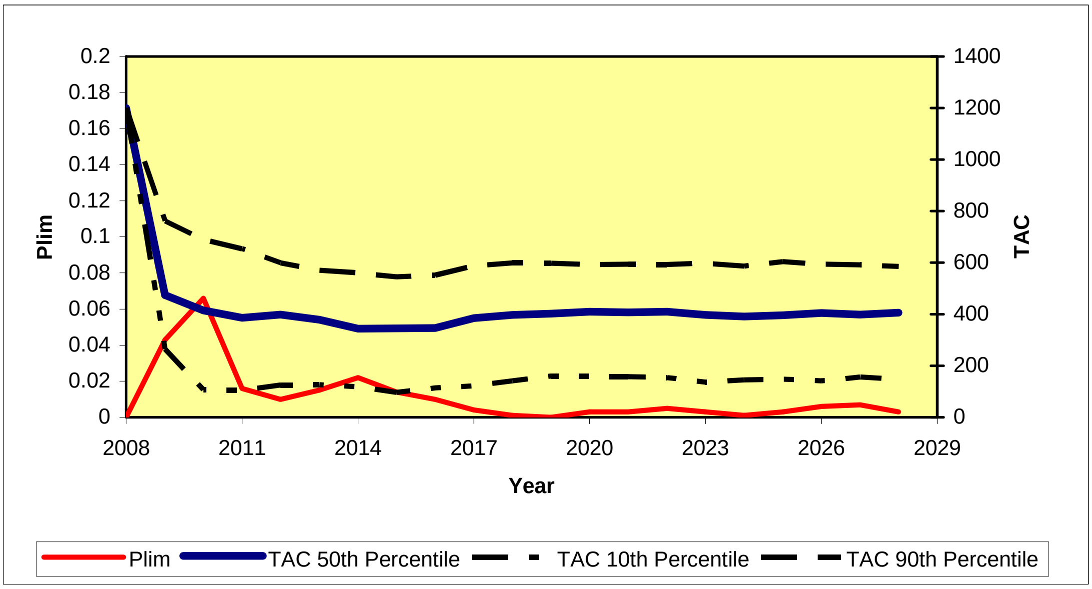
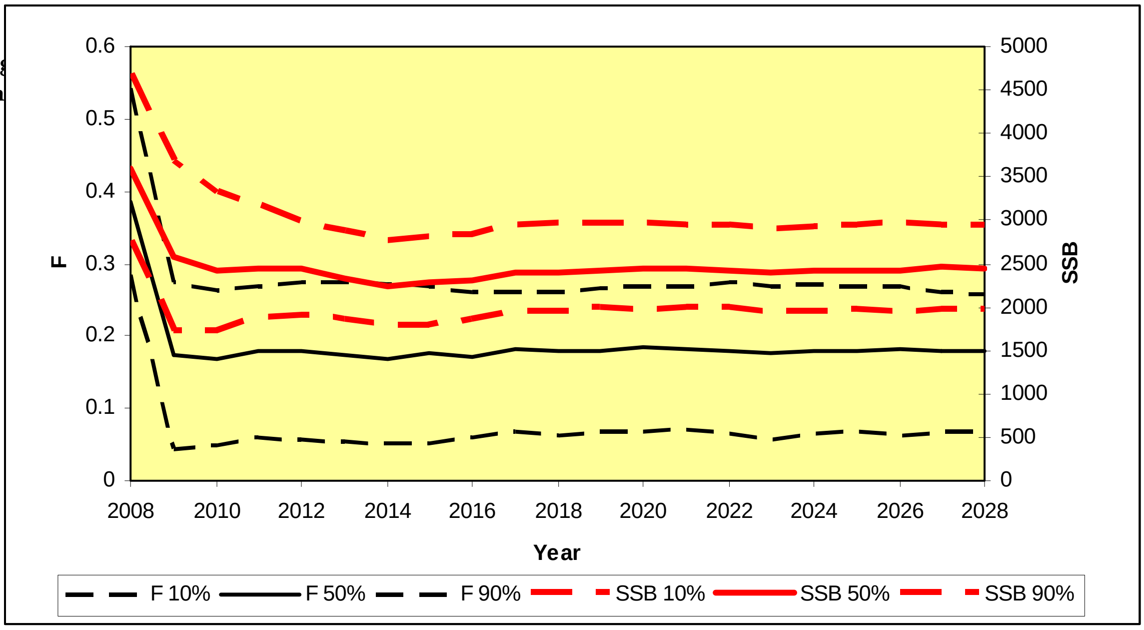


Figure 101.3.6. Risk to Blim and TAC (10, 50 and 90 percentiles) with Trigger biomass = 2500 thousand tonnes and the harvest rule with a target F=0.18 applied already in 2009 (no F reduction phase)

Fi
an



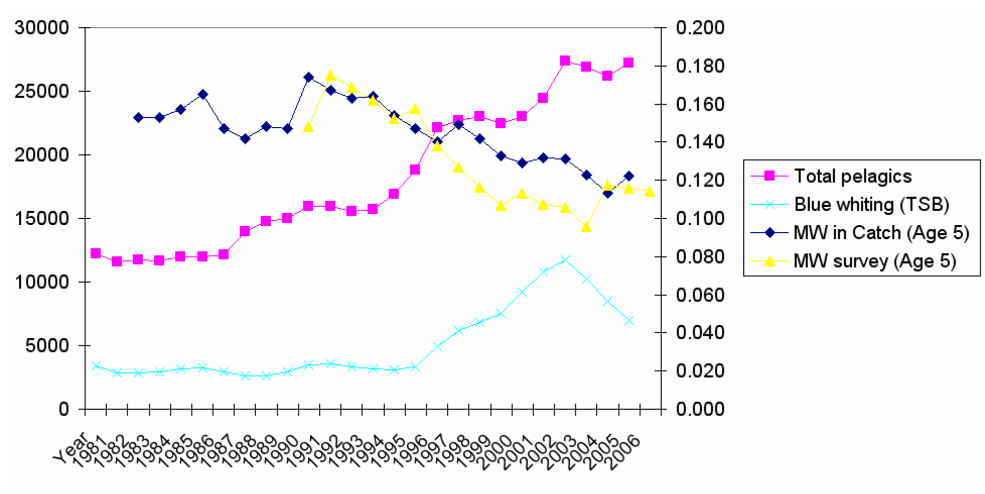


Figure 10.15.1. Biomass of the main pelagic fish in the feeding area, blue whiting biomass and blue whiting mean weight (age 5) in catches and in spawning survey.

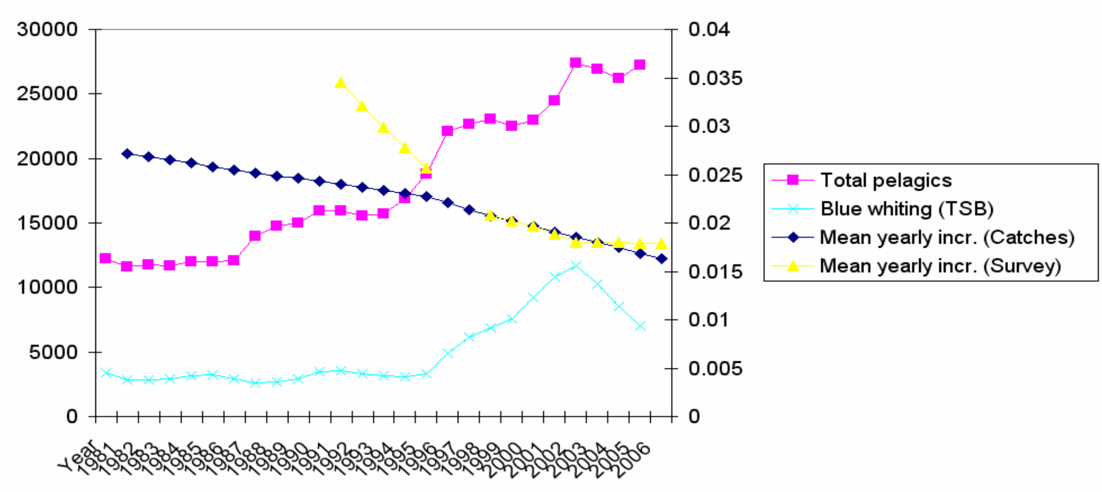


Figure 10.15.2. Biomass of the main pelagic fish in the feeding area, blue whiting biomass and blue whiting yearly weight increment (lowess smoothed line based on all ages) in catches and in spawning survey.

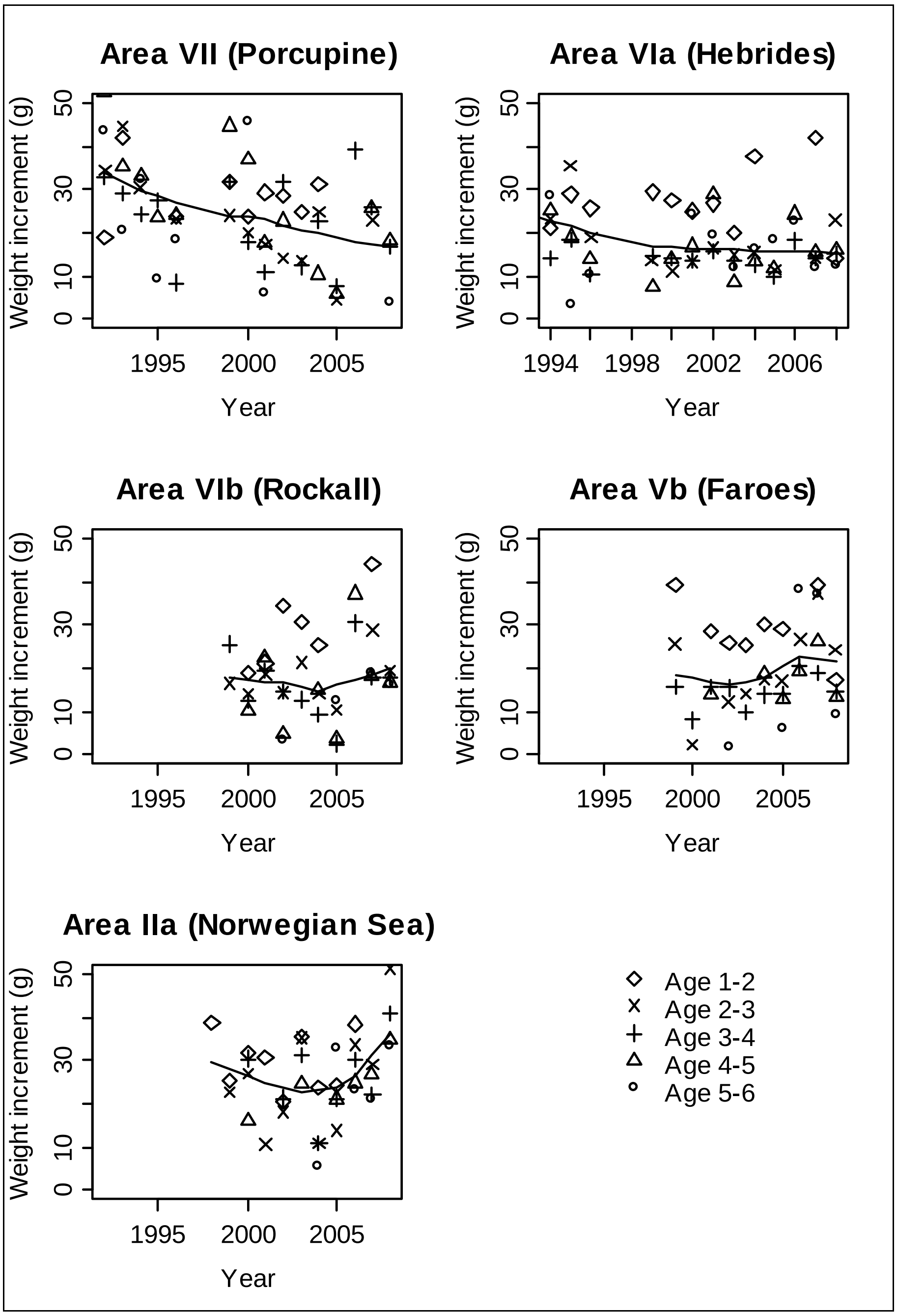


Figure 10.15.3. Yearly growth rate (Kg) by year. Data from spawning stock survey in subareas VII, VIa, VIb, Vb and from Norwegian ecosystem survey in IIa. Applied smoothed lines are done with lowess method.

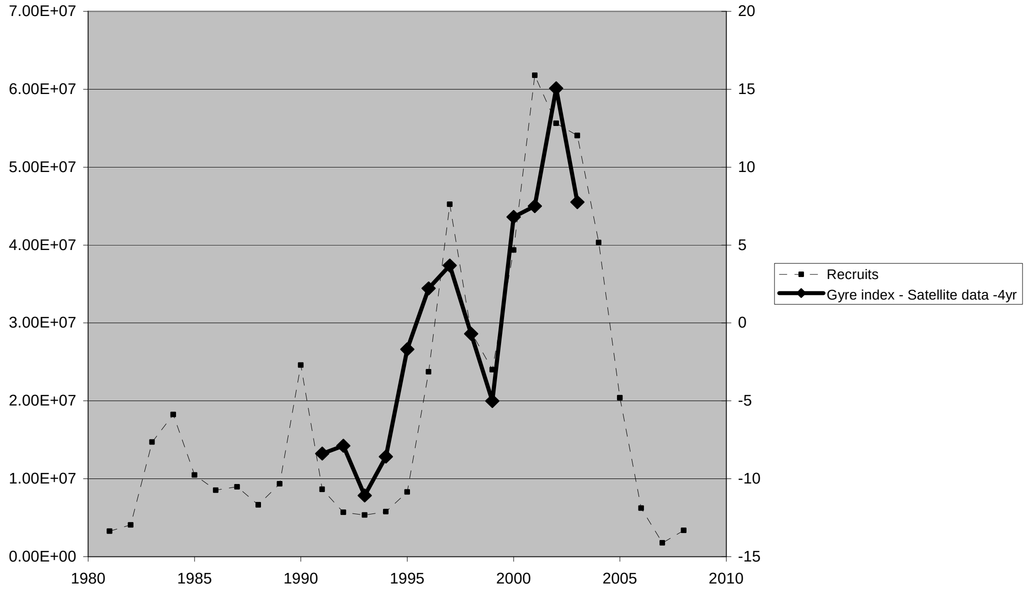


Figure 10.18.1. Subpolar Gyre index and blue whiting recruitment. The gyre index has been shifted 4 years back in time.

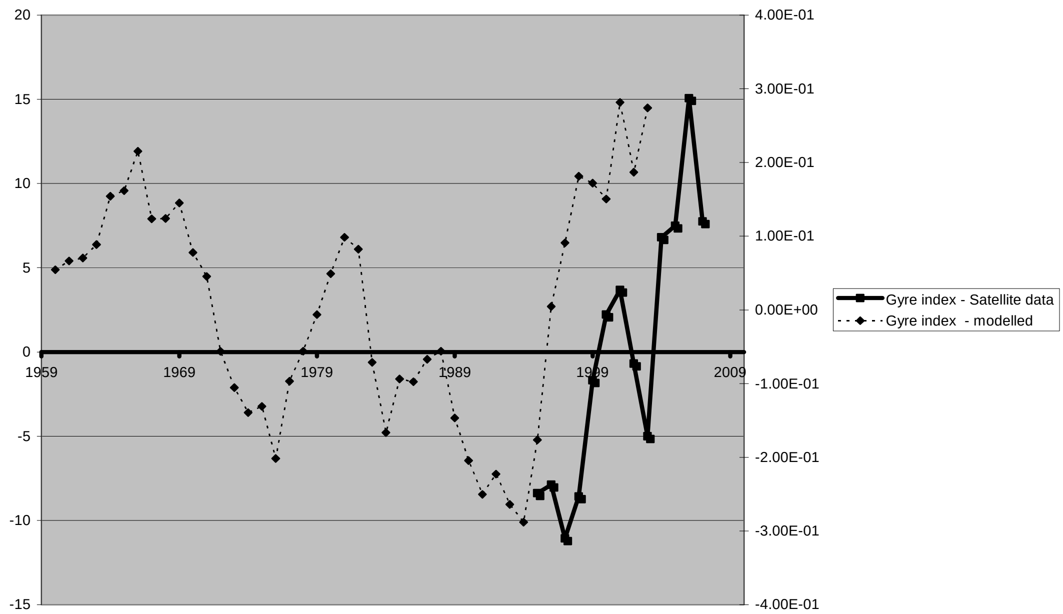


Figure 10.18.2. Model based Subpolar Gyre index and satellite data based Subpolar Gyre index. The gyre index is connected to Atlantic Multidecadal Oscillation (AMO).

11 Recommendations

The Working Group for Widely Dispersed stocks makes the following recommendations:

RECOMMENDATION	FOR FOLLOW UP BY:
1. General a) To develop programmes that would convert National data into INTERCATCH format. 3. 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. This applies particularly to mackerel and horse mackerel fisheries and NSSH. 4. That ICES provides an archive for storing historic catch data. 5. The WGWIDE meeting could be held in the second half of June but not before because essential survey data would not be available. However, on years of the Egg survey (every 3 years starting in 2010) the assessment of Mackerel and Horse mackerel needs to be held in September at the earliest. 6. WGWIDE has no agreed view regarding stocks in the group.	a) National Laboratories. b) National management c) ICES Secretariat
2. Sardine a) the continuation of the Portuguese November survey and support for its re-organization as a recruitment survey for both anchovy and sardine; b) the collection of samples from sardine fisheries in the northern areas of the species range, and especially in ICES Divisions VII (including historic biological and fisheries data); c) continue the collection of fisheries and survey data from the Bay of Biscay; d) to plan at least one spring acoustic survey in the northern area in order to estimate the fraction of the stock outside existing surveys.	a-d) National laboratories

	7. Mackerel and Horse Mackerel Egg Surveys Given the difficulty in processing all samples to provide the preliminary Egg survey estimate it is recommended that a big enough number of samples are processed from each survey at an early phase to avoid later revision of estimates corresponding to entire areas of the survey.	WGMEGS
	8. Norwegina Spring Spawning Herring a) Contingency plans to avoid partial coverage of the survey b) The Working Group recommends that effort should be put into updating estimates on proportion mature at age for Norwegian spring spawning herring from recent years with using back calculation techniques on scale and compare it with data on direct measurements on proportion mature at age from the May survey during the period since 1997 when this survey was assumed to cover the entire stock.	PGNAPES b) This work will be done by IMR. Based on this, an evaluation will be done and the most reliable method will be adopted in the assessment in 2009.
	9. Mackerel a) Examine patterns in fecundity b) WG members extract any historic data on catch at age (or faling this length) of NEA mackerel from 1972 to 1980 and supply this to : Andy Campbell / John Simmonds by 1st January 2009.	National Labs
5.		
6.		

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13 Abstracts of Working Documents

E. Abad[1]*, J. Castro[2], A. Punzón[1] and P. Abaunza[1]

Métiers of the Northern Spanish coastal fleet using purse seine gears

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[2] IEO, Centro Oceanográfico de Vigo.P.O. 1552, 36280-Vigo, Spain

Abstract:

Logbooks from the Spanish purse seine fleet operating in ICES Divisions VIIIc and IXa North during the 2003–2005 period were analysed in order to identify métiers; i.e. groups of fishing trips with homogeneous catch profiles. The CLARA method, a non-hierarchical cluster analysis specific for large data sets, was used to classify the fishing trips. From the resulting clusters, 6 trip types were found to be consistent enough along the time series: 1) targeting sardine, 2) targeting anchovy, 3) targeting mackerel, 4) targeting horse-mackerel, 5) targeting seabreams and 6) mixed-species trips (others).

P. Díaz[1], A. Lago de Lanzós[1], G. Costas[2], C. Franco[1], and P. Cubero[1]

Preliminary results of sardine Daily Egg Production off the northern coast of Spain in April 2008

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[2] IEO, Centro Oceanográfico de Vigo. P.O. 1552, 36280-Vigo, Spain

Abstract:

This document presents the results of the SAREVA0408 ichthyoplankton survey conducted by IEO (Instituto Español de Oceanografía). This survey was carried out on board R/V *Cornide de Saavedra* for April 2008. The covered area was the North and North-western Iberian Peninsula waters and the inner part of the Bay of Biscay (from 42°N to 45°N).The present paper includes data on sardine (Sardina pilchardus) egg distribution and abundance from the SAREVA0408 survey, as well as the estimation of daily egg production (DEPM) for sardine in the north Spanish Atlantic, Cantabrian waters and south of the Bay of Biscay.

Asta Gudmundsdottir

Norwegian spring spawning herring: Total international catch in numbers in 2007

Marine Research Institute, Reykjavik, Iceland

Abstract:

In this document the total international catches from the Norwegian spring spawning herring in 2007 are presented.

Jan Arge Jacobsen

Wide distribution of mackerel

Faroese Fisheries Laboratory

Abstract:

Large concentrations of mackerel have been observed in the Faroese area the last few years by the Faroese vessels fishing for herring during summer. The amounts have been so high the last three years that the vessels fishing for herring had to "flee" northwards out of the Faroe zone in order to catch herring in clean concentrations. This document gives an overview of the extensive mackerel distribution in the area north of the Faroes in spring and summer 2008 based on data from three Faroese surveys.

Jacques Massé[1], Erwan Duhamel[2], Pierre Beillois[1], Patrick Grellier[1], Martin Huret[1], Gwenn Kervella[1], Pierre Petitgas[1]

Direct assessment of pelagic species by the PELGAS08 acoustic survey

Abstract:

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 PELGAS08 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 counting the number of fish eggs using **CUFES** system, and discrete sampling at **stations.** A commercial pair trawlers were accompanying Thalassa all along the survey such as to double the number of identifications hauls and increase the reliability of identification of echoes. This WD report acoustic assessments and length distributions of main species, age distribution for anchovy and sardine and some environmental data. Sardine recruitment seems one of the highest since 2000, anchovy one is still low and horse mackerel, mackerel and blue whiting are quite rare in the Bay of Biscay compared to nineties.

Leif Nøttestad

Mapping the northerly distribution of NEA mackerel (*Scomber scombrus*) in summer 2008

IMR, Bergen, Norway

Abstract:

A major finding from this survey was that mackerel was caught as far north as 75.18°N between Bear island and Spitzbergen in quite warm Atlantic water masses between 26 July- 9 August 2008. This is a new record for mackerel expansion and represents a distance >500 km further north as compared to the northernmost distribution in 2002. The temperature (°C) distribution at 20 m depth showed a range from 6–11°C, providing feeding and migrating mackerel with relatively warm temperatures at these high latitudes. Mackerel were caught in 77% of the tows. The mean length was 37 cm (30–45 cm range) and mean weight was 482 grams. Herring overlapped in fine-scale distribution with mackerel in the northernmost part of the distribution area.

C. O'Donnel[1^*], E. Mullins[1], G. Johnston[1], E. Bethke[8], G. Holst[3], D. Wall[9] (R/V Celtic Explorer); I. Oganin[4,] S. Harlin[4] (R/V Fridtjof Nansen); A. Salthaug[2*], V. Anthonypillai[2*], J. Kristiansen[2], J. de Lange[2], E. Meland[2] (F/V Gardar); J. A. Jacobsen[5], L. Smith[5*], M. M. Joensen[5], F. Skúvadal[5] (R/V Magnus Heinason); S. Ybema[6], T. Pasterkamp[6], K. Bakker[6], J. Freijser[6], E. Armstrong[7], M. Kloppman[8] and D. Tijssen[3] (R/V Tridens)

International blue whiting spawning stock survey spring 2008

[1] Marine Institute, Galway, Ireland

[2] Institute of Marine Research, Bergen, Norway

[3] Danish Institute for Fisheries Research, Denmark

[4] PINRO, Murmansk, Russia

[5] Faroese Fisheries Laboratory, Tórshavn, the Faroes

[6] Institute for Marine Resources & Ecosystem Studies, IJmuiden, The Netherlands

[7] FRS Marine Laboratory, Aberdeen

[8] Federal Research Institute for Fisheries, Hamburg

[9] Irish Whale and Dolphin Group (NGO)

* Participated in the after-survey workshop

^ Survey coordinator in 2008

Abstract:

In spring 2008, five research vessels representing the Faroe Islands, Ireland, the Netherlands, Norway and Russia surveyed the spawning grounds of blue whiting west of the British Isles. The estimated total abundance of blue whiting for the 2008 international survey was 8 million tonnes, representing an abundance of $68x10^9$ individuals. The spawning stock was estimated at 7.9 million tonnes and $67x10^9$ individuals. In comparison to the results in 2007, there is a significant decrease (30%) in the observed stock biomass and a related decrease in stock numbers. Stock in the survey area is dominated by age classes 5 and 4 years, of the 2003 and 2004 year classes respectively, contributing half of spawning stock biomass

JR. Pérez[1*], G. Costas[1], M.B. Santos[1], M. Bernal[2], A. Solla[1], L. Iglesias[1], C. Dueñas[3], and J. Barrado[3]

Preliminary results of the 2005 adult parameters for sardine off the North Iberian Peninsula (IXa N & VIIIc ICES Divisions).

[1] IEO, Centro Oceanográfico de Vigo. P.O. 1552, 36280-Vigo, Spain

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[3] IEO; Centro Oceanográfico de Santander. P.O. BOX 240, 39080-Santander, Spain

Abstract:

We present a summary of the preliminary results obtained during the Spanish PELACUS 0405 and SAREVA 0308 surveys on sardine fecundity. The data obtained are use to estimate adults parameters in order to estimate the Spawning Stock Biomass of the Atlantic-Iberian sardine (Sardina pilchardus) applying the Daily Eggs Production Method (DEPM). IEO (Instituto Español de Oceanografía) carried out these surveys in April 2008 on board the R/V Thalassa and R/V Cornide de Saavedra covering the waters off the Northern Iberian Peninsula (ICES Divisions VIIIc and IXaN).

Antonio Punzón and Begoña Villamor

Changes in the timing of the spawning migration of the Southern component of the Northeast Atlantic mackerel (Scomber scombrus, L. 1758).

Instituto Español de Oceanografía. CO Santander. Promontorio San Martín SN. P.O. Box 240, Santander 39080, Spain

Abstract:

Part of the Northeast Atlantic mackerel population migrates towards the southern spawning area (Cantabrian Sea) at the end of winter. In this seasonal handline fishery targeting mackerel, the most important in the study area that targets this species, the timing of the peak of catches has shifted forward in recent years. This paper presents results pointing to the possibility that this shift may be due to a change in the timing of the pre-spawning migration to the southern area of the Northeast Atlantic mackerel population. Three types of fleet have been identified within this fishery, and in all of them there is a forward shift in time in effort exerted. Moreover, a new model has been defined for the standardization of CPUE. This has allowed us to determine that migration shifted forward by one month between 2000 and 2006. A shift on this scale has important consequences for the management of the resource, the fleets that exploit it and the resource evaluation survey designs that will have to be adapted to this new scenario.

A. Silva[1], M. Azevedo[1] and Y. Stratoudakis[1]

Towards a management strategy for the sardine fishery: how to advance?

[1] IPIMAR, Avenida de Brasilia, 1449–006, Lisboa

Abstract:

This document presents an overview of the current state of the sardine fishery and of the assessment for the stock and provides a reflexion towards the future management of the stock.

Dankert W. Skagen and Åsmund Skålevik*

A Toolbox for Age-structured Stock Assessment using Catch and Survey data (TA-SACS)

IMR, Bergen, Norway

* in collaboration with scientists from VNIRO, PINRO and IMR

Abstract:

TASACS manual.

Dankert W. Skagen

Estimating mortality of NEA mackerel from tag recaptures with the Jolly-Seber method.

IMR, Bergen, Norway. e-mail: dankert@imr.no

Abstract:

The Norwegian tag-recapture material for mackerel and a method for estimate total mortality from that material are described. Similar results have been presented annually to the MHSAWG. The results are updated and now include tag recaptures throughout 2007. The update made little difference from the results presented last year. Because no tags were released in 2005, the last estimate of mortality still is for May 2003 – May 2004.

Dankert W. Skagen

Norwegian Spring-spawning herring: Analysis of the signals in the data and preliminary exploration with TASACS.

IMR, Bergen, Norway

Abstract:

This working document looks at the available data for Norwegian Spring Spawning Herring (NSSH). In addition to elementary analyses of the data, some interpretations of the data using the options in TASACS are presented and where appropriate, compared with the interpretation by the SeaStar assessment. The analysis highlights conflicts between data from various sources, and how such conflicts can be revealed.

Dankert W. Skagen

Ways to assess the stock of Norwegian Spring Spawning herring

IMR, Bergen, Norway

Abstract:

The catch and survey data for NSS herring were analyzed with the range of assessment methods available in the TASACS and compared with the results of last years assessment with SeaStar. Some causes of differences were suggested. The paper also discusses advantages and disadvantages with different assessment methods.

Erling Kåre Stenevik

Maturity ogive of Norwegian Spring Spawning Herring

Institute of Marine Research, Norway

Abstract:

The maturity ogives for NSSH used in assessment of the stock has been based on different methods which are generally not well-documented. It is difficult to obtain random samples of proportion mature from surveys due to the different catchability of mature and immature fish of the same age groups due to spatial segregation and it is difficult to obtain reliable estimates of this catchability difference. This may introduce large uncertainties in estimates of maturity ogives from surveys, and an alternative approach is suggested in this working document which includes back-calculation of proportion mature at age based on scale readings.

Sveinn Sveinbjörnsson, and Stefán Brynjólfsson

Experimental fishery for mackerel at southeast- and south Iceland 8–14 August 2007

Marine Rearch Institute, Reykjavík, Iceland

Abstract:

In this document the results obtained during the experimental fishery for mackerel at southeast and south of Iceland in August 2007 are presented.

Sveinn Sveinbjörnsson

Observations on commercial Mackerel fishery on board an Icelandic purse sein/trawler in July 2008.

MRI, Reykjavík Iceland

Abstract:

In this document a summary of the information collected by an observer on board a fishing vessel fishing for Mackerel at South-East Iceland during July 2008 is presented.

Alain Tétard

The French fishery of blue whiting

Ifremer & Compagnie des pêches de Saint-Malo

Abstract:

Since autumn 2007 the French fishing industry has undertaken a self sampling program for blue whiting. The aim of this program is to give detailed information on the length structure of the catches in addition to the statistical data from the log book. This working paper gives a general overview of the French activity and shows the first results of this self sampling program during last winter. The size compositions from the samples show small fish in the Bay of Biscay and bigger fish in the northern areas (North West of Ireland and North Scotland)). This program just started last year and will be continued to provide more data further results allow to give more information as the annual length composition of the French catches.

Annex 1 – Participants List

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ICES Headquarters, 2-11 September 2008

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Annex 2: TASACS: A Toolbox for Age-structured Stock Assessment using Catch and Survey data

Dankert W. Skagen and Åsmund Skålevik, IMR, Bergen, Norway

in collaboration with scientists from

VNIRO, PINRO and IMR

Overview

TASACS is a toolbox of programs analyse catch and survey data and to perform an analytic assessment of a fish stock. The assessment programs are integrated in a working environment for organizing the work and presentation and book-keeping of the results.

The routines in the toolbox are based on well established theory and procedures, and should cover the needs for assessing most stocks where standard information (catch in numbers at age, weights and maturities at age and survey indices–or alternatively catch per unit of effort–with and/or without age disaggregation) is available. The toolbox provides a wide selection of implementations of the theory. Although the development was triggered by the need for a unified software for analyzing the data for Norwegian Spring Spawning herring, the software is designed as a general toolbox to serve the needs for any stock where the standard data are available.

The coding and testing of the program was done by the authors. The model formulations and the contents of the package is the result of collaboration between scientists from PINRO, VNIRO and IMR. The programs have been written in accordance with the protocols from a series of meetings with these scientists.

The TASACS toolbox has the following elements:

1) The TASACS program for performing an assessment, with a variety of options.

2) A set of procedures that call the assessment program (1) to perform:
   - Single runs with current parameters
   - Ordinary assessment runs (estimation of parameters)
   - Bootstrap runs
   - (Parameter perturbations–not implemented yet)
   - Retrospective runs

3) A set of post-processing routines to present results

4) The TASACS working environment for
   - Inspecting and editing input data and parameters, as well as model settings.
   - Calling tasks (cfr. pt. 2 and 3) to be done
   - Book-keeping of runs and results

The communication with the assessment program is trough files. These are normally edited in the working environment. The assessment program can run on its own, however if the necessary files have be made separately. All files are ascii-files and can be made with any text editor.

The TASACS assessment program itself is written in Fortran 95, and compiles and runs on any platform. The working environment is written mostly in Delphi, and requires Windows as operating system.

The assessment program uses the following kinds of files:

- Input observations (data-files). These are ascii-files formatted according to the Lowestoft file format standard.
- Parameter files, with proposed values and active flags for all model parameters. If the parameter is declared as active (flag=1), the value is just an initial value for the search.
- Files with weightings of the individual data (weightings files).
- Index file, with basic specifications, including names of other files. This file is generated by the working environment and used as the link between that and the program.

The TASACS environment has facilities for inspecting and editing the files in an understandable lay-out, for starting the procedures described above, and for presenting results and diagnostics.

The main output from the assessment program itself is two ASCII- files with the main results in matrix form.

1) Summary.txt: A summary file with stock numbers, fishing mortalities and a summary of biomasses, recruitments and average fishing mortalities over time.

2) Output.txt: This file has the additional information needed for the diagnostics.

The files are read by the post-processing routines, but can also easily be read by other programs, e.g. R-scripts.

The TASACS package is self-contained and can be compiled and run without additional software or libraries. It has not been included in packages like FLR. However, it is structured in such a way that the core parts of the program can be called from e.g. R as .dll files. In the standard distribution, the assessment program itself is in a .dll file, which is seen by the TASACS environment. Likewise, the output is on files that should be easy to read from R, to utilize existing software for presentation etc.

The TASACS assessment program.

The method is basically to construct a model population driven by model parameters and optionally by data, derive expected observations and express the fit of the model to the observed data as an objective function. The user can decide which parameters to estimate, by attaching an 'active flag' to each parameter. The objective function is formally a functional on the space of active parameters, given the remaining parameters and the data. An optimization routine searches over the space of active parameters to find the set of active parameters that give the smallest value of the objective function. The model population with this set of parameters is taken as the estimate of the stock.

The model data are generated from the population model and catchability models. Both for the population model, catchability models and objective functions several options are available. The optimization is by a searching routine. An outline of the main building blocks is given in Figure 1.

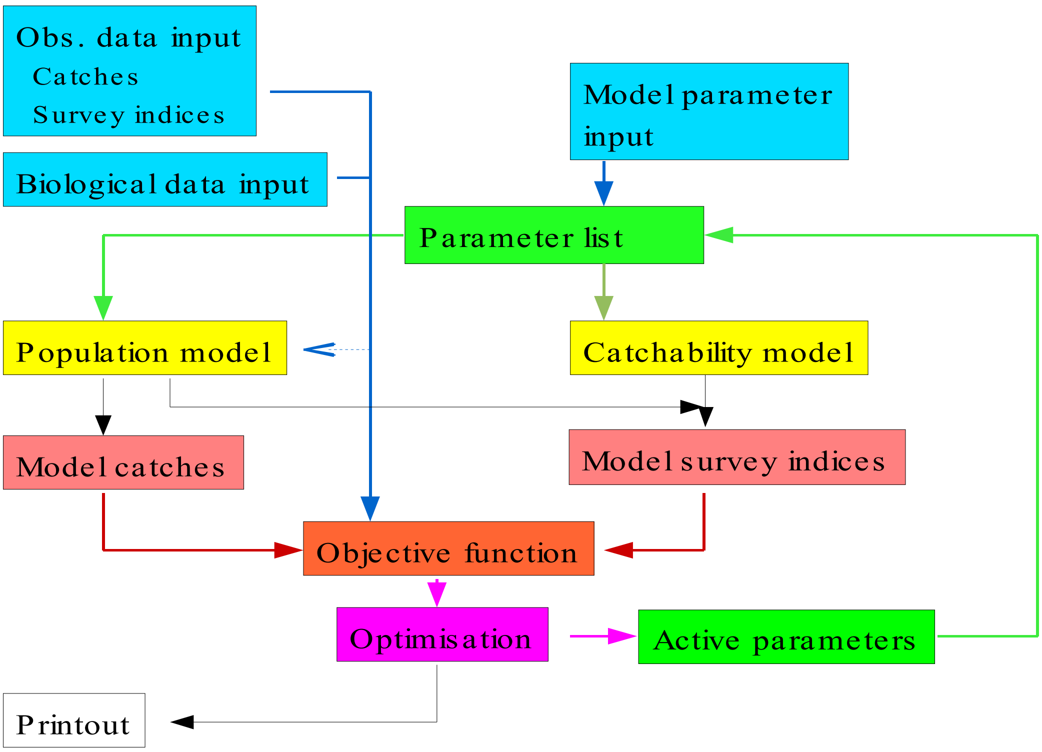


Figure 1. Building blocks in the TASACS assessment program

In the following, each of these building blocks is described.

Population models:

The population model generates a matrix of stock numbers *N(a,y)* by age and year, and a corresponding matrix of fishing mortalities *F(a,y)*. Model catch numbers at age and year are generated if they deviate from the observed catches. The lowest age in the age range is the recruiting age. The oldest age is regarded as a plus group in the population. The oldest true age is assumed to be the age below the plus age.

The year range is from the first to the last model year. In the population models that require catch numbers at age (VPA and ISVPA), the model calculates *N*s and *F*s only up to and including the last year with catch data. If this year is earlier than the last model year, the stock is projected forwards to include the last model year. This is done to allow the use of survey data after the last year with catch data, even with these population models.

Three population models are available:

1) A VPA

2) An ordinary separable model

3) An ISVPA type separable model

The VPA:

Input parameters:

- Survivor numbers at all ages in the last year
- Survivor numbers at oldest true age in previous years (optional)
- Natural mortalities *M(a,y)* at age and year

Input observation data:

- Catch numbers at age by year

Output:

- Primary: Matrix of *N(a,y)*
- Secondary: Matrix of *F(a,y)* derived from the *N*-matrix

Calculation of N-values. Let *N0(a,y)* denote the stock numbers *N(a,y)* at age *a* at the start of year *y*, and *N1(a,y)* the survivors , i.e. the stock number at age *a* at the end of year *y*. In the backward calculation of N-values, the survivors *N1* in year *y* at age *a* are identical to the numbers *N0 (a+1,y+1)* at the start of next year. At each time step, *N0* is calculated from *N1* using Popes equation. Hence:

N1(a,y) = N0(a+1,y+1) (1a)

N0(a,y) = N1(a,y)**exp(M(a,y) + C(a,y)*exp(M(a,y)/2 (1b)

The start of this back-calculation is survivors *N1* at the end of each year class cohort.

The fishing mortalities are derived from the stock numbers and the natural mortality as :

F(a,y)= log (N0(a,y)/N1(a,y))−M(a,y)

In cases where *N1(a,y) = 0,* the convention in TASACS is to let *F* be undefined (see under zero catches below)

Terminal stock numbers: A VPA algorithm generates stock numbers at age and fishing mortalities at age in each year class cohort as a one-parameter family of trajectories. The remaining parameter can be either a stock number or a fishing mortality anywhere in the cohort. The choice in TASACS is to use the *N* at the end of the last year in the cohort (i.e. at the oldest true age in all years and at all ages in the last year with catch data) as the remaining parameter. The cohorts are calculated backwards from these stock numbers using Popes equation, and the fishing mortalities are derived afterwards. For obtaining the terminal *N1(a,y),* the option depends on the year.

Case y is the last year with catch data (Yc):

Take *N1(a,Yc)* as a parameter, and derive *N0* using eqn. (*1b*).

Case y is not the last year with catch data, but a is the oldest true age A.

Here are two alternatives:

Alternative 1:

Take *N1(A,y)* as a parameter and derive *N0* using *eqn. 1b*. This assumes that there is data to estimate it. This option is used if the flag on *N1(A,y)* = 1 or 2.

Alternative 2:

Use the catch numbers *C(A,y)* and fishing mortalities *F(A,y)* in the terminal year. The stock numbers *N0* at the start of the terminal year are computed from *F* and *C* as:

N0(A,y) = C(A,y)*Z(Aa,y)/F(A,y)/[1-exp(-Z(A,y))]

where Z(A,y) = F(A,y) + M(A,y).

This is the convenient way to handle cohorts where no other data than catch data are available.

With this alternative, a value for *F(A,y)* (the terminal *F*) is needed. The following algorithm is used to obtain *F(A,y)*,:

For each year earlier than the last year, derive an *F'(A,y)* as:

F'(A,y)=F(A,y+1)*Average{F(a,y)}/Average{F(a,y+1)}

If *F(A,y)* is undefined in the last year, the value of *F* at the oldest age in the last year where there is a defined *F* is used to trigger the generation of *F*'.

The averages are taken over all ages in the range that are defined as reference ages, and where the *F*s at age are valid in both years. If *F(A,y+1)* is undefined (see below), *F'(A,y+1)* is used instead. If the *average(F(a,y+1)=0*, or *y* is the last catch year, take *F'(A,y) = F(a,y), a* being the oldest age with a valid *F*.

F'(A,y) is applied as *F(A)* when there are catch data at the oldest age, i.e. when *C(A)>0*.

This procedure always provides a value for *F(A,y)*. This value is used to derive the terminal *N*, unless the rules described in the section on zero catches below apply. It assumes that the selection at oldest age relative to the average selection at younger ages is constant, and that the difference in *F(A)* from one year to the next follows the differences in overall fishing mortality. The procedure has some similarity to that used in ICA, but ICA does not handle undefined fishing mortalities.

The choice of alternative is declared with the flag on the *N1(a,y)*. If the flag is 1 or 2, alternative 1 is used. If the flag is 0, alternative 2 is used, with the exceptions outlined under handling of zero catches below. In this case, the proposed values for *N1* are not used. Note that in just this case for *N(A,y),* the interpretation of the active flag =0 is different from the standard.

The ordinary separable model:

Input parameters:

- Selection at age *S(a)*, all true ages
- Annual fishing mortalities *Fy(y)*, all model years
- Survivor numbers at age in the last model year, all true ages
- Survivor numbers at last true age in all previous years
- Natural mortalities at age and year

Input observation data:

- None

Output:

- Primary: Matrix of *F(a,y)* derived from the parameters.
- Matrix of *N(a,y)*
- Model catches.

The fishing mortality *F(a,y)* at age *a* in year *y* is assumed to be a product of a year factor *Fy(y)* and a selection at age *S(a)*. This defines fishing mortalities at all ages and years as *F(a,y) = Fy(y)*S(a)*, and accordingly, relative stock numbers at age within each year class. The absolute stock numbers is then determined by scaling the cohort to hit a number at age within each year class. In the present implementation, this number is the survivors *N1* at the end of each year class, which becomes a parameter for each year class. For previous years, we set

N1(a,y)=N0(a+1,y+1)

Then for all years, the stock numbers *N0* at the start of the year are calculated backwards in time as

N0(a,y)=N1(a,y)*exp(F(a,y)+M(a,y))

Model catches are derived using the catch equation:

C(a,y)= F(a,y)*N(a,y)*(1-exp(-Z(a,y)))/Z(a,y)

On the parameter input file, the selection is stated for each year. Normally, the flags are set so that the selection is equal for all years, using the first years' selections at age as active parameters. It is possible, however, to declare selections in later years as active as well, implying different selections in different periods.

Scaling of fishing mortalities in the separable model:

Since the *F(a,y)* is a product *S(a)*Fy(y)*, the selection has to be on a fixed scale in order to have a unique two-way correspondence between *S(a)* and *Fy(y)* on one hand and *F(a,y)* on the other. In the TASACS program, the selection is rescaled when entering the separable population model, so that the average over the reference ages is *1*. The annual *F*-factor is not touched. Hence, the annual F-factor is interpreted as the normally reported average *F*, while the stated selections at age are interpreted as relative.

ISVPA type separable model:

This model estimates fishing mortalities in a separable model, but it uses the catch data to reduce the numbers of undetermined parameters in an iterative process.

ISVPA has several alternative procedures to model the population, the ones represented here corresponds to the 'catch controlled' and the 'effort controlled' versions and 'weighted arithmetic mean procedure' (Vasilyev 2005), but with ordinary fishing mortalities instead of the instantaneous fishing mortality used in the original ISVPA.

A key point in ISVPA is the normalization of selection, where selections at age are scaled so that their sum over all ages is one. This leads to a scaling of selections and yearly F-factors that is different from the general rule in TASACS, as described below.

Input parameters:

- Fishing mortality year factor in the last year with catch data.
- Selection at age (relative) and annual fishing mortalities in earlier years have to be given as input. They are used as starting values for the iterative search in ISVPA, and will be changed by the ISVPA procedure, but up-dated values are not copied to the parameter list. The active flag on these input 'parameters' is ignored.
- Natural mortalities at age and year

Input observation data:

- Catch numbers at age by year

Output:

- Primary: Matrix of *N(a,y)*
- Secondary: Matrix of *F(a,y)* derived from the *N*-matrix

The original version of ISVPA estimates fishing mortalities and stock numbers assuming separable fishing mortalities, as a function of the terminal F year factor. The terminal F year factor is not an entirely free parameter, however, as the catch objective function is sensitive to the choice of this parameter. In the original ISVPA, this objective function is considered together with objective function terms from the fit to other data. In the TASACS implementation, the fit to the catches internally in the ISVPA routines is not used outside these routines. This discrepancy may be corrected in future releases.

Algorithm

Let *A* be oldest true age and *Y* last year.

1) Get proposed values for all *F(a,y)*: *F(a,y)=F(y)*S(a)*

2) Calculate all *N(A,y)* and *N(a,Y)* from the *F(a,y)* and the observed catches C(a,y), using eqn (1).

$$N(a,y) = C(a,y)*Z(a,y)/F(a,y)/[1-\exp(-Z(a,y))] \qquad (1)$$

where *Z(a,y) = F(a,y) + M(a,y)* and *M(a,y)* is natural mortality.

If the catch is 0, the *N* is 0.

3) Calculate the other *N(a,y)* backwards for each year class:

3.1 If *N(a+1,y+1)* >0 and *C(a,y)*>0, then *N(a,y)* is computed by (eqn.2)

$$N(a,y) = N(a+1,y+1)*\exp(M(a,y) + C(a,y)*\exp(M(a,y)/2) \qquad (2)$$

3.2 If *N(a+1,y+1)* >0 and *C(a,y)*=0, than *N(a,y)* is computed by (eqn.2).

3.3 If *N(a*+1,*y*+1*)* =0 and *C(a,y)*=0, then *N(a,y)* = 0.

3.4 If *N(a*+1,*y*+1*)* =0 and *C(a,y)*>0, then *N(a,y)* is computed by (eqn.1).

4) Calculate the F(a,y) as F(a,y) = log{N(a,y)/N(a+1,y+1)}−M(a,y).

If F(a,y) is undefined because N is 0, or F(a,y)=0 because C(a,y)=0, use F(a,y) = S(a)* F(y).

5) Calculate new selections at age *S(a):*

5.1 Age loop (except oldest age): $S'(a) = 1/Ny*\Sigma_y\{F(a,y)/F(y)\}$ using all years.

5.2 The *F(y)* are from the previous iteration.

5.3 Selection at oldest age: *S(A) = S(A-1)*

5.4 Age loop: Normalize the S(a) to get S'(a): $S'(a) = S(a)/ \Sigma_a S(a)$

6) Calculate new F(y) as $F(y) = 1/N_A*\sum_a[F(a,y)/S(a)]$ for all y<Y.

The sum is over all ages *a.*

7) Derive smooth selections *Ssmooth* as the weighted average between the new *S(a)* and the *S(a)* from the previous iteration*:*

S(a)smooth = K*S(a)new+(1-K)*S(a)old, 0 <K <1.

The value of K is a compromise: a bigger K makes the convergence faster, a smaller K better suppresses possible oscillations.

8) New F(y) is weighted average between F(y) and the previous F(y): F(y)smooth =K*F(y)new+(1-K)*F(y)old

9) Calculate model catches from catch equation 3 using the theoretical *F(a,y)=S(a)F(y)*

$$C(a,y)= F(a,y)*N(a,y)*(1-\exp(-Z(a,y))/Z(a,y) \quad (3)$$

10) Calculate log squared differences: $[\log\{C_{obs}(a,y)/C_{model}(a,y)\}]^2$ (or use some other measure of closeness of fit to catch-at-age data)

11) Compare log squared differences from the current iteration with the three last iterations. Convergence criterium: The maximum log squared difference difference is < 10E-5. If not converged, goto *1*.

Within this procedure (in pt.5) it is possible to estimate different vectors of *S(a)* for different intervals of years and to apply them in respective years (in pt.6) for estimation of *F(y*). The normalization and inter-iteration smoothing is applied to each vector of *S(a).*

The procedure produces so called unbiased estimates of *F(a,y)* when assuming a lognormal error distribution in the separable approximation:

$\sum_a\{\log F(a,y)-\log[F(y)S(a)]\}=0$ for each year y, and

$\sum_y\{\log F(a,y)-\log[F(y)S(a)]\}=0$ for each age group a

This algorithm will render the *F(Y)* unchanged. Assuming that the M-values are fixed, the *F(Y)* is the only free parameter in the algorithm.

The result is a set of *F(a,y)*. Then there is two options for deriving the final N-matrix:

In the catch controlled version, the set of *N(a,y)* is derived from the terminal *F*-values and the observed catches using the VPA algorithm. The final fishing mortalities are then derived N-values with eqn (4).

$F(a,y) = \log(N(a,y)/N(a+1,y+1)) - M(a,y)$ (4)

In the effort controlled version, the output N-values are model N-values (except for those at the end of each year class). Model catches are calculated from the catch equation (3) using the theoretical *F(a,y)=S(a)F(y)*.

Scaling of the fishing mortalities in ISVPA.

The selection at age as stated in the input to ISVPA is rescaled internally when entering the ISVPA to get the sum of selections at age equal to 1. The *F(Y)* given as a parameter to the ISVPA algorithm is also rescaled internally with the inverse of the scaling factor for the selections.

The *F(Y)* is the only free parameter that the ISVPA sees. Even though it is rescaled internally, the rescaling is consistent as the selections on the parameter list and in the parameter file are not updated by the ISVPA.

Some special features in the population models in TASACS

Specification of population model parameters.

Both the population models and the catchability models are basically specified through their structural assumptions (e.g. a separable assumption) and a set of model parameters. The estimation procedure is to find the set of parameters that give the best fit to the observed data (measured as an objective function−see below), under the structural assumptions applied.

Since TASACS is designed as a toolbox, with several optional population models, an important aim has been consistency of parameter definitions for the various models as far as possible, despite the different requirements for parameters in the different models. Where N-values are needed as parameters, they always represent survivors. The F-level parameters represent average F over the reference ages. There are a few exceptions, in particular the interpretation of the flags for the N-values at oldest age in the VPA. Some parameters are redundant with some models. TASACS has filters to ignore redundant parameters when calling the models. The actually relevant parameters are listed in the descriptions of each model.

Typically, the number of model parameters is too large to estimate them all. For example, fishing mortality and natural mortality usually are strongly confounded, and one of them (normally the natural mortality) has to be assumed at given values.

In TASACS, the analyst has the opportunity to decide which parameters to assume at fixed values, and which to estimate. The latter are called 'active parameters' . The decision is expressed by flags attached to each parameter. Only those parameters that are flagged as active are seen by the optimization routine, and hence are actually estimated. It is also possible to specify by a flag that the value of a parameter shall equal the similar parameter in the previous year or at the previous age. That allows for specifying constant values over time or age.

All parameters are listed on a parameter list, which is read from a parameter input file. The simplest way to generate this file is by using the editor in the TASACS environment, which ensures that the format of the parameter file gets right. Both values and flags can be set with the editor. During optimization and when the optimization is finished, the current parameters are dumped to a file named paramOut.txt. It is possible to specify this file as the parameter input file. That allows restarting the optimization with the best parameters obtained so far.

Because some parameters may be irrelevant for the model used, the parameter file does not necessarily reflect all the results. **Only parameters that are active, or copies of active parameters** (see under flags below) **and are relevant for the actual population model, are updated. Therefore, the paramOut.txt file does not necessarily show the current values of all parameters.** However, if the program is restarted with the same population model and the paramOut.txt file is used as parameter input, the optimization will continue from where it was when the file was generated.

Interpretation of the active flags:

Flag = 0: Keep the parameter fixed.

Exception: In the VPA population model, Flag = 0 for the stock numbers at oldest age means that the stock numbers shall be derived from the assumed F-values, as outlined above.

Flag = 1: To be optimized by the optimization routine (if it is relevant for the population model used)

Flag = 2: Use the same value as that for the previous parameter on the list.

For example, if this applies to a year factor, the parameter shall have the same value as the year before.

Flag = -1. Use the same value as for the previous age

This flag applies only to age factors in the specification of selections at age and catchabilities at age. This is the way to specify a 'flat' selection or catchability at age.

Handling of zero catches

TASACS has facilities to handle the situation where catch numbers at age are zero. Catch observations with the value zero cause problems in at least two ways:

1) The link between Catch, F and N in the terminal age in the VPA algorithm breaks down if the catch is zero.

2) Some objective functions do not allow zeros (e.g. log SSQ).

In many assessment programs, the problem is fixed by substituting zeros with a small number. In the NSSH data, there is a long period with zero catches at most ages, and this fix will to a large extent influence the results.

Instead, TASACS has a modification of the objective function, and a special handling of zeros in the VPA algorithm. The modified VPA is described here, the objective function is dealt with later on.

The VPA with zero catches.

The key to the handling of zero catches in the VPA in TASACS is to allow a fishing mortality to be undefined.

When a catch at age is zero, it can be because there was no fish or because there was no fishery (real or apparent because the catch was not picked up by the sampling). Hence, there may be two situations:

1) *N* at the end of the year at that age (*N1*) is zero. Then, with no catch we can assume that the *N* at the start of the year (*N0*) is also zero. The fishing mortality is undefined. Going backwards in the cohort to the last year where there was a non-zero catch, we assume that the last fish was taken in that

year. Hence, in that *N0 = C*exp(M/2* and *N1 = 0* and the fishing mortality is infinite. In TASACS, we leave the *F* undefined in this case.

2) *N1 >0*. Then, according to Popes equation, *N0 = N1*exp(M)* and *F=0.* The information about *N0* and *N1* must come from somewhere else. In TASACS, case 2 is assumed if

   a) There is catches later on from the cohort, or

   b) *N1* at the last age is entered as a parameter with flag = 1 or 2.

Extending the model beyond the last year with catch data.

A common situation is that there are survey data in the year after the last year with catch data. It may also be of interest to project the stock forwards to get estimates of the stock beyond the last catch data year, e.g. to get input for a projection. TASACS considers a final year (*Y*) and a final catch data year (*Yc*), and has routines to fill in the *N*-matrix and *F*-matrix between these years, with slightly different algorithms for each of the population models.

VPA and ISVPA.

Internally, these models are run with the last catch year (*Yc*) as the last year. When leaving the population model, the survivors in the last catch year *N1(a,Yc)* and fishing mortalities at age *F(a,Yc)* are available. From there, the stock is projected forwards until the end of year *Y*. The fishing mortalities are assumed to have the same selection at age as in year Yc, but a year factor *Fy(y)* that is a parameter for each year *Yc+1 .. Y.* Hence,

F(a,y) = F(a,Yc)*Fy(y)/Fy(Yc).

Here, *Fy(Y)* is taken from the parameter list while *Fy(Yc)* is the average of the estimated *F(a,Yc)* over the reference ages. If the *Fy* has flag = 2 in these years, the same fishing mortality as in the last catch year is assumed. It may also be estimated (flag = 1), if there is relevant information to do so. Using flag = 0 is a way of projecting the stock forwards with other fishing mortalities. It should be noted, however, that this is a primitive way of projecting the stock forwards compared to a normal working group procedure.

The initial numbers of the year classes that are not yet represented in year *Yc,* i.e. at youngest age in years *y>Yc* are parameters. Contrary to other *N*-value parameters, these initial numbers are interpreted as recruits, i.e. numbers *N0* at the start of the year. This is to allow entering recruitment values obtained elsewhere. Note that when *Y* = *Yc*, the *N* at youngest age is treated as a survivor number.

Separable model:

Here, the population and fishing mortalities are generated by the parameters, so no special action is needed.

Objective functions:

In the years after the last catch data years, the catch objective function terms are set to zero. Survey data are included in the objective function as relevant.

Parameters and flags for the years after the last catch year.

VPA and ISVPA: Yearly F-factor and N at youngest age are needed. The N-values at youngest age are treated as recruits (i.e. numbers at the start of the year).

Separable: No special consideration.

The choice of flags depends on the information available, no special rules.

Estimating the plus group

The stock numbers in the plus group are calculated independently of the population models, after the population model has been run. TASACS have two methods for calculating the stock numbers in the plus group:

- Direct from catch
- As a dynamic pool.

The user decides which method to use. However, when the stock is projected beyond the last catch year, the dynamic pool method always is used.

Direct from catch:

Assuming that the fishing mortality at plus age is equal to that at the oldest true age, the stock number is calculated as

N0(A+1,y) = C(A+1,y)*Z(A+1,y)/F(A+1,y)/[1-exp(-Z(A+1,y))]

As a dynamic pool.

Again, it is assumed that the fishing mortality at plus age is equal to that at the oldest true age. The plus group in each year is the sum of what is left over in the plus group from last year, and what is transferred from the oldest true age:

N(A+1,y) = N(A+1,y-1)*exp(-Z(A+1,y-1)) + N(A,y-1)*exp(-Z(A,y-1))

In the first year, the *N*-value is calculated from the catch.

Catchability models

The program allows for 3 types of survey observations representing relative abundance measures:

- Yearly indices of abundance in numbers at age.
- Yearly indices of spawning biomass
- Yearly indices of total biomass

Each of these is related to the stock abundance *A* through a catchability function.

I = *Q(A)* where *A* can be numbers at age or biomass.

The only function that is implemented at present is that of proportionality:

*I=q*A*, where *q* is the catchability.

Age structured indices *I(a,y)*:

Catchabilities are normally assumed to be dependent on age, but equal for all years. As parameters, the catchabilities are nevertheless represented as separable by age and year, and specified as a year factor (which normally should be fixed at a constant value) and an age factor. Normally, the parameter flags should be set so that the catchabilities in the first year are the active parameters, and these carry over to subsequent years. However, the age factor can be allowed to vary between years, to pick up changes in survey selectivity by setting the active flag to 1 in the year where it changes. This is equivalent to splitting the survey into two periods.

If the index is regarded as an absolute measure of abundance, the catchability is set to 1 and the flag to 0.

The abundance A is the model stock numbers $N(a,y)$ at age, reduced by the fraction of the fishing mortality and natural mortality realized before the survey.

SSB indices $I_{SSB}(y)$

Catchabilities are normally assumed to be constant over all years, but are represented by year in the parameter file. As for age structured indices, a shift in catchability in some year can be indicated by setting an active flag in that year.

The abundance A is the model spawning stock biomass, derived from stock numbers at age (reduced by mortality before spawning), weights at age in the stock and proportions mature at age.

Total biomass indices.

These are analogous to spawning biomass indices, except that the biomass is calculated without taking proportions mature into account. The weights at age applied are the weights in the stock.

Objective functions.

The objective function is the measure of model fit to observed data. At present, the following objective functions are implemented:

- Weighted log sum of squares
- Median deviations
- Gamma likelihood (written, and working, but not well controlled)
- Gamma deviance
- Poisson-like

The objective function Φ is a sum of partial objective functions, each originating from one source of data. Each objective function is in turn the weighted sum of contributions $\phi(x, \hat{x})$ from single observations x and the corresponding model value $\hat{x}$:

$\Phi = \sum_{sources} {}^*\Phi_{source}$ and $\Phi_{source} = \sum_i w_i\, \phi(x_i, \hat{x}_i)$

where w_i is the weighting of the ith individual observation, as described below. So far, the w_i have to be set manually. Iterative weighting may be considered in due course.

Weighted log sum of squares.

$\phi(x, \hat{x}) = w^*(\log((x+\varepsilon)/(\hat{x}+\varepsilon))^2$

The ε is introduced to handle the situation where $x = 0$. Having this term in both the numerator and denominator maintains the minimum at $\hat{x} = x = 0$. Typically, it is given a value similar to the resolution in the data.

Median deviations

For each source, sort the $\phi(x_i, \hat{x}_i) = (log((x+\varepsilon)/(\hat{x}+\varepsilon))^2$

Φ_{source} is the sum of the X central elements. This is a non-parametric measure of closeness, which will ignore outliers. Typically, X=10 is used. A larger X gives a smoother function, but increases the risk of including outliers.

Gamma likelihood

The gamma distribution function has two parameters, k (the shape parameter) and θ (the scaling parameter). The expectation value is the product $k*\theta$. Following the procedure in Sea Star, one of them (here k) is specified by the user, and the other follows from the model value $\hat{x}$ as $\theta = \hat{x}/k$.. In future versions, k will be estimated as an additional free parameter.

The negative log likelihood for observing x when the model says $\hat{x}$ is then

$\phi(x_i, \hat{x}_i) = (k_i-1)\ln(x_i) - kx/\hat{x}_i - k_i\ln(\hat{x}/k_i) - \ln(\Gamma(k))$

where the log of the gamma function $\Gamma(k)$ can be calculated using Stirlings approximation:

$\ln(\Gamma(z)) \sim 1/2*(\ln(2\pi)-\ln(z)) + z*(\ln[z+1/\{12z-1/(10z)\}]-1)$

(Documented in http://en.wikipedia.org/wiki/Stirling%27s_approximation)

The Gamma Deviance function

is also implemented, as an alternative. This function is

$\phi(x_i, \hat{x}_i) = -\ln(x/\hat{x}) + (x-\hat{x})/\hat{x}$

This brings us outside the domain of likelihood functions, but it is a function with some convenient properties:

- It is 0 when $x=\hat{x}$
- It is steeper when $x>\hat{x}$, which is opposite from the log SSQ. Hence, it reacts more strongly to prevent unduly large x, and is more tolerant to too small x.

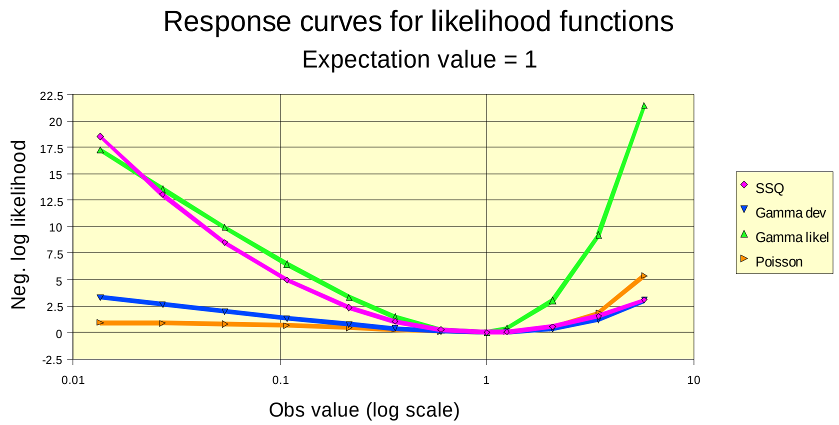
Poisson-like:

This is a simplified version of the Poisson likelihood. The term relating to $x!$ is left out, since this term is only dependent on the observations. The function ϕ can be used as a proxy in cases where the distribution is multinomial, and its derivative is the same as for the multinomial likelihood function. The function is taken from AMCI, where it is commonly used with tag return data. At large negative deviations, this function is almost flat, which slows down convergence markedly.

$\phi(x_i, \hat{x}_i) =$ $\hat{x} - x + x*\log(x/\hat{x})$ if $x>0$

$\hat{x}$ if $x=0$

The figure below shows the shape of some of these functions.



Weighting:

So far the weighting is by weight factors set manually as part of the input. The weights are the product of two factors:

- A common weight given to each data source
- An individual weight given to each observation

Optimization

The optimization process is to find the set of active model parameters that lead to the best fit of the model to the data, i.e. to the lowest value of the objective function. As seen from the optimization procedure perspective, the objective function is a functional on the vector of active parameters. Hence, the optimization suggests a set of active parameters, calls the objective function routine to get the value of the objective function with the current parameters, and examines how the objective function now compares with that at previous attempts. The objective function routine in turn calls the population model and the catchability models to get the modeled observations according to the current parameters.

TASACS uses a simple searching routine to find the optimal set of active parameters. The routine is similar to that in AMCI (Skagen 2005). The searching routine is relatively slow, but has proven to be quite robust, and rarely gets stuck in local minima if the problem is well posed, i.e. if there is sufficient information in the data to estimate the active parameters.

The searching procedure starts with an initial set of active parameters, taken from the parameter input. Each parameter is then increased and decreased with a certain fraction *delta*, and the parameter value that gives the lowest objective function value is kept. After going through all active parameters, the process is repeated, until a maximum number of rounds has been made, or there is no improvement from one round to the next. In each round, the sequence in which the parameters are examined is drawn randomly, to avoid being trapped by correlated parameters. If the maximum number of rounds is reached, the *delta* is increased. If there is no improvement from one round to the next, the *delta* is decreased. The process is repeated until there is no improvement even at a very low *delta*. The starting value for *delta*, the increase and decrease of *delta* and the maximum number of rounds are set based on experience. At present, starting *delta* is 0.25, *delta* increase factor is 2, *delta* decrease factor is 0.4, number of rounds is 25 and the convergence criterium is *delta* < 0.0001.

For each round, the value of delta and the objective function are shown on the screen, and a graphical representation of the *N*-matrix and the *F*-matrix is displayed. Typically, if the information to estimate all parameters properly is insufficient, the search is slow, and goes back and forth between increment and decrement of *delta*, with very small improvement of the objective function for each round. If this happens, the choice of active parameters should be re-considered.

Procedures that use the TASACS assessment program

Population model as it stands

With this option, the population model is simply run once with the parameters as they stand. Results are produced. No optimization is performed.

Ordinary assessment runs.

This is the normal procedure to perform an assessment. This procedure just calls the TASACS assessment program and runs it, i.e. it estimates the active parameters by optimization. The results are stored under the current run.

Bootstrap runs

The TASACS environment can perform bootstrap runs with stochastic observations data. The following options are available:

1) Non-parametric around the observed data.
2) **Parametric** (with a log-normal distribution with specified CV) around the **observed** data
3) Non-parametric around the modeled data
4) **Parametric** (with a log-normal distribution with specified CV) around the **modeled** data.
5) Replicas of data read from a file.

Options can be chosen individually for each source of data, i.e. for the catch numbers at age and for each of the survey index series.

Non-parametric data are generated by drawing randomly (without replacement) from the collection of unweighed log residuals for that source of data, and generating new data as

Obsnew = Obsorig*exp(log_residual)

Parametric data are generated as

$Obsnew = Obsorig*exp(\xi+\sigma^2/2)$, where ξ is a normally distributed random number with mean 0 and specified σ.

Reading data from a file is intended for methodological studies, where e.g. raw survey data are re-sampled and carried through the aggregation process leading to the indices used by the program. The data sets are read in the sequence they stand. If the number of data sets is too small, the file is read over again.

The number of bootstrap replicas is specified by the user, and the results are output to files for further processing. Stock numbers and fishing mortalities at age for the last year can be written to files for use in subsequent stochastic predictions.

Retrospective runs.

Retrospective runs are assessments where the *n* last data years are excluded, to show how the assessment outcome changes as recent data are removed. When *n* years are to be excluded, TASACS does this by removing the *n* last years from each set of data, and moving the parameter flags for the last years *n* years backwards. Both the last catch data year and the last assessment year are moved. This ensures that e.g. surveys performed after the last catch data year still are treated as such, and it ensures that the adequate parameter flags are used.

The results are output as for the ordinary single runs, and can be post-processed to illustrate the results as wished.

Parameter perturbations (not made yet).

This is essentially a diagnostic procedure, to show the influence of data on the estimates of parameters. The basis is a single run. Then, one of the active parameters is changed by 10%, and fixed at that value. The remaining free parameters are estimated. The primary output is the values of the contributions to the objective function by each observed data. This will indicate data that would 'prefer' the new value of the parameter, and data that would 'prefer' the old one, which is an indication of the influence of the individual data on the final estimates of crucial parameters. The output to be presented is the change in objective function contributions for the data that have the largest impact.

Post processing

Output files

The output from a single assessment run is on 2 files:

1) Standard report file (Summary.txt) , with tables of *F(a,y)*, *N(a,y)* and a summary table with annual Recruitment, TSB, SSB, mean F and reported catch in weight.

2) Output file (Output.txt): Has all the remaining information that is needed for post-processing:

For each data source:

- A table of observed values
- A table of modeled values.
- A table of weightings
- A table of Phi-values (contributions to the objective function from individual data)

In addition, bootstrap runs and retrospective runs generate files with the main results.

The post processing routines are written in Delphi (Pascal). These are stand-alone programs. The only link to TASACS is through the files mentioned above, and through their place in the program organizing framework. Hence, making other post-processing routines in other languages (for example R) can be done without interfering with the other parts of the TASACS package.

Graphical output.

The TASACS package has a set of graphical routines, to display the results and some diagnostics.

Output from the summary table.

This is a set of 4 graphs showing the time course of Recruitment, SSB, F and Catch.

Residual plots and phi-plots:

Residual plots are bubble plots of the log ratio $ln(x(a,y)/\hat{x}(a,y))$ between each observation x and its modeled counterpart $\hat{x}$. Both unweighted and weighted residuals are shown. In the same plot, there is a display of the phi-values which are the actual contributions to the objective function from each observation. Finally, the weightings of the observations are displayed as bubbles.

Comparison of distributions of modeled and observed values:

Q-Q plots.

These are plots of the cumulated distribution of observed and modeled values. Let x(i)) be the ith value of the cumulated distribution of the observations x_i, $i=1..n_{obs}$, and $\hat{x}_i$. the model value representing this observation. The Q-Q plot is an x-y plot of the x_i versus the $\hat{x}_i$. Plots are made separately for each category of observations.

An adaptation of Kolmogorovs test for goodness of fit (Kolmogorov plots):

Kolmogorovs test is in itself a test on the deviation of the empirical cumulated distribution of observations from an assumed parametric distribution. In our case, we regard the modeled values as the parametric model. Their distribution is complex at best, but we have discrete values that have been calculated, and we want them to be as close to the observations as possible. The test looks at the whole ensemble of observations as a distribution, which we also do here.

Let $F(x)$ be the cumulated distribution of x_i, $i=1..n_{obs}$, i.e. $F(x) = 1/n_{obs}*\{\text{number of } x_i < x\}$. Let $F_{mod}(x)$ be defined the same way, on the set of modeled values $\hat{x}$. Then, the Kolmogorov statistic is

$$D = \sup_{x \in (-\infty,\infty)} | F(x)-Fmod(x) |$$

Procedure:

For each category of observations (i.e. catch numbers at age and year, indices from one survey etc. sort the modeled values. For each of the model values $\hat{x}_i$ (the number i in the row), count the number j of observed values x that are smaller than $\hat{x}_i$, and note the value $|i/n_{mod}-j/n_{obs}|$. The criterion is the largest of these values.

The plot shows for each observation, the rank *i* of the observation vs. the rank *j* of the corresponding modeled value.

Year class plots.

These are plots of all information about each year-class, assembled in one graph. The values are normalized (the largest value of each kind of data is set to 1) to facilitate comparison. The panel to the right allows selecting the kind of information to be displayed, and to set colors and line types.

Year class Ns

These are plots where all information that is considered by the objective function (survey date and – with a separable model. catch data, are translated to N-values with the estimated catchabilities and fishing mortalities. This gives an indication of the 'message' in each observation, on a common basis. The plots can include all data on the input file and just those considered by the objective function (i.e. those with a non-zero weighting).

Bootstrap output

The plots showing bootstrap results has 4 panels:

- SSB: 10, 50 and 90 percentiles, and the SSB in the original run
- F level: 10, 50 and 90 percentiles, and the SSB in the original run
- A banana-plot with F-level and SSB in the last model year for each replica
- The cumulated distribution of objective function values, with the objective function value of the original run indicated.

Retrospective output.

Bundle plots showing F-level, SSB and recruitment for each retrospective year.

Annex 3: Technical Minutes RGWIDE

REVIEW OF ICES WGWIDE REPORT 2008

ICES headquarters, 29 Sept - 30 Sept 2008

Reviewers: Ghislain Chouinard (chair, Canada)

António Ávila de Melo (Portugal)
Jan Horbowy (Poland) (by correspondence)

Robert Mohn (Canada) (by correspondence)

Chair WG: Beatriz Roel (UK)

Secretariat: Cristina Morgado

General

The Review Group examined the assessments conducted by the Working group on widely distributed stocks during September 2008. The review considered the following stocks:

i) Northeast Atlantic Mackerel (combined Southern, Western, and North Sea spawning components)

ii) Western, southern and North Sea horse mackerel (*Trachurus trachurus*)

iii) Sardine in Divisions VIIIc and IXa

iv) Norwegian spring-spawning herring

v) Blue whiting combined stock (Subareas I–IX, XII, and XIV)

The review also considered the general sections and the responses to four special requests concerning blue whiting and Northeast Atlantic mackerel. The Review group noted the large volume of information considered by the Working Group and the breadth of the techniques used in the analyses. The use of different approaches with different assumptions is often a powerful tool to investigate the robustness of the analyses and the Working Group has done a lot of good work in that regard. The Review group also noted that the WG paid particular attention to items raised in the technical minutes of the previous review and addressed many of them during their work.

The report was generally well written and clearly structured. The level of details was good, however reviewers with little or no specific knowledge of these assessments would need to have more background (i.e. objectives, methods, areas covered) for some of the surveys (e.g. sardine DEPM surveys) used as abundance indicators. It is not suggested here that the report be expanded but that reference documents on the history, gear, survey coverage and other aspects be referenced and be placed on the Sharepoint to be accessed by the reviewers.

For this report, no stock annex section (technical annex) was produced with the report. However, the RG recognizes that the Working Group had a large workload. Some of the information normally found in such an annex could be found in the Introduction of the report (assessment checklists) but not for all stocks (e.g. Blue whiting). The production of such an annex could be simplified by using the checklists found in the Introduction as the technical annex and moving this information to the "Stock Annex section". As well, it would be important to specify the age range and period included in the catch-at-age, the age range and period for each of the abundance indices used in the assessment, the assumptions of the models and the parameters estimated. For stocks with benchmarks and well established assessments, much of this work should be done in advance of the WG meeting and modifications could be made during the meeting as necessary.

The RG also acknowledge the Ecosystem section and considered both in the Introduction and in the stock specific sections. The WG did a good job at summarizing potential ecosystem impacts in general and specifically for each stock. This represents a step forward to the integration of ecosystem information in the advice. Where possible such as where specific relationships or mechanisms have been identified, it would be useful to extend the discussion to the current context. For example, in the case of sardine a study reported that recruitment appeared to be related to temperature. In this instance, it would have been useful to indicate what the outlook could be for sardine recruitment given the recent observed temperature.

In the tables of the results of the short term catch projections, it appears that Biomass values are beginning of the year and SSB values are mid-year (see Tables 2.8.3 and 8.9.1.2. as examples). This should be clearly indicated in the tables.

Benchmark assessment proposal

Benchmarks to be performed **before the next assessment**

Stock	Problem	Last benchmark

Northeast Atlantic Mackerel (combined Southern, Western, and North Sea spawning compents

Assessment type	Update assessment
Assessment:	presented and agreed
Forecast:	presented and agreed
Assessment model:	ICA
Consistency:	same as last year with addiction of 1 extra year and +12% revision of the egg survey index value for 2007.
Stock status:	WGWIDE proposed new reference points. Based on these new reference points B would be above Blim and Bpa and F between Flim and Fpa
Man. Plan.:	Yes, evaluated by ICES (ICES 2008. Report on NEA mackerel long-term management scientific evaluation. ICES CM 2008/ACOM:54)

General comments

1) From a description of the discards, there are some estimates (included in the assessment) but they only account for part of the discarded fish. On p. 60 it is written: "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". The RG considers that if export data to Japan are available, then this data combined with the size distribution of catches could be used to roughly estimate that portion of discards. This requires intercessional work.

2) Underreporting seems to be the problem for this fishery. As the figures for underreported catches may be difficult to obtain, sensitivity of the assessment to some realistic levels of underreporting could be provided.

3) Several options for estimating recruitment with RCT3 were considered, results are only provided on Figure 2.4.3.3.1. The WG concluded that recruitment data were noisy and the calibration regression did not provide improved information over GM. However, more detailed documentation of this analysis and at least one RCT3 output as an example and input data could be provided.

4) In the projection, the exploitation pattern was scaled to terminal F. As there is no trend in fishing mortality in recent years the RG would rather scale it to average F of recent three years. This will not have significant impact on the current prediction as differences in these Fs were minor (3 years average F is 0.24 while F2007 =0.25).

5) The RG noted that the update of the egg survey index for 2007 changes the perception of the stock compared to the 2007 assessment using the previous survey index, with a 9.5% increase for TSB, 8.9% increase for SSB and a 10.2% decrease for the fishing mortality.

Technical comments

Improvements for next year:

The RG recommend the WG to use, if available, export data to Japan and size distribution of catches to arrive at discards estimate.

In the next assessment, if there is still no trend in the fishing mortality in recent years, the RG recommend the use of the projection exploitation pattern scaled to the average F of the three most recent years.

hings that need update before ADG:

None

Conclusions

RG agrees with WG on Northeast Atlantic Mackerel (combined Southern, Western, and North Sea spawning components) stock.

North Sea horse mackerel (*Trachurus trachurus)*

Assessment type	Update landings only
Assessment:	No assessment
Forecast:	None
Assessment model:	None
Consistency:	same as last year
Stock status:	not known
Man. Plan.:	No management plan

General comments

The report should include a full description of sampling intensity to accompany Table 4.4.3.

Technical comments

Improvements for next year:

Things that need update before ADG:

N/A

Conclusions

RG agrees with WG on stock

Western horse mackerel (*Trachurus trachurus*) (Divisions IIa, IVa, Vb, VIa, VIIa-c,e-k, VIIIa-e)

Assessment type:	Exploratory assessment
Assessment:	presented
Forecast:	not presented
Assessment model:	SAD version for 2008
Consistency:	SAD08 explicitly incorporates and directly fits potential and realised fecundity data, with separate parameters for the two types of fecundity data. The realised fecundity data point and associated CV is now derived from a normal distribution which covers the range of realised fecundity values reported recently and so allowing the incorporation of a more realistic level of uncertainty about realised fecundity.
Stock status:	SSB increased from 2001 till 2005, declining since then but so far well above the proxy for Blim (the 1982 SSB, that produced the largest year-class of the 1982-2007 interval, despite being at the lowest level of the SSB trajectory); fishing mortality stable at ages 1-3 and declining trough older ages (4-8); 1982 year-class exceptionally high, followed by moderate year-classes on the first half of the 1990's, an above average year-class on 2001 and weak ones since then.
Man. Plan:	Management plan evaluated by ICES, providing a constant TAC set for 3 years. The TAC was last set in 2007, based on an egg production estimate derived from triennial egg survey results, and will remain unchanged for 2008-2010. But so far the TAC has only been given for a partial distribution of this stock whereas it should apply to all areas where western horse mackerel is caught.

General comments

The TAC set by EU is not in accordance with the distribution of the stock.

French and Spanish bottom trawl and acoustic surveys are carried out in a systematic and standardized way, covering different areas of the western horse mackerel distribution. As regards each type of survey, efforts should be made in order to derive combined age disaggregated abundance indices to be used within the assessment framework.

The existing egg surveys are not able to cover to full extent the end of the horse mackerel spawning event, despite their good geographical coverage. Furthermore, being horse mackerel an indeterminate spawner, egg production conversion to SSB is bleak

Catch-at age data analysis suggests that selection has shifted towards younger fish over the past decade.

Technical comments

The simulation testing of the assessment model suggests that unbiased population estimates rely on the assumption of constant realized fecundity over time, but not on either a high or fishing mortality scenario.

The reliability of the results is heavily dependent on the reliability of the realized fecundity parameter and its stability over time. Although estimates for the uncertainty of the egg input data are available, the assessment model does not take this uncertainty into account. If there is an increasing trend in the realized fecundity parameter that is not accounted for, then the model over-estimates SSB and recruitment, and underestimates fishing mortality and realized fecundity. Even in the case of realized fecundity parameter varying randomly over time performance is also poor, producing large relative errors.

The comparison between the results of two models, SPALY and SAD08, shows that the differences observed between the trajectories of SSB, recruitment and fishing mortality are dependent on the similarity of magnitude of the CV associated with the realised fecundity parameter incorporate in both models.

A recent change in selectivity-at-age for younger ages violates the assumption of constant selectivity in the separable period and should be contributing to the retrospective bias of the assessment.

Substantial 5-year retrospective bias; substantial differences between results from SAD versus (unchanged) SPALY model; selectivity at age sensitive to the length of SAD separable window.

Improvements for next year: include independent estimates of uncertainty related to realised fecundity into the model. Explore the performance of age structured models not dependent on fecundity data and allowing for flexibility on catchability and selectivity at age.

Things that need update before ADG:

N/A

Conclusions:

RG agrees with WG on stock

Southern horse mackerel (*Trachurus trachurus*) (Division IXa)

Assessment type	full assessment
Assessment:	presented and agreed
Forecast:	a short-term forecast was carried out by fixing a TAC for the whole period (2008-2010) at the status quo catch of the year 2007 (23000 ton.), assuming a constant recruitment given by the 1992-2006 geometric mean of the estimated recruitments, and assuming no changes in the selectivity pattern of all fleets.
Assessment model:	The ASAP model was used in the version ASAP 2.0.18.
Consistency:	Catch data disaggregated by fleets and SSB indices from the egg surveys included in the present assessment.
Stock status:	Reference points have not been defined for this stock. No apparent trend on fishing mortality since late 1990's. SSB increasing recently, being slightly above the average level of the past decade. Strong recruitment in 1996, followed by another one in 2004.
Man. Plan.:	No management plan evaluated by ICES. The assessment indicates an increase in SSB on recent years, linked to the above average recruitment in 2004. The apparent stability in the overall exploitation level is due to a decrease in fishing mortality in most fleets, but a sharp rise is observed in the fishing mortality of the Spanish bottom-trawl fleet operating in Subdivision IXa North. Status quo catch will not hamper the actual SSB increase, if current catch and current exploitation pattern in all fleets is kept constant as well.

General comments

1) Catch statistics for the period 1991-2007 have been reviewed in order to split them by Subdivision (VIIIc or IXa). The Spanish catches in Subdivision IXa South (Gulf of Cádiz) since 2002 are now available. These catches represent less than the 5% of the total catch and so far are not included in the assessment. Apart a peak in 1998, total catch from 1991 till 2007 don't present an overall trend. Nevertheless, the higher proportion of catches from the Spanish fleets observed since 1997 could have induced a shift in the overall exploitation of this stock (Portuguese bottom-trawl and purse-seine fleets have exploitation patterns focused on juvenile age groups, while Spanish bottom-trawl and artisanal fleets are targeting adult fish).

2) Portuguese and Spanish bottom trawl surveys are available, with gears having a similar catchability for horse mackerel despite their different design. These surveys provide combined tuning indices for the whole distribution of the stock. Each year-class index was smoothed with a moving average in order to reduce the wide inter annual variability of the survey indices. Cohorts present a consistent decreasing pattern in the combined survey data set

3) Three SSB estimates from egg production estimates using DEPM were available for 2002, 2005 and 2007. This SSB index was treated as relative in the assessment and associated to a catchability.
4) In order to have a proxy of the stock size trajectory back in time, historical effort and catch data for the Portuguese bottom trawl fleet have been collected and analysed. A new CPUE at age series from one Spanish fleet operating mainly in Subdivision IXa North is now available, but still considered to be too short to be used in the assessment. The preliminary CPUE at age analysis suggests that this fleet could provide useful information on mortality for older ages (8 plus).
5) In 2007 a new estimate of maturity proportion by age is available for Division IXa. A maturity ogive from Subdivision IXa South was adopted for the 1992-2006 interval.

Technical comments

The ASAP model is constrained to a Beverton and Holt spawner-recruit relationship in order to generate predicted recruitment each next year from previous year SSB.

The objective function in ASAP is the weighted sum of a number of negative log-likelihoods, all of them containing an input weight (lambda) that allows different emphasis on each particular component of the objective function. These weights are dependent of the user perception on the quality of each type of input and correspondent priority should be given to achieve a good fit to the most accurate data sets first.

Apart clear year effects on the residuals of the fit to the survey data (but no patterns across ages), the model is generally well fitted to the other data sets (total catch, catch proportions at age by fleet and the three SSB's derived from the egg surveys).

No systematic bias is detected either on SSB, recruitment trajectories or selectivity patterns by fleet on the 4 year (2007-2004) retrospective analysis from the ASAP assessment.

Improvements for next year:

In order to explore the future effects that the particular selection pattern of each fleet could have on the horse mackerel population, short term stochastic projections should be carried out under a (constant) total catch within a range of percentages of the status quo catch, but allowing random variability of recruitment within the 1992-2007 estimated recruitments.

Things that need update before ADG:

N/A

Conclusions:

RG agrees agree with WG on stock

Sardine in Divisions VIIIc and IXa

Assessment type	Update assessment
Assessment:	presented and agreed
Forecast:	presented and agreed
Assessment model:	AMCI (Assessment model incorporating data from various sources)
Consistency:	same as last year with addition of 1 extra year
Stock status:	stock currently slightly above average of last 30 years but declining and expected to decline further as recruitment has been poor in recent years. There are no reference points for this stock
Man. Plan.:	no management plan exists for this stock.

General comments

1) The TOR for this stock was met as it was an update assessment. The catch and abundance indices were updated appropriately, data from Ireland was preliminary but they normally contribute a very small percentage of the total catch. The fishery landings come exclusively from directed fishing trips. It is noted that some of the catch included in the assessment comes from areas outside VIIIc and IXa but near the border of these areas. This raises issues of stock delineation.

2) While this was an update assessment, some new analyses were conducted. For example, French acoustic surveys (2000-2008, excluding 2008), conducted outside of the stock area, were explored to investigate the consistency of year-class signals. This would be useful to explore the potential links of sardines from XIIIc and IXa with sardines from other areas. The WG is encouraged to continue such analyses.

3) The surveys are well described relative to the last survey conducted, however the WG report would benefit from having a more complete description of the survey in terms of time series available and the age groups comprised within each index and used in the assessment. Some, but not all, of that information can be found in the checklists in the Introduction section. It would be useful to place that information in a technical annex and expand the descriptions (e.g. indicate ages in the catch- at-age used in the assessment, indicate the ages used in the assessment for each survey, where global SSB index, indicate ages included).

4) In section 8.8.2 on Reliability of the assessment, it is indicated that the result of this years' assessment are comparable to those obtained last year. It should be noted that this observation has more to do with consistency than to reliability. One could have a consistent assessment that is unreliable.

Technical comments:

Some figures were corrected in the report.

Conclusions

While there appear to be uncertainties in stock structure, the RG agrees with the WG on Sardine in Divisions VIIIc and IXa.

Norwegian spring-spawning herring

Assessment type	Benchmark assessment
Assessment:	presented and agreed
Forecast:	presented and agreed
Assessment model	VPA (TASACS framework)
Consistency:	similar to last year – VPA but with a different model (Seastar / TASAC)
Stock status:	B above Blim and Bpa, F below Fpa
Man. Plan.:	Man. Plan since 1996, evaluated by ICES but not this year

General comments

1) The RG noted that the work conducted was generally extensive and consistent with a benchmark assessment. There was extensive analysis and exploration of the information including catch curve analyses of both catch and survey data as well as analyses of the coherence of the survey information in tracking year-classes. More detailed information on potential unaccounted mortality could be useful. The level of sampling in this fishery appears to be very adequate.

2) The RG concurs with the recommendation of the WG to pursue the exploration of the back-calculation method referred to in the WG report for the determination of proportion mature at age.

3) Several stock assessment methods were examined including several contained in the TASACS toolbox, TISVPA and SeaStar. Results of the various analyses were similar except for ISVPA which was considered less reliable because of strong cohort effects. The VPA within TASACS was chosen as the selected model. The RG considered that the selection was done objectively as it was based on the somewhat better fit of the survey data to the catch data.

Technical comments

The RG notices that there was a discussion of natural mortality values. The RG considered that the WG option for the *M* value, were relatively low, when compared to some other long lived species that use *M* of 0.2 in the assessment. The RG considered that it would be instructive to produce a profile of a range of *M*'s and the resultant sum of squares from at least one of the models presented. These profiles are even more valuable if the individual terms of the objective function are plotted as well as the total as it shows which data sources are pushing the *M* to higher of lower values. This might help with the observation made in several places that the data chosen is more important than the model chosen. The WG conducted analyses with different *M* and found that these indeed suggested a low *M*. It was indicated by the Chair of the WG that the *M* value used in the assessment was derived from tagging studies.

It was noted that estimates of natural mortality may also be available from multi-species VPA and the values derived in these models should be compared with those used in the assessment.

The RG considered that a diagnostic using the objective function and terminal F for TASACS could also be in the form of profiles as in ISVPA. Although a bit more work, the profiles are easier to interpret if they are in terms of likelihood instead of SSQ. The RG noted the large retrospective pattern which is understood to be associated with the 2002 year-class and apparent in all models tested. A measure of the magnitude of the retrospective patterns could be obtained by comparing them to the uncertainties in the estimates as illustrated in figure 9.5.3.6. The RG noted that a recent GARM meeting in the USA had resulted in useful tools for dealing with such problems.

Results of the benchmark assessment are consistent with results from last year.

Improvements for next year:

The retrospective patterns remain fairly large and, though the cause appears to be identified, methods that may help resolve these patterns could be explored further.

In terms of ecosystem relationships, the relationship between herring abundance and trends in R/SSB of demersal species such as cod should be investigated as herring are believed to consume cod larvae. At high herring biomass, one could expect lower R/SSB ratios for cod assuming other conditions are constant.

Things that need update before ADG:

Conclusions

RG agrees with with the WG on Norwegian spring-spawning herring.

Blue whiting combined stock (Subareas I–IX, XII, and XIV

Assessment type:	Update assessment
Assessment:	presented and agreed
Forecast:	presented and agreed
Assessment model:	Stochastic multi-species (SMS) was used to provide the final assessment. Analyses with FLICA, TISVPA and XSA were also conducted and resulted in similar trends and values for F, SSB and recruitment.
Consistency:	Similar to last year with the addition of one year. In addition, there was a change in the two periods with constant selection pattern.
Stock status:	B is above Bpa, F is below Flim but above Fpa (harvested unsustainably), 2005, 2006 year classes are amongst the lowest, 2007 year class also probably low.
Man. Plan.:	Yes, in place since 2006 but found not to be precautionary. A new draft plan has been suggested and was evaluated by the WG in May and September 2008 (this review). The WG concluded that the proposed plan is not consistent with the precautionary approach but suggested one change which would make it precautionary.

General comments

1) This stock used to be assessed as 2 stocks but is now assessed as 1 stock. Recent genetic analysis (2008) seems that there may be more than one component. The RG agrees that until more information is available the stock be assessed as one unit but that information on stock identity is reviewed regularly.

2) Discards are thought to be small in the fishery but it would be useful to present any available data on this issue. It would be useful to have some indication of the reliability of the reporting of blue whiting as by-catch in other fisheries. This is a large stock and fishery sampling is extensive though not to the extent required by regulation. The RG concurs with the WG recommendation to review the precision levels of the sampling programme.

3) Fishing mortality has declined from 2004 to 2006, but has increased slightly to 0.41 in 2007. SSB has declined since its historical peak in 2003 at around 7 million tonnes to 3.4 million tonnes at the beginning of 2008. A TAC of 1.25 million t in 2008 in combination with the small 2005-2007 year class will reduce SSB further to just above Bpa 1st January 2009.

4) The RG appreciated the efforts made by the WG to produce comprehensive analyses. In addition to the analyses to determine the periods for the selectivity constants, the sensitivity to the weights attributed to the IBWSS was also examined and assessments using 3 other techniques (FLICA, TISVPA and XSA) were also explored. These analyses suggested that the

results do not depend heavily on the weights attributed to the survey or the stock assessment method used.

Technical comments:

It would be useful to provide the rationale why the Norwegian bottom trawl survey in the Barents Sea is not used in the assessment. It is understood that the survey is conducted in late March which coincides with the end of the spawning season which takes place off Ireland. However, age 1 are available from 1981 onwards and used in the recruitment predictions. The RG suggests that the use of age 1 from this survey in the assessment model could be investigated.

The SMS assessment has been used as final assessment, following the approach used in the last three years. Some work on choice of constant selectivity periods was done; in the previous assessment the periods were arbitrarily chosen. The selection was based on log-likelihood and residuals distribution. This resulted in the 1999 and onwards being selected as best for second constant selectivity period. The RG considered this an improvement but noted that information from the fishery and the biology could also have been considered. Obviously, changes in selection may be due to change in fishing gears and/or change in growth rate. Large trends in growth decline have been observed for blue whiting. The changes in growth could also be taken into account when selecting the selection periods. The RG noted that the 2nd selection period matched well with the period of relatively stable weight at age in spawning stock survey ((Figure 10.4.3.1.2).

A comparison of the present assessment with an assessment using last year periods for constant selection would give more precise information on the sensitivity of assessment to the choice of constant selection period. A comparison of figures 10.5.1.8 (retrospective) and 10.5.1.9 (historical performance) suggests that the change in constant selection period does not have a large effect.

In projections, the recruitment (2006-2007 yc) was taken as the lowest observed (1980 yc), following RCT3 analyses which indicated very low estimates, finally considered unrealistically low. While the RG can accept that approach, the statement in the WG report on p. 579 relating to this would need to be revised. The sentence reads "For forecast it is assumed that the age-1 abundance in 2007 and 2008 are at the same level as the lowest recruitment in the full assessment period. This assumption gives a s-lightly higher recruitment compared to the estimates from the surveys alone". The RCT3 estimates were 1700-1800 (p. 615) while the value used in prediction is ca. 3280 and much higher in relative terms. The projection with RCT3 recruitment estimates for comparison could be done as both survey and catch data indicate very low 2006 yc.

The WG prepared RCT3 data file "by years" instead of "by year-classes" which creates confusion on the output (p. 615) where reference is to year-class but in WG configuration it is year.

The text over the text table on p. 577 indicates that data used in projections are in bold which not the case is.

Improvements for next year:

- Investigate the use of age 1 index from the Norwegian bottom trawl survey in the Barents Sea in the

-During discussion of the advice, it became apparent that the original Flim may not have been correctly derived originally. This should be examined in the WG assessment.

Things that need update before ADG:

N/A

Conclusions

RG agrees with WG on stock status

<u>Special requests</u>

EC/Faroe Islands/Iceland/Norway request on long-term management of blue whiting

Request

The full text is in the advice. The specific items to be delivered are identified below:

1) ICES are requested to assess whether the draft 1ong-term management plan is in accordance with the Precautionary Approach.

2) ICES are requested to assess the medium-term consequences of the application of this plan.

3) ICES are invited to suggest and to evaluate alternative values for the "trigger biomass" value of 2.5 million tonnes and the target fishing mortality rate.

4) ICES are requested to provide a range of options in accordance with paragraph 5 of Annex I for the reduction of fishing mortality to the target level identified in paragraph 4 of Annex I with a clear indication of the associated levels of risk and uncertainty.

Comments

Sufficient analyses were conducted following previous analyses in May and the TOR's of the request have been addressed. It would be useful to refer to the figures in the text. For the non-technical reader, it would be useful to indicate that the risk to Blim is denoted by Plim.

Irish request on management plan for blue whiting and stock structure

Request

Ireland requests ICES to consider the following two questions as part of its evaluation process Ireland takes the view that these questions are important considerations in the development of a blue whiting management plan.

> *1. Should such a management plan include provision for the separate management of juveniles, as is the case for North Sea herring?*
>
> *2. What is the latest scientific information on the stock structure of blue whiting? Any plan that is developed would have to be robust to possible changes to the assessment and management units.*

Comments

The yield per recruit analyses conducted to reply to question 1 are considered adequate and thus the advice is well supported by analyses. Question 2 was addressed by a summary of recent research of stock identity of blue whiting and provides the necessary information as well as advice on the exploitation strategy in order to be precautionary.

Irish request on long-term management for North East Atlantic mackerel

Request

In light of the scientific report on long term management for mackerel, Ireland requests ICES:

> *(1) to identify the appropriate Fpa for NEA mackerel;*
>
> *(2) to comment on the appropriateness of the range of fishing mortalities specified in the existing TAC setting arrangement of the Coastal States, should any change in Fpa be identified.*

Comments

Adequate response supported by analyses.

Norway/EC/Faroe Island request regarding the management of mackerel in the North-East Atlantic

Request

1. In its 2007 advice, ICES presented analyses indicating that unreported catches are still a major uncertainty affecting the reliability of the assessment. The coastal States request ICES to:

> *i. Provide estimates of the magnitude in tonnes and precision of the unaccounted mortality in the fisheries on North-East Atlantic mackerel;*
>
> *ii. Indicate where possible the sources of this mortality;*
>
> *iii. Evaluate where possible any historical changes in this unaccounted mortality;*
>
> *iv. Provide estimates of historic Spawning Stock Biomass and Fishing Mortality that*
>
> *would be compatible with these estimates of unaccounted mortality.*

2. The coastal States request ICES to include the North-East Atlantic mackerel stock in their routine reviews of reference points.

Comments

Adequate response supported by analyses