ICES STOCK ANNEX WGCSE REPORT 2009

ICES ADVISORY COMMITTEE

STOCK ANNEXES TO ICES CM 2009/ACOM:09

Stock Annexes to the Report of the Working Group on the Celtic Seas Ecoregion (WGCSE)

13–19 May 2009

Copenhagen, Denmark

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CIEM Conseil International pour l'Exploration de la Mer

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Annex 3.2: Stock Annex for CodVIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock: West of Scotland Cod (Division VIa)

Working Group: Celtic Seas Ecoregion

Last updated: 15 May 2009

A. General

A.1. Stock definition

Cod occur mainly in the central and northern areas of Division VIa. Young adult cod are distributed throughout the waters to the west of Scotland, but mainly occur in offshore areas where they can occasionally be found in large shoals. Tagging experiments have revealed that in late summer and early autumn there is a movement of cod from west of the Hebrides to the north-coast areas. There is a return migration in the late winter and early spring. There is only a very limited movement of adult fish between the West Coast and the North Sea.

Recent surveys of spawning fish distribution in ICES Area VIa (West of Scotland) suggested the persistence of the main spawning concentrations identified over 50 years ago by egg surveys. From 383 cod tagged during the spawning season and recaptured during successive spawning seasons >90% were recaptured within 80 km of coastal release sites, such as the Clyde, Moray Firth and the Minch. Cod released at these coastal spawning grounds also tended to remain in these areas during the summer feeding season implying that they belonged to resident spawning groups, (Wright *et al*., 2006).

A.2. Fishery

The minimum landing size of cod in the human consumption fishery in this area is 35 cm.

The demersal fisheries in Division VIa are predominantly conducted by otter trawlers fishing for cod, haddock, anglerfish and whiting, with bycatches of saithe, megrim, lemon sole, ling and skate *sp*.. Since 1976, effort by Scottish heavy trawlers and seiners has decreased. Light trawler effort has declined rapidly since 1997 after a long-term increasing trend. Cod is believed to be no longer targeted in any fisheries now operating in ICES Division VIa. Cod are a bycatch in *Nephrops* and anglerfish fisheries in Division VIa. These fisheries use a smaller mesh size than the 120 mm mandatory for cod targeted fisheries, but landings of cod are restricted through bycatch regulations.

2000 onwards

Emergency measures were introduced in 2001 to allow the maximum number of cod to spawn (see emergency measures below). Council Regulation No 423\2004 introduced a cod recovery plan affecting Division VIa. The measures only took effect, however east of a line defined in Council Regulation No 51\2006 known as the west of Scotland management line (see Figure A9.1). For 2009 a new line was defined in the cod long-term management plan Council Regulation No 1342\2008 (Figure A9.1). Vessels operating west of this line and conforming to criteria within the plan can claim extra fishing effort up to specified limits but are now otherwise still under the jurisdiction of the management plan.

From mid September 2003 to mid July 2004 the Irish trawl fishery off Greencastle, Co Donegal that traditionally targets juvenile cod was closed. The closure was instigated by the local fishing industry to allow an assessment of seasonal closure as a potential management measure. The fishing industry again called for and received statutory instruments closing the fishery from November 2004 until mid February 2005 and from mid November until 14th February 2006. The closure is expected to have reduced the Irish fishing mortality on cod that would otherwise have occurred in 2003 to 2005. The closure was not continued after 2005 because all vessels that fished in the area had been decommissioned. More generally, the days-at-sea limitations associated with the cod recovery plan and this seasonal closure has lead some of the Irish Demersal fleet to switch effort away from VIa.

At the end of 2005 the 'Registration of Buyers and Sellers' regulation (The Registration of Fish Buyers and Sellers and Designation of Fish Auction Sites Regulations 2005: Statutory Instrument 2005 No. 1605 and The Registration of Fish Sellers and Buyers and Designation of Auction Sites (Scotland) Amendment Regulations 2005: Scottish Statutory Instrument 2005 No. 438) was introduced in the UK and became fully operational from 1st January 2006. This implemented an EU directive as did the Irish 'Sales Notes' legislation. In summary these require that fish processed and sold in the UK and Ireland can be traced through the supply chain.

Because of restrictive TACs, seasonal/spatial closures of the fishery, and effort restrictions based on bycatch composition the probability of misreporting and under reporting in the past is considered to have been high. From 2006 under reporting is expected to have reduced to low or negligible levels as a consequence of the 'Buyers and Sellers' and 'Sales Notes' acts.

Technical measures

Technical measures regarding demersal fishing gear are laid out in Commission regulation (EC) 850/98 and were amended by regulation (EC) 2056/2001 specifically aimed at aiding cod recovery. Under regulation (EC) 2056/2001 the minimum mesh size for vessels fishing for cod in the mixed demersal fishery in EC Zones 1 and 2 (West of Scotland and North Sea excluding Skagerrak) changed from 100 mm to 120 mm from the start of 2002, with a one-year derogation of 110 mm for vessels targeting species other than cod. This derogation was not extended beyond the end of 2002. The increase in minimum mesh size from 100 to 120 mm in 2001/2002 partly caused a shift to *Nephrops* targeted fisheries using 80 mm mesh sizes.

Since mid-2000, UK vessels in this fishery have been required to include a 90 mm square mesh panel (SSI 227/2000), predominantly to reduce discarding of the large 1999 year class of haddock. Further unilateral legislation in 2001 (SSI 250/2001) banned the use of lifting bags in the Scottish fleet.

Under Council Regulation No. 51/2006 the use of gillnets has been banned outside 200 m depth. WGFTFB 2006 report that this has greatly reduced effort at depths greater than 200 m in VIa. The measure was aimed to protect monkfish and deep-water shark and it is unclear what effect it will have on cod.

Emergency measures, area closures and effort limitation

Emergency measures were enacted in 2001, consisting of area closures from 6 March–30 April, in an attempt to maximize cod egg production. These measures were retained into 2003 and 2004.

From mid September 2003 to mid July 2004 the Irish trawl fishery off Greencastle, Co Donegal that traditionally targets juvenile cod was closed (Irish Statutory Instrument

(SI) No. 431 of 2003). In December 2003 the closed area was extended along its eastern edge by amendment to the Statutory Instrument (SI No. 664 of 2003). A new Statutory Instrument (SI No. 670 of 2004) reinstated the closed area from 1st November 2004 until 14th February 2005. The closure was not instigated after 2005. This was because all vessels that fished in the area had been decommissioned.

The following area closures were in effect in 2008:

1) A closure in the Clyde for spawning cod from 14th February to 30th April. This closure has been operating since 2001 and was last revised by The Sea Fish (prohibited methods of fishing) (Firth of Clyde) Order 2002.
2) A closure introduced in 2004 by Council Regulation No. EC 2287\2003, known as the 'windsock'.

The closed areas that remain in force were reviewed by the STECF group on evaluation of closed area schemes (STECF-SGMOS-07–03).

Effort reductions for much of the international fleet to 16 days-at-sea per month have been imposed since February 2003 (EU 2003\0090). Initially days-at-sea allowances were defined by calendar month. From 2006 the limit was defined on an annual basis. The maximum number of days a fishing vessel may be absent from port to the West of Scotland varies for particular gears and the allocations since 2003 are given below:

GEAR	MAXIMUM DAYS ALLOWED					
	2003:	2004:	2005:	2006:	2007:	2008:
	Monthly limit			Annual limit		
Demersal trawls, seines or similar towed gears of mesh size ≥ 100 mm except beam trawls[1];	9	10	9			
Demersal trawls, seines or similar towed gears of mesh size between 70 mm to 99 mm except beam trawls[1];	25	22	21			
Demersal trawls, seines or similar towed gears of mesh size ≥120 mm except beam trawls;				91	85	70
Demersal trawls, seines or similar towed gears of mesh size 100 mm to 119 mm except beam trawls;				91	84	69
Demersal trawls, seines or similar towed gears of mesh size between 90 mm to 99 mm except beam trawls;				227	227	227
Demersal trawls, seines or similar towed gears of mesh size between 70 mm to 89 mm except beam trawls;				227	227	204
Demersal trawls, seines or similar towed gears of mesh size between 16 mm to 31 mm except beam trawls.	23	20	19	228	228	228

[1] Replaced by new mesh size ranges.

For 2009 effort limits were changed to be on the basis of a kWdays effort pot assigned per nation per fleet effort category. The baselines assigned in 2009 were based on track record per fleet effort category averaged over 2004–2006 or 2005–2007 depending on national preference. The following table lists the new fleet effort categories and demonstrates how they map to the previous gear groups.

GEAR GROUP (2006–2008)	GEAR GROUP 2009
Demersal trawls, seines or similar towed gears of mesh size ≥120 mm except beam trawls;	TR1
Demersal trawls, seines or similar towed gears of mesh size 100 mm to 119 mm except beam trawls;	TR1
Demersal trawls, seines or similar towed gears of mesh size between 90 mm to 99 mm except beam trawls;	TR2
Demersal trawls, seines or similar towed gears of mesh size between 70 mm to 89 mm except beam trawls;	TR2
Demersal trawls, seines or similar towed gears of mesh size between 16 mm to 31 mm except beam trawls.	TR3

The documents listing these days at sea limitations are:

YEAR OF APPLICATION	REGULATION
2003	(EC) No 2341/2002–Annex XVII
2004	(EC) No 2287/2003–Annex V
2005	(EC) No 27/2005–Annex IVa
2006	(EC) No 51/2006–Annex IIa
2007	(EC) No 41/2007–Annex IIa
2008	(EC) No 40/2008–Annex IIa
2009	(EC) No 43/2009–Annex IIa

A Commission Decision (C (2003) 762) in March 2003 allocated additional days absent from port to particular vessels and Member States. UK vessels were granted four additional days per month (based on evidence of decommissioning programmes). An additional two days was granted to demersal trawls, seines or similar towed gears (mesh ≥ 100 mm, except beam trawls) to compensate for steaming time between home ports and fishing grounds and for the adjustment to the newly installed effort management scheme.

Subsequently it has been possible for vessels to qualify for extra days-at-sea if special conditions (specified in the Annex) are met, (see relevant regulation Annex for details).

The new effort regulations provided an incentive for some vessels previously using >100 mesh in otter trawls to switch to smaller mesh gears to take advantage of the larger numbers of days-at-sea available. This would also require these vessels to be targeting *Nephrops* or anglerfish, megrim and whiting with various catch and bycatch composition limits after EC Regulation No 850/98 Annex I (with additional measures in Reg (EC) 2056/2001).

Management plan

Council regulation (EC) No 423\2004 set out a multi-annual recovery plan that constrains effort to specified harvest control rules. For stocks above $\mathbf{B}_{\text{lim}}$, the harvest control rule (HCR) requires:

1) setting a TAC that achieves a 30% increase in the SSB from one year to the next,

2) limiting annual changes in TAC to ± 15% (except in the first year of application), and,

3) a rate of fishing mortality that does not exceed $\mathbf{F}_{pa}$.

For stocks below $\mathbf{B}_{lim}$ the Regulation specifies that:

4) conditions 1–3 will apply when they are expected to result in an increase in SSB above $\mathbf{B}_{lim}$ in the year of application,

5) a TAC will be set lower than that calculated under conditions 1–3 when the application of conditions 1–3 is not expected to result in an increase in SSB above $\mathbf{B}_{lim}$ in the year of application.

For 2009 Council regulation (EC) No 423\2004 was repealed and replaced by Council regulation (EC) No 1342\2008. The objective of the plan is to ensure the sustainable exploitation of the cod stock on the basis of maximum sustainable yield while maintaining a fishing mortality of 0.4.

For stocks above B_{pa}, but where mortality is above 0.4 the harvest control rule (HCR) requires:

1) setting a TAC that achieves a 10% decrease in the fishing mortality in the year of application of the TAC compared with the previous year, or a TAC that achieves a fishing mortality of 0.4, whichever is the higher.

2) limiting annual changes in TAC to ± 20%.

For stocks above B_{lim}, the HCR requires:

3) setting a TAC that achieves a 15% decrease in the fishing mortality in the year of application of the TAC compared with the previous year, or a TAC that achieves a fishing mortality of 0.4, whichever is the higher.

4) limiting annual changes in TAC to ± 20%.

For stocks below B_{lim} the Regulation requires:

5) setting a TAC that achieves a 25% decrease in the fishing mortality in the year of application of the TAC compared with the previous year;

6) limiting annual changes in TAC to ± 20%.

In addition the plan states:

1) That if lack of sufficiently accurate and representative information does not allow a TAC affecting fishing mortality to be set with confidence then

   a) If advice is for catches of cod to be reduced to the lowest possible level, the TAC shall be reduced by 25%,

   b) In all other cases the TAC shall be reduced by 15% (unless STACF advises this is not appropriate).

2) TACs are to be set-net of discards and fish corresponding to other sources of cod mortality caused by fishing.

3) Initial baseline values for effort shall be set for effort groups defined by the Council then annual effort and cod catch calculated for those effort groups. For effort groups where the percentage cumulative catch is ≥ 20% of that for all fleets, maximum allowable effort shall be adjusted by the same amount as the TAC.

4) If STECF advises cod stocks are failing to recover properly the EU Council will set a TAC and maximum allowable effort lower than those derived from the HCR.

Decommissioning schemes

Between 2001 and 2003 165 Scottish vessels were decommissioned from the overall Scottish fleet (all areas), representing a 34% reduction in number of vessels compared with 1999. The Scottish Government estimates this represented a 30% reduction in effort by trawls of over 100 mm mesh. It is not known what proportion of these reductions came from Area VIa.

A.3. Ecosystem aspects

Geographic location and timing of spawning

Spawning has occurred throughout much of the region in depths <200 m. However, a number of spawning concentrations can be identified from egg surveys in the 1950s, 1992 and from recent surveys of spawning adult distribution. The most commercially important of these, range from the Butt of Lewis to Papa Bank. There are also important spawning areas in the Clyde and off Mull. The relative contribution of these areas is not known. Based on recent evidence there are no longer any significant spawning areas in the Minch. Peak spawning appears to be in March, based on egg surveys (Raitt, 1967). Recent sampling suggests that this is still the case.

The main concentrations of juveniles are now found in coastal waters.

Fecundity

Fecundity data are available from West, 1970 and Yoneda and Wright, 2004. Potential fecundity for a given length is higher than in the northern North Sea but lower than off the Scottish east coast (see Yoneda and Wright, 2004). There was no significant difference in the potential fecundity-length relationship for cod between 1970 (West, 1970) and 2002–2003 (Yoneda and Wright, 2004).

B. Data

B.1. Commercial catch

B1.1. Landings

The following table gives the source of landings data for West of Scotland cod:

	Kind of data				
Country	Caton (catch-in-weight)	Canum (catch-at-age in numbers)	Weca (weight-at-age in the catch)	Matprop (proportion mature-by-age)	Length composition in catch
UK(NI)	X				
UK(E&W)	X				
UK(Scotland)	X	X	X	X	X
Ireland	X	X	X		X
France	X				
Norway	X				

Quarterly landings and length/age composition data are supplied from databases maintained by national Government Departments and research agencies. These figures may be adjusted by national scientists to correct for known or estimated misreporting by area or species. Data are supplied in the requested format to a stock coordinator nominated by the ICES Northern Shelf Demersal Working Group, who compiles the international landings and catch-at-age data and maintains a time-series of such data with any amendments. To avoid double counting of landings data, each UK region supplies data for UK landings into its regional ports, and landings by its fleet into non-UK ports.

Quarterly landings are provided by the UK (Scotland), UK (E/W), UK (NI), France and Ireland .The quarterly estimates of landings-at-age by UK (Scotland) and Ireland are raised to include landings by France, UK (E/W), UK (NI) and Norway (distributed proportionately over quarters), then summed over quarters to produce the annual landings-at-age.

The Excel spreadsheet files used for age distribution, adjustments and aggregations can be found with the stock co-ordinator and for the current and previous year in the ICES computer system under **w:\acfm\wgnsds\year\personal\name** (of stock co-ordinator).

The result files (FAD data) can be found at ICES and with the stock co-ordinator, as ASCII files on the Lowestoft format, under **w:\acfm\wgnsds\year\cod-iris\input data\xsa_ica**

B1.2. Discards

EU countries are now required under the EU Data Collection regulation to collect data on discards of cod and other species. To date estimates of discards are available only from UK (Scotland) and Ireland. Observer data are collected using standard at-sea sampling schemes. Results are reported to ICES. A table of data made available by year is given below.

Country	1978–2003	2004–2005	2006–2008
UK(Scotland)	X	X	X
Ireland		X	

The quantity, length and age of cod discarded by Scottish *Nephrops* trawlers are collected during observer trips on board commercial vessels. Cod discarded by boats using other gears (heavy trawl, seine, light trawl and pair trawl) are also collected by Scotland. Cod discarded by otter board trawl and otter board/twin rig gears are collected by Ireland.

B.2. Biological

Natural mortality is assumed to be constant (M=0.2, applied annually) for the whole range of ages and years. There are no direct estimates of M.

Proportion mature-at-age is currently assumed constant over the full time-series.

Age	1	2	3	4+
Proportion mature-at-age	0.0	0.52	0.86	1.0

B.3. Surveys

Four research vessel survey series for cod in VIa have been available to the Working Group since 2005. In all surveys listed the highest age represents a true age not a plus group.

- Scottish first-quarter west coast groundfish survey (ScoGFSQ1): ages 1–7, years 1985–2008.

The survey gear is a GOV trawl, and the design is a minimum of one station per rectangle, but with more depending on logistic limitations. Ages are reported from 0 to the maximum obtained. The ages reported to ICES are restricted to 1–7. Sex/Maturity-Sex and Maturity (ICES 4-stage scale) are reported. The Scottish groundfish survey has been conducted with a new vessel and gear since 1999. The catch rates for the series as presented are corrected for the change on the basis of comparative trawl haul data (Zuur *et al.*, 2001).

- Irish fourth-quarter west coast groundfish survey (IreGFS): ages 0–3, years 1993–2002.

The Irish quarter four survey was a comparatively short series, was discontinued in 2003 and has been replaced, (by the IRGFS). There were also problems regarding consistency of survey methodology.

- Scottish fourth-quarter west coast groundfish survey (ScoGFSQ4): ages 0–8, years 1996–2007.

The Scottish quarter four survey was presented to the WG for the first time in 2005. To date it has not been accepted as suitable for inclusion in an assessment.

- Irish fourth quarter west coast groundfish survey (IRGFS); ages 0–3, years 2003–2007.

This survey uses the RV Celtic Explorer and is part of the IBTS coordinated western waters surveys. The vessel uses a GOV trawl, and the design is a depth stratified survey with randomized stations. Effort is recorded as minutes towed.

For surveys existing at the time survey descriptions are given in Appendices 1 and 2 of the Report of the 1999 meeting of the Northern Shelf Working Group (ICES CM 2000/ACFM:1). Up to 2008 the WG could not use the IreGFS, IRGFS or ScoGFSQ4 surveys in survey based analyses using the available software, as a consequence of insufficient number of ages consistently tracked by these surveys, (both the IreGFS and ScoGFSQ4 surveys track ages 1 and 2 well but not other ages). Therefore, all subsequent analyses were carried out using only the ScoGFSQ1 series.

B.4. Commercial cpue

The commercial cpue data available consists of the following:

- Scottish seiners (ScoSEI): ages 1–6, years 1978–2005.
- Scottish light trawlers (ScoLTR): ages 1–6, years 1978–2005.
- Irish otter trawlers (IreOTR): ages 1–7, years 1995–2005.

Table A9.1 summarizes commercial effort and landings-per-unit effort. No commercial cpue data have been used in the final assessment presented by the WG during any meeting since 1999, although the Scottish series were previously used in exploratory and comparative analyses. Irish otter trawl cpue data (IreOTR) were presented for the first time at the 2001 WG meeting. Updated series have been presented to subsequent meetings. Given the current concerns about misreporting of catch and effort, this series has not been considered further as a tuning fleet. No cpue data has been presented for years after 2005.

B.5. Other relevant data

None.

C. Historical stock development

Models used: XSA (up to 2001 WG); TSA (2002 and 2003 WG); TSA and XSA (2004 WG); SURBA (2005 WG). SURBA and TSA (2006 and 2007 WG); TSA (2008 WG).

Software used: Lowestoft VPA suite; Marine Lab Aberdeen TSA and SURBA software.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1978–last data year	1–7+	Yes
Canum	Catch-at-age in numbers	1978–last data year	1–7+	Yes
Weca	Weight-at-age in the commercial catch	1978–last data year	1–7+	Yes
West	Weight-at-age of the stock at spawning time.	1978–last data year	0–7+	Yes
Mprop	Proportion of natural mortality before spawning	1978–last data year	1–7+	No-set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1978–last data year	1–7+	No-set to 0 for all ages in all years
Matprop	Proportion mature-at-age	1978–last data year	1–7+	No-the same ogive for all years
Natmor	Natural mortality	1978–last data year	1–7+	No-set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range	Usage
Research Vessel Survey				
Tuning fleet 1	ScoGFS-Q1	1985–last data year	1–7	Used
Tuning fleet 2	IreGFS-Q4	1993–2002	0–3	Not used
Tuning fleet 3	ScoGFS-Q4	1996–last data year	0–8	Not used
Tuning fleet 4	IRGFS – Q4	2003–last data year	0–3	Not used
Commercial cpue data				
Tuning fleet 5	Scottish Seiners	1978–last data year	1–6	Not used
Tuning fleet 6	Scottish Light Trawlers	1978–last data year	1–6	Not used
Tuning fleet 7	Irish Otter Trawlers	1995–last data year	1–7	Not used

XSA

Model Options chosen:

Tapered time weighting not applied

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 4

Survivor estimates shrunk towards the mean F of the final 5 years or the 5 oldest ages

S.E. of the mean to which the estimate are shrunk = 2.00

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

TSA

The current set-up of TSA was adopted at WGNSDS 2006 and reviewed and confirmed at WGNSDS 2007. The main issues are summarized in the following bullet points whereas long standing parameter values are given in a text table.

- No persistent trend in survey catchability is included as there is no *a priori* reason to suspect a trend in survey catchability and, without landings data to contrast against, there is no divergence between catch and survey data to measure.
- At WGNSDS 2007 a TSA run was also performed with catch data excluded for the years 1995–2005 but 2006 catch data included, (i.e. assuming 2006 commercial data to be unbiased). The mean F estimate reduced sharply for the terminal year but the WG concluded that such an approach introduced an inconsistency in the mortality time-series. It was considered the mortality estimate reverted from an estimate of mortality over and above M to one of fishing mortality. The WG also considered that the terminal year estimate combined with the current fixed value of natural mortality would be an underestimate of overall mortality.
- The mean fishing mortality reference points for VIa cod were determined under the assumption of M=0.2. The values of mean F from the current assessments are estimates of mortality over and above M i.e. mortality from fishing plus non fishing mortality which cannot be encompassed within the standard value for natural mortality. For management purposes this combined mortality would still need to fall below the level of F_{lim}, as higher levels of mortality over and above M are considered to have led to stock decline in the early 1980s.
- Using TSA run on a reduced set of catch data would allow conventional forecasts based on absolute assessment results (forecasts using relative assessment results were considered of limited use in a previous year) while also producing assessment results that matched (to the greatest extent possible) the SSB trends found from an agreed best SURBA run and which accounted (to a greater or lesser extent) for unallocated mortality.

TSA parameter settings for analyses conducted at 2004, 2005, 2006, 2007 and 2008 WG.

Parameter	Setting	Justification
Age of full selection.	am = 4	Based on inspection of previous XSA runs.
Multipliers on variance matrices of measurements.	Blandings(a) = 2 for ages 6, 7+ Bsurvey(a) = 2 for age 1, 5, 6	Allows extra measurement variability for poorly sampled ages.
Multipliers on variances for fishing mortality estimates.	H(1) = 4	Allows for more variable fishing mortalities for age 1 fish.
Downweighting of particular data points (implemented by multiplying the relevant q by 9)	Landings: age 2 in 1981 and 1987, age 7 in 1989. Discards: age 1 in 1985 and 1992, age 2 in 1998. Survey: age 1 in 2000, age 2 in 1993, age 6 in 1995. Ages 4, 5, 6 in 2001 (the latter are from a single large haul, 24 fish > 75 cm in 30 mins). Age 3 in 2008 (large haul near 4W line).	Large values indicated by exploratory prediction error plots.
Discards	Discards are allowed to evolve over time constrained by a trend. Ages 1 and 2 are modelled independently.	
Recruitment.	Modelled by a Ricker model, with numbers-at-age 1 assumed to be independent and normally distributed with mean $\eta 1\ S \exp(-\eta 2\ S)$, where S is the spawning-stock biomass at the start of the previous year. To allow recruitment variability to increase with mean recruitment, a constant coefficient of variation is assumed.	
Large year classes.	The 1986 year class was large, and recruitment-at-age 1 in 1987 is not well modelled by the Ricker recruitment model. Instead, N(1, 1980) is taken to be normally distributed with mean $5\eta 1\ S \exp(-\eta 2\ S)$. The factor of 5 was chosen by comparing maximum recruitment to median recruitment from 1966-1996 for VIa cod, haddock, and whiting in turn using previous XSA runs. The coefficient of variation is again assumed to be constant.	

SURBA

The model settings for the preferred SURBA run in 2005, 2006 and 2007 were:

	Year range:	1985–2005
2005 WG	Age range:	1–6
	Catchability-at-age:	0.0256, 0.1035, 0.4711, 0.7493, 1.0, 0.6685
	Age weighting:	1.0, 1.0, 1.0, 1.0, 1.0, 1.0, for all ages in all years
	Lambda:	2.0
	Cohort weighting:	Not applied
2006 WG	Year range:	1985–2006
	Age range:	1–6
	Catchability-at-age:	0.0304, 0.1045, 0.2092, 0.4443, 0.7217, 1
	Age weighting:	1.0, 1.0, 0.0, 0.0, 0.0, 1.0 for 2001 1.0, 1.0, 1.0, 1.0, 1.0, 1.0 for all other years
	Lambda:	2.0
	Cohort weighting:	Not applied
2007 WG	Year range:	1985–2007
	Age range:	1–6
	Catchability-at-age:	0.0226, 0.1036, 0.2000, 0.4167, 0.6885, 1
	Age weighting:	1.0, 1.0, 0.0, 0.0, 0.0, 1.0 for 2001 1.0, 1.0, 1.0, 1.0, 1.0, 1.0 for all other years
	Lambda:	2.0
	Cohort weighting:	Not applied

Values (but not method of determination) of catchabilities-at-age differed between WGs. Catchabilities-at-age were derived by comparing raw survey indices with numbers-at-age estimates from a TSA run. These ratios were then standardized relative to a given reference age. The justification is that even if there are concerns over misreporting of commercial data, so long as the relative catch numbers between ages remain constant the catchabilities generated using a catch-at-age analysis will be valid. A TSA run not allowing a trend in survey catchability and using all years of available catch data is chosen to provide the TSA output.

D. Short-term projection

Model used: Age structured

Software used*:* MFDP prediction with management option table and yield-per-recruit routines. MLA suite (WGFRANSW) used for sensitivity analysis and probability profiles.

The following configuration was agreed at WGNSDS 2008.

Initial stock size: Taken from XSA or TSA for age 1 and older.

Maturity: The same ogive as in the assessment is used for all years.

F and M before spawning: Set to 0 for all ages in all years.

- Natural mortality: Set to 0.2 for all ages in all years.

Weight-at-age in the stock: Average stock weights for last three years. Assumed equal to the catch weight-at-age, (adopted because mean weights-at-age have been relatively stable over the recent past). CVs are calculated from the standard errors on weights-at-age.

Weight-at-age in the catch: Average weight of the three last years.

Exploitation pattern: Average of the three last years. Not partitioned to give landings and discard F as the WG consider the mortality outputs from TSA not to represent F at-age but rather estimated total mortality that cannot be accounted for by the standard value used for natural mortality. Therefore that it was not possible to determine the proportion of the mortality caused by fishing.

Intermediate year assumptions: Status quo Z-0.2 (0.2 being the current value assumed for natural mortality at all ages).

Stock recruitment model used: None, recruitment in the intermediate year (terminal year year-class at-age 1) is taken from the TSA assessment, (the value is based largely on the ScoGFSQ1 survey datum from the terminal year). For the TAC year and following year the short term (10 years to year before terminal year) geometric mean recruitment-at-age 1 is used.

In 2006, 2007 and 2008 a short-term projection was made but it was considered little confidence could be placed in the short-term projections. This was because concerns over the reliability of the commercial catch-at-age data lead to use of a catch-at-age analysis but with landings and discards data removed from 1995 onward. The WG considers the mortality outputs from TSA not to represent F at-age but rather estimated total mortality that cannot be accounted for by the standard value used for natural mortality. These mortality values are currently labelled 'Z-0.2' (0.2 being the current value assumed for natural mortality-at-all-ages). Consideration of the diagnostics lead to the conclusion that mean Z-0.2 is estimated with considerable uncertainty (these estimates are based on the age structure indicated by the survey-series, which are known to be noisy).

In 2005 projections were attempted using outputs from a survey based assessment and an *ad hoc* spreadsheet. Similar concerns over adequate estimation of mortality also apply in this case.

E. Medium-term projections

Medium-term projections have been carried out in previous years using the Aberdeen software suite.

Medium-term predictions have not been made at any of the 2005 to 2008 working groups on the grounds that recruitment could not be assumed to conform to historical patterns given the stock was at a historical low.

F. Long-term projections/yield and biomass-per-recruit

Model used: yield and biomass-per-recruit over a range of F values.

Software used: MFDP

- Selectivity pattern: mean F array from last 3 years of assessment (to reflect recent selection patterns).
- Stock and catch weights-at-age: mean of last three years.
- Maturity: Fixed maturity ogive as used in assessment.

Long-term projections have not been performed since 2008 because it is not considered appropriate to do so when the assessment is conducted as an update assessment.

Yield and biomass-per-recruit are taken from the ICES standard graphs.

G. Biological reference points

Reference Point	Technical Basis
B_{pa} = 22 000 t	Previously set at 25 000 t, which was considered a level at which good recruitment is probable. Since reduced to 22 000 t as a consequence of an extended period of stock decline
B_{lim} = 14 000 t	Smoothed estimate of Bloss, (as estimated in 1998)
F_{pa} = 0.6	Consistent with B_{pa}.
F_{lim} = 0.8	F values above 0.8 led to stock decline in the early 1980s

H. Other issues

Natural Mortality: A report by the Sea Mammal Research unit (SMRU, 2006) gives estimates of cod consumed by grey seals to the west of Scotland for two years, based on analysis of collected seal scats. The estimated values and their confidence limits are given in the following text table:

Year	Total consumption (Tonnes)	95% C.I.	Cod TSB from 2008 assessment (Tonnes)
1985	5372	3023–8831	30 267.6
2002	7131	4128–9920	12 789.3

These values, although highly uncertain, suggest predation mortality on cod is greater than can be accommodated by the standard value of natural mortality used for gadoid species in ICES Division VIa. A working document detailing approaches to quantify the level of mortality caused by seal predation and the results obtained was submitted to WGNSDS 2008, (Holmes, 2008).

I. References

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Yoneda, M. and Wright, P. J. 2004. Temporal and Spatial variation in reproductive investment of Atlantic cod *Gadus morhua* in the northern North Sea and Scottish west coast. Marine Ecology Progress Series, 276: 237–248.

Table A9.1. Cod in Division VIa. Landings-effort series made available to the WG. Effort (first column) is given as reported hours fished per year, numbers landed are in thousands.

SCOSEI	SCOTTISH SEINERS					
1978	2005					
1	1	0	1			
1	6					
33 617	743.00	224.48	64.14	41.83	13.01	3.72
38 465	120.91	128.90	197.32	25.17	19.13	5.03
38 640	403.38	223.25	75.45	37.21	13.44	4.13
37 208	26.53	473.12	129.81	42.39	7.95	0.88
36 689	405.78	139.18	137.35	31.99	14.11	3.76
38 080	1205.65	509.03	65.34	58.51	14.63	4.88
29 561	275.95	56.40	78.78	25.58	17.39	10.23
26 365	982.36	199.94	27.31	23.41	4.88	4.88
19 960	348.05	84.78	30.70	6.35	4.23	1.06
26 332	4461.36	552.51	48.68	67.56	18.88	4.97
21 383	63.84	451.06	41.87	4.98	3.99	1.00
39 350	560.31	138.71	152.45	31.07	6.74	4.16
23 235	99.96	566.35	31.11	60.19	11.87	2.06
25 787	364.64	132.65	164.98	16.25	28.93	8.39
20 273	1390.05	228.60	35.92	46.85	4.09	5.01
24 315	86.98	389.31	87.56	10.26	16.08	2.90
21 305	175.94	138.49	145.48	23.03	5.90	4.96
21 950	134.47	372.92	68.30	60.81	9.78	2.11
15 205	82.21	318.54	106.62	17.28	15.61	1.30
11 449	317.44	102.89	77.06	23.31	12.33	13.52
11 166	98.32	656.93	28.31	12.89	3.30	1.31
8638	40.64	60.26	58.57	2.03	1.08	0.74
6431	243.84	32.99	13.49	7.36	0.39	0.35
5893	7.48	101.54	4.62	0.80	1.05	0.07
3817	32.15	25.07	26.48	2.02	0.62	0.30
2370	8.76	31.65	4.56	2.22	0.07	0.01
1159	0.66	0.69	0.60	0.12	0.44	0.05
476	1.67	3.77	0.74	0.54	0.21	0.03

Table 3.3 cont. Cod in Division VIa. Landings-effort series made available to the WG. Effort (first column) is given as reported hours fished per year, numbers landed are in thousands.

SCOLTR	SCOTTISH LIGHT TRAWLERS					
1978	2005					
1	1	0	1			
1	6					
127 387	2242.51	685.36	185.50	133.92	32.74	7.94
99 803	161.44	212.39	485.00	57.12	31.06	6.01
121 211	694.04	699.09	328.14	129.35	34.24	10.46
165 002	123.59	1588.52	524.05	183.42	31.06	3.88
135 280	1623.74	367.84	616.01	163.81	46.10	5.89
112 332	1634.45	1408.23	196.00	163.65	51.38	18.08
132 217	974.48	593.35	419.46	85.37	93.80	30.56
142 815	6421.55	1734.74	218.21	131.35	21.19	22.25
126 533	1403.22	376.19	384.35	67.13	30.32	3.25
131 720	23524.40	1058.11	143.60	116.68	27.92	12.96
158 191	319.66	2464.85	309.82	49.97	37.98	8.00
217 443	1795.80	291.27	989.06	200.39	46.89	19.53
142 502	195.62	1334.61	87.08	202.71	37.25	6.93
209 901	2081.88	815.93	534.85	38.68	97.23	30.51
189 288	2197.22	655.91	193.06	240.73	17.16	24.27
189 925	246.98	1274.46	301.98	46.14	80.17	10.51
174 879	348.87	458.79	463.67	88.90	16.55	22.76
175 631	488.40	839.26	188.99	168.65	21.32	4.31
214 159	133.75	790.18	355.22	79.78	83.08	9.88
179 605	819.38	371.40	394.35	109.46	18.88	18.82
142 457	181.66	1343.76	100.25	64.43	21.22	5.63
98 993	129.77	226.02	433.87	20.55	19.74	11.62
76 157	988.51	233.22	79.43	119.99	6.99	6.12
35 698	95.85	461.23	51.31	26.92	24.54	1.39
15 174	219.71	85.50	183.12	15.46	5.34	6.88
9357	31.84	192.04	37.63	49.04	2.22	0.82
7113	15.33	25.63	33.93	5.11	10.68	1.20
3063	12.70	37.33	14.32	15.40	2.88	2.79

Table 3.3 cont. Cod in Division VIa. Landings-effort series made available to the WG. Effort (first column) is given as reported hours fished per year, numbers landed are in thousands.

IreOTR		Irish otter trawlers					
1995	2005						
1	1	0	1				
1	7						
56 335	77	453	115	33	6	1	1
60 709	72	200	95	30	15	4	1
62 698	215	120	57	24	6	5	2
57 403	28	138	16	16	7	3	0
53 192	10	65	16	3	2	0	0
46 913	131	42	17	6	1	0	0
48 358	19	90	14	5	3	0	0
37 231	39	32	22	2	1	0	0
39 803	7	37	6	5	1	0	0
35 140	3	7	3	1	1	0	0
30 941	4	8	2	1	0	0	0

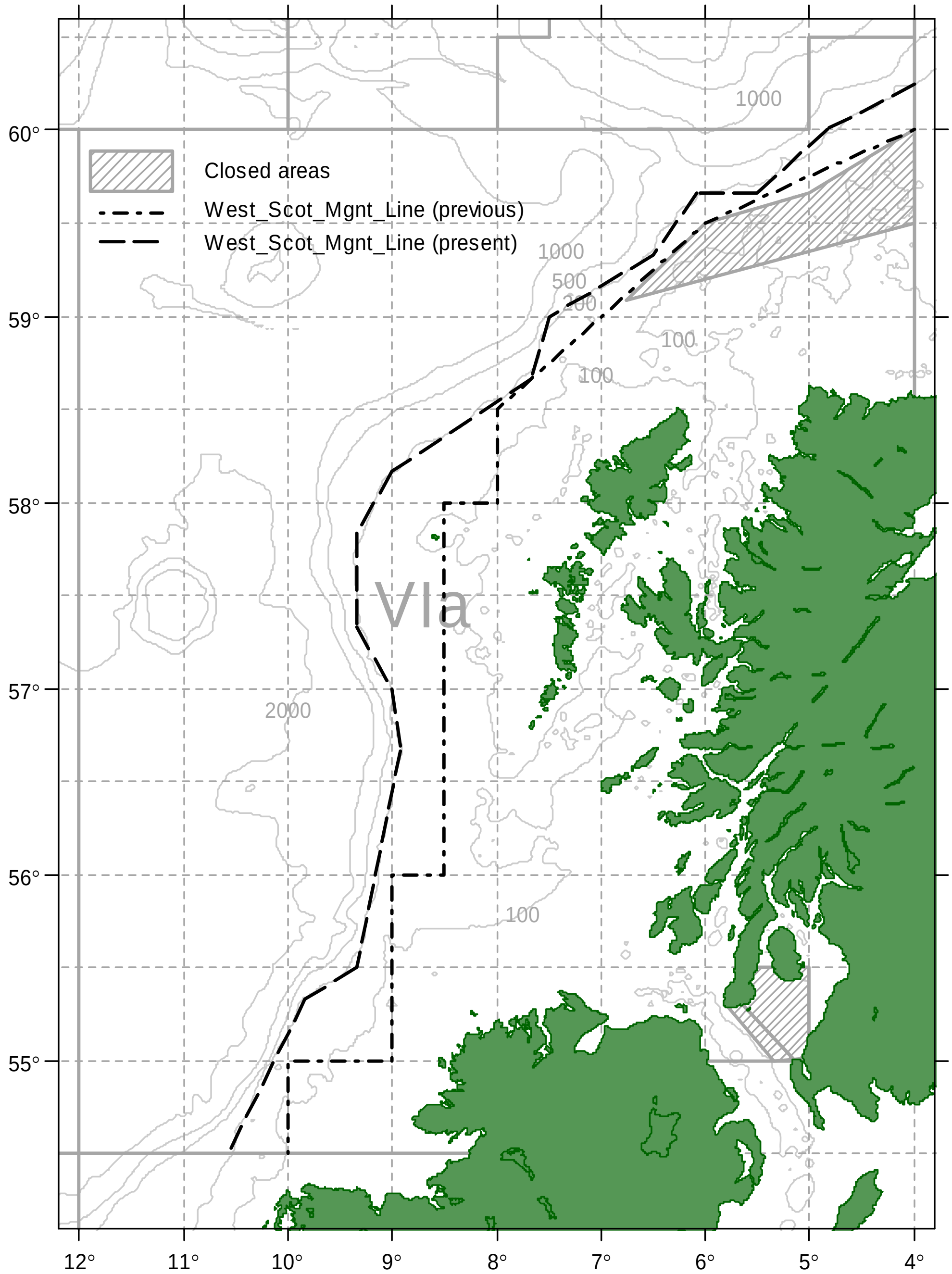


Figure A9.1. Cod in Division VIa. Map showing closed area in the far northeast of VIa known as the 'windsock' introduced by Council Regulation No 2287\2003 and closed area in the Clyde. The Sea Fish (prohibited methods of fishing) (Firth of Clyde) Order 2002. Dark line running close to shelf edge and following the 200 m depth contour is the current West of Scotland management line. Dark line running further east is the previous West of Scotland management line.

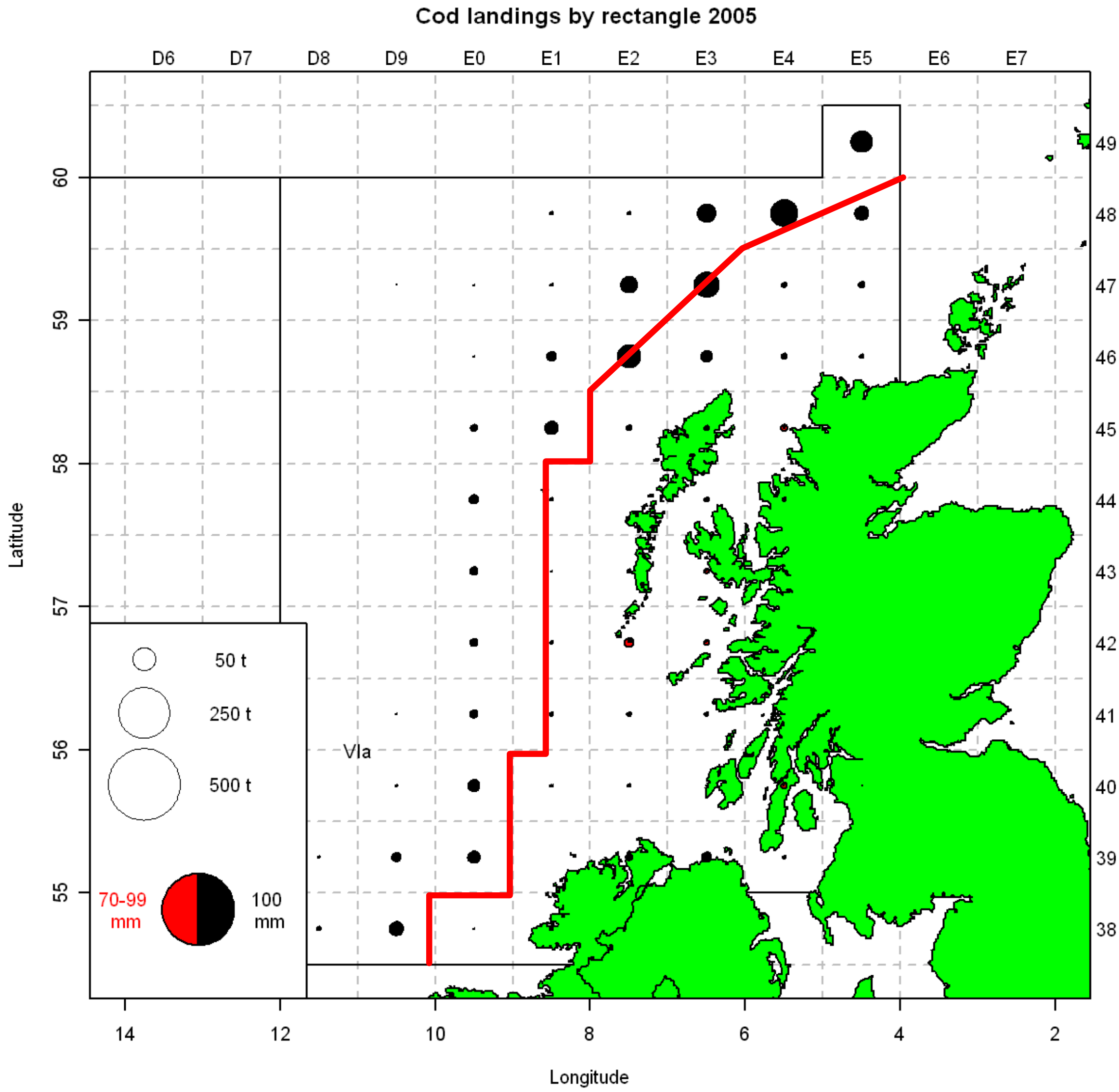


Figure A9.2. Cod in Division VIa. International landings by ICES statistical rectangle. Data compiled from reported landings by Scotland, Ireland and France in 2005. Dark line running close to shelf edge is boundary to cod recovery plan (Council Regulation No. 423/2004) and associated effort restrictions repealed in 2009.

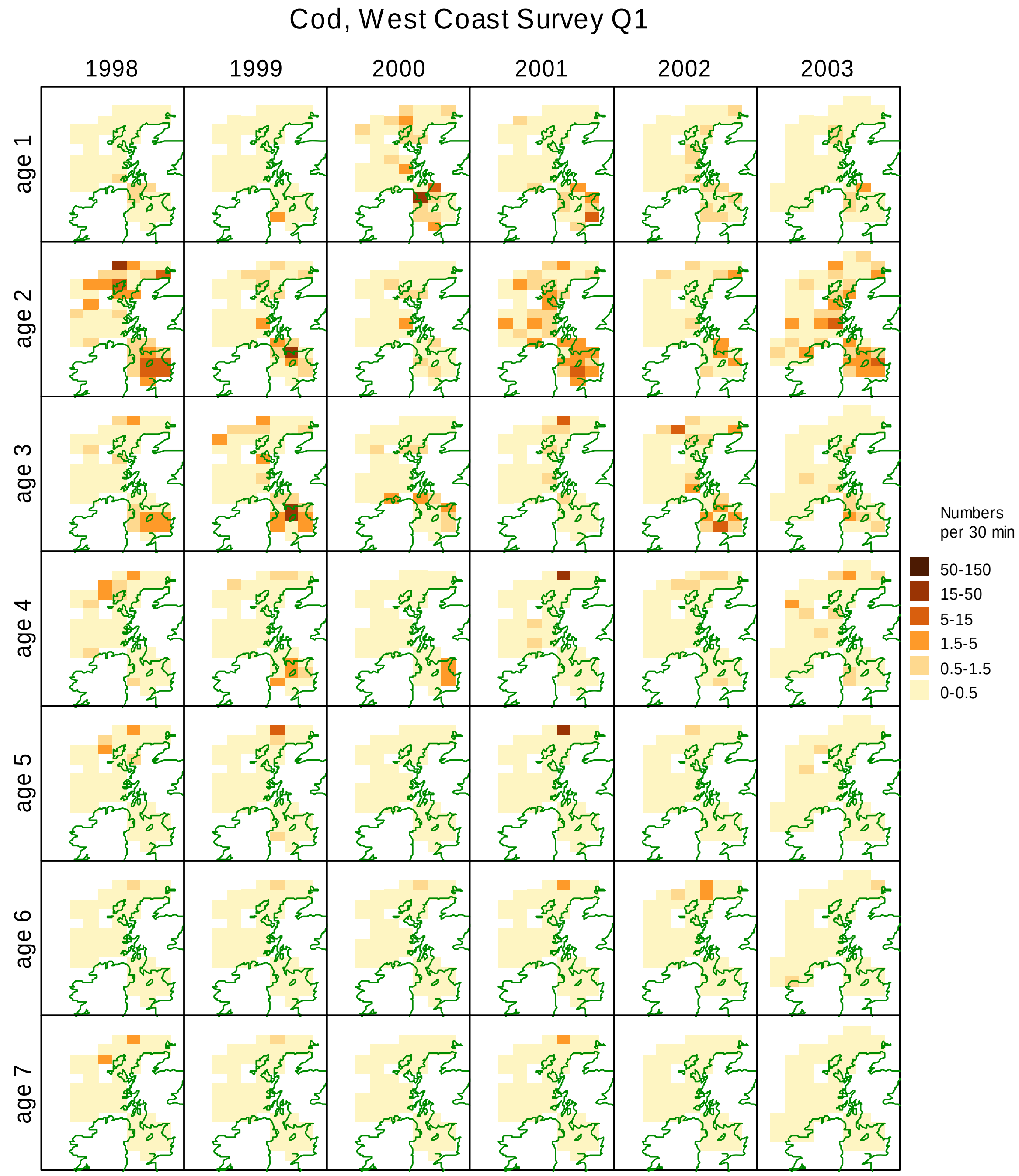


Figure A9.3. Cod in Division VIa. Cpue numbers-at-age by ICES statistical rectangle resulting from Scottish quarter one groundfish survey (ScoGFSQ1). Cohorts can be followed down diagonals.

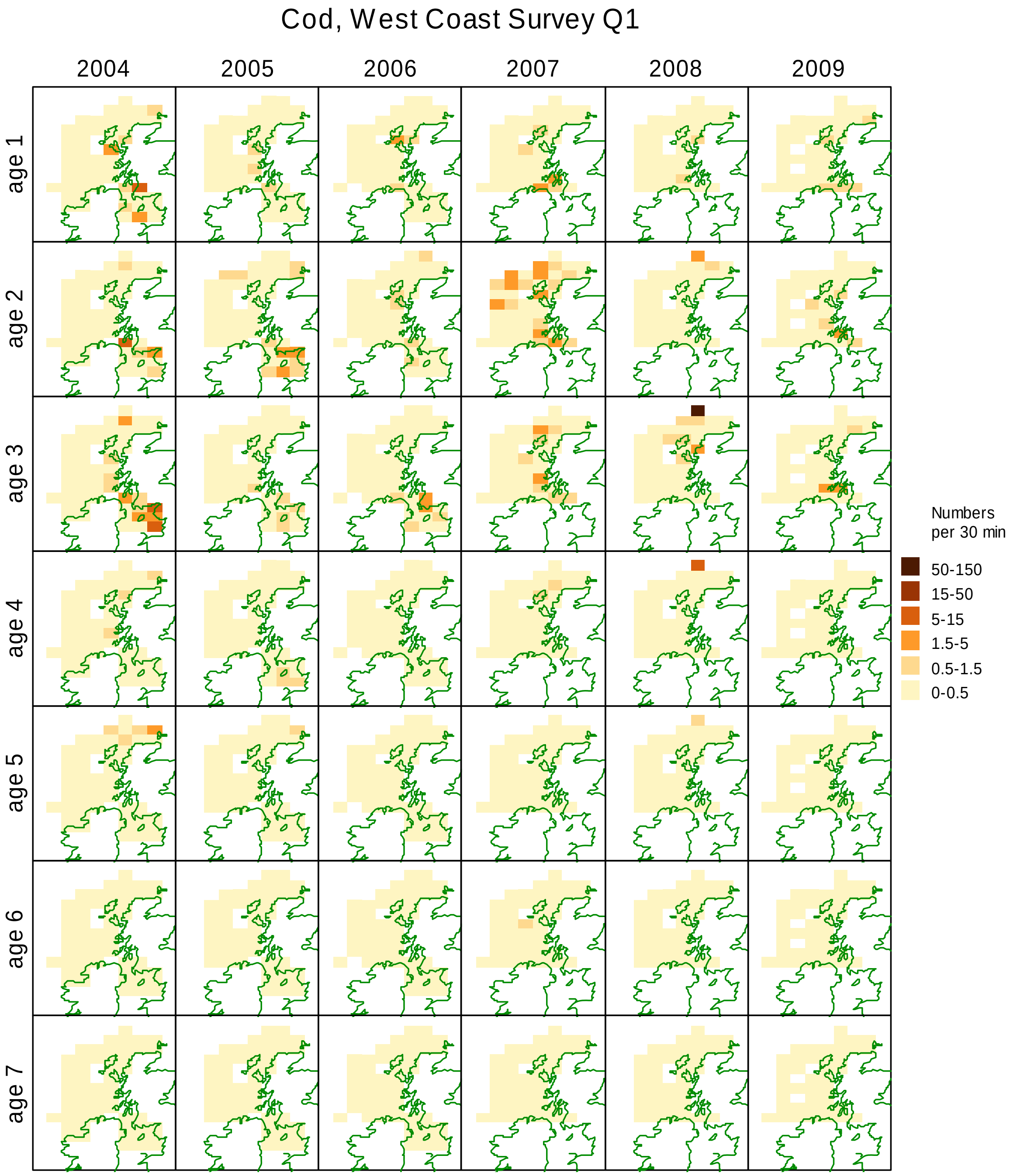


Figure A9.3. cont. Cod in Division VIa. Cpue numbers-at-age by ICES statistical rectangle resulting from Scottish quarter one groundfish survey (ScoGFSQ1). Cohorts can be followed down diagonals.

Annex 3.3: Quality Handbook: Haddock VIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock	West of Scotland Haddock (Division VIa)
Working Group	Assessment of Northern Shelf Demersal Stock
Last updated	May 2009

A. General

A.1. Stock definition

The haddock is widely distributed around the west coast of Scotland and can be caught in most areas within the 200 m depth contour. The stocks occurring off the northwest coast of Scotland are usually identified according to the regions which support a fishery, but genetic and biological marker studies suggest the possibility of different populations of haddock. A continuous population of haddock is thought to extend from the west coast around to the north of Scotland. Results from tagging experiments and larval transport studies suggest that there may be links between west coast haddock and those in the North Sea.

A.2. The fishery

The minimum landing size of haddock in the human consumption fishery in this area is 30 cm.

The demersal fisheries in Division VIa are predominantly conducted by demersal trawlers fishing for cod, haddock, anglerfish and whiting, with bycatches of saithe, megrim, lemon sole, ling and several species of skate. Since 1976, effort by Scottish heavy trawlers and seiners has decreased. Light trawler effort has declined rapidly since 1997 after a long-term increasing trend.

2000 onwards

Emergency measures were introduced in 2001 to allow the maximum number of cod to spawn (see emergency measures below). Council Regulation (EC) No. 423\2004 introduced a cod recovery plan affecting Division VIa. This has been revised and updated (Council Regulation (EC) No. 1342/2008). The measures only take effect east of a line defined in Council Regulation No 51\2006. The days-at-sea limitations associated with the cod recovery plan and this seasonal closure has lead some of the Irish Demersal fleet to switch effort away from VIa.

Under Council Regulation (EC) No. 51/2006 the use of gillnets has been banned outside 200 m depth. WGFTFB 2006 report that this has greatly reduced effort at depths greater than 200 m in VIa. The measure was aimed to protect monkfish and deep-water shark and it is unclear what effect it will have on haddock.

Technical measures

The minimum mesh size for vessels fishing for haddock in the mixed demersal fishery in EC Zones 1 and 2 (West of Scotland and North Sea excluding Skagerrak) changed from 100 mm to 120 mm from the start of 2002. This came under EU regulations regarding the cod recovery plan (Commission Regulation EC 2056/2001), with a one-year derogation of 110 mm for vessels targeting species other than cod. This derogation was not extended beyond the end of 2002.

Since mid-2000, UK vessels in this fishery have been required to include a 90 mm square mesh panel (SSI 227/2000), predominantly to reduce discarding of the large 1999 year class of haddock. Further unilateral legislation in 2001 (SSI 250/2001) banned the use of lifting bags in the Scottish fleet.

Under Council Regulation No. 51/2006 the use of gillnets has been banned outside 200 m depth.

Emergency measures and effort limitation

Emergency measures were enacted in 2001, consisting of area closures from 6 March–30 April, in an attempt to maximize cod egg production. These measures were retained into 2003 and 2004.

In 2005 the following area closures were in effect:

1) The Greencastle codling fishery from mid-November to mid-February. This closure has been operating since 2003.
2) A closure in the Clyde for spawning cod from 14th February to 30th April. This closure has been operating since 2001 and was last revised by The Sea Fish (prohibited methods of fishing) (Firth of Clyde) Order 2002.
3) A closure introduced in 2004 by Council Regulation No. EC 2287\2003, known as the ‘windsock’.

Effort reductions for much of the international fleet to 16 days-at-sea per month have been imposed since February 2003 (EU 2003\0090). The maximum number-of-days in any calendar month for which a fishing vessel may be absent from port to the West of Scotland varies for particular gears and the allocations since 2003 are given below:

Gear	Maximum Days Allowed			
	2003:	2004:	2005:	2006:
Demersal trawls, seines or similar towed gears of mesh size ≥ 100 mm except beam trawls	9	10	8	91/12
Demersal trawls, seines or similar towed gears of mesh size between 70 mm and 99 mm except beam trawls[1];	25	22	21	127/12
Demersal trawls, seines or similar towed gears of mesh size between 16 mm and 31 mm except beam trawls.	23	20	19	128/12

1: With mesh size between 80 mm and 99 mm in 2004.

The documents listing these days-at-sea limitations are,

2004: (EC) No 2287/2003

2005: (EC) No 27/2005-Annex IVa

2006: (EC) No 51/2006-Annex IIa

A Commission Decision (C (2003) 762) in March 2003 allocated additional days absent from port to particular vessels and Member States. UK vessels were granted 4 additional days-per-month (based on evidence of decommissioning programmes). An additional two days was granted to demersal trawls, seines or similar towed gears (mesh ≥ 100 mm, except beam trawls) to compensate for steaming time between home ports and fishing grounds and for the adjustment to the newly installed effort management scheme.

For 2006 one extra day was allocated to trawls >=100 mm if the mesh was >120 mm and the net contained a square mesh panel of 140 mm mesh size. Altogether 148 days in the year was allowed for vessels with mesh between 100 and 120 mm if the catch contained < 5% cod in 2002. This allowance rises to 160 days in the year if the same 140 mm square mesh panel is used together with a mesh size > 120 mm.

The new effort regulations provided an incentive for some vessels previously using >100 mesh in otter trawls to switch to smaller mesh gears to take advantage of the larger numbers of days-at-sea available. This would also require these vessels to be targeting *Nephrops* or anglerfish, megrim and whiting with various catch and bycatch composition limits after EC Regulation No 850/98.

Decommissioning schemes. Vessel decommissioning has been underway since 2002. Information on the number of vessels operating in the cod recovery zone to have been decommissioned in Division VIa between 2001 and 2004 was as follows:

	Total VIa 2001	Decomm. To 2004	Percentage
Number of vessels > 10 m	298	96	30.2%

A.3. Ecosystem aspects

Geographic location and timing of spawning

Spawning of haddock usually occurs in February and March and in almost any area where the fish are distributed. There is major spawning between the Butt of Lewis and Shetland. Some larvae from the west coast spawning grounds can be transported to the North Sea, which they enter through the Fair Isle/Shetland Gap or to the northeast of Shetland. Young haddock then spend the first few months of life in the upper water layers before adopting the demersal way of life. The survival rate of young haddock is very variable from year to year.

Fecundity

The majority of haddock mature-at-age two with usually all mature by age three. However, mature age two haddock spawn fewer eggs for a given size than an age three haddock. A three-year-old female of good size is able to produce around 300 000 eggs in a season and releases her eggs in a number of batches over many weeks.

Diet

The diet of haddock varies seasonally and according to location and body size. In winter, haddock of all sizes feed mainly on benthic invertebrates, for example, polychaetes, small crustaceans and echinoderms. In spring and summer, fish prey, especially sandeels, are important particularly for larger haddock. Norway pout is also important prey for haddock. During herring spawning seasons, haddock will feed heavily on herring eggs.

B. Data

B.1. Commercial catch

B1.1. Landings

The following table gives the source of landings data for West of Scotland haddock:

	Kind of data				
Country	Caton (catch-in-weight)	Canum (catch-at-age in numbers)	Weca (weight-at-age in the catch)	Matprop (proportion mature-by-age)	Length composition-in-catch
UK(NI)	X				
UK(E&W)	X				
UK(Scotland)	X	X	X	X	X
Ireland	X	X	X		X
France	X				
Norway	X				

Quarterly landings and length/age composition data are supplied from databases maintained by national Government Departments and research agencies. These figures may be adjusted by national scientists to correct for known or estimated misreporting by area or species. Data are supplied in the requested format to a stock coordinator, who compiles the international landings and catch-at-age data and maintains a time-series of such data with any amendments. To avoid double counting of landings data, each UK region supplies data for UK landings into its regional ports, and landings by its fleet into non-UK ports.

Quarterly landings are provided by the UK (Scotland), UK (E/W), UK (NI), France and Ireland .The quarterly estimates of landings-at-age by UK (Scotland) and Ireland are raised to include landings by France, UK (NI) and Norway (distributed proportionately over quarters), then summed over quarters to produce the annual landings-at-age.

B1.2. Discards

EU countries are now required under the EU Data Collection regulation to collect data on discards of haddock and other species. Up to 2003, estimates of discards were available only from UK (Scotland) and Ireland. Observer data are collected using standard at-sea sampling schemes. Results are reported to ICES.

The quantity, length and age of haddock discarded by Scottish *Nephrops* trawlers are collected during observer trips on board commercial vessels. Haddock discarded by boats using other gears (heavy trawl, seine, light trawl and pair trawl) are also collected by Scotland. Haddock discarded by otter board trawl and otter board/twin rig gears are collected by Ireland.

Discards from Scottish and Irish boats using several different gear types are estimated by observers.

B.2. Biological

Natural mortality is assumed to be constant (M=0.2, applied annually) for the whole range of ages and years. There are no direct estimates of M.

Proportion mature-at-age is currently assumed constant over the full time-series as follows:

Age	1	2	3+
Proportion mature	0.00	0.57	1.0

These maturity values were derived from a French survey carried out in Division VIa in 1983. They were first discussed in the 1984 meeting of the North Sea Roundfish Working Group (ICES-NSRWG 1984), and were first used at the 1985 meeting (ICES-NSRWG 1985). Proportions of *F* and *M* before spawning were both set to 0.0, in order to generate abundance (and hence SSB) estimates dated to January 1st.

B.3. Surveys

Four research vessel survey series for haddock in VIa were available to the Working Group in 2009. In all surveys listed the highest age represents a true age not a plus group.

- Scottish first-quarter west coast groundfish survey (ScoGFSQ1): ages 1–7, years 1985–2009.

The survey gear is a GOV trawl, and the design is a minimum of one station per rectangle, but with more depending on logistics. Ages are reported from 0 to the maximum obtained. Sex/Maturity-Sex and Maturity (ICES 4-stage scale) are reported. The Scottish groundfish survey has been conducted with a new vessel and gear since 1999. The catch rates for the series as presented are corrected for the change on the basis of comparative trawl haul data (Zuur *et al*., 2001).

- Irish fourth-quarter west coast groundfish survey (IreGFS): ages 0–3, years 1993–2002.

The Irish quarter four survey was a comparatively short series. It was discontinued in 2003 and has been replaced by the IRGFS (see below).

- Scottish fourth quarter west coast groundfish survey (ScoGFSQ4): ages 0–8, years 1996–2008.

As is the case for the European IBTS surveys (such as ScoGFS Q1 above) the survey gear is a GOV trawl, and the design is a minimum of one station per rectangle, but with more depending on logistics. Ages are reported from 0 to the maximum obtained. Sex/Maturity-Sex and Maturity (ICES 4-stage scale) are reported. The Scottish groundfish survey has been conducted with a new vessel and gear since 1999. The catch rates for the series as presented are corrected for the change on the basis of comparative trawl haul data (Zuur *et al*., 2001).

- Irish fourth-quarter west coast groundfish survey (IRGFS); ages 0–3, years 2003–2008.

This survey used the RV Celtic Explorer and is part of the IBTS coordinated western waters surveys. The vessel uses a GOV trawl, and the design is a depth stratified survey with randomized stations. Effort is recorded as minutes towed. There were 41 stations sampled in 2003, 44 in 2004 and 34 in 2005, corresponding to 1229, 1321 and 1010 minutes towed.

Plots of the spatial distribution of the ScoGFS Q1 survey mean catch rates per ICES statistical rectangle by age class are given in Figure 1. The numbers caught in the most recent Scottish Groundfish Surveys are indicated in Figure 2.

B.4. Commercial cpue

Three commercial Scottish cpue series have been made available in recent years. Irish otter trawl cpue data (IreOTR) were presented for the first time at the 2001 WG meeting. Updated series have been presented to subsequent meetings. Given the current concerns about misreporting of catch and effort, this series has not been considered further as a tuning fleet.

The commercial cpue data available consists of the following:

- Scottish seiners (ScoSEI): ages 1–6, years 1978–2005.
- Scottish light trawlers (ScoLTR): ages 1–6, years 1978–2005.
- Irish otter trawlers (IreOTR): ages 1–7, years 1995–2005.

Reported effort has declined in recent years to very low levels in both Scottish fleets for which effort data are available to the WG (pairtrawlers and light trawlers; see Table 1). The historical mean levels of lpue (landings-per-unit-effort) for these fleets were more constant, although variable. However, problems with effort recording mean that these estimates are unlikely to be valid: further details are available in the report of the 2000 meeting of the ICES WG on the Assessment of Demersal Stocks in the North Sea and Skagerrak (ICES-WGNSSK 2000). For this reason, commercial Scottish lpue data has not been used in the current assessment. Data are also available (although not updated to 2007) from the Irish trawler fleet (IreOTB; Table 4.1.8), but are not used in the assessment as a consequence of concerns about targeting leading to hyperstability.

B.5. Other relevant data

None.

C. Historical stock development

In 2007 ICES changed its advisory structure: the previous committees (ACE, ACFM and ACME) were merged into a single committee now known as ACOM. Amongst many of the modifications to accompanying working practices, it was intended that all stock assessments conducted by the Expert Groups from 2008 should be update analyses based on the work conducted by the last benchmark meeting. For west of Scotland haddock, a benchmark assessment *per se* has not taken place for some time. However, at the 2004 WGNSDS, "a full and detailed examination" of the assessment was carried out following concerns of ACFM about the assumptions and parameter settings implemented in the TSA methods used to assess this stock (ICES, 2004). The investigation used Time Series Analysis (TSA) Extended Survivors Analysis (XSA) and Survey Based Assessment (SURBA) models. Although the results from this investigation were in some ways contradictory, and the WG remained uncertain about the most appropriate model for the stock, subsequent Review Groups concluded that a TSA assessment, using the Scottish Quarter 1 Groundfish Survey and excluding the catch and discard data from 1995 onwards, should be presented as the final assessment in 2005. In 2006 this assessment was modified slightly to incorporate an additional survey, the Scottish Quarter 4 Groundfish Survey (western division bottom-trawl survey). In 2007, concerns were raised about the potential impact on management advice of using a plus-group at-age 8 when the dominant large 1999 year class has reached that age in 2007, and also about the removal in the previous assessment of older ages in the Scottish Q4 Groundfish Survey (ScoGFS Q4). Several exploratory analyses were carried out, from which it was concluded that the same procedure should be used in 2007 as was used 2006, but with two additional ages in the ScoGFS Q4 dataset. In 2008, subject to the ACOM request, an update assessment was carried out using the same procedures as in 2007. In 2009 an update assessment was carried out using the same procedure as in 2008. This used the TSA assessment model and tuning data from the two Scottish Groundfish surveys.

Software used: Lowestoft VPA suite; Marine Scotland Science (Marine Lab Aberdeen) TSA and SURBA software.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1966 – last data year	1 – 8+	Yes
Canum	Catch-at-age in numbers	1966 – last data year	1 – 8+	Yes
Weca	Weight-at-age in the commercial catch	1966 – last data year	1 – 8+	Yes
West	Weight-at-age of the stock at spawning time.	1968 – last data year	1 – 8+	Yes:
Mprop	Proportion of natural mortality before spawning	1978 – last data year	1 – 8+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1978 – last data year	1 – 8+	No – set to 0 for all ages in all years
Matprop	Proportion mature-at-age	1978 – last data year	1 – 8+	No – the same ogive for all years
Natmor	Natural mortality	1978 – last data year	1 – 8+	No – set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Research Vessel Survey			
Tuning fleet 1	ScoGFS-Q1	1985–last data year	1–7
Tuning fleet 3	ScoGFS-Q4	1996–last data year	1–7

Summary of data ranges used in recent assessments:

Data	2006 assessment	2007 assessment	2008 assessment	2009 assessment
Catch data	Years: 1978–1994 Ages: 1–8+	Years: 1978–1994 Ages: 1–8+	Years: 1978–1994 Ages: 1–8+	Years: 1978–1994 Ages: 1–8+
Survey: ScoGFS Q1	Years: 1985–2006 Ages: 1–7	Years: 1985–2007 Ages 1–7	Years: 1985–2008 Ages 1–7	Years: 1985–2009 Ages 1–7
Survey: ScoGFS Q4	Years: 1996–2005 Ages: 1–5	Years: 1996–2006 Ages 1–7	Years: 1996–2007 Ages 1–7	Years: 1996–2008 Ages 1–7
Survey: IreGFS	Not used	Not used	Not used	Not used

TSA

TSA parameter settings for the 2003–2009 analyses.

Parameter	Notation	Description	2003	2004	2005	2006	2007	2008	2009
Initial fishing mortality	F (1, 1978)	Fishing mortality at age a in year y	0.42	0.28	0.26	0.23	0.25	0.40	0.40
	F (2, 1978)		0.67	0.5	0.51	0.50	0.56	0.71	0.70
	F (4, 1978)		0.53	0.51	0.51	0.51	0.52	0.56	0.57
Survey selectivities ScoGFS Q1	Φ(1)	ScoGFS Q1 survey selectivity at age a	3.99	2.25	2.35	2.49	2.58	2.60	2.58
	Φ(2)		4.84	2.71	2.45	2.55	3.01	3.07	3.01
	Φ(4)		2.1	1.51	2.11	2.19	2.04	1.92	1.94
Survey selectivities ScoGFS Q4	Φ(1)	ScoGFS Q4 survey selectivity at age a	-	-	-	1.99	1.62	1.77	1.75
	Φ(2)		-	-	-	1.99	1.76	1.88	1.84
	Φ(4)		-	-	-	2.25	2.39	2.61	2.64
Fishing mortality standard deviations	σF	Transitory changes in overall F	0.00	0.11	0.10	0.10	0.12	0.20	0.20
	σU	Persistent changes in selection (age effect in F)	0.05	0.04	0.01	0.00	0.09	0.03	0.03
	σV	Transitory changes in the year effect in F	0.27	0.23	0.22	0.23	0.23	0.33	0.35
	σY	Persistent changes in the year effect in F	0.00	0.14	0.09	0.09	0.07	0.00	0.00
Survey catchability standard deviations	σΩ1	Transitory changes in ScoGFS Q1 catchability	0.00	0.08	0.18	0.30	0.19	0.12	0.12
	σβ1	Persistent changes in ScoGFS Q1 catchability	0.14	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
	σΩ2	Transitory changes in ScoGFS Q4 catchability	-	-	-		0.16	0.20	0.19
	σβ2	Persistent changes in ScoGFS Q4 catchability	-	-	-		0.00*	0.00*	0.00*
Measurement coefficients of variation	cv landings	Coefficent of variation of landings-at-age data	0.22	0.25	0.23	0.20	0.20	0.24	0.25
	cv discards	Coefficent of variation of discards-at-age data	0.51	0.43	0.45	0.42	0.41	0.54	0.54
	cv survey	Coefficent of variation of ScoGFS Q1 survey data	0.40	0.34	0.53	0.57	0.33	0.35	0.36
	cv survey	Coefficent of variation of ScoGFS Q4 survey data	-	-	-	0.57	0.22	0.34	0.35
Discard curve parameters	σP	Transitory changes in overall discard proportion	0.50	0.19	0.20	0.19	0.18	0.20	0.20
	σα1	Transitory changes in discard-ogive intercept	0.00	0.15	0.02	0.00	0.14	0.00	0.00
	σν1	Persistent changes in discard-ogive intercept	0.26	0.21	0.22	0.21	0.32	0.26	0.25
	σα2	Transitory changes in discard-ogive slope	0.34	0.01	0.03	0.21	0.23	0.22	0.23
	σν2	Persistent changes in discard-ogive slope	0.02	0.61	0.43	0.23	0.002	0.000	0.000
Trend parameters	θν1	Trend parameter for discard-ogive intercept	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
	θν2	Trend parameter for discard-ogive slope	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
Recruitment	η1	Ricker parameter (slope at the origin)	9.10	9.63	9.71	9.73	9.06	11.35	11.08
	η2	Ricker parameter (curve dome occurs at 1/η2)	0.33	0.29	0.31	0.29	0.30	0.35	0.35
	cv rec	Coefficent of variation of recruitment curve	0.52	0.89	0.89	0.90	0.62	0.60	0.61

D. Short-term projection

TSA produces short-term forecasts as part of every standard model run. The recruitment values used in these forecasts have been discussed above. The model will also forecast fishing mortality rates. It does so by iterating forward the time-series model that had been fitted to historical data. These forecast mortalities therefore retain the time-series characteristics of the preceding data. However, it is not clear to the WG what the precise statistical properties of these mortality forecasts are. It is likely that they follow a pattern of damped oscillation towards an eventual steady state, but without further analysis the WG did not feel confident in using them as the basis for a forecast.

Model used: Age structured

Software used*:* MFDP prediction with management option table and yield-per-recruit routines. MLA suite (WGFRANSW) used for sensitivity analysis and probability profiles.

- Initial stock size. Taken from XSA or TSA for age 1 and older. The recruitment-at-age 0 in the last data year is estimated as a GM because of a perceived downward trend in recruitment in recent years.
- Natural mortality: Set to 0.2 for all ages in all years.
- Maturity: The same ogive as in the assessment is used for all years.
- F and M before spawning: Set to 0 for all ages in all years.
- Weight-at-age in the stock: based on either of simple three-year means or linear model projections: simple three year means are used for the younger ages (1–2) and linear model projections for the older ages (3–8+).

Weight-at-age in the catch: as above for stock weights.

- Exploitation pattern: Average of the three last years.
- Intermediate year assumptions: status quo F.
- Stock recruitment model used: TSA estimate of recruits-at-age 1 for intermediate year, Ricker model from TSA used for intermediate year +1 and the long-term geometric mean recruitment-at-age 1 is used for intermediate year +2.

E. Medium-term projections

Stochastic medium-term projections were not produced for this stock. The reliance of the fishery on intermittent large year classes, and the fluid nature of the fishery and related management, make the usefulness of medium-term projections questionable in any case.

F. Yield and biomass per recruit/long-term projections

Model used: yield and biomass per recruit over a range of F values.

Software used: MFDP

- Selectivity pattern: mean F array from last 3 years of assessment (to reflect recent selection patterns).
- Stock and catch weights-at-age: mean of last three years.
- Maturity: Fixed maturity ogive as used in assessment.

G. Biological reference points

B_{pa} is set at 30 000 tonnes and is defined as B_{lim}*1.4. B_{lim} is defined as the lowest observed SSB, considered to be 22 000 tonnes when the current reference points were established in 1998. F_{pa} is 0.5 on the technical basis of a high probability of avoiding SSB falling below B_{pa} in the long term. F_{lim} is not defined. In the 2007 ACFM report, F_{max} was estimated at 0.44 and $F_{0.1}$ was 0.2.

H. Other issues

None.

I. References

ICES 2004 Report of the Working Group on the Assessment of Northern Shelf Demersal Stocks (WGNSDS). ICES CM 2005/ACFM:01.

Table 1. Haddock in Division VIa. Commercial effort and tuning-series made available to the WG. Effort (first column) is given as reported hours fished per year; numbers landed are in thousands. Note that a) these data are not used in the final assessment, and b) 2006 data were not available to the WG in 2007.

Scottish pair trawl (ScoPTR)

		Age						
Year	**Effort**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1988	73448	1836.79	19333.629	2791.134	1561.027	3555.323	132.086	47.031
1989	69051	358.121	622.245	6453.549	833.344	617.05	1530.389	96.988
1990	24365	2656.973	1209.336	432.811	2413.249	161.21	59.431	119.9
1991	33826	2528.117	3815.61	267.76	165.98	1059.521	75.441	58.562
1992	24141	1531.621	1587.775	1068.706	80.518	28.226	195.827	17.505
1993	23975	1784.422	8049.086	3189.459	582.533	48.833	41.065	141.79
1994	21003	602.661	2354.895	2614.523	861.39	226.916	7.311	14.371
1995	22848	2494.133	1573.402	3915.253	1501.48	365.819	103.337	3.1
1996	22237	3993.635	7475.948	1085.826	2281.053	1002.653	282.516	73.796
1997	8552	1327.954	1136.375	3876.218	340.837	523.864	192.329	37.903
1998	8425	416.432	2137.106	1315.696	2734.416	232.941	149.879	35.896
1999	2483	450.826	1936.938	1521.928	399.642	641.984	47.192	34.913
2000	2335	1545.384	394.239	620.963	319.038	45.263	69.646	15.32
2001	1342	4.767	230.091	97.936	241.187	46.188	10.688	37.264
2002	14	31.473	115.105	120.723	2.223	2.909	1.247	0.356
2003	5	38.548	107.443	150.615	288.114	29.322	4.005	0.232
2004	88	52.807	141.598	40.075	98.517	221.673	13.792	2.687
2005	0	9.956	22.448	31.323	22.161	32.8	106.663	0.189

Irish otter trawl (IreOTB)

		Age						
Year	**Effort**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1995	56335	222	298	530	461	92	28	98
1996	60709	165	531	670	281	175	33	12
1997	62698	99	358	515	282	339	133	89
1998	57403	51	1092	552	312	186	218	232
1999	53192	98	315	437	266	198	109	123
2000	46913	50	131	188	303	158	76	65
2001	48358	14	304	144	101	126	100	44
2002	37231	31	162	388	27	65	97	47
2003	42899	4	36	108	231	29	36	29
2004	35140	0	33	82	71	82	11	13
2005	30941	1	23	41	56	87	29	7

Table 1. cont.

Scottish light trawl (ScoLTR)

		Age			
Year	**Effort**	**2**	**3**	**4**	**5**
1965	37387	22.091	1642.12	168.954	6.998
1966	40538	2.929	0	702.277	20.987
1967	80916	1326.106	72.823	6.981	188.483
1968	65348	514.409	132.176	9.014	13.019
1969	106586	6100.801	273.493	81.818	4.989
1970	129741	60.985	7188.79	93.986	17.997
1971	129187	426.996	323.964	7715.896	29.996
1972	154288	20885.215	447.018	197.01	4635.228
1973	93992	1171.622	1396.082	8.999	18.998
1974	88651	950.263	706.156	425.086	4.001
1975	132353	4525.993	476.288	360.261	320.234
1976	139225	11482.937	2002.98	171.894	208.87
1977	143547	362.858	3581.037	660.848	94.978
1978	127387	205.97	157.024	1412.263	205.04
1979	99803	2419.532	162.972	32.994	802.863
1980	121211	3869.366	1034.891	183.982	37.996
1981	165002	14862.966	4468.331	423.043	40.004
1982	135280	958.723	17379.104	1721.828	70.994
1983	112332	5747.308	1345.07	10272.253	662.105
1984	132217	2210.088	3687.112	809.84	6080.328
1985	142815	16310.439	905.133	691.017	214.069
1986	126533	2565.893	13292.803	408.899	163.349
1987	131653	4040.797	2770.494	6465.25	249.058
1988	158191	17326.463	2369.239	1008.226	2273.141
1989	217443	1459.316	10332.354	934.04	394.722
1990	131360	1293.654	541.378	3520.472	213.722
1991	209901	8386.068	414.358	218.113	1814.306
1992	189288	3850.242	2937.112	133.408	49.73
1993	189925	17312.309	6469.671	1479.199	89.402
1994	174879	7106.326	6307.283	1574.576	409.496
1995	175631	4850.552	9835.464	2704.111	551.303
1996	214159	15882.858	2665.141	4524.729	1511.694
1997	179605	4231.875	9987.962	882.602	1119.138
1998	142457	6845.462	3530.308	7753.948	573.554
1999	98993	6266.816	4506.559	1124.841	2152.395
2000	76157	2725.197	4725.382	2259.356	499.511
2001	35698	14958.081	1246.235	2075.946	687.201
2002	15174	4200.486	16918.947	400.382	421.166
2003	9357	2114.331	2803.164	6108.682	76.951
2004	7117	3675.178	1203.565	2307.81	3900.374
2005	3063	1643.009	1317.835	787.027	955.533

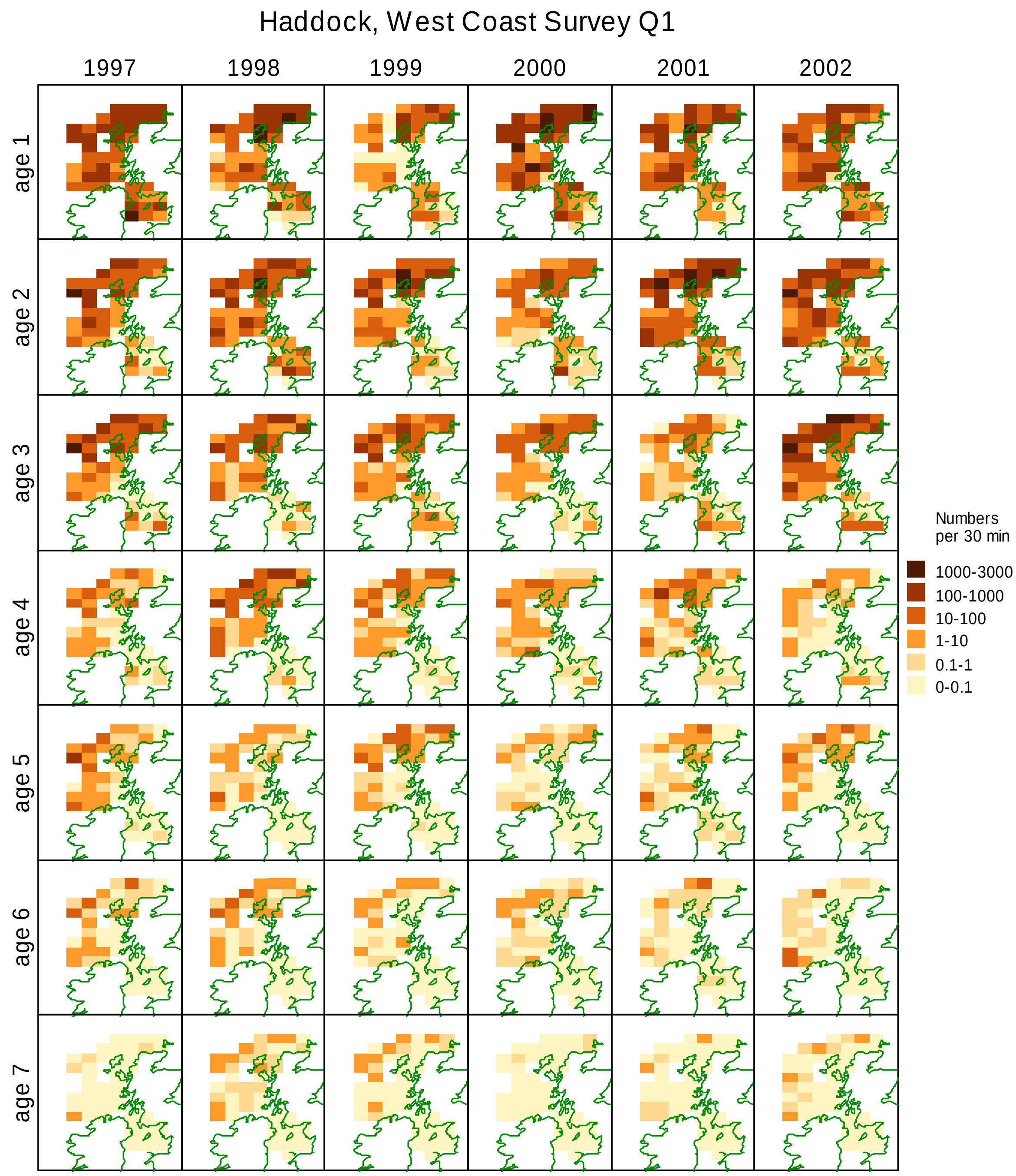


Figure 1. Haddock in Division VIa. Number per 30 min tow, averaged over ICES statistical rectangles from the west of Scotland groundfish Q1 (IBTS) survey 1997–2002, ages 1–7.

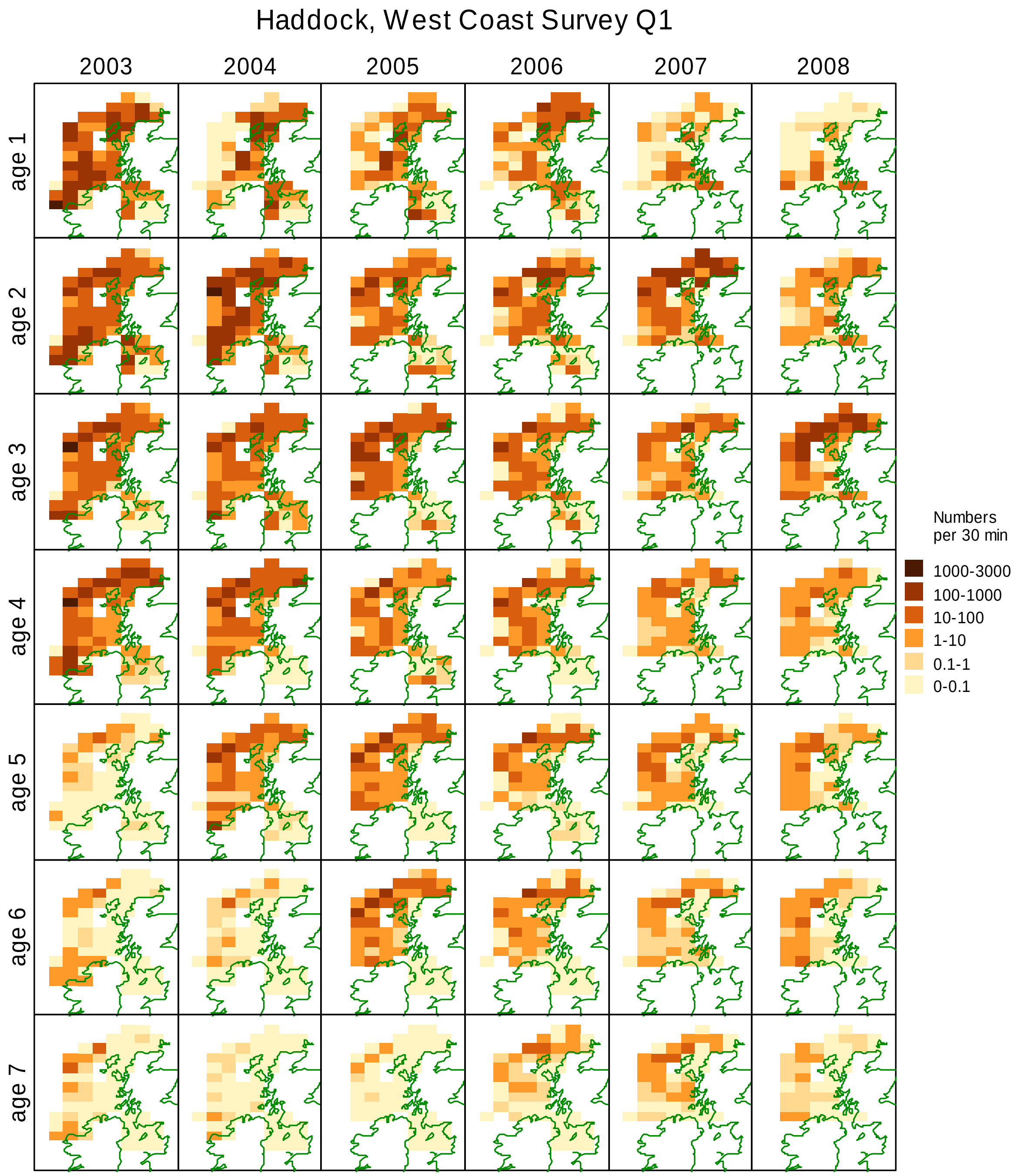


Figure 1. continued. Haddock in Division VIa. Number per 30 min tow, averaged over ICES statistical rectangles from the west of Scotland groundfish Q1 (IBTS) survey 2003–2008, ages 1–7.

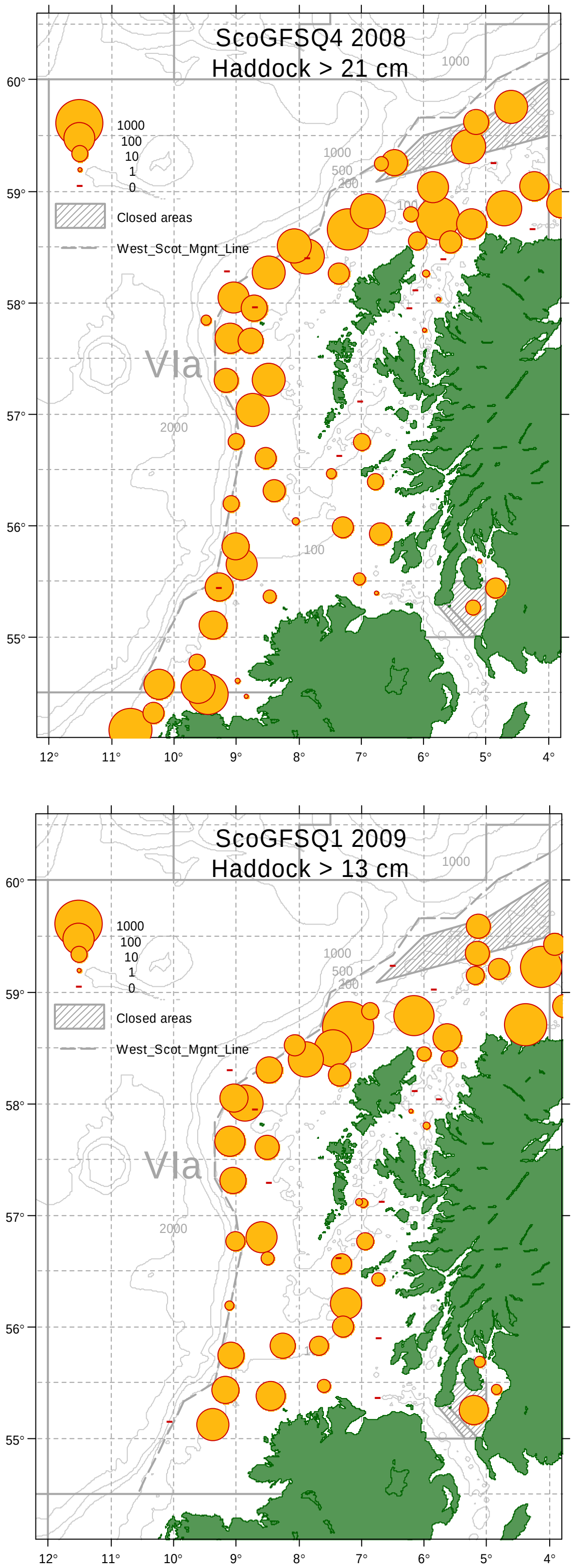


Figure 2. Haddock in Division VIa. Numbers per 30 min tow from the Scottish groundfish surveys (ScoGFS): Quarter 4 (2008) and Quarter 1 (2009).

Annex 3.4: Quality Handbook: Whiting in Area VI

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Whiting (Area VI)
Working Group	Assessment of Northern Shelf Demersal Stocks
Last updated	19 May 2007 (h.dobby@marlab.ac.uk)

A. General

A.1. Stock definition

Whiting occur throughout Northeast Atlantic waters, in a wide range of depths; from shallow inshore waters down to 200 m. Adult whiting are widespread throughout Area VIa, while large numbers of juvenile fish occur in inshore areas. Whiting are less common in Division VIb, and it is likely these fish are migrants from VIa, rather than a separate stock.

Although an exploration of stock identity in the North Sea has been carried out, stock definition in Area VI and surrounding waters remains poorly defined (ICES-SGISIMUW, 2005). Tagging experiments on recruiting fish have revealed that whiting stocks west of Ireland are distinct from those in the Minches, Clyde and the Irish Sea. On the basis of preliminary results from FRS project MF0464, there appears to be three putative populations of whiting are found in VIa, between which interchange is limited. These are along the northwest of Scotland, the Stanton Bank region and the Firth of Clyde. Maximum likelihood analysis indicates a high degree of mixing for adult whiting between IVa whiting and the VIa component off the northwest of Scotland. Within VIa, there was little indication of interaction between population components in the south and that off the northwest coast.

A.2. The fishery

The demersal fisheries in Division VIa are predominantly conducted by otter trawlers fishing for cod, haddock, anglerfish and *Nephrops*, with bycatches of whiting, saithe, megrim, lemon sole, ling and a number of skate species. Since 1976, effort by Scottish heavy trawlers and seiners has decreased. Light trawler effort has declined rapidly since 1997 after a long-term increasing trend. More recently, days-at-sea limitations associated with the cod recovery plan and the seasonal closure of some areas has lead to some switching of effort away from VIa.

The demersal whitefish fishery in Area VI occurs largely in Division VIa with the UK, Ireland, Spain and France being the most important exploiters. Landings from Rockall (Division VIb) are generally less than 10 t. The whiting fishery in VIa is dominated by the UK (Scotland) and Irish fleets. French whiting landings have declined considerably since the late 1980s.

Landings of whiting in Division VIa are affected by emergency measures introduced in 2001 as part of the cod recovery programme. Council Regulation 423\2004 introduced a cod recovery plan affecting division VIa. The measures only take effect, however east of a line defined in Council Regulation No 51\2006. Measures brought in 2002, such as a switch from 100 to 120 mm mesh codends at the start of 2002 (Commission Regulation EC2056/2001), are likely to have had some impact on whiting. The UK implemented a regulation requiring the fitting of a square mesh panel in certain towed gears.

Most catch of whiting comes in non-whiting directed fisheries, particularly the *Nephrops* trawl fishery. The *Nephrops* trawl fishery in VIa discards significant amounts of small whiting, making whiting landings figures a poor indicator of removals as a consequence of fishing. The proportion of whiting discarded has been very high and appears to have increased in recent years. Whiting also has a low market demand, which contributes to increased discarding and highgrading.

The minimum landing size of whiting in the human consumption fishery in this area is 27 cm.

There have been some problems regarding area misreporting of Scottish landings during the early 1990s, which are linked to area misreporting of other species such as haddock and anglerfish into Division VIb. More recently there has been area misreporting of anglerfish from VIa to IVa, which may have affected the reliability of whitings landings distribution.

A.3. Ecosystem aspects

No information.

B. Data

B.1. Commercial catch

Monthly length–frequency distribution data were available from Scotland for Area VIa. A total international catch-at-age distribution for Division VIa was obtained using the raising procedure described in Section 2.3 to raise this distribution to the WG estimates of total international catch from this area. Landings officially reported to ICES were used for countries not supplying estimates directly to the WG. The Scottish market sampling length-weight relationships (given below) have been used to raise the sampled catch-at-length distribution data Working Group estimates of total landings for Division Via.

Month	b	a
1	2.9456	0.01
2	2.9456	0.0094
3	2.9456	0.009
4	2.9456	0.0088
5	2.9456	0.0088
6	2.9456	0.0089
7	2.9456	0.009
8	2.9456	0.0092
9	2.9456	0.0095
10	2.9456	0.0096
11	2.9456	0.0097
12	2.9456	0.0097

Discard age-compositions are generally available from both Scotland and Ireland, but in recent years (2006 and 2007) lack of access to fishing vessels by Irish observers has meant that no Irish data have been collected. Work is underway to revise the Scottish discard estimates with an aim to reduce bias and increase precision. Such revisions are particularly important for the estimation of total catch for this stock which has very high discards across a wide age range. A working document set out the methodology of this work at the 2004 meeting of WGNSDS (Fryer and Millar, 2004).

B.2. Biological

Natural mortality is assumed to be constant (M=0.2, applied annually) for the whole range of ages and years.

A combined sex maturity is assumed, knife-edged at-age 2. The use of a knife edged maturity ogive has been a source of criticism in previous assessments. However, recent research on gadoid maturity conducted by the UK (NI) gives no evidence of substantial change in whiting maturity since the 1950s, although there has been an increase in the incidence of precocious maturity-at-age 1, particularly in males, since 1998, in the Irish Sea.

As in previous years, SSB is computed at the start of each year, and the proportions of M and F before spawning were set to zero. Stock weights are calculated using a procedure first described in the 1998 Working Group report. To derive representative stock weights for the start of the year for year i and age j the following formula is adopted:

(CW i,j + CW i+1,j+1)/2 = SW at start of year.

B.3. Surveys

Four research vessel survey series for whiting in VIa were available to the Working Group in 2007. In all surveys listed the highest age represents a true age not a plus group.

- Scottish first-quarter west coast groundfish survey (ScoGFSQ1): ages 1–7, years 1985–2007.

The survey gear is a GOV trawl, and the design is a minimum of one station per rectangle, but with more depending on logistic limitations. Ages are reported from 0 to the maximum obtained. Sex/Maturity-Sex and Maturity (ICES 4-stage scale) are reported. The Scottish groundfish survey has been conducted with a new vessel and gear since 1999. The catch rates for the series as presented are corrected for the change on the basis of comparative trawl haul data (Zuur *et al.*, 2001).

- Irish fourth-quarter west coast groundfish survey (IreGFS): ages 0–3, years 1993–2002.

The Irish quarter four survey was a comparatively short series, was discontinued in 2003 and has been replaced by the IRGFS.

- Scottish fourth-quarter west coast groundfish survey (ScoGFSQ4): ages 0–8, years 1996–2007.

The Scottish quarter four survey was presented to the WG for the first time in 2007.

- Irish fourth quarter west coast groundfish survey (IRGFS); ages 0–3, years 2003–2007.

This survey used the RV Celtic Explorer and is part of the IBTS coordinated western waters surveys. The vessel uses a GOV trawl, and the design is a depth stratified survey with randomized stations. Effort is recorded as minutes towed. There were 41 stations sampled in 2003, 44 in 2004 and 34 in 2005, corresponding to 1229, 1321 and 1010 minutes towed.

Further descriptions of these surveys and distribution plots of whiting catch-rates obtained on these surveys can be found in the IBTS WG report of 2008.

The indices are provided in Table B.2.

The distribution of catches per unit of effort from the surveys in 2008 are given in Figure B.1 for the Scottish fourth-quarter west coast groundfish survey (ScoGFSQ4); and Figure B.2 for the first-quarter west coast groundfish survey (ScoGFSQ1).

B.4. Commercial cpue

As a consequence of a number of concerns regarding the non-mandatory recording of effort as hours fished, the present assessment of the stocks does not make use of commercial catch-per-unit effort data. The data are included here for completeness (Table B.1) and include:

- Scottish light trawlers (ScoLTR): ages 1–7 years 1965–2005;
- Scottish seiners (ScoSEI): ages 1–6 years 1965–2005;
- Scottish *Nephrops* trawlers (ScoNTR): ages 1–6 years 1965–2005;
- Irish Otter Trawlers (IreOTB): ages 1–7 years 1995–2005.

Data to update these time-series were not available for 2006 or 2007.

B.5. Fecundity

Fecundity data for a number of areas are available from Hislop and Hall, 1974, and was estimated at 4.933 $L^{3.25}$ for whiting in Area VI.

C. Historical stock development

Whiting has never been a particularly valuable species and has tended not to be targeted by commercial fishers. It tends to be taken more as a bycatch, with other species fished more intensively in Division VIa, such as haddock, cod and anglerfish. As with other gadoids in VIa, whiting stocks have declined steadily since the late 1970s.

D. Short-term projection

Not done.

E. Medium-term projections

No medium-term projections are carried out for this stock.

F. Yield and biomass-per-recruit/long-term projections

Not done.

G. Biological reference points

Precautionary approach reference points:

VIa-“Long-term information on the historical yield and catch composition all indicate that the present stock size is low. A survey-based assessment covering the more recent period indicates that the stock is at its lowest level over this time period. Total mortality is at the highest level over the time period. ICES considers that B_{lim} is 16 000 t and B_{pa} be set at 22 000 t. ICES proposes that F_{lim} is 1.0 and F_{pa} be set at 0.6.”

VIb-“Landings of whiting from Division VIb are negligible. No assessment has been carried out on this stock.”

H. Other issues

None.

I. References

J. R. G. Hislop. 1975. The breeding and growth of whiting, *Merlangius merlangus*, in captivity. J. Cons. int. Explor. Mer, 36(2): 119–127.

Hislop, J. and Hall, W. 1974. The fecundity of whiting, *Merlangius merlangius* (L.), in the North Sea, Minch and at Iceland. J. Cons. int. Explor. Mer, 36(1): 42–49.

ICES. 2000. ICES CM 2000/ACFM:1.

ICES SGSIMUW. 2005. Report of the Study Group on Stock Identity and Management Units of Whiting. ICES CM 2005/G:03.

Table B.1. Tuning series available to whiting in Via (commercial cpue and research vessel surveys).

2008 WHITING AREA 6A							
108							
SCOLTR: Scottish Light Trawl: Effort in hours: Numbers-at-age (thousands)							
1965	2005						
1	1	0	1				
1	7						
37387	2011.623	469.253	3512.923	393.473	14.925	5.445	0.909
40538	1036.117	926.485	162.985	5508.27	333.46	32.68	6.196
80916	2539.797	4967.604	1637.023	101.256	2456.915	133.979	12.466
65348	1931.014	3404.448	1868.458	677.298	51.295	844.125	58.939
106856	46.897	8823.442	2211.584	578.006	278.879	28.188	516.892
129741	94.958	5275.823	8514.611	712.848	143.241	35.554	3.428
137728	1566.57	4472.064	1026.561	9818.08	337.772	63.477	25.237
154288	13450.885	4637.042	1716.159	334.786	5435.152	309.86	29.756
93992	4613.649	12778.492	680.372	148.997	42.975	478.522	39.083
88651	7452.711	15917.02	1773.837	159.241	17.112	6.477	78.812
132353	10597.964	6684.991	10431.537	837.283	79.71	12.155	2.811
139225	10858.324	15481.895	3550.826	5483.438	412.525	13.045	4.668
143574	18222.115	4276.619	5983.177	773.244	1126.782	74.579	1.916
127387	9805.191	5887.935	1561.61	1814.903	127.832	244.126	3.76
99803	1846.163	9530.148	2446.896	368.018	290.896	31.887	57.01
121211	1856.938	4385.272	4359.469	1052.873	170.989	172.29	10.997
165002	983.137	13544.1	4617.56	1330.75	504.711	152.752	62.619
135280	8248.806	2593.129	10934.792	1899.759	316.934	74.891	62.409
112332	4809.036	4322.894	2548.597	8292.216	1696.241	253.9	54.475
132217	29865.064	4084.418	2582.188	1149.781	5206.862	592.972	221.473
142815	9243.535	11577.551	2515.313	663.96	360.662	917.939	82.73
126533	3187.288	6006.487	2693.592	621.738	98.497	50.635	93.945
131720	12328.429	6004.925	2767.12	1229.144	147.776	43.178	32.132
158191	5358.52	15325.219	2988.119	1334.433	316.668	46.956	2.997
217443	3161.234	1640.767	5226.339	1473.139	434.728	129.89	14.252
169667	4110.42	4152.38	972.043	1380.502	386.872	51.478	6.092
209901	7018.52	2968.053	3981.784	336.752	423.153	73.429	5.829
189288	9761.596	6548.587	1727.049	2100.437	113.974	102.439	10.66
189925	2623.886	10105.623	4392.988	1169.932	1701.769	51.678	46.841
174879	3251.43	6503.608	5363.793	1739.967	333.927	291.821	13.881
175631	1775.509	5661.947	5310.813	1995.375	569.453	114.177	107.935
214159	2738.034	8043.865	4647.63	2543.265	833.461	213.15	24.196
179605	3107.284	3973.701	5098.515	1858.52	532.696	95.153	39.379
142457	3997.939	3171.019	2547.76	2327.54	654.589	149.808	79.812
98993	559.916	3273.961	1709.217	814.593	793.265	122.037	34.883
76157	4363.101	2324.771	2202.561	627.094	169.833	201.883	8.678
35698	575.281	2603.626	1358.595	783.414	117.804	37.996	5.442
15174	389.652	848.153	1566.132	374.617	166.509	16.845	5.038
9357	565.293	207.507	273.115	578.307	100.052	41.916	0.206
7116	1769.901	1215.938	242.922	199.9	221.001	27.997	3.138
3063	217.522	400.094	268.966	23.085	27.158	14.318	2.462

Table B.1. continued.

SCOSEI: Scottish Seine: Effort in hours: Numbers-at-age (thousands)						
1965	2005					
1	1	0	1			
1	6					
153103	8570.938	4534.63	19453.707	1412.984	62.399	15.334
156511	2872.249	12671.39	1491.149	13027.566	736.15	68.22
158208	7058.77	23604.969	5804.573	363.182	5528.921	304.951
150094	11817.932	14128.65	4897.227	1409.535	134.705	1651.222
140718	1314.237	19167.426	4024.433	1038.908	420.643	45.006
95629	979.255	2065.056	9177.95	815.703	176.987	51.144
98748	3280.938	6459.36	2466.983	14808.06	484.003	73.488
70741	20563.777	7286.501	1143.727	588.902	3139.349	112.588
59596	16428.303	16410.354	1995.231	373.15	97.243	886.47
56448	8764.309	28089.33	3578.12	289.184	22.105	9.317
56420	15931.473	9161.576	13093.543	585.337	37.682	9.127
57090	7559.305	30718.529	6226.15	4887.683	283.504	18.081
41920	14522.98	4873.693	6783.85	584.118	1035.664	43.296
33599	9880.994	4708.252	812.33	1086.089	65.835	152.233
38465	3779.036	13497.126	3739.924	473.079	392.189	16.481
38700	2222.899	3686.353	4277.55	1081.223	273.049	118.803
37208	789.787	9229.84	3128.155	1025.456	426.614	90.387
36689	1146.222	1977.49	9664.041	1183.655	229.857	68.248
38080	3803.96	3110.436	1942.945	5805.497	1181.95	138.395
29561	3965.733	2170.117	1220.296	382.107	2024.552	218.843
26365	18813.885	6473.455	1248.851	327.561	171.234	557.447
19960	1423.965	4902.12	1815.778	359.211	53.845	24.911
26332	8664.831	3706.126	2068.674	916.903	142.281	19.137
21383	7392.194	8210.657	1658.022	1078.674	218.449	22.005
39350	2182.008	1845.431	4488.746	1282.547	272.354	186.923
27664	2699.332	2964.297	687.892	940.682	279.68	34.508
25787	4160.412	2318.718	3285.513	305.785	290.789	53.282
20273	7513.958	5370.645	1341.721	1622.613	102.037	101.204
24315	1509.725	6046.03	2291.531	675.422	789.292	22.916
21305	1725.208	3310.909	2498.717	701.186	108.245	140.133
21950	721.806	2616.333	2260.832	970.329	298.966	83.208
15205	1270.19	2353.781	1371.875	819.771	297.3	67.732
11449	1096.1	1273.361	1933.262	696.409	187.498	33.748
11166	4251.142	1659.104	1010.394	614.297	265.65	62.355
8638	823.21	2152.386	706.708	294.599	179.097	43.194
6431	2601.077	887.944	755.637	152.896	66.565	19.536
5893	728.924	1007.442	454.373	240.788	40.285	22.082
3817	335.558	583.357	482.121	132.428	40.991	2.935
2370	3130.339	260.924	133.135	290.007	34.543	8.6
1173	7323.289	758.611	165.379	83.46	77.222	2.096
476	676.408	225.196	143.246	10.154	15.355	3.048

Table B.1. continued.

SCONTR: Scottish Nephrops Trawl: Effort in hours: Numbers-at-age (thousands)					
1965	2005				
1	1	0	1		
1	6				
101975	1659.715	453.604	1101.02	102.448	4.875
116972	613.623	951.561	154.546	785.807	44.575
135811	1788.967	2002.916	444.377	15.668	322.969
166713	1761.346	1850.07	637.399	159.199	12.641
155131	736.536	2706.572	437.098	155.072	44.263
144704	439.172	645.419	1379.363	127.922	31.719
127638	1072.488	444.198	235.897	1405.7	60.499
185397	3744.591	1908.742	232.266	70.731	730.108
186342	3462.89	5445.012	486.932	168.428	24.824
186342	1933.55	5427.964	650.405	87.286	11.605
203053	5916.971	2730.363	2846.712	319.449	35.425
224347	4061.224	4343.339	893.637	1142.92	125.278
196403	3573.612	1393.724	1431.401	168.241	289.689
219562	6053.242	2596.492	417.688	570.766	110.339
273713	659.614	3413.303	934.795	207.461	216.936
254147	1439.22	1529.161	1377.826	281.539	44.696
286461	1090.91	5250.686	1199.303	430.934	105.108
288902	2882.413	422	2552.725	439.981	95.697
293396	2702.936	1289.896	464.524	1258.148	205.504
312947	15763.118	731.211	414.638	132.72	870.58
384215	14885.186	3109.454	505.209	225.601	91.132
368971	2231.072	1259.03	707.734	246.405	8.838
395355	12048.819	1562.25	799.307	375.73	43.994
397682	19926.506	12751.985	539.705	138.471	31.741
379169	9854.602	485.161	443.582	152.424	71.883
390391	7434.593	1407.942	58.831	63.502	8.758
414817	13745.576	1280.079	294.651	27.112	43.958
391325	15245.132	3122.017	453.21	211.635	19.575
406753	6063.665	2833.312	611.27	159.111	112.856
380688	22785.318	4821.332	2174.707	613.104	18.004
333756	14759.284	5645.468	494.013	362.773	33.499
345007	14700.369	1316.965	633.638	192.741	44.427
354884	7854.017	1893.631	387.294	176.713	17.444
350882	13268.769	1926.434	620.474	116.935	63.417
337585	7208.116	1905.577	475.713	92.945	80.71
332659	31208.406	934.503	360.23	101.447	28.855
305743	1743.097	1271.809	189.3	80.436	14.844
258169	7281.766	1291.392	483.271	29.948	8.517
255729	4468.485	586.213	191.646	197.557	41.643
232356	3881.27	1310.954	239.992	157.625	102.126
220936	1738.881	829.542	258.178	41.47	16.707

Table B.2. Available catch-effort and survey tuning-series. For ScoGFSQ1, numbers are standardized to catch-rate per 10 hours. "+" indicates value less than 0.5 after standardizing. For IreGFS, effort is given as minutes towed, numbers are in units.

	SCOGFSQ1: SCOTTISH GROUNDFISH SRUVEY - EFFORT IN HOURS – NUMBERS-AT-AGE							
	Effort	Age						
Year	(hours)	1	2	3	4	5	6	7
1985	10	3140	1792	380	85	23	156	18
1986	10	1456	1526	403	68	10	9	10
1987	10	6938	1054	584	143	36	2	1
1988	10	567	3469	653	189	42	5	1
1989	10	910	505	586	237	48	3	0
1990	10	1818	572	122	216	61	4	1
1991	10	3203	277	298	22	39	9	1
1992	10	4777	1597	410	517	56	18	0
1993	10	5532	6829	644	91	30	11	2
1994	10	6614	2443	1487	174	56	15	6
1995	10	5598	2831	1160	370	70	17	32
1996	10	9384	2238	635	341	135	30	5
1997	10	5663	2444	1531	355	102	17	4
1998	10	9851	1352	294	195	50	14	1
1999	10	6125	4952	489	103	16	1	0.4
2000	10	12862	471	152	34	10	11	0
2001	10	4653	1954	242	41	8	1	1
2002	10	5542	1028	964	86	15	1	1
2003	10	6934	746	436	300	32	2	4
2004	10	5888	1566	189	131	44	9	1
2005	10	1308	723	183	35	8	11	2
2006	10	1441	466	282	77	0.3	3	0.6
2007	10	614	522	127	75	16	3	2
2008	10	593	127	77	26	8	3	0
2009	10	906	387	103	105	20	9	7

	IR-WCGFS : IRISH WEST COAST GFS (VIA) - EFFORT (MIN. TOWED) - WHITING NUMBER-AT-AGE						
	Effort	Age					
Year	(min)	0	1	2	3	4	5
1993	2130	14403	32643	11419	1464	231	13
1994	1865	264	11969	4817	2812	78	57
1995	2026	34584	5609	6406	734	186	80
1996	2008	376	7457	3551	374	232	5
1997	1879	1550	13865	8207	1022	524	50
1998	1936	1829	4077	3361	663	121	5
1999	1914	3337	3059	1965	322	11	12
2000	1878	682	10102	2126	109	109	4
2001	965	1118	5201	2903	149	70	3
2002	796	594	8247	9348	820	280	0

IRGFS: Irish groundfish survey - effort in minutes – numbers-at-age								
	Effort	Age						
Year	(min)	0	1	2	3	4	5	6
2003	1127	1101	12886	2894	512	290	102	1
2004	1200	6924	3114	1312	104	35	16	1
2005	960	910	2228	1126	91	5	4	0
2006	1510	99	1055	921	214	27	3	0
2007	1173	138	1989	2380	722	169	251	122
2008	1135	24	4342	1328	573	243	123	36

IreOTB : Irish otter trawl - Effort in hours – numbers-at-age (thousands)							
1995	2005						
1	1	0	1				
1	7						
56335	222	298	530	461	92	28	98
60709	165	531	670	281	175	33	12
62698	99	358	515	282	339	133	89
57403	51	1092	552	312	186	218	232
53192	98	315	437	266	198	109	123
46913	50	131	188	303	158	76	65
48358	14	304	144	101	126	100	44
37231	31	162	388	27	65	97	47
39803	90	294	604	492	131	30	0
35140	33	387	266	245	200	28	21
30941	23	159	188	78	41	19	2

(cont). Whiting in VIa. Available catch-effort and survey tuning-series. For ScoGFSQ4, numbers are standardized to catch-rate per 10 hours. "+" indicates value less than 0.5 after standardizing.

ScoGFSQ4 : Quarter four Scottish groundfish survey - Effort in hours – numbers-at-age										
	Effort	Age								
Year	(hours)	0	1	2	3	4	5	6	7	8
1996	10	5154	1908	1116	570	188	51	6	1	0
1997	10	8001	2869	951	323	160	46	12	1	0
1998	10	1852	2713	1124	149	100	20	1	0	+
1999	10	8203	2338	582	141	33	24	1	1	0
2000	10	4434	4055	789	160	9	7	1	0	0
2001	10	9615	1957	1420	155	40	12	2	0	0
2002	10	14658	1591	621	479	30	9	5	0	0
2003	10	9932	3446	567	338	83	27	4	0	0
2004	10	5923	1758	940	83	57	62	1	0	0
2005	10	2297	308	318	76	9	4	0.9	0.7	0
2006	10	415	296	140	101	35	8	3	0.5	0
2007	10	1894	434	326	99	83	48	0.6	0	0
2008	10	2297	208	78	110	28	24	4	0	+

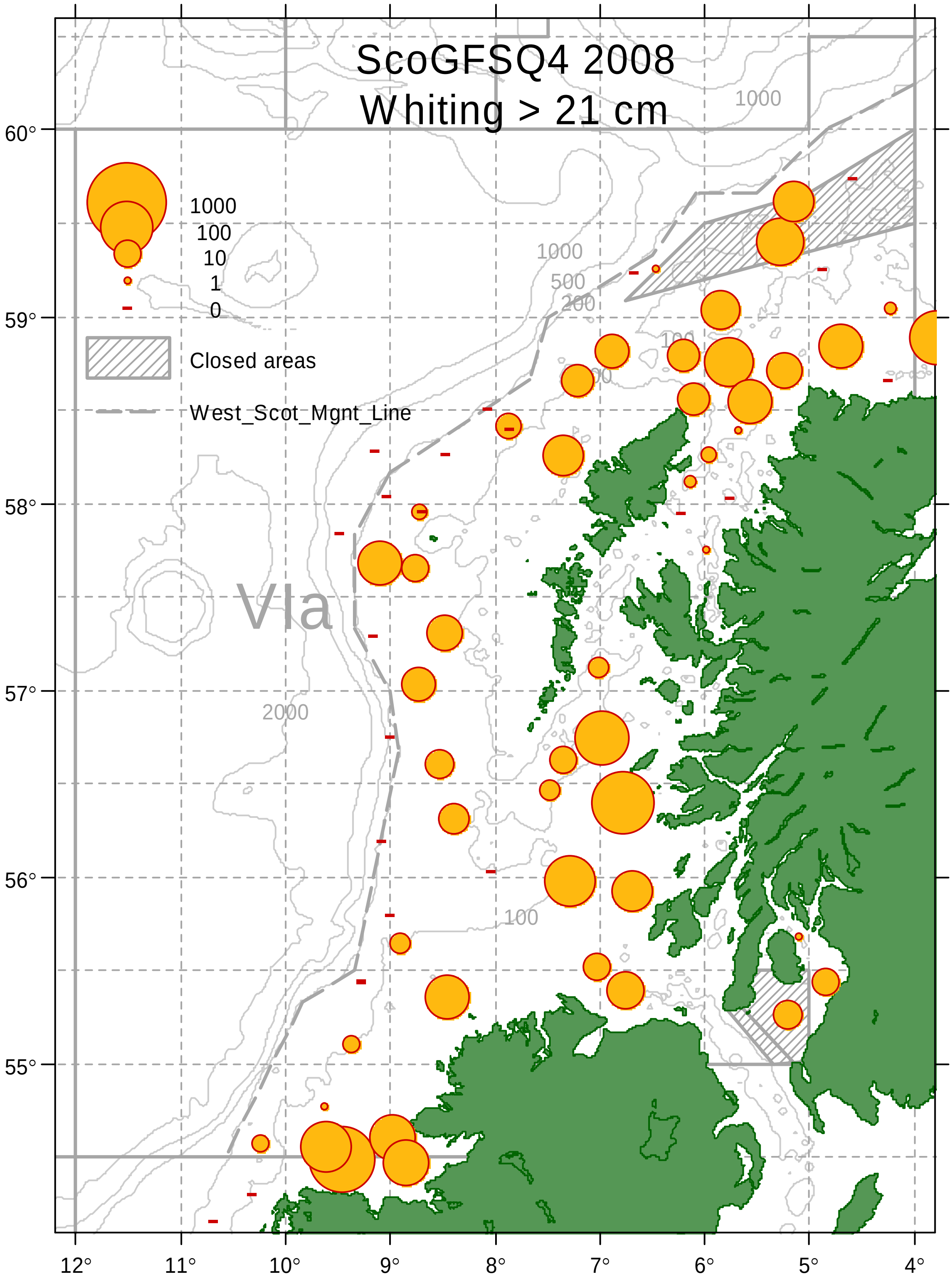


Figure B.1. Map of the west coast of Scotland showing the catch per unit of effort of whiting during the 2008 Scottish fourth-quarter west coast groundfish survey. Each circle is centred on the sample location and the size of the circle is proportional to the number density (n/30 mins fished) of whiting greater than 21 cm (age 1+), according to the legend (top left).

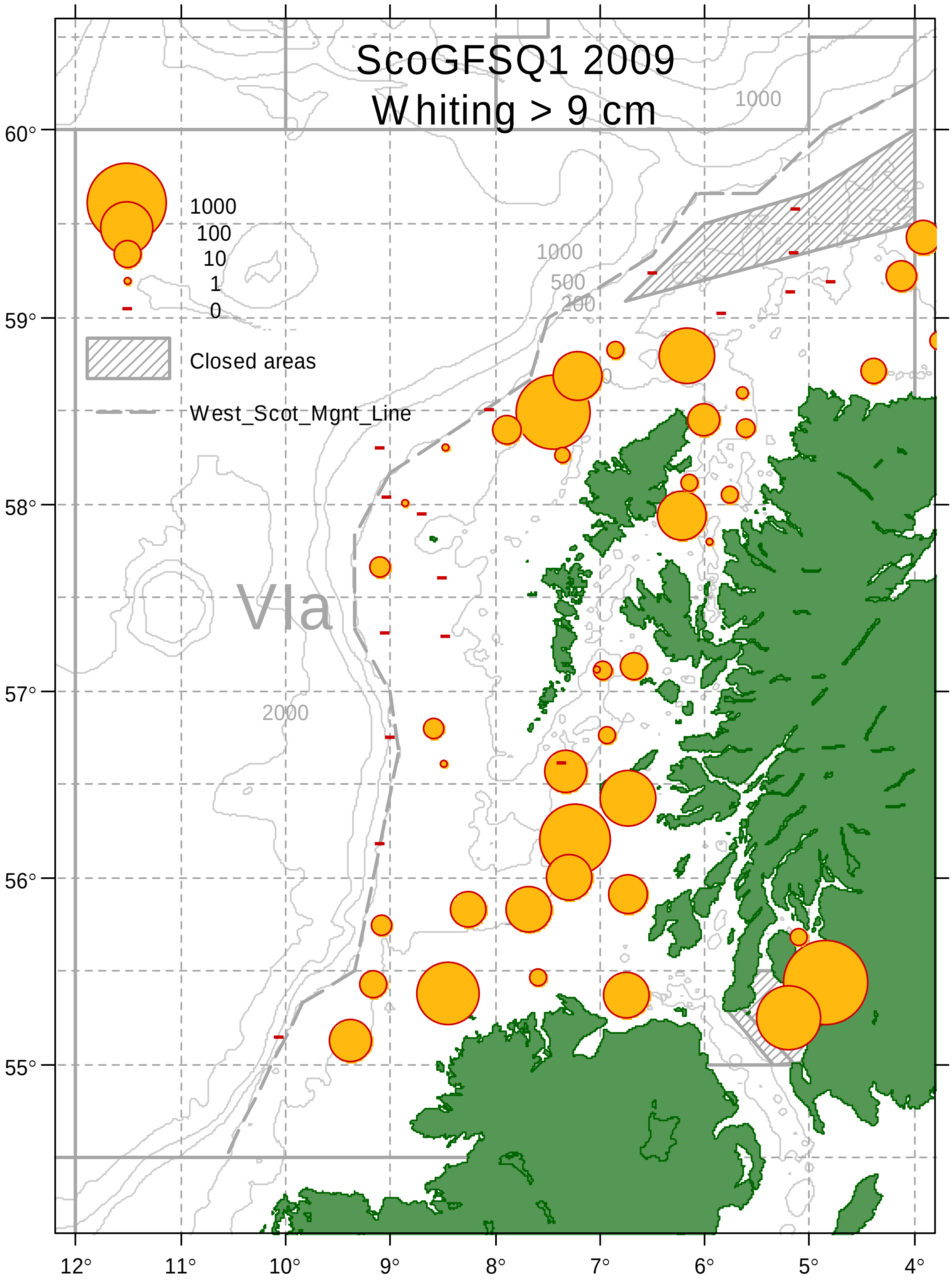


Figure B.2. Map of the west coast of Scotland showing the catch per unit of effort of whiting during the 2008 Scottish first-quarter west coast groundfish survey (ScoGFSQ1). Each circle is centred on the sample location and the size of the circle is proportional to the number density (n/30 mins fished) of whiting greater then 9cm (age 1+), according to the legend (top left).

Annex 3.5: Stock Annex: FU11, North Minch

Stock specific documentation of standard assessment procedures used by ICES.

Stock	North Minch *Nephrops* (FU 11)
Date:	09 March 2009 (WKNEPH2009)
Revised by	Sarah Clarke/Carlos Mesquita

A. General

A.1. Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt and clay content of between 10–100% to excavate its burrows. This means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small-scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. The North Minch Functional Unit (FU11) is located off the northwest coast of Scotland. The northern boundary of the FU is the 59°N line, although there are no areas of suitable sediment north of 58°30′N. The boundary with the South Minch FU is at 57°30′N. The North Minch includes areas of sediment in the Inner Sound, between Skye and the mainland, with other small, isolated areas of sediment.

A.2. Fishery

The North Minch *Nephrops* fishery is predominantly exploited by *Nephrops* trawlers using single rig gear with a 70 mm mesh, although about 15% of landings are currently made by creel vessels. About 15% of the trawl landings are made with a 100 mm mesh, and only 1% of landings appear to be made by twin-rig vessels.

All the creel vessels are local, and roughly three quarters of the trawl landings are made by vessels based between Mallaig and Kinlochbervie on the mainland, and Stornoway on the Isle of Lewis. The major landing ports are Ullapool, Gairloch and Stornoway. In all, about 135 trawlers contribute to the landings, 75% of which are local. Mean engine power is 206kW, and mean vessel length 15.5 m. Most vessels were built between the 1960s and 1980s.

The minimum landing size for *Nephrops* in the North Minch is 20 mm CL, and less than 0.5% of the animals are landed under size. Discarding takes place at sea, and landings are made by category for whole animals (small, medium and large) and as tails. The main bycatch species is haddock, although whiting and Norway pout also feature significantly in discards.

The fishery is exploited throughout the year, with the highest landings usually made in spring and summer. Vessels usually have a trip duration of one day in winter, but up to six days in summer.

The current legislation governing *Nephrops* trawl fisheries on the West coast of Scotland was laid down by the North Sea and West of Scotland cod recovery plan (EC 2056/2001), which established measures additional to EC 850/98. This regulation was amended in 2003 by Annex XVII of EC 2341/2002, which establishes fishing effort and additional conditions for monitoring, inspection and surveillance for the recovery of certain cod stocks. This regulation effectively limits vessels targeting *Nephrops* with 70–99 mm mesh size to 25 days at sea per month. The use of square mesh and headline panels are compulsory in this fishery.

Additional Scottish legislation (SSI No 2000/226) applies to twin trawlers operating North of 560N, A mesh size of 100 mm or above must be used without a lifting bag and with not more than 100 meshes round the circumference but with up to 5 mm double twine. By comparison, vessels using a single trawl may use 70–89 mm mesh with a lifting bag and 120 meshes round the codend but with 4 mm single twine.

A.3. Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the Working Group.

B. Data

B.1. Commercial catch

Length and sex compositions of *Nephrops* landed from the North Minch are estimated from port sampling in Scotland. Length data from Scottish sampling are applied to all catches and raised to total international landings. Rates of discarding by length class are estimated for Scottish fleets by on-board sampling, and extrapolated to all other fleets. The proportion of discarded to landed *Nephrops* changes with year, often determined by strong year classes. Discard sampling started in 1990, and for years prior to this estimates have been made based on later data. Landings and discards-at-length are combined (assuming a discard survival rate of 25%) to removals. Removals are raised separately for each sex.

Scottish *Nephrops* trawler lpue remains at a high level in 2007, demonstrating a marked increase for females; although lpue on males reveals a reduction in 2007 (Table B1.1 and Figure B1.1). However, it is difficult to conclude whether these data are representative of actual lpue as improved reporting of landings in recent years (as a consequence of 'buyers and sellers') will have contributed to this increase and the trends also likely to be affected by non-mandatory effort recording (hours fished). These comments also apply to the paragraphs below.

In general, males make the largest contribution to the landings (Figure B1.2). Effort has traditionally been higher in the 2nd and 3rd quarters of the year in this fishery, but has declined in the 3rd quarter in the most recent years and it is now the 2nd quarter that exhibits the highest fishing effort. Male lpue declined between 1996 and 1998, but has increased since then, and has been particularly high in the 1st and 4th quarters of recent years. The lpue for females is highest in summer between the hatching and spawning periods.

Cpue data for each sex, for *Nephrops* above and below 35 mm CL, are shown in Figure B1.3. This size was chosen for all the Scottish stocks examined as the general size limit above which the effects of discarding practices and the addition of recruits were likely to be small. The data demonstrate a peak in cpue for smaller individuals in 1994 (and for females in 1995), with values declining to the longer term average until 2001. Since then, values have been increasing and reached a peak in 2006. The drop in 2007 may be associated with reduced recruitment and corresponds to the reduced UWTV densities (see report). The cpue for larger males demonstrate a similar pattern, although the cpue has increased further in 2007. Cpue for the larger females appears to be very stable, with small increases in the past two years.

Trawl and creel fisheries are sampled separately.

B.2. Biological

Mean weights-at-age for this stock are estimated from fixed Scottish weight–length relationships (Howard *et al.*, 1988). Relevant biological parameters are as follows: natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females.

Summary

Growth parameters:

Males; L_∞ = 70 mm, k = 0.16

Immature Females; L_∞ = 70 mm, k = 0.16

Mature Females; L_∞ = 60 mm, k = 0.06,

Size at maturity = 27 mm

Weight length parameters:

Males a = 0.00028, b = 3.24

Females a= 0.00074, b = 2.91

Discards

Discard survival rate: 25%

Discard rate: 19.9%

Proportion of F and M prior to spawning was specified as zero to give estimates of spawning-stock biomass at January 1.

B.3. Surveys

Abundance indices are available from the following research-vessel surveys:

Underwater TV survey: years 1995–present. The survey usually occurs in June. The burrowing nature of *Nephrops*, and variable emergence rates mean that trawl catch rates may bear little resemblance to population abundance. An underwater TV survey has been developed, estimating *Nephrops* population abundance from burrow density raised to stock area. The survey provides a total abundance estimate, and is not age or length structured.

Because of this uncertainty in sediment distribution and suitability, the North Minch is divided into four arbitrary rectangles, roughly corresponding to discrete patches of mud in (or on the border of) the functional unit, for survey purposes (Figure B3.1). Samples are distributed randomly over the area of suitable sediment within each rectangle. In the assessment, burrow densities in the four rectangles are raised to the area of suitable sediment in each region.

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as an absolute it is necessary to correct for these potential biases. The history of bias estimates are given in the following table and are based on simulation models, preliminary experimentation and expert opinion, the biases associated with the estimates of *Nephrops* abundance in the North Minch are:

	Time period	Edge effect	Detection rate	Species identification	Occupancy	Cumulative bias
FU11: North Minch	<=2009	1.38	0.85	1.1	1	1.33

B.4. Commercial cpue

Catch-per-unit-effort time-series are available from the following fleets:

Scottish *Nephrops* trawl gears: Landings-at-age and effort data for Scottish *Nephrops* trawl gears are used to generate a cpue index. Cpue is estimated using officially recorded effort (hours fished) although the recording of effort is not mandatory. Combined effort for *Nephrops* single trawl and multiple *Nephrops* trawl is raised to landings reported by the four gears listed above. Discard sampling commenced in 1990 for this fishery, and for years prior to this, an average of the 1990 and 1991 values is applied. There is no account taken of any technological creep in the fleet.

For more information see Section B.1.

B.5. Other relevant data

C. Historical stock development

1) Survey indices are worked up annually resulting in the TV index.

2) Adjust index for bias (see section B3). The combined effect of these biases is to be applied to the new survey index.

3) Generate mean weight-in-landings. Check the time-series of mean landing weights for evidence of a trend in the most recent period. If there is no firm evidence of a recent trend in mean weight, use the average of the three most recent years. If, however, there is strong evidence of a recent trend then apply most recent value (don't attempt to extrapolate the trend further in future).

D. Short-term projection

4) The catch option table will include the harvest ratios associated with fishing at $F_{0.1}$ and F_{max}. These values have been estimated by the Benchmark Workshop (see Section 9.2) and are to be revisited by subsequent benchmark groups. The values are FU specific and have been put in the Stock Annexes.

5) Create catch option table on the basis of a range of harvest ratios ranging from 0 to the maximum observed ratio or the ratio equating to F_{max}, whichever is the larger. Insert the harvest ratios from step 4 and also the current harvest ratio.

6) Multiply the survey index by the harvest ratios to give the number of total removals.

7) Create a landings number by applying a discard factor. This conversion factor has been estimated by the Benchmark Workshop and is to be revisited at subsequent benchmark groups. The value is FU specific and has been put in the Stock Annex.

8) Produce landings biomass by applying mean weight.

The suggested catch option table format is as follows.

	Implied fishery			
	Harvest rate	Survey Index	Retained number	Landings (tonnes)
	0%	12 345	0	0.00
	2%	"	247	123.45
	4%	"	494	246.90
	6%	"	741	370.35
	8%	"	988	493.80
F0.1	8.60%	"	1062	530.84
	10%	"	1235	617.25
	12%	"	1481	740.70
Fmax	13.50%	"	1667	833.29
	14%	"	1728	864.15
	16%	"	1975	987.60
	18%	"	2222	1111.05
	20%	"	2469	1234.50
	22%	"	2716	1357.95
Fcurrent	21.5%	"	2654	1327.09

E. Medium-term projections

None presented.

F. Long-term projections

None presented.

G. Biological reference points

Harvest ratios equating to fishing at $F_{0.1}$ and F_{max} were calculated in WK*Neph* 2009. These calculations assume that the TV survey has a knife-edge selectivity at 17 mm and that the supplied length frequencies represented the population in equilibrium.

F-reference point	Harvest ratio
F0.1	8.8%
Fmax	15.4%

H. Other issues

I. References

Table B1.1. *Nephrops*, North Minch (FU11): Landings (tonnes), effort ('000 hours trawling) and lpue (kg/hour trawling) of Scottish *Nephrops* trawlers, 1981–2007 (data for all *Nephrops* gears combined, and for single and multirigs separately).

Year	All *Nephrops* gears combined			Single rig			Multirig		
	Landings	Effort	LPUE	Landings	Effort	LPUE	Landings	Effort	LPUE
1981	2320	78.5	29.6	2320	78.5	29.6	na	na	na
1982	2323	82.4	28.2	2323	82.4	28.2	na	na	na
1983	2784	64.9	42.9	2784	64.9	42.9	na	na	na
1984	3449	79.3	43.5	3449	79.3	43.5	na	na	na
1985	3236	96.8	33.4	3236	96.8	33.4	na	na	na
1986	2642	93.2	28.4	2642	93.2	28.4	na	na	na
1987	3458	121.2	28.5	3458	121.2	28.5	na	na	na
1988	3449	115.0	30.0	3449	115.0	30.0	na	na	na
1989	2603	87.9	29.6	2603	87.9	29.6	na	na	na
1990	1941	79.8	24.3	1941	79.8	24.3	na	na	na
1991	2228	93.4	23.9	2123	90.5	23.5	105	2.9	36.7
1992	2978	99.4	30.0	2810	95.7	29.4	168	3.7	45.4
1993	2699	105.4	25.6	2657	104.4	25.4	42	1.0	43.4
1994	2916	100.8	28.9	2916	100.8	28.9	0	0.0	0.0
1995	2940	94.2	31.2	2937	94.1	31.2	3	0.1	60.0
1996	2355	78.0	30.2	2354	78.0	30.2	1	0.0	0.0
1997	2553	90.0	28.4	2510	88.8	28.3	43	1.2	35.8
1998	2023	84.9	23.8	1973	83.4	23.7	50	1.5	33.3
1999	2791	96.7	28.9	2750	95.5	28.8	41	1.2	34.2
2000	2695	92.6	29.1	2675	92.2	29.0	21	0.4	52.5
2001	2651	82.1	32.3	2599	80.9	32.1	51	1.2	43.3
2002	2775	79.3	35.0	2684	76.5	35.1	91	2.8	32.5
2003	2607	74.1	35.2	2589	73.9	35.0	17	0.2	85.0
2004	2400	69.7	34.4	2377	69.0	34.4	23	0.2	99.6
2005	2267	58.0	39.1	2241	57.7	38.8	26	0.2	114.5
2006	3446	62.4	55.2	3383	61.8	54.7	63	0.6	105.0
2007	3362	65.7	51.2	3304	65.4	50.5	58	0.3	193.3

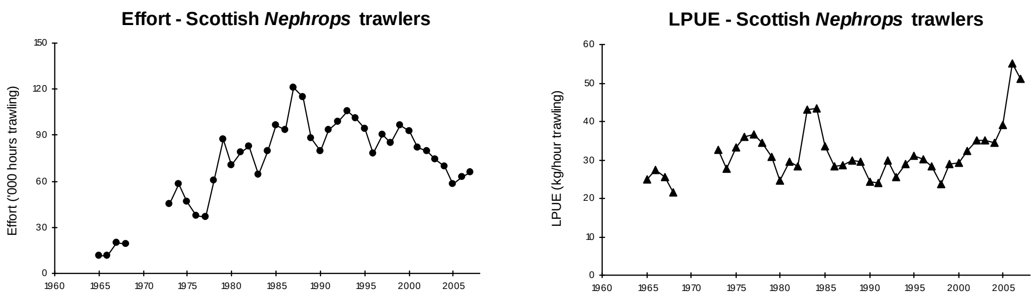


Figure B1.1. *Nephrops*. North Minch (FU11). Effort and lpue from Scottish *Nephrops* trawlers.

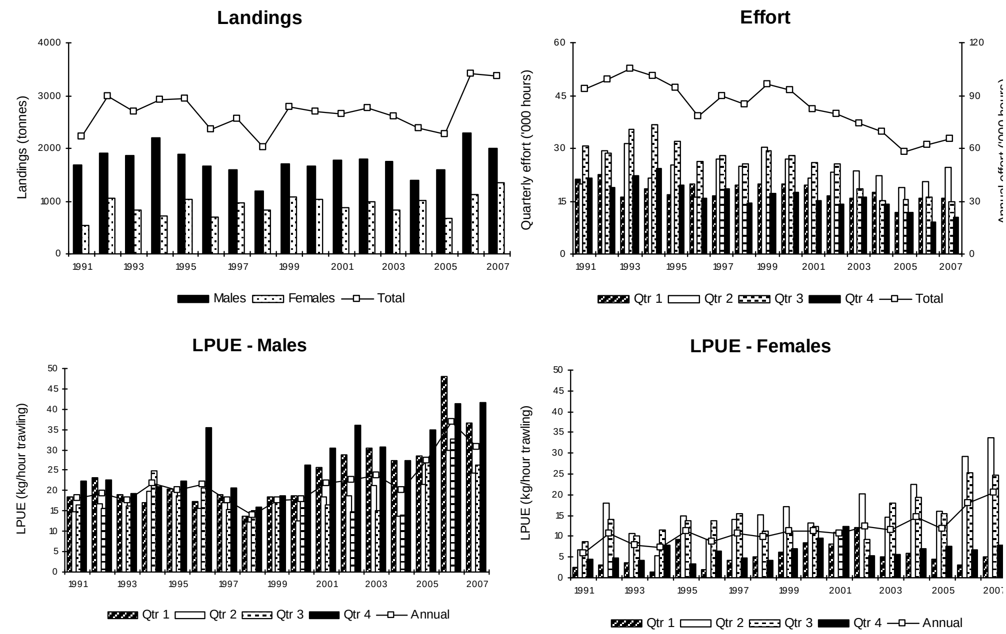


Figure B1.2: *Nephrops*. North Minch (FU11), Landings, effort and lpues by quarter and sex from Scottish *Nephrops* trawlers.

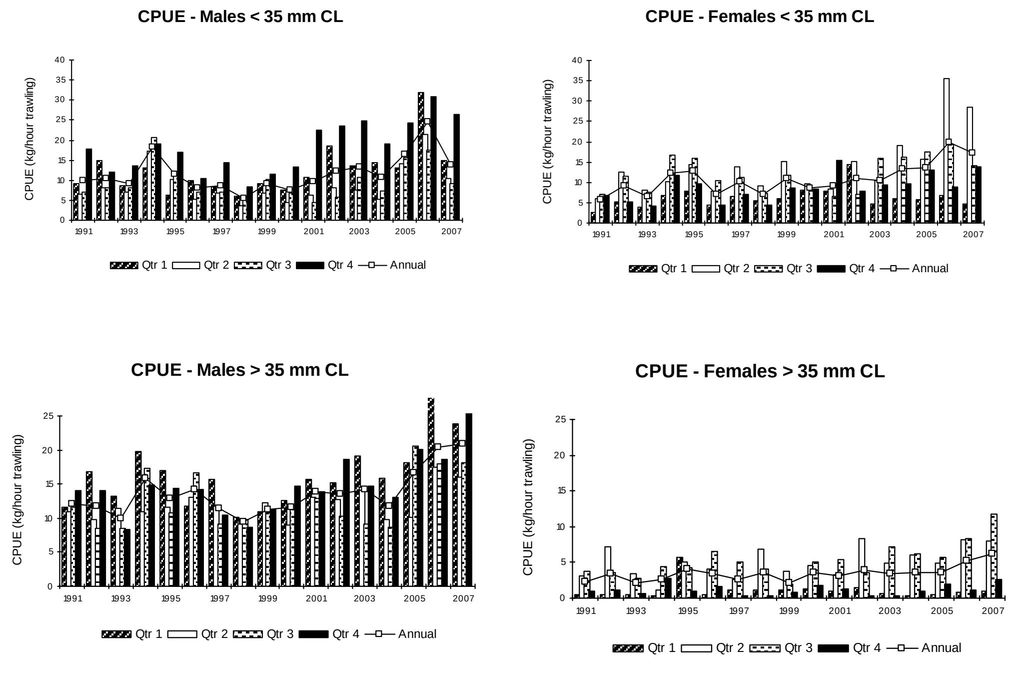


Figure B1.3. *Nephrops*, North Minch (FU11), cpues by sex and quarter for selected size groups, Scottish *Nephrops* trawlers.

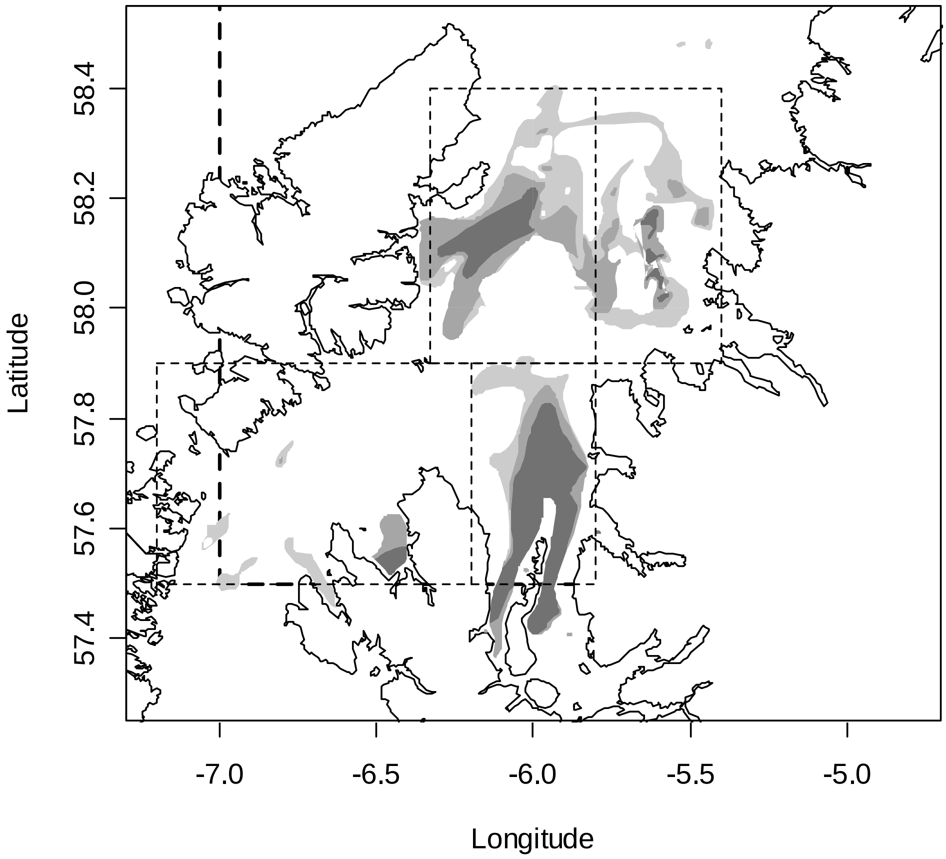


Figure B3.1. Distribution of *Nephrops* sediments in the North Minch. Thick dashed lines represent the boundary of the functional unit. Thin dashed lines represent the arbitrary rectangles used as survey strata. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

Annex 3.6: Stock Annex: FU12, South Minch

Stock specific documentation of standard assessment procedures used by ICES.

Stock	South Minch *Nephrops* (FU12)
Date:	09 March 2009 (WK*NEPH*2009)
Revised by	Sarah Clarke/Carlos Mesquita

A. General

A.1. Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt and clay content of between 10–100% to excavate its burrows, and this means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small-scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. In the South Minch area the *Nephrops* stock inhabits a generally continuous area of muddy sediment extending from the south of Skye to the Stanton Bank, to the south of the Outer Hebrides. The South Minch functional unit (FU12) is located off the west coast of Scotland, and is bounded to the north and south by the 56°00' and 57°30' circles of latitude, and to the west by the 8°W meridian. Out with the functional unit, a mixed fishery for gadoids and *Nephrops* takes place on Stanton Bank, to the southwest of the Outer Hebrides.

A.2. Fishery

The South Minch *Nephrops* fishery is predominantly exploited by *Nephrops* trawlers, although about 15% of landings are made by creel vessels, which has increased in recent years. About 90% of trawler landings are made by vessels targeting *Nephrops*, and only 1% of landings are made by twin-rig vessels. Of the *Nephrops* trawlers, about 80% of landings are made with a 70 mm mesh.

All the creel vessels are local, and roughly half of the trawl landings are made by vessels based between Mallaig and Campbeltown. Visiting vessels originate in the North Minch (8% of landings) and the Scottish East coast. The East coast vessels tend to be larger than the local ones, and carry out longer trips. Mean engine power of the local vessels is 200 kW, and their mean length 15.0 m. Most vessels were built between the 1960s and the 1980s. The major landing ports are Oban and Mallaig. The smaller vessels usually have a trip duration of 1–3 days, whereas larger boats may stay out for 5–6 days.

The minimum landing size for *Nephrops* in the South Minch is 20 mm CL and less than 0.5% of animals are landed under size. Discarding takes place at sea and landings are made by category for whole animals (small and large) and as tails. The main bycatch species are whiting and haddock, with whiting in particular featuring heavily in discards. Of the non-commercial species caught, poor cod, Norway pout and long rough dab contribute significantly to the discards.

The fishery is exploited throughout the year, with the highest landings usually being made in spring and summer. A seasonal sprat fishery often develops in November and December, which is targeted by vessels of all sizes (including those that usually target *Nephrops*). Some vessels also turn to scallop dredging when *Nephrops* catches or prices drop, although the scope for this has been limited in recent years with ASP and PSP closures of the scallop fishery in some areas.

The current legislation governing *Nephrops* trawl fisheries on the West coast of Scotland was laid down by the North Sea and West of Scotland cod recovery plan (EC 2056/2001), which established measures additional to EC 850/98. This regulation was amended in 2003 by Annex XVII of EC 2341/2002, which establishes fishing effort and additional conditions for monitoring, inspection and surveillance for the recovery of certain cod stocks. This regulation effectively limits vessels targeting *Nephrops* with 70–99 mm mesh size to 25 days at sea per month. The use of square mesh and headline panels are compulsory in this fishery.

Additional Scottish legislation (SSI No 2000/226) applies to twin trawlers operating North of 56^{0}N, A mesh size of 100 mm or above must be used without a lifting bag and with not more than 100 meshes round the circumference but with up to 5 mm double twine. By comparison, vessels using a single trawl may use 70–89 mm mesh with a lifting bag and 120 meshes round the codend but with 4 mm single twine.

A.3. Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the Working Group.

B. Data

B.1. Commercial catch

Length and sex compositions of *Nephrops* landed from the South Minch are estimated from port sampling in Scotland. Length data from Scottish sampling are applied to all catches and raised to total international landings. Rates of discarding by length class are estimated for Scottish fleets by on-board sampling, and extrapolated to all other fleets. The proportion of discarded to landed *Nephrops* changes with year, often determined by strong year classes. Discard sampling started in 1990, and for years prior to this estimates have been made based on later data. Landings and discards-at-length are combined (assuming a discard survival rate of 25%) to removals. The differences in catchability between sexes have lead to the two sexes being assessed separately. And hence removals are raised separately for each sex.

Reported *Nephrops* trawl effort in 2007 was similar to the four previous years, while total landings demonstrate a marked increase since 2006 (Figure B1.1), possibly as a result of more accurate reporting since the introduction of the "buyers and sellers" regulations in the UK in this year.

Reported effort by Scottish *Nephrops* trawlers demonstrated a steady decline since 1990 to 2002, but has since stabilized (Figure B1.2 and Table B1.1). The reliability of these data (and the resulting lpue trends) is questionable because the logsheet recording of 'hours fished' is known to have been erratic in the past as it is a non-mandatory field on the logsheet. Scottish *Nephrops* trawler lpue remained stable between 1998 and 2001, but has demonstrated an increase more recently, particularly over the last two years (2006 and 2007).

Males contribute more to the landings than females (Figure B1.2), as in all other functional units. Effort is normally highest in the 2nd quarter in this fishery, and generally lowest in the 4th quarter. Male lpue has remained relatively stable over the time-series prior to 2006, but demonstrates a marked increase in 2006 and 2007, possibly as a result of the aforementioned introduction of the "buyers and sellers" regulations.

Discarding of undersize and unwanted *Nephrops* occurs in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since

1990. Discarding rates averaged over the period 2005 to 2007 for this stock were 21% by number or 12% by weight. This represents a decrease on the 2003 to 2005 period.

Cpue data for each sex, for *Nephrops* above and below 35 mm CL, are shown in Figure B1.3. This size was chosen for all the Scottish stocks examined as the general size limit above which the effects of discarding practices and the addition of recruits were likely to be small. The data reveal a peak in cpue for smaller individuals in 1995, with values declining to the longer term average after this, and a second rise in 2001 which has continued upwards to 2007. The higher values are particularly evident for males in the 1st and 4th quarters. The cpue for females over 35 mm has fluctuated without trend over the time period, and demonstrate consistently higher values in the 2nd and 3rd quarters of the year.

Trawl and creel fisheries are sampled separately.

B.2. Biological

Mean weights-at-age for this stock are estimated from fixed Scottish weight–length relationships (Howard *et al.*, 1988, citation required). Relevant biological parameters are as follows: natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females.

Summary

Growth parameters:

Males; L_∞ = 66 mm, k = 0.16

Immature Females; L_∞ = 66 mm, k = 0.16

Mature Females; L_∞ = 59 mm, k = 0.06,

Size at maturity = 25 mm

Weight length parameters:

Males a = 0.00028, b = 3.24

Females a= 0.00074, b = 2.91

Discards

Discard survival rate: 25%

Discard rate: 16.7%

Proportion of F and M prior to spawning was specified as zero to give estimates of spawning-stock biomass at January 1.

B.3. Surveys

Abundance indices are available from the following research-vessel surveys:

Underwater TV survey: years 1995–present. The survey usually occurs in June. The burrowing nature of *Nephrops*, and variable emergence rates mean that trawl catch rates may bear little resemblance to population abundance. An underwater TV survey has been developed, estimating *Nephrops* population abundance form burrow density raised to stock area. A random stratified sampling design is used, on the basis of British Geological Survey sediment strata. The survey provides a total abundance estimate, and is not age or length structured (Figure B3.1).

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as an absolute it is necessary to correct for these potential biases. The history of bias estimates are given in the following table and are based on simulation models, preliminary experimentation and expert opinion, the biases associated with the estimates of *Nephrops* abundance in the South Minch are:

	Time period	Edge effect	Detection rate	Species identification	Occupancy	Cumulative bias
FU12: South Minch	<=2009	1.37	0.85	1.1	1	1.32

B.4. Commercial cpue

Landings-per-unit-effort time-series are available from: *Nephrops* single trawl, multiple *Nephrops* trawl, light trawl and multiple demersal trawl.

Scottish *Nephrops* trawl gears: Landings-at-age and effort data for Scottish *Nephrops* trawl gears are used to generate a cpue index. Cpue is estimated using officially recorded effort (hours fished) although the recording of effort is not mandatory. Combined effort for *Nephrops* single trawl and multiple *Nephrops* trawl is raised to landings reported by the four gears listed above. Discard sampling commenced in 1990 for this fishery, and for years prior to this, an average of the 1990 and 1991 values is applied. There is no account taken of any technological creep in the fleet.

For more information see Section B.1.

B.5. Other relevant data

C. Historical stock development

1) Survey indices are worked up annually resulting in the TV index.

2) Adjust index for bias (see Section B3). The combined effect of these biases is to be applied to the new survey index.

3) Generate mean weight-in-landings. Check the time-series of mean landing weights for evidence of a trend in the most recent period. If there is no firm evidence of a recent trend in mean weight use the average of the three most recent years. If, however, there is strong evidence of a recent trend then apply most recent value (don't attempt to extrapolate the trend further in future).

D. Short-term projection

4) The catch option table will include the harvest ratios associated with fishing at $F_{0.1}$ and F_{max}. These values have been estimated by the Benchmark Workshop (see Section 9.2) and are to be revisited by subsequent benchmark groups. The values are FU specific and have been put in the Stock Annexes.

5) Create catch option table on the basis of a range of harvest ratios ranging from 0 to the maximum observed ratio or the ratio equating to F_{max}, whichever is the larger. Insert the harvest ratios from step 4 and also the current harvest ratio.

6) Multiply the survey index by the harvest ratios to give the number of total removals.

7) Create a landings number by applying a discard factor. This conversion factor has been estimated by the Benchmark Workshop and is to be revisited at subsequent benchmark groups. The value is FU specific and has been put in the Stock Annex.

8) Produce landings biomass by applying mean weight.

The suggested catch option table format is as follows.

	Implied fishery			
	Harvest rate	Survey Index	Retained number	Landings (tonnes)
	0%	12345	0	0.00
	2%	"	247	123.45
	4%	"	494	246.90
	6%	"	741	370.35
	8%	"	988	493.80
F0.1	8.60%	"	1062	530.84
	10%	"	1235	617.25
	12%	"	1481	740.70
Fmax	13.50%	"	1667	833.29
	14%	"	1728	864.15
	16%	"	1975	987.60
	18%	"	2222	1111.05
	20%	"	2469	1234.50
	22%	"	2716	1357.95
Fcurrent	21.5%	"	2654	1327.09

E. Medium-term projections

None presented.

F. Long-term projections

None presented.

G. Biological reference points

Harvest ratios equating to fishing at $F_{0.1}$ and F_{max} were calculated in WK*Neph* 2009. These calculations assume that the TV survey has a knife-edge selectivity at 17 mm and that the supplied length frequencies represented the population in equilibrium.

F-reference point	Harvest ratio
F0.1	9.6%
Fmax	16.0%

Table B1.1. ***Nephrops*****. South Minch (FU12).): Landings (tonnes), effort ('000 hours trawling) and lpue (kg/hour trawling) of Scottish** ***Nephrops*** **trawlers, 1981–2007 (data for all** ***Nephrops*** **gears combined, and for single and multirigs separately).**

Year	All *Nephrops* gears combined			Single rig			Multirig		
	Landings	Effort	LPUE	Landings	Effort	LPUE	Landings	Effort	LPUE
1981	2965	81.6	36.4	2965	81.6	36.4	na	na	na
1982	2925	93.1	31.4	2925	93.1	31.4	na	na	na
1983	2595	77.9	33.3	2595	77.9	33.3	na	na	na
1984	3228	93.4	34.6	3228	93.4	34.6	na	na	na
1985	3096	130.3	23.8	3096	130.3	23.8	na	na	na
1986	2694	105.8	25.5	2694	105.8	25.5	na	na	na
1987	2927	126.3	23.2	2927	126.3	23.2	na	na	na
1988	3544	120.9	29.3	3544	120.9	29.3	na	na	na
1989	3846	138.3	27.8	3846	138.3	27.8	na	na	na
1990	3732	153.5	24.3	3732	153.5	24.3	na	na	na
1991	3597	150.5	23.9	3109	134.6	23.1	488	15.8	30.8
1992	3479	127.3	27.3	3092	115.0	26.9	387	12.3	31.5
1993	3608	126.5	28.5	3441	122.5	28.1	167	4.0	41.5
1994	3743	144.4	25.9	3650	141.4	25.8	93	3.0	31.3
1995	3442	100.4	34.3	3407	99.6	34.2	35	0.9	39.8
1996	3108	106.4	29.2	3036	104.1	29.2	71	2.4	30.1
1997	3519	117.5	29.9	3345	112.1	29.8	174	5.4	32.0
1998	2851	101.4	28.1	2792	99.5	28.1	59	1.9	30.4
1999	3165	111.5	28.4	3111	109.3	28.5	54	2.2	24.6
2000	2939	106.2	27.7	2819	102.1	27.6	121	4.1	29.7
2001	2823	101.7	27.8	2764	99.8	27.7	59	1.9	30.8
2002	2234	75.7	29.5	2210	75.1	29.4	25	0.6	38.9
2003	2812	94.3	29.8	2716	93.5	29.0	96	0.8	113.9
2004	2865	89.8	31.9	2598	84.7	30.7	267	5.1	52.0
2005	2810	82.5	31.9	2566	79.3	32.4	244	3.2	76.8
2006	3569	93.3	38.3	3271	89.5	36.5	298	3.8	78.4
2007	4436	90.8	39.3	3820	83.1	46.0	616	7.7	80.0

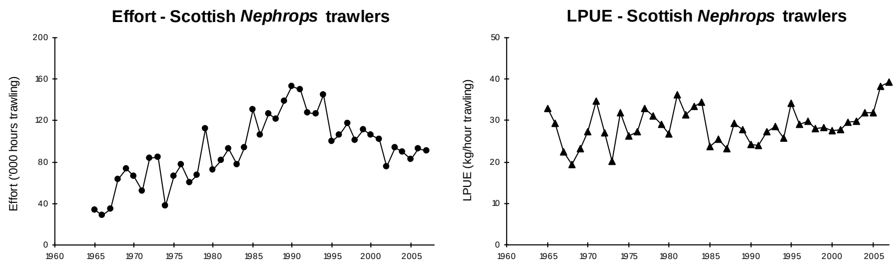


Figure B1.1. ***Nephrops*****, South Minch (FU12). Effort and lpue by Scottish** ***Nephrops*** **trawlers.**

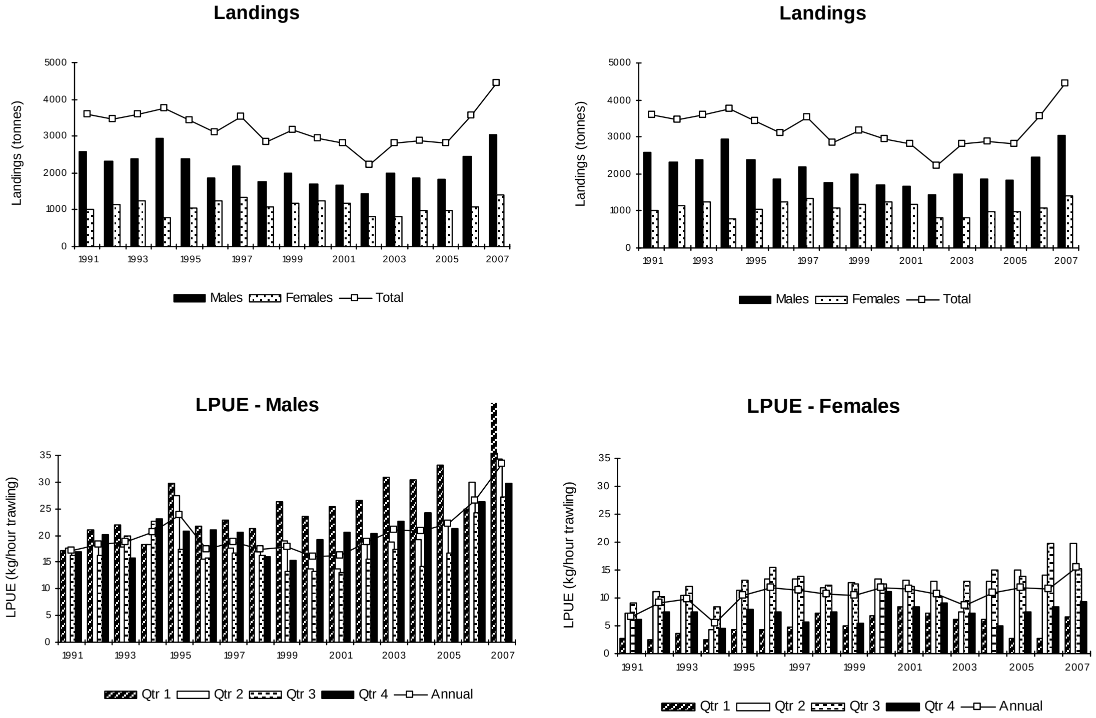


Figure B1.2. ***Nephrops*, South Minch (FU12), Landings, effort and lpues by quarter and sex from Scottish *Nephrops* trawlers.**

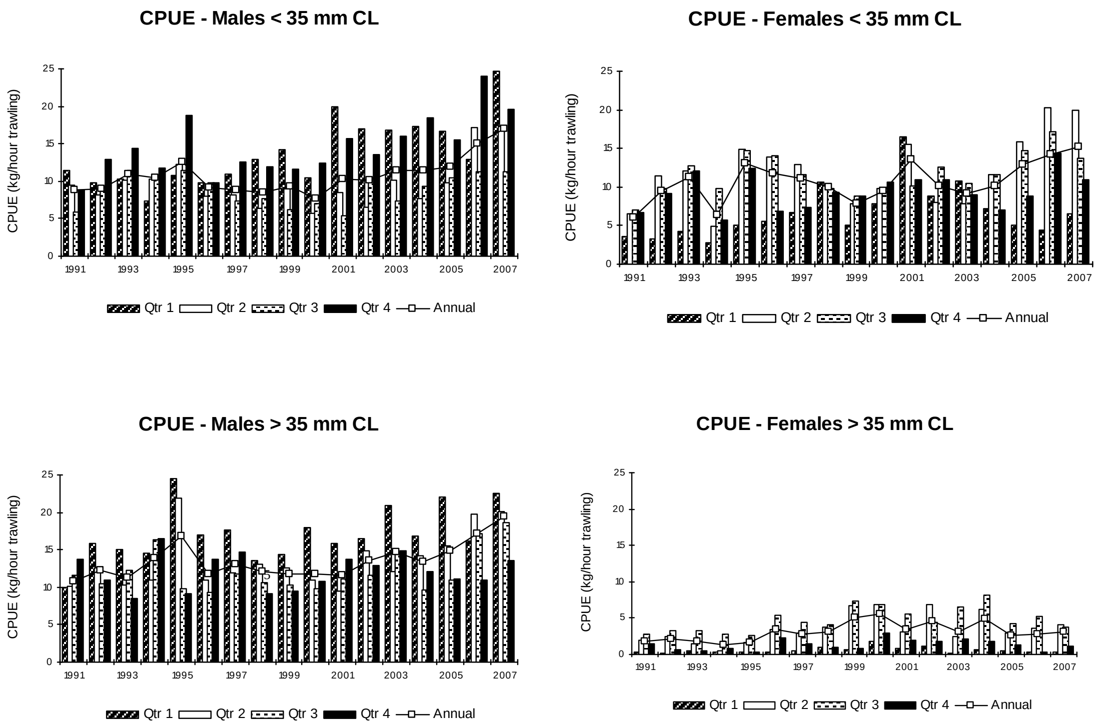


Figure B1.3.*Nephrops*, South Minch (FU12), cpues by sex and quarter for selected size groups, Scottish *Nephrops* trawlers.

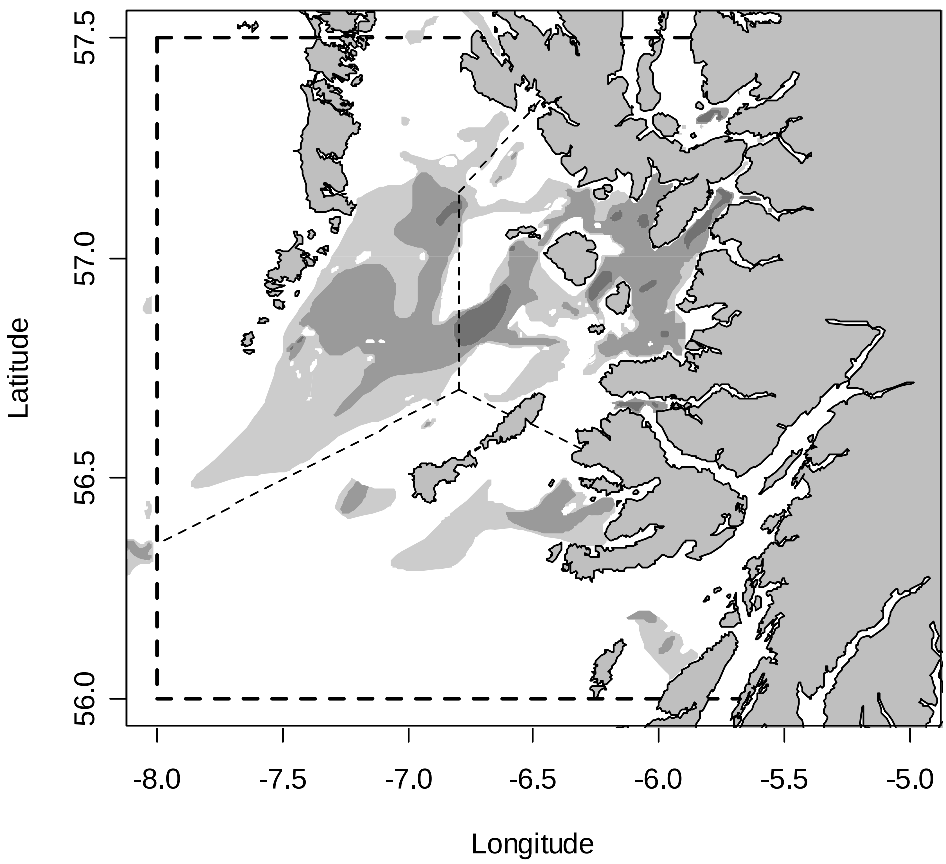


Figure B3.1. Sediment strata in the South Minch. Light Grey – Muddy sand, Grey – Sandy mud, Dark Grey – Mud. Light dashed lines represent spatial strata imposed on the sampling regime to ensure adequate spatial coverage.

Annex 3.7: Stock Annex: FU13, Clyde

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Clyde *Nephrops* (FU13)
Date	09 March 2009
Revised by	Sarah Clarke/Carlos Mesquita

A. General

A.1. Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt and clay content of between 10–100% to excavate its burrows, and this means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small-scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. In the Clyde area the *Nephrops* stock inhabits an area of muddy sediment extending throughout the Firth of Clyde, and another smaller area in the Sound of Jura, as shown in Figure B3.1. The two areas are separated by a large area of sandy gravely sediment around the Mull of Kintyre, and are treated as separate populations because they have differing population characteristics.

A.2. Fishery

Firth of Clyde

The Firth of Clyde *Nephrops* fishery is predominantly exploited by a dedicated *Nephrops* trawler fleet of approximately 120 vessels, with less than 2–3% of the landings made by creel vessels. The 90 resident Clyde trawlers make about 90% of the *Nephrops* landings. Under the Scottish 'Inshore Fishing Order' of 1989 (Prohibition of Fishing and Fishing Methods), fishing with mobile gear is prohibited within the Firth of Clyde over weekends, and with vessels >70 feet (about 21 m) in length.

The trawler fleet that fishes the Firth of Clyde mostly consists of vessels between 10 and 20 m in length (mean overall length 14 m), with a mean engine power of 185 kW. Almost half the fleet was built during the 1960s, with less than 20% built after 1979. Most vessels use single otter trawls with a 70 mm mesh codend, but just under a third of *Nephrops* landings are taken by vessels using twin-rig trawls with an 80 mm mesh codend. Vessels employing twin-rig gear are generally slightly more powerful than the single rig vessels (mean power 214 kW compared with 176 kW).

The regular fleet is comprised of Scottish vessels, but some catches are taken by Northern Ireland and Republic of Ireland vessels. The major landing ports are Troon, Campbeltown, Girvan and Tarbert, but smaller landings are also made at Carradale, Largs and Rothsay.

The minimum landing size for *Nephrops* in the Clyde is 20 mm CL. Compliance with the minimum landing size is good, with samples suggesting only a very small undersized component in the landings (< 0.5%).

Nephrops growth varies within the area, with low density animals growing to large sizes in the North, and with higher density animals reaching smaller sizes in the South. Far more *Nephrops* material (undersized individuals and 'heads' from tailed animals) is discarded in the South. Discarding usually takes place at sea and landings are made by category for whole animals (small, medium and large) and as tails. In poor weather or for the last haul of the day, discarding may take place within the harbour, thus increasing discard mortality.

Only a small fish bycatch is made in the Firth of Clyde, with whiting and cod being the most important species. The composition of the bycatch and discards varies within the Firth of Clyde, with more flatfish (common and long rough dab), echinoderms and crustaceans (other than *Nephrops*) caught in the North, whereas more roundfish (particularly whiting) are caught in the South. These differences reflect the different habitats and fish communities in the area.

The fishery is exploited throughout the year, with highest landings usually made between July and September. Vessels usually have a trip duration of one day, sailing to shoot before dawn, and carrying out 3–4 hauls of 4 hours per day.

Sound of Jura

The fishery for *Nephrops* in the Sound of Jura constitutes part of the Clyde FU, but is examined separately from the fishery within the Firth of Clyde, because of differences in the biological parameters of the *Nephrops* populations.

The fleet exploiting the Sound of Jura is also different from the Firth of Clyde, with vessels tending to be slightly smaller but more powerful. Most landings are taken by Scottish vessels (which are virtually all local to the area), with a very small proportion taken by boats from the rest of the UK. The local trawler fleet consists of vessels between 9 and 16 m in length, and with a mean engine power of 185 kW.

Just over half the landings are made by twin-rig *Nephrops* trawlers using 80 mm meshes, with most of the remainder landed by single rig vessels using 70 mm meshes. Vessels employing twin-rig gear are generally larger and more powerful than those using single rig trawls (15 m and 220 kW compared with 13 m and 160 kW). The main landing ports are Port Askaig, West Loch Tarbert and Crinan.

The minimum landing size for *Nephrops* in the Sound of Jura is 20 mm CL. *Nephrops* are found in high densities in this stock, but only grow to relatively small sizes. Discarding takes place at sea (this can be a large proportion of the catch by number, because of the small mean size of the animals caught), and landings are made by category for whole animals (small, medium and large) and as tails.

Catches of fish in the Sound of Jura area are generally poor, and *Nephrops* are clearly the target species, with only small bycatches of whitefish and flatfish.

The fishery is exploited throughout the year, with highest landings usually made between April and June. Vessels usually have a trip duration of one day, with 3–4 hauls per day.

For both areas the current legislation governing *Nephrops* trawl fisheries on the West coast of Scotland was laid down by the North Sea and West of Scotland cod recovery plan (EC 2056/2001), which established measures additional to EC 850/98. This regulation was amended in 2003 by Annex XVII of EC 2341/2002, which establishes fishing effort and additional conditions for monitoring, inspection and surveillance for the recovery of certain cod stocks. This regulation effectively limits vessels targeting *Nephrops* with 70–99 mm mesh size to 25 days at sea per month. The use of square mesh and headline panels are compulsory in this fishery. Additional UK legislation has also been applied in the southern areas of the Firth of Clyde in recent years, aimed at protecting the aggregating cod in the south of the Clyde during February, March and April.

A.3. Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the Working Group.

B. Data

B.1. Commercial catch

Length and sex compositions of *Nephrops* landed from the Firth of Clyde are estimated from port sampling in Scotland. Length data from Scottish sampling are applied to all catches and raised to total international landings. Rates of discarding by length class are estimated for Scottish fleets by on-board sampling, and extrapolated to all other fleets. The proportion of discarded to landed *Nephrops* changes with year, often determined by strong year classes. Discard sampling started in 1990, and for years prior to this estimates have been made based on later data. Landings and discards at length are combined (assuming a discard survival rate of 25%) to removals. As a consequence of differences in catchability between sexes removals are raised separately for each sex.

Reported effort has declined from high levels in the mid 1990s until 2004, but has demonstrated an increase since then (Figure B1.1). Landings also declined, to a lesser extent, over this time period and demonstrate a sharp increase over the past two years. Scottish *Nephrops* trawler lpue has increased markedly since 2001(Figure B1.1 and Table B1.1). However this may be more of an artefact as a consequence of improved reporting of landings data because of the introduction of the buyers and sellers regulations in the UK in 2006. In addition, logsheet recording of 'hours fished' is known to be erratic as it is a non-mandatory field on the logsheet. It is therefore not clear whether the observed interannual trends described below are actually indicative of real trends in lpue.

Males contribute more to the landings than females. Effort has previously been highest in the 3rd quarter in this fishery, but has become far more even through the year as the overall level of effort has declined (Figure B1.2). Male lpue demonstrated an increase in 1995, to a relatively stable level, then a further increase between 2001 and 2005. It has increased again in 2006 and remains high in 2007 particularly in the first and fourth quarters. Female lpue is lower than that for males, but displays similar increases after 1995 and 2001; the highest rates are obtained in the second and third quarters.

Cpue data for each sex, for *Nephrops* above and below 35 mm CL, are shown in Figure B1.3. This size was chosen for all the Scottish stocks examined as the general size limit above which the effects of discarding practices and the addition of recruits were likely to be small. For both sexes the data demonstrate a series of increases in cpue for smaller individuals in 1995, 2003 and 2007. The cpue for larger males remained relatively stable prior to 2003, fell to a slightly lower level in 2005, then increased markedly in 2006, remaining high but falling in 2007. Cpue for the larger females has fluctuated around a stable level for the entire time-series, demonstrating significantly higher values in the second quarter. These trends, are however, effected by the recent improvements in the reliability of catch data and erratic effort recording and are therefore difficult to interpret reliably.

B.2. Biological

Mean weights-at-age for this stock are estimated from fixed Scottish weight–length relationships (Howard *et al.*, 1988, citation required). Relevant biological parameters are as follows: natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females.

Summary

Growth parameters:

Males; L_∞ = 73 mm, k = 0.16

Immature Females; L_∞ = 73 mm, k = 0.16

Mature Females; L_∞ = 60 mm, k = 0.06,

Size at maturity = 25 mm

Weight length parameters:

Males a = 0.00028, b = 3.24

Females a= 0.00074, b = 2.91

Discards

Discard survival rate: 25%

Discard rate: 18.6%

Proportion of F and M prior to spawning was specified as zero to give estimates of spawning-stock biomass at January 1.

B.3. Surveys

The burrowing nature of *Nephrops*, and variable emergence rates mean that trawl catch rates may bear little resemblance to population abundance. An underwater TV survey has been developed, estimating *Nephrops* population abundance from burrow density raised to stock area. A random stratified sampling design is used, on the basis of British Geological Survey sediment strata and latitude (Tuck *et al*., 1999) (see Figure B3.1). The survey provides a total abundance estimate, and is not age or length structured. A series of annual underwater TV surveys are available since 1995 for the Firth of Clyde and Sound of Jura. While the survey in the Clyde has been continuous, the TV survey for the Sound of Jura was not conducted from 1997 to 2000, and again in 2004. Such large gaps in the series make interpretation of any trends from the data difficult. The number of valid stations in the survey has remained relatively stable throughout the time period. An average of 36 stations have been sampled in each year, then raised to a stock area of 2062.2 km^2 for the Firth of Clyde, and an average of 10 stations have been considered valid each year for the Sound of Jura. Confidence intervals around the abundance estimates have remained relatively stable through the time period.

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as an absolute it is necessary to correct for these potential biases. The history of bias estimates are given in the following table and are based on simulation models, preliminary experimentation and expert opinion, the biases associated with the estimates of *Nephrops* abundance in the Fladen are:

	Time period	Edge effect	detection rate	species identification	occupancy	Cumulative bias
FU13: Clyde	<=2009	1.19	0.75	1.25	1	1.19

B.4. Commercial cpue

Landings-per-unit-effort time-series are available from the following fleets: *Nephrops* single trawl, multiple *Nephrops* trawl, light trawl and multiple demersal trawl.

Scottish *Nephrops* trawl gears: Landings-at-age and effort data for Scottish *Nephrops* trawl gears are used to generate a cpue index. Cpue is estimated using officially recorded effort (hours fished) although the recording of effort is not mandatory. Combined effort for *Nephrops* single trawl and multiple *Nephrops* trawl is raised to landings reported by the four gears listed above. Discard sampling commenced in 1990 for this fishery, and for years prior to this, an average of the 1990 and 1991 values is applied. There is no account taken of any technological creep in the fleet.

More information is contained in Section B.1

B.5. Other relevant data

C. Historical stock development

1) Survey indices are worked up annually resulting in the TV index.

2) Adjust index for bias (see Section B3). The combined effect of these biases is to be applied to the new survey index.

3) Generate mean weight in landings. Check the time-series of mean landing weights for evidence of a trend in the most recent period. If there is no firm evidence of a recent trend in mean weight use the average of the three most recent years. If, however, there is strong evidence of a recent trend then apply most recent value (don't attempt to extrapolate the trend further in future).

D. Short-term projection

4) The catch option table will include the harvest ratios associated with fishing at $F_{0.1}$ and F_{max}. These values have been estimated by the Benchmark Workshop (see Section 9.2) and are to be revisited by subsequent benchmark groups. The values are FU specific and have been put in the Stock Annexes.

5) Create catch option table on the basis of a range of harvest ratios ranging from 0 to the maximum observed ratio or the ratio equating to F_{max}, whichever is the larger. Insert the harvest ratios from step 4 and also the current harvest ratio.

6) Multiply the survey index by the harvest ratios to give the number of total removals.

7) Create a landings number by applying a discard factor. This conversion factor has been estimated by the Benchmark Workshop and is to be revisited at subsequent benchmark groups. The value is FU specific and has been put in the Stock Annex.

8) Produce landings biomass by applying mean weight.

The suggested catch option table format is as follows.

			Implied fishery	
	Harvest rate	Survey Index	Retained number	Landings (tonnes)
	0%	12 345	0	0.00
	2%	"	247	123.45
	4%	"	494	246.90
	6%	"	741	370.35
	8%	"	988	493.80
F0.1	8.60%	"	1062	530.84
	10%	"	1235	617.25
	12%	"	1481	740.70
Fmax	13.50%	"	1667	833.29
	14%	"	1728	864.15
	16%	"	1975	987.60
	18%	"	2222	1111.05
	20%	"	2469	1234.50
	22%	"	2716	1357.95
Fcurrent	21.5%	"	2654	1327.09

E. Medium-term projections

None presented.

F. Long-term projections

None presented.

G. Biological reference points

Harvest ratios equating to fishing at $F_{0.1}$ and F_{max} were calculated in WK*Neph* 2009. These calculations assume that the TV survey has a knife-edge selectivity at 17 mm and that the supplied length frequencies represented the population in equilibrium.

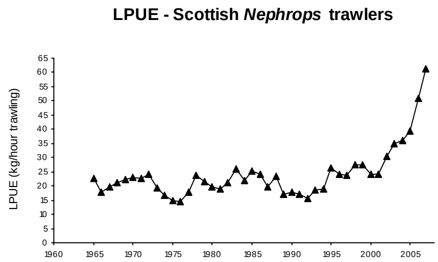
F-reference point	Harvest ratio
F0.1	8.7%
Fmax	15.1%

H. Other issues

I. References

Table B1.1. ***Nephrops*, Firth of Clyde (FU13): Landings (tonnes), effort ('000 hours trawling) and lpue (kg/hour trawling) of Scottish *Nephrops* trawlers, 1981–2007 (data for all *Nephrops* gears combined, and for single and multirigs separately).**

Year	All *Nephrops* gears combined			Single rig			Multirig		
	Landings	Effort	LPUE	Landings	Effort	LPUE	Landings	Effort	LPUE
1981	1861	108.8	17.1	1861	70.5	26.4	na	na	na
1982	1798	93.1	19.3	1798	148.0	12.1	na	na	na
1983	3258	131.9	24.7	3258	108.8	29.9	na	na	na
1984	2433	122.5	19.9	2433	93.1	26.1	na	na	na
1985	3154	131.6	24.0	3154	131.9	23.9	na	na	na
1986	2745	141.5	19.4	2745	122.5	22.4	na	na	na
1987	2126	126.8	16.8	2126	131.6	16.2	na	na	na
1988	3190	141.6	22.5	3190	141.5	22.5	na	na	na
1989	2393	144.3	16.6	2393	126.8	18.9	na	na	na
1990	2435	142.8	17.0	2435	141.6	17.2	na	na	na
1991	2489	152.9	16.3	1594	144.3	11.0	895	39.5	22.7
1992	2091	144.6	14.5	1316	142.8	9.2	775	42.4	18.3
1993	2650	156.8	16.9	1771	113.5	15.6	879	43.1	20.4
1994	1996	118.0	16.9	1484	102.2	14.5	512	27.6	18.6
1995	3501	133.8	26.2	2583	113.7	22.7	918	31.5	29.1
1996	3530	150.1	23.5	2474	90.4	27.4	1048	38.1	27.5
1997	3020	131.9	22.9	2158	98.0	22.0	861	33.9	25.4
1998	4107	150.8	27.2	2964	110.2	26.9	1142	40.5	28.2
1999	3175	117.2	27.1	2322	86.3	26.9	853	30.9	27.6
2000	2980	124.4	24.0	2100	90.9	23.1	880	33.5	26.3
2001	2711	111.6	24.3	2445	100.2	24.4	266	11.4	23.3
2002	3043	99.6	30.6	2896	94.0	30.8	147	5.6	26.3
2003	2937	84.2	34.9	2839	81.2	35.0	97	3.0	32.3
2004	2611	72.3	36.1	2531	69.6	36.4	80	2.7	29.6
2005	3133	79.8	39.3	3108	78.7	39.5	25	1.1	23.8
2006	4356	87.1	50.0	4348	85.4	50.9	8	1.7	4.7
2007	6069	113	53.7	6055	99	61.2	14	1.6	8.8
* provisional na = not available, landings not recorded to Multirig trawl before 1991.									



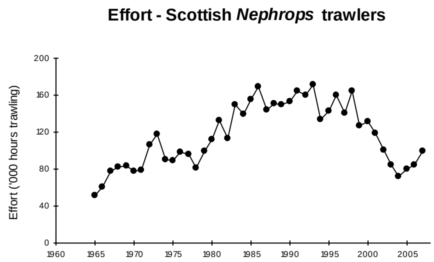


Figure B1.1. ***Nephrops*, Firth of Clyde (FU13), Effort and lpue for Scottish *Nephrops* trawlers.**

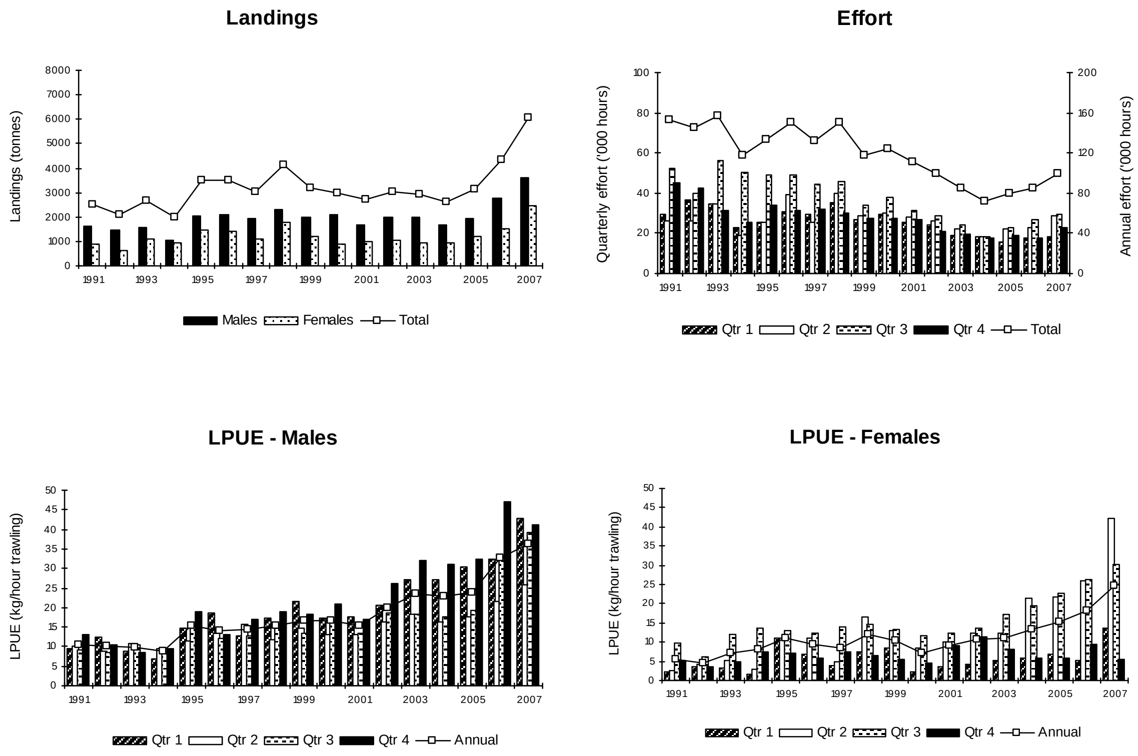


Figure B1.2. ***Nephrops*****, Firth of Clyde (FU13), Landings, effort and lpues by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

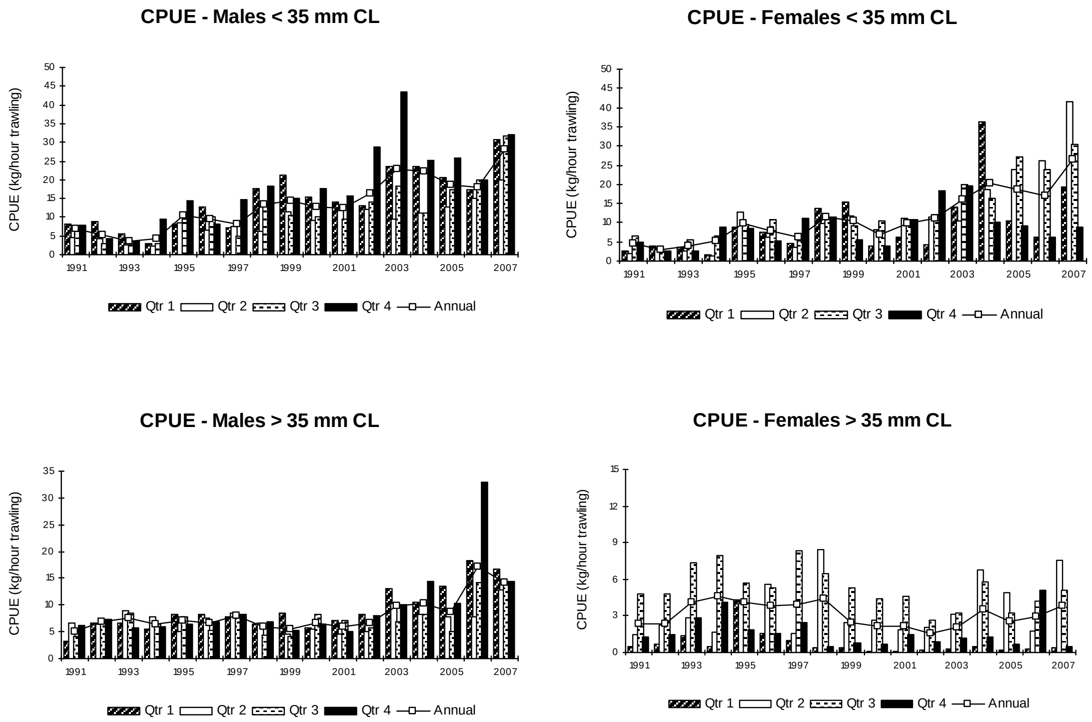


Figure B1.3. ***Nephrops*****, Firth of Clyde (FU13), cpues by sex and quarter for selected size groups, Scottish** ***Nephrops*** **trawlers.**

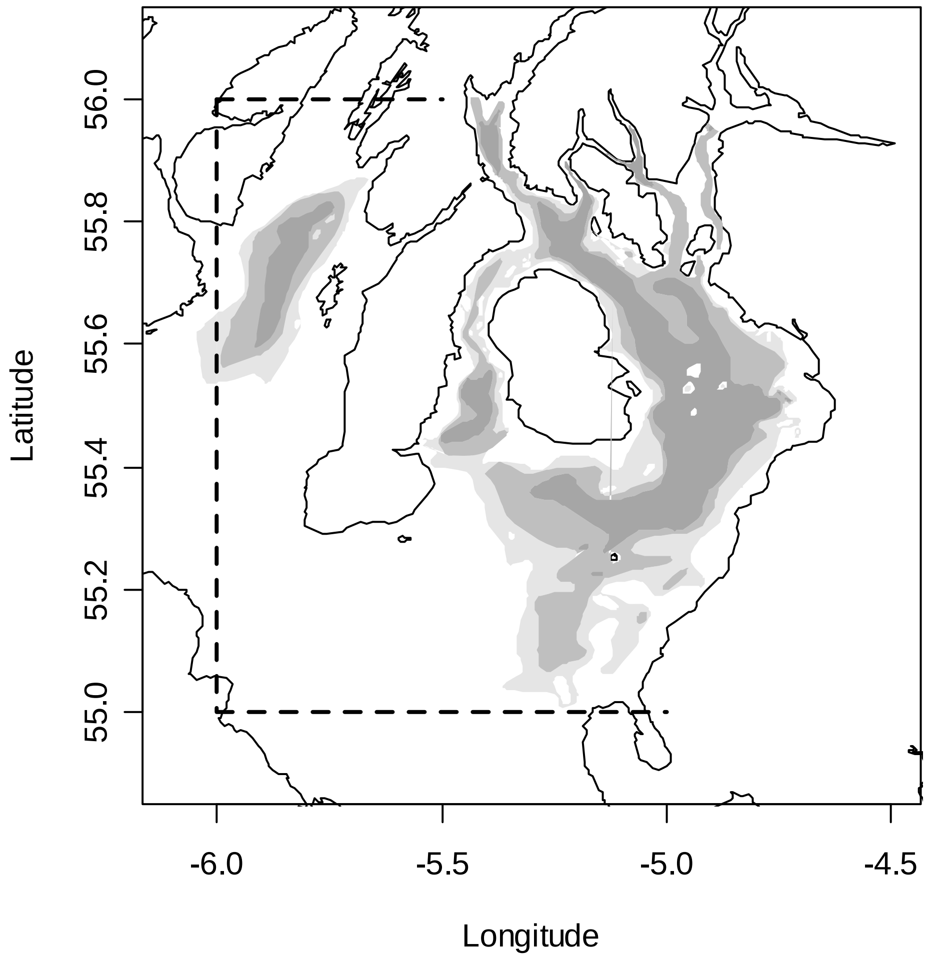


Figure B3.4. Distribution of suitable sediments in Clyde. Light grey - muddy sand; medium grey - sandy mud; dark grey - mud.

Annex 4.3: Quality Handbook: Haddock VIb

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Haddock in Division VIb
Working Group:	WGCSE
Date:	29 May 2009
Revised by	Andrzej Jaworski

A. General

A.1. Stock definition

The haddock stock at Rockall is an entirely separate stock from that on the continental shelf of the British Isles (Chuksin and Gerber, 1976; Shestov, 1977; Blacker, 1982; Newton *et al*., 2008). The TAC for haddock VIb was previously (before 2004) set for Subarea Vb, VI, XII and XIV combined, with a limitation on the amount to be taken in Vb and VIa. In 2004, the TAC for Division VI was split and the VIb TAC for haddock was included with Divisions XII and XIV. This combined TAC has been in place since then.

A.2. Fishery

The development of the Rockall haddock fishery is documented in the 2001 Working Group Report (ICES-WGNSDS, 2001) and in the Report of the ICES Group meeting on Rockall haddock convened in January 2001 (ICES, WGNSDS, 2002). That meeting was set up to respond to a NEAFC request for information on the Rockall haddock fishery. NEAFC agreed to consider regulation of the international fishery in 2001.

The Rockall haddock fishery changed markedly in 1999 when a revision of the EU EEZ placed the southwestern part of the Rockall plateau in international waters. This has opened opportunities for other nations, notably Russia, to exploit the fishery in this area. The table of official statistics includes Russian catches from the Rockall area.

The Russian fleet started fishing operations in international waters at Rockall in May–October 1999. The Russian haddock fishery uses bottom trawls with codend mesh size of 40–100 mm (mainly 40–70 mm) and retains haddock of all length classes in the catch. This fishery targets concentrations of haddock mainly during spring and the beginning of summer. Russian catches increased from 458 t in 1999 to 2154 t in 2000. In 2001, they were markedly reduced to 630 t as a consequence of the introduction of a closed area and low density of fish concentrations. Russian catches increased again in 2002–2004 from 1630 to 5844 t. In 2005–2007, they decreased from 4708 t to 1282 t, and are estimated to be 1669 t in 2008.

Prior to 1999, the UK and Ireland fisheries had been principally summer fisheries but in more recent years the Scottish and Irish fishery was conducted throughout the year with the peak in April–May. This shift in the fishery appears to have followed the discovery of concentrations of haddock in deeper water to the west of Rockall, at depths between 200 m and 400 m. High catch rates attracted effort into the area. However, catch rates in 2000 were reported to be poor in deeper water. Anecdotal evidence suggests that increased discarding has been associated with the deeper-water fishery compared with the traditional fishery at northern Rockall. In 2004–2007, a considerable proportion of EU landings were taken in the international waters. Historical fishing patterns of the Scottish fleet at Rockall are presented by Newton *et al*., 2004.

There are some indications that, as a consequence of a general decline in catches by the Scottish and Irish fleets in Division VIa, there is an increasing focus in the Rockall fishery in Division VIb (ICES, WGFTFB, 2007). Paired gear (both seine and trawl) are to be tested by some Scottish fishers, which, if it proves successful, can lead to a considerable increase in effective effort in VIb. The fishery at Rockall seems particularly attractive given the lack of effort restrictions in this area.

Information on the Russian fishery and biological investigations from commercial vessels fishing in Rockall during 2008 are presented in WD11 to WGCSE 2009.

An analysis of the spatial and depth distributions of Rockall haddock in association with oceanographic variables is presented by Vinnichenko and Sentyabov, 2004, a WD to WGNSDS 2004. Changes in distribution have occurred over a period coincidental with changes in oceanographic variables. Information on oceanographic conditions on Rockall bank in spring 2005 was presented by Sentyabov at WGNSDS 2005.

A.3. Ecosystem aspects

In May 2001, the International Waters component of statistical rectangle 42D5, which is mainly at depths less than 200 m, was closed by NEAFC to all fishing activities, except with longlines. That area had the following coordinates:

Latitude	Longitude
57.000°N	15.000°W
57.000°N	14.700°W
56.575°N	14.327°W
56.500°N	14.450°W
56.500°N	15.000°W

In spring 2002, the EU component of this rectangle, again mostly shallow water, was also closed to trawling activities (EC No 2287/2003). The whole Rockall Haddock Box is bounded by the following coordinates:

Latitude	Longitude
57°00’N	15°00’W
57°00’N	14°00’W
56°30’N	14°00’W
56°30’N	15°00’W

At the 25th Annual Meeting of NEAFC (in November 2006), a closure of three areas on the Rockall Bank to bottom fishery was proposed to protect cold-water corals: North West Rockall, Logachev Mounds and West Rockall Mounds (NEAFC AM, 2006). This measure will be in force for the period January 2007–December 2009.

In 2007, the ICES prepared advice for NEAFC and arrived at the conclusion about the expediency of establishing a new closed area on the so-called Empress of British Banks and adjusting the boundaries of the currently closed area of North West Rockall. At the 26th Annual Meeting of NEAFC (in November 2007), a new closed area

(Empress of British Banks) was established, and the boundaries of the North West Rockall closure were slightly modified (NEAFC AM, 2007). As a consequence of the complex shape of the boundaries of the North West Rockall closure proposed by ICES, which potentially could cause problems with enforcement, the introduced changes differed from the ICES recommendation. NEAFC also requested ICES to continue providing all available new information on distribution of vulnerable habitats in the NEAFC Convention Area and fisheries activities in and in the vicinity of such habitats.

WGDEC supported the ICES conclusion on the necessity of revising the boundaries of the North West Rockall area established to protect cold-water corals and recommended to consider proposals at the WGNSDS meeting. These recent proposals greatly simplify the boundaries, which would create better conditions for enforcement (see WD8 to WGNSDS, 2008).

B. Data

B.1. Commercial catch

Landings

Nominal landings as reported to ICES are given in Table 4.3.1 of the main report, along with Working Group estimates of total estimated landings. Reported international landings of Rockall haddock in 1991–2005 were about 4000–6000 t, except for 2001–2002, when they decreased down to about 2300–3000 t. In 2006, they were also low at 2760 t, but increased slightly to 3348 in 2007 and 4221 t in 2008. Revisions to official catch statistics for previous years are also displayed in Table 4.3.1.

Anecdotal evidence suggests that misreporting of haddock from Rockall have occurred historically (which may have led to discrepancies in assessment), but an estimation of overall magnitude is not possible.

Age composition and mean weight-by-age of Scottish and Irish landings were obtained from port sampling. Data on the volume, length–age and weight composition of landings for the period from 1988 to 1998 correspond to values used at this WG.

In 2002, there was no sampling of the Russian catch and therefore the length composition has to be estimated for this year.

In 2002 and 2003, the structure of the Russian fishery on the Rockall Bank was the same: the same vessels were operating with the same gear in the same fishing areas. The relationship between the haddock length composition obtained from the trawl survey and that in the Russian catches is assumed to be the same for 2002 and 2003; i.e. it is assumed that the length dependent selectivity pattern in 2002 is the same as that in 2003 as there no changes to the fishery in these years. The relationship is described as:

$$P_L = S_L p_L \qquad (1)$$

where P_L is the proportion of fish with length L in catches, p_L is proportion of fish with length L in the stock (survey), and S_L is the proportion of fish of length L taken aboard. S_L is determined using a theoretical selectivity curve (Stock Annex, Figure 4.3.1) which may be described by the following formula:

$$S_L = \frac{1}{1+\exp(S_1 - S_2 L)}. \qquad (2)$$

where S_L is the proportion of fish of size L taken aboard, L is the size group, S_1 and S_2 are coefficients.

The selectivity curve (Stock Annex Figure 4.3.1), fitted to the data on catch measurements in different periods of the Russian fishery in 2003 is described well by Equation 2 with coefficients S_1 = 12.539 and S_2 = 0.4951. The estimated length frequency distributions for 2003 are compared with the measured length frequency distributions for this year in Stock Annex Figure 4.3.2. The size distribution in the Russian catch in 2002 is then estimated by applying the theoretical selectivity curve to the survey length frequency in 2002.

To determine the age composition in Russian catches in 2002, the combined age–length key for all years of Russian catches was used.

Discards

The haddock catch estimated by landings is underestimated as a result of unaccounted discarding of small individuals in the Scottish and Irish fisheries in most years. On Russian vessels, the whole catch of haddock is retained on board and therefore, total catch is equivalent to landings.

Haddock discards on board Scottish vessels in 1999 and 2001 and Irish vessels in 1995, 1997, 1998, 2000 and 2001 were determined directly. In other years, indirect estimates of discarding were calculated.

The direct estimates from the Scottish trawlers in 1985, 1999 and 2001 demonstrated a larger proportion of discards of small haddock: from 12 to 75% by weight (Table 4.3.6 in the main report) and up to 80–90% of catch numbers. Discard trips in 1995, 1997, 1998, 2000 and 2001 demonstrated that discarding by Irish fishing vessels also reaches considerable values (Table 4.3.7 in the main report).

Total numbers and weight landed and discarded-by-age on the Scottish observer trips in 1999 and 2001 are presented in Stock Annex Tables 4.3.1 and 4.3.2.

The analysis of the discard data collected by Scottish scientists in 1999 and 2001 indicated that only a relatively small proportion of fish taken aboard is landed (Figure 4.2.5). The probability of being retained increases with increasing fish length (Stratoudakis *et al.*, 1999; Palsson *et al.*, 2002; Palsson, 2003; Sokolov, 2003). The relationship between the number of individuals caught and number discarded may be described by the following relationship:

$$ND_L = PD_L \times NP_L \qquad (3)$$

where ND_L is the number of discarded fish with length L, NP_L is the number of fish caught at-length L, PD_L is the portion of discarded fish at-length L.

The length composition of fish taken on board by Scottish and Irish trawlers was calculated by applying the logistic selectivity curve (Stock Annex Figure 4.3.3) to the haddock stock length composition obtained from the survey. The selectivity parameters were calculated from Scottish and Irish catches taken by trawls with mesh size that are typical for the fleets of those countries operating at Rockall. The parameters were calculated as S_1 = 12.608 and S_2 = 0.4360 for the Scottish fleet. S_1 = 26.248 and S_2 = 0.8524 were used for Irish catches.

The catch-at-length compositions obtained by the theoretical curve of selectivity agree well with available results of catch measurements in 1999 and 2001and the distributions are compared in Stock Annex Figure 4.3.4.

The proportion of fish discarded from catches at different sizes may be determined and modelled using a logistic curve (Stock Annex Figure 4.3.5) described by the following equation:

$$PD_L = \frac{1}{1+\exp(-b(L-DL_{50}))} \tag{4}$$

where L is size group, DL_{50} is the fish length at which 50% of this size fish caught is discarded and b is a constant reflecting the angle of curve slope. The parameters were determined from research on discards by Scottish vessels (Stock Annex Table 4.3.3). The following values were used in subsequent calculations: $DL_{50} = 34.66$ cm, $b = -0.8764$. The logistic curve of discards may be found using Equation 2 and the coefficient values: $S_1 = -15.494$ and $S_2 = -0.4565$.

To determine abundance of discards the following procedure was used:

a) A theoretical catch-at-length distribution (%) was calculated by applying the theoretical selectivity curve to the survey length composition.

b) An estimate of total catch-at-length was made by summing the reported landings-by-length to the number of discards-at-length calculated from the assumed discard ogive and the landings-at-length data.

c) An intermediate theoretical catch size distribution in numbers is calculated by dividing the estimate of the total numbers retained (numbers greater than 34 cm) in B by the fraction retained from the theoretical catch length distribution calculated in a).

d) Theoretical discard size frequency is then calculated by applying the theoretical discard ogive to the intermediate theoretical catch size distribution.

The spreadsheet containing these calculations can be found in the stock file.

Calculations where the discard curve was applied agree well with the results of size composition measurements by Scottish vessels in 1999 and 2001 (Annex Figure 4.3.6).

Aboard Irish vessels, larger fish are retained (Annex Figure 4.3.7). The portion of discards was calculated using Equation 2 with coefficients $S_1 = -10.093$ and $S_2 = -0.2459$, from the combined 1995–2002 Irish discard trips.

The Russian fleet fish in the areas covered only partially by the bottom-trawl surveys. However, Russian vessels retain all haddock and therefore there is no need to calculate discards. There is no information on large-scale fisheries of other countries outside the surveyed area. In addition, available data on the real length composition of catches indicate a correspondence between length composition obtained by the results from surveys and commercial catches, including the catches obtained in the parts of Russian fishery (Stock Annex Figures 4.3.2 and 4.3.6).

The amount of discarded haddock by age was determined using a length-age key derived by the data collected during the trawl survey allowing for selectivity of the fishery (Annex Figure 4.3.3).

In 1998 and 2000, the trawl survey for haddock in the Rockall Bank area was not carried out. To determine the haddock length composition in these years, the length distribution was calculated from the survey data in the previous and following years.

For this purpose, the length-age matrices characterizing the stock status in the years before and after the missing data year were obtained. The length-age distribution from the year before the missing year was projected forward on the basis of mean growth increment at-age and estimated total mortality. Similarly the distribution from the year after was projected backwards. The length composition in the missing year was then calculated from these two estimates.

The total loss (Z) used in the calculation described above was determined by minimization of values of deviation square sum between survey age-group abundance values in previous and following years by the data from surveys and calculated data. At that, the factor of age effect (S_a) was taken into account. The mean growth increment at-age was also estimated from the survey data. The method of calculation is explained further in WD8 to WGNSD 2004 and a spreadsheet demonstrating the calculations is in the stock file.

B.2. Biological

Age composition and mean weight-at-age of Scottish and Irish landings were obtained from port sampling.

Age composition and mean weight-at-age of Russian landings were obtained by observers on board commercial fishing vessels. In 2002, there was no sampling of the Russian catch and therefore the length composition for that year had to be estimated (for estimation details, see Stock Annex). Observer data from commercial vessels are also available for Norwegian landings for 2006–2008.

In the absence of any direct estimates of natural mortality, M has been set at 0.2 for all ages and years.

Natural mortality coefficient and portion of mature individuals by age used for estimation correspond to those adopted by Working Group before.

Previous Working Groups have adopted a maturity ogive with knife-edge maturity-at-age 3 in assessments of this stock (see the Table below).

Age	1	2	3	4	5	6	7+
Proportion mature	0	0	1	1	1	1	1

The data from new Russian histological examination of haddock gonad samples mass sexual maturation occurs at-age of two years with length of 25 cm (WGNSDS WD6 2006). These data agree well with the results of recent Scottish research in compliance with which the majority of fish become mature at the age of 2 years (ICES 2003; Newton *et al.*, 2004). Visual estimation of maturity stage of post-spawning haddock on the Rockall Bank in expeditions leads to considerable errors. For more precise estimation of length and age-at-maturity for haddock it is necessary to conduct investigations in prespawning and spawning periods as well as to collect gonads for further histological analysis (see WGNSDS WD6 2006 for further details).

Research on determining more precise values for natural mortality and maturity ogive parameters should be continued and new estimates could be used in future stock assessments.

In the absence of any direct estimates of natural mortality, M has been set at 0.2 for all ages and years. MSVPA estimates for the North Sea haddock stock give estimates of M of 2.05 at-age 0, 1.65 at-age 1, 0.40 at-age 2, 0.25 at-ages 2 and 4, and 0.20 at-ages 5+ (ICES CM 2003/ACFM:02). Similarly, large values of M at the younger ages at Rockall would have implications for interpretation of fishing mortality patterns from survey-based methods such as SURBA which essentially estimate total mortality conditional upon assumptions regarding survey catchability-at-age.

ACFM in 2001 encouraged the WG to investigate a more realistic maturity ogive for this stock. At the 2002 Working Group combined sex maturity ogives were presented to the WG for Russian sampling in 2000–2001 and Scottish sampling in 2002. In 2003 new sex disaggregated maturity data were supplied to the Working Group for Russian sampling. The results of all these recent studies indicate that a large proportion of both females and males at-age 2 were mature.

B.3. Surveys

There is only one research survey index available for VPA assessment of this stock from the Scottish survey conducted annually in September (Figure 4.2.4, Table 4.2.8). However, from 1997 onwards the Scottish survey was only conducted in alternate years. Because of concerns about the haddock stock at Rockall some extra time was allocated to carry out a partial survey in September 2002. Full surveys have been conducted since 2005 to improve the quality of assessment. The Scottish survey is currently conducted on about 40 (the target number for a survey) standard trawl stations. However, the survey area and number of stations varied in different years. The majority of stations are within the 200 m depth contour. In 2002 the survey was carried out in the central and northern parts of the bank. In 1999 the survey switched from using an Aberdeen 48′ bottom trawl to a GOV trawl and from 60 min tows to 30 min tows. The indices have been adjusted for tow duration, but no calibration has been made for gear changes. A 20 mm mesh size is used on the survey.

In spring 2005, the Russian trawl-acoustic survey (TAS) for haddock on the Rockall Bank was conducted for the first time (Oganin *et al.*, 2005). However, no such survey has been carried out in subsequent years. In the 2005 survey, the trawl survey method estimated the total stock number at 190.63 million individuals and its biomass at 43 400 t (see the Table below). The acoustic survey yielded a haddock biomass estimate of 60 000 t with the abundance of 225.9 million (see the WGNSDS 2006 Report for more details of the trawl-acoustic survey). The estimates of haddock abundance and biomass from the two methods are quite similar. The results of the Russian trawl-acoustic survey are summarized in the table below:

Survey type	Area component	Area (sq. miles)	Total stock		Spawning stock	
			Abundance (106)	Biomass (103 t)	Abundance (106)	Biomass (103 t)
Trawl survey	Whole	5554	190.6	43.4		
Acoustic survey	International waters	3374	144.2	41.1	133.0	38.5
	EU zone	2180	81.7	18.9	52.4	16.3
	Whole	5554	225.9*	60.0*	185.4	54.8

*** Pelagic component estimated to make up 13.7%.**

The Irish Fisheries Board (BIM) and the Marine Institute recently conducted a collaborative series of surveys to assess the length structure of haddock at various locations on the Rockall Bank and tested the selectivity of a number of codend configurations, which are typically used by both the Irish and Russian fleets.

B.4. Commercial cpue

Commercial cpue series are available for Scottish trawlers, light trawlers, seiners, Irish otter trawlers and Russian trawlers fishing in VIb. The effort data for these five fleets are shown in Figure 4.2.1 and Table 4.2.7. Commercial cpue series for the different fleets are shown in Figure 4.2.2.

In 2005–2007, the Russian effort in bottom fishery (in hours and number of vessels/days) decreased because of economic reasons. The effort in 2008 increased slightly compared with 2007. Haddock catches varied accordingly with the changes in fishing effort. In 2006–2007, fishing efficiency in the Russian haddock fishery (mainly with trawlers of tonnage class 10) increased compared with previous years. In 2008, with trawlers of class 8 and 9 only, it was still high (on average, 12.2 t per fishing day for trawlers of class 9), but lower than the efficiency in 2007 (on average, 16.9 t per fishing day for a trawler of class 10). In the period of the targeted fishery (April–May), the mean catch of haddock per hour trawling by a trawler of tonnage class 9 was 0.86 t (in 2007, it was 0.88 t for a trawler of class 10) (Figure 4.2.2). The dynamics of catch per unit of effort for this type of vessels agrees well with year-to-year variations in total biomass of haddock (Figure 4.2.3).

The effort data from the Scottish fleets are known to be unreliable as a consequence of changes in the practices of effort recording and non-mandatory effort reporting (see the Report of WGNSSK 2000, CM 2001/ACFM:07, for further details). It is unknown what proportion of Scottish and Irish effort was applied directly to the haddock fishery. The apparent effort increase may just be the result of more exact reporting of effort as a consequence of VMS, but another suggestion is that it arises from a 'days at sea' measure. Working at Rockall keeps 'days at sea' elsewhere intact (the years in question do correspond to the introduction of the days at sea legislation) and it is possible that vessels are either working extra days in VIb or they are simply reporting extra days from VIb. It is difficult to conclude which of these scenarios is more likely.

The Irish otter trawl effort-series indicated low values between 2002 and 2005 with the lowest value in 2004. In 2006–2008, the effort increased considerably.

The WG decided that the commercial cpue data, which do not include discards and have not been corrected for changes in fishing power despite known changes in vessel size, engine power, fish-finding technology and net design, were unsuitable for catch-at-age tuning.

B.5. Other relevant data

C. Historical stock development

Model used:

The assessment is based on catch-at-age data and one survey index (Scottish Groundfish Survey) and conducted using the XSA method.

Software used:

XSA from Lowestoft suite of VPA programs.

Model Options chosen:

Settings for the final XSA assessment in the recent years are displayed in the Table below.

Assessment year	2005	2006	2007	2008	2009
Assessment model	XSA	XSA	XSA	XSA	XSA
Time-series weights	none	none	none	none	none
Model	power	power	power	power	power
Catchability dependent for ages <	4	4	4	4	4
Regression type	C	C	C	C	C
Q plateau	5	5	5	5	5
Shk se	1.0	1.0	1.0	1.0	1.0
Shk age-year	4 years 3 ages	4 years 3 ages	4 years 3 ages	4 years 3 ages	4 years 3 ages
Min se	0.3	0.3	0.3	0.3	0.3
Plus group	7	7	7	7	7
Fbar	2–5	2–5	2–5	2–5	2–5

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch-in-tonnes	1991–2008	1–7+	Yes
Canum	Catch-at-age in numbers	1991–2008	1–7+	Yes
Weca	Weight-at-age in the commercial catch	1991–2008	1–7+	Yes
West	Weight-at-age of the spawning stock at spawning time.	1991–2008	1–7+	Yes
Mprop	Proportion of natural mortality before spawning	1991–2008	1–7+	No, set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1991–2008	1–7+	No, set to 0 for all ages in all years
Matprop	Proportion mature-at-age	1991–2008	1–7+	No, the same ogive for all years
Natmor	Natural mortality	1991–2008	1–7+	No, set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	SCOGFS	1991–2008	1–6

D. Short-term projection

Model used: Age-structured

Software used: MFDP prediction with management option table and yield-per-recruit routines. MLA used for probability profiles and sensitivity analysis.

Initial stock size: Taken from XSA for age 1 and older. The recruitment at-age 1 in 2009 is estimated using RCT3. For forecasting recruitment in 2010 and thereafter, a geometric mean was used for 1991–2006.

Natural mortality: Set to 0.2 for all ages in all years.

Maturity: The same ogive as in the assessment is used for all years.

F and M before spawning: Set to 0 for all ages in all years.

Weight-at-age in the stock: Three-year means (mean weights in the stock are assumed to be the same as catch weights, see below).

Weight-at-age in the catch: Three-year means.

Exploitation pattern: Average of the three last years. Landings F are varied in the management option table.

Intermediate year assumptions: Status quo F.

Stock recruitment model used: XSA estimate of recruits at-age 1 for intermediate year. RCT3 model used for intermediate year +1 in 2009 and the long-term geometric mean recruitment-at-age 1 is used for forecasting recruitment in 2010 and thereafter.

Procedures used for splitting projected catches: F vectors in each of the last three years of the assessment are multiplied by the proportion landed at-age to give partial F for landings. The vectors of partial F are then averaged over the last three years to give the forecast values.

E. Medium-term projections

Model used: Age structured

Software used: MLA used for Medium-Term Projections.

Initial stock size: Taken from the XSA for age 1 and older. The recruitment-at-age 1 in 2009 is estimated using RCT3. For forecasting recruitment in 2010 and thereafter, a geometric mean was used for 1991–2006.

Natural mortality: Set to 0.2 for all ages in all years.

Maturity: The same ogive as in the assessment is used for all years.

F and M before spawning: Set to 0 for all ages in all years.

Weight-at-age in the stock: Three-year means (mean weights in the stock are assumed to be the same as catch weights, see below).

Weight-at-age in the catch: Three-year means.

Exploitation pattern: Average of the three last years.

Intermediate year assumptions:

Stock recruitment model used: RCT3 model used for intermediate year +1 in 2009.

Uncertainty models used:

1) Initial stock size;
2) Natural mortality;
3) Maturity;

4) F and M before spawning;
5) Weight-at-age in the stock;
6) Weight-at-age in the catch;
7) Exploitation pattern;
8) Intermediate year assumptions;
9) Stock recruitment model used;

F. Yield and biomass-per-recruit/long-term projections

Model used: Yield and biomass-per-recruit over a range of F values.

Software used: MLA and "st graf".

Maturity: Fixed maturity ogive as used in the assessment.

F and M before spawning: Set to 0 for all ages in all years.

Weight-at-age in the stock: Three-year means (mean weights in the stock are assumed to be the same as catch weights, see below).

Weight-at-age in the catch: Three-year means.

G. Biological reference points

Biological reference points for this stock are given below:

B_{lim}: 6000 t (lowest observed SSB)

B_{pa}: 9000 t (B_{loss} × 1.4)

F_{pa}: 0.4 (by analogy with other haddock stocks).

H. Other issues

I. References

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Table 4.3.1. Scottish landings and raised discards of haddock in 1999 estimates at Rockall from discard observer trips conducted on Scottish vessels.

	Age													
	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
Landing, N (*1000)	0	0	436.9	1211.9	1069.5	849.4	1220.6	1432.3	411.9	87.7	0.4	0	1.4	6722
Landing, tonnes	0	0	135.8	432.5	420.7	383.9	646	760.7	245.5	49.6	0.5	0	4.3	3079.5
Discards, N (*1000)[1]	22.4	14420.8	15276.9	6844.7	2534.8	1516	734.3	219.4	39.6	0	0	0	0	41609.1
Discards, tonnes[1]	1.5	2284.1	3658.2	1936.2	799.1	515.4	248.8	86.2	17.6	0	0	0	0	9547.2
Discards, N (*1000)[2]	12.5	13306.1	15895.9	7168.1	2588.9	1555.7	772.5	247.9	48.6	12.2	0.7	0	0	41609.2
Discards, tonnes[2]	0.3	2241.2	3791.3	2035.1	821.7	538.7	268	103.8	22.7	6.3	0.5	0	0	9829.6

[1] raised estimates from discard observer trips at Rockall.

[2] estimates obtained from a logistic discard curve for 1999.

Table 4.3.2. Scottish landings and raised discards of haddock in 2001 estimates at Rockall from discard observer trips conducted aboard Scottish commercial vessels.

	Age													
	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
Landing, N (*1000)	0	0	326.5	489.1	132.9	774.3	326	223.9	113.5	22.4	3.8	0	0	2412.3
Landing, tonnes	0	0	128.6	157	82.4	262.4	125.2	90.2	59.3	19.9	3	0	0	928
Discards, N (*1000)[1]	3.1	6309.9	549.7	228.4	66.3	8.1	1	0.1	0.1	0.1	0	0	0	7166.8
Discards, tonnes[1]	0.2	967.4	126.8	58.7	17.8	2.4	0.3	0.1	0	0	0	0	0	1173.8
Discards, N (*1000)[2]	531	5987.3	436.2	162.6	46.9	2.9	0.5	0.1	0	0	0	0	0	7167.6
Discards, tonnes[2]	14.3	936.2	93	38.6	11.6	0.9	0.2	0.1	0	0	0	0	0	1094.9

[1] raised estimates from discard observer trips at Rockall.

[2] estimates from a logistic discard curve for 2001.

Table 4.3.3. Values of DL_{50} by Scottish discard trips in the Rockall area.

Year	DL50	b
1999	36.62	–0.5923
2001	31.20	–0.8238
Theoretical:	34.66	–1.2328

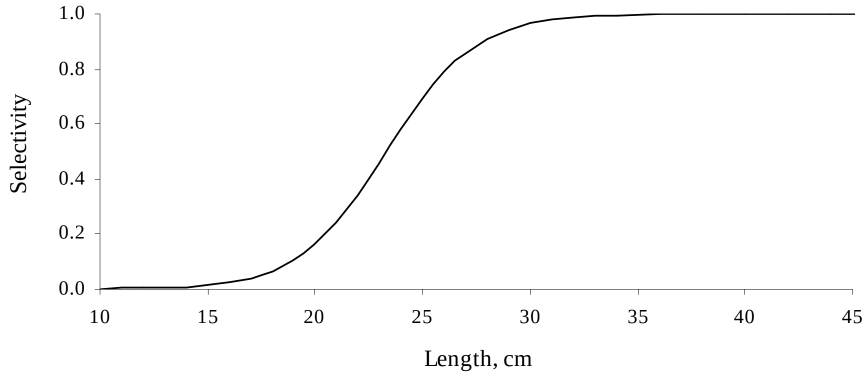

Figure 4.3.1. Theoretical haddock selectivity curve used to estimate the proportion of haddock lifted on board Russian trawlers.

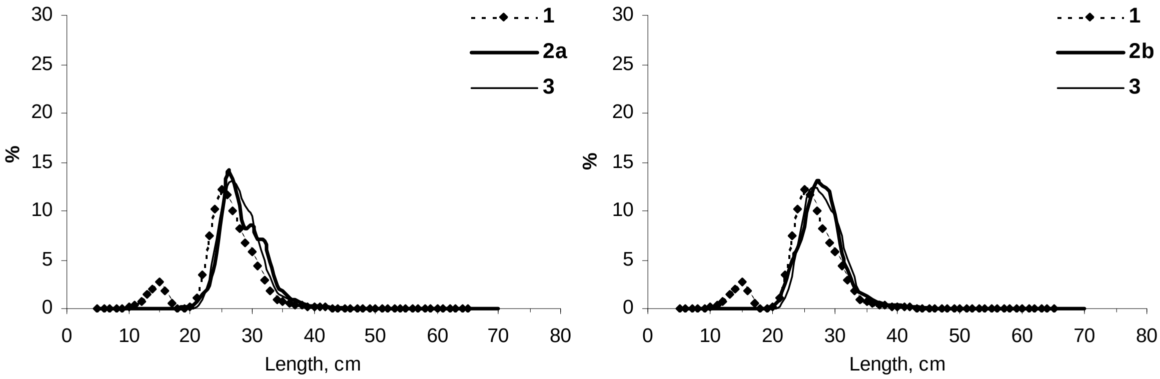

Figure 4.3.2. Length distribution of haddock in 2003: 1 – by Scottish groundfish survey, 2a – by commercial Russian trawlers in June, 2b – by commercial Russian trawlers in July, 3 – theoretically derived.

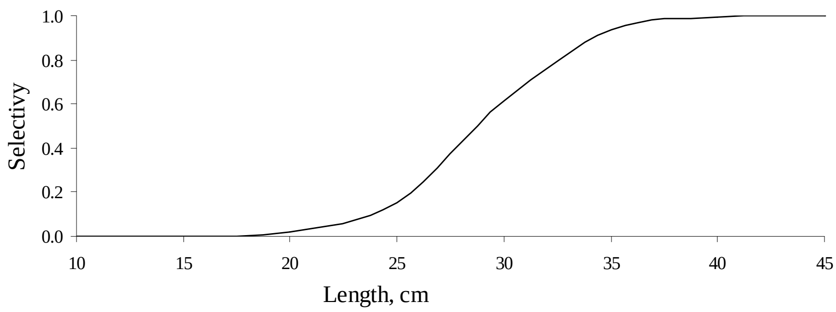

Figure 4.3.3. Theoretical haddock selectivity curve used to estimate the proportion of haddock lifted on board Scottish trawlers.

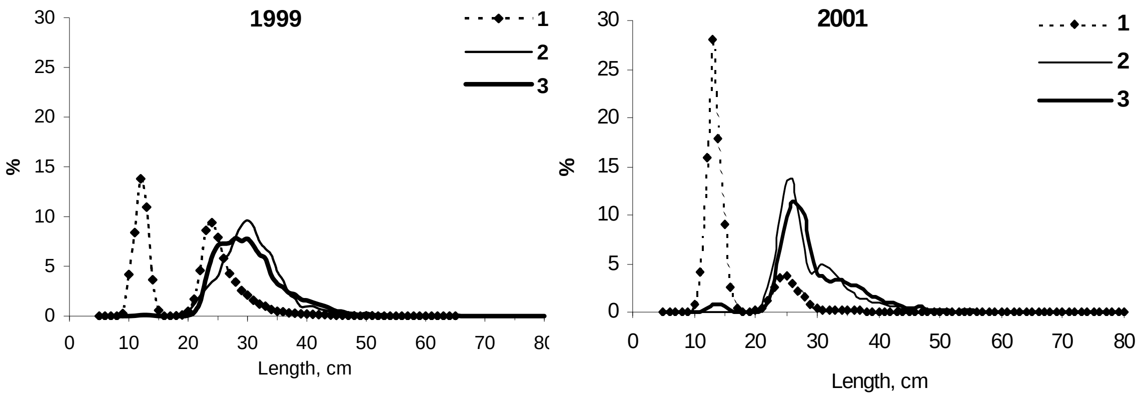

Figure 4.3.4. Length distribution of haddock in 1999 and 2001: 1 – by Scottish groundfish survey, 2 – by commercial Scottish trawlers, 3 – theoretically derived.

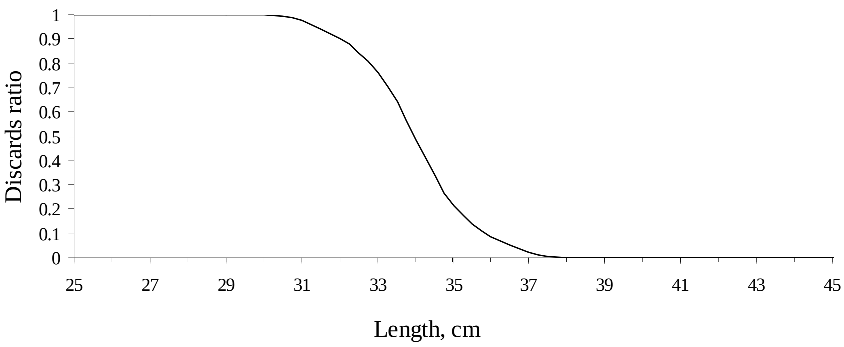

Figure 4.3.5. Selectivity curve used to estimate the proportion of discarded haddock in catches Scottish trawlers.

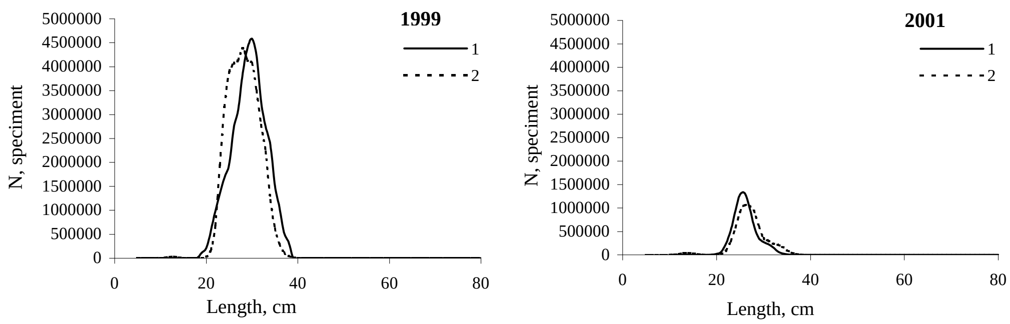

Figure 4.3.6. Length distribution of discarded haddock in catches Scottish trawlers in 1999 and 2001: 1 – research data; 2 – theoretically derived.

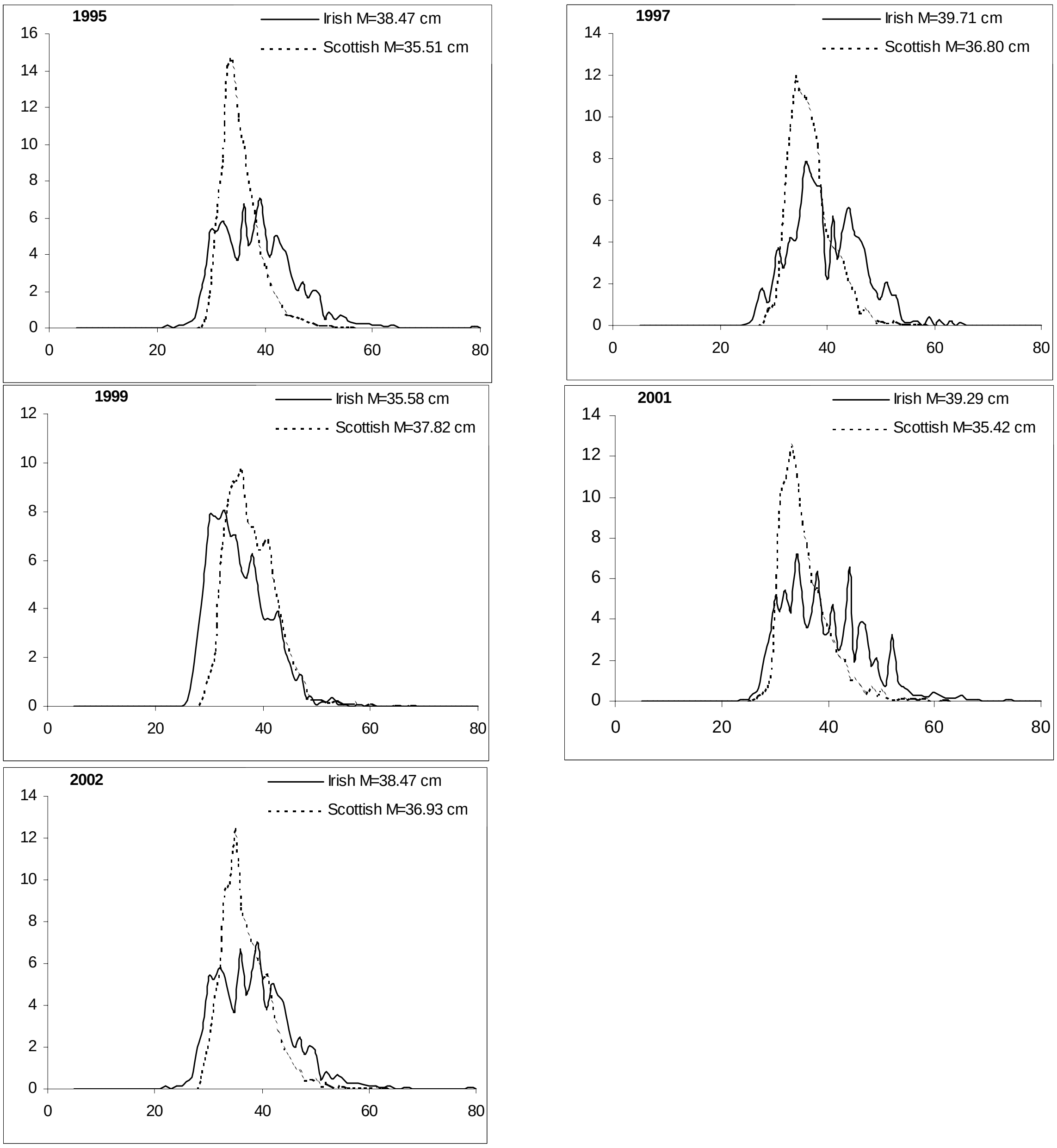

Figure 4.3.7. Length distribution of haddock landings in VI b (Scottish and Irish data).

Annex 5.2: Quality Handbook: Northern Shelf Anglerfish

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Anglerfish (Northern Shelf–Division IIIa, Subarea IV and Subarea VI, and Norwegian Sea Division IIa)
Working Group	Assessment of Northern Shelf Demersal Stocks
Date	17 May 2005
Last updated	19 May 2008

A. General

A.1. Stock definition

Anglerfish occur in a wide range of depths, from quite shallow inshore waters down to at least 1000 m. Small anglerfish occur over most of the northern North Sea and Division VIa, but large fish, the potential spawners, are more rarely caught. Little is known about when and where anglerfish spawn in northern European waters and consequently stock structure is unclear. This lack of knowledge is as a consequence of the unusual spawning habits of anglerfish. The eggs and larvae are pelagic, but whereas most marine fish produce individual free-floating eggs, anglerfish eggs are spawned in a large, buoyant, gelatinous ribbon which may contain more than a million eggs. As a consequence of this strange behaviour, anglerfish eggs and larvae are rarely caught in conventional surveys.

A recent EU-funded research project entitled 'Distribution and biology of anglerfish and megrim in the waters to the West of Scotland' (Anon, 2001) has however, improved our understanding. A particle tracking model was use to predict the origins of young fish and indicates that post-larval anglerfish may be transported over considerable distances before settling to the seabed (Hislop *et al.*, 2001). Anglerfish in deeper waters to the west of Scotland and at Rockall could therefore be supplying recruits to the western shelf and the North Sea. Furthermore, results of microsatellite DNA analysis carried out as part of this project demonstrate no structuring of the anglerfish stock into multiple genetic populations within or among samples from Divisions IVa, Division VIa and Rockall. In fact this project also suggested that anglerfish from further south (Sub-area VII) may also be part of the same stock. Fish tagged and released around the Shetland Islands (Division IVa) by Laurenson *et al.*, 2005 have occasionally been recaptured in Sub-area V and also Division IIa.

The WGNSDS considered the stock structure on a wider European scale in 2004, and found insufficient evidence to indicate an extension of the stock area northwards to include Division IIa. Anglerfish in IIa is at present treated separately by the working group.

A.2. Fishery

A.2.1. Northern Shelf anglerfish fisheries

UK vessels account for more than 50% of the total reported anglerfish landings from the Northern Shelf area. The Danish and Norwegian fleets are the next most important exploiters of this stock in the North Sea while Irish and French vessels take a significant proportion of the landings to the West of Scotland. The fishery for anglerfish in Subarea VI occurs largely in Division VIa with the UK and France being the most important exploiters, followed by Ireland. Landings from Rockall (Division VIb) are generally less than 1000 t with the UK taking on average around 50% of the total.

In the North Sea, the majority of landings are reported in Division IVa which reflects the northerly distribution of the species within the North Sea (Knijn *et al*., 1993).

A general description of the anglerfish fisheries of the most important nations taking part in this fishery is given below:

Scottish (UK) fishery

The Scottish fishery for anglerfish in Division VIa comprises two main fleets targeting mixed round-fish. The Scottish Light Trawl Fleet (SCOLTR) takes around 60% of landings and the Scottish Heavy Trawl Fleet (SCOTRL) over 20%. Around 10% of landings are bycatch from the *Nephrops* trawlers. The development of a directed fishery for anglerfish has led to considerable changes in the way the Scottish fleet operates. Part of this is a change in the distribution of fishing effort; the development of a directed fishery having led to effort shifting away from traditional round-fish fisheries in inshore areas to more offshore areas and deeper waters. The expansion in area and depth range fished has been accompanied by the development of specific trawls and vessels to exploit the stock. There has been an almost linear increase in landings from Division VIa since the start of the directed fishery until 1996 which has been followed more recently by a very severe decline, indicating the previous increase was almost certainly due only to the expansion and increase in efficiency of the fishery. More recent declines in landings (2002–2004) may have been as a consequence of restrictive TACs and the decline is not necessarily representative of the actual landings.

The Scottish fleet operating in VIb consists mainly of large otter trawlers (SCOTRL) targeting haddock and anglerfish at Rockall. Their activity depends on weather and the availability of haddock quota in VIb.

The Scottish fishery for anglerfish in the North Sea is located in two main areas: on the Shelf Edge to the north and west of Shetland and at the Fladen Ground. It expanded in a similar manner since the 1980s to that operating in Division VIa. The fishery to the north and west of Shetland operates as an extension to that in Division VIa and consists mainly of light trawlers targeting mixed round-fish. The highest reported landings in recent years (to 2007) come from the statistical rectangles around Shetland. The light-trawler fleet accounted for approximately 55% of Scottish reported landings in this area in 2007. The landings from the fishery at Fladen are lower but still significant (around 15% of the total) with anglerfish caught as a bycatch in the *Nephrops* fishery which consists of approximately 200 vessels in 2007. A small component of the landings (~10% in recent years) comes from the gillnet fishery which operates on the shelf edge in the far northwest of Division IVa. A large proportion of the landings in the gillnet fishery are taken by Spanish owned, UK registered vessels.

Ahead of the anglerfish STECF review group meeting in 2006 (SGRST-06–03), attempts were made to develop descriptions of the main Scottish anglerfish fisheries which were spatially more relevant to the stock distribution and activity of fishing vessels, rather than by ICES area. The descriptions used data on catch rates from various sources, including research vessel surveys, observer trips on board commercial boats, consultation with skippers and analysis of individual trip records. An 'anglerfish fishery' area was defined as the combined area of high abundance (catch-rates) from FRS/industry survey and observer data analysis. A '*Nephrops* fishery' area was assumed to cover the *Nephrops* grounds which are well defined by soft substratum and are described in the appropriate ICES WGs. The areas are mostly separate but where overlaps occur, these are taken to be part of the anglerfish area. A third area is defined to include all other statistical rectangles.

In the Scottish 'anglerfish' area, large meshed otter trawlers have the largest contribution to the total landings associated with anglerfish. This métier has a mixed species catch composition with haddock being the most important species and anglerfish and cod the next most important. In the *Nephrops* area the largest overall landings associated with anglerfish come from the <100 mm gear category with the dominant species being *Nephrops*, followed by haddock and anglerfish.

Previous studied have found it difficult to identify a specific anglerfish fishery as catch composition can vary a great deal over a small spatial scale (i.e. less than a statistical rectangle). Further analysis of the main, large mesh trawl operating in the 'anglerfish area' is required to provide a more comprehensive picture of catch composition. This has so far been beyond the scope of the WG.

Irish fishery

The Irish fleet which takes around 15–20% of the total Division VIa landings is a light trawl fleet targeting anglerfish, hake, megrim and other gadoids on the Stanton Bank and on the slope northwest of Ireland. This fleet uses a mesh size of 80 mm or greater. Irish Division VIa landings come mainly from the Stanton bank with some landings from Donegal Bay and the slope northwest of Ireland. Since 1996 there has been an increase in the number of vessels using twin rigs in this fleet. There have also been changes to the fleet composition since 2000, with around ten vessels decommissioned and four new vessels joining the fleet. The activity of this fleet is not thought to have been significantly affected by the recent hake and cod recovery plans.

The Irish fleet otter trawl in Division VIb take anglerfish as a bycatch in the haddock fishery on the Rockall Bank. The fleet targeting haddock uses 100 mm mesh and twin rig trawls. Occasionally Irish-Spanish flag vessels target anglerfish, witch and megrim with 80 mm mesh on the slope in VIb. Discarding practices of these vessels are not known although discarding of anglerfish from the fleet targeting haddock in Division VIb is not thought to be significant (Anon, 2001). The fleet composition changed in 2001. Four vessels have recently been decommissioned and two new vessels have joined the fleet that targets haddock. In 2006 and 2007, the effort of the Irish fleet operating at Rockall has increased with the increase in Rockall haddock TAC.

Danish fishery

According to logbook records, the majority of Danish anglerfish landings are taken in the northeastern North Sea, in the part constituting the Norwegian Deeps, situated in the Norwegian EEZ of the North Sea. Other important fishing areas for anglerfish are the Fladen Ground (also in IVa) and in the Skagerrak (IIIa). More than 80% of the Danish landings come from ICES Divisions IVa and IIIa. The remaining part is from the most northern part of Division IVb.

The majority of the Danish vessels are taking anglerfish with demersal trawls with over 90% of these vessels in the size range 20–40 m.

Fishery definitions by gear type and mesh size as currently used by Danish Fisheries Directorate for the North Sea are given in the following text table:

FISHERY/GEAR	MESH SIZE, MM
Dem. Trawl	>= 100 mm
Nephrops trawl	70–99 mm

Shrimp trawl	33–69 mm
Industrial trawl	< = 32 mm
Beam trawl	>= 80 mm

Note that in the North Sea demersal trawls account for more than 90% of total Danish landings. However, it is necessary to further specify that at present the majority of the Danish catches of anglerfish are taken by fisheries in the Norwegian zone of IVa applying demersal trawls with mesh size >= 120 mm. In 2006, the fishery with demersal trawl in the Norwegian Deeps (in the Norwegian zone) accounted for around 75% of total Danish landings by all gears from the entire North Sea. In the Skagerrak (IIIa) the two main fisheries taking anglerfish are the (mixed) *Nephrops* fishery and the demersal trawl fishery. In both areas minor landings are taken in gillnets and as bycatch in fisheries for shrimp (*Pandalus*).

Information on the species composition of the landings from Danish fisheries taking anglerfish is available from the Danish logbook records and also from the Danish at-sea samples from observers on discard trips. Further details can be found in Section 6.2.1 of ICES WGNSDS 2007. Typically anglerfish constitutes less than 15% by weight of the landings from demersal trawlers fishing in the Norwegian Deeps.

Norwegian fisheries

A Norwegian directed gillnet fishery (360 mm mesh size), targeting large anglerfish, carried out by small vessels in coastal waters in the eastern part of the Northern North Sea started in the early 1990s. These vessels are responsible for around 60–70% of the total Norwegian landings from this area and they comprise around 6% of the total landings from Division IVa since 1999. The remaining Norwegian landings in IVa are mostly bycatch in various trawl fisheries. A similar pattern of fishing is found in the Skagerrak (IIIa). The third quarter has in recent years been the most important season for the directed fishery, whereas the second quarter is apparently most important for other gears.

Other fisheries

French demersal trawlers also take a considerable proportion of the total landings from this area. The vessels catching anglerfish may be targeting saithe and other demersal species or fishing in deep water for roundnose grenadier, blue ling or orange roughy.

Since the mid-1990s, a deep-water gillnet fishery targeting anglerfish has been conducting a fishery on the continental slopes to the West of the British Isles, North of Shetland, at Rockall and the Hatton Bank. These vessels, though mostly based in Spain are registered in the UK, Germany and other countries outside the EU such as Panama. Gear loss and discarding of damaged catch are thought to be substantial in this fishery. Until now these fisheries have not been well documented or understood and they seem to be largely unregulated, with little or no information on catch composition, discards and a high degree of suspected misreporting. There are currently (2005) around 16 vessels participating in the fishery, 12 UK registered and four German registered.

In response to the concerns with these gillnet fisheries for deep-water sharks and anglerfish in Subarea VI, the EC banned the setting of gillnets in waters greater than 200 m in 2006 (Council Regulation 51/2006). However, this regulation was reviewed in July 2006 and a new regulation put in place which is a permanent ban, but allows a derogation for entangling nets in waters less than 600 m, not exceeding 100 km in total length with a maximum soak time of 72 hours. (EC Regulation No 40/2008 Annex III, article 8). NEAFC have also introduced an indefinite ban. There is also legislation proposed which will extend the ban to other areas including Division IVa.

In addition, the EU has recently funded a ghost net retrieval programme, DEEP-CLEAN, (coordinated by the Marine Institute, Ireland) which is due to commence in autumn 2007. The intention of this programme is to a) maximize the recovery of lost or abandoned gillnets and b) to quantify the scale and biological consequences.

A.2.2. Division IIa anglerfish fisheries

In Division IIa most of the anglerfish is caught by small vessels in a directed gillnet fishery close to the coast. The legal mesh size has, since 1995, been 360 mm and maximum 2 days soaking time. Offshore gillnetting, trawls and Danish seines are responsible for the other catches. For the directed gillnet fishery, the area between N 62° and N 64° has been the most important with maximum catches almost reaching 3000 tonnes in 1993. During recent years the catches have varied between 1000–2000 tonnes. A fishery north of N 64° has developed rapidly, with catches reaching 2400 tonnes in 2007, exceeding the level of catches in the southern part of IIa for the first time. For the other gears, catches have increased from around 100 tonnes in the early 1990s to approximately 300–500 tonnes during the last four years. Very low catch figures are reported from other nations north of N 62°.

A.3. Ecosystem aspects

No information.

B. Data

B.1. Commercial catch

B.1.1. Data compilation

Quarterly length–frequency distribution data were available from Scotland and Ireland for Division VIa and Spain for Subarea VI in the past. A total international catch-at-length distribution for Division VIa was obtained by summing national raised catch-at-length distributions then raising this distribution to the WG estimates of total international catch from this area. Landings officially reported to ICES were used for countries not supplying estimates directly to the WG. Since 2001, the Scottish market sampling length–weight relationships (given below) have been used to raise the sampled catch-at-length distribution data Working Group estimates of total landings for Division VIa. Length-frequency data availability for VIb has been limited to Scottish and Irish samples.

Year Range	Formula (L – length in cm, W – weight in g)	Source
1992–2000	W=0.01626L2.988	Coull *et. al.*, 1989
2001 onwards	W=0.0232L2.828	Scottish Market Sampling

For anglerfish in the North Sea, catch-at-age composition data are available from Scotland for the years 1992 to 2007. In the past the Scottish quarterly age–length keys were applied to the available length–frequency data and non-sampled catches were attributed to age assuming their length–frequency distributions to be equivalent to the combined sampled distribution.

As a first step in assembling assessment data for the North Sea component of the stock, length compositions from Scottish market sampling have been raised to Working Group estimates of total landings in the past. The Working Group estimate of total landings was assumed equal to the landings obtained by national scientists plus official landings as reported to ICES for those countries not providing landings data to the Working Group. The Scottish market sampling data are only available from 1993 onwards, and even for these years the level of sampling has been relatively low. More recently, additional length samples are available from the Danish and Norwegian fisheries since 2002 including samples from Division IIIa.

Total international catch-at-length distribution data for the whole Northern shelf (Division IIIa, Subarea IV and Subarea VI) have previously been obtained by summing the length distributions from the individual areas and assuming that this distribution is representative of the whole Northern Shelf. This was then raised to Working Group estimates of total landings for the Northern shelf.

In addition, catch-at-length distribution data are available from the Norwegian directed coastal gillnetting in Division IIa from 1993 to 2007, although there are no data from 1997–2001. There is also catch-at-length distribution data from anglerfish caught as bycatch in the offshore gillnetting and longlining fleets for 2004–2007. No attempts have been made to present raised catch-at-length distribution for anglerfish from Division IIa.

B.1.2. Commercial catch data quality

For a number of years, anglerfish in Sub-area VI, XII, XIV and Division Vb (EU zone) were subjected to a precautionary TAC (8600 t), based on average landings in earlier years. In 2002 the TAC was set at 4770 t and was further reduced to 3180 t in 2003 and 2004. The TAC was increased in 2005 to 4686 t and to 5155 t for 2007. At the WG in 2003, it was highlighted that the reduction off the TAC in 2003 to just two-thirds of that in 2002 would likely imply an increased incentive to misreport landings and increase discarding unless fishing effort was reduced accordingly (Section 6.4.6, ICES WGNSDS 2003). Anecdotal information from the fishery in 2003 to 2005 appeared to suggest that the TAC was particularly restrictive in these years. The official statistics for these years are, therefore, likely to be particularly unrepresentative of actual landings.

The absence of a TAC for Subarea IV prior to 1999 means that before then, landings in excess of the TAC in other areas, were likely to be misreported into the North Sea. In 1999, a precautionary TAC was introduced for North Sea anglerfish, but unfortunately for current and future reporting purposes, the TAC was set in accord with recent catch levels from the North Sea which includes a substantial amount misreported from Subarea VI. The area misreporting practices have thus become institutionalised and the statistical rectangles immediately east of the 4°W boundary (E6 squares) have accounted for a disproportionate part of the combined VIa/North Sea catches of anglerfish.

The Working Group historically (prior to 2005) provided estimates of the actual Division VIa landings by adjusting the reported data for Division VIa to include a proportion of the landings declared from Division IVa in the E6 ICES statistical rectangles. The correction has been applied by first estimating a value for the true catch in each E6 square then allocating the remainder of the catch into VIa squares in proportion to the reported catches in those squares. The ‘true’ catches in the E6 squares are estimated by replacing the reported values by the mean of the catches in the adjacent squares to the east and west. This mean is calculated iteratively to account for increases in catches in the VIa squares resulting from reallocation from the E6 squares. Such a reallocation of catches may still inadvertently include some landings taken legally in Division IVa on the shelf edge to the west of Shetland, but these are likely to comprise fish within the distribution of the Division VIa stock component. As a consequence of technical problems associated with changes to the Scottish Executive database and lack of landings data provided to the Working Group by some of the major nations exploiting the fishery, WG estimates of the actual Division VIa landings have not been calculated for recent years (2005–2007).

B.2. Biological

Previous assessments of this stock used the natural mortality rate applied to anglerfish in Division VI adopted by an earlier Hake Assessment Working Group of 0.15 yr^{1}. This value is once more adopted for all ages and lengths in the absence of any direct estimates for this stock.

Historically, the catch-at-age analysis of anglerfish in Division VIa used the same maturity ogive as that applied to anglerfish in Subareas VII and VIII by the Working Group on the Assessment of Southern Shelf Demersal Stocks. However, a number of more recent maturity studies based on the VIa stock indicate that maturity does not occur until much later than previously estimated. Afonso-Dias and Hislop, 1996 give a length-maturity ogive for this stock, 50% maturity at approximately 74 cm in females, and 50 cm in males. However, this study was based on few samples. New information has become available from the EU-funded project (Anon, 2001) which indicates female 50% maturity at approximately 94 cm and males at 57 cm. The corresponding age-based ogives indicate 50% maturity at approximately age 9 in females and age 5 in males. This has also been supported by more recent studies by Laurenson *et al.*, 2005.

B.3. Surveys

In previous lengths-based assessments of this stock, a recruitment index was used which had been obtained from the Scottish March West Coast survey. The index consists of numbers of anglerfish less than 30 cm caught per hour. However, at more recent meetings of this WG it has been concluded that the traditional groundfish surveys are ineffective at catching anglerfish and do not provide a reliable indication of stock size. As a result of this conclusion, and the urgent requirement for fishery-independent data, FRS, Scotland began a new joint science/industry survey in 2005. This is a targeted anglerfish survey with a scientific design using commercial gear. In 2006, Ireland extended the anglerfish survey to cover the remaining part of VIa (from 54°30′ to 56°39′). Further details of the survey including information on design, sampling protocol and gear and vessel are given in Fernandes *et al.*, 2007.

B.4. Commercial cpue

B.4.1. Official logbook data

Previous length-based assessments attempted to use effort data to constrain the temporal trend in fishing mortality. Scottish Light Trawl data, disaggregated into an inshore and offshore component, the latter of which is associated with the anglerfish fishery, for both West of Scotland and Shetland (N Sea) were provided to the Working Group. However, these data are no longer considered to be reliable because of non-mandatory recording of hours fished in the logbook data. Further details of the Scottish fleet effort recording problem can be found in the Report of the 2000 WGNSSK (ICES, 2001). Because these data are considered unreliable, they are not presented here.

Irish lpue data as hours fished has been presented to the WG for Division VIa and Division VIb for all fleets up to 2006 (displayed in Table B.4.1). The measure of kWdays is believed to be a more reliable proxy for effort than hours fished as a consequence of reporting issues and these data are presented in the WG report.

Danish landings and effort data (hours fished) from logbook data are also available to the WG for Division IIIa and Division IVa. Although these data are considered to be reliable (in terms of accuracy of reporting), it is not know to what extent they are useful in providing an indicator of stock size as a consequence of management regulations in the Norwegian zone (TAC constraints) and technological creep.

No effort data have been made available to the WG for fisheries operating in Division IIa.

B.4.2. Tallybook data

Analysis of skippers' personal diary information collected in 2004 and 2005 in an attempt to improve knowledge of the state of the stock and of the Scottish anglerfish fishery provided valuable information to ICES (Bailey, *et al*., 2004) on temporal and spatial trends in catch rate. Following the success of this data collation exercise, ICES advised the process to continue and a more formal scheme was proposed by FRS.

Extensive discussions with the fishing industry during 2005 resulted in FRS implementing the monkfish tallybook project at the start off 2006. The project is part of a long-term approach to providing better information on the monkfish fishery and the state of the stock, and is being operated in conjunction with fishers' organizations (Scottish Fishermen's Federation, Fishermen's Association Limited and Pecheurs de Manche et Atlantique) and the North Atlantic Fisheries College (NAFC) Marine Centre, Shetland. These organizations have been responsible for distributing the tallybooks, coordinating the returns and allocating a vessel code before the anonymised tallybook sheets are forwarded to FRS. The tallybooks are filled in on a haul-by-haul basis to give weight caught by size category and information on haul location, duration and depth in a standardized format as well as gear and mesh being used. Additionally information on mature females has been requested. Data are stored in a database at FRS.

So far, the time-series is relatively short, with the first returns from fishing trips at the end of December 2005 and the most recent from March 2008. Initial participation in the scheme was high with returns received from up to 37 vessels with a wide spatial coverage (across Subarea VI, Division IVa, IIa and Vb) and different target species. Of the 37 vessels which have so far supplied information, 2 are French and these are operating towards the southern end of the shelf edge in Division VIa northwest of Ireland. The haul depth information collated so far indicates that most of the hauls are taken in depths between 100 and 400 m although there are a significant number of hauls from depths between 600 and 800 m. The records from the deeper water are largely from the French vessels although it does appear that a number of the Scottish vessels make occasional trips into deeper water. Average catch rates are similar to those previously seen in the diary data and observer data (presented in previous WG reports) and range from around 10 Kg/hr for boats targeting *Nephrops* to over 100 Kg/hr for some whitefish boats.

Analysis of the catch rate data is presented in the WG report and in Dobby *et al*., 2007.

B.5. Other relevant data

None.

C. Historical stock development

Since 2003 the WG has been unable to provide an assessment of anglerfish. This is as a consequence of a combination of unreliable commercial data: landings misreporting in some of the main fleets involved in the fishery and uncertain effort data, and poor catchability of anglerfish in traditional research vessel surveys.

Although, the stock status has been classified as uncertain in recent years, TAC increases of 10% occurred in both the West of Scotland and North Sea areas on the basis of advice from the STECF review group meeting (SGRST-06–03) which examined trends in commercial catch rate data and fishery information.

In previous years the stock assessment has been conducted using a length-based model for which the settings are outlined below.

Model used: Catch-at-length analysis (modified CASA-Sullivan *et al.*, 1990; Dobby, 2002).

Software used: Fortran coded executable-LBAV4_1.

Model Options chosen:

Sex differentiated von Bertalanffy growth, variability distributed according to a beta function. Parameters taken from Scottish anglerfish survey in 2000: L_4(F)=140.5, K(F)=0.117, L_4(M)=110.5, K(M)=0.154.

Fishing mortality in 1993=1.0

Historical equilibrium fishing mortality fitted using mean of historical WG estimates of landings which is approximately 18 000 t over 1987–1991.

Logistic exploitation pattern with fitted parameters.

Trend in temporal fishing mortality equal to trend in recent SCOLTR effort data

Total recruitment normally distributed over length classes

Input data types and characteristics:

Name	Year range	Variable from year to year Yes/No
Catch in tonnes	1993–last data year	Yes
Catch-at-length in numbers	1993–last data year	Yes
Weight-at-length in the commercial catch	1993–last data year	Yes/No–2 weight-length relationships: covering 1993–2000, and 2001 onwards
Weight-at-length of the spawning stock at spawning time.	1993–last data year	Yes/No-assumed to be the same as weight-at-length in the catch
Proportion mature at length	1993–last data year	No–the same ogive for all years
Natural mortality	1993–last data year	No–set to 0.15 for all lengths in all years

Auxiliary data:

Type	Name	Year range	Size range
Recruitment index	Scottish March West Coast survey	1993–last data year	< 30 cm

D. Short-term projection

In previous years the short-term forecast has used a length-structured method with settings outlined below.

Model used: Length-structured

Software used*:* Fortran coded executable LBForecast.exe

Initial stock size: taken from catch-at-length analysis. The long-term geometric mean recruitment is used in all projection years. Natural mortality: Set to 0.15 for all lengths in all years

Maturity: The same ogive as in the assessment is used for all years

Weight–length relationship: as used in the assessment (Scottish Market sampling)

Exploitation pattern: Fixed exploitation at length pattern is estimated in the catch-at-length analysis. This is assumed to apply in all further years.

E. Medium-term projections

No medium-term projections are carried out for this stock.

F. Yield and biomass-per-recruit/long-term projections

Previous yield and biomass-per-recruit calculations were carried out on the basis of the results of length-based assessments which are no longer carried out.

G. Biological reference points

Precautionary approach reference points: "ICES considers that there is currently no biological basis for defining B_{lim} or F_{lim}. ICES proposes that $F_{35\%SPR}$ =0.30 be chosen as F_{pa}. It is considered to be an approximation of F_{MSY}."

The statement included above first appeared in 1998, but the WG has been unable to find the basis of the derivation of this reference point and considers it no longer appropriate to include it.

H. Other issues

In previous ('catch-at-length') assessments of this stock, the SSB was always estimated to be at a very low level. The length data have been based on the UK landings only (in Subdivisions. IVa and VIa), where very few individuals over 80 cm appear in the catch and therefore the model predicts very few in the population. Because females do not mature until they are over 90 cm in length the SSB is estimated to be very low. The length data from the eastern part of the North Sea (Danish and Norwegian fisheries) for the recent years indicate a higher amount of larger individuals in the catches. Although the Danish and Norwegian landings are small compared with the UK landings, the inclusion of the Danish and Norwegian length frequencies in the data used for any future assessment may change the concept of the magnitude of the SSB.

The fact that mature female anglerfish are rarely observed either on scientific surveys or by observers on board commercial vessels supports a very low estimate of biomass, yet there is little evidence of reduction in spatial distribution as fish are still recruiting to relatively inshore areas. It has been hypothesized that females may become pelagic when spawning as they produce a buoyant, gelatinous ribbon of eggs, and would therefore not appear in the catch of trawlers. (Anglerfish have been caught near the surface, Hislop *et al*., 2000). This would imply different exploitation patterns for males and females: a dome-shaped pattern (decreased exploitation at larger sizes) for females and a logistic pattern for males. It is also not known whether anglerfish are an iteroparous or semelparous species. The latter would also account for the almost complete absence of spawning females in commercial catches or research vessel surveys.

The key features of the species' life history in relation to its exploitation are the location of the main spawning areas, and whether or not there is any systematic migration of younger fish back into the deeper waters to spawn. At present, despite the large increase in catches during the mid 1990s, there is no apparent contraction in distribution; fish are still recruiting to relatively inshore areas such as the Moray Firth in the northern North Sea. The fact that spawning may occur largely in deep water off the edge of the continental shelf may offer the stock some degree of refuge. However, this assumes that the spawning component of the stock is resident in the deep water, and is thus not subject to exploitation. It is not known to what extent this is true, but if such a reservoir exists then the currently used assessment methods which make dynamic pool assumptions about the population are likely to be inappropriate. Nevertheless, it is clear that further expansion of the fishery into deeper water is likely to have a negative effect on the SSB and given the spatial development of the fishery, it cannot be ruled out that the serial depletion of fishing grounds has been occurring. In addition, some life-history characteristics of anglerfish suggest that it may be particularly vulnerable to high exploitation. A detailed discussion of the fishery development and biology can be found in Sections 7.5.4 and 7.5.5 of the 2000 report of this Working Group (ICES, 2001).

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Table B.4.1. Anglerfish in Subarea VI. Landings, effort and lpue from the Irish OTB fleet.

	IR-OTB-4–6			IR-TBB-4–6			IR-SCC-4–6			IR-GN-4–6		
	IV–VI			IV–VI			IV–VI			IV–VI		
Year	Landings (t)	Effort (hr)	lpue (kg/hr)	Landings (t)	Effort (hr)	lpue (kg/h)	Landings (t)	Effort (hr)	lpue (kg/hr)	Landings (t)	Effort (hr)	lpue (kg/hr)
1995	769.21	66.54	11.56		0.00		5.70	2.65	2.15	0.87	1.57	0.55
1996	698.93	68.90	10.14	16.54	1.23	13.45	4.91	2.94	1.67	1.91	2.25	0.85
1997	680.78	72.71	9.36	2.055	1.07	1.93	7.79	3.00	2.60	3.40	1.83	1.86
1998	656.23	66.40	9.88	10.381	2.36	4.41	12.72	2.95	4.32	0.95	1.22	0.77
1999	512.92	63.23	8.11	1.939	1.12	1.73	12.14	4.22	2.87	6.19	0.49	12.65
2000	471.95	63.33	7.45	0.045	0.13	0.35	4.64	3.86	1.20	0.87	0.11	7.60
2001	408.46	55.99	7.30	0.12	0.12	0.98	2.95	1.31	2.26	22.23	0.43	51.69
2002	317.13	40.00	7.93		0.00		5.06	1.58	3.20	4.94	0.23	21.48
2003	299.17	44.44	6.73		0.00		3.84	2.22	1.73	1.86	0.54	3.45
2004	197.89	37.50	5.28	0.176	0.35	0.50	2.15	0.98	2.20	2.46	0.54	4.57
2005	350.33	34.79	10.07		0.04	0.00	1.07	0.69	1.56	0.00	0.04	0.00
2006	423.39	34.62	12.23	0.12	0.07	1.71	1.18	0.49	2.40	0.02	0.24	0.07

Annex 6.2: Quality Handbook: Cod VIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Irish Sea COD (Division VIIa
Working Group	Working Group on Celtic Seas Ecosystems (WGCSE)
Date:	17 May 2009
Revised by	M.J. Armstrong

A. General

A.1. Stock definition

All catches and survey data from within ICES Division VIIa are assumed to come from a unit stock. Stock structure of cod in European waters has been the subject of increasing study in recent years. Current information is summarized in Crozier *et al*., 2007.

Recent egg surveys in 2006 and 2008, using DNA probes to distinguish early stage eggs of cod from other gadoids, confirm the location of distinct cod spawning grounds in the western and eastern Irish Sea (Armstrong *et al*., 2008). Historical tagging studies indicated spawning site fidelity (Brander, 1979) but varying degrees of mixing of cod between the Irish Sea, Celtic Sea and west of Scotland/north of Ireland. Studies based on meristics, allele frequencies and micro-satellite markers genetics and population structure have not provided unequivocal evidence of genetically isolated stocks in the Irish Sea and surrounding waters.

A recent tagging programme run from 1997–2000, in which over 2200 cod were tagged using external and data storage tags revealed that although there was some movement of cod between the Irish and Celtic Seas, the component of Irish Sea cod in the Celtic Sea was low. Furthermore, no cod tagged in the Celtic Sea were recovered from the Irish Sea (Connolly and Officer, 2001). One problem with interpreting this evidence is that the overall stock sizes in both areas have declined significantly in recent years. There may therefore have been changes in geographic range and movement patterns making comparison of recent results with earlier studies problematic.

More recent tagging of cod off Greencastle on the north coast of Ireland (O'Cuaig and Officer, 2007), and limited tagging on UK Fisheries Science Partnership surveys (Armstrong *et al*., WD2 to WGNSDS 2007), have demonstrated movements of cod between Division VIa and VIIa. Most recaptures in VIIa from cod tagged in VIa have come from the North Channel and in or near the deep basin in the western Irish Sea that is a southward extension of the North Channel. The research surveys used for tuning the VIIa cod assessment cover only the western and eastern Irish Sea, and do not extend into the deeper water of the North Channel, where large catches of cod were made by midwater trawlers in the 1980s and 1990s.

Immature cod may disperse over a wide area as demonstrated by fish tagged and released from various parts of the Irish Sea (including Belfast Lough). These demonstrated a substantial migration into the Celtic Sea and round the north and west of Ireland. Once these fish mature however they appear to return to the Irish Sea spawning grounds. Extensive tagging off the West of Scotland produced no recaptures from the Irish Sea. A summary of cod movements between the Irish Sea and Celtic Sea and Bristol Channel is given in Pawson, 1995.

Further tagging and genetics studies are required to investigate stock structure, seasonal movements and mixing in VIIA and neighbouring areas. New tagging studies of cod in the Irish Sea, Celtic Sea and to the north of Ireland have taken place in 2008–2009.

A.2. Fishery

Irish Sea fisheries for cod have changed considerably over the last four decades: A brief description is given below.

1960s and 1970s. UK and Irish single otter trawlers targeted spawning cod in spring in both the western and eastern Irish Sea. Fisheries for young cod (codling) took place in autumn and winter. The growing single-rig *Nephrops* fleet took bycatches of cod. Several strong year classes of cod were formed resulting in good catches. Fleets were catching around 40–50% of the stock of adult fish each year.

1980s. Development of midwater trawls and bottom-trawls capable of fishing on rough grounds opened up opportunities to fish in difficult areas such as the North Channel. "Dual purpose" trawls were developed to optimize catches of *Nephrops* and whitefish. The English beam trawl fleet grew rapidly in the 1980s, taking a bycatch of cod. The percentage of the stock of adult cod caught each year increased from 50% to 60%. Throughout the 1980s, TACs remained well above scientific advice to avoid triggering of The Hague Preference agreement which would have given Irish fleets a relatively bigger fraction of the TAC.

1990s. Mid-water trawlers developed a summer and autumn fishery for cod. The English otter trawl fleet declined and was reduced to inshore vessels taking mixed demersal fish, including codling. Fishing effort of the English beam trawl fleet peaked in 1990 then declined. Twin-rig trawling for *Nephrops* and whitefish grew rapidly in the 1990s. This fleet also took a bycatch of cod. The Irish whitefish fleet moved increasingly to grounds off the south and west coasts, leaving mainly a *Nephrops* fleet and a number of vessels fishing rays, cod and haddock in the Irish Sea. A major change in the 1990s was the growth of the haddock stock. Vessels that would have fished for cod also targeted haddock in the western Irish Sea, although still taking a bycatch of cod in certain areas and time periods.

*2000 onwards***.** Emergency measures were introduced in 2000 to allow the maximum number of cod to spawn. These measures included a closure of the western and eastern Irish Sea spawning grounds from mid February to the end of April, and modifications to trawl gear to improve selectivity. The closure was retained in 2001–2005, but only in the western Irish Sea. Derogations were allowed for *Nephrops* fishing in the closure, and experimental fisheries for haddock, flatfish and rays were permitted in some years with observers. Irish scientists successfully tested inclined separator panels in *Nephrops* trawlers, demonstrating large reductions in bycatch of cod. Vessels using such panels have been allowed to fish over a wider area of the closure since 2002. Vessels displaced from the closed area either switched to twin-rigging for *Nephrops*, fished for cod in the North Channel and Clyde, or tied up. From 2001, the Clyde fishing grounds were also closed in spring as part of emergency measures to protect west-of-Scotland cod. TACs for Irish Sea cod from 2000 onwards were reduced substantially.

Technical measures

The fishery is managed by a combination of TAC, area closures, technical measures, and effort restrictions.

In 2000, the cod spawning grounds were closed for ten weeks from mid-February to maximize the reproductive output of the stock (EU Regulations 304/2000 and 2549/2000). Revisions in 2001, 2002, and 2003 reduced the closure to the western Irish Sea only, coupled with changes in net design to improve selectivity. There are various derogations for gears not targeting cod, notably *Nephrops* trawls. During the closure, whitefish trawlers have been displaced to other fishing grounds or have switched to *Nephrops* trawling using 70–89 mm mesh nets. On the basis of the information available, STECF 2007 was unable to determine the extent to which the closure has reduced fishing mortality to a lower value than would otherwise have occurred, through protection of adult cod during spawning or through influencing changes in fishing effort in the different fleets. STECF advised that a comprehensive evaluation of how fleet activities have been affected by the closure and other regulations and factors is required to evaluate the cod closure.

The cod recovery plan introduced a system for limiting fishing effort by adjusting the number of fishing days allowed for various vessel categories deploying gears with various mesh sizes. STECF 2008 reported that the fishing effort of trawlers using 100–119 mm mesh declined by 83% between 2003 and 2007, and by 86% for vessels with a track record of <5% cod in their landings. This was as a consequence of a combination of factors restricting the activities of these vessels. A number of whitefish vessels switched to *Nephrops* gears to take advantage of the additional days at sea and the high value of *Nephrops* and some were removed from the fleet. Despite vessels switching to *Nephrops* fishing, the fishing effort of trawlers with 70–99 mm mesh declined by 2% between 2003 and 2007 and by 16% for vessels with a track record of <5% cod. This partly reflects vessels being decommissioned or increasingly fishing in the North Sea. Effort of beam trawlers declined by 48% and effort of fixed nets declined by 31% between 2003 and 2007.

New technical regulations for EU waters came into force on 1 January 2000 (Council Regulation (EC) 850/98 and its amendments). The regulation prescribes the minimum target species' composition for different mesh size ranges. Since 2001, cod in Division VIIa have been a legitimate target species for towed gears with a minimum codend mesh size of 100 mm. The minimum landing size for cod in the Irish Sea is 35 cm.

Management plans

Regulation (EC) No 423/2004 introduced cod recovery measures aimed at progressive rebuilding of spawning-stock biomass. However in 2008 the EU adopted a long-term plan for cod stocks and the fisheries exploiting those stocks (Council Regulation (EC) 1342/2008) that repeals Regulation (EC) No 423/2004, and has the objective of ensuring the sustainable exploitation of the cod stocks on the basis of maximum sustainable yield while maintaining a target fishing mortality of 0.4 on specified age groups.

Effort control

Direct control of fishing effort has been a key aspect of cod recovery plans. Monthly effort limitation was extended to the Irish Sea (and other "cod recovery" areas) under Annex V to Council Regulation (EC) No 2287/2003. This Regulation and subsequent amendments (e.g. Council Regulation (EC) No 27/2005) restrict the number of allowable days fishing per month according to gear type, mesh size band and various derogations.

The effort regulations have provided an incentive for some vessels previously using >100 mm mesh in otter trawls to switch to smaller mesh gears, thus claiming a larger number of days-at-sea.

A.3. Ecosystem aspects

Recruitment and the environment

There is evidence that the reduction in cod recruitment observed in the Irish Sea since the 1990s may be as a consequence of a combination of small spawning-stock biomass and poor environmental conditions, coinciding with a shift towards above-average sea temperatures (ICES, 2006).

B. Data

B.1. Commercial catch

B1.1. Landings

Source of landings and age composition data

	Kind of data				
Country	Caton (catch-in-weight)	Canum (catch-at-age in numbers)	Weca (weight-at-age in the catch)	Matprop (proportion mature-by-age)	Length composition in catch
UK(NI)	X	X	X	X	X
UK(E&W)	X	X	X		X
UK(Scotland)	X				
UK (IOM)	X			X	
Ireland	X	X	X		X
France	X				
Belgium	X				
Netherlands	X				

Procedures for compiling international catch-at-age data

Quarterly landings data are supplied by the UK (N. Ireland), UK (E&W), UK (Scotland), Ireland, Belgium, France and the IOM from databases maintained by national Government Departments and research agencies. The landings figures may be adjusted by national administrations or scientists to correct for known or estimated misreporting by area or species. To avoid double counting of landings data, each UK region supplies data for UK landings into its regional ports, and landings by its fleet into non-UK ports.

Member States that have collected length and age composition data for VIIa cod as required by the EU data Collection Framework supply quarterly landings-at-age data electronically to a stock coordinator at Cefas. Quarterly estimates of landings-at-age are provided by the UK (E&W), UK (NI) and Ireland. These are raised to include landings by the other countries, then summed over quarters to produce the annual figures for input to stock assessment.

The stock coordinator compiles the international landings and catch-at-age data and maintains a time-series of such data with any amendments (**Cod 7a CNAA 1991–200x.XLS**). Data are currently also entered on InterCatch. The Excel spreadsheet files used for age distribution, adjustments and aggregations can be found with the stock co-ordinator and for the current and previous year in the ICES computer system under **w:\acom\wgcse\2009\stock\cod-iris\working data**. The result files (FAD data) can be found at ICES and with the stock co-ordinator, as ASCII files on the Lowestoft format, under **w:\acom\wgcse\2009\stock\cod-iris\working data.**

The national data for the 1960s–1980s are currently not available electronically and will need to be recompiled.

Adjustments to official landings data

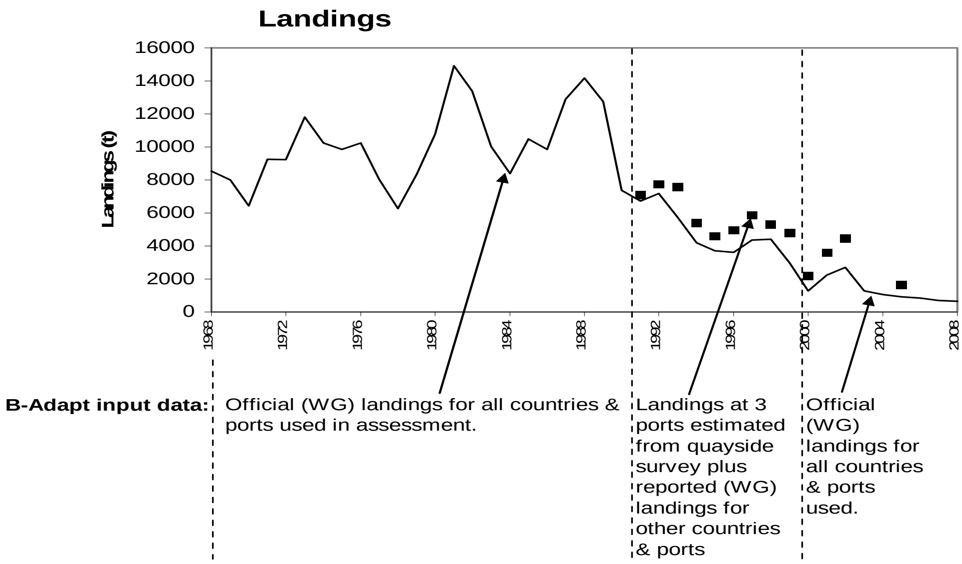
Official landings data may be adjusted at source before being transmitted to the ICES stock coordinator. This may include reallocation of EU logbook records from one Management Area to another if there is evidence of area misreporting.

The input data on fishery landings and age compositions are split into three periods:

1) 1968–1990. Landings in this period, provided to ICES by stock coordinators from all countries, were assumed to be accurate and were used directly as the input data for the assessment.

2) 1991–1999. TAC reductions in this period caused substantial misreporting of cod landings into several major ports, mainly species misreporting. Landings into these ports were estimated based on observations of cod landings by different fleet sectors during regular port visits (see below for method). Landings into other ports were obtained from official records as in period (1).

3) 2000 onwards. Cod recovery measures were considered to have caused greater problems with estimation of fishery removals than in period (2). The official catch data for all countries, as in period (1) were input to B-Adapt and the annual total removals (in excess of the assumed M) were estimated within the assessment model. These estimated removals can be compared with the official landings plus sample-based landings in 2000-2002 and 2005.



The method adopted for estimating landings into one Member State from 1991–2002 and 2005 was as follows:

1) The weight of cod in each landing observed during regular visits to the markets at each of the three major ports for the purposes of obtaining length measures was estimated based on the numbers of boxes multiplied by the average weight of cod per box, or based on the raised length frequency and length–weight parameters (VIIa landings only).

2) The mean total weight of cod per landing, and associated standard error, was estimated separately for different gear types and ports by averaging over all trips during the year.
3) The mean weight per trip was then raised by the reported number of trips using each gear in each of the three ports, from VIIa.
4) The raised landings estimates per gear type were summed over the three ports, then further raised to include trips for each gear landing in the remaining minor ports in the Member State, to give annual totals for each gear type for the Member State.

This procedure is analogous to the procedure used for estimating annual discards based on observer trips. The assessment data input to the WGCSE B-Adapt model includes the sample-based landings estimates only for the years 1991–1999.

B1.2. Discards

EU countries are now required under the EU Data Collection Framework to collect data on discards of cod and other species. Up to 2003, estimates of discards are available only from limited observer schemes and a self-sampling scheme. Observer data are collected using standard at-sea sampling schemes. Results are reported to ICES.

Discards data (numbers-at-age and/or length frequencies) are currently supplied to the VIIa cod stock coordinator by Ireland, UK(Northern Ireland) and UK (E&W). These may be supplied raised to the appropriate fleet métiers (Ireland) or as unraised data. Data supplied to the most recent WGCSE meeting are in **w:\acom\wgcse\2009\stock\cod-iris\working data.**

Discards raising

Ireland: Length frequencies from Irish (Marine Institute) observer trips in specified fleet métiers are raised to the trip level, averaged across trips during each year (not by quarter) then multiplied by the annual number of trips per year in the Irish fleet in VIIa to give raised annual LFDs for discards. An age–length key from discards trips is then applied to give annual discards by age class and métier.

Northern Ireland self sampling scheme: The quantity of cod discarded from the UK (NI) *Nephrops* fishery from 1996 to 2002 was estimated on a quarterly basis from samples of discards and total catch provided by skippers. The discards samples contain the heads of *Nephrops* tailed at sea. Using a length–weight relationship, the live weight of *Nephrops* that would have been landed as tails only is calculated from the carapace lengths of the discarded heads. The number of cod in the discard samples is summed over all samples in a quarter and expressed as a ratio of the summed live weight of *Nephrops* in the discard samples (i.e. those represented as heads only in the samples). The reported live weight of *Nephrops* landed as tails only is then used to estimate the quantity of cod discarded using the cod:*Nephrops* ratio in the discard samples. The length frequency of cod in the discard samples is then raised to the fleet estimate. Age data have not been collected; however the discards are mainly of small cod that can be allocated to ages 0 and 1 based directly on their length. Roughly 40 discard samples were collected annually.

Northern Ireland observer trips: Length frequencies from NI (AFBI) observer trips in specified fleet métiers are raised to the trip level, summed across trips during each year or by quarter (if requested) then raised to the annual number of trips per year in the NI fleet in VIIa to give raised annual LFDs for discards. An age–length key from discards trips is then applied to give annual discards by age class and métier.

UK (E&W) observer trips: Trips are arranged on vessels selected using a vessel randomization scheme. Discard numbers are raised to sampled hauls then to the trip. The trip raised length frequencies from Cefas observer trips in specified fleet métiers are then raised to the trip level, summed across trips during each quarter. Data are currently not provided raised to the fleet level.

B.2. Biological

Natural mortality is assumed to be constant (M=0.2, applied annually) for the whole range of ages and years. There are no direct estimates of M.

Proportion mature-at-age is currently assumed constant over the full time-series, and was estimated from UK(NI) trawl surveys in March 1992–1996.

AGE	1	2	3+
Prop mat	0.0	0.38	1.00

B.3. Surveys

Five research vessel survey series for cod in VIIa were used by WGCSE in 2009 In all surveys listed the highest age represents a true age not a plus group.

- UK (England and Wales) Beam Trawl Survey (E/W-BTS): ages 0 and 1, years 1988 onwards.

The survey covers the entire Irish Sea excluding the North Channel and is conducted in September on the R.V. *Corystes*. The survey uses a 4 m beam trawl targeted at flatfish. The survey is stratified by area and depth band, although the survey indices are calculated from the total survey catch in the eastern Irish Sea, and without accounting for stratification except for ALKs. Numbers of 0–gp and 1–gp cod at-age per 100 km towed are provided for prime stations only (i.e. those fished in most surveys). An automated data extraction and analysis routine in *r* is now used, and the series was revised in 2008 using this routine. The 2009 assessment used data for years 1993 onwards.

- UK (Northern Ireland) October Groundfish Survey (NIGFS-Oct): ages 0–7, years 1992–2008.

The survey-series commenced in its present form in 1992. It comprises 45 3–mile tows at fixed station positions in the northern Irish Sea, with an additional 12 1–mile tows at fixed station positions in the St George's channel from October 2001 (the latter are not included in the tuning data). The surveys are carried out using a rock-hopper otter trawl deployed from the R.V. *Lough Foyle*. The survey designs are stratified by depth and seabed type. Virtually all cod are aged apart from 0–gp and 1–gp fish when particularly abundant. An ALK for the whole survey is used for filling in for any length groups with no ages at a station. Mean numbers-at-age per 3–mile tow are calculated separately by stratum, and weighted by surface area of the strata to give a weighted mean for the survey or group of strata. From 2002 onwards, all stations in the survey have been reduced to 1 nautical mile. A number of comparative 1–mile and 3–mile tows are done during each survey to build up calibration data. Since 2005, the RV Lough Foyle used for all surveys since 1992 has been replaced by the larger RV Corystes. The trawl gear and towing practices have remained the same.

- UK (Northern Ireland) March Groundfish Survey (NIGFS-Mar): ages 1–7, years 1992 onwards.

General description as for NIGFS-October above, except that 3–mile stations have been retained in all strata other than in the St Georges Channel. Since 2005, the RV *Lough Foyle* used for all surveys since 1992 has been replaced by the larger RV *Corystes*. The trawl gear and towing practices have remained the same. The 1992 survey had only partial coverage of the western Irish Sea and is no longer used in the assessment.

- UK (Northern Ireland) Methot–Isaacs–Kidd Survey (NIMIK): age 0, years 1993–2008.

The survey uses a Methot–Isaacs–Kidd frame trawl to target pelagic juvenile gadoids in the western Irish Sea at 40–45 stations. The survey is stratified and takes place in June during the period prior to settlement of gadoid juveniles. Indices are calculated as the arithmetic mean of the numbers-per-unit sea area.

- UK (Scotland) groundfish survey in Spring (ScoGFS-Q1): ages 1–8, years 1996–2006.

This survey represented an extension of the Scottish West Coast groundfish survey (Area VI), using the research vessel *Scotia*. The survey gear is a GOV trawl, and the design is two fixed-position stations per ICES rectangle from 1997 onwards (17 stations) and one station per rectangle in 1996 (9 stations). The survey extends from the Northern limit of the Irish Sea to around 53° 30′.

B.4. Commercial cpue

Commercial cpue for several national fleets are available to ICES, but these are no longer used in the assessment.

B.5. Other relevant data

C. Historical stock development

Model used: B-Adapt (see appendix 1 for method).

Software used: B-Adapt-F.exe (13/5/06)

Model Options chosen:

SETTING	VALUES
Plus group	5-plus
Fbar range	2 – 4 (arithmetic mean)
Year range for tuning VPA	1992 onwards
Surveys after final year of catch data used.	Yes; Fmult = 0.75 for 2009 WGCSE
VPA model or cohort analysis used	v (exact)
First age with constant catchability	0 for all tuning fleets
q-plateau	Entered as 3 for all tuning fleets
Tapered time weighting applied	No
Number of missing catch multipliers	9 for WGCSE 2009 (bias estimated from 2000 onwards)
No. ages for terminal F mean, and scaling factor for mean	ages = 1; scaling factor = 1.0; arithmetic mean (i.e. F(4) = F(3))
Constraint on F or catch? Stiffness weight (λ)	Constrain F; λ = 1.0
Prior weighting of fleets	None
Output tables	VPA output table 16 (not SOP corrected)

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch-in-tonnes	1968 onwards	0 – 7+	Yes
Canum	Catch-at-age in numbers	1968 onwards	0 – 7+	Yes
Weca	Weight-at-age in the commercial catch	1968 onwards	0 – 7+	Yes
West	Weight-at-age of the spawning stock at spawning time.	1968 onwards	0 – 7+	Yes (assumed same weights as Weca)
Mprop	Proportion of natural mortality before spawning	1968 onwards	0 – 7+	Constant value of 0.0
Fprop	Proportion of fishing mortality before spawning	1968 onwards	0 – 7+	Constant value of 0.0
Matprop	Proportion mature-at-age	1968 onwards	0 – 7+	No
Natmor	Natural mortality	1968 onwards	0 – 7+	Constant value of 0.2

NOTE: (1) 1968–2008 landings-at-age including sample based estimates for 1991–1999 at three major ports and WG (official) landings figures for other ports. (2) Plus gp reset to 5+ in B-Adapt run.

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	E/W BTS	1993 onwards	0
Tuning fleet 2	NIGFS–Oct	1992 onwards	0
Tuning fleet 3	NIGFS-Mar;	1993 onwards	1–4
Tuning fleet 4	ScoGFS-Q1	1996-2006	1–5
Tuning fleet 5	NIMIK	1994 onwards	0

D. Short-term projection

Short-term predictions currently not carried out but are available within the B-Adapt bootstrap option for the chosen F multipliers for the intermediate and future years.

E. Medium-term projections

Model used: B-Adapt bootstrap option

Software used: B-Adapt-F.exe (13/5/06)

Initial stock size: Forecasts are projections from 1000 bootstrap simulations of the historical stock development. Initial numbers-at-age in each simulation are the survivors at-ages 1–5+ for the year following the last year with catch-at-age data, and numbers at-age 0 bootstrapped from the 2002 onwards estimates in each simulation.

Natural mortality: M=0.2

Maturity: As for assessment.

F and M before spawning:	Zero
Weight-at-age in the stock:	Mean wt-at-age last three years.
Weight-at-age in the catch:	Mean wt-at-age last three years
Exploitation pattern:	F-at-age in final year of historical assessment for each bootstrap simulation.
Intermediate year assumptions:	F multiplier implicit in harvest control rule adopted according to the long-term management plan. (F_{mult} 0.75 used in WGCSE 2009).

Stock recruitment model used: Bootstrap from 2002 onwards estimates for 0-gp in each simulation

Uncertainty models used

1)	Initial stock size:	B-Adapt bootstrap estimates
2)	Natural mortality:	Exact
3)	Maturity:	Exact
4)	F and M before spawning:	Exact
5)	Weight-at-age in the stock:	Bootstrap last three years?
6)	Weight-at-age in the catch:	Bootstrap last three years?
7)	Exploitation pattern:	B-Adapt bootstrap estimates
8)	Intermediate year assumptions:	Exact F multiplier
9)	Stock recruitment model used:	Bootstrap 2002 onwards 0-gp es timates in each simulation

F. Long-term projections

Last calculations of yield-per-recruit reference points was by WGNSDS 2004 based on the exploitation patterns from XSA fitted to data out to a 7+ group. The B-Adapt runs in recent years use a 5+ group and this is considered problematic for long-term yield and SSB per recruit calculations because of the expected large accumulation of fish in a 5+ group at low F's and the inability of the YPR model to adjust mean weight in the plus group as the age composition expands.

Model used:	Yield per recruit
Software used:	MFYPR
Maturity:	As per assessment
F and M before spawning:	Zero
Weight-at-age in the stock:	Mean last 3 years
Weight-at-age in the catch:	Mean last 3 years
Exploitation pattern:	Average last 3 years

Procedures used for splitting projected catches: None required

G. Biological reference points

	Type	Value	Technical basis
Precautionary approach	Blim	6000 t	Blim= Bloss, lowest observed level.
	Bpa	10 000 t	Bpa = MBAL, this level affords a high probability of maintaining the SSB above Blim. Below this value the probability of below-average recruitment increases.
	Flim	1.00	Flim= Fmed
	Fpa	0.72	Fpa: Fmed* 0.72. This F is considered to have a high probability of avoiding Flim. Fishing mortalities above Fpa have been associated with the observed stock decline.
Targets	Fy	0.40	(Council Regulation (EC) 1342/2008)

(PA reference points unchanged since: 1998)

Yield and spawning biomass per recruit F-reference points (from 2004 Assessment)

	Fish Mort Ages 2–4	Yield/R	SSB/R
Fmax	0.31	2.15	8.00
F0.1	0.18	2.01	12.75

Candidates for reference points consistent with high long-term yields and a low risk of depleting the productive potential of the stock are in the range of $F_{0.1}$–F_{max}.

H. Other issues

I. References

Crozier, W., Heath, M. and Righton, D. 2007. Spatial structure of cod populations: What are the implications for the assessment and management of cod stocks? A Mini-Symposium, 22–23 May, 2007, The Agri-Food and Biosciences Institute (AFBI), Newforge Lane, Belfast, United Kingdom BT9 5PX.

ICES. 2006. Report of the Working Group on the Assessment of Northern Shelf Demersal Stocks, 9–18 May 2006 (ICES CM 2006/ACFM:30).

ICES. 2009. Report of the Working Group on Celtic Seas Ecosystems, 12–19 May 2009 (ICES CM 2009/ACOM:xx).

STECF. 2007. Evaluation of closed area schemes (SGMOS-07–03).

Appendix 1: B-adapt method

The following text is adapted from Appendix 4 to the 2004 WGNSSK report (ICES CM 2005/ACFM:07), where further details on the background of the model and simulation testing can be found.

Absolute values of landings and landings-at-age, based on reported catches, for gadoid stocks in Divisions Via and VIIa are considered too biased to allow an analytical age based assessment using conventional assessment methods. Comparisons of analyses using reported catches and analyses using survey data alone indicate a clear mismatch between the levels of reported landings and actual removals. The mismatch may be as a consequence of a number of causes (misreporting, non-reporting, unaccounted discards, natural mortality, changes in catchability of fleet or surveys), and although these cannot be distinguished, an alternative model can be used to estimate a more realistic level of removals than indicated by the reported landings.

It is straightforward to demonstrate that if bias is present in the data on removals, the magnitude and sign of the log-catchability residuals is proportional to the degree of bias. If $C_{a,y}$ represents catch-at-age a in year y, $N_{a,y}$ population numbers-at-age by year, $F_{a,y}$ fishing mortality-at-age by year, $Z_{a,y}$ total mortality (fishing + natural mortality M) and B_y the bias in year y; in the years without bias

$$N_{a,y} = C_{a,y} Z_{a,y} (1\text{-}\exp(\text{-}Z_{a,y})) / F_{a,y}$$

and for the years with bias

$$N_{a,y} = B_y C_{a,y} Z_{a,y} (1\text{-}\exp(\text{-}Z_{a,y})) / F_{a,y}$$

Survey catch per unit of effort ($u_{a,y,f}$, where f denotes fleet or survey) is related to population abundance by a constant of proportionality or catchability $q_{a,f}$ which is assumed, in this study, to be constant in time and independent of population abundance

$$N_{a,y} = u_{a,y,f} / q_{y,f}$$

If the unbiased survey catchability can be calculated, an estimate of bias can be obtained from

$$B_y = N_{a,y} / (u_{a,y,f} / q_{y,f})$$

Gavaris and Van Eeckhaute, 1998 examined the potential for using a relatively simple ADAPT model structure to estimate the removals bias of Georges Bank haddock. Their model fitted a year effect for the bias in each year of the assessment time-series under the assumption that bias does not distort the age composition of landings, only the overall total numbers. The authors determined that the model was over-parameterized and that it was necessary to introduce a constraint, that one year-class abundance was known exactly, in order to estimate the remaining catchability, bias and population abundance parameters. They concluded that, for the datasets to which they applied the model, the indices of abundance from trawl surveys were so highly variable that this resulted in estimates of bias with wide confidence intervals and therefore the model could only be used as a diagnostic tool. A modification to the Gavaris and Van Eeckhaute ADAPT model (referred to here as BADAPT) can be made by assuming that the time-series of landings can be divided into two periods; a historical time-series in which landings were relatively unbiased and a recent period during which landings-at-age were biased by a common factor across all ages. The fit of the model to the early period of unbiased data provides estimates of appropriately scaled population abundance and survey catchability, thereby removing the indeterminacy noted by Gavaris and Van Eeckhaute.

Note that it is assumed that during both periods, landings numbers-at-age have relatively low random sampling variability (relative to survey variance) so that the population numbers-at-age can be determined using the virtual population analysis (VPA) equations. This assumption has been found to hold for the North Sea cod by the EMAS project (EMAS 2001) which examined the errors associated with current sampling programmes. Within B-ADAPT, population numbers are estimated from the VPA equations

$$N_{a,y} = B_y C_{a,y} Z_{a,y} (1-\exp(-Z_{a,y})) / F_{a,y}$$
$$N_{a,y} = N_{a+1,y+1} \exp(Z_{a,y})$$

where B_y is estimated for years in which bias was considered to have occurred and defined as 1.0 for years without bias. Selection is assumed to be flat topped with fishing mortality at the oldest age defined as the scaled (s) arithmetic mean of the estimates from n younger ages, where n and s are user defined. That is for the oldest age o:

$$F_o = s\ [F_{o-1} + F_{o-2} + \ +F_{o\ n}] / n$$

The parameters estimated to fit the population model to the cpue calibration data are the surviving population numbers $N_{a,fy}$ at the end of the final assessment year fy (estimated for all ages except the oldest) and the bias B_y in each year of the user selected year range. Under the assumption of lognormally distributed errors, the least-squares objective function for the estimated cpue indices is

$$SSQ_{vpa} = {}_{a,y,f}\{ \ln u_{a,y,f} [\ln q_{a,f} + \ln N_{a,y}]\}^2$$

The year range of the summation extends across all years in the assessment for which catch-at-age data are available and also (if required) the year after the last catch-at-age data year. This allows for the inclusion of survey information collected in the year of the assessment WG meeting.

Testing with simulated data (ICES CM 2005/ACFM:07, Appendix 4) established that increasing the uncertainty in the survey indices results in estimates of bias and the derived fishing mortality that are more variable from year to year. One solution to this problem is to introduce smoothing to the model estimates.

A constraint used frequently in stock assessment models is that of restricting the amount that fishing mortality can vary from year to year. This reflects limitations on the ability of fleets to rapidly increase capacity and the lack of historical effort regulation reducing catching opportunities. However, given the current overcapacity in the fleets prosecuting the North Sea cod fishery this form of smoothing constraint was not considered appropriate. Anecdotal information supplied by the commercial industry has indicated that the recent severe changes in the TAC have not been adhered to. Therefore it was considered more appropriate to apply smoothing to the total catches, across the years in which the bias was estimated. Smoothing of catches was introduced by an addition to the objective function sum of squares:

$$SSQ_{catches} = \{\ln (B_y\ a\ [C_{a,y} CW_{a,y}])\ \ln (B_{y+1}\ a\ [C_{a,y+1}\ CW_{a,y+1}]\ )\}^2$$

Here $CW_{a,y}$ are the catch weights-at-age a in year y and natural logarithms were used to provide residuals of equivalent magnitude to those of log-catchability within SSQ_{vpa}. is a user defined weight that allowed the effect of the smoothing constraint to be examined. The year range for the summation of the catch smoothing objective function was from the last year of the unbiased catches to the last year of the assessment. The total objective function used to estimate the model parameters was therefore

$$SSQ = SSQ_{vpa} + SSQ_{catches}$$

The least-squares objective function was mimimised using the NAG Gauss Newton algorithm with uncertainty estimated using two methods, calculation of the variance covariance matrix and bootstrap re-sampling of the log-catchability residuals to provide new cpue indices.

Annex 6.3: Quality Handbook: Haddock VIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Irish Sea Haddock (Division VIIa)
Working Group:	Celtic Seas Ecoregion
Last updated:	19 May 2009
Revised by:	P-J. Schön

A. General

A.1. Stock definition

A.2. Fishery

Directed fishing for haddock in the Irish Sea is mainly carried out by UK (Northern Ireland) midwater trawlers using 100 mm mesh codends, particularly targeting aggregations that can be detected acoustically. These conditions prevail mainly during winter and spring when the hours of darkness are longest, and the fish are aggregating on the spawning grounds in the western Irish Sea. Other demersal whitefish vessels from Northern Ireland, Ireland and to a lesser extent Scotland, using single or twin trawls with 100 mm mesh, also target haddock when abundant. (Prior to the introduction of Council technical conservation Regulation 850/98 in 2001, most whitefish vessels in the Irish Sea used 80 mm codends.) Bycatches of haddock are made in the UK (NI) and Irish *Nephrops* fisheries using single nets with 70 mm codends or twin trawls with 80 mm codends. The haddock stock is mainly distributed in the western Irish Sea and south of the Isle of Man, preferring the coarser seabed sediments around the periphery of the muddy *Nephrops* grounds. Juveniles are taken extensively in the otter trawl fisheries in these areas, leading to substantial discarding (see Section B1.2).

The nature of the fishery has been modified by the cod closure since 2000 (Council Regulation (EC) No 304/2000). Targeted fishing with whitefish trawls was prohibited inside the closure from mid February to the end of April. Derogations for *Nephrops* fishing were allowed. Irish *Nephrops* trawlers were involved in an experiment to test inclined separator panels in 2000 and 2001, the object being to minimize the bycatch of cod. Fishing inside a small area of the western Irish Sea closed to all fishing in spring 2000 and 2001 was permitted if separator panels were used. These panels would also have allowed escapement of part of the haddock catch. Closure of the main whitefish fishing grounds in spring 2000 resulted in a shift in fishing activities of midwater trawlers and other UK(NI) whitefish vessels into the North Channel (area VIIa) and Firth of Clyde (VIa south). A subsequent closure of the Firth of Clyde in spring 2001 under the VIa cod recovery programme (Council Regulation (EC) No 456/2001) resulted in a reduction in reported fishing activity in this region. Several rounds of decommissioning in 1995–1997, 2001 and 2003 have reduced the size of the commercial fleets. UK vessels decommissioned at the beginning of 2002 accounted for 17% of the haddock landings from the Irish Sea in 1999–2001. A further round of decommissioning in 2003 removed 19 out of 237 UK vessels that operated in the Irish Sea at the beginning of 2004, representing a loss of 8% of the fleet by number and 9.3% by tonnage.

Gear specific effort regulations (days-at-sea) have been introduced in the Irish Sea in 2004. Annex V to Council Regulation (EC) No 2341/2002 regulated the maximum number of days in any calendar month of 2004 for which a fishing vessel may be absent from port in the Irish Sea. Monthly effort limitation under this Regulation is as follows: 10 days for demersal trawls, seines and similar towed gears with mesh size >= 100 mm, 14 days for beam trawls of mesh size >= 80 mm and static demersal nets, 17 days for demersal longlines, and 22 days for demersal trawls, seines and similar towed gears with mesh size 70–99 mm. Additional days are available for vessels meeting certain conditions such as track record of low cod catches. In particular, an additional two days are available for whitefish trawlers (mesh >= 100 mm) and beam trawlers (mesh >=80 mm) which spend more than half of their allocated days in a given management period fishing in the Irish Sea, in recognition of the area closure in the Irish Sea and the assumed reduction in fishing mortality on cod.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

B1.1. Landings

The following table gives the source of landings data for Irish Sea haddock:

	Kind of data				
Country	Caton (catch-in-weight)	Canum (catch-at-age/in-numbers)	Weca (weight-at-age in the catch)	Matprop (proportion mature-by-age)	Length composition in catch
UK(NI)	X	X	X	X	X
UK(E&W)	X				
UK(Scotland)	X				
UK (IOM)	X				
Ireland	X	X	X		X
France	X				
Belgium	X				

Quarterly landings and length/age composition data are supplied from databases maintained by national Government Departments and research agencies. These figures may be adjusted by national scientists to correct for known or estimated misreporting by area or species. Data are supplied in Excel files to a stock coordinator nominated by the ICES Northern Shelf Demersal Working Group, who compiles the international landings and catch-at-age data and maintains a time-series of such data with any amendments. To avoid double counting of landings data, each UK region supplies data for UK landings into its regional ports, and landings by its fleet into non-UK ports.

Quarterly landings are provided by the UK (E&W), UK (Scotland), Belgium and France and annual landings are provided by UK (IOM). The quarterly estimates of landings-at-age into UK (NI) and Ireland are raised to include landings by France, Belgium, UK (E&W), UK (Scotland), UK (IOM) (distributed proportionately over quarters), then summed over quarters to produce the annual landings-at-age.

The Excel spreadsheet files used for age distribution, adjustments and aggregations can be found with the stock co-ordinator and for the current and previous year in the ICES computer system under **w:\acfm\wgnsds\year\personal\name** (of stock co-ordinator).

The result files (FAD data) can be found at ICES and with the stock co-ordinator, as ASCII files on the Lowestoft format, under **w:\acfm\wgnsds\year\data\whg_7a**.

B1.2. Discards

The potential magnitude of discarding was evaluated using limited data from the following fleets:

- Northern Ireland self sampling scheme for *Nephrops*. The fisher self-sampling scheme that provides discards data for VIIa whiting was altered in 1996 to record quantities of other species in the samples. The quantity of haddock discarded from the UK (NI) *Nephrops* fishery is estimated on a quarterly basis from samples of discards and total catch provided by skippers. The discards samples contain the heads of *Nephrops* tailed at sea. Using a length–weight relationship, the live weight of *Nephrops* that would have been landed as tails only is calculated from the carapace lengths of the discarded heads. The number of haddock in the discard samples is summed over all samples in a quarter and expressed as a ratio of the summed live weight of *Nephrops* in the discard samples (i.e. those represented as heads only in the samples). The reported live weight of *Nephrops* landed as tails only is then used to estimate the quantity of haddock discarded using the haddock:*Nephrops* ratio in the discard samples. Length frequencies of haddock in the samples are then raised to the fleet estimate. No otoliths were collected, but the length frequencies could be partitioned to age class based on appearance of modes and comparison with length-at-age distributions in March and October surveys. The age data from 2001and 2002 were derived using survey and commercial fleet ALKs. The UK (NI) estimates are available since 1996 but the reliability of these estimates has not been determined. Roughly 40 discard samples are collected annually. There are several limitations to these data: only a small subset of single-rig trawlers is sampled; the method of raising to the fleet discards will be affected by any inaccuracies in the reported landings of *Nephrops*; and there are no estimates of landings of whiting from these vessels with which to calculate proportions discarded-at-age. The WG has not used these data in past assessments.
- Northern Ireland observer sampling (all fleets): Length frequencies from NI (AFBI) observer trips in specified fleet métiers are raised to the trip level, summed across trips during each year or by quarter (if requested) then raised to the annual number of trips per year in the NI fleet in VIIa to give raised annual LFDs for discards. An age–length key from discards trips is then applied to give annual discards by age class and métier.
- Irish otter trawl fleet (IR-OTB). Discards are estimated by observers on Irish trawlers operating in VIIa. Estimates for this fleet are given in the Report of the ICES Study Group on Discards and Bycatch Information (ICES CM 2002 ACFM:09). The anomalous high estimate of discards for this fleet in 2001 was a result of an inappropriate raising procedure, and data for this year are not presented. No discard data were available for 2002 as a consequence of a very limited number of sampling trips (n=1). This sampling level has increased in 2003, but is still low (n=6). A re-analysis of the Irish discard data raised to the number of trips, instead of landings, was performed based on methods described by Borges *et al.*, 2005 and provided to the WG in 2005.

B.2. Biological

Natural mortality was assumed to be constant (M=0.2, applied annually) for the whole range of ages and years, in the absence of a direct estimate of natural mortality of Irish Sea haddock.

A combined sex maturity is assumed, knife-edged at-age 2 for all years. Recent research on the changes in maturity of the Irish Sea haddock stock conducted by the UK (NI) demonstrated, using a GLM analysis on the effects of year, region, age, and length on the probability of being mature, that maturity is determined differently for male and female haddock. Maturity was found to be predominantly a function of length in male haddock, whereas age was the main factor in females. Interannual variation in the proportion mature was mostly confined to the age 2 group, whereas other age groups were either fully immature or fully mature. Over 99% of 3-year-olds were mature.

The proportion of F and M before spawning are set to zero to reflect a SSB calculation date of 1 January.

Working Groups prior to 2001 used constant weights-at-age over years based on analysis of some early survey data. However, evidence of a decline in mean length of adult haddock over time needed to be reflected in the stock weights-at-age. Since 2001 the WG calculated stock weights are calculated by fitting a von Bertalanffy growth curve to all available survey estimates of mean length-at-age in March, with an additional vector of parameters estimated to allow for year-class effects in asymptotic length. To increase the number of observations for older age classes, the mean lengths-at-age in UK (NI) first-quarter landings were included for age classes three and over. (Comparisons of survey and landings data demonstrated that values from landings were larger than from the survey at-ages 1 and 2 because of selectivity patterns in the fishery, but very similar for ages 3 and over.) Stock weights-at-age were calculated from the model-fitted mean lengths-at-age, using length–weight parameters calculated from all March survey samples (2001 WG) or annual length-weight parameters (since 2002 WG). The time-series of length weight parameters are listed below:

	Length–weight parameters		Expected weight-at-length	
Year	a	B	30 cm	40 cm
1993	0.01132	2.972	278	653
1994	0.00374	3.279	261	669
1995	0.00354	3.291	257	661
1996	0.00565	3.156	259	642
1997	0.00723	3.104	278	680
1998	0.00633	3.119	256	629
1999	0.00449	3.208	246	620
2000	0.00439	3.208	241	606
2001	0.00402	3.242	247	627
2002	0.00369	3.268	247	633
2003	0.00459	3.197	242	607
2004	0.00514	3.156	236	585
2005	0.00489	3.174	238	593
2006	0.00506	3.165	239	595
2007	0.00469	3.194	244	612
2008	0.00523	3.159	242	601

The following model was fitted to the length-at-age data:

$L_{t,yc} = LI_{yc} .(1\text{-}\exp(-K(t-t_0)))$

where LI_{yc} is the estimated asymptotic length for year-class yc. Parameters were estimated using Microsoft Solver in Excel by minimizing $\Sigma(\ln(\text{observed } L_t \text{ / expected. } L_t))^2$.

The year-class effects demonstrate a smooth decline from the mid-1990s coincident with the rapid growth of the stock, and may represent density-dependent growth effects. The year-class parameters effectively remove the temporal trend in residuals around a single von Bertalanffy model fit without year-class effects.

To estimate mean weight-at-age for year classes prior to 1990, represented as older fish in the early part of the time-series, the year-class effect for the 1990 year class and length–weight parameters for 1993 were assumed.

B.3. Surveys

Seven research vessel survey-series for haddock in VIIa were available to the Working Group in 2009. In all surveys listed the highest age represents a true age not a plus group.

- UK(NI) groundfish survey (NIGFS) in March (age classes 1 to 6, years 1992–2009)

The survey-series commenced in its present form in 1992. It comprises 45 3-mile tows at fixed station positions in the northern Irish Sea, with an additional 12 1-mile tows at fixed station positions in the St George's channel from October 2001 (the latter are not included in the tuning data). The surveys are carried out using a rock-hopper otter trawl deployed from the R.V. Lough Foyle (1992–2004) and the R.V. Corystes since 2005. The survey designs are stratified by depth and seabed type. The mean numbers-at-length per 3-mile tow are calculated separately by stratum, and weighted by surface area of the strata to give a weighted mean for the survey or group of strata. The survey design and time-series of results including distribution patterns of whiting are described in detail in Armstrong *et al.*, 2003.

- UK(NI) groundfish survey (NIGFS) in October (age classes 0 to 5; years 1991 to 2008)

Description as for UKNI-GFS-March above.

- UK(NI) Methot–Isaacs–Kidd (MIK) net survey in June (age 0; years 1994–2008)

The survey uses a Methot–Isaacs–Kidd frame trawl to target pelagic juvenile gadoids in the western Irish Sea at 40–45 stations. The survey is stratified and takes place end of May/early June during the period prior to settlement of gadoid juveniles. Indices are calculated as the arithmetic mean of the numbers-per-unit sea area.

- Republic of Ireland Irish Sea-Celtic Sea groundfish survey (IR-ISCSGFS) in November (ages 0 to 5; years 1997–2002)

This survey commenced in 1997 and is conducted in October–November on the R.V. *Celtic Voyager*. The α and β of the series are set to account for the variable timing of this survey within the fourth quarter. The survey uses a GOV otter trawl with standard groundgear and a 20 mm codend liner. The survey operates mainly in the western Irish Sea but has included some stations in the eastern Irish Sea. The survey design has evolved over time and has different spatial coverage in different years. Indices are calculated as arithmetic means of all stations, without stratification by area. The survey was terminated in 2002 as a consequence of a vessel change.

```
IRE OTB [Irish Otter trawl - Effort in hours numbers-at-age in 1000’s]
1995 2002
1 1 0 1
2 5
   80314   262     29      15    1
   64824  1257     33       1    1
   92178    96    191       7    1
   93533  1341     95     110    3
  110275    56    471       7    1
   82690   118     17      31    3
   77541   232    251      10    5
   77863    97    174      22    1
```

- Republic of Ireland groundfish survey (IR-GFS) in autumn (age classes 0 to 6, years 2003–2004)

This survey commenced in 2003 and is an IBTS-coordinated survey, conducted in October–November on the R.V. *Celtic Explorer*. The survey is an extension of a survey covering Divisions VI and VIIb–k. A GOV otter trawl with standard groundgear and a 20 mm codend liner is used. Indices are calculated as arithmetic means of all stations, without stratification by area. The survey operated for only two years within the Irish Sea.

```
IR-GFS Autumn [Irish groundfish survey in Autumn (Celtic Explorer)]
2003  2004
1 1 0.89 0.91
0 6
    1170   5520  1069   406     3   4   0   1
    1030   8132  2062   131    46   7   0   0
```

- UK(Scotland) groundfish survey (SCOGFS) in spring (age classes 1 to 6, years 1996–2006)

This survey represents an extension of the Scottish West Coast groundfish survey (Area VI), using the research vessel *Scotia*. The survey gear is a GOV trawl, and the design is two fixed-position stations per ICES rectangle from 1997 onwards (17 stations) and one station per rectangle in 1996 (9 stations). The survey extends from the Northern limit of the Irish Sea to around 53° 30′. The survey was terminated in 2006.

```
SGFS Spring [Scottish groundfish survey in Spring – Effort: numbers
caught/10 hr]
1997  2006
1 1 0.15 0.21
1 4
       1   6581    65   213     9   2   0
       1    564   472     4     9   0   0
       1    246    21   137     2   1   0
       1    819   338     8    15   0   0
       1     62   299    71     6   5   1
       1    944    72   111    16   0   0
       1    318  1420     7    16   3   0
       1   1591   242   355     0   3   0
       1    514   371    41    40   0   0
       1     97   252    91     0   3   0
```

- UK(Scotland) groundfish survey (SCOGFS) in autumn (age classes 0 to 6, years 1996–2004)

The survey covers a similar area to the ScoGFS in Spring, but has only 11–12 stations. The survey was terminated in 2005.

```
SGFS Autumn [Scottish groundfish survey in Autumn – Effort: numbers
caught/10 hr]
1997 2005
1 1 0.83  0.88
0 3
        1    104    437     4    27   1   0   0
        1    291     29    41     2   2   0   0
        1   4988    473     0    22   2   0   0
        1    790    332    38     2   4   0   0
        1   1647    389  1462    27  62  60   7
        1    178    189     2    13   2   0   0
        1    601     86   100     5   2   0   0
        1    394    416    39    18   2   0   0
        1   1399    526   171     9   3   0   0
```

To allow the inclusion of the NIGFS-March and ScoGFS-Spring surveys for the year after the last year with commercial catch data, the surveys may be treated as if they took place at the end of the previous year, and the age range and year range of the surveys are shifted back accordingly in the data files.

B.4. Commercial cpue

Only one historical cpue dataseries were provided to the WG for VIIa haddock.

```
IRE OTB [Irish Otter trawl - Effort in hours numbers-at-age in 1000’s]
1995 2002
1 1 0 1
2 5
   80314   262    29     15    1
   64824  1257    33      1    1
   92178    96   191      7    1
   93533  1341    95    110    3
  110275    56   471      7    1
   82690   118    17     31    3
   77541   232   251     10    5
   77863    97   174     22    1
```

B.5. Other relevant data

None.

C. Historical stock development

The 2004–2007 Working Group spent a considerable amount of time exploring the possibility of using TSA, ICA and B-Adapt (which allows for years with missing catch data). The results of these models were unsatisfactory. Because the assessment suffers from poor data quality with a relatively short time-series, from 2004 onwards the WG presented assessments of recent stock trends based on survey data only. The 2004 assessment focused on a Time-Series Analysis (TSA), which allows the 2003 commercial catch data to be treated as missing. Since 2005 a Survey Based Assessment (SURBA) was used; which is considered to give a reliable picture of the status of the stock at least for SSB and recruitment.

Model used: SURBA

Software used: SURBA version 3.0

Model Options chosen:

	WGNSDS 2005	WGNSDS 2006	WGNSDS 2007	WGNSDS 2008
Year range:	1992–2005	1992–2006	1992–2007	1992–2008
Age range:	1–4	1–5	0–5	1–5
Catchability:	1.0 at all ages	1.0 at all ages	1.0 at all ages	1.0 at all ages
Age weighting	1.0 at all ages	1.0 at all ages	1.0 at all ages	1.0 at all ages
Smoothing (Lambda):	1.0	1.0	1.0	1.0
Cohort weighting:	not applied	not applied	not applied	not applied
Reference age	2	2	1	2
Survey used	NIGFS-Mar	NIGFS-Mar	NIGFS-Mar, NIGFS-Oct	NIGFS-Mar

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 2	NIGFS-Mar	1992–(last data year)	1–5

The 2005 WG performed an extensive analysis of survey data for Irish Sea haddock. The effect of smoothing (lambda=1.0 and 0), fitting constant catchability (1.0 for all ages) or variable catchability-at-age and the choice of reference age were explored. The results indicated that the choice of catchability-at-age and using different values for the smoothing parameter had very little effect on the temporal trends in SSB or recruitment, and a lambda value of 1.0 reduces the noise in Z without over-smoothing the trends. Changing the reference age had very little effect on the results.

The VIIa haddock stock has been assessed prior to the 2004 WG using XSA with the following model setting and input data:

Model used: XSA

Software used: Lowestoft VPA suite

Model Options chosen:

Tapered time weighting not applied

Catchability independent of stock size for ages 1–3

Catchability independent of age for ages >= 3

Survivor estimates shrunk towards the mean F of the final 5 years or the oldest age

S.E. of the mean to which the estimate are shrunk = 0.500

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch-in-tonnes	1993 – last data year	0 – 5+	Yes
Canum	Catch-at-age in numbers	1993 – last data year	0 – 5+	Yes
Weca	Weight-at-age in the commercial catch	1993 – last data year	0 – 5+	Yes
West	Weight-at-age of the stock at spawning time.	1993 – last data year	0 – 5+	Yes: uses growth model from UK (NI) March GFS data
Mprop	Proportion of natural mortality before spawning	1993 – last data year	0 – 5+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1993 – last data year	0 – 5+	No – set to 0 for all ages in all years
Matprop	Proportion mature-at-age	1993 – last data year	0 – 5+	No – the same ogive for all years
Natmor	Natural mortality	1993 – last data year	0 – 5+	No – set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	NIGFS-Oct	1991–last data year	0–3
Tuning fleet 2	NIGFS-Mar (adjusted)	1991–(last data year-1)	0–3
Tuning fleet 3	ScoGFS-Spring (adjusted)	1996–(last data year-1)	0–3
Tuning fleet 4	MIK net May/June	1994–last data year	0

For details of procedures see WG reports from WGNSDS 1997–2007.

D. Short-term projection

No short-term forecast has been performed for this stock since 2003.

Short-term inputs prior to 2004 are give below:

Model used: Age structured

Software used: MFDP prediction with management option table and yield-per-recruit routines. MLA suite (WGFRANSW) used for sensitivity analysis and probability profiles.

Initial stock size. Taken from the XSA for age 1 and older. The recruitment-at-age 0 in the last data year is estimated as a short-term GM (1993 onwards).

Natural mortality: Set to 0.2 for all ages in all years

Maturity: The same ogive as in the assessment is used for all years

F and M before spawning: Set to 0 for all ages in all years

Weight-at-age in the stock: average stock weights for last three years.

Weight-at-age in the catch: Average weight of the three last years

Exploitation pattern: Average of the three last years. Landings F's are varied in the management option table.

Intermediate year assumptions: status quo F

Stock recruitment model used: None, the short-term geometric mean recruitment-at-age 0 is used

Procedures used for splitting projected catches: F vectors in each of the last three years of the assessment are multiplied by the proportion landed-at-age to give partial Fs for landings. The vectors of partial Fs are then averaged over the last three years to give the forecast values.

E. Medium-term projections

No medium-term projections are done for this stock as the short time-series of stock and recruitment estimates precluded any meaningful prediction of the medium-term dynamics of the stock.

F. Yield and biomass per recruit/long-term projections

Last calculations of yield-per-recruit reference points was by WGNSDS 2004 based on the exploitation patterns from XSA fitted to data out to a 5+ group.

Model used: yield and biomass per recruit over a range of F values that may reflect fixed or variable discard F's

Software used: MFYPR

Selectivity pattern: mean F array from last 3 years of assessment (to reflect recent selection patterns).

Stock and catch weights-at-age: long-term mean (1993 onwards).

Proportion discarded: partial F vectors are the recent average

Maturity: Fixed maturity ogive as used in assessment.

Procedures used for splitting projected catches: None required

G. Biological reference points

The ACFM view on this stock (ACFM, October 2002) is that there is currently no biological basis for defining appropriate reference points, in view of the rapid expansion of the stock size over a short period. ACFM proposes that F_{pa} be set at 0.5 by association with other haddock stocks. The absolute level of F in this stock at present is poorly known. The point estimate of F(2–4) for 2002 (0.89), however, is above F_{pa}.

H. Other issues

None.

I. References

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Borges, L., Zuur, A.F., Rogan, E. and Officer, R. 2005. Choosing the best sampling unit and auxiliary variable for discards estimations. Working Document No. 3 submitted to 2005 meeting of the ICES Working Group on Assessement of Northern Shelf Demersal Stocks. 25pp.

Annex 6.4: Quality Handbook: Irish Sea East *Nephrops* (FU14)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Irish Sea East *Nephrops* (FU14)
Working Group	Assessment of Northern Shelf Demersal Stocks
Date	May 2009

A. General

A.1. Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt and clay content of between 30–100% to excavate its burrows, and this means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small-scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. In the eastern Irish Sea the *Nephrops* stock inhabits an area of muddy sediment extending along the Cumbria coast and its fishery contributes to less than 10% of overall Irish Sea landings. There is little evidence of mixing between the east and west Irish Sea stocks because of the nature of water current movements in the Irish Sea. The two are treated as separate populations because they have differing population characteristics.

A.2. The fishery

Between 1999 and 2003 the number of vessels fishing for *Nephrops* in FU14 declined by 40% to a fleet of around 50 vessels. This was largely as a consequence of the reduction in the number of visiting UK vessels and the decommissioning of part of the Northern Irish and local English fleets. Since then the number of vessels fishing the area has returned to around 80 vessels mainly from Northern Ireland. Currently, around 30 of these vessels, between 6 and 23 m in length, have their 'home' ports in Whitehaven, Maryport and Fleetwood, England. The rest of the fleet is generally made up of larger vessels from Kilkeel or Portavogie, Northern Ireland.

Between 1987 and 2006, landings from FU14 appeared relatively stable, fluctuating around a long-term average of about 550 t. Landings in 2007, however bucked this trend, and are at their highest level since 1978 at 959 t, this is after landings dropped in 2003 to their lowest apparent level since 1974. The 2008 figure of 729 t is lower than 2007 but it still remains high, above any other figure recorded since 1990. The introduction of the buyers and sellers legislation in 2006 really precludes direct comparison with previous years as reporting levels are considered to have significantly improved since.

Over the last 10 years UK vessels have landed, on average, 89% of the reported annual international landings. ROI vessels increased their share of the landings to 35% in 2002 but it has since declined to 4% in 2008 (Table 14.5). In 2008, most of the landings were made into England with a large proportion of these landings (67% of the directed landings and 62% of the total landings) being made by visiting Northern Irish vessels. UK *Nephrops* directed effort has fluctuated around a downward trend since 1993 but has remained relatively stable since 2003 fluctuating around a mean of 13 800 hrs.

The changes to the structure and landing practices of the Northern Irish fleet (see above) will have had some impact on this dataseries. From 2002–2004, fewer of the

Northern Irish fleet were landing in England. The differences between lpue figures for individual vessels suggest that earlier years may have included less truly directed effort. Reductions in quota between 2002 and 2006 for VIIa cod and plaice may have restricted total effort in FU14 thereby reducing the more casual effort on *Nephrops*. Further research is needed to better define the directed fishery. From 2003 the main fleets targeting *Nephrops* include *Nephrops* directed single-rig and twin-rig otter trawlers operating out of ports in UK (NI), UK (E&W) and Ireland.

Regulations

Regulations introduced as part of a revised package of EC Fisheries Technical Conservation measures in 2000 remain in place. This legislation incorporates a system of 'mesh size ranges' for each of which has been identified a list of target species. In effect, nets in the 70–79 mm mesh size range must have at least 35% of the list of target species (which includes *Nephrops*) and the 80–99 mm mesh size range requires at least 30% of the list of target species. A square mesh panel (SMP) of 80 mm is required for 70–79 mm nets in the Irish Sea. Vessels using twin-rig gear in the Irish Sea must comply with a minimum mesh size of 80 mm (no SMP is required for nets with 80 mm meshes and above).

Other regulations restricting trawling in other fisheries within the Irish Sea will affect effort on these and other stocks. This could either attract local effort or even relocate effort to fisheries in other areas. Although unrestrictive the result of better catch information through the buyers and sellers legislation introduced to the UK from 2006 will have the same effect as quota uptake of stocks which used to be misreported will be quicker.

As well as an area VII TAC other *Nephrops* conservation measures in the Irish Sea are a minimum landing size of 20 mm CL length (equivalent to 37 mm tail length or 70 mm total length).

In addition to *Nephrops* measures the cod spawning areas of the Irish Sea are closed to whitefish directed vessels between 14th February to 30th April part of the Irish Sea cod recovery plan. There is derogation for *Nephrops* vessels during this closure.

A.3. Ecosystem aspects

The Working Group has collated no information on the ecosystem aspects of this stock.

B. Data

B.1. Commercial catch

Length and sex compositions of *Nephrops* landed from the Irish Sea East are estimated from port sampling by England and Wales. Length data from this sampling are applied to catch samples collected at sea and raised to total international landings. Catch length samples are collected independently of landings length samples but both are considered representative. The independent raising process means that the final annual catch length frequency distribution still requires scaling to the reported landings. Using a discard ogive derived from samples collected in the early 1990s an initial estimate of discards is taken from the catch distribution. These are then added to the landings distribution to create a dummy catch distribution. The difference between the numbers-at-length for both the raised sampled and dummy catch distribution was then used to tune a raising factor by minimizing the sums of squares. Once the raising factor is derived, the final discard length distribution is the difference between the raised catch distribution and the landings distribution, and a final catch distribution is a sum of the landings and discard distributions. In 2008 a new discard ogive was calculated from the discard samples collected from 2003 until March 2008 and applied to the 2003 to date. The lack of discard and catch data between 1995 and 1999 is likely to adversely affect the quality of any analytical assessments. Apparent differences between catch LFDs and discard practices in 1992 to 1994 and 1999 to 2000 are discussed in the Section 5.12 of the 2001 WGNEPH report (ICES, 2001a). 2001 and 2002 catch and landings sampling provided catch compositions to help estimate the LFDs for the missing years. Quarterly discard distributions for the years 1995 to 1999 were estimated by using the discard LFDs for the two preceding and the two following years.

Trial XSAs using these data were attempted at the 2003 WGNEPH. In the absence of routine methods of direct age determination in *Nephrops*, age compositions of removals were inferred from length compositions by means of 'slicing'. This procedure, introduced at the 1991 WG, uses von Bertalanffy growth parameters to determine length boundaries between age classes. All animals in length classes between boundaries are assigned deterministically to the same age class. The method is implemented in the L2AGE programme which automatically generates the VPA input files. The programme was modified in 1992 to accommodate the two-stage growth pattern of female *Nephrops* (ICES, 1992) and again in 2001 to separate 'true' as opposed to 'nominal' age classes (ICES, 2001a). The age classes are 'true' to the extent that the first slicing boundary, i.e. lower length boundary for 'age' 0, is the length-at-age zero rather than the lowest length in the data. This was to ensure comparability of 'age' classes across stocks.

B.2. Biological

Mean weights-at-age for this stock are estimated from studies by Bailey and Chapman, 1983.

A natural mortality rate of 0.3 was assumed for all age classes and years for males and immature females, with a value of 0.2 for mature females. The lower value for mature females reflects the reduced burrow emergence while ovigerous and hence an assumed reduction in predation.

The time-invariant values used for proportion mature-at-age are: males age 1+: 100%; females age 1: 0%; age 2+: 100%. The source of these values is not known.

Proportion of F and M prior to spawning was specified as zero to give estimates of spawning-stock biomass at January 1. In the absence of independent estimates, the mean weights-at-age in the total catch were assumed to represent the mean weights in the stock.

B.3. Surveys

ACFM recommended that UWTV surveys could provide useful fishery-independent data on the status of *Nephrops* stocks. The UWTV surveys conducted in August 2007 and 2008 are presented here as a preliminary to future assessments. Two previous UWTV surveys were conducted for this fishery in 1997 and 1998 with limited success, because of weather. These surveys and their design were documented at WKNEPHTV (ICES, 2007). The surveys in 2007 and 2008 are consistent but follow a different design to the earlier surveys. For ease of comparison, and consistency, the survey has been based on the current ROI and NI survey in the Western Irish Sea. A randomized fixed grid (3.4 x 3.4 nm) of 34 stations plus a transect of 3 stations in Wigtown bay were sampled. Figure B.3.1 shows the distribution of stations in the TV surveys with the size of the symbol reflecting the *Nephrops* burrow density.

The survey protocols used were the same, and followed the standards set by WKNEPHTV (ICES, 2007). In 2007 poor visibility hampered the survey and despite repeated attempts at over 15 stations, turbidity scores precluded the use of some of the counts. On first analysis only 20 were considered usable. The 2008 survey was far more successful, sea conditions were far better and the quality of the video data collected was much improved. All 37 stations were considered useable. Table B.3.1 provides the estimates for the burrow density and abundance. Figure B.3.1 shows the range of densities experienced across the ground with the higher densities occurring in the centre of the survey area and diminishing towards the perimeter. Figure B.3.2 shows the frequency and range of different densities occurring over the ground on each survey and compares the overall estimate with those from other survey areas. The mean burrow density falls within the range of densities seen on the other grounds assessed at this working group.

These are the first two of a planned series of surveys. The limited number of stations available on the first survey; uncertainties about the limits of the stock and characteristics of this fishery and in light of SGSURV and WKNEPH 2009 the data will require further analysis and a further survey to qualify the precision of these estimates. These results therefore are only presented as provisional.

Table B.3.1. Irish Sea East (FU14): Results from NI UWTV survey of *Nephrops* ground.

Year	Area	No. stations	Non Zero stations	Mean burrow density	Abundance
	km²			no./m²	millions
2007*	1043	20	18	0.38	393
2008*	1043	35	31	0.36	334

*** provisional**

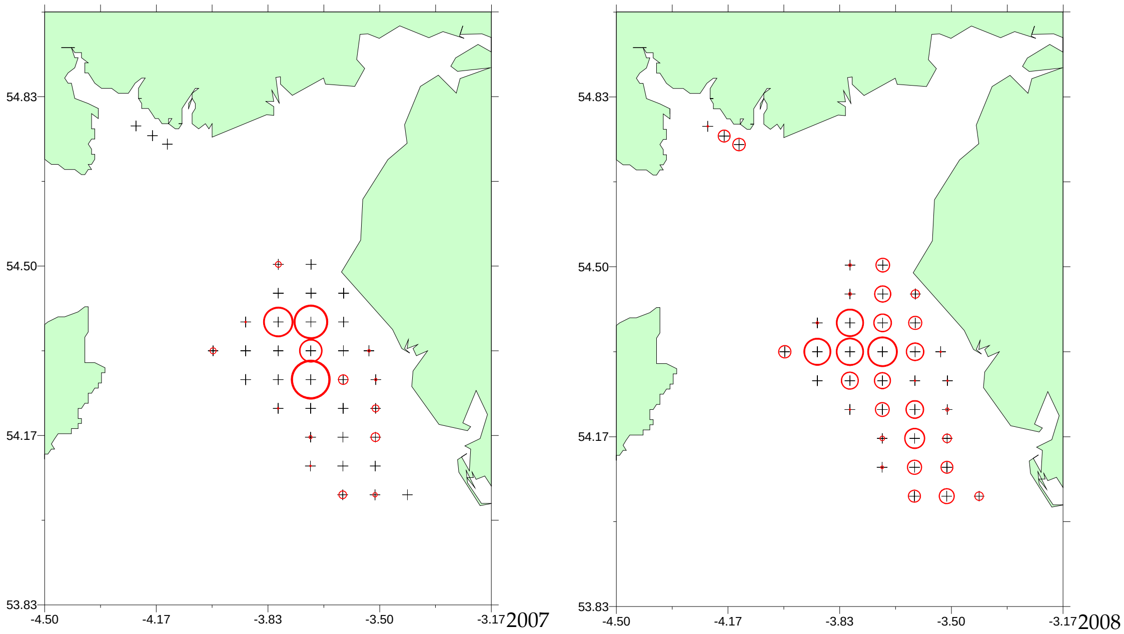
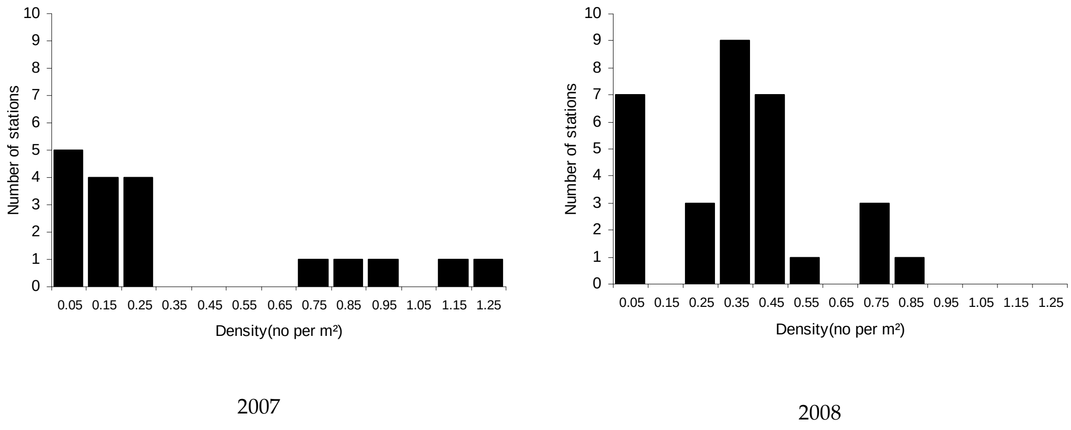
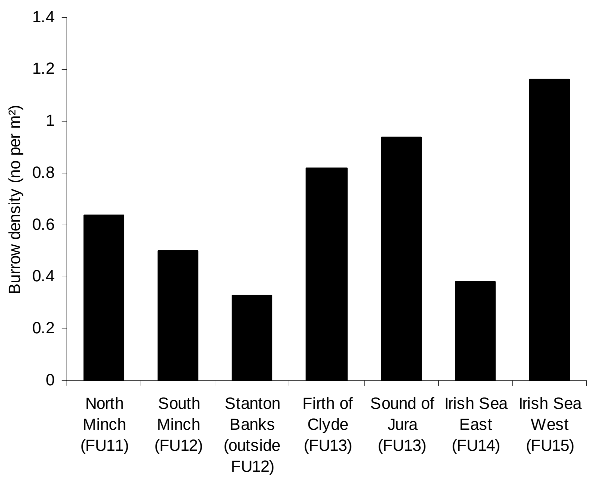


Figure B.3.1. Irish Sea East (FU14): UWTV survey station distribution and relative density.

a)





b)

Figure B.3.2. Irish Sea East (FU14): (a) Frequency distribution of densities on UWTV survey. (b) Estimated burrow density compared with most recent density estimates from surveys carried out on other *Nephrops* populations.

B.5. Other relevant data

When carrying out the XSA in 2003 the landings-per-unit-effort time-series for the following fleet was used:

England and Wales *Nephrops* trawl gears. Landings-at-age and effort data from this fishery are used to generate a cpue index. There is also a cpue series from 1995 for Republic of Ireland vessels. Catch-at-age are estimated by raising length sampling of discards and landings to officially recorded landings and slicing into ages (knife edge slicing using growth parameters). Cpue is estimated using officially recorded effort (hours fished) although the recording of effort is not mandatory. Combined effort for *Nephrops* trawlers is raised to landings. Discard sampling commenced in 1992 for this fishery, though some years have been missed as discussed above. There is no account taken of any technological creep in the fleet.

C. Historical stock development

D. Short-term Projection

E. Medium-term projections

F. Yield and biomass per recruit/long-term projections

G. Biological reference points

H. Other issues

I. References

Biological Input Parameters

Parameter	Value	Source
Discard Survival	0.00	
MALES		
Growth - K	0.160	Irish Sea West data ; Bailey and Chapman (1983)
Growth - L(inf)	60	"
Natural mortality - M	0.3	Brander and Bennett (1986, 1989)
Length/weight - a	0.00022	Hossein *et al*. (1987)
Length/weight - b	3.348	"
FEMALES		
Immature Growth		
Growth - K	0.160	Irish Sea West data ; Bailey and Chapman (1983)
Growth - L(inf)	60	"
Natural mortality - M	0.3	Brander and Bennett (1986, 1989)
Size-at-maturity	24	Briggs (1988)
Mature Growth		
Growth - K	0.100	Irish Sea West data ; Bailey and Chapman (1983)
Growth - L(inf)	56	"
Natural mortality - M	0.2	Brander and Bennett (1986, 1989)
Length/weight - a	0.00114	Hossein *et al.* (1987)
Length/weight - b	2.820	"

Annex 6.5: Stock Annex: Irish Sea West *Nephrops* (FU15)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Irish Sea West *Nephrops* (FU15)
Working Group	WKNEPH 2009
Date	6 March 2009

A. General

A.1. Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt and clay content of between 10–100% to excavate its burrows, and this means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small-scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. In the western Irish Sea the *Nephrops* stock inhabits an extensive area of muddy sediment between the Isle of Man and Northern Ireland and its fishery contributes to more than 90% of overall Irish Sea landings. There is little evidence of mixing between the east and west Irish Sea stocks because of the nature of water current movements, which is characterized in the west by a gyre, which has retention affect on both sediment and larvae. The eastern and western *Nephrops* stocks are treated as separate populations as they have different population characteristics.

A.3. Ecosystem aspects

A number of studies have examined *Nephrops* larvae distribution in order to examine how recruitment may impinge upon the distribution of a "catchable" (adult) *Nephrops* population and the maintenance of the population. Hillis, 1968 found that although generally the larvae occupied the same areas as the adults, there was some evidence of advective losses to the southeastern part of their range, most probably because of tidal currents (White *et al.*, 1988). More recent studies in the western Irish Sea have uncovered the existence of a seasonal cyclonic gyre which appears to facilitate retention of larvae over the mud patch (Dickey-Collas *et al.*, 1996; Hill *et al.*, 1996; Horsburgh *et al.*, 2000).

B. Data

B.1. Commercial catch

Length and sex compositions of *Nephrops* landed from the Irish Sea West are estimated from port sampling by Ireland and Northern Ireland and Ireland. A lack of cooperation by the Northern Ireland industry prevented sampling commercial catches over the period 2003–2007. The Irish LFDs are therefore raised to the international catch for these years. Northern Ireland sampling resumed in 2008 and these data are combined with those from Ireland for that year. Sample data are used to compute international removals (Landings + dead discards).

Landings-per-unit-effort time-series are available from the following fleets:

Northern Ireland *Nephrops* trawl gears. Landings-at-age and effort data from this fishery since 1986 are used to generate a cpue index. There is also a cpue series since 1995 for a subset of Republic of Ireland *Nephrops* vessels. Catch-at-age are estimated by raising length sampling of discards and landings to officially recorded landings and slicing into ages (knife edge slicing using growth parameters). Cpue is estimated using officially recorded effort (hours fished). Discard sampling commenced in the mid 1980s by Northern Ireland and the Republic of Ireland. There is no account taken of any technological creep in the fleet.

B.2. Biological

Mean weights-at-length for this stock are estimated from studies by Pope and Thomas, 1955.

A natural mortality rate of 0.3 was assumed for males and immature females, with a value of 0.2 for mature females. The lower value for mature females reflects the reduced burrow emergence while ovigerous and hence an assumed reduction in predation.

Maturity for females is taken as 22.1 mm carapace length (McQuaid *et al*., 2006).

Proportion of F and M prior to spawning was specified as zero to give estimates of spawning-stock biomass at January 1. In the absence of independent estimates, the mean weights-at-age in the total catch were assumed to represent the mean weights in the stock.

B.3. Surveys

Ireland and Northern Ireland jointly carry out underwater television (UWTV) surveys on the main *Nephrops* grounds in the western Irish Sea (Figure 1) since 2003. These surveys are based on a randomized fixed grid design. The methods used during the survey are similar to those employed for UWTV surveys of *Nephrops* stocks elsewhere and are detailed in WKNEPHTV, 2007 and WKNEPHBID, 2008.

Northern Ireland have carried out a spring (April) and summer (August) *Nephrops* trawl surveys since 1994. These surveys provide data on catch rates and length frequency distributions from of stations throughout in the western Irish Sea. These surveys generate data on *Nephrops* size composition, mean size, maturity and sex ratio.

A number of factors are suspected to contribute bias to the UWTV surveys. In order to use the survey abundance estimate as an absolute it is necessary to correct for these potential biases. The history of bias estimates are given in the following table and are based on simulation models, preliminary experimentation and expert opinion, the biases associated with the estimates of *Nephrops* abundance in the Irish Sea West are:

	Time period	Edge effect	Detection rate	Species identification	Occupancy	Cumulative bias
FU15: Irish Sea West	<=2009	1.24	0.75	1.15	1	1.14

B.4. Commercial cpue

B.5. Other relevant data

Table 1 is a summary of available data along with an assessment of its reliability.

Table 2 is a summary of assessment parameters.

C. Historical stock development

1) Survey indices are worked up annually resulting in the TV index.
2) Adjust index for bias (see Section B3). The combined effect of these biases is to be applied to the new survey index.

3) Generate mean weight-in-landings. Check the time-series of mean landing weights for evidence of a trend in the most recent period. If there is no firm evidence of a recent trend in mean weight use the average of the three most recent years. If, however, there is strong evidence of a recent trend then apply most recent value (don't attempt to extrapolate the trend further in future).

D. Short-term projection

4) The catch option table will include the harvest ratios associated with fishing at $F_{0.1}$ and F_{max}. These values have been estimated by the Benchmark Workshop (see Section 9.2) and are to be revisited by subsequent benchmark groups. The values are FU specific and have been put in the Stock Annexes.

5) Create catch option table on the basis of a range of harvest ratios ranging from 0 to the maximum observed ratio or the ratio equating to F_{max}, whichever is the larger. Insert the harvest ratios from step 4 and also the current harvest ratio.

6) Multiply the survey index by the harvest ratios to give the number of total removals.

7) Create a landings number by applying a discard factor. This conversion factor has been estimated by the Benchmark Workshop and is to be revisited at subsequent benchmark groups. The value is FU specific and has been put in the Stock Annex.

8) Produce landings biomass by applying mean weight.

The suggested catch option table format is as follows.

	Implied fishery			
	Harvest rate	Survey Index	Retained number	Landings (tonnes)
	0%	12345	0	0.00
	2%	"	247	123.45
	4%	"	494	246.90
	6%	"	741	370.35
	8%	"	988	493.80
$F_{0.1}$	8.60%	"	1062	530.84
	10%	"	1235	617.25
	12%	"	1481	740.70
F_{max}	13.50%	"	1667	833.29
	14%	"	1728	864.15
	16%	"	1975	987.60
	18%	"	2222	1111.05
	20%	"	2469	1234.50
	22%	"	2716	1357.95
$F_{current}$	21.5%	"	2654	1327.09

E. Medium-term projections

None presented.

F. Long-term projections

None presented.

G. Biological reference points

Harvest ratios equating to fishing at $F_{0.1}$ and F_{max} were calculated in WK*Neph* 2009. These calculations assume that the TV survey has a knife-edge selectivity at 17 mm and that the supplied length frequencies represented the population in equilibrium.

$F_{0.1}$ = 10.9%

F_{max}= 20.2%

I. References

Dickey-Collas, M., Gowen, R.J. and Fox, C.J. 1996. Distribution of larval and juvenile fish in the western Irish Sea: Relationship to phytoplankton, zooplankton biomass and recurrent physical features. *Marine and Freshwater Research* 47: 169–181.

Horsburgh, K.J., Hill, A.E., Brown, J., Fernand, L., Garvine, R.W., Angelico, M.M.P. 2000. Seasonal evolution of the cold pool gyre in the western Irish Sea. *Progress in Oceanography* 46: 1–58.

Hill, A.E., Brown, J. and Fernand, L. 1996. The western Irish Sea gyre: a retention mechanism for the Norway Lobster (*Nephrops norvegicus) Oceanologica Acta* 19: 357–369.

Hillis, J.P. 1968. Larval distribution of *Nephrops norvegicus* (L.) in the Irish Sea and North Channel. *ICRES C.M*. 1968. Doc. No. K6. (Mimeo).

McQuaid, N., Briggs, R.P. and Roberts, D. 2006. Estimation of the size of onset of sexual maturity in *Nephrops norvegicus* (L.). *Fisheries Research.*

White, R.G., Hill, A.E. and Jones, D.A. 1988. Distribution of *Nephrops norvegicus* (L.) larvae in the western Irish Sea: an example of advective control on recruitment. *Journal of Plankton Research* 10(4): 735–747.

Table 1. Summary table of Available data.

FU15 Irish Sea West: Data Available															
Data															
Commercial Data	pre-1995	1994	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Landings															
Effort															
cpue/lpue															
Mean size															
Sex ratio															
LFDs															
catch															
landings															
discards															
Survey Data															
Trawl surveys															
Catch rate															
mean size															
LFDs															
Sex ratio															
Camera Surveys															
Density estimate															
Data Quality															
Poor															
Acceptable															
Reliable															

Table 2: Biological Input Parameters.

PARAMETER	VALUE	SOURCE
Discard Survival	0.10	ICES (1991a)
Discard rate	40.2%	2007 discard sampling.
MALES		
Growth - K	0.160	Hillis (1979) ; ICES (1991a)
Growth - L(inf)	60	"
Natural mortality - M	0.3	Brander and Bennett (1986, 1989)
Length/weight - a	0.00032	After Pope and Thomas (1955) (data for Scottish stocks)
Length/weight - b	3.210	"
FEMALES		
Immature Growth		
Growth - K	0.160	Hillis (1979) ; ICES (1991a)
Growth - L(inf)	60	"
Natural mortality - M	0.3	Brander and Bennett (1986, 1989)
Size-at-maturity	22.1	McQuaid *et al.*, 2006
Mature Growth		
Growth - K	0.100	Hillis (1979) ; ICES (1991a)
Growth - L(inf)	56	"
Natural mortality - M	0.2	Brander and Bennett (1986, 1989)
Length/weight - a	0.00068	After Pope and Thomas (1955) (data for Scottish stocks)
Length/weight - b	2.960	"

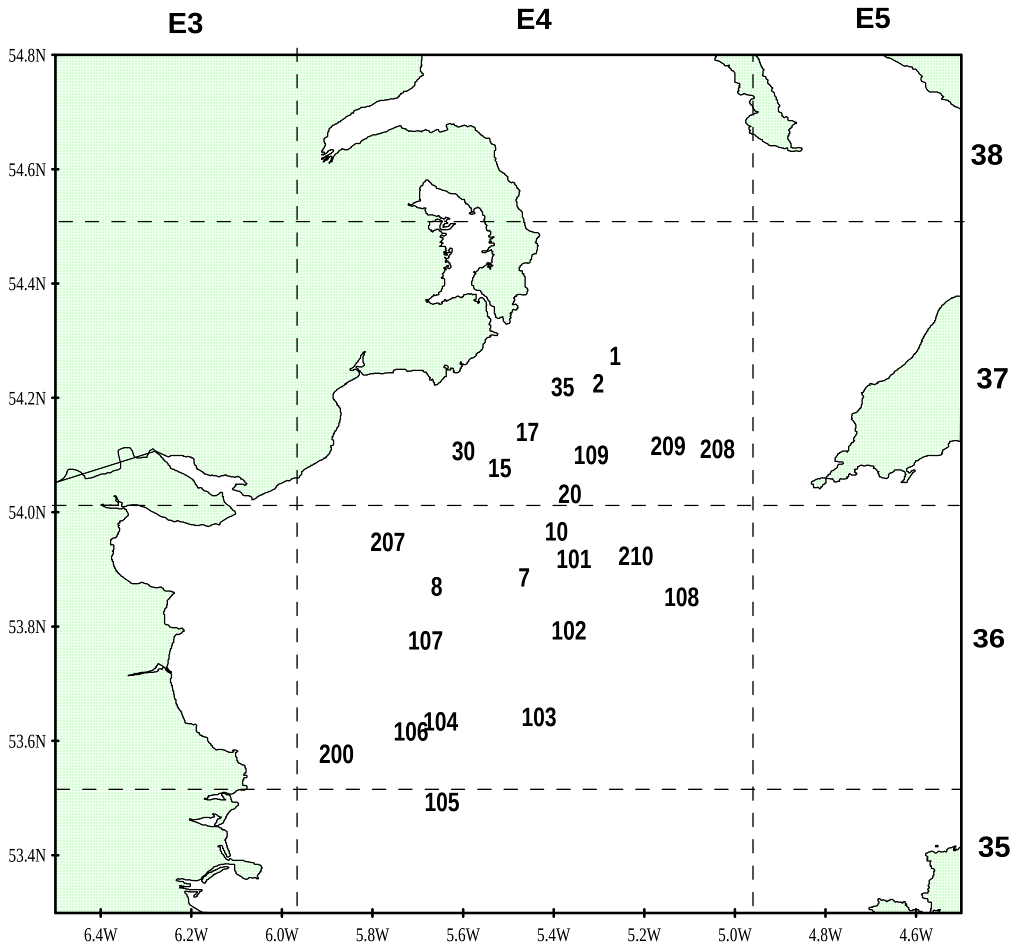


Figure 1: Western Irish Sea Nephrops stations

Annex 6.6: Quality Handbook: WhitingVIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Irish Sea Whiting (Division VIIa)
Working Group:	Assessment of Northern Shelf Demersal Stocks
Last updated:	WGNSDS 2008
Updates:	Inclusion of Fishery Data from Ireland

A. General

A.1. Stock definition

Whiting in Division VIIa are considered a single-stock for management purposes. In 2004 an informal meeting was established to review current knowledge of the distribution, movements and stock structure of whiting in the Irish Sea, and linkages between whiting in the Irish Sea and surrounding management areas. Information on egg and larval, tagging, survey studies was presented as a working document (WD10) in WGNSDS, 2005. The results of this are synopsized below:

UK egg and larva surveys have demonstrated that whiting spawn in spring throughout the eastern Irish Sea and in the coastal waters of the western Irish Sea. This is supported by the distribution of actively spawning fish caught during trawl surveys in March.

Transport of whiting eggs, larvae or pelagic prerecruits from Celtic Sea spawning grounds into the Irish Sea is likely to be impeded by the Celtic Sea thermal front that becomes increasingly established from spring onwards.

Whiting recruitment grounds are in the same general area as the spawning grounds, and young whiting are widespread in the coastal bights of the Irish Sea. The gyre system that becomes established from late spring onwards in the western Irish Sea appears important in retaining larvae and pelagic prerecruits of whiting, as demonstrated by the results of frame-trawl surveys of pelagic prerecruits in the western Irish Sea.

As the whiting become demersal from late summer onwards, they are found throughout the western Irish Sea although densities appear highest around the periphery of the mud patch in coastal waters and along the southern boundary between Ireland and the Isle of Man. This pattern is also noted by fishers operating in this area. Densities of young whiting in the eastern Irish Sea appear highest off Cumbria and the Solway Firth in autumn, but are more widespread in spring.

Tagging studies in the late 1950s reveal some seasonal dispersal of whiting from the Irish Coast to as far as the Clyde, Liverpool Bay and the Celtic Sea, with evidence of return migrations. Whiting tagged in these studies ranged from about 20–40 cm, averaging around 30 cm. Whiting recaptured well away from the tagging sites off County Down in the western Irish Sea tended to be several cm larger, on average, than the tagged whiting.

Both the western Irish Sea and the Clyde have historically been characterized by catches of immature and first-maturing whiting, although the eastern Irish Sea has a broader age-range of whiting. This pattern persists to the present day.

The evidence of interchange of whiting between the western Irish Sea and other areas within the Irish Sea precludes treating different areas within the Irish Sea as containing functionally separate stocks. Spatial modelling of the populations would require information on rates of dispersal between areas.

Trawl surveys continue to show that juvenile whiting are very abundant in the coastal waters of the Irish Sea, and that whiting are one of the most abundant fish species taken in the surveys. Hence, there have been no indications of depressed recruitment associated with the apparent steep decline in abundance of large whiting. Length at 50% maturity in female whiting is only 20–21 cm in the Irish Sea and neighbouring management areas, and spawning appears predominantly by young whiting of 1–3 years old.

A.2. The fishery

Most landings by the Irish and UK (NI) fleet, which take the bulk of the Division VIIa whiting catch, are from the western Irish Sea (ICES CM 2003/ACFM:04) and are made predominately by single- and twin-rig trawlers. A small number of UK pairtrawlers also fish for whiting. The UK (E&W) fleet has declined substantially over time, and the bulk of its landings are from inshore otter trawlers targeting mixed flatfish and roundfish in the eastern Irish Sea. Discarding in this stock is thought to be high in all fleets, particularly in the *Nephrops* fishery. The *Nephrops* directed fishery operates on the main whiting nursery areas in the western Irish Sea, and is particularly intensive in summer. The mesh size mainly in use in the fishery is 70 mm in single trawls and 80 mm in twin trawls targeting *Nephrops*. The western Irish Sea fishery for whiting has declined substantially in recent years, and the increase in abundance of haddock has resulted in few vessels targeting whiting.

Vessels operating with 70 mm and 80 mm mesh are required to use square mesh panels. Square mesh panels were introduced as a technical measure to reduce fishing mortality on whiting. Square mesh panels have been mandatory for all UK trawlers (excluding beam trawlers) in the Irish Sea since 1993 and for Irish trawlers since 1994. Although the effects of this technical measure have not been formally evaluated, the *Nephrops* fishery still generates substantial quantities of whiting discards. Effort by Irish *Nephrops* trawlers in the main areas of whiting bycatch has demonstrated some reduction during the period of the Irish Sea cod recovery plan closures. However, the summer peak in activity of the *Nephrops* fishery was not affected by the recovery plans. As the activities of the *Nephrops* fleet were not restricted by the cod recovery plan, it is unlikely that the recovery plan was effective in reducing levels of discarding in this stock.

There has been some recent decommissioning of vessels in the Irish Sea. Most recently, Ireland introduced a further decommissioning scheme in 2008, which aims to remove 11 140 GT from the fleet register. This is targeted at vessels over 10 years of age and >18 m in length. To date the majority of applications emanate from east and west coast ports from vessels, which traditionally target *Nephrops* with uptake from the South East also. It is expected that much of the actual effort removed from the decommissioning scheme may be partially negated through the introduction of ~21 modern second hand vessels (mostly ex-French) into the fleet over the last few years.

The reported landings of whiting in 1999–2001 by UK vessels decommissioned in 2002 amounted to about 7% of the total international landings of whiting in those years. While few new Irish vessels have joined the fishery, some vessels from County Donegal have reported catches of whiting in VIIa. These vessels have been attracted into the Celtic Sea fishery in recent years in response to poor catches in other areas. Irish landings of whiting in the southwestern part of VIIa now contribute the bulk of the total Irish landings in the Division (ICES CM 2003/ACFM:04). The difference in grounds in the southern part of VIIa means that whiting in the area are more likely to function as part of the Celtic Sea stock rather than the Irish Sea stock.

Irish otter board trawlers fishing ICES area VIIa generally use twin-rig gear to fish for *Nephrops*. However there are also localized mixed fisheries both in the north and south ends of VIIa. The Irish Sea *Nephrops* fleet is highly opportunistic and of this fleet, there are only a handful of boats that fish the Irish Sea Prawn Grounds 100% of the time. The rest of the fleet divides its time between the Irish Sea, Smalls, Aran and Porcupine Grounds dependant on tides, weather and market forces. Because of the need to fish further away from their home port and in rougher sea conditions, many of the older and smaller wooden vessels are being replaced with new and second hand steel vessels. Most of these newer vessels are French-style twin-riggers. To maximize the return on their investment, many of the owners of newer vessels are opting for relief skippers and crews so that the vessels are fishing as much as possible.

In 2006, for the Irish fleet for the first time, *Nephrops* landings from the Smalls grounds (VIIg) have surpassed those from the Irish Sea grounds. This reflects the increasing amount of effort by East Coast vessels in 7g where in general, better prices are obtained for their catch. Two significant fleet movements occurred in 2006 for the Irish fleets. First, there was a brief shift in effort by the *Nephrops* fleet towards the Aran Grounds around October as a consequence of reports of good fishing in the area. Also, some of the larger twin-riggers in the fleet switched to tuna fishing in the Bay of Biscay during summer.

The main species targeted by the otter trawl fleet are *Nephrops*, cod, ray, haddock, anglerfish and whiting. The Irish beam trawl fleet predominantly targets black sole and other high-quality flatfish and divides its effort between VIIa and VIIg depending on weather, tides and market forces.

For the UK NI fleet decommissioning at the end of 2003 removed 19 out of 237 UK vessels that operated in the Irish Sea, representing a loss of 8% of the fleet by number and 9.3% by tonnage. Of these vessels, 13 were vessels that used demersal trawls with mesh size >=100 mm. The previous round of decommissioning in 2001 removed 29 UK (NI) *Nephrops* and whitefish vessels and 4 UK (E&W) vessels registered in Irish Sea ports at the end of 2001. Of these, 13 were vessels that used demersal trawls with mesh size >=100 mm.

A.3. Ecosystem aspects

Recruitment in Irish Sea whiting appears less variable than in cod and haddock, although there is some similarity in the timing of strong and weak year classes that may indicate a similar response to changes in environmental conditions affecting spawning or early stage survival. The diet of Irish Sea whiting has been examined in some detail since the 1970s using samples collected from research vessels. Cannibalism occurs in adult whiting; however the effect of this on the assessment of the stock has not yet been investigated. Young whiting are common in the diets of larger predators such as cod and anglerfish.

B. Data

B.1. Commercial catch

B1.1. Landings

The following table gives the source of landings data for Irish Sea whiting:

	Kind of data				
Country	Caton (catch-in-weight)	Canum (catch-at-age in numbers)	Weca (weight-at-age in the catch)	Matprop (proportion mature-by-age)	Length composition-in-catch
UK(NI)	X	X	X	X	X
UK(E&W)	X	X	X		X
UK(Scotland)	X		X		
UK (IOM)	X				
Ireland	X	X	X		X
France	X				
Belgium	X				
Netherlands	X				

Quarterly landings and length/age composition data are supplied from databases maintained by national Government Departments and research agencies. These figures may be adjusted by national scientists to correct for known or estimated misreporting by area or species. Data are supplied on paper or Excel files to a stock coordinator nominated by the ICES Northern Shelf Demersal Working Group, who compiles the international landings and catch-at-age data, and maintains a time-series of such data with any amendments. To avoid double counting of landings data, each UK region supplies data for UK landings into its regional ports, and landings by its fleet into non-UK ports.

The UK (E&W) currently supplies raised quarterly length frequencies of landings but only sporadic age data. The catch and mean weight-at-age are estimated using combined UK (NI) and Irish quarterly length-weight relationships and age–length keys. Quarterly landings are provided by the UK (Scotland), Belgium and France and annual landings are provided by UK (IOM). The quarterly estimates of landings-at-age into UK (E&W), UK (NI) and Ireland are raised to include landings by France, Belgium, UK (Scotland), UK (IOM) (distributed proportionately over quarters), then summed over quarters to produce the annual landings-at-age.

The Excel spreadsheet files used for age distribution, adjustments and aggregations can be found with the stock co-ordinator and for the current and previous year in the ICES computer system under **w:\acfm\wgnsds\year\personal\name** (of stock co-ordinator).

The result files (FAD data) can be found at ICES and with the stock co-ordinator, as ASCII files on the Lowestoft format, under **w:\acfm\wgnsds\year\data\whg_7a**.

B1.2. Discards

The Irish Sea *Nephrops* fishery takes place on the whiting nursery grounds of the north-western Irish Sea and has traditionally produced high whiting discarding. The quantity of whiting discarded from the UK (NI) *Nephrops* fishery in 2002 was estimated on a quarterly basis from samples of discards and total catch provided by skippers. The discards samples contain the heads of *Nephrops* tailed at sea. Using a length–weight relationship, the live weight of *Nephrops* that would have been landed as tails only is calculated from the carapace lengths of the discarded heads. The number of whiting in the discard samples is summed over all samples in a quarter and expressed as a ratio of the summed live weight of *Nephrops* in the discard samples (i.e. those represented as heads only in the samples). The reported live weight of *Nephrops* landed as tails only is then used to estimate the quantity of whiting discarded using the whiting:*Nephrops* ratio in the discard samples. The length frequency of whiting in the discard samples is then raised to the fleet estimate, and numbers and mean weight-at-age of discarded whiting is computed from the age length key and length–weight parameters for whiting. The UK (NI) estimates are available since 1980 but the reliability of these estimates has not been determined. Roughly 40 discard samples are collected annually.

There are several limitations to these data: only a small subset of single-rig trawlers is sampled; the method of raising to the fleet discards will be affected by any inaccuracies in the reported landings of *Nephrops*; and there are no estimates of landings of whiting from these vessels with which to calculate proportions discarded-at-age. However, the WG has used these data in past assessments because removal of discards data would remove a large fraction of catch from the assessment.

A re-analysis of the Irish discard data raised to the *Nephrops* landings produced estimates of discards from the Irish *Nephrops* fleet that were more consistent with those of the UK (NI) *Nephrops* fleet. However, this method of raising could not be used to recalculate an entire time-series of discard estimates from the Irish *Nephrops* fleet. The quarterly UK (NI) discard ratios were therefore used by the Working Group to estimate the tonnage discarded from the Irish *Nephrops* fishery. Length frequencies and age–length keys from the whiting discarded by the Irish *Nephrops* fleet are used to estimate the numbers discarded-at-age from the Irish *Nephrops* fleet.

At the WGNSDS 2006 revised Irish discard estimates (1996–2005) raised according to the methods described in Borges *et al.*, 2005 were available to the Working Group See Table 1.0. These are available in the ICES files. Discard rates in this series were variable compared with previous estimates based on the UK NI self sampling scheme. Given the differences in raising procedure applied to the NI Discard estimates and the Irish discard estimates further examination of the discard data is needed before international estimates of discard numbers-at-age can be made. The Working Group did therefore not estimate international discard volumes and numbers-at-age for 2004.

B.2. Biological

Natural mortality was assumed to be constant (M=0.2, applied annually) for the whole range of ages and years.

A combined sex maturity is assumed, knife-edged at-age 2. The use of a knife edged maturity ogive has been a source of criticism in previous assessments. However, recent research on gadoid maturity conducted by the UK (NI) gives no evidence of substantial change in whiting maturity since the 1950s, although there has been an increase in the incidence of precocious maturity-at-age 1, particularly in males, since 1998.

As in previous years, SSB is computed at the start of each year, and the proportions of M and F before spawning were set to zero.

Stock weights are calculated using a procedure first described in the 1998 Working Group report. To derive representative stock weights for the start of the year for year *i* and age *j* the following formula is adopted:

$(CW_{i,j} + CW_{i+1,j+1})/2$ = SW at start of year.

These values are then smoothed using a 3-year moving average.

Recent investigations into the biological parameters (maturity, sex and growth parameters) of whiting in VIIa (funded under the Data Directive Regulation (1639/2001)) took place during a Biological Sampling survey (BBS) in March 2004. Parameter estimates of maturity-at-length indicate the L_{50} for whiting in VIIa for males and females is 13.65 cm and 19.76 cm, respectively. Maturity-at-age for both sexes are similar for most stock area (VIIa, b, j and g) with the notable exception of age 1 males in the Celtic Sea where the estimates are outside the 95% CI bounds for VIIa and considerably lower than VIa. In most areas whiting were mature by age three and most were mature at-age 2. The sex ratio for whiting tended to increase with length for nearly all the age classes in all areas indicating that females tend to have larger length-at-age than males (Gerritsen, 2005).

Gerritsen *et al.*, 2002 describes the relationships between maturity, length and age of whiting sampled on a length-stratified basis from NI groundfish surveys of the Irish Sea during spawning in spring 1992–2001. Findings reveal that most one-year-old females were immature whereas most two-year-old females were mature; almost all 3-year-olds of both sexes were mature. Length at 50 maturity average around 19 cm in males and 22 cm in females.

B.3. Surveys

Seven research vessel survey series for whiting in VIIa were available to the Working Group in 2005. In all surveys listed the highest age represents a true age not a plus group.

- UK (England and Wales) Beam Trawl Survey (UK E&W-BTS): ages 0 and 1, years 1988–2002: The survey covers the entire Irish Sea and is conducted in September on the R.V. *Corystes*. The survey uses a 4 m beam trawl targeted at flatfish. The survey is stratified by area and depth band, although the survey indices are calculated from the total survey catch without accounting for stratification. Numbers of whiting at-age per km towed are provided for prime stations only (i.e. those fished in most surveys).
- UK (Northern Ireland) October Groundfish Survey (NIGFS-October): ages 0–5, years 1992–2005: The survey series commenced in its present form in 1992. It comprises 45 3 mile tows at fixed station positions in the northern Irish Sea, with an additional 12 1 mile tows at fixed station positions in the St George's channel from October 2001 (the latter are not included in the tuning data). The surveys are carried out using a rock-hopper otter trawl deployed from the R.V. *Lough Foyle*. The survey designs are stratified by depth and seabed type. The mean numbers-at-length per 3 mile tow are calculated separately by stratum, and weighted by surface area of the strata to give a weighted mean for the survey or group of strata. The strata are grouped into western Irish Sea and eastern Irish Sea, and a separate age–length key is derived for each area to calculate abundance indices by age class. The survey design and time-series of re-

sults including distribution patterns of whiting are described in detail in Armstrong *et al.*, 2003.

- UK (Northern Ireland) March Groundfish Survey (NIGFS-March): ages 1–5, years 1992–2006: Description as for UKNI-GFS-October above.
- UK (Northern Ireland) Methot–Isaacs–Kidd Survey (UKNI-MIK): age 0, years 1993–2005: The survey uses a Methot–Isaacs–Kidd frame trawl to target pelagic juvenile gadoids in the western Irish Sea at 40–45 stations. The survey is stratified and takes place in June during the period prior to settlement of gadoid juveniles. Indices are calculated as the arithmetic mean of the numbers-per-unit sea area.
- Ireland's Irish Sea Celtic Sea Groundfish Survey (IR-ISCSGFS): ages 0–5, years 1997–2002: This survey commenced in 1997 and is conducted in October-November on the R.V. *Celtic Voyager*. The α and β of the series are set to account for the variable timing of this survey within the fourth quarter. The survey uses a GOV otter trawl with standard groundgear and a 20 mm codend liner. The survey operates mainly in the western Irish Sea but has included some stations in the eastern Irish Sea. The survey design has evolved over time and has different spatial coverage in different years. Indices are calculated as arithmetic means of all stations, without stratification by area.
- UK (Scotland) groundfish survey in spring (ScoGFS-spring): ages 1–8, years 1996–2006: This survey represents an extension of the Scottish West Coast groundfish survey (Area VI), using the research vessel *Scotia*. The survey gear is a GOV trawl, and the design is two fixed-position stations per ICES rectangle from 1997 onwards (17 stations) and one station per rectangle in 1996 (9 stations). The survey extends from the Northern limit of the Irish Sea to around 53° 30′.
- UK (Scotland) groundfish survey in autumn (ScoGFS-autumn): ages 0–5, years 1997–2005: The survey covers a similar area to the ScoGFS in spring, but has only 11–12 stations.
- IRGFS (Ireland): This survey commenced in 2003 aboard the R.V. Celtic Explorer. It is a depth stratified survey using a GOV trawl with a 20 mm mesh liner on the codend. The survey currently covers VIIb, j, g and VIa. Protocols for the survey are governed by the International Bottom Trawl Survey Working Group (IBTS).

To allow the inclusion of the NIGFS-March and ScoGFS-spring surveys for the year after the last year with commercial catch data in an XSA, the surveys may be treated as if they took place at the end of the previous year, and the age range and year range of the surveys may be shifted back accordingly in the data files.

The following research surveys were available to the 2009 Working group:

- UK (NI) groundfish survey: March 1992–2008.
- UK (NI) groundfish survey: October 1992–2008.
- UK (Scotland) groundfish survey: March 1996–2008.
- UK (Scotland) groundfish survey: autumn 1997–2005.
- Irish groundfish survey: autumn 2003 and 2004.

- UK (NI) MIK net surveys of pelagic-stage 0-group cod, western Irish Sea 1994–2008.
- UK (E&W) beam trawl survey: 0-1 gp cod, 1988–2006.

FSP surveys of Irish Sea round fish: 2004–2007.

Further details of the tuning data are given in Appendix 1 and 2 of the 1999 WG Report.

B.4. Commercial cpue

No cpue data have been provided for the French (Lorient) trawl fleet since 1992. Four commercial catch-effort dataseries were available to the WG:

- Irish otter trawl (IR-OTB): ages 1–6, years 1995–2002: Effort and cpue data provided for the Irish fleet comprise total annual effort (hours fished, not corrected for fishing power) and total numbers-at-age in landings from otter trawlers. The data were revised to take account of updated logbook information. This fleet operates mainly in the western Irish Sea, targeting *Nephrops* and/or whitefish. The distribution of fishing is concentrated in the western part of the range of the whiting stock in the Irish Sea. Hence the catch rates will represent changes in abundance of whiting in the western part of VIIa. The use of this fleet as a tuning index therefore relies on the assumption that trends in abundance in the west of VIIa reflect those of the entire stock. The catch-at-age data comprise a large proportion of the total international catch. Hence, some correlation of errors can be expected between the tuning dataset and the catch-at-age data. The effect of such correlations has not been evaluated. The otter trawl catch-at-age data contained data for landings only. Hence the reliability of the tuning fleet will be limited for age groups which are heavily discarded.
- UK (Northern Ireland) pelagic trawl: ages 2–6, years 1993–2002: The pelagic trawl catch-at-age data contained data for landings only. Hence the reliability of the tuning fleet will be limited for age groups which are heavily discarded. This fleet currently targets haddock and cod in the deeper waters of the western Irish Sea and the North Channel. Bycatches of whiting are currently very small and are heavily discarded as a consequence of their low value. The fleet is considered unsuitable for indexing whiting abundance.
- UK (Northern Ireland) single rig otter trawl: ages 0–6, years 1993–2002: This fleet operates mainly in the western Irish Sea. The distribution of fishing does not encompass the entire range of the whiting stock (which surveys suggest is distributed across the Irish Sea). Whiting discards from single-rig trawlers (estimated from fisher self-sampling scheme) are included.
- UK (England and Wales) otter trawl: ages 2–6, years 1981–2000: Estimates up to and including 2000 of commercial lpue from UK (E&W) otter trawlers contain data for landings only. Hence the reliability of the tuning fleet will be limited for age groups which are heavily discarded. This fleet operates mainly in the eastern Irish Sea. The distribution of fishing does not encompass the entire range of the whiting stock (which surveys suggest is distributed across the Irish Sea) or the main whiting nursery grounds (in the western Irish Sea). Age compositions in most years have been estimated from length frequencies using

ALKs that were obtained from sampling of fleets operating mainly in the western Irish Sea. This has introduced additional uncertainties into the data.

B.5. Other relevant data

None.

C. Historical stock development

Model used:

XSA (up to 2002)

SURBA 2.0–2003

SURBA 3.0–2004

SURBA 2.2 - 2005

Software used:

Lowestoft VPA suite

XSA Model Options chosen:

Tapered time weighting not applied

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 4

Survivor estimates shrunk towards the mean F of the final 5 years or the 2 oldest ages

S.E. of the mean to which the estimate are shrunk = 0.500

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch-in-tonnes	1980–last data year	0–6+	Yes
Canum	Catch-at-age in numbers	1980–last data year	0–6+	Yes
Weca	Weight-at-age in the commercial catch	1980–last data year	0–6+	Yes
West	Weight-at-age of the stock at spawning time.	1980–last data year	0–6+	Yes: uses smoothed catch weights adjusted to start of year
Mprop	Proportion of natural mortality before spawning	1980–last data year	0–6+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1980–last data year	0–6+	No – set to 0 for all ages in all years
Matprop	Proportion mature-at-age	1980–last data year	0–6+	No – the same ogive for all years
Natmor	Natural mortality	1980–last data year	0–6+	No – set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	NIGFS-Oct	1992–last data year	0–5
Tuning fleet 2	NIGFS-Mar (adjusted)	1991–(last data year-1)	0–4
Tuning fleet 3	ScoGFS-Spring	1996–last data year	1–5
Tuning fleet 4	UK(E&W) BTS	1988–last data year	0–1

For analysis of alternative procedures see WG reports from WGNSDS 1997–2005.

D. Short-term projection

- Model used:

Age structured

- Software used: MFDP prediction with management option table and yield per recruit routines. MLA suite (WGFRANSW) used for sensitivity analysis and probability profiles.
- Initial stock size. Taken from the XSA for age 1 and older. The recruitment at age 0 in the last data year is estimated as a short-term GM (1992 onwards) because of a reduction in mean recruitment since then.

- Natural mortality: Set to 0.2 for all ages in all years.
- Maturity: The same ogive as in the assessment is used for all years.
- F and M before spawning:
  Set to 0 for all ages in all years.
- Weight-at-age in the stock:
  average stock weights for last three years.
- Weight-at-age in the catch:
  Average weight of the three last years.
- Exploitation pattern:
  Average of the three last years. Discard F's, which are generated by the *Nephrops* fleet as there are no discard estimates for other fleets, are held constant whereas landings F's are varied in the management option table.
- Intermediate year assumptions:
  status quo F
- Stock recruitment model used:
  None, the short-term geometric mean recruitment-at-age 0 is used.
- Procedures used for splitting projected catches:
  F vectors in each of the last three years of the assessment are multiplied by the proportion landed or discarded at-age to give partial Fs for landings and discards. The vectors of partial Fs are then averaged over the last three years to give the forecast values.

E. Medium-term projections

No medium-term projections are done for this stock as a consequence of problems with estimating current F.

F. Yield and biomass per recruit/long-term projections

- Model used: yield and biomass per recruit over a range of F values that may reflect fixed or variable discard F's.
- Software used: MFY or MLA
- Selectivity pattern:
  mean F array from last 3 years of assessment (to reflect recent selection patterns).
- Stock and catch weights-at-age:
  mean of last three years (weights-at-age have declined as the stock has declined since the 1980s; it is not known if this is an environmental effect on growth that is independent of stock size).
- Proportion discarded:

partial F vectors are the recent average.

- Maturity: Fixed maturity ogive as used in assessment.

G. Biological reference points

Precautionary approach reference points have remained unchanged since 1999. B_{pa} is set at 7000 t and is defined as B_{lim}*1.4. B_{lim} is defined as the lowest observed SSB (ACFM, 1999), considered to be 5000 t. There is not considered to be clear evidence of reduced recruitment at the lowest observed SSBs. F_{pa} is set at 0.65 on the technical basis of high probabilities of avoiding F_{lim} and of SSB remaining above B_{pa} in the long term. F_{lim} is defined as 0.95, the fishing mortality estimated to lead to a potential stock collapse.

H. Other issues

None.

I. References

Armstrong, M.J., Peel, J., McAliskey, M., McCurdy, W., McCorriston, P. and Briggs, R. 2003. Survey indices of abundance for cod, haddock and whiting in the Irish Sea (Area VIIaN): 1992–2003. Working Document No. 3 submitted to 2003 meeting of the ICES Working Group on Assessment of Northern Shelf Demersal Stocks. 33pp.

Borges, L.; Rogan, E. and Officer, R. 2005. "Discarding by the demersal fishery in the waters around Ireland", Fish. Res. (in press).

Gerritsen, H. 2005. Biological parameters for Irish Demersal Stocks in 2004. WD5 (WGNSDS, 2005).

Table 1.0. Revised Discard estimates raisesd according to the method oulined in Borges *et al.,* 2005.

Age	1996 Numbers ('000)	1996 Weight (kg)	1997 Numbers ('000)	1997 Weight (kg)	1998 Numbers ('000)	1998 Weight (kg)	1999 Numbers ('000)	1999 Weight (kg)	2000 Numbers ('000)	2000 Weight (kg)	2001 Numbers ('000)	2001 Weight (kg)	2002 Numbers ('000)	2002 Weight (kg)	2003 Numbers ('000)	2003 Weight (kg)	2004 Numbers ('000)	2004 Weight (kg)	2005 Numbers ('000)	2005 Weight (kg)
0	5631.20	0.015	4110.63	0.027	5073.57	0.027	187.26	0.036	7850.12	0.033	20981.54	0.016	29017.16	0.021	1921.76	0.016	17091.56	0.018	442.07	0.010
1	5925.33	0.035	8361.19	0.044	5939.53	0.064	276.50	0.102	3098.24	0.047	8883.11	0.054	12097.93	0.033	2419.56	0.036	7347.29	0.034	2531.84	0.035
2	1802.90	0.111	3243.45	0.120	3826.20	0.107	150.99	0.174	137.80	0.153	1413.48	0.126	576.17	0.112	1287.21	0.178	731.35	0.101	783.68	0.091
3	144.34	0.217	696.18	0.200	440.05	0.185	43.70	0.235	30.31	0.229	479.38	0.133	152.95	0.105	603.20	0.246	142.50	0.165	129.28	0.159
4	6.02	0.206	68.71	0.241	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	108.64	0.268	96.30	0.218	40.12	0.154
5	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	22.95	0.136	17.66	0.123	0.00	0.000	0.00	0.000	24.48	0.371
6	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000
7	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000
8	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000
9	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000
10	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000
OTB Discards (tonnes, whole weight)		520.8		#####		1010.3		71.6		434.3		1054.5		1100.9		523.6		680.3		201.3

Sampling Information	1996	1997	1998	1999	2000	2001	2002	2003	2004	
Number of Trips	8	8	7	4	10	2	1	9	11	8
Number of Hauls	48	44	58	40	111	34	7	60	122	96

Annex 6.7: Quality Handbook: Irish Sea Plaice

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Plaice (division VIIa)
Working Group:	Assessment of Northern Shelf Demersal Stocks
Date:	16th May 2009
Last updated:	13th May 2004

A. General

A.1 Stock definition

The degree of separation between the stocks of plaice in the Irish Sea and the Celtic Sea is currently unclear. Numerous tagging studies indicate a southerly movement of mature fish from the southeast Irish Sea into the Bristol Channel during the spawning season. Although some of these fish remain in this area, the majority return to summer feeding grounds in the Irish Sea (Dunn and Pawson, 2002). Mixing is also considered to occur between the Celtic Sea and Eastern Channel stocks and time-series of recruitment estimates for all three stocks demonstrate very similar patterns.

The majority of movements by plaice in the Irish Sea is considered to be in the north-south direction and the level of mixing between the east and west components of the Irish Sea stock is believed to be small. (Dunn and Pawson, 2002). Length-at-age measurements from research surveys as well as anecdotal information from the fishing industry suggests that plaice in the western Irish Sea grow at a much slower rate than those in the eastern Irish Sea. Earlier studies have suggested that the east and west components of the stock are distinct (Brander, 1975; Sideek, 1989) and should therefore be considered independently of each other. Morphometric differences have been observed between the east and west components of the stock; a comment in the 1982 WG report states that plaice to the west of the 5°W line are approximately 3 cm larger-at-age (for the most abundant age groups) than those to the east of this line. This however, contradicts the findings of the September beam trawl survey for which plaice caught off the Irish coast are found to be smaller-at-age than those caught in the eastern Irish Sea.

Recent examination of survey results which contrasted recruitment indices from the east with those from the west demonstrated good levels of correspondence of year-class strengths between the two substocks. This would indicate either that the two substocks are subject to similar large-scale environmental forces, and respond similarly to them or, alternatively that they represent two subpopulations of a single-stock which share a common spawning.

There are considered to be three principle spawning areas of plaice in the Irish Sea. One off the Irish coast, another between the Isle of Man and the Cumbrian coast and the third off the north Wales coast (Nichols *et al.*, 1993; Fox *et al.*, 1997). Cardigan Bay has also been identified as a spawning ground for plaice in the Irish Sea (Simpson, 1959).

A.2 The fishery

The status and activities of the fishing fleets operating in ICES Subdivision VIIa are described by Pawson *et al.*, 2002 and also by Anon, 2002. The majority of vessels operating in the Irish Sea are otter trawlers fishing for cod, haddock, whiting and plaice with bycatches of angler-fish, hake and sole. Since 2001 these trawlers have adopted mesh sizes of 100–120 mm and other gear modifications depending on the requirements of recent EU technical conservation regulations and national legislation. Square mesh panels have been mandatory for UK otter trawlers since 1993 and for Irish trawlers since 1994. The number of Irish vessels operating in this area has declined in recent years. Fishing effort in the England and Wales fleet declined rapidly after 1989 and over 1992–1995 was about 40% of the levels reported in the late 1980s.

Although some of the otter trawlers also take part in the fishery for sole, there have been a growing number of beam trawlers, particularly from southern England and Belgium exploiting this stock. This fishery has important bycatches of plaice, rays, brill, turbot and angler-fish. The fishing effort of the Belgium beam trawl fleet varies according to the catch rates of sole in the Irish Sea compared with other areas in which the fleet operates.

A fleet of vessels primarily from Ireland and Northern Ireland take part in a targeted *Nephrops* fishery using 70 mm mesh nets with 75 mm square mesh panels. This fishery takes a substantial bycatch of whiting, most of which is discarded. Some inshore shrimp beam trawlers occasionally switch to flatfish when shrimp become temporarily unavailable. Other gear types employed in the Irish Sea to catch demersal species are gillnets and tanglenets, notably by inshore boats targeting cod, bass, grey mullet, sole and plaice.

The minimum landing size for plaice in the Irish Sea was set in 1980 to 25 cm (Council Regulation (EEC) No 2527/80). This was later increased to 27 cm.

Since 2000 a recovery programme has been implemented to reduce exploitation of the cod spawning stock in the Irish Sea. In 2002 the European Commission regulations included a prohibition on the use of demersal trawl, enmeshing nets or lines within the main cod spawning area in the northwest Irish Sea between the 14th February and 30th April. Some derogations were permitted for *Nephrops* trawls and beam trawlers targeting flatfish.

The Fishery is described further in Section 6.1 of the Report.

A.3 Ecosystem aspects

B. Data

B.1 Commercial catch

Landings

International catch-at-age data based on quarterly market sampling and annual landings figures are available from 1964. Throughout the period 1978 to 2008 quarterly age compositions have typically represented a large proportion of the total international landings. Table B1 details the derivation of international landings for the period 1978 to 2008.

Up until 1982 the stock was assessed on a separate sex basis. The catch numbers of males and females were worked up separately and the numbers of males and females in the stock as estimated from each assessment combined to give a total biomass estimate. From 1983 a combined sex assessment of the stock has been conducted and the numbers of males and females in the catch have been combined at the international data aggregation level prior to running a single assessment.

Discards

In 1986 the UK fleet was restricted to a 10% bycatch of plaice for almost the entire year. Estimates were made of the increased quantity of plaice that would have been discarded based on comparisons of cpue values for 1985–86 with those for 1984–85. The estimated quantity of 250 tonnes was added to the catch. A similar situation arose the following year and 250 tonnes was added to the catch for 1987.

The 10% plaice bycatch restriction was enforced again in 1988 to all UK (E&W) vessels in the 1st quarter and to beam trawlers in the 2nd and 3rd quarters however, this time the landings were not corrected for discard estimates.

Discard information is not routinely incorporated into the assessment. A sufficient time-series of discard information is not currently available though studies were conducted in 1993–94, 2005 and is currently ongoing.

B.2. Biological

Weights-at-age

A number of different methodologies have been employed to determine weights-at-age for this stock. Stock weights and catch weights-at-age were determined on a separate sex basis and remained unchanged from 1978 until 1983. Catch weights were derived from a von Bertalanffy length-at-age fit to Belgian (70–74), UK (E&W) (64–74) and Irish (62–66) catch samples. The estimated lengths-at-age were converted to weights-at-age using a Belgian length–weight dataset (ages 2–15 females; 3–9 males). Stock weights were calculated as the mean of adjacent ages from the catch weights, where catch weights represented 1st July values and stock weights 1st January.

From 1983 weights-at-age have been calculated on a combined sex basis. Catch weights were taken from market sampling measurements combined on a sex weighted basis and smoothed. For the period 1983 to 1990 catch weights were smoothed by eye, from 1991 onwards a smooth curve was fitted using a numerical minimization routine. Stock weights were derived from the smoothed international catch weights-at-age curve with values representing 1st January. In 1985 the stock weights-at-age were adjusted for ages 1 to 4. The difference between the smoothed catch weights and survey (F.V. *Silver Star*) observations were adjusted using the maturity ogive to give "best estimate" stock weights "for ages where growth and maturity differences can bias sampling procedures". (*This procedure remains a little opaque*). The same procedure was adopted in 1996 (when stock weights in 1982 and 1983 were also revised so as to be consistent with this methodology) and 1997. In 1988 however, the *Silver Star* survey was discontinued and stock weights-at-ages 1 to 3 were calculated as means of the 3 previous years. Correction of the estimated stock weights of the younger age groups did not occur in 1989 or in subsequent years which explains the sudden increase in weight of the younger age groups for this stock from 1988 onwards.

Catch weights at the younger ages also reveal a similar increase coincident with the start of the smoothing process. This apparent increase in the estimated catch weights is not believed to have affected the derivation of catch numbers because smoothing of the catch weights occurs after having determined the catch numbers-at-age. SOP checks are generally very close to 100%.

The 1982 WG report notes a study by R. Cross, unpublished stating that there was no evidence of a change in growth rates for the stock nor was there any evidence of density-dependent effects on growth.

Natural mortality and maturity ogives

As for the weights-at-age, natural mortality and maturity was initially determined on a separate sex basis. Natural mortality was taken as 0.15 for males and 0.1 for females. In 1983 when a combined sex assessment was undertaken a sex weighted average value of 0.12 was used as an estimate of natural mortality. This estimate of natural mortality has remained unchanged since 1983.

The maturity estimates used prior to 1982 are not specified. A new separate sex maturity ogive (Sideek, 1981) was implemented in 1982. This ogive was recalculated as sex weighted mean values in 1983 when the assessment was conducted on a combined sex basis. The maturity ogive was revised again in 1992 based on the results of an EU project. Maturity ogives are applied as vectors to all years in the assessment.

AGE	1978–1982		1983–1992	1992–2008
	M	F		
1	0	0	0	0
2	0.3	0.04	0.15	0.24
3	0.8	0.4	0.53	0.57
4	1.0	0.94	0.96	0.74
5	1.0	1.0	1.0	0.93
6	1.0	1.0	1.0	1.0

The proportion of fishing mortality and natural mortality before spawning was originally set to 0. It was changed in 1983 to a value of 0.2 on the grounds that approximately 20% of the catch was taken prior to March (considered to be the time of peak spawning activity). As for Celtic Sea plaice the proportion of F and M before spawning was reset to 0, as it was considered that these settings were more robust to changes in the fishing pattern, especially with respect to the medium term projections.

B.3 Surveys

In 1993 the UK (E&W) beam trawl survey series which began in 1988 was considered to be of sufficient length for inclusion in the assessment. Since 1991 tow duration has been 30 minutes but prior to this it was 15 minutes. In 1997 values for 1988 to 1990 were raised to 30 minute tows, however, data for 1988 and 1989 were of poor quality and gave spurious results. The series was therefore truncated to 1990. A similar March beam trawl survey began in 1993 and was made available to the WG in 1998. The March beam trawl survey ended in 1999 but continued to be used as a tuning index in the assessment until 2003.

An Irish juvenile plaice survey index was presented to the WG in 2002 (1976–2001, ages 2–8). Between 1976 and 1990 this survey had used an average ALK for that period. Serious concerns were expressed regarding the quality of the data for this period and the series was truncated to 1991. The stations for this survey are located along the coast of southeast Ireland between Dundalk Bay and Carnsore Point and there was some concern that this localized survey series would not be representative of the plaice population over the whole of the Irish Sea. Numerous tests were conducted at the 2002 WG to determine the validity of this and other tuning indices and it was concluded that this survey could be used as an index of the plaice population over the whole of the Irish Sea.

The SSB of cod, haddock and plaice have also been estimated using the Annual Egg Production Method (AEPM) (Armstrong *et al.*, 2002). This method uses a series of ichthyoplankton surveys to quantify the spatial extent and seasonal pattern of egg production, from which the total annual egg production can be derived. The average fecundity (number of eggs spawned per unit body weight) of mature fish is estimated by sampling adult females immediately prior to the spawning season. Dividing the annual egg production by average fecundity gives an estimate of the biomass of mature females. Total SSB can be estimated if the sex ratio is known.

The AEPM spawning-stock biomass estimates for plaice in 2006 were consistent with the results from the equivalent surveys in 1995 and 2000. Substantial discrepancies between absolute estimates of SSB from the Annual Egg Production method (AEPM) and the ICES catch-based assessments were again observed. Both however demonstrate increasing trends in SSB, but to differing degrees.

SSB estimates for plaice from 1995, 2000 and 2006 AEPM surveys.

	Plaice	
	SSB (t)	RSE(%)
1995 (Stage 1A)	10 509	22
2000 (Stage 1A)	14 700	16
2006 (Stage 1A equiv.)1	14 640	16

B.4 Commercial cpue

Prior to 1981 tuning data were not used in the assessment of this stock. A separable assessment method was used and estimates of terminal S and F were derived iteratively based on an understanding of the recent dynamics of the fishery.

In 1981 the choice of terminal F was determined from a regression of exploited stock biomass on cpue. Catch and effort series were available for the UK (E&W) trawl fleet and the Belgian beam trawl fleet for the period 1964 to 1980. In 1994 the Belgian and UK cpue series were combined to provide one mean standardized international index. The UK (E&W) trawl series was revised in 1986 (not known how) and in 1987 was recalculated as an age based cpue index allowing the use of the hybrid method of tuning an *ad hoc* VPA.

The UK (E&W) trawl tuning series was revised in 1999 and separate otter trawl and beam trawl tuning series were produced using length samples from each gear type and an all gears ALK. Because the data could only be separated for 1988 onwards the two new tuning series were slightly reduced in length. In 1996 UK (E&W) commercial effort data were re-scaled to thousands of hours so as to avoid numerical problems associated with low cpue values and in 2000 the UK (E&W) otter trawl series was re-calculated using otter trawl age compositions only rather than combined fleet age compositions as previously.

Two newly revised survey indices for the *Lough Beltra* were presented to the WG in 1996 though they were considered too noisy for inclusion in the assessment. They were revised again for the following year and found to be much improved but were again not included because they ended in 1996 and the WG felt that they would add little to the assessment. An Irish otter trawl tuning index was made available in 2001 (1995–2000, age 0 to 15). Although this fleet mainly targets *Nephrops*, vessels do on occasion move into areas where plaice are abundant. Landings of plaice by this fleet were approximately 15% of total international landings in 2000 and the WG considered that this fleet could provide a useful index of abundance for plaice.

The effects of vessel characteristics on lpue for UK (E&W) commercial tuning series was investigated in 2001 to investigate the requirement for fishing power corrections as a consequence of MAGP IV re-measurement requirements. It was found that vessel characteristics had less effect on lpue than geographic factors and unexplained noise and concluded that corrections were not necessary. However, vessels of certain size tended to fish in certain rectangles. This confounding may have resulted in the underestimation of vessel effects.

Currently (2009WG) age based tuning data available for this assessment comprise of 3 commercial fleets; the UK (E&W) otter trawl fleet (UK (E&W)OTB, 1987–2008), the UK (E&W) beam trawl fleet (UK (E&W)BT, 1989–2008) and the Irish otter trawl fleet (IR-OTB, 1995–2008). As a consequence of inconsistencies in these commercial tuning fleets, Irish Sea plaice assessments since 2004 have only included the UK (E&W) beam trawl survey (September: 1989–2007) and the two UK (NI) spawning biomass indices. For more information see WGNSDS 2004.

B.5 Other relevant data

C. Historical stock development

The stock of plaice in the Irish Sea has been assessed by ICES since 1977.

Model used

In 1987 the stock was assessed using a Laurec-Shepherd (hybrid) tuned VPA. Concerns about deteriorating data quality prompted the use in 1994 of XSA. The XSA settings for each of the assessments since 1992 are detailed in Table C.1.

Trial runs have, over the years, explored many of the options with regards XSA settings.

- The applicability of the power model on the younger ages was explored in 1994; 1996; 1998; 1999; 2000 and 2001.
- Different levels of F shrinkage were explored in 1994; 1995; 1997.
- The effect of different time tapers was investigated in 1996.
- The S.E. threshold on fleets was examined in 1996.
- The level of the catchability plateau was investigated in 1994.

As a consequence of perceived inconsistencies in the commercial tuning fleets, and subsequent removal from the assessment in 2004, ICES has subsequently provided advice based on an ICA assessment to allow the inclusion of two UK (NI) spawning biomass indices.

In 2009 FLICA was used to run the assessment, the R and FLR packages were documented within the WG report.

The assessment settings used each year are documented in Table 2.

D. Short term projection

Software: Multi Fleet Deterministic Projection (MFDP)

Age based short-term projections are conducted for a 3 year period using initial stock numbers derived from assessment analyses. Numbers at the recruiting age are considered poorly estimated and are generally overwritten using a geometric mean of past recruitment values. Recent recruitments have been estimated to be at a lower level and to be less variable than those earlier in the time-series. Consequently a short-term geometric mean (from 1990:present) is used. If large retrospective bias is apparent in the assessment, the GM mean is trimmed to the final assessment year minus two years, and the forecast survivor inputs overwritten for age = recruitment + 1, with the long-term geometric mean estimate depreciated for F_{sq} and M.

The exploitation pattern is typically an un-scaled 3 year arithmetic mean, though alternative options may be used depending on recent F trajectories and the working group's perception of the fishery.

Catch and stock weights-at-age are generally taken as the mean of the last 3 years. Maturity ogive and natural mortality estimates are those used in the assessment method.

E. Medium term projections

Software: MLA miscellany

Input values to the medium-term forecast are the same as those used in the short-term forecast. Any stock recruit relationship is poorly defined and although a Beverton–Holt SRR has been assumed in earlier years, a simple geometric mean may now be considered more appropriate.

F. Yield and biomass-per-recruit/long-term projections

Software: Multi Fleet Yield per Recruit (MFYPR).

Yield-per-recruit calculations are conducted using the same input values as those used for the short-term forecasts.

G. Biological reference points

Biological reference points were proposed for this stock by the 1998 working group as below:

F_{lim}	No proposal	
F_{pa}	0.45	(on the basis of F_{med} and long-term considerations)
B_{lim}	No proposal	
B_{pa}	3100 t	(on the basis of B_{loss} and evidence of high recruitments at low SSBs

H. Other issues

None.

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Table B.1. Data sources and derivation of international landings. % sampled indicates the percentage of the total landings represented by sampling.

Year of WG	Data	Source UK	Belgium	Ireland	Netherland	Derivation of international landings	% sampled
1978	Len. comp.	quarterly[1]	quarterly[1]	quarterly[1]		Irish raised to Irish and N.Irish; UK raised to UK (E&W) and Scotland	85
	ALK	quarterly[1]	quarterly[1]	quarterly[1]		Belgian raised to Belgian, Dutch and French	
	Age comp.	quarterly[1]	quarterly[1]	quarterly[1]		UK + Bel + IR combined to total int. separate sex	
1979							
1980	Len. comp.	quarterly[1]	quarterly[1]	quarterly[1]		Irish raised to Irish and N.Irish; UK raised to UK (E&W), Sco and IOM.	86
	ALK	quarterly[1]	quarterly[1]	quarterly[1]		Belgian raised to Belgian, Dutch and French	
	Age comp.	quarterly[1]	quarterly[1]	quarterly[1]		UK + Bel + IR combined to total int. separate sex	
1981							
1982		As for 1980	As for 1980	As for 1980		As for 1980, separate sex	92
1983		As for 1980	As for 1980	As for 1980		As for 1980; sexes combined	90
1984	Len. comp.	quarterly	2nd qtr	quarterly		Irish raised to Irish and N.Irish	90
	ALK	quarterly	2nd qtr	quarterly		UK raised to UK (E&W), Scotland, I.O.M., French, Dutch and Belgian	
	Age comp.	quarterly	2nd qtr	quarterly		UK + IR combined to total int. sexes combined	
1985	Len. comp.	quarterly	quarterly	quarterly		Irish raised to Irish and N.Irish; UK raised to UK (E&W), Sco and IOM	92
	ALK	quarterly	quarterly	quarterly		Belgian raised to Belgian, Dutch and French	
	Age comp.	quarterly	quarterly	quarterly		UK + Bel + IR combined to total int. sexes combined	
1986	Len. comp.	quarterly	quarterly	quarterly		Irish raised to Irish.,N.Irish and French	91
	ALK	quarterly	quarterly	quarterly		UK raised to UK (E&W), Scotland and I.O.M.; Belgian used alone	
	Age comp.	quarterly	quarterly	quarterly		UK + Bel + IR combined to total int.	
1987		As for 1986	As for 1986	As for 1986		As for 1986	84
1988		As for 1986	As for 1986	As for 1986		As for 1986 except Irish beam trawl raised using UK age comps	75
1989		As for 1986	As for 1986	As for 1986		As for 1986 (Irish beam trawl now sampled)	86
Year of WG	Data	Source UK	Belgium	Ireland	Netherland	Derivation of international landings	% sampled

Year of WG	Data	Source: UK	Source: Belgium	Source: Ireland	Source: Netherland	Derivation of international landings	% sampled
1990							
1991		As for 1986	As for 1986	As for 1986		As for 1986	83
1992		As for 1986	As for 1986	As for 1986		As for 1986	83
1993		As for 1986	As for 1986	As for 1986		As for 1986	91
1994		As for 1986	As for 1986	As for 1986		As for 1986 (Belgian samples supplemented with UK data)	90
1995							
1996		As for 1986	As for 1986	As for 1986		As for 1986	89
1997		As for 1998	As for 1998	As for 1998	As for 1998	As for 1998	83
1998	Len. comp.	quarterly	quarterly	quarterly	Quarterly	Irish raised to Irish., N.Irish and French; Belgian and Dutch used alone	87
	ALK	quarterly	quarterly	quarterly	Quarterly	UK raised to UK (E&W), Scotland and I.O.M.	
	Age comp.	quarterly	quarterly	quarterly	Quarterly	UK + Bel + IR + NL combined to total int.	
1999		As for 1986	As for 1986	As for 1986		As for 1986 (except UK raised to include NL landings)	89
2000		As for 1999	As for 1999	As for 1999		As for 1999	88
2001		As for 1998	As for 1998	As for 1998	As for 1998	As for 1998	87
2002		As for 1986	As for 1986	As for 1986		As for 1986	88
2003	Len. comp.	quarterly	1st qtr	quarterly		Belgium raised using 1st qtr values	70
	ALK	quarterly	1st qtr	quarterly		UK raised to Sco and France; Irish raised to Irish and N.Irish	
	Age comp.	quarterly	1st qtr	quarterly		UK + Bel + IR combined to total int.	
2004	Len. comp.	quarterly	-	quarterly			99 [2]
	ALK	quarterly	-	quarterly		UK raised to Sco and IOM; Irish raised to France and N.Irish	
	Age comp.	quarterly	-	quarterly		UK+ IR + Bel combined to total int	
2005	Len. comp.	quarterly	1–2 Qtrs	quarterly		Belgium raised using 1-2 qtrs values	98 [2]
	ALK	quarterly	1–2 Qtrs	quarterly		UK raised to Sco and IOM; Irish raised to France and N.Irish	
	Age comp.	quarterly	1–2 Qtrs	quarterly		UK+ IR + Bel combined to total int	
2006	Len. comp.	quarterly	quarterly	quarterly			99 [2]

Year of WG	Data	Source UK	Belgium	Ireland	Netherland	Derivation of international landings	% sampled
	ALK	quarterly	quarterly	quarterly		UK raised to Sco and IOM; Irish raised to France and N.Irish	
	Age comp.	quarterly	quarterly	quarterly		UK+ IR + Bel combined to total int	
2007	As for 2006	As for 2006	As for 2006		As for 2006	As for 2006	99 [2]
2008	As for 2006	As for 2006	As for 2006		As for 2006	As for 2006	100 [2]
2009	Len. comp.	quarterly	Annual	quarterly			100 [2]
	ALK	quarterly	Annual	quarterly		UK raised to Sco and IOM; Irish raised to France and N.Irish	
	Age comp.	quarterly	Annual	quarterly		UK+ IR + Bel combined to total int	

1 Assumed – (not explicitly stated in report).

2 % sampled calculated using official samples table from WG report.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Assmnt Age Range	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+
Fbar Age Range	3–8	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6
Assmnt Method	L.S.	L.S.	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA
Tuning Fleets													
UK trawl yrs	81–90	82–91	76–92	76–93	76–94								
ages	1–8	1–8	1–8	1–8	1–8								
UK otter yrs						86–95	87–96	88–97	89–98	90–99	91–00	87–01	87–02
ages						2–8	2–8	2–8	2–8	2–8	2–8	2–8	2–8
UK beam yrs									89–98	90–99	91–00	89–01	89–02
Ages									2–8	2–8	2–8	2–8	2–8
Bel Beam yrs					85–94	86–95	87–96	88–97					
Ages					2–8	3–8	3–8	3–8					
IR otter yrs												95–01	95–02
Ages												2–8	2–8
UKBTS Sept yrs			88–92	88–93	88–94	88–95	89–96	89–97	89–98	90–99	91–00	89–01	89–02
Ages			1–4	1–4	1–4	1–4	1–4	1–4	1–4	1–4	1–4	1–4	1–4
UKBTS Mar yrs								93–97	93–98	93–99	93–99	93–99	93–99
Ages								1–4	1–4	1–4	1–4	1–4	1–4
IR-JPS yr												91–01	91–02
agess												1–6	1–6
Time taper			20yr tri	20yr tri	20yr tri	No	No	No	No	No	No	No	No
Power model ages			1	0	1	1	1	1	1	0	0	0	0
P shrinkage			True	False	True	True	True	True	True	False	False	False	False
Q plateau age			5	5	5	5	5	5	5	5	5	5	5
F shrinkage S.E			0.3	0.3	0.5	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Num yrs			5	5	5	5	5	5	5	5	5	5	5
Num ages			5	5	4	4	4	4	4	4	4	4	4
Fleet S.E.			0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

	2004	2005	2006	2007	2008	2009
Assmnt Age Range	1–9+	1–9+	2–9+	2–9+	2–9+	2–9+
Fbar Age Range	3–6	3–6	3–6	3–6	3–6	3–6
Assmnt Method	ICA	ICA	ICA	ICA	ICA	ICA
Tuning Fleets						
UK(E&W)OTB ages	1987 – 2003 ages 5–8	Omitted	Omitted	Omitted	Omitted	Omitted
UK(E&W)BTS Sept ages	1989 – 2003 ages 1–7	1989 – 2003 ages 1–7	1989 – 2003 ages 1–7	1989 – 2003 ages 1–7	1989 – 2003 ages 1–7	1989 – 2003 ages 1–7
UK(E&W)BTS March Ages	1993-1999 ages 1 – 4	Omitted	Omitted	Omitted	Omitted	Omitted
UK(E&W)BT Ages	1989 – 2003 ages 5–8	Omitted	Omitted	Omitted	Omitted	Omitted
IR-OTB Ages	1995-2003 ages 5–8	Omitted	Omitted	Omitted	Omitted	Omitted
UK(NI) GFS Mar Ages	1992–2003 Biomss index	1992–2003 Biomss index	1992–2003 Biomss index	1992–2003 Biomss index	1992–2003 Biomss index	1992–2003 Biomss index

UK(NI) GFS Oct Ages	1992-2003 Biomss index	1992-2003 Biomss index	1992-2003 Biomss index	1992-2003 Biomss index	1992-2003 Biomss index	1992-2003 Biomss index
Time series weights	Full time-series unweighted	Full time-series unweighted	Full time-series unweighted	Full time-series unweighted	Full time-series unweighted	Full time-series unweighted
Num yrs for separable	3	5	5	6	7	8
Reference age	4	4	5	5	5	5
Terminal S	0.7	1.0	1.0	1.0	1.0	1.0
Catchability model fitted	Linear	Linear	Linear	Linear	Linear	Linear
SRR fitted	No	No	No	No	No	No

Annex 6.8: Quality Handbook SoleVIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Irish Sea Sole (Division VIIa)
Working Group	WGCSE 2009
Last updated	27 May 2009 (Colm Lordan)
Note	The annex is in the old WGNSDS format only Section C and beyond have been update in 2009.

A. General

A.1. Stock definition

Sole occur throughout the Irish Sea, but are found more abundant in depth less than 60 m.

A.2. The fishery

There are three main countries fishing for sole in the Irish Sea; Belgium, taking the bulk of the landings (50–75%), and the UK and Ireland, also taking considerable amounts. The Netherlands and France take the remainder. Approximately 25 Belgian beam trawlers are operating in the Irish Sea, targeting sole. The UK trawl fleet operates predominantly in the eastern side of the Irish Sea in Liverpool Bay and Morecambe Bay. Sole catches from Ireland are mainly coming from bycatches in the *Nephrops* fishery (operation in the North West of the Irish Sea).

When fishing in VIIa it is prohibited to use any beam trawl of mesh size range 70–79 mm or 80–90 mm unless the entire upper half of the anterior part of such a net consists of a panel of netting material attached directly to the headline of the net, extending towards the posterior of the net for at least 30 meshes and constructed of diamond-meshed netting material of which no individual mesh is of mesh size less than 180 mm. The Irish otter trawl fleet employs either a 70 mm mesh with square mesh panels or more commonly an 80 mm mesh. Similarly the Belgian and UK (E&W) beam trawls use 80 mm mesh gear. Otter trawlers targeting roundfish have, since 2000, used 100 mm mesh gear.

It was concluded at the 2000 Working Group and confirmed in 2001 that the cod recovery measures first enacted in 2000 would have had little impact on the sole fishery. The closed area in 2001 covered a reduced area confined to the west of the Irish Sea and therefore is also expected to have had little effect on the level of fishing effort for sole The spawning closure for cod in 2002 is also unlikely to have had an impact on the sole fishery. The effort regulations and maximum daily uptake, implemented in 2003 will delay the uptake of the quota but is also unlikely to be restrictive for the total uptake.

Discard estimates are estimated to be minor. Preliminary data indicating ranges from 0 to 2% by weight discarded.

No data are available on the extent of misreporting of landings from this stock. However, the quota in 2003 became restrictive.

A.3. Ecosystem aspects

No information.

B. Data

B.1. Commercial catch

Quarterly age compositions for 2002 were available from UK (E&W), Belgium and Ireland, as well as quarterly landings from France and Northern Ireland. The quarterly UK (E&W) age compositions were raised to total UK landings. A total international age composition was obtained by combining the quarterly age compositions from Belgium, the UK, and Ireland, and raising them to the total international landings.

B.2. Biological

Currently there are no direct (from tagging) or independent (from survey information) estimates of natural mortality. Therefore, as in previous years, annual natural mortality (M) was assumed to be constant over ages and years, at 0.1 yr^{-1}.

The maturity ogive used in this and previous assessments is based on survey information for this stock.:

Age	1	2	3	4	5	6 and older
Mat.	0.00	0.38	0.71	0.97	0.98	1.00

Proportions of M and F before spawning were set to zero, as in previous years.

Males and Females of this stock are strongly dimorphic, with much reduced rates of growth after reaching maturity, while females continue to grow. Given the minimum landing size of 24 cm the majority of landings represent mature females.

B.3. Surveys

Two UK (E&W) beam trawl surveys were available to the Working Group.

Area covered

Irish Sea; 52^0 N to 55^0 N; 3^0 W to 6^0 30′ W.

Target species

Flatfish species, particularly juvenile plaice and sole. Length data recorded for all finfish species caught; samples for age analysis taken from selected species.

Time period

1988–present: September (continuing).

1993–1999: March.

Gear used

Commercially rigged 4 m steel beam trawl; chain matrix; 40 mm codend liner.

Mean towing speed: 4 knots over the ground. Tow duration: 30 minutes. Tow duration for trips in 1988–1991 was 15 minutes; in 1992 comparative tows of 15 and 30 minutes length were carried out, and subsequent cruises used a standard 30 minute tow. The data from earlier years were converted to 30 minutes tow equivalent using relationships for each species derived from the comparative work in 1992.

Vessel used: R.V. *Corystes* (CEFAS).

Survey design

Survey design is stratified by depth band and sector (Depth bands are 0–20, 20–40, 40+). Station positions are fixed. Number of stations = 35 in the eastern Irish Sea, 15 in the western Irish Sea, and 16 in St George's Channel (primary stations). Sampling intensity highest in the eastern Irish Sea, in the main flatfish nursery and fishery areas.

Method of analysis

Raised, standardized length frequencies for each station combined to give total length distribution for a stratum (depth band/sector). Sector age length keys applied to stratum length distributions 1988–1994; stratum age–length keys applied 1995 onwards. Mean stratum cpue (kg per 100 km and numbers-at-age per 100 km) are calculated. Overall mean cpue values are simple totals divided by distance in metres (or hours fished). Population number estimates derived using stratum areas as weighting factors.

The September beam trawl survey has proven to estimate year-class strength well, and providing 50% to 80% of the weighting to the total estimates of the incoming years classes.

B.4. Commercial catch-effort data

Cpue and effort series were available from the Belgium beam trawlers, UK (E&W) beam and otter trawlers, the Irish otter trawlers and from two UK beam trawl surveys (September and March).

Cpue for both UK and Belgian beam trawlers has declined since the beginning of the time-series, but has remained relatively constant over the last decade.

Effort from both commercial beam trawl fleets increased from the early seventies until the late eighties. Since then UK beam trawl effort has declined to a minimum in 2000, and has remained at this level up till now. In the nineties, the Belgian beam trawl effort fluctuated around a lower level than the late eighties. Since 2000 the effort has increased substantially with 64% and 27% respectively each year, despite which cpue has remained stable in this and other fleets.

The UK (E&W) September beam trawl survey appears to track year-class strength well. As previously investigated, this tuning fleet is also quite consistent in estimating year-class strength of the same year class at different ages. Therefore the Working Group had confidence in using the UK (E&W) September survey.

There has been no March beam trawl survey since 1999. The tuning data available for this assessment comprise the beam trawl survey UK beam trawl survey, September and March cruise series, UK (E&W) beam trawl fleet (UK (E&W)BTF), UK (E&W) otter trawl fleet (UK (E&W)OTF), the Irish juvenile plaice survey (IR-JPS), the Irish Sea Celtic Sea groundfish survey (ISCS-GFS), and Irish otter trawl fleet (IR-OTF). Standardized cpue for the above fleets are demonstrated in Table 11.2.1. Details of surveys and commercial fleet tuning data are given in Appendices 1 and 2 of the 1998 report (ICES CM 1998: Assess1).

Similarly the Irish otter trawl fleet mainly targets *Nephrops*, however, vessels from this fleet do on occasion move into areas where plaice are abundant. Landings of plaice by this fleet have been approximately 15% of the total international landings and the Working Group considered that this fleet may provide a reliable index of abundance for plaice.

B.5. Tuning data evaluation

A thorough investigation of the utility of the different tuning indices available for this stock was conducted by the 2002 working group the results of which are summarized below:

Following an initial consideration of the appropriateness of each tuning fleet and its anticipated utility as an index of abundance, the tuning data from both commercial fleets and research surveys were evaluated externally to the assessment programme to test for internal and external consistency. These tests comprised plots of the effort corrected-mean standardized indices for each age; tests for cross correlation of ages between fleets and of ages within fleets and the results of single fleet SurBA (WD1) runs.

The Working Group considered that the Irish groundfish survey would not be appropriate to use in the assessment as it is designed principally for gadoids and would not be expected to provide a reliable index for flatfish stocks. Similarly the Irish otter trawl fleet mainly targets *Nephrops*, however, vessels from this fleet do on occasion move into areas where plaice are abundant. Landings of plaice by this fleet are approximately 15% of the total international landings and the working group considered that this fleet may provide a reliable index of abundance for plaice. For the period 1976 to 1990 the juvenile plaice survey had used a combined ALK. Serious concerns were expressed regarding the quality of the data for this period and it was decided that this series should be truncated to 1991.

The juvenile plaice survey stations are located along the coast of southeast Ireland between Dundalk Bay and Carnsore Point and there was some concern that this localized survey series would not be representative of the plaice population over the whole of the Irish Sea. Plots of the effort corrected-mean standardized indices for the juvenile plaice survey and the September beam trawl survey by age revealed some correspondence between the two series. It should be noted that recruitment over the past 13 years has been remarkably stable and there is very little contrast in year-class strengths for the period covered by the tuning fleets making cross comparisons difficult. The 1991 year class is clearly identified by the juvenile plaice survey at-ages 1, 2, 4, 5,and 6, suggesting good internal consistency for this fleet. This year class is also apparent, though to a lesser extent, in the September beam trawl survey-series. It was therefore decided that the juvenile plaice survey could be used as an appropriate index for the plaice population in the whole of the Irish Sea.

A test for cross correlation between fleets (following a test for autocorrelation) revealed significant results for the UK (E&W) beam trawl fleet and the UK (E&W) otter trawl fleet at-ages 1 to 4; for the juvenile plaice survey and the UK (E&W) otter trawl fleet at-age 6 and for the juvenile plaice survey and the September beam trawl survey at-age 5, indicating a consistent signal between these fleets at these ages. The lack of contrast in year-class strengths, mentioned above, and the short time-series of some fleets meant that it was difficult to identify consistent signals between fleets and resulted in very few significant tests for cross-correlation.

SurBA runs for the September beam trawl survey, the UK (E&W) beam trawl fleet and the UK (E&W) otter trawl fleet revealed fairly consistent results for predicted SSB and mean F. Results for the juvenile plaice survey demonstrated a much noisier pattern but were considered to conform sufficiently to the general trend. Although SurBA has been developed specifically for use with survey data, runs for the two commercial series were considered to be acceptable as the residual patterns over time did not demonstrate any apparent trends. This was not the case for the Irish otter trawl fleet and the results of SurBA runs for this fleet were not considered further.

Although it was difficult to derive any firm conclusions from individual tests, it was concluded from the overall body of evidence that in addition to the four fleets used last year, the juvenile plaice survey and the Irish otter trawl fleet should be considered as appropriate abundance indices for tuning the assessment.

C. Historical stock development

Model used: In most of the recent years XSA was the model used. The exception to this was 2005 when SURBA was used.

Model Options chosen since 2004:

Assessment Year	2004	2005	2006	2007	2008
Assessment Model	XSA	Surba	XSA	XSA	XSA
Fleets					
Bel Beam Trwl	1975–2003 4-9		omitted	omitted	omitted
UK Trawl	1991–2003 2-9		omitted	omitted	omitted
UK Sept BTS	1988–2003 2-9	1988-2004 1-9	1988–2005 2-7	1988-2006 2-7	1988-2007 2-7
UK Mar BTS	1993–1999 2-9		1993–1999 2-7	1993-1999 2-7	1993-1999 2-7
Time Ser. Wts	tricubic 20yrs		linear 20 yrs	linear 20 yrs	linear 20 yrs
Power Model	none		none	none	none
Q plateau	5		5	7	7
Shk se	0.8		1.5	1.5	1.5
Shk age-yr	5 yrs 5 ages		5 yrs 3 ages	5 yrs 3 ages	5 yrs 3 ages
Pop Shk se	0.3		0.3	0.3	0.3
Prior Wting	none		none	none	none
Plusgroup	10		8	8	8
Fbar	4-7		4-7	4-7	4-7

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1970–last data year	2–8+	Yes
Canum	Catch-at-age in numbers	1970–last data year	2–8+	Yes
Weca	Weight-at-age in the commercial catch	1970–last data year	2–8+	Yes/No-constant-at-age from 1960–1979
West	Weight-at-age of the spawning	1970–last data year	2–8+	Yes-but based on back caluclated
Mprop	Proportion of natural mortality	1970–last data year	2–8+	No-set to 0 for all ages in all years
Fprop	Proportion of fishing mortality	1970–last data year	2–8+	No-set to 0 for all ages in all years
Matprop	Proportion mature-at-age	1970–last data year	2–8+	No-the same give for all years
Natmor	Natural mortality	1970–last data year	2–8+	No-set to 0.2 for all ages in all

Tuning data used in the assessment:

TYPE	NAME	YEAR RANGE	AGE RANGE
Tuning fleet 1	UK beam trawl survey (September)	1989–last data year	2–7
Tuning fleet 2	UK beam trawl survey (March)	1993–1999	2–7

Note: Several other commercial tuning fleets and some other surveys have been used or made available in the past.

D. Short-term projection

Model used: Age structured deterministic projection

Software used: MFDP

Initial stock size. Taken from the XSA for ages 3 and older. The recruitment-at-age 2 in the last data year is estimated using RCT3. The long-term geometric mean recruitment (1970 to penultimate estimate) is used for age 2 in all projection years.

Natural mortality: Set to 0.2 for all ages in all years

Maturity: The same ogive as in the assessment is used for all years

F and M before spawning: Set to 0 for all ages in all years

Weight-at-age in the stock: Average weight of the three last years

Weight-at-age in the catch: Average weight of the three last years

Exploitation pattern: Average of the three last years, scaled by the Fbar (4–7) unscaled

Intermediate year assumptions: Status quo F

Stock recruitment model used: None, the long-term geometric mean recruitment-at-age 2 is used

Procedures used for splitting projected catches: Not relevant

E. Medium-term projections

Not carried out in recent years.

F. Yield and biomass-per-recruit/long-term projections

Model used: Age structured deterministic projection

Software used: MFYPR

Inputs as for STF

G. Biological reference points

	Type	Value	Technical basis
Precautionary approach	Blim	2200 t	Blim = Bloss The lowest observed spawning stock, followed by an increase in SSB.
	Bpa	3100 t	Bpa ~ Blim * 1.4. The minimum SSB required ensuring a high probability of maintaining SSB above its lowest observed value, taking into account the uncertainty of assessments.
	Flim	0.40	Flim = Floss. Although poorly defined, there is evidence that fishing mortality in excess of 0.4 has led to a general stock decline and is only sustainable during periods of above-average recruitment.
	Fpa	0.30	This F is considered to have a high probability of avoiding Flim.
Targets	Fy	Not defined.	

(changed in 2007, SSB estimates rescaled)

Annex 7.2: Stock Annex: Cod VII e–k

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Cod in VIIe–k (Celtic Sea cod)
Expert Group	Celtic Sea Working Group
Date	WGCSE 2009
Revised by	Robert Bellail

A. General

A.1. Stock definition

Since 1997, this assessment has related to the cod in Divisions VIIe–k, covering the Western Channel and the Celtic Sea. The area assessed has gradually increased from VIIfg before 1994 to VIIfgh, to VIIefgh in 1996 and finally to VIIe–k.

Up to 2008, the management area was set in Divisions VIIb–k, VIII, IX, X, and CECAF 34.1.1 which does not correspond to the area assessed.

In 1994, at the request of ACFM, the ICES Working Group on Southern Shelf Demersal Stocks (WGSSDS) studied the possible extension of the area assessed from VIIfg to VIIfgh. Examination of data from surveys and logbooks indicated a continuity of the distribution of VIIg cod into VIIh. Depending on the year, catches in Division VIIh represented 9–15% of the catches in VIIfg, with a coincidence of years of peak or low catches in both areas. Therefore, catches from VIIh were included in the assessment. In 1996, at the request of ACFM, WGSSDS studied the possible extension of the area assessed from VIIfgh to VIIefgh. The population dynamics parameters for VIIfgh and VIIe cod were examined and compared for the period 1988–1994, when independent tuning fleets, international catch-at-age, mean weights-at-age in the landings and in the stocks were available for both areas. Patterns of F were consistent between VIIe and VIIfgh in earlier years (1988–1990), and SSBs trends were similar in the period 1988–1992. The patterns of recruitments (age 1) were found to be fairly consistent through this period 1988–1994, though it cannot be assumed that this consistency was also valid in earlier years when catch-at-age were only available in Divisions VIIf, g, h. It was therefore decided to combine Western Channel Cod with the Celtic Sea Cod assessment for the years 1988–1995, but an independent assessment of Celtic sea Cod in VIIfgh was maintained for the longer period available 1971–1995. This was to allow scaling of the historical (1971–1987) SSBs and recruitments values from VIIfgh to VIIe–h.

At WGSSDS 1997, because of the lack of a long independent series of catch-at-age in Divisions VIIj,k, the estimate of landings from Divisions VIIjk was discussed and it was decided to combine the data of Divisions VIIe,f,g,h and Divisions VIIjk for the period 1993–1996 and to raise the data in Divisions VIIe–h to landings in Divisions VIIe–k for the period 1988–1992. The results of an XSA assessment of this series in Divisions VIIe–k for 1988–1996 had been compared with the results of the assessment in Divisions VIIe–h for trends of F, SSB and recruitment. Patterns of these parameters were found very similar and the merging of Divisions VIIjk with Divisions VIIe–h mainly resulted in a scaling upwards of SSB and recruitment. The new assessment areas comprised cod in Divisions VIIe–k.

At the 1999 WGSSDS meeting, an alternative procedure to the tedious re-scaling of SSB and recruitment of the earlier series 1971–1987 in VIIfgh to VIIe–k every year was proposed (Bellail, 1999, WD3). A long series of landings data from 1971–1987 was reconstructed. An average raising factor (1.24) from VIIfgh to VIIe–k in the period 1988–1997 was applied to VIIfgh landings of the series 1971–1987. Results of assessment for SSB and R were very close to those obtained when these parameters were scaled. ACFM accepted this procedure.

In the past few biological criteria have been used to justify the widening the stock area. However, recent tagging work by Ireland and the UK supports the idea that there is a resident stock in the Celtic Sea and Western Channel (VIIe–k) and mixing with other areas appears to be minimal. The Irish Sea front, running from SE Ireland (Carnsore point) to the Welsh Coast, appears to act as boundary between the Irish Sea and Celtic Sea stock. Juveniles found close to the SE Irish Coast (south of VIIa) are considered part of the Celtic Sea stock.

Migrations are known to occur in this cod stock. Cod can be caught throughout the English Channel (ICES areas VIId and VIIe) in autumn (quarter 4) and winter (quarter 1), being more aggregated during the spawning season in January/February. Electronic tagging experiments in the English Channel (VIId and VIIe) have demonstrated that cod tagged on or close to English Channel spawning grounds in quarters 4 and 1 either remain close to the point of release (residency), or move to feeding grounds to the south and/ or west. Smaller fish (<50 cm) are more likely to be resident. Migrants tend to move offshore to deeper areas, whereas the habitat selection of residents is less clearcut.

In the light of the migratory phenotypes identified by electronic tagging, historical mark-recapture experiments can be re-evaluated. Although sample size is limited, results from data on the movements of adult cod (>50 cm) demonstrate that, after tagging in VIIe (the western Channel) in quarters 1 and 4, 47% of cod (27 of 58) are recaptured in ICES Areas VIIf through VIIj, while 48% are recaptured in VIIe (i.e. are probably resident). In contrast, no adult cod tagged in VIId were recaptured in ICES Areas VIIf through VIIj, 5% moved into VIIe and 51% remain in VIId. Juvenile cod are more likely to be recaptured in the same area that they were tagged in. These figures vary slightly when recaptures are separated into autumn/winter and spring/summer seasons, but are broadly comparable. The data therefore provide evidence that cod in the eastern English Channel and western English Channel might be classed as separate substocks, and that movement of cod between eastern English Channel and the Celtic Sea is limited, whereas movement between the western Channel and the Celtic Sea is frequent.

A.2. Fishery

Cod in Divisions VIIe–k are mainly taken as components of catches in mixed demersal trawl fisheries with a minor part by gillnets. Landings are made throughout the year but are generally more abundant during the first semester. Constraining TACs set since 2003 and the impact of the Trevose Head Closure applied since 2005 have led the landings to spread across the first-3 quarters of the year.

WGSSDS has been collating a database of landings and effort for the Celtic Sea. Available data on cod landings are analysed and presented. Effort data are not yet fully available for similar investigations. Recent temporal and spatial patterns in landings distributions for the main fleets catching Celtic Sea Cod are shown in Figure A.2.1 and Figure A.2.2. Highest landings are in quarter 1 when the cod aggregate to spawn. There is an indication that Q1 landings have declined in 2006 and 2007 as a result of the closure of a known spawning area at Trevose Head, although this was not the case in 2005 the first year of introduction of the closure. In most years there is a distinct peak in landings in February or March. The scale of this peak may be related to the relative strength of age 2 fish entering the fishery. The majority of the landings come from VIIg, ~55%, and the relative contributions of different ICES Divisions to the landings has been fairly stable over recent years. In 2002 there were larger than normal landings from rectangle 30E4 in VIIf.

The majority of the landings are made by demersal trawls targeting roundfish (i.e. cod, haddock and whiting), although, in recent years an increasing component have been from gillnets and otter trawls targeting *Nephrops* and benthic species.

A.3. Ecosystem aspects

No environmental drivers are known for this stock.

B. Data

B.1. Commercial catch

Landings

On a quarterly basis, France and UK (E+W) have provided catch numbers-at-age and catch weights-at-age for their landings. Ireland has provided with the same data in Divisions VIIg and j separately and estimates of misreporting in VIIg. Landings only are available for Belgium.

Irish data are first aggregated to the landings in VIIe–k then both datasets for France, UK and Ireland are added and raised to international landings taking into account Belgian data. Then the quarterly datasets are summed up to the annual values.

As a consequence of an update to the French database of landings statistics, some minor revisions (downward) have been applied since 2002 and the updated datasets for international landings.

Nothing is hidden in the aggregating procedure but the level of available data has changed and consequently the aggregation procedures. Compiling the previous reports of the WGSSDS and before the reports of the WGIRCS demonstrate the following datasets available and the history of the aggregation procedures to produce the landings numbers-at-age series:

YEAR RANGE	LANDINGS VIIE–K	LENGTH STRUCTURE (LS) VIIE–K	AGE STRUCTURE (AS) VIIE–K
1971–1976	Annual VIIfgh expanded to Annual VIIe–k using the mean landings VIIe–k 1988–1997 over the mean landings VIIfgh 1988–1997 as a ratio	UK VII fg raised to international landings in VIIfg	UK alks VIIa to UK Ls VIIfg then UK VIIfg As raised to international landings
1977–1980		UK VIIfg + FRVIIfg raised to international landings in VIIfg	UK alks VIIa to UK Ls VIIfg and FR Ls VIIfg then As summed and raised to international landings
1981–1987		UK VIIfg FR VIIfg raised to VIIfgh	FR alks VIIfg to UK&FR Ls VIIfg then As summed and raised to international landings

1988–1989	UK VIIfg UK VIIe FR VIIfg raised to VIIfgh	FR alks VIIfg to FR Ls UK alks VIIfg to UK Ls UK alks VIIe to UK Ls then As summed and raised to international landings
1990	UK VIIfg UK VIIe FR VIIfg raised to VIIfgh IR VIIg	FR alks VIIfg to FR Ls UK alks VIIfg to UK Ls UK alks VIIe to UK Ls IR alks VIIg to IR Ls then As summed and raised to international landings
1991–98	UK VIIfg UK VIIe FR VIIfg raised to VIIfgh IR VIIg IR VIIj annual	FR alks VIIfg to FR Ls UK alks VIIfg to UK Ls UK alks VIIe to UK Ls IR alk VIIg to IR VIIg Ls IR alk VIIj to IR VIIj Ls then sum of As VIIg or VIIfg raised to VIIfgh international, As UK VIIe raised to VIIe international, As IR VIIj raised to VIIjk international landings, (VIIfgh internat+ VIIe internat + VIIjk internat) = VIIek
1999–2001	UK VIIfg UK VIIe FR VIIfg raised to VIIfgh IR VIIg IR VIIj quarterly	FR alks VIIfgh to FR Ls UK alks VIIfg to UK Ls UK alks VIIe to UK Ls IR alk VIIg to IR VIIg Ls IR alk VIIj to IR VIIj Ls then sum of As VIIg or VIIfg raised to VIIfgh international, As UK VIIe raised to VIIe international, As IR VIIj raised to VIIjk international landings, (VIIfgh internat+ VIIe internat + VIIjk internat) = VIIek
2002–2008	FR-VIIe–k UK VIIe–k IR VIIg IR VIIj	FR alks VIIfgh to FR Ls UK alks VIIfg to UK Ls UK alks VIIe to UK Ls IR alk VIIg to IR VIIg Ls IR alk VIIj to IR VIIj Ls Then sum As UK raised to UK landings in VIIe-k, Sum As IR raised to IR landings in VIIe-k, Then AsUK+As IR+ As FR raised to international landings

At each step of the aggregations, mean weight-at-age is the weighted mean by numbers-at-age.

Discards

Discards data sampled under EU/DCR since 2003 have been generally presented in previous WGSSDS but not used in the assessments as they do not cover all the main fleets and quarters yet.

As a consequence of the annual management system adopted by the French POs since 2003 in response to the quota restrictions, highgrading has occurred in the French fishery, mainly in VIIfgh. On an annual basis, a procedure using both the UK and French landings length data allowed estimation of the French highgrading for the years 2003–2005 (WD 1 WGSSDS 2006). The adjustments were reapplied to improved estimates of French landings from 2003 at the ICES WKROUND 2009. This procedure could not be used in further years as highgrading has also occurred in that years. Datasets of highgrading used at WGCSE are displayed in tables below.

International VIIe-k	2003				tonnes	COD	
Landings	Q1	Q2	Q3	Q4	Total	T live weight	calculated 16 dec 2008
UK	122.734	107.236	61.847	54.359	346.176		updated 07/06/05
Irlande	203.623	154.198	86.521	73.043	517.385		updated 07/06/05
France	2039.9	1519.3	1221.7	441	5221.9		updated 23/04/07
Belgium	134.977	0.052	0.291	0.592	135.912		
Total	2501.23408	1780.786181	1370.358912	568.9938268	6221.373		

high grading VIIe-k
du fichier
fr VII fgh 2003 21 mai 2007 highgrading incorporé.xls

Fr highgrading VII e-k

Age	Quarter 1 Numbers	Quarter 1 Weight (kg)	Quarter 2 Numbers	Quarter 2 Weight (kg)	Quarter 3 Numbers	Quarter 3 Weight (kg)	Quarter 4 Numbers	Quarter 4 Weight (kg)	Year 2003 Numbers	Year 2003 Weight (kg)	Year 2003 Numbers	Year 2003 Weight (kg)	Year 2003 Numbers	Year 2003 Weight (kg)
0	0		0		0		0		0					
1	191	0.482	2445	0.368	41069	0.858	23184	0.863	66890	0.841	36320	0.977	103210	0.889
2	55899	1.327	117018	1.829	184883	2.000	68899	3.089	426698	2.041	129043	1.194	555741	1.844
3	380578	4.111	246167	4.201	153930	4.538	40286	5.701	820960	4.296	6427	1.498	827387	4.274
4	112512	6.601	65203	6.647	30561	6.462	9085	8.301	217361	6.667			217361	6.667
5	6246	9.183	4404	9.548	2305	9.442	1643	10.712	14599	9.506			14599	9.506
6	4075	10.635	2891	11.566	1283	10.920	788	11.675	9037	11.064			9037	11.064
7	1284	12.047	1324	11.866	2790	12.035	337	12.731	5734	12.040			5734	12.040
8	226	15.832	521	11.432	0		0		747	12.762			747	12.762
9	0		97	11.139	0		0		97	11.139			97	11.139
10	0		0		0				0				0	
Tot	561011		440069		416820		144222		1562123		171790		1733913	
SOP		2501.23408		1780.786181		1370.358912		568.9938268		6221.373		199.157		6420.529912
Landings	2501.23408		1780.786181		1370.358912		568.9938268		6221.373	1.000000	199.157		6420.530	1.000000

International VIIe-k	2004				tonnes	COD	
Landings	Q1	Q2	Q3	Q4	Total	T live weight	
UK	90.224	61.895	54.068	76.086	282.273		updated 08/06/05
Irlande	204.5	181.1	146.7	130.8	663.124964		**updated15/12/2008**
France	947.6	628.2	529.7	318.9	2424.4		updated 05/04/07 marees agreg Harmonie, no change
Belgium	117.995	17.903	6.878	10.653	153.429		updated 08/06/05
Total	1360.311136	889.075251	737.38247	536.458107	3523.226964		

Highgrading t VII e-k FR =
voir fichier
fr VII fgh 04 rev 22 mai 07 highgrading incorporé.xls

Highgrading Fr VII e-k

VII e-k internat

Age	Quarter 1 Numbers	Quarter 1 Weight (kg)	Quarter 2 Numbers	Quarter 2 Weight (kg)	Quarter 3 Numbers	Quarter 3 Weight (kg)	Quarter 4 Numbers	Quarter 4 Weight (kg)	Year 2004 Numbers	Year 2004 Weight (kg)	Year 2004 Numbers	Year 2004 Weight (kg)	Year 2004 Numbers	Year 2004 Weight (kg)
0	0		0		0		0		0					
1	6349	0.591	21568	0.653	104213	0.730	83832	1.054	215963	0.844	124725	0.954	340688	0.884
2	76605	1.258	81975	2.139	77196	2.774	41041	3.274	276817	2.241	20792	1.333	297609	2.177
3	40993	4.053	58060	4.363	50346	4.754	24067	5.515	173466	4.563	1162	1.442	174628	4.543
4	96862	6.759	38111	7.078	16715	7.841	16345	8.137	168032	7.073			168032	7.073
5	33909	9.372	14538	9.411	6377	9.447	3797	10.066	58622	9.435			58622	9.435
6	4713	10.158	2119	11.734	1177	10.729	442	13.395	8451	10.802			8451	10.802
7	3023	11.680	245	11.059	292	13.092	259	15.182	3818	11.985			3818	11.985
8	2732	13.850	548	15.433	0		0		3281	14.115			3281	14.115
9	0		0		0		0		0				0	
10	0		301	12.468	0		0		301	12.468			301	
Tot	265186		217465		256316		169784		908751		146679	148388	1055430	3667.424715
SOP		1359.710284		889.1393975		737.4084899		536.5371543		3522.795326				
Landings	1360.311136		889.075251		737.38247		536.458107		3523.226964	0.999877				

International VIIe-k		2005				tonnes	COD	UK VII ek + IRL VIIe-k+	Calcul Hg VII e-k
Landings	Q1	Q2	Q3	Q4	Total	live weight		FR VIIe-k raised to	voir fichier
UK	86.713	62.739	84.188	75.310	308.95		updated 01/06/07	Internat VII e-k	fr VII fgh 05 rev 11 dec 2008 high grading input.xls
Irlande	236.48	295.69	169.19	168.81	870.177		updated 15/06/07		
France	317.6	457.3	502	346.2	1623.1		**updated 12/12/2008**		
Belgium	108.941	48.332	10.995	17.631	185.899		updated 06/06/06, no revision in 2007		
Total	**749.737**	**864.063**	**766.371**	**607.955**	**2988.126**				
Total (pb jk)									

											Highgrading Fr VII e-k		VII ek international Fr high grading added	
	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Year 2005		Year 2005		Year 2005	
Age	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)
0									0					
1	7080	0.588	30135	0.606	92223	0.745	123814	0.831	253252	0.766	41718	0.833	294970	0.776
2	136862	1.688	222355	1.861	158785	2.491	108930	3.007	626932	2.182	37470	1.049	664402	2.118
3	57144	4.075	53852	3.218	16671	4.579	10524	5.452	138192	3.907			138192	3.907
4	15613	5.945	17600	4.611	12203	7.537	6460	8.366	51876	6.168			51876	6.168
5	15574	9.018	15946	8.730	8514	9.635	4580	10.590	44614	9.194			44614	9.194
6	4018	11.333	2652	11.752	3413	11.578	1071	11.716	11154	11.544			11154	11.544
7	244	11.487	779	8.611	792	10.944	139	10.308	1954	10.037			1954	10.037
8	12	9.105	35	9.107	3	9.097	162	13.772	212	12.657			212	12.657
9	0		0		228	15.550	130	10.841	358	13.835			358	13.835
10	0		0		0		0		0				0	
Tot	236547		343354		292832		255811		1128544		79188		1207732	
SOP		749.7352977		864.0631444		766.3723535		607.9554279		2988.126224		74.049		3062.175
Landings	749.7		864.1		766.4		608.0		2988.1	1.000000	74.049		3062.2	

In 2008 the French self sampling programme on Celtic Sea cod has produced datasets allowing estimation of discarding and highgrading rates on a quarterly basis. Assuming the same pattern of discarding in recent years, estimates of French discarding and highgrading back to 2006 were also computed. Estimates of highgrading were also calculated for the French tuning fleets used in the analysis (ICES WKROUND, 2009, *WD 17)*. Since the WKROUND, the database of the 2008 self sampling has increased and led to a slight update of the estimates of the level of French highgrading. Datasets of highgrading used at WGCSE 2009 are displayed in tables below.

FR high grading (see file HG FR 2006.xls)					computed 6 jan 2009					
	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Year 2006	
Age	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)
0									0	
1			28904	0.815	141105	0.738	40750	0.820	210758	0.764
2	69340	0.975	96098	1.257	42829	1.365	11891	2.443	220159	1.253
3	67	2.971	20	2.956			1701	6.505	1787	6.334
4							252	7.741	252	7.741
5									0	
6									0	
7									0	
8									0	
9									0	
10									0	
Tot	69407		125022		183934		54593		432956	
SOP		67.801		144.405		162.554		75.487		450.247
Landings (T)	67.800		144.400		162.500		75.500		450.200	1.000

FR high grading (see file HG FR 2007.xls)			computed 13 jan 2009							
	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Year 2007	
Age	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)
0									0	
1			34957	0.690	142002	0.728	39471	0.836	216430	0.742
2	76339	0.972	199517	1.223	50733	1.295	9517	2.583	336106	1.216
3	864	1.373	3148	2.008	1852	1.538	1444	6.121	7308	2.626
4							510	7.855	510	7.855
5									0	
6									0	
7									0	
8									0	
9									0	
10									0	
Tot	77202		237622		194588		50942		560354	
SOP		75.4		274.5		172.0		70.4		592.3
Landings (T)	75.4		274.5		172.0		70.4		592.3	1.000

FR high grading (see file HG FR 2008.xls)			computed 15 avril 2009							
	Quarter 1		Quarter 2		Quarter 3		Quarter 4		0	
Age	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)	Numbers	Weight (kg)
0									0	
1			24408	0.752	18557	0.706	28402	0.820	71368	0.767
2	74523	0.974	129272	1.227	7613	1.318	5974	2.544	217382	1.179
3	170	2.449	560	2.105	0	0.000	951	6.097	1681	4.398
4							481	6.817	481	6.817
5									0	
6									0	
7									0	
8									0	
9									0	
10									0	
Tot	74693		154240		26170		35809		290912	
SOP		73.0		178.2		23.1		47.6		321.8
Landings (T)	73.0		178.2		23.1		47.6		321.8	1.000

Lpue

The Table below summarizes the available data.

Name	Area	Series
FR gadoid fleet [1]	VIIfgh	1983–2007
FR Nephrops fleet [1]	VIIfgh	1983–2007
FR otter trawlers [2]	VIIe	1983–2007
FR otter trawlers [2]	VIIfgh	1983–2007
FR otter trawlers [2]	VIIe-k	1983–2007
UK otter trawlers	VIIe	1972–2007
UK otter trawlers	VIIe-k	1972–2007
UK beam trawlers	VIIe-k	1978–2007
IR otter trawlers	VIIg	1995–2007
IR beam trawlers	VIIg	1995–2007
IR Scottish seiners	VIIg	1995–2007
IR otter trawlers	VIIj	1995–2007
IR beam trawlers	VIIj	1995–2007
IR Scottish seiners	VIIj	1995–2007

[1] **For Q2+3+4 for consistency with the Trevose Head Closure since 2005 during the first quarter.**

[2] **Annual values, including the Fr gadoid and *Nephrops* fleets.**

B.2. Biological

Weights-at-age

At the 1999 WGSSDS, data for the years 1971–1980 were set to the average 1981–1997. A revision was carried out at 2001 WGSSDS where the values for the period 1971–1980 were set to the average values 1981–2000. Depending on the annual datasets available by country for the period 1988–2001, catch weights-at-age data were calculated as the weighted means from French, Irish and UK datasets. Since 2002, VIIe–k catch weights-at-age have been calculated as the annual weighted means of French, Irish and UK datasets in VIIe–k.

Stock weights-at-age are the catch weight-at-age data from the 1st quarter.

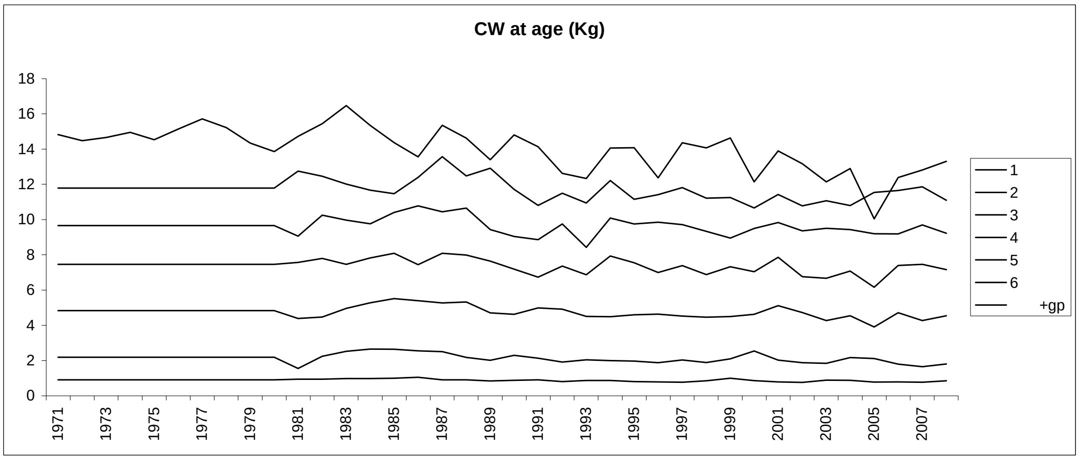

Figure B.1.1. Cod in VIIe–k. Series of mean weights-at-age in the catch (landings). The decreasing trend at-age 7+ is as a consequence of both the lower catch numbers in this component and the variable proportion from year to year of the oldest true age groups in the + group. In 2005, only Irish datasets provided with this age group in a large amount during the 1st quarter with low mean weight. Values 71-80= average value 1981–2000.

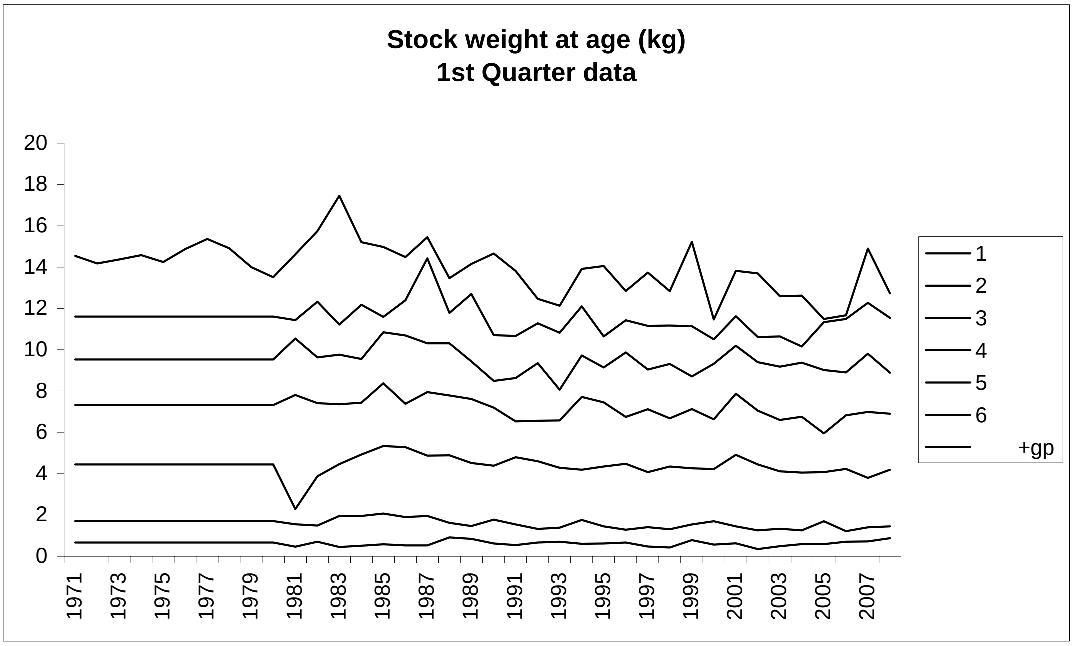

Figure B.1.2. Cod in VIIe–k. Mean weights-at-age in the stock (1st quarter value of landings-at-age).

Maturity

The maturity ogive applied since 1999, was estimated from the datasets of the UK-WCGFS survey (1st quarter) has been used for the overall series. It replaced an assumed ogive used for the year prior to 1999, derived from Irish Sea cod data, when both stocks (VIIa and VIIfg) were assessed in the Irish Sea and Bristol Channel WG up to 1992. Table below summarizes the maturity ogives used.

Age	1	2	3	4	5+
Before 1999	0.00	0.05	1.00	1.00	1.00
Current	0.00	0.39	0.87	0.93	1.00

Natural mortality

In the assessments, natural mortality is assumed to be constant (M=0.2) for the whole range of years and ages.

B.3. Surveys

Three surveys-series are available. The common range of ages used is 1–5:

The discontinued UK-WCGFS (1986–2004), conducted during the first quarter, is generally truncated into a shorter series (1992–2004) as it demonstrated a strong trend (dome-shaped) when using the full series. This pattern is related to the progressive extension of the studied area of this survey from VIIe to VIIefgh over the years. This time-series only contributes to the estimates at older ages (4 and older). As a consequence of the lack of new data the series is no longer used for calibration.

The FR-EVHOE survey (1997–2008), during the 4th quarter, covers the Divisions VIIfghj. The full series is used.

The IrGFS survey (2003–2008), during the 4th quarter, in VIIg and VIIj is also used in the assessment. It is the main contributor to the terminal year estimates, partly because this series is short.

The absolute numbers of cods caught in all of these surveys are extremely low.

B.4. Commercial cpue

Two French commercial fleets are used for tuning: the French trawlers targeting Gadoids in Divisions VIIf, g, h (FR-GADOIDS) and the French *Nephrops* trawlers in VIIf,g,h (FR-*NEPHROPS*), for which cod is generally a bycatch. Both fleets account on average for ~30% of the international landings from 1988; the series starts in 1983. Other commercial fleets used are the English West Coast otter trawlers (UK-WECOT) in VIIe from 1988 and the Irish 7J otter trawlers (IR-7J-OT) in VIIj from 1995. Both fleets fish throughout the majority of the assessed area.

B.5. Other relevant data

Input from industry

No new datasets.

C. Historical stock development

Model used:

The Separable VPA was used at the former Irish Sea and Bristol Channel WG and the Laurec-Shepherd model in the period 1987–1992. The XSA was the model used subsequently. SURBA was also used for survey catch-at-age analysis in 2005–2007.

Corrections for some misreporting estimates have been input to the datasets used in the assessment but the change of discarding practices to manage the restricting national quotas may affect the assessment. This also affects the reliability of the commercial tuning fleets used.

In previous assessments (2006, 2007 and 2008), adding the new year's data has generally raised the stock numbers at younger ages (age 1 and 2) resulting in increased estimates of recruitment strength. These upwards revisions are considered a result of the recent highgrading practices. Given this uncertainty and the recent reports from the industry of underreporting the XSA assessment, which assumes unbiased catch data cannot be applied. Improved datasets on landings, recorded and highgrading are required before XSA could be used.

WKROUND 2009 evaluated XSA with adjusted recent catch levels against B-Adapt and the SAM state-space model, which estimate additional unallocated mortality. All models exhibited different patterns in the recent years with a high degree of uncertainty. The group concluded that no model could be recommended as a basis for providing advice on recent stock trends until further investigations or additional datasets were available to resolve the situation.

D. Short-term projection

No decision has been taken on the forecast methodology.

E. Sensitivity analysis and medium-term projections

Medium-term forecasts are not provided for this stock.

F. Long-term projections

Long-term forecasts are not provided for this stock.

G. Biological reference points

Reference points

	Type	Value	Technical basis
Precautionary approach	B_{lim}	6 300 t	$B_{lim} = B_{loss}$.(B76), the lowest observed spawning-stock biomass.
	B_{pa}	8 800 t	$B_{pa} = B_{lim}$ * 1.4. Biomass above this value affords a high probability of maintaining SSB above B_{lim}, taking into account the variability in the stock dynamics and the uncertainty in assessments.
	F_{lim}	0.90	The fishing mortality estimated to lead to potential collapse.
	F_{pa}	0.68	F_{pa} = 5th percentile of F_{loss}. This F is considered to have a high probability of avoiding F_{lim} and maintaining SSB above B_{pa} in the medium term (assuming normal recruitment), taking into account the uncertainty assessments.
Targets	F_y	Not defined.	

(unchanged since: 2004)

Because of the current uncertainties on the state of this stock, the Benchmark WK is unable to make new proposals for the Reference Points and the 2004 values remain.

H. Other issues

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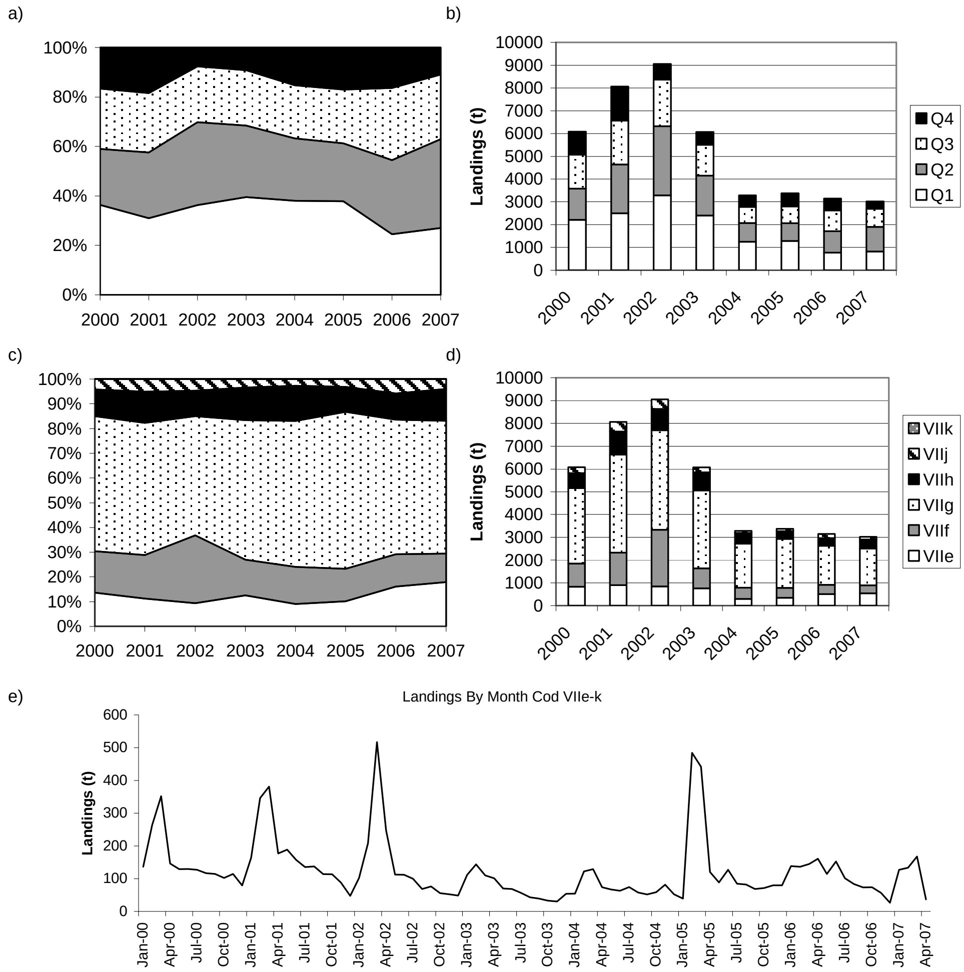
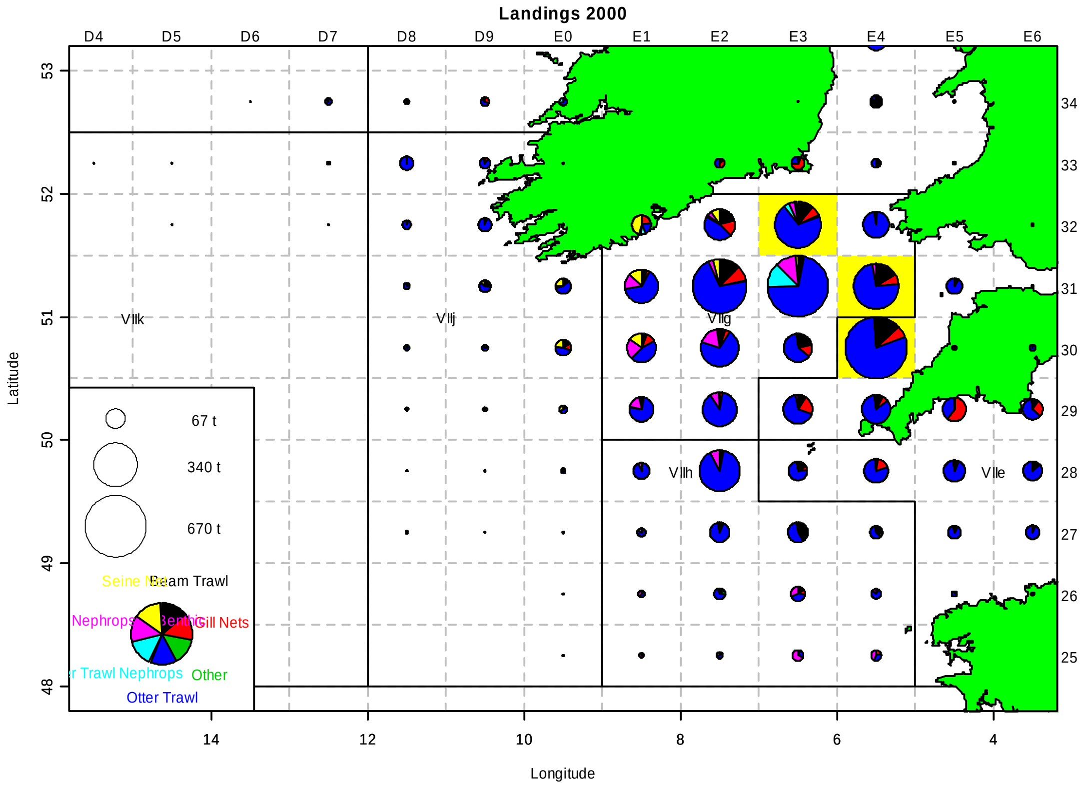


Figure A.2.1 Temporal and spatial patterns in landings patterns for Celtic Sea Cod (VIIe–k).



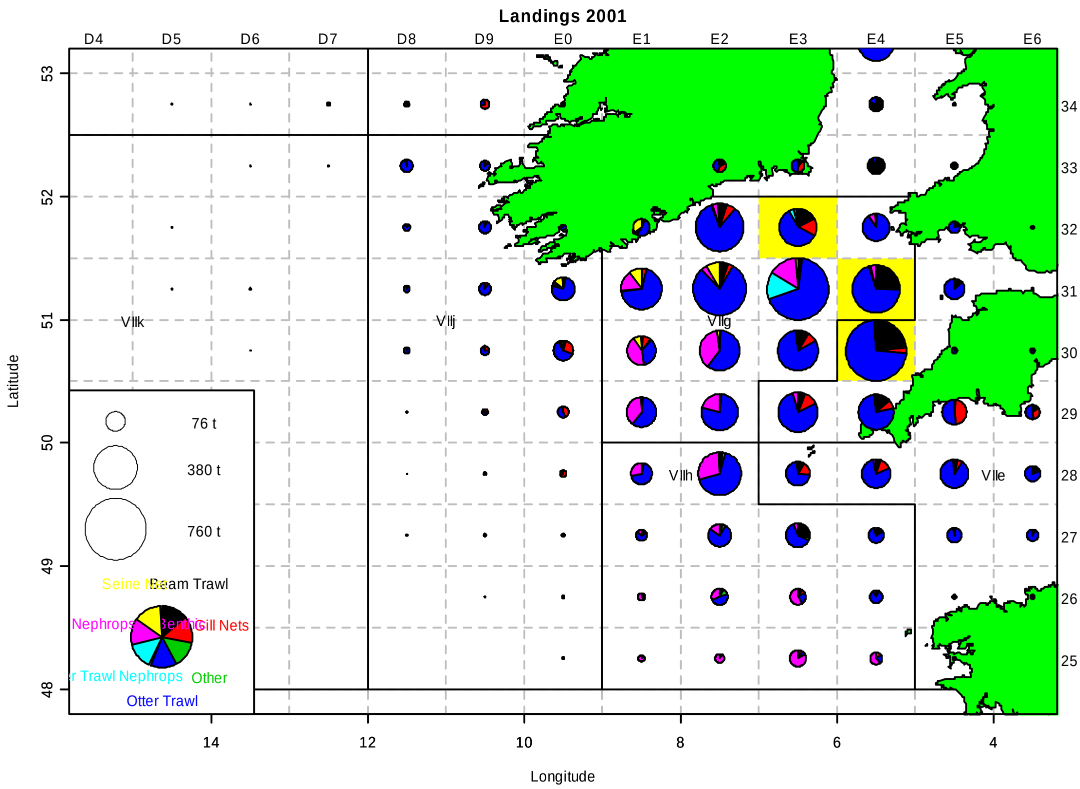
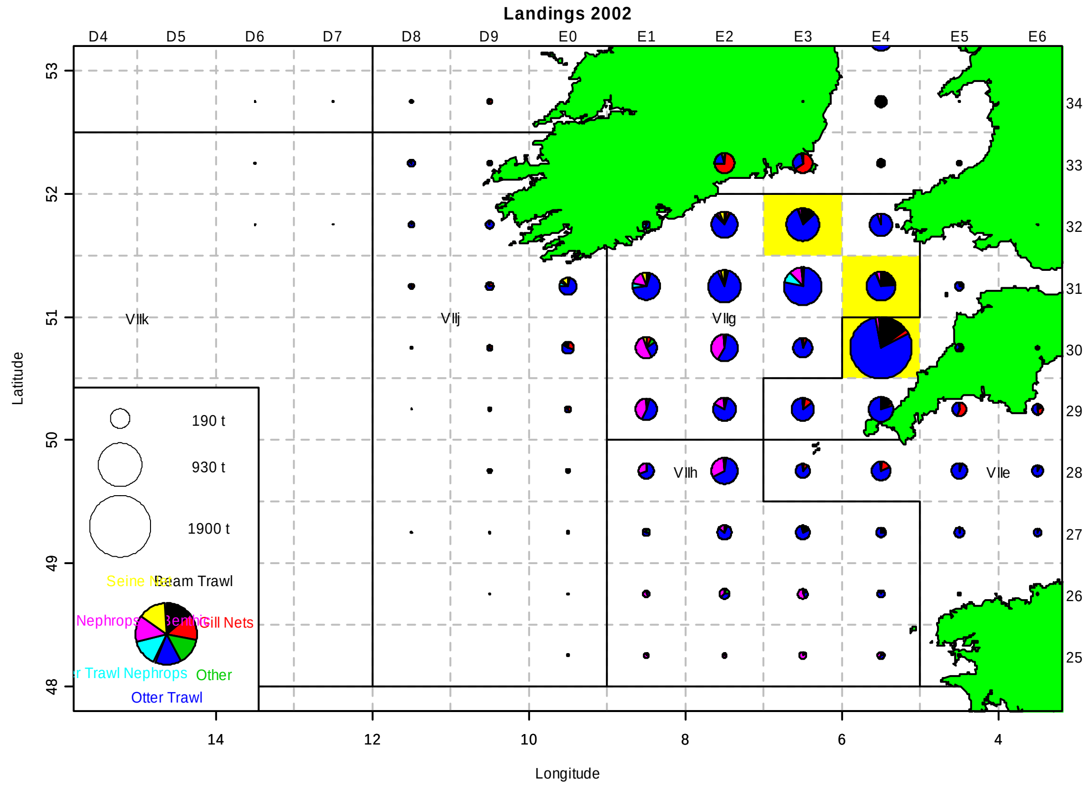


Figure A.2.2. The spatial and temporal distribution of Cod landings from the Celtic Sea, from 2000–2007 by gear type. The Closed rectangles are highlighted in yellow. Each year is scaled to, the maximum.



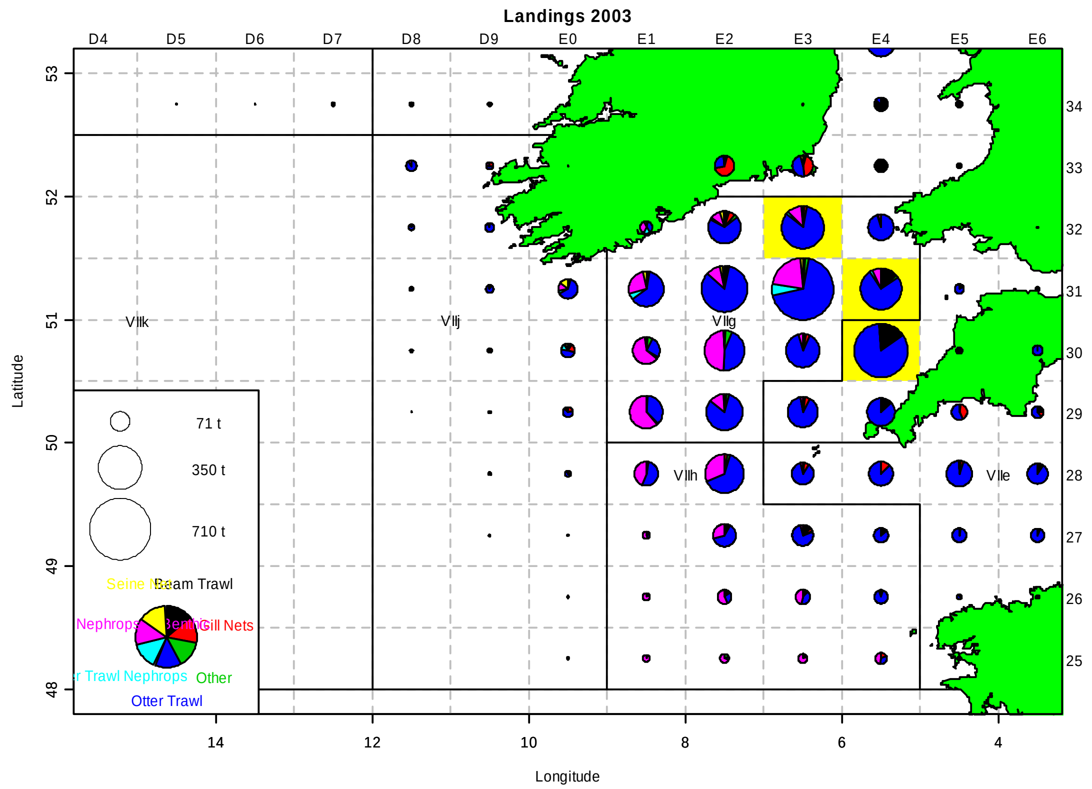
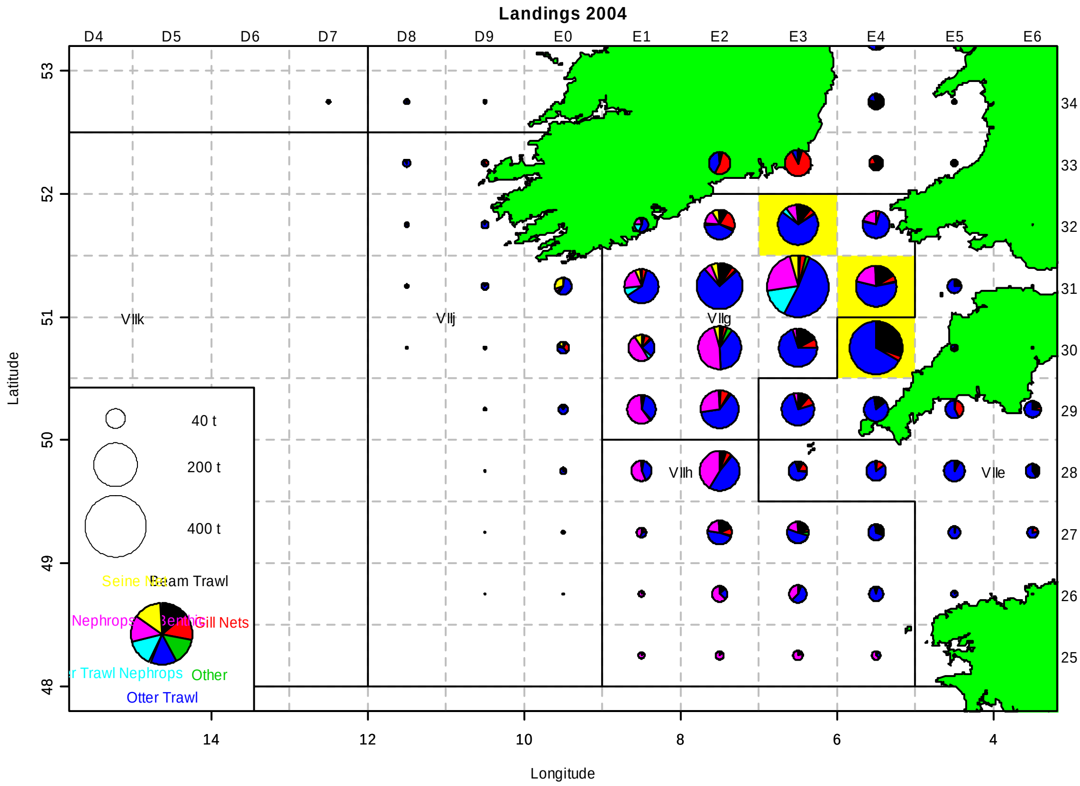


Figure A.2.2. continued.



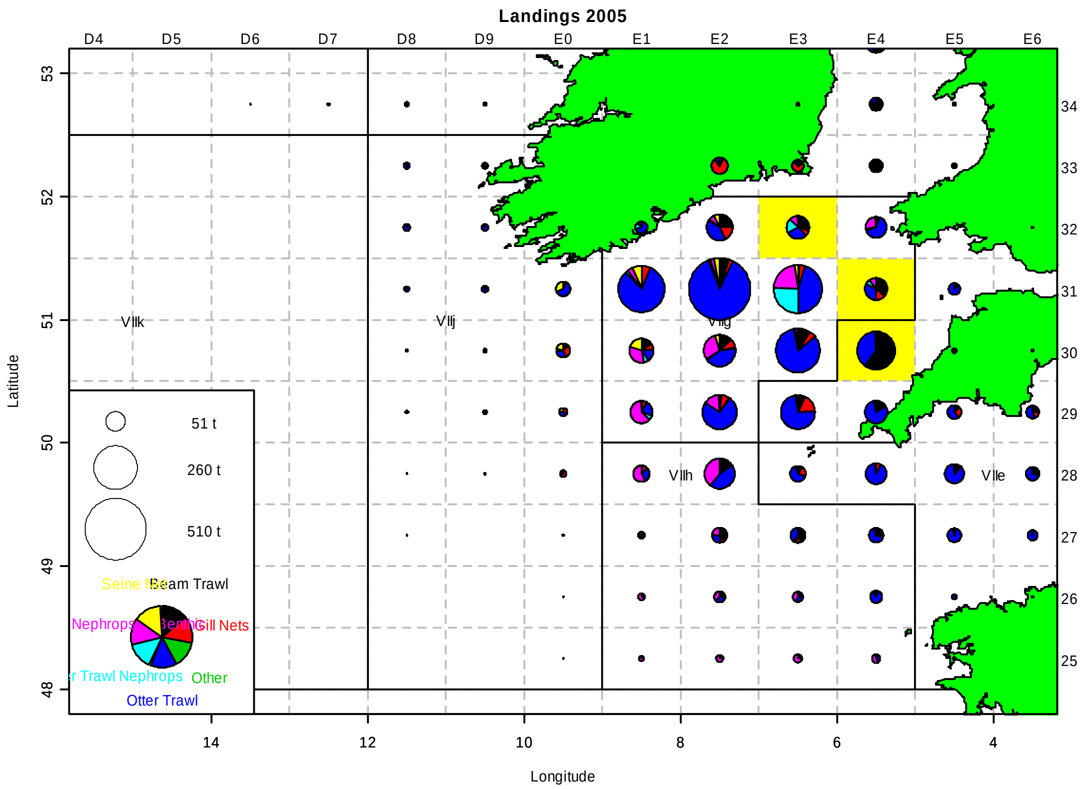
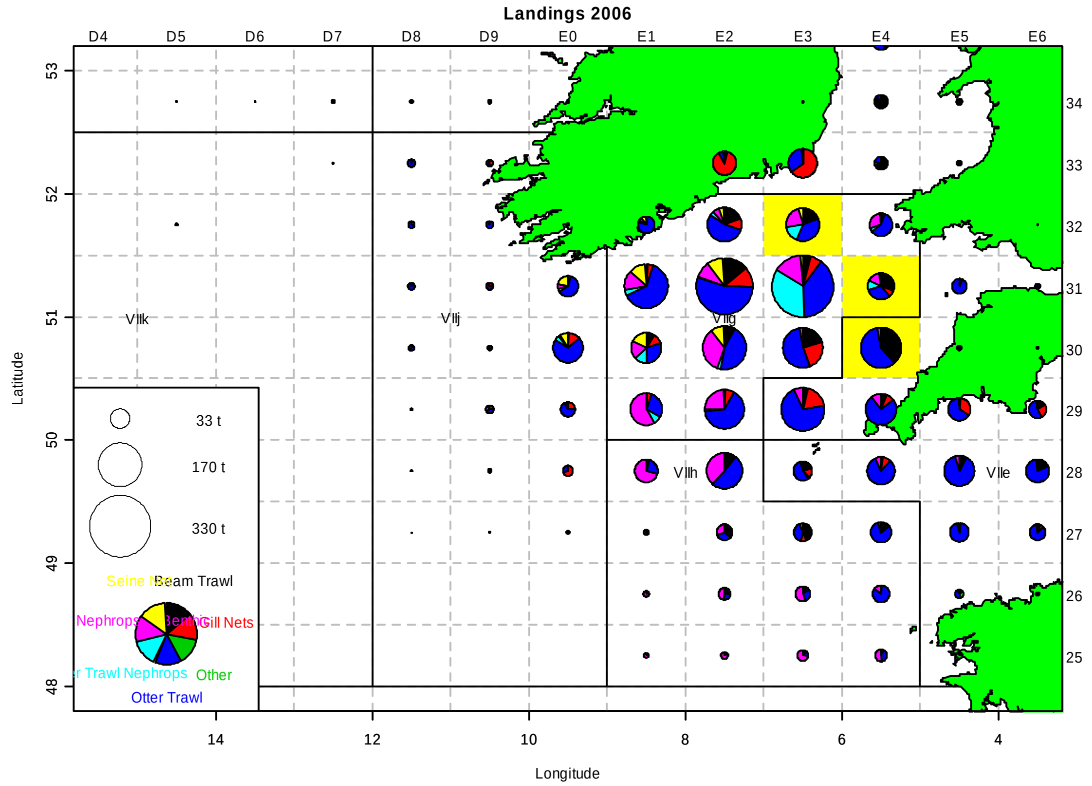


Figure A.2.2. continued.



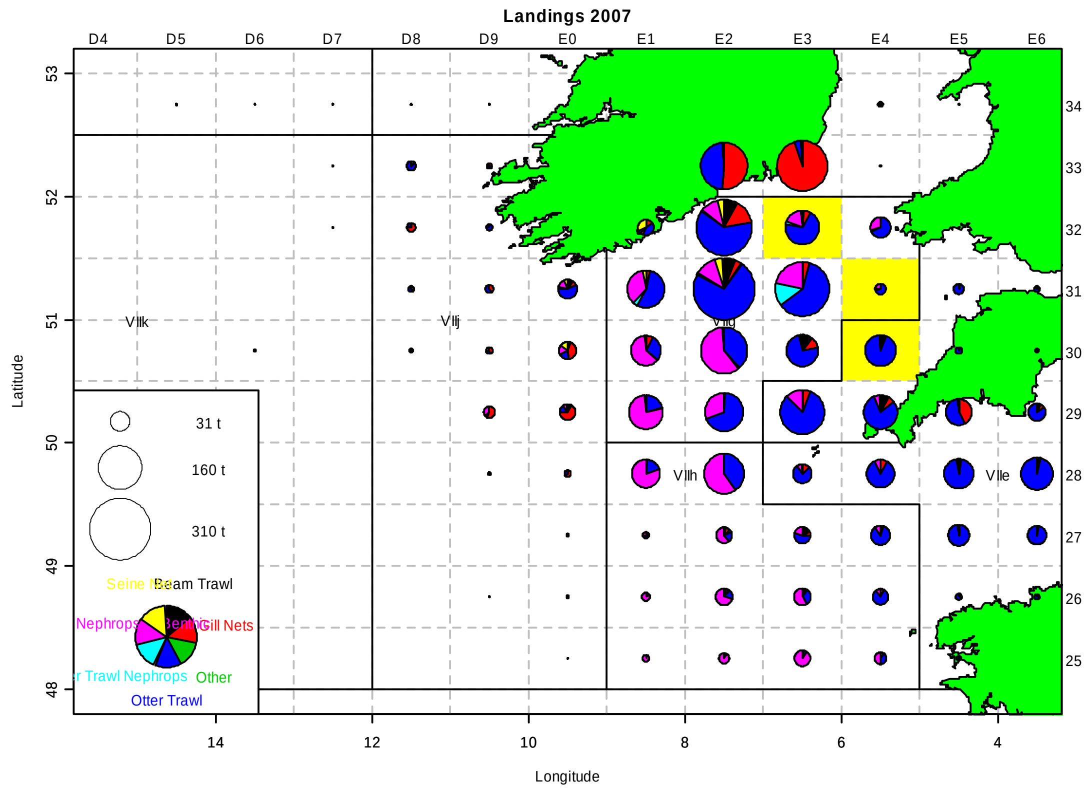


Figure A.2.2. continued.

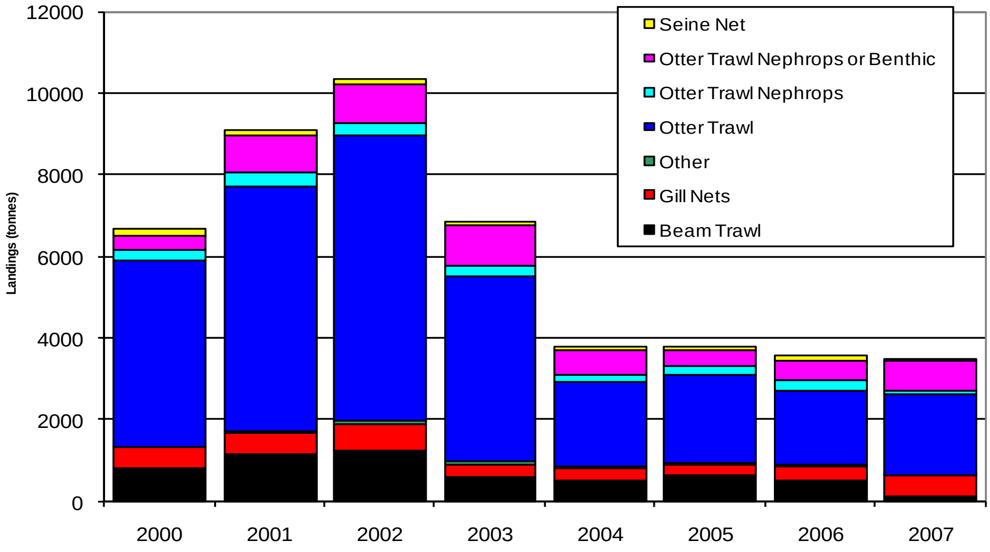


Figure A.2.2. continued.

Annex 7.4: Quality Handbook: Stock Annex Haddock VIIb–k

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Haddock VIIb–k
Working Group:	WGCSE
Date:	last revision 13/05/09
Revised by	Hans Gerritsen

A. General

A.1. Stock definition

For assessment purposes, the stock is defined as VIIb–k excluding VIId. The TAC for haddock is set for VIIb–k, VIII, IX and X. However, official international landings from VIII, IX and X have been less than 2% of all landings in the TAC area in most years since 1973.

Adult haddock appear to be continuously distributed from the north of Biscay along the Irish coasts and the west of Scotland into the North Sea. It is not clear from their distribution if the VIIb–k stock is distinct from the surrounding areas. Irish Otter trawl lpue in the northernmost rectangles of VIIb is relatively high and similar lpue continues into VIa, suggesting that the haddock in the north of VIIb might belong to the same stock as those in VIa (Gerritsen, 2009). The pattern of lpue in the Irish Sea appears to be relatively distinct from VIIb–k with relatively high otter and beam trawl lpue in VIIg, low lpue in VIIa-South and high lpue in VIIa-North (Gerritsen, 2009). Results from the French EVHOE survey suggest that relatively low densities of haddock continue from VIIh into VIIIa. Irish Groundfish Survey data indicates two distinct nursery areas with high catches of 0-group haddock: one area off the southwest coast of Ireland (VIIb south and VIIj north) and one area off the southeast coast (VIIg north). Catches of older haddock in VIIb are generally low and it is not clear whether the young fish from VIIb move north to VIa or south to VIIj stock (Gerritsen and Stokes, 2006).

A.2. Fishery

Haddock in Divisions VIIb–k are taken as a component of catches in mixed trawl fisheries. France usually takes about 50–80% of the landings. French landings are made mainly by gadoid trawlers, which prior to 1980 were mainly fishing for hake in the Celtic Sea. Ireland has historically taken about 25–40% of the landings. Irish demersal trawlers from Dunmore East and Castletownbere and other ports in southwest Ireland have traditionally targeted haddock in a mixed trawl fishery. In Divisions VIIb and VIIc, the Irish fleet operates mainly from the ports of Rossaveal and the Aran Islands. Fleets from Belgium, Norway, the Netherlands, Spain, and the UK take the remainder of the landings. Landings reported between 1984 and 1995 varied between 2600 t and 4900 t, then increased sharply to 10 300 t in 1997. Since then the landings have varied between 5000 t and 10 000 t without a clear long-term trend.

The vast majority of the landings are taken by otter trawls, most of the remainder of the landings are taken by seines and beam trawls.

A detailed description of the Irish Fishery is given in the annual WD to WGCSE: 'A summary of the Irish Fishery and Sampling of Haddock in VIIb–k'.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

Sampling and data raising

Data on landings-at-age and mean weight-at-age-are available for fleets landing into Ireland since 1993 and from France and the UK since 2002. The UK catch numbers are supplied for the combined VIIe–k area and the landings data from each Division are used to scale the catch numbers to each Division. French VIIf,g,h catch numbers were combined with Irish VIIg data to estimate VIIf,g,h catch numbers. The Table below displays the data available and the procedures used to derive quarterly length compositions, age compositions and mean weights-at-age.

		Data source:				
Division	**Data**	**UK**	**France**	**Ireland**	**Belgium**	**Derivation of international landings**
VII b,c	Length composition			VII b		
	ALK			VII b		
	Age Composition			VII b		IRL raised
	Mean weight at age			VII b		IRL VIIb
	Landings		VIIb,c	VIIb,c		
VII e	Length composition	VIIe-k				Derived from UK VIIe-k
	ALK	VIIe-k				Raised to international Landings
	Age Composition	VIIe-k				
	Mean weight at age	VIIe-k				
	Landings	VIIe	VIIe		VIIe	
VII f,g,h	Length composition		VII f,g,h	VII g		
	ALK		VII f,g,h	VII g		
	Age Composition		VII f,g,h	VII g		IRL & FRA raised
	Mean weight at age		VII f,g,h	VII g		IRL & FRA raised
	Landings	VIIf,g	VIIf,g,h		VIIf,g,h,j,k	
VIIe-h	Length composition					VIIf,g,h & VIIe
	ALK					
	Age Composition					
	Mean weight at age					
	Landings					
VII j-k	Length composition			VII j		IRL raised
	ALK			VII j		
	Age Composition			VII j		IRL raised
	Mean weight at age			VII j		IRL VIIj
	Landings	VIIj,k	VIIj,k	VIIk		
VII b,c,e,f,g,h,j,k	Length composition					
	ALK					
	Age Composition					VIIb,c + VIIe + VIIfgh + VIIjk
	Mean weight at age					Weighted mean by numbers caught
	Landings					

Weights-at-age

Previous to the WGSSDS 2004, a three year running average was applied to the stock weights-at-age. In 2004, the working group estimation of stock weights was done using a quadratic function fitted through cohorts to the first-quarter catch weight data. In 2005 the stock weights were modelled using a von Bertalanffy growth equation. The raw stock weight data demonstrate significant year-effects and although these might be as a result of changes in sampling or ageing errors, it is also possible that weights-at-age are subject to interannual variation in condition. As the modelled stock weight did not fit the data very well and because it is not clear whether stock weights-at-age are more influenced by cohort- or year-effects, it was decided in 2007 to revert to using a three year running average to smooth the data, and constraining the weights in older ages to at least those of the preceding age in the cohort.

B.2. Biological

In the absence of a direct estimate of natural mortality, a constant value of 0.2 was assumed for all age classes and years. Maturity was assumed to be knife-edged at-age 2. Recent Irish Survey data are generally in agreement with this maturity ogive, although males occasionally mature-at-age one. F and M before spawning were set to 0 for all ages in all years.

B.3. Surveys and commercial tuning fleets

Description

All surveys described below are coordinated by the IBTSWG (International Bottom Trawl Survey Working Group).

The UK7efghjWCS first-quarter annual groundfish survey was carried out on the RV Cirolana until 2003. In 2004 it was carried out on the RV Endeavour and discontinued thereafter. The survey fished fixed station positions allocated by area and depth strata. The survey used a modified Portuguese High-Headline trawl (PHHT) with 350 mm rubber bobbins, a bunt tickler chain and a 20 mm codend liner.

The FR7fghjEVHOE fourth-quarter annual groundfish is carried out on the RV Thalassa. Age data are available from 2001 onwards. ALK data from the Irish survey were applied to the EVHOE data for the years 1997–2000 to estimate numbers-at-age for these years. The sampling design is a stratified random allocation. The number of hauls per stratum is optimized by a Neyman allocation taking into account the most important commercial species in the area (hake, monkfish and megrim). The fishing gear used is a GOV with an average vertical opening of 4 m and a horizontal opening of 20 m.

The fourth-quarter Irish west-coast groundfish survey (WCGFS) was carried out in VIaS and VIIbj on chartered commercial vessels. The sampling design attempted to allocate at least two stations per rectangle. Stations were selected randomly within each rectangle from known clear tow positions. A Rockhopper GOV with 12 inch discs was used. The nets were fitted with a 20 mm codend liner. Between 1999 and 2002 Ireland carried out the fourth-quarter Irish Sea-Celtic Sea Groundfish Survey (ISCSGFS) in VIIag on RV Celtic Voyager. The survey used a GOV Trawl with a mean vertical opening is 6 m and door spread 48 m. In 2003 the ISCSGFS and WCGFS surveys were replaced by the fourth-quarter Irish Groundfish Survey (IGFS) which covers VIaS, VIIbgj. This survey is carried out on RV Celtic Explorer. The IGFS has a random stratified design and uses a GOV (with rock-hopper in VIa) with a 20 mm codend liner.

The IR7gSAGFS index consists of a combination of the ISCSGFS and IGFS in VIIg. The two survey series were standardized by swept-area estimates.

The IGFS also provides indices for VIIb and VIIj. (IR7bIGFS and IR7jIGFS).

The commercial IR7bjOTB fleet consists mainly of vessels from 15 to 35 m in length, operating from the west and southwest coast of Ireland. (Vessels of the Irish OTB fleet in VIIg regularly switch between targeting *Nephrops* to targeting whitefish. Significant numbers of new boats have also been added to this fleet, making it unsuitable as a tuning fleet).

The commercial FR7fghGAD fleet consists of French vessels targeting gadoids.

Consistency

The surveys used in the assessment generally reveal good internal consistency for ages 0 to age 3 or 4. The current surveys also demonstrate reasonably good agreement in the estimated numbers of recruits (age 0). The tuning fleets used in the assessment generally demonstrate good consistency from the age of 2 or 3 up to ages 6 or 7.

B.4. Commercial cpue

Effort and lpue data are available from the Irish otter trawl fleets operating in Divisions VIIb, VIIj and VIIg since 1995, French gadoid trawlers in VIIfgh since 1993 and effort data are available for the UK beam trawl fleet in VIIe–k and all other trawl gears in VIIe–k since 1983. The effort in the French gadoid fleet has decreased in recent years and is now at a similar level to the Irish and UK fleets. Effort in the Irish OTB VIIg fleet has increased in recent years, whereas the Irish OTB effort in VIIb and VIIj appears to have levelled off in recent years. The lpue of the French gadoid fleet is still much higher than that of the other fleets. The Irish and UK fleets have seen a minor increasing trend in lpue in recent years.

B.5. Other relevant data

Discard data

Discard data are available for the Irish otter trawl fleets in VIIbgj since 1995. French discard data are available since 2005 and UK discard data are available since 2003. The French and UK data are not raised to the national level.

Because the Irish discard data cover nearly the entire time-series, these data were used to estimate discard numbers-at-age by raising them to the international level. Otter trawlers account for most of the international effort in VIIb–k, no attempt was made to estimate discards for the other main gears (seine and beam trawl). No discard data were available for 1993–1994, discarding in these years was estimated from the average of 1995–99, which was a period with relatively low discarding.

Irish otter trawl discard length distributions were raised to the national level of discards by estimating the mean length distribution per trip and multiplying this by the total number of otter trawl trips following recommendations by Borges *et al.*, 2005.

Irish discard data from VIIgj were used to estimate international discards by using the ratio of the international effort in VIIe–k to the Irish effort in VIIgj. This approach assumes that Irish discarding in VIIjg is representative of the international discards and does not take differences in vessel power or target species into account.

The age structure of young haddock appears to vary between years and between VIIb and VIIgj It was therefore considered appropriate to apply separate Age–Length Keys (ALKs) to VIIb and VIIgj on an annual basis. For years where age data were insufficient or absent, the average ALK of all years was applied for the relevant area. For many years, it was possible to clearly identify the youngest cohorts from the length distributions. Based on this, some spurious age readings were adjusted. The following rules were applied to correct the data:

Area	Year	Lengths	Change ages from	Change ages to	Observations affected
VIIb	all	<14	1	0	14
VIIb	2003	>14	0	1	28
VIIb	96,97,99,00,01,02,04,05	>15	0	1	8
VIIb	2006	>18	0	1	31
VIIb	all	>25	1	2	110
VIIb	all	<20	2	1	10
VIIgj	all	<22	2	1	28
VIIgj	all	<25	3	2	7

The changes affected 236 age observations out of a total of 3021. Some of the ageing problems might be attributed to the fact that many discard otoliths were not read by dedicated age readers.

C. Historical stock development

Model used: XSA

Software used: FLR, VPA95

Exploratory data analysis and the assessment were carried out using FLR under R version 2.4.1 with packages FLCore 1.4–3, FLAssess 1.4.1, FLXSA 1.4–2 and FLEDA 1.4–2. A separable assessment was performed using the Lowestoft VPA95 software to screen for outliers in the catch numbers. The final assessment was performed in R as well as the Lowestoft VPA95 software.

Model settings Separable VPA (data screening only)

Option	Setting
Year range	1993-current
Age range	1-8+
Year weighting	Default
Age weighting	Default
Reference age	2
Terminal F	From previous year's XSA
Terminal S	1.25

Model settings XSA

The model settings below have been unchanged since 2007.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year
Caton	Catch in tonnes	1993-current	0-8+	Yes
Canum	Catch-at-age in numbers	1993-current	0-8+	Yes
Weca	Weight-at-age in the commercial catch	1993-current	0-8+	Yes
West	Weight-at-age of the stock at spawning time.	1993-current	0-8+	Yes
Mprop	Proportion of natural mortality before	1993-current	0-8+	No
Fprop	Proportion of fishing mortality before	1993-current	0-8+	No
Matprop	Proportion mature-at-age	1993-current	0-8+	No
Natmor	Natural mortality	1993-current	0-8+	No

A plusgroup of 8+ was used. Age group 0 was included in the assessment data to allow inclusion of 0-group indices in the XSA runs. However, catch numbers-at-age 0 were set to zero to avoid spurious F-shrinkage effects at this age.

Model Options:

Option	Setting
Ages catch dep stock size	None
Q plateau	4
Taper	No
F shrinkage SE	1.5
F shrinkage year range	5
F shrinkage age range	3
Fleet SE threshold	0.3
Prior weights	No

Tuning data:

Type	Name	Year range	Age range
Survey	IR7bjWCGFS	1993-2002	Not used
Survey	UK7efghjWCS	1996-2004	Not used
Survey	FR7fghjEVHOE	1997-current	0-5
Survey	IR7gSAGFS	1999-current	0-5
Survey	IR7bIGFS	2003-current	Not used
Survey	IR7jIGFS	2003-current	Not used
Commercial	IR7bjOTB	1995-current	2-7
Commercial	FR7fghGAD	2002-current	2-6

History of previous assessments, changes are highlighted using bold font.

		2002 XSA	2003 XSA	2004 XSA	2005 XSA	2006 XSA	2007-CURRENT XSA
Catch data	Years	93-01	93-02	93-03	93-04	93-05	93-06
	Ages	1-8+	1-8+	0-8+	3-8+	3-8+	0-8+
Survey tuning fleets							
IR7bjWCGFS	Years	93-01	93-02	93-02	93-02	93-02	Not used
	Ages	1-1	1-1	0-3	3-3	3-5	
UK7efghjWCS	Years	98-01	98-02	98-03	Not used	98-03	Not used
	Ages	1-3	1-3	1-5		3-5	
FR7fghjEVHOE	Years	Not used	Not used	97-03	97-04	97-05	97-current
	Ages			0-3	3-3	3-5	0-5
IR7gSAGFS	Years	Not used	Not used	Not used	Not used	Not used	99- current
	Ages						0-5
IR7gISCSGFS	Years	Not used	Not used	97-03	97-04	Not used	Not used
	Ages			0-3	3-3		
Commercial tuning fleets							
IR7bjOTB	Years	95-01	95-02	95-03	95-04	95-05	95- current
	Ages	1-7	1-7	1-7	3-7	3-7	2-7
FR7fghGAD	Years	Not used	Not used	Not used	Not used	Not used	02- current
	Ages						2-6
Model options							
Ages catch dep stock size		None	None	None	None	None	None
Q plateau		4	4	4	4	4	4
Taper		No	No	No	No	No	No
F shrinkage SE		1.5	1.5	1.5	1.5	1.5	1.5
F shrinkage year range		5	5	5	5	5	5
F shrinkage age range		3	3	3	3	3	3
Fleet SE threshold		0.3	0.3	0.3	0.3	0.3	0.3
Prior weights		No	No	No	No	No	No

D. Short-term projection

Model used: Multifleet Deterministic Projection. Landings and discards are modelled as separate fleets.

Software used: MFDP1a.

Initial stock size: Taken from the XSA for age 1 and older. The recruitment-at-age 0 in the last data year is estimated as a long-term GM (full time-series).

Natural Mortality: 0.2 for all ages in all years as used in XSA.

Maturity: knife edge at-age 2 for all years as used in XSA.

F and M before spawning: Set to 0 for all ages in all years as used in XSA.

Weight-at-age in the stock and catch: average from last 3 years.

Exploitation pattern average from last 3 years (from XSA).

Intermediate year assumptions: status quo F.

Stock recruitment model used: None, the long-term GM recruitment-at-age 0 is used.

F_{bar} range: ages 2–5.

Rescale to last year: No.

E. Medium-term projections

None.

F. Yield and biomass-per-recruit

Model used: Yield and biomass-per-recruit over a range of F values.

Software used: MFDP.

Selectivity pattern: mean F array from last 3 years of XSA (to reflect recent selection patterns).

Stock and catch weights-at-age: mean of last three years.

Maturity: knife edge at-age 2 for all years as used in XSA.

G. Biological reference points

It is not possible to derive precautionary reference points for this stock from the short time-series of information available.

H. Other issues

None.

I. References

Borges, L., Zuur, A.F., Rogan, E. and Officer, R. 2005. Choosing the best sampling unit and auxiliary variable for discards estimations. Fish Res, 75(1–3): 29–39.

Gerritsen, H. 2009. Spatial distribution of Irish Landings, Effort and LPUE of Demersal Stocks in Divisions VI and VII in 1995–2008. Working Document 1 to ICES WGCSE, Copenhagen 12–19 May 2009.

Gerritsen H and Stokes D. 2006. Stock structure of Haddock in VIIb–k: Information from the Irish Groundfish Surveys Working document 7. ICES WGSSDS, Copenhagen , 27 June–6 July 2006.

Annex 7.5: Stock Annex: FU17, Aran Grounds

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Aran Grounds *Nephrops* (FU17)
Date:	06 March 2009 (WKNEPH2009)
Revised by	Colm Lordan and Jennifer Doyle (WKNEPH, 2009)

A. General

A.1. Stock definition

Nephrops is limited to muddy habitat, and requires sediment with a silt and clay content of between 10–100% to excavate its burrows, and this means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* probably only undertake very small-scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. In FU17, the main *Nephrops* stock inhabits an extensive area of muddy sediment known as the Aran Grounds which lie to the west and southwest of the Aran Islands; there are also smaller discrete mud patches in Galway Bay and Slyne Head.

A.2. Fishery

In recent years the *Nephrops* stock in FU17 are almost exclusively exploited by Irish vessels. Figure A.2.1 shows the spatial distribution of landings and lpue for Irish otter trawl vessels in 2005 using logbook and VMS data linked together to give finer spatial resolution. The Aran ground fishery is clearly highlighted.

The *Nephrops* fishery 'at the back of the Aran Islands' can be considered the mainstay of the Ros a Mhíl fleet. Without this *Nephrops* fishery the majority of vessels in the fleet would cease being economically viable (Meredith, 1999). The Irish fishery consists of entirely of otter trawl vessels. The majority of vessels use twin-rigs and 80 mm. Smaller vessels do use 70 mm with a SMP. Some vessels have using 90 mm. Vessels from Ros a Mhíl, Dingle, Union Hall, Dunmore East, Clogherhead and Kinsale mainly exploit the fishery.

The number of Irish vessels reporting *Nephrops* landings from FU17 has fluctuated around 50/yr (Figure A.2.2). Around 18 vessels report landings in excess of 10 t. These are the main vessels in the fishery accounting for around 85% of the total landings. The majority of these vessels are between 20–22 m overall length (Figure A.2.3). There has been a slight shift to lager vessels over time. The majority of vessels are in the power range of 200–400 KW (Figure A.2.4). There has also been a shift to more powerful vessels over time with the introduction of twin-rigs to the fishery in the early 2000s. Most of the larger boats move freely between the *Nephrops* fisheries in FU15, 16, 20-22 and other areas depending on the tides and weather.

The fishery displays a distinctive seasonal pattern with highest landings, catches, lpue and cpue in April–June and October–November. The monthly landings time-series with the average pattern is shown in Figure A.2.5. The first period of elevated landings is associated with the emergence of females from their burrows post-hatching of their eggs. The sex ratio during this period is biased towards females (Figure A.2.6). Females mature quickly during the early summer and spawning occurs in July and August. This is coincident with a decline in landings and cpue in the fishery. The Ros a Mhíl fleet traditionally tie up in August each year for maintenance and refurbishment.

The following TCMs are in place for *Nephrops* in VII (excluding VIIa) after EC 850/98: Minimum Landing Sizes (MLS); total length >85 mm, carapace length >25 mm, tail length >46 mm. Mesh Size Restrictions; Vessels targeting *Nephrops* using towed gears having at least 35% by weight of this species on board will require 70 mm diamond mesh plus an 80 mm square mesh panel as a minimum or having at least 30% by weight of *Nephrops* on board will require 80–99 mm diamond mesh.

A.3. Ecosystem aspects

Physical Oceanography

The Aran ground is coincident with a pool of oceanic water, which is rich in nutrients and low in dissolved oxygen. The currents throughout the water column over the ground are generally weak although there is a well-documented bottom density front on the eastern flank of the ground (Nolan and Lyons, 2006). This is a seasonal feature, which establishes in May and persists until autumn. The front causes a persistent jet like flow from south to north close to the seabed through the *Nephrops* ground. The mean position of jet varies from year to year by up to 30 km. Timing and position of the jet may influence recruitment and settlement success of post-larval *Nephrops* because it could advect larval from the area. Salinity differences, as a consequence of over winter freshwater input, are thought to heavily influence the density structure and location of this front. Until a time-series of recruitment and jet dynamics is established, it is not possible to draw any firm conclusions about the impact of this ecosystem feature on the stock and fishery. Potential sinks for advected larvae include Slyne head and possibly Galway Bay.

Temperature and salinity time-series

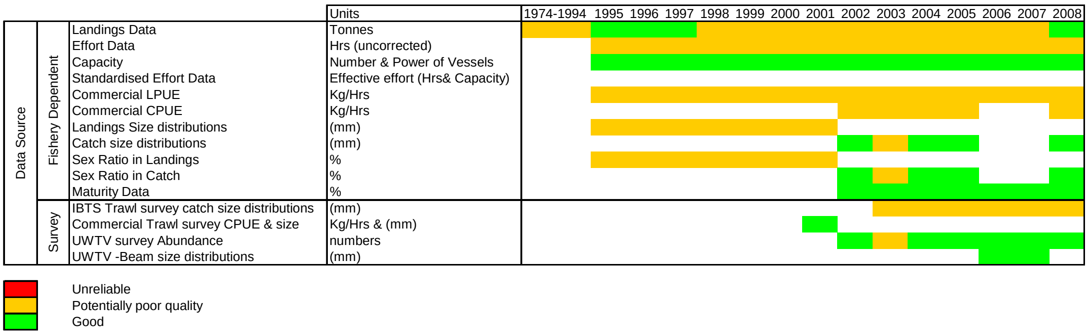
An emerging time-series of temperature and salinity data are available for a transect through the Aran Grounds (Nolan and Lyons, 2006). In all years since 1999 (except 2001) the 53°N section has exhibited positive anomalies in temperature of between 0.2°C and 2°C (Figure A.3.1). In 2001, the temperature anomaly from the long-term climatology was zero. Years with lower temperature anomalies seem to coincide with years of strongly negative salinity anomalies (e.g. 2001 and 2005, 2006) perhaps reflecting the limited influence of ENAW on the section in those years as the section is dominated by coastal discharges from the Loire and Shannon. Salinity anomalies along 53°N range from -0.3 to +0.1 psu over the period. The freshest years were 2001, 2005 and 2006. In 2000, 2003 and 2004 ENAW has a stronger influence on the salinity structure and positive anomalies in salinity from the long-term climatology are the result. The higher UWTV abundance in 2003 and 2004 is coincident with the warmest anomaly but the time-series remains too short to draw definitive conclusions.

Sediment distribution

There is a growing body of information on the spatial extent of the sediment suitable for *Nephrops* from UWTV surveys, seabed mapping programmes and the fishing industry. Figure A.3.1 depicts contour and post plots of the a) mean size (phi) and classification based on the Friedman and Sanders, 1978 scales and b) sorting (σ_g) of the sediments on the Aran Grounds based on PSA results from samples collected from 2002–2006 UWTV surveys. The majority of the ground has similar mean particle size at around 4–5µm. There are some patches of softer silt towards the middle of the ground. Figure A.3.2. is bathymetry of the Aran grounds obtained from seabed mapping programmes. The eastern flank of the ground shallows up quickly but the majority of the ground is gradually deepening from around 100 m to 110 m with the deepest parts to the southwest.

B. Data

The Table below summarizes the available data for this stock and attempts to quantify the quality subjectively.



B.1. Commercial catch

Prior to 1988 landings data for this fishery are only available to the WG for France. Since 1988 reported landings data for the Irish fleet were obtained from EU logbooks. The quality of landings data is not well known. In earlier, years there are no landings from Ireland although there was probably some catch. The Irish landings have been close to quota for this TAC area since around 1997 (Figure B.1.1). In more recent years (2003–2005 and 2008) there are a few observations of both under- and overreporting but it is not possible to correct landings using these as it is not known how representative they might be.

Landings length and sex compositions were estimated from port sampling by Ireland (between 1995–2001). There was a perception during this period that that discarding was not significant. In 2002 a new catch self-sampling programme was put in place. This involves unsorted catch and discard samples being provided by vessels or collected by observers at sea on discard trips. The catch sample is partitioned into landings and discards using an on-board discard selection ogive derived for the discard samples (Table B.1.1). Sampling effort is stratified monthly but quarterly aggregations are used to derive length distributions and selection ogives. The length–weight regression parameters given in Table B.2.1 are used to calculate sampled weights and appropriate quarterly raising factors. The sampling intensity and coverage has varied over the time-series (Table B.1.1). The quality of the sampling has not yet been qualitatively assessed for precision and accuracy.

Nephrops landings and discards from the Aran Grounds have not been sampled for the majority of 2006 and all 2007 as a consequence of a lack of cooperation by the industry. However, sampling resumed in 2008 and the intensity and coverage is considered the best to date.

Fish and other bycatches in the fishery have been collected by on-board observers since 1994. The number of trips is variable over time with a gap in the series in 2006 and 2007.

B.2. Biological

Biological parameters for this stock are outlined in Table B.2.1.

Length–weight

Mean weights-at-age for this stock are estimated from studies on Scottish stocks by Pope and Thomas, 1955. This relationship was examined in 2003 and it seemed appropriate. Given the variability of length–weight parameters found in Allan *et al.*, 2009 it would be worth monitoring these more closely in future.

Natural mortality

A natural mortality rate of 0.3 was assumed for all age classes and years for males and immature females, with a value of 0.2 for mature females. The lower value for mature females reflects the reduced burrow emergence while ovigerous and hence an assumed reduction in predation. The accuracy of these assumptions is unknown. Cod are not common on the Aran Grounds but other potential predators include dogfish, monkfish megrim and gurnards. Stomach contents data on the Irish GFS could be used to examine this in future.

Maturity

The L_{50} of females using a macroscopic visual maturity scale is known to vary depending sampling month (Lordan and Gerritsen, 2006). The L_{50} in July was chosen as the most appropriate estimate given the maturity schedules observed (Figure B.2.1). It is worth mentioning that commercial vessel surveys in November 2001 and in June 2002 demonstrated considerable differences between the maturity schedules of female *Nephrops* sampled in shallower waters of Galway Bay compared with the Aran Grounds.

Proportion of F and M prior to spawning was specified as zero to give estimates of spawning-stock biomass at January 1. In the absence of independent estimates, the mean weights-at-age in the total catch were assumed to represent the mean weights in the stock.

Discard survival

Given the trip durations (~5 days average) and behaviour of the fleet the majority of discards on the Aran Grounds are returned to the sea over suitable sediment. The proportion scavenged by birds is probably quite low. Tow durations, volume of catches, prolonged sorting on deck and relatively high density of *Nephrops* on the seabed probably results in relatively low discard survival. This is estimated to be around 10%.

B.3. Surveys

Since 2002 Ireland has conducted underwater television survey (UWTV) annually on the main *Nephrops* grounds, Aran grounds. Indicator camera stations are also carried out on the adjacent grounds of Galway Bay and Slyne Head weather and time permitting. The surveys were based on a randomized fixed grid design. The methods used during the survey were similar to those employed for UWTV surveys of *Nephrops* stocks around Scotland and elsewhere and are documented by WKNEPHTV (ICES, 2007).

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as an absolute it is necessary to correct for these potential biases. The history of bias estimates are given in the following table and are based on simulation models, preliminary experimentation and expert opinion, the biases associated with the estimates of *Nephrops* abundance in the Aran Grounds are:

	Time period	Edge effect	Detection rate	Species identification	Occupancy	Cumulative bias
FU17: Aran	<=2009	1.35	0.9	1.05	1	1.3

B.4. Commercial cpue

Prior to 1988 landings data for this fishery are only available to the WG for France. Since 1988 reported landings data for the Irish fleet were obtained from EU logbooks (Table B.4.1.)

Effort data for FU17 is available from 1995 for the Irish otter trawl *Nephrops* directed fleet (Table B.4.2.). A threshold of 30% of *Nephrops* in reported landings by trip is used to identify the catches and effort of this fleet. This threshold was based on an analysis of the trip-by-trip catch compositions. In 2007 this fleet accounted for ~90% of the landings and compared with an average of 70% over the time period. These data have not been standardized to consider vessel or efficiency changes during the time period. Landings per unit effort (lpues) have been fluctuating around an average of 39 kg/hr with an increasing trend since 2004, to the highest observed (59 kg/hr) in the time-series in 2007 (Figure B.4.1.).

B.5. Other relevant data

C. Historical stock development

Age structured XSA assessment for this stock was carried *Nephrops* WG in 2003 (ICES, 2003). The results were considered unreliable for several reasons most importantly; inadequate historical sampling of catch, growth and natural mortality assumptions and concern about accuracy of tuning data. Since then the focus has been on developing a time-series of UWTV survey data as the basis of assessment and advice for this stock.

The 2009 Benchmark decided on the following procedure:

1) Survey indices are worked up annually resulting in the TV index.

2) Adjust index for bias (see Section B3). The combined effect of these biases is to be applied to the new survey index.

3) Generate mean weight-in-landings. Check the time-series of mean landing weights for evidence of a trend in the most recent period. If there is no firm evidence of a recent trend in mean weight use the average of the three most recent years. If, however, there is strong evidence of a recent trend then apply most recent value (don’t attempt to extrapolate the trend further in future).

D. Short-term projection

4) The catch option table will include the harvest ratios associated with fishing at $F_{0.1}$ and F_{max}. These values have been estimated by the Benchmark Workshop (see Section 9.2) and are to be revisited by subsequent benchmark groups. The values are FU specific and have been put in the Stock Annexes.

5) Create catch option table on the basis of a range of harvest ratios ranging from 0 to the maximum observed ratio or the ratio equating to F_{max}, whichever is the larger. Insert the harvest ratios from step 4 and also the current harvest ratio.

6) Multiply the survey index by the harvest ratios to give the number of total removals.

7) Create a landings number by applying a discard factor. This conversion factor has been estimated by the Benchmark Workshop and is to be revis-

ited at subsequent benchmark groups. The value is FU specific and has been put in the Stock Annex.

8) Produce landings biomass by applying mean weight.

The suggested catch option table format is as follows.

			Implied fishery	
	Harvest rate	Survey Index	Retained number	Landings (tonnes)
	0%	12345	0	0.00
	2%	"	247	123.45
	4%	"	494	246.90
	6%	"	741	370.35
	8%	"	988	493.80
$F_{0.1}$	8.60%	"	1062	530.84
	10%	"	1235	617.25
	12%	"	1481	740.70
F_{max}	13.50%	"	1667	833.29
	14%	"	1728	864.15
	16%	"	1975	987.60
	18%	"	2222	1111.05
	20%	"	2469	1234.50
	22%	"	2716	1357.95
$F_{current}$	21.5%	"	2654	1327.09

E. Medium-term projections

None presented.

F. Long-term projections

None presented.

G. Biological reference points

The time-series of available length frequencies were insufficient to generate reliable estimates of $F_{0.1}$ and F_{max}.

H. Other issues

I. References

ICES 2007. Report of the Workshop on the use of UWTV surveys for determining abundance in *Nephrops* stocks throughout European waters (WKNEPHTV). ICES CM: 2007/ACFM: 14 Ref: LRC, PGCCDBS.

ICES 2008. Report of the Workshop and training course on *Nephrops* Burrow Identification (WKNEPHBID). ICES CM: 2008/LRC: 03 Ref: ACOM.

ICES 2008. Report of the Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim (WGHMM). ICES CM: 2008/ ACOM:07

ICES 2005. Using UWTV surveys to develop a conceptual ecosystem model of Aran Grounds *Nephrops* population distribution. ICES CM 2005/L:30 Annual Science Conference.

Nolan,G.D. and Lyons. 2006.Ocean climate variability on the western Irish Shelf, an emerging time-series., K., *Proceedings of the ICES Annual Science Conference*, Theme Session C, C:28.

Fernand, L., Nolan, G.D., Raine, R., Chambers, C.E., Dye, S.R., White, M. and Brown, J. 2006. The Irish coastal current: A seasonal jet-like circulation. *Continental Shelf Research*, Vol. 26, Issue 15, 1775–1793.

ICES 2006. Report of the Workshop on *Nephrops* Stocks. Annex 6: Working Document by Lordan and Gerritsen. ICES CM 2006/ACFM:12.

Colm Lordan and Hans Gerritsen, 2006. The accuracy and precision of maturity parameters from sampling of female *Nephrops* from stocks around Ireland. WD6 in the Report of the Workshop on *Nephrops* stocks. ICES CM 2006/ACFM:12.

Table B.1.1. *Nephrops* in FU17 (Aran Grounds). Landings and discard numbers by year and sex.

	Female Numbers '000s		Male Numbers '000s		Both sexes
Year	Landings	Discards	Landings	Discards	% Discard
2001	18,665	12,161	29,949	13,250	34%
2002	23,105	9,374	31,256	8,326	25%
2003	14,530	9,577	29,538	8,744	29%
2004	16,109	7,068	12,930	4,282	28%
2005	20,280	11,383	21,828	8,967	33%
2006					
2007	No Sampling				

Table B.2.2. Numbers of samples and numbers measured for the FU17 *Nephrops* Stock by year.

Number of Samples				Total numbers of *Nephrops* measured			
Year	Graded Landings	Catch	Discards	Year	Graded Landings	Catch	Discards
1990	24			1990	10451		
1991	20			1991	8260		
1992	0			1992	0		
1993	0			1993	0		
1994	0			1994	0		
1995	13			1995	6370		
1996	3			1996	1440		
1997	11			1997	5203		
1998	12			1998	5388		
1999	16			1999	6944		
2000	5			2000	2255		
2001	32	5	5	2001	13231	3194	3891
2002		13		2002		9399	
2003	1	9	9	2003		6284	4829
2004		14	14	2004	578	12934	13167
2005		13	9	2005		8729	7559
2006		2	0	2006		767	436
2007		0	0	2007			
2008		19	18	2008		4944	8701

Table B.2.1. Biological Input Parameters for FU17 *Nephrops* Stock.

PARAMETER	VALUE	SOURCE
Discard Survival	10%	WKNEPH 2009
Discard rate	????	
MALES		
Growth - K	0.150	based on FUs 15 and 16
Growth - L(inf)	60	based on FU 15
Natural mortality - M	0.3	assumed, in line with other stocks
Length/weight - a	0.000322	based on Scottish data (Pope and Thomas, 1955)
Length/weight - b	3.207	"
FEMALES		
Immature Growth		
Growth - K	0.150	based on FUs 15 and 16
Growth - L(inf)	60	based on FU 15
Natural mortality - M	0.3	assumed, in line with other stocks
Size at maturity (L50)	22	ICES 2006 (Lordan and Gerritsen)
Mature Growth		
Growth - K	0.100	based on FUs 15 and 16
Growth - L(inf)	50	based on FU 15
Natural mortality - M	0.2	assumed, in line with other stocks
Length/weight - a	0.000684	based on Scottish data (Pope and Thomas, 1955)
Length/weight - b	2.963	"

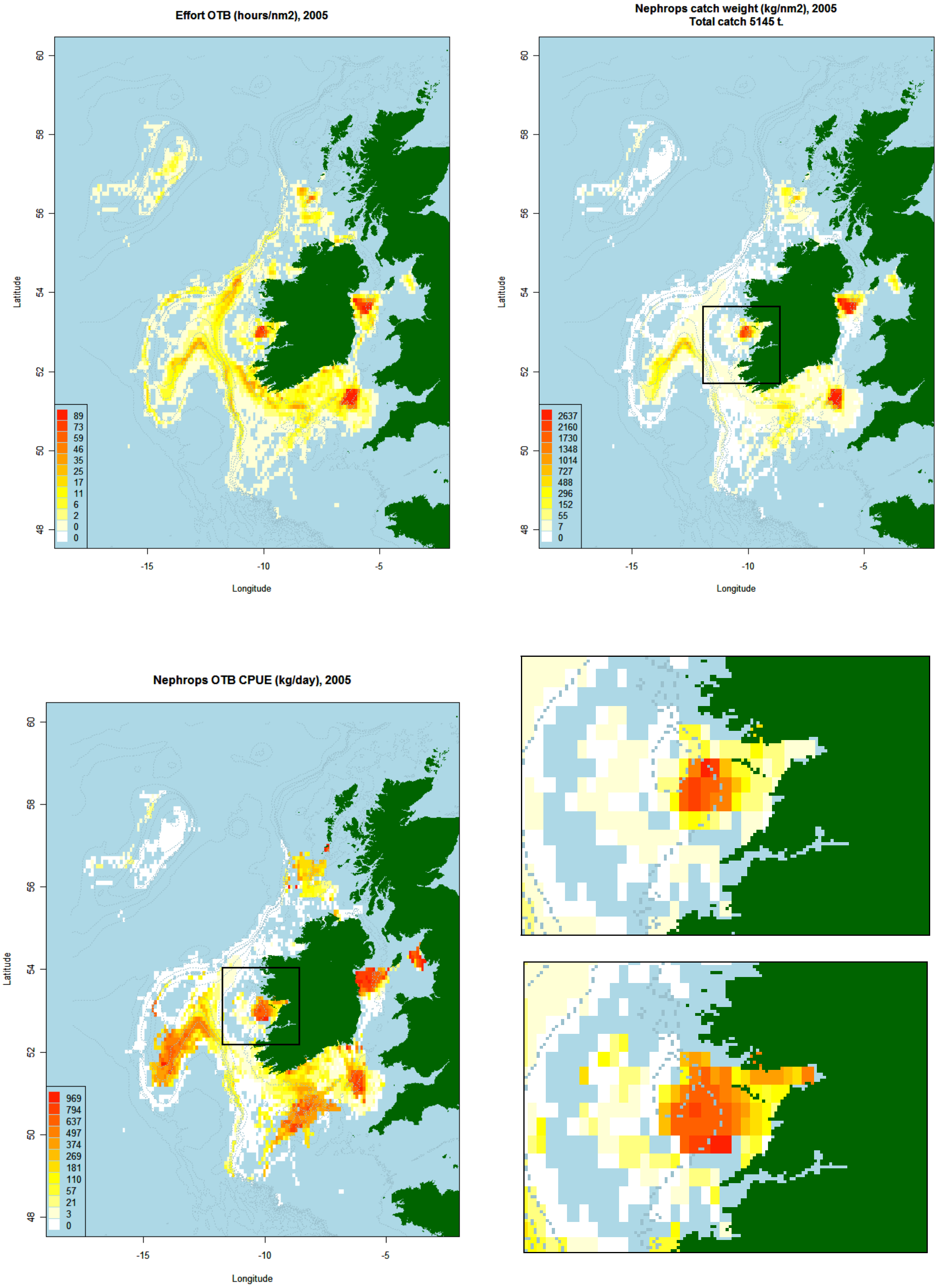


Figure A.2.1. Effort, catch and catch per unit of effort for *Nephrops*, Irish otter trawlers in 2005. The boxed and zoomed in plots show a zoomed in view of landings and lpue from the fishery on the Aran ground.

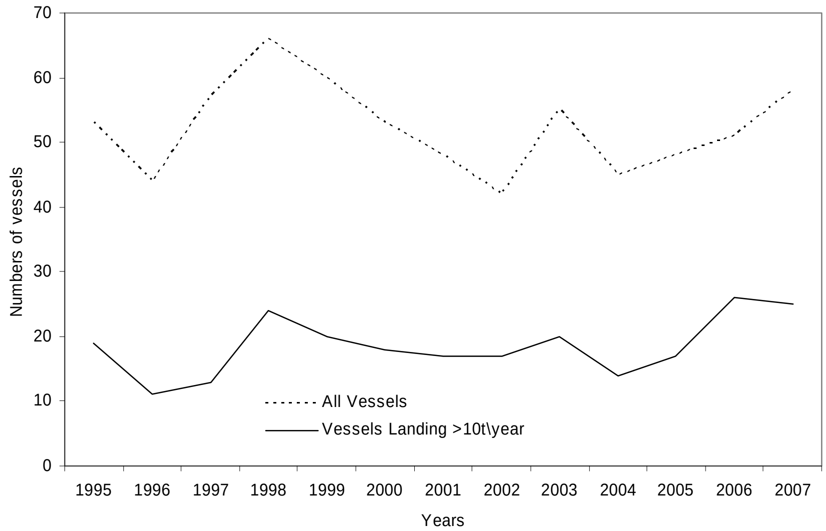


Figure A.2.2. Time-series of the number of Irish vessels reporting landings of *Nephrops* from FU17. The vessels with annual landings >10 t/yr can be considered the main participants in the fishery these general account for ~85% of the total landings.

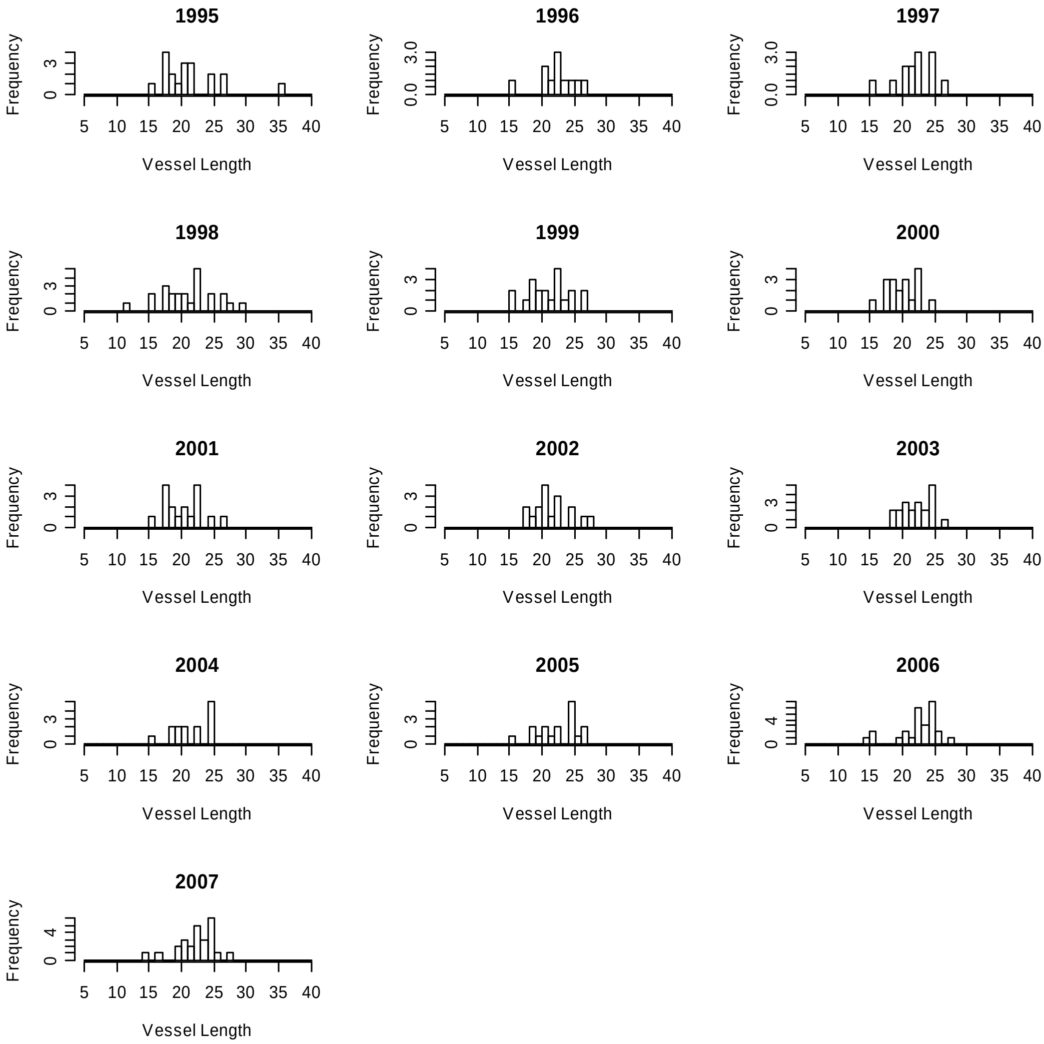


Figure A.2.3. The time-series of length distributions of Irish vessels landing >10 t of *Nephrops* from FU17.

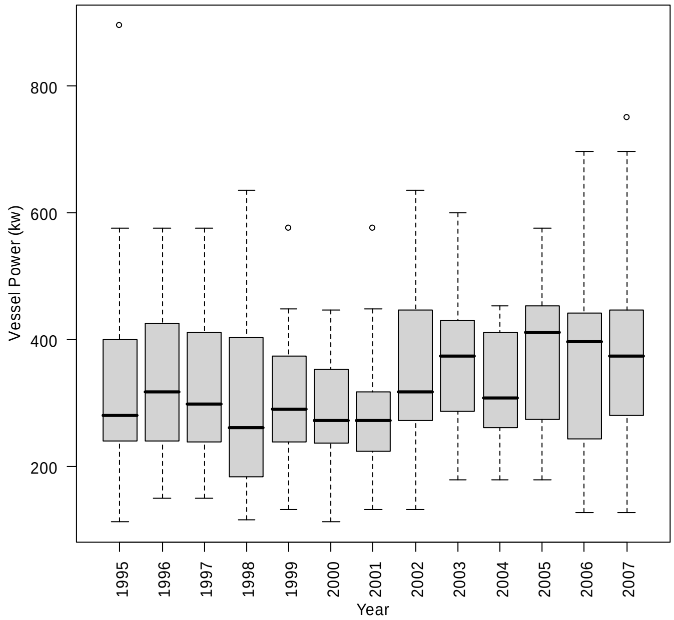


Figure A.2.4. Box plot of the time-series of vessel power in KW of Irish vessels landing >10 t of *Nephrops* from FU17.

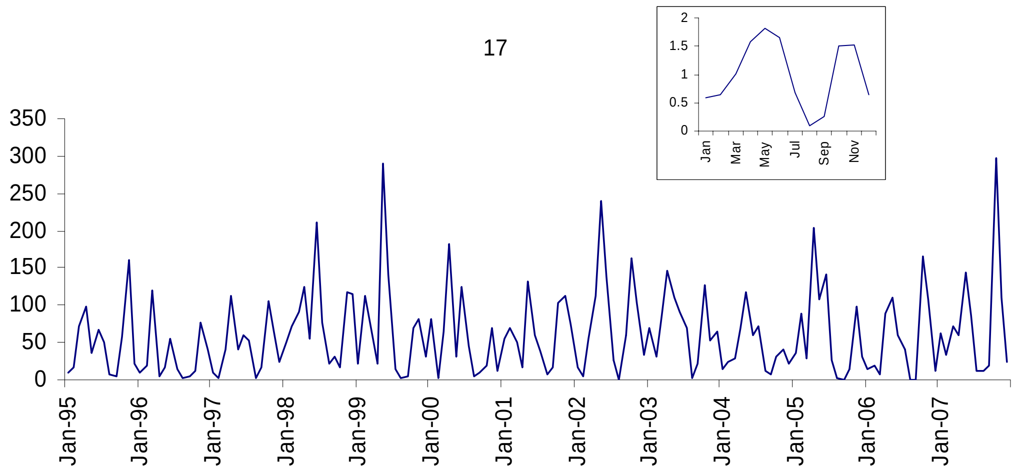


Figure A.2.5. Monthly landings of *Nephrops* from FU17 from 1995–2007. The inset shows the average pattern for all years.

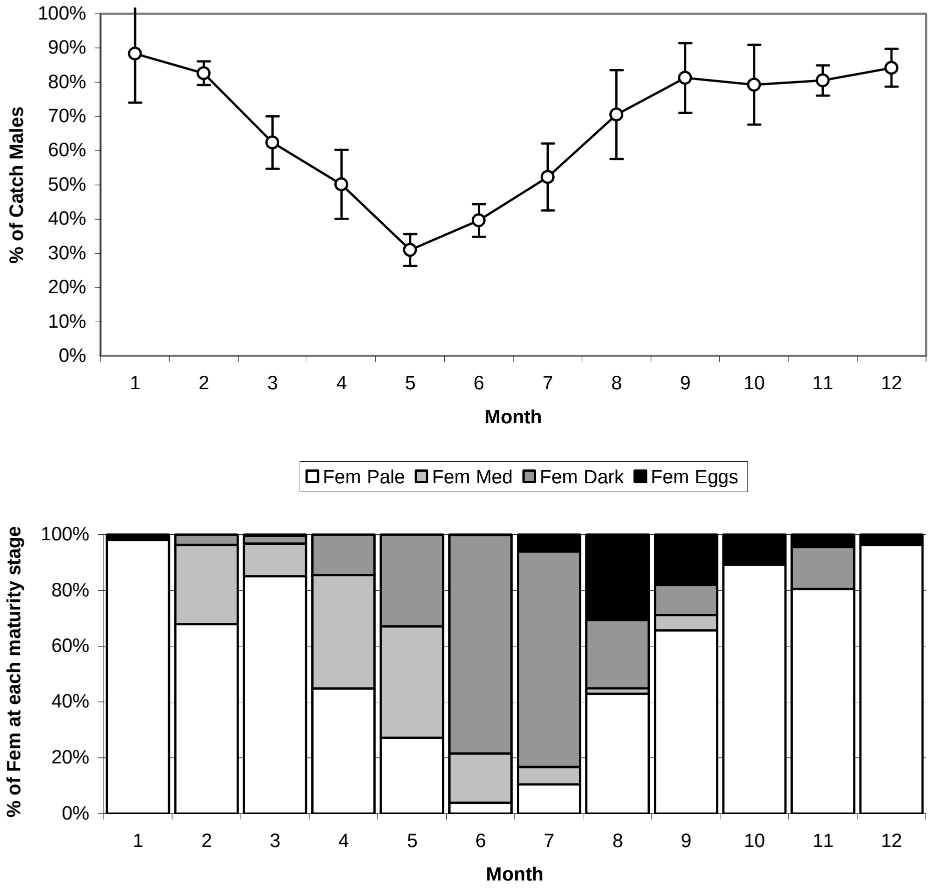


Figure A.2.6. The upper panel shows the sex ratio in sampled catches 2003–2008 (error bars = 95% confidence intervals). The low panel shows the female maturity schedule i.e. percentage at each maturity stage by month.

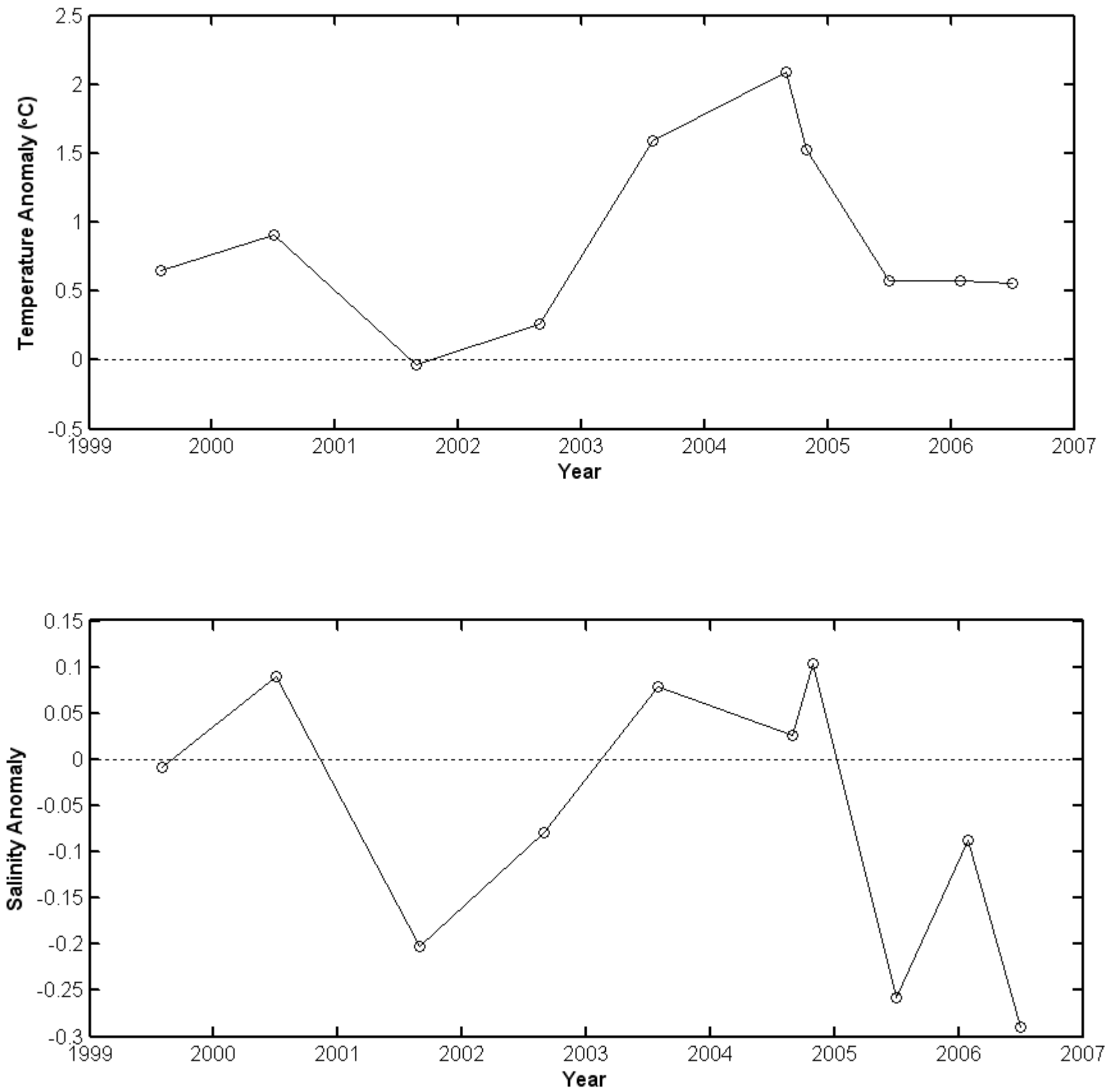
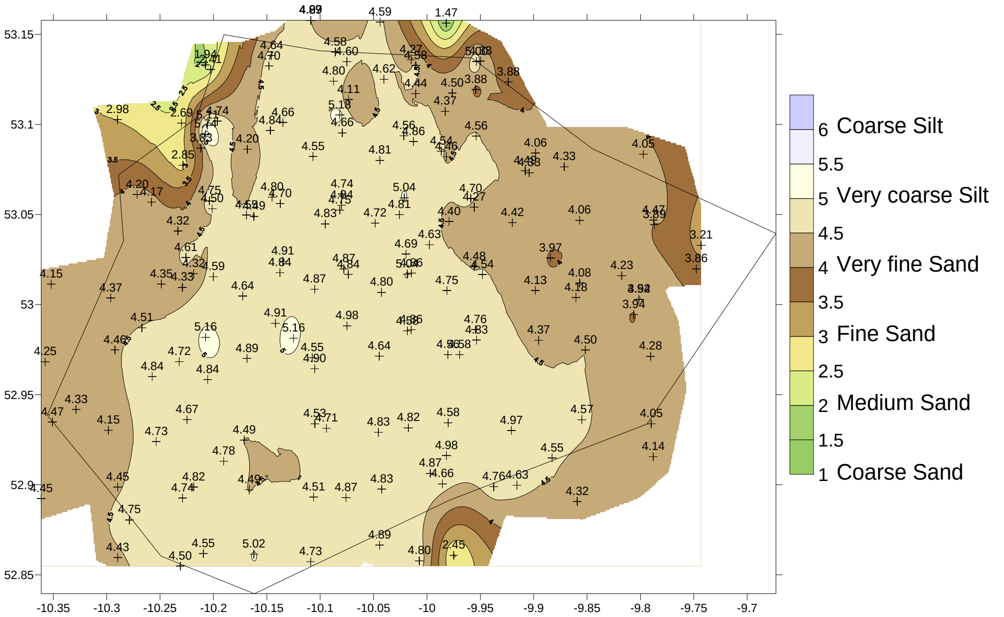


Figure A.3.1. Anomalies in temperature (upper panel) and salinity (lower panel) for the 53°N section running through the Aran Grounds (1999–2006).

a)



b)

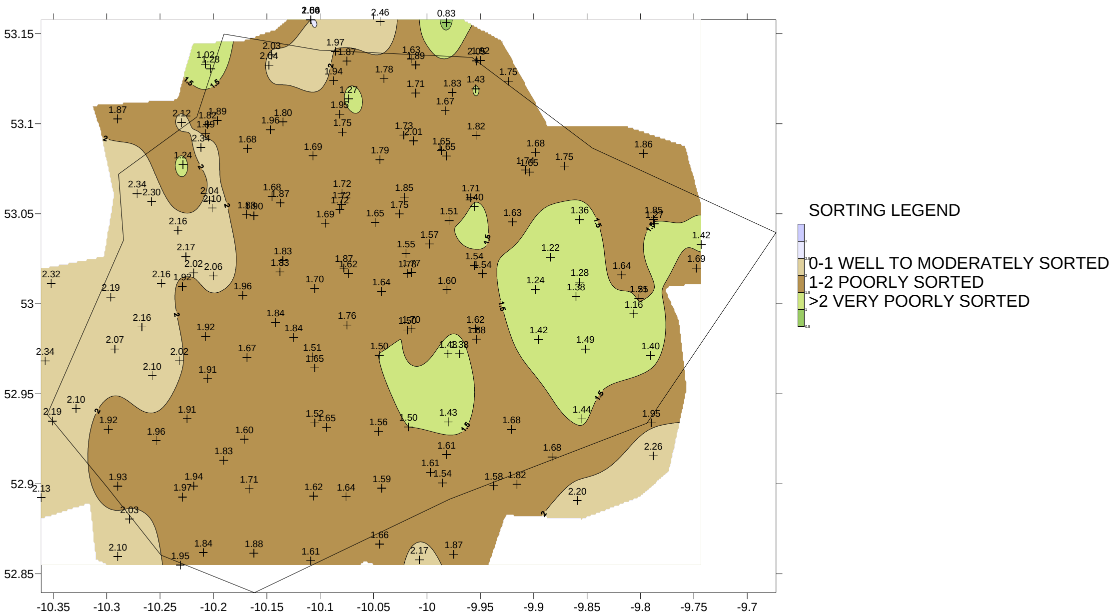


Figure A.3.1. Contour and post plots of the a) mean size (phi) and classification based on the Friedman and Sanders, 1978 scales and b) sorting (σ_g) of the sediments on the Aran Grounds based on PSA results from samples collected from 2002–2006.

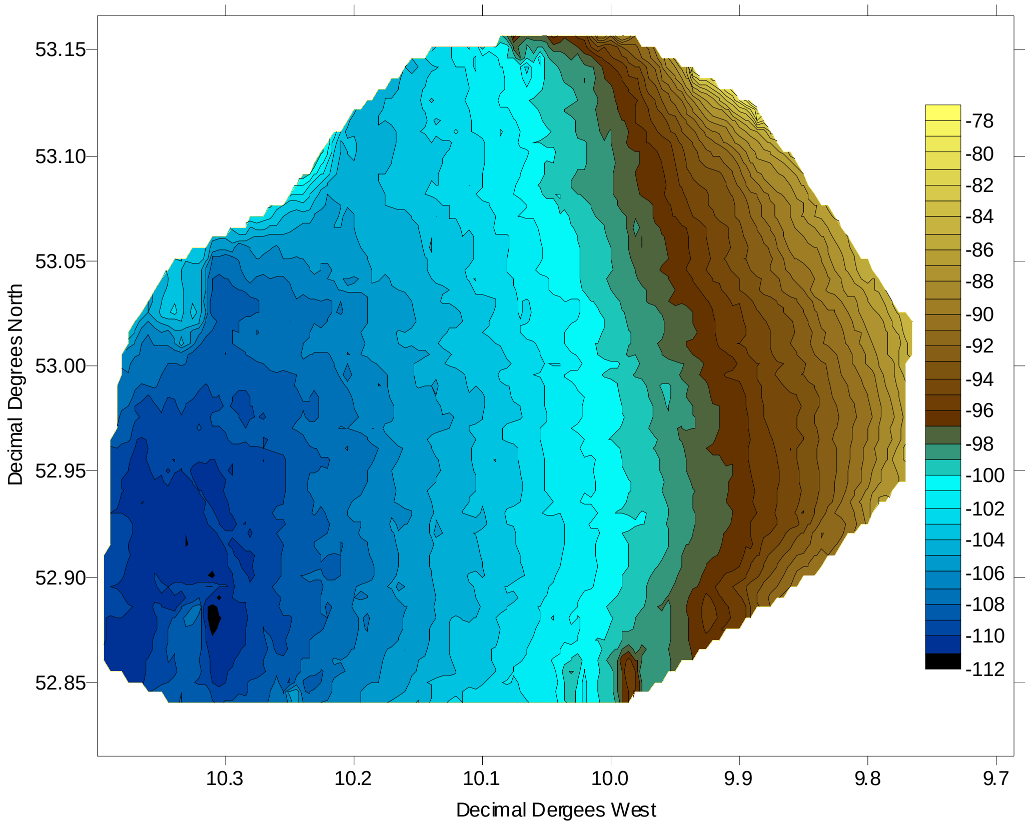


Figure A.3.2. The bathymetry of the Aran grounds.

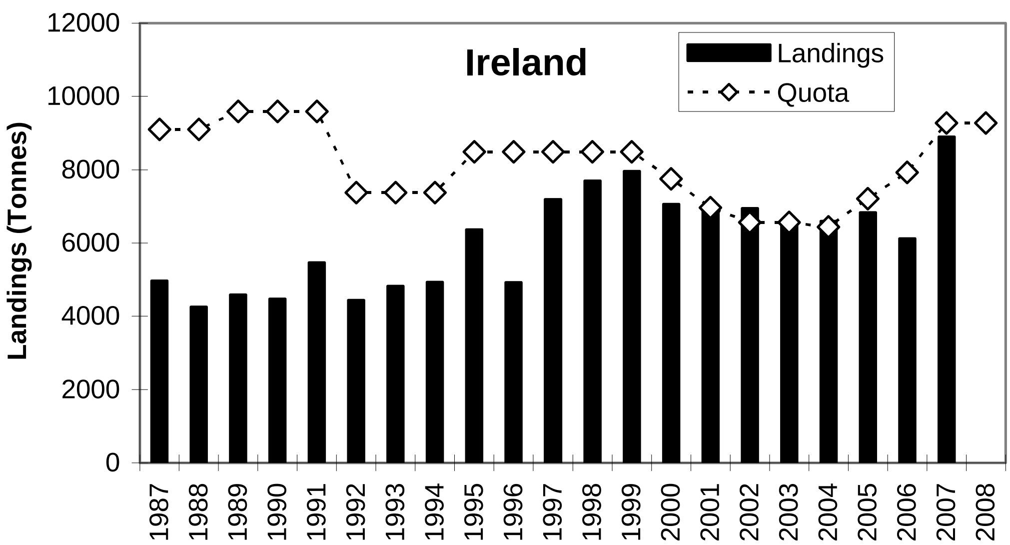


Figure B.1.1. ***Nephrops*** **landings and quota for Ireland since the introduction of TACs in 1987.**

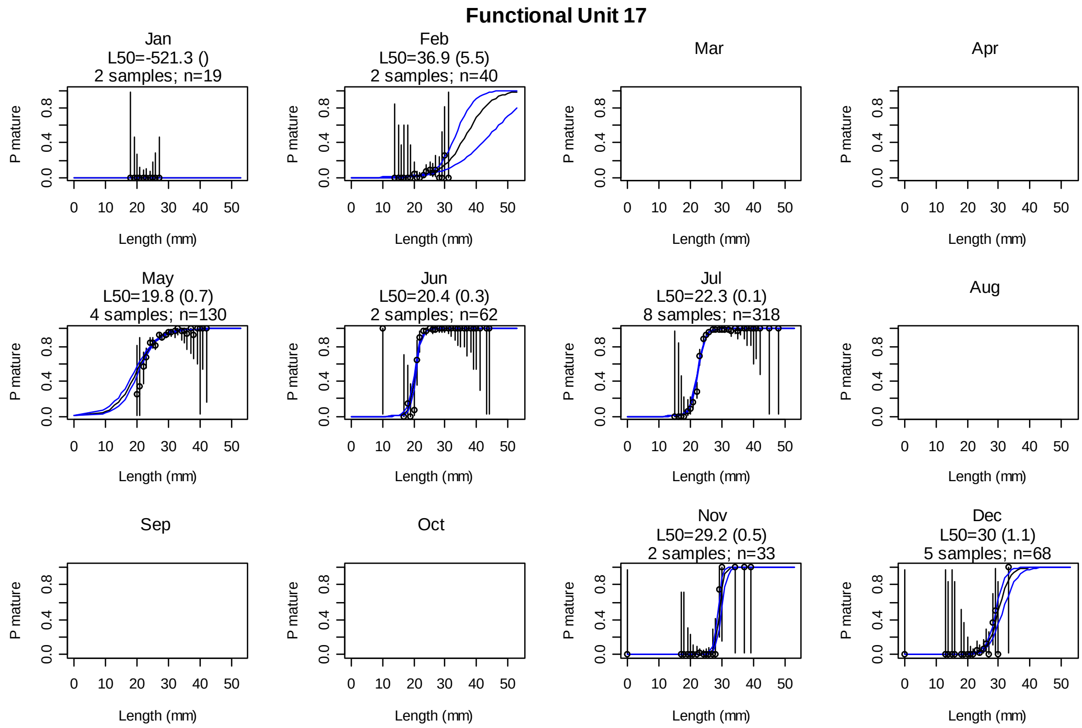


Figure B.2.1. Female proportions mature-at-length for FU17. The 95% confidence limits of the proportions mature-at-length are indicated by the vertical bars. The black curve indicates the model and its standard errors are given by the blue lines. The L_{50} is the estimated length at 50% maturity and its standard error is given between brackets. Blank plots indicate no sampling took place.

Annex 7.6: Quality Handbook: Stock Annex *Nephrops* FU16

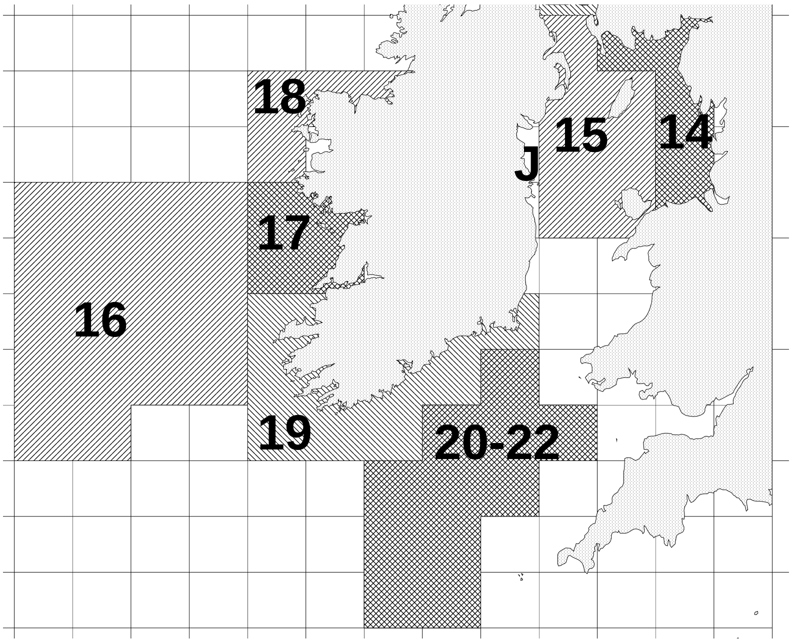
Stock specific documentation of standard assessment procedures used by ICES.

Stock	FU16 Porcupine Bank
Working Group:	WGCSE 2009
Date:	Version 1 20/05/2009
Revised by	Colm Lordan

A. General

A.1. Stock definition

The Functional Unit for assessment includes some parts of the following ICES Divisions VIIb,c,j,k. The exact stock area is shown on the map below includes the following ICES Statistical rectangles: 31–36 D5–D6; 32–35 D7–D8.



A.2. Fishery

France

The French fleet fishing *Nephrops* in FU16 also fishes in Division VIIg–h and was described in detail in the 1999 WGNEPH report (ICES, 1999a). The French fleet only lands large *Nephrops* from this FU. Investigation of the landings data by statistical rectangle carried out by WGNEPH in 2002. These indicated that the majority of the French landings between 1999 and 2000 were from the south of the Porcupine Bank.

Ireland

The fishery is mainly seasonal taking place mainly between April and July. Landings for the remainder of the year are minimal. Most of the Irish vessels are multi-purpose trawlers and are relatively large (between 20 and 35 m in total length). Irish vessels land both whole prawns and tails depending on markets from this FU and the sizes of the Irish landings are significantly smaller than those for the French and Spanish fleets. The Irish vessels are mainly using twin-rig trawls. Fishing is often weather dependent (particularly for the smaller vessels), with trip duration varying between 7 and 10 days. Investigation of the landings data by statistical rectangle provided to the WGNEPH in 2002 indicates that the majority of the Irish landings between 1995 and 2001 were from the south central area of the Porcupine Bank.

The recent spatial distribution of the fishery is shown in Figure 1.

Spain

The Spanish fishery in the Porcupine area is a typical multispecies fishery, targeting different demersal species, among which is *Nephrops*. The fleet, which consists of about 35 vessels, is composed of side trawlers and is part of the so-called '300 fleet' in the Adhesion Treaty of Spain to the EEC in 1986. Within the Porcupine fleet, two components can be distinguished: one consisting of vessels fishing with finfish trawls (average engine power 980 hp), and the other fishing with *Nephrops* trawls (average engine power 680 hp). The average duration of their trips is 15 days, of which 10–12 are actual fishing days. The major landing port is La Coruña.

The target species for the finfish directed fleet are hake, megrim and anglerfish, with *Nephrops* as a valued bycatch. Vessels fishing with *Nephrops* trawls are much more directed towards *Nephrops* (especially in spring and summer), and fish is a bycatch. These two fleets not are currently disaggregated in the time-series.

A.3. Ecosystem aspects

Productivity of deep-water *Nephrops* stocks is generally lower that those on the shelf although individual *Nephrops* grow to relatively large sizes.

A persistent Taylor column circulation around Porcupine Bank provides an important mechanism for the retention of pelagic eggs and larvae of the various marine species spawning in the area. (Mohn, *et al*., 2002). The *Nephrops* stock on the Porcupine Bank is distributed on mud patches in relatively deep waters 200–600 m. It is not know how larvae are retained over these grounds but the Taylor column may help with larval retention.

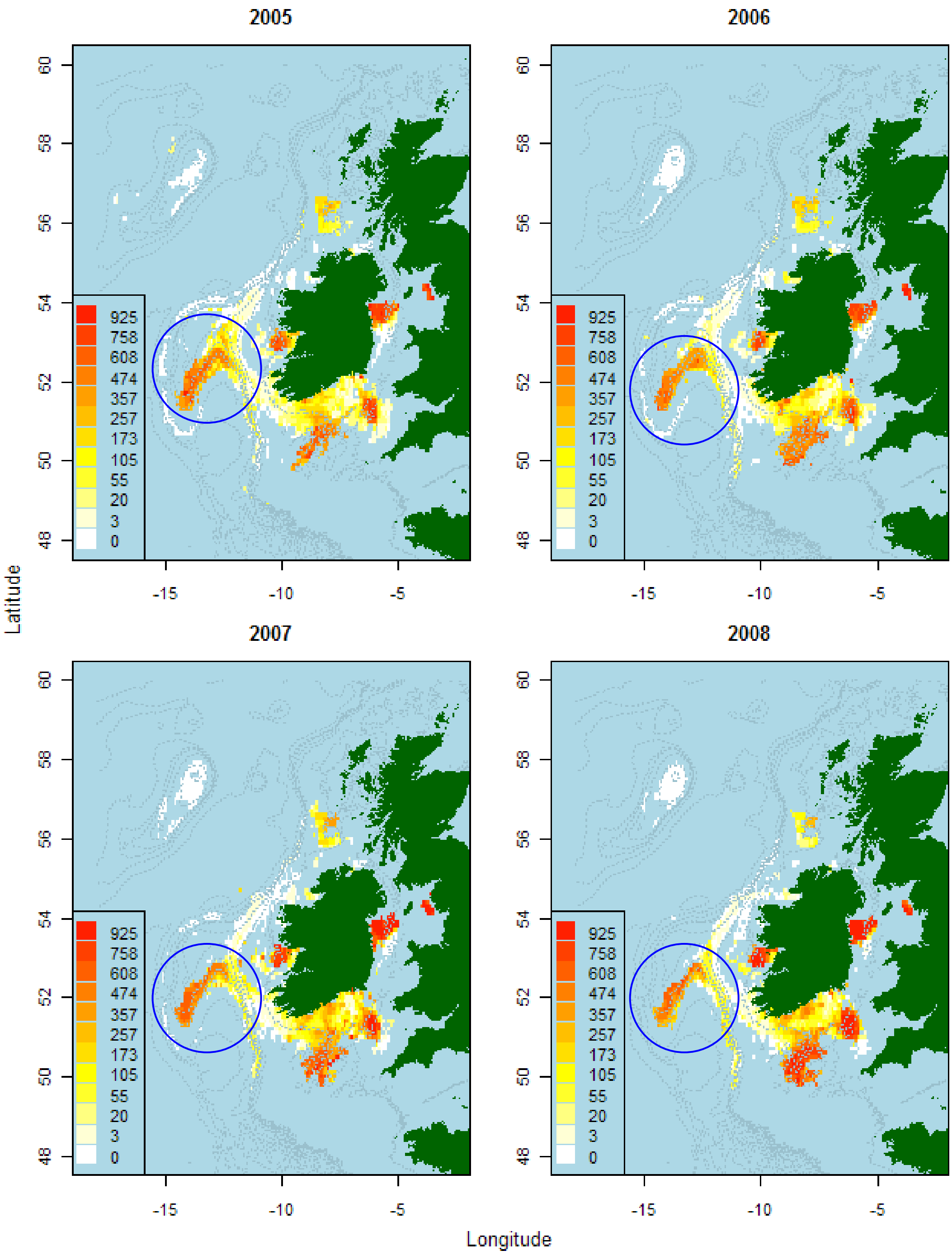


Figure 1. The spatial distribution of lpue of *Nephrops* caught by Irish otter trawlers between 2005–2008 derived using integrated VMS and logbook records.

B. Data

B.1. Commercial catch

Commercial catch and effort data are supplied by Ireland, France, Spain and the UK. These are the countries exploiting the stock.

B.2. Biological

Parameter	Value	Source
Discard Survival		Discards considered negligible
MALES		
Growth - K	0.140	based on values in other areas (Anon. 1991)
Growth - L(inf)	75	based on maximum sizes observed in samples
Natural mortality - M	0.2	Anon.1990 (estimated)
Length/weight - a	0.00009	based on Celtic Sea (FU 20-22)
Length/weight - b	3.550	"
FEMALES		
Immature Growth		
Growth - K	0.140	Not applicable
Growth - L(inf)	75	
Natural mortality - M	0.2	
Size at maturity	26.2	Fariña and González Herraiz (2001)
Mature Growth		
Growth - K	0.160	Anon.1991
Growth - L(inf)	60	based on maximum sizes observed in samples
Natural mortality - M	0.2	As for males
Length/weight - a	0.00009	"
Length/weight - b	3.550	"

B.3. Surveys

The only fishery-independent source of data the Spanish Porcupine trawl survey which commenced in 2001. Further information on thus survey is provided in the IBTS report (ICES, 2009) and in previous IBTS reports.

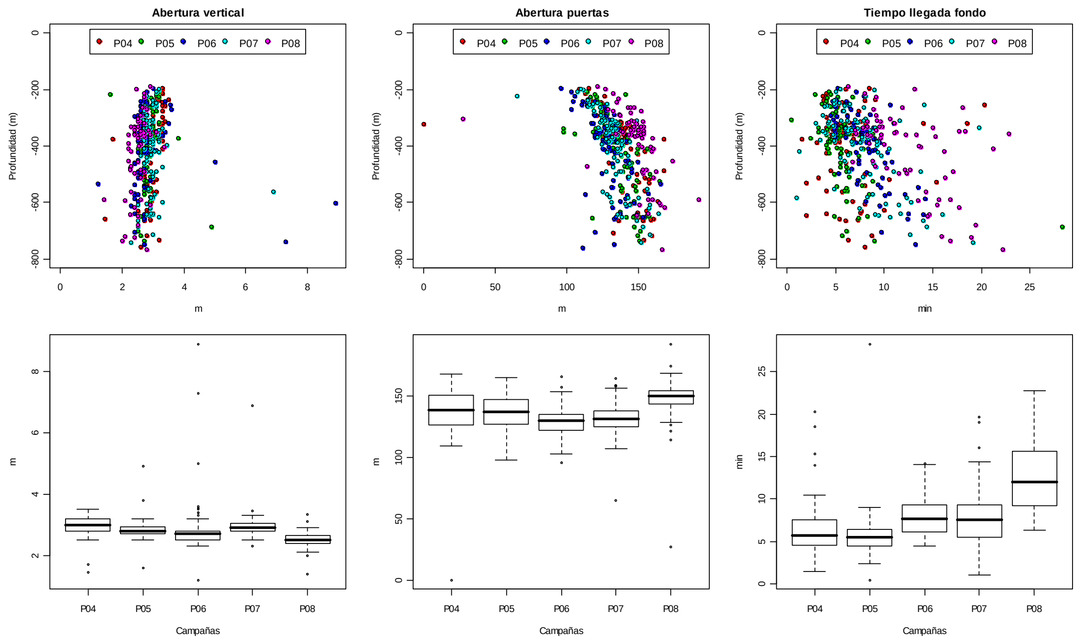


Figure 2. Door spread, vertical opening and time to settle on the ground between 2004 and 2008.

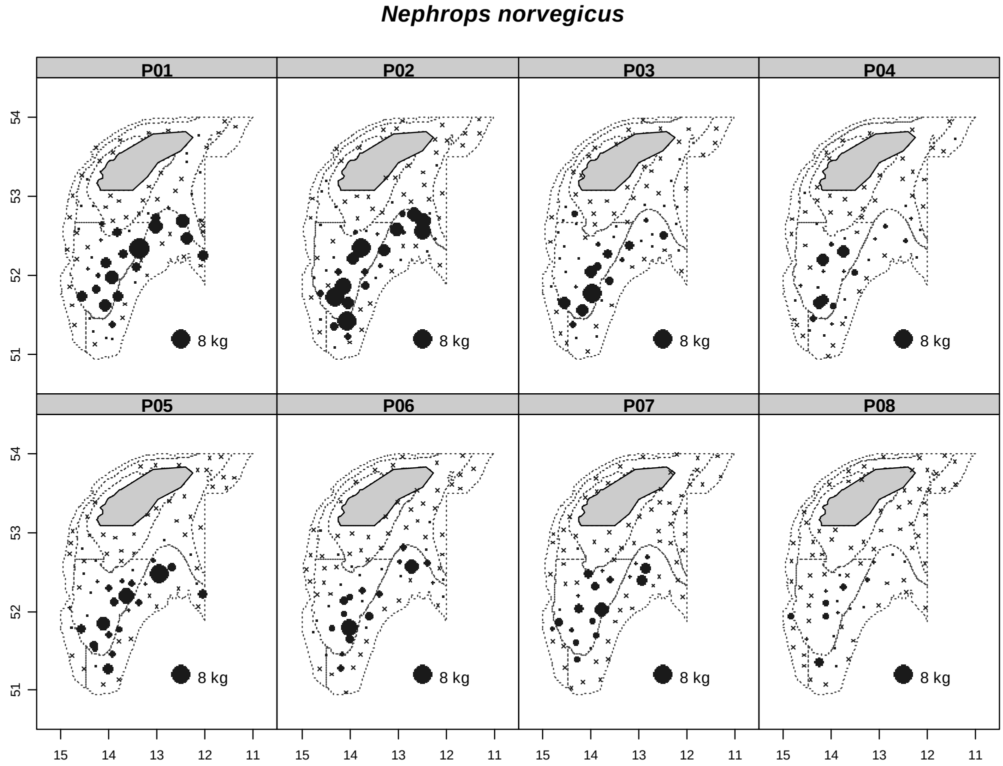


Figure 3. Distribution of *Nephrops norvegicus* catches in biomass in Porcupine surveys between 2001 and 2008.

B.4. Commercial lpue

The *Nephrops* fishery on the Porcupine Bank is both seasonal and opportunistic with increased targeting during periods of high *Nephrops* emergence and good weather.

Effort and lpue data are not standardized, and hence do not consider vessel capabilities, efficiency, seasonality or other factors that may bias perception of lpue abundance trend over the longer term. The available effort time-series are summarized below:

COUNTRY	FIRST YEAR OF EFFORT DATA	UNITS	COMMENT
France	1983	Hours	For trips where *Nephrops* constituted 10% of the landed value
Ireland	2005	Hours	For trips where *Nephrops* constituted 30% of the landings in weight
Spain	1971	ay*BHP/100 (x1000)	

Only commercial landings data are available for all countries involved in the fishery.

B.5. Other relevant data

C. Historical stock development

An experimental age structured assessment for this stock was carried out by the *Nephrops* WG in 1993 (ICES, 1993), in 2003 (ICES, 2003) and by the WGHMM (ICES, 2005) in all cases the assessments being considered inadequate. This conclusion was based on poor quality, and unexplainable inconsistencies in the input data. Unknown growth rates and concern about the utility of age based assessment models impeded progress to an accepted assessment. In addition the lack of a time-series of reliable standardized cpue data was also perceived as a problem. This problem has been solved with the developing Porcupine trawl survey-series.

Model used: XSA, LCA

Software used: n/r

Model Options chosen: No Final model was accepted

G. Biological reference points

No reference points have been proposed or used for this stock.

H. Other issues

None.

I. References

Gerritsen, H. 2009. Working Document 1 ICES Working Group for the Celtic Seas Ecoregion13–19 May 2009.

Annex 7.7: Quality Handbook Stock Annex: WGCSE-*Nephrops* FU 20–22 (Celtic Sea; VIIfgh)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	*Nephrops* (*Nephrops norvegicus*): Division VIIfgh
Working Group	WGCSE (Working Group for Celtic Seas Ecoregion)
Date created	June 2007
Last updated	May 2009

A. General

A.1 Stock definition

The management area for this stock is delimited in area VIIfgh (FU20–22; Figure 1). The management unit is pertinent because of the sedentary feature of *Nephrops*. However, the sources of recruits are much more poorly defined. There is no evidence that the whole exploited area belongs to the same stock or that there are several patches linked in meta-population sense.

A.2 Fishery

Nephrops present particular ground features and in the FU20–22 are known to occur in several areas of muddy sediment and the stock structure is uncertain. The *Nephrops* fisheries target different areas and have very different size structures in *Nephrops* catches and landings. These fisheries also have differences in non-*Nephrops* bycatch composition.

As for all crustaceans, *Nephrops* grow by successive moults which are to a large extent tied to reproduction. For this species moult occurs twice a year, in spring and autumn until sexual maturity. Once males are sexually mature, they continue to moult twice a year whereas females moult only once a year in the latter spring/summer right after the hatching of their eggs. In previous references (1970–1980s), it is pointed out that maturation of females happens at a median size of 31 mm CL (10 cm of total length) which corresponds to 3.5 years old individuals. There is no specific reference for the sexual maturation of males in the FU20–22, but biological references on close areas with similar hydrological conditions (FU15; Western Irish Sea) indicate a first size of functional maturity of 29–31 mm CL.

As reported by the WGNEPH 2004 and the WGSSDS 2005 and 2006, *Nephrops* in FU20–22 is mainly exploited by trawlers from France, Republic of Ireland and UK although the contribution of other countries is lower. The spatial distribution of landings by statistical rectangles is provided below (Figure 2–5). It indicates heterogeneous spatial behaviour of the main fleets.

France

No major changes have taken place in the fishery for more than fifteen years apart from the implementation of a new mesh regulation in 2000 which increased the minimum codend mesh size from 80 to 100 mm (in fact, the regulation involves to 90 mm mesh size, but 100 mm meshes are adopted aiming to avoid problems with bycatch composition). The 100 mm mesh size also allows them to switch to finfish (cod, whiting, haddock) when *Nephrops* catch rates are low (*e.g.* because of diurnal and seasonal variations of catchability for this species or during periods of bad weather). The MLS applied by the French Producers' Organisations is fixed at 11.5 cm total length (*i.e.* 35 mm CL). The total number of vessels from the harbours of the South Brittany remains stable (more than 90 declared *Nephrops* catches from the Celtic Sea in recent years, but around 70 are actually targeting this species). A part of these units (15–20) switch to other *Nephrops* stocks (FU16; Porcupine Bank; Figure 1) mainly in 2nd and 3rd quarters when the meteorological conditions are favourable. At the opposite, many trawlers (20–30) move towards the FU19 *Nephrops* (SE and SW Irish coast) mainly in autumn and winter according to difficulties as a consequence of weather.

Analytical investigations were carried out on the data collected in 2006 and 2007 involving in the French trawlers. Global indices for fishing effort and lpue provided by this fleet (97 trawlers composed by 73 exclusive in Celtic Sea, 15 switching to Porcupine Bank *i.e.* FU16 and 8 also targeting *Nephrops* in the Bay of Biscay *i.e.* FU23–24) seem to be pertinent: 99% of vessels*months registered for sales at auction can also be found in logbooks (94% of French landings in 2007). In 2006, almost 50% of French landings occurred in two ICES rectangles (29E2, 30E2; the rectangle 30E2 during the 2nd quarter concentrated 21% of yearly landings). In 2007, the contribution of the two rectangles 29E1 and 30E2 was 41% of yearly landings. In 2008, the rectangles 28E1 and 30E2 were represented by 44% of yearly landings. The peak of production is observed during the 2nd quarter of the year (Figure 4): in 2006, the maximum landings are obtained in June whereas a shift occurred in 2007 (maximum value in May which may be caused by bad meteorological conditions in June). In 2008, the shape of French landings vs. month was bi-modal (May and July were the mostly represented months).

The historical review of French landings reveals that the contribution of the rectangle 31E3 (concentrating the major part of Irish landings) declined over the last 10 years: from 41% of total French landings registered in 1999 this contribution is currently less than 10% (Figure 3). During the last 10 years, the most productive rectangle for French trawlers was 30E2 mainly during the late 2000s: the average annual contribution of this rectangle was around 15% in the early 2000s, but this proportion reached more than 30% during the recent years. It seems that the French fleet moved gradually from 31E3 to 30E2 under the steeply increasing concentration of Irish trawlers on the "traditional" *Nephrops* grounds (Smalls, Labadie).

Republic of Ireland

More than 60 Irish vessels target *Nephrops* in the Celtic Sea. In 2007, 95 Irish trawlers were registered as landing *Nephrops*, but 63 of them exceeded threshold of 10 t (Figure 6). In 2008, 99 Irish vessels reported landings from this area whereas 67 of them landed more than 10 t. The fishery presents a more typical seasonal profile than the French vessels and most of the landings are made between March and July. These vessels are mid-size multi-purpose trawlers, with a length of 18–23 m and engine power between 250 and 350 kW. Many of the vessels switch between FU15 and FU20–22, depending on the tides in the Irish Sea. Other vessels switch from targeting finfish in winter to *Nephrops* in spring and early summer. The mesh size used by Irish vessels is 80 mm, and increasingly these vessels are using twin trawls. The MLS applied by Irish trawlers is the European one fixed at 8.5 cm total length (*i.e.* 25 mm CL).

The Irish landings seem to be more concentrated spatially than the French. During the period 2003–2006, 63–67% of the Irish nominal landings were provided by one ICES rectangle (31E3). The Irish fishing effort is located more northerly than the French one.

UK

The UK fishery in the Celtic Sea has generally remained unchanged. Since the early 2000s, the number of UK *Nephrops* directed vessels has increased from around 10 to 15, but their contributions in total landings remains minor (usually less than 50 t of landings). The maximum historical value of UK landings is reported in 2008 (242 t).

A.3 Ecosystem aspects

Nephrops occur in discrete patches where the sediment is suitable for them to construct their burrows. There is a larval phase of long duration where there may be some mixing with *Nephrops* from other areas depending on the oceanographic conditions, but the mechanisms for this in the Celtic Sea are not currently known.

Cod has been identified as a predator of *Nephrops* in some areas, and the generally low level of the cod stock is likely to have resulted in reduced predation on *Nephrops*.

B. Data

B.1 Commercial catch

Landings are reported mainly by France and the Republic of Ireland. French landings fluctuated between 2000 and 3800 t. Irish landings rose from around 500 to more than 2000 t in the last 15 years. The highest value of Irish landings is observed in 2007 (more than 3200 t). A part of this trend is as a consequence of greater accuracy of reporting mainly after the end of the late 1990s. The contribution of French landings has gradually decreased from 80–90% at the end of 1980s to 50–60% at the beginning of 2000s. Between 2004 and 2005, French landings remained stable whereas Irish landings steeply increased and the total harvested quantity was the highest during the last decade. For the first time, in 2007, the Irish ladings exceeded the French ones (3230 t against 2080 t). This may be caused by constraints linked to the international context affecting fuel prices for fishing vessels. The overall fishing profile remains typically seasonal with a dominance of the 2nd and 3rd quarters (60–70%; the other quarters are less productive because of meteorological conditions and of less accessibility of females as a consequence of burrowing).

During the recent years, the evolution of the French fishing effort and lpue was sometimes considerably different from the evolution of the same indicators for the Irish fleet (*e.g.* between 2004 and 2005: -5% of fishing effort and +2% of lpue for French trawlers against +50% of fishing effort and +25% of lpue for Irish trawlers). In 2007, an increase occurred for lpue values of both main fleets: a slight upwards trend of French trawlers (+13% associated to a strong reduction of the fishing effort: -25% whereas the total number of vessels remained almost stable) and a steep one for the Irish fleet (+36% coinciding with +31% of the fishing effort which was displayed by an increasing number of trawlers operating in the Celtic Sea: +19% between 2006 and 2007). This underlines the divergence of features of the targeting vessels for each country and indicates the great heterogeneity of the area. A direct comparison between both countries cannot be undertaken because the fishing effort is not available in the same unit (France: otter trawlers getting at least 10% of their total landings by targeting this species; Ireland: otter trawl vessels where >30% of monthly landings in live weight were *Nephrops*). Furthermore, the actual fishing areas are different and the Irish fleet is more restricted spatially as already reported by WGSSDS 2005–2008.

B.2 Biological

Natural mortality and maturity-at-age

A natural mortality of 0.3 is applied to all *Nephrops* males whereas the mortality of females changes at the size of first maturity (occurring at 31 mm CL as explained previously): a value of 0.2 is usually applied on mature individuals.

The L2AGE slicing programme usually applied on *Nephrops* stocks allocates length classes into age groups by assuming von Bertalanffy model of individual growth. This slicing is applied to length distributions by sex. All parameters, L∞ and K by sex, calculated mean sizes by age for each sex, natural mortality and maturity by sex (assumed to be knife-edged for males and S-shaped for females) and combined are given below.

Table 1. *Nephrops* FU20–22 (Celtic Sea). Individual growth, natural mortality, maturity parameters by sex.

Males and immature females: L∞=68, K=0.17; mature females: L∞=49, K=0.10									
age		1	2	3	4	5	6	7	8+
Size	males	11	20	27	34	39	44	47	51
(CL mm) mm	females	11	20	27	32	33	35	36	37
M	males	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	females	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
	combined	0.3	0.3	0.3	0.25	0.25	0.25	0.25	0.25
Maturity	males	0	0	1	1	1	1	1	1
	females	0	0	0	0.5	1	1	1	1
	combined	0	0	0.5	0.75	1	1	1	1

Biological sampling

Landings: The total French landings have been available since 1983 (on quarterly basis since 1987) whereas the Irish series began in 1987 (on quarterly basis since 1995).

Lpue and fishing effort: Lpue series are provided since 1987 in France while Irish data are available over 1996. It has to be noted that the French and Irish method of calculation of the fishing effort are not carried out by the same way (threshold of 10% in weight for *Nephrops* on total landings applied for French trawlers whereas 30% is the threshold used for Irish fleet), thus a direct comparison of those indices is not appropriate.

DLF of landings: French sampling plan at auction started in 1983, but only after 1986 the data can be used on quarterly basis. The Irish plan as written previously began in 2002 (in fact, solely 2003 has been entirely sampled in the FU20–22 area; 2002s data involving the whole Management Area M: see processing by WGSSDS 2006; two quarters were not sampled in 2004 and 2005: see processing by WGSSDS 2006). For French landings, the increasing proportion of tailed individuals (see below) and the inappropriate method of sampling before the end of 2007 provided.

DLF of discards: French estimation of discards occurred only in three separate years (1985, 1991 and 1997), but only the data collected in 1997 can be included in analytical investigations. The available dataset is given for only one year of discard sampling (1997) because of unavailable quarterly data for landings for the first year of discard sampling (1985) whereas data collected in 1991 were considered as unreliable (samples sorted by fishers). Irish sampling has been undertaken since 2002 (lack of information for two quarters in 2004; see processing by WGSSDS 2006).

Length compositions of the landings by sex are provided for the two main fleets, but the time-series are different. Sampling of French landings since 1984 has provided length frequencies by sex on a monthly basis. As a consequence of uncertainty of the older datasets, the data for 1984–1986 were omitted from further analysis. The Irish sampling programme was launched in 2002 under the EU DCR and gave length frequencies for the period 2002–2006 (after simulation undertaken for some missing information in 2004 as explained during WGSSDS 2006).

French estimation of discards occurred only in several separate years (1985, 1991 and 1997; in 2005, samples for two quarters, 3rd and 4th, were also provided), but only the data collected in 1997 can be included in analytical investigations because of unavailable quarterly data on landings for the first year of discard sampling (1985) whereas data collected in 1991 were considered as unreliable (samples sorted by fishers not representative of the discarding behaviour of the whole fleet). The 1997 French plan on board demonstrated high spatial and temporal variability of discard size-composition vs. that of landings (CV>30%). The Irish sampling launched under DCR gave results as presented by Table 2.

The heterogeneity of the dataset in addition to that of the harvested area by each country affects the discard rate by fleet: it was higher for French vessels: 65% in 1997 against 37% for Irish in 2003 (the only one year with sampling, but only 11% during the quarters 2 and 3 in 2004) and by sex (stronger for females growing less quickly).

Table 2. FU20–22 Irish sampling summary.

		Number of samples			Numbers Measured		
Year	Quarter	Catch	Discards	Landings	Catch	Discards	Landings
2003	1	1	1		186	417	
	2	5	5		4057	3016	
	3	3	3		2535	3638	
	4	2	1		996	528	
2004	1	0	0		0	0	
	2	3	2		1634	2781	
	3	7	6		4284	7171	
	4	0	0		0	0	
2005	1	1	1		1330	2271	
	2	2	2		2208	3238	
	3	2	0		1634	0	
	4	2	0		1627	0	
2006	1	2	1	2	1891	1152	2252
	2	10	2	2	7241	1049	363
	3	5	1	0	3178	1101	0
	4	9	0	0	8266	0	0
2007	1	1	3	0	767	770	0
	2	12	0	0	9648	0	0
	3	15	4	2	7784	1862	411
	4	6	5	0	1959	1417	0
2008	1	2	5		680	1758	
	2	10	13		3409	5333	
	3	3	2		878	546	
	4	4	4		1356	1573	

Extrapolations

Landings: DLF of tailed *Nephrops*

The WGCSE 2009 pointed out a significantly increasing proportion of tailed individuals in French landings whereas this proportion was already high for Irish trawlers. In 2008, 20% of total French landings involved in tailed *Nephrops* (19% in 2007, 15% in 2006 and 11% in 2005; less than 5% until the beginning of 2000s). The overall upwards trend is illustrated by the Figure 7 presenting also monthly tailed fractions (after conversion of weight of tails to total one).

The seasonal variability of tailed *Nephrops* may be explained by biological features of the species (two peaks appear by year corresponding to the two moulting periods, spring and winter) and by the particular conditions of trips (12–15 days) compromising the conservation of *Nephrops*. As regards to the annual increasing proportion of tails (96% explained by using an exponential function), industry explained it by the economic difficulties of the vessels because of the rapidly increasing fuel prices. Tailed individuals are intended to compensate this loss for the crew participation at the total investment by trip. As the European MLS for FU20–22 *Nephrops* is fixed at 8.5 cm of total length (25 mm CL) and the MLS retained by the French Producers' Organizations is equal to 11.5 cm (35 mm CL), it was expected that tailed individuals should be comprised between these two sizes.

Before the end of 2007, the tailed *Nephrops* could not be sampled at auction and, as the sampling on board remains difficult to apply routinely (long trip duration for French trawlers), the problem was partially tackled by apportioning tailed individuals to the smallest category of landings at auction. Since the end of 2007, new biometric relationships established during the EVHOE survey have been used: they allow fitting CL vs. 2nd abdominal segment of tail by sex (Figure 8). The DLF of French landings for 2008 were estimated by two ways: one using the extrapolations from tails to CL, the other apportioning tails to the small category as for previous years. The resulting difference appears relevant (Figure 9): in 2008, 46 million *Nephrops* were provided by the previous method whereas 58 million were estimated by including tails (+28%). Almost 30% of landed individuals were below the French Producers' Organization MLS, but no *Nephrops* was undersized compared with European MLS. Moreover, the sex ratio seems to be affected by the tailing practice: 13% of *Nephrops* (7.4 million) were females although this percentage would be 7% (3.2 million) under the previous method. The mean size of French landings for 2008 decreases at around 2.5–5 mm CL by sex when tails are involved by sampling. However, the mean CL for 2008 remains larger than the Irish one.

Table 3. *Nephrops* in VIIfgh. Mean sizes (CL in mm) of French and Irish landings for 2008. French values are calculated (1) including the samples involving in tailed individuals and (2) using the previous method (no sampling of tails; the total tailed proportion was apportioned in the smallest category of entire *Nephrops* at auction).

French sampling			Irish sampling		
Males	Females	Total	Males	Females	Total
37.6	34.7	37.2	32.0	29.7	31.1
40.1	39.6	40.1			

This result emphasizes the WGSSDS 2008 conclusion that the size composition may be overestimated when raised to the composition of entire individuals.

Discards: years with no sampling on board

Generalities

As the sampling plan for both countries was not routinely undertaken, the whole time-series of landings by quarter either for the French fleet (years 1987–2007) or for the Irish one (years 1995–2007, years 1987–1994 are only represented by annual landings) misses information. Therefore, a methodology of extrapolation from sampled data to years or quarters with no information was developed (see WD 1; WGSSDS 2007).

The main concepts of the derivation (back-calculation) are summarized as:

1) The first step involves applying hand-sorting selection of retained catches which is explained by S-shaped (logistic) function vs. size. As statistically tested by fleet, the hand-sorting function is stable within-quarter for given parameters of the exploitation pattern (if mesh size and MLS remain constant within period).

2) The second step consists in removing undersized individuals unusual in landings which can generate unreliably extreme values of discards as a consequence of sampling problems (very high CV of landings for the extreme size classes). Hence, size classes less than a tested threshold (*e.g.* 1 or 5% of cumulative landings) were eliminated.

3) The third step allows the generation of missing size classes by applying a probability density function which can be symmetrical or not. The whole calculation is based on multiple maximum likelihood function according to the number of missing years. Relationship as between mean sizes of landings and of discards tested on the FU23–24 *Nephrops* (Bay of Biscay; WGHMM) can also be included in the final fitting.

Particularities for FU20–22 *Nephrops* stock

The approach summarized above was already developed on the FU23–24 *Nephrops* stock (Bay of Biscay) and its validation was investigated during the WGHMM 2007 (Figures 10–14). The WGSSDS 2007 examined statistical formulation and validation of this method on French (years 1987–2006) and Irish (years 2002–2006, investigation by quarter) discards for FU20–22. There are some differences from the calculation applied on the Bay of Biscay as:

1) The available French dataset is given for only one year of discard sampling (1997). It means that the hand-sorting S-shaped curves by quarter are calculated on only one year[1] instead of six for the Bay of Biscay stock.

2) The cumulative percentage level for removing of undersized generated discards (see above: 2nd stage) is fixed at 5% for French data and 1% for Irish data (also 1% for the Bay of Biscay *Nephrops* stock). For the French fishery in Celtic Sea, this can be justified by the high variability of landing samples between trips (higher coefficients of variation at auction because of higher heterogeneity of the fished area and of long duration of trips *i.e.* 12–15 days and, hence, less availability of samples at auction).

3) For the French discards, with only one year of discard sampling, the initial value of the parameter Lm cannot be assumed to be equal to any expected mean size of discards *vs.* mean size of landings (see above 3rd stage). Furthermore, the interval in which Lm should be contained is not statistically calculable. Hence, Lm is initially introduced as the size corresponding to the maximum number of discarded individuals as provided by the 2nd stage of calculation (*i.e.* after removing extremely high values of discards obtained after the 1st stage: hand-sorting logistic function). Its interval is built by using an *a priori* coefficient of variation around the initial Lm (CV of 0.10 and 0.20 were tested). For the Irish data, no constraint on relationship between mean sizes of discards and landings was set because of lack of any information on that as a consequence of the short time-series.

4) The large mesh size of the French vessels in the FU20–22 area indicates that the distribution of length frequencies of discards is probably no symmetrical because of selectivity effects which should be more significant than for the FU23–24 stock or for the Irish trawlers in the FU20–22.

5) For French discards, the absence of reference about any relationship between mean sizes of landings and discards at the opposite of the Bay of Biscay, implies that the final fitting aims to provide the more linear as pos-

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1 The six trips sampled in 2005 provided new s-shaped curves of hand-sorting for Q3 and Q4 which were used for simulations of the recent period since 2000 *i.e.* since the mesh size change.

sible relationship (after log-log transformation) with only one reference point (year 1997). Hence, the optimization is more based on geometric concept than on statistical one.

1st stage: the S-shaped hand-sorting curve

Let j be a year with no dataset on discards. By quarter k, the number of discarded individuals by sex (m or f) and by size L, ND_{jklm} (or ND_{jklf}), is not calculated on data provided from other years, but from the number of landed individuals NL_{iklm} (or NL_{iklf}) during the same year, quarter k, sex (m or f) and size L:

$$ND_{jklm} = NL_{jklm}.\exp(-\alpha_k.(L-L50_k)) \quad \text{or} \quad ND_{jklf} = NL_{jklf}.\exp(-\alpha_k.(L-L50_k)) \quad [1]$$

α_k and $L50_k$ are the parameters of the S-shaped curve (logistic model) fitted by quarter k describing the commercial *Nephrops* hand-sorting on board. For this fitting, both sexes are combined and the dependent variable is expressed by the number of landed individuals for size L and the independent one is the total number of catches by size L for the years with discard sampling on board.

The estimates α_k and $L50_k$ were calculated by assuming the stability of hand-sorting process on board if mesh size and MLS remain unchanged. The short Irish time-series 2002–2006 was considered as a common dataset, but, for the French trawlers, the overall time-series was divided into three periods:

1) *Years 1987–1990*: The results of sampling carried out in 1985 are not available on computing support. Thus, there is no formal information if the hand-sorting on board could be approximated by the more recent parameters of 1990s. α and L50 were not got fixed, but their values were estimated by the multiple likelihood function as for the parameters of the probability density by year (see below).
2) *Years 1991–1999*: The hand-sorting was fitted on data from 1997 (1991s data were not representative of the whole fleet). The missing data of years 1991–1996 and 1998–1999 were therefore estimated.
3) *Years 2000–2006*: Because of the mesh size change, the hand-sorting should be different from 1997s sampling data. However, there is no new information for the 1st and 2nd quarters (the 2005s sampling plan provided relevant results only for the 3rd and 4th quarters). Hence, α and L50 for the first two quarters were fixed equal to 1997s parameters, but the simulation for the other two quarters is based on 2005s data.

2nd stage: removing of unreliable size classes of discards

This derivation approach reduces interdependence between yearly datasets which may induce lack of contrast in recruitment time-series. In spite of that, some inconveniencies of the new approach have to be taken into account: (1) the hand-sorting on board S-shaped curve implies that, for a given size class, no calculation of discards is possible while there is no landed individuals and (2) the exponential expression gives extremely unreliable high values of discards when undersized individuals are sampled in landings (mainly because of hand-sorting deviation as a consequence of sampling rate not representative for extreme size classes).

1) *Undersized individuals unusual in landings*. As written previously, undersized *Nephrops* sampled in landings should produce unreliable high discarded amounts by size because of the exponential calculation. All size classes representing less than a minimum cumulative percentage level in

landings by year were removed (5% for French landings, 1% for Irish landings).

2) *Discarded individuals by size exceeding observed mean ratios discards/landings*. Generated discarded numbers were removed when the calculated ratio discards/landings by size (decreasing function *vs.* size) exceeded observed mean ratios by size[2]. Almost all size classes involved by (2) were already removed by (1). This operation was added at the aim of elimination of not normally high ratios discards/landings for large sizes (which has a little impact on total discarded number as a consequence of the S-shaped function of hand-sorting).

This calculation process retains only a part of the initial hand-sorting generated distributions of discards mainly the decreasing part of discarded individuals.

3rd stage: simulation of densities of probability of discarded individuals (yearly distribution for French and quarterly for Irish discards)

Finally, the assumed distribution of discards for the whole range of sizes was calculated from the descending part. This process needs to input the probability density of discards given by:

$$\varphi(L) = \frac{\alpha}{1 + \exp(\beta.(L - Lm)} \qquad [2]$$

where α, β, Lm are coefficients of the distribution ($\phi(L)=\alpha/2$ when L=Lm).

Because of the assumed skewness for the French discard distribution, as explained above, the whole function of the probability density is approximated by:

$$\varphi(L) = \frac{\alpha}{1 + \exp(-\gamma\beta.(L - Lm)} \quad \text{for} \quad L \leq Lm$$

$$\varphi(L) = \frac{\alpha}{1 + \exp(\beta.(L - Lm)} \quad \text{for } L > Lm \qquad [3]$$

with a complementary coefficient γ: if $\gamma=1$ the whole probability density is symmetrical, if $\gamma<1$ the skewness of the distribution is positive if $\gamma>1$ the skewness is negative ($\gamma=1$ for Irish discards, $\gamma\neq1$ for French discards).

The fitting of $\phi(L)$ is processed on two stages:

- *Lm and α are fixed*: α is initially fixed at $2*\phi max$ which is the maximum frequency retained after the 2nd stage of calculation (see above), Lm is fixed at the size corresponding to the maximum number of discarded individuals as provided by the 2nd stage of calculation (see previously) and, hence, β is given by:

$$\beta = \frac{1}{n}\sum_{L=L\min}^{L\min+n-1} \ln\left[2.\frac{\varphi\max}{\varphi(L)} - 1\right]^{\frac{1}{L-Lm}} \qquad [4]$$

(L_{min}= first size represented by not null individuals and n= number of total size classes with discards different from zero).

2 This procedure is performed only on Irish dataset whereas it is not pertinent for French data (only one year dataset).

All parameters are estimated: α, β, Lm got obtained by the 1st stage are input for the final calculation using Newton cancellation of gradient and assuming stochastic approach for Lm. Lm is assumed to be included in the interval defined accordingly to an a priori CV of Lm (see above)[3].

Otherwise, the final run includes constraints as:

- The sum of frequencies for descending part of distribution is equal to that calculated by the model *i.e.* the retained values of the 2nd stage of calculation described previously are assumed to be reliable.
- $L_m \geq L_{min}$ [$L_{min}=(1-Z_{1-\alpha/2}.CV)*L_m$] (usually: α=0.05=>$Z_{1-\alpha/2}$=1.96)
- $L_m \leq L_{max}$[$L_{max}=(1+ Z_{1-\alpha/2}.CV)*L_m$]
- For French discards, the coefficient of determination of the relationship between the mean sizes of landings and the mean sizes of discards for missing years has to be as close as possible to 1 (with no possibility of statistical test because of only one year dataset).
- Statistical formulation and validation

Calculation of variances

Matrix of variances-covariances of model parameters

The Generalized Reduced Gradient and the Complex method do not give an estimate of the matrix of variances-covariances of the four (three for Irish) parameters. In this case, it is usually recommended to apply non-parametric techniques such as the Bootstrap method. The calculation can also be carried out according to parametric procedure (Lin, 1987; Fifas and Berthou, 1999; Fifas *et al.*, 2004) using Jacobian matrix (*i.e.* matrix of partial derivatives of the objective).

The matrix of variances-covariances is obtained by the following relationship:

$$[M] = s^2.[I]^{-1} \qquad [5]$$

with:

[M]= matrix of variances-covariances; $[I]^{-1}$= inverse of matrix of information; s^2= sum of mean residual squares of the fitted function (s^2=SCE/DDL[4]):

$$SCE = -\sum_{i=1}^{Lj<Lm}\left[\varphi(L_i) - \frac{\alpha}{1+\exp(-\gamma\beta.(L_i - Lm))}\right]^2 + \sum_{i=j+1}^{Lj>=Lm}\left[\varphi(L_i) - \frac{\alpha}{1+\exp(\beta.(L_i - Lm))}\right]^2$$

[6]

The matrix of information is obtained by:

$$[I] = [J]'.[J] \qquad [7]$$

[J] is the Jacobian matrix (nc rows and 4 columns for French data, 3 for Irish):

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3 For French discards, are also included in the optimisation algorithm, the parameters α and L50 of the first period (1987–1990) which remained unknown.

4 DDL is equal to nc-4 for French discards, but equal to nc-3 for Irish data (parameter γ is omitted).

$$[J]=\begin{bmatrix} \frac{\partial\varphi(L_1)}{\partial\alpha} & \frac{\partial\varphi(L_1)}{\partial\beta} & \frac{\partial\varphi(L_1)}{\partial\gamma} & \frac{\partial\varphi(L_1)}{\partial Lm} \\ \frac{\partial\varphi(L_2)}{\partial\alpha} & \frac{\partial\varphi(L_2)}{\partial\beta} & \frac{\partial\varphi(L_2)}{\partial\gamma} & \frac{\partial\varphi(L_2)}{\partial Lm} \\ . & . & . & . \\ \frac{\partial\varphi(L_{nc})}{\partial\alpha} & \frac{\partial\varphi(L_{nc})}{\partial\beta} & \frac{\partial\varphi(L_{nc})}{\partial\gamma} & \frac{\partial\varphi(L_{nc})}{\partial Lm} \end{bmatrix} \quad [8]$$

[J]' is the transpose of [J], the partial derivatives of the equation [8], also defined as *absolute coefficients of sensitivity of order 1* written as a(α), a(β), a(γ), a(L_m) are given below:

$$\frac{\partial\varphi(L)}{\partial\alpha}=\frac{\varphi(L)}{\alpha} \quad [9]$$

$$\frac{\partial\varphi(L)}{\partial\beta}=\gamma.(L-Lm).\varphi(L).(1-\frac{\varphi(L)}{\alpha}) \text{ if } L \le L_m \quad [10a]$$

$$\frac{\partial\varphi(L)}{\partial\beta}=-(L-Lm).\varphi(L).(1-\frac{\varphi(L)}{\alpha}) \text{ if } L > L_m \quad [10b]$$

$$\frac{\partial\varphi(L)}{\partial\gamma}=\beta.(L-Lm).\varphi(L).(1-\frac{\varphi(L)}{\alpha}) \text{ if } L \le L_m \quad [11a]$$

$$\frac{\partial\varphi(L)}{\partial\gamma}=0 \text{ if } L > L_m \quad [11b]$$

$$\frac{\partial\varphi(L)}{\partial Lm}=-\beta.\gamma.\varphi(L).(1-\frac{\varphi(L)}{\alpha}) \text{ if } L \le L_m \quad [12a]$$

$$\frac{\partial\varphi(L)}{\partial\gamma}=\beta.\varphi(L).(1-\frac{\varphi(L)}{\alpha}) \text{ if } L > L_m \quad [12b]$$

Uncertainty of simulated discards

The matrix of variances-covariances of the four (three for Irish) parameters of the model and the use of partial derivatives of order 1 provide an approximate calculation of the variance of the variable Ψ(L) corresponding to simulated discards vs. size L. This procedure is based on limited developments of order 1 in Taylor's series (called Delta methods: Laurec, 1986; Laurec and Mesnil, 1987; Chevaillier, 1990; Chevaillier and Laurec, 1990; Fifas and Berthou, 1999; Fifas *et al.*, 2004).

By using Taylor's polynomial on a function Φ against parameters θ_1, θ_2, …, θ_k it is possible to present the variance of Φ by:

$$V[\Phi] \approx \sum_{i=1}^{k}\left(\frac{\partial\Phi}{\partial\theta i}\right)^2.V[\theta_i] + 2.\sum_{i=1}^{k-1}\sum_{j=i+1}^{k}\frac{\partial\Phi}{\partial\theta i}.\frac{\partial\Phi}{\partial\theta j}Cov[\theta_i,\theta_j] \quad [13]$$

Then, the variance of simulated discards vs. size, V[Ψ(L)], is written as:

$$V[\Psi(L)] \approx a(\alpha)^2.V[\alpha] + a(\beta)^2.V[\beta] + a(\gamma)^2.V[\gamma] + a(Lm)^2.V[Lm] + 2.a(\alpha).a(\beta).Cov[\alpha,\beta] +$$

$$2.a(\alpha).a(\gamma).Cov[\alpha,\gamma] + 2.a(\alpha).a(Lm).Cov[\alpha,Lm] + 2.a(\beta).a(\gamma).Cov[\beta,\gamma] + 2.a(\beta).a(Lm).Cov[\beta,L$$

$$2.a(\gamma).a(Lm).Cov[\gamma,Lm] \quad [14]$$

where the absolute coefficients of sensitivity of order 1 (partial derivatives) are defined above (equations [9] to [12])

Validation

The generated by simulation values are tested against discards estimated by sampling. This procedure is undertaken on French data of 1997 and also on available Irish set (all quarters of 2003, 2004-Q2, 2004-Q3, 2005-Q1, 2005-Q2, 2006 apart from Q4 *i.e.* 11 quarters). As performed for the Bay of Biscay *Nephrops* stock, this validation involves in three main stages (Figures 10–14): (1) Examination of the total amount of discards calculated by simulation that should not be significantly different from that obtained by sampling. (2) Test by linear regression performed on simulated numbers vs. size as dependent variable against sampled numbers as independent one. The slope of this relationship should not be significantly different from 1 (bisecting line) and the intercept should not be significantly different from 0. (3) Test of cumulative frequencies of the sets, sampled and simulated, using non parametric approaches such as Kolmogorov-Smirnov.

Results

Hand-sorting S-shaped curves

The French and Irish hand-sorting logistic curves estimated by sampling are provided by Figure 15. In the Table 4, are also presented the French parameters involving in years 1987–1990 (simulated by the multiple likelihood function applied for probability density of discards; see above).

Table 4. Summary of parameters of S-shaped hand-sorting curves.

	FR (years 1987–1990)		FR (year 1997)		IRL (years 2003–2005)	
Quarter	A	L50	A	L50	A	L50
Q1	0.797	32.685	1.006	32.776	0.480	25.876
Q2	0.494	35.573	0.718	36.019	0.426	26.016
Q3	0.331	32.227	0.851	33.654	0.559	25.785
Q4	0.697	31.138	0.815	32.381	0.412	24.886

These values indicate the high heterogeneity between the two fleets which accentuates the *a priori* high spatial heterogeneity of the targeted resource. Some weak differences are observed between the simulated values α and L50 of the first French period (1987–1990) and the sampling of 1997. Nevertheless, these parameters are given by deterministic way, therefore, there is no possibility of further statistical comparison.

Estimates of French discards

Estimates of French discards (1987–2006), total number of discarded individuals, parameters α, β, γ and Lm and corresponding coefficients of variation (CV, in %), are given below (Table 5). Table 6 and Figure 16 present discard rates by sex and combined for the overall time-series.

Table 5. French *Nephrops* trawlers, Celtic Sea (FU20–22). Estimates of discards, coefficients of model and coefficients of variation of parameters.

YEAR	DISC	CV(DISC)	LM	CV(LM)	A	CV(A)	B	CV(B)	Γ	CV(Γ)
1987	125752	4.62	30.278	3.25	25773	13.79	0.293	32.11	0.768	44.61
1988	425396	4.88	28.917	5.28	59518	16.97	0.260	39.24	0.534	56.57
1989	99536	4.02	31.061	4.36	14417	13.86	0.221	33.01	0.740	45.69
1990	81530	8.74	30.579	8.28	12219	28.86	0.221	61.77	0.866	92.51
1991	389726	5.69	29.479	5.70	57932	18.85	0.218	40.78	0.868	60.75
1992	377075	18.48	30.752	14.57	61039	58.97	0.314	142.51	0.534	193.98
1993	118210	199.42	31.299	147.10	20679	612.24	0.258	1356.53	0.879	1956.90
1994	93687	7.62	31.438	6.77	14384	24.84	0.232	54.91	0.830	79.80
1995	131541	136.57	31.808	95.39	25096	418.52	0.273	880.20	0.808	1323.18
1996	82811	6.05	32.357	5.61	12121	20.20	0.255	49.20	0.637	66.91
1997	96612	6.21	32.403	2.11	18050	15.36	0.673	46.01	0.397	55.62
1998	30494	7.62	31.393	10.98	3453	28.85	0.161	61.94	0.893	94.65
1999	36900	12.14	31.827	10.67	5618	40.01	0.236	84.90	0.791	127.28
2000	22234	46.41	33.790	56.24	2655	171.90	0.175	359.92	0.863	552.62
2001	98962	5.59	31.766	7.43	11594	20.94	0.191	46.64	0.682	69.25
2002	34283	18.42	33.466	21.52	4223	66.86	0.193	150.64	0.762	217.87
2003	59692	4.73	34.452	3.48	9659	15.04	0.285	36.31	0.638	49.26
2004	29493	9.36	33.546	9.20	4050	32.24	0.202	69.23	0.874	103.22
2005	15097	18.92	34.739	17.57	2098	65.03	0.205	136.51	0.873	206.98
2006	17286	6.86	36.327	7.29	2350	24.93	0.238	64.77	0.530	85.17

<u>Note</u>: the sampled year 1997 is given in bold and italic fonts whereas in coloured fonts are presented the years for which the model based on the probability density seems to be inappropriate (years 1993, 1995, 2000; extremely high CV of parameters and discarded numbers). The total discarded number cited for 1997 is the value obtained by sampling.

Table 6. French *Nephrops* trawlers, Celtic Sea (FU20–22). Discard rate (%) by year.

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
total	65.0	83.8	58.6	51.2	86.2	82.0	60.9	55.8	63.4	54.3	65.4	40.1	40.3	31.7	64.9	37.4	49.3	40.7	28.8	28.7
males	46.5	67.0	38.5	32.8	73.7	65.3	40.7	37.0	44.2	33.6	45.6	23.0	23.8	19.8	46.4	21.0	30.0	24.0	16.6	18.2
females	86.7	96.5	86.1	79.6	96.0	96.3	90.2	82.3	88.3	88.1	94.7	75.0	72.9	55.6	85.5	80.8	90.6	81.4	68.8	48.9

As presented above, the model based on probability density with skewness gives generally adequate results (see parameters' CV) except for three years on twenty of the overall time-series. Nevertheless, the provided CV are estimated by the model and do not necessarily reflect the actual uncertainty because of complex organization of samples (subsampling stratified plan applied on board). This is illustrated by the sampled year 1997 which demonstrated high spatial and temporal variability of discard size-composition vs. that of landings (CV of samples>30%) although the estimated by the model CV seems unlikely (weak value of 6.21%). Moreover, the generated by the model total number of discarded *Nephrops* for 1997 was underestimated (66 millions *i.e.* 68% of the total number estimated by sampling: 97 millions). The use of the coefficient γ in the model was justified by the expected skewness of discard distributions as a consequence of the selectivity effect: in fact, all values of γ do not exceed 1. However, using the simulated model for the year 1997 with assumed symmetrical distribution of discards and with no constraint on relationship between mean sizes in discards and in landings provided more satisfactory results (Figure 17). The symmetrical simulation gave un estimate of 83 millions of discards *i.e.* 86% of the 97 millions calculated by sampling closer than the value generated with skewness. Moreover, the CV of parameters α, Lm and mainly β are less strong.

There is no current statistical evidence for choosing symmetrical or not distribution for simulations and there is no possibility of validating any relationship between mean sizes in discards and landings while the actual sampling is limited to only one complete year.

However, as underlined in the Stock Annex, the generated by model cpue (including discards calculated by the probabilistic simulation with skewness) demonstrate a good agreement with EVHOE groundfish survey indices for the period 1997–2005 (R^2=0.65) while the relationship between lpue and EVHOE indices seems more sparse (R^2=0.36). As also reported by WGSSDS 2007, throughout the overall time-series, some high (years 1988, 2001) or low (year 1990) values of simulated discard rates coincide with increase or decrease of lpue for 1–2 years later (increase in 1989–1990 and 2002–2003, decrease in 1991–1992). It is noticeable that no constraint was set for back-calculations on the relationship between discard rate (year i) and lpue (years i+1/i+2).

Estimates of Irish discards

Estimates of Irish discards by quarter (since 2002), total numbers of discarded individuals, parameters α, β and Lm and corresponding coefficients of variation (CV, in %), are provided below (Table 7).

A first examination of results reveals an overall better statistical adequacy than for French discards. Except for one sampled quarter (coloured fonts; 2005-Q2), the coefficients of determination are strong and the CV of model parameters remain relatively low. Despite this initial overview, the adequacy of the probabilistic approach will be tested as regards the procedure developed for the Bay of Biscay stock.

The Table 8 and Figure 18 present quarterly discard rates by sex and combined for the overall time-series. Discard rates by sampling and by simulation can be directly compared for 11 quarters (Table 8): it seems that the average simulated discard percentage is slightly lower than the sampled one (26.0% against 27.3%), but for 8 quarters on 11, the simulated values are underestimated.

The Table 9 and Figure 19 give comparisons between sampled and simulated discarded numbers. Two sampled years (2003 and 2005) for the 1st quarter give low correlations between sampled and simulated discards. Despite more good correlation levels (9 on 11), the overall conclusion is that the null hypothesis (slope=1) is refused apart from one example (2004-Q2) which although provides biased results of simulated discards (very high ratio Nexp/Nobs). It is worth noting that the descending part of simulated DLF of discards seems to be more coherent with the sampled DLF than the ascending one (except for one case on 11, 2005-Q2 which is denoted by the less good statistical consistency of simulation in regards with the low value of ϱ^2: Table 7). Introduction of some constraint between mean sizes in discards and in landings as for the French example may give different results for the ascending DLF.

Table 7. Irish *Nephrops* trawlers, Celtic Sea (FU20–22). Estimates of discards, coefficients of model and coefficients of variation of parameters (bold characters=sampled quarters).

YEAR	Q	DISC	LM	CV(LM)	A	CV(A)	B	CV(B)	P²
2002	Q1	2664	26.039	0.95	1282	13.89	0.674	18.09	0.990

2003	Q1	6318	20.994	1.97	1476	11.52	0.319	15.53	0.855
2004	Q1	2208	24.743	1.34	998	18.48	0.625	24.42	0.960
2005	Q1	7613	25.929	0.88	3764	13.27	0.691	17.29	0.994
2006	Q1	11279	25.218	0.68	4594	8.56	0.564	11.32	0.929
2002	Q2	1670	27.891	1.10	666	14.69	0.555	19.37	0.950
2003	Q2	10236	25.119	0.72	4204	8.98	0.571	11.84	0.980
2004	Q2	4953	24.685	1.05	1003	6.39	0.278	8.59	0.951
2005	Q2	23437	25.139	1.42	3701	6.79	0.214	9.27	0.608
2006	Q2	15977	26.854	0.35	7902	5.61	0.688	7.35	0.987
2002	Q3	729	27.444	0.77	363	13.40	0.686	17.73	0.982
2003	Q3	15985	22.042	0.43	5780	4.04	0.504	5.33	0.940
2004	Q3	1291	28.143	0.26	571	3.90	0.615	5.13	0.969
2005	Q3	4795	24.751	0.64	2562	10.55	0.739	13.85	0.960
2006	Q3	2518	25.484	0.44	1144	6.48	0.626	8.60	0.927
2002	Q4	11343	24.442	0.56	5197	7.89	0.631	10.46	0.990
2003	Q4	2166	24.284	0.83	630	7.23	0.402	9.64	0.967
2004	Q4	1561	27.543	0.93	713	14.91	0.630	19.77	0.992
2005	Q4	9249	24.318	0.67	4603	10.22	0.687	13.49	0.992
2006	Q4	10394	25.289	0.67	5666	11.50	0.753	15.11	0.990

Table 8. Irish *Nephrops* trawlers, Celtic Sea (FU20–22). Discard rate (%) by quarter and year (for the sampled quarters: the cited percentages in bold correspond to the sampling results; those in brackets are obtained by the simulation).

YEAR	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006
quarter	Q1	Q1	Q1	Q1	Q1	Q2	Q2	Q2	Q2	Q2	Q3	Q3	Q3	Q3	Q3	Q4	Q4	Q4	Q4	Q4
total	7.3	26.9	15.4	35.3	41.1	2.6	37.6	11.5	21.4	29.5	1.2	41.2	10.1	11.1	19.5	9.9	26.4	2.3	54.3	7.2
		(41.6)		(24.5)	(32.4)		(29.9)	(16.5)	(28.8)	(24.1)		(40.6)	(9.0)		(15.6)		(22.9)			
males	6.6	22.1	13.7	37.9	34.5	2.5	34.0	11.1	19.3	22.9	1.3	42.2	9.3	5.2	17.0	10.9	20.7	4.3	47.0	8.0
females	8.9	75.1	18.7	34.0	56.8	2.7	40.5	11.7	22.7	32.7	1.2	40.6	11.4	40.0	20.9	6.5	59.1	0.2	71.2	3.8

It would also be interesting to re-examine the comparisons after assuming skewness of discards distributions (use of coefficient $\gamma \neq 1$ as for the French fleet). It is noticeable that for 5 quarters on 11 (Figure 19) the DLF of samples deviates from the assumed symmetry of simulations, then smaller individuals are underestimated (however, the overestimation of the small *Nephrops* by the simulation occurs less often, but provides extremely divergent results). Although, there is no current basis for further analysis of this point because there is no evidence of any particular effect of some biological feature affecting the symmetry of distributions *i.e.* moulting which occurs in spring and autumn (example examined in the French fishery of the Bay of Biscay). The short time-series and the low sampling rate do not allow the generalization of this first overview.

Table 9. Irish *Nephrops* trawlers, Celtic Sea (FU20–22). Relationships between discarded numbers by sampling (Nobs) and by simulation (Nexp).

YEAR/QUARTER		NEXP=Ψ(NOBS)	P²	P(SLOPE)	NEXP/NOBS
2003	Q1	Nexp=0.87*Nobs+84.99	0.44	0.41	194%
2005	Q1	Nexp=0.60*Nobs-2.72	0.72	0.00*	60%
2006	Q1	Nexp=0.72*Nobs-12.49	0.89	0.00*	69%

2003	Q2	Nexp=0.72*Nobs-3.87	0.84	0.00*	71%
2004	Q2	Nexp=0.94*Nobs+45.90	0.85	0.38	152%
2005	Q2	Nexp=0.78*Nobs+267.45	0.85	0.00*	148%
2006	Q2	Nexp=0.83*Nobs-39.77	0.94	0.00*	76%
2003	Q3	Nexp=0.89*Nobs+32.24	0.94	0.00*	97%
2004	Q3	Nexp=0.86*Nobs+0.92	0.97	0.00*	88%
2006	Q3	Nexp=0.80*Nobs-2.90	0.91	0.00*	77%
2003	Q4	Nexp=0.74*Nobs+5.79	0.88	0.00*	83%

Note: *=significant result (1-α=0.95)

Conclusion

The biological sampling on board for *Nephrops* FU20–22 stock remains poor for both main fleets. The duration of trips for French trawlers (12–15 days) restricts possibilities of regular participation of observers. Moreover, in agreement with results of sampling design applied in 1997, the long duration of trips implies a high spatial variability of harvested areas by trip and a low total number of trips sampled by quarter. Thus, the CV of discarded numbers estimated by sampling remains high. By the way, the simulations developed on French discards are hampered by the sampling of only one year throughout a long time-series. The discard practices during the whole period may change, but there is no current possibility to test the effect of such a modification on the hand-sorting on board. In spite of that, some discard rates by year agree overall with independent indices as EVHOE groundfish survey indices (as pointed by last year's WG) and with the most notable changes in lpue during the whole time-series.

The Irish dataset takes more promising because of a shorter duration of trips. Hence, conceptual problems of sampling design inherent to the French fleet should not affect the Irish data. As the Irish fleet seems to be more recruitment directed, the indices provided by the sampling on board should improve the diagnostic accuracy. In the meantime, the simulation based on the probabilistic approach indicated an overall consistent reconstitution of discards for more sampled quarters. Many further investigations have to be carried out in the order to validate extrapolations from French catches to Irish for the period before 2002.

B.3 Surveys

Direct *Nephrops* assessment by trawling is inappropriate because of notable diurnal variations of availability which is higher during dawn and dusk. The most adapted way is based on transect with video and TV runs of burrows (combined with hauls on area and geo-statistical analysis of catches with the aim of separating burrows of *Nephrops* from those of squat lobster), but it needs heavy preliminary arrangements because the spatial heterogeneity of resource requires to well define the survey area and the sampling plan in order to avoid biased results. The current situation will be improved in future once a data time-series has been collected by the Irish specifically designed survey program launched in 2006. However, the Irish and French exploited areas are different. On FU20–22 the French groundfish survey EVHOE while not focusing on *Nephrops* does provide an indication of the length distributions and the strength of recruitment (Figure 20). An Irish groundfish survey giving size composition of *Nephrops* catches has also been carried out since 2003. Moreover, a UK bottom-trawl survey had occurred on the same area between 1984 and 2004, but only two sampling stations were within FU20–22 area.

A comparative analysis conducted between lpue and cpue of French and Irish vessels with EVHOE indices reveals a good agreement between commercial French cpue and EVHOE series for the period 1997–2005 (R^2=0.65) while the relationship is more sparse (R^2=0.36) when the commercial French lpue are used (Figure 21). The Irish data are not significantly linked to the French dataset probably as a consequence of the difference of harvested area and the short time-series.

The results of the UWTV survey initiated by Republic of Ireland in 2006 involving in the three first years, 2006–2008, are shown by Figures 20–25 and Tables 10–11. It is noticeable that the strongest values of this short time-series (2006) coincide with the highest level on "Smalls" as reported by Irish industry in 2007. In a time frame of around 2–4 years, this survey should provide valuable information to tune data for the FU20–22 *Nephrops* stock especially on the "Smalls" ground where are located more than the $^2/_3$ of the total Irish yearly production. Nevertheless, the historical longer series of French landings in the Celtic Sea is less involved by the area covered by UWTV (the contribution of the rectangle 31E3 in the total French production fell from 41% in 1999 at less than 10% in 2008). This implies the necessity to tune data for the whole area by additional series corresponding.

B.4. Commercial cpue

Between 2006 and 2007, the French fishing effort declined notably by -25% and the lpue increased (+13%) although the evolution of the same indicators for the Irish fleet was different (+31% of fishing effort and +36% of lpue). It is noticeable that the decrease of the French fishing effort was caused by the reduction of the number of trips by vessel whereas the total number of vessels remained almost stable. The evolution of the Irish fishing effort involves either in increase of the fishing vessels (95 Irish trawlers were listed in 2007 against 80 for 2006) or in increase of the number of trips by vessel.

Between 2007 and 2008, the effort of the French trawlers decreased slightly *i.e.* 99 789 h against 101 980 h for 2007 whereas the Irish fishing effort remained stable (59 727 h against 59 899 h in 2007). Lpue of both fleets increased mainly for French trawlers (+22%: 22.6 kg/h against 18.5 kg/h for 2007) and, to a lesser degree, for Irish (+11%: 55.2 kg/h against 49.4 in 2007).

C. Historical stock development

There is no currently specific development for analytical assessment of the stock. By the WGNEPH 2003, the FU20–22 *Nephrops* stock was analytically assessed by XSA (software VPA; Darby and Flatman, 1994). Because of the lack of long and consistent Irish series (before DCR), the analysis was limited on the male component involved by French trawlers (see input parameters: Table 1).

D. Short-term projection

No short-term projection is performed for this stock.

E. Medium-term projections

No medium-term projection is performed for this stock.

F. Long-term projections

No long-term projection is performed for this stock.

G. Biological reference points

There is no biological reference point for this stock.

H. Other issues

I. References

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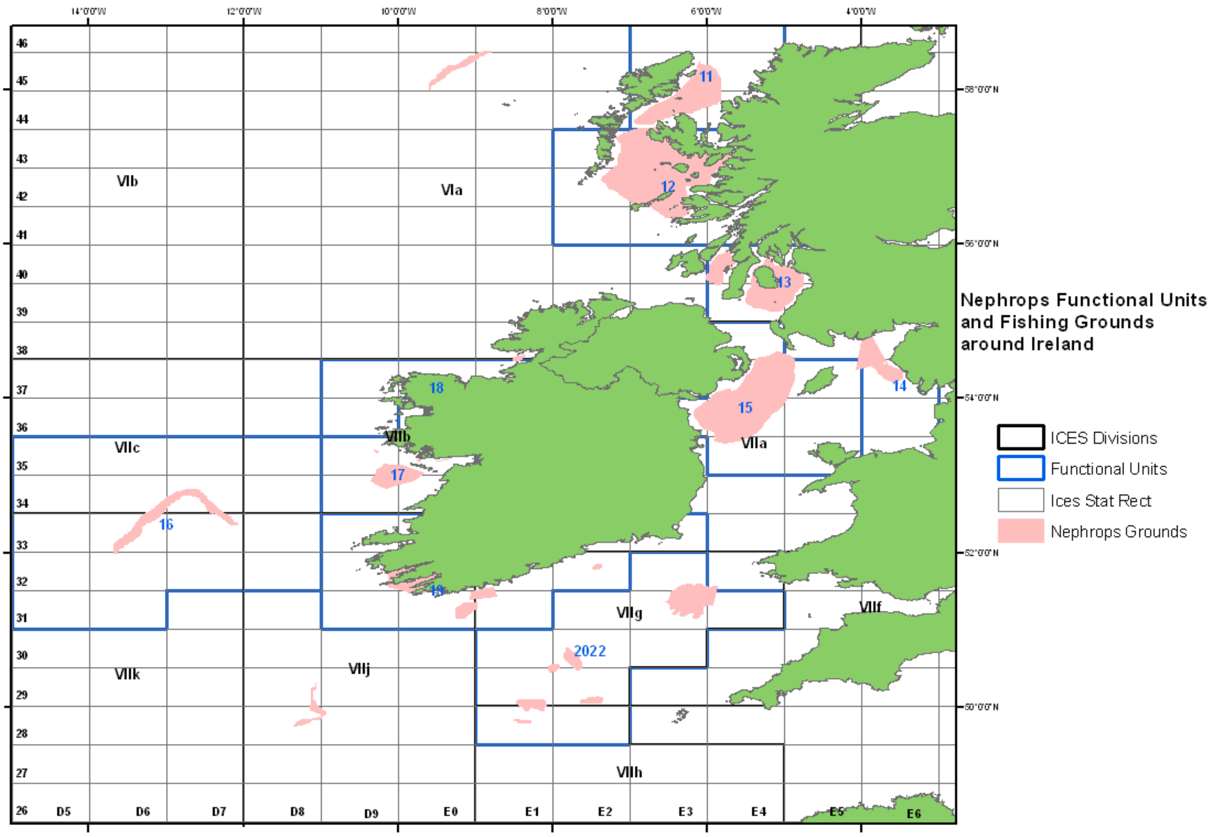


Figure 1. Functional units 20–22 (*Nephrops* grounds in Celtic Sea).

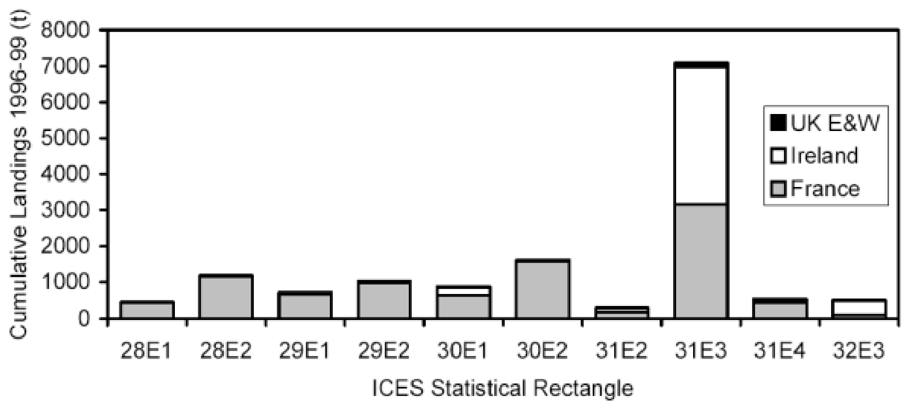
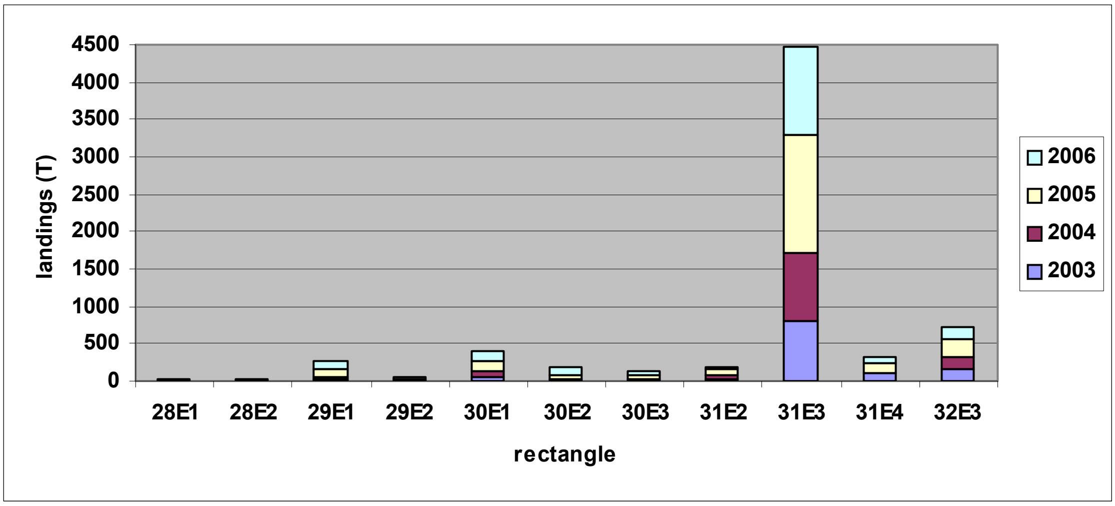


Figure 2. *Nephrops* FU20–22 (Celtic Sea). Spatial distribution of landings of the main fleets (average value of the period 1996–1999).



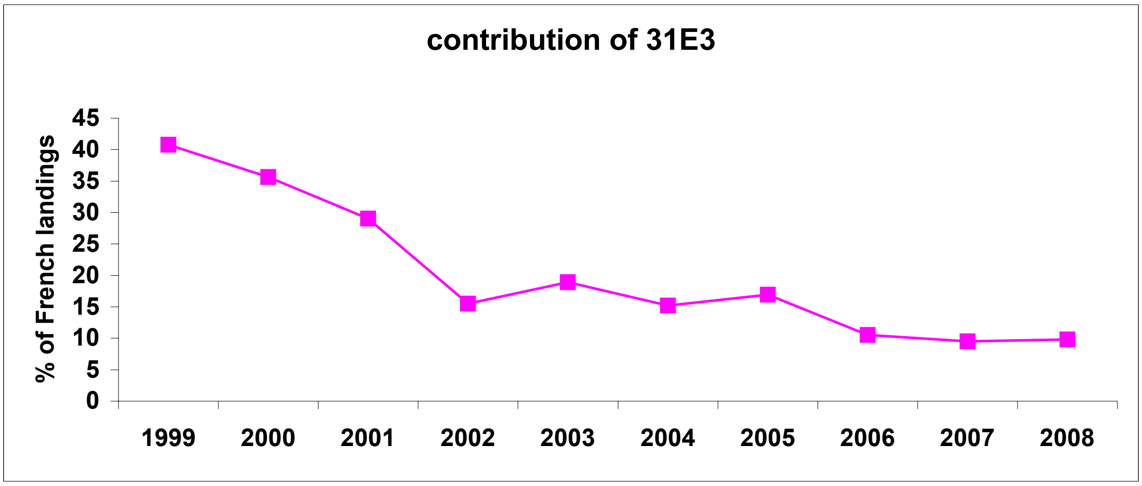


Figure 3. ***Nephrops*** **FU20–22 (Celtic Sea). Above: Spatial and by year distribution of Irish landings. Below: Contribution of the rectangle 31E3 (concentrating more than 2/3 of the total Irish production) in the total French landings. Years 1999–2008.**

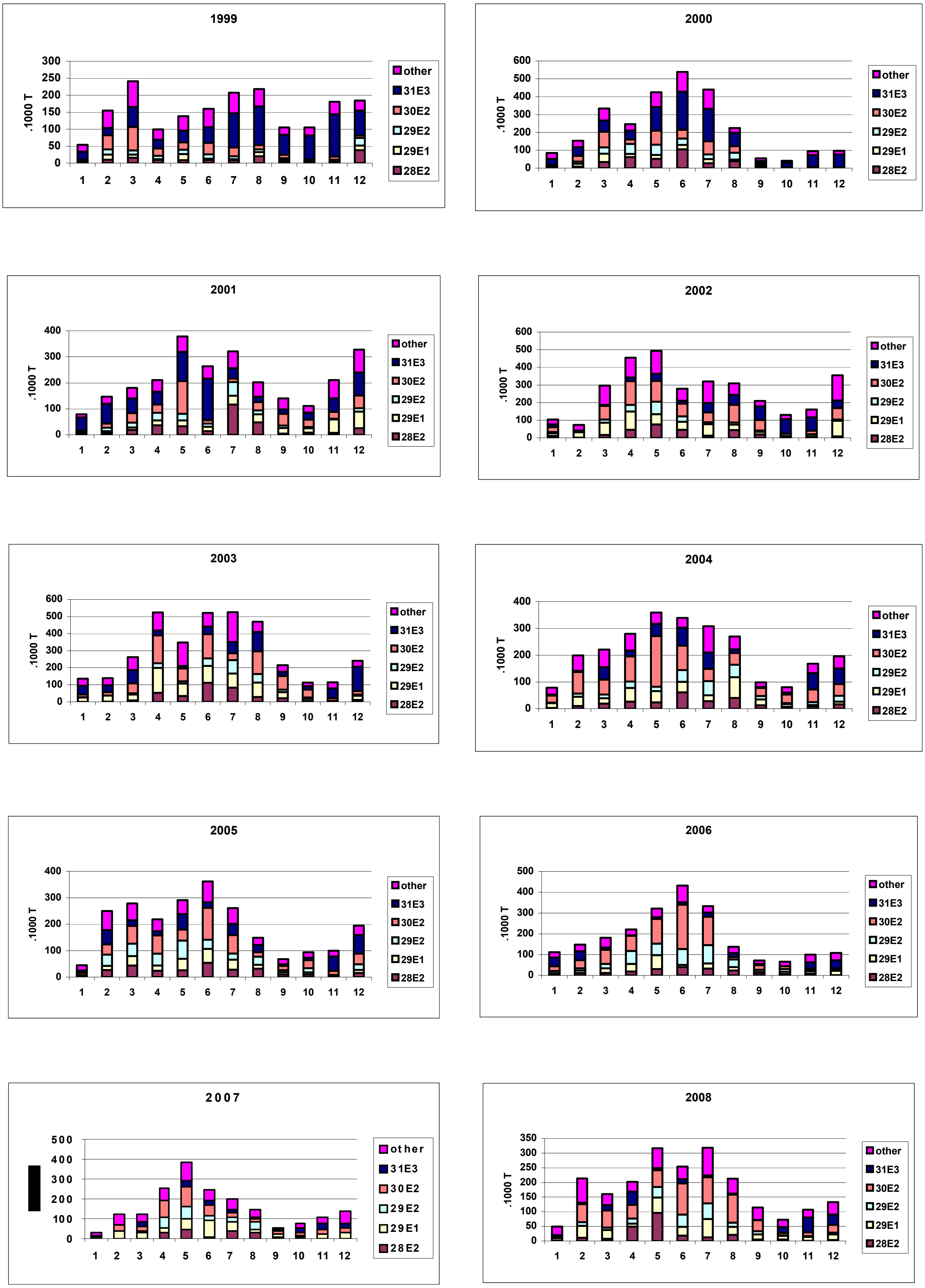


Figure 4. ***Nephrops*** **FU20–22 (Celtic Sea). Spatial and monthly distribution of French landings.**

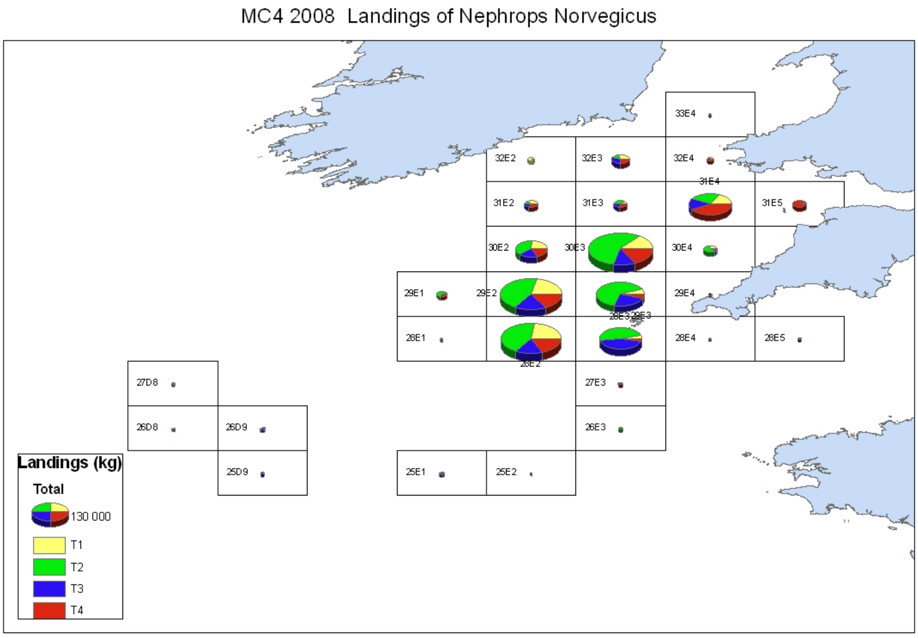


Figure 5. ***Nephrops*** **FU20–22 (Celtic Sea). Spatial distribution of French landings in 2007.**

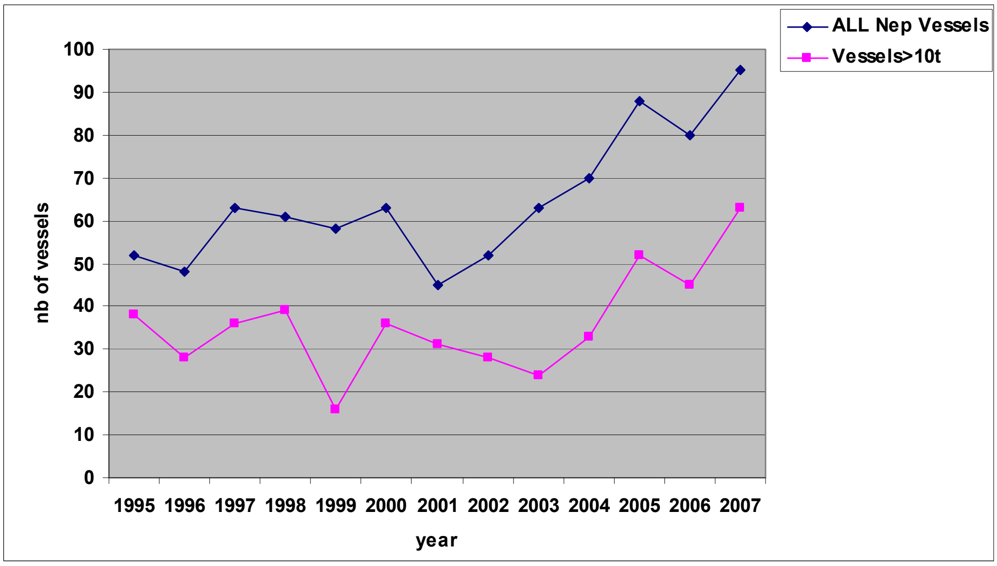


Figure 6. ***Nephrops*** **FU20–22 (Celtic Sea). Number of Irish trawlers involving** ***Nephrops*** **landings.**

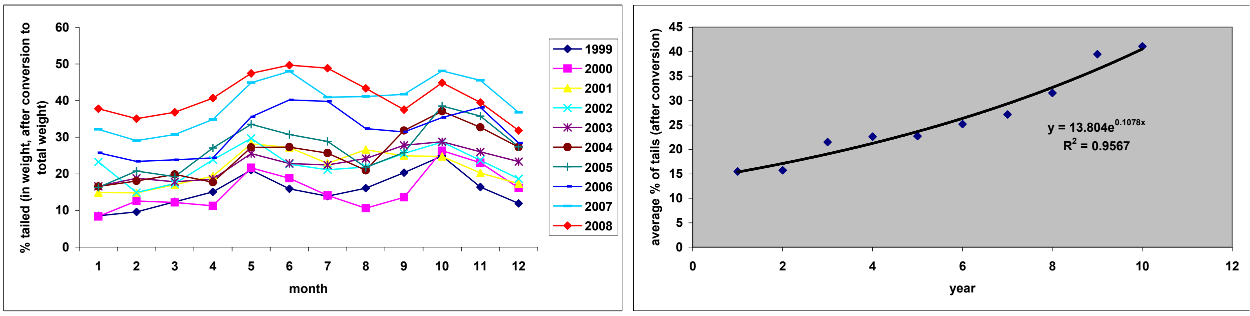


Figure 7. *Nephrops* FU20–22 (Celtic Sea). Tailed proportion (in converted weight) in landings by month (left) and by year (right).

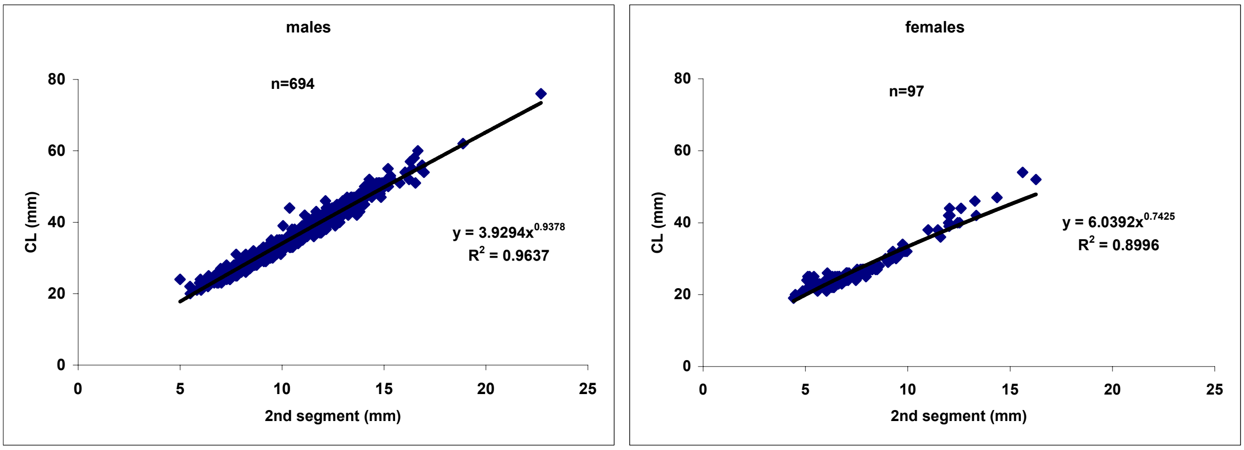


Figure 8. *Nephrops* of the Celtic Sea (VIIfgh, FU20–22). Biometric relationships (CL vs. 2nd abdominal segment by sex). Data harvested during the survey EVHOE 2007.

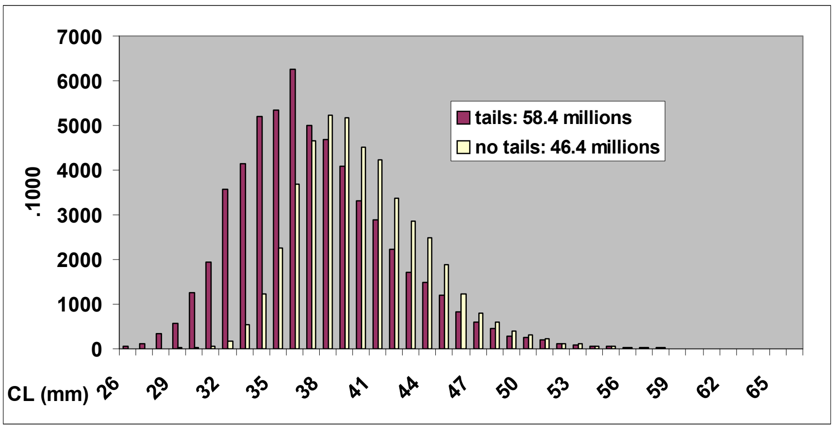


Figure 9. *Nephrops* of the Celtic Sea (VIIfgh, FU20–22). French landings for 2008. Length distributions (1) including the data on tails and (2) using the previous method (no sampling of tails; the total tailed proportion was apportioned in the smallest category of entire *Nephrops* at auction).

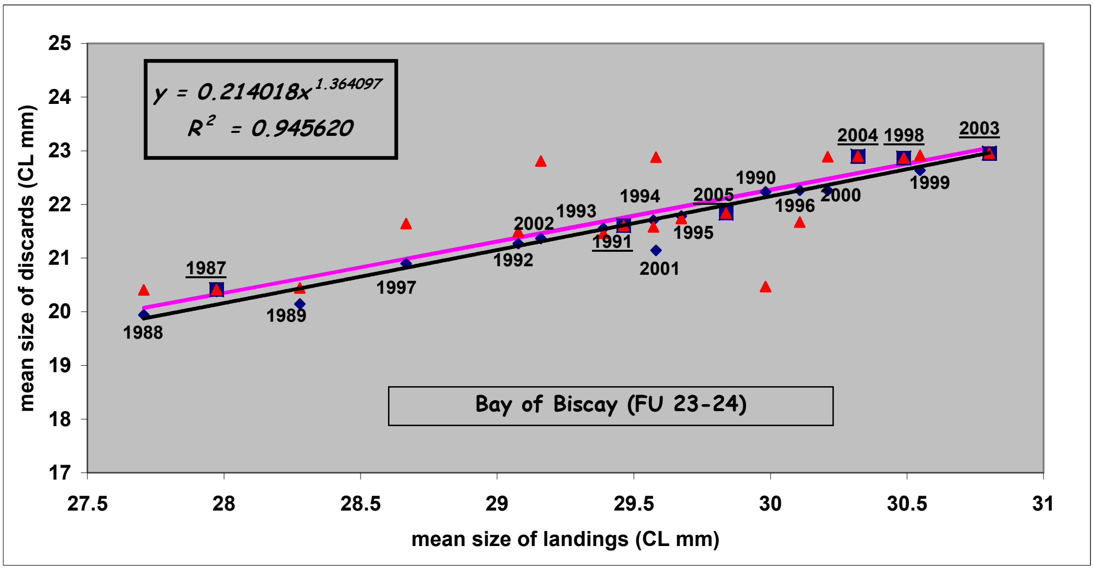


Figure 10. *Nephrops* of FU23–24 (Bay of Biscay). Final results of logistic derivation of discards. Relationship between mean sizes of landings and discards. The triangular fonts represent the results of the *status quo* (proportional derivation) method. The underlined years correspond to the available datasets of sampling on board. The rhombus fonts correspond to the logistic derivation. The dark curve is provided by the final fitting on the whole time-series. The bright curve is the result of the fitting on the years with available data.

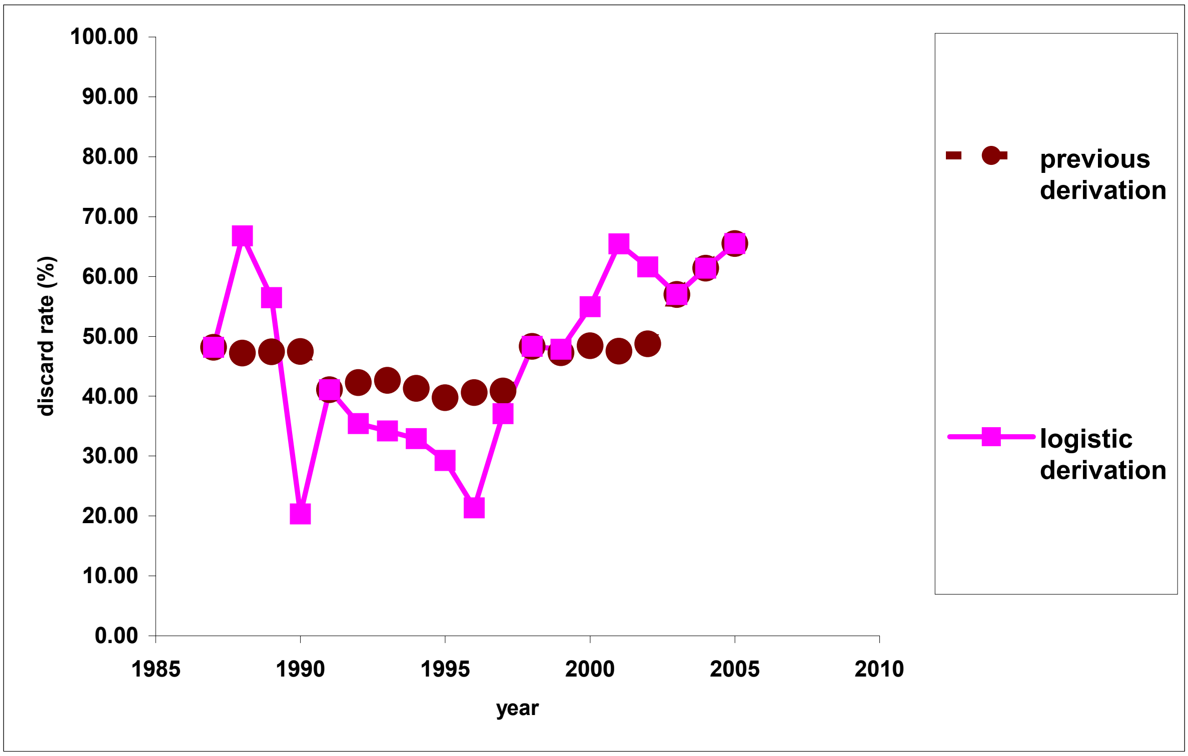


Figure 11. *Nephrops* of FU23–24 (Bay of Biscay). Comparison between discard rates obtained by previous (proportional) derivation and by logistic derivation. Combined sexes and whole year datasets.

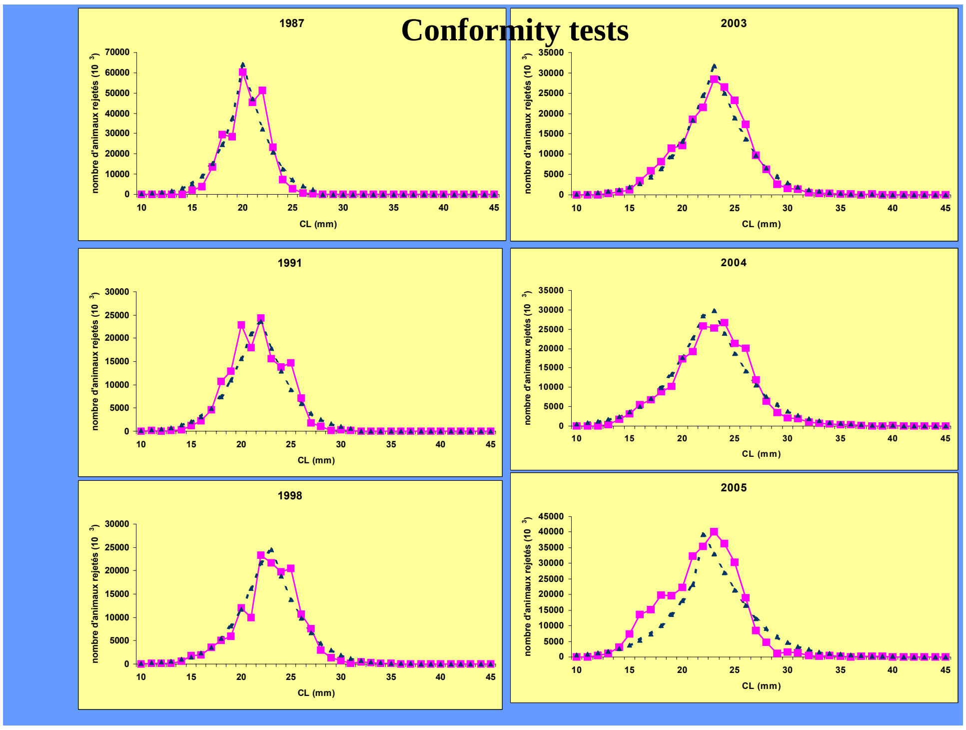


Figure 12. ***Nephrops*** **of FU23–24 (Bay of Biscay). Comparison between distributions of length frequencies (carapace length, CL in mm) of discards obtained by sampling and by simulation (broken lines).**

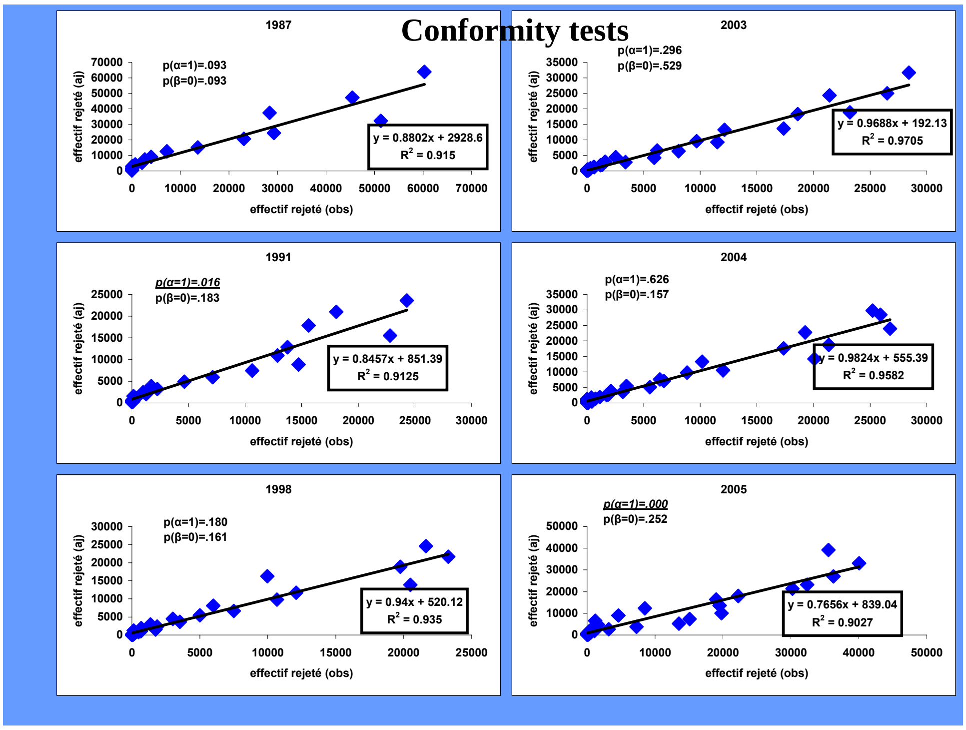
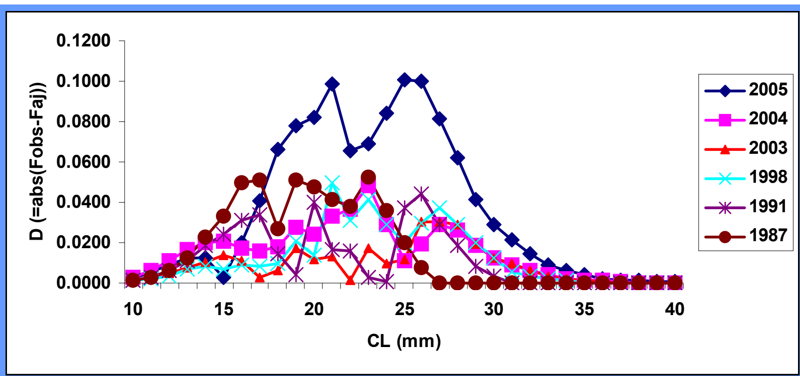


Figure 13. ***Nephrops*** **of FU23–-24 (Bay of Biscay). Comparison between discarded numbers of individuals obtained by simulation (Y-axis) and by sampling (X-axis). Statistical tests on linear regressions of Y vs. X by year.**



year	Da	Dobs	%
2005	0.113	0.101	85
2004	0.127	0.048	107
2003	0.135	0.031	100
1998	0.154	0.049	106
1991	0.157	0.044	97
1987	0.115	0.052	108

Figure 14. ***Nephrops*** **of FU23–24 (Bay of Biscay). Statistical test (Kolmogorov-Smirnov) between cumulated frequencies of sampled and simulated discards by year.**

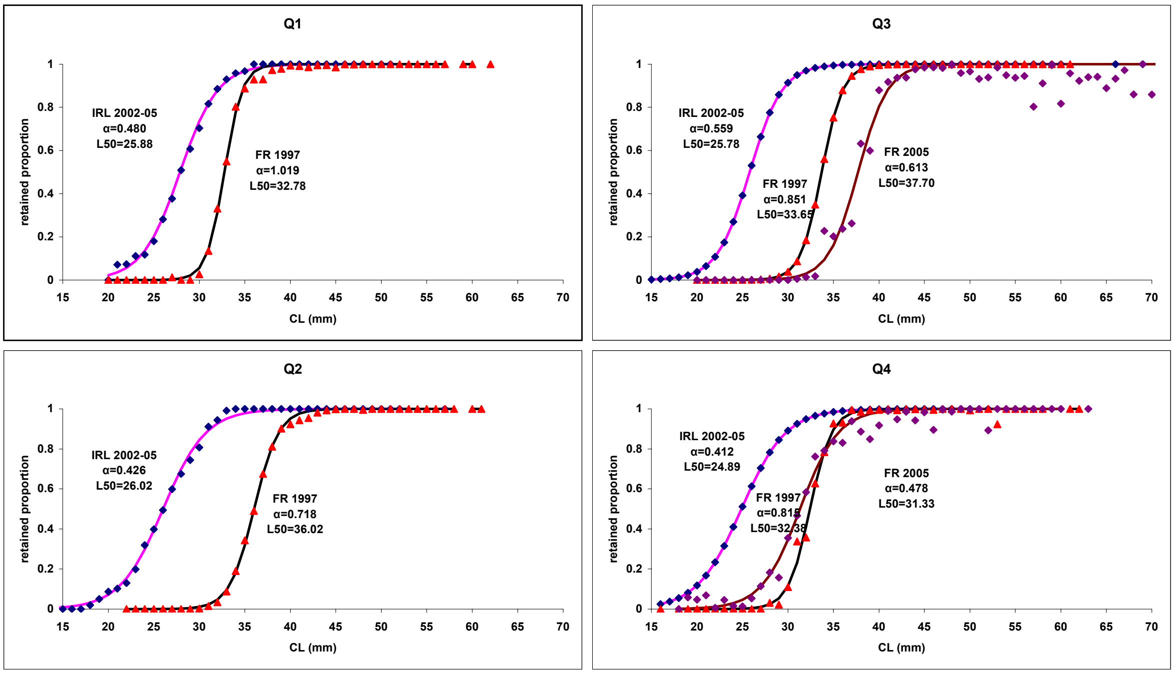


Figure 15. ***Nephrops*** **FU20–22 (Celtic Sea). Different hand-sorting logistic curves by quarter, country and dataset. In 2005 no sample was collected in France during the 1st quarter and the 2nd quarter provided inconsistent results.**

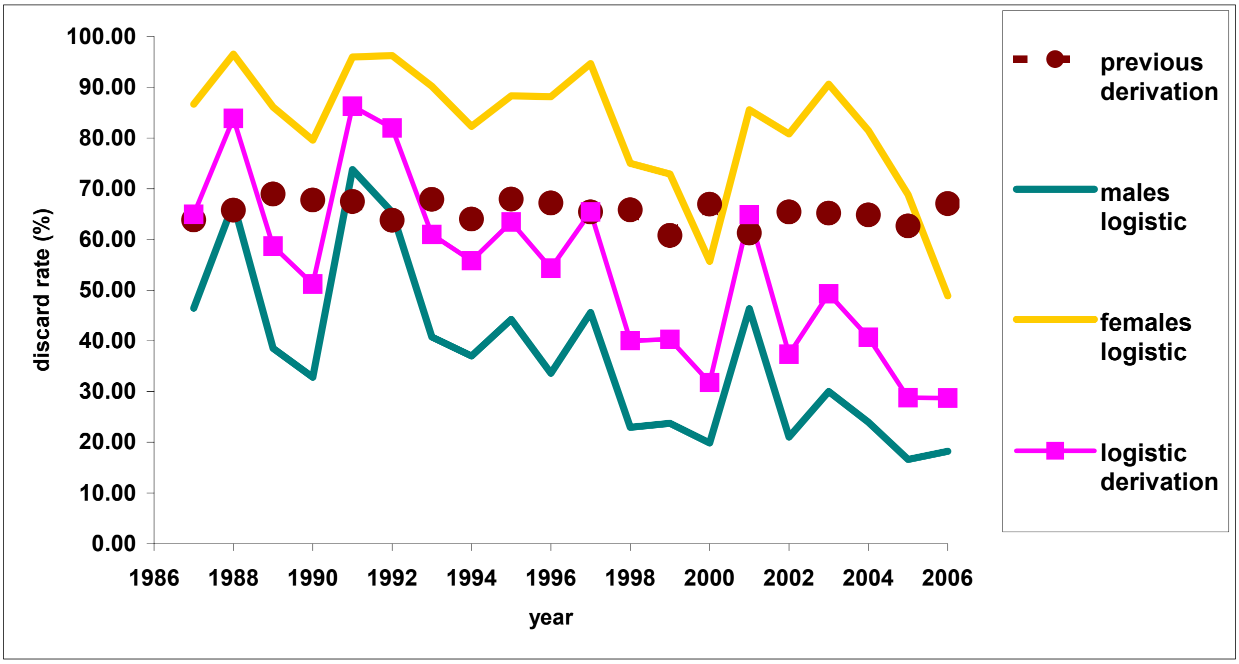
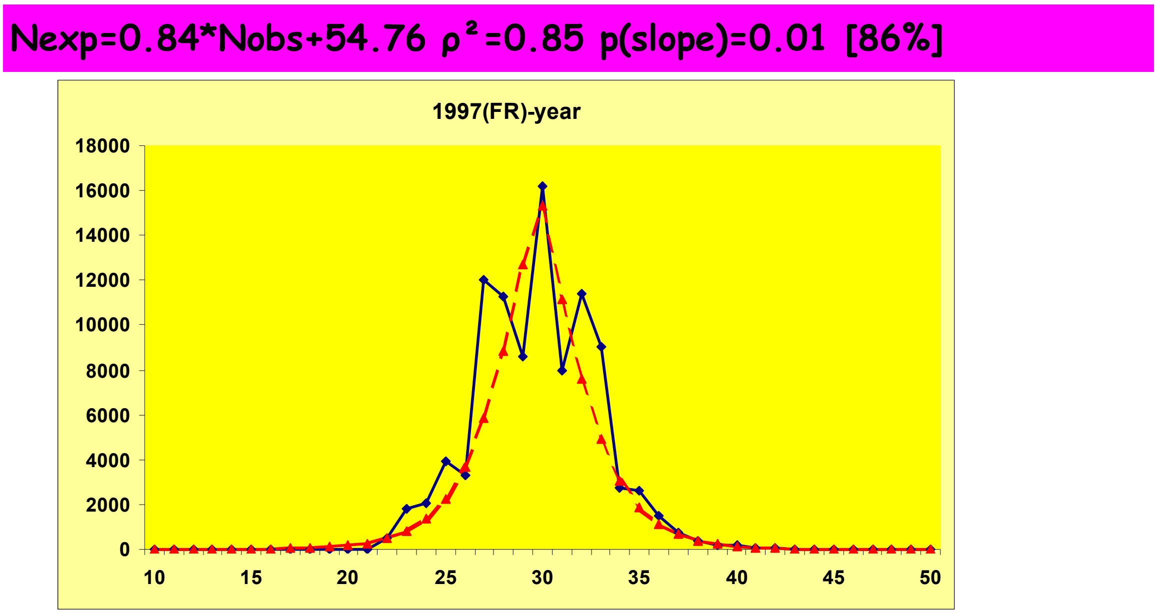


Figure 16. ***Nephrops*** **of FU20–22 (Celtic Sea). Comparison between discard rates obtained by previous (proportional) derivation (used by WGNEPH until 2004) and by logistic derivation. Combined sexes and whole year datasets.**



YEAR	DISC	LM	CV(LM)	A	CV(A)	B	CV(B)	Ρ²
1997	83 306	29.807	1.29	32 335	9.42	0.538	6.43	0.913

Figure 17. ***Nephrops*** **of FU20–22 (Celtic Sea). French fleet. Results of the discard simulation of the year 1997. The distribution is assumed symmetrical and no constraint was set on relationship between mean sizes in discards and landings. Simulated number (Nexp) illustrated by broken line are compared with sampled one (Nobs).**

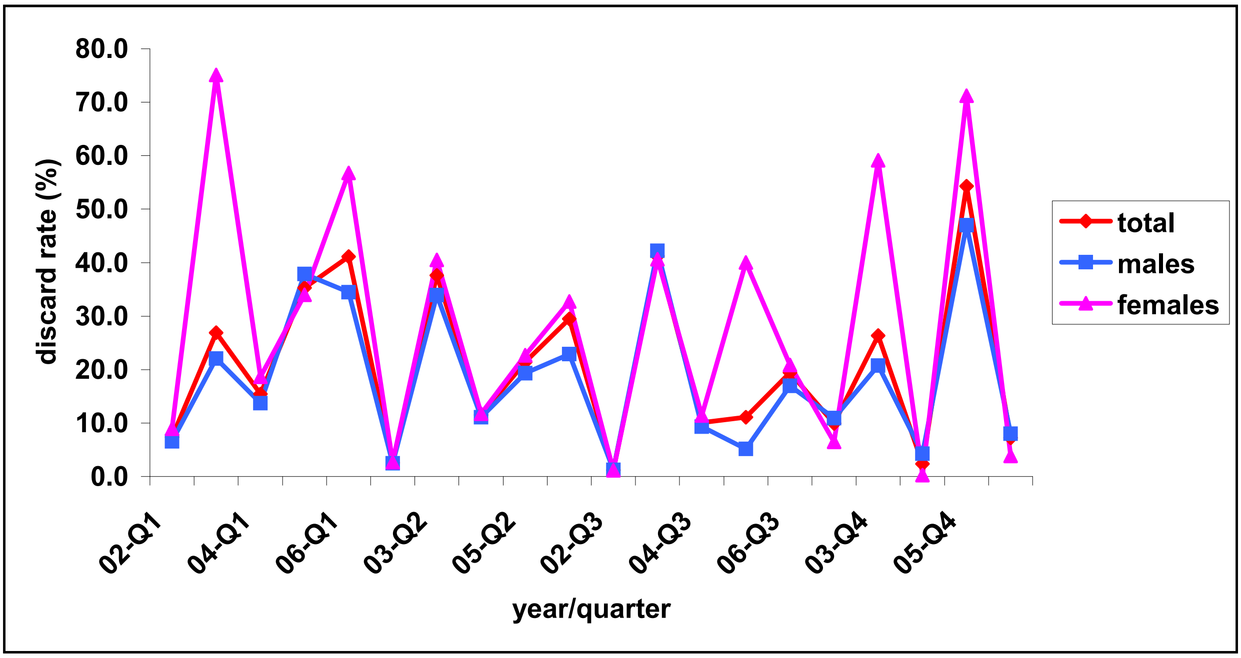


Figure 18. ***Nephrops*** **of FU20–22 (Celtic Sea). Discard rate (%) of Irish trawlers by year and quarter.**

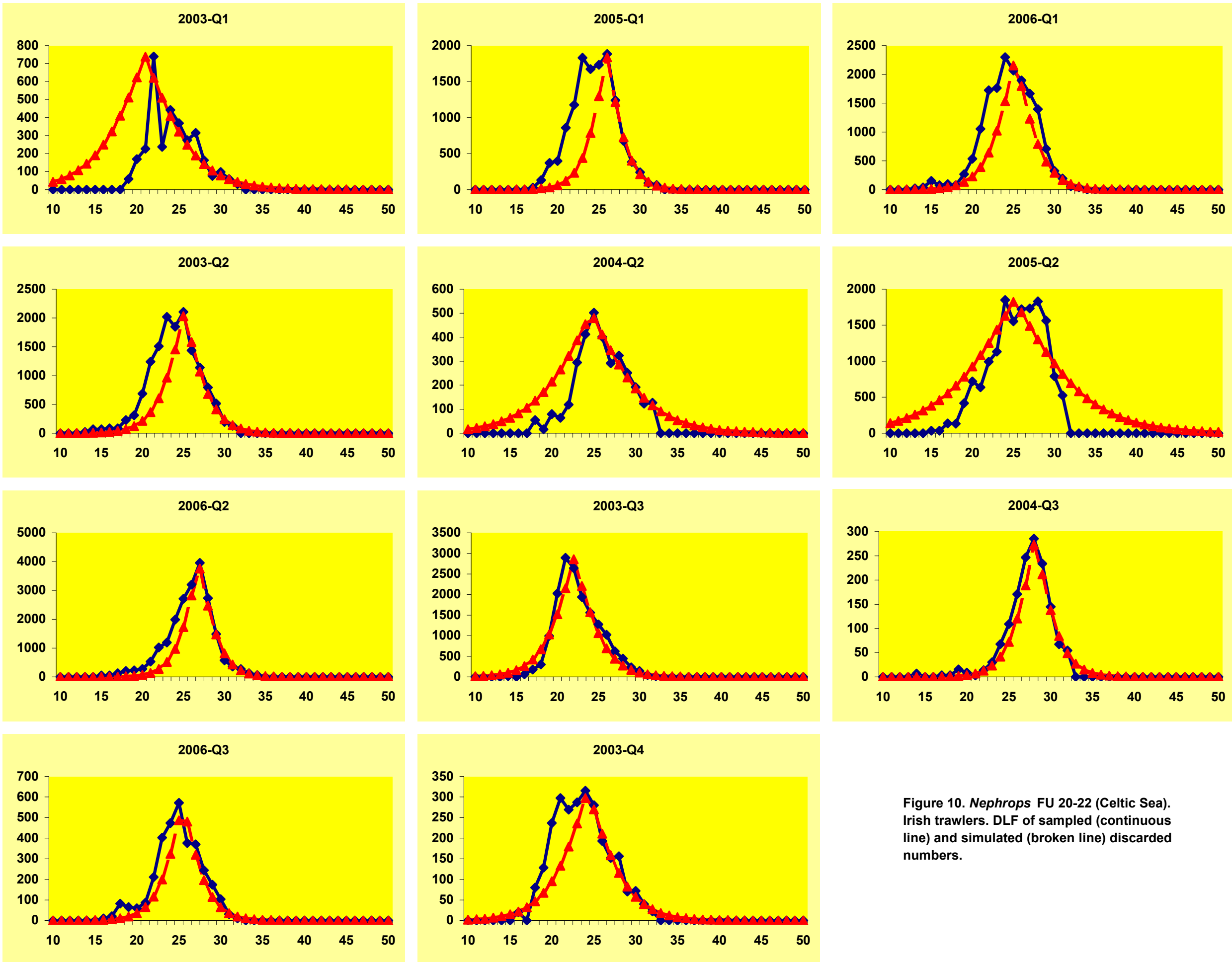


Figure 19. ***Nephrops*** **FU20–22 (Celtic Sea). Irish trawlers. DLF of sampled (continuous line) and simulated (broken line) discarded numbers.**

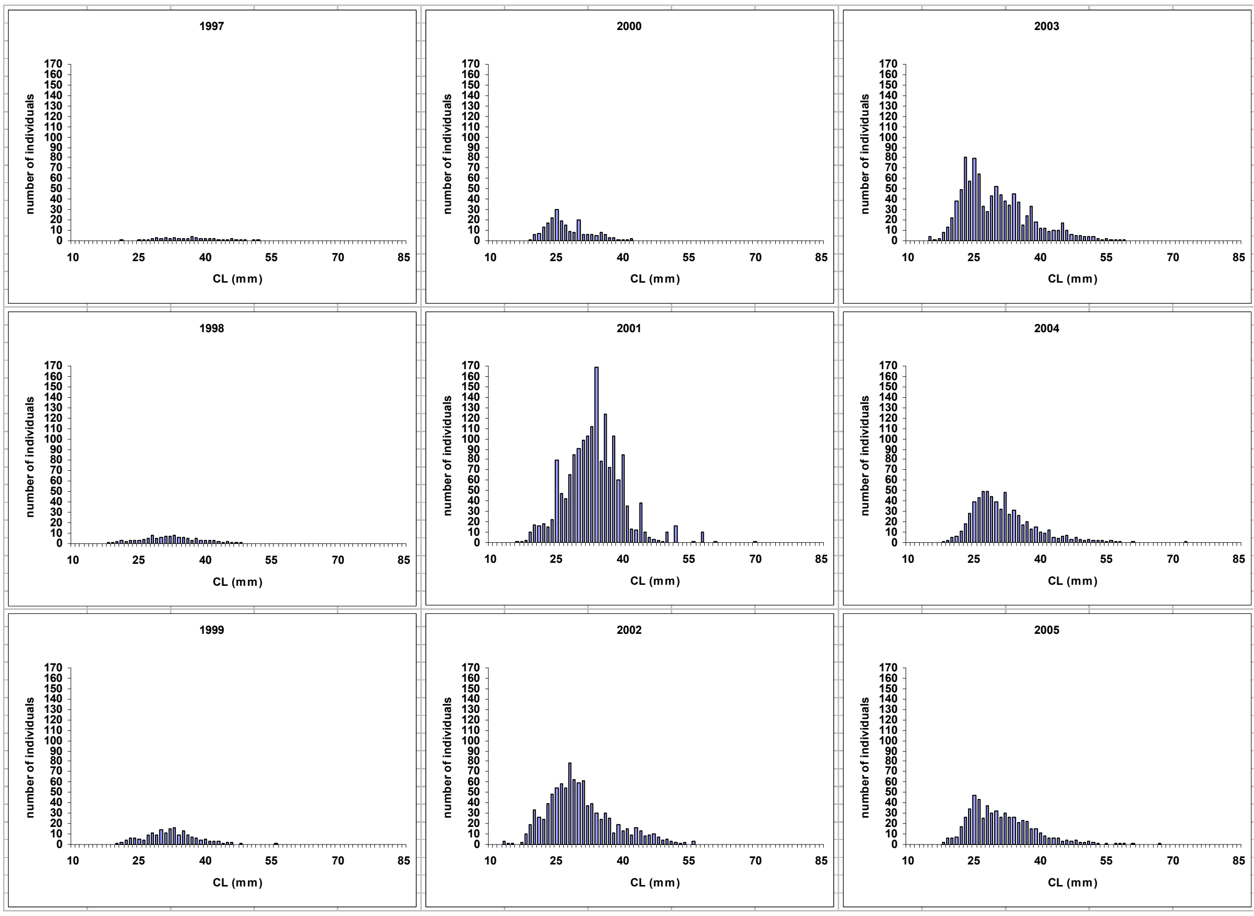


Figure 20. *Nephrops* FU20–22. Indices of the French groundfish survey EVHOE.

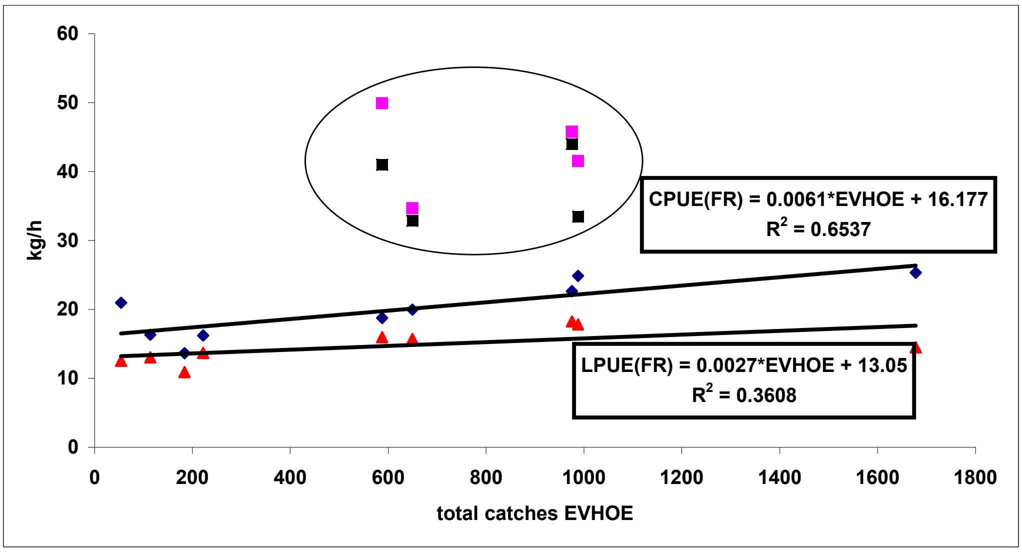


Figure 21. *Nephrops* FU20–22. Comparison of indices EVHOE and of commercial lpue and cpue for French and Irish trawlers.

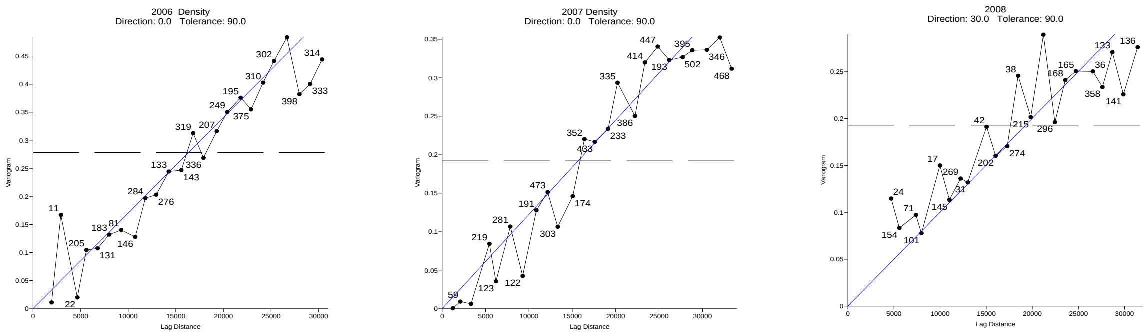


Figure 22. Unidirectional mean variograms for the Celtic Sea FU20–22 by year from 2006–2008.

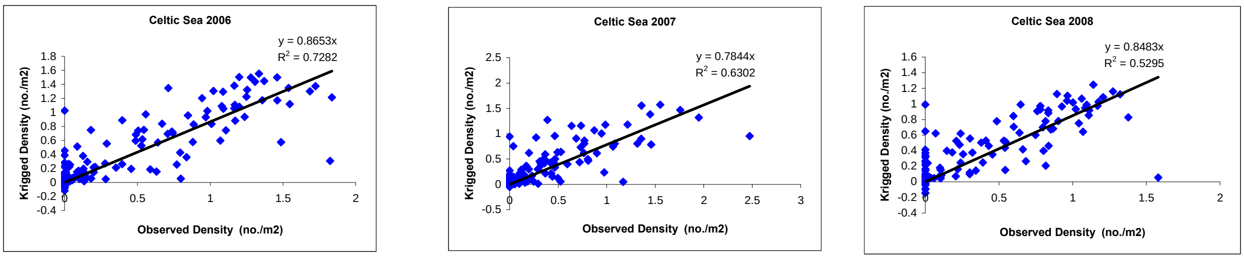


Figure 23. Cross validation plots for the Celtic Sea FU20–22 by year from 2006–2008.

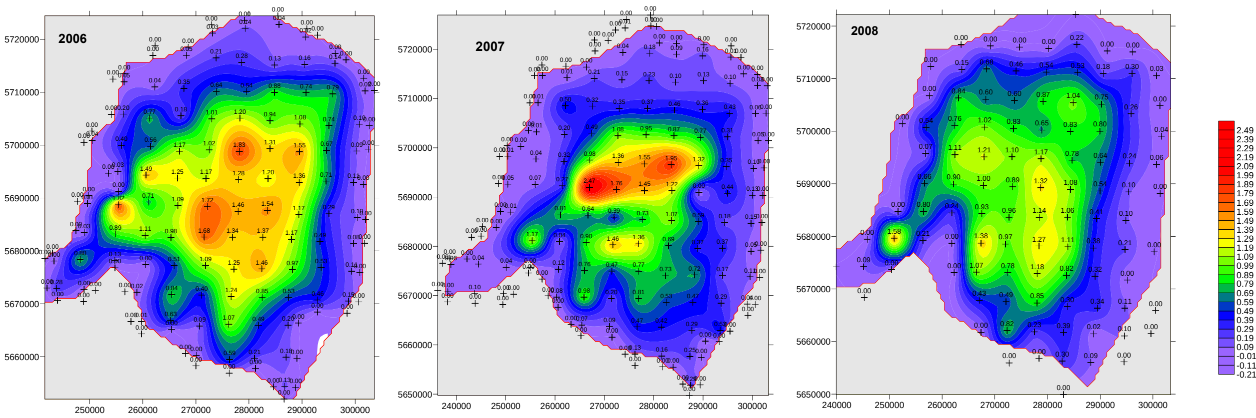


Figure 24. Contour plots of the krigged density estimates for the Celtic Sea FU20–22 by year from 2006–2008.

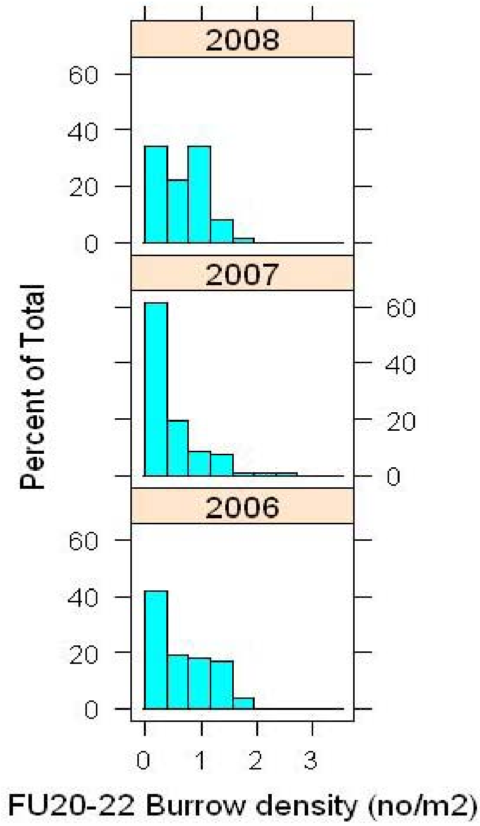


Figure 25. Burrow density distributions for the Celtic Sea FU20–22 by year from 2006–2008.

Table 10. Summary geostatistics for the *Nephrops* UWTV surveys of the Celtic Sea from 2006–2008.

Ground	Year	Number of stations	Number of boundary points	Mean Density (No./M2)	Standard Deviation	CVgeo (%)	Var	Domain Area (m2)	Raised abundance estimate (million burrows)
Smalls	2006	100	50	0.62	0.50	80%	0.25	2847	1914
Smalls	2007	107	63	0.46	0.44	96%	0.19	2915	1402
Smalls	2008	76	31	0.47	0.40	85%	0.16	2698	1448

Table 11. Summary statistics for the *Nephrops* UWTV survey indicator stations of the Labadie and Nymphe Bank and Seven Heads Grounds from 2006–2008.

Ground	Year	Number of stations	Mean Density (No./M2)*	Area Surveyed (M2)	Burrow count	Standard Deviation	95%CI	CV
Labadie Bank	2006	9	0.42	1,322	760	0.37	0.28	29%
	2007	-	-	-	-	-	-	-
	2008	-	-	-	-	-	-	-
Nymphe Bank	2006	2	0.27	195	89	0.39	3.47	100%
	2007	-	-	-	-	-	-	-
	2008	-	-	-	-	-	-	-
Seven Heads	2006	7	0.23	995	293	0.25	0.23	41%
	2007	-	-	-	-	-	-	-
	2008	-	-	-	-	-	-	-

*random stratified estimates are given for the Labadie Bank, Nymphe Bank and Seven Heads grou

\- Area not surveyed in 2007 to 2008 due to weather

Annex 7.10: Stock Annex WGCSE: Celtic Sea Plaice

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Plaice (Division VIIfg)
Working Group:	Celtic Sea Ecoregion
Date	12th July 2003
Last updated	16th May 2009 (part – SF and CL)

A. General

A.1 Stock definition

The degree of separation between the stocks of plaice in the Irish Sea and the Celtic Sea is currently unclear. Numerous tagging studies indicate a southerly movement of mature fish from the southeast Irish Sea into the Bristol Channel during the spawning season. Although some of these fish remain in this area the majority return to summer feeding grounds in the Irish Sea (Dunn and Pawson, 2002). Mixing is also considered to occur between the Celtic Sea and Eastern Channel stocks and time-series of recruitment estimates for all three stocks demonstrate very similar patterns.

Principal spawning grounds have been identified off Trevose Head in Division VIIf and off the coast of southeast Ireland in Division VIIg. Nursery grounds are located in the coastal waters of south Wales and southeast Ireland.

Figure A shows the spawning areas for VIIfg plaice.

A TAC is in place for ICES Areas VIIf and g which corresponds to the stock area.

Figure B shows the management and assessment areas for VIIfg plaice.

A.2 Fishery

Plaice are taken mainly as a bycatch in beam trawl fisheries directed at sole and anglerfish, and as part of a mixed demersal fishery (rays, gadoids, flatfish and squid) by otter trawlers. The main fleets are from Belgium, France and the UK (England and Wales). Otter trawling predominated until the mid-1970s, when beam trawl effort increased rapidly. Landings rose to a maximum in the late 1980s, declined during the early 1990s, then fluctuated around 1000 t. Landings in recent years however, have declined from this level.

The main fishery occurs in the spawning area off the north Cornish coast, at depths greater than 40 m, about 20 to 25 miles offshore. Although plaice are taken throughout the year, landings are heaviest in the first and third quarters.

Changes in fishing technology and fishing patterns

In the 1970s, the fishery for plaice in VIIf and g was carried out mainly by Belgian beam trawlers and Belgian and UK otter trawlers. The use of beam trawls, which target sole in this area, became more prevalent during the 1980s and most of the Belgian otter trawlers have now been replaced by beam trawlers.

A.3 Ecosystem aspects

B. Data

B.1 Commercial catch

International catch-at-age data based on quarterly market sampling and annual landings figures are available from 1977. For the period 1991 to 2005 quarterly age compositions have typically represented around 70% of the total international landings, though in 2002 this fell to around 25% when age compositions were not available for the Belgian fleet. Belgian age sampling in 1993 was at a reduced level and was augmented with UK data. There was no UK sampling in the 4th quarter of 1994 and landings of 1 year olds by the UK otter trawl fleet may be underestimated in this year. Sampling levels during the earlier years in the time-series are considered to be low for all fleets and the quality of the catch data, particularly for older ages, up until around 1992 is believed to be poor. In 1995 UK age compositions for the period 1984–1988 were revised using new ALKs which used data from adjacent time periods where necessary. In the 2005 benchmark assessment, it was noted that numbers-at-age 1 in the landings data were very sparse and variable, reflecting the selection on this age (and especially considering the probable substantial discarding), so the values were replaced by zero to avoid fitting to noise. Keeping age 1 in the assessment allows the survey data at-age 1 to contribute.

Table A1 shows the history of the derivation of catch numbers-at-age.

Table A2 shows the history of precision levels for catch-at-age data.

B.2 Biological

Weights-at-age

As a consequence of low sampling levels weights-at-age were considered to be poorly estimated. Up until 1990 constant weights-at-age had been used in the assessment, based on observations made over the period 1984–1987. In 1991 catch weights and stock weights were estimated using quadratic fits for each year. This procedure was repeated in 1992, and subsequent years, except that a calculated intercept was used rather than forcing the curve through the origin.

Total international catch and stock weights-at-age are calculated as the weighted mean of the national weights-at-age, smoothed using a quadratic fit. Catch weights-at-age are taken as mid-year values (age = 1.5, 2.5, etc.), and stock weights-at-age are January 1 values (age = 1.0, 2.0, etc.). Catch weights-at-age are scaled to give a SOP of 100%, and the same scaling has been applied to the stock weights-at-age.

Weights-at-age for this stock are smoothed because sampling levels have in the past been relatively poor, and the resulting datasets have been noisy. Thus fitting a curve through the data avoids problems of missing data or poorly represented weight-at-age. Sampling levels demonstrate some improvement but data for the older ages are still variable.

Natural mortality and maturity ogives

Initial estimates of natural mortality (0.12 ^{yr} all years and all ages) and maturity were based on values estimated for Irish Sea plaice. A new maturity ogive based on UK (E&W) VIIfg survey data for March 1993 and March 1994 (Pawson and Harley, 1997) was produced in 1997 and is applied to all years in the assessment.

Age	1	2	3	4	5+
Old Maturity	0	0.15	0.53	0.96	1.00
New Maturity	0	0.26	0.52	0.86	1.00

The proportion of mortality before spawning was originally set at 0.2 as approximately 20% of the total catch was taken prior to late February–early March, considered to be the time of peak spawning activity. The proportion of F and M before spawning was changed to zero at the request of ACFM in 1996 as it was considered that these settings were more robust to seasonal changes in fishing patterns, especially with respect to the medium-term projections.

B.3 Surveys

To date data have been available for only one survey in VIIf and g: the UK 4 m beam trawl survey.

Appendix 1 provides a history of the survey and details the survey methodology and objectives.

B.4 Commercial cpue

Lpue has declined since the late 1980s for E+W commercial fleets: rapidly during 1989–1991 and more slowly since then. The Belgian beam trawl-series demonstrates lpue falling after 1991, recovering to an intermediate level in 1997 then declining. Irish lpue data demonstrate a decline for all towed gears since 1997–1998.

The survey-series demonstrates cpue at a peak in 1989–1990, followed by a rapid decline during 1992–1994. A recovery to a recent high in 1996 has been followed by a return to below-average levels in 2002–2005.

UK beam trawl effort has generally increased over the time-series, reaching new high levels in VIIf and VIIg (East) in 1999. Effort in VIIf has remained high in 2000, but has declined in VIIg (East). Belgian beam trawl fleet data demonstrate a sharp decline in effort in 1990–1991 followed by a return to the level seen in the early 1980s. UK otter trawl effort in VIIf has slowly declined over the time-series.

Figure C shows the areas referred to in the lpue tables

Figures D and E show plots of UK effort for 1998–2005 by ICES rectangle for beam and otter trawl gears.

B.5 Other relevant data

C. Historical stock development

The stock of plaice in the Celtic Sea has been assessed by ICES since 1978 and has been managed by TAC since 1987.

Tuning data

Until 1992 tuning information for this stock comprised the Belgian beam trawl fleet (from 1977) and the UK (E&W) otter trawl fleet (from 1981). Effort was re-calculated for the Belgian beam trawl fleet in 1993 and again (subject to the discovery of errors) in 1994. The UK (E&W) tuning series was revised in 1995 and separate otter trawl and beam trawl tuning-series were produced using length samples from each gear type and an all gears ALK. Because the data could only be separated for 1988 onwards the two new tuning-series were slightly reduced in length. In 1996 UK (E&W) commercial effort data were re-scaled to thousands of hours so as to avoid numerical problems associated with low cpue values.

In 1993 the UK (E&W) beam trawl survey-series which began in 1988 was considered to be of sufficient length for inclusion in the assessment. Since 1991 tow duration has been 30 minutes but prior to this it was 15 minutes. In 1997 values for 1988 to 1990 were raised to 30 minute tows, however, data for 1988 and 1989 were of poor quality and gave spurious results. The series was therefore truncated to 1990.

Two new first quarter survey-series were made available to the Working Group in 1998. The UK (E&W) (*Cirolana*) March survey using a Portuguese high headline trawl (PHHT) and the UK (E&W) (*Corystes*) March beam trawl survey. Both of which started in 1993 The March *Corystes* beam trawl survey covered a reduced area in 1995 and a different vessel was used in 1996, consequently it has not been considered appropriate to include in the assessment. Although the *Cirolana* PHHT survey was included in the assessment in 1999 it has subsequently been excluded as catches of plaice are generally very low.

The effects of vessel characteristics on lpue for UK (E&W) commercial tuning-series was investigated in 2001 to investigate the requirement for fishing power corrections as a result of MAGP IV remeasurement requirements. It was found that vessel characteristics had less effect on lpue than geographic factors and unexplained noise and concluded that corrections were not necessary. However, vessels of certain size tended to fish in certain rectangles. This confounding may have resulted in the underestimation of vessel effects.

Assessment methods and settings

In 1991 the stock was assessed using a Laurec-Shepherd tuned VPA. Concerns about deteriorating data quality prompted the use in 1992 of XSA. Since then XSA has been the model used.

Trial runs have, over the years, explored most of the options with regards to XSA settings.

The applicability of the power model on the younger ages was explored in 1994; 1995; 1996 and 1998.

The use of P shrinkage was investigated in 2001.

Different levels of F shrinkage were explored in 1994; 1995; 2000 and 2002

The level of the + group was examined in 1995.

The effect of different time tapers was investigated in 1996.

The S.E. threshold on fleets was examined in 1996 and 2001

The level of the catchability plateau was investigated in 1994; 1995 and 2002.

Effects of removing data for younger ages in commercial tuning fleets, changing the standard error thresholds, and of including historical tuning fleet data, were investigated in 2005.

Since then the assessments have been updates.

Table B demonstrates the history of VIIfg plaice assessments and details the parameters used.

D. Short-term projection

Software: Multi Fleet Deterministic Projection (MFDP)

Age based short-term projections are conducted for a 3-year period using initial stock numbers derived from XSA analyses. Numbers-at-age 1 are considered poorly estimated, and in the 2005 assessment catch numbers-at-age 1 were replaced by zero values. Population numbers-at-age 1 use a geometric mean of past recruitment values. Recent recruitments have been estimated to be at a lower level and to be less variable than those earlier in the time-series. Consequently a short-term geometric mean (from 1989 to penultimate data year) is used.

The exploitation pattern is typically an unscaled 3 year arithmetic mean, though alternative options may be used depending on recent F trajectories and the Working Group's perception of the fishery.

Catch and stock weights-at-age are generally taken as the mean of the last 3 years. Maturity ogive and natural mortality estimates are those used in the assessment method.

E. Medium-term projections

Software: MLA miscellany

Input values to the medium-term forecast are the same as those used in the short-term forecast. Any stock–recruit relationship is poorly defined and although a Beverton–Holt SRR has been assumed in earlier years, a simple geometric mean is now considered more appropriate, though it remains unclear whether the full time-series or a reduced time-series from 1989 should be used.

F. Yield and biomass-per-recruit/long-term projections

Software: Multi Fleet Yield-per-Recruit (MFYPR)

Yield-per-recruit calculations are conducted using the same input values as those used for the short-term forecasts.

G. Biological reference points

Biological reference points were proposed for this stock by the 1998 working group as below.

F_{lim}	No proposal	
F_{pa}	No proposal	
B_{lim}	1100 t	(equal to B_{loss})
B_{pa}	1800 t	(equal to B_{lim} * exp(1.645*0.3))

An F_{pa} value of 0.6 was proposed by ACFM in 1998 basis (~c. F_{med}, >95% probability of SSB > B_{pa} in medium term).

H. Other issues

None.

I. References

Dunn, M.R. and Pawson, M.G. 2002. The stock structure and migrations of plaice populations on the west coast of England and Wales. In *Journal of fish biology* (2002), Vol. 61, pp 360–393.

Pawson, M.G and Harley, B.F.M., (unpubl.: Cefas internal report).

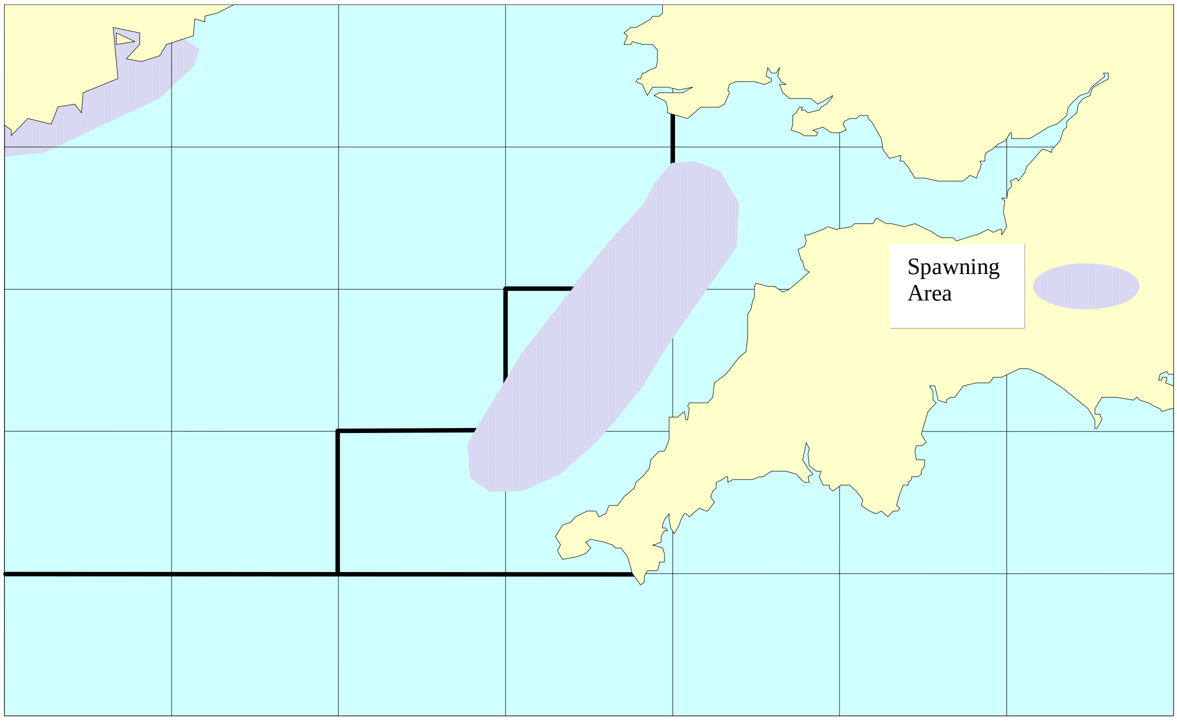


Figure A. Spawning areas for VIIfg plaice.

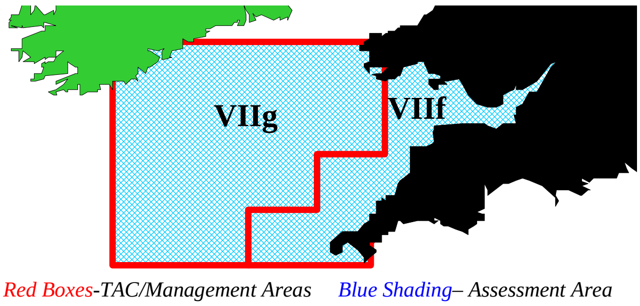


Figure B. Management and assessment areas for VIIfg plaice.

Table A. VIIfg plaice. Catch Derivation table for assessment years 1982–2001.

		SOURCE				
YEAR OF WG	DATA	UK	BELGIUM	IRELAND	DERIVATION OF INTERNATIONAL LANDINGS	% SAMPLED
1982	length composition	-	quarterly	-	Belgium raised to total international	26
	ALK	-	quarterly	-		
	Age composition	-	quarterly	-		
1983	length composition	quarterly	quarterly	-	No assessment carried out	27
	ALK	-	quarterly	-		
	Age composition	-	quarterly	-		
1984		-	As for 1983	-	As for 1983	27
1985	length composition	quarterly	quarterly	-	UK+Belgium combined then raised to total international	49
	ALK	quarterly	quarterly	-		
	Age composition	quarterly	quarterly	-		
1986		As for 1985	As for 1985	-	As for 1985	58
1987		As for 1985	As for 1985	-	As for 1985	56
1988	length composition	quarterly	quarterly	-	UK raised to inc France and Ireland	81
	ALK	quarterly	quarterly	-	UK+Belgium combined to total international	
	Age composition	quarterly	quarterly	-		
1989		As for 1988	As for 1988	-	As for 1988	62
1990		As for 1988	As for 1988	-	As for 1988	61
1991		As for 1988	As for 1988	-	As for 1988	61
1992	length composition	quarterly	quarterly	quarterly	UK raised to inc France	64
	ALK	quarterly	quarterly	quarterly	UK+Ireland+Belgium combined to total international	
	Age composition	quarterly	quarterly	quarterly		
1993		As for 1992	As for 1992	-	As for 1992	53
1994	length composition	quarterly	quarterly	quarterly	UK raised to inc France	70

		Source				
Year of WG	Data	UK	Belgium	Ireland	Derivation of international landings	% sampled
	ALK	quarterly	quarterly	quarterly	Belgium ALKs supplemented with UK(E+W) data	
	Age composition	quarterly	quarterly	quarterly	UK+Ireland+Belgium combined to total international	
1995		As for 1992	As for 1992	As for 1992	As for 1992	56
1996		As for 1992	As for 1992	As for 1992	As for 1992	76
1997		As for 1992	As for 1992	As for 1992	As for 1992	75
1998		As for 1992	As for 1992	As for 1992	As for 1992	73
1999		As for 1992	As for 1992	As for 1992	As for 1992	72
2000		As for 1992	As for 1992	As for 1992	As for 1992	74
2001		As for 1992	As for 1992	As for 1992	As for 1992	60

Table A. (cont.) VIIfg plaice. Catch Derivation table for assessment years 2002–2009.

		Source				
Year of WG	Data	UK	Belgium	Ireland	Derivation of international landings	% sampled
2002	length composition	quarterly	-	quarterly	UK raised to inc France;	25
	ALK	quarterly	-	quarterly	UK+Ireland raised to include Belgium	
	Age composition	quarterly	-	quarterly		
2003	length composition	quarterly	1st qtr	quarterly	Belgium raised using 1st qtr values	70
	ALK	quarterly	1st qtr	quarterly	UK raised to inc France	
	Age composition	quarterly	1st qtr	quarterly	UK + Bel + IR combined to total int.	
2004	length composition	quarterly	Q1 & Q2 only	quarterly	Belgium raised using 1st and 2nd qtr values	70
	ALK	quarterly	Q1 & Q2 only	quarterly	UK raised to inc France	
	Age composition	quarterly	Q1 & Q2 only	quarterly	UK + Bel + IR combined to total int.	
2005	length composition	quarterly	-	quarterly	Ireland by gear raised to total Irish.	70
	ALK	quarterly	-	quarterly	UK raised to include French landings	
	Age composition	quarterly	annual	annual	UK + Bel + IR combined to total int.	

		Source				
Year of WG	Data	UK	Belgium	Ireland	Derivation of international landings	% sampled
2006	length composition	quarterly	-	quarterly	Ireland by gear raised to total Irish.	
	ALK	quarterly	-	quarterly	UK raised to include French landings	
	Age composition	quarterly	annual	annual	UK + Bel + IR combined to total int.	
2007	length composition	quarterly	-	quarterly	Ireland by gear raised to total Irish.	76
	ALK	quarterly	-	quarterly	UK raised to include French landings	
	Age composition	quarterly	annual	annual	UK + Bel + IR combined to total int.	
2008	length composition	quarterly	-	quarterly	Ireland by gear raised to total Irish.	77
	ALK	quarterly	-	quarterly	UK raised to include French landings	
	Age composition	quarterly	annual	annual	UK + Bel + IR combined to total int.	
2009	length composition	quarterly	quarterly	quarterly	Ireland by gear raised to total Irish.	77
	ALK	quarterly	quarterly	quarterly	UK raised to include French landings	
	Age composition	quarterly	quarterly	quarterly	UK + Bel + IR combined to total int.	

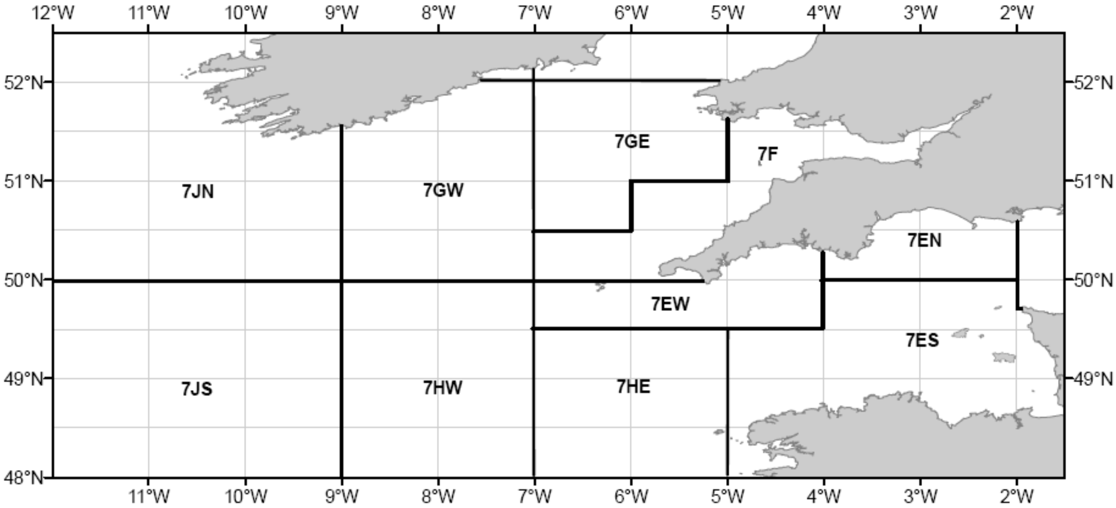


Figure C. Areas referred to in the Report.

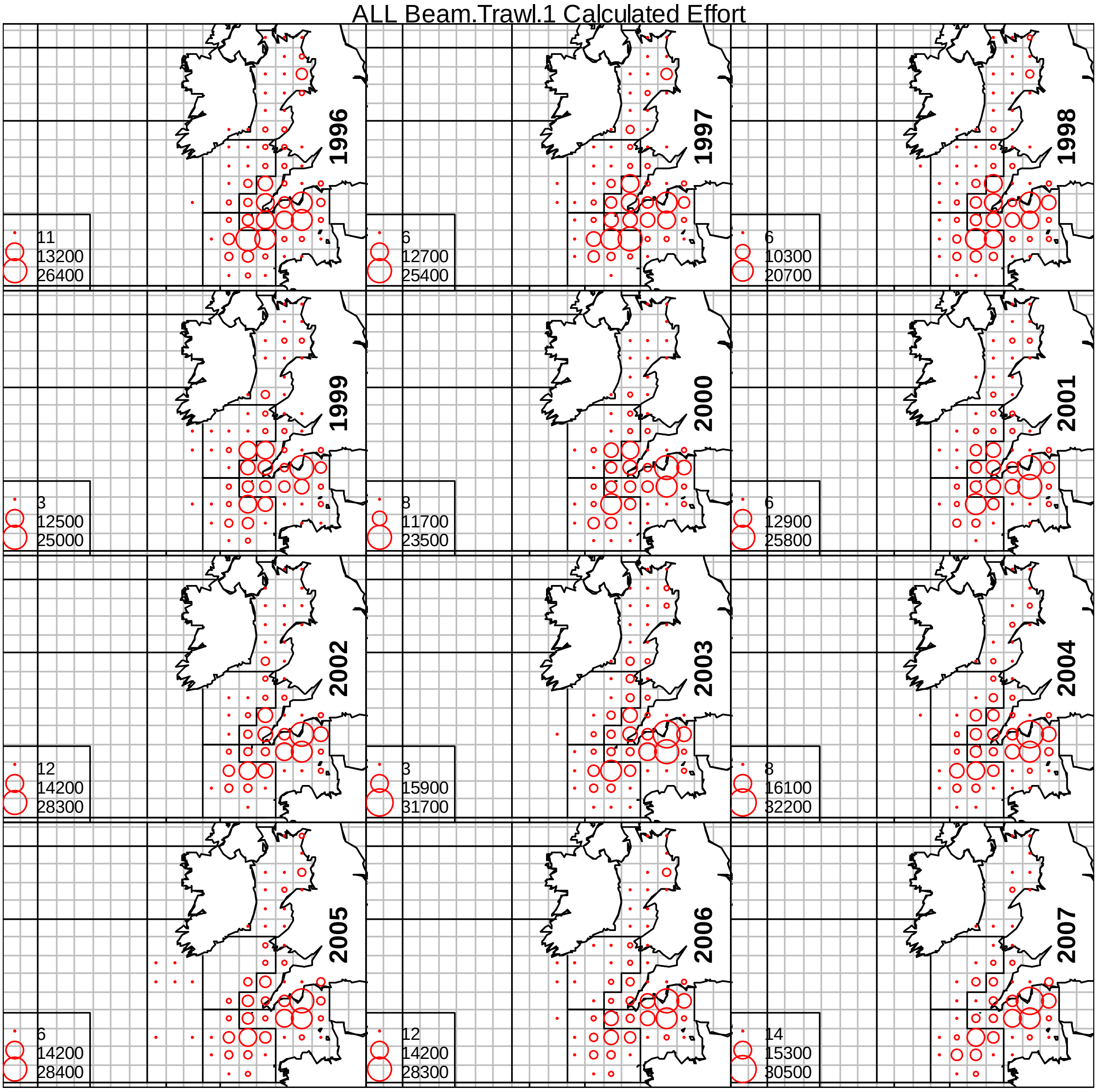


Figure D. Demersal effort time-series, beam trawl for UK (E+W).

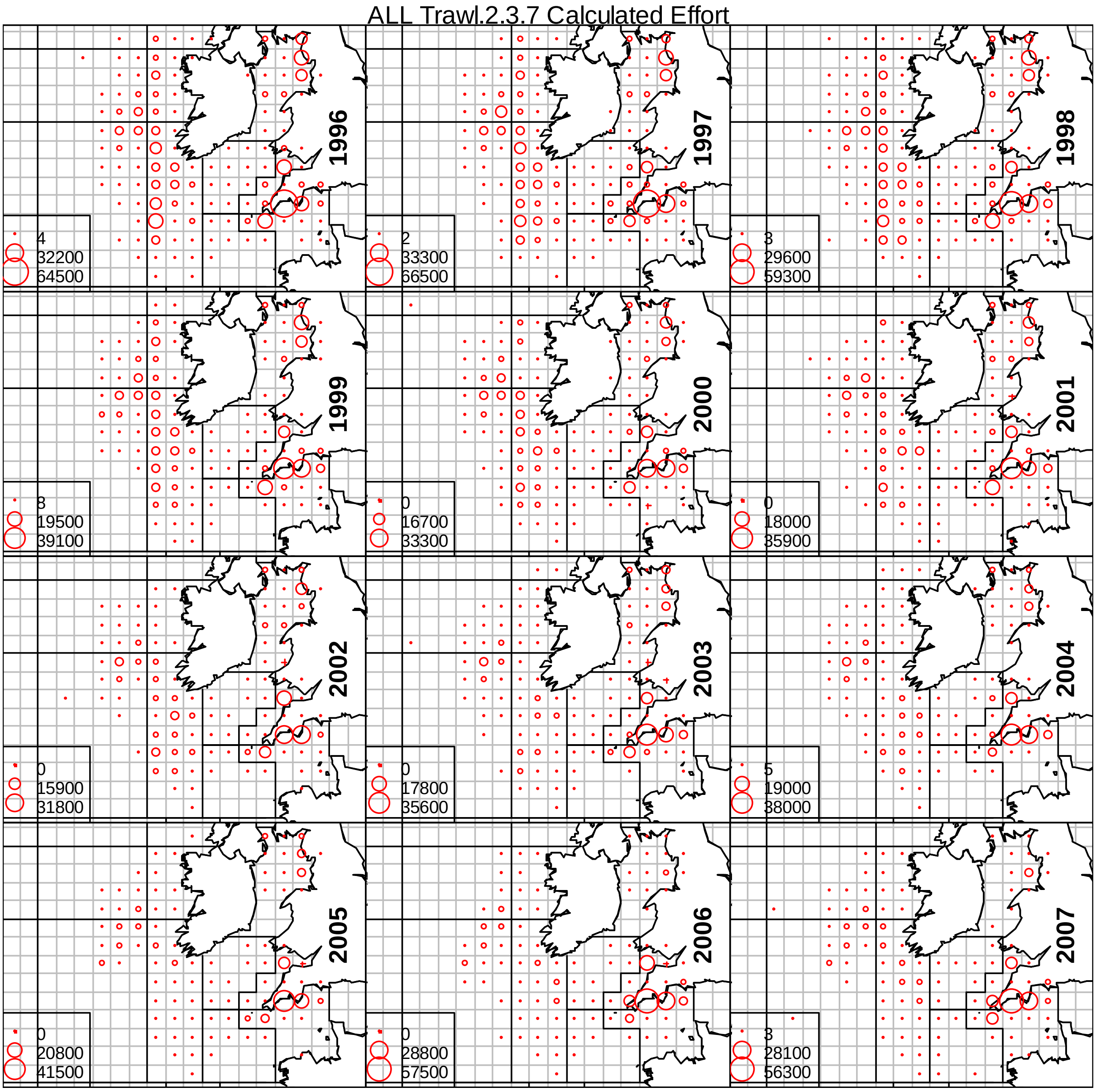


Figure E. Demersal effort time-series, otter trawl for UK (E+W).

Table B. VIIfg plaice. Assessment parameters used.

	1991*	1992*	1993*	1994	1995	1996	1997	1998	1999	2000
Assessment Age Range	1-8+	1-8+	1-9+	1-9+	1-9+	1-9+	1-9+	1-9+	1-9+	1-9+
Fbar Age Range	3-8	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6
Assessment Method	L.S.	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA
Tuning Fleets										
UK otter yrs	81-90	81-91	81-92	81-93	89-94	89-95	89-96	89-97	89-98	89-99
Ages	2-8	2-8	2-8	2-8	1-8	1-8	1-8	1-8	1-8	1-8
UK beam yrs					90-94	90-95	90-96	90-97	90-98	90-99
Ages					1-8	1-8	2-8	2-8	2-8	2-8
Bel beam yrs	77-90	77-91	77-92	77-93	77-94	86-95	87-96	77-97	77-98	
Ages	3-8	3-8	3-8	3-8	3-8	3-8	3-8	3-8	3-8	
UK-BTS yrs			88-92	88-93	88-94	88-95	90-96	90-97	90-98	90-99
Ages			1-4	1-5	1-5	2-5	1-5	1-5	1-5	1-5
UK PHHT yrs									93-98	
Ages									2-8	
Time taper		20yr tri	20yr tri	20yr tri	20yr tri	None	None	None	None	None
Power model ages		1	1	1	0	1-5	1-5	1-5	1-5	1-5
P shrinkage		TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
Q plateau age		7	7	7	7	7	7	7	7	7
F shrinkage S.E		0.3	0.8	0.8	0.8	1.5	1.5	1.5	1.5	0.5
Num yrs		5	5	5	5	5	5	5	5	5
Num ages		5	5	5	4	4	4	4	4	4
Fleet S.E.		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

*** Early version of XSA and age/year ranges used not specified. Assumed all years used but age range used uncertain.**

Table B. (continued) VIIfg plaice. Assessment parameters used.

	2001	2002	2003	2004	2005	2006	2007	2008	2009
Assessment Age Range	1-9+	1-9+	1-9+	1-9+	1-9+	1-9+	1-9+	1-9+	1-9+
Fbar Age Range	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6
Assessment Method	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA
Tuning Fleets									
UK otter yrs	89-00	89-01	89-02	89-03	89-04	89-05	89-06	89-07	89-08
Ages	1-8	1-8	1-8	1-8	4-8	4-8	4-8	4-8	4-8
UK beam yrs	90-00	90-01	90-02	90-03	90-04	90-05	90-06	90-07	90-08
Ages	2-8	2-8	2-8	2-8	4-8	4-8	4-8	4-8	4-8
Bel beam yrs									
Ages									
UK-BTS yrs	90-00	90-01	90-02	90-03	90-04	90-05	90-06	90-07	90-08
Ages	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5
UK PHHT yrs									
Ages									
Time taper	None	None	None	None	None	None	None	None	None
Power model ages	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5
P shrinkage	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Q plateau age	7	7	7	7	7	7	7	7	7
F shrinkage S.E	0.5	0.5	0.5	0.5	2.5	2.5	2.5	2.5	2.5
Num yrs	5	5	5	5	5	5	5	5	5
Num ages	4	4	4	4	4	4	4	4	4
Fleet S.E.	0.3	0.3	0.3	0.3	0.5	0.5	0.5	0.5	0.5

Appendix 1: Beam trawl surveys of the Bristol Channel (ICES Division VIIf)

1. History of the survey

The CEFAS near-west groundfish survey has taken place every autumn since 1988, and covers the Irish Sea (ICES Division VIIa), Bristol Channel (VIIf) and parts of the Celtic Sea (VIIg). Equivalent spring surveys were also conducted between 1993 and 1999. The survey was initially designed to provide abundance indices for prerecruit (1 and 2 year old) plaice (*Pleuronectes platessa*) and sole (*Solea solea*), while also providing abundance and length data for all species caught, and age and other biological data for commercially important species. R.V. Corystes has been used for all the near-west groundfish surveys except the 1996 and 1999 spring surveys, where F.V. Carhelmar was used instead.

2. Current survey of objectives

The primary objectives of the Irish Sea beam trawl survey are to (a) carry out a 4 m beam trawl survey of groundfish to i) obtain fisheries independent data on the distribution and abundance of commercial flatfish species, and ii) derive age compositions of sole and plaice for use in the assessment of stock size; and (b) to collect biological data, including maturity and weight-at-age, for sole, plaice, lemon sole and other commercially important species. The epibenthic bycatch from these catches has been quantified since 1997, and these surveys are also used to collect biological samples in support of other CEFAS projects and training courses.

3. Survey methods

The standard gear used is a 4 m beam trawl with chain mat, flip up rope, and a 40 mm codend liner to retain small fish. The gear is towed at 4 knots (over the ground) for 30 minutes, averaging 2 nautical miles per tow. Fishing is only carried out in daylight, shooting after sunrise and hauling no later than sunset, as the distribution of some species is known to vary diurnally.

Once on board the catch is sorted to species level, with the exception of small gobies and sandeels, which are identified to genus. Plaice, sole, dab, and elasmobranchs are sorted by sex, all fish categories weighed, and total lengths are measured to the full centimetre below, or half centimetre if the species is pelagic. Area stratified samples of selected species are sampled for weight, length, sex, maturity, and otoliths or scales removed for ageing.

32 stations were consistently fished in VIIf in the period 1993–2003 (see map), although the presence of static fishing gear, etc. may prevent the sampling of certain stations. For more information about this survey see Parker-Humphreys, 2004.

4. Abundance index calculation

The abundance index is calculated by allocating the appropriate ages to the fish that are caught. This gives the age composition (AC) of the catch, and this is used in the appropriate working group analysis.

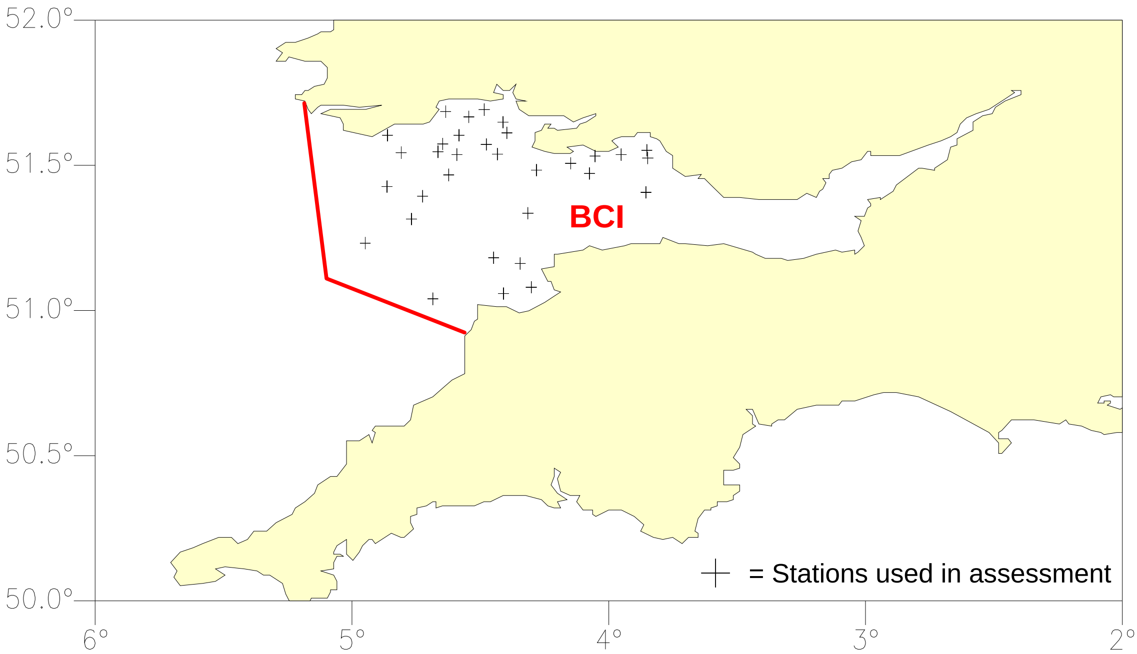
The AC's are calculated by proportioning a length distribution (LD) to an appropriate age–length key (ALK). To account for possible population differences within sector BCI (Bristol Channel inner), biological samples are taken from two depth-bands of <20 m, and >19 m. Where appropriate the ALK's are separated by sex, and this allows a particular 'sector, depth-band and sex' ALK to be raised to the corresponding LD to give an accurate AC for that particular habitat. The AC's can then be combined as required to give results in the form of 'numbers-at-age, per distance or time'.

The Table below demonstrate the stratifications used to calculate the 'near-west groundfish survey' abundance indices.

		ALK stratified by			LD stratified by			
Species	**Sector**	**Sector**	**Depth band**	**Sex**	**Sector**	**Depth band**	**Sex**	**Used in assessment?**
Plaice	BCI	✓	X	✓	✓	✓	✓	✓
Sole	BCI	✓	X	✓	✓	✓	✓	✓
Whiting	BCI	✓	X	X	✓	✓	X	✓

5. Map of the survey grid

Additional stations have been sampled throughout the time period, but as these stations are not consistently fished, they are excluded from this map.



6. Summary

Area covered	-	ICES Division VIIf
Target species	-	Flatfish, particularly prerecruit plaice and sole
Time period	-	September-October. 1988 to present.
Gear used	-	One 4 m beam trawl with chain mat, flip-up ropes and 40 mm codend liner
Mean towing speed	-	4 knots over the ground
Tow duration	-	30 minutes
Vessel used	-	R.V. Corystes

7. References

Parker-Humphreys, M. 2004. Distribution and relative abundance of demersal fishes from beam trawl survey in the Bristol Channel (ICES Division VIIf) 1993–2001. *Science series Technical Report*, CEFAS, Lowestoft. **123**.

Annex 7.13: Quality Handbook Celtic Sea Sole

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Sole (Division VIIf,g)
Working Group	Assessment of Southern Shelf Demersal Stocks
Date	29th July 2004
Last updated	19th May 2009, Willy Vanhee

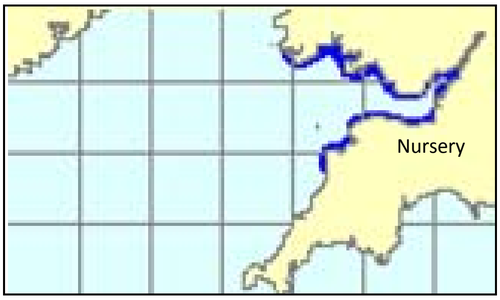
A. General

A.1 Stock definition

A description of the stock definition of sole in the Celtic Sea was given in the leaflet "Fisheries information – cod, sole, plaice and whiting in the southwest of the British Isles" published by CEFAS under a EU funded project (SAMFISH: EU Study Contract 99–009, Improving sampling of western and southern European Atlantic Fisheries) and is taken over here.

In the coastal waters of western England and Wales, sole are found in greatest abundance in the northeastern Irish Sea and the eastern Celtic Sea. The main spawning areas for sole in the Celtic Sea are in deep waters (40–75 m) off Trevose Head, where spawning usually takes place between March and May. Sole nursery grounds are generally located in shallow waters such as estuaries, tidal inlets and sandy bays. Juvenile sole (0 and 1 year old fish) are found chiefly in depths up to 40 m, and adult sole (fish aged 3 plus) are generally found in deeper water. Spawning and nursery grounds are well defined.

Over 6000 sole were tagged on the nursery grounds of the Bristol Channel and the Irish Sea between 1977 and 1988. The majority of fish tagged in Swansea Bay and Carmarthen Bay were between 15 and 24 cm in length. Most of the recaptures of these tagged fish occurred two or more years after release, which meant that many fish tagged as juveniles were recaptured as adults. The majority of returned fish were reported off the north coasts of Devon and Cornwall, and over a wide area in the eastern Celtic Sea and St George's Channel. These results suggest that once an adult sole has recruited to an area, it tends to remain there, and that there is only limited movement of sole between the Celtic Sea and adjoining areas.



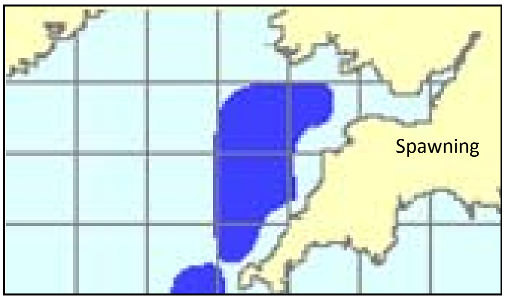


Figure A.1 Nursery and spawning areas of sole in the Celtic Sea (After Coull, K.A., Johnstone, R., and S.I. Rogers. 1998. Fisheries Sensitivity Maps in British Waters. Published and distributed by UKOOA Ltd.)

A.2 Fishery

Fisheries for sole in VIIf,g involve vessels from Belgium, taking approx. two thirds, the UK taking approximately one quarter, and France and Ireland taking minimal amounts of the total landings. Nominal landings are available from 1986 onwards. Sole are mainly targeted by beam trawlers and the fishery is concentrated on the north Cornish coast off Trevose Head and around Lands End. There is an average landing of 1000 tonnes throughout its history (See also Figures A.2 and A.3).

Discard information is being collated and it seems to be minor.

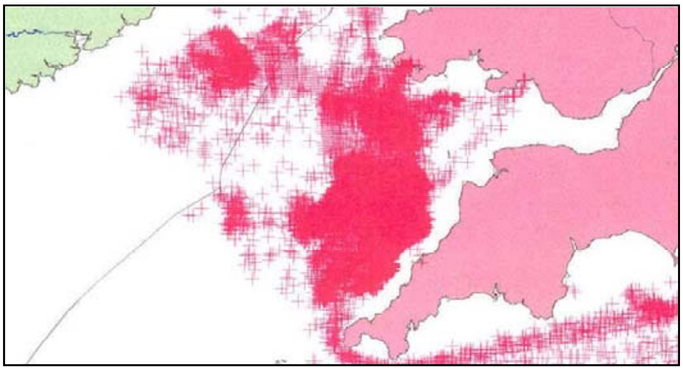


Figure A.2 Effort distribution of the Belgian beam trawl fleet operating in the Celtic Sea. (VMS data 2002)

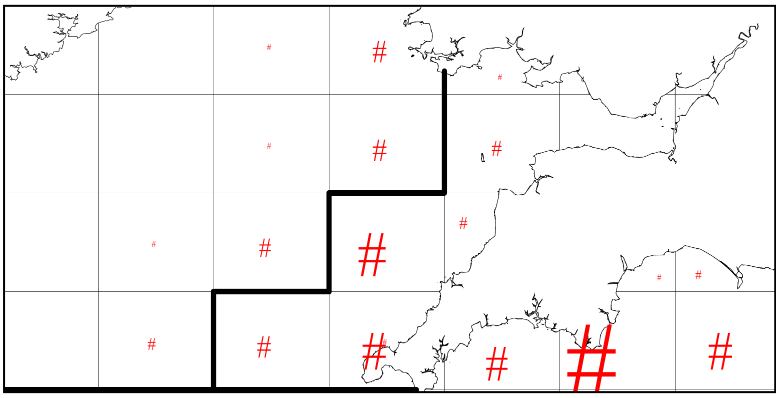


Figure A.3. Effort distribution of the English beam trawl fleet operating in the Celtic Sea. Data based on total demersal landings in 2003.

A.3 Management

Celtic Sea sole is managed by TAC. Other management measures are technical measures including minimum landing size (24 cm) and minimum mesh sizes (80 mm for beam trawlers.

Besides national authorities can impose additional management measures, such as temporal closures, trip catch controls and monthly catch controls.

Council Regulation (EC) No 27/2005, Annex III, part A 12 (b) prohibited fishing in ICES rectangles 30E4, 31E4 and 32E3 during January-March 2005. This prohibition did not apply to Beam trawlers during March.

Council Regulation (EC) No 51/2006, Annex III, part A 4.2 prohibited fishing in ICES rectangles 30E4, 31E4 and 32E3 during February and March 2006 with derogations for vessels using pots, creels or nets with less than 55 mm mesh size. The prohibition does not apply within 6 nautical miles from the baseline.

Council Regulation (EC) No 41/2007, Annex III, part A 7.2 prohibited fishing in ICES rectangles 30E4, 31E4 and 32E3 during February and March 2007 with derogations for vessels using pots, creels or nets with less than 55 mm mesh size. The prohibition does not apply within 6 nautical miles from the baseline.

Council Regulation (EC) No 40/2008, Annex III, part A 6.2 prohibited fishing in ICES rectangles 30E4, 31E4 and 32E3 during February and March 2008. The prohibition does not apply within 6 nautical miles from the baseline.

Council Regulation (EC) No 43/2009, Annex III, part A 6.2 prohibited fishing in ICES rectangles 30E4, 31E4 and 32E3 during February and March 2009. The prohibition does not apply within 6 nautical miles from the baseline.

A.4 Ecosystem aspects

So far, no ecosystem aspects have been taken into consideration.

B. Data

B.1 Commercial catch

Quarterly data are available for catch numbers for the Belgian, the Irish and UK fleets. These comprise around 90% of the international landings. Derivation of the age composition is demonstrated in the table below. Since 2005 only catch numbers for Belgian and UK fleets were available. Quarterly total landings are available from France and since 2005 also from Ireland.

	DATA SOURCE:			
VIIfg	B	IRE*	UK	Derivation of international landings in VIIfg
Length composition	VIIfg	VIIfg	VIIfg	
ALK	VIIfg	VIIfg	VIIfg	
Age Composition	VIIfg	VIIfg	VIIfg	B, IRE + UK, raised to total international landings*

*** Since 2005 no Irish length compositions or ALKs therefore since 2005, B + UK age composition raised to total international landing.**

Numbers-at-age 1 in the catch are low in most years, therefore these were not considered to add useful information and are replaced by zeros.

Historical compilation of the commercial catch data not included yet

B.2 Biological

Weights-at-age

Catch weights-at-age are calculated, weighted by national catch numbers-at-age, then quadratically smoothed in year (using age = 1.5, 2.5, etc.) and SOP-corrected. The text Table below demonstrates the quadratic fit of the data, the R^2 of the fit, the periodicity of the data being collected and the countries that delivered the data to calculate the fit.

Year	Quadratic fit W(t) =	R^2	Periodicity data	Contributing countries
2002	-0.0659 + 0.0825*(AGE+0.5) - 0.0017*(AGE+0.5)^2	0.93	Quarterly	B, IRE, UK
2003	0.0503 + 0.0484*(AGE+0.5) - 0.0001*(AGE+0.5)^2	0.91	Quarterly	B, IRE, UK
2004	-0.0333 + 0.0671*(AGE+0.5) - 0.0006*(AGE+0.5)^2	0.96	Quarterly	B, IRE, UK
2005	-0.0542 + 0.0846*(AGE+0.5) - 0.0019*(AGE+0.5)^2	0.96	Quarterly	B, UK
2006	0.0023 + 0.0553*(AGE+0.5) - 0.0003*(AGE+0.5)^2	0.95	Quarterly	B, UK
2007	0.0023 + 0.0553*(AGE+0.5) - 0.0003*(AGE+0.5)^2	0.95	Quarterly	B, UK
2008	-0.0267 + 0.07*(AGE+0.5) - 0.0015*(AGE+0.5)^2	0.88	Quarterly	B, UK
2009	+0.0093 + 0.0612*(AGE+0.5) - 0.0012*(AGE+0.5)^2	0.90	Quarterly	B, UK

Stock weights-at-age are the catch weights of the Belgian beam trawl fleet (BEL-BEAM) in the first quarter, smoothed by fitting with a Gompertz function. The text Table gives a historical overview of the parameters that have been used in the Gompertz function [$W(t) = a \times \exp(b \times (1 - \exp(c \times t)))$].

Year	Parameter a	Parameter b	Parameter c	R^2
2002	13.89	4.220	-0.3376	
2003	86.14	3.049	-0.1115	0.4
2004	3.77	3.47	-0.196	0.4

Since 2005 Stock weights are the catch weights of the Belgian (BEL-BEAM) and the UK (UKCSBT) beam trawl fleets in the first quarter and smoothed by fitting a quadratic fit.

Year	Quadratic fit W(t) =	R^2	Periodicity data	Contributing countries
2005	-0.0113 + 0.065*(AGE) - 0.0003*(AGE)^2	0.96	1st quarter	B, UK
2006	0.0381 + 0.0397*(AGE) + 0.0009*(AGE)^2	0.97	1st quarter	B, UK
2007	0.0381 + 0.0397*(AGE) + 0.0009*(AGE)^2	0.97	1st quarter	B, UK
2008	-0.0389 + 0.0638*(AGE) - 0.0006*(AGE)^2	0.94	1st quarter	B, UK
2009	+0.0112 + 0.0517*(AGE) - 0.0002*(AGE)^2	0.98	1st quarter	B, UK

Stock and catch weights have no explicit trends. The values for 2001 demonstrated a strange convergence and were replaced by the mean of the 2000 and the 2002 weights.

At some ages, the weights in the stock are higher than the weights in the catch. This is because sole caught from spawning concentrations in the 1st quarter are heavier (10 to 15 %) than after spawning.

Historical compilation of the weight-at-age data not fully included yet

Natural mortality and maturity ogives

Natural mortality was assumed to be 0.1 for all ages and years. This is consistent with the natural mortality estimates used for sole by other ICES working groups (WGNSSK: IV, VIId, WGNSDS: VIIa, WGSSDS: VIIfg, VIIIa,b) and consistent with estimates of M reported in Horwood, 1993.

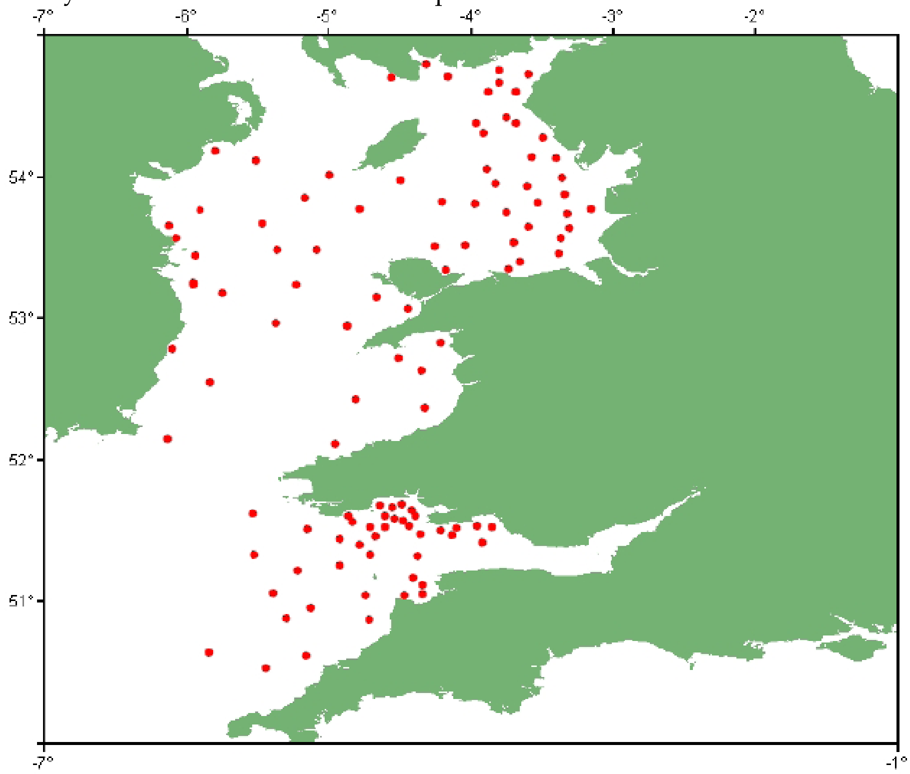
The maturity ogive applied to all years is, a combined sex maturity ogive taken from Area VIIfg attributed to Pawson and Harley, WD presented to WGSSDS in 1997.

Age	1	2	3	4	5	6 and older
	0.00	0.14	0.45	0.88	0.98	1.00

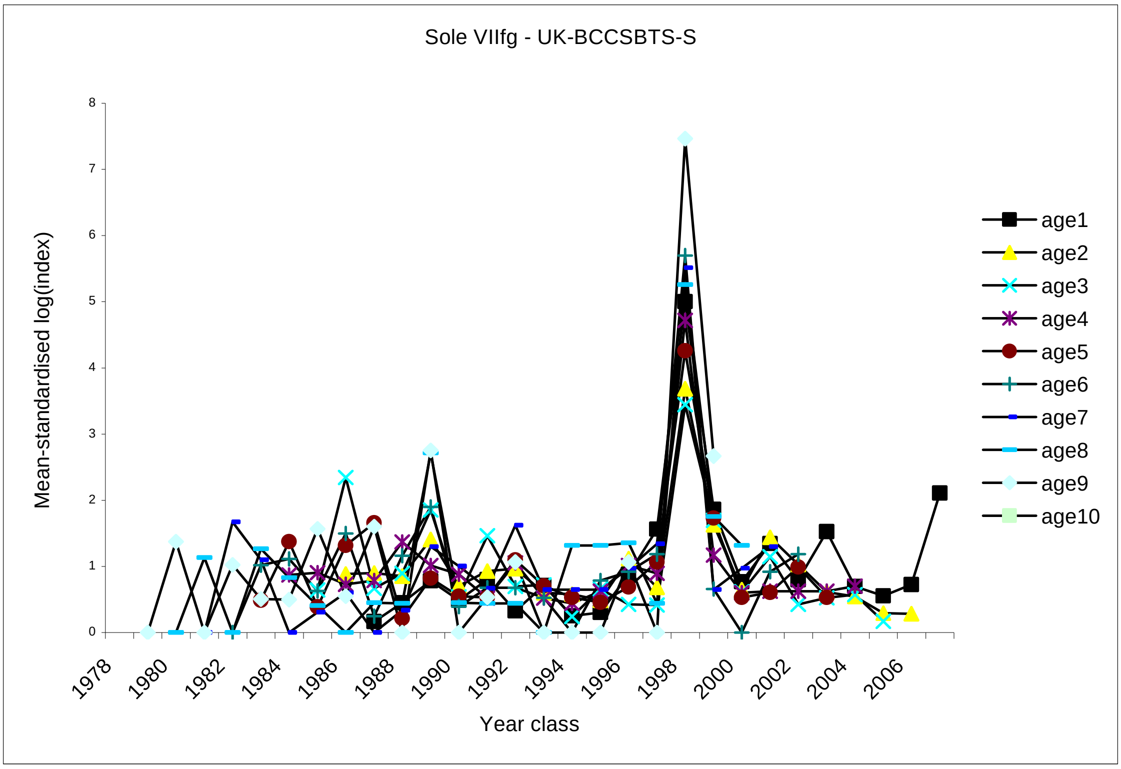
The proportion of M and F before spawning was set to zero.

B.3 Surveys

Abundance indices for Celtic Sea sole are available for one survey, the UK beam trawl survey (UK-BCCSBTS-S). The survey has been conducted in September for approx. 24 days annually since 1988. There are 101 core fishing and hydrographic stations distributed around the Irish Sea, Bristol Channel and Celtic Sea between 50 to 55 degrees N and between the English, Welsh and Irish coasts. The survey is coordinated by the ICES WGBEAM and a map of 2009 stations is shown below.



Abundance indices for the youngest ages (standardized to the mean of the respective ages), together with the VPA recruitment estimates are given in the Figure below. The Figure below shows that the survey is able to track the strength of the year classes.



B.4 Commercial cpue

Commercial cpue data are available for a number of fleets and have so far been described in Section 4.3.6 of the Report.

B.5 Other relevant data

No other relevant data included so far.

C. Historical stock development

After a period (1978–1990) of continuous increases in the fishing mortality (from 0.19 to 0.64), F dropped in the two following years to 0.40. In the period 1995–2003, fishing mortality fluctuated around a high level, except for 2000. Since 2003 fishing mortality has dropped from 0.57 to 0.33 in 2006.

Recruitment has fluctuated around 5 million recruits with occasional strong year classes. The 1998 year class is estimated to be the strongest in the time-series.

SSB is estimated to have declined continuously from the highest value of 7900 t in 1971 to the lowest observed in the time-series in 1998. The exceptional year class of 1998 had increased SSB to above the long-term average, but as the influence of this year class on SSB wanes, SSB has declined.

Tuning data

XSA tuning data that have been used in recent assessments are those from Belgium beam trawlers (BEL-BEAM), 1971 onwards; from the UK beam trawl fleet (UK-CSBT), Division VIIf, 1991 onwards; and from the UK Corystes September beam trawl survey (UK-BCCSBTS-S), 1988 onwards. The Belgian beam trawl fleet is temporally discontinued in 2003. This is as a result of a change in the calculation of the effort statistics from the official logbooks and sale slip notes in the most recent years. Before the next benchmark assessment, a new derivation of these data should become available.

There do exist other tuning data for this stock (e.g. a UK otter trawl fleet), but these have not been included in the assessment as they were not considered to be representative for this stock.

The Irish Groundfish survey, held in the 4th quarter is available since 2003 but is not yet used in the XSA as the time-series is too short.

Assessment methods and settings

Celtic Sea sole has been assessed with XSA. An overview of this year's and last year's settings is given in Section 4.3.4.

	1998 ASSESSMENT			1999 ASSESSMENT			2000 ASSESSMENT			2001 ASSESSMENT			2002 ASSESSMENT		
Fleets	Years	Ages	α-β	Years	Ages	α-β	Years	Ages	α-β	Years	Ages	α-β	Years	Ages	α-β
BEL-BEAM commercial	89-97	2-9	0-1	89-98	2-9	0-1	86-99	2-9	0-1	86-00	2-9	0-1	86-01	2-9	0-1
UK-CSBT commercial	89-97	2-9	0-1	89-98	2-9	0-1	87-99	3-9	0-1	91-00	2-9	0-1	91-01	2-9	0-1
UK-BCCSBTS-S survey	89-97	1-4	0.75-0.85	89-98	1-4	0.75-0.85	88-99	1-4	0.75-0.85	88-00	1-4	0.75-0.85	88-01	1-4	0.75-0.85
-First data year	1989			1989			1986			1986			1986		
-Last data year	1997			1998			1999			2000			2001		
-First age -Last age	1 10+			1 10+			1 10+			1 10+			1 10+		
Time series weights	None			None			None			None			None		
-Model	Mean q model all ages			Mean q model all ages			Power model (ages 1 & 2)			Power model (ages 1 & 2)			Power model (ages 1 & 2)		
-Q plateau set at-age	7			7			7			7			7		
-Survivors estimates shrunk towards mean F	5 years / 5 ages			5 years / 5 ages			5 years / 5 ages			5 years / 5 ages			5 years / 5 ages		
-s.e. of the means	0.5			0.5			1.5			1.5			1.5		
-Min s.e. for pop. Estimates	0.3			0.3			0.3			0.3			0.3		
-Prior weighting	None			None			None			None			None		

	2003 ASSESSMENT			2004 ASSESSMENT			2005 ASSESSMENT			2006 ASSESSMENT			2007 ASSESSMENT		
Fleets	Years	Ages	α-β	Years	Ages	α-β	Years	Ages	α-β	Years	Ages	α-β	Years	Ages	α-β
BEL-BEAM commercial	87-02	2-9	0-1	71-03	2-9	0-1	71-03	2-9	0-1	71-03	2-9	0-1	71-03	2-9	0-1
UK-CSBT commercial	91-02	2-9	0-1	91-03	2-9	0-1	91-04	2-9	0-1	91-05	2-9	0-1	91-06	2-9	0-1
UK-BCCSBTS-S survey	88-02	1-4	0.75-0.85	88-03	1-4	0.75-0.85	88-04	1-4	0.75-0.85	88-05	1-9	0.75-0.85	88-06	1-9	0.75-0.85
-First data year	1987			1971			1971			1971			1971		
-Last data year	2002			2003			2004			2005			2006		
-First age	1			1			1			1			1		
-Last age	10+			10+			10+			10+			10+		
Time series weights	None			None			None			None			None		
-Model	Power model (ages 1 & 2)			Power model (ages 1 & 2)			Power model (ages 1 & 2)			Mean q model all ages			Mean q model all ages		
-Q plateau set at-age	7			7			7			7			7		
-Survivors estimates shrunk towards mean F	5 years / 5 ages			5 years / 5 ages			5 years / 5 ages			5 years / 5 ages			5 years / 5 ages		
-s.e. of the means	1.5			1.5			1.5			1.5			1.5		
-Min s.e. for pop. Estimates	0.3			0.3			0.3			0.3			0.3		
-Prior weighting	None			None			None			None			None		

	2008 ASSESSMENT			2009 ASSESSMENT		
Fleets	Years	Ages	α-β	Years	Ages	α-β
BEL-BEAM commercial	71-03	2-9	0-1	71-03	2-9	0-1
UK-CSBT commercial	91-07	2-9	0-1	91-08	2-9	0-1
UK-BCCSBTS-S survey	88-07	1-9	0.75-0.85	88-08	1-9	0.75-0.85
-First data year	1971			1971		
-Last data year	2007			2008		
-First age -Last age	1 10+			1 10+		
Time series weights	None			None		
-Model	Mean q model all ages					
-Q plateau set at-age	7			7		
-Survivors estimates shrunk towards mean F	5 years / 5 ages					
-s.e. of the means	1.5			1.5		
-Min s.e. for pop. Estimates	0.3			0.3		
-Prior weighting	None			None		

A complete overview of the historical settings will be made intersessional

D. Short-term projection

Population numbers for ages 2 and older are taken from the XSA output (estimates of the year = the assessment year minus 1).

GM recruitment is assumed.

Fishing mortality is set at the mean over the last three years, not rescaled. In 2007 assessment rescaled to F 2006.

Weights-at-age in the catch and in the stock are averaged over the last three years.

E. Medium-term projections

Population numbers for ages 2 and older are taken from the prediction output (estimates of the year = the assessment year).

GM recruitment is assumed.

Fishing mortality is set at the mean over the last three years, not rescaled.

Weights-at-age in the catch and in the stock are averaged over the last three years.

In 2007 no medium-term projections done.

F. Yield and biomass-per-recruit/long-term projections

Population numbers for ages 2 and older are taken from the XSA output (estimates of the year = the assessment year minus 1).

GM recruitment is assumed.

Fishing mortality is set at the mean over the last three years, not rescaled In 2007 assessment rescaled to F 2006.

Weights-at-age in the catch and in the stock are averaged over the last three years.

G. Biological reference points

Biological reference point values are given in the text Table below:

	ACFM 98-03
F_{lim}	0.52 (based on F_{loss}, WG98)
F_{pa}	0.37 (F_{lim} x 0.72)
B_{lim}	Not defined
B_{pa}	2200 t (based on B_{loss} (1991), WG98)

In 2004 the WG rejected the biological reference points with the following arguments:

Biomass and F reference points for Celtic Sea sole have been reconsidered during this Working Group. The basis on which the reference points were set in the past is not valid anymore because there is no stock–recruitment relation for this stock. The more, the highest recruitment has been produced by the lowest biomass.

(1) As there is no stock–recruitment relationship, the use of a biomass reference point for management purposes is less relevant. Nevertheless, SSB should be maintained (a) within a range were recruitment is not impaired and (b) above the lowest observed biomass (under the condition that SSB has increased afterwards).

(2) Using $\mathbf{F}_{loss}$ (now estimated to be 0.84) as a basis for setting reference points cannot be done when there is no stock–recruitment relation. Therefore the current $\mathbf{F}_{pa}$ value cannot be used for management purposes. The assessment indicates that at current levels of fishing mortality, SSB is maintained in the range were recruitment is not impaired and above the lowest observed biomass (Figure 4.3.14). Therefore the WG considers current fishing mortality to be sustainable.

H. Other issues

No other issues so far.

Annex 7.15: Stock Annex Whiting VIIe–k: Quality Handbook

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Whiting VIIe–k
Working Group	Celtic Sea Eco-region
Date	18 May 2009
Revised by	Sarah Davie

A. General

A.1. Stock definition

The degree of separation of whiting stocks between the Irish Sea, and ICES Divisions VIIb–c from the Celtic Sea, is currently unclear. SAMFISH (EU Study Contract 99–009, Improving sampling of western and southern European Atlantic Fisheries) described the stock unit as follows:

The main spawning areas of whiting in the Western Channel and Celtic Sea are off Start Point, off Trevose Head and southeast of Ireland. The spawning season is from February to May, and the larvae are found in midwater before moving to live near the seabed by September. For the next two years, juvenile whiting are found in shallow coastal and estuarine areas, being particularly abundant around Start Point. Nearly 4000 adult whiting were tagged and released off Start Point during August 1958 and 1960. Most returns were within three months of release and demonstrated little indication of movement. Subsequent recaptures indicated more movement of whiting into the Celtic Sea than between the western and eastern Channel. Whiting released in summer between 1957 and 1961 near Carmarthen Bay moved south and west towards the two spawning grounds off Trevose and southeast of Ireland. There was no evidence of emigration out of the Celtic Sea area. Returns of whiting tagged and released in the County Down spawning area in the Irish Sea demonstrate more movement south into the Celtic Sea than north to the west of Scotland.

A.2. Fishery

Whiting in Divisions VIIe–k are taken as a component of catches in mixed trawl fisheries. Whiting landings through the mid 1980s totalled between 10 000 t and 15 000 t, through the mid to late 1990s landings were elevated to around 20 000 t. Since the turn of the century landings have been in decline and are now below 10 000 t. Through the 1980s and early 1990s France accounted for around 60–85% of landings. While Ireland accounted for between 10% and 20% of landings, the UK 10%, and Belgium had minimal contribution (1–2%). Landings from both the UK and Belgium have remained at similar levels over time. Since the early 1990s Ireland has accounted for a greater proportion of landings. Proportions since 2004 have been similar to France whose landings have been falling since the turn of the century.

French landings are made mainly by gadoid trawlers, which prior to 1980 were mainly fishing for hake in the Celtic Sea. Irish demersal trawlers from Dunmore East and Castletownbere and other ports in southwest Ireland have traditionally targeted Celtic Sea whiting in a mixed trawl fishery. In response to poor catches in other areas vessels have been attracted into this fishery in recent years from County Donegal.

A detailed description of the Irish fishery is given in the annual WD to WGSSDS: 'A summary of the Irish Fishery and Sampling of Whiting in VIIe–k'.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

Data on international landings-at-age and mean weight-at-age are available for Irish, French and UK fleets from 1999 to present. The following procedures have been applied to aggregate the data for the areas VIIe, VIIfgh and VIIj,k and build the database for VIIe–k. UK VIIe–k data were used to scale catch numbers according to the landings for each area. French VIIf,g,h data were used with Irish VIIg data to scale VIIf,g,h catch numbers. Irish VIIj data were used to scale VIIj,k catch numbers. The Table below demonstrates the data available and the procedures used to derive quarterly length compositions, age compositions and mean weights-at-age.

		Data source:				
Division	Data	UK	France	Ireland	Belgium /Other	Derivation of international landings:
VII e	Length composition	VIIe-k				
	ALK	VIIe-k				
	Age Composition	VIIe-k				UK raised
	Mean weight-at-age	VIIe-k				UK VIIe-k
	Landings	VIIe	VIIe	VIIe	VIIe	
VII f,g,h	Length composition	VIIe-k	VIIf,g,h	VIIg		
	ALK	VIIe-k	VIIf,g,h	VIIg		
	Age Composition	VIIe-k	VIIf,g,h	VIIg		(UK + FR+ IRL) raised to international landings
	Mean weight-at-age	VIIe-k	VIIf,g,h	VIIg		Weighted mean by numbers caught
	Landings	VIIf,g,h	VIIf,g,h	VIIf,g,h	VIIf,g,h	
VII j,k	Length composition			VIIj		
	ALK			VIIj		
	Age Composition			VIIj		IRL raised
	Mean weight-at-age			VIIj		IRL VIIj
	Landings	VIIj,k	VIIj,k	VIIj,k	VIIj,k	

Data source:						
Division	**Data**	**UK**	**France**	**Ireland**	**Belgium /Other**	**Derivation of international landings:**
VII e,f,g,h,j,k	Length composition					
	ALK					
	Age Composition					VIIe + VII fgh + VIIjk
	Mean weight-at-age					Weighted mean by numbers caught
	Landings					VIIe + VII fgh + VIIjk

B.2. Biological

Age group 0 is included in the assessment data to allow inclusion of 0-group indices in the XSA, although in most years, no landings are recorded. Very small landings of 0-group whiting were not included in the catch-at-age data-file to avoid spurious F-shrinkage effects at this age. Mean weights-at-age in the catch were derived by combining French, Irish and English data, weighted by the numbers landed at-age.

Mean weight-at-age in the stock are taken as mean weights-at-age in the quarter 1 catch. Where age 1 was poorly represented in quarter 1 landings, quarter 2 values were used as estimates of mean weight-at-age 1 in the stock. Stock weights-at-age are smoothed using a three year rolling average across ages to dampen the noise exhibited by the stock weight dataset. This approach is also used in Irish Sea whiting and Celtic Sea haddock.

Natural mortality is assumed to be 0.2 over all age groups and years.

Maturity data collected in the Celtic Sea in November 2002 during the French EVHOE survey were presented to the WG (Working Document 1: WGSSDS 2003). Results indicated 13 % of age 1 fish are mature, 97% at-age 2, and 100% at-age 3 and older. These results are similar to previous assumptions of knife-edged maturity at-age 2. Exploratory analyses indicated that use of the French maturity ogive made little impact on the assessment. The WG therefore retained the assumptions of knife-edged maturity at-age 2. Since 2006 the knife edge maturity ogive has been replaced with indices calculated based on data from the UK WCGFS (Working Document 3: WGSSDS 2006) but a fixed vector is still used. Maturity sampling by Ireland and the UK on dedicated surveys confirms the use of this ogive but is insufficient to provide annual data.

The proportions of F and M before spawning were both set to zero to reflect the SSB calculation date of 1 January.

The knife edge maturity ogive was replaced with new indices calculated based on data from the UK WCGFS as detailed in WD 3, WGSSDS, 2006.

Age	0	1	2	3	4	5+
Maturity	0	0.39	0.90	0.99	0.99	1.00

B.3. Surveys

The following surveys are available as survey tuning data input for the assessment of whiting VIIe–k:

- UK-WCGFS, 1987–2004

The March UK groundfish survey was extended in 1992 to provide better coverage for gadoids in VIIf,g. The whiting tuning data calculated from this survey is for VIIf,g. The survey was carried out on the RV Cirolana until 2003. In 2004 it was carried out on the RV Endeavour and discontinued thereafter. The survey fished fixed station positions allocated by area and depth strata. The survey used a modified Portuguese High-Headline trawl (PHHT) with 350 mm rubber bobbins, a bunt tickler chain and a 20 mm codend liner.

- UK-BCCSBTS-S, 1988–2001

The Autumn UK Bristol Channel beam trawl survey (VIIf) is commercially rigged (1989 style) with 4 m beam trawl fitted with a chain mat, flip-up ropes, and a 40 mm codend liner. The gear is towed at 4 knots (ground speed) for 30 minutes. This survey provides information for age 0 and age 1 whiting.

- FR-EVHOE, 1997–present

This fourth-quarter annual groundfish is carried out on the RV Thalassa. Age data are available from 2001 onwards. The sampling design is a stratified random allocation. The number of hauls per stratum is optimized by a Neyman allocation taking into account the most important commercial species in the area (hake, monkfish and megrim). The fishing gear used is a GOV with an average vertical opening of 4 m and a horizontal opening of 20 m.

- IR-WCGFS, 1993–2002

The fourth-quarter Irish west-coast groundfish survey (WCGFS) was carried out in VIaS and VIIbj on chartered commercial vessels. The sampling design attempted to allocate at least two stations per rectangle. Stations were selected randomly within each rectangle from known clear tow positions. A Rockhopper GOV with 12 inch discs was used. The nets were fitted with a 20 mm codend liner. This survey was discontinued after the 2002 survey, giving way to a new Irish groundfish survey on board the RV *Celtic Explorer*.

- IR-ISCSGFS, 1997–2002

Ireland commenced a Celtic Sea research vessel survey on board the RV *Celtic Voyager* in 1997 carried out in VIIa and VIIg. The survey used a GOV Trawl with a mean vertical opening is 6 m and door spread 48 m. Data from this survey (IR-ISCSGFS) were presented for the first time to the 2003 WG. The data made available were from prime stations only in a limited area of Division VIIg. The survey was discontinued after the 2002 survey, giving way to a new Irish groundfish survey on board the RV *Celtic Explorer*.

- IR-GFS 7g and j, 2003–present

Ireland commenced a new fourth quarter survey in 2003 on board the RV *Celtic Explorer* which covers VIaS, VIIbgj as part of the internationally coordinated, Quarter 4 IBTS survey program. The IGFS has a random stratified design and uses a GOV (with rock-hopper in VIa) with a 20 mm codend liner. This is a substantially different design to the Irish Sea / Celtic Sea groundfish survey (IR-ISCSGFS) it replaces. Data from this survey (IR-GFS) were presented for the first time to the 2004 WG.

- IR-IGFS Swept Area, 1999–present

This survey index constitutes a combination of the IR-ISCSGFS and IR-GFS surveys in the area of overlap between them (VIIg). The two surveys were standardized using a swept-area estimate of catches, described in WD 5 (WGSSDS 2006). This survey was presented for the first time to the 2006 WG.

B.4. Commercial cpue

Information on effort, and whiting landings and lpue are available from a number of commercial fleets. This includes two French (gadoid and *Nephrops* directed) since 1983, four Irish (VIIj, and VIIg otter trawlers, and Scottish seines) since 1995, in addition to effort only from UK England and Wales VIIe–k beam trawlers and VIIe–k otter trawlers since 1983.

Across the majority of commercial fleets lpue has fallen over time, as is the case with landings. In the mid 1990s at the start of the Irish Scottish seine dataseries lpue was high, falling steeply over several years. Lpue continues to remain at these lower levels with some annual fluctuation. In relation to otter trawlers, the French gadoid directed fleet consistently revealed the highest lpue. This too has declined over the period of data available to levels half those of the early 1980s. The Irish VIIg otter trawl fleet is the only one to demonstrate an overall increasing lpue trend although the increase has been relatively small.

B.5. Other relevant data

No other relevant data to report.

C. Historical stock development

Data screening: Exploratory data analysis carried out using FLR. A separable VPA was performed using the Lowestoft VPA95 software to screen for outliers in the catch numbers.

Model used: XSA

Software used: FLR under R version 2.4.1 in conjunction with FLCore 1.4–3, FLAssess 1.4.1, FLXSA 1.4–2 and FLEDA 1.4–2

Lowestoft VPA95 software also for XSA and separable VPA

Model Options:

Option	Setting
Ages catch dep stock size	None
Q plateau	5
Taper	No
F shrinkage SE	1.00
F shrinkage year range	5
F shrinkage age range	3
Fleet SE threshold	0.50

Prior weights	No

Input data types and characteristics:

Type	Name	Year range	Age range	Variable year to year
Caton	Catch in tonnes	1982–current	0–7+	Yes
Canum	Catch-at-age in numbers	1982–current	0–7+	Yes
Weca	Weight-at-age in the commercial catch	1982–current	0–7+	Yes
West	Weight-at-age of the stock at spawning time.	1982–current	0–7+	Yes:
Mprop	Proportion of natural mortality before spawning	1982–current	0–7+	No
Fprop	Proportion of fishing mortality before spawning	1982–current	0–7+	No
Matprop	Proportion mature-at-age	1982–current	0–7+	No
Natmor	Natural mortality	1982–current	0–7+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	FR-Gadoid Late	1993–current	3–6
Tuning fleet 2	FR-*Nephrops*	1993–current	3–6
Tuning fleet 3	FR-EVHOE	1997–current	0–4
Tuning fleet 4	UK-WCGFS	1987–current	1–6
Tuning fleet 5	IR-IGFS Swept area	1999–current	0–6

Settings for each assessment since 1999 are detailed in Table 1. Trial runs have, over the years, explored most of the options with regards XSA settings. This stock has not had a benchmark assessment, however exploratory assessments have been carried out within the WGSSDS up until 2007.

D. Short-term projection

Model used: Multi Fleet Deterministic Projection

Software used: MFDP1a

Initial stock size: initial stock numbers derived from XSA analyses. Numbers-at-age 0 are not considered to be well estimated and are replaced with a geometric mean of the full time-series (1982–2007). Recruitment has been at a low level since 1995 with the exception of the 1999 year class. The two most recent years have displayed good recruitment, with last year's being revised downward. Recruitment is solely estimated from the FR-EVHOE and IR-GFS7gSweptArea surveys, in recent years the French survey estimates have been far higher than those of the Irish survey. Because of these reasons the geometric mean is used.

Natural mortality: That used in the assessment

Maturity: Maturity ogive used in the assessment

F and M before spawning: Those used in the assessment method

Weight-at-age in the stock: Unscaled 3 year arithmetic mean

Weight-at-age in the catch: Unscaled 3 year arithmetic mean

Exploitation pattern: Unscaled 3 year arithmetic mean (though alternative options may be used depending on recent F trajectories and the Working Group's perception of the fishery).

Intermediate year assumptions: *Status quo* F

Stock–recruitment model used: Geometric mean of full time-series (1982 to present-1) for age 0 recruitment

F_{bar}: That used in the assessment

E. Medium-term projections

None

F. Long-term projections

Model used: Multi Fleet Yield-per-recruit

Software used: MFYPR2a

Yield-per-recruit calculations are conducted using the same input values as those used for the short-term forecasts.

G. Biological reference points

A summary of reference point proposals to date, their technical basis and currently adopted reference points is given in the text Table below:

	WG 1998	ACFM 1998	WG 2000	ACFM 2000
F_{lim}	No Proposal	No Proposal	1.18 (F_{lim}=F_{loss})	No Proposal
F_{pa}	No Proposal	No Proposal	0.72 (F_{pa}=F_{lim} x $e^{-1.645 \times 0.3}$)	No Proposal
B_{lim}	15,000 t	15,000 t	15 000 t (B_{lim}=B_{loss})	15,000 t (B_{lim}=B_{loss})
B_{pa}	18,000 t	21,000 t	21 000 t (B_{pa}=B_{loss} x 1.4)	21,000 t (B_{pa}=B_{loss} x 1.4)

The technical basis of ACFM's 1998 B_{pa} proposal is given below (1999 WG text):

B_{pa} = B_{lim} x 1.4 = 21 000 t. In the past the WG have selected MBAL as 18 000 t based on evidence of reduced recruitment at SSB's <18 000 t. However this MBAL is driven by a period of low recruitments at low SSB in the earlier years of the time-series (1982–1985) when the data are probably not reliable. Examination of the stock–recruit plot provides no compelling evidence of reduced recruitment below SSB of 18 000 t.

The technical basis of the WG's 2000 F_{lim} and F_{pa} proposals are given below:

On the basis of results obtained from a LOWESS fitted non-parametric stock and recruitment relationship and the derived equilibrium SSB and yield curves with the original data trajectories the 2000 Working Group considered that F_{pa} and F_{lim} could be defined because F_{loss} appeared reasonably estimated. However, taking into account the uncertainties in the data the 2000 Working Group decided to use 0.3 as the SE in calculation of F_{pa} from F_{loss}. The technical basis for the proposed reference points are defined below:

$F_{lim} = F_{loss}$ (1.18 in this year's assessment)

$F_{pa} = F_{lim}$ x e-1.645*0.3 = 0.72

The currently adopted reference points are as follows:

	Current Reference Points
F_{lim}	No Proposal
F_{pa}	No Proposal
B_{lim}	15,000 t ($B_{LIM} = B_{LOSS\ 1983}$, $ACFM_{1998}$)
B_{pa}	21,000 t ($B_{PA} = B_{LOSS\ 1983}$ x 1.4)

H. Other issues

No other issues.

I. References

Table 1. Model settings/Input data/Tuning data.

		1999	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
Catch date range:	***Years***	82-98	82-99	82-00	82-01	82-02	82-03	82-04	82-05	82-06	82-07	82-08
	Ages	1-7+	0-7+	0-7+	0-7+	0-7+	0-7+	0-7+	0-7+	0-7+	0-7+	0-7+
Assmnt Method:		XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA
Fbar Age Range:		2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5
Time taper:		No	No	No	No	No	No	No	No	No	No	No
Q plateau age:		4	4	4	4	4	4	4	4	5	5	5
F shrinkage S.E:		0.8	2.5	1.5	1.5	1.5	1.5	1.5	1.5	1	1	1
	Num yrs	5	5	5	5	5	5	5	5	5	5	5
	Num ages	3	3	3	3	3	3	3	3	3	3	3
Fleet S.E:		0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.5	0.5	0.5	0.5
Commercial Tuning Fleets:												
FR-Gadoid	*Yrs*	89-98	90-99	93-00	82-92	82-92	82-92	83-92	83-05			
	Ages	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6			
FR-Gadoid Late	*Yrs*				93-01	93-02	93-03	93-04		93-06	93-07	93-08
	Ages				3-6	3-6	3-6	3-6		3-6	3-6	3-6
FR-Nephrops	*Yrs*	89-98	90-98	93-00	93-01	87-02	87-03	87-04	87-05	93-06	93-07	93-08
	Ages	2-6	4-6	2-6	2-6	2-6	2-6	2-6	3-6	3-6	3-6	3-6
IR-7g&j-OT	*Yrs*			95-00	95-01	95-02	95-03	95-04	95-05			
	Ages			1-6	1-4	1-4	1-4	1-4	3-4			
Survey Tuning series:												
FR-EVHOE	*Yrs*			97-00	97-01	97-02	97-03	97-04	97-05	97-06	97-07	97-08
	Ages			0-4	0-4	0-4	0-4	0-4	0-4	0-4	0-4	0-4
UK-WCGFS	*Yrs*	92-98	92-99	93-00	92-01	92-02	92-03	92-04	92-04	87-01	87-01	87-01
	Ages	1-6	1-6	2-6	2-4	2-4	2-4	2-4	1-6	1-6	1-6	1-6
UK-BCCSBTS	*Yrs*	89-98	90-99	89-00	89-01	89-02	89-03	89-04	89-05			
	Ages	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1			
IR WCGFS	*Yrs*			93-00								
	Ages			1-1								
IR-IGFS Swept area	*Yrs*								99-05	99-06	99-07	99-08
	Ages								0-6	0-6	0-6	0-6

Annex 8.2: WGCSE-Western Channel Plaice

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Plaice (*Pleuronectes platessa*): Division VIIe
Working Group	**Working Group for the Celtic Seas Ecoregion** [WGCSE]
Date created	6 July 2003 (SF)
Last updated	19 May 2009 (IDH)

A. General

A.1 Stock definition

The management area for this stock is strictly that for ICES Area VIIe called the Western English Channel, although the TAC area includes the larger component of VIId (Eastern English Channel).

Between 1965 and 1976, more than 5500 plaice were tagged and released around Start Point. Analysis of the recaptures from plaice tagged while spawning in the Channel during January and February demonstrated that 20% spent summer in the western Channel, 24% in the eastern Channel, and approximately 56% migrated to the North Sea after spawning. Few of the plaice tagged in the western Channel during April and May were recaptured outside the Channel however, suggesting that there is a resident stock that does not migrate to the North Sea after spawning in the Channel.

The main spawning areas are south of Start Point and south of Portland Bill. Spawning takes place between December and March with a peak in January and February.

Figure A shows the spawning areas for VIIe plaice.

A.2 Fishery

In the western English Channel plaice are taken mainly as a bycatch in beam trawls directed at sole and anglerfish. The main plaice fishery is concentrated to the south and west of Start Point. Although plaice are taken throughout the year, landings are usually heaviest during February/March and October/November. The fisheries taking plaice in the western English Channel mainly involve vessels from the bordering countries: UK vessels report about 68%, France 24% and Belgium 8% of the total plaice landings from ICES Division VIIe (based on 2007/08). Landings reached a peak of more than 2500 tonnes in 1990, then declined rapidly, before stabilizing in the last few years.

Main métiers

There are ten main métiers which exploit important fish and shellfish stocks in the Channel. Otter trawling accounts for a wide range of target species in season, cuttlefish, anglerfish, gurnard, rays, cod, whiting, plaice, sole, squid and lemon sole, involving involves boats from France (600), England (470), Belgium (15) and the Channel Islands (11). Beam trawling is also important for boats from the 3 former nations (26, 83 and 65 respectively), targeting sole, anglerfish and plaice, with up to 25 of the Belgian boats extending this fishery into the Bay of Biscay. Many boats from France (626) and England (80) join two Channel Islands vessels dredging for scallops and taking a valuable bycatch of sole and anglerfish. The other main towed gear is midwater trawls, used either for the small pelagic species, mackerel, sprat, pilchard and herring, or for bass and black bream with a bycatch of gadoids by French (40) and English (25) boats. Purse seines are used by 8 UK vessels to take mainly mackerel and pilchard in the western Channel.

The fixed netting métier in the Channel is really composed of several métiers using specific net gears and mesh sizes depending on target species, the most important being with gillnets and trammelnets (580 French and 380 English boats) for sole, cod, ling, pollack, hake, plaice, bass and spider crab. Rays, anglerfish, turbot, crabs, lobster and crawfish are also taken in tanglenets (305 French, 300 English and 7 Channel Islands).

Similarly, potting (960 French, 275 English and 560 Channel Islands) uses several distinct gears to catch brown (edible) crabs, spider crabs, cuttlefish, lobsters and whelk, both inshore and offshore, and there are zones in the western Channel partitioning potting and towed gears for alternating periods. Longlining has been replaced by fixed net in many cases, but conger eel, sharks, rays and bass are still taken (260 French, 60 English and 13 Channel Islands). Handlines are used for mackerel, bass, pollack and ling by small boats working along both the English (390) and French (120 French and 90 Channel Islands) coasts of the Channel. This information is accurate as at WG07.

B. Data

B.1 Commercial Catch

Sampling and data raising

Quarterly age compositions were available only from UK (England and Wales) landings for the years 1995–2008 (and 1989), which accounted for approximately 68% of total international landings. The total international age composition was obtained by raising the combined gears quarterly UK (England and Wales) age compositions to include the landings of the Channel Isles, France and Belgium, and summing to give an annual total.

For the earlier years of 1990–1994, French age compositions were also available. For these years, the UK (England and Wales) age compositions were raised to UK (Total) by including landings from the Channel Islands. Finally, UK (Total) and French age compositions were combined and raised to include Belgian landings. For the years 1981–1988 Prior to this, the stock data were aggregated for area of VIId and VIIe. For these years, Belgium also provided age compositions data and this was combined with UK (Total) and French age compositions. French age compositions were based on age data provided by the UK.

Age data representing French landings were available for 2002 and 2003, but were not used in the assessment.

Table A demonstrates the national data availability for VIIe plaice stock for the time period 1981–2008.

Table B demonstrates a time-series of CV's of numbers-at-age for sampling; UK (E+W) all fleets combined.

Weights-at-age

Total international catch and stock weights-at-age were calculated as the weighted mean of the annual weight-at-age data supplied (weighted by landed numbers), and smoothed using a quadratic fit:

[e.g.: Wt = (0.1109*Age) - (0.0004*(Age^2)) - 0.008; $R^2 = 0.98$]

where catch weights-at-age are mid-year values (age = 1.5, 2.5, etc.), and stock weights-at-age are 1st January values (age = 1.0, 2.0, etc.). Catch weights-at-age have been scaled to give a SOP of 100%, and the same scaling has been applied to stock weights-at-age.

This technique has been used for many years (at least since stock has been assessed by the Southern Shelf Demersal WG. In early years in the time-series, weights-at-age were averaged over a period of years, and derived from separate-sex mean weights-at-age.

B.2 Biological

The main spawning areas for plaice in the western Channel are south of Start Point and Portland Bill. Spawning takes place from December to March, with a peak in January and February.

On average, about a quarter of plaice in the western Channel are mature at-age 2, half are mature at-age 3 and all are mature at-age 5. The majority of plaice landed in the western Channel in 2001, for example, were at-ages 2–5, and therefore 73% of those landed were mature.

Natural mortality and maturity ogives

Initial estimates of natural mortality (0.12 ^{yr} all years and all ages) and maturity were based on values estimated for Irish Sea plaice (Siddeek, 1981). A new maturity ogive based on UK (E&W) VIIfg survey data for March 1993 and March 1994 (Pawson and Harley, 1997) was produced in 1997 and is applied to all years in the assessment.

Age	1	2	3	4	5+
Old Maturity	0	0.15	0.53	0.96	1.00
New Maturity	0	0.26	0.52	0.86	1.00

The proportion of mortality before spawning was originally set at 0.2 as approximately 20% of the total catch was taken prior to late February–early March, considered to be the time of peak spawning activity. The proportion of F and M before spawning was changed to zero prior to the 1994 Southern Shelf Demersal Working Group as it was considered that these settings were more robust to seasonal changes in fishing patterns, especially with respect to the medium-term projections.

B.3 Surveys and survey tuning data

An annual 4 m beam trawl survey has taken place in the Lyme Bay area of the Western English Channel since 1984, initially aboard chartered fishing Vessels (MV BOGEY 1 and latterly MV CARHELMAR) and more recently aboard the CEFAS research vessel CORYSTES, coming back to MV CARHELMAR in 2005.

Appendix 1 provides a history of the survey and details the survey methodology and objectives.

The Western English Channel beam trawl survey data are used to calculate assessment tuning data for both VIIe plaice and sole. Indices of abundance-at-age for years 1986 to the present, and for ages 1–5 have been used. Since 2007, this age range has been extended to include data for ages 1–8. Appendix 1 also describes how these indices of abundance-at-age are derived.

Since 2003 a Fisheries Science Partnership (FSP: Cefas-UK industry cooperative project) has been conducting a survey using commercial vessels with scientific observers and following a standard grid of stations extending from the Scilly Isles to Lyme Bay. The survey covers a substantially larger area than the current survey (UK-WECBTS) and is thought to be more representative of the stock in UK waters. This dataset was first included in the 2007 assessment, and the exploratory analysis can be seen in that report (ICES, 2007; Section 3.2.5). However, recently the vessel(s) used for the survey have changed from the FV Nellie and the FV Lady T, to the FV Carhelmar. In 2008, in addition to the vessel changes there have been other sample protocol changes, notably the change to using 4 m 'survey' beam trawls from the commercial 12 m beam trawls previously used by the other vessels.

B.4 Commercial lpue

The UK (E+W) commercial lpue is calculated for 3 sectors within VIIe (VIIe north, VII south and VIIe west). Beam trawl lpue in the North of VIIe reached a peak in 1990, fell sharply to 1994 and is now fluctuates at low levels. The south and west sectors both peaked in the early 1990s but have steadily declined since. Otter trawl lpue in north of VIIe peaked in 1988 before falling sharply until 1995. Since then it has remained at these much lower levels. Lpue in the south is generally lower, but fluctuates to high peaks throughout the time-series, whereas in the west it has remained stable at a lower level for the duration of the time-series.

Survey cpue (Beam trawl survey in the North of VIIe) has early 1990s revealed a similar but slightly earlier trend in the early years but indicates a more pronounced temporary increase in catches during 2000 and 2001 compared with the commercial-series.

UK beam trawl effort has increased rapidly over the time-series, reaching record high levels in 2003 and has remained at this high level since. UK trawl effort has slowly decreased over the time-series, reaching a record low level in 2008. Effort is calculated as fishing power corrected using GRT.

Figures B and C show plots of UK effort for 1998–2008 by ICES rectangle for otter trawl and beam trawl gears, respectively.

Commercial tuning data

Commercial tuning information for this stock comprises of the UK (E&W) otter trawl fleet and the UK (E+W) beam trawl fleet. These fleets have been used by Working Groups for a number of years, and initially contained data for years back to 1976 (otter) and 1978 (beam). However in the most recent assessments carried out for this stock, otter trawl fleet data are currently used only for years 1988 to the present and for ages 3–9 and Beam trawl fleet is currently used for years 1989 to the present, and ages 3–9. Since 2004, an historic otter trawl fleet (1976–1987) has been reintroduced using ages 2–9 only.

B.5 Other relevant data

C. Historical stock development

This stock was been assessed by the ICES Southern Shelf Demersal WG from 1992 to 2008. In 2009, this stock was assessed at the newly formed ICES Celtic Seas Ecoregion Working Group. It has been managed by a TAC since 1984. The TAC is applicable to VIId (Eastern Channel) and VIIe combined, although in 1997 there was a separate limit for landings from VIIe. This was unpopular with the industry; as a consequence of the national split being based on VIId and VIIe combined reported landings for the reference period, and has not been repeated since.

Technical measures in force

Technical measures currently in force in the Western English Channel are a minimum mesh size of 80 mm for otter and beam trawlers and 70 mm for *Nephrops* trawlers. Panels of 75 mm square mesh are compulsory in all *Nephrops* fisheries in ICES Subarea VII.

There is also a minimum landing size (MLS) on 27 cm in force.

Assessment methods and settings

The standard settings for a catch data screening run using a separable VPA are reference age of 4; F set to 0.7 and S set to 0.8.

In 1991 the stock was assessed using a Laurec-Shepherd tuned VPA. Concerns about deteriorating data quality prompted the use in 1992 of XSA.

Trial runs have, over the years, explored most of the options with regards XSA settings.

The effect of the power model on the younger ages was explored in 1994; 1995; 1996; 1998 and 2004.

The use of P shrinkage was investigated in 2001; 2004.

Different levels of F shrinkage were explored in 1994; 1995; 2000; 2002 and 2004.

The level of the + group was examined in 1995 and 2004.

The effect of different time tapers was investigated in 1996.

The S.E. threshold on fleets was examined in 1996; 2001 and 2007.

The level of the catchability plateau was investigated in 1994; 1995; 2002 and 2004.

Table C demonstrates the history of VIIe plaice assessments and details the parameters used.

D. Short-term projection

Standard ICES software is used for the short-term projections; MFDP.

No short-term forecast has been provided since 2006 as the Review Group deemed it unhelpful in the management of the stock given the strong retrospective bias in F.

E. Medium-term projections

F. Yield and biomass-per-recruit/long-term projections

Standard ICES software is used for the long-term projections; MFYPR.

As with most plaice stocks, there is no clear stock–recruitment relationship evident.

Not carried for this stock since 2006.

G. Biological reference points

Biological reference points were proposed for this stock by the 1998 Working Group as below.

F_{lim}	Not defined	
F_{pa}	0.45	(low probability that $SSB_{MT}<B_{pa}$)
B_{lim}	1300 t	(equal to B_{loss})
B_{pa}	2500 t	(equal to M_{BAL})

The current Working Group view of these reference points is that they are considered unreliable.

H. Other issues

I. References

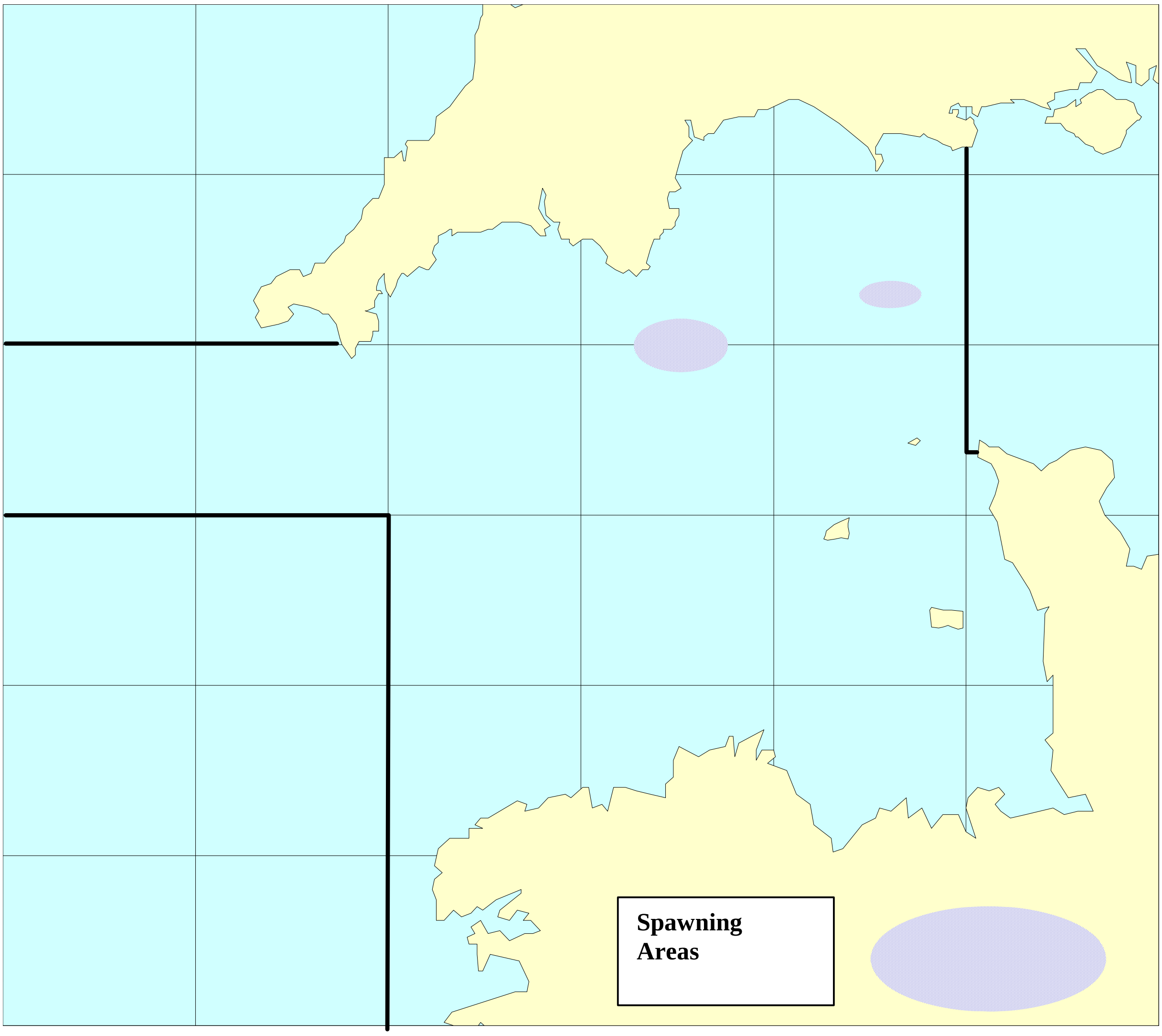


Figure A. Map of spawning areas for VIIe plaice.

Table A. VIIe plaice. Catch Derivation table for assessment years 1981–2008.

		SOURCE				
YEAR OF WG	DATA	UK	BELGIUM	FRANCE	DERIVATION OF INTERNATIONAL LANDINGS	% SAMPLED
1981*	length composition	quarterly	quarterly	quarterly	UK ALK used with French LDs	100
	ALK	quarterly	quarterly	-	UK+Belgium+France combined to total international	
	Age composition	quarterly	quarterly	-	No analytical assessment carried out	
1982*		As for 1981	As for 1981	As for 1981	As for 1981	100
1983*		As for 1981	As for 1981	As for 1981	As for 1981	100
1984*		As for 1981	As for 1981	As for 1981	As for 1981	100
1985*		As for 1981	As for 1981	As for 1981	As for 1981	100
1986*		As for 1981	As for 1981	As for 1981	As for 1981	100
1987*		As for 1981	As for 1981	As for 1981	As for 1981	100
1988*		As for 1981	As for 1981	As for 1981	As for 1981	100
1989*	length composition	quarterly	-	-	UK raised to total international	70
	ALK	quarterly	-	-		
	Age composition	quarterly	-	-		
1990	length composition	quarterly	-	quarterly	UK+France raised to total international	96
	ALK	quarterly	-	quarterly		
	Age composition	quarterly	-	quarterly		
1991		As for 1990	-	As for 1990	As for 1990	97
1992		As for 1990	-	As for 1990	As for 1990	97
1993		As for 1990	-	As for 1990	As for 1990	98
1994	length composition	quarterly	-	quarterly	UK ALKs applied to French LDs	96
	ALK	quarterly	-	-	UK+France raised to total international	
	Age composition	quarterly	-	-		
1995		As for 1989	-	-	As for 1989	83
1996		As for 1989	-	-	As for 1989	82

		SOURCE				
YEAR OF WG	DATA	UK	BELGIUM	FRANCE	DERIVATION OF INTERNATIONAL LANDINGS	% SAMPLED
1997		As for 1989	-	-	As for 1989	78
1998		As for 1989	-	-	As for 1989	79
1999		As for 1989	-	-	As for 1989	75
2000		As for 1989	-	-	As for 1989	72
2001		As for 1989	-	-	As for 1989	72
2002		As for 1989	-	-	As for 1989	78
2003		As for 1989	-	-	As for 1989	81
2004		As for 1989	-	-	As for 1989	79
2005		As for 1989	-	-	As for 1989	74
2006		As for 1989	-	-	As for 1989	74
2007		As for 1989	-	-	As for 1989	67
2008		As for 1989	-	-	As for 1989	69

*** stock assessed as VIId,e plaice.**

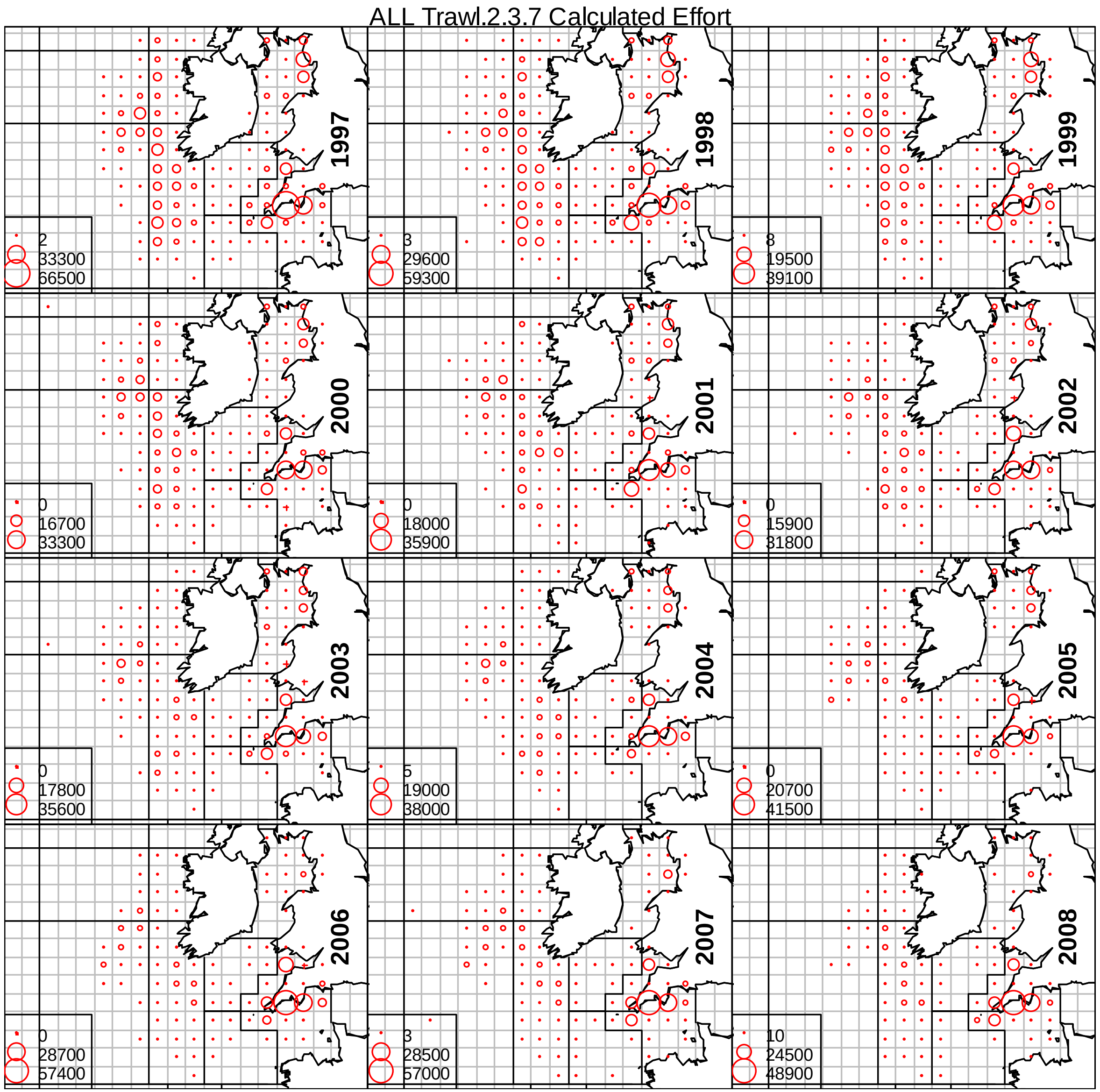


Figure B. UK (E+W) Otter trawl fleet effort (hours fished) based on demersal landings.

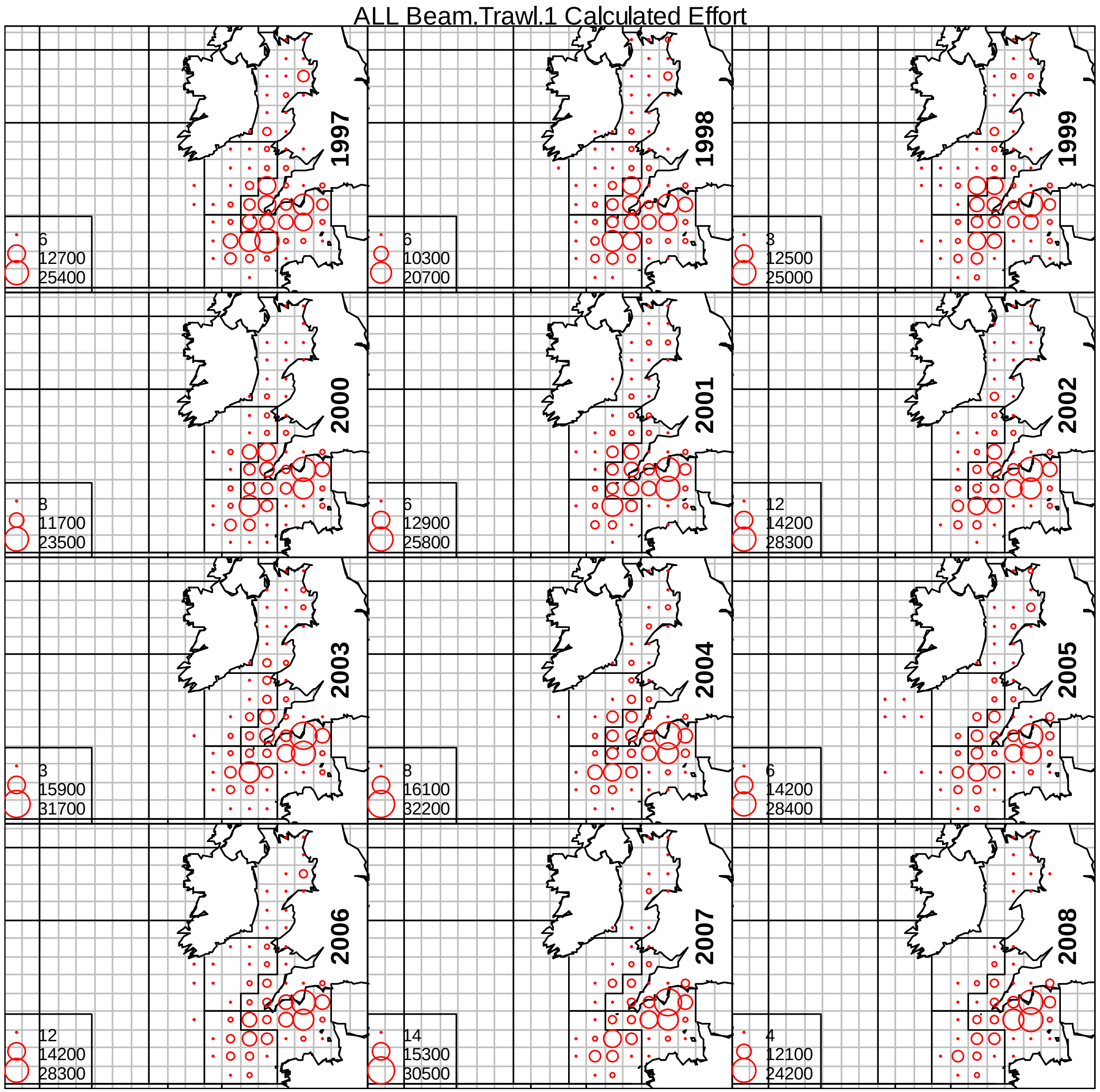


Figure C. UK (E+W) Beam trawl fleet effort (hours fished) based on demersal landings.

Table B. CV of numbers-at-age for commercial sampling.

		CV BY AGE								
YEAR	COUNTRY	1	2	3	4	5	6	7	8	9
2005	UK(E+W)	18%	3%	3%	3%	6%	7%	11%	10%	9%
2006	UK(E+W)	21%	4%	3%	5%	5%	8%	10%	15%	14%
2007	UK(E+W)	42%	5%	3%	4%	6%	6%	9%	13%	20%
2008	UK(E+W)	42%	4%	4%	5%	6%	8%	8%	10%	14%

Table C. History of VIIe plaice assessments.

Assessment parameters used (1991-2008)																			
	1991*	1992*	1993*	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Assessment Age Range	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+
Fbar Age Range	3-8	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7
Assessment Method	LS/Trad VPA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA
Tuning Fleets :																			
UK trawl yrs	76-90	76-91	76-92	84-93	84-94	86-95	87-96	88-97	88-98	88-99	88-00	88-01	88-02	88-03	88-04	88-05	88-06	88-07	88-08
Ages	1-9	1-9	1-9	2-9	2-9	2-9	2-9	2-9	2-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9
UK trawl (historic) yrs														76-87	76-87	76-87	76-87	76-87	76-87
Ages														2-9	2-9	2-9	2-9	2-9	2-9
UK beam yrs	78-90	78-91	78-92	84-93	84-94	86-95	87-96	89-97	89-98	89-99	89-00	89-01	89-02	89-03	89-04	89-05	89-06	89-07	89-08
Ages	1-9	1-9	1-9	2-9	2-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9
UK b/trawl survey yrs		86-91	86-92	86-93	86-94	86-95	87-96	88-97	86-98	86-99	86-00	86-01	86-02	86-03	86-04	86-05	86-06	86-07	86-08
Ages		1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-8	1-8	1-8
UK FSP survey yrs																	03-06	03-07	03-07
Ages																	1-8	1-8	1-8
Time taper		20yr tri	20yr tri	20yr tri	20yr tri	None	None	None	None	None	None	None	None	None	None	None	None	None	None
Power model ages		1	1	1	1-3	1-3	1-3	0	1	1-5	1-5	1-5	1-5	0	0	0	0	0	0
P shrinkage		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Q plateau age		8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
F shrinkage S.E		0.3	0.3	0.3	0.8	1.5	1.5	1.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Num yrs		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Num ages		5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Fleet S.E.		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

* Early version of XSA/VPA and tuning fleet age/year ranges used not specified. Assumed all years used but age range

Appendix A: Beam trawl surveys of the western English Channel (ICES Division VIIe)

1. History of the survey

Complaints from the fishing industry in the southwest about the lack of scientific investigation and knowledge of the local sole stock provided the catalyst for the survey in VIIe. Following enquiries of the local fishery officers and normal tendering procedures, a skipper-owned 300 hp beam trawler, the Bogey 1, was selected. The first year (1984) the survey consisted of a collection of tows on the main sole grounds. In 1989 the Bogey 1 was replaced with the Carhelmar and the survey continued unchanged until 2002 when R.V. Corystes took over the survey as an extension to its 'near-west groundfish survey'.

As a consequence of the changes occurring through the time-series, the surveys completed on R.V. Corystes (2002 onwards) will be described separately to the 'previous' surveys (pre 2002).

2.a. Survey objectives (1984 to 2001, and 2005 onwards)

To provide independent (of commercial) indices of abundance of all age groups of sole and plaice on the west channel grounds, and an index of recruitment of young (1–3 year old) sole prior to full recruitment to the fishery.

2.b. Survey objectives (2002 to 2004)

The primary objectives of the Irish Sea beam trawl survey are to (a) carry out a 4 m beam trawl survey of groundfish to i) obtain fisheries independent data on the distribution and abundance of commercial flatfish species, and ii) derive age compositions of sole and plaice for use in the assessment of stock size; and (b) to collect biological data, including maturity and weight-at-age, for sole, plaice, lemon sole and other commercially important species. The epibenthic bycatch from these catches has been quantified, and these surveys are also used to collect biological samples in support of other CEFAS projects and training courses.

3.a. Survey methods (1984 to 2001, and 2005 onwards)

For the years 1984–1988 the vessel was unchanged and was equipped with two 6 m chain mat beam trawls with 75 mm codends. For the survey hauls one of the codends was fitted with a 60 mm liner. In 1989 the Bogey 1 was replaced by the latest design 24 m 300 hp (220 kw) beam trawler Carhelmar. In 1988 two commercial chain mat 4 m beam trawls (measured inside the shoe plates) were purchased by MAFF as dedicated survey gear. Both beams were fitted with the standard flip-up ropes and 75 mm codend. For years 1989 and 1990 only 1 codend was fished with a 40 mm liner but from 1991 with the introduction of 80 mm codends both were fitted with 40 mm liners. The vessel and gear has remained unchanged since 1991.

Between 1989 and 2001 the survey remained relatively unchanged apart from small adjustments to the position of individual hauls to provide an improved spacing. In 1995 two inshore tows in shallow water (8–15 m) were introduced. The survey now consists of 58 tows of 30 minutes duration, with a towing speed of 4 knots in an area within 35 miles radius of Start Point. The survey design is stratified by 'distance from the coast' bands, in contrast to the VIIa, f and g survey that is stratified by depth bands. The reason for this is that the coastal shelf with a depth of water less than 40 m is relatively narrow and in addition is often fished with fixed gear. The survey bands (in miles) are 0–3, 3–6, 6–12, 12+ inshore, and 12+ offshore.

3.b. Survey methods (2002 to 2004)

The standard gear used is a single 4 m beam trawl with chain mat, flip up rope, and a 40 mm codend liner to retain small fish. The gear is towed at 4 knots (over the ground) for 30 minutes, averaging 2 nautical miles per tow. Fishing is only carried out in daylight, shooting after sunrise and hauling no later than sunset, as the distribution of some species is known to vary diurnally.

Once on board the catch is sorted to species level, with the exception of small gobies and sandeels, which are identified to genus. Plaice, sole, dab, and elasmobranchs are sorted by sex, all fish categories weighed, and total lengths are measured to the full centimetre below, or half centimetre if the species is pelagic. Area stratified samples of selected species are sampled for weight, length, sex, maturity, and otoliths or scales removed for ageing.

The standard grid of 58 stations was fished in 2002 and 2003 (see map), and although other stations have been fished in this period, they were for exploratory purposes and were not included in the assessment.

4. Abundance index calculation

Plaice and sole abundance indices are calculated by allocating the appropriate ages to the fish that are caught. This gives the age composition (AC) of the catch, and this is used in the appropriate working group analysis.

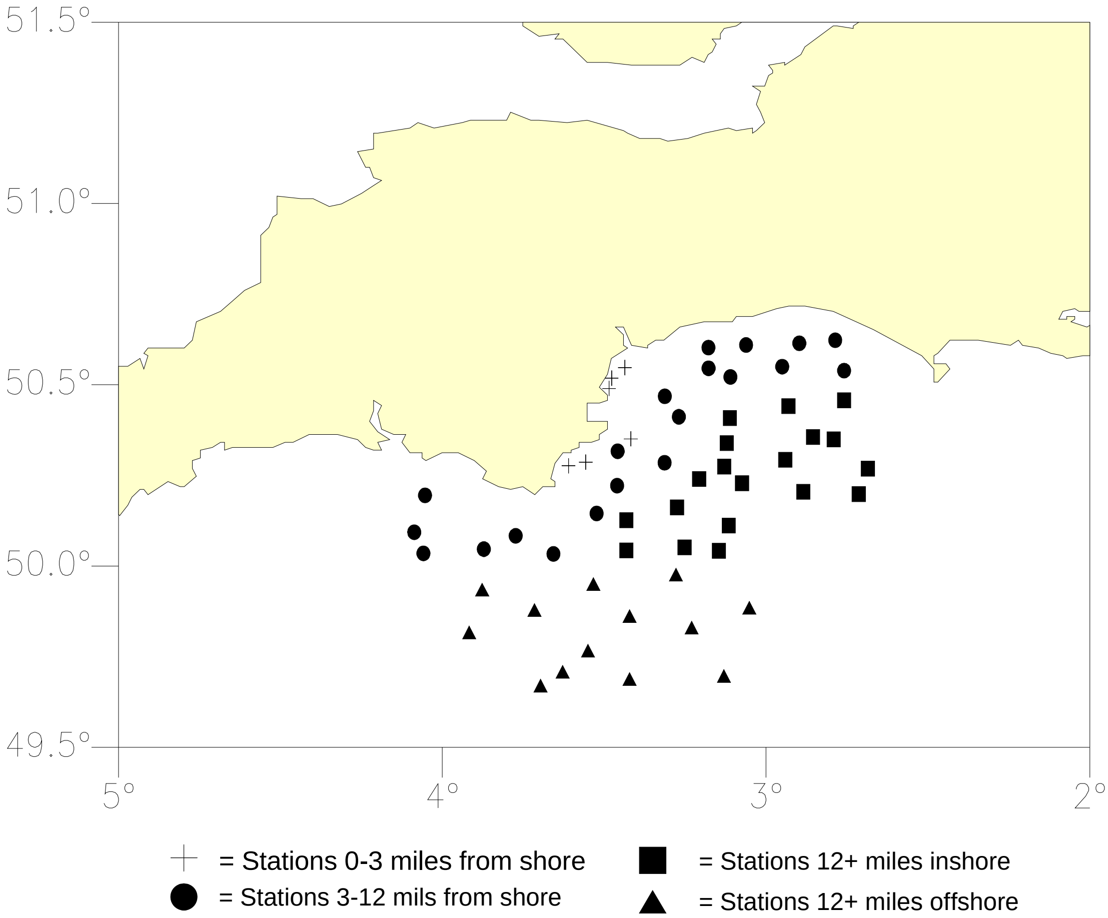
The AC's are calculated by proportioning a length distribution (LD) to an appropriate age–length key (ALK). To account for possible population differences within ICES Division VIIe, biological samples are taken from sectors stratified by distance from shore (see map). The survey bands (in miles) are 0–3, 3–12, 12+ inshore, and 12+ offshore. Where appropriate the ALK's are separated by sex, and this allows a particular 'sector, depth-band and sex' ALK to be raised to the corresponding LD to give an accurate AC for that particular habitat. The AC's can then be combined as required to give results in the form of 'numbers-at-age, per distance or time'.

Between 1984 and 1990 a total survey age–length key was applied to the 'grid' length distribution, but from 1990 onwards stratum stratified age–length keys were used.

The Table below demonstrates the stratifications currently used to calculate the 'near-west groundfish survey' abundance indices

5. Map of survey grid

Additional stations have been fished throughout the time period, but as these stations are not consistently fished, they are excluded from this map.



6. Summary

Area covered	ICES Division VIIe
Target species	Flatfish, particularly prerecruit plaice and sole
Time period	September-October. 1988 to present.
Gear used	1984–1988 – 2 * 6m beam trawls
	1989–2001 – 2 * 4m beam trawls
	– 1* 4m beam trawl
	2005–Present – 2 * 4m beam trawls
Mean towing speed	4 knots over the ground
Tow duration	30 minutes
Vessel used	1984–1988 - F.V. Bogey 1
	1989–2001 - F.V. Carhelmar
	2002–2004 - R.V. Corystes
	2005–Present - F.V. Carhelmar

Annex 8.3: Stock Annex: Sole in Division VIIe

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Sole in Division VIIe (Western Channel)
Date:	19/02/2009
Revised by	Sven Kupschus (WKFLAT)

A. General

A.1. Stock definition

The management area for this stock is strictly that for Area VIIe. Biologically speaking however the picture is much less clear. Sole in general are relatively sedentary, once settled they perform a seasonal inshore offshore movements during their spawning migration with a random longshore component. Therefore the management unit of the stock is well defined for mature fish. There is good evidence to suggest that the stock is split into two biological stocks on either side of the Hurd Deep. If this prevents complete mixing of the stock it an assessment methodology capable of taking account of this should be applied. This could explain differences in the trends representative of stock dynamics in the different fisheries. The two main fisheries on the UK coast around Lyme Bay and the Start as well as the fishery on the coast in the eastern part of the management area are clearly separated by the deeper waters of the channel, so that the fishery covers only about half of the management area so that incomplete mixing may be a problem in this stock.

The source of recruitment to the stock is not clear either as little is known about spawning and nursery grounds in the management area. Additionally, tagging information suggests that during years of strong sole recruitment in area VIIfandg some juveniles may migrate to VIIe. The stock boundary to VIId is also likely to be poorly defined as it represents no natural boundary to sole movement. During periods of strong recruitment in VIId a substantial portion of the VIId recruits (up to 30%) may move into VIIe where their impact will be felt very strongly as a consequence of the much smaller stock size in the latter region. The ingress of juveniles from other areas may explain the lack of a suitable stock–recruitment relationship for this stock.

The assessment method used until 2008 does not deal with uncertainty about stock boundaries.

A.2. Fishery

The principal gears used for sole in the Western Channel are otter- and beam trawls, for the UK fleet and entangling nets and otter trawls for the French fleet. In recent years, UK vessels have accounted for around three quarters of the total international landings, with France taking approximately a quarter and Belgian vessels the remainder. UK landings were low and stable between 1950 and the mid-1970s, but increased rapidly after 1978 as a consequence of the replacement of otter trawlers by beam trawlers. Because the UK fleet is the major component of the international landings, they follow a similar trend. Sole is the target species of an offshore beam trawl fleet, which is concentrated off the south Devon and Cornish coasts, and also catches plaice and anglerfish. In recent years a winter fishery targeting cuttlefish has developed for the English beam trawl fleet in the Western Channel, lasting from November to the end of March. This has taken some of the reliance of the fleet away from sole, but sole still represents a substantial portion of the catch during this time so it is not clear to what degree the switch to cuttle-fishing has reduced fishing mortality on sole.

Discarding of sole in this fishery is thought to be minor, supported by the time-series (2002–2008) of discard information for the UK fleet shown in Figure A.2.1. Landings of sole reached a high level above 1400 t in the 1980s, boosted initially by high recruitment in the late 1970s, followed by an increase in exploitation. Landings declined between 1988 and 1991, following the recruitment of 3 below-average year classes (1986–1988); since 1991 they have fluctuated between 800 t and 1100 t. Substantial quantities of sole caught in VIIe have been reported to two rectangles in VIId in order to avoid quota restrictions. Corrections for this misreporting were first made during the 2002 WG, but misreporting to other areas has been more difficult to identify. In addition, black landings are likely to have occurred to various degrees since quotas became restrictive in the late 1980s. No estimates of the scale of the problem exist so that this uncertainty has not been incorporated into the assessment process.

A.3. Ecosystem aspects

Little is known with regards of the effect of the environment on the stock dynamics of VIIe sole. Certainly the division is on the convergence between the Celtic Sea proper and the Channel/North Sea ecosystem. If predicted increases in temperature were to materialize changes to the stock dynamics of this and other species in the Division would be expected. To date there is good evidence of a sizeable increase in the abundance of bass in the area, a species with a similar pan European distribution as sole. In addition there is some anecdotal evidence of changes in the range of some species such as langoustine, triggerfish, and black sea bream from warmer parts of the Atlantic. In the North Sea it has also been suggested that cold periods immediately prior to spawning have a tendency to increase year-class strength and there is some indication of this for this stock, but no statistical analysis has been carried out to date.

Beam trawling is known to have a significant impact on the seabed. It is understood though that those areas affected continue to be productive in terms of the target species. After the initial degradation of the habitat usually associated with the loss of sessile macro fauna, continued use of beam trawls seems to have few further impacts.

B. Data

B.1. Commercial catch

UK (>60%) and France (>30%) together provide almost all the catches for this stock. UK Landings data are based on EU logbook data for 7e catches. In 2002 the UK industry indicated that there had been substantial misreporting of landings to two rectangles in Area VIId. It was possible to identify the misreported landings spatially and by reported lpue. Having identified misreported landings, data were corrected back to 1985 by the 2002 WG. This method of correction is ongoing. French official landings statistics have been poor since 1997, but since 1997 landings data have been calculated much more accurately using buyer and sellers notes. France has provided corrected landings information to the Working Group since 2002.

Numbers-at-age prior to 1994 are calculated by raising the UK age composition to UK and Channel Island Catches, adding the French age composition data, and finally raising the resulting age composition to the total international landings. From 1995 WG to 2005 WG the International landings for the stock were based entirely on

English quarterly sampling effort then raised to quarterly international landings. Since 2006 WG French age data from 2003 onwards have been included.

Numbers-at-age 1 in the catch are low or zero in most years and most likely reflect variation in the sampling, rather than variation in the stock itself. Therefore, these were not considered to add useful information and are replaced by zeros.

Table A demonstrates the history of the derivation of catch numbers-at-age.

B.2. Biological

Weights-at-age

Total international catch and stock weights-at-age for each years catch data are calculated as the weighted mean of the annual weight-at-age data (weighted by catch numbers), and smoothed in-year using a quadratic fit so that:

$$Wt = a + b^*Age + c^* Age^2$$

where catch weights-at-age are mid-year values, and stock weights-at-age are 1 January values. Following the estimation of the weights-at-age catch-numbers are adjusted to so that the sum of products of the weights and catches sum to the estimated Landings (SOP correction). Catch numbers-at-age 1 are replaced by zeros, but the catch weights-at-age 1 were retained because they are part of the smoothing procedure and do not affect the assessment. They are also essential if a medium-term forecast is performed.

A smoother is applied to sampled catch weights-at-age to adjust for variation in the weight-at-age that may result from low levels of sampling rather than differences in growth rate between cohorts. It also allows estimation of the stock weights-at-age by extrapolation of the curve rather than by using quarter 1 samples, which may be sparse. However this smoother is applied through the plus group and the age range in the plus group is such that this will tend to overestimate the weights at the younger ages. This needs to be corrected as soon as possible.

Natural mortality and maturity-at-age

Natural mortality is assumed constant over ages and years at 0.1. This is consistent with the natural mortality estimates used for sole by other ICES working groups (WGNSSK: IV, VIId, WGNSDS: VIIa, WGSSDS: VIIfg, VIIIa,b) and consistent with estimates of M reported in Horwood, 1993 for VIIfg sole as well as other stocks and papers cited therein.

Assessments prior to 1997 had use knife edge maturity-at-age 3. This was changed in 1997 to a maturity ogive from area VIIfandg according to Pawson and Harley (WD presented to WGSSDS in 1997), which is applied in all years, 1969 to present, since the 1997 WG.

AGE	1	2	3	4	5	6,7, ...12+
Prop. Mature	0.00	0.14	0.45	0.88	0.98	1.00

Proportions of F and M before spawning are both set to zero to reflect the SSB calculation date of 1 January.

B.3. Surveys

Currently the only available survey for this stock is the Western Channel Beam trawl Survey conducted by the UK in late September, early October (UK-BTS). The survey covers a relatively small area of VIIe from Start Point through to the middle of Lyme Bay and out to the edges of the Hurd Deep covering the immediate area of fishing for the Brixham and Plymouth fleets. Sampling started originally in 1984 on the chartered commercial fishing vessel 'Bogey One', replaced in 1988 by the 'Carhelmar' and moved to the research vessel 'Corystes' in 2002 to 2004. Concerns were raised regarding differences in catchability between the Carhelmar and Corystes, and in 2003 the survey was carried out on both vessels. The results of the comparison convinced Cefas to return the survey to the long-serving Carhelmar and to replace the 2003 data with the data from the comparison trials in order to improve consistency. Consequently, the time-series has been largely recovered, with only 2002 and 2004 data coming from the RV Corystes.

The survey cpue demonstrates a decline from 1986 to 1995 in line with the commercial data, after which SSB seems to have largely stabilized at lower levels. The abundance indices at-ages 1 and 2 demonstrate little overall trend, but ages 3 to 6 indicate a decline over the middle part of the series, despite intermittent peaks and troughs. The 1989 year class is indicated to be strong at all ages and this year class can also be traced through the catch-at-age matrix. More recently the 1998 year class can be tracked reasonably consistently.

Appendix 1 provides a history of the survey and details the survey methodology and objectives.

B.4. Commercial cpue

In the early part of the 20th century the fishery for VIIe sole was largely prosecuted by otter trawlers and inshore netters. During the mid to late 1970s landings sharply increased with a considerable increase in nominal effort as the beam trawl fleet developed. Otter trawl effort declined with levels in 2002 being about half that of effort found in the late seventies. Beam trawl effort in hours fished has continued to rise since 1988, but at a slower rate than previously as a consequence of licensing and quota restrictions, but boat size and power as well as beam sizes have also increased suggesting that the effective effort has continued to rise more sharply than suggested by the effort data alone.

Lpue has declined since the late eighties in both the otter and beam trawl fleets suggesting a marked decline in the SSB of this stock. Interestingly the catch-at-age information for these fleets does not suggest a marked decline in the age structure over this time suggesting the decline may be associated with environmental impacts rather than fishing, but given the uncertainty in current landings data, it is difficult to distinguish between the potential causes of the discrepancy between the lpue and catch-at-age data. Little information is currently available regarding the development of the French fishery on this stock on the southern side of the Channel.

The UK beam trawl fleet in recent years has been landing large quantities of cuttlefish during winter. Investigations of the landings data indicated that misreporting was particularly high during the period of the cuttlefish fishery indicating that lpue was unlikely to be substantially lower than during the remainder of the year, justifying the inclusion of all trips in the lpue time-series. Similarly, there was no indication of differences in lpue for those trips split between divisions (misreporting to VIId) so that trips reporting to VIIe as well as those reporting to the two adjacent rectangles in VIId were included in the derivation of the tuning fleets.

UK beam trawl effort has climbed markedly since 1992. Otter trawl effort has stabilized following its decline during the 1980s and early 1990s.

For the purpose of the lpue tuning effort used in the assessment until 2008 a subset (vessels greater than 13.27 m) of the boats operating in VIIe is taken and their combined landings over the period are used to calculate lpue. The commensurate effort figure in kWh for their effort is used for each individual landing. The relationship between the kWh and the landings is then used to determine the relationship between lpue and power, and a correction made to effort values for changes in the fleet composition. A map of the areas corresponding to the lpue series exploring spatial changes in the distribution of effort is shown in Figure B4.1. The latter procedure is now very dated and should be look at with some urgency, as it may be contributing to the retrospective pattern.

For the calculation of lpue, landings misreported to VIId (see catch data section) are corrected in the same manner as the catch data. No corrections are made to the effort statistics, as the time spent in VIId for the purposes of misreporting has been negligible.

B.5. Other relevant data

None.

C. Historical stock development

WKFLAT 2009 concluded that at the present time it is not possible to perform a quantitative assessment on the stock that could be seen to be representative of recent trends in F and SSB. Therefore no assessment, short-term forecast or sensitivity analysis can be performed. Some suitable information is available from the survey (Appendix 1) that could be used for management until such time that a suitable assessment model can be developed.

Although this stock has been exploited historically for a long time at low levels, official landing statistics and catch-at-age data are available from 1969 onwards. At this time landings were 353 t mainly attributable to otter trawlers and netters. The development of a beam trawl fleet in UK waters lead to rapid increases in landings from the stock in the late 1970s which resulted in a commensurate decline in SSB after an initial increase in stock size to its maximum in 1980 as a consequence of particularly good recruitment in 1976. The decline as assessed by XSA occurred despite subsequent good recruitment in 1980, 1984, 1986 and 1990 leading to an apparently depressed recruitment period since 1991. It is unclear whether this reduction in recruitment is linked to the decline in SSB, environmental effects, or is an artefact of the misreporting of landings as a consequence of the TAC constraints introduced in 1987, and becoming restrictive in 1989.

Key uncertainties with regards to the data quality/assessment quality of this stock are the uncertainty regarding the degree of mixing between this and adjacent stock, particularly with regards to recruitments, the fact that the survey covers only a small portion of the stock the lack of a discernible stock–recruit relationship which does not allow us to determine reference points with any certainty.

Table B demonstrates the history of VIIe sole assessments and details the assessment model used (XSA) and the parameters and settings used in each year's assessment until 2008.

D. Short-term projection

In lieu of an assessment no short-term prediction is carried out.

E. Medium-term projections

Not applicable for the time being.

F. Long-term projections

Not applicable for the time being.

G. Biological reference points

Biological reference points in this stock were originally set in 1998 as described in the Table below along with the reasoning and amended in 2001 to take account of a change to the assessment methodology.

	WG(1998)/ACFM(1998)	SINCE WG(2001)/ACFM (2001)
		Age range extended from 1–10+ to 1–12+
$\mathbf{F}_{lim}$	0.36 ($\mathbf{F}_{loss}$ WG98)	0.28 ($\mathbf{F}_{loss}$ WG01)
$\mathbf{F}_{pa}$	0.26 ($\mathbf{F}_{lim}$*0.72)	0.20 ($\mathbf{F}_{lim}$*0.72)
$\mathbf{B}_{lim}$	1800 t ($\mathbf{B}_{loss}$= B_{73} WG98)	2000 t ($\mathbf{B}_{loss}$= B_{00} WG01)
$\mathbf{B}_{pa}$	2500 t ($\mathbf{B}_{lim}$*1.4)	2800 t (Historical development)

The assessment methodology that formed the basis for these precautionary reference points is rejected by WKFLAT and these reference points are therefore no longer considered appropriate. The reference point table will therefore be updated as follows:

	Type	**Value**	**Technical basis**
Precautionary approach	B_{lim}	Undefined	
	B_{pa}	Undefined	
	F_{lim}	Undefined	
	F_{pa}	Undefined	
Targets	F_{mgt}	0.27	EC Multi-annual plan.

(unchanged since 2009)

Once a new assessment methodology has been accepted its implications on reference points will need to be evaluated.

H. Other issues

A management plan was agreed for VIIe sole in 2007:

Council Regulation (EC) No 509/2007 establishes a multi-annual plan for the sustainable exploitation of VIIe sole. Years 2007–2009 are deemed a recovery plan, with subsequent years being deemed management plan. For 2008 the TAC is required to be at a value whose application will result in a 20% reduction in F compared with F_{bar} (03–05). If this value exceeds a 15% change in TAC, a 15% change in TAC shall be implemented.

I. References

Horwood, J. 1993. The Bristol channel sole (*Solea solea* (L.)): a fisheries case study. Advances in marine biology. 1993, vol. 29, pp. 215–367.

Pawson, M.G and Harley, B.F.M. 1997. (unpubl.: Cefas internal report).

WKFLAT 2009.

Table A. VIIe Sole. Catch derivation table for assessment years 1981–2007.

		Source			
Year of WG	Data	UK	France	Derivation of international landings	% sampled
1981	length composition	quarterly	quarterly	UK ALKs applied to French LDs	95
	ALK	quarterly	-	UK+France raised to total international	
	Age composition	quarterly	-		
1982		As for 1981	As for 1981	As for 1981	99
1983		As for 1981	As for 1981	As for 1981	92
1984		As for 1981	As for 1981	As for 1981	96
1985		As for 1981	As for 1981	As for 1981	96
1986		As for 1981	As for 1981	As for 1981	96
1987	length composition	quarterly	quarterly	UK+France raised to total international	95
	ALK	quarterly	quarterly		
	Age composition	quarterly	quarterly		
1988		As for 1987	As for 1987	As for 1987	96
1989		As for 1987	As for 1987	As for 1987	95
1990		As for 1987	As for 1987	As for 1987	94
1991		As for 1987	As for 1987	As for 1987	96
1992		As for 1987	As for 1987	As for 1987	97
1993		As for 1987	As for 1987	As for 1987	94
1994	length composition	quarterly	quarterly	UK ALKs applied to French LDs	92
	ALK	quarterly	-	UK+France raised to total international	
	Age composition	quarterly	-		
1995	length composition	quarterly	-	UK raised to total international	81
	ALK	quarterly	-		
	Age composition	quarterly	-		
1996		As for 1995	-	As for 1995	78
1997		As for 1995	-	As for 1995	73

		SOURCE			
YEAR OF WG	DATA	UK	FRANCE	DERIVATION OF INTERNATIONAL LANDINGS	% SAMPLED
1998		As for 1995	-	As for 1995	64
1999		As for 1995	-	As for 1995	57
2000		As for 1995	-	As for 1995	56
2001		As for 1995	-	As for 1995	59
2002		As for 1995	-	As for 1995	60
2003	length composition	As for 1995	quarterly	UK and French raised to total international	~95%
	ALK	As for 1995	biannually		~95%
2004		As for 1995	As for 2003	As for 2003	~95%
2005		As for 1995	As for 2003	As for 2003	~95%
2006		As for 1995	As for 2003	As for 2003	~95%
2007		As for 1995	As for 2003	As for 2003	~95%
2008		As for 1995	As for 2003	As for 2003	~95%

Table B. History of VIIe sole assessments.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Assmnt Age Range	1-9+	1-9+	1-9+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-12+	1-12+	1-12+	1-12+	1-12+	1-12+	1-12+	1-12+
Fbar Age Range	F(3-8)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)
Assmnt Method	L.S.	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA
Tuning Fleets																		
UK Inshore beam	1983-92	1973-92	1973-92	1973-93	1973-93	1986-95	1987-96	1983-97	1984-98	1986-99	1986-00			1973-87	1973-87	1973-87	1973-87	1973-87
Ages	2-9	2-9	2-9	2-9	2-9	2-9	2-9	2-9	2-9	2-9	2-11			2-11	2-11	2-11	2-11	2-11
UK Offshore beam	1983-92	1973-92	1973-92	1973-93	1973-93	1986-95	1987-96	1983-97	1984-98	1986-99	1986-00			1973-87	1973-87	1973-87	1973-87	1973-87
Ages	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-11			3-11	3-11	3-11	3-11	3-11
UK < 24m beamtr Ages												1989-01 2-11						
UK > 24m beamtr Ages												1988-01 2-11						
UK combined beam													1988-02	1988-03	1988-04	1988-05	1988-06	1988-07
Ages													3-11	3-11	3-11	3-11	3-11	3-11
UK otter trawl												1988-01	1988-02	1988-03	1988-04	1988-05	1988-06	1988-07
Ages												3-11	3-11	3-11	3-11	3-11	3-11	3-11
UK BTS yrs		1984-91	1984-92	1984-93	1984-94	1986-95	1987-96	1983-97	1984-98	1984-99	1984-00	1984-01	1988-02	1988-03	1988-04	1988-05	1984-06	1988-07
Ages		2-6	2-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-9	1-9	1-9	1-9	1-9
Time taper		20yr tri	20yr tri	20yr tri	20yr tri	No	No	No	No	No	No	No	No	No	No	No	No	No
Power model ages		1	1-2	1-4	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	No	No	No	No
P shrinkage		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q plateau age		8	5	6	7	7	7	7	7	7	9	9	9	9	9	8	8	8
F shrinkage S.E		0.3	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
Num yrs		5	5	5	5	5	5	5	5	5	5	5	5	5	3	4	5	5
Num ages		5	3	5	3	3	3	3	3	3	5	5	5	5	5	5	5	5
Fleet S.E.		0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.5	0.5	0.5

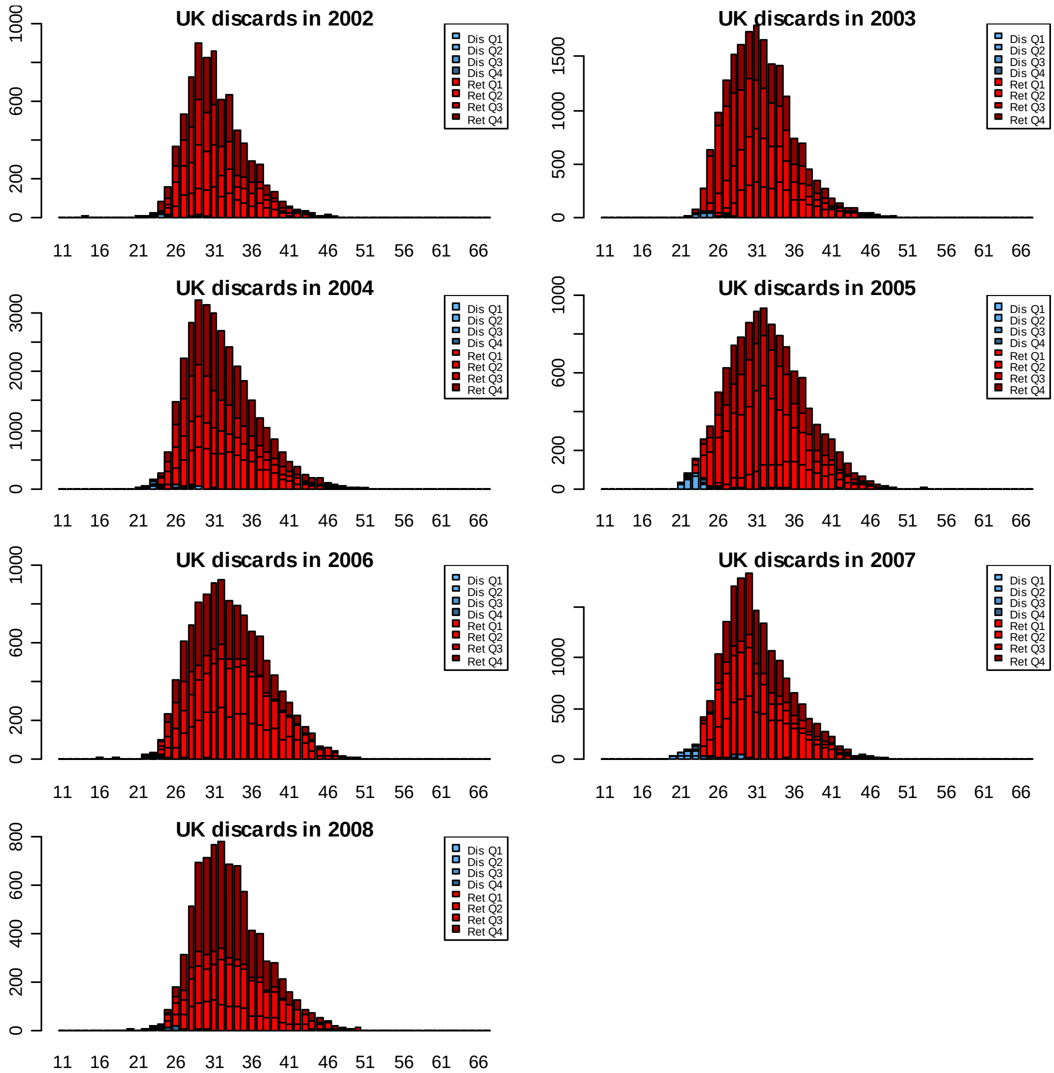


Figure A2.1. Time-series of UK discard data raised to trip information.

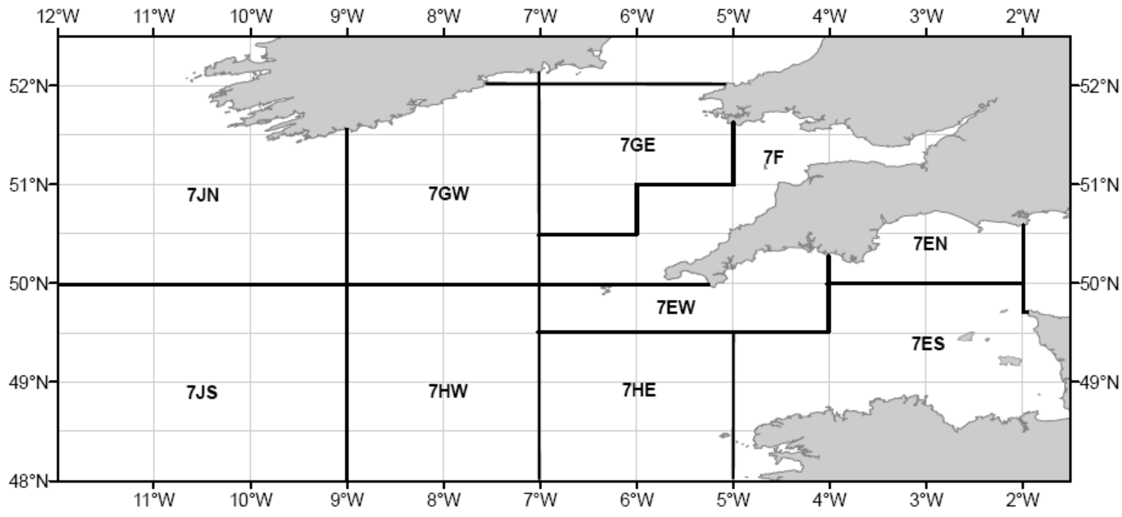


Figure B4.1. Areas used for the calculation of lpue time-series exploring temporal chages in the distribution of stock and effort.

Appendix 1: Beam trawl surveys of the western English Channel (ICES Division VIIe)

1. History of the survey

Complaints from the fishing industry in the southwest about the lack of scientific investigation and knowledge of the local sole stock provided the catalyst for the survey in VIIe. Following enquiries of the local fishery officers and normal tendering procedures, a skipper-owned 300 hp beam trawler, the Bogey 1, was selected. The first year (1984) the survey consisted of a collection of tows on the main sole grounds. In 1989 the Bogey 1 was replaced with the Carhelmar and the survey continued unchanged until 2002 when R.V. Corystes took over the survey as an extension to its 'near-west groundfish survey'.

As a consequence of the changes occurring through the time-series, the surveys completed on R.V. Corystes (2002 onwards) will be described separately to the 'previous' surveys (pre 2002).

2.a. Survey objectives (1984 to 2001)

To provide independent (of commercial) indices of abundance of all age groups of sole and plaice on the west channel grounds, and an index of recruitment of young (1–3 year old) sole prior to full recruitment to the fishery.

2.b. Survey objectives (2002 to present)

The primary objectives of the Irish Sea beam trawl survey are to (a) carry out a 4 m beam trawl survey of groundfish to i) obtain fisheries independent data on the distribution and abundance of commercial flatfish species, and ii) derive age compositions of sole and plaice for use in the assessment of stock size; and (b) to collect biological data, including maturity and weight-at-age, for sole, plaice, lemon sole and other commercially important species. The epibenthic bycatch from these catches has been quantified, and these surveys are also used to collect biological samples in support of other CEFAS projects and training courses.

3.a. Survey methods (1984 to 2001)

For the years 1984–1988 the vessel was unchanged and was equipped with two 6 m chain mat beam trawls with 75 mm codends. For the survey hauls one of the codends was fitted with a 60 mm liner. In 1989 the Bogey 1 was replaced by the latest design 24 m 300 hp (220 kw) beam trawler Carhelmar. In 1988 two commercial chain mat 4 m beam trawls (measured inside the shoe plates) were purchased by MAFF as dedicated survey gear. Both beams were fitted with the standard flip-up ropes and 75 mm codend. For years 1989 and 1990 only 1 codend was fished with a 40 mm liner but from 1991 with the introduction of 80 mm codends both were fitted with 40 mm liners. The vessel and gear has remained unchanged since 1991.

Between 1989 and 2001 the survey remained relatively unchanged apart from small adjustments to the position of individual hauls to provide an improved spacing. In 1995 two inshore tows in shallow water (8–15 m) were introduced. The survey now consists of 58 tows of 30 minutes duration, with a towing speed of 4 knots in an area within 35 miles radius of Start Point. The survey design is stratified by 'distance from the coast' bands, in contrast to the VIIa,f+g survey that is stratified by depth bands. The reason for this is that the coastal shelf with a depth of water less than 40 m is relatively narrow and in addition is often fished with fixed gear. The survey bands (in miles) are 0–3, 3–6, 6–12, 12+ inshore, and 12+ offshore.

3.b. Survey methods (2002 to present)

The standard gear used is a single 4 m beam trawl with chain mat, flip up rope, and a 40 mm codend liner to retain small fish. The gear is towed at 4 knots (over the ground) for 30 minutes, averaging 2 nautical miles per tow. Fishing is only carried out in daylight, shooting after sunrise and hauling no later than sunset, as the distribution of some species is known to vary diurnally.

Once on board the catch is sorted to species level, with the exception of small gobies and sandeels, which are identified to genus. Plaice, sole, dab, and elasmobranchs are sorted by sex, all fish categories weighed, and total lengths are measured to the full centimetre below, or half centimetre if the species is pelagic. Area stratified samples of selected species are sampled for weight, length, sex, maturity, and otoliths or scales removed for ageing.

The standard grid of 58 stations was fished in 2002 and 2003 (see map), and although other stations have been fished in this period, they were for exploratory purposes and were not included in the assessment.

4. Abundance index calculation

Plaice and sole abundance indices are calculated by allocating the appropriate ages to the fish that are caught. This gives the age composition (AC) of the catch, and this is used in the appropriate working group analysis.

The AC's are calculated by proportioning a length distribution (LD) to an appropriate age–length key (ALK). To account for possible population differences within ICES Division VIIe, biological samples are taken from sectors stratified by distance from shore (see map). The survey bands (in miles) are 0–3, 3–12, 12+ inshore, and 12+ offshore. Where appropriate the ALK's are separated by sex, and this allows a particular 'sector, depth-band and sex' ALK to be raised to the corresponding LD to give an accurate AC for that particular habitat. The AC's can then be combined as required to give results in the form of 'numbers-at-age, per distance or time'.

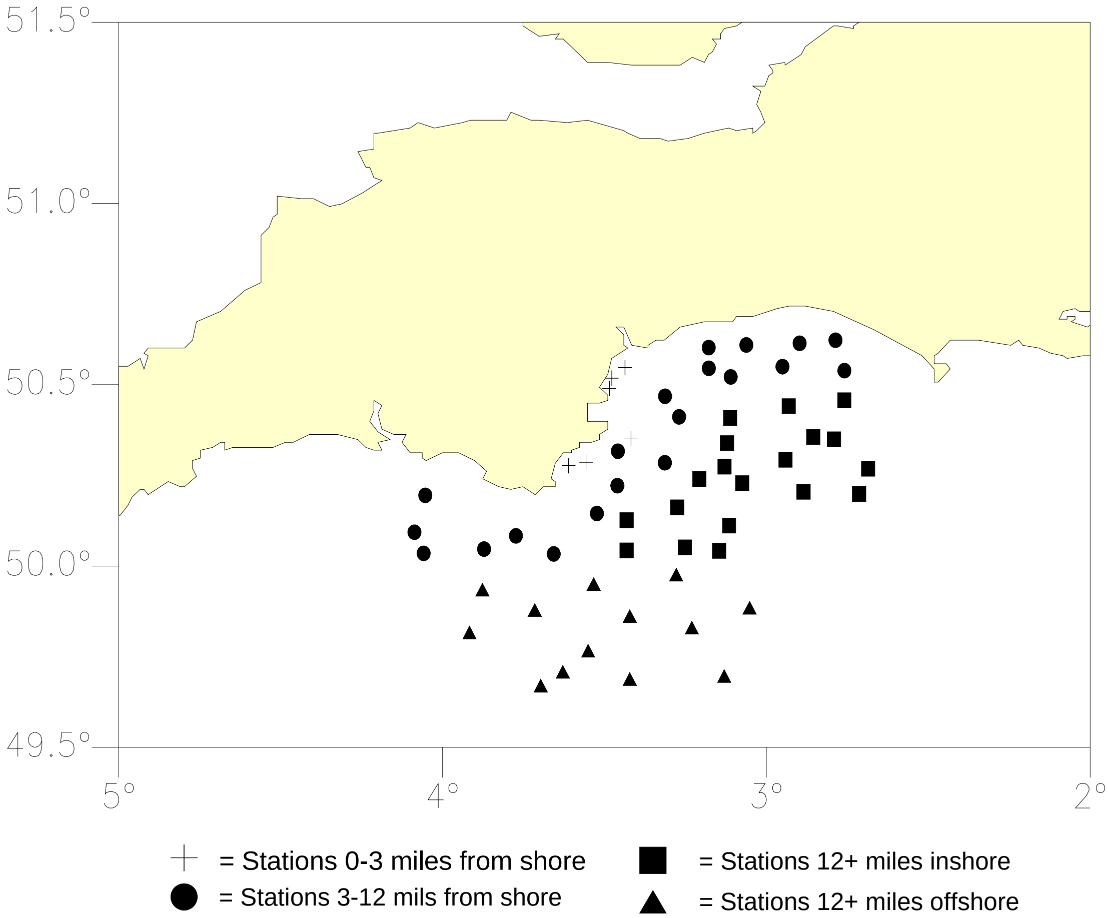
Between 1984 and 1990 a total survey age–length key was applied to the 'grid' length distribution, but from 1990 onwards stratum stratified age–length keys were used.

The Table below demonstrates the stratifications currently used to calculate the 'near-west groundfish survey' abundance indices.

		ALK stratified by			LD stratified by			
Species	Sector	Sector	Depth band	Sex	Sector	Depth band	Sex	Used in assessment?
Plaice	VIIe	✓	✓	✓	✓	✓	✓	✓
Sole	VIIe	✓	✓	X	✓	✓	X	✓

5. Map of survey grid

Additional stations have been fished throughout the time period, but as these stations are not consistently fished, they are excluded from this map.



6. Summary

Area covered	ICES Division VIIe
Target species	Flatfish, particularly prerecruit plaice and sole
Time period	September-October. 1988 to present.
Gear used	1984–1988 – 2 * 6m beam trawls
	1989–present , except 2002,2004 – 2 * 4m beam trawls
	2002, 2004 – 1* 4m beam trawl
Mean towing speed	4 knots over the ground
Tow duration	30 minutes
Vessel used	F.V. Bogey 1 1984–1988
	F.V. Carhelmar 1989–2001, 2003 and 2005 - present
	R.V. Corystes 2002 and 2004