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

26 August - 1 September 2014

ICES Headquarters, Copenhagen, Denmark

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Executive Summary

The Working Group (WG) on Widely Distributed Stocks (WGWIDE) met at ICES HQ in Copenhagen, Denmark, from 26 August to 1 September 2014. The meeting was attended by 31 delegates from Netherlands, Ireland, Spain, Norway, Portugal, Iceland, United Kingdom (England and Scotland), Faroe Islands, Greenland, Denmark, Russia and Germany. Other fisheries scientists participated by correspondence. The WG reports on the status and considerations for management of northeast Atlantic mackerel, blue whiting, western and North Sea horse mackerel, northeast Atlantic boarfish and Norwegian spring spawning herring stocks.

WGWIDE also replied to one special request regarding the short term forecasting of blue whiting stocks.

Northeast-Atlantic (NEA) Mackerel. This species is widely distributed through the ICES area and currently supports one of the most valuable European fisheries. Mackerel is fished by a variety of fleets from many countries (ranging from open boats using hand lines on the Iberian coasts to large freezer trawlers and Refrigerated Sea Water (RSW) vessels in the Northern Area. NEA mackerel assessment was benchmarked in February 2014 (WKPELA). The benchmark was successful in producing a state-space assessment model with three fisheries-independent survey series and tagging data, in addition to the catch-at-age data from ages 0-12 (plus group). After the benchmark, a WGWIDE subgroup run the assessment in April 2014 and update advice for 2013 was released in May 2014.

The benchmark changed the perception of the stock, adjusting the SSB upwards. As a consequence, the long term management plan is now under evaluation. Nevertheless, advising according to the current management plan is considered precautionary, but might not lead to maximizing the long term yield.

Blue whiting. This pelagic gadoid is widely distributed in the eastern part of the North Atlantic. The assessment this year was considered an update. SSB has almost doubled from 2010 (2.9 million tonnes) to 2014 (5.5 million tonnes) and is clearly above precautionary biomass reference point B_{pa} (2.25 million tonnes). This increase is due to historical low fishing mortality since 2011 in combination with a higher recruitment (age 1) since 2010. The uncertainty around the recruitment in the most recent year is high. The year classes 2005-2008 are in the very low end of the historical recruitments, but recruitment since 2009 and 2010 year class are estimated higher. Information on the 2012 and 2013 year classes is uncertain, but the level is confirmed from qualitative analysis of survey indices.

WGWIDE provided a response to a NEAFC request considering the short term forecast used in the blue whiting assessment. As a result of the analyses, WGWIDE decided to switch from stochastic short term forecast to deterministic short term forecast.

Western Horse Mackerel. The WG performed an analytical assessment for western horse mackerel following the benchmark procedure. Year classes following 2001 have been weak, 2010 recruitment in particular is the lowest in the time-series. 2008 year class is estimated as higher than the recent average. Fishing mortality has been increasing since 2007 as a result of increasing catches and decreasing biomass as the 2001 year-class was reduced. In the absence of any notably large recent year classes, SSB is perceived to be declining and SSB in 2013 is estimated as the third lowest in the time-series. The current outlook for the coming years suggests that this decline will continue.

North Sea horse mackerel. Exploratory data analyses were conducted for the North Sea horse mackerel stock. However, these exploratory assessment models are not considered acceptable as a basis for advice. The available data all suggest that the North Sea horse mackerel stock is currently at a low biomass in the North Sea, potentially increasing slightly in the most recent years.

Northeast Atlantic Boarfish. This is a small, pelagic, planktivorous, shoaling species, found at depths of 0 to 600 m. The species is widely distributed from Norway to Senegal. The fishery for boarfish in the NEA is a new one, and hence landings of boarfish have showed a sharp increase in recent years. An analytical assessment was accepted for this stock last year, but there is high uncertainty in the estimates of total biomass due to the short time-series, and the assessment is still sensitive to the inclusion of data from the acoustic survey given the short time series currently available. Bottom-trawl survey indices are considered indicative of trends in their respective areas. Since 2012 there has been a sharp decline in the estimated total stock biomass of boarfish in the North East Atlantic, and total stock biomass in 2014 is below the proposed $B_{trigger}$ (B_{msy}). Fishing mortality is estimated to have increased from a negligible rate in 2007 to a peak of 0.216 in 2010. The fishing mortality in 2013 was estimated to be 0.134, still under F_{MSY}.

Norwegian spring spawning herring. This is the largest herring stock in the world. It is highly migratory and distributed throughout large parts of the NE Atlantic. The assessment was performed using the assessment tools software TASACS (benchmarked in 2008). Even though F has been decreasing in recent years, in the absence of any strong year classes since 2004, the stock has declined still further in 2014. SSB at the start of 2014 is estimated to be below B_{pa}. This decline is expected to continue in the near future even when fishing according to the management plan, though it is expected that following the management plan will lead to the stock stabilising above B_{lim}.

1 Introduction

1.1 Terms of Reference

2013/2/ACOM15 The **Working Group on Widely Distributed Stocks** (WGWIDE), chaired by Katja Enberg, Norway, will meet in ICES HQ, Denmark, 26 August to 1 September 2014 to:

a) Address generic ToRs for Regional and Species Working Groups (see table below).

The assessments will be carried out on the basis of the stock annex in National Laboratories, prior to the meeting. This will be coordinated as indicated in the table below.

WGWIDE will report by 9 September 2014 for the attention of ACOM.

Fish Stock	Stock Name	Stock Coord.	Assess. Coord. 1	Assess. Coord. 2	Advice
boc-nea	Boarfish in the Northeast Atlantic	Ireland			Update
her-noss	Herring in the Northeast Atlantic (Norwegian spring-spawning herring)	Norway	Norway	Russia	Update
hom-nsea	Horse mackerel (Trachurus trachurus) in Division IIIa, Division IVb,c and VIId (North Sea stock)	Spain	Netherlands	UK (England & Wales)	Multiyear
hom-west	Horse mackerel (Trachurus trachurus) in Divisions IIa, IVa, Vb, VIa,, VIIa-c, e-k, VIIIa-e (Western stock)	Spain	UK (England & Wales)	Netherlands	Update
mac-nea	Mackerel in the Northeast Atlantic (combined Southern, Western and North Sea spawning components)	Ireland	Netherlands	UK (Scotland)	Update
whb-comb	Blue whiting in Subareas I-IX, XII and XIV (Combined stock)	Spain	Denmark	Russia	Update

In addition to these specific requests to WGWIDE the group is also tasked with addressing generic ToRs described below for each of the stocks where appropriate:

a) If no stock annex is available this should be prepared prior to the meeting, based on the previous year advice basis or on the data limited advice basis proposed as the basis for advice this year.

b) Audit the assessments and forecasts carried out for each stock under consideration by the Working Group and write a short report.

c) Propose specific actions to be taken to improve the quality and transmission of the data (including improvements in data collection).

d) Propose indicators of stock size (or of changes in stock size) that could be used to decide when an update assessment is required and suggest threshold % (or absolute) changes that the EG thinks should trigger an update assessment on a stock by stock basis.

e) Consider target categories for stocks in the medium term as proposed and revise as needed

f) Consider ecosystem overviews where available, and propose and possibly implement incorporation of ecosystem drivers in the analytical basis for advice

g) For the ecoregion or fisheries considered by the working group, produce a brief report summarising for the stocks and fisheries where the item is relevant:

   i) Mixed fisheries overview and considerations;

   ii) Species interaction effects and ecosystem drivers;

   iii) Ecosystem effects of fisheries;

   iv) Effects of regulatory changes on the assessment or projections;

h) Prepare planning for benchmarks next year, and put forward proposals for benchmarks of integrated ecosystem, multi or single species for 2015

i) Draft the required elements of the Popular Advice for each stock.

j) In the autumn, where appropriate, check for the need to reopen the advice based on the summer survey information and the guidelines in AGCREFA (2008 report). The relevant groups will report on the AGCREFA 2008 procedure on reopening of the advice before 14 October and will report on reopened advice before 29 October.

For <u>update</u> advice stocks:

k) Produce a first draft of the advice on the fish stocks and fisheries under considerations according to ACOM guidelines and implementing the generic introduction to the ICES advice (Section 1.2). If no change in the advice is needed, one page 'same advice as last year' should be drafted.

l) For each stock , when possible prior to the meeting:

   i) Update, quality check and report relevant data for the stock:

Load fisheries data on effort and catches (landings, discards, bycatch, including estimates of misreporting when appropriate) in the INTERCATCH database by fisheries/fleets, either directly or, when relevant, through the regional database. Data should be provided to the data coordinators at deadlines specified in the ToRs of the individual groups. Data submitted after the deadlines can be incorporated in the assessments at the discretion of the Expert Group chair; Abundance survey results; Environmental drivers.

   ii) Produce an overview of the sampling activities on a national basis based on the INTERCATCH database or, where relevant, the regional database,

   iii) Update the assessment using the method (analytical, forecast or trends indicators) as described in the stock annex.

   iv) Produce a brief report of the work carried out regarding the stock, summarising for the stocks and fisheries where the item is relevant:

      1. Input data (including information from the fishing industry and NGO that is pertinent to the assessments and projections);

      2. Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;

      3. Stock status and catch options for next year;

4. Historical performance of the assessment and brief description of quality issues with the assessment;
5. In cooperation with the Secretariat, update the description of major regulatory changes (technical measures, TACs, effort control and management plans) and comment on the potential effects of such changes including the effects of newly agreed management and recovery plans. Describe the fleets that are involved in the fishery.

m) On basis of the outcomes of WKMSYREF calculate F_{msy} for stocks where the information exists but the calculations have not been done yet, resolve inconsistencies between F_{msy} and MSY $B_{trigger}$/B_{lim} and if possible, fill in the Precautionary Approach reference points where they are missing

For <u>re-examine</u> advice stocks

n) Consider the advice for 2013 and review data and/or method to ascertain if there is reason to update advice for 2014.
   i) Where an update is required, revert to an update procedure
   ii) Where no advice update is required, produce a brief report of the work carried out regarding the stock, indicating why the advice is not updated. A one page, 'same advice as last year' should be drafted.

For stocks with <u>multiyear</u> advice or <u>biennial</u> 2nd year advice

o) In principle, there is no reason to update this advice. The advice should be drafted as a one page version referring to earlier advice. If a change in the advice (basis) is considered to be needed, this should be agreed by the working group on the first meeting day and communicated to the ACOM leadership. Agreement by the ACOM leadership will revert the stock to an <u>update</u> procedure.

1.2 List of participants

WGWIDE 2014 was attended by 31 delegates from Netherlands, Ireland, Spain, Norway, Portugal, Iceland, United Kingdom (England and Scotland), Faroe Islands, Greenland, Denmark, Russia and Germany. Other fisheries scientists participated by correspondence. The full list of participants is in Annex 1.

1.3 Quality and Adequacy of fishery and sampling data

1.3.1 Sampling Data from Commercial Fishery

The working group again carried out a brief review of the sampling data and the level of sampling on the commercial fisheries. Sampling coverage for mackerel is 89%. In comparison to last year the proportion of the horse mackerel catch sampled increased from 68% to 77% but there is still only a limited number of countries providing data. Norwegian spring spawning herring and blue whiting sampling covers 91% and 96% of the total catch, respectively. Following the memorandum of understanding agreement between the EU and ICES boarfish (*Capros aper*) was included into WGWIDE since 2011 and tables on the sampling level for this species are added in this section.

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

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

Mackerel

Year	TOTAL CATCH (wg catch)	% catch covered by sampling programme*	No. samples	No. Measured	No. Aged
1992	760000	85	920	77000	11800
1993	825000	83	890	80411	12922
1994	822000	80	807	72541	13360
1995	755000	85	1008	102383	14481
1996	563600	79	1492	171830	14130
1997	569600	83	1067	138845	16355
1998	666700	80	1252	130011	19371
1999	608928	86	1109	116978	17432
2000	667158	76	1182	122769	15923
2001	677708	83	1419	142517	19824
2002	717882	87	1450	184101	26146
2003	617330	80	1212	148501	19779
2004	611461	79	1380	177812	24173
2005	543486	83	1229	164593	20217
2006	472652	85	1604	183767	23467
2007	579379	87	1267	139789	21791
2008	611063	88	1234	141425	24350
2009	734889	87	1231	139867	28722
2010	869451	91	1241	124695	29462
2011	938819	88	923	97818	22817
2012	892762	89	1216	135610	38365
2013	931732	89	1092	115870	25178

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

Sampling activity in 2013 covered 89% of the working group catch, in line with previous years, despite a reduction in the number of samples. It should be noted that this figure is based on the total sampled catch and thus the largest catching nations that can sample 100% of their catch mask any deficiencies at national level and with more widely dispersed fisheries. This is especially true when a large proportion of the total catch is taken in large, directed fisheries which are relatively straightforward to sample.

Denmark, Iceland, Ireland, Norway, Portugal, Russia, Scotland and Spain all sampled over 95% of their catch. As in previous years, England & Wales sampled a small fraction of their total catch, corresponding to the handline fishery in area VIIe. The freezer trawler fleet operating out of the Netherlands, Germany, England and France is covered by the Dutch and German sampling programs as the fleet is principally Dutch-owned. Individual samples within this fishery consist of only 25 aged fish which can be limiting when only a single sample is available in a particular area and quarter. In particular, there is a lack of sampling activity in the fourth quarter for this fleet. The Dutch program also provided samples for English registered freezer trawlers landing into the Netherlands. Of the remaining countries with significant catches Northern Ireland and Sweden did not provide any sampling information. France conducted length-frequency sampling but no ageing was carried out. Greenland conducted length frequency sampling of commercial catch but could not complete the ageing of the samples in time for the working group. The ALK from the ecosystem survey was used to convert to numbers at age.

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

COUNTRY	OFFICIAL CATCH	% catch covered by sampling programme*	NO. SAMPLES	NO. MEASURED	NO. AGED
Belgium	62	0	0	0	0
Denmark	33218	97	12	1132	1075
Estonia	1367	0	0	0	0
Faroe Islands	143001	79	18	1178	1141
France	14643	0	0	0	0
Germany	20931	68	69	20454	1187
Greenland	52783	99	147	15943	224
Guernsey	9	0	0	0	0
Iceland	151235	99	151	3266	3208
Ireland	56511	100	49	8643	1980
Isle of Man	8	0	0	0	0
Netherlands	21159	28	21	1707	525
Norway	164607	99	154	4483	4456
Portugal	254	100	52	2958	463
Russia	80817	100	73	26806	749
Spain	16414	96	222	13597	6617
Sweden	2906	0	0	0	0
UK (England & Wales)	16542	40	74	9145	2016
UK (Northern Ireland)	12348	0	0	0	0
UK (Scotland)	134909	99	50	6558	1537
Total	923732	89	1092	100427	25178

*** Percentage based on Working Group catch,**

- unknown

The following table describes the mackerel sampling intensity levels in terms of catch in each ICES division. Only areas with relatively minor catches are insufficiently sampled.

AREA	OFF. CATCH	WG CATCH	NO SAMPLES	NO AGED	NO MEAS.	NO AGED/ kT*	NO MEAS/ kT*
IIa	216643	216643	121	2729	28850	13	133
IIb	8	8	0	0	0	0	0
IIIa	650	650	0	0	0	0	0
IIIc	1	1	0	0	0	0	0
IIId	1	1	0	0	0	0	0
IVa	258461	258791	174	6009	10362	23	40
IVb	1346	1346	4	100	427	74	317
IVc	463	466	1	25	101	54	217
Va	129245	129245	136	2713	2766	21	21
Vb	49313	49313	5	434	438	9	9
VIa	131932	132206	81	2253	19625	17	149
VIb	129	129	0	0	0	0	0
VIIa	54	54	0	0	0	0	0
VIIb	18988	19140	14	277	2384	15	126
VIIc	277	409	0	0	0	0	0
VIId	5423	5632	16	492	1473	91	272
VIIe	770	1020	28	862	3269	1119	4245
VIIf	339	339	32	804	3988	2372	11764
VIIg	14	30	0	0	0	0	0
VIIh	164	500	1	25	58	152	354
VIIj	15711	16206	43	705	8964	45	571
VIIIa	2456	2456	1	25	79	10	32
VIIIb	5813	5669	21	708	1171	122	201
VIIIcE	13 449	13 681	169	2 786	10 478	207	779
VIIIcW	1 388	583	26	1 884	3 244	1 357	2 337
VIIId	4	4	0	0	0	0	0
IXaN	372	4 448	26	3 244	1 884	8 720	5 065
IXaCN	257	873	52	463	2 958	1 801	11 510
IXaS	788	1 176	0	0	0	0	0
XIVb	69 141	69 154	159	523	16 243	8	235

*** Based on official catches**

Horse Mackerel

The following table shows a summary of the overall sampling intensity on horse mackerel catches in recent years in all areas 1992-2009 and in the western and North Sea areas for the following years. The Southern horse mackerel is now dealt with by ICES WGHANSA.

Year	TOTAL CATCH (wg catch)	% catch covered by sampling programme*	No. samples	No. Measured	No. Aged
1992	436 500	45	1 803	158447	5797
1993	504190	75	1178	158954	7476
1994	447153	61	1453	134269	6571
1995	580000	48	2041	177803	5885
1996	460200	63	2498	208416	4719
1997	518900	75	2572	247207	6391
1998	399700	62	2539	245220	6416
1999	363033	51	2158	208387	7954
2000	272496	56	1610	186825	5874
2001	283331	64	1502	204400	8117
2002	241336	72	1768	235697	8561
2003	241830	79	1568	200563	12377
2004	216361	68	1672	213066	16218
2005	234876	78	2315	241629	15866
2006	215277	72	1623	231344	12009
2007	187995	62	1321	174897	10749
2008	198085	77	1362	186800	11915
2009	247637	87	1258	92846	13345
2010	224462	78	703	48465	13984
2011	222415	62	502	40964	7604
2012	186432	68	501	41148	8220
2013	179382	77	686	87300	9776

*** Percentage related to Working Group catch**

The large numbers of measured fish 1992—2009 were due to intensive length measurement programs in the southern areas. In 2008, 76% of the horse mackerel measured were from Division IXa.

Countries that usually carried out sampling were Ireland, the Netherlands, Germany, Norway and Spain and they covered 18—97% of their respective catches. In 2013 Germany, Ireland, the Netherlands, Norway, UK (England) and Spain provided samples and age distributions. The lack of sampling data for relatively large portions of the horse mackerel catches continues to have a serious effect on the accuracy and reliability of the assessment and the Working Group remain concerned about the low number of fish that are aged.

The horse mackerel sampling intensity for the Western stock in 2013 was as follows:

COUNTRY	OFFICIAL CATCH	% CATCH SAMPLED*	NO. SAMPLES	NO. MEASURED	NO. AGED
Belgium	14	0	0	0	0
Denmark	6829	0	0	0	0
France	3593	0	0	0	0
Germany	24835	80	99	35034	1340
Ireland	35791	99	50	9581	2021
Netherlands	53697	71	46	7808	1150
Norway	6596	88	17	935	510
Spain	22541	100	426	25599	3355
Sweden	1	0	0	0	0
UK (England)	3959	76	18	3194	450
UK(Northern Ireland)	2325	0	0	0	0
UK(Scotland)	503	0	0	0	0
Total	160686	78	656	82151	8826

*** Percentage based on Working Group catch**

The horse mackerel sampling intensity for the North Sea stock in 2013 was as follows:

COUNTRY	OFFICIAL CATCH	% CATCH SAMPLED*	NO. SAMPLES	NO. MEASURED	NO. AGED
Belgium	51	0	0	0	0
Denmark	1020	0	0	0	0
France	1010	0	0	0	0
Germany	2941	47	2	224	252
Ireland					
Netherlands	8725	86	15	2889	373
Norway	377	0	0	0	0
Spain	4401	100	13	2036	325
UK (England)	172	0	0	0	0
UK(Scotland)	8725	86	15	2889	373
Total	18696 **	71	30	5149	950

*** Percentage based on Working Group catch**

The horse mackerel sampling intensity by division was as follows:

Area	Official Catch	WG Catch	N samples	N aged	N measured	N aged per 1000t	N measured per 1000t
IIa	30	30					
IIIa	19	19					
IIIc	183*	-					
IVa	6720	6720	19	560	1123	83	167
IVb	801	800	3	73	852	91	1065
IVc	677	677					
VIa	43264	43266	42	1435	8500	33	196
VIb	98*	-					
VIIa	1	1					
VIIb	32784	32786	44	1420	11169	43	341
VIIc	4120	4121	2	94	331	23	80
VIId	17202	17202	27	877	4297	51	250
VIIe	17980	17980	31	775	6040	43	336
VIIf	7	7					
VIIg	2	2					
VIIh	10909	10909	10	453	2067	42	189
VIIj	17751	17752	77	609	26672	34	1503
VIIk	129	128	2	50	227	390	1771
VIIIa	3023	3023					
VIIIb	6186	6187	99	420	7052	68	1140
VIIIcE	6326	6324	237	2301	15045	364	2379
VIIIcW	11447	11447	93	709	3925	62	343
VIIId	3	2					
Total	179381	179382	686	9776	87300	1328	9761

*** not used in the assessment as not officially assigned to a stock**

Norwegian Spring Spawning Herring (NSSH)

Year	TOTAL CATCH	% catch covered by sampling programme	No. samples	No. Measured	No. Aged
2000	1207201	86	389	55956	10901
2001	766136	86	442	70005	11234
2002	807795	88	184	39332	5405
2003	789510	71	380	34711	11352
2004	794066	79	503	48784	13169
2005	1003243	86	459	49273	14112
2006	968958	93	631	94574	9862
2007	1266993	94	476	56383	14661
2008	1545656	94	722	81609	31438
2009	1686928	94	663	65536	12265
2010	1457015	91	1258	124071	12377
2011	992.997	95	766	79360	10744
2012	825.999	93	649	59327	14768
2013	684.743	91	402	33169	11431

91% of the total catch was covered by national sampling programmes. The following table gives a summary of the sampling activities of the NSSH catching countries. The sampling coverage by country is between 42 and 100%. No sampling was carried by Scotland, Greenland and Sweden representing together 3 % of the total catch.

COUNTRY	OFFICIAL CATCH	% catch covered by sampling programme	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	17159,85	100%	3	339	153
Faroe Islands	105037,58	71%	9	767	756
Germany	4243,85	55%	4	278	261
Greenland	11787,63	0%	0	0	0
Iceland	90729,00	100%	100	4350	2943
Ireland	3814,76	94%	2	115	80
Netherlands	5625,90	42%	6	418	150
Norway	359458,00	99%	144	6064	5764
Russia	78521,00	98%	134	20838	1324
Scotland	8342,15	0%	0	0	0
Sweden	23,00	0%	0	0	0
Total for Stock	684742,74	91%	402	33169	11431

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

Area	Official Catch	WG Catch	No Samples	No Aged	No Measured	No Aged/ 1000 tonnes*	No Measured/ 1000 tonnes*
IIa	564741	564741	300	8829	26118	16	46
IIb	37690	37690	32	455	3985	12	106
IVa	3403	3403	0	0	0	0	0
Va	45811	45811	69	2097	3016	46	66
Vb	29993	29993	1	50	50	2	2
XIVa	3089	3089	0	0	0	0	0
Total	684743	684743	402	11431	33169	17	48

*** Based on official catches**

Blue Whiting

Year	TOTAL CATCH	% catch covered by sampling programme	No. samples	No. Measured	No. Aged
2000	1412928	*	1136	125162	13685
2001	1780170	*	985	173553	17995
2002	1556792	*	1037	116895	19202
2003	2321406	*	1596	188770	26207
2004	2377569	*	1774	181235	27835
2005	2026953	*	1833	217937	32184
2006	1966140	*	1715	190533	27014
2007	1610090	87	1399	167652	23495
2008	1246465	90	927	113749	21844
2009	635639	88	705	79500	18142
2010	524751	87	584	82851	16323
2011	103591	85	697	84651	12614
2012	373937	80	1143	173206	15745
2013	625837	96	915	111079	14633

*** no figures given**

96% of the total catch was covered by national sampling programmes which is the highest coverage of the last six years. The sampling summary of the blue whiting catching countries is shown in the following table. No sampling was carried out by France and the UK (England, Wales and Northern Ireland) representing together 2,25% of the total catches (France 1,4%, UK 0,85%).

COUNTRY	OFFICIAL CATCH	% catch covered by sampling programme	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	2167	85	3	112	112
Faroe Islands	85678	100	9	845	644
France	8978	0	0	0	0
Germany	11418	43	29	2033	155
Iceland	104918	94	37	2049	2743
Ireland	13205	94	11	3751	900
Netherlands	51635	99	75	12090	1874
Norway	196246	100	214	7861	1340
Portugal	2056	100	23	2105	725
Russia	120674	100	280	56951	4138
Spain	15274	100	227	22323	1766
UK(England + Wales)	4100 8166	0	0	0	0
UK(Scotland)	8166	100	7	959	236
UK(Northern Ireland)	1232	0	0	0	0
Total	625837	96	915	111079	14633

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

Area	Official Catch	No Samples	No Aged	No Measured	No Aged/ 1000 tonnes*	No Measured/ 1000 tonnes*
IIa	27238	261	2520	22463	92	822
IIb	922	19	303	3120	328	3382
IIIa	89	0	0	0	0	0
IVa	8590	3	100	364	12	42
IVb	70	0	0	0	0	0
IXa	5053	99	1072	8893	212	1760
Va	3324	3	150	297	45	89
Vb	226911	123	3328	21602	15	95
VIa	88088	56	2160	5731	25	65
VIb	46690	41	580	8012	12	172
VIIb	6485	0	0	0	0	0
VIIc	113009	110	2449	19994	22	177
VIIg	0	0	0	0	0	0
VIIh	0	0	0	0	0	0
VIIIa	1136	0	0	0	0	0
VIIIb	669	0	0	0	0	0
VIIIc	12051	151	1414	15535	118	1289
VIIId	685	0	0	0	0	0
VIIj	296	29	155	2033	524	6868
VIIk	84084	20	397	3035	5	36
XII	253	0	0	0	0	0
XIVa	174	0	0	0	0	0
XIVb	10	0	0	0	0	0
Total	625387	915	14633	111079	1409	14798

*** Based on official catches**

Boarfish

Year	TOTAL CATCH	% catch covered by sampling programme	No. samples	No. Measured	No. Aged
2001	120	0	0	0	0
2002	91	0	0	0	0
2003	11387	0	0	0	0
2004	5151	0	0	0	0
2005	5959	0	0	0	0
2006	7137	0	0	0	0
2007	21576	NA	3	217	0
2008	34751	NA	1	152	0
2009	90370	NA	9	1 475	0
2010	144047	NA	95	10 675	403*
2011	37096	NA	27	4 066	704
2012	87355	NA	80 (68)***	9 656 (8 565)***	814**
2013	75409	NA	76	9 392	0****

***A common ALK was developed from fish collected from both commercial and survey samples. This comprehensive ALK was used to produce catch numbers at age data for pseudo-cohort analyses.**

****A common ALK was developed from fish collected from samples from Danish, Irish and Scottish commercial landings. This comprehensive ALK was used for all métiers to produce catch numbers-at-age data for pseudo-cohort analyses. Only aged fish measured to 0.5cm were included in the ALK.**

***** Only Irish collected samples were used for length frequency, see stock annex.**

****** 2012 ALK used.**

COUNTRY	OFFICIAL LANDINGS (excluding discards)	% landings covered by sampling programme	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	13182	NA	14	1221	0*
Ireland	52250	NA	62	8818	0*
UK(Scotland)	4380	0	0	0	0*
Total	75409	NA	76	9392	0*

*** 2012 ALK used.**

Area	Official Landings	No Samples	No Aged	No Measured	No Measured/ 1000 tonnes*
VIa	553	1	0	123	222
VIIb	10505	17	0	2235	213
VIIe	883	0	0	0	0
VIIg	1808	0	0	0	0
VIIh	14038	14	0	2060	147
VIIj	39529	40	0	5105	129
VIIIa	2224	4	0	516	232
VIIId	270	0	0	0	0
Total	69811	76	0	10039	144

1.3.2 Catch Data

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

The working group considers that the best estimates of catch it can produce are likely to be underestimates.

1.3.3 Discards

Discarding in pelagic fisheries is more sporadic than in demersal fisheries. This is because the nature of pelagic fishing is to pursue schooling fish, creating hauls with low diversity of species and sizes. Consequently, discard rates typically show extreme fluctuation (100% or zero discards). High discard rates occur especially during ´slippage´ events, when the entire catch is released. The main reasons for ´slipping´ are daily or total quota limitations, illegal size and mixture with unmarketable by-catch. Quantifying such discards at a population level is extremely difficult as they vary considerably between years, seasons, species targeted and geographical region.

Discard estimates of pelagic species from pelagic and demersal fisheries have been published by several authors. Discard percentages of pelagic species from demersal fisheries were estimated between 3% to 7% (Borges *et al.*, 2005) of the total catch in weight, while from pelagic fisheries were estimated between 3% to 17% (Pierce *et al.* 2002; Hofstede and Dickey-Collas 2006, Dickey-Collas & van Helmond 2007, Ulleweit & Panten 2007, Borges *et al.* 2008, van Helmond *et al.* 2009, 2010, 2011, van Overzee *et al.* 2013). Slipping estimates have been published for the Dutch freezer trawler fleet only, with values at around 10% by number (Borges *et al.* 2008) and around 2% in weight (van Helmond *et al.* 2009, 2010 and 2011) over the period 2003—2010. Nevertheless, the majority of these estimates were associated with very large variances and composition estimates of ´slippages´ are liable to strong biases and are therefore open to criticism.

Borges *et al.* (2008) show that for the Dutch freezer trawler fleet between 2002 and 2005, the most important commercial species discarded is mackerel, accounting for 40% of total pelagic discards. Other important discarded species are herring (18%), horse mackerel (15%) and blue whiting (8%). These discards are also the consequence of fisheries targeted at other species (*e.g.* mackerel in the horse mackerel and herring targeted fisheries). Boarfish was found to account for 5% of the discards. Total amount of discards by species in this fleet were estimated by van Overzee *et al.* (2013) for the years 2003—2012. They indicate that discards in these years for blue whiting (3.5%; range 1—16%), herring (NSSH and other stocks: 3%; range 1-7%) and horse mackerel (1.4%; range 1—5%) are low, but higher for mackerel (24.2%; range 16—37%). Dutch-owned freezer-trawlers also operate in European waters under German, UK, and French flags. Van Overzee *et al.* (2013) showed for the German pelagic fishery directed on mackerel for the years 2011 and 2012 0% discards rates for North Sea herring, horse mackerel and mackerel. For the herring directed fishery (NSSH and North Sea herring) the discards rates for blue whiting were between 0% for 2011 and 42% for 2012, for mackerel between 0 and 50% and for herring in both years 0%.

From 2015 onwards a landing obligation for European Union fisheries will be in place for fisheries directed on small pelagic fish including mackerel, horse mackerel, blue whiting and herring. To date it cannot be foreseen to which amount this will influence the discarding behaviour of the fisheries. A general discard ban is already in place for Norwegian, Faroese and Icelandic fisheries.

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

Mackerel

The Netherlands, Spain, Germany, Ireland, Denmark, Greenland and Portugal provided discard data on mackerel to the working group. Age disaggregated data was available from Spain, Portugal and Germany which indicates that the discarded catch is dominated by age 0 and 1 fish (>85% by number). For 2013 the total mackerel discards reported were 4664 t. The working group considers this to be an underestimate (see section 2.3.1) and the discard sampling to be incomplete.

Horse Mackerel

In the past discards of juvenile horse mackerel have been thought to constitute an in the past discards of juvenile horse mackerel have been thought to constitute a problem. However, in recent years a targeted fishery has developed on juveniles, including 1-year old fish and discarding of juveniles is now thought to be small. Over the years the Netherlands, Germany, Ireland and Spain have provided discard data. However, based on these data it is impossible to estimate the total discard rate in the horse mackerel fishery, since the discard rates reported are quite different. In 2013 discard data were available from Spain, the Netherlands and Germany. Ireland observed zero discard during observed trips.

Norwegian Spring Spawning Herring

The Working Group has no comprehensive data to estimate discards of herring. Although discarding may occur on this stock, it is considered to be very low and a minor problem to the assessment. This is confirmed by estimates from sampling programmes carried out by some EU countries in the Data Collection Framework. Estimates on discarding in 2008 and 2009 of about 2% in weight were provided for the trawl fishery carried out by the Netherlands. In 2010 and 2012, this metier was sampled by Germany. No discarding of herring was observed (0%).

The Norwegian coast guard maintains a close presence with the pelagic fishing fleet in Norwegian waters with several vessels and a plane. IMR has a co-operation with a number of reference vessels in the pelagic fleet, primarily for the purposes of biological sampling but also recording losses through gear damage or slipping. These data indicate that the frequency of slipping and the total quantities of fish slipped are low and, although the quantity remains unknown, are too small to have a significant effect on the reliability of the assessment.

Blue Whiting

Overall discards of blue whiting are thought to be small. Estimates from the DCF discard sampling programme for 2013 were available from Germany (2%), the Netherlands (1%), Portugal (25%) and Spain (26%). Discards in the Dutch and German fishery (pelagic freezer trawlers) are mostly by-catch in fisheries not directed on blue whiting. No discards were observed within the Irish sampling programme. Most of the other blue whiting fishing countries assume their discards to be zero (Denmark, Faroe, France, Russia, Norway and Iceland) due to existing discard bans in these countries and/or information from the industry.

Boarfish

Discard data were available from Dutch and German pelagic freezer trawlers and from Irish and Portuguese demersal fleets for the period 2003-2013. The Portuguese data relate to Division IXa and are not relevant to this stock. No Spanish discard data were submitted to the WG this year so the average of the previous ten years was used. Discards were not obtained from UK or French freezer trawlers, though discard patterns in these fleets are likely to be similar to the Dutch fleet. It is to be expected that discarding occurred before 2003, in demersal fisheries, however it is difficult to predict what the levels may have been.

1.3.4 Age-reading

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

Mackerel

Following the recommendation of the workshop on age reading of mackerel in 2010 (WKARMAC) a small scale otolith exchange was carried out by TI-SF between December 2013 and April 2014. The exchange was based on 164 otolith images and analysed using the WebGR application. A report of the exchange was available to WGWIDE.

Overall agreement between all readers was 68.2%. Good agreements were reached for age 1 and 2 (93 and 92%, resp.), for age 3 and 4 agreements were between 74 and 76%, agreement for age 5 was 61% and for age 6 and 7 57%. Only very low agreement was found for the older ages 8 to 14 (between 47% for age 8 and 31% for age 13).

Taking the results of the exchange in account the carrying out of a workshop in 2016 is recommended dealing with the generic terms of references for workshops on age calibration in order to increase the agreement between the laboratories involved in stock assessment especially for older fish.

Furthermore, it was recommended that WGWIDE will update the study on the influence of aging errors on the NEA mackerel assessment outputs which was carried out in 2011 (Brunel, 2011) in order to again validate the effect on the SSB estimation.

Horse mackerel

A Workshop on age reading of horse mackerel (*Trachurus trachurus*), Mediterranean horse mackerel (*Trachurus mediterraneus*) and blue jack mackerel (*Trachurus picturatus*) (WKARHOM) exchanged information by correspondence in 2011 and met in April 2012 to review information on age determination, compare different otolith-based age determination methods, identify sources of age determination error, provide specific guidelines for the interpretation of growth structures in otoliths, create a reference collection and data base of otolith images, and address the generic ToRs adopted for workshops on age calibration.

A total of 25 scientists and technicians, from 11 laboratories in 8 countries (France, Germany, Ireland, Italy, Norway, Portugal, Romania and Spain) participated in the workshop. For the assessment of the sources of age determination error, 16 age readers participated in the otolith exchange, 7 of the institutions read sectioned otoliths, 3 read whole otoliths, 2 read broken burnt whole otoliths and 3 read sectioned otoliths and whole otoliths. There were 10 sets of images of *Trachurus trachurus*, *T. mediterreaneus* and *T. picturatus*, from Ireland, North Spain, South Spain, Azores, Mauritania and Adriatic Sea. Percentage of agreement ranged from 36% to 67% for different otolith sets. The effect of otolith preparation techniques on age determination showed significant differences between readers and between otolith preparation methods, and also showed that the differences between methods were not the same across age readers. There were differences in interpretation primarily in the old individuals, with estimated age from sliced otoliths being higher than estimated age from whole otoliths.

A selection of 30 otoliths from horse mackerel (n = 23), Mediterranean horse mackerel (n = 5) and blue jack mackerel (n = 2) were selected for the reference collection. All otoliths for the reference collection were chosen by the most experienced readers during the workshop and covered an age span from 0 to 18 years old. Ages were agreed on by all participants. The main achievements of the workshop were the inclusion, for the first time, of *T. picturatus* and *T. mediterraneus*, a review on current otolith preparation and lab procedures, a quantification of disagreement between readers, the clarification of different ageing criteria previously used, an agreement on common criteria for ageing, the update of an ageing manual, and the assembling of an otolith reference collection for future use. Therefore, WKARHOM has set the basis for training of new readers and future improvement on otolith reading agreement. Preparations for the follow-up workshop in 2015 have already started. The workshop will be chaired by Teresa Garcia (Spain) and Alba Jurado (Spain) and will take place Sta. Cruz de Tenerife (Canary Islands, Spain), 26—30 October 2015.

Norwegian Spring Spawning Herring

Following a recommendation of the Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS) a small scale exchange was carried out by IMR in 2013. As Norwegian spring spawning herring is aged based on scales or otoliths depending on the institute reading, the small scale exchange aimed to determine the agreement between these two age-reading methods. Therefore 129 otoliths and scales were chosen from the same fish to be included in the exchange. Readers were allowed to read both structures, and it was taken into account which structure they were used to reading. A report of the exchange was available to WGWIDE.

The percentage agreement in all the comparisons in the exchange was quite low compared to what could be expected. The results comparing age readings of the readers usually reading the structures showed an agreement of only 67.4%. Agreements were higher in readings containing only one structure – even when readers not used to the structure participated, than the agreement found combining both structures in one EFAN-sheet, while only including the readers used to the structures. The ATAQCS-sheet comparing otoliths and scales showed a high percentage of disagreeing otoliths/scales, and up to six years difference between the modal ages of the two structures. These results are quite disturbing and it is important to continue this small scale exchange with a large scale exchange including both images and the real structures.

Since few institutes collect both structures by default, a request is made for institutes to collect a sample for the next exchange, especially in areas outside IIa.

Blue Whiting

A workshop (WKARBLUE) on age reading of blue whiting (*Micromesistius poutassou*) took place in Bergen, Norway, from 10—14 June 2013 chaired by Jane Amtoft Godiksen and Manuel Meixide.

A sample of 158 otoliths was annotated by the participants previously to the meeting, using WebGR, and a sub-sample of 50 of them was re-annotated at the meeting. Two new samples from Faeroes and Russia of 50 otoliths each were available at the meeting, together with pictures that were uploaded to WebGR.

The overall agreement obtained in the workshop were very poor in all samples with the exception of the Faroese one, showing that biased readings were present in many cases, even in experienced readers.

WKARBLUE recommends a new workshop in 2017, and the survey group recommended that the age readers look closer into a discrepancy problem for ages 1-3 in the 2014 blue whiting age reading material. Furthermore, PGCCDBS proposed an age calibration of blue whiting otoliths in 2016.

Boarfish

This stock is not part of the EU data collection framework so there is momentary no funding for age reading available. Age length keys were produced in 2012. The age reading was conducted by DTU Aqua on samples from all three countries in the fishery: Ireland, Denmark and UK (Scotland).

1.3.5 Biological Data

No specific issues were reported regarding biological data for this section.

1.3.6 Quality Control and Data Archiving

Current methods of compiling fisheries assessment data

Information on official, area misreported, unallocated, discarded and sampled catches have again this year been recorded by the national laboratories on the WG-data exchange sheet (MS Excel; for definitions see text table below) and sent to the stock co-ordinators or uploaded on the WGWIDE SharePoint. Co-ordinators collate data using the either the *sallocl* (Patterson, 1998) application which produces a standard output file (*Sam.out*) or the InterCatch hosted application.

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

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

Quality of the Input data

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

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

Overall, data quality has improved and sampling deficiencies have been reduced compared to earlier years, partly due to the implementation of the EU sampling regulation for commercial catch data. However, some nations have still not or inadequately aged samples. Others have not even submitted any data, so only catch data from Eurostat are available, which are not aggregated quarterly but are yearly catch data per area. Sampling deficiencies are documented by the data transmission tables which were filled in by the stock coordinators. These tables can be found on the WGWIDE SharePoint.

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

Transparency of data handling by the Working Group and archiving past data

The national data on the amount and the structure of catches and effort are archived in the ICES Intercatch database. The data are provided directly by the individual countries and are highly aggregated for the use of stock assessments. In the past three years ICES maintained records of submission, use, quality and relevance of data, use of data in assessment provided by the individual countries, named as "Data Tables". The intention of this information was to fulfil ICES' obligations as a scientific organisation to make the data used in the assessment fully transparent but also to comply with ICES' obligations to the EU. These data were also used by the EC to evaluate whether EU member states have complied with EU data regulations and have submitted the data to ICES. It was decided by ICES that no data tables are supplied since 2013.

The subject of transmission of data to ICES and other end-users has been discussed by STECF in 2011 (STECF PLEN 11—02 and STECF EWG 11—08) in the context of the introduction of regional data bases (RDB) to support international co-operation in data collection by EU member states. The RDBs are now nearly implemented. STECF and ICES expects that the RDBs will develop rapidly and that in the near future it will be possible to use the RDB to aggregate data accommodating the data needs of end-users like ICES. The STECF EWG has presented a roadmap for the expected transmission routes and procedures for the submission of data by EU member states to ICES. The roadmap aims for submission of member state data to ICES through the RDB.

In recent years, ICES has implemented a Sharepoint solution for the storage and sharing of working group data and documentation. **The WG recommends all historical data and WG files are available through the appropriate Sharepoint site.**

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

Stock data problems relevant to data collections

A number of other stock data problems were brought forward to the contact person and are listed in Annex 05 for the information of ICES, RCMs and PGCCDBS.

InterCatch

Acceptance test of InterCatch

All stock coordinators should make sure that catch data are imported into InterCatch and use InterCatch, following the Generic Terms of Reference. InterCatch is the standardised documentation system for stock assessment expert groups and a part of the ICES Quality Assurance Program. Therefore it is suggested that stock coordinators request national data submitters to import catch data into InterCatch over the internet in the InterCatch format to ease the stock coordinators work. Stock coordinators should verify that InterCatch fulfils the needs of their stocks and gives the expected output. Hereby the stock coordinator can also approve InterCatch as the system, which can be use in the future.

Table of Use and Acceptance of InterCatch

Stock code for each stock of the expert group	InterCatch used as the: 'Only tool' 'In parallel with another tool' 'Partly used' 'Not used'	If InterCatch have not been used what is the reason? Is there a reason why InterCatch cannot be used? Please specify it shortly. For a more detailed description please write it in the 'The use of InterCatch' section.	Discrepancy between output from InterCatch and the so far used tool: Non or insignificant Small and acceptable significant and not acceptable Comparison not made	Acceptance test. InterCatch has been fully tested with at full data set, and the discrepancy between the output from InterCatch and the so far used system is acceptable. Therefore InterCatch can be used in the future.
mac-nea	'In parallel with another tool'			Can be used
her-noss	In parallel with another tool		Small and acceptable	Can be used
hom-nsea	Only tool		Comparison not made	Can be used
hom-west	Only tool		Comparison not made	Can be used
whb-comb	Only tool	InterCatch was used last years		Can be used

1.4 Comment on update and benchmark assessments

For this year, ICES had scheduled update assessments for Blue Whiting, Norwegian Spring Spawning Herring, Western horse mackerel and NEA Mackerel. NEA mackerel assessment was now carried out for the second time after the benchmark process in February 2014 (WKPELA 2014). The boarfish assessment was also carried out for the second time (though this is not yet benchmarked) and for the North Sea horse mackerel data explorations were undertaken and some simple HCRs were examined (no accepted assessment for this stock).

1.4.1 Latest benchmark results

NEA mackerel was benchmarked in February 2014 (WKPELA 2014). The benchmark was successful in producing a state-space assessment model with three fisheries-independent survey series and tagging data, in addition to the catch-at-age data from ages 0—12 (plus group). After the benchmark, a WGWIDE subgroup run the assessment in April 2014 and update advice for 2013 was released in May 2014. The benchmarked assessment was thus run second time in WGWIDE 2014 in August.

1.4.2 Planning future benchmarks

Norwegian spring spawning herring is scheduled for a benchmark in 2016. NEA mackerel benchmark should take place no later than 2017. Boarfish has not been benchmarked yet at all, and there is a need for a benchmarked assessment. However, work is ongoing regarding genetic structure of the stock, and this is supposed to be finished such that a benchmark could take place in 2016. However, the assessment is highly dependent on an acoustic survey, which only has 3 years of estimates at the moment. By spring 2017 there would be 5 points from this survey, which could be better for a benchmark. Thus, for boarfish, WGWIDE would like to keep an option available for benchmark in 2016, but it might be that 2017 will be better suited. For the Western and North Sea horse mackerel, a joint benchmark is needed, as it might even be discussed whether these stocks should be assessed as one or keep them as separate units. Table 1.4.2.1 summarizes the benchmark planning for WGWIDE stocks.

Table 1.4.2.1. Benchmark planning for WGWIDE stocks.

Stock	Year benchmark planned
Norwegian spring-spawning herring	2016
NEA mackerel	At latest 2017
Boarfish	2016/2017
Western horse mackerel	2017
North Sea horse mackerel	2017

1.5 Special Requests to ICES

1.5.1 EU Request for Western horse mackerel management plan evaluation

A special request related to Western horse mackerel management plan evaluation was issued to ICES by the EU in December 2013. The request states the following:

Request

1) ICES is requested to fully evaluate the plan, and ascertain whether it is precautionary in the long term as well as in the short term.

2) Should the plan be found not to be precautionary in the long term, ICES is requested to identify reinforcements in the harvesting rules that would resolve the plan's shortcomings in that respect.
3) ICES is furthermore requested to identify what TAC should apply in 2013 in accordance with a revised harvesting rule under point 2 above.

The request is being address at present by a task group of scientists convened by ICES. A brief narrative of progress to date is presented in section 5.7.2 of this Report.

1.5.2 NEAFC Request for advice regarding blue whiting

Special request related to blue whiting forecast was issued to WGWIDE in spring 2014. The request states the following:

Request:

The North-East Atlantic Fisheries Commission (NEAFC) has noted that ICES in its blue whiting forecast for 2014, assumed the level of recruitment in 2013 to be the same as that in 2012 rather than the geometric mean of the years 1981—2010, which means the spawning biomass in 2015 might be overestimated.

Furthermore, NEAFC noted that the distribution of spawning biomass estimates using the stochastic forecast model is both wide and skewed, which in its view could lead to an overestimation of the F values that are deemed precautionary.

ICES is requested to review the assumptions and performance of the stochastic forecast model. ICES is also requested to assess whether or not there are any implications with respect to the reliability of its previous evaluations of the various options to revise the management plan, as outlined in special requests 9.3.3.1 and 9.3.3.7 of June and October 2013 respectively.

The SAM model provides uncertainty of fishing mortality and stock numbers in the final year estimates that can only be fully applied in a stochastic short-term forecast. The default stochastic projections applied for SAM assessments are carried out by projecting the final year's SAM estimates of stock numbers (log(N)) and fishing mortality (log(F)). Using the variance-covariance matrix of those estimates, a high number (1000) of replicates of the initial stock numbers and fishing mortalities are randomly drawn, such that the variance and co-variance between stock N and F are maintained. Due to additional information affecting recruitment (qualitative use of recruitment indices from surveys not used by SAM), the initial stock estimate for age 1 and age 2, and future recruitment can optionally be raised by an input factor. The 1000 replicates are then simulated forward according to the management options. The forecast result presented in the option table is finally derived from the median of the 1000 replicates.

Compared to a deterministic forecast the stochastic forecast gives slightly higher estimates of TAC and SSB. For this year's advice the TAC for 2015 is estimated 4—5% higher and SSB in 2016 is 8—9% higher. The difference is due to the assumed log-normal distributed stock number. The median of the projected stock N is unbiased compared to the stock N from a deterministic forecast, but the median of quantities like yield and SSB, which is the sum of several age groups N weighted by e.g. F, mean weight and proportion mature, will be higher. The difference between the stochastic and deterministic values increases by when there is more uncertainty around the stock numbers and fishing mortalities used for the forecast.

In the evaluations carried out to answer special requests 9.3.3.1 and 9.3.3.7 the HCS software was used (ICES 2013). These simulations did not directly run a SAM model for each year. Instead, assessment errors were generated matching the level observed in the most recent (at the time) SAM assessment for the stock. This was done by taking the true stock numbers according to the population model and using an autoregressive model with a combination of a year factor and an age factor noise terms to generate errors in the terminal stock numbers. This is to mimic not only year to year uncertainty in the 'assessed' stock numbers, but also some retrospective error.

As is done in practice, the 'assessed' stock numbers are projected forward to the TAC year to get the TAC. This projection is deterministic, based on the point estimates, with specified assumptions for catches or fishing mortalities, according to the harvest rule under study.

At WGWIDE, the default SAM stochastic forecast has been applied for the last three years. For this year however, a deterministic version was applied for advice to match that used in the MSE evaluation (ICES advice 2013). The conclusion that a HCR with target F=0.30 is precautionary, is sensitive to the choice of forecast model. This conclusion is dependent on the use of a deterministic forecast, and may no longer be valid should a stochastic forecast, with a TAC estimated 4—5% higher than in the MSE, is applied in reality. Due to time constraints it was not possible to correct the evaluation and re-estimate a precautionary target F. Therefore ICES uses a deterministic forecast this year which is consistent with the assumptions in the management strategy evaluation.

1.6 Ecosystem considerations for widely distributed and migratory pelagic fish species

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

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

An important challenge for the future meetings of this working group will be to take ecosystem considerations into account in stock assessment methods in order to reduce levels of uncertainty regarding the status and prediction of stocks. WGWIDE encourages further work to be carried out on ecosystem considerations linked to widely distributed fish stocks including NEA mackerel, Norwegian spring-spawning herring, blue whiting and horse mackerel. Emphasis should be on how ecosystem considerations from scientific studies and knowledge may be implemented and applied for management considerations. A close collaboration with the Working Group on Integrated Assessment on Norwegian Sea (WGINOR) will help in operationalizing ecosystem approach for the widely distributed pelagics assessed in WGWIDE.

Climate variability and climate change

Climate, in its wider sense, refers to the state of the atmosphere, for instance in terms of partitioned air masses (IPCC 2001; 2007). Climate variability, caused by the variations of atmospheric characteristics around the average climatic state, occurs via recurrent and persistent large-scale patterns of pressure and circulation anomalies. The North Atlantic Oscillation (NAO) is the recurrent pattern of variability in circulation of air masses over the North Atlantic region, corresponding to the alternation of periods of strong and weak differences between Azores high and Icelandic low pressure centers. Variations in the NAO influence winter weather over the North Atlantic (storm track, precipitations, strength of westerly winds) and hence have a strong impact on oceanic conditions (sea temperature and salinity, Gulf Stream intensity, wave height). Since 1996 the Hurrell winter NAO index has been fairly weak but mainly positive, except for during 2001, 2004 and 2006 (ICES, 2007). The Iceland Low and the Azores High were both weaker than normal in 2007 and 2008, and the centre of the Iceland Low was displaced towards the southwest to the entrances to the Labrador Sea (ICES 2007, 2008, 2009). The 2011 winter NAO index was negative although not as low as 2010 but lower than the long-term average (1950—2010). Hence, favourable winds supporting a strong Atlantic influence in the waters west of the British Isles and other regions continued to be lower than during high NAO years.

Accumulation of anthropogenic greenhouse gases in the atmosphere is currently effecting climate change (IPCC 2001; 2007). The classical measure of global warming is the Northern Hemisphere Temperature anomaly (NHT) (Jones and Moberg, 2003) which is computed as the anomaly in the annual mean of sea water and land air surface temperature over the northern hemisphere. Since the early 1900s, a warming of the northern hemisphere is evident. A first period of increasing temperature occurred from the early 1920s to about 1945. The period from the 1950s to the middle of the 1970s, corresponded to a light decrease of the NHT. During the last three decades, NHT anomalies have exhibited a strong warming trend. Many fish species are long-lived and therefore the effects of oceanographic conditions may be buffered at the population scale and integrated over time, even at the individual scale (Tasker *et al.* 2008). Nevertheless, pelagic planktivorous species such as northeast Atlantic mackerel, Norwegian spring-spawning herring and blue whiting may take advantage of warming ocean ecosystems expending possible feeding opportunities, through increasing their geographical distribution area, e.g. in Arctic waters.

Circulation pattern

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

Temperature

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

Feeding and spawning distributions and migration patterns of widely distributed species are also closely related to temperature: the timing of migration can be triggered by temperature and migration routes are related to temperature gradients (Harden Jones 1968; Leggett 1977). A better understanding of these effects could provide valuable information for both assessment and management of widely distributed stocks.

Time-series of sea surface temperature (SST) and salinity for the North Atlantic show generally rising trends in the recent years. An increasing trend in temperature and salinity was observed in the upper ocean during the period from 1996-2008 (ICES 2008), and during the period 2008-2010 the Atlantic Water surface temperatures were above the long term mean (NOAA 2010). This positive anomaly in the sea temperature in Northeast Atlantic continued in 2011-2013 (IESNS report 2013). The increase in SST at several of the stations in the NE Atlantic has been up to 3^{o}C since the early 1980s. This rate of warming is very high relative to the rate of global warming (ICES 2007, 2008). The upper layers of the North Atlantic and Nordic Seas remained exceptionally warm and saline in 2006 and 2007 compared with the long-term average (ICES WGOH 2007, 2008), but also above the long-term average in 2008–2014. The largest anomalies were observed at high latitudes. The North Sea, Baltic Sea and Bay of Biscay had an unusually warm winter and spring. This was due to a combination of stored heat from the warm autumn in 2006, and high solar radiation in 2007 (ICES WGOH 2008). A similar trend was evident in 2008-2010, but not as extreme as the two years before. In 2011 this trend seems to have been further weakened.

Phytoplankton

Phytoplankton abundance in the NE Atlantic has increased in cooler regions (north of 55^{o}N) and decreased in warmer regions (south of 50^{o}N) (Tasker *et al.* 2008). These changes in the primary production are likely to have impacts on zooplankton because of tight trophic coupling (Richardson and Schoeman, 2004). In the Norwegian Sea the average phytoplankton concentrations have shown a reducing trend the last decade, whereas the North Sea has shown an increased trend in phytoplankton concentrations the last few years (Naustvoll *et al.* 2010).

Zooplankton

Indicators of zooplankton communities which have been developed over recent years reveal important changes in the pelagic ecosystems of the North East Atlantic (Beaugrand, 2005). A northwards shift of 10° of latitude of the biogeographical boundaries of copepod species has, for instance, occurred during the past four decades (Beaugrand *et al.* 2002). One well-known example of these changes is the decline in the North Sea of the sub-arctic copepod *Calanus finmarchicus*, an important food item for a number of fish species, and its replacement by *Calanus helgolandicus*, a temperate water species. This invasive species dominates at times along the southwestern coast of Norway (Ellertsen and Melle 2009). Due to a different life-strategy and the lack of suitability as food, any increase in the population of this species at the expense of *C. finmarchicus* might have a detrimental effect on pelagic planktivorous fish e.g. mackerel, herring and blue whiting. Progressive increases in abundance of warm water/subtropical phytoplankton species into more temperate areas of the northeast Atlantic (Beaugrand *et al.* 2005) have in turn influenced zooplankton communities. The average biomass of zooplankton in the Norwegian Sea has followed a decreasing trend since 2002, and reached a record low in 2009, but have shown an upward trend since then and was in 2014 just over the average of the time series 1997—2014 (IESNS report 2014). The overall distribution pattern of zooplankton biomass has changed during the recent years. Previously the highest biomass of zooplankton was usually observed in the cold waters of the East Icelandic Current, where high aggregations of adult herring and mackerel were also observed. From about 2009 these western high density areas are less pronounced (IESNS report, 2012).

The reason for a decline in the biomass index of zooplankton during the period 2002—2009 in Nordic Seas is unknown. A number of possible reasons could explain this decline and the present low level, including reduction in phytoplankton (Naustvoll *et al.* 2010; i.e. bottom-up), possible changes in phytoplankton community, possible changes in zooplankton community, and increased grazing pressure by pelagic fish stocks (i.e. top–down). Simultaneously to the recent (2009—2014) upward trend in the zooplankton index in May (IESNS report 2014), as well as in the IESSNS surveys in July/August (2011—2013; Nøttestad *et al.* 2013), the weight-at-age (this report) and length-at-age (WGINOR report 2013) in the Norwegian spring-spawning herring feeding in the area are showing increasing trend. It is an indication that the Norwegian Sea is neither being overgrazed at present by the pelagic fish stocks in the area, nor that the herring stock is starving (i.e. increased natural mortality) because of relatively low zooplankton indices in recent years, as was hinted at in recent WGWIDE report (ICES 2012). Further studies on this issue will take place within the ICES working group on integrated assessment in Norwegian Sea (WGINOR report 2013), where the zooplankton index will also be revised and produced for the different areas in the Nordic Seas. The goal of WGINOR is to come up with a holistic ecosystem assessment of the Norwegian Sea and it will be the task in the years to come.

Species interactions

A central element in ecosystem considerations is how different species interact with each other (Rothschild 1986, Skjoldal *et al.* 2004). The distribution of species considered by WGWIDE can overlap to a large extent during some part of the year and according to life history stages. Since these species are mainly planktivorous, density dependent competition for food could be expected. All the species are potential predators on eggs and larvae and the larger species (mackerel and horse mackerel) are also potential predators of the juveniles. Consequently, cannibalism and inter-specific interaction between pelagic species could play an important role in the dynamics of these pelagic stocks.

Various pelagic species (e.g. mackerel, horse mackerel, sardine, blue whiting) also represent an important food source for many top predators such as marine mammals, seabirds and other species of pelagic fish. Many pelagic ecosystems (particularly those in upwelling areas) are characterised by a wasp-waist control, where a few, but highly abundant fish species effectively regulate the populations of their prey (top-down control) but also of their predators (bottom-up control). This type of regulatory mechanism makes pelagic fish have a key role in ecosystem functioning (Skjoldal *et al.* 2004).

There is a large body of literature on the diet of predator species feeding on pelagic fish in the Northeast Atlantic: sardine, mackerel, horse mackerel, blue whiting and herring have all been found in the diet of several cetacean and seabird species and are also part of the diet of other fish species (e.g. hake, tuna found with sardine and anchovy) (Anker Nilssen and Lorentzen, 2004; Nøttestad and Olsen 2004). Comparison of population estimates of pelagic fish with those of top predators (e.g. minke whale, fin whale, killer whales) suggests that predation on pelagic fish by other pelagic fish has a much bigger potential for impact in regulating populations than that the predation by marine mammals and seabirds (Furness (2002), in the context of the North Sea). Nevertheless, top predators could play a bigger role in pelagic fish dynamics at regional or local scales particularly when fish biomass is low (Holst *et al.* 2004; Nøttestad *et al.* 2004).

1.7 Future Research and Development Priorities

As part of the planning towards future benchmark assessments, the working group prepared a list of research priorities for each stock, and as a whole than can potentially improve the quality of the advice generated for each stock. We have considered scientific research, improvements to data collection and development of assessment techniques, both generally and on a stock-by-stock basis, as appropriate. The most important of these developments are described below.

1.7.1 General

Area where WGWIDE can improve considerably is work towards integrated ecosystem assessments. Some of WGWIDE members also participate in the work of the Working Group on Integrated Assessment for Norwegian Sea (WGINOR), which help in communication between these two groups. However, there are also other regional Integrated Ecosystem Assessment groups that could be relevant for WGWIDE and the stocks assessed by it. We hope to put more emphasis on this in the coming years.

1.7.2 NEA Mackerel

Although the stock was benchmarked this year (WKPELA 2014), there are already rather many issues for the next benchmark (2016/2017). These include:

- RFID tags, inclusion of the time series to the assessment model
- Recruitment index mackerel (model): Include additional gear effects in the recruitment model. Make use of existing French-Irish intercalibration data, to account for the two gear types ´GOV´ and ´French trawl´. (Teunis - IBP). Consider inclusion of first quarter NS-IBTS data in the model (Teunis - IBP)
- Continuous Plankton Recorder (CPR) for the mackerel survey.
- Examine whether the larvae data from the Continuous Plankton Recorder (CPR) from 1984—2004 can be used. [Cefas – Sophy Pittois].
- Alternative explanations for the drop in mean weight-at-age in recent years should be investigated, including the possibility of sampling bias due to shifting spawning timing, the effect of spatial expansion of the stock, and density-dependence.
- The IESSNS it still a short time-series (5 years) and the catchability estimated by the model is still very uncertain. The incorporation of this survey in the assessment should be re-evaluated in the near future when more survey years are available. Specifically WGWIDE should explore the use of the IESSNS index as multinomial in SAM (only use the age distributions, not the abundance).

- The triennial egg survey: WGWIDE should consider the influence of the lack of egg-survey data in inter-egg-survey year assessments, and propose settings to be added to the Stock Annex for future years.
- SAM model should be adapted so that the post tagging survival is modelled as a random walk, to allow for temporal variability of this parameter.
- Current M value was estimated using both tagging-recapture information and catches from the 1970, which are now known to be severely underestimated. The estimation of M should be revisited using most recent and accurate data.

1.7.3 Blue Whiting

- There is a need for more information regarding population structure in these stocks. Numerous scientific studies have suggested that blue whiting in the North Atlantic consists of multiple stock units. The ICES Stock Identification Methods Working Group (SIMWG) reviewed this evidence in 2014 (ICES SIMWG 2014) and concluded that the perception of blue whiting in the NE Atlantic as a single-stock unit is not supported by the best available science. SIMWG further recommended that blue whiting be considered as two units. However, there is currently no information available that can be used as the basis for generating advice on the status of the individual stocks. There is therefore a need to begin to collate information on these stocks in the leadup to a potential benchmark of this stock in the future. Potential data sources identified by the group include
    - Otolith-shape analysis has recently been shown to be able to reliably identify the stock-origin of sampled fish Keating *et al.* (2014). Use of this method in conjunction with age-reading in both scientific surveys and catch sampling can therefore provide a valuable source of information about the individual stocks. WGWIDE therefore recommends that during the next "Age Reading Workshop for Blue Whiting", otoliths from the whole area of this stock distribution should be collected to perform shape analysis, and used to both standardize the technique and plan for its roll-out.
    - The spatial and temporal coverage of the International Blue-whiting spawning stock survey (IBWSS) currently does not include the southern component, which spawns in the Porcupine Seabight in February-March (Pointin and Payne 2014). WGWIDE therefore recommends expansion of this survey to cover this component.
    - This Mackerel Egg Survey (MEGS) survey has previously been shown to provide valuable information about the distribution of fish spawning, including blue whiting (Ibaibarriaga *et al.* 2007). This survey covers the spatial and temporal distribution of spawning in both blue whiting stocks extremely well, and can therefore provide valuable information about their relative abundances. WGWIDE therefore requests that blue whiting larval be identified and counted per haul during the 2016 version of this survey.

1.7.4 NSS Herring

Norwegian spring spawning herring is scheduled for a benchmark in 2016. There are several issues with the current assessment model, and work is already being undertaken in national laboratories to improve the assessment of this stock. Last year WGWIDE set up the following issue list for benchmark, but these are all still open to discussion:

- exploration of alternative assessment models including different configurations of TASACS which produce more stable input values for the oldest age group
- investigate the bias in the assessment
- an analysis of variability or changes in the catchability of fleet 5. This is the major fleet used for tuning the assessment and seems to be causing retrospective patterns in the assessment
- the inclusion of a new tuning series (IESSNS) in the assessment
- the use of surveys in the assessment for tuning
- based on data, to be provided by the major fishing nations, whether estimates of slipping should be included in the assessment
- update maturity ogives for recent years following procedures as described by WKHERMAT.
- extend the time series used in the assessment with earlier years before 1988
- the need to continue the use of weighted average F in the assessment and advice. NSSH is one of the few stocks in which weighted F's are applied.
- the consequences for the reference points and management plans if the use of weighted F is discontinued.

1.7.5 Horse Mackerel

Generally speaking, management is most effective when its measures apply to all fisheries exploiting a stock and when catches can be identified as originating from that stock with some certainty. Considering the potential of mixing between Western and North Sea horse mackerel occurring in Division VIId/VIIe, better insight into the origin of catches from that area will be a major benefit, if not crucial, for improvement of the quality of future scientific advice and thus management of the North Sea and Western horse mackerel stocks.

- One way of possibly distinguishing between individuals of the two stocks is with the GCxGC-MS (Gas chromatography x Gas chromatography–mass spectrometry). A pilot project aimed at determining whether this technique could be used for distinguishing between Western and North Sea horse mackerel was planned at IMARES but due to funding restrictions this is unlikely to proceed further.
- Alternative methods for resolving the stock identity in the channel could be explored
- Methods for distinguishing between fish of North Sea or Western origin in the catches in this region (e.g. otolith shape analyses) should be explored

North Sea horse mackerel

There are numerous difficulties fitting an assessment model for this stock: unclear stock boundaries, limited fishery independent data sources, difficulty aging horse mackerel and lack of strong cohort signals in the catch at age data.

The IBTS survey used to develop indices for this stock is a bottom trawl survey targeting primarily ground fish (gadoids), but also catching pelagic species (e.g. horse mackerel). This survey does not cover the full distribution area of the stock. Though it covers the area of the North Sea where the population is thought to be in Quarter 3, it does not cover Division VIId where the majority of the fishery occurs (in Quarter 1 and 4). Alternative fishery independent data sources would be beneficial in developing an assessment model for this stock

- CPR larvae data in the stock distribution area could be analysed
- The French CGFS survey in VIId may provide information on horse mackerel abundance
- Ongoing projects at IMARES on utilizing commercial acoustics data for mackerel and blue whiting could be extended to horse mackerel
- Any other data on horse mackerel abundance in the channel would be useful

Improving the quality of age data for this species would help resolved some the lack of clear cohort signals in the catch data. Additionally, aging of horse mackerel caught in the IBTS survey (currently only length measures are taken) would improve the indices derived from this data source.

- Maintain regular age-reading workshops to ensure accuracy and consistency of age reading of this species (through ICES).
- Recommend age reading of horse mackerel caught in the IBTS survey

1.7.6 Boarfish

This stock would benefit immensely if it were included in the data collection framework. The advantages would be apparent in a number of different areas, primarily:

- Support for age reading of otoliths from catch samples of boarfish would allow the compilation of annual age-length keys for the fishery. This is of great importance if the stock is to move to a more appropriate age based assessment in the future.
- The boarfish acoustic survey could be conducted on a dedicated research vessel, which would allow the collection of multi-frequency acoustic data as well as oceanographic and other supplementary data.

As it is, the boarfish acoustic survey may not cover the entire area of this stock. Extending the survey coverage to the south or having a closer alignment with other surveys covering that area could answer many uncertainties about the fluctuations in the estimated biomass.

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2 Northeast Atlantic Mackerel

2.1 ICES Advice and International Management Applicable to 2014

From 2001 to 2007 the internationally agreed TACs covered most of the distribution area of the northeast Atlantic mackerel. Since 2008, no agreement has been reached among the Coastal States on the sharing of the mackerel quotas. An overview of the declared quotas and transfers for 2014, as available to WGWIDE, is given in the text table below. Total removals of mackerel are expected to be approximately 1.4 Mt in 2014, exceeding the recommended upper catch limit for 2014 by about 390 kt.

2014 quota component	Expected catch amount (t)
EU (incl. Swedish quota)	611205
- Spanish payback	-9747
- Other EU payback	-6568
Norway	279115
Russia	116700
Iceland	147721
- Iceland transfer from 2013 -> 2014	6908
Faroes	156240
Greenland	90000
Discards	4664
Total	1396238

The quota figures and transfers in the text table above were based on various national regulations, official press releases, and discard estimates.

Various international and national measures to protect mackerel are in operation throughout the mackerel catching countries. Refer to Table 2.2.4 for an overview.

2.2 The Fishery

2.2.1 Fleet Composition in 2013

A description of the fleets operated by the major mackerel catching nations is given in Table 2.2.1.

The total fleet can be considered to consist of the following components:

Freezer trawlers. These are commonly large vessels (up to 150 m) that usually operate a single mid-water pelagic trawl, although smaller vessels may also work as pair trawlers. These vessels are at sea for several weeks and sort and process the catch on board, storing the mackerel in frozen 20 kg blocks. The Dutch, German and the majority of the French and English fleets consist of these vessels which are owned and operated by a small number of Dutch companies. They fish in the North Sea, west of the UK and Ireland and also in the English Channel and further south along the western coast of France. The Russian summer fishery in subarea IIa is also prosecuted by freezer trawlers and partly the Icelandic fishery in Va and XIVb.

Purse Seiners. The majority of the Norwegian catch is taken by these vessels, targeting mackerel overwintering close to the Norwegian coastline. The largest vessels (>20m) are RSWs, storing the catch in tanks containing refrigerated seawater. Smaller purse seiners use ice to chill their catch which they take on prior to departure. A purse seine fleet is also the most important component of the Spanish fleet. They are numerous and target mackerel early in the year close to the northern Spanish coast. These are dryhold vessels, chilling the catch with ice. Denmark also has a purse seine fleet operating in the northern North Sea.

Pelagic Trawlers. These vessels vary in size from 20-100 m and operate both individually and as pairs. The largest of the pelagic trawlers use RSW tanks for storage. Iceland, Greenland, Faroes, Scotland and Ireland all fish mackerel using pelagic trawlers. Scottish and Icelandic vessels mostly operate singly whereas Ireland and Faroes vessels tend to use pair trawls. Spain also has a significant trawler fleet which target mackerel with a demersal trawl in areas VIII and IXaN.

Lines and Jigging. Norway, England have handline fleets operating inshore in the Skagerrak (Norway) and in area VIIe/f (England) around the coast of Cornwall, where other fishing methods are not permitted. Spain also has a large artisanal handline fleet as do France and Portugal. A small proportion of the total catch reported by Scotland (IVa and IVb) and Iceland (Va) is taken by a handline fleet.

Gillnets. Gillnet fleets are operated by Norway and Spain.

2.2.2 Fleet Behaviour in 2013

The most important changes in recent years are related to the geographical expansion of the northern summer fishery (areas II, V and XIVb) and changes in southern waters due to stricter TAC compliance by Spanish authorities. Fishing in the North Sea and west of the British Isles followed a traditional pattern, targeting mackerel on their spawning migration from the Norwegian deep in the northern North Sea, westwards around the north coast of Scotland and down the west coast of Scotland and Ireland.

Fishing by Faroese vessels has increased dramatically in recent years and has shifted exclusively to pair trawling. A small proportion of the Faroese quota is granted to smaller, traditionally demersal trawlers (using pair trawls).

The Russian freezer trawler fleet operates over a wide area in Northern waters. This fleet targets herring and blue whiting in addition to mackerel. In the third quarter the Russian vessels took the bulk of their catch from the international waters of area IIa. Smaller catches were also taken further south, between the Faroes and Iceland.

Total catches from Icelandic vessels were similar to those in 2012 with the majority of the catch taken in Va in waters south and west of Iceland. There was a slight increase in catch taken from area XIVb. Also targeting mackerel in area XIVb were Greenlandic vessels. This fleet has increased its catch rapidly and in 2012 caught over 50kt of mackerel with the majority from an area 30—34 degrees west. Some small catches were taken even further west close to the Greenlandic south coast.

An agreement between Norway and EU permitting reciprocal access was negotiated after 2009 when Norwegian vessels were curtailed in catching their full quota due to an earlier than expected migration.

In 2010 Spanish authorities introduced a new TAC allocation and control regime which resulted in closure of the mackerel fishery in quarter 2 to the purse seine and artisanal fleets when the majority of their respective quotas were exhausted. As in 2013, due primarily to changes in the timing of the migration, the fishery was closed in late March in 2013. Since the turn of the century the Spanish fishery has shifted forward by approximately 30 days. In addition, part of the purse seiner fleet from the inner part of the Bay of Biscay is using hand lines instead, mainly due to the higher market prize of this fishing method.

2.2.3 Recent Changes in Fishing Technology and Fishing Patterns

Northeast Atlantic mackerel, as a widely distributed species, is targeted by a number of different fishing métiers. Most of the fishing patterns of these métiers remained unchanged during the most recent years, although the timing of the spawning migration and geographical distribution can change from year to year and this affects the fishery in various areas.

Recent changes are notable for two areas and métiers in particular:

In 2010 the Faroese fleet switched from purse-seining in Norwegian and EU waters to pair trawling in the Faroese area. The Faroese fleet used to catch their mackerel quota in Divisions IVa and VIa during September-October with purse-seiners. However, as no agreement was obtained among the Coastal States since 2009, the mackerel quota has been taken in Faroese waters during June-October by the same fleet using pair trawls. The mackerel distribution is more scattered during summer and pair trawls seem to be effective in such circumstances.

Also targeting summer feeding mackerel, Icelandic vessels have increased effort and catch dramatically in recent years from 4kt in 2006 to approximately 150kt annually since 2011. This fishery operates over a wide area E, NE, SE, S and SW off Iceland. Since 2011 there has been less fishing activity to the north and north-east and an increase in catches taken south and west of Iceland. Greenland has reported increased catches from area XIVb since 2011.

Part of the northeast Atlantic mackerel population migrates towards the southern spawning area (ICES Division VIIIc - Cantabrian Sea) at the end of winter. Catch, survey and biological data indicate a forward shift in timing of spawning migration of the southern component of mackerel in the last decade (Punzón and Villamor 2009; Villamor *et al.*WD 2011). This temporal shift of about one month in the migration pattern of mackerel to the southern area might be linked to the fact that average temperatures in this area have been trending higher during winter-spring in the last few years.

2.2.4 Regulations and Their Effects

An overview of the major existing technical measures, TACs, effort controls and management plans are given in Table 2.2.4. Note that there may be additional existing international and national regulations that are not listed here.

Between 2010 and 2013 no Coastal State Agreement/NEAFC Agreement was in place and no overall international regulation on catch limitation was in force. In 2014 an *ad hoc* agreement was reached but only involving the EU, Faroes and Norway.

Management aimed at a fishing mortality in the range of 0.15—0.20 in the period 1998—2008. The current management plan aims at a fishing mortality in the range 0.20—0.22. The fishing mortality realised during 1998—2008 was in the range of 0.27 to 0.46. Implementation of the management plan resulted in reduced fishing mortality and increased biomass. Since 2008 catches have greatly exceeded those given by the plan.

The measures advised by ICES to protect the North Sea spawning component aim at setting the conditions for making a recovery of this component possible. Before the late 1960s, the North Sea spawning biomass of mackerel was estimated at above 3 million tonnes. Due to overexploitation, recruitment has failed since 1969, leading to a decline in the size of this component. The North Sea spawning component has increased since 1999, but continued protection is needed as it is still considered to be very small.

The closure of the mackerel fishery in Divisions IVb,c and IIIa throughout the whole year is designed to protect the North Sea component in this area and also the juvenile western mackerel which are numerous, particularly in Division IVb,c during the second half of the year. This closure has unfortunately resulted in increased discards of mackerel in the non-directed fisheries (especially horse mackerel fisheries) in these areas as vessels at present are permitted to take only 10% of their catch as mackerel bycatch. No data on the actual amount of mackerel taken as bycatch are available, but the reported landings of mackerel in Divisions IIIa and IVb,c from 1997 onwards might seriously underestimate catches due to discarded bycatch.

The advised closure of Division IVa for fishing during the first half of the year is based on the perception that the western mackerel enter the North Sea in July/August, and stay there until December before migrating to their spawning areas. Updated observations taken in the late 1990s suggested that this return migration actually started in mid- to late February. This was believed to result in large-scale misreporting from the northern part of the North Sea (Division IVa) to Division VIa. Recent EU TAC regulations have permitted some small quotas in IIIa and IVb,c. In the same regulation it is also stated that within the limits of the quota for the western component (VI, VII, VIIIa,b,d,e, Vb (EU), IIa (non EU), XII, XIV), a certain quantity of this stock may be caught in IVa but only during the periods 1 January to 15 February and 1 September to 31 December.

In the southern area a Spanish national regulation affecting mackerel catches of Spanish fisheries has been implemented since 2010 distributing the Spanish catch quota by gear. In 2013 the different fisheries were opened at the end of February (28.37% quota for trawlers, 33.85% for purse seiners and 36.5% for artisanal fisheries and the remaining quota for the Gulf of Cadiz fisheries (0.78%) and NEAFC northern areas (0.50%)), and closed at the end of March. Nevertheless, a 7% of the assigned quota for purse seiners and artisanal fleets was left for the second half of the year. This year Spanish mackerel fishing opportunity in VIIIc and IXa was established at 17 100 mt resulting from the original quota (22 709 mt), reduced by 8 226 mt due to the scheduling payback quota due to overfishing of the mackerel quota allocated to Spain in 2010 (Commission Regulation (EU) No 165/2011), and by the addition of 2 600 mt due to the flexible quota regulation and 17 from the VIIIa,b quota.

Within the area of the southwest Mackerel Box off Cornwall in southern England only handliners are permitted to target mackerel. This area was set up at a time of high fishing effort in the area in 1981 by Council Regulation to protect juvenile mackerel, as the area is a well-known nursery. The area of the box was extended to its present size in 1989.

Additionally, there are various other national measures in operation in some of the mackerel catching countries.

A landing obligation is due to come into force in 2015 for all EU vessels. The details of this regulation remain to be finalized at the time of writing.

2.3 Catch Data

2.3.1 WG Catch Estimates

The total estimated Working Group catch for 2013 was 931732t, an increase of 39379t on the estimated catch in 2012. Catches increased substantially from 2006-2010 and have averaged 910kt since 2011. Minor revisions to earlier years were incorporated into the time series as a result of the data review carried out as part of the benchmark exercise (ICES CM 2014 / ACOM:43).

The combined 2013 TACs arising from agreements and autonomous quotas amount to 895 336t. The Working Group catch estimate (931732t) represents an overshoot of approximately 4%. The combined fishable TAC for 2014, as best ascertained by the Working Group (see Section 2.1), amounts to 1396238t.

Catches reported for 2013 and in previous Working Group reports are considered to be best estimates. In most cases, catch information comes from official logbook records. Other sources of information include catch processors. Some countries provide information on discards and slipped catch from observer programs, logbooks and compliance reports. In several countries discarding is illegal. Spanish data is based on the official data supplied by the Fisheries General Secretary (SGP) but supplemented by scientific estimates which are recorded as unallocated catch in the WG estimates (see Section 1.3.7)

The text table below gives a brief overview of the basis for the working group catch estimates.

Country	Official Log Book	Other Sources	Discard Information
Denmark	Y (landings)	Y (sale slips)	Y
Faroe1	Y (catches)	Y (coast guard)	NA
France	Y (landings)		N
Germany	Y (landings)		Y
Greenland	Y (catches)		Y
Iceland1	Y (landings)		NA
Ireland	Y (landings)		Y
Netherlands	Y (landings)	Y	Y
Norway1	Y (catches)		NA
Portugal		Y (sale slips)	Y
Russia1	Y (catches)		NA
Spain	Y	Y	Y
Sweden	Y (landings)		N
UK	Y (landings)	Y	N

[1]For these nations a discarding ban is in place such that official landings are considered to be equal to catches.

The Working Group considers that the estimates of catch are likely to be an underestimate for the following reasons:

Estimates of discarding or slipping are either not available or incomplete for most countries. Anecdotal evidence suggests that discarding and slipping can occur for a number of reasons including high-grading (fish weighing more than 600g attracts a premium price), lack of quota, storage or processing capacity and when mackerel is taken as by-catch.

Confidential information suggests substantial under-reported landings for which numerical information is not available for most countries. Recent work has indicated considerable uncertainty in true catch figures (Simmonds *et al.*2010) for the period studied.

Estimates of the magnitude and precision of unaccounted mortality suggests that, on average for the period prior to 2007, total catch related removals were equivalent to 1.7 to 3.6 times the reported catch (Simmonds *et al.*2010).

Reliance on logbook data from EU countries implies (even with 100% compliance) a precision of recorded landings of 89% from 2004 and 82% previous to this (Council Regulation (EC) Nos. 2807/83 & 2287/2003). Given that over reporting of mackerel landings is unlikely for economic reasons, the WG considers that, where based on logbook figures, the reported landings may be an underestimate of up to 18% (11% from 2004). Where inspections were not carried out there is a possibility of a 56% under reporting, without there being an obvious illegal record in the logsheets. Without information on the percentage of the landings inspected it is not possible for the Working Group to evaluate the underestimate in its figures due to this technicality. EU landings represent about 65% of the total estimated NEA mackerel catch.

The accuracy of logbooks from countries outside the EU has not been evaluated by WGWIDE. Monitoring of logbook records is the responsibility of the national control and enforcement agencies.

The total catch as estimated by the Working Group is shown in Table 2.3.1.1. It is broken down by ICES area and illustrates the development of the fishery since 1969.

Discard Estimates

With a few exceptions, estimates of discards have been provided to the Working Group for the areas VI, VII/VIIIa,b,d,e and III/IV (see Table 2.3.1.1) since 1978. Historical discard estimates were revised during the data compilation exercise undertaken for the benchmark assessment (ICES CM 2014 / ACOM:43). The Working Group considers the estimates for these areas as incomplete. In 2013 discard data for mackerel were provided by seven nations: The Netherlands, Germany, Ireland, Spain, Portugal, Greenland and Denmark. Total discards amounted to 4 664t from these nations (mainly Netherlands and Spain). The German program consisted of 2 mackerel-directed trips on pelagic freezer trawlers. The Danish discards apply only to observations from some demersal fisheries. The Irish pelagic discard program included 30 trips (for all pelagic species).

Age-disaggregated data was made available to the Working Group from Portugal, Spain and Germany indicating that the majority of discarded fish were age 0 or 1 in areas VIII and IX. In area VII, particularly in the first semester, the discarded catch consisted of a wider range of ages although 95% of the discarded catch was age 6 or younger.

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

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

2.3.2 Distribution of Catches

The fishery has changed significantly in the recent past. Of the total catch in 2013, Norway accounted for the greatest proportion (18%) followed by Iceland (16%), Faroe (15%) and Scotland (14%). In the absence of an international agreement, Faroe, Greenland, Iceland and Russia declared unilateral quotas in 2013. Russia, Ireland and Greenland all had catches over 50kt with Danish, Dutch, French and Spanish catches in 2013 of greater than 20kt. Spanish catches have reduced significantly in recent years, primarily due to stricter enforcement.

In 2013, catches in the northern areas (II, V, XIV) amounted to 464 495 t, an increase of 17 293t on the 2012 catch and more than 300 000 t greater than the catch in 2009 (see Table 2.3.2.1). Faroese and Russian catches increased significantly although Norwegian catches decreased by 77kt as a greater proportion of the Norwegian quota was taken in area IVa than in 2012. The wide geographical distribution of the fishery noted in previous years has continued with large catches (69kt) now taken in area XIVb by Iceland and Greenland.

The time series of catches by country from the North Sea, Skagerrak and Kattegat (Subarea IV, Division IIIa) is given in Table 2.3.2.2. Catches in 2013 amounted to 261 254 t, an increase on 2012 corresponding to the large Norwegian catches as outlined above. Small catches were also reported in areas IIIb, c and d.

Catches in the western area (Subareas VI,VII and Divisions VIIIa,b,d and e) were slightly lower at 183 795 t and remain close to the long term average. These catches are detailed in Table 2.3.2.3.

Table 2.3.2.4 details the catches in the southern areas (Division VIIIc and Subarea IXa) which are taken almost exclusively by Spain and Portugal. The reported catch of 22 188t is the lowest in recent times and substantially below the 52 194t and 107 748t in 2010 and 2009 respectively. The reduced catch is primarily a result of stricter TAC compliance by Spanish administrators. A new regulation in 2010 allocated quota between the fleets (trawl, purse seine and artisanal).

The distribution of catches by quarter (%) is described in the text table below:

Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4
1990	28	6	26	40	2002	37	5	29	28
1991	38	5	25	32	2003	36	5	22	37
1992	34	5	24	37	2004	37	6	28	29
1993	29	7	25	39	2005	46	6	25	23
1994	32	6	28	34	2006	41	5	18	36
1995	37	8	27	28	2007	34	5	21	40
1996	37	8	32	23	2008	34	4	35	27
1997	34	11	33	22	2009	38	11	31	20
1998	38	12	24	27	2010	26	5	54	15
1999	36	9	28	27	2011	22	7	54	17
2000	41	4	21	33	2012	22	6	48	24
2001	40	6	23	30	2013	19	5	52	24

The quarterly distribution of catch in 2013 is similar to 2010-2012 with the Northern summer fishery in Q3 accounting for the greatest proportion of the total catch. Fisheries in area IIa extended into quarter 4 to a greater extent than in previous years. The proportion of the catch taken in quarter 1 is the lowest in the time series.

Catches per ICES statistical rectangle are shown in Figures 2.3.2.1 to 2.3.2.4. It should be noted that these figures are a combination of official and WG catches and may not indicate the true location of the catches or represent the location of the entire stock. These data are based on catches reported by all the major catching nations and represents almost the entire WG catch.

- First quarter 2013 (178 837 t – 19%)

The distribution of catches in the first quarter is shown in Figure 2.3.2.1. The quarter 1 fishery is similar to that in previous years with the Scottish and Irish pelagic fleets targeting mackerel in VIa, VIIb and VIIj. Substantial catches are also taken by the Dutch owned freezer trawler fleet. The largest catches were taken in area VIa, as in recent years. The Spanish fisheries also take significant catches along the north coast of Spain during the first quarter.

- Second quarter 2013 (47 662 – 5%)

The distribution of catches in the second quarter is shown in Figure 2.3.2.2. The quarter 2 fishery is traditionally the smallest and this was also the case in 2013. The most significant catches occurred towards the end of the quarter in the northern areas by Icelandic, Norwegian and Russian fleets. Large catches south of Iceland, midway between Iceland and Faroe and to the southeast of Faroe were reported.

- Third quarter 2013 (482 216 – 52%)

Figure 2.3.2.3 shows the distribution of the quarter 3 catches. Large catches were taken throughout areas IIa (Russian, Norwegian vessels), IVa (Norwegian, Scottish vessels), Vb (Faroese vessels) and Va (Icelandic vessels). The fishery extended further west than in 2012 with increased catches reported in area XIVb, particularly by Greenland where catches were on a par with those from SE Iceland, north of the Faroes and around the Shetland Isles.

- Fourth quarter 2013 (223 048t – 24%)

The fourth quarter distribution of catches is shown in Figure 2.3.2.4. The summer fishery in northern waters has largely finished, with very large catches taken by Norway, Scotland and Ireland around the Shetland Isles and along the north coast of Scotland. The pattern of catches is very similar to that reported in recent years.

2.3.3 Catch-at-Age

The 2013 catches in number-at-age by quarter and ICES area are given in Table 2.3.3.1. This catch in numbers relates to a total Working Group catch of 931732t. These figures have been appended to the catch-at-age assessment table (see Table 2.6.1.1).

Age distributions of commercial catch were provided by Denmark, England, Germany, Greenland, Faroes, Iceland, Ireland, the Netherlands, Norway, Portugal, Russia, Scotland and Spain. There remain gaps in the age sampling of catches, notably for French, Swedish and Northern Irish fleets.

Catches for which there were no sampling data were converted into numbers-at-age using data from the most appropriate fleets. Accurate national fleet descriptions are required for the allocation of sample data to unsampled catches. The sampling coverage is further discussed in Section 1.3.

The percentage catch numbers-at-age by quarter and area are given in Table 2.3.3.2.

Over 75% of the catch in numbers consists of 3—7 year olds with all year classes between 2007 and 2011 contributing between 13% and 17% of the total catch by number.

In subareas VIIa,d,e,f,g and h, young mackerel (1—3 year olds) account for over half the catch by number although these areas are relatively lightly exploited. In subareas VIIIc and IXa the catch is also dominated by juvenile fish.

2.3.4 Effort and Catch per Unit Effort

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

Table 2.3.4.1 and Figure 2.3.4.1 show the fishing effort data from Spanish commercial fleets. The table includes effort from Santoña and Santander handline fleets (Sub-division VIIIc East) for which mackerel is the target species from February to May, and annual effort from A Coruna trawl fleet (Subdivision VIIIc West); however, 2013 data were not available for this last fishing fleet. Spanish fleet effort figure shows a significant decrease in 2003 due to the catastrophe of the Prestige oil spill. Hand-line fleet effort showed an increasing trend from 1993 to 1998 but since then the effort, excluding the ban due to the Prestige, shows a clear declining trend, more relevant for the Santoña fleet, which could be related with the new catch regulations.

Figure 2.3.4.2 and Table 2.3.4.2 show the CPUE corresponding to the Spanish fleets referred above. There is clear drop in the handline fleets CPUE since 2011 which could be related with the daily quota established for 2011. On the contrary the trawler fleet from A Coruña shows an increasing trend in its CPUE since 2007.

2.4 Biological Data

2.4.1 Length Composition of Catch

The mean lengths-at-age in the catch per quarter and area for 2013 are given in Table 2.4.1.1.

For the most common ages which are well sampled there is little difference to recent years. The length of juveniles is traditionally rather variable. Lengths recorded in 2013 for ages 0—2 are significantly greater than those recorded in 2012 which in turn was lower than 2011. The rapid growth of 0-group fish and the variability due to sampling is likely to be the most significant factor. In recent years, more juvenile fish have been sampled in northern waters. Previously, these fish were only caught in the southern fishery. A slight reduction in length for age 3 and above is consistent with an observed reduction in catch weight.

Length distributions of the 2013 catches were provided by England, Faeroes, Iceland, Ireland, Germany, Greenland, the Netherlands, Norway, Portugal, Russia, Scotland and Spain. The length distributions were available from most of the fishing fleets and account for over 90% of the catches. These distributions are only intended to give an indication of the size of mackerel caught by the various fleets and are used as an aid in allocating sample information to unsampled catches. Length distributions by country and fleet for 2013 catches are given in Table 2.4.1.2. They show clear differences between quarters, particularly for the Spanish, Portuguese and English fleets.

2.4.2 Weights-at-Age in the Catch and Stock

The mean weights-at-age in the catch per quarter and area for 2013 are given in Table 2.4.2.1. The trend towards lighter weights-at-age for the most age classes (except 0 to 2 years old) starting around 2005 continued in 2013 (Figure 2.4.2.1). These changes in weight-at-age are consistent with the changes noted in length in Section 2.4.1.

The WG used weights-at-age in the stock calculated as the average of the weights-at-age in the three spawning components, weighted by the relative size of each component (as estimated by the 2013 egg survey for the southern and western components and the 2011 egg survey for the North Sea component). Mean weights-at-age for the western component are estimated from Dutch, Irish and German commercial catch data combined with fish measured during the 2013 mackerel egg survey and during the Norwegian tagging survey. Only samples coming from areas and periods corresponding to spawning, as defined at the 2014 benchmark assessment (ICES CM 2014/ACOM:43) and laid out in the stock annex, were used to compute the mean weights-at-age in the western spawning component. For the North Sea spawning component, mean weights-at-age were calculated from samples of the UK and Dutch commercial catches collected from areas IVa and IVb in the second quarter. Stock weights for the southern component, are based on samples from the Portuguese and Spanish catch taken in VIIIc and IXa in the 2nd quarter of the year, combined with weights derived from data collected on the 2013 mackerel egg survey. The mean weights in the three components and in the stock in 2013 are shown in the text table below.

The decreasing trend in the weights-at-age in the catch, observed since 2005 for fish of age 3 and older, continued in 2013 (Figure 2.4.2.2).

	North Sea Component	Western Component	Southern Component	NEA Mackerel 2013
Age				Weighted mean
0				0.000
1	0.098		0.105	0.108[1]
2	0.139	0.150	0.133	0.146
3	0.213	0.174	0.196	0.180
4	0.272	0.241	0.263	0.247
5	0.299	0.277	0.297	0.282
6	0.340	0.318	0.323	0.320
7	0.367	0.344	0.334	0.342
8	0.433	0.375	0.355	0.372
9	0.417	0.418	0.391	0.412
10	0.536	0.433	0.456	0.442
11	0.580	0.478	0.556	0.499
12+		0.538	0.474	0.526
Component Weighting	2.86%	74.05%	23.09%	
Number of fish sampled	150	1463	1372	

[1]in the absence of data for age 1 in the western component, the mean over the last 3 years for this component was used to compute the mean weight in the stock

2.4.3 Natural Mortality and Maturity Ogive

Natural mortality is assumed to be 0.15 for all age groups and constant over time.

The maturity ogive for 2013 was calculated as the average of the ogives of the three spawning components weighted by the relative size of each component calculated as described above for the stock weights. The ogives for the North Sea and Southern components are fixed over time. For the Western component the ogive is updated every year, using maturity data from commercial catch samples collected during the first and second quarters (ICES CM 2014/ACOM:43 and stock annex). The 2013 maturity ogives for the three components and for the mackerel stock are shown in the text table below.

A trend towards later maturation (decreasing proportion mature at age 2) has been observed from the mid-2000s to 2011, followed by quite stable values over the last 3 years (Figure 2.4.3).

Age	North Sea	Western Component	Southern Component	NEA Mackerel
0	0	0	0	0
1	0	0.14	0.02	0.11
2	0.37	0.55	0.54	0.55
3	1	0.98	0.70	0.92
4	1	1	1	1
5	1	1	1	1
6	1	1	1	1
7	1	1	1	1
8	1	1	1	1
9	1	1	1	1
10	1	1	1	1
11	1	1	1	1
12+	1	1	1	1
Component Weighting	2.86%	74.05%	23.09%	

2.5 Fishery Independent Data

2.5.1 International Mackerel Egg Survey Index

Mackerel Egg Survey in the Western and Southern areas

The ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS) met in Reykjavik from 7–11 April 2014, chaired by Cindy van Damme (IMARES, the Netherlands) and Finlay Burns (MSS, Aberdeen, Scotland), to finalize the results of the Mackerel and Horse Mackerel Egg Survey in 2013 and to plan the North Sea Mackerel Egg Survey in 2014.

In 2013 the Faroe Islands, Iceland, Portugal, Spain, Scotland, Ireland, the Netherlands, Norway and Germany participated in the survey. Despite technical and weather problems, temporal and spatial coverage was found to be sufficient in order to deliver a reliable estimate of mackerel and horse mackerel annual egg production. The application of an alternating transect survey design enabled survey effort to be deployed over the wide spatial area, necessary due to the continued expansion of the spawning area and season. Despite fewer fecundity and atresia samples being taken than planned, good spatial and temporal distribution of the sampling was achieved, and was sufficient in providing an estimation of realized fecundity.

The estimate of total mackerel egg production was 3.12 *1015 which is an increase of 47% with respect to 2010 (2.12*1015). The analyses of potential fecundity gave a value of 1257 eggs per gram female for mackerel for the western and southern components combined. The overall prevalence of atresia as a percentage of the population was 22% and the potential fecundity lost in the spawning season was 48 eggs /g. This reduced the potential fecundity by 4%. Spawning stock biomass (SSB) for the NEA mackerel stock was estimated using the realized fecundity estimate of 1209 eggs/g female, a sex ratio of 1:1 and a raising factor of 1.08 (ICES, 1987) to convert spawning fish to total fish.

However, it was necessary to revise the 2013 results after the WGMEGS meeting due to two reasons:

1) The egg production was calculated using a formula (Mendiola et al., 2006) for the egg development rate which had not been used before and was therefore calculated inconsistently in comparison to the data points 1992 to 2010 (calculated using the egg development rate by Lockwood *et al.*(1977)).

2) In order to follow the recommendation of the 2014 benchmark workshop on mackerel (ICES CM 2014/ACOM:43) the whole time series was recalculated using a standardized calculation script which triggered some changes in the allocation of some stations in sampling periods. This new time series uses a consistent egg development equation for all surveys 1992-2013.

(see section below "Review of the egg survey data series" for further explanations).

This gave a revised estimate of spawning-stock biomass (SSB) in 2013 of 3.82 (originally 4.29) million tonnes for the western component and 1.21 (1.28) million tonnes for the southern component and a combined estimate of 5.03 (5.57) million tonnes.

Egg Survey in the North Sea

At the beginning of the year Norway decided to withdraw from the 2014 North Sea egg survey. It was not possible to find other participants for replacement leaving the Netherlands to be the sole participant in the 2014 North Sea egg survey. Unfortunately, the Dutch research vessel broke down during the survey. Therefore, the survey was called off and postponed to 2015.

Review of the egg survey data series

In 2014, WGMEGS carried out a revision of the egg production database from 1992 to date, as recommended by the 2014 WKPELA benchmark workshop (ICES CM 2014/ACOM:43). This involved checking the raw data, reviewing criteria for including or excluding data, and procedures followed to process the data, etc.

After this, between WGMEGS and WGWIDE 2014, a new time-series of egg-based SSB was produced where the 1992, 1995 and 2013 data points were revised substantially; these revisions were reviewed during WGWIDE 2014. The original 1992 estimate had not included the egg production from the southern area of the survey so it was corrected to include those data. In addition, the 1992 survey did not cover the entire distribution of the mackerel eggs. It was based on a grid covering a denoted "standard area" where transects were interrupted before reaching two consecutive zero stations. However, WGWIDE decided to retain the 1992 data point despite this shortcoming on the basis that the core of the egg distribution had been covered. The 1995 survey had covered the whole egg distribution (continuing along a transect until two zero stations are reached) and this technique was adopted as the adaptive sampling procedure for the egg survey. However, the calculation of the 1995 estimate reported originally used only data from the standard area corresponding to that used in 1992 (WGMEGS; ICES CM 1996/H:2). The estimate revised in 2014 includes data from the entire surveyed area.

The 2013 SSB estimate was revised substantially from the one presented by WGMEGS 2014 that was used in the previous assessment (for update of the 2014 advice). In the time series provided to the WGWIDE subgroup for updated mackerel advice (ICES CM 2014/ACOM:48) by WGMEGS, the 2013 SSB index was calculated by applying an egg development equation based on a publication by Mendiola *et al.*(2006), whereas for the data points 1992-2010 the Lockwood *et al.*(1977) formulation was implemented. This change in the methodology was not clearly brought to the attention of the 2014 WKPELA benchmark workshop, and only came to the attention of WGWIDE at the

2014 meeting. Changing the methodology in the middle of a time series was not considered acceptable by WGWIDE 2014. The time-series was revised by applying Mendiola's method instead of Lockwood et al.'s consistently for the calculation of all data points. This decision was made after examination of the methods and analyses presented by Mendiola *et al.*(2006) by WGMEGS. The evaluation by WGWIDE supported the WGMEGS decision. Applying Mendiola et al.´s (2006) formula gives slightly higher egg productions due to a shorter observed egg development in comparison to Lockwood *et al.*(1977).

Another reason for the revision of the 2013 SSB is due to the re-allocation of stations to different survey periods because of the required standardization of the calculation procedures. The original estimate was based on the allocation of stations to survey periods according to the initial survey plan whereas the standardized new TAEP re-calculation required all stations, and therefore egg production values, to be allocated according to the period dates as reported in the WGMEGS report for each survey.

In 2013, there was a very late amendment in the timing of one individual survey in period 3 that was undertaken in south and central Biscay during late March and early April of 2013. The survey was due to commence on the 25th March; however, the survey was moved forward at very short notice and commenced on the 22nd March. This brought the first 4 days of the survey within period 2. Due to the number of surveys and participants involved in the MEGS survey this is not an unusual event and during the subsequent analysis of the data the impact of their removal on the total annual egg production (TAEP) was assessed. The very low abundances involved meant that their contribution to the overall TAEP for 2013 was negligible (0.12%) and so in order to minimize disruption to the settled survey plan for period 3 WGMEGS retained the out-of-period stations within period 3 rather than remove them. However, the revised estimate resulted from allocating the data of this specific survey to the correct period in which they were collected. The result was that these stations were moved forward into period 2. The same stations had also been sampled by another survey early on in period 2 which had yielded very large numbers of stage 1 mackerel eggs. By incorporating these very low density stations (previously in period 3) to period 2 (because the average station production is used in each period) it significantly reduced the daily egg production values for these previously high abundance stations, resulting in an overall reduction in SSB as compared to the original estimate used in the assessment to provide the advice update in 2014. Figure 2.5.1.1 shows the reported and revised egg production curves for the Western area of the 2013 survey.

The new and old time series are shown in Figures 2.5.1.2 to 2.5.1.4 and in Table 2.5.1.1. The blue line in Figure 2.5.1.2 represents the input data used for the 2014 WGWIDE assessment.

2.5.2 Recruitment Index

A recruitment index was derived from catch data from the International Bottom Trawl Surveys (IBTS) in Q4. Full documentation can be found in Jansen *et al.*(working document to 2014 WKPELA).

Trawling was done by research vessels from Scotland, Ireland, England and France, collectively known as the international bottom-trawl surveys, in October–December (IBTS Q4). The surveys sample the fish community on the continental shelf and upper shelf slope. IBTS Q4 covers the shelf from Spain to Scotland, excluding the North Sea. Trawling was done at 3.5–4.0 knots. Two trawls deviated substantially from the GOV-type, namely the Spanish BAKA trawl and the Irish trawl that was used from 1998 to

2002. The BAKA trawl had a vertical opening of only 2.1–2.2 m and was fished at only 3 knots. This was substantially less suitable for catching juvenile mackerel and therefore excluded from the analysis. The Irish trawl used in 1998 to 2002 was a GOV trawl in reduced dimensions. The reduced wingspread and trawl speed was accounted for in the model.

Technical problems were encountered during the Scottish fourth quarter survey in 2013, so only approximately 30% of the hauls were taken. These hauls were evenly distributed throughout the survey area. In 2010, the Scottish survey was cancelled. Since 2011, the English survey has been discontinued and the Scottish survey has not consistently covered the area around Donegal Bay.

WGWIDE recommends that the English survey is reinstated and that the Spanish area is surveyed using a GOV-trawl.

A geostatistical log-Gaussian Cox process model (LGC) with spatio-temporal correlations was used to estimate the catch rates of mackerel recruits through space and time. The modelled catch rate surface in 2013 was mapped in Figure 2.5.2.1 (right). The recruits appeared to be distributed further south than the average distribution of the time series Figure 2.5.2.1 (left).

These catch rates were then squared and integrated over the spatial surfaces to produce annual mean catch rates. This was used in the assessment as a relative abundance index of mackerel at age 0 (recruits) – see Table 2.5.2.1 and Figure 2.5.2.2. The cohort from 2013 appears to be the most abundant in the time series. However, supplementary analysis (below) suggest that the 2013 cohort is above average, but not as large as estimated by the Q4 model.

The 2014 WKPELA benchmark workshop (ICES CM 2014 / ACOM:43) recommended further work on extending the Q4-model with data from IBTS Q1 in the North Sea and other northern areas. Further progress of this analysis was presented at the meeting. Most noteworthy was the inclusion of data from first quarter IBTS surveys to cover the important nursery areas in the northern North Sea. Furthermore, the index calculated by the LGC model was benchmarked against a swept-area index derived from the same data. This analysis suggested that the LGC approach was better at extracting the cohort abundance signal than the "raising" method. A WGWIDE subgroup reviewed the new results as described in Jansen *et al.*(under review). WGWIDE regards the LGC implementation as a valid and well documented approach. WGWIDE furthermore regards the addition of the first quarter survey data as an improvement over the version implemented during the 2014 WKPELA benchmark workshop (ICES CM 2014 / ACOM:43). However, the analysis suggested a possible difference in catchability between first and fourth quarter surveys, so this should be further explored before the new index is implemented in the assessment. The preliminary results including data from both Q4 and Q1 suggests that the 2013 cohort is above average, but not as large as estimated by the Q4 model that has been used in this year's assessment.

2.5.3 Ecosystem surveys in the Nordic Seas in July–August (IESSNS index)

Northeast Atlantic Mackerel and Ecosystems

In July-August 2014, four vessels: the chartered trawler/purse seiners M/V "Brennholm", M/V "Vendla" (Norway), M/V "Finnur Fridi" (Faroe Islands), and the research vessel R/V "Arni Friðriksson" (Iceland) participated in the joint ecosystem survey (IESSNS) in the Norwegian Sea and surrounding waters (Nøttestad *et al.*WD 2014). The five weeks of cruises from 2nd of July to 12th August 2014 are part of a long-term project to collect updated and relevant data on abundance, distribution, aggregation, migration and ecology of northeast Atlantic mackerel and other major pelagic species. Major aims of the survey were to quantify abundance, spatio-temporal distribution, aggregation and feeding ecology of northeast Atlantic mackerel in relation to distribution of other pelagic fish species such as Norwegian spring-spawning herring, oceanographic conditions and prey communities. Opportunistic whale observations were performed on the Norwegian vessels to collect data on distribution and aggregation of marine mammals for ecologically related studies.

All vessels that participated in the IESSNS 2014 survey used the same designed pelagic sampling trawl (Multpelt 832) and similar protocol for both rigging and operation agreed upon in Hirtshals in February 2013 from the ICES WKNAMMM workshop between the industry and scientists (ICES CM 2013/SSGESST:18). The swept area methodology for abundance estimation of NEA mackerel was further developed by dedicated experiments with parallel trawling and direct comparison of mackerel trawl catches between vessels in the same areas. Trawling experiments were done with multi-beam sonar monitoring of mackerel behaviour and aggregation before and during trawling. Systematic underwater video recordings of mackerel swimming and aggregation behaviour, patchiness and catchability were also conducted both in 2013 and 2014. The 2014 WKPELA benchmark workshop (ICES CM 2014/ACOM:43) benchmarked the assessment of mackerel in the Northeast Atlantic. It was agreed during the meeting to accept the swept area methodology back to 2007. Decisions were made to include age-disaggregated indices for age group 6+ scaled by the coverage each year from the IESSNS into the assessment. Detailed studies on age disaggregated biomass estimates and exploration on how well the different year classes in the NEA mackerel stock can be followed from year to year have been analyzed and results are available in the international survey report from July-August 2014 (Nøttestad *et al.*WD 2014).

Survey tracks

The four vessels followed predetermined survey lines with pre-selected pelagic trawl stations (Figure 2.5.3.1). The cruise tracks covered several Exclusive Economic Zones (EEZs): Norwegian EEZ (including Norway mainland, Jan Mayen EEZ and Svalbard zone), EU EEZ, Faroese EEZ, Icelandic EEZ, Greenlandic EEZ, and International waters. The distance between pelagic trawl stations was approximately 50-60 nmi for all vessels. CTD stations from the surface to 500 m depth in combination with WP2 plankton net samples from the surface down to 200 m depth were taken systematically on every pelagic trawl station onboard all vessels.

Temperature

The temperatures in the Nordic Seas in July-August 2014 are considerable warmer with 1-3°C higher temperatures than the long-term average temperature during the last 20 years (Figure 2.5.3.2). The temperature in the upper layers (10m and 20m) shows warm water of Atlantic origin covering most of the survey area (Figure 2.5.3.3). Generally the temperature pattern in the survey area in 2014 was higher compared to the 2013 situation in practically all areas within the Nordic Seas. This year the coverage was extended northwards and westwards compared to last year, and the high temperature was recorded in western areas in the Irminger Sea southeast of Greenland,, where it reached 10°C. Most of the Norwegian Sea and the area south of Iceland had surface temperatures around 10-13°C, It was warmer north of Iceland and west of Jan Mayen in 2014 compared to 2013. The warm Atlantic water extended north beyond the 73 degrees in the eastern Norwegian Sea. The temperature distribution at 50m was generally considerable colder than in the upper 20-30 m of the water column. The temperature deeper from 50 m depth and downwards was especially colder in the south-western Norwegian Sea, where the cold East Icelandic Current (EIC) and features like the Iceland-Faroe-Front (IFF) was clearly detected. In the eastern Norwegian Sea warm Atlantic water was also detected down to 400m depth. In waters deeper than 100-200m the influence of the EIC is more pronounced and extends further south into Faroese and east into Norwegian waters

Zooplankton concentrations and distribution

The average plankton biomass showed a similar situation from 8.6 g/m^2 in July-August 2013 to 8.3 g/m^2 over all stations throughout the survey area in July-August 2014 (Figure 2.5.3.4). The plankton concentrations were generally higher in the central and especially the northern part of the Norwegian Sea in 2014 compared to in 2013, whereas we found a clear decrease in plankton concentrations in Icelandic and Greenland waters in 2014 compared to in 2013. The zooplankton samples for species identification have not been examined in detail.

The increased biomass of zooplankton in the central and northern part of the Norwegian Sea in July-August 2014 is in agreement with the increase that has been observed in the zooplankton biomass in the Norwegian Sea in the May survey in 2013 after a decade with a decreasing trend in zooplankton biomass. These data need nevertheless to be treated with some care, due to various amounts of phytoplankton (phaeosystis) between years and areas in the samples influencing the total amount of zooplankton (g dry weight/m^2) which is relevant and valuable as available food for pelagic planktivorous fish such as mackerel, herring and blue whiting.

Spatial distribution of NEA mackerel

The mackerel was distributed in most of the surveyed area covering 2.45 million square kilometers, and the zero boundaries were found in most areas, although not in the west in Greenland waters where considerable catches were taken at the stations furthest in the southwestern regions of the survey, We did not cover the mackerel south of the IESSNS survey in the North Sea and west of the British Isles. The total mackerel catches (kg) taken during the joint ecosystem survey with the Multpelt 832 quantitative sampling trawl is presented in standardized rectangles in Figure 2.5.3.5. The map is showing different concentrations of mackerel from zero catch to more than 5000 kg.

Age distribution of NEA mackerel

The 2011 year class contributed to more than 32% in number followed by the abundant 2010-year classes around 21%. The 2007, 2008 and 2009 year classes were contributing with around 11% each of the total number. The previously strong 2005- and 2006 year classes contributed with only 3% and 7% of the total number, respectively (Figure 2.5.3.6).

Spatial overlap between pelagic fish species

The spatial distribution and overlap between the major pelagic fish species from the joint ecosystem survey in the Nordic Seas and surrounding coastal and offshore areas are shown in Figure 2.5.3.7. The spatiotemporal overlap between NEA mackerel and NSS herring in July-August 2014 was generally low within the covered area, nevertheless with highest overlap in the northwestern part of the Norwegian Sea (east Icelandic area, international area and Jan Mayen waters). Herring were most densely aggregated in close relation to where we found the highest concentrations of zooplankton. Mackerel, on the other hand, were found over much larger areas and present in areas with varying zooplankton concentrations. Norwegian spring-spawning (NSS) herring was predominantly distributed in the outskirts of the Nordic Seas along the outer edges of the mackerel distribution in waters colder than 7°C.

Abundance estimation and zonal distribution of NEA mackerel

The total swept area estimate of NEA mackerel in summer 2014 was 9.0 million tonnes based with coverage of 2.41 million square kilometers in the Nordic Seas from about 58 degrees south of Cape Farwell in Greenland waters up to 76.30 degrees north and from the Norwegian coast along the Finnmark coast in the east and westwards into the Irminger Sea at the southern tip of Greenland (Figures 2.5.3.8a and 2.5.3.8b; Table 2.5.3.1).

The geographical coverage and survey effort in 2014 (2.45 mill km^2) was similar to 2013 (2.41 mill km^2) and significantly larger than in 2012 (1.5 mill km^2) and in 2010 (1.7 mill km^2). The coverage was limited to 1.1 mill km^2 in 2011 and 0.99 mill km^2 in 2007. In 2011 the northern part of the Norwegian Sea was not properly covered due to only one Norwegian vessel participating in the survey. The swept area biomass estimates of 4.8 million tonnes in 2010 and 5.1 million tonnes estimate in 2012 may be compared with the biomass estimates of 8.8 million tonnes in 2013 and 9.0 million tonnes in 2014. These abundance estimates strongly suggest that the NEA mackerel have increased significantly both in geographical distribution and abundance over the last 7 years. All these biomass estimates must be considered to be underestimations and only represent part of the stock.

Additionally, a master of science thesis has been written by Diaz (2013) entitled "schooling dynamics of summertime migrating northeast Atlantic mackerel (*Scomber scombrus*) in the Norwegian Sea using multibeam sonar", given as a WD to WGWIDE 2013. The schooling dynamics of NEA mackerel in nature is largely unknown because they lack a swimbladder, resulting in a weak acoustic signature, and therefore are difficult to detect in the summer when swimming in loose school formations. However, high frequency omnidirectional SONAR (SOund Navigation And Ranging) is capable of detecting NEA mackerel in the acoustic echosounder blind zone close to the surface. These results showed that there were regional differences in fish size, swimming speed and direction, school depth, temperature and zooplankton abundance. Mackerel were detected and caught where the temperature was above approximately 6° C. The thermocline depth had a profound influence on the depth distribution of schools throughout the Norwegian Sea during summer. NEA mackerel were consistently found shallower than 40 m depth both during day and night. The fish generally swam north except for in the SW region, coinciding well with prevailing current directions. Fish were significantly larger in the north than in the south, and plankton abundance was higher in the west than in the east. The observed school dynamics in relation to abiotic and biotic factors are explained in terms of the ecology of NEA mackerel during the summer feeding migration.

A comprehensive survey manual for the survey will be compiled in the coming months. It will be based on the methodology that has been evolved in recent years in this survey regarding the trawl and trawling procedure (e.g. Nøttestad *et al.*2012; 2013; 2014) as well as manual from the IESNS survey in May in Norwegian Sea regarding acoustic, biological sampling, zooplankton and CTD (Rybakov *et al.*, WD to 2014 WGWIDE).

Intercalibration and monitoring of trawl gear (Multpelt 832)

Comparative pelagic trawl hauls were conducted between the Norwegian vessels M/V "Brennholm" and M/V "Vendla" 1-2 July 2014. The Norwegian vessels had four comparative hauls. The Norwegian vessels conducted the hauls in an area with moderate abundance of both mackerel and herring.

In recent years the pelagic trawl used in the IESSNS survey has been standardized but a standard method to monitor trawl performance has not been developed. In 2013 and 2014 international surveys, a trawl performance method was tested where trawl sensors were attached to the trawl at different locations. Performance of the pelagic trawl (Multpelt 832) was monitored at all stations on the Faroese vessel. Four pairs of fishing gear sensors recorded spread of trawl doors, under wings and trawl opening during trawling. Depth of ground rope was also reported. Recording frequency was every other second. Sensor performance was good at trawl doors and ground rope as data were recorded at all stations where as sensors at under wings and trawl opening recorded data at 70 % of stations. These results indicate trawl sensors provide a reliable method to monitor trawl performance during trawling. Detailed information on trawl performance during each haul is in Jacobsen and Olafsdottir (2013, WD to WGWIDE). Further information and results are given in the IESSNS survey report from July-August 2014 (Nøttestad *et al.*WD to 2014 WGWIDE).

Ultimate goal

The ultimate goal has been to get accepted and use this combined swept area estimate as an absolute/relative abundance index of spawning stock biomass (SSB) and possibly recruitment index, on an annual basis in the assessment of NEA mackerel after the NEA mackerel benchmark in February 2014. One of the main objectives of the IESSNS is to provide reliable and consistent age-disaggregated abundance indices of NEA mackerel. The WKPELA meeting held at ICES in Copenhagen in February 2014 benchmarked the assessment of mackerel in the Northeast Atlantic (ICES CM 2014/ACOM:43). It was agreed during the meeting to include age-disaggregated indices for age group 6+ scaled by the coverage each year from the IESSNS into the assessment – see Table 2.6.9.

The internal consistency plot for age-disaggregated year classes (see Nøttestad *et al.*WD 2014) has greatly improved since 2013, especially for younger year classes. There is now good internal consistency between year classes 1—10 years old, except between the less abundant 5 and 6 year olds providing little contrast within a narrow scale of values. The improved consistency in younger year classes for NEA mackerel in the IESSNS survey should be taken into consideration by ICES, specifically by including also younger mackerel 1—5 years of age, and not only age 6+ mackerel, into the tuning series as input on abundance of NEA mackerel to the assessment. These issues were discussed at WGWIDE 2014. It was agreed that a benchmark should be convened in 2017 to consider extending the IESSNS inputs once a longer time series is established.

A joint survey report from the 2014 Ecosystem surveys in the Nordic Seas and surrounding coastal and offshore waters from 2nd of July to 12th August (IESSNS) has been written and presented at the ICES WGWIDE meeting in Copenhagen, Denmark 26. August –1. September 2014 (Nøttestad *et al.*WD 2014)

2.5.4 Tag Recapture data

The Institute of Marine Research in Bergen has conducted tagging experiments on mackerel since 1968, both in the North Sea and to the west of Ireland during the spawning season May–June. However, only the information from mackerel tagged west of Ireland is used in the mackerel assessment, and only information on recaptures of mackerel tagged with steel-tags until 2006 (releases from 1977 to 2004). See the 2014 WKPELA benchmark workshop (ICES CM 2014 / ACOM:43) for a thorough description on how the tag-recapture information is used in the assessment.

Steel-tags

These tags have been recovered at metal detector/deflector gate systems installed at plants processing mackerel for human consumption. This system demanded a lot of manual work, paying for external personnel to stay at the plants during processing. Among the typical 50 fish deflected, the hired personal must find the tagged fish with a hand-hold detector and send the fish to IMR for analysis. This has been time consuming and expensive. Besides being used in present mackerel assessment model, the tagging data have also been used in estimates of mortality, and recently in estimation of spawning stock biomass, and further has the tagging data been valuable for understanding the migration of the mackerel (Tenningen *et al.*2011).

RFID tags

New and promising radio-frequency identification (RFID) tagging project on NEA mackerel was in 2011 initiated at the Institute of Marine Research, Bergen (IMR) in Norway. The new RFID tagging project has moved away from manual and expensive to an automatic and cost-effective scanning system.

RFID is a technology that uses radio waves to transfer data from an electronic tag, called an RFID tag, through a reader for the purpose of identifying and tracking the object.

The RFID-project run by the Institute of Marine Research (IMR) in Bergen, Norway is now fully operational and 8 Norwegian factories have installed the scanners, where RFID tagged mackerel are automatically recaptured and updated in the central database in Bergen over GRPS. In the EU, one scanner is installed in Denmark, five scanners in Scotland and three in Ireland. In the North Atlantic one scanner is installed on the Faroe Islands and one on Iceland. In addition Icelandic processors are considering installing two more systems. The industry will have to provide additional data about catches screened through the RFID systems, such as total catch weight, position of catch (ICES rectangle), mean weight in catch etc. Regular biological sampling of the catches landed at these factories is also needed. Altogether, these data are essential for the estimation of numbers screened per year class, which is needed as input to the tag data-table currently used in the SAM-assessment for steel tags. Not all European RFID-systems have been up and running but it is the ambition to have them all ready for the 2014 mackerel autumn fishery.

During the period 2011—2014 as many as 160000 mackerel has been tagged with the new tags and 247 of these tags have recaptured. There is a web-based software solution that is used to track the different systems, import data on catch information, and biological sampling data of released fish and screened catches. Based on this information the system can estimate numbers released and screened by year class in a known biomass landed, which is used to estimate abundance by year class and totally.

The major aim for the RFID program is to expand the tagging time series by including these data in the assessment model for NEA mackerel, at latest during the next benchmark, possibly in 2017. The tag data format will be the same as the one already included in the 2014 benchmark with steel tags, but treated as a different time series.

2.5.5 Other surveys

2.5.5.1 International Ecosystem survey in the Norwegian Sea (IESNS)

In recent years an increasing amount of mackerel has been observed in the Norwegian Sea during the combined survey in May targeting herring and blue whiting. The edge of the distribution has also been found progressively further north and west. However, the mackerel was mainly found in the eastern part of the survey area up to 67°N in May 2014, with few exceptions at western stations further south. This distribution is comparable to the May surveys in 2012 and 2013. It should be noted, however, that the sampling may not provide a representative picture of mackerel distribution because of its vertical distribution and relatively low trawling speed (Rybakov *et al.*WD to 2014 WGWIDE).

2.5.5.2 Acoustic estimates of mackerel in the Iberian Peninsula and Bay of Biscay (PELACUS)

PELACUS 0314 was carried out on board R/V Miguel Oliver from 12th March to 6th April. The methodology was similar to that of the previous surveys (see Carrera and Riveiro, WD for further details). Survey design consisted in a grid with systematic parallel transects with random start, separated by 8 nm, perpendicular to the coastline, covering the continental shelf from 40 to 1000 m depth and from Portuguese-Spanish border to the Spanish-French one. (Figure 2.5.5.2.1). The backscattering acoustic energy from marine organisms is measured continuously during daylight using 18, 38, 120 and 200 kHz transducers previously calibrated according to the standard procedures. Pelagic trawls are carried out whenever possible to help identify the species (and size classes) that reflect the acoustic energy. For this purpose a series of TS length relationship are used as shown in Table 2.5.5.2.1. In the case of boarfish, two different TS length relationships were used, one corresponding to the historical value (b20=-72.6 dB) and the other corresponding to the recent estimation made by Fässler *et al.*(2013) (b20=-66.2 dB) A continuous underwater fish egg sampler with an internal water intake located at 5 m depth is used to sample the composition of the ichthyoplankton while trained observers record marine mammal, seabird, floating litter and vessel presence and abundance. At night, data on the hydrography and hydrodynamics of the water masses are collected via the deployment of rosettes and conductivity, temperature and depth sensors. Information on the composition, distribution and biomass of phytoplankton and zooplankton is derived from the analyses of samples taken by plankton nets.

A total of 3260 nautical miles were covered, 1075 of them corresponding to the survey track. Weather conditions were good along the survey period, except 5 days just in the middle of the survey, in coincidence with the change of part of the crew and the scientific staff. In the western areas (i.e. IXa-N) Sea Surface Temperature ranged from 13.18º to 22.27ºC, with a mean value of 14.13º (median, 14.07º). In the same way SSS, ranged from 28.28 to 36.31 ppm (mean 33.70 and median 33.91 ppm), with a strong correlation with longitude, being waters less salted and warmer close to the coast due to the river flows. Fluorescence ranged from 0.84 to 2.75 (mean 1.20, median , 1.12). In the northern areas (VIIIc) temperature ranged from 12.58º to 14.92ºC (mean, 13.26º, median 13.18º) being 0.75º colder than that of the western area. In addition, salinity ranged from 31.64 to 36.04 ppm (mean 35.23, median 35.34 ppm), thus water was saltier than in the western area. Fluorescence ranged from 0.94 to 3.63 (mean 1,64, median 1.52).

A total of 52 fishing station were performed (Figure 2.5.5.2.2). Mackerel was the most abundant fish species (34% of the total catch in number) and was also present in the 88% of the fishing hauls and mainly occurred in the Cantabrian Sea although some adults together with juveniles has been caught in IXa-N and VIIIc-west. In these areas mean length was around 24 cm, without significant differences in length distribution (Kolmogorov Smirnov test) whilst in the Cantabrian Sea mean length increased up to 35cm, thus spawners, with slight differences but significant in both mean length and length distribution between those hauls performed in shallower waters (<140 m depth) and those located close to the shelf edge.

Total mackerel biomass estimate was 811 462 tonnes, corresponding to 1 725 million fish (Table 2.5.5.2.2 and 2.5.5.2.3), 47 % higher than the previous year (244 809 t corresponding to 1 725 million fish). As in previous year juveniles were mainly located in the western part (VIIIc-w and IXaN), where age group 1 accounted for the 83% of total fish number and the 63% of the total biomass. In the Cantabrian Sea (VIIIc-East), where the bulk of the population was located (97% of the fish number and 99% of the total biomass), age groups 4, 5 and 6 accounted for the 65% of the total biomass. On the other hand, age group 2 only represents the 1% of the total abundance. This result is consistent with that obtained the previous year when the strength of age class 1 was weak (Figure 2.5.5.2.3).

During this years survey, mackerel mainly occurred in a subsurface layer, located at around 50 m depth. Besides it showed very strong diving reactions especially when marine mammals (mainly common dolphin) were present. Besides, it showed rapid ascendant movements from the sea bottom (Figure 2.5.5.2.4).

On the other hand, the times series of mackerel stomach contents (1999-2014) has been presented this year. Data came from the biological samples obtained in different trawls hauls during PELACUS (i.e. only day time data). Figure 2.5.5.2.5 shows the percentage of non empty stomachs. 75% of stomachs analyzed, ranging from to 56 to 92%, were full or partial full. Main prey has varied along time series, but copepods and mackerel eggs were the most important preys in number along the time series. In volume, three periods can be distinguished; from 2001 to 2004 salps accounted for around 54% of the stomach volume; 2006 to 2011 when copepods accounted for the 40% of the total stomach volume, reaching the maximum in 2009 and then showing a continuous declining trend; and since 2011 when crustacean became more important (Euphausiacea, Mysidacea, Decapoda, both adult and larvae) (Figure 2.5.5.2.6)

2.6 Stock Assessment

NEA Mackerel was classed as an update assessment this year. The final assessment was carried out by fitting the state-space assessment model SAM (Nielsen and Berg, 2014) using the web interface on stockassessment.org (assessment name: NEA-Mac-WGWIDE-2014-V2) following the settings defined by the 2014 benchmark assessment (ICES CM 2014/ACOM: 43) and described in the Stock Annex. The assessment model is fitted to catch-at-age data for ages 0 to 12 (plus group) for the period 1980 to 2013 (with a strong down-weighting of the catches for the period 1980—1999) and three surveys: 1) the SSB estimates from the triennial Mackerel Egg survey (every three year in the period 1992—2013), 2) the recruitment index from the western Europe shelves IBTS Q4 surveys (1998–2013) and 3) the abundance estimates for ages 6 to 11 from the

IESSNS survey (2007 and 2010–2014). The model also incorporates tagging-recapture data from the Norwegian tagging program (for fish recaptured between 1980 and 2005).

The new data used in this assessment compared to the previous assessment carried out in May 2014 for the update of the 2014 ICES advice (ICES CM 2014/ACOM:48) were:

- Revision of the entire egg survey SSB time series (see Section 2.5.1).
- Addition of the year 2013 in the IBTS recruitment index
- Addition of the year 2014 data in the IESSNS indices
- Addition of the 2013 catch-at-age, weights-at-age in the catch and in the stock and maturity ogive, proportions of natural and fishing mortality occurring before spawning.

Input parameters and configurations are summarized in Table 2.6.1. The input data are given in Tables 2.6.2 to 2.6.9. Given the size of the data base (1700 lines) the tagging data are not presented in this report, but are available on stockassessment.org in the data section. Model outputs are given in table 2.6.10—13.

2.6.1 Model diagnostics

The estimated parameters for the final model and their uncertainty estimates are shown in Table 2.6.10. The model gives a good fit to the catch data (lowest observation variance). Among the surveys, the egg survey has the lowest observation variance (best fit). The IESSNS survey and the recruitment index both have a higher observation variance. CVs on the observation variances are usually large (from 18 to 33%). The catchability of the egg survey is 1.47, significantly larger than 1, which implies that the assessment considers the egg survey index to be an overestimate. The uncertainty on the estimated catchabilities is higher for the recruitment index and for the IESSNS indices and lower for the egg survey index. Post-release survival for tagged fish is estimated at 38.3% with a low associated CV.

There are few strong correlations between the fitted parameters (Figure 2.6.1.1). The only exception is the negative correlation between the random walk variance for the fishing mortalities and the observation variance of the catches (i.e. stable F with large residuals to the catches vs. variable F with good fit to the catches). Otherwise, the majority of the other parameters appear independent of each other, which is an encouraging sign.

Residuals for the catches did not show any temporal pattern (Figure 2.6.1.2). Residuals for ages 0 and 1 are larger than for subsequent ages 2 to 6. Residuals for ages 7 to 12 are also larger than for ages 2 to 6. This suggest that decoupling the observation variance of the catches (for example by grouping age 0 and 1, ages 2 to 6 and ages 7 and older) could have been more appropriate. However, exploratory runs showed that such a configuration resulted in a more unstable model. Residuals for the surveys are given in Figures 2.6.1.3 to 2.6.1.5. Residuals for the egg survey show a slight temporal pattern with positive residuals in the period 1995—2001 and negative residuals since 2010. The model estimates a steeper increase in the SSB in the recent years than what is indicated by the egg survey. Residuals to the recruitment index also indicate that the model consistently overestimates the recruitment compared to the index during the period 2006 to 2010 while the index suggests higher recruitment than the model for the years 2004, 2005 and 2013. The data used to compute the recruitment index does not fully cover all nursery areas of mackerel. This may be an explanation for the pattern observed in the residuals (e.g. gradual change in the contribution of the nursery grounds in relation to the total recruitment). Residuals for the IESSNS indices were in general small, except for the year 2007 where large negative residuals were observed for most ages; and in 2010 and 2011 for age 11 (Figure 2.6.1.5). The spatial coverage of the IESSNS in 2007 was quite small compared to the subsequent years, which might explain this year effect.

Residuals for the tag recaptures do not show any temporal or age pattern (Figure 2.6.1.6).

2.6.2 State of the Stock

The stock summary is presented in Figure 2.6.2.1 and Table 2.6.11. The spawning stock biomass is estimated to have varied between 2 million tonnes in the late 1990s and early 2000s and 4.5 million tonnes in 2011. SSB remains stable in the most recent years. The fishing mortality has been declining since the mid-2000s and seems to have stabilized at around 0.22 in the recent years. The recruitment time series from the assessment shows a clear increasing trend since the late 1990s in which two very large year classes (2 to 3 times the average) are superimposed (2002 and 2006). The 2010 year class appears to be large compared to the long term average. The model indicates that the 2011 and 2012 recruitments are very large (similar to the 2002 year-class). There is insufficient information to estimate accurately the size of the 2013 year class.

There is some indication of changes in the selectivity of the fishery over the last 20 years (Figure 2.6.2.2). In the year 1990, the fishery seems to have exerted a high fishing mortality on the fish 7 years and older. This changed gradually until 2000, when the fishing mortality on younger ages (5- and 6-year-olds) increased compared to the older fish. In the following years, the selectivity pattern changed again towards a lower fishing mortality on the age-classes younger than 7 years until 2008. Finally, in the recent years, the fishing mortality on younger ages (4 to 7) increased again compared to the older ages.

2.6.3 Quality of the assessment

Large confidence intervals are associated with the SSB in the years before 1992. This results from the absence of information from the egg survey index, the downgrading of the information from the catches and the assessment being only driven by the tagging data and natural mortality in the early period. The confidence intervals become narrower from the early 1990s to the mid-2000s, corresponding to the period where information is available from the egg survey index, the tagging data and (partially) catches. The uncertainty increases again in the recent years, for the period when the IESSNS indices are introduced, and where no tagging data are available and where catches are not providing sufficient information of the most recent year classes. The SSB estimate for 2013 is estimated with a precision of +/- 25% (Figures 2.6.2.1 and 2.6.2.3). There is generally also a large uncertainty on the fishing mortality, especially before 1995. The estimate of F_{bar} in 2013 has a precision of +/- 33%. The uncertainty on the recruitment is high for the years before 1998 (precision of on average +/- 55%). The precision improves slightly for the years for which the recruitment index is available (+/- 45%) except for the last estimated recruitment (+/- 63%).

Given the short length of the IESSNS time series, the retrospective analysis could not be carried out for more than 4 years (Figure 2.6.2.4). There is no systematic retrospective pattern observed for the SSB. Removing one or two years (2013 and 2012) of data had almost no effect on the estimated SSB. Removing 3 and 4 years (2011 and 2010) affected the perception of SSB for the year 2009 and 2010 but did not affect the earlier years. A retrospective pattern is however observed for the fishing mortality. The value of F_{bar} is systematically revised upward for the inclusion of each additional year of data. The magnitude of this revision is small, and well within the confidence intervals of F_{bar}. The revision however is not limited to the most recent year, but affects all estimates since 2005.

Removing 3 or 4 years of data leaves only 3 and 2 data points to estimate the catchability of the IESSNS, respectively, which considerably increases the uncertainty on this parameter. In this situation, the IESSNS has a much lower influence on the assessment and the output is comparable to the run that leaves out the IESSNS (Figure 3.6.4.5.2 in the 2014 WKPELA benchmark workshop (ICES CM 2014/ACOM: 43)). The short length of the IESSNS time series is, therefore, a source of instability in the assessment. However, this is not the most likely explanation for the retrospective pattern observed in the fishing mortality. This pattern was already observed in the past (see e.g. ICES CM 2012/ACOM:15) when the assessment was run with ICA and included only the egg survey as a tuning index.

2.7 Short term forecast

The short-term forecast provides estimates of SSB and catch in 2015 and 2016, given assumption of the current year's (also called intermediate year) catch and a range of management options for the catch in 2015.

All procedures used this year follow those used in the benchmark of 2014 as described in the Stock Annex.

2.7.1 Intermediate year catch estimation

Estimation of catch in the intermediate year (2014) is based on declared quotas as shown in the text table below. Modifications of the total of the declared quotas in 2014 come from: inter-annual transfer of quotas not fished in 2013, discards and quota payback.

The detailed calculations of intermediate year catch for the short-term forecast (STF) are provided in the text tables below.

Estimation of 2014 catch	Tonnes	Reference
EU quota	611205	Coastal state agreement, 12 Mar 2014
Spanish payback	-9747	European Council Regulation 2011/165
EU quota deductions	-6568	EC press release 11/8 2014
Norwegian quota	279115	Coastal state agreement, 12 Mar 2014
Russian quota	116700	Estimate from Russian WGWIDE members
Discards	4664	Previous years estimate
Icelandic quota	147721	Ministry of Industries and Innovation: Press release 16 April 2014. No. 376/2014.
Inter-annual quota transfer 2013->2014 (IS)	6908	Fisheries Directory webpage
Faroese quota	156240	Coastal state agreement, 12 Mar 2014
Greenland quota	90000	Estimate from Greenland institute of Natural Resources
Total expected catch (incl. discard)	1396238	

WGWIDE assumes that the entire TAC will be taken by EU and Norway. However, the Coastal States agreement (12 Mar 2014) allows for a 10 % transfer to 2015 (also known as "banking"). This option may become relevant in 2014, due to the reduced export opportunities after the export ban to Russia was implemented. This unusual situation in the mackerel market economy has brought forward discussions of whether an extraordinary amount of transfer could be approved. Forecast scenarios were therefore run assuming 0, 10 and 20 % quota transfer by EU and Norway.

2.7.2 Initial abundances at age

The recruitment estimate at age 0 from the assessment in the terminal assessment year (2013) was considered too uncertain to be used, because this year class has not yet fully recruited into the fishery. The last recruitment estimate was therefore replaced by predictions from the RCT3 software (Shepherd, 1997). The RCT3 software evaluates the historical performance of the IBTS recruitment index, by performing a linear regression between the index and the SAM estimates over the period 1998 to 2012. The prediction of recruitment in 2013 is then calculated as a weighted mean of the IBTS index in 2013 and a time tapered geometric mean of the SAM estimates from 1990 to 2012. Note that the 2014 WKPELA benchmark workshop (ICES CM 2014/ACOM: 43) used another year range of SAM estimates (1998 to present), however, WGWIDE included the entire time series from 1990. WKPELA's argument for truncating the time series of recruit estimates was that the productivity of the stock may be different in recent years than in the early 1990s. However, this is already accounted for by using a time tapered geometric mean where the latest years are given more weight. The difference between these two approaches is minor (0.5 %).

The log(index) from IBTS in 2013 was 16.45, substantially higher than the time tapered geometric mean (15.50) from 1990—2012. RCT3 calculated the weighted mean to be 15.90 (8 064 mill). The weighting factors were 0.43 for the IBTS index and 0.57 for the time tapered geometric mean, given the historical performance of the IBTS index. RCT 3 output is given in Table 2.7.2.1.

2.7.3 Short term forecast

A deterministic short-term forecast was calculated using FLR. Table 2.7.3.1 lists the input data and Tables 2.7.3.2 and 2.7.3.3 provide projections for various fishing mortality multipliers and catch constraints in 2015.

Assuming catches for 2014 of 1 396 kt (0% banking by EU and Norway), F was estimated at 0.32 and SSB at 4.61 Mt in 2014. If catches in 2015 equal the catch in 2014, F is expected to increase to 0.36 in 2015 with a corresponding reduction in SSB to 3.84 Mt in spring 2016, assuming an F of 0.36 again in 2016.

Exploitation in 2015 at FMSY (0.25) will yield catches of 1 017 kt. If the target F range (0.20 to 0.22) in management plan is followed, then the yield in 2015 will be between 831 kt and 906 kt.

Forecasts were also performed assuming inter-annual quota transfer ("banking") from 2014 to 2015 by EU and Norway of 10 and 20%. For these forecasts, the amount of catches "banked" in 2014 was discounted from the intermediate year catch used as a constraint on the first year of the forecast. The corresponding intermediate year catches and quantities banked can be found in Tables 2.7.3.4 and 2.7.3.5, with the output of the forecast. The "advice" catches were then calculated for a range of management options for 2015, with corresponding "advice" F and SSB values. The amounts banked were then added to the "advice" catches and the forecast was run a second time using realised 2015 catches as a constraint for the year 2015 to estimate the effective F in 2015 and the realised SSB values. The underlying assumption is that the amounts banked in 2014 will not be taken into account in the calculation of the TAC advice for 2015, and that they will be added *a posteriori* to the TAC, resulting *de facto* in F values higher than the ones used as a basis to set the TAC.

Results in Tables 2.7.3.4 and 2.7.3.5 show that for an advice TAC for 2015 given based on the management plan target F=0.22, the effective fishing mortality after addition of the amounts banked in 2014 would be 0.27. In general, banking in 2014 would result in lower F in 2014, but equally high F in 2015 (as for the catches). It would only result in marginal difference in the 2015 and 2016 SSB (maximum difference of 4% observed for the 2016 SSB for the constant catch scenario and 20% banking).

2.8 Biological Reference Points

Following the ICES guidelines, the 2014 WKPELA benchmark workshop (ICES CM 2014/ACOM:43) set new reference points for NEA mackerel. The new values are listed in Table 2.8.1, and their technical bases are described below.

2.8.1 Precautionary reference points

B_{lim} **-** There is no evidence of significant reduction in recruitment at low SSB within the time series hence the previous basis for B_{lim} was retained. B_{lim} is taken as B_{loss}, the lowest estimate of spawning stock biomass from the revised assessment. This was estimated to have occurred in 2002; B_{loss} = 1 840 000 t.

F_{lim} **-** F_{lim} is derived from B_{lim} and is determined as the F that on average would bring the stock to B_{lim}; F_{lim} = 0.39.

B_{pa} **-** The ICES basis for advice requires that a precautionary safety margin incorporating the uncertainty in actual stock estimates leads to a precautionary reference point B_{pa}, which is a biomass reference point with a high probability of being above B_{lim}. B_{pa} was calculated as B_{lim} * exp(1.645σ) where σ = 0.15 (the estimate of uncertainty associated with the spawning biomass as estimated in the 2013 assessment in the most recent year (2012)); B_{pa} = 2 350 000t.

F_{pa} **-** F_{pa} is derived from B_{pa} and is determined as the F that on average would bring the stock to B_{pa}; F_{pa} = 0.26.

2.8.2 MSY reference points

The ICES MSY framework specifies a target fishing mortality, F_{MSY}, which, over the long term, maximises yield, and also a spawning biomass, MSY $B_{trigger}$, below which target fishing mortality is reduced linearly relative to the SSB $B_{trigger}$ ratio.

Following the ICES guidelines (ICES CM 2013/ACOM:37), WKPELA found that F=0.25 would be an appropriate F_{MSY} target as on average it resulted in the highest mean yields with a low risk of reducing the spawning biomass below B_{lim}.

The ICES basis for advice notes that, in general, F_{MSY} should be lower than F_{pa}, and MSY $B_{trigger}$ should be equal to or higher than B_{pa}. ICES WKMSYREF2 (ICES CM 2014/ACOM:47) highlighted that the values of F_{MSY} should be checked using stochastic simulation to ensure that expected errors in the advice do not result in >5% probability of SSB< B_{lim}.

Given the combination of changes described above it is to be expected that the current management plan fishing mortality target range will still be precautionary, and ICES can continue to provide advice under this plan. However, the current management plan $B_{trigger}$ is below the revised B_{pa} therefore it would not be precautionary. The management plan is in the process of being re-evaluated and should provide the appropriate combination of $B_{trigger}$ and fishing mortality range consistent with the precautionary approach.

2.9 Comparison with previous assessment and forecast

The last available assessment was carried out in spring 2014 to update the ICES advice for 2014. This assessment was based on catch data going up to 2012 (ICES CM 2014/ACOM:48). The new 2014 WGWIDE assessment gives a revised perception of the stock (text table below and Figure 2.9.1). The differences in the 2012 TSB and SSB estimates between the previous and the present assessments are small. The 2012 fishing mortality estimate has been revised upwards.

	TSB 2012	SSB 2012	F4-8 2012
2014 advice update assessment	5677 kt	4408 kt	0.190
2014 WGWIDE assessment	5548 kt	4181 kt	0.213
% difference	-2%	-5%	12%

A comparison of the model parameters estimated is given in Table 2.6.10. Parameter values (and their CVs) are quite similar to the previous assessment. The main differences are found in the observation variances, which have increased, except for the IBTS recruitment index which is now fitted better in the model. These changes are however not significant considering the uncertainty on these parameters. The only parameter significantly different is the catchability of the egg survey. This can be explained by the revision of the egg survey time series. The revised index being consistently higher than the old one, this explains the increase in the survey catchability.

The uncertainty on the SSB and $F_{bar4\text{-}8}$ for the last year in the assessment is very similar to the previous assessment.

The prediction of mackerel catch for 2013 used for the short-term forecast in the 2014 advice update assessment was 895 kt, about 37 kt (4%) lower than the 2013 catch reported in 2014 used in the present assessment (text table below). Most of this difference is explained by the actual overcatch of the 2013 quotas (69 kt) being larger than the estimate from the 2013 WGWIDE (7kt). The anticipated 2013 discards (15 kt) used in the previous forecast were substantially higher that the 2013 discards reported in 2014 (5kt).

The new assessment produced an estimate of the SSB in 2013 of 4.3Mt, which is 2.5% lower than the forecast estimate. The fishing mortality $F_{bar4\text{-}8}$ for 2013 estimated this year is 13% higher than the value estimated by the short term forecast in the previous assessment. Most of these discrepancies can be explained by the revision of the perception of the stock described above.

	Catch (2013)	SSB (2013)	F4-8(2013)
2014 advice update assessment	895 kt	4408 Mt	0.188
2014 WGWIDE assessment	932 kt	4300 Mt	0.217
% difference	3.97%	-2.51%	13.36%

2.10 Management Considerations

The stock assessment for NE Atlantic mackerel was benchmarked in 2014 (ICES CM 2014/ACOM:43). This led to a revised perception of the stock compared to the last assessment of the stock in 2012. SSB from the 2014 assessment is now estimated to have varied between 2 million tonnes in the late 1990s and early 2000s and 4.5 million tonnes in 2011; this compares to 1.6 and 3 million tonnes over the same period in the 2012 assessment.

Despite the changes in the stock assessment, the current Management Plan fishing mortality target range is still considered to be precautionary, and ICES can continue to provide advice under this plan. However, it may no longer result in a long-term maximisation of the yield. The Management Plan will be re-evaluated in late 2014 and should provide the appropriate combination of $B_{trigger}$ and fishing mortality range consistent with the precautionary approach and MSY objectives.

In 2014, as in all years since 2008, unilateral quotas have been set, which together are higher than the TAC indicated by the Management Plan. The updated scientific advice for 2014 was for an upper catch limit of 1.011 Mt. The agreed Coastal States decision, between EU, Norway and Faroes, was 1.24 Mt (equivalent to F=0.28). However, in addition to these figures, Greenland declared a catch limit of 100000 tonnes in its waters, Iceland a catch limit of 147721 tonnes for its fisheries and Russia 102211 tonnes for its fisheries. The WG estimate of removals in 2014, taking into account payback and deductions, is ~1.4 Mt, 38% higher than the upper bound of the scientific advice, corresponding to a fishing mortality of F=0.32. ICES notes that both the agreed TAC and the sum of the declared catch limits exceed the advised fishing mortality based on FMSY (FMSY = 0.25) as well as the precautionary limit for F (Fpa = 0.26).

2.11 Ecosystem considerations

An overview of the main ecosystem drivers possibly affecting the different life-stages of Northeast Atlantic mackerel and relevant observations are given in the Stock Annex. The discussion here is limited to recent features of relevance.

A forward shift in timing of spawning migration from April to March has been indicated during the last decade (Punzón and Villamor 2009). In winter 2011—2012 the timing of the spawning migration was even more pronounced in the Cantabrian Sea from early January to February compared to March and April just some years before. This suggested a temporal shift of about two months, with an earlier spawning migration pattern of mackerel into the southern area in winter 2012 compared to earlier times, which might be linked to increased temperatures during winter and spring in the last few years. However, the triennial egg survey in 2013 showed that the peak of spawning in the Cantabrian Sea was later than in both 2007 and 2010.

Measuring available planktonic food and actual feeding of mackerel is a crucial task for improved understanding of mackerel ecology. Measurements show plankton concentrations in May in the Norwegian Sea have been increasing since the lowest level in 2009—2010 over the time series since 1996, and are currently at a similar level as before the decrease (Nottestad *et al.*, 2014 WD to WGWIDE). Moreover, in coherence with the

IESNS in May 2014, increased densities of plankton were found in the central and particularly northern part of the Norwegian Sea in July-August 2014, whereas there was a marked decrease in plankton concentrations in Iceland and Greenland water (Nøttestad *et al*., 2014 WD to WGWIDE).

A large spatial expansion of the mackerel stock has been measured by systematic and standardized pelagic trawling in the Nordic Seas in summers from 2007—2014 (Nøttestad *et al.*2014 WD to WGWIDE). Simultaneously to this expansion, the summer surface temperatures have been high in the Nordic Seas (Hughes *et al.*2011; Nøttestad *et al*., 2012; 2013; 2014 WDs to WGWIDE). The sea surface temperature anomaly (SSTA) for July 2014 showed that the temperatures in the Nordic Seas were about 1—3°C above long-term mean over the last 20 years. More or less the entire Northeast Atlantic Ocean including the Norwegian Sea was significantly warmer compared to the long-term average. The high surface temperatures observed in the Nordic Seas during summer in recent years, especially in 2014, have largely increased the potential feeding habitat for mackerel within their preferred "comfort" zone of above 6-7°C.

In the southern part of the distribution area mackerel overlap with chub mackerel (Scomber colias), the landing have increased from the 1990s to the 2000s (Table 2.11.1), if this reflect an increase in abundance, increased interspecific competition with mackerel is possible.

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Table 2.2.1. 2013 Mackerel fleet composition of major mackerel catching nations.

Country	Len (m)	Engine power (hp)	Gear	Storage	No vessels
Denmark	57-63	4077-8188	Trawl	Tank	5
	57-77	2475-6689	Purse Seine	Tank	6
Faroe Islands	49-69	2400-4000kw	Purse Seine/Trawl	RSW	4
	70-79	3900-8000kw	Purse Seine/Trawl	RSW	5
	68-90	3200-6000kw	Trawl	Freezer	2
	<50		Trawl		30
France			Pelagic Trawl	Dry Hold	9
			Pelagic Trawl	Freezer	3
Germany	90-140	3800-12000	Single Midwater Trawl	Freezer	4
Greenland	50-65	2991-5017	Pelagic Trawl	Freezer	4
	55-75	4076-7600	Pelagic Trawl	Freezer/RSW	12
	75-95	7192-8048	Pelagic Trawl	Freezer/RSW	5
	95-115	4351-8049	Pelagic Trawl	Freezer	3
	115-125	3600-7831	Pelagic Trawl	Freezer	3
Iceland	51-60	2502-4079	Single Midwater Trawl	RSW, Freezer	6
	61-70	2000-7507	Single Midwater Trawl	RSW, Freezer	17
	71-80	3200-11257	Single Midwater Trawl	RSW, Freezer	12
	>80	8051	Single Midwater Trawl	Freezer	1
Ireland	16-37	171-1119	Midwater Trawl	Dryhold	4
	48-71	1007-3460	Midwater Trawl	RSW	9
	22-37	368-1119	Pair Midwater Trawl	Dryhold	20
	27-65	256-1499	Pair Midwater Trawl	RSW	14
Netherlands	55	2125	Pair Midwater Trawl	Freezer	1
	88-145	4400-10455	Single Midwater Trawl	Freezer	9
Norway	>27		Purse Seine		80
	21-27		Purse Seine		17
	<21		Purse Seine		164
			Trawler		21
			Handline/Gillnet		155
Portugal	10-20		Trawl	Freezer	2
	20-30		Trawl	Freezer	7
	30-40		Trawl	Freezer	5
	0-10		Trawl	Other	259
	10-20		Trawl	Other	68
	20-30		Trawl	Other	60
	30-40		Trawl	Other	29

	0-10		Purse Seine	Other	79
	10-20		Purse Seine	Other	103
	20-30		Purse Seine	Other	79
Spain	18-24	147-294.3	Trawl	Dryhold	2
	24-40	161.9-529.8	Trawl	Dryhold	57
	0-10	33.8	Purse Seine	Dryhold	1
	10-12	33.8-106.7	Purse Seine	Dryhold	113
	12-18	20.6-241.4	Purse Seine	Dryhold	119
	18-24	69.9-397.4	Purse Seine	Dryhold	2
	24-40	139.8-809.4	Purse Seine	Dryhold	3
	0-10	4.4-73.6	Handline	Dryhold	81
	10-12	11.8-117.7	Handline	Dryhold	113
	12-18	17.7-167.8	Handline	Dryhold	119
	18-24	161.9-184.0	Handline	Dryhold	2
	24-40	232.5-331.1	Handline	Dryhold	3
	0-10	27.2-73.6	Gillnet	Dryhold	3
	10-12	20.6-117.7	Gillnet	Dryhold	16
	12-18	29.4-241.4	Gillnet	Dryhold	44
	18-24	110.4-397.4	Gillnet	Dryhold	23
	24-40	128.8-809.4	Gillnet	Dryhold	6

Table 2.2.4. Overview of major existing regulations on mackerel catches

Technical measure	National/International level	Specification	Note
Catch limitation	Coastal States/NEAFC	2010, 2011, 2012: not agreed	
Management plan	European (EU, NO)	If SSB >= 2.200.000t, F = 0.2 to 0.22 If SSB is between 1.670.000t and 2.200.000t, F = 0.22 * SSB/2.200.000 TAC should not be changed more than 20% If SSB < 1.670.000t, parties shall decide on a TAC which is less than that arising from the calculation above	
Minimum size (North Sea)	European (EU, NO, Fo)	30cm in the North Sea	
Minimum size (all areas except North Sea)	European (EU, FO)	20cm in all areas except North Sea	10% undersized allowed
Minimum size	National (NO)	30cm in all areas	
Catch limitation	European (EU, NO, FO)	Within the limits of the quota for the western component (VI,VII, VIIIabde, Vb(EC), IIa(nonEC), XII, XIV), a certain quantity may be taken from IVa but only during the periods 1 January to 15 February and 1 October to 31 December.	
Area closure	National (UK)	South-West Mackerel Box off Cornwall	except where the weight of the mackerel does not exceed 15 % by liveweight of the total quantities of mackerel and other marine organisms onboard which have been caught in this area
Area limitations	National (IS)	Pelagic trawl fishery only allowed outside of 200m depth contours around Iceland and/or 12 nm from the coast.	
Quota adaptation	European (EU)	Reducing of Spanish mackerel quota with a scheduled payback until 2015 following the exceeding of fishing opportunities in 2010	

Technical measure	National/International level	Specification	Note
National catch limitations by gear, semester and area	National (ES)	30.5% of the Spanish national quota is assigned for the trawl fishery, 27.7% for purse seiners and 34.6% for the artisanal fishery	90,6 % of the Spanish national quota should be caught in ICES Div, IXa N and VIIIc. Besides, a 30.5% is assigned to the trawler fleet (8 tm as maximum daily catch per vessel), 27.7% to purse seiner (8 tm as maximum daily catch per vessel) and 34.6% to the artisanal fleet (2.3 tm as maximum daily catch per vessel); for all of them, a 7% of the catches should be kept for the second half of the year.
High-grading ban	European (EU)	High-grading (discarding fish of lower commercial value due to limited space on board) is banned in European water	
Discard prohibition	National (NO, IS, FO)	All discarding is prohibited for Norwegian, Icelandic and Faroese vessels	

Table 2.3.1.1. NE Atlantic Mackerel. Catches by area (t). Discards not estimated prior to 1978 (data submitted by Working Group members).

Year	Subarea VI			Subarea VII and Divisions VIIIabde			Subareas III and IV			Subareas I,II,V and XIV			Divisions VIIIc and IXa			Total		
	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch
1969	4800		4800	47404		47404	739175		739175	7		7	42526		42526	833912		833912
1970	3900		3900	72822		72822	322451		322451	163		163	70172		70172	469508		469508
1971	10200		10200	89745		89745	243673		243673	358		358	32942		32942	376918		376918
1972	13000		13000	130280		130280	188599		188599	88		88	29262		29262	361229		361229
1973	52200		52200	144807		144807	326519		326519	21600		21600	25967		25967	571093		571093
1974	64100		64100	207665		207665	298391		298391	6800		6800	30630		30630	607586		607586
1975	64800		64800	395995		395995	263062		263062	34700		34700	25457		25457	784014		784014
1976	67800		67800	420920		420920	305709		305709	10500		10500	23306		23306	828235		828235
1977	74800		74800	259100		259100	259531		259531	1400		1400	25416		25416	620247		620247
1978	151700	15100	166800	355500	35500	391000	148817		148817	4200		4200	25909		25909	686126	50600	736726
1979	203300	20300	223600	398000	39800	437800	152323	500	152823	7000		7000	21932		21932	782555	60600	843155
1980	218700	6000	224700	386100	15600	401700	87931		87931	8300		8300	12280		12280	713311	21600	734911
1981	335100	2500	337600	274300	39800	314100	64172	3216	67388	18700		18700	16688		16688	708960	45516	754476
1982	340400	4100	344500	257800	20800	278600	35033	450	35483	37600		37600	21076		21076	691909	25350	717259
1983	320500	2300	322800	235000	9000	244000	40889	96	40985	49000		49000	14853		14853	660242	11396	671638
1984	306100	1600	307700	161400	10500	171900	43696	202	43898	98222		98222	20208		20208	629626	12302	641928
1985	388140	2735	390875	75043	1800	76843	46790	3656	50446	78000		78000	18111		18111	606084	8191	614275
1986	104100		104100	128499		128499	236309	7431	243740	101000		101000	24789		24789	594697	7431	602128
1987	183700		183700	100300		100300	290829	10789	301618	47000		47000	22187		22187	644016	10789	654805
1988	115600	3100	118700	75600	2700	78300	308550	29766	338316	120404		120404	24772		24772	644926	35566	680492

Year	Subarea VI			Subarea VII and Divisions VIIIabde			Subareas III and IV			Subareas I,II,V and XIV			Divisions VIIIc and IXa			Total		
1989	121300	2600	123900	72900	2300	75200	279410	2190	281600	90488		90488	18321		18321	582419	7090	589509
1990	114800	5800	120600	56300	5500	61800	300800	4300	305100	118700		118700	21311		21311	611911	15600	627511

Table 2.3.1.1. NE Atlantic Mackerel. Catches by area (t). Continued.

Year	Subarea VI			Subarea VII and Divisions VIIIabde			Subareas III and IV			Subareas III,V and XIV			Divisions VIIIc and IXa			Total		
	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch
1991	109500	10700	120200	50500	12800	63300	358700	7200	365900	97800		97800	20683		20683	637183	30700	667883
1992	141906	9620	151526	72153	12400	84553	364184	2980	367164	139062		139062	18046		18046	735351	25000	760351
1993	133497	2670	136167	99828	12790	112618	387838	2720	390558	165973		165973	19720		19720	806856	18180	825036
1994	134338	1390	135728	113088	2830	115918	471247	1150	472397	72309		72309	25043		25043	816025	5370	821395
1995	145626	74	145700	117883	6917	124800	321474	730	322204	135496		135496	27600		27600	748079	7721	755800
1996	129895	255	130150	73351	9773	83124	211451	1387	212838	103376		103376	34123		34123	552196	11415	563611
1997	65044	2240	67284	114719	13817	128536	226680	2807	229487	103598		103598	40708		40708	550749	18864	569613
1998	110141	71	110212	105181	3206	108387	264947	4735	269682	134219		134219	44164		44164	658652	8012	666664
1999	116362		116362	94290		94290	313014		313014	72848		72848	43796		43796	640311		640311
2000	187595	1	187595	115566	1918	117484	285567	165	304898	92557		92557	36074		36074	736524	2084	738608
2001	143142	83	143142	142890	1081	143971	327200	24	339971	67097		67097	43198		43198	736274	1188	737462
2002	136847	12931	149778	102484	2260	104744	375708	8583	394878	73929		73929	49576		49576	749131	23774	772905
2003	135690	1399	137089	90356	5712	96068	354109	11785	365894	53883		53883	25823	531	26354	659831	19427	679288
2004	134033	1705	134738	103703	5991	109694	306040	11329	317369	62913	9	62922	34840	928	35769	640529	19962	660491
2005	79960	8201	88162	90278	12158	102436	249741	4633	254374	54129		54129	49618	796	50414	523726	25788	549514
2006	88077	6081	94158	66209	8642	74851	200929	8263	209192	46716		46716	52751	3607	56358	454587	26594	481181
2007	110788	2450	113238	71235	7727	78962	253013	4195	257208	72891		72891	62834	1072	63906	570762	15444	586206
2008	76358	21889	98247	73954	5462	79416	227252	8862	236113	148669	112	148781	59859	750	60609	586090	37075	623165
2009	135468	3927	139395	88287	2921	91208	226928	8120	235049	163604		163604	107747	966	108713	722035	15934	737969
2010	106732	2904	109636	104128	4614	108741	246818	883	247700	355725	5	355729	49068	4640	53708	862470	13045	875515

Year	Subarea VI			Subarea VII and Divisions VIIIabde			Subareas III and IV			Subareas III,V and XIV			Divisions VIIIc and IXa			Total		
2011	160756	1836	162592	51098	5317	56415	301746	1906	303652	398132	28	398160	24036	1807	25843	935767	10894	946661
2012	121114	952	122067	65728	9532	75261	218400	1046	219446	447207		447207	24941	3431	28372	877390	14963	892353
2013	132062	273	132335	49871	1589	51460	260921	333	261254	464481	13	464495	19732	2455	22188	927067	4664	931732

Table 2.3.2.1. NE Atlantic Mackerel. Catch (t) in the Norwegian Sea (IIa) and Area V 1984–2013 (Data submitted by Working Group members).

Country	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Denmark	11787	7610	1653	3133	4265	6433	6800	1098	251	
Estonia									216	
Faroe Islands	137				22	1247	3100	5793	3347	1167
France		16				11		23	6	6
Germany Fed. Rep.			99		380					
Germany Dem. Rep.			16	292		2409				
Iceland										
Ireland										
Latvia									100	4700
Lithuania										
Netherlands										
Norway	82005	61065	85400	25000	86400	68300	77200	76760	91900	100500
Poland										
Sweden										
United Kingdom			2131	157	1413		400	514	802	
USSR/Russia	4293	9405	11813	18604	27924	12088	28900	13361	42440	49600
Misreported (IVa)										
Misreported (VIa)										
Misreported (Ukn)										
Unallocated										
Discards										
Total	98222	78096	101112	47186	120404	90488	118700	97819	139062	165973

Table 2.3.2.1. NE Atlantic Mackerel. Catch (t) in the Norwegian Sea (IIa) and Area V 1984–2013. Continued.

Country	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Denmark		4746	3198	37	2090	106	1375	7	1	
Estonia	3302	1925	3741	4422	7356	3595	2673	219		
Faroe Islands	6258	9032	2965	5777	2716	3011	5546	3272	4730	
France	5	5		270						
Germany										
Greenland			1							
Iceland			92	925	357				53	122
Ireland						100				495
Latvia	1508	389	233							
Lithuania							2085			
Netherlands			561			661			569	44
Norway	141114	93315	47992	41000	54477	53821	31778	21971	22670	125481
Poland				22						
Sweden								8		
United Kingdom	1706	194	48	938	199	662		54	665	692
Russia	28041	44537	44545	50207	67201	51003	491001	41566	45811	40026
Misreported (IVa)	-109625	-18647			-177	-40011				
Misreported (VIa)						-100				
Misreported (Ukn)									-570	
Unallocated										-44
Discards										
Total	72309	135496	103376	103598	134219	72848	92557	67097	73929	53883

Table 2.3.2.1. NE Atlantic Mackerel. Catch (t) in the Norwegian Sea (IIa) and Area V 1984–2013. Continued.

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark							4845	269		391
Estonia										13671
Faroe Islands	650	30		278	123	2992	66312	121499	107198	142976
France	2	1						2		197
Germany				7					101	74
Greenland								621	52841	527831
Iceland		363	4222	36706	112286	1161601	1210081	1592631	1492821	1512351
Ireland	471							90		
Latvia										
Lithuania										
Netherlands	34	2393		10	72		90	178	5	1
Norway	10295	13244	8914	493	3474	3038	104858	43168	110741	33817
Poland										
Sweden									4	825
United Kingdom	2493				4					2
Russia	49489	40491	33580	35408	32728	414141	58613	73601	74587	80812
Misreported (IVa)										
Misreported (VIa)										
Misreported (Ukn)	-553									
Unallocated	32	-2393		-10	-18					
Discards	9				112		5	28		131
Total	62922	54129	46716	72891	148781	163604	355729	398160	447202	464495

1 – includes catches in I, XII and XIVb

Table 2.3.2.2. NE Atlantic Mackerel. Catch (t) in the North Sea, Skagerrak and Kattegat (Sub-area IV and IIIa) 1988-2013 (Data submitted by Working Group members).

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Belgium	20	37		125	102	191	351	106	62	114
Denmark	32588	26831	29000	38834	41719	42502	47852	30891	24057	21934
Estonia					400					
Faroe Islands		2685	5900	5338		11408	11027	17883	13886	32882
France	1806	2200	1600	2362	956	1480	1570	1599	1316	1532
Germany Fed. Rep.	177	6312	3500	4173	4610	4940	1497	712	542	213
Iceland										
Ireland		8880	12800	13000	13136	13206	9032	5607	5280	280
Latvia					211					
Netherlands	2564	7343	13700	4591	6547	7770	3637	1275	1996	951
Norway	59750	81400	74500	102350	115700	112700	114428	108890	88444	96300
Poland										
Romania							2903			
Sweden	1003	6601	6400	4227	5100	5934	7099	6285	5307	4714
United Kingdom	1002	38660	30800	36917	35137	41010	27479	21609	18545	19204
USSR (Russia from 1990)										3525
Misreported (IIa)							109625	18647		
Misreported (VIa)	180000	92000	126000	130000	127000	146697	134765	106987	51781	73523
Misreported (Unknown)										
Unallocated	29630	6461	-3400	16758	13566			983	236	1102
Discards	29776	2190	4300	7200	2980	2720	1150	730	1387	2807
Total	338316	281600	305100	365875	367164	390558	472397	322204	212839	229487

Table 2.3.2.2. NE Atlantic Mackerel. Catch (t) in the North Sea, Skagerrak and Kattegat (Sub-area IV and IIIa) 1988-2013. Continued.

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	20071
Belgium	125	177	146	97	22	2	4	1	3	1
Denmark	25326	29353	27720	21680	343751	275081	25665	232121	242191	252171
Estonia										
Faroe Islands	4832	4370	10614	18751	12548	11754	11705	9739	12008	11818
France	1908	2056	1588	1981	2152	1467	1538	1004	285	7549
Germany	423	473	78	4514	3902	4859	4515	4442	2389	5383
Iceland		357								
Ireland	145	11293	9956	10284	20715	17145	18901	15605	4125	13337
Latvia										
Netherlands	1373	2819	2262	2441	11044	6784	6366	3915	4093	5973
Norway	103700	106917	142320	158401	161621	150858	147068	106434	113079	131191
Poland								109		
Romania										
Sweden	5146	5233	49941	5090	52321	4450	4437	3204	3209	38581
United Kingdom	19755	32396	58282	52988	61781	67083	62932	37118	28628	46264
Russia	635	345	1672	1				4		
Misreported (IIa)		40000								
Misreported (VIa)	98432	59882	8591	39024	49918	62928	23692	37911	8719	
Misreported (Ukn)										
Unallocated	3147	17344	34761	24873	22985	-730	-783	7043	171	2421
Discards	4753		1912	24	8583	11785	11329	4633	8263	4195
Total	269700	313015	304896	339970	394878	365894	317369	254374	209192	257208

Table 2.3.2.2. NE Atlantic Mackerel. Catch (t) in the North Sea, Skagerrak and Kattegat (Subarea IV and IIIa) 1988-2013. Continued.

Country	2008	2009	2010	2011	2012	2013
Belgium	2	3	27	21	39	62
Denmark	26716	23491	36552	32800	36492	31924
Estonia						
Faroe Islands	7627	6648	4639	543	432	25
France	490	1493	686	1416	5736	1788
Germany	4668	5158	25621	52911	4560	5755
Iceland						
Ireland	11628	12901	14639	15810	20422	13523
Latvia						
Netherlands	1980	2039	1300	9881	6018	4863
Norway	114102	118070	129064	162878	64181	130056
Poland						
Romania						
Sweden	36641	73031	34291	32481	4560	2081
United Kingdom	37055	47863	52563	69858	75959	70840
Russia			696			4
Misreported (IIa)						
Misreported (VIa)	17280	1959				
Misreported (Ukn)						
Unallocated	2039	-629	660			
Discards	8862	8120	883	1906	1046	333
Total	236111	235049	247700	303652	219446	261254

[1-]**includes small catches in IIIb,c,d**

Table 2.3.2.3. NE Atlantic Mackerel. Catch (t) in the Western area (Sub-areas VI and VII and Divisions VIIIa,b,d,e) 1985–2013 (Data submitted by Working Group members).

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Belgium										
Denmark	400	300	100		1000		1573	194		2239
Estonia										
Faroe Islands	9900	1400	7100	2600	1100	1000				4283
France	7400	11200	11100	8900	12700	17400	4095		2350	9998
Germany	11800	7700	13300	15900	16200	18100	10364	9109	8296	25011
Guernsey										
Ireland	91400	74500	89500	85800	61100	61500	17138	21952	23776	79996
Isle of Man										
Jersey										
Lithuania										
Netherlands	37000	58900	31700	26100	24000	24500	64827	76313	81773	40698
Norway	24300	21000	21600	17300	700		29156	32365	44600	2552
Poland									600	
Spain				1500	1400	400	4020	2764	3162	4126
United Kingdom	205900	156300	200700	208400	149100	162700	162588	196890	215265	208656
Misreported (Area IVa)		-148000	-117000	-180000	-92000	-126000	-130000	-127000	-146697	-134765

Misreported (Unknown)										
Unallocated	75100	49299	26000	4700	18900	11500	-3802	1472		4632
Discards	4500			5800	4900	11300	23550	22020	15660	4220
Total	467700	232599	284100	197000	199100	182400	183509	236079	248785	251646

Table 2.3.2.3. NE Atlantic Mackerel. Catch (t) in the Western area (Sub-areas VI and VII and Divisions VIIIa,b,d,e) 1985–2013. Continued.

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Belgium										1
Denmark	1143	1271			552	82	835		113	
Estonia	361									
Faroe Islands	4284		24481	3681	4239	4863	2161	2490	2260	674
France	10178	14347	19114	15927	14311	17857	18975	19726	21213	18549
Germany	23703	15685	15161	20989	19476	22901	20793	22630	19200	18730
Guernsey										
Ireland	72927	49033	52849	66505	48282	61277	60168	51457	49715	41730
Isle of Man										
Jersey										
Lithuania										
Netherlands	34514	34203	22749	28790	25141	30123	33654	21831	23640	21132
Norway			223							
Poland										
Spain	4509	2271	7842	3340	4120	4500	4063	3483		

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
United Kingdom	190344	127612	128836	165994	127094	126620	139589	131599	167246	149346
Misreported (Area IVa)	-106987	-51781	-73523	-98255	-59982	-3775	-39024	-43339	-62928	-23139
Misreported (Unknown)										
Unallocated	28245	10603	4577	8351	21652	31564	37952	27558	5587	9714
Discards	6991	10028	16057	3277		1920	1164	15191	7111	7696
Total	270212	213272	196110	218599	204885	297932	280553	252620	233157	244432

Table 2.3.2.3. NE Atlantic Mackerel. Catch (t) in the Western area (Sub-areas VI and VII and Divisions VIIIa,b,d,e) 1985–2013. Continued.

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium					1	2			
Denmark			6	10		48	2889	8	903
Estonia									
Faroe Islands		59	1333	3539	4421	36	8		
France	15182	14625	12434	14944	16464	10301	11304	14448	12438
Germany	14598	14219	12831	10834	17545	16493	18792	14277	15102
Guernsey		10					10	5	9
Ireland	30082	36539	35923	33132	48155	43355	45696	42627	42988
Isle of Man						14	11	11	8
Jersey	9	8	6	7	8	6	7	8	8

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013
Lithuania		95	7				23		
Netherlands	18819	20064	18261	17920	20900	21699	18336	19794	16295
Norway			7	3948	121	30	2019	1101	734
Poland	461	1368	978						
Russia						1			
Spain	4795	4048	2772	7327	8462	6532	1257	773	635
United Kingdom	115586	67187	87424	768821	109147	107840	111103	93775	92957
Misreported (Area IVa)	-37911	-8719		-17280	-1959				
Misreported (Unknown)									
Unallocated	13412	4783	10042	-952	490	4503	399	16	-144
Discards	20359	14723	10177	27351	6848	7518	7153	10485	1862
Total	190597	169009	192201	177662	230603	218377	219007	197327	183795

Table 2.3.2.4. NE Atlantic Mackerel. Catch (t) in Divisions VIIIc and IXa, 1977–2013 (Data submitted by Working Group members).

Country	Div	1977	1978	1979	1980	1981	1982	1983	1984	1985
France	VIIIc									
Poland	IXa	8								
Portugal	IXa	1743	1555	1071	1929	3108	3018	2239	2250	4178
Spain	VIIIc	19852	18543	15013	11316	12834	15621	10390	13852	11810
Spain	IXa	2935	6221	6280	2719	2111	2437	2224	4206	2123
USSR	IXa	2879	189	111						
Total	IXa	7565	7965	7462	4648	5219	5455	4463	6456	6301
Total		27417	26508	22475	15964	18053	21076	14853	20308	18111

Country	Div	1986	1987	1988	1989	1990	1991	1992	1993	1994
France	VIIIc									
Poland	IXa									
Portugal	IXa	6419	5714	4388	3112	3819	2789	3576	2015	2158
Spain	VIIIc	16533	15982	16844	13446	16086	16940	12043	16675	21246
Spain	IXa	1837	491	3540	1763	1406	1051	2427	1027	1741
USSR	IXa									
Total	IXa	8256	6205	7928	4875	5225	3840	6003	3042	3899
Total		24789	22187	24772	18321	21311	20780	18046	19719	25045

Country	Div	1995	1996	1997	1998	1999	2000	2001	2002	2003
France	VIIIc									226
Poland	IXa									
Portugal	IXa	2893	3023	2080	2897	2002	2253	3119	2934	2749
Spain	VIIIc	23631	28386	35015	36174	37631	30061	38205	38703	17384
Spain	IXa	1025	2714	3613	5093	4164	3760	1874	7938	5464
Discards	VIIIc									531
Discards	IXa	3918	5737	5693	7990	6165	6013			
Total	IXa	27549	34123	40708	44164	43796	36074	4993	10873	8213
Total								43198	49575	26354

Table 2.3.2.4. NE Atlantic Mackerel. Catch (t) in Divisions VIIIc and IXa, 1977–2013 (D94ata submitted by Working Group members). Continued..

Country	Div	2004	2005	2006	2007	2008	2009	2010	2011	2012
France	VIIIc	177	151	43	55	168	383	392	44	283
Poland	IXa									
Portugal	IXa	2289	1509	2620	2605	2381	1753	2363	962	824
Spain	VIIIc			43063	53401	50455	91043	38858	14709	17768
Spain	IXa			7025	6773	6855	14569	7347	2759	845
Discards	VIIIc	928	391	3606	156	73	725	4408	563	2187
Discards	IXa		405	1	916	677	241	232	1245	1244
Unallocated	VIIIc	28429	42851						4691	4144
Unallocated	IXa	3946	5107					108	871	1076
Total	IXa	6234	7021	9646	10293	9913	16562	10049	5836	3989

Total		35768	50414	56358	63906	60609	108713	53708	25843	28372

Country	Div	2013
France	VIIIc	220
Poland	IXa	
Portugal	IXa	254
Spain	VIIIc	14617
Spain	IXa	1162
Discards	VIIIc	1428
Discards	IXa	1027
Unallocated	VIIIc	-573
Unallocated	IXa	4053
Total	IXa	6497
Total		22188

Table 2.3.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2013.

Quarters 1-4

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0							30.83	2259.26
1	14.18	0.05	0.13	0.19	4510.25	703.88	81.16	6633.01
2	143.07	0.35	1.38	1.47	96795.89	2160.72	1478.62	5201.75
3	362.29	0.28	1.16	1.17	184334.54	1175.84	314.18	3296.03
4	293.39	0.04	0.19	0.19	91991.97	542.26	0.57	2527.60
5	348.83	0.03	0.09	0.11	120107.89	516.82	0.20	1044.42
6	238.71	0.03	0.09	0.11	106602.70	468.65	77.80	922.83
7	195.03	0.01	0.06	0.05	79088.42	207.68	0.19	831.31
8	72.49	0.01	0.05	0.05	38093.59	72.98	0.19	417.25
9	46.11				19517.42	22.75		321.56
10	16.63				5855.13	31.31		220.14
11	0.39				3362.29	4.37		47.03
12	3.72				1644.76	1.21		135.07
13	0.39				124.88	0.19		72.07
14					85.49	0.18		
15+					0.00			125.90
SOP	650.4	0.2	0.7	0.7	259953.2	1352.7	465.9	5705.2
Cth	649.6	0.2	0.7	0.7	258791.2	1346.4	465.6	5632.4
SOP%	99.9%	100.0%	100.0%	100.0%	99.6%	99.5%	99.9%	98.7%

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0	0.09	0.45	0.03	2054.73	23.39		2045.53	3.22	
1	46.45	55.34	13.91	728.70	844.43	18.74	302.46	408.91	
2	54.90	106.80	38.94	729.82	513.54	48.17	217.85	1353.57	
3	31.25	531.11	37.12	692.22	282.93	17.09	211.68	3435.68	0.00
4	14.83	4261.23	139.21	432.12	138.27	11.83	134.80	4189.19	0.00
5	19.10	8463.41	200.53	250.09	39.42	6.68	128.55	7040.58	0.00
6	15.68	14979.08	321.98	156.84	16.66	9.11	231.33	12018.30	0.00
7	14.62	13920.81	281.00	122.61	27.27	11.36	98.89	12755.09	0.01
8	8.29	4077.49	77.04	76.73	12.52	4.93	36.78	3922.10	0.00
9	4.47	3507.81	52.77	31.36	6.35	3.75	29.67	2177.19	0.00
10	1.49	710.92	0.23	66.49	6.19	1.44	1.52	375.00	0.00
11	0.48	419.63	3.89	0.79	4.98	0.72	0.78	764.37	0.00
12	0.23	0.82		0.31		0.19	0.17	19.58	0.00
13	0.12	52.63			0.53				
14	0.04						0.03	14.97	
15+	0.01	24.97		14.01	0.22				
SOP	54.4	19062.4	407.4	1038.0	339.8	31.2	512.3	15999.5	0.0
Cth	54.4	19140.1	409.4	1019.9	339.2	29.9	500.2	16205.9	0.0
SOP%	100.0%	100.4%	100.5%	98.3%	99.8%	95.9%	97.6%	101.3%	104.0%

Table 2.3.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2013 (cont)

Quarters 1-4

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0		0.02	1951.61	0.00	0.12		2093.95	278.81	451.09
1	1281.72	165.23	7123.53	152.18	18.95		1927.78	6485.04	1382.86
2	1417.45	653.71	2920.84	245.47	193.62	0.00	929.38	6967.20	1169.62
3	826.32	385.37	262.99	831.75	119.26	0.11	63.66	1408.48	231.07
4	1248.38	1174.98	211.24	3282.06	64.43	0.26	70.03	315.36	102.02
5	1529.98	2563.64	182.92	7929.64	127.71	0.68	69.76	465.08	48.50
6	893.73	3083.11	113.07	11082.10	303.54	1.67	88.13	789.54	343.95
7	652.21	2887.12	80.49	10380.33	357.68	3.37	41.94	746.51	211.83
8	539.55	1837.58	34.41	4515.44	250.76	1.60	40.82	549.06	212.18
9	468.34	1507.97	11.64	1178.98	104.49	1.06	32.26	304.25	234.34
10	411.02	752.69	8.45	845.17	96.38	0.55	13.04	272.13	219.24
11	0.19	208.65	2.70	248.95	46.59	0.25	6.70	146.93	137.61
12	0.26	260.46	1.22	80.50	37.74	0.09	1.30	133.85	134.13
13	0.20	197.47					0.65		
14									
15+									
SOP	2466.5	5682.9	1280.5	13617.3	573.0	3.5	873.8	4418.6	1166.9
Cth	2455.6	5669.3	1427.8	13680.6	583.1	3.7	873.1	4447.8	1175.9
SOP%	99.6%	99.8%	111.5%	100.5%	101.8%	103.6%	99.9%	100.7%	100.8%

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	Total
0			132.12				0.00		11325.24
1	217.57		13079.87	0.12	771.13	9.60	0.11		46977.47
2	18873.60	0.04	58547.98	11809.64	8722.14	53.53	19.61	4808.69	226179.35
3	57012.41	0.75	56285.16	35456.43	22068.55	80.05	89.09	60234.54	430080.58
4	78733.91	3.23	76092.96	18851.57	31998.60	48.15	63.19	25342.26	342280.30
5	99272.54	3.29	66158.05	21490.72	64354.75	71.98	64.84	34746.76	437247.56
6	94687.80	2.32	45639.71	25040.57	78132.46	53.99	69.88	24834.28	421219.72
7	85440.95	2.73	19839.47	20406.71	70855.26	51.07	47.08	18829.22	338388.36
8	65046.02	3.03	7020.89	10762.40	47712.68	16.88	19.17	7289.92	192724.91
9	51050.30	2.96	4023.81	6633.95	20141.65	6.96	12.20	7290.35	118726.72
10	22613.95	1.50	1064.94	3260.23	8928.20	3.09	1.75	474.67	46253.48
11	8473.72	0.61	263.74	1079.76	3699.16	0.51	1.74	4.26	18931.79
12	5703.24	0.32	268.54	959.07	1596.13	0.51	0.00		10983.39
13	3356.32	0.21	2.09	502.02	250.36	0.51			4560.62
14	910.30	0.04	1.05	137.80	308.99				1458.88
15+	143.89	0.01		1.61	542.57				853.19
SOP	216620.4	7.8	129244.9	49315.2	131430.3	128.9	132.0	69154.3	931690.7
Cth	216643.0	7.8	129245.0	49312.6	132205.9	128.9	132.0	69154.3	931732.3
SOP%	100.0%	100.0%	100.0%	100.0%	100.6%	100.0%	100.0%	100.0%	100.0%

Table 2.3.3.1. NE Atlantic Mackerel. Catch numbers (‘000s) -at-age by area for 2013 (cont)

Quarter 1

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0								
1	0.86			0.10	0.06	0.08	0.02	6.87
2	1.89			0.22	0.23	0.17	0.17	145.12
3	0.69			0.08	0.59	0.06	0.04	432.69
4	0.17			0.02	1.53	0.02	0.00	353.24
5	0.34			0.04	3.21	0.03	0.01	158.40
6	0.34			0.04	4.36	0.03	0.01	157.63
7					4.79			144.84
8					3.91			83.60
9					1.20			59.11
10					0.53			36.87
11					0.24			10.55
12					0.11			15.28
13					0.10			5.00
14					0.01			
15+					0.00			27.98
SOP	0.7			0.1	8.3	0.1	0.1	525.9
Cth	0.7			0.1	8.3	0.1	0.1	524.6
SOP%	100.0%			100.0%	100.2%	100.0%	100.0%	99.7%

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0									
1	0.01	6.83	13.65	1.16	0.01	17.06	78.50	399.31	
2	0.37	51.83	37.07	7.39	23.66	46.33	213.56	1316.44	
3	0.39	508.17	35.29	180.45	19.61	16.07	206.97	3384.86	
4	0.14	4239.78	133.70	160.89	8.86	9.91	125.49	4091.39	
5	0.15	8427.74	197.09	127.43	3.84	2.85	121.92	6926.90	
6	0.13	14926.58	317.51	75.11	3.01	2.17	221.29	11812.06	
7	0.05	13859.39	275.90	59.89	1.29	1.63	86.22	12384.00	
8	0.01	4051.71	75.00	24.26	1.12	0.54	30.93	3727.38	
9	0.06	3486.42	52.00	9.30	4.42	0.12	26.69	2061.27	
10	0.01	704.56	0.03	42.86	1.12	0.01	0.30	313.43	
11	0.01	416.26	3.83		0.37	0.02	0.31	739.09	
12							0.02	10.32	
13		52.59							
14							0.03	14.91	
15+		24.97		9.30	0.16				
SOP	0.3	18951.8	397.0	252.0	13.6	17.9	276.0	15538.0	
Cth	0.3	19029.1	400.9	252.5	13.6	16.4	281.0	15736.7	
SOP%	99.6%	100.4%	101.0%	100.2%	100.1%	91.5%	101.8%	101.3%	

Table 2.3.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2013 (cont)

Quarter 1

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0							520.26		
1		0.00	6751.16	149.29	2.22		542.82	3.77	419.13
2		4.46	2232.10	215.72	171.88	0.00	319.70	147.55	166.07
3	150.82	48.58	110.77	715.52	109.24	0.01	17.06	127.54	39.70
4	603.27	944.82	61.28	2901.45	51.41	0.12	22.24	61.52	5.61
5	1055.72	2319.33	35.75	7177.80	113.45	0.19	35.88	169.28	0.34
6	603.27	2820.50	31.78	10249.84	293.36	0.46	43.77	399.55	0.80
7	452.45	2670.66	27.57	9685.93	351.24	0.63	25.16	494.61	1.00
8	301.64	1658.80	14.95	4251.82	246.95	0.12	28.80	317.64	0.64
9	301.64	1387.07	6.63	1111.23	103.33	0.10	23.17	66.81	0.13
10	301.64	689.36	5.04	805.56	95.83	0.01	10.31	60.50	0.12
11		185.54	1.68	236.22	46.44	0.03	5.08	14.16	0.03
12		239.16	0.86	79.18	37.68		0.78	4.81	0.01
13		183.54					0.57		
14									
15+									
SOP	1084.2	4876.9	814.3	12497.9	542.9	0.6	276.7	582.8	45.3
Cth	1084.2	4909.2	952.9	12559.5	552.7	0.6	276.1	585.4	48.0
SOP%	100.0%	100.7%	117.0%	100.5%	101.8%	101.7%	99.8%	100.4%	106.1%

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	Total
0									520.26
1				0.00	18.48				8411.40
2				0.63	4263.73				9366.32
3				1.60	15155.57				21262.37
4				0.92	28103.21				41880.98
5				1.58	58467.90				85347.17
6				2.14	73605.04				115570.78
7				2.42	66581.78				107111.46
8				1.29	46243.04				61064.14
9				0.39	19518.46				28219.56
10				0.13	8665.03				11733.26
11				0.05	3651.03				5310.94
12				0.05	1549.17				1937.43
13				0.00	211.08				452.89
14				0.00	308.97				323.92
15+				0.04	539.73				602.18
SOP				3.7	120642.6				177349.5
Cth				3.7	121417.2				178653.9
SOP%				99.9%	100.6%				100.7%

Table 2.3.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2013 (cont)

Quarter 2

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0								
1	7.66	0.04	0.07	0.03	48.64	653.76	62.06	23.77
2	45.68	0.08	0.16	0.07	224.12	1763.01	1179.38	506.36
3	130.26	0.03	0.06	0.03	141.64	782.32	249.82	1531.05
4	96.21	0.01	0.01	0.01	157.77	194.77	0.30	1256.58
5	141.66	0.01	0.03	0.01	183.64	274.09	0.10	561.84
6	109.78	0.01	0.03	0.01	239.43	266.59	62.06	559.14
7	95.22				355.31	32.50	0.10	516.23
8	36.10				274.08	13.16	0.10	296.12
9	23.01				67.09	0.86		213.86
10	8.20				36.60	2.75		134.68
11	0.19				11.30			36.48
12	1.86				8.02			55.21
13	0.19				10.78			18.49
14					0.11			
15+								97.92
SOP	259.2	0.0	0.1	0.0	649.1	729.0	368.7	1875.8
Cth	258.4	0.0	0.1	0.0	649.1	725.2	368.7	1871.0
SOP%	99.7%	100.0%	100.0%	100.0%	100.0%	99.5%	100.0%	99.7%

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0									
1	0.64			11.43	17.43				
2	4.09	0.19	0.37	70.94	111.93		0.56	5.89	
3	3.78	1.94	1.57	151.06	93.45	0.06	3.25	41.01	0.00
4	1.42	13.94	5.26	96.63	24.20	1.16	8.33	92.40	0.00
5	1.50	23.81	3.44	72.04	5.91	2.66	5.70	109.72	0.00
6	1.61	37.47	4.47	40.11	4.45	4.24	7.87	201.57	0.00
7	1.37	32.54	5.10	43.13	5.50	3.73	7.93	367.48	0.01
8	0.91	8.84	2.04	17.60	1.12	1.02	3.17	191.89	0.00
9	0.37	9.94	0.77	8.16	0.87	1.46	1.28	114.65	0.00
10	0.18	1.18	0.19	23.63	1.16	0.25	0.29	61.04	0.00
11	0.08	1.31	0.07	0.79		0.23	0.10	24.97	0.00
12	0.02			0.31		0.01	0.00	9.18	0.00
13	0.02				0.53				
14	0.01							0.05	
15+	0.00			4.71	0.05				
SOP	4.1	49.7	9.8	169.7	44.8	5.7	13.6	443.4	0.0
Cth	4.1	49.0	8.0	170.1	44.3	5.7	13.1	450.9	0.0
SOP%	100.0%	98.6%	81.8%	100.3%	99.0%	100.2%	95.9%	101.7%	104.0%

Table 2.3.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2013 (cont)

Quarter 2

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0							538.09		
1			48.53	0.00	0.00		476.66	37.68	43.67
2			110.98	0.96	0.00		216.47	109.88	220.29
3	54.42	3.66	63.62	37.29	0.07	0.08	23.22	20.81	134.37
4	217.92	27.63	112.80	163.31	0.35	0.11	25.63	15.87	68.30
5	382.05	107.29	121.66	467.61	1.47	0.40	17.47	29.95	29.26
6	219.62	189.24	71.52	697.15	2.84	0.99	20.97	287.93	297.69
7	164.34	192.00	50.83	615.74	3.02	2.24	9.33	199.66	206.71
8	110.29	159.66	17.44	218.17	1.57	1.21	6.90	200.34	208.11
9	109.92	115.70	4.88	44.61	0.42	0.79	5.36	225.03	233.88
10	109.38	60.07	3.39	26.57	0.34	0.44	1.63	210.80	219.10
11	0.19	21.52	1.02	6.60	0.11	0.18	0.89	132.36	137.57
12	0.26	21.30	0.36	1.33	0.06	0.07	0.38	129.04	134.12
13	0.20	13.93							
14									
15+									
SOP	394.5	355.8	154.1	744.2	3.4	2.4	219.4	694.0	769.6
Cth	394.5	360.1	155.9	746.7	3.4	2.5	219.3	699.6	773.4
SOP%	100.0%	101.2%	101.1%	100.3%	100.5%	104.0%	100.0%	100.8%	100.5%

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	Total
0									538.09
1	216.13			0.11					1648.31
2	1696.67		1454.55	6340.09	2.95		19.12	46.83	14131.64
3	4212.45		6652.04	21942.60	10.25		88.67	217.22	36592.08
4	6506.33		4704.01	7876.73	6.11		62.59	153.31	21890.00
5	6101.24		4862.89	6131.88	21.28		64.33	157.59	19882.54
6	7298.16		5254.76	7531.67	19.94		69.54	170.30	23671.17
7	8304.07		3553.24	6269.51	23.29		46.94	114.95	21222.01
8	6421.11		1462.92	2114.77	14.14		19.12	46.82	11848.71
9	1504.81		932.16	981.64	9.03		12.17	29.79	4652.51
10	942.69		140.10	681.32	3.32		1.74	4.26	2675.30
11	275.08		131.62	416.47	1.22		1.74	4.26	1206.34
12	151.00		4.30	165.46	0.67				682.95
13	211.00		2.09	0.09	0.01				257.33
14			1.05	0.01	0.02				1.24
15+				1.03	2.84				106.55
SOP	15350.1		9906.9	13936.4	39.8		131.0	320.9	47645.2
Cth	15351.1		9907.0	13931.6	39.8		131.0	320.9	47654.7
SOP%	100.0%		100.0%	100.0%	100.1%		100.0%	100.0%	100.0%

Table 2.3.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2013 (cont)

Quarter 3

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0								79.70
1	5.15	0.01	0.05	0.05	1664.13	48.10	15.04	4584.36
2	85.39	0.27	1.20	1.18	8968.55	340.70	285.90	3250.73
3	223.89	0.25	1.09	1.07	28649.87	292.06	60.99	916.75
4	190.60	0.04	0.16	0.16	19356.52	269.69	0.16	550.90
5	204.04	0.01	0.05	0.05	33784.26	164.05	0.05	212.07
6	127.48	0.01	0.05	0.05	28169.57	135.20	15.04	124.01
7	99.63	0.01	0.05	0.05	25471.83	142.09	0.05	92.96
8	36.40	0.01	0.05	0.05	9740.30	41.47	0.05	24.60
9	23.11				6226.65	14.09		25.05
10	8.43				2181.55	26.39		25.05
11	0.19				52.38	0.06		
12	1.86				504.26	0.53		44.29
13	0.19				52.38	0.06		25.05
14								
15+								
SOP	380.8	0.1	0.6	0.6	61155.6	464.5	89.5	2086.6
Cth	380.8	0.1	0.6	0.6	61161.3	464.5	89.5	2051.2
SOP%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	98.3%

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0	0.05				4.32				
1	44.19		0.24	359.53	684.77	1.32	0.24	3.35	
2	42.67		1.44	402.34	292.08	1.46	1.44	20.32	
3	15.69	0.91	0.24	186.79	132.52	0.85	0.41	6.00	
4	6.46	1.25	0.24	78.38	85.89	0.74	0.47	5.15	
5	7.34	4.45		27.82	22.30	1.15	0.83	3.77	
6	6.35	11.06		17.95	6.21	2.70	2.07	4.67	
7	6.03	25.11		9.16	17.68	6.00	4.70	3.61	
8	5.00	13.59		18.34	7.73	3.36	2.54	2.64	
9	3.07	8.82		9.65	0.41	2.16	1.65	1.08	
10	0.87	4.95			3.10	1.18	0.93	0.53	
11	0.33	2.01			3.66	0.48	0.38	0.31	
12	0.14	0.78				0.19	0.15	0.07	
13	0.03								
14	0.03							0.01	
15+	0.01								
SOP	31.9	26.9	0.6	231.7	227.0	7.4	5.5	13.6	
Cth	31.9	28.0	0.5	230.5	226.8	7.7	5.7	13.7	
SOP%	100.1%	104.0%	85.4%	99.5%	99.9%	103.3%	103.7%	100.8%	

Table 2.3.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2013 (cont)

Quarter 3

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0		0.02	680.22	0.00	0.12		598.25	72.60	444.72
1	1030.33	0.39	36.23	2.07	15.79		547.68	5466.54	881.82
2	1139.44	5.96	106.90	18.76	19.02		275.14	5930.01	743.75
3	499.27	16.42	60.23	47.72	7.39	0.01	21.65	1152.57	51.82
4	343.40	42.43	36.89	128.72	7.95	0.02	20.16	231.54	27.91
5	74.12	52.21	25.51	167.53	7.20	0.06	15.40	262.56	18.79
6	56.94	27.80	9.78	79.99	4.56	0.16	21.19	101.27	45.43
7	28.47	15.01	2.09	46.26	1.89	0.35	7.01	51.86	4.11
8	102.59	10.29	2.03	26.73	1.33	0.19	5.04	30.76	3.42
9	45.65	5.10	0.13	13.41	0.34	0.12	3.72	12.19	0.32
10		3.27	0.03	7.46	0.08	0.07	1.09	0.69	0.02
11		1.60		3.46	0.02	0.03	0.73	0.34	0.01
12						0.01	0.13		
13							0.08		
14									
15+									
SOP	794.0	74.3	96.4	221.7	18.3	0.4	244.9	2774.9	336.3
Cth	785.3	61.3	100.0	221.1	18.5	0.4	244.9	2793.2	338.5
SOP%	98.9%	82.4%	103.8%	99.7%	101.0%	104.0%	100.0%	100.7%	100.7%

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	Total
0			132.12				0.00		2012.11
1			13079.87		1.07		0.11		28472.44
2	17090.18	0.01	57075.80	5468.92	5.98		0.48	4761.85	106337.87
3	52429.27	0.52	49544.97	13402.11	8.94		0.42	60017.32	207750.02
4	70743.47	3.08	71212.63	10643.55	5.38		0.60	25188.95	199183.52
5	89808.48	2.80	60907.28	14586.40	8.04		0.51	34589.16	234958.32
6	81452.69	1.90	40032.33	15414.44	6.03		0.34	24663.97	190541.25
7	75052.10	2.22	15986.51	11271.60	5.70		0.13	18714.27	147068.55
8	58278.18	2.76	5416.92	6664.15	1.89		0.05	7243.10	87685.55
9	48048.15	2.80	3038.76	4440.58	0.78		0.03	7260.56	69188.35
10	21665.86	1.46	924.84	1587.67	0.35		0.01	470.41	26916.27
11	8194.40	0.60	132.12	442.99	0.06		0.00		8836.14
12	5519.02	0.29	264.24	573.32	0.06		0.00		6909.33
13	3145.30	0.20		281.68	0.06				3505.02
14	910.12	0.04		137.80					1048.00
15+	143.89	0.01		0.54					144.46
SOP	195151.0	6.9	118667.0	30291.4	14.4		1.0	68833.4	482249.3
Cth	195170.6	6.9	118667.0	30294.1	14.4		1.0	68833.4	482244.1
SOP%	100.0%	100.0%	100.0%	100.0%	100.0%		100.0%	100.0%	100.0%

Table 2.3.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2013 (cont)

Quarter 4

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0							30.83	2179.56
1	0.51		0.00		2797.42	1.94	4.04	2018.01
2	10.11		0.02		87602.98	56.84	13.17	1299.54
3	7.45		0.01		155542.43	101.41	3.34	415.55
4	6.41		0.01		72476.15	77.79	0.11	366.87
5	2.78		0.00		86136.78	78.65	0.04	112.11
6	1.11		0.00		78189.35	66.82	0.69	82.05
7	0.19		0.00		53256.49	33.09	0.04	77.27
8					28075.30	18.34	0.04	12.93
9					13222.48	7.80		23.54
10					3636.46	2.17		23.54
11					3298.36	4.31		
12					1132.38	0.68		20.29
13					61.63	0.13		23.54
14					85.36	0.18		
15+								
SOP	9.7		0.0		198140.2	159.1	7.5	1216.9
Cth	9.7		0.0		196972.4	156.6	7.3	1185.5
SOP%	100.4%		100.4%		99.4%	98.4%	96.6%	97.4%

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0	0.03	0.45	0.03	2054.73	19.07		2045.53	3.22	
1	1.62	48.51	0.02	356.57	142.22	0.36	223.73	6.24	
2	7.77	54.78	0.06	249.15	85.87	0.38	2.30	10.91	
3	11.38	20.10	0.03	173.91	37.34	0.11	1.06	3.81	
4	6.81	6.26		96.22	19.31	0.02	0.52	0.25	
5	10.11	7.41		22.80	7.37	0.02	0.10	0.19	
6	7.58	3.98		23.68	2.99	0.00	0.09		
7	7.16	3.76		10.43	2.80	0.00	0.05		
8	2.37	3.35		16.54	2.55	0.02	0.14	0.19	
9	0.98	2.62		4.25	0.65	0.02	0.05	0.19	
10	0.43	0.23			0.81	0.00			
11	0.07	0.04			0.95	0.00			
12	0.07	0.04				0.00			
13	0.07	0.04							
14									
15+									
SOP	18.2	34.0	0.0	384.7	54.5	0.2	217.2	4.5	
Cth	18.2	34.0	0.0	366.8	54.6	0.2	200.4	4.6	
SOP%	100.0%	99.9%	88.0%	95.3%	100.1%	100.0%	92.3%	101.7%	

Table 2.3.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2013 (cont)

Quarter 4

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0			1271.39	0.00			437.35	206.21	6.37
1	251.39	164.84	287.62	0.81	0.94		360.62	977.06	38.25
2	278.01	643.28	470.86	10.02	2.72		118.07	779.75	39.51
3	121.82	316.71	28.37	31.21	2.57	0.01	1.73	107.57	5.18
4	83.79	160.09	0.27	88.59	4.72	0.01	2.00	6.43	0.20
5	18.08	84.83		116.70	5.60	0.03	1.01	3.28	0.10
6	13.89	45.57		55.11	2.79	0.06	2.20	0.79	0.02
7	6.95	9.44		32.41	1.53	0.14	0.43	0.38	0.01
8	25.03	8.83		18.72	0.91	0.08	0.08	0.32	0.01
9	11.14	0.10		9.72	0.39	0.05	0.01	0.22	0.01
10				5.58	0.12	0.03	0.00	0.14	0.00
11				2.67	0.01	0.01	0.00	0.07	0.00
12						0.00	0.00		
13							0.00		
14									
15+									
SOP	193.7	375.7	215.7	153.5	8.4	0.2	132.8	366.8	15.8
Cth	191.6	338.7	219.0	153.3	8.5	0.2	132.8	369.6	15.9
SOP%	98.9%	90.1%	101.5%	99.8%	100.3%	104.0%	100.0%	100.7%	100.9%

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	Total
0									8254.78
1	1.44				751.58	9.60			8445.32
2	86.75	0.04	17.63		4449.48	53.53			96343.52
3	370.68	0.23	88.15	110.12	6893.78	80.05			164476.10
4	1484.10	0.15	176.31	330.37	3883.91	48.15			79325.80
5	3362.81	0.49	387.88	770.86	5857.53	71.98			97059.53
6	5936.95	0.42	352.62	2092.32	4501.45	53.99			91436.52
7	2084.78	0.51	299.72	2863.18	4244.49	51.07			62986.33
8	346.73	0.27	141.05	1982.20	1453.62	16.88			32126.50
9	1497.34	0.16	52.89	1211.35	613.39	6.96			16666.30
10	5.40	0.03		991.10	259.51	3.09			4928.65
11	4.23	0.01		220.24	46.85	0.51			3578.36
12	33.22	0.03		220.24	46.23	0.51			1453.68
13	0.02	0.00		220.24	39.21	0.51			345.38
14	0.19	0.00							85.73
15+	0.00	0.00							0.00
SOP	6119.3	0.9	671.0	5083.7	10733.4	128.9			224446.7
Cth	6121.3	0.9	671.0	5083.2	10734.5	128.9			223179.6
SOP%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%			99.4%

Table 2.3.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2013. Zeros represent values <0.5%.

Quarters 1-4

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0							2%	9%
1	1%	6%	4%	6%	1%	12%	4%	28%
2	8%	44%	44%	44%	13%	37%	75%	22%
3	21%	35%	37%	35%	25%	20%	16%	14%
4	17%	6%	6%	6%	12%	9%	0%	11%
5	20%	3%	3%	3%	16%	9%	0%	4%
6	14%	3%	3%	3%	14%	8%	4%	4%
7	11%	2%	2%	2%	11%	4%	0%	3%
8	4%	2%	2%	2%	5%	1%	0%	2%
9	3%				3%	0%		1%
10	1%				1%	1%		1%
11	0%				0%	0%		0%
12	0%				0%	0%		1%
13	0%				0%	0%		0%
14					0%	0%		
15+					0%			1%

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0	0%	0%	0%	38%	1%		59%	0%	
1	22%	0%	1%	14%	44%	14%	9%	1%	
2	26%	0%	3%	14%	27%	36%	6%	3%	
3	15%	1%	3%	13%	15%	13%	6%	7%	1%
4	7%	8%	12%	8%	7%	9%	4%	9%	2%
5	9%	17%	17%	5%	2%	5%	4%	15%	6%
6	7%	29%	28%	3%	1%	7%	7%	25%	15%
7	7%	27%	24%	2%	1%	8%	3%	26%	34%
8	4%	8%	7%	1%	1%	4%	1%	8%	19%
9	2%	7%	5%	1%	0%	3%	1%	4%	12%
10	1%	1%	0%	1%	0%	1%	0%	1%	7%
11	0%	1%	0%	0%	0%	1%	0%	2%	3%
12	0%	0%		0%		0%	0%	0%	1%
13	0%	0%			0%				
14	0%						0%	0%	
15+	0%	0%		0%	0%				

Table 2.3.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2013. Zeros represent values <0.5% (cont)

Quarters 1-4

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0		0%	15%	0%	0%		39%	1%	9%
1	14%	1%	55%	0%	1%		36%	34%	28%
2	15%	4%	23%	1%	11%	0%	17%	37%	24%
3	9%	2%	2%	2%	7%	1%	1%	7%	5%
4	13%	7%	2%	8%	4%	3%	1%	2%	2%
5	17%	16%	1%	19%	7%	7%	1%	2%	1%
6	10%	20%	1%	27%	18%	17%	2%	4%	7%
7	7%	18%	1%	25%	21%	35%	1%	4%	4%
8	6%	12%	0%	11%	15%	17%	1%	3%	4%
9	5%	10%	0%	3%	6%	11%	1%	2%	5%
10	4%	5%	0%	2%	6%	6%	0%	1%	4%
11	0%	1%	0%	1%	3%	3%	0%	1%	3%
12	0%	2%	0%	0%	2%	1%	0%	1%	3%
13	0%	1%					0%		
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0			0%				0%		0%
1	0%		4%	0%	0%	2%	0%		2%
2	3%	0%	17%	8%	2%	13%	5%	3%	9%
3	10%	4%	16%	23%	6%	20%	23%	33%	16%
4	13%	15%	22%	12%	9%	12%	16%	14%	13%
5	17%	16%	19%	14%	18%	18%	17%	19%	17%
6	16%	11%	13%	16%	22%	14%	18%	14%	16%
7	14%	13%	6%	13%	20%	13%	12%	10%	13%
8	11%	14%	2%	7%	13%	4%	5%	4%	7%
9	9%	14%	1%	4%	6%	2%	3%	4%	4%
10	4%	7%	0%	2%	2%	1%	0%	0%	2%
11	1%	3%	0%	1%	1%	0%	0%	0%	1%
12	1%	1%	0%	1%	0%	0%	0%		0%
13	1%	1%	0%	0%	0%	0%			0%
14	0%	0%	0%	0%	0%				0%
15+	0%	0%		0%	0%				0%

Table 2.3.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2013. Zeros represent values <0.5% (cont)

Quarter 1

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0								
1	20%			20%	0%	20%	9%	0%
2	44%			44%	1%	44%	65%	9%
3	16%			16%	3%	16%	16%	26%
4	4%			4%	7%	4%	1%	22%
5	8%			8%	15%	8%	3%	10%
6	8%			8%	21%	8%	5%	10%
7					23%			9%
8					19%			5%
9					6%			4%
10					3%			2%
11					1%			1%
12					1%			1%
13					0%			0%
14					0%			
15+					0%			2%

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0									
1	1%	0%	1%	0%	0%	18%	7%	1%	
2	28%	0%	3%	1%	35%	48%	19%	3%	
3	30%	1%	3%	26%	29%	17%	19%	7%	
4	11%	8%	12%	23%	13%	10%	11%	9%	
5	12%	17%	17%	18%	6%	3%	11%	15%	
6	10%	29%	28%	11%	4%	2%	20%	25%	
7	4%	27%	24%	9%	2%	2%	8%	26%	
8	1%	8%	7%	3%	2%	1%	3%	8%	
9	4%	7%	5%	1%	7%	0%	2%	4%	
10	0%	1%	0%	6%	2%	0%	0%	1%	
11	0%	1%	0%		1%	0%	0%	2%	
12							0%	0%	
13		0%							
14							0%	0%	
15+		0%		1%	0%				

Table 2.3.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2013. Zeros represent values <0.5% (cont)

Quarter 1

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0							33%		
1		0%	73%	0%	0%		34%	0%	66%
2		0%	24%	1%	11%	0%	20%	8%	26%
3	4%	0%	1%	2%	7%	1%	1%	7%	6%
4	16%	7%	1%	8%	3%	7%	1%	3%	1%
5	28%	18%	0%	19%	7%	11%	2%	9%	0%
6	16%	21%	0%	27%	18%	27%	3%	21%	0%
7	12%	20%	0%	26%	22%	38%	2%	26%	0%
8	8%	13%	0%	11%	15%	7%	2%	17%	0%
9	8%	11%	0%	3%	6%	6%	1%	4%	0%
10	8%	5%	0%	2%	6%	1%	1%	3%	0%
11		1%	0%	1%	3%	2%	0%	1%	0%
12		2%	0%	0%	2%		0%	0%	0%
13		1%					0%		
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0									0%
1				0%	0%				2%
2				6%	1%				2%
3				14%	5%				4%
4				8%	9%				8%
5				14%	18%				17%
6				19%	23%				23%
7				22%	20%				21%
8				11%	14%				12%
9				3%	6%				6%
10				1%	3%				2%
11				0%	1%				1%
12				0%	0%				0%
13				0%	0%				0%
14				0%	0%				0%
15+				0%	0%				0%

Table 2.3.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2013. Zeros represent values <0.5% (cont)

Quarter 2

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0								
1	1%	20%	20%	20%	3%	16%	4%	0%
2	7%	44%	44%	44%	13%	44%	76%	9%
3	19%	16%	16%	16%	8%	20%	16%	26%
4	14%	4%	4%	4%	9%	5%	0%	22%
5	20%	8%	8%	8%	10%	7%	0%	10%
6	16%	8%	8%	8%	14%	7%	4%	10%
7	14%				20%	1%	0%	9%
8	5%				16%	0%	0%	5%
9	3%				4%	0%		4%
10	1%				2%	0%		2%
11	0%				1%			1%
12	0%				0%			1%
13	0%				1%			0%
14					0%			
15+								2%

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0									
1	4%			2%	7%				
2	26%	0%	2%	13%	42%		1%	0%	
3	24%	1%	7%	28%	35%	0%	8%	3%	1%
4	9%	11%	23%	18%	9%	8%	22%	8%	2%
5	9%	18%	15%	13%	2%	18%	15%	9%	6%
6	10%	29%	19%	7%	2%	29%	20%	17%	15%
7	9%	25%	22%	8%	2%	25%	21%	30%	34%
8	6%	7%	9%	3%	0%	7%	8%	16%	19%
9	2%	8%	3%	2%	0%	10%	3%	9%	12%
10	1%	1%	1%	4%	0%	2%	1%	5%	7%
11	0%	1%	0%	0%		2%	0%	2%	3%
12	0%			0%		0%	0%	1%	1%
13	0%				0%				
14	0%							0%	
15+	0%			1%	0%				

Table 2.3.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2013. Zeros represent values <0.5% (cont)

Quarter 2

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0							40%		
1			8%	0%	0%		35%	2%	2%
2			18%	0%	0%		16%	7%	11%
3	4%	0%	10%	2%	1%	1%	2%	1%	7%
4	16%	3%	19%	7%	3%	2%	2%	1%	4%
5	28%	12%	20%	21%	14%	6%	1%	2%	2%
6	16%	21%	12%	31%	28%	15%	2%	18%	15%
7	12%	21%	8%	27%	29%	34%	1%	12%	11%
8	8%	18%	3%	10%	15%	19%	1%	13%	11%
9	8%	13%	1%	2%	4%	12%	0%	14%	12%
10	8%	7%	1%	1%	3%	7%	0%	13%	11%
11	0%	2%	0%	0%	1%	3%	0%	8%	7%
12	0%	2%	0%	0%	1%	1%	0%	8%	7%
13	0%	2%							
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0									0%
1	0%			0%					1%
2	4%		5%	10%	3%		5%	5%	9%
3	10%		23%	36%	9%		23%	23%	23%
4	15%		16%	13%	5%		16%	16%	14%
5	14%		17%	10%	18%		17%	17%	12%
6	17%		18%	12%	17%		18%	18%	15%
7	19%		12%	10%	20%		12%	12%	13%
8	15%		5%	3%	12%		5%	5%	7%
9	3%		3%	2%	8%		3%	3%	3%
10	2%		0%	1%	3%		0%	0%	2%
11	1%		0%	1%	1%		0%	0%	1%
12	0%		0%	0%	1%				0%
13	0%		0%	0%	0%				0%
14			0%	0%	0%				0%
15+				0%	2%				0%

Table 2.3.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2013. Zeros represent values <0.5% (cont)

Quarter 3

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0								1%
1	1%	2%	2%	2%	1%	3%	4%	46%
2	8%	44%	44%	44%	5%	23%	76%	33%
3	22%	40%	40%	40%	17%	20%	16%	9%
4	19%	6%	6%	6%	12%	18%	0%	6%
5	20%	2%	2%	2%	20%	11%	0%	2%
6	13%	2%	2%	2%	17%	9%	4%	1%
7	10%	2%	2%	2%	15%	10%	0%	1%
8	4%	2%	2%	2%	6%	3%	0%	0%
9	2%				4%	1%		0%
10	1%				1%	2%		0%
11	0%				0%	0%		
12	0%				0%	0%		0%
13	0%				0%	0%		0%
14								
15+								

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0	0%				0%				
1	32%		11%	32%	54%	6%	2%	7%	
2	31%		67%	36%	23%	7%	9%	39%	
3	11%	1%	11%	17%	11%	4%	3%	12%	
4	5%	2%	11%	7%	7%	3%	3%	10%	
5	5%	6%		3%	2%	5%	5%	7%	
6	5%	15%		2%	0%	13%	13%	9%	
7	4%	34%		1%	1%	28%	30%	7%	
8	4%	19%		2%	1%	16%	16%	5%	
9	2%	12%		1%	0%	10%	10%	2%	
10	1%	7%			0%	5%	6%	1%	
11	0%	3%			0%	2%	2%	1%	
12	0%	1%				1%	1%	0%	
13	0%								
14	0%							0%	
15+	0%								

Table 2.3.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2013. Zeros represent values <0.5% (cont)

Quarter 3

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0		0%	71%	0%	0%		39%	1%	20%
1	31%	0%	4%	0%	24%		36%	41%	40%
2	34%	3%	11%	3%	29%		18%	45%	33%
3	15%	9%	6%	9%	11%	1%	1%	9%	2%
4	10%	24%	4%	24%	12%	2%	1%	2%	1%
5	2%	29%	3%	31%	11%	6%	1%	2%	1%
6	2%	15%	1%	15%	7%	15%	1%	1%	2%
7	1%	8%	0%	9%	3%	34%	0%	0%	0%
8	3%	6%	0%	5%	2%	19%	0%	0%	0%
9	1%	3%	0%	2%	1%	12%	0%	0%	0%
10		2%	0%	1%	0%	7%	0%	0%	0%
11		1%		1%	0%	3%	0%	0%	0%
12						1%	0%		
13							0%		
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0			0%				0%		0%
1			4%		2%		4%		2%
2	3%	0%	18%	6%	13%		18%	3%	8%
3	10%	3%	16%	16%	20%		16%	33%	16%
4	13%	16%	22%	13%	12%		22%	14%	15%
5	17%	15%	19%	17%	18%		19%	19%	18%
6	15%	10%	13%	18%	14%		13%	13%	14%
7	14%	12%	5%	13%	13%		5%	10%	11%
8	11%	15%	2%	8%	4%		2%	4%	7%
9	9%	15%	1%	5%	2%		1%	4%	5%
10	4%	8%	0%	2%	1%		0%	0%	2%
11	2%	3%	0%	1%	0%		0%		1%
12	1%	2%	0%	1%	0%		0%		1%
13	1%	1%		0%	0%				0%
14	0%	0%		0%					0%
15+	0%	0%		0%					0%

Table 2.3.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2013. Zeros represent values <0.5% (cont)

Quarter 4

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0							59%	33%
1	2%		2%		0%	0%	8%	30%
2	35%		35%		15%	13%	25%	20%
3	26%		26%		27%	23%	6%	6%
4	22%		22%		12%	17%	0%	6%
5	10%		10%		15%	17%	0%	2%
6	4%		4%		13%	15%	1%	1%
7	1%		1%		9%	7%	0%	1%
8					5%	4%	0%	0%
9					2%	2%		0%
10					1%	0%		0%
11					1%	1%		
12					0%	0%		0%
13					0%	0%		0%
14					0%	0%		
15+								

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0	0%	0%	23%	68%	6%		90%	13%	
1	3%	32%	14%	12%	44%	39%	10%	25%	
2	14%	36%	45%	8%	27%	41%	0%	44%	
3	20%	13%	18%	6%	12%	11%	0%	15%	
4	12%	4%		3%	6%	2%	0%	1%	
5	18%	5%		1%	2%	2%	0%	1%	
6	13%	3%		1%	1%	0%	0%		
7	13%	2%		0%	1%	0%	0%		
8	4%	2%		1%	1%	2%	0%	1%	
9	2%	2%		0%	0%	2%	0%	1%	
10	1%	0%			0%	0%			
11	0%	0%			0%	0%			
12	0%	0%				0%			
13	0%	0%							
14									
15+									

Table 2.3.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2013. Zeros represent values <0.5% (cont)

Quarter 4

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0			62%	0%			47%	10%	7%
1	31%	11%	14%	0%	4%		39%	47%	43%
2	34%	45%	23%	3%	12%		13%	37%	44%
3	15%	22%	1%	8%	12%	1%	0%	5%	6%
4	10%	11%	0%	24%	21%	2%	0%	0%	0%
5	2%	6%		31%	25%	6%	0%	0%	0%
6	2%	3%		15%	12%	15%	0%	0%	0%
7	1%	1%		9%	7%	34%	0%	0%	0%
8	3%	1%		5%	4%	19%	0%	0%	0%
9	1%	0%		3%	2%	12%	0%	0%	0%
10				2%	1%	7%	0%	0%	0%
11				1%	0%	3%	0%	0%	0%
12						1%	0%		
13							0%		
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0									1%
1	0%				2%	2%			1%
2	1%	2%	1%		13%	13%			14%
3	2%	10%	6%	1%	21%	20%			25%
4	10%	6%	12%	3%	12%	12%			12%
5	22%	21%	26%	7%	18%	18%			15%
6	39%	18%	23%	19%	14%	14%			14%
7	14%	22%	20%	26%	13%	13%			9%
8	2%	12%	9%	18%	4%	4%			5%
9	10%	7%	3%	11%	2%	2%			2%
10	0%	1%		9%	1%	1%			1%
11	0%	1%		2%	0%	0%			1%
12	0%	1%		2%	0%	0%			0%
13	0%	0%		2%	0%	0%			0%
14	0%	0%							0%
15+	0%	0%							0%

Table 2.3.4.1. NEA Mackerel (Southern component). Effort data by fleets.

	TRAWL		HOOK (HAND-LINE)	
	AVILES	A CORUÑA	SANTANDER	SANTOÑA
	(VIIIc East)	(VIIIc West)	(VIIIc East)	(VIIIc East)
	(Days * 100 CV)	(Days * 100 CV)	(Nº fishing trips)	(Nº fishing trips)
	Annual	Annual	Feb. -May	Feb. -May
1983	12568	51017	-	-
1984	10815	48655	-	-
1985	9856	45358	-	-
1986	10845	39829	-	-
1987	8309	34658	-	-
1988	9047	41498	-	-
1989	8063	44401	-	605
1990	8492	44411	322	509
1991	7677	40435	209	724
1992	12693	38896	70	698
1993	7635	44479	151	1216
1994	9620	39602	130	1926
1995	6146	41476	217	1696
1996	4525	35709	560	2007
1997	4699	35191	736	2095
1998	5929	35191	754	3022
1999	6829	30131	739	2602
2000	4453	30073	719	1709
2001	2385	29923	700	2479
2002	2748	21823	1282	2672
2003	2526	12328	265	759
2004	-	19198	626	2151
2005	-	20663	553	1504
2006	-	12866	845	1933
2007	-	21202	1031	1895
2008	-	20212	1143	1350
2009	-	21112	839	1780
2010	-	13744	533	846
2011	-	11532	796	755
2012	3168	11887	893	697
2013	-	-	630	679

(-) Not available

Table 2.3.4.2. NEA mackerel (Southern component). CPUE index in Spanish commercial fleets.

	TRAWL		HOOK (HAND-LINE)	
	AVILES	A CORUÑA	SANTANDER	SANTOÑA
	(VIIIc East)	(VIIIc West)	(VIIIc East)	(VIIIc East)
	(Kg / 100 CV)	(Kg / 100 CV)	(Kg/Nº fish. trips)	(Kg/Nº fish. trips)
	Annual	Annual	Feb. -May	Feb. -May
1983	14	23	-	-
1984	24	27	-	-
1985	18	25	-	-
1986	41	23	-	-
1987	13	24	-	-
1988	16	33	-	-
1989	19	29	-	1427
1990	83	39	740	1924
1991	68	36	633	1394
1992	35	13	906	856
1993	13	13	613	1791
1994	57	44	2388	1591
1995	95	36	3136	1988
1996	124	33	1166	1509
1997	133	39	2138	1868
1998	142	80	2362	2128
1999	136	44	2438	2085
2000	312	65	1796	1880
2001	223	61	2323	2401
2002	342	58	2062	1871
2003	357	52	1868	1413
2004	-	19	2046	1313
2005	-	143	3618	2425
2006	-	442	2908	2742
2007	-	22	2676	2889
2008	-	12	1921	2832
2009	-	67	4659	3546
2010	-	67	4659	4568
2011	-	95	2033	2079
2012	77	-	1990	1896
2013	-	-	1757	2396

(-) Not available

Table 2.4.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2013.

Quarters 1-4

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0							236	237
1	268	237	242	238	274	238	255	271
2	303	279	283	280	300	265	298	297
3	320	307	308	307	315	302	305	315
4	340	325	326	325	339	338	325	343
5	350	339	346	340	346	340	354	349
6	358	350	352	350	355	351	355	372
7	361	395	395	395	360	372	395	373
8	367	405	405	405	367	380	405	375
9	377				374	391		404
10	384				382	394		401
11	430				380	378		400
12	376				392	381		390
13	430				411	405		449
14					425	425		
15+					415			398

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0	210	184	184	236	216		236	184	
1	263	268	236	256	251	238	243	236	
2	284	297	275	278	277	274	274	272	
3	306	320	311	310	295	292	302	297	338
4	333	337	332	341	315	319	318	329	331
5	353	347	351	362	331	342	346	341	347
6	362	361	360	361	341	361	356	354	360
7	368	368	368	381	330	369	358	360	370
8	377	380	383	368	339	374	348	381	371
9	381	382	375	389	344	382	351	381	383
10	395	394	404	402	356	394	393	390	392
11	396	409	405	383	334	390	395	389	383
12	404	391		390		390	394	408	390
13	435	415			415				
14	428						415	415	
15+	415	425		405	405				

Table 2.4.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2013 (cont)

Quarters 1-4

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0		265	205	265	265		237	223	246
1	273	310	232	241	285		282	286	248
2	290	311	255	277	269	245	286	291	274
3	319	325	295	339	282	333	332	301	291
4	330	336	327	345	325	333	351	342	322
5	344	350	340	356	359	344	372	359	354
6	358	365	357	365	373	358	362	380	407
7	368	374	366	371	377	368	382	380	406
8	369	388	381	381	385	372	396	390	411
9	378	406	399	393	403	382	399	407	415
10	360	399	405	401	405	392	414	410	416
11	416	415	409	406	418	383	419	418	420
12	425	425	417	419	424	390	418	421	421
13	433	433					445		
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0			280				280		232
1	260		298	222	263	264	298		273
2	294	299	306	275	282	290	287	321	297
3	304	296	333	297	303	311	305	324	315
4	311	297	346	323	334	340	330	341	333
5	329	310	355	337	347	360	345	350	344
6	344	327	361	349	358	368	355	358	354
7	352	342	370	357	365	373	362	365	361
8	355	347	378	361	375	389	370	371	366
9	359	355	391	366	383	401	374	379	371
10	366	364	381	376	389	415	350	366	376
11	372	374	404	378	399	415	410	410	383
12	386	381	410	400	401	415	410		393
13	389	389	385	400	422	445			396
14	389	378	390	390	428				400
15+	406	406		414	431				421

Table 2.4.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2013 (cont)

Quarter 1

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0								
1	231			231	231	231	238	235
2	255			255	268	255	288	285
3	290			290	300	290	300	307
4	325			325	334	325	325	338
5	325			325	348	325	325	343
6	345			345	361	345	350	370
7					368			373
8					376			377
9					386			395
10					385			391
11					392			400
12					391			394
13					411			415
14					428			
15+					415			398

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0									
1	234	235	235	250	215	235	235	235	
2	271	307	273	282	258	273	273	271	
3	302	320	310	317	285	290	302	297	
4	312	337	332	345	317	315	317	329	
5	337	347	351	364	341	336	346	341	
6	327	361	360	366	330	351	356	354	
7	344	368	368	387	372	366	356	360	
8	316	380	383	368	335	374	342	381	
9	340	382	375	415	343	386	347	380	
10	325	394	405	402	376	397	384	389	
11	325	409	405		325	387	406	389	
12							425	425	
13		415							
14							415	415	
15+		425		405	405				

Table 2.4.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2013 (cont)

Quarter 1

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0							241		
1		265	230	240	253		268	229	197
2		322	247	268	264	245	274	270	255
3	315	343	272	338	277	299	331	279	278
4	320	335	318	344	317	334	360	320	294
5	344	350	341	355	358	336	377	360	360
6	358	366	366	365	374	352	365	366	366
7	368	375	373	371	377	360	384	371	371
8	370	388	389	382	385	385	396	377	377
9	380	406	404	393	403	379	400	384	384
10	360	399	407	401	405	395	415	387	387
11		416	410	406	418	385	418	394	394
12		425	418	419	424		416	402	402
13		433					445		
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0									241
1				222	222				231
2				269	274				267
3				292	300				301
4				330	333				334
5				345	346				347
6				353	357				358
7				364	364				365
8				373	374				376
9				382	382				384
10				399	389				390
11				394	399				400
12				407	401				405
13				412	418				424
14				435	428				427
15+				418	431				429

Table 2.4.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2013 (cont)

Quarter 2

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0								
1	270	231	231	231	256	235	255	235
2	299	255	255	255	270	262	298	286
3	315	290	290	290	302	296	305	307
4	335	325	325	325	336	328	325	339
5	346	325	325	325	349	330	355	343
6	357	345	345	345	363	347	355	370
7	361				371	382	395	373
8	367				377	399	405	377
9	377				388	415		395
10	384				381	396		391
11	430				377			400
12	376				390			394
13	430				409			415
14					390			
15+								398

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0									
1	231			237	227				
2	268	319	319	270	267		319	312	
3	293	325	332	309	287	319	325	326	338
4	318	338	335	339	310	344	334	334	331
5	339	348	353	364	303	346	352	349	347
6	355	364	364	364	346	365	362	361	360
7	362	369	374	382	343	369	373	370	370
8	374	386	386	369	352	386	383	373	371
9	382	380	398	401	321	381	391	384	383
10	388	406	404	401	373	403	404	392	392
11	401	405	408	383		403	408	384	383
12	393			390		390	390	390	390
13	416				415				
14	428							415	
15+	415			405	405				

Table 2.4.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2013 (cont)

Quarter 2

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0							238		
1			230	265	265		283	233	246
2			273	325	282		291	246	269
3	315	338	308	342	337	338	334	270	287
4	320	337	330	347	343	331	347	325	312
5	344	347	341	356	354	347	368	347	349
6	358	368	354	363	363	360	364	408	409
7	368	375	362	368	367	370	380	407	407
8	370	384	377	376	376	371	396	412	412
9	380	404	393	384	387	383	400	415	415
10	360	397	403	396	393	392	410	416	416
11	416	403	407	401	402	383	420	421	421
12	425	420	415	410	410	390	421	421	421
13	433	433							
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0									238
1	260			222					254
2	278		287	258	266		286	286	270
3	288		305	291	301		305	305	294
4	310		330	320	332		330	330	321
5	336		345	338	344		345	345	340
6	351		354	347	359		354	354	353
7	364		361	354	367		361	361	362
8	372		370	365	380		370	370	372
9	383		374	354	379		374	374	379
10	375		352	377	411		350	350	383
11	380		409	382	389		410	410	394
12	390		392	400	426				406
13	410		385	412	419				411
14			390	435	428				392
15+				418	435				400

Table 2.4.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2013 (cont)

Quarter 3

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0								247
1	270	255	255	255	268	270	255	272
2	306	286	286	286	293	278	298	298
3	323	309	309	309	312	311	305	327
4	342	325	325	325	333	343	325	349
5	353	355	355	355	344	353	355	364
6	360	355	355	355	355	356	355	381
7	362	395	395	395	359	371	395	366
8	367	405	405	405	366	378	405	353
9	377				375	397		455
10	384				384	395		435
11	430				430	430		
12	376				376	376		385
13	430				430	430		465
14								
15+								

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0	205				205				
1	264		315	260	250	273	315	315	
2	284		315	279	281	290	315	314	
3	305	338	315	306	302	324	325	308	
4	331	331	315	336	318	341	323	318	
5	347	347		355	332	348	347	346	
6	357	360		349	345	360	360	358	
7	364	370		366	323	370	370	366	
8	372	371		366	337	371	371	374	
9	375	383		365	365	382	383	384	
10	388	392			345	392	392	390	
11	393	383			335	383	383	394	
12	401	390				390	390	394	
13	423								
14	428							415	
15+	415								

Table 2.4.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2013 (cont)

Quarter 3

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0		265	192	265	265		235	264	247
1	273	318	305	316	287		289	288	271
2	290	344	313	340	299		293	293	279
3	320	353	326	354	329	338	330	304	308
4	349	363	331	363	354	331	348	350	352
5	355	369	334	369	363	347	366	361	363
6	365	365	346	365	357	360	353	357	397
7	365	374	355	372	366	370	377	370	367
8	367	376	352	375	364	371	394	373	353
9	365	393	378	389	391	383	398	387	387
10		402	385	400	414	392	414	418	418
11		413		411	425	383	421	430	430
12						390	421		
13							445		
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0			280				280		227
1			298		264		298		286
2	296	235	307	294	290		307	321	302
3	305	289	336	306	311		336	324	319
4	311	297	347	323	340		347	341	331
5	327	305	356	336	360		356	350	341
6	343	323	362	349	368		362	358	351
7	351	339	372	356	373		372	365	357
8	352	346	380	356	389		380	371	358
9	359	355	396	365	401		396	379	364
10	366	364	386	372	415		386	366	369
11	372	374	400	361	415		400		372
12	385	380	410	392	415		410		386
13	388	389		385	445				389
14	389	378		390					389
15+	406	406		406					406

Table 2.4.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2013 (cont)

Quarter 4

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0							236	237
1	289		289		279	288	247	269
2	309		309		300	305	297	298
3	330		330		316	321	306	327
4	351		351		341	344	325	356
5	365		365		347	350	355	360
6	375		375		354	358	355	376
7	379		379		361	366	395	375
8					367	371	405	346
9					373	379		455
10					381	389		435
11					379	378		
12					398	385		385
13					395	395		465
14					425	425		
15+								

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0	218	184	184	236	218		236	184	
1	261	273	305	252	255	273	245	282	
2	290	288	305	279	278	288	296	298	
3	311	310	305	307	296	310	317	306	
4	340	342		340	312	345	354	345	
5	360	356		349	343	345	359	345	
6	368	368		350	336	361	365		
7	373	373		353	326	369	365		
8	389	374		368	343	366	368	365	
9	401	372		365	365	366	365	365	
10	415	415			345	392			
11	413	415			335	383			
12	415	415				390			
13	445	445							
14									
15+									

Table 2.4.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2013 (cont)

Quarter 4

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0			212	265			235	208	208
1	273	310	271	324	312		289	282	283
2	290	311	278	348	323		293	288	290
3	320	321	295	356	342	338	330	299	302
4	349	331	315	364	361	331	348	327	327
5	355	332		369	368	347	366	340	340
6	365	342		366	364	360	353	359	359
7	365	347		373	372	370	377	380	380
8	367	346		375	374	371	394	382	382
9	365	365		390	393	383	398	408	408
10				401	411	392	414	418	418
11				411	425	383	421	430	430
12						390	421		
13							445		
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0									232
1	289				264	264			273
2	312	313	330		290	290			300
3	313	311	356	340	311	311			316
4	330	311	355	357	340	340			341
5	361	340	362	354	359	360			349
6	354	344	366	357	367	368			355
7	359	354	376	365	371	373			362
8	369	364	375	373	386	389			368
9	360	360	393	378	397	401			373
10	411	368		383	412	415			383
11	416	381		405	408	415			381
12	394	391		420	413	415			402
13	389	389		420	445	445			421
14	468	378							425
15+	406	406							406

Table 2.4.1.2. NE Atlantic Mackerel. Percentage length composition in catches by country and fleet, 2013. Zeros represent values <0.5%.

Handline Fleets/ Purse Seiners

	UKE Kines								NO PS					DK PS	
	VIIe				VIIf				IIa			IVa		IVa	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q2	Q3	Q4	Q3	Q4	Q3	Q4
15															
16															
17															
18						0%									
19				0%		0%		1%							
20				0%		1%	0%								
21		0%	0%	0%	0%	1%		1%							
22		1%	5%	1%	0%	1%	1%	4%							
23		3%	13%	1%	0%	2%	5%	9%							
24	1%	2%	11%	4%	15%	5%	25%	9%							
25	2%	8%	14%	11%	12%	14%	20%	16%				0%	0%		
26	1%	12%	16%	15%	16%	17%	7%	19%				0%	0%		
27	3%	14%	11%	20%	9%	17%	8%	9%				1%	1%		0%
28	4%	13%	8%	12%	14%	14%	8%	11%	0%	0%	0%	1%	3%		1%
29	8%	10%	6%	8%	8%	8%	7%	4%	1%	0%	0%	2%	7%	1%	5%
30	6%	9%	4%	5%	7%	6%	6%	4%	0%	4%	4%	6%	11%	3%	10%
31	8%	7%	4%	7%	6%	5%	5%	3%	0%	4%	4%	9%	13%	9%	12%
32	8%	6%	1%	6%	7%	3%	3%	3%	1%	6%	6%	8%	11%	7%	14%
33	12%	4%	2%	3%	2%	2%	2%	3%	3%	8%	9%	8%	10%	7%	10%
34	17%	2%	1%	2%	1%	0%	1%	1%	7%	20%	22%	14%	12%	18%	13%
35	12%	3%	1%	1%	1%	1%	1%	1%	9%	20%	20%	19%	13%	20%	12%
36	10%	2%	1%	0%	1%	1%	0%	1%	22%	18%	17%	16%	10%	16%	11%
37	5%	1%	1%	0%	0%	0%	0%	0%	19%	10%	9%	8%	5%	10%	7%
38	2%	1%	0%		0%	0%	0%	0%	16%	5%	4%	5%	3%	5%	3%
39	0%	1%	0%		0%		0%	0%	11%	2%	2%	2%	1%	3%	0%
40	0%	1%	0%				0%		6%	1%	1%	1%	0%	1%	0%
41	0%	1%	0%		0%	0%			2%	0%	0%	0%	0%		0%
42		0%	0%						0%	0%	0%		0%		
43		0%	0%						1%	0%	0%	0%			
44			0%												
45															
46															
47															

Table 2.4.1.2. NE Atlantic Mackerel. Percentage length composition in catches by country and fleet, 2013. Zeros represent values <0.5% (cont)

Southern Fleets

	ES Purse Seine				ES Trawl				ES Artisanal				PT All			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
15																
16																
17								1%								
18								6%								
19	0%							11%							2%	1%
20	0%			0%				8%							3%	6%
21				0%	0%			4%					1%		3%	15%
22	0%			0%				1%					5%			15%
23	0%			0%				0%					5%			15%
24	0%				0%								5%			1%
25	1%		0%		1%								4%	2%		
26	0%		2%	4%	3%				0%	0%	0%	0%	5%	7%	2%	3%
27	0%		15%	33%	4%		8%	0%					3%	11%	17%	10%
28	0%		33%	34%	2%		29%	0%	0%	0%	0%			11%	17%	15%
29	0%		28%	12%	1%		22%	1%			1%		1%	11%	9%	15%
30	0%		11%	9%	0%		10%	1%	0%	2%	8%	11%	4%	6%	17%	3%
31	1%		2%	4%	0%		7%	0%	0%	3%	7%	13%	3%	5%	14%	
32	2%	2%	2%	2%	1%	1%	4%	1%	1%	3%	23%	22%	8%	1%	5%	
33	6%	16%	2%	0%	1%	2%	2%	1%	4%	5%	13%	14%	6%	2%		
34	14%	21%	0%	0%	3%	7%	2%	6%	12%	11%	13%	12%	9%	3%		
35	21%	21%	1%	0%	8%	13%	3%	11%	21%	20%	7%	6%	6%	3%		
36	22%	19%	3%	0%	19%	24%	6%	22%	23%	21%	9%	7%	7%	5%		
37	15%	10%	0%	0%	21%	9%	3%	12%	16%	15%	4%	5%	9%	4%		
38	8%	7%	1%	0%	15%	3%	1%	6%	10%	9%	4%	3%	5%	5%		
39	4%	4%	0%	0%	8%	4%	1%	4%	7%	6%	4%	4%	4%	8%	3%	
40	2%				6%	8%	0%	2%	4%	3%	3%	2%	4%	6%	3%	
41	1%				4%	15%	0%	1%	1%	1%	1%	1%	3%	5%	2%	
42	0%				2%	10%	0%	0%	1%	1%	1%	1%	1%	4%		
43	0%				1%	3%			0%	0%	1%	0%	1%	1%		
44	0%				0%	1%			0%	0%	0%	0%	1%	2%	2%	
45					0%											
46					0%								0%			
47																

Table 2.4.1.2. NE Atlantic Mackerel. Percentage length composition in catches by country and fleet, 2013. Zeros represent values <0.5% (cont)

Pelagic Trawl Fleets

	FO			IS			GL	IE		UKS			
				Va		Va	XIVb			VIa	VIIb	IVa	
	Q2	Q3	Q4	Q2	Q3	Q4	Q3	Q1	Q4	Q1	Q1	Q3	Q4
15													
16													
17													
18													
19													
20													
21													
22							1%	0%					
23	0%							0%		0%			
24	2%							0%					
25	2%						4%	0%	0%	0%			
26	3%			0%			3%	0%	1%	0%			
27	3%	1%		1%	0%		3%	1%	2%	0%		0%	0%
28	9%	2%		1%	1%		3%	1%	3%	1%			2%
29	11%	4%		9%	5%		4%	1%	6%	1%			3%
30	11%	9%		11%	8%		5%	2%	7%	1%		2%	8%
31	5%	10%		10%	5%		5%	3%	9%	2%	1%	6%	10%
32	6%	6%		6%	6%	1%	6%	4%	9%	4%	2%	4%	8%
33	10%	11%	2%	10%	9%	3%	9%	7%	7%	9%	7%	12%	12%
34	14%	13%	5%	14%	15%	5%	11%	12%	9%	15%	13%	20%	16%
35	11%	17%	17%	18%	16%	19%	14%	19%	13%	21%	24%	21%	16%
36	7%	13%	22%	14%	16%	22%	12%	20%	14%	20%	24%	17%	14%
37	2%	9%	23%	1%	9%	22%	7%	13%	10%	11%	15%	8%	7%
38	2%	3%	14%	2%	5%	13%	4%	8%	5%	7%	8%	5%	3%
39	1%	1%	9%	1%	3%	7%	2%	4%	3%	4%	2%	1%	1%
40	0%	0%	4%		2%	3%	2%	3%	1%	2%	1%	1%	1%
41		0%	2%	1%	1%	2%	1%	1%	1%	1%	2%	1%	0%
42			3%		0%	2%	1%	0%	0%	0%	0%	1%	0%
43			1%	0%	0%		1%	0%	0%	0%	0%		
44							1%	0%	0%	0%	0%		
45							1%						
46													
47					0%								

Table 2.4.1.2. NE Atlantic Mackerel. Percentage length composition in catches by country and fleet, 2013. Zeros represent values <0.5% (cont)

Freezer Trawlers

	DE					NL			UKE				RU	
	VIa	VIIb	VIIj		VIId								IIa	
	Q1	Q1	Q1	Q2	Q4	Q1	Q3	Q4	Q1	Q2	Q3	Q4	Q2	Q3
15		0%												
16		0%												
17		0%												
18		0%												
19		0%												
20		1%												
21	0%	0%								4%				
22	0%	0%			0%					4%				
23	1%	0%			0%			0%	0%	16%			0%	0%
24	1%	0%	0%		0%			0%		12%				0%
25	2%	0%			5%		0%	0%	1%	12%	2%		0%	0%
26	2%	0%	0%		15%	2%	1%	0%	2%	8%	5%		6%	0%
27	3%	0%	0%		22%		0%	0%	3%	12%	10%	2%	14%	1%
28	5%	0%	0%		21%	3%	0%	0%	2%	4%	12%	1%	17%	2%
29	3%	1%	1%		16%	0%	0%	0%	5%	4%	23%	5%	24%	6%
30	2%	1%	1%	0%	8%	3%	0%	0%	1%	4%	16%	4%	12%	10%
31	3%	1%	2%	1%	3%	3%	0%	0%	8%	4%	7%	8%	7%	7%
32	6%	3%	5%	2%	3%	3%	0%	0%	6%	8%	6%	15%	3%	7%
33	9%	9%	12%	5%	1%	8%	0%	0%	12%	4%	3%	16%	3%	8%
34	16%	17%	19%	12%	2%	9%		0%	12%		3%	16%	4%	14%
35	17%	22%	23%	18%	0%	17%	0%	0%	14%		5%	13%	4%	16%
36	14%	20%	18%	21%	1%	15%		0%	15%	4%	2%	9%	3%	13%
37	7%	11%	9%	17%	1%	8%	0%	0%	10%		1%	5%	2%	8%
38	3%	5%	5%	11%	0%	10%		0%	5%		0%	3%	1%	4%
39	2%	4%	3%	8%	0%	6%		0%	4%		1%	2%	0%	2%
40	1%	2%	1%	5%	0%	3%			1%		1%		0%	1%
41	0%	1%	0%	2%		4%		0%	0%			1%		0%
42	0%	0%	0%	0%	0%	1%			0%					0%
43	0%	0%	0%			3%		0%	0%					0%
44	0%	0%	0%			0%								0%
45								0%						
46	0%		0%					0%						
47	0%													

Table 2.4.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2013.

Quarters 1-4

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0							94	95
1	169	107	113	108	186	110	146	145
2	256	181	188	182	233	153	230	202
3	307	229	233	230	280	225	261	241
4	365	288	296	288	350	332	292	337
5	403	302	321	304	374	337	332	339
6	427	320	329	321	403	353	372	436
7	436	447	447	447	422	445	447	444
8	444	473	473	473	441	474	473	445
9	494				469	557		565
10	510				494	566		556
11	580				477	487		524
12	510				570	514		486
13	640				598	586		822
14					718	718		
15+					607			516

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0	79	42	42	94	83		94	36	
1	144	146	100	129	135	102	100	85	
2	182	207	169	176	177	165	141	138	
3	231	247	235	239	211	205	207	180	288
4	305	293	280	340	266	276	238	261	269
5	357	324	333	384	308	325	326	294	308
6	382	369	363	388	326	371	352	339	342
7	405	391	390	473	302	387	370	369	369
8	459	435	447	429	337	401	359	435	369
9	495	441	412	551	332	423	300	439	405
10	516	493	617	569	382	450	452	466	435
11	525	553	543	404	317	443	465	474	404
12	550	438		431		431	450	516	431
13	690	588			523				
14	673						546	546	
15+	607	637		531	531				

Table 2.4.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2013 (cont)

Quarters 1-4

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0		148	62	148	148		98	89	98
1	153	243	80	96	183		170	188	111
2	194	244	114	153	136	97	180	197	145
3	255	273	188	271	157	276	286	218	177
4	271	261	258	283	247	276	344	320	249
5	280	288	296	308	320	303	412	355	326
6	319	354	350	330	355	343	382	386	469
7	330	365	380	347	363	370	444	381	456
8	351	407	437	377	388	377	498	408	474
9	399	476	515	412	446	408	512	464	487
10	343	459	540	440	453	437	572	469	490
11	510	507	556	457	495	413	591	497	505
12	572	571	599	499	518	431	573	505	508
13	627	627					723		
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0			210				210		91
1	140		251	72	133	134	251		173
2	244	250	271	184	169	184	217	297	234
3	270	262	341	215	212	232	253	315	281
4	295	274	380	285	294	309	318	364	333
5	335	296	409	331	333	372	363	395	359
6	379	351	425	363	368	400	385	417	386
7	403	387	461	384	394	419	406	439	406
8	419	409	482	408	430	478	425	442	428
9	440	436	538	431	465	529	456	515	457
10	463	464	495	455	489	593	390	446	472
11	483	493	621	442	532	592	633	633	493
12	533	529	615	545	528	592	617		540
13	555	567	508	580	644	744			571
14	546	521	525	525	673				581
15+	665	665		646	582				587

Table 2.4.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2013 (cont)

Quarter 1

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0								
1	98			98	98	98	112	83
2	134			134	155	134	208	168
3	192			192	216	192	237	214
4	265			265	300	265	265	317
5	274			274	344	274	274	310
6	306			306	385	306	338	424
7					418			442
8					453			453
9					505			516
10					482			487
11					520			524
12					536			476
13					597			582
14					673			
15+					607			513

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0									
1	100	97	97	122	73	97	83	83	
2	154	226	164	177	126	164	140	136	
3	217	247	231	239	173	201	206	179	
4	231	293	278	339	249	266	235	260	
5	296	324	332	381	309	332	325	294	
6	269	369	362	395	286	385	351	339	
7	314	391	388	503	444	440	366	369	
8	232	435	444	385	290	476	348	438	
9	291	441	409	615	303	516	284	440	
10	252	493	548	573	466	568	426	471	
11	252	553	541		252	490	510	476	
12							592	592	
13		588							
14							546	546	
15+		637		531	531				

Table 2.4.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2013 (cont)

Quarter 1

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0							103		
1		125	77	93	110		146	81	45
2		225	98	129	125	97	158	132	110
3	204	274	137	261	144	195	284	147	148
4	204	249	236	275	216	284	373	222	178
5	271	285	298	303	311	292	428	315	315
6	309	353	381	329	354	344	395	333	333
7	325	363	408	347	363	373	451	346	346
8	307	408	471	377	388	472	499	363	363
9	382	476	537	412	445	441	514	383	383
10	343	460	548	439	453	518	577	395	395
11		510	562	454	495	467	592	415	415
12		572	604	499	518		583	442	442
13		627					723		
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0									103
1				72	72				80
2				139	152				135
3				181	201				200
4				277	291				285
5				325	329				322
6				353	366				360
7				389	392				384
8				424	428				424
9				464	463				456
10				530	486				478
11				510	532				521
12				540	526				530
13				627	626				622
14				763	673				667
15+				636	582				580

Table 2.4.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2013 (cont)

Quarter 2

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0								
1	171	98	98	98	145	105	148	83
2	242	134	134	134	160	146	230	169
3	291	192	192	192	234	206	261	214
4	350	265	265	265	332	287	292	318
5	389	274	274	274	371	290	334	312
6	422	306	306	306	408	314	372	425
7	433				438	434	447	444
8	444				470	478	473	454
9	493				542	670		518
10	509				484	573		490
11	580				491			524
12	510				558			480
13	640				593			582
14					525			
15+								516

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0									
1	95			108	87				
2	149	279	279	161	140		237	223	
3	196	275	319	231	175	244	259	256	288
4	250	304	331	323	223	314	280	277	269
5	312	330	391	386	219	321	335	318	308
6	360	379	434	392	323	382	369	350	342
7	384	399	479	468	308	392	408	376	369
8	427	465	537	380	333	450	452	383	369
9	463	437	593	526	249	435	478	415	405
10	479	545	628	562	402	517	535	439	435
11	537	537	648	404		522	555	412	404
12	502			431		431	431	432	431
13	544				523				
14	673							546	
15+	607			531	531				

Table 2.4.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2013 (cont)

Quarter 2

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0							99		
1			77	125	125		173	81	97
2			139	232	152		192	97	132
3	204	288	211	272	259	288	293	135	166
4	204	255	266	282	273	269	329	240	218
5	271	281	298	307	300	308	398	288	291
6	309	362	341	325	323	342	385	462	463
7	325	378	366	337	335	369	437	457	458
8	309	402	420	359	360	369	496	476	476
9	383	475	488	384	394	405	507	487	487
10	344	448	530	423	412	435	534	490	490
11	510	470	547	438	440	404	576	505	505
12	572	551	586	470	469	431	544	508	508
13	627	627							
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0									99
1	140			72					130
2	192		217	130	114		216	216	161
3	231		253	179	185		253	253	203
4	263		317	236	275		317	317	269
5	317		362	275	303		362	362	315
6	360		385	294	351		385	385	348
7	404		406	309	364		406	406	376
8	447		424	336	414		425	425	421
9	516		455	316	421		456	456	450
10	429		396	358	520		390	390	422
11	495		628	376	467		633	633	470
12	560		534	417	576				496
13	595		508	627	626				595
14			525	763	673				530
15+				636	574				520

Table 2.4.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2013 (cont)

Quarter 3

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0								107
1	172	131	131	131	168	171	148	147
2	265	194	194	194	225	174	230	207
3	315	234	234	234	281	254	261	279
4	372	292	292	292	342	356	292	355
5	412	334	334	334	380	395	334	405
6	432	337	337	337	417	405	372	483
7	438	447	447	447	424	450	447	417
8	444	473	473	473	442	480	473	364
9	495				487	585		832
10	510				512	567		788
11	580				580	580		
12	510				510	510		494
13	640				640	640		938
14								
15+								

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0	75				75				
1	145		267	139	137	153	227	227	
2	185		267	179	195	194	227	226	
3	239	288	267	245	241	276	253	207	
4	316	269	267	357	281	347	248	232	
5	348	308		406	323	317	308	296	
6	369	342		374	357	344	342	332	
7	394	369		418	294	369	369	356	
8	456	369		496	337	374	369	385	
9	493	405		522	522	408	405	416	
10	488	435			357	435	435	430	
11	513	404			327	404	404	454	
12	536	431				431	431	453	
13	643								
14	673							546	
15+	607								

Table 2.4.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2013 (cont)

Quarter 3

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0		148	41	148	148		95	147	98
1	153	262	205	258	190		183	191	140
2	194	334	223	323	216		192	201	155
3	272	364	256	367	290	288	282	227	225
4	401	395	271	397	366	269	332	353	338
5	421	419	280	417	397	308	392	389	382
6	431	403	315	405	376	342	355	378	508
7	407	436	341	430	409	369	430	423	392
8	493	442	334	438	401	369	492	432	345
9	522	508	425	493	503	405	508	485	485
10		545	453	539	598	435	576	620	620
11		596		589	652	404	604	674	674
12						431	605		
13							723		
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0			210				210		87
1			251		134		251		205
2	249	136	273	246	184		273	298	256
3	273	252	352	273	232		352	315	305
4	298	274	384	317	309		384	364	343
5	332	286	412	351	372		412	395	371
6	378	344	430	390	400		430	417	401
7	403	383	473	412	419		473	439	419
8	416	404	498	412	478		498	442	426
9	438	435	564	441	529		564	515	457
10	465	464	510	462	593		510	447	470
11	483	493	613	426	592		613		483
12	532	528	617	534	592		617		534
13	552	567		510	744				553
14	546	521		525					543
15+	665	665		665					665

Table 2.4.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2013 (cont)

Quarter 4

Age	IIIa	IIIb	IIIc	IIId	IVa	IVb	IVc	VIId
0							94	94
1	214		214		198	207	113	142
2	264		264		234	246	228	208
3	332		332		279	286	255	282
4	395		395		353	360	292	392
5	450		450		372	379	334	391
6	482		482		398	408	370	469
7	492		492		420	439	447	482
8					440	458	473	326
9					460	496		832
10					484	539		788
11					476	486		
12					597	517		494
13					563	563		938
14					718	718		
15+								

Age	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk
0	84	42	42	94	84		94	36	
1	132	153	239	119	134	153	106	168	
2	183	188	239	174	175	188	196	197	
3	232	243	239	239	212	248	253	218	
4	308	351		344	257	406	391	407	
5	372	376		372	333	385	436	387	
6	400	400		366	308	358	431		
7	419	419		365	279	371	407		
8	478	503		469	357	504	471	517	
9	529	523		522	522	515	522	522	
10	592	593			331	435			
11	585	592			303	404			
12	592	592				431			
13	744	744							
14									
15+									

Table 2.4.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2013 (cont)

Quarter 4

Age	VIIIa	VIIIb	VIIIc	VIIIcE	VIIIcW	VIIId	IXaCN	IXaN	IXaS
0			72	148			95	69	69
1	153	243	149	278	247		183	180	177
2	194	243	160	347	275		192	193	186
3	272	268	189	372	330	288	281	216	214
4	401	297	230	399	389	269	332	286	286
5	421	299		418	416	308	392	322	322
6	431	329		407	401	342	355	385	385
7	407	345		432	429	369	430	457	457
8	493	341		441	436	369	492	466	466
9	522	404		496	511	405	508	573	573
10				541	587	435	576	620	620
11				588	652	404	605	674	674
12						431	605		
13							723		
14									
15+									

Age	IIa	IIb	Va	Vb	VIa	VIb	XII	XIVb	All
0									90
1	214				134	134			167
2	272	275	334		186	184			231
3	290	286	428	356	235	232			277
4	324	294	409	414	309	309			350
5	424	355	422	404	371	372			374
6	403	380	445	414	399	400			399
7	416	404	478	442	418	419			421
8	472	457	455	472	473	478			444
9	424	443	508	490	519	529			462
10	552	472		512	582	593			496
11	587	510		601	564	592			485
12	549	544		672	598	592			606
13	567	567		670	744	744			678
14	856	521							718
15+	665	665							665

Table 2.5.1.1. NEA mackerel. Comparison between the SSB values used for the updated advice in April 2014 (old) and the new time series used by WGWIDE 2014 (new). The Mendiola *et al.*(2006) equation was used to calculate all data points of the new time series but only for the 2013 data point of the old time series.

Year	SSB (million tons) derived from the international mackerel egg survey					
	Southern component		Western component		Both components	
	New	Old	New	Old	New	Old
1992	0.55	-	3.35	2.93	3.90	2.93
1995	0.45	0.31	3.39	2.47	3.84	2.78
1998	1.04	0.80	3.38	2.95	4.42	3.75
2001	0.47	0.37	2.80	2.53	3.27	2.90
2004	0.36	0.28	2.80	2.47	3.17	2.75
2007	0.75	0.70	3.22	2.95	3.97	3.65
2010	0.95	0.86	3.89	3.43	4.84	4.29
2013	1.21	1.28	3.82	4.29	5.03	5.57

Table 2.5.2.1. IBTS Q4 recruitment index derived from square root transformed CPUE. See Jansen *et al.*(2014, WKPELA WD) and Jansen *et al.*(under review) for details.

Year	IBTS Q4 Index
1998	0.611
1999	0.652
2000	0.422
2001	0.797
2002	0.863
2003	0.538
2004	0.880
2005	1.131
2006	1.076
2007	0.547
2008	0.688
2009	0.481
2010	0.636
2011	1.186
2012	1.051
2013	1.339

Table 2.5.3.1. Swept area estimates of NEA mackerel biomass in the different Exclusive Economic Zones (EEZs) according to the international coordinated ecosystem (IESSNS) survey in July-August 2014.

Exclusive economic zone / international area	Area (in thous. km2)	Biomass (in thous. tonnes)	Biomass (%)
EU	78	226	2.5
Norwegian	640	2267	25.2
Icelandic	478	1593	17.7
Faroese	268	549	6.1
Jan Mayen	222	732	8.2
International north	275	1759	19.6
International west	52	83	0.9
Greenland	335	1164	13.0
Spitzbergen	105	611	6.8
Total	2453	8984	100.0

Table 2.5.5.2.1. b20 values from the length target strength relationship of the main fish species assessed in PELACUS survey (WHB is blue whiting; MAC-mackerel; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel (Trachurus picturatus); BOG-bogue (Boops boops); MAS-chub mackerel (Scomber colias); BOC-board fish (Capros aper); and HMM-Mediterranean horse mackerel (Trachurus mediterraneus))

Species	WHB	MAC	HOM	PIL	JAA	ANE	BOG	MAS	BOC	HMM
b_{20}	-67.5	-84.9	-68.7	-72.6	-68.7	-72.6	-67.0	-68.7	-72.6 -66.2	-68.7

Table 2.5.5.2.2. Biomass, abundance, mean length and mean weight at age of mackerel from the Spanish spring acoustics surveys (PELACUS 04) from 2001 to 2014.

	2001				2002				2003			
AGE	Number (millions)	L (cm)	W (g)	Biomass t ('000)	Number (millions)	L (cm)	W (g)	Biomass t ('000)	Number (millions)	L (cm)	W (g)	Biomass t ('000)
1	29.0	25.9	126.2	3.7	621.4	23.3	80.5	50.0	5678.6	23.1	81.6	463.2
2	47.6	31.0	213.7	10.2	94.8	32.0	221.9	21.0	324.5	28.9	165.1	53.6
3	184.3	33.7	277.3	51.1	378.1	34.3	277.1	104.8	109.0	33.5	261.3	28.5
4	386.6	36.1	340.3	131.6	706.8	35.8	317.9	224.7	229.0	35.0	299.7	68.6
5	382.1	37.5	383.0	146.4	1065.9	36.8	348.0	370.9	265.2	37.1	359.1	95.2
6	393.6	38.0	397.7	156.5	604.6	38.2	390.9	236.3	230.1	38.0	385.7	88.8
7	202.7	39.5	446.7	90.5	674.5	39.1	419.2	282.8	94.3	39.8	443.4	41.8
8	143.5	40.0	464.5	66.7	191.4	39.9	447.2	85.6	88.5	40.1	454.6	40.2
9	83.7	40.5	481.7	40.3	158.4	40.3	461.4	73.1	19.6	41.5	505.1	9.9
10	17.0	40.2	469.3	8.0	100.2	41.0	490.2	49.1	10.0	41.9	519.9	5.2
11	26.3	42.1	541.4	14.2	54.0	41.4	504.0	27.2	14.0	42.6	549.6	7.7
12	12.3	41.9	533.8	6.5	12.4	43.5	586.7	7.3	3.8	41.5	503.1	1.9
13	1.9	41.5	517.1	1.0	0.0	0.0	0.0	0.0	3.7	43.1	566.9	2.1
14	6.1	43.5	596.5	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15+	9.4	42.8	568.1	5.3	2.9	45.5	676.9	2.0	2.0	43.3	578.1	1.2
TOTAL	1926.2	37.3	381.9	735.6	4665.3	35.5	329.0	1534.8	7072.1	25.5	128.4	907.8
	2004				2005				2006			
1	195.2	25.0	114.6	22.4	43.4	24.8	112.1	4.6	83.7	20.8	58.5	4.9
2	952.4	28.3	164.5	156.6	106.5	29.2	181.8	19.0	9.3	29.7	177.2	1.7
3	599.3	32.8	258.1	154.7	229.1	32.3	245.4	56.1	57.3	31.9	223.1	12.8
4	227.5	37.5	377.8	86.0	259.6	36.5	349.4	92.4	230.7	33.5	262.7	60.6
5	425.6	38.1	395.5	168.3	82.6	38.3	403.4	34.2	104.7	36.7	345.0	36.1
6	336.7	39.1	428.4	144.2	163.8	38.8	417.6	70.4	34.2	38.5	398.1	13.6
7	181.5	40.1	461.7	83.8	114.9	39.5	438.4	52.0	22.2	39.2	420.5	9.3
8	106.1	40.8	483.2	51.3	63.8	39.8	451.7	29.8	7.6	40.9	483.3	3.6
9	76.5	41.0	492.5	37.7	33.6	41.0	493.9	17.2	2.0	41.9	513.6	1.0
10	31.1	42.3	538.0	16.7	15.3	42.3	535.4	8.5	3.4	41.3	495.1	1.7
11	18.9	42.2	533.9	10.1	13.7	41.8	518.8	7.4	1.4	42.7	545.7	0.8
12	13.5	43.3	573.8	7.7	6.6	42.0	526.6	3.6	0.5	42.8	551.1	0.3
13	3.2	43.9	599.8	1.9	11.3	42.5	544.1	6.4	0.1	43.8	590.7	0.1
14	0.0	0.0	0.0	0.0	5.1	43.8	592.6	3.2	0.0	0.0	0.0	0.0
15+	5.9	46.4	710.5	4.2	7.3	43.7	594.9	4.6	0.0	44.5	621.0	0.0
TOTAL	3173.2	33.8	298.0	945.6	1156.6	35.9	346.7	409.5	557.3	32.7	263.0	146.6
	2007				2008				2009			
1	182.2	21.5	64.1	11.7	407.1	24.4	100.4	40.9	7.5	24.3	98.5	0.7
2	34.6	25.6	110.5	3.8	100.5	27.1	135.2	13.6	65.1	29.3	176.1	11.5
3	22.1	33.4	254.5	5.6	327.4	29.8	180.7	59.1	148.4	30.0	189.4	28.1
4	129.6	34.9	291.7	37.8	125.8	33.5	261.9	32.9	201.7	32.5	248.1	50.0
5	189.4	36.1	324.0	61.4	233.6	36.2	328.2	76.5	86.8	35.0	314.3	27.3
6	117.5	38.1	379.7	44.6	277.5	36.3	328.5	91.0	148.8	36.9	370.0	55.0

7	31.9	39.8	435.9	13.9	131.0	37.9	374.1	48.9	180.8	37.7	394.7	71.3
8	20.5	39.7	431.5	8.8	25.2	39.5	423.4	10.6	93.0	39.5	454.8	42.2
9	4.8	41.2	484.0	2.3	20.1	39.5	422.7	8.5	32.6	40.2	484.7	15.7
10	6.1	40.7	464.7	2.8	20.5	40.2	443.6	9.0	14.9	40.7	500.8	7.5
11	1.5	41.4	490.3	0.8	9.2	41.1	474.8	4.4	4.6	41.6	537.0	2.4
12	4.7	44.5	608.6	2.8	7.3	41.8	500.0	3.6	3.5	42.2	561.9	2.0
13	0.7	43.5	567.6	0.4	2.4	43.4	561.4	1.3	4.1	42.4	569.2	2.3
14	2.6	44.0	591.5	1.5	1.1	44.6	607.1	0.7	0.0	0.0	0.0	0.0
15+	0.7	46.5	697.9	0.5	0.4	46.5	690.3	0.3	0.0	0.0	0.0	0.0
TOTAL	748.9	32.5	265.4	198.8	1689.2	31.7	238.0	401.4	991.8	34.8	319.0	316.2
	2010				2011				2012			
1	431.8	23.6	89.2	38.6	1936.9	22.5	77.4	149.3	698.05	22.07	74.36	51.83
2	72.7	30.6	194.8	14.2	29.7	30.5	201.3	6.0	16.7	27.71	150.62	2.5
3	189.6	31.5	214.9	40.9	63.1	32.3	239.2	15.1	11.18	33.27	265.58	2.98
4	662.7	33.6	262.3	174.1	90.6	33.7	273.6	24.7	32.34	34.63	299.04	9.69
5	873.3	35.0	296.3	258.8	154.8	35.0	308.5	47.6	60.04	35.62	325.28	19.53
6	306.6	36.8	346.3	106.1	144.1	36.1	340.6	49.0	147.09	36.58	353.17	51.84
7	388.9	38.1	385.6	149.8	57.7	38.2	406.2	23.4	121.31	37.66	386.73	46.77
8	239.2	38.2	388.3	92.8	54.2	39.5	446.9	24.1	61.9	39.43	445.95	27.53
9	113.9	39.5	427.5	48.6	31.2	39.6	451.5	14.0	32.39	40.12	470.22	15.19
10	26.4	40.8	470.2	12.4	10.3	41.0	503.5	5.2	19.11	40.54	485.42	9.26
11	16.5	40.9	475.8	7.8	4.7	41.0	503.1	2.4	8.07	40.66	489.56	3.94
12	10.3	41.4	492.4	5.0	3.1	41.8	533.3	1.6	2.78	41.94	538.24	1.49
13	7.5	41.9	509.7	3.8	2.4	41.6	527.1	1.2	1.36	42.38	555.37	0.75
14	5.3	42.4	530.5	2.8	0.0	0.0	0.0	0.0	1.36	42.38	555.37	0.75
15+	3.0	43.1	557.7	1.7	0.0	0.0	0.0	0.0	1.19	44.53	649.03	0.78
TOTAL	3347.8	34.0	286.0	957.5	2582.9	25.8	141.2	363.7	1214.88	28.46	201.91	244.81
	2013				2014							
1	99	24.5	93.0	9	68.1	22.5	71.5	5.1				
2	653	26.5	119.1	81	42.8	32.0	217.4	9.1				
3	123	28.6	152.4	20	157.4	32.3	223.7	34.6				
4	114	34.2	267.6	31	340.4	33.3	245.5	81.9				
5	228	35.3	296.0	68	675.8	34.5	275.3	181.7				
6	235	36.2	322.3	76	581.1	36.1	318.0	179.5				
7	178	36.7	335.3	60	502.4	36.6	333.9	163.0				
8	64	37.6	361.4	23	246.9	36.7	335.2	80.4				
9	11	38.1	378.2	4	84.5	38.2	381.8	31.3				
10	8	40.0	439.4	4	33.1	39.2	414.3	13.3				
11	3	40.8	470.1	1	34.7	39.4	420.9	14.2				
12	2	41.2	490.3	1	34.7	39.4	420.9	14.2				
13												
14												
15+												
TOTAL	1718	31.2	200.2	379	2802.0	35.1	291.0	808.4				

Table 2.5.5.2.3. Mackerel Abundance and Biomass by ICES sub-divisions from Spanish spring acoustic surveys (PELACUS04) from 2001 to 2014.

	ICES IXa-N		ICES VIIIc-W		VIIIc-EW		VIIIc-EE		TOTAL	
	Abund. (109)	Biomass (kt)	Abund. (109)	Biomass (kt)	Abund. (109)	Biomass (kt)	Abund. (109)	Biomass (kt)	Abund. (109)	Biomass (kt)
2001	0.02	7.4	0.31	120.1	1.23	489.1	0.36	119.1	1.93	735.7
2002	0.00	0.0	0.82	333.7	3.80	1191.1	0.04	10.0	4.67	1534.8
2003	4.58	376.6	1.07	184.4	0.88	202.5	0.54	144.3	7.14	907.8
2004	0.61	118.6	1.03	304.3	1.50	515.7	0.03	7.0	3.17	945.6
2005	0.16	45.6	0.23	13.0	0.60	228.6	0.16	32.3	1.06	409.5
2006	0.01	0.7	0.39	100.5	0.15	41.5	0.02	4.0	0.56	146.6
2007	0.16	11.2	0.22	77.4	0.36	108.4	0.01	1.8	0.75	198.8
2008	0.16	21.4	0.38	109.0	0.84	235.0	0.05	4.2	1.42	369.7
2009	0.06	11.8	0.04	10.1	0.57	220.2	0.33	74.1	0.99	316.2
2010	0.38	34.2	0.88	293.7	2.09	628.6	0.00	1.0	3.35	957.5
2011	1.42	109.2	0.51	39.4	0.65	212.4	0.01	2.7	2.58	363.7
2012	0.61	45.03	0.02	1.3	0.57	190.7	0.02	7.8	1.21	244.8
2013	0.00	00.00	0.46	58.0	1.06	270.9	0.19	49.7	1.72	378.6
2014(1)	0.02	2.4	0.03	3.0			2.75	803	2.80	808.4

(1) Without split VIIIcEw and VIIIcEe

Table 2.6.1. Input data and parameters and the model configurations for the assessment.

Input data types and characteristics:

Name	Year range	Age range	Variable from year to year
Catch in tonnes	1980 - 2013		Yes
Catch-at-age in numbers	1980 - 2013	0-12+	Yes
Weight-at-age in the commercial catch	1980 - 2013	0-12+	Yes
Weight-at-age of the spawning stock at spawning time.	1980 – 2013	0-12+	Yes
Proportion of natural mortality before spawning	1980 -2013	0-12+	Yes
Proportion of fishing mortality before spawning	1980 -2013	0-12+	Yes
Proportion mature-at-age	1980 -2013	0-12+	Yes
Natural mortality	1980 -2013	0-12+	No, fixed at 0.15

Tuning data:

Type	Name	Year range	Age range
Survey (SSB)	ICES Triennial Mackerel and Horse Mackerel Egg Survey	1992, 1995, 1998, 2001, 2004, 2007, 2010, 2013.	Not applicable (gives SSB)
Survey (abundance index)	IBTS Recruitment index	1998-2013	Age 0
Survey (abundance index)	International Ecosystem Summer Survey in the Nordic Seas (IESSNS)	2007, 2010-2014	Ages 6-11
Tagging/recapture	Norwegian tagging program	1980-2005 (recapture years)	Ages 2 and older

SAM parameter configuration :

Setting	Value	Description
Coupling of fishing mortality states	1/2/3/4/5/6/7/8/8/8/8/8/8	Different F states for ages 0 to 6, one same F state for ages 7 and older
Correlated random walks for the fishing mortalities	0	F random walk of different ages are independent
Coupling of catchability parameters	0/0/0/0/0/0/0/0/0/0/0/0/0	No catchability parameter for the catches
	0/0/0/0/0/0/0/0/0/0/0/0/0	One catchability parameter estimated for the egg
	1/0/0/0/0/0/0/0/0/0/0/0/0	One catchability parameter estimated for the recruitment index
	0/0/0/0/0/0/2/2/2/2/2/2/0	One catchability parameter estimated for the IESSNS (same for age 6 to11)
Power law model	0	No power law model used for any of the surveys
Coupling of fishing mortality random walk variances	1/1/1/1/1/1/1/1/1/1/1/1/1	Same variance used for the F random walk of all ages

Coupling of log abundance random walk variances	1/2/2/2/2/2/2/2/2/2/2/2/2	Same variance used for the log abundance random walk of all ages except for the recruits (age 0)
Coupling of the observation variances	1/1/1/1/1/1/1/1/1/1/1/1/1	Same observation variance for all ages in the catches
	0/0/0/0/0/0/0/0/0/0/0/0/0	One observation variance for the egg survey
	2/0/0/0/0/0/0/0/0/0/0/0/0	One observation variance for the recruitment index
	0/0/0/0/0/0/3/3/3/3/3/3/0	One observation variance for the IESSNS (all ages)
Stock recruitment model	0	No stock-recruiment model

TABLE 2.6.2 NEA Mackerel. CATCH IN NUMBER

Units : Thousands

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
0	33101	56682	11180	7333	287287	81799	49983	7403	57644	65400	24246
1	411327	276229	213936	47914	31901	268960	58126	40126	152656	64263	140534
2	393025	502365	432867	668909	86064	20893	424563	156670	137635	312739	209848
3	64549	231814	472457	433744	682491	58346	38387	663378	190403	207689	410751
4	328206	32814	184581	373262	387582	445357	76545	56680	538394	167588	208146
5	254172	184867	26544	126533	251503	252217	364119	89003	72914	362469	156742
6	142978	173349	138970	20175	98063	165219	208021	244570	87323	48696	254015
7	145385	116328	112476	90151	22086	62363	126174	150588	201021	58116	42549
8	54778	125548	89672	72031	61813	19562	42569	85863	122496	111251	49698
9	130771	41186	88726	48668	47925	47560	13533	34795	55913	68240	85447
10	39920	146186	27552	49252	37482	37607	32786	19658	20710	32228	33041
11	56210	31639	91743	19745	30105	26965	22971	25747	13178	13904	16587
12	104927	199615	156121	132040	69183	97652	81153	63146	57494	35814	27905

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	10007	43447	19354	25368	14759	37956	36012	61127	67003	36345	26034
1	58459	83583	128144	147315	81529	119852	144390	99352	73597	102407	40315
2	212521	156292	210319	221489	340898	168882	186481	229767	132994	142898	158943
3	206421	356209	266677	306979	340215	333365	238426	264566	223639	275376	234186
4	375451	266591	398240	267420	275031	279182	378881	323186	261778	390858	297206
5	188623	306143	244285	301346	186855	177667	246781	361945	281041	295516	309937
6	129145	156070	255472	184925	197856	96303	135059	207619	244212	241550	231804
7	197888	113899	149932	189847	142342	119831	84378	118388	159019	175608	195250
8	51077	138458	97746	106108	113413	55812	66504	72745	86739	106291	120241
9	43415	51208	121400	80054	69191	59801	39450	47353	50613	52394	72205
10	70839	36612	38794	57622	42441	25803	26735	24386	30363	31280	42529
11	29743	40956	29067	20407	37960	18353	13950	16551	17048	18918	20546
12	52986	68205	68217	57551	39753	30648	24974	22932	32446	34202	40706

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	70409	14744	11553	12426	75651	19302	25886	17615	23453	30429	23803
1	222577	187997	31421	46840	149425	88439	59899	36514	78605	62708	66164
2	70041	275661	453133	135648	173646	190857	167748	113574	137101	115346	200064
3	367902	91075	529753	668588	159455	220575	399086	455113	303928	322725	214251
4	350163	295777	147973	293579	470063	215655	284660	616963	739221	469953	416037
5	262716	235052	258177	120538	195594	455131	260314	319465	611729	654395	454147
6	237066	183036	145899	121477	97061	203492	255675	224848	284788	488713	510469
7	151320	133595	89856	63612	73510	77859	124382	194326	143039	244210	323103
8	118870	94168	65669	38763	33399	59652	57297	73171	102072	113012	142390
9	79945	75701	40443	23947	18961	30494	32343	29738	45841	53363	69454
10	43789	45951	35654	18612	13987	16039	19482	14989	21222	25046	30573
11	21611	25797	16430	7955	8334	11416	6798	7470	6255	12311	11648
12	40280	30890	19509	10669	10186	12801	9581	5003	8523	10775	11741

age	2013
0	11325
1	46977
2	226179
3	430081
4	342280
5	437248
6	421220
7	338388
8	192725
9	118727
10	46253
11	18932
12	17856

TABLE 2.6.3 NEA Mackerel. WEIGHTS AT AGE IN THE CATCH

Units : Kg

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.057	0.060	0.053	0.050	0.031	0.055	0.039	0.076	0.055	0.049	0.085	0.068	0.051
1	0.131	0.132	0.131	0.168	0.102	0.144	0.146	0.179	0.133	0.136	0.156	0.156	0.167
2	0.249	0.248	0.249	0.219	0.184	0.262	0.245	0.223	0.259	0.237	0.233	0.253	0.239
3	0.285	0.287	0.285	0.276	0.295	0.357	0.335	0.318	0.323	0.320	0.336	0.327	0.333
4	0.345	0.344	0.345	0.310	0.326	0.418	0.423	0.399	0.388	0.377	0.379	0.394	0.397
5	0.378	0.377	0.378	0.386	0.344	0.417	0.471	0.474	0.456	0.433	0.423	0.423	0.460
6	0.454	0.454	0.454	0.425	0.431	0.436	0.444	0.512	0.524	0.456	0.467	0.469	0.495
7	0.498	0.499	0.496	0.435	0.542	0.521	0.457	0.493	0.555	0.543	0.528	0.506	0.532
8	0.520	0.513	0.513	0.498	0.480	0.555	0.543	0.498	0.555	0.592	0.552	0.554	0.555
9	0.542	0.543	0.541	0.545	0.569	0.564	0.591	0.580	0.562	0.578	0.606	0.609	0.597
10	0.574	0.573	0.574	0.606	0.628	0.629	0.552	0.634	0.613	0.581	0.606	0.630	0.651
11	0.590	0.576	0.574	0.608	0.636	0.679	0.694	0.635	0.624	0.648	0.591	0.649	0.663
12	0.580	0.584	0.582	0.614	0.663	0.710	0.688	0.718	0.697	0.739	0.713	0.708	0.669

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.061	0.046	0.072	0.058	0.076	0.065	0.062	0.063	0.069	0.052	0.081	0.067	0.048
1	0.134	0.136	0.143	0.143	0.143	0.157	0.176	0.135	0.172	0.160	0.170	0.156	0.151
2	0.240	0.255	0.234	0.226	0.230	0.227	0.235	0.227	0.224	0.256	0.267	0.263	0.268
3	0.317	0.339	0.333	0.313	0.295	0.310	0.306	0.306	0.305	0.307	0.336	0.323	0.306
4	0.376	0.390	0.390	0.377	0.359	0.354	0.361	0.363	0.376	0.368	0.385	0.400	0.366
5	0.436	0.448	0.452	0.425	0.415	0.408	0.404	0.427	0.424	0.424	0.438	0.419	0.434
6	0.483	0.512	0.501	0.484	0.453	0.452	0.452	0.463	0.474	0.461	0.477	0.485	0.440
7	0.527	0.543	0.539	0.518	0.481	0.462	0.500	0.501	0.496	0.512	0.522	0.519	0.496
8	0.548	0.590	0.577	0.551	0.524	0.518	0.536	0.534	0.540	0.536	0.572	0.554	0.539
9	0.583	0.583	0.594	0.576	0.553	0.550	0.569	0.567	0.577	0.580	0.612	0.573	0.556
10	0.595	0.627	0.606	0.596	0.577	0.573	0.586	0.586	0.603	0.600	0.631	0.595	0.583
11	0.647	0.678	0.631	0.603	0.591	0.591	0.607	0.594	0.611	0.629	0.648	0.630	0.632
12	0.679	0.713	0.672	0.670	0.636	0.631	0.687	0.644	0.666	0.665	0.715	0.684	0.655

age	2006	2007	2008	2009	2010	2011	2012	2013
0	0.038	0.089	0.051	0.104	0.048	0.029	0.089	0.091
1	0.071	0.120	0.105	0.153	0.118	0.113	0.123	0.173
2	0.197	0.215	0.222	0.213	0.221	0.231	0.187	0.234
3	0.307	0.292	0.292	0.283	0.291	0.282	0.285	0.281
4	0.357	0.372	0.370	0.331	0.331	0.334	0.340	0.333
5	0.428	0.408	0.418	0.389	0.365	0.368	0.374	0.359
6	0.479	0.456	0.444	0.424	0.418	0.411	0.401	0.386
7	0.494	0.512	0.497	0.450	0.471	0.451	0.431	0.406
8	0.543	0.534	0.551	0.497	0.487	0.494	0.468	0.428
9	0.584	0.573	0.571	0.538	0.515	0.540	0.503	0.457
10	0.625	0.571	0.620	0.586	0.573	0.580	0.537	0.472
11	0.636	0.585	0.595	0.599	0.604	0.611	0.538	0.493
12	0.689	0.666	0.662	0.630	0.630	0.664	0.585	0.554

TABLE 2.6.4 NEA Mackerel.WEIGHTS AT AGE IN THE STOCK

Units : Kg

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.063	0.063	0.063	0.063	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.120	0.118	0.118	0.117	0.114	0.118	0.111	0.076	0.106	0.109	0.096	0.174	0.112
2	0.205	0.179	0.159	0.179	0.204	0.244	0.184	0.157	0.181	0.162	0.166	0.184	0.201
3	0.287	0.258	0.217	0.233	0.251	0.281	0.269	0.234	0.238	0.230	0.247	0.243	0.260
4	0.322	0.312	0.300	0.282	0.293	0.308	0.301	0.318	0.298	0.272	0.290	0.303	0.308
5	0.356	0.335	0.368	0.341	0.326	0.336	0.350	0.368	0.348	0.338	0.332	0.347	0.360
6	0.377	0.376	0.362	0.416	0.395	0.356	0.350	0.414	0.392	0.392	0.383	0.392	0.397
7	0.402	0.415	0.411	0.404	0.430	0.407	0.374	0.415	0.445	0.388	0.435	0.423	0.419
8	0.434	0.431	0.456	0.438	0.455	0.455	0.434	0.431	0.442	0.449	0.447	0.492	0.458
9	0.438	0.454	0.455	0.475	0.489	0.447	0.428	0.483	0.466	0.432	0.494	0.500	0.487
10	0.484	0.450	0.473	0.467	0.507	0.519	0.467	0.507	0.506	0.429	0.473	0.546	0.513
11	0.520	0.524	0.536	0.544	0.513	0.538	0.506	0.492	0.567	0.482	0.495	0.526	0.543
12	0.534	0.531	0.544	0.528	0.567	0.591	0.542	0.581	0.594	0.556	0.536	0.615	0.568

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.111	0.114	0.114	0.109	0.108	0.083	0.112	0.108	0.112	0.109	0.112	0.111	0.116
2	0.190	0.163	0.201	0.185	0.196	0.172	0.210	0.194	0.190	0.206	0.181	0.158	0.140
3	0.266	0.240	0.278	0.250	0.257	0.248	0.260	0.253	0.246	0.245	0.251	0.258	0.221
4	0.323	0.306	0.327	0.322	0.310	0.299	0.317	0.301	0.303	0.288	0.277	0.318	0.328
5	0.359	0.368	0.385	0.372	0.356	0.348	0.356	0.357	0.342	0.333	0.341	0.355	0.378
6	0.410	0.418	0.432	0.425	0.401	0.383	0.392	0.394	0.398	0.360	0.401	0.406	0.403
7	0.432	0.459	0.458	0.446	0.460	0.409	0.424	0.416	0.417	0.418	0.407	0.449	0.464
8	0.459	0.480	0.491	0.471	0.473	0.455	0.456	0.438	0.451	0.429	0.489	0.482	0.481
9	0.480	0.496	0.511	0.513	0.505	0.475	0.489	0.464	0.484	0.458	0.490	0.507	0.548
10	0.515	0.550	0.517	0.508	0.511	0.530	0.508	0.489	0.521	0.511	0.488	0.517	0.536
11	0.547	0.592	0.560	0.538	0.546	0.500	0.545	0.514	0.535	0.523	0.521	0.577	0.507
12	0.577	0.604	0.602	0.573	0.585	0.547	0.576	0.551	0.574	0.557	0.540	0.591	0.605

age	2006	2007	2008	2009	2010	2011	2012	2013
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.107	0.083	0.135	0.110	0.111	0.112	0.108	0.108
2	0.165	0.149	0.160	0.162	0.163	0.181	0.153	0.146
3	0.238	0.206	0.207	0.214	0.206	0.219	0.209	0.180
4	0.293	0.288	0.260	0.268	0.253	0.269	0.250	0.247
5	0.334	0.330	0.349	0.295	0.297	0.329	0.284	0.282
6	0.402	0.362	0.354	0.354	0.346	0.366	0.309	0.320
7	0.411	0.448	0.397	0.389	0.380	0.378	0.353	0.342
8	0.436	0.452	0.450	0.437	0.407	0.417	0.376	0.372
9	0.456	0.509	0.453	0.464	0.430	0.443	0.443	0.412
10	0.467	0.525	0.476	0.522	0.486	0.479	0.494	0.442
11	0.528	0.530	0.484	0.550	0.535	0.518	0.502	0.499
12	0.570	0.590	0.515	0.563	0.573	0.527	0.561	0.526

TABLE 2.6.5 NEA Mackerel. NATURAL MORTALITY

Units : NA

	year														
age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
3	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
4	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
5	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
6	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
7	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
8	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
9	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
10	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
11	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
12	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

	year														
age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
3	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
4	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
5	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
6	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
7	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
8	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
9	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
10	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
11	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
12	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

	year			
age	2010	2011	2012	2013
0	0.15	0.15	0.15	0.15
1	0.15	0.15	0.15	0.15
2	0.15	0.15	0.15	0.15
3	0.15	0.15	0.15	0.15
4	0.15	0.15	0.15	0.15
5	0.15	0.15	0.15	0.15
6	0.15	0.15	0.15	0.15
7	0.15	0.15	0.15	0.15
8	0.15	0.15	0.15	0.15
9	0.15	0.15	0.15	0.15
10	0.15	0.15	0.15	0.15
11	0.15	0.15	0.15	0.15
12	0.15	0.15	0.15	0.15

TABLE 2.6.6 NEA Mackerel. PROPORTION MATURE

Units : NA

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.105	0.109	0.110	0.111	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116
2	0.487	0.503	0.511	0.532	0.486	0.487	0.497	0.412	0.404	0.419	0.406	0.466	0.523
3	0.840	0.817	0.877	0.880	0.871	0.888	0.923	0.924	0.917	0.916	0.913	0.920	0.930
4	0.933	0.919	0.934	0.970	0.968	0.967	0.989	0.990	0.990	0.993	0.994	0.993	0.995
5	0.963	0.971	0.970	0.991	0.988	0.988	0.990	0.996	0.994	0.999	0.999	0.998	0.998
6	0.980	0.978	0.980	0.995	0.996	0.994	0.997	0.997	0.997	0.998	1.000	0.998	0.996
7	0.983	0.980	0.979	0.994	0.994	0.996	1.000	1.000	1.000	1.000	1.000	1.000	0.999
8	1.000	0.999	0.999	0.998	0.998	0.997	0.997	0.997	0.997	0.997	0.998	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.116	0.116	0.116	0.116	0.109	0.109	0.109	0.118	0.118	0.118	0.120	0.120	0.120
2	0.558	0.607	0.573	0.588	0.608	0.626	0.606	0.637	0.632	0.696	0.705	0.719	0.704
3	0.936	0.941	0.922	0.916	0.859	0.873	0.874	0.906	0.909	0.944	0.939	0.940	0.941
4	0.996	0.997	0.996	0.997	0.987	0.988	0.988	0.987	0.984	0.994	0.990	0.990	0.991
5	0.999	0.999	0.999	1.000	0.997	0.997	0.997	0.997	0.996	0.999	0.999	0.998	0.998
6	0.996	0.996	0.996	0.998	0.998	0.998	0.999	0.998	0.998	0.999	0.999	0.999	0.999
7	0.999	0.999	0.999	0.999	1.000	1.000	1.000	1.000	0.999	0.999	0.999	0.999	0.999
8	1.000	1.000	1.000	1.000	0.998	0.998	0.998	0.998	0.999	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

age \ year	2006	2007	2008	2009	2010	2011	2012	2013
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.107	0.107	0.107	0.108	0.108	0.108	0.105	0.105
2	0.680	0.610	0.588	0.585	0.547	0.545	0.527	0.546
3	0.913	0.905	0.910	0.912	0.909	0.912	0.910	0.916
4	0.994	0.994	0.996	0.997	0.997	0.997	0.997	0.999
5	0.999	0.999	0.998	1.000	0.999	0.999	0.999	1.000
6	1.000	1.000	1.000	1.000	0.999	0.999	0.999	0.999
7	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

TABLE 2.6.7 NEA Mackerel. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

year

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.177	0.179	0.181
2	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.177	0.179	0.181
3	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.254	0.285	0.316
4	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.254	0.285	0.316
5	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.392	0.402	0.411
6	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.392	0.402	0.411
7	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.392	0.402	0.411
8	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.392	0.402	0.411
9	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.392	0.402	0.411
10	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.392	0.402	0.411
11	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.392	0.402	0.411
12	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.392	0.402	0.411

year

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.216	0.252	0.287	0.250	0.212	0.175	0.179	0.183	0.187	0.202	0.217	0.231	0.230
2	0.216	0.252	0.287	0.250	0.212	0.175	0.179	0.183	0.187	0.202	0.217	0.231	0.230
3	0.318	0.321	0.323	0.329	0.335	0.340	0.364	0.389	0.413	0.406	0.399	0.393	0.375
4	0.318	0.321	0.323	0.329	0.335	0.340	0.364	0.389	0.413	0.406	0.399	0.393	0.375
5	0.436	0.461	0.486	0.491	0.496	0.500	0.464	0.426	0.389	0.404	0.419	0.433	0.402
6	0.436	0.461	0.486	0.491	0.496	0.500	0.464	0.426	0.389	0.404	0.419	0.433	0.402
7	0.436	0.461	0.486	0.491	0.496	0.500	0.464	0.426	0.389	0.404	0.419	0.433	0.402
8	0.436	0.461	0.486	0.491	0.496	0.500	0.464	0.426	0.389	0.404	0.419	0.433	0.402
9	0.436	0.461	0.486	0.491	0.496	0.500	0.464	0.426	0.389	0.404	0.419	0.433	0.402
10	0.436	0.461	0.486	0.491	0.496	0.500	0.464	0.426	0.389	0.404	0.419	0.433	0.402
11	0.436	0.461	0.486	0.491	0.496	0.500	0.464	0.426	0.389	0.404	0.419	0.433	0.402
12	0.436	0.461	0.486	0.491	0.496	0.500	0.464	0.426	0.389	0.404	0.419	0.433	0.402

year

age	2006	2007	2008	2009	2010	2011	2012	2013
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.230	0.229	0.198	0.165	0.134	0.174	0.213	0.112
2	0.230	0.229	0.198	0.165	0.134	0.174	0.213	0.112
3	0.358	0.341	0.307	0.272	0.239	0.226	0.212	0.076
4	0.358	0.341	0.307	0.272	0.239	0.226	0.212	0.076
5	0.370	0.339	0.309	0.277	0.247	0.217	0.188	0.222
6	0.370	0.339	0.309	0.277	0.247	0.217	0.188	0.222
7	0.370	0.339	0.309	0.277	0.247	0.217	0.188	0.222
8	0.370	0.339	0.309	0.277	0.247	0.217	0.188	0.222
9	0.370	0.339	0.309	0.277	0.247	0.217	0.188	0.222
10	0.370	0.339	0.309	0.277	0.247	0.217	0.188	0.222
11	0.370	0.339	0.309	0.277	0.247	0.217	0.188	0.222
12	0.370	0.339	0.309	0.277	0.247	0.217	0.188	0.222

TABLE 2.6.8 NEA Mackerel. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

year

1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	
0	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333
1	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333
2	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333
3	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333
4	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333
5	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333
6	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333
7	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333
8	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333
9	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333
10	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333
11	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333
12	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333

year

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346
1	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346
2	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346
3	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346
4	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346
5	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346
6	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346
7	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346
8	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346
9	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346
10	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346
11	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346
12	0.341	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346

year

age	2006	2007	2008	2009	2010	2011	2012	2013
0	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246
1	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246
2	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246
3	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246
4	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246
5	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246
6	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246
7	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246
8	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246
9	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246
10	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246
11	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246
12	0.342	0.339	0.311	0.283	0.255	0.252	0.249	0.246

TABLE 2.6.9 NEA Mackerel. SURVEY INDICES

Mackerel egg survey (SSB index)

1992	3903155
1993	-1
1994	-1
1995	3840254
1996	-1
1997	-1
1998	4418744
1999	-1
2000	-1
2001	3273832
2002	-1
2003	-1
2004	3166579
2005	-1
2006	-1
2007	3965634
2008	-1
2009	-1
2010	4835955
2011	-1
2012	-1
2013	5025630

IBTS
Age0 abundance index

1998	0.610556724
1999	0.651645802
2000	0.421783455
2001	0.796551079
2002	0.863241606
2003	0.538444879
2004	0.880215459
2005	1.130632667
2006	1.076123061
2007	0.547059771
2008	0.687584007
2009	0.480565796
2010	0.636229662
2011	1.185808357
2012	1.050932122
2013	1.339493007

IESSNS
Age 6-11 abundance index

2007	0.1937	0.0661	0.0470	0.0354	0.0130	0.0104
2008	NA	NA	NA	NA	NA	NA
2009	NA	NA	NA	NA	NA	NA
2010	0.6296	0.2733	0.1900	0.1162	0.0310	0.0203
2011	0.9953	0.4638	0.2264	0.0998	0.0513	0.0466
2012	1.3108	0.8903	0.3539	0.1857	0.0647	0.0328
2013	1.3009	1.2022	0.5729	0.1950	0.0787	0.0687
2014	1.071	1.0911	0.6883	0.3018	0.1469	0.0350

TABLE 2.6.10 NEA Mackerel. Final assessment estimated parameters (WGWIDE 2014)and comparison with the parameters estimated during the previous assessment (ICES CM 2014/ACOM:48)

	WGWIDE 2014		Previous assessment	
Parameter	Estimate	CV	Estimate	CV
Random walk variance				
Fishing mortality at age	0.258	20%	0.286	17%
log(N-at-age 0)	0.416	21%	0.468	20%
log(N-at-age1 to 12+)	0.183	11%	0.185	12%
Observation variance				
catches	0.122	33%	0.101	41%
egg survey index	0.193	33%	0.174	31%
recruit index	0.286	31%	0.338	25%
IESSNS indices	0.257	18%	0.223	19%
tag recaptures over dispersion	1.206	27%	1.206	27%
Survey catchability				
Recruitment index	1.46E-07	14%	1.15E-07	15%
IESSNS indices	6.10E-07	14%	5.31E-07	14%
egg survey index	1.471	9%	1.280	9%
post tagging survival	0.383	10%	0.379	10%

TABLE 2.6.11 NEA Mackerel. STOCK SUMMARY. Low = lower limit and High = higher limit of 95% confidence interval.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Fbar4-8	Landings (tonnes)
1980	6331198	5688744	3964935	0.172	734950
1981	5204322	5427559	3594804	0.172	754045
1982	2735979	5199120	3584036	0.173	716987
1983	2473142	5214741	3894205	0.173	672283
1984	4470452	5142243	4139146	0.175	641928
1985	3937277	5261886	4053130	0.181	614371
1986	3949107	4828276	3623678	0.188	602201
1987	4625060	4643598	3638201	0.198	654992
1988	3534209	4770683	3580453	0.209	680491
1989	3416065	4457060	3331723	0.227	585920
1990	2853338	4386315	3361843	0.252	626107
1991	3207492	4355718	3213914	0.285	675665
1992	3534209	3817094	2856192	0.32	760690
1993	3011654	3492052	2505503	0.351	824568
1994	2827773	3044965	2169484	0.365	819087
1995	2597344	2999631	2152198	0.338	756277
1996	3097172	2782889	2057495	0.294	563472
1997	2931427	2830602	2049282	0.268	573029
1998	3541284	2757955	2053385	0.274	666316
1999	3859314	3128299	2233320	0.301	640309
2000	2981688	3087894	2176002	0.342	738606
2001	4940613	2808048	2032953	0.392	737463
2002	8360259	2940235	1899308	0.431	771422
2003	3433189	3295274	1916479	0.462	679287
2004	4180745	3311792	2361954	0.426	660491
2005	5832755	3100271	2273884	0.321	549514
2006	10039120	3405833	2262543	0.293	481181
2007	4685579	3674766	2450984	0.348	586206
2008	4965378	4390703	3038881	0.308	623165
2009	4560761	4780234	3682123	0.262	737969
2010	5774718	5126840	3968902	0.245	875515
2011	7818474	5774718	4515380	0.236	946661
2012	7268060	5548288	4180745	0.213	892353
2013	8064141*	5609656	4299460	0.217	931732

*** : the last estimated recruitment was replaced by the output of RCT3**

TABLE 2.6.12 NEA Mackerel. ESTIMATED FISHING MORTALITY

Units : f

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.011	0.011	0.011	0.011	0.011
1	0.036	0.036	0.036	0.036	0.036	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
2	0.054	0.054	0.053	0.052	0.053	0.052	0.051	0.051	0.051	0.050	0.051	0.051	0.052
3	0.085	0.085	0.084	0.084	0.085	0.088	0.091	0.093	0.097	0.102	0.107	0.113	0.117
4	0.149	0.149	0.151	0.150	0.151	0.156	0.164	0.178	0.188	0.206	0.220	0.235	0.241
5	0.151	0.151	0.152	0.155	0.157	0.161	0.166	0.170	0.180	0.187	0.192	0.201	0.218
6	0.185	0.187	0.188	0.190	0.196	0.204	0.212	0.221	0.227	0.249	0.270	0.289	0.305
7	0.187	0.187	0.186	0.186	0.186	0.191	0.199	0.211	0.224	0.247	0.288	0.351	0.418
8	0.187	0.187	0.186	0.186	0.186	0.191	0.199	0.211	0.224	0.247	0.288	0.351	0.418
9	0.187	0.187	0.186	0.186	0.186	0.191	0.199	0.211	0.224	0.247	0.288	0.351	0.418
10	0.187	0.187	0.186	0.186	0.186	0.191	0.199	0.211	0.224	0.247	0.288	0.351	0.418
11	0.187	0.187	0.186	0.186	0.186	0.191	0.199	0.211	0.224	0.247	0.288	0.351	0.418
12	0.187	0.187	0.186	0.186	0.186	0.191	0.199	0.211	0.224	0.247	0.288	0.351	0.418

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.011	0.011	0.011	0.011	0.011	0.012	0.012	0.012	0.007	0.008	0.005	0.003	0.003
1	0.035	0.035	0.035	0.035	0.035	0.034	0.034	0.033	0.029	0.037	0.026	0.016	0.016
2	0.054	0.055	0.055	0.057	0.060	0.062	0.065	0.069	0.068	0.068	0.066	0.074	0.067
3	0.123	0.125	0.127	0.128	0.131	0.139	0.159	0.183	0.166	0.175	0.139	0.163	0.147
4	0.241	0.240	0.230	0.220	0.208	0.213	0.230	0.266	0.296	0.302	0.253	0.239	0.192
5	0.226	0.224	0.226	0.235	0.254	0.286	0.317	0.372	0.342	0.374	0.373	0.355	0.288
6	0.321	0.321	0.314	0.300	0.293	0.293	0.316	0.362	0.459	0.446	0.476	0.439	0.354
7	0.484	0.519	0.460	0.357	0.291	0.289	0.322	0.355	0.432	0.517	0.604	0.547	0.384
8	0.484	0.519	0.460	0.357	0.291	0.289	0.322	0.355	0.432	0.517	0.604	0.547	0.384
9	0.484	0.519	0.460	0.357	0.291	0.289	0.322	0.355	0.432	0.517	0.604	0.547	0.384
10	0.484	0.519	0.460	0.357	0.291	0.289	0.322	0.355	0.432	0.517	0.604	0.547	0.384
11	0.484	0.519	0.460	0.357	0.291	0.289	0.322	0.355	0.432	0.517	0.604	0.547	0.384
12	0.484	0.519	0.460	0.357	0.291	0.289	0.322	0.355	0.432	0.517	0.604	0.547	0.384

age	2006	2007	2008	2009	2010	2011	2012	2013	2014
0	0.006	0.005	0.005	0.004	0.004	0.004	0.003	0.002	0.002
1	0.021	0.014	0.014	0.012	0.016	0.013	0.011	0.009	0.009
2	0.056	0.038	0.032	0.032	0.037	0.038	0.043	0.044	0.044
3	0.105	0.094	0.091	0.092	0.093	0.098	0.094	0.109	0.109
4	0.173	0.159	0.154	0.168	0.176	0.165	0.163	0.181	0.181
5	0.239	0.259	0.239	0.220	0.222	0.211	0.196	0.207	0.207
6	0.350	0.365	0.285	0.281	0.255	0.251	0.231	0.214	0.209
7	0.353	0.478	0.430	0.320	0.286	0.276	0.236	0.243	0.251
8	0.353	0.478	0.430	0.320	0.286	0.276	0.236	0.243	0.251
9	0.353	0.478	0.430	0.320	0.286	0.276	0.236	0.243	0.251
10	0.353	0.478	0.430	0.320	0.286	0.276	0.236	0.243	0.251
11	0.353	0.478	0.430	0.320	0.286	0.276	0.236	0.243	0.251
12	0.353	0.478	0.430	0.320	0.286	0.276	0.236	0.243	0.251

TABLE 2.6.13 NEA Mackerel. ESTIMATED POPULATION ABUNDANCE

Units : NA

age	1980	1981	1982	1983	1984	1985	1986	1987
0	6331198	5204322	2735979	2473142	4470452	3937277	3949107	4625060
1	4528947	5615269	4833107	2105366	1848712	4347015	3259225	3262486
2	2012725	3745254	4842782	4368805	1581683	1351871	4114385	2639236
3	845768	1629852	3125172	4325334	4184928	1162403	996496	3921560
4	1424028	667303	1260476	2636598	3779113	3828563	905280	718557
5	3125172	1080571	493856	897169	2032953	3017683	2978707	720716
6	2500497	2308249	810171	377755	646288	1558135	2242272	2103262
7	861991	1786913	1646233	578967	277618	467428	1087074	1551915
8	331042	615383	1275693	1171740	408808	204638	325462	783088
9	890911	236570	439327	910728	834009	293021	148449	225032
10	254231	636666	168721	313013	650177	593030	211082	104925
11	369904	181680	454067	120451	223463	463240	418738	148598
12	718557	777625	683512	809361	661325	629071	769888	826537

age	1988	1989	1990	1991	1992	1993	1994	1995
0	3534209	3416065	2853338	3207492	3534209	3011654	2827773	2597344
1	4303762	2870509	2984671	2294441	2749693	3162900	2520581	2419327
2	2639236	3905905	2278436	2543369	1803068	2305942	2757955	2053385
3	2103262	2273884	3752752	2010713	2383308	1518145	1893618	2317501
4	3576875	1649528	1803068	2913891	1460077	1928012	1048635	1381942
5	476394	2816484	1077334	1226899	1815733	939403	1304069	653436
6	570918	327420	1951288	795718	946002	1140526	585370	930986
7	1409859	448202	213630	1244196	501822	593623	658026	353274
8	1077334	1040280	336718	136353	722159	307737	324811	271577
9	559053	747882	702921	233515	84120	386157	167879	158103
10	154045	386157	487966	460469	143918	46677	186839	89949
11	73350	102744	259367	303155	271577	81308	23600	98716
12	669978	504842	403931	422523	429768	382697	246965	139107

age	1996	1997	1998	1999	2000	2001	2002	2003
0	3097172	2931427	3541284	3859314	2981688	4940613	8360259	3433189
1	2107473	2755198	2378546	2864774	3301872	1674458	5792068	7725213
2	2014739	1666106	2390469	1878530	2269341	2605148	1131438	4833107
3	2074021	1869161	1228126	2312871	1664441	1694672	2324464	816678
4	1746283	1716847	1600777	1182333	1770903	1191829	1387480	1474751
5	931918	1167062	1457160	1246687	938464	1195410	882929	819951
6	477347	697320	838190	887355	855122	605615	752382	511447
7	554599	315527	466028	600189	614768	576079	372503	353628
8	204638	327420	253723	306815	372131	397918	324811	216858
9	128798	142771	204638	177194	190422	230729	214058	175431
10	80017	81471	100408	129444	112984	120692	119611	105768
11	48339	43871	53263	66171	71325	66703	59219	59456
12	128927	105556	100609	106617	119253	120331	103156	73644

age	2004	2005	2006	2007	2008	2009	2010	2011
0	4180745	5832755	10039120	4685579	4965378	4560761	5774718	7818474
1	2438759	3478111	6837960	7210148	4519898	3870909	4611206	5330737
2	6524011	2202272	3288690	5677378	6070794	3988796	3917640	3450398
3	3652783	5020299	1803068	2703344	4995260	5564958	3693186	3645485
4	714258	1893618	3233255	1578523	2193480	4239687	4770683	3318422
5	917126	516071	1064483	2101160	1297565	1760309	3233255	3656438
6	432354	463703	352921	675359	1177613	959339	1361367	2319820
7	244019	220577	269682	228205	410446	742665	641138	1044449
8	167879	125367	127899	163081	167042	276509	427624	485532
9	105556	82207	69633	87553	96086	114348	191568	242316
10	81471	57584	49762	41564	55050	55326	84036	111079
11	42531	30061	30669	30061	20611	30212	31070	58630
12	51072	38330	37012	36425	29792	22181	35846	45936

age	2012	2013	2014
0	7268060	6022422	6022422
1	6622609	5722979	5173190
2	5010268	5609656	4881680
3	2684486	4333994	4620438
4	3029778	2171655	3345076
5	2782889	2460807	1561254
6	2649814	2340792	1878530
7	1618483	1830317	1837653
8	730146	1016626	1310606
9	339422	530195	671991
10	153277	208355	342491
11	64151	102539	113777
12	62567	87904	128541

Table 2.7.2.1 RCT3 output.

```
Analysis by RCT3_R ver3.1 of data from file :

RCT3/RCT3init.txt

RCT3 for NEA Mackerel

Data for 1 surveys over 24 years :  1990 - 2013

Regression type = c
Tapered time weighting applied
Power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E. for any survey taken as 0.000
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.


yearclass = 2013

          I-----------Regression----------I  I-----------Prediction---------I

 Survey/  Slope  Inter-   Std  Rsquare  No.  Index Predicted   Std     WAP
 Series           cept   Error          Pts  Value   Value    Error   Weights

 IBTS.index   1.72  14.14   0.30  0.581     15   1.34   16.45    0.409    0.428

                                        VPA Mean =   15.50    0.354    0.572



 Year     Weighted      Log      Int      Ext     Var      VPA       Log
 Class     Average      WAP      Std      Std    Ratio               VPA
          Prediction            Error    Error

 2013     8064141     15.90    0.27     0.47     3.09
```

Table 2.7.3.1 NE Atlantic Mackerel. Short-term prediction: INPUT DATA

2014	Stock Numbers	M	Maturity ogive	Prop of F before spw.	Prop of M before spw.	Weights in the stock	Exploitation pattern	Weights in the catch
0	4272254	0.15	0.000	0.000	0.249	0.000	0.003	0.070
1	6925455	0.15	0.106	0.166	0.249	0.109	0.011	0.136
2	4881680	0.15	0.539	0.166	0.249	0.160	0.042	0.217
3	4620438	0.15	0.913	0.171	0.249	0.203	0.100	0.283
4	3345076	0.15	0.998	0.171	0.249	0.255	0.170	0.336
5	1561254	0.15	0.999	0.209	0.249	0.298	0.205	0.367
6	1878530	0.15	0.999	0.209	0.249	0.332	0.232	0.399
7	1837653	0.15	1.000	0.209	0.249	0.358	0.252	0.429
8	1310606	0.15	1.000	0.209	0.249	0.388	0.252	0.463
9	671991	0.15	1.000	0.209	0.249	0.433	0.252	0.500
10	342491	0.15	1.000	0.209	0.249	0.472	0.252	0.530
11	113777	0.15	1.000	0.209	0.249	0.506	0.252	0.547
12+	128541	0.15	1.000	0.209	0.249	0.538	0.252	0.601
2015								
0	4272254	0.15	0.000	0.000	0.249	0.000	0.003	0.070
1	-	0.15	0.106	0.166	0.249	0.109	0.011	0.136
2	-	0.15	0.539	0.166	0.249	0.160	0.042	0.217
3	-	0.15	0.913	0.171	0.249	0.203	0.100	0.283
4	-	0.15	0.998	0.171	0.249	0.255	0.170	0.336

2014	Stock Numbers	M	Maturity ogive	Prop of F before spw.	Prop of M before spw.	Weights in the stock	Exploitation pattern	Weights in the catch
5	-	0.15	0.999	0.209	0.249	0.298	0.205	0.367
6	-	0.15	0.999	0.209	0.249	0.332	0.232	0.399
7	-	0.15	1.000	0.209	0.249	0.358	0.252	0.429
8	-	0.15	1.000	0.209	0.249	0.388	0.252	0.463
9	-	0.15	1.000	0.209	0.249	0.433	0.252	0.500
10	-	0.15	1.000	0.209	0.249	0.472	0.252	0.530
11	-	0.15	1.000	0.209	0.249	0.506	0.252	0.547
12+	-	0.15	1.000	0.209	0.249	0.538	0.252	0.601
2016								
0	4272254	0.15	0.000	0.000	0.249	0.000	0.003	0.070
1	-	0.15	0.106	0.166	0.249	0.109	0.011	0.136
2	-	0.15	0.539	0.166	0.249	0.160	0.042	0.217
3	-	0.15	0.913	0.171	0.249	0.203	0.100	0.283
4	-	0.15	0.998	0.171	0.249	0.255	0.170	0.336
5	-	0.15	0.999	0.209	0.249	0.298	0.205	0.367
6	-	0.15	0.999	0.209	0.249	0.332	0.232	0.399
7	-	0.15	1.000	0.209	0.249	0.358	0.252	0.429
8	-	0.15	1.000	0.209	0.249	0.388	0.252	0.463
9	-	0.15	1.000	0.209	0.249	0.433	0.252	0.500
10	-	0.15	1.000	0.209	0.249	0.472	0.252	0.530
11	-	0.15	1.000	0.209	0.249	0.506	0.252	0.547
12+	-	0.15	1.000	0.209	0.249	0.538	0.252	0.601

Table 2.7.3.2 NE Atlantic Mackerel. Short-term prediction: Multi-option table for 1 396 kt catch in 2014 and a range of F-multipliers in 2015.

2014				
TSB	SSB	Fmult	Fbar	Landings
6162863	4605433	1.200	0.324	1 396 238

2015					2016		
TSB	SSB	Fmult	Fbar	Landings	TSB	SSB	Implied change in the landings
5563709	4528449	0	0.00	0	6074888	5193026	-100%
-	4504959	0.1	0.03	144669	5952195	5048093	-90%
-	4481618	0.2	0.06	285283	5833030	4908243	-80%
-	4458423	0.3	0.10	421967	5717282	4773282	-70%
-	4435374	0.4	0.13	554844	5604844	4643024	-60%
-	4412470	0.5	0.16	684032	5495610	4517292	-51%
-	4389710	0.6	0.19	809644	5389481	4395912	-42%
-	4367093	0.7	0.23	931792	5286359	4278720	-33%
-	4344618	0.8	0.26	1050581	5186150	4165558	-25%
-	4322284	0.9	0.29	1166116	5088763	4056273	-16%
-	4300091	1	0.32	1278497	4994108	3950720	-8%
-	4278036	1.1	0.36	1387820	4902102	3848758	-1%
-	4256119	1.2	0.39	1494179	4812662	3750252	7%
-	4234340	1.3	0.42	1597664	4725707	3655073	14%
-	4212697	1.4	0.45	1698364	4641162	3563096	22%
-	4191189	1.5	0.49	1796363	4558950	3474202	29%
-	4169816	1.6	0.52	1891744	4478999	3388275	35%
-	4148577	1.7	0.55	1984585	4401241	3305206	42%
-	4127470	1.8	0.58	2074965	4325607	3224889	49%
-	4106494	1.9	0.62	2162957	4252031	3147220	55%
-	4085650	2.0	0.65	2248633	4180451	3072103	61%

Table 2.7.3.3. NE Atlantic Mackerel. Short-term prediction: Management option table for 1 396 kt catch in 2014 and a range of catch options for 2015.

options	Fbar (2015)	Catch (2015)	SSB (2015)	TSB (2015)	SSB (2016)	TSB (2016)	% change TAC 2014->2015	% change SSB 2015->2016
Catch(2015) = Zero	0.00	0	4528449	5563709	5193026	6074888	-100%	15%
Catch(2015) = 2014 catch -20%	0.28	1116990	4331839	5563709	4101120	5130162	-20%	-5%
Catch(2015) = 2014 catch	0.36	1396238	4276318	5563709	3840274	4895020	0%	-10%
Catch(2015) = 2014 catch +20%	0.45	1675486	4217654	5563709	3581774	4660363	20%	-15%
Fbar(2015) = 0.20	0.20	831030	4385786	5563709	4375334	5371421	-40%	0%
Fbar(2015) = 0.21	0.21	868912	4378797	5563709	4338944	5339435	-38%	-1%
Fbar(2015) = 0.22	0.22	906469	4371822	5563709	4302946	5307731	-35%	-2%
Fbar(2015) = 0.26 (Fpa)	0.26	1053508	4344058	5563709	4162779	5183682	-25%	-4%
Fbar(2015) = 0.25 (Fmsy)	0.25	1017221	4350979	5563709	4197257	5214285	-27%	-4%

Table 2.7.3.4 : NE Atlantic Mackerel. Short-term prediction: Management option table using an assumption of 10% banking for EU and Norway in 2014 (catches and SSB in tonnes)

Fbar (2014)	0.30
Catch (2014)	1307206
banked 2014->2015	89032
SSB (2014)	4623227
TSB (2014)	6162862

	Fbar (2015) advice	Fbar (2015) effective	Catch (2015) advice	Catch (2015) + banking 2014	SSB (2015) advice	SSB (2015) real	TSB (2015) real	SSB (2016) real	TSB (2016) real	% change TAC 2014->2015	% change SSB 2015->2016
Catch(2015) = Zero	0.00	0.02	0	89032	4599641	4585223	5638587	5189779	6071038	-93%	13%
Catch(2015) = 2014 catch	0.33	0.35	1307206	1396238	4365556	4347570	5638587	3925265	4966544	7%	-10%
Fbar(2015) = 0.20	0.20	0.22	846079	935110	4454113	4437581	5638587	4360695	5355150	-28%	-2%
Fbar(2015) = 0.21	0.21	0.23	884637	973669	4446985	4430340	5638587	4323823	5322610	-26%	-2%
Fbar(2015) = 0.22	0.22	0.24	922864	1011895	4439870	4423113	5638587	4287350	5290358	-23%	-3%
Fbar(2015) = 0.26(Fpa)	0.26	0.28	1072515	1161547	4411550	4394336.	5638587	4145355	5164173	-11%	-6%
Fbar(2015) = 0.25(Fmsy)	0.25	0.27	1035584	1124616	4418610	4401511	5638587	4180279	5195301	-14%	-5%

Table 2.7.3.5 : NE Atlantic Mackerel. Short-term prediction: Management option table using an assumption of 20% banking for EU and Norway in 2014 (catches and SSB in tonnes)

Fbar (2014)	0.28
Catch (2014)	1218174

banked 2014->2015	178064										
SSB (2014)	4640744										
TSB (2014)	6162863										
	Fbar (2015) advice	Fbar (2015) effective	Catch (2015) advice	Catch (2015) + banking 2014	SSB (2015) advice	SSB (2015) real	TSB (2015) real	SSB (2016) real	TSB (2016) real	% change TAC 2014->2015	% change SSB 2015->2016
Catch(2015) = Zero	0.00	0.04	0	178064	4670890	4641815	5713506	5186563	6067231	-85%	12%
Catch(2015) = 2014 catch	0.29	0.34	1218174	1396238	4454474	4418875	5713506	4009363	5038089	15%	-9%
Fbar(2015) = 0.20	0.20	0.25	861152	1039216	4522491	4489104	5713506	4346081	5338911	-15%	-3%
Fbar(2015) = 0.21	0.21	0.26	900387	1078451	4515222	4481606	5713506	4308726	5305817	-11%	-4%
Fbar(2015) = 0.22	0.22	0.27	939285	1117349	4507968	4474121	5713506	4271778	5273016	-8%	-5%
Fbar(2015) = 0.26(Fpa)	0.26	0.31	1091552	1269616	4479091	4444310	5713506	4127956	5144695	4%	-7%
Fbar(2015) = 0.25(Fmsy)	0.25	0.30	1053977	1232041	4486289	4451744	5713506	4163326	5176349	1%	-6%

Table 2.8.1 ICES Reference points for NEA mackerel as proposed by the 2014 WKPELA benchmark workshop.

Type		Value	Technical basis
Management Plan	SSBtrigger	2.2 million t	Medium-term simulations conducted in 2008 Revision required1
	F target	0.20-0.22	Medium-term simulations conducted in 2008 Revision required1
MSY Approach	MSY Btrigger	2.36 million t	Proxy based on Bpa Revision required2
	FMSY target	0.25	Stochastic simulation conducted at WKPELA 2014
Precautionary Approach	Blim	1.84 million t	Bloss in 2002 from WKPELA 2014 benchmark assessment
	Bpa	2.36 million t	exp(1.654*σ)*Bim, σ=0.15
	Flim	0.39	Floss, the F that on average leads to Blim
	Fpa	0.26	F that on average leads to Bpa

[1]**Under evaluation**

[2]**To be revised at WGWIDE after the management plan evaluation.**

Table 2.11.1. Catches in tonnes of *Scomber colias* in Divisions VIIIb, VIIIc and IXa in the period 1982 – 2013.

Subdivisions		1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
VIIIb	Spain	0	0	0	0	0	0	0	0	0	487	7	4	427	247	778
VIIIc	Spain	322	254	656	513	750	1150	1214	3091	1923	1502	859	1892	1903	2558	2679
IXa N & S	Spain	0	0	0	0	0	0	0	0	0	0	895	3357	8573	5068	5437
IXa-CN, CS & S	Portugal	2458	1364	8059	9118	8184	8876	3816	6447	8568	10142	8981	7341	4430	3884	4759
Sub-Divisions		**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
VIIIb	Spain	362	1218	632	344	426	99	157	40	222	262	744	42	122	520	384
VIIIc	Spain	5026	1765	418	1905	1496	1509	2525	2741	3150	4260	7153	5203	3930	8939	17694
IXa N & S	Spain	2340	1381	983	1001	553	1566	981	888	812	2984	8239	8544	11860	12218	9152
IXa-CN, CS & S	Portugal	5408	6690	13877	10520	4228	5301	8030	14714	14905	13031	20222	23286	14428	22283	30635
Subdivisions		**2012**	**2013**													
VIIIb	Spain	2089	4688													
VIIIc	Spain	12068	5356													
IXa N & S	Spain	13499	8597													
IXa-CN, CS & S	Portugal	37191	39250													
Unallocated			1070													

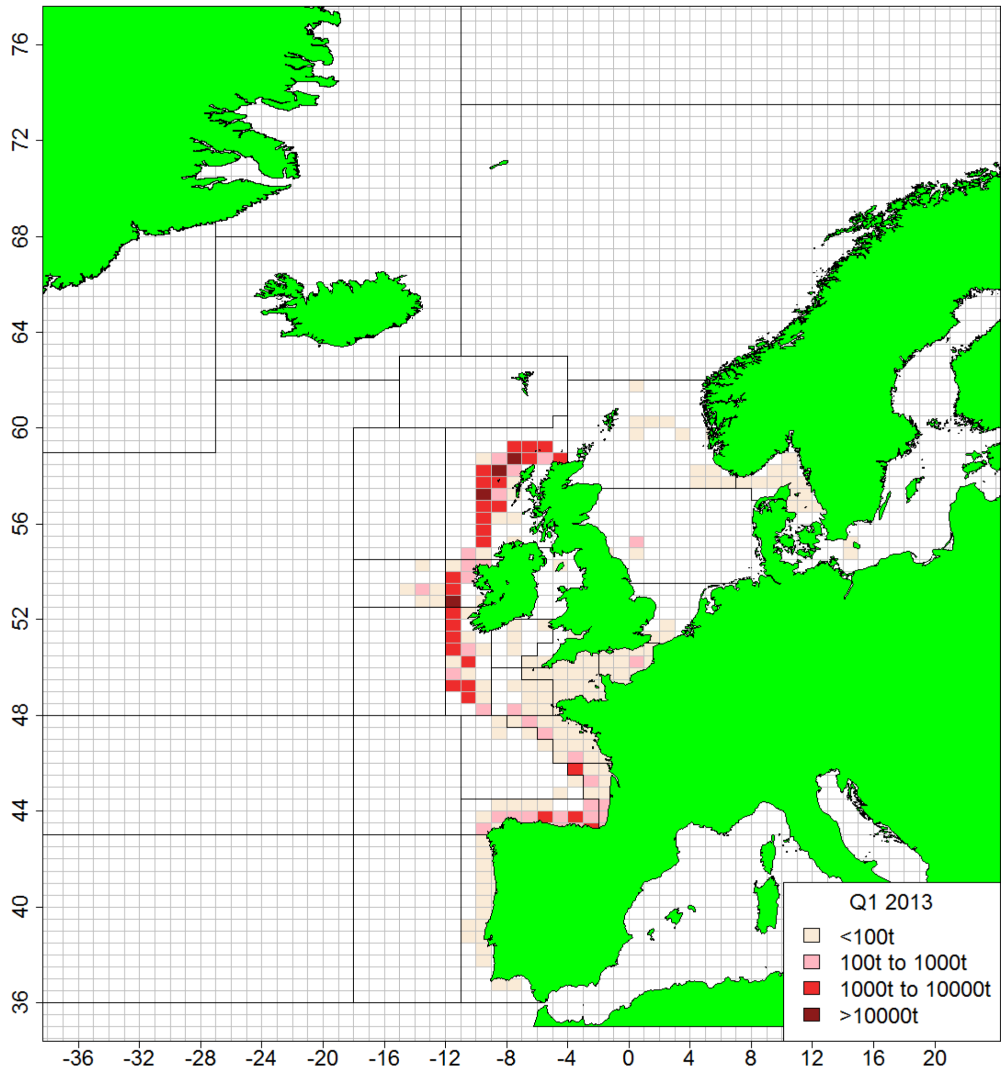


Figure 2.3.2.1. NE Atlantic Mackerel. Commercial catches in 2013, quarter1.

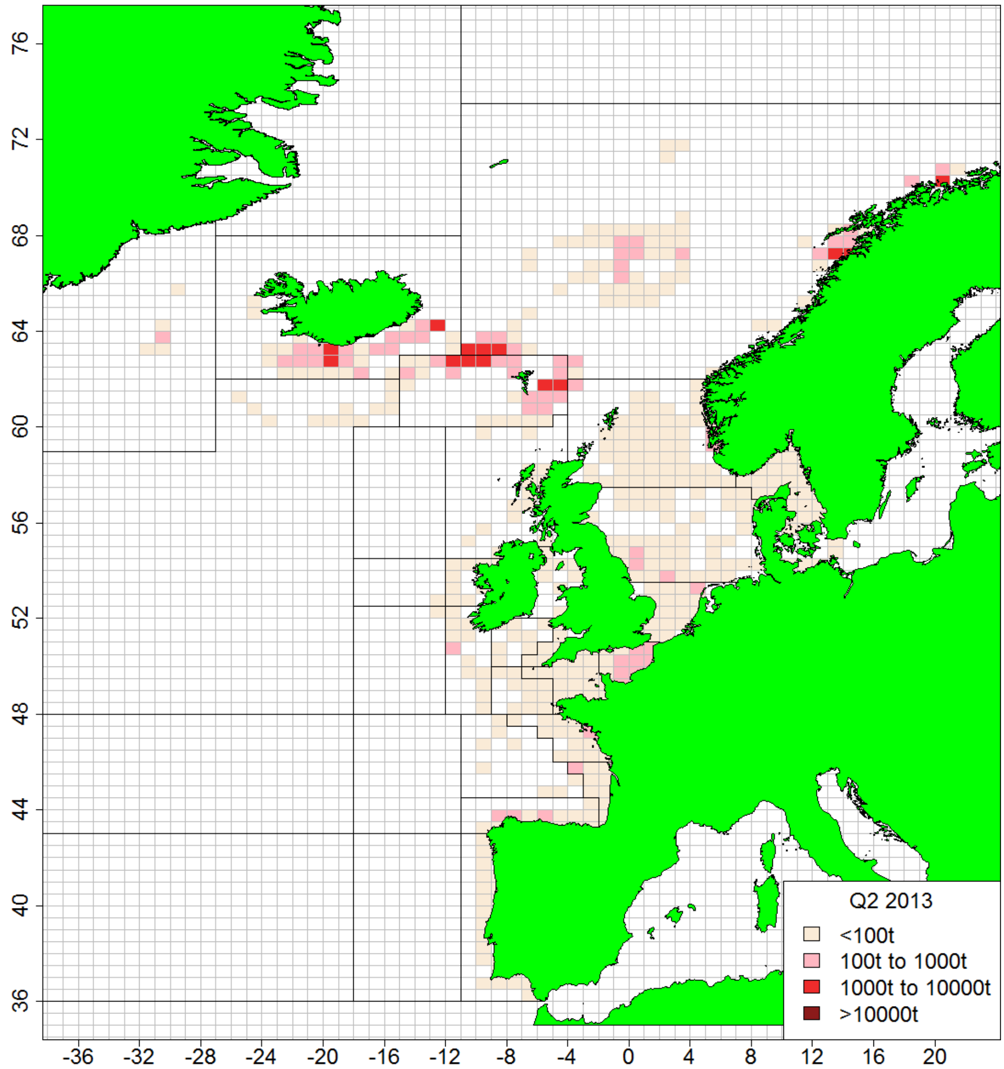


Figure 2.3.2.2. NE Atlantic Mackerel. Commercial catches in 2013, quarter 2.

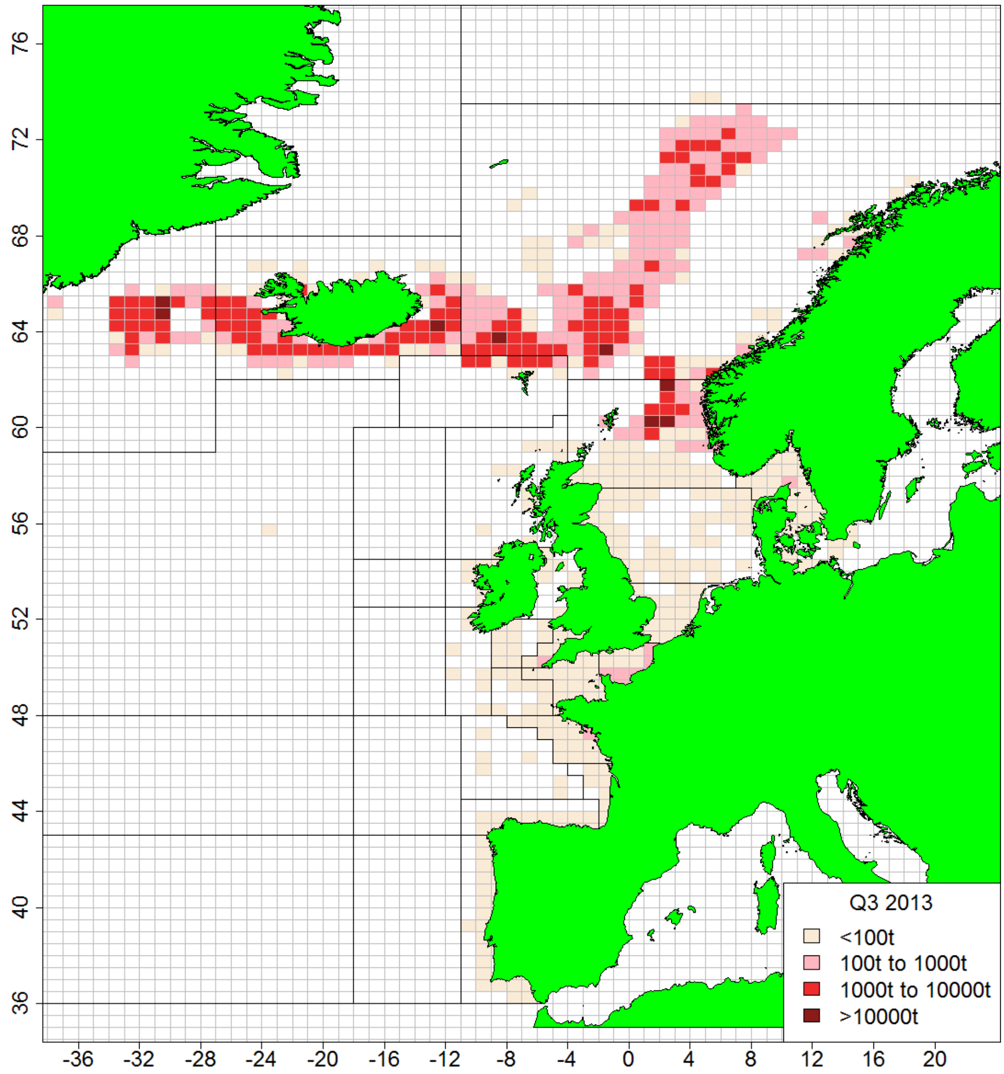


Figure 2.3.2.3. NE Atlantic Mackerel. Commercial catches in 2013, quarter 3.

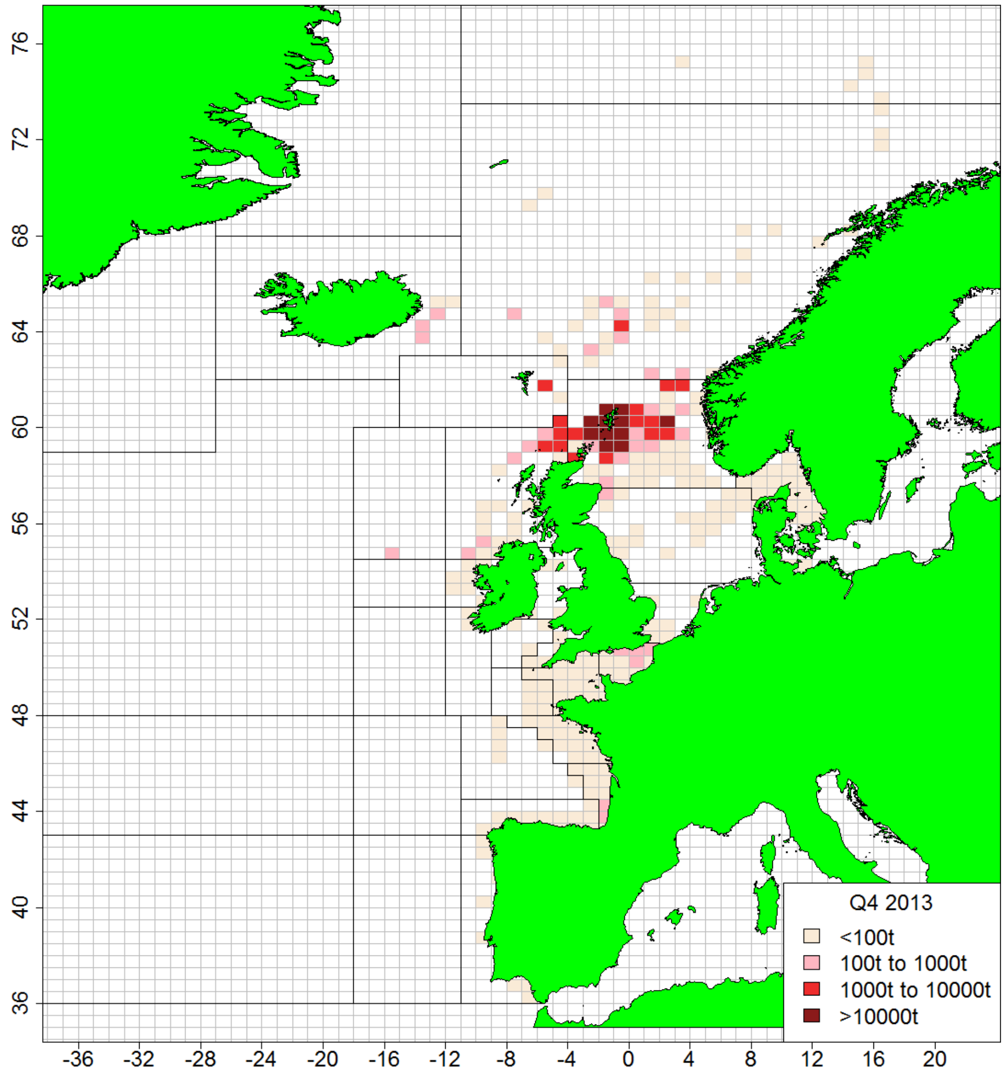


Figure 2.3.2.4. NE Atlantic Mackerel. Commercial catches in 2013, quarter 4.

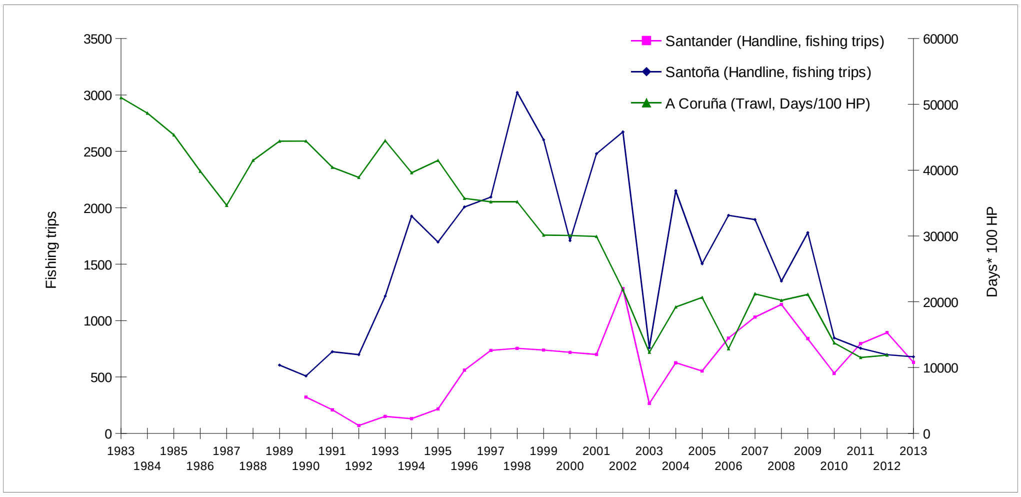


Figure 2.3.4.1. NEA mackerel (Southern component). Effort data by fleets.

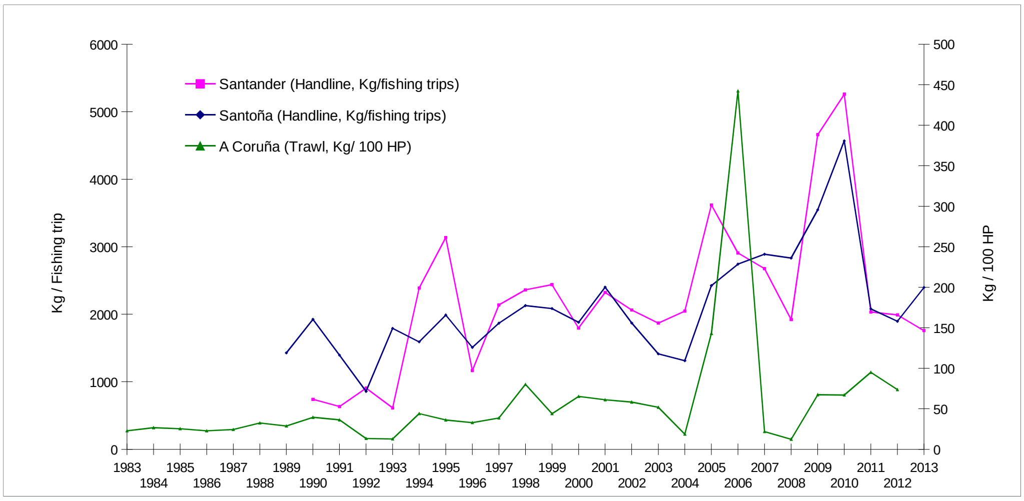


Figure 2.3.4.2. NEA mackerel (Southern component). CPUE index by fleet.

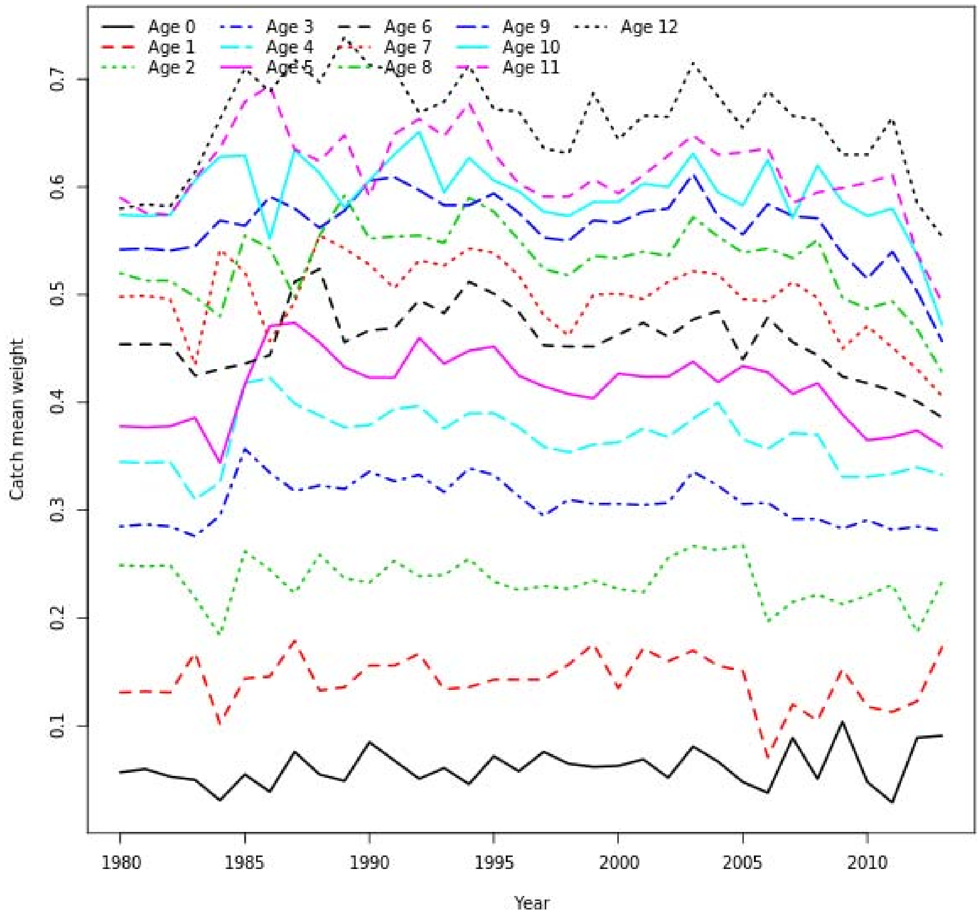


Figure 2.4.2.1. NE Atlantic mackerel. Weights-at-age in the catch.

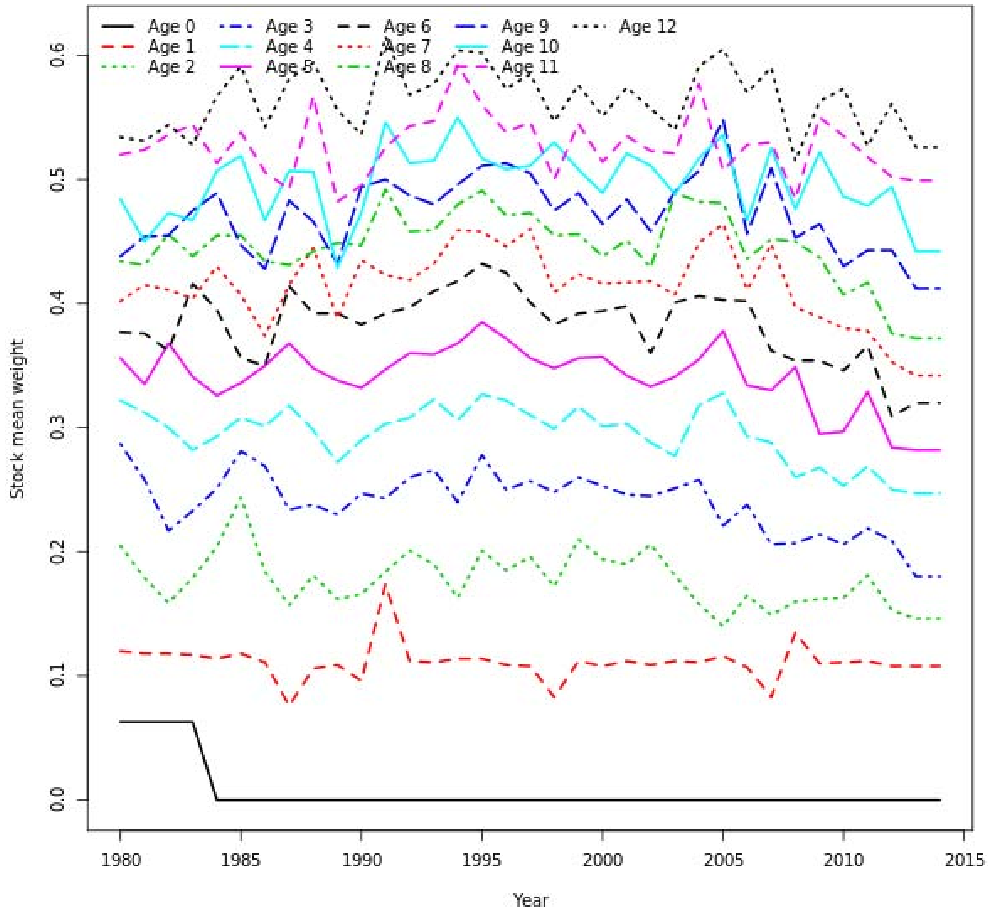


Figure 2.4.2.2. NE Atlantic mackerel. Weights-at-age in the stock.

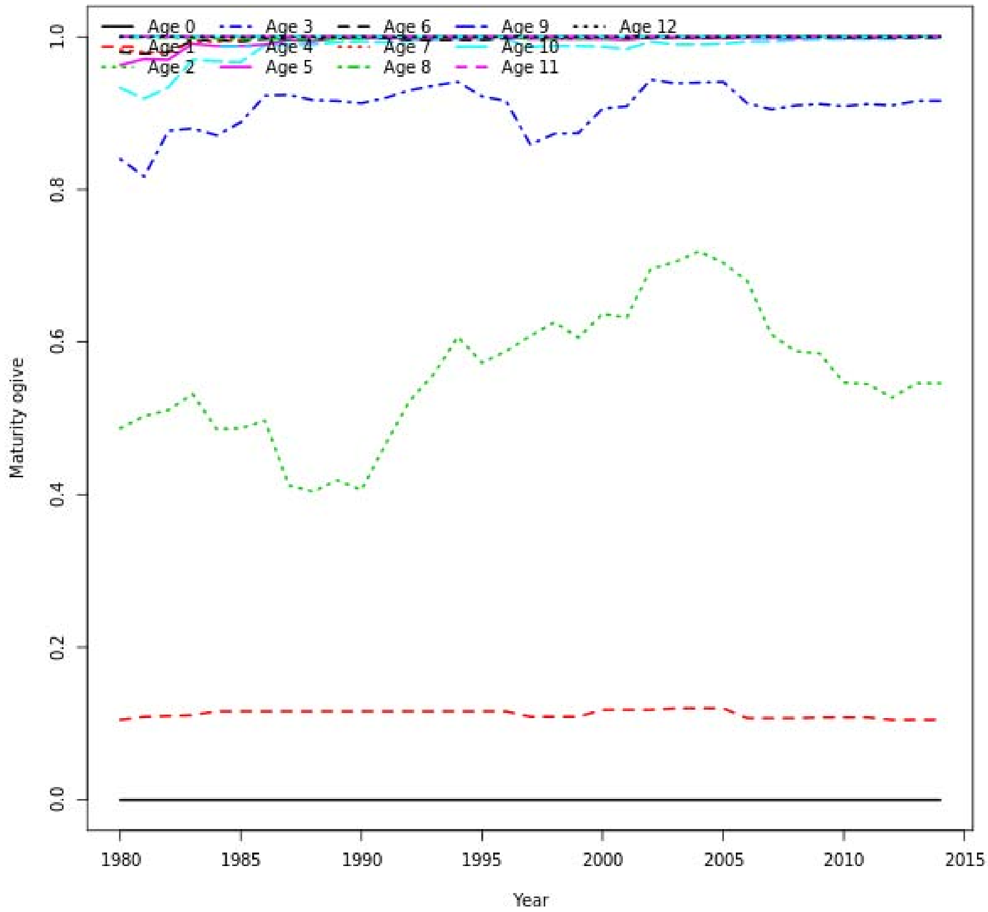


Figure 2.4.3. NE Atlantic mackerel. Proportion of mature fish at age

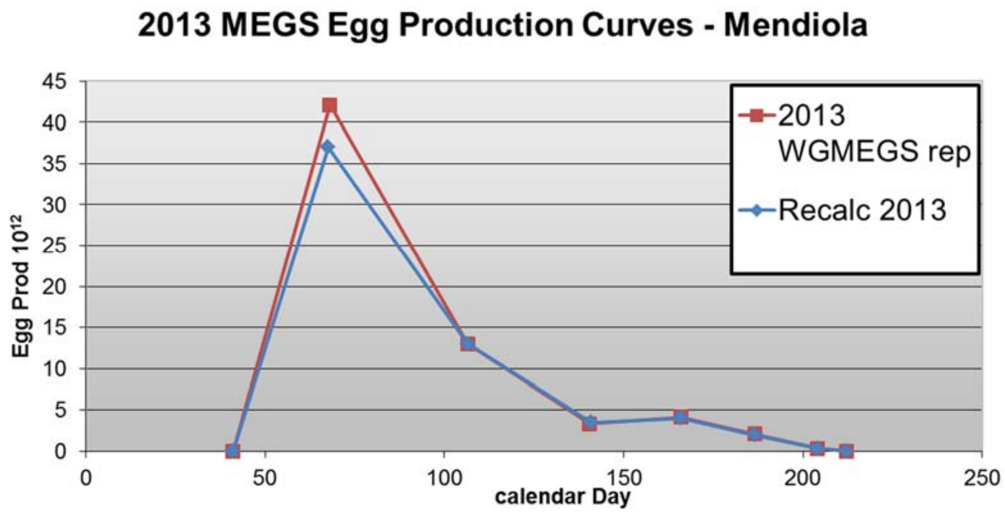


Figure 2.5.1.1. NE Atlantic mackerel. Comparison of the originally reported and revised egg production curve for the Western area.

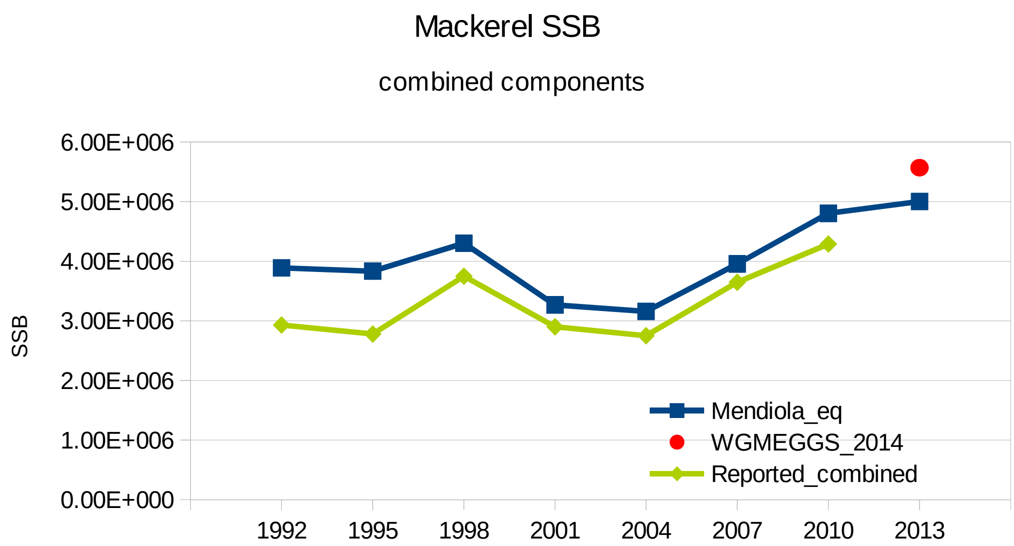


Figure 2.5.1.2. NE Atlantic mackerel. Mackerel SSB estimates derived from the mackerel egg surveys for the combined survey area. The green line represents the input data for the mackerel assessment until 2012. The red spot is the estimate given by WGMEGS for the updated advice. The blue line represents the agreed input data by WGWIDE 2014.

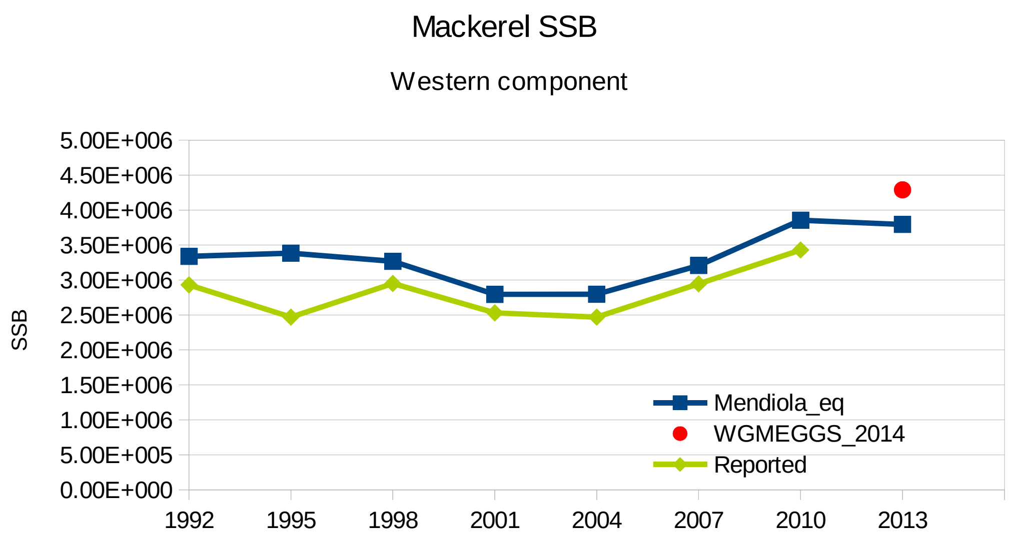


Figure 2.5.1.3. NE Atlantic mackerel. Mackerel SSB estimates derived from the mackerel egg surveys for the western component of the survey area only. The green line represents the input data for the mackerel assessment until 2012. The red spot is the estimate given by WGMEGS for the updated advice. The blue line represents the agreed input data by WGWIDE 2014.

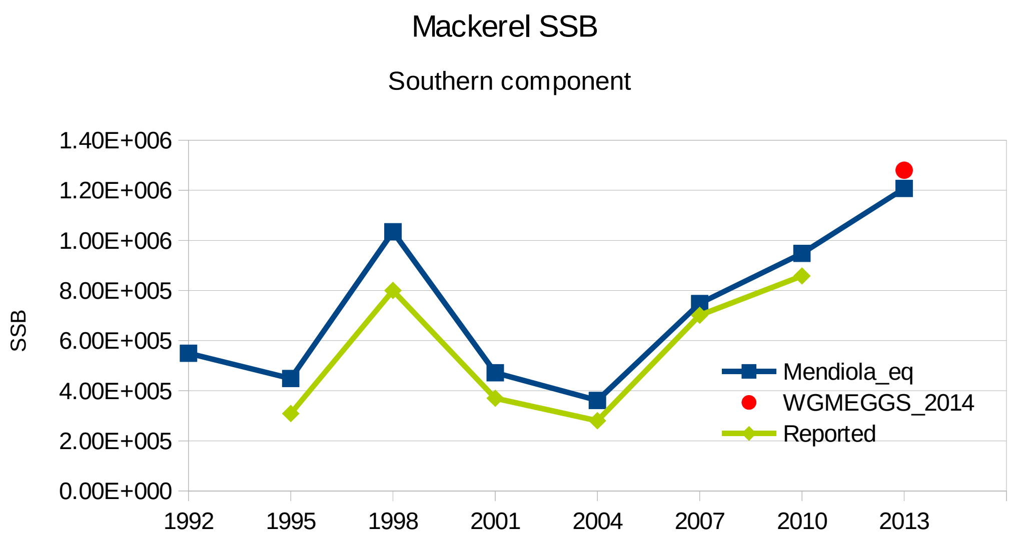


Figure.2.5.1.4. NE Atlantic mackerel. Mackerel SSB estimates derived from the mackerel egg surveys for the southern component of the survey area only. The green line represents the input data for the mackerel assessment until 2012. The red spot is the estimate given by WGMEGS for the updated advice. The blue line represents the agreed input data by WGWIDE 2014.

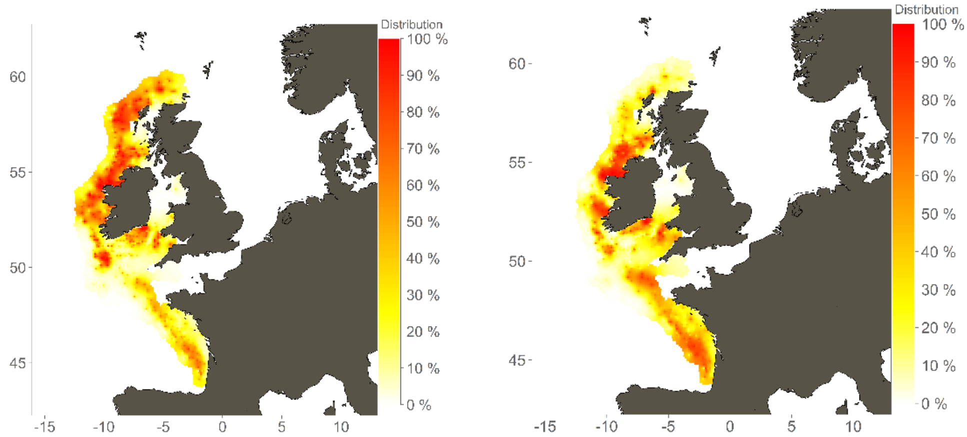


Figure 2.5.2.1. Distributions of modelled squared catch rates of mackerel at approximately 3-9 months of age in fourth quarter demersal trawl surveys. Left) average rates for 1998-2013, and Right) 2013. See Jansen *et al.*(2014, WKPELA WD) and Jansen *et al.*(under review) for details.

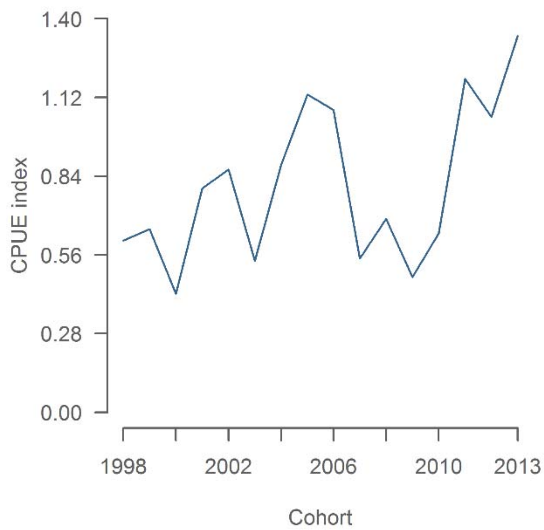


Figure 2.5.2.2. IBTS Q4 recruitment index derived from square root transformed CPUE. See Jansen *et al.*(2014, WKPELA WD) and Jansen *et al.*(under review) for details.

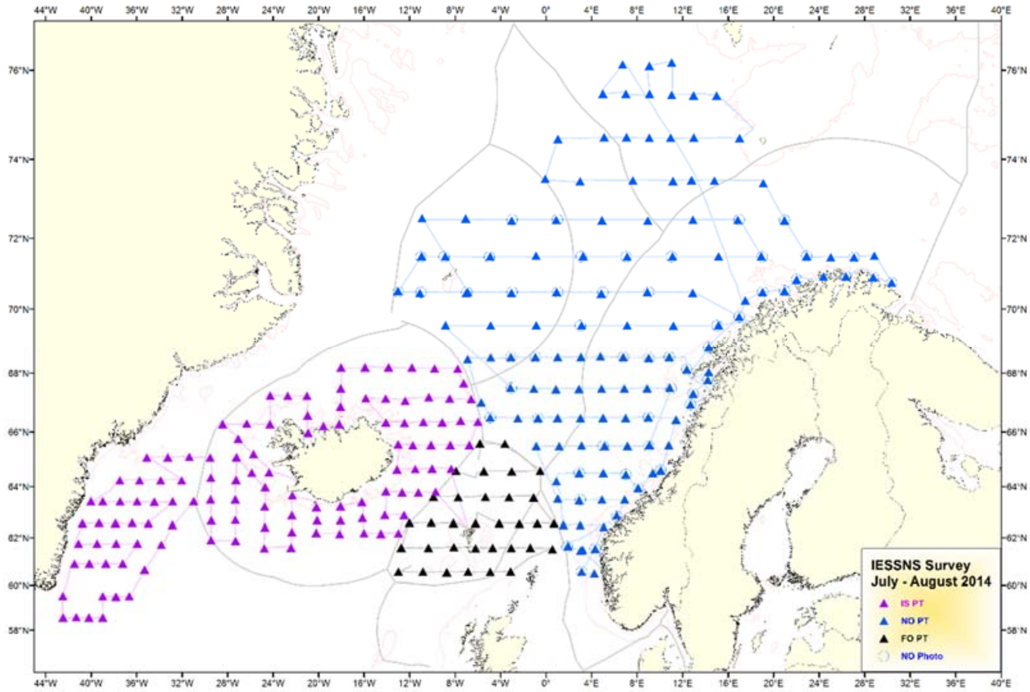


Figure 2.5.3.1. CTD stations (0-500 m) using SEABIRD SBE 37 (Arni Fridriksson) SEABIRD SB 25+ (Finnur Friði) and SAIV SD2002 (Brennholm and Vendla) CTD sensors and WP2 plankton net samples (0-200 m depth) from 2 July to 12 August 2014. These were taken systematically on every pelagic trawl station on all four vessels. Underwater filming with GoPro cameras inside the trawls were performed on all vessels, although only shown from the two Norwegian vessels (NO Photo).

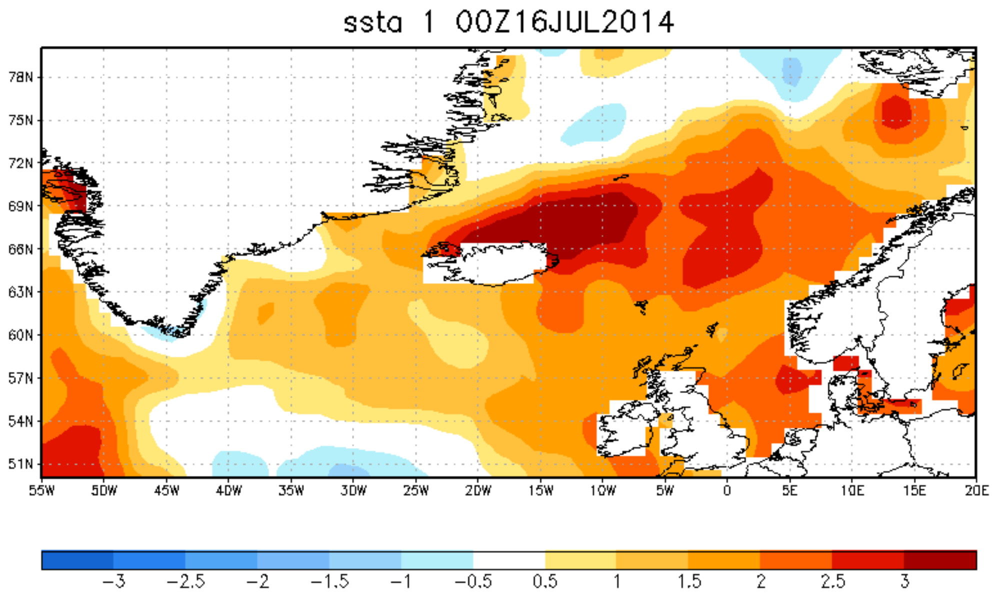


Figure 2.5.3.2. Sea surface temperature anomalies (°C; averaged for the entire month of July 2014) showing significantly warmer conditions (1-3°C) in July 2014 in most of the Northeast Atlantic in comparison to a 20 year average.

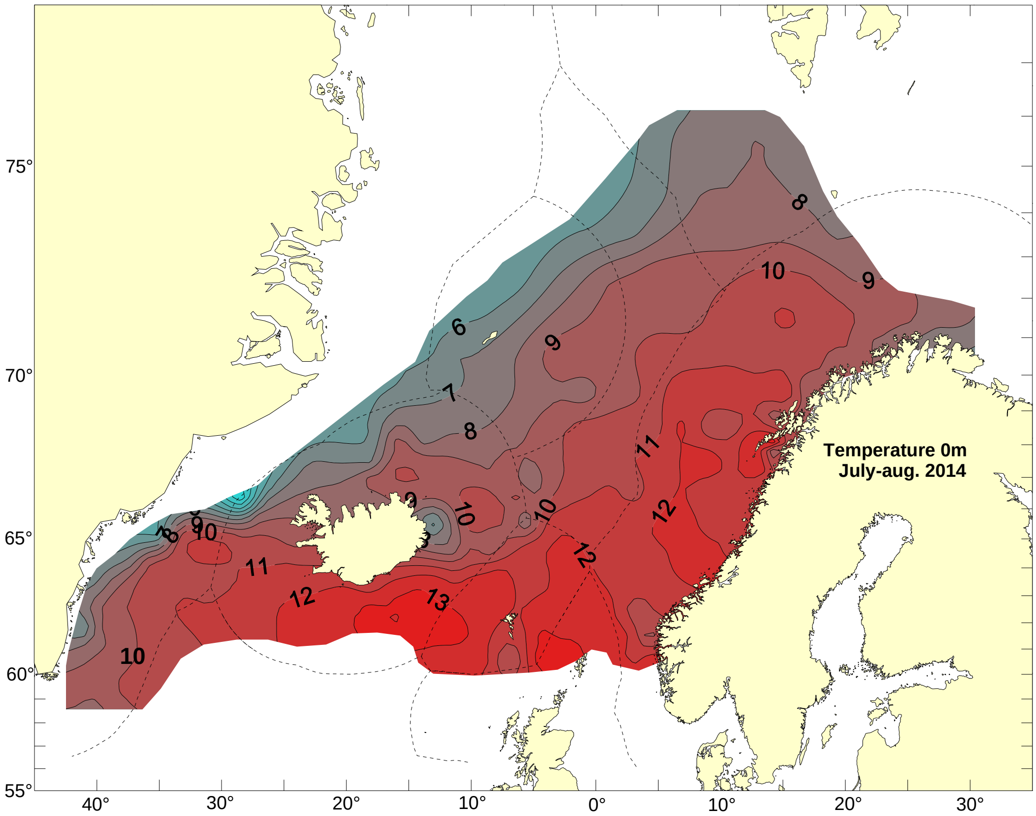


Figure 2.5.3.3. Temperature (°C) at 10 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

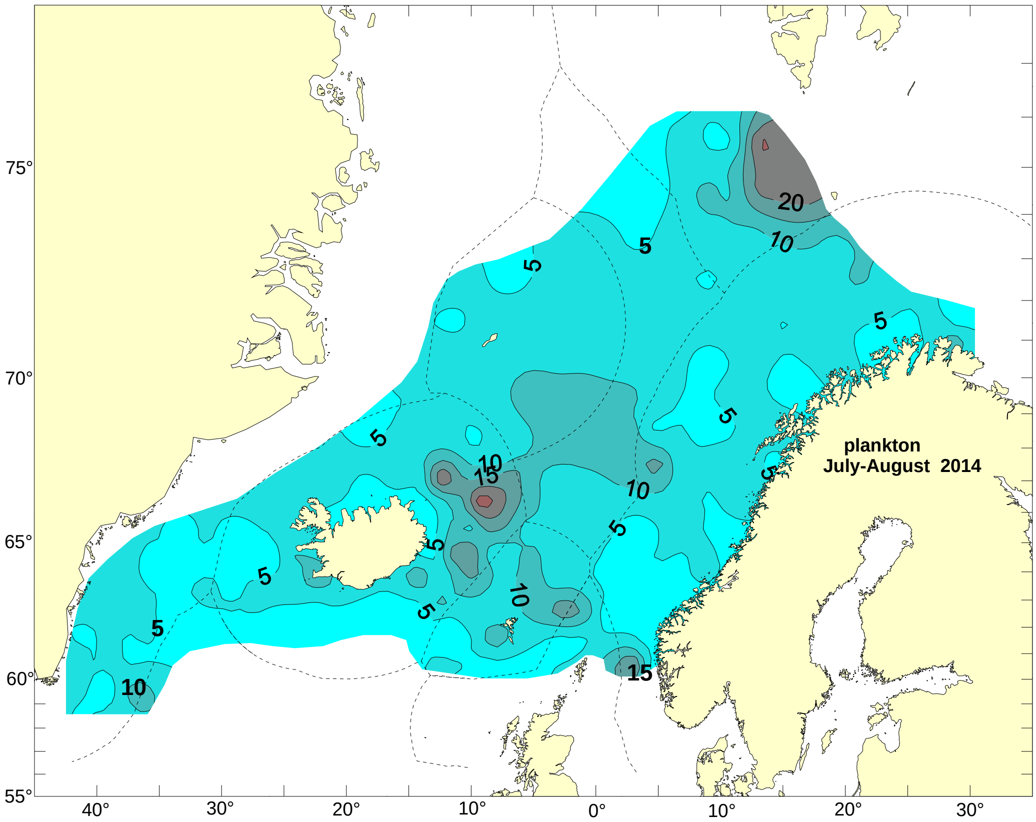


Figure 2.5.3.4. Zooplankton biomass (g dw/m2, 0-200 m) in the Norwegian Sea and surrounding waters, 2nd of July -12th of August 2014.

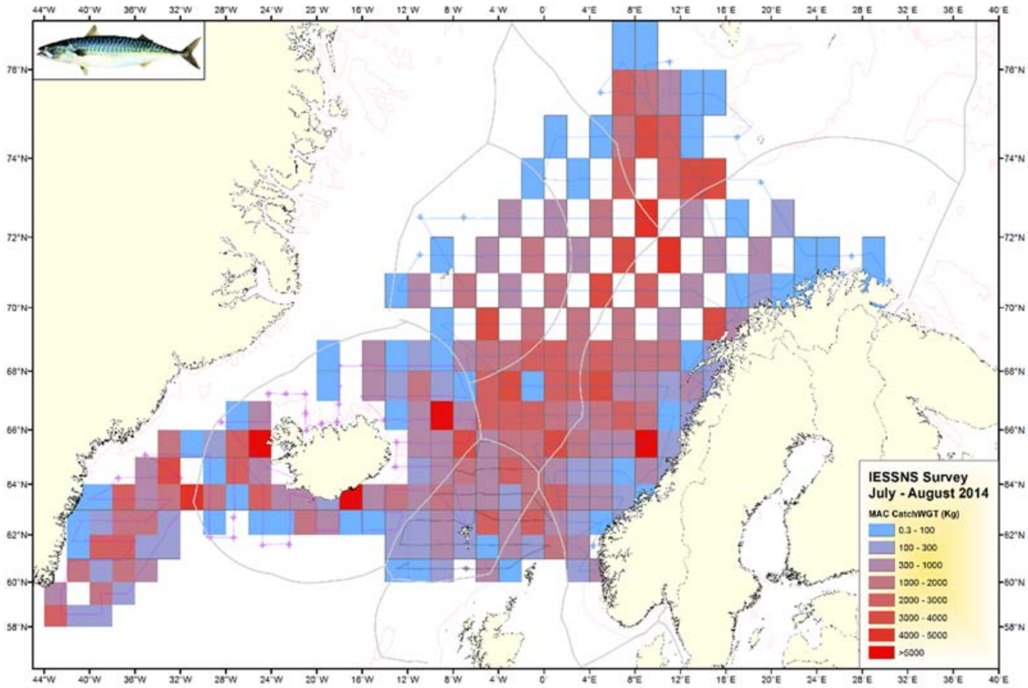


Figure 2.5.3.5. Catches of mackerel in kg represented in standardized rectangles. Light blue represents small catches (<100 kg), while dark red represents catches of more than 5000 kg mackerel. Empty rectangles have not been trawled due to very dense station net and distances between neighbouring pelagic trawl stations in northern waters. Small + indicate trawling done, but where no mackerel was caught. Vessel tracks are shown as continuous lines.

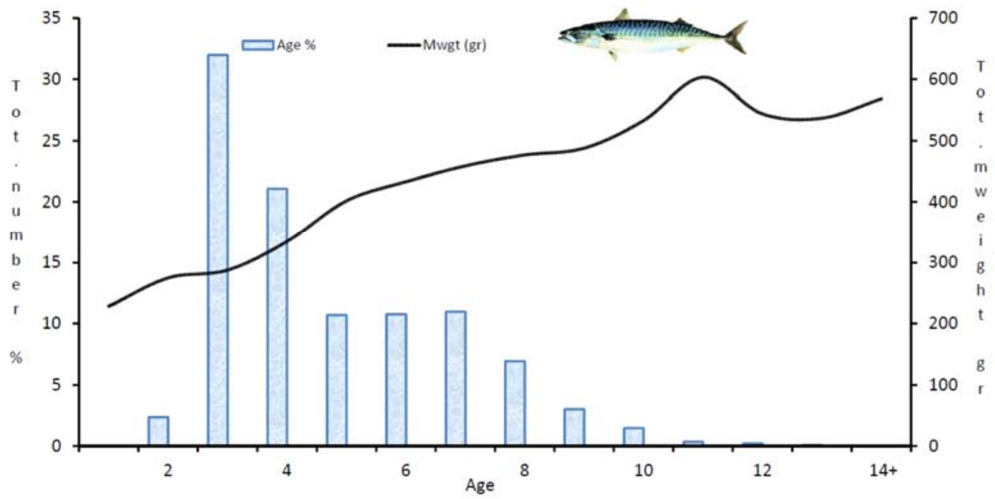


Figure 2.5.3.6. Age and weight distribution in percent (%) of Northeast Atlantic mackerel in the Norwegian Sea and surrounding waters from the IESSNS survey 2nd of July to 12th of August 2014.

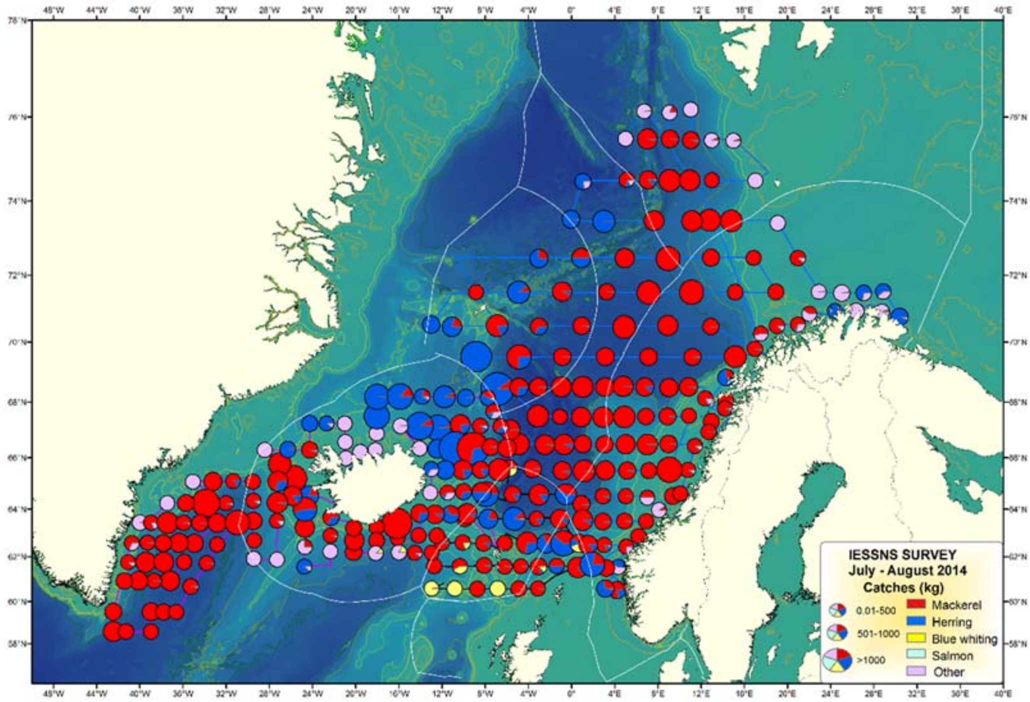


Figure 2.5.3.7. Distribution and spatial overlap between mackerel (red), herring (blue), blue whiting (yellow) and salmon (violet) from joint ecosystem surveys conducted onboard M/V "Brennholm" and M/V "Vendla" (Norway), M/V "Finnur Friði" (Faroe Islands) and R/V "Arni Fridriksson" (Iceland) in the Norwegian Sea and surrounding waters between 2nd of July and 12th of August 2014. Vessel tracks are shown as continuous lines.

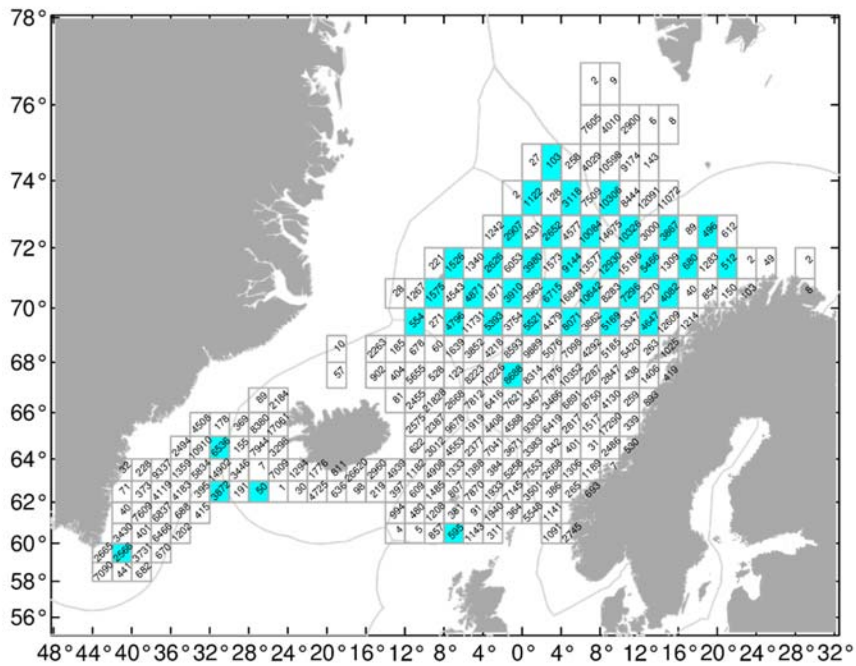


Figure 2.5.3.8a. Mean mackerel catch index (kg/km) in 1° lat. by 2° lon. rectangles from swept area estimates in July/August 2014, where interpolated rectangles are denoted with blue shading.

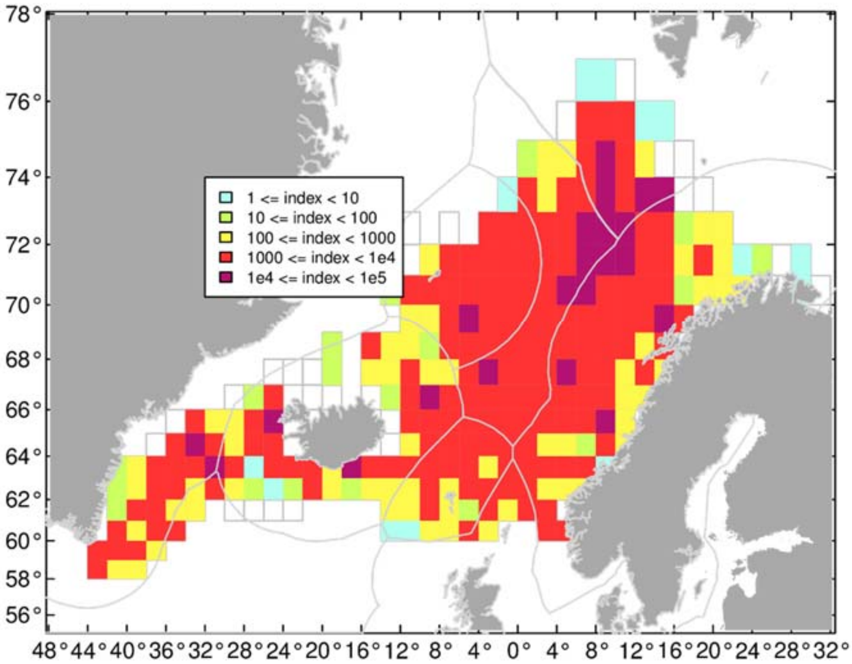


Figure 2.5.3.8b. Mean mackerel catch index (kg/km) in 1° lat. by 2° lon. rectangles from swept area estimates in July/August 2014. Light blue represents very small catches (<10 kg), while dark violet represents catches of more than 10 000 kg/km2 of mackerel. Empty rectangles shown in the map indicate that trawling has been done, but where no mackerel was caught.

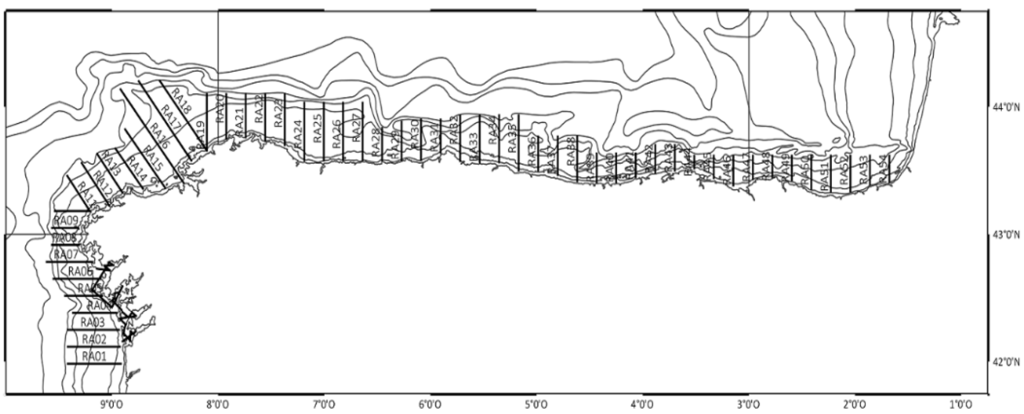


Figure 2.5.5.2.1: Survey track for PELACUS 0314

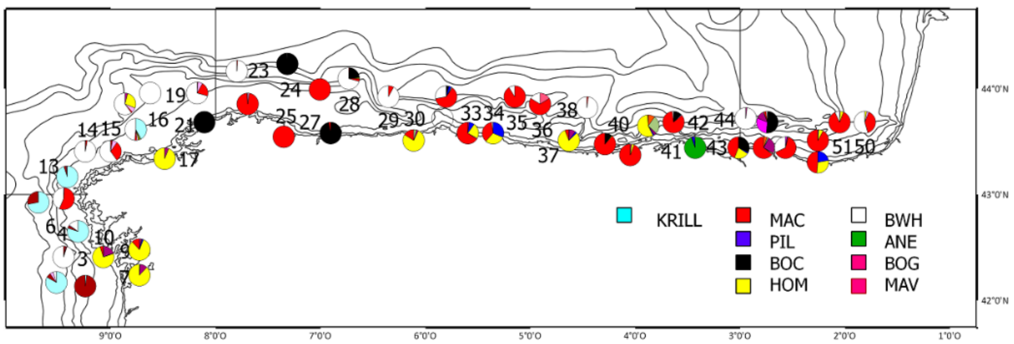
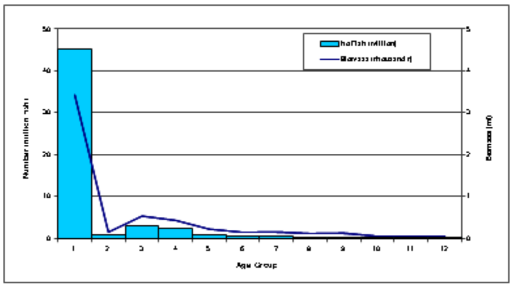
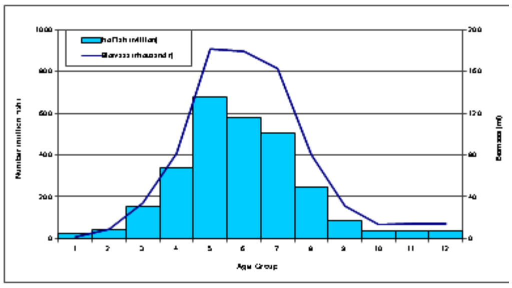


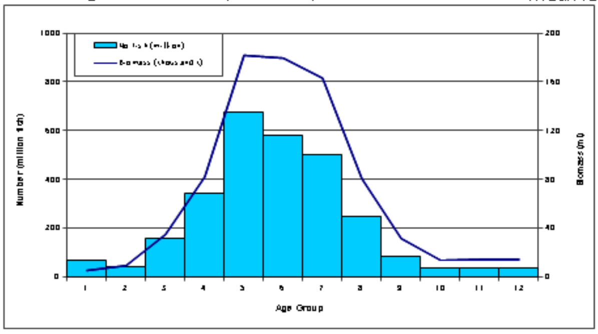
Figure 2.5.5.2.2: Trawl hauls and catch proportions in number during PELACUS 0314



Biomass: 5.47 thousand mt
Mean weight: 87.65 g
Number: 54 million fish
Mean length: 24.03 cm (s.d. 3.96)



Biomass: 802.95 thousand mt
Mean weight: 296.75 g
Number: 2748 million fish
Mean length: 35.31 cm (s.d. 2.51)



Biomass: 808.42 thousand mt
Mean weight: 290.99 g
Number: 2802 million fish
Mean length: 35.09 cm (s.d. 2.98)

Figure 2.5.5.2.3: Mackerel abundance and biomass estimates by age group. Top left, VIIIc-West and IXaN; top right, VIIIc-East; and bottom panel whole area.

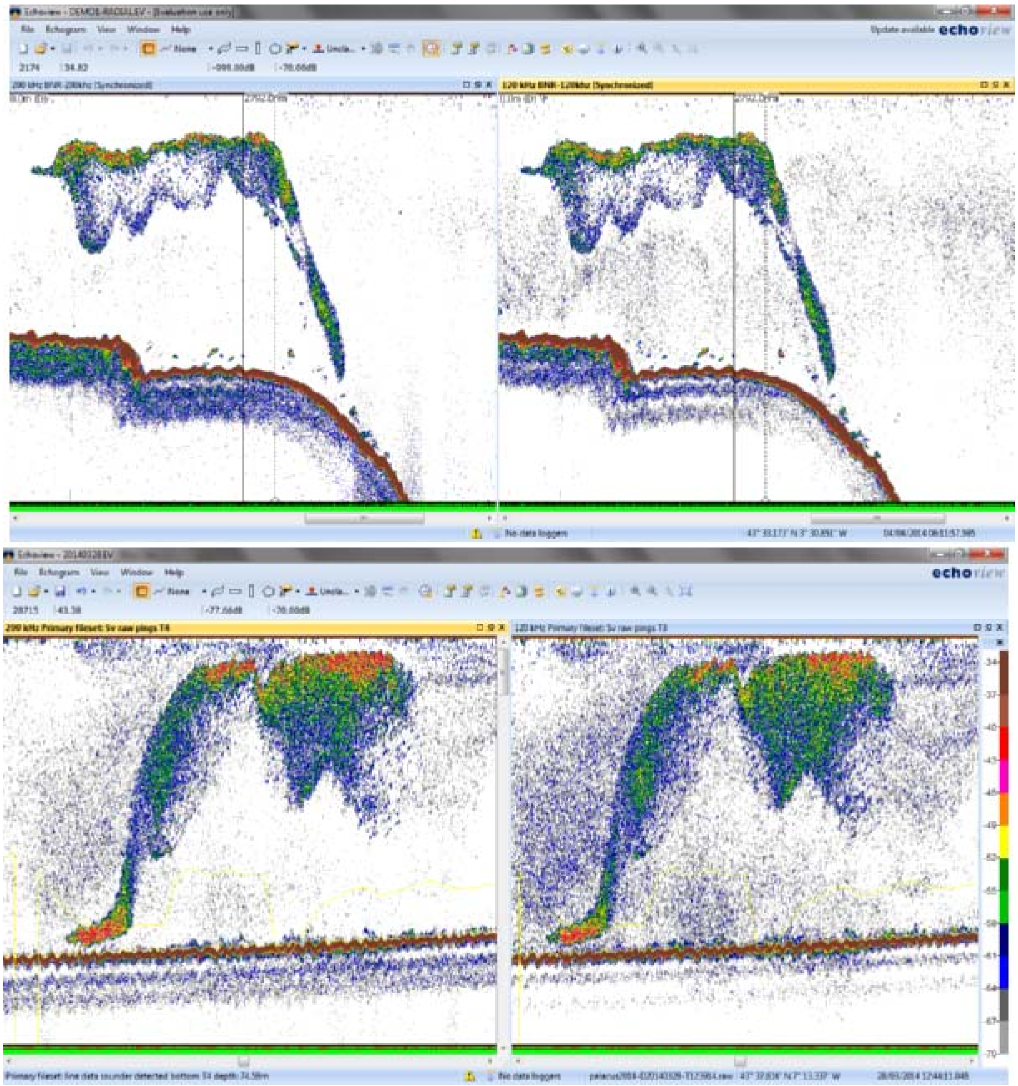


Figure 2.5.5.2.4: Mackerel diving (top panel) and raising (bottom panel) reactions observed at 120 (right) and 200 khz (left) during PELACUS survey.

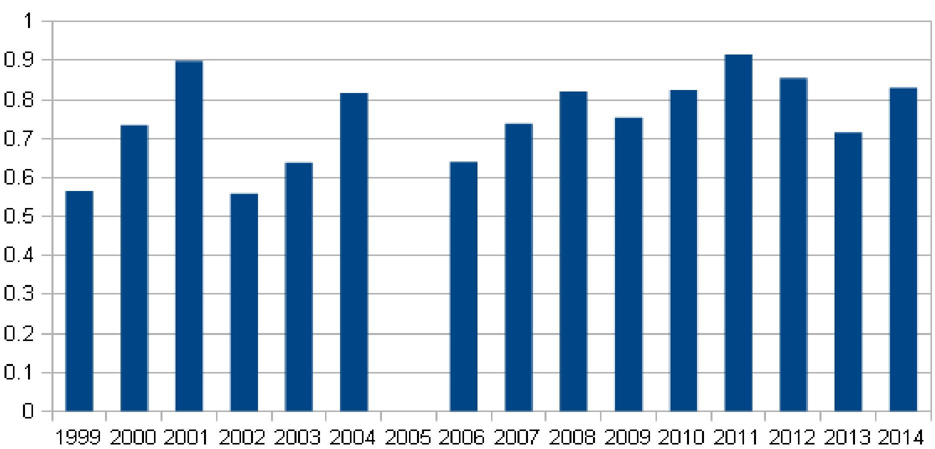


Figure 2.5.5.2.5:Percentage of non-empty mackerel stomachs taken during PELACUS time series (1999-2014).

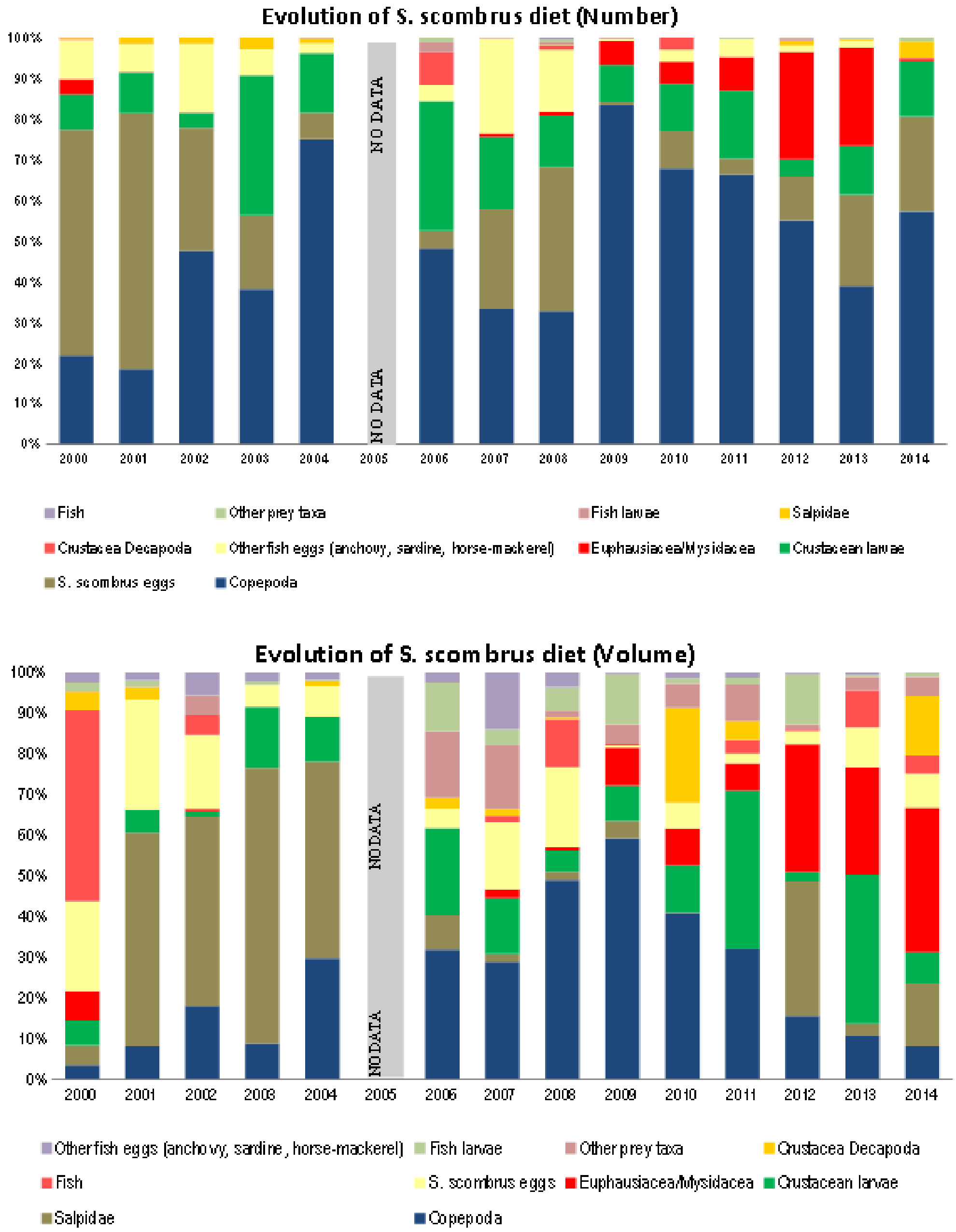


Figure 2.5.5.2.6: Mackerel diet in number (top panel) and in volume (bottom panel). All figures are in percentage.

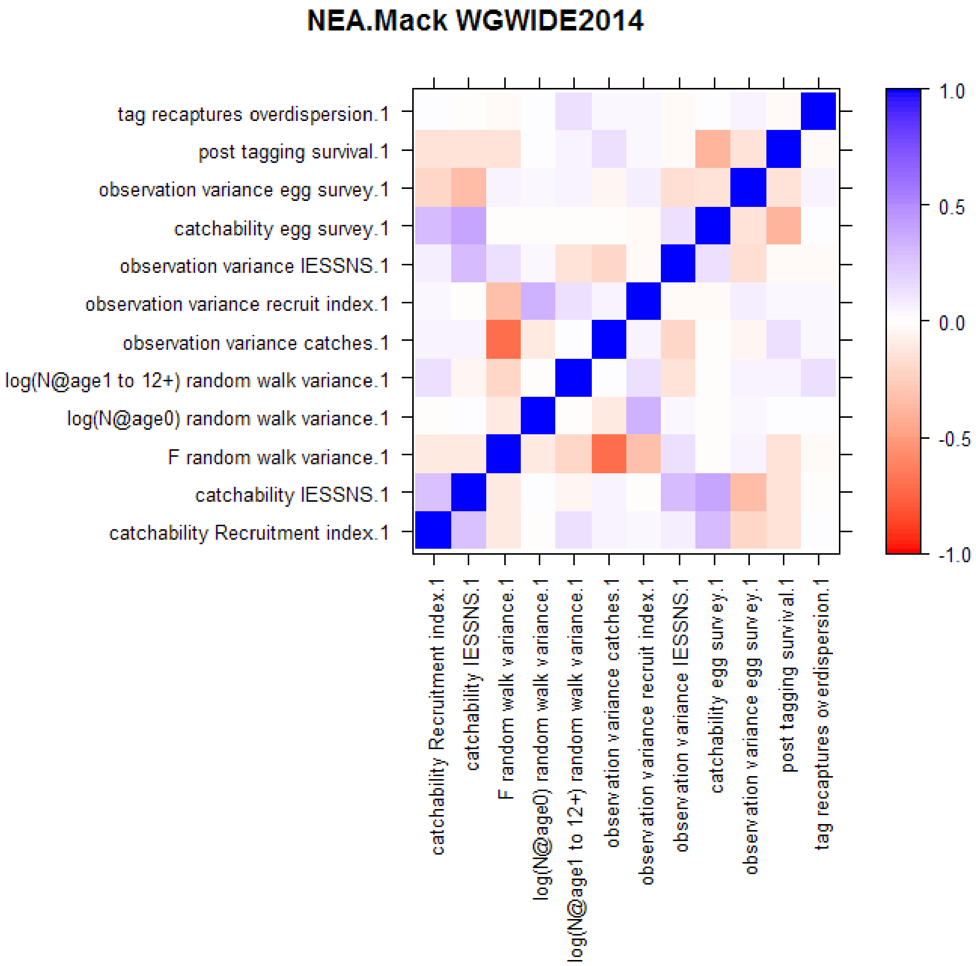


Figure 2.6.1.1. NE Atlantic mackerel. Parameter correlations for the final model. The horizontal and vertical axes show the parameters estimated by the model. The colouring indicates the (Pearson) correlation between the two parameters

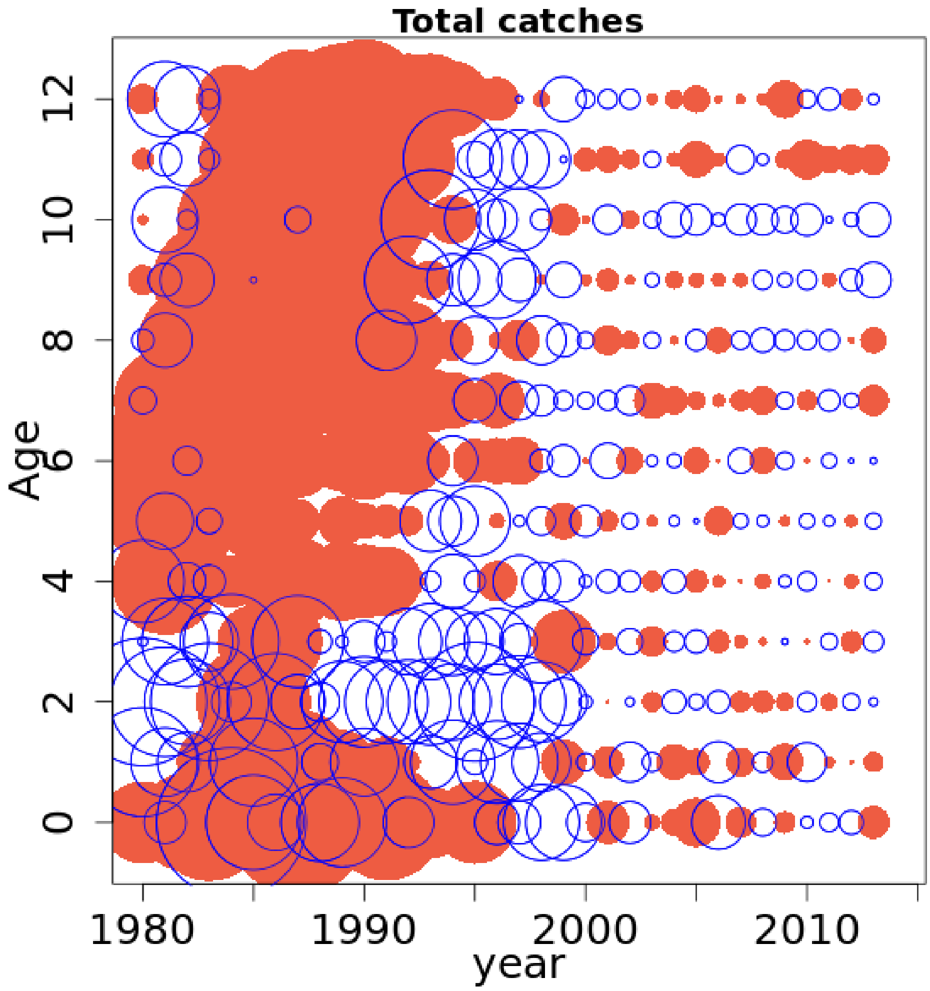


Figure 2.6.1.2. NE Atlantic mackerel. Normalized residuals for the fit to the catch data (catch data prior to 2000 were not used to fit the model). Blue circles indicate positive residuals (observation larger than predicted) and filled red circles indicate negative residuals.

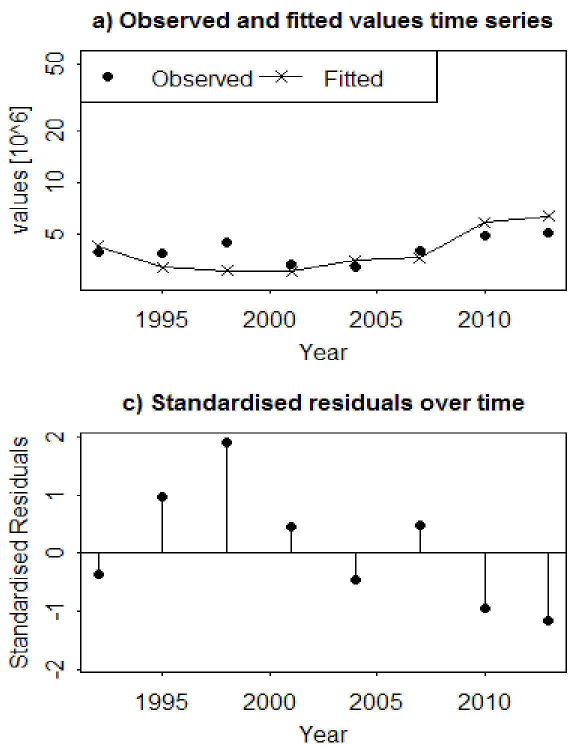


Figure 2.6.1.3. NE Atlantic mackerel. model diagnostics for the fit to the egg survey index time-series.

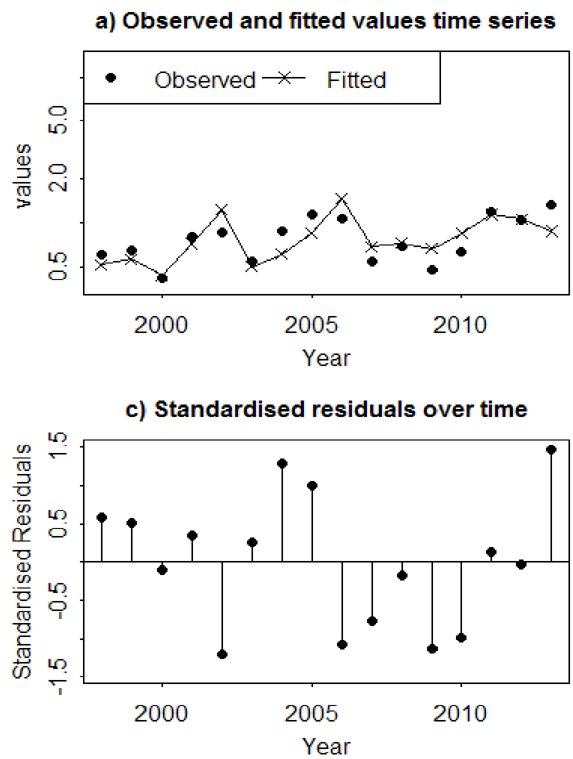


Figure 2.6.1.4. NE Atlantic mackerel. model diagnostics for the fit to the recruitment index time-series.

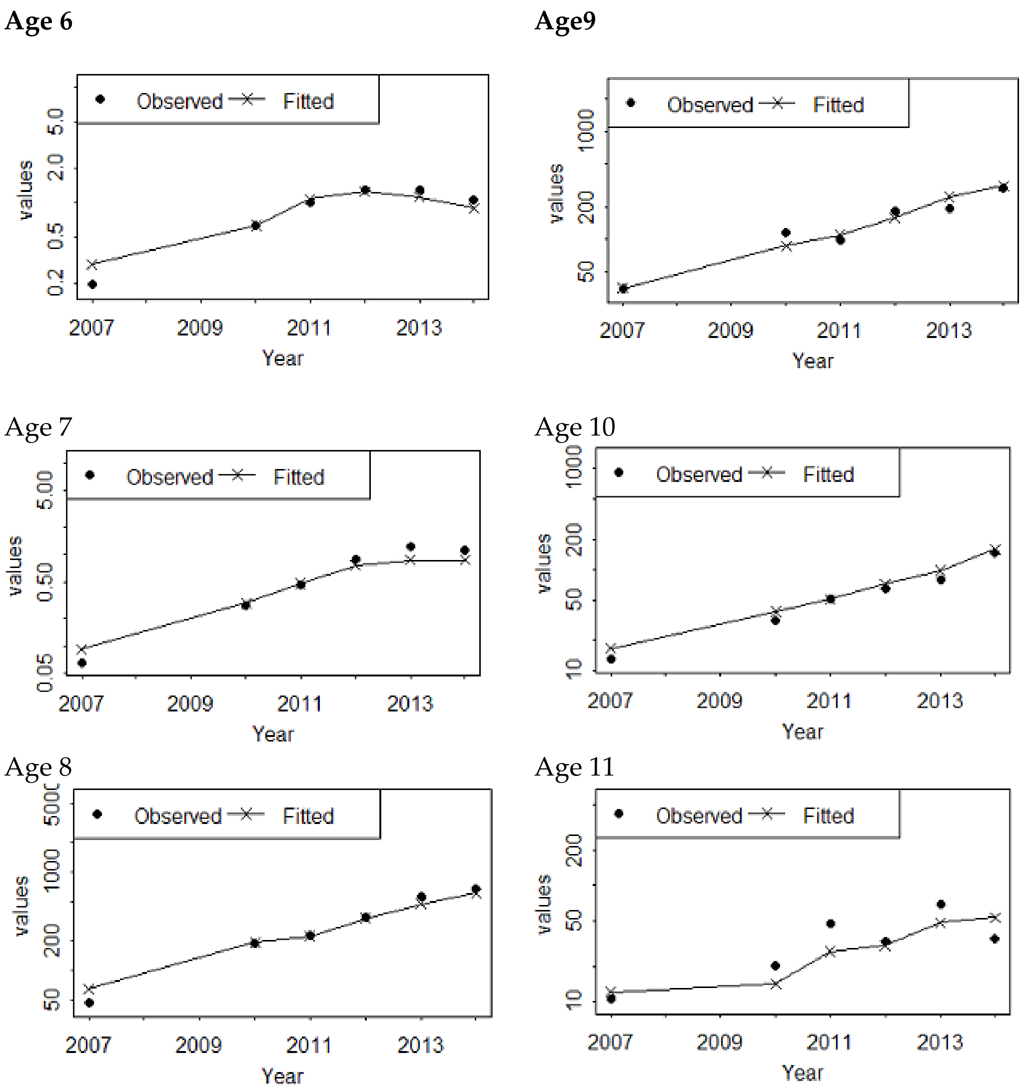


Figure2.6.1.5. NE Atlantic mackerel. fit of the final assessment to the IESSNS indices for ages 6 to 11 (observed vs. fitted).

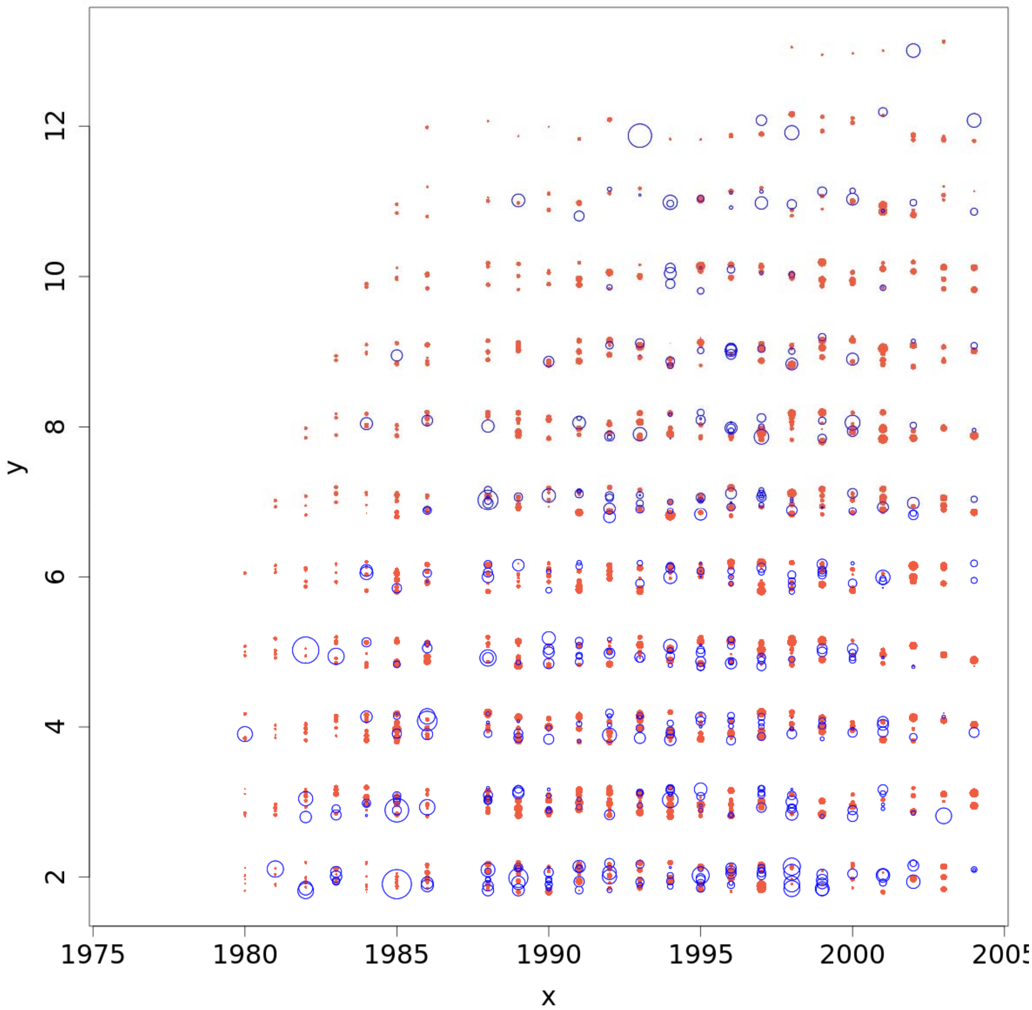


Figure2.6.1.6. NE Atlantic mackerel. Normalized residuals for the fit to the recaptures of tags in the final assessment. The x-axis represents the release year, and the y-axis is the age of the fish at release. The different circles for a same x-y point represent the successive recaptures. Blue circles indicate positive residuals (observation larger than predicted) and filled red circles indicate negative residuals

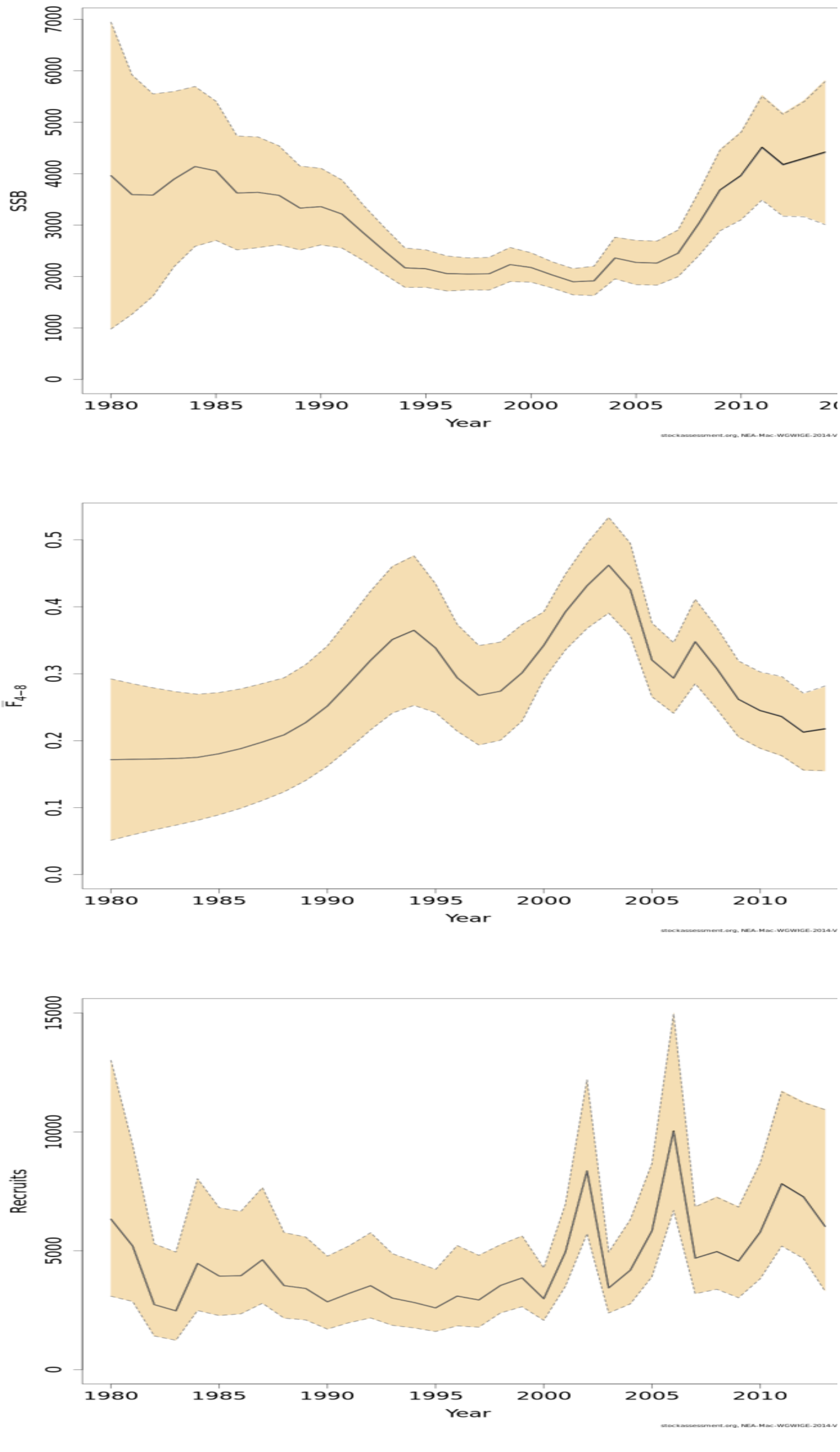


Figure2.6.2.1. NE Atlantic mackerel. Perception of the NEA mackerel stock, showing the SSB, Fbar4-8 and recruitment (with 95% confidence intervals) from the SAM assessment

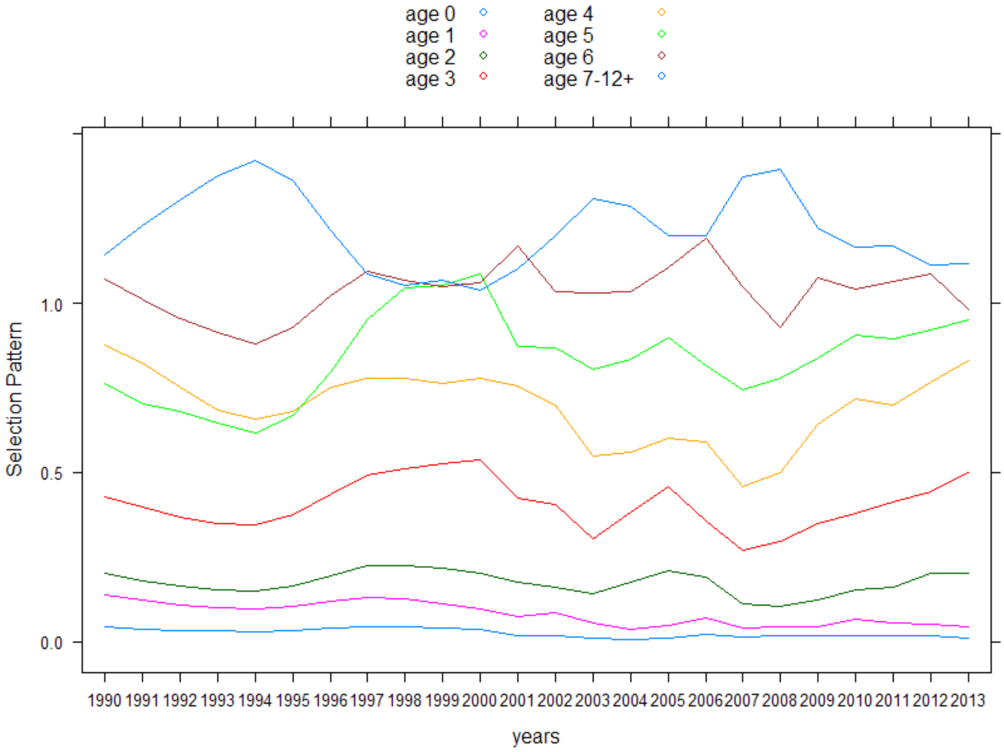


Figure 2.6.2.2. NE Atlantic mackerel. Estimated selectivity for the period 1990 to 2013, calculated as the ratio of the estimated fishing mortality-at-age and the Fbar4-8 value in the corresponding year.

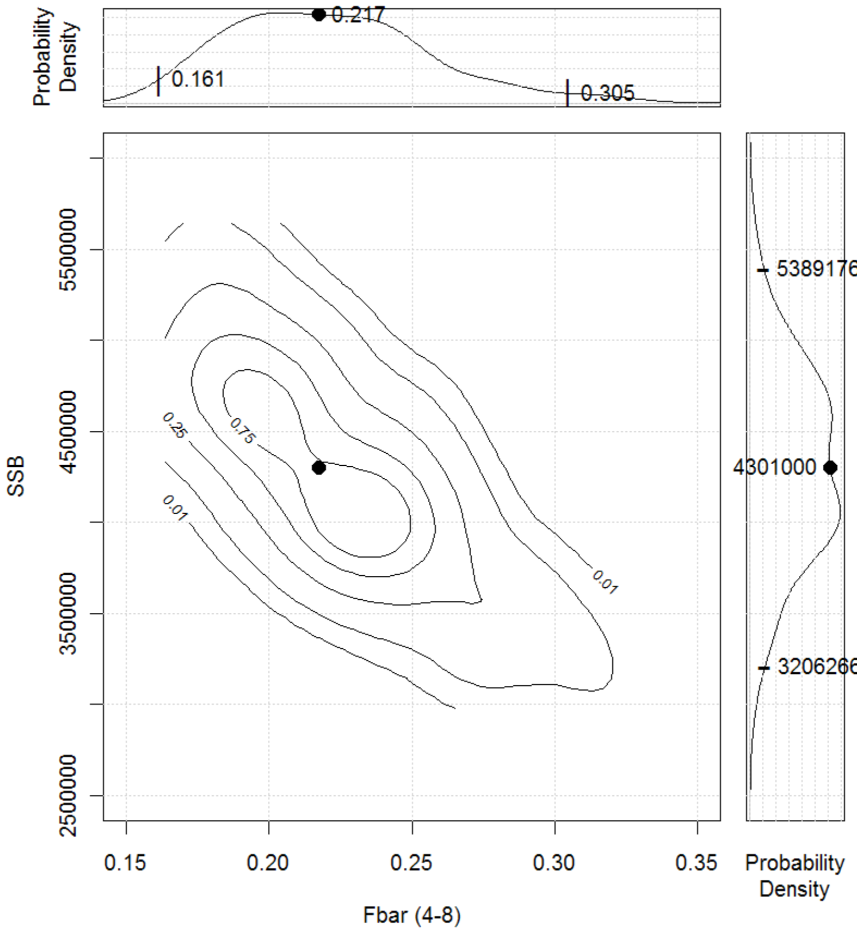


Figure 2.6.2.3. NE Atlantic mackerel. Joint distribution of the estimates of SSB and Fbar in 2013 resulting from the uncertainty in the parameters estimated by resampling parameters from the variance covariance matrix estimated by SAM.

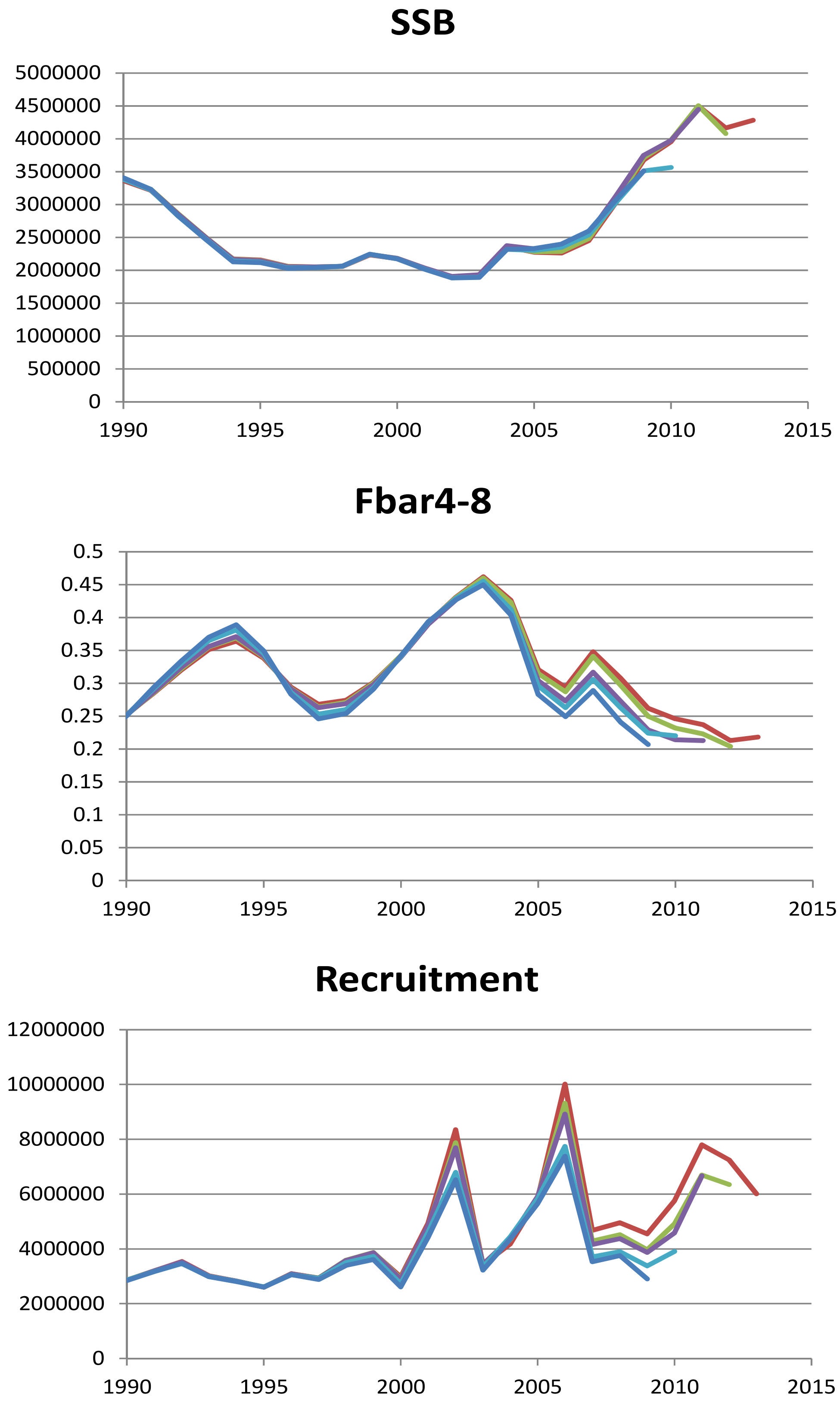


Figure 2.6.2.4. NE Atlantic mackerel. Analytical retrospective patterns (2013 to 2010) of SSB, Fbar4-8 and recruitment from the benchmarked SAM assessment.

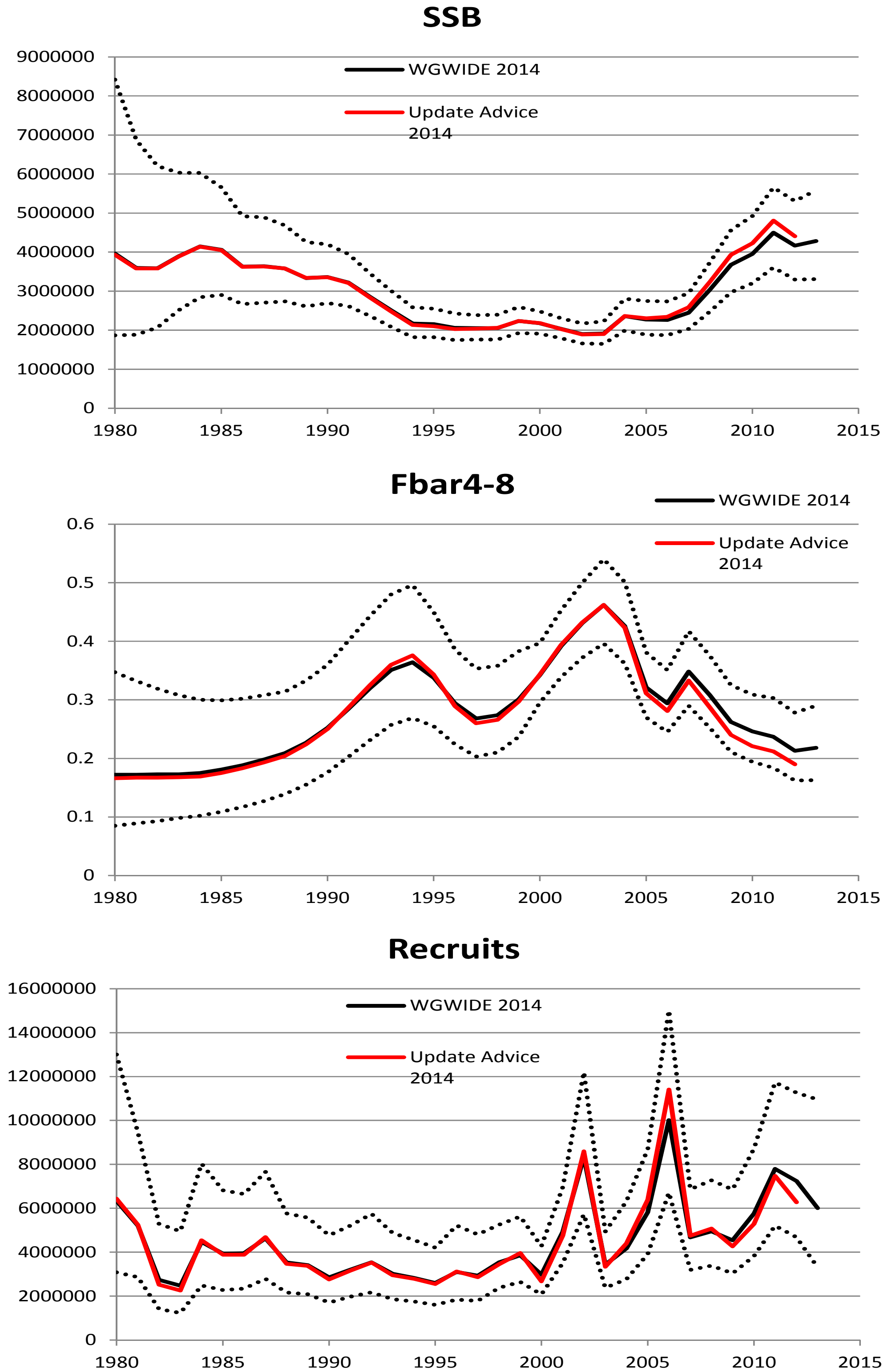


Figure 2.9.1. NE Atlantic mackerel. Comparison of the stock trajectories between the 2014 WGWIDE assessment and the 2014 advice update assessment.

3 Horse Mackerel

3.1 Fisheries in 2013

The total international catches of horse mackerel in the North East Atlantic are shown in Table 3.1.1 and Figure 3.3.1. The southern horse mackerel stock is now assessed by ICES WGHANSA). The total catch from all areas in 2013 for the Western and North Sea stock was 183782tons which is 10783 tons less than in 2012 (6% lower than in 2012 and 20% lower than 2011). Ireland, Denmark, Scotland, France, Germany and the Netherlands have a directed trawl fishery and Norway a directed purse seine fishery for horse mackerel. Spain has directed and mixed trawl and purse seine fisheries. In earlier years most of the catches were used for meal and oil while in later years most of the catches have been used for human consumption.

The quarterly catches of North Sea and western horse mackerel by Division and Subdivision in 2013 are given in Table 3.1.2 and the distribution of the fisheries are given in Figure 3.1.1.a–d. The figures are based on data provided by Denmark, Germany, Ireland, Netherlands, Norway, Northern Ireland, Scotland, Sweden, England + Wales and Spain representing 95% of the total catches. The distribution of the fishery is similar to the later years.

The Dutch and German fleets operated mainly west of the Channel, in the Channel area, north and west of Ireland and in the southern North Sea. Ireland fished mainly north and west of Ireland and Norway in the north eastern part of the North Sea. The Spanish fleet operated mainly in their respective waters. **First quarter:** This is the fishing season with most of the catches 74,978 tons. As usual the fishery was mainly carried out west of Scotland and west and south of Ireland, in the Channel and along the Spanish coast (Figure 3.1.1.a).

Second quarter: 20037 tons. As usual, catches were significantly lower than in the first quarter as the second quarter is the main spawning period. Most of the catches were taken south of Ireland, along the Spanish coast, in the south eastern part of the North Sea and in the Channel (Figure 3.1.1.b).

Third quarter: 12996 tons. Most of the catches were taken in Spanish waters, west and in the Channel. Also some smaller catches were reported from the Shetland area and from the North Sea (Figure 3.1.1.c).

Fourth quarter: (71370 tons). The catches were distributed in four main areas (Figure 3.1.1.d):

- Spanish waters,
- Northern Irish waters and West and north of Scotland
- northern-central part of the North Sea
- the Channel

3.2 Stock Units

For many years the Working Group has considered the horse mackerel in the north east Atlantic as separated into three stocks: the North Sea, the Southern and the Western stocks (ICES 1990/Assess: 24, ICES 1991/Assess: 22). For further information see Stock Annex Western Horse Mackerel. The boundaries for the different stocks are given in Figure 3.2.1.

3.3 Allocation of Catches to Stocks

The distribution areas for the three stocks are given in the Stock Annex Western Horse Mackerel. The catches in 2013 were allocated to the three stocks as follows:

Western stock: 3 and 4 quarter: Divisions IIIa and IVa. 1—4 quarter: IIa, Vb, VIa, VIIa–c,e–k and VIIIa-e.

North Sea stock: 1-2 quarter: Divisions IIIa and IVa. 1—4 quarter: IVb,c and VIId.

Southern stock: Division IXa. All catches from these areas were allocated to the southern stock. This stock is now dealt with by another working group (ICES WGHANSA).

The catches by stock are given in Table 3.1.1 and Figure 3.3.1. The catches by stock and countries for the period 1997—2013 are given in Table 3.3.2—3.3.4.

In 2013 some small catches were reported from Divisions VIb (31 tons) and IIIc (183 tons) which were no allocated in any stock.

3.4 Estimates of discards

Over the years only Netherlands has provided data on discards and in some few years also Germany has provided such data. For 2013 the Netherlands, Germany, Ireland and Spain provided such data. Their catches represented about 85% of the total catch of western horse mackerel. Based on the limited data available and that discards rates show an extreme fluctuations (0—100% discards) it is extremely difficult to estimate the amount of discard in the horse mackerel fisheries (see section 1.3.3). Moreover the provided discard rates were to be below of 1%in weight with exception in subarea VII that presented a bigger discard rate. Therefore the amounts of discards given in Table 3.1.2 are not representative for the total fishery.

3.5 *Trachurus* Species Mixing

Three species of genus *Trachurus*: *T. trachurus*, *T. mediterraneus* and *T. picturatus* are found together and are commercially exploited in NE Atlantic waters. Following the Working Group recommendation (ICES 2002/ACFM: 06) special care was taken to ensure that catch and length distributions and numbers at age of *T. trachurus* supplied to the Working Group did not include *T. mediterraneus* and/or *T. picturatus*.

T. mediterraneus fishery takes mainly place in the eastern part of ICES Division VIIIc. There is not a clear trend in *T. mediterraneus* catches in this area but in the last years show a low level (Table 3.5.1). Information of *T. picturatus* fishery is available in the WGHANSA Report (Working Group on Horse Mackerel, Anchovy and Sardine).

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

3.6 Length Distribution by Fleet and by Country:

Ireland, Germany, Netherlands, Norway, and Spain provided length distribution for their catches in 2013. The length distributions given by Ireland, Germany, the Netherlands, Norway and Spain covered app. 82% of the total landings of the Western and North Sea horse mackerel catches and are shown in Table 3.6.1.

Table 3.1.1 HORSE MACKEREL general. Catches (t) by Sub-area. Data as submitted by Working Group members. Data of limited discard information are only available for some years.

Subarea	1979	1980	1981	1982	1983	1984	1985
II	2	-	+	-	412	23	79
IV + IIIa	1412	2151	7245	2788	4420	25987	24238
VI	7791	8724	11134	6283	24881	31716	33025
VII	43525	45697	34749	33478	40526	42952	39034
VIII	47155	37495	40073	22683	28223	25629	27740
IX	37619	36903	35873	39726	48733	23178	20237
Total	137504	130970	129074	104958	147195	149485	144353
Subarea	1986	1987	1988	1989	1990	1991	1992
II	214	3311	6818	4809	11414	4487	13457
IV + IIIa	20746	20895	62892	112047	145062	77994	113141
VI	20455	35157	45842	34870	20904	34455	40921
VII	77628	100734	90253	138890	192196	201326	188135
VIII	43405	37703	34177	38686	46302	49426	54186
IX	31159	24540	29763	29231	24023	34992	27858
Total	193607	222340	269745	358533	439901	402680	437698
Subarea	1993	1994	1995	1996	1997	1998	1999
II	3168	759	13133	3366	2617	2538	2557
IV + IIIa	140383	112580	98745	27782	81198	31295	58746
VI	53822	69616	83595	81259	40145	35073	40381
VII	221120	200256	330705	279109	326415	250656	186604
VIII	53753	35500	28709	48269	40806	38562	47012
IX	31521	28442	25147	20400	29491	41574	27733
Total	503767	447153	580034	460185	520672	399698	363033
Subarea	2000	2001	2002	2003	2004	2005	2006
II	1169	60	1324	24	47	176	30
IV + IIIa	31583	19839	49691	34226	30540	40564	38911
VI	20657	24636	14190	23254	21929	22055	15751
VII	137716	138790	97906	123046	116139	107475	101912
VIII	54211	75120	54560	41711	24125	41495	34122
IX	26160	24912	23665	19570	23581	23111	24557
Total	272496	283357	241335	241831	216361	234876	215283
Subarea	2007	2008	2009	2010	2011	2012	2013
II	366	572	1847	1656	648	66	30
IV + IIIa	16407	15377	78591	13670	25183	5265	6722
VI	26279	25902	17776	22612	39528	44975	43266
VII	93132	98746	89563	145320	127903	123579	83684
VIII	28387	33892	33355	43227	35675	17402	26983
IX	23423	23596	26496	27217	22575	25316	29382
Total	187994	198085	247628	253702	251512	216603	190068

[1]Preliminary. * Southern Horse Mackerel (ICES Division IX) is assessed by ICES WGHANSA since 2011

Table 3.1.2 HORSE MACKEREL Western and North Sea Stock combined. Quarterly catches (1000 t) by Division and Subdivision in 2013.

Division	1Q	2Q	3Q	4Q	TOTAL
IIa+Vb	0	0	+	+	+
III	0	0	+	+	+
IVa	0	+	767	5936	6720
IVbc	544	344	359	231	1478
VIId	7025	946	458	8773	17202
VIa,b	18586	56	239	24383	43264
VIIa–c,e–k	44766	13119	2782	23016	83683
VIIIa,b,d,e	2370	1870	997	3975	9212
VIIIc	1687	3685	7390	5011	17773
Sum	74978	20037	12996	71370	179381

+ less than 50 t

Table 3.3.1 HORSE MACKEREL general. Landings and discards (t) by year and Division, for the North Sea, Western, and Southern horse mackerel stocks. (Data submitted by Working Group members.)

Year	IIIa	IVa	IVbc	Discards	VIId	North Sea Stock	IIa Vb	IIIa	IVa	VIab	VIIa-c e-k	VIIIabde	VIIIc	Disc	Western Stock	Western + NS Stock	Southern Stock (IXa)x	All stocks
1982	27881		-		1247	4035	-		-	6283	32231	3073	19610	-	61197	65232	39726	104958
1983	44201		-		3600	8020	412		-	24881	36926	2643	25580	-	90442	98462	48733	147195
1984	258931		-		3585	29478	23		94	31716	38782	2510	23119	500	96744	126222	23178	149400
1985	-		22897		2715	26750	79		203	33025	35296	4448	23292	7500	103843	130593	20237	150830
1986	-		19496		4756	24648	214		776	20343	72761	3071	40334	8500	145999	170647	31159	201806
1987	1138		9477		1721	11634	3311		11185	35197	99942	7605	30098	-	187338	198972	24540	223512
1988	396		18290		3120	23671	6818		42174	45842	81978	7548	26629	3740	214729	238400	29763	268163
1989	436		25830		6522	33265	4809		853042	34870	131218	11516	27170	1150	296037	329302	29231	358533
1990	2261		17437		1325	18762	11414	14878	1127532	20794	182580	21120	25182	9930	398645	417407	24023	441430
1991	913		11400		600	12000	4487	2725	638692	34415	196926	25693	23733	5440	357288	369288	34992	404280
1992			13955	400	688	15043	13457	2374	101752	40881	180937	29329	24243	1820	394793	409836	27858	437694
1993			3895	930	8792	13617	3168	850	134908	53782	204318	27519	25483	8600	458628	472245	31521	503766
1994			2496	630	2503	5689	759	2492	106911	69546	194188	11044	24147	3935	413022	418711	28442	447153
1995	112		7948	30	8666	16756	13133	128	90527	83486	320102	1175	27534	2046	538131	554887	25147	580034
1996	1657		7558	212	9416	18843	3366		18356	81259	252823	23978	24290	16870	420942	439785	20400	460185
1997			14078	10	5452	19540	2617	2037	650733	40145	318101	11677	29129	2921	471700	491240	29491	520731
1998	3693		10530	83	16194	30500	25404		17011	35043	232451	15662	22906	830	326443	356943	41574	398517
1999			9335		27889	37224	25575	2095	47316	40381	158715	22824	24188		298076	335300	27733	363033
2000			25954		22471	48425	11696	1105	4524	20657	115245	32227	21984		196911	245336	26160	271496
2001	85	69	8157		38114	46356	60	72	11456	24636	100676	54293	20828		212090	258446	24912	283357
2002			12636	20	10723	23379	1324	179	36855	14190	86878	32450	22110	305	194292	217671	23665	241336
2003	48	623	10309		21098	32078	24	1974	21272	23254	101948	21732	19979		190183	222261	19570	241831
2004	351		18348		16455	35154	47		11841	21929	98984	8353	15772	701	157627	192781	23581	216361
2005	357		13892	62	15460	29711	176		26315	22054	91431	26483	14775	760	181994	211705	23111	234816

2006	1099	2661	7998	78		23790	35626	30		27152	15722	77970	20651	13470	99	155094	190720	24557	215277
2007	63	2056	9118	139		29788	41164	366	110	4940	26279	63223	14428	13960	102	123408	164572	23423	187994
2008	27	1003	2330			31389	34749	5727	3	12014	25902	67325	14537	19345	43	139741	174490	23596	198085
2009	38	72	18711	1036		24366	44223	1847	-	58738	17775	65122	12452	20903	81	176918	221141	26496	247637
2010	+	100	1965	2		20188	22255	1627	88	11516	22641	114483	2042	37505	15366	205268	227004	27217	254221
2011	0.2		10458			18886	29344	648	1	14724	39298	103156	2303	32943	6522	199593	228937	22575	251512
2012	0.2	355	1588			19480	21423	66	9	3312	44975	104098	5051	12351	3280	173142	194565	25316	219881
2013	0	17	1478		0	17202	18697 18697697	30	19	6703	43264	83683	9212	17773	4401	165085	183782	29382	213164

[1]Divisions IIIa and IVb,c combined.

[2]Norwegian catches in IVb included in Western horse mackerel.

[3] Includes Norwegian catches in IVb (1,426 t).

[4]Includes 1,937 t from Vb.

[5]Includes 132 t from Vb

[6]Includes 250 t from Vb.

[7] all fom Vb

[X] Southern Horse Mackerel is assessed by ICES WGHANSA since 2011

Table 3.3.2 National catches of the Western Horse mackerel stock.

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005
Belgium	18	-	-	-	19	-	-	+	+
Denmark	62897	29542	22663	13084	6108	10152	11739	11480	1021
Estonia	78	22	-	-	-	-	-	-	-
Faroe Islands	1095	216	905	824	-	699	59	3847	3695
France	39188	24267	25141	20457	15145	18951	10383	8060	10690
Germany Fed.Rep.	28533	27872	17629	13348	11493	12614	15826	17830	16734
Ireland	74250	70811	57956	55300	51874	36483	35855	26431	35361
Lithuania	-	-	-	-	-	-	-	-	-
Netherlands	82885	92535	75333	57971	73439	42019	47327	40987	43445
Norway	45058	13363	46410	2087	7956	36689	20315	10751	25113
Russia	554	345	121	80	16	3	-	5	-
Spain	31087	14882	25123	22669	23053	23214	24588	16272	16636
Sweden	1761	10	1952	1101	68	575	1074	568	148
UK (Engl. + Wales)	19778	12162	9257	1555	7096	5971	4440	4617	3560
UK (N. Ireland)	-	1158	-	-	-	-	-	-	426
UK (Scotland)	32865	18283	11197	7230	8029	2907	672	1523	142
Unallocated	48732	20145	4389	823	7794	3710	17905	15256	24263
Discard	2921	830	-	382	-	305	-	701	760
Total	471700	326443	298076	196911	212090	194292	190183	158328	181994

Country	2006	2007	2008	2009	2010	2011	2012	2013[1]
Belgium	-	-	-	-	19	2	0.2	14
Denmark	8353	7617	5261	6009	5941	6109	4002	6829
Estonia	-	-	-	-	-	-		
Faroe Islands	1205	478	841	-	374	349	-	
France	11034	12748	12626	-	260	8271	1795	3593
Germany Fed.Rep.	10863	5784	11708	15121	17688	21114	17063	24835
Ireland	26779	30091	35612	40754	44488	38464	45242	35791
Lithuania	6829	5467	5548	-	-	-	-	
Netherlands	37130	29083	43648	39451	61504	55692	66396	53697
Norway	27114	4182	1223	59764	11978	13755	3251	6596
Russia	-	-	-	-	-	-		
Spain	13878	14257	19851	21077	38744	34581	13560	22541
Sweden	-	76	9	258	2	90	-	1
UK (Engl. + Wales)	3583	5482	3365	6482	12714	11716	12122	3959
UK (N. Ireland)	224	-	-	-	-	-	-	2325
UK (Scotland)	469	778	1077	1413	2348	2928	1335	504
Unallocated	7534	7263	2294	-7010	7237	-	5095	--
Discard	99	102	43	81	14846	6522	3280	4401
Total	155094	123408	143106	183400	218143	199593	173141	165087

[1]**Preliminary**

Table 3.3.3. National catches of the North Sea Horse mackerel stock.

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005
Belgium	-	19	21	19	19	30	5	4	6
Denmark	180	1481	3377	7855	17316	2310	2902	8738	3987
Faroe Islands	-	-	135	-	-	-	-	-	-
France	3246	2399	-	-	1696	1246	2326	2530	5236
Germany Fed.Rep.	7847	5844	5920	3728	968	3267	2936	4912	2248
Ireland	-	2861	27	130	338	-	-	1	-
Lithuania	-	10711	-	-	-	-	-	-	-
Netherlands	36855	-	8117	7987	13867	15187	24118	26302	25579
Norway	-	-	238	-	36	-	-	-	-
Sweden	-	3401	5	40	46	14	-	97	91
UK (Engl. + Wales)	269	907	11	1585	3333	2323	1965	1552	3859
UK (Scotland)	29	-	-	421	-	-	-	-	-
Unallocated	-28896	2794	19373	26660	8737	-1018	-2174	-8982	-11358
Discard	10	83	-	-	-	20	-	-	62
Total	19540	30500	37224	48425	46356	23379	32078	35154	29711

Country	2006	2007	2008	2009	2010	2011	2012	2013[1]
Belgium	4	6	3	5	17	26	46	51
Denmark	1341	255	57	89	15	142	1514	1020
Faroe Islands	-	-	-	-	-	-	0	
France	4380	5349	2246	-	813	273	1047	1010
Germany Fed.Rep.	1691	87	1176	1299	3794	3642	5356	2941
Ireland	2077	1	897	-	-	-	0	
Lithuania	2377	296	-	-	-	-	0	
Netherlands	27284	31154	19439	22546	17094	16289	12157	8725
Norway	113	1243	21	12855	526	7359	129	377
Sweden	491	53	35	402	-	-	0	
UK (Engl. + Wales)	596	-	1060	1235	1809	1699	935	4401
UK (Scotland)	300	625	6	4	111	93	240	172
Unallocated	-5106	1956	10869	5988	-116	0	0	0
Discard	78	139	-	1036	2	0	0	0
Total	35626	41164	35809	45659	24146	29523	21424	18696

[1]**Preliminary**

Table 3.5.1. Catches (t) of *Trachurus mediterraneus* in Divisions VIIIab VIIIc and Sub-Area VII

	VII	VIIIab	VIIIc East	VIIIc West	TOTAL
1989	0	23	3903		3926
1990	0	298	2943		3241
1991	0	2122	5020		7142
1992	0	1123	4804		5927
1993	0	649	5576		6225
1994	0	1573	3344		4917
1995	0	2271	4585		6856
1996	0	1175	3443		4618
1997	0	557	3264		3821
1998	0	740	3755		4495
1999	0	1100	1592		2692
2000	59	988	808		1854
2001	1	525	1293		1820
2002	1	525	1198		1724
2003	0	340	1699		2039
2004	0	53	841		894
2005	1	155	1005		1162
2006	1	168	794		963
2007	0	126	326		452
2008	0	82	405		487
2009	0	42	1082		1124
2010	0	97	370		467
2011	0	119	1096		1225
2012	0	186	667	116	969
2013	0	52	238	0	290

Table 3.6.1 Horse mackerel general. Length distributions (%) Catches by fleet and country in 2013. (0.0= <0.05%)

	Netherlands	Ireland	Norway	Germany						Spain		
	Pel. trawl	All_fleet	P.seine	All_fleet						P.seine	Trawl	Artisanal
cm	All	All	All	VIIh	Via	VIIb	VIIc	VIId	VIIj	VIIIbc	VIIIbc	VIIIbc
5												
6												
7												
8												
9												
10										0.0		
11										0.0	0.0	
12	0.0									0.3	0.0	
13										1.3	0.0	
14										6.5	0.5	
15	0.4									15.4	1.6	
16	4.6									17.3	1.8	0.3
17	4.0									13.0	1.9	0.3
18	4.9			4.7				0.4		8.9	1.2	0.5
19	3.5			3.4				4.0		4.9	1.7	1.9
20	1.8	0.0		2.4				7.1		5.2	2.2	3.3
21	1.7	0.1		2.4				14.3	0.0	5.3	2.0	2.1
22	3.4	0.3		5.2				17.4	0.1	3.2	2.5	1.1
23	3.6	0.9		9.2	0.0			8.9	0.5	3.6	3.3	2.1
24	3.7	2.0	0.1	10.9	0.2	0.5		7.1	2.4	2.5	3.5	2.7
25	8.8	3.7	0.1	15.7	1.0	3.0		5.8	7.3	1.1	3.0	4.9
26	14.4	6.6	0.7	23.2	5.4	9.4		9.4	12.9	0.7	4.1	6.6
27	13.6	11.6	2.7	17.3	12.9	15.6	1.3	7.1	13.7	0.5	3.6	4.5
28	8.6	13.4	8.3	4.6	17.6	12.5	0.4	9.8	10.4	0.6	3.3	6.0
29	4.3	11.7	13.9	0.8	11.6	10.9	1.7	3.1	9.6	0.8	5.3	4.9
30	3.2	9.0	12.0		8.4	11.6	8.1	4.5	14.6	1.1	6.1	4.6
31	3.2	10.7	15.5		8.1	10.0	19.6	0.9	12.4	1.2	5.1	3.3
32	3.1	8.8	13.5	0.2	6.0	7.6	24.3		8.3	1.4	5.0	4.6
33	2.7	5.7	13.6		4.6	5.6	14.0		3.9	1.3	5.2	4.1
34	1.8	3.9	9.7		4.6	4.3	14.5		1.8	1.2	5.1	4.0
35	1.5	3.4	4.1		4.4	3.7	4.3		0.8	1.0	4.1	3.4
36	1.0	2.3	2.6		4.4	2.6	5.5		0.6	0.8	5.6	2.1
37	1.1	2.2	1.3		4.8	1.6	2.1		0.4	0.5	4.4	3.9
38	0.6	1.7	1.0		3.0	0.6	1.7		0.2	0.3	5.8	4.5
39		1.3	1.0		1.6	0.3	1.3		0.1	0.2	3.6	6.6
40		0.4			0.8	0.2	1.3		0.0	0.1	2.8	8.0

41	0.5	0.2	0.4	0.1	0.0	0.0	1.8	5.8
42 +		0.0	0.2		0.0	0.0	3.8	4.0

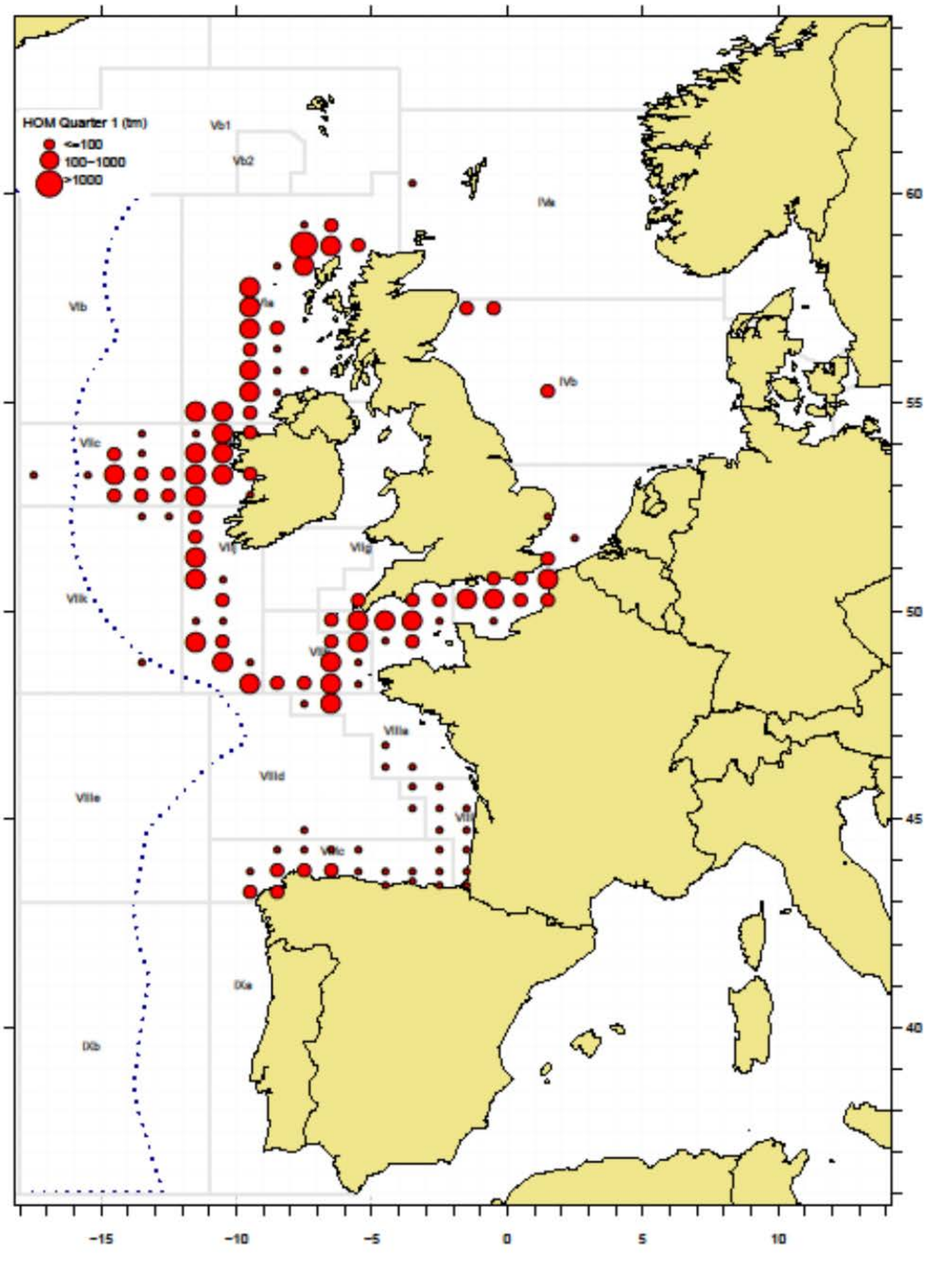


Figure 3.1.1a. Horse mackerel catches 1st quarter 2013

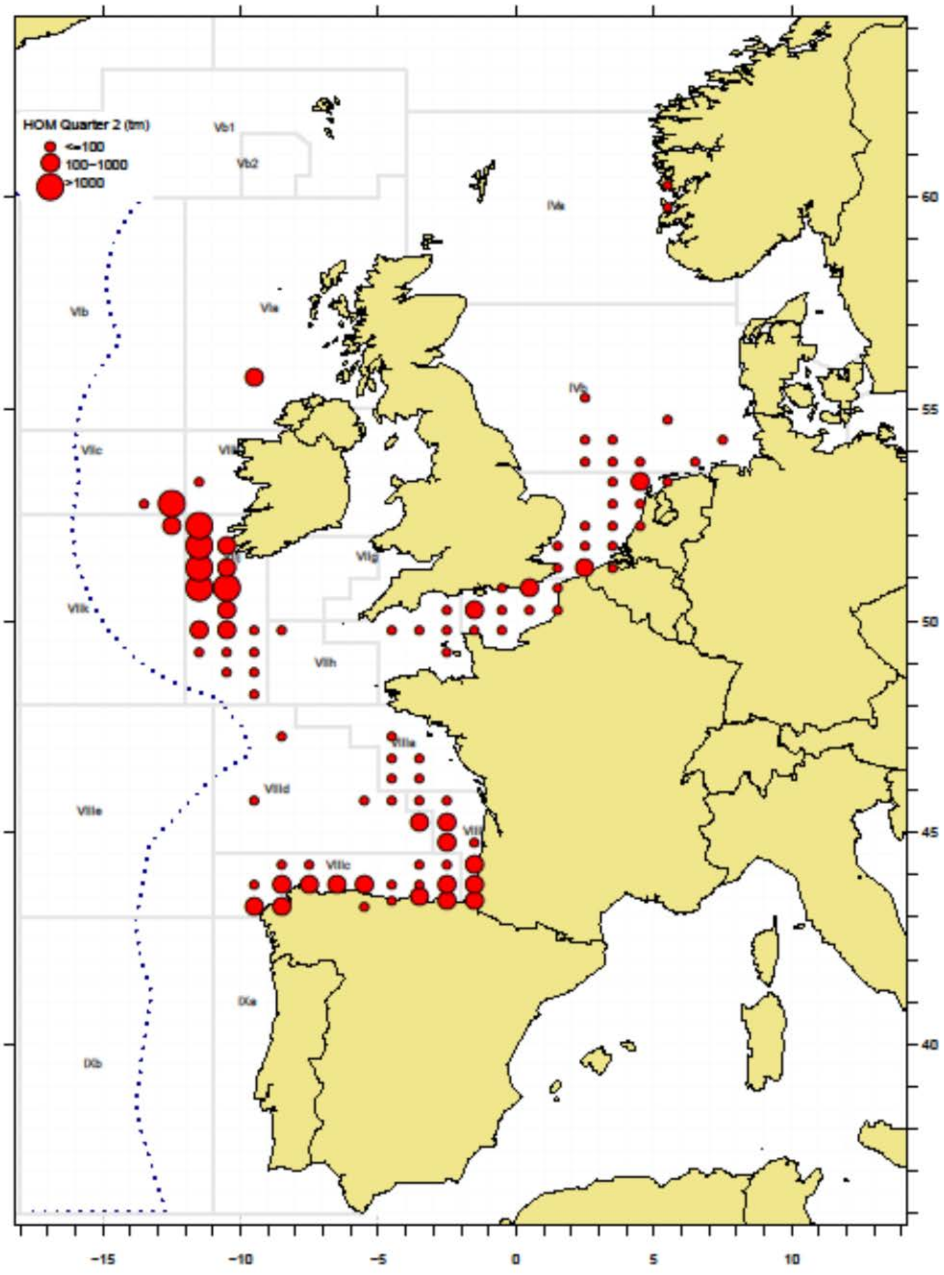


Figure 3.1.1b. Horse mackerel catches 2nd quarter 2013

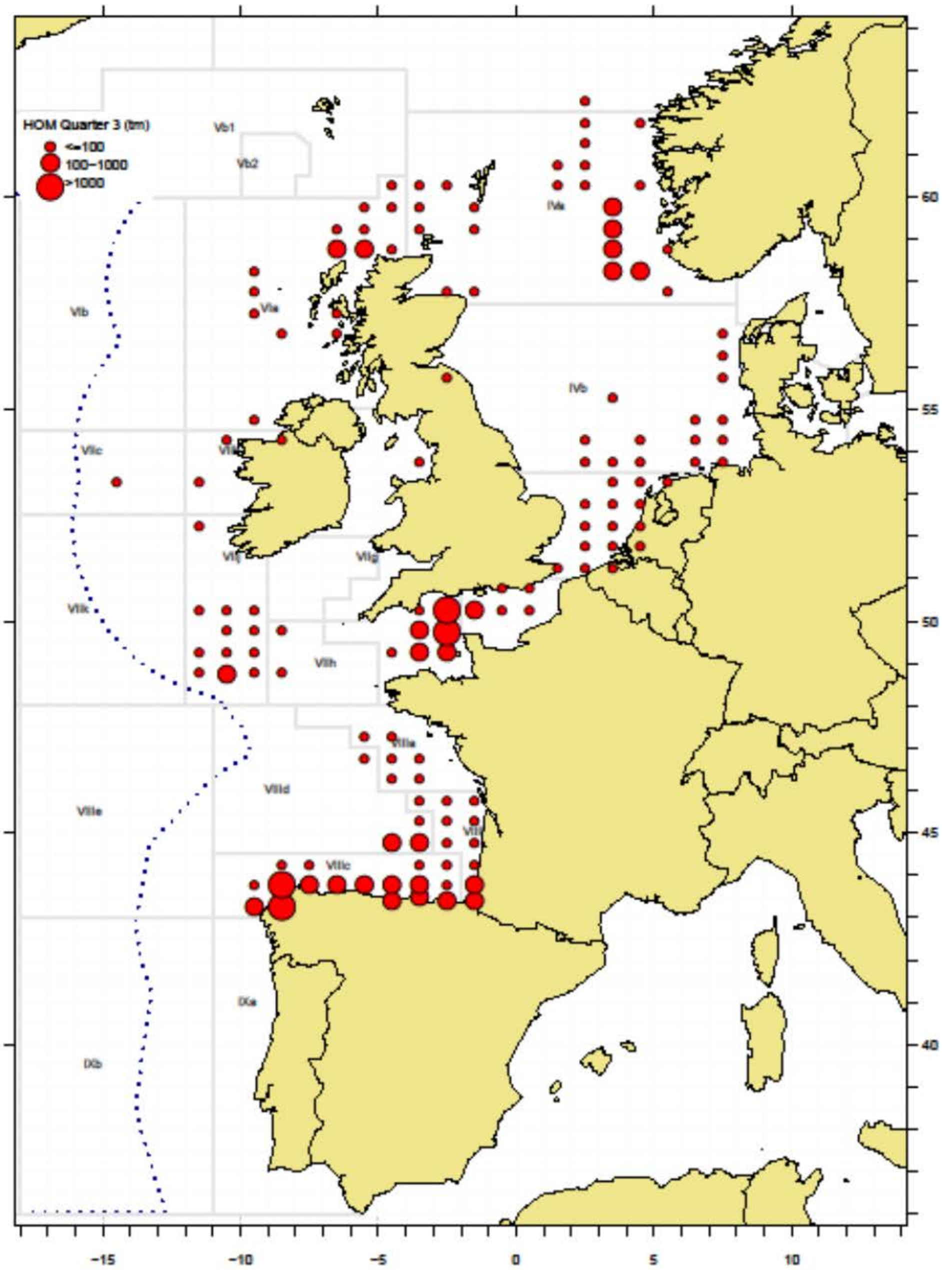


Figure 3.1.1c. Horse mackerel catches 3rd quarter 2013

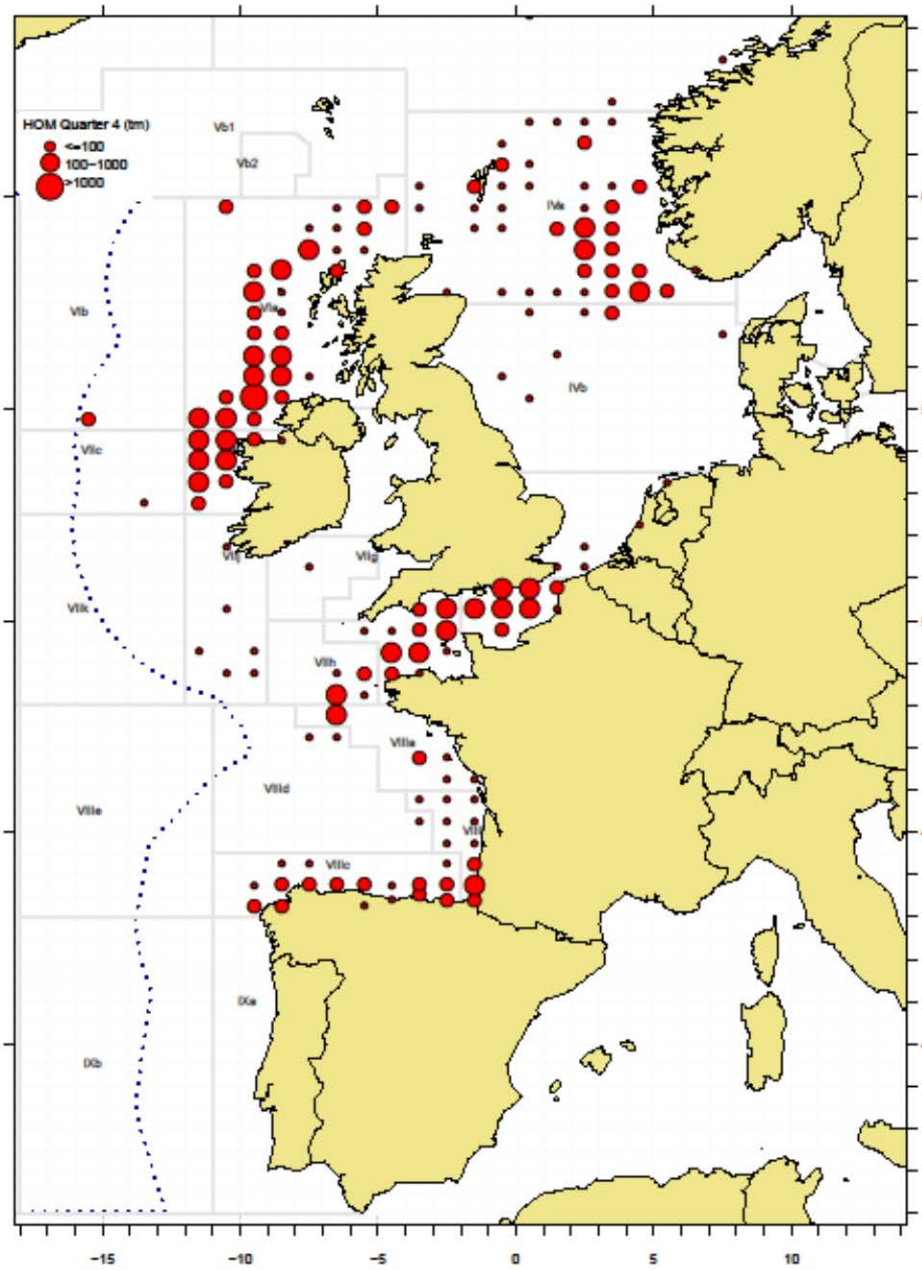


Figure 3.1.1d. Horse mackerel catches 4th quarter 2013

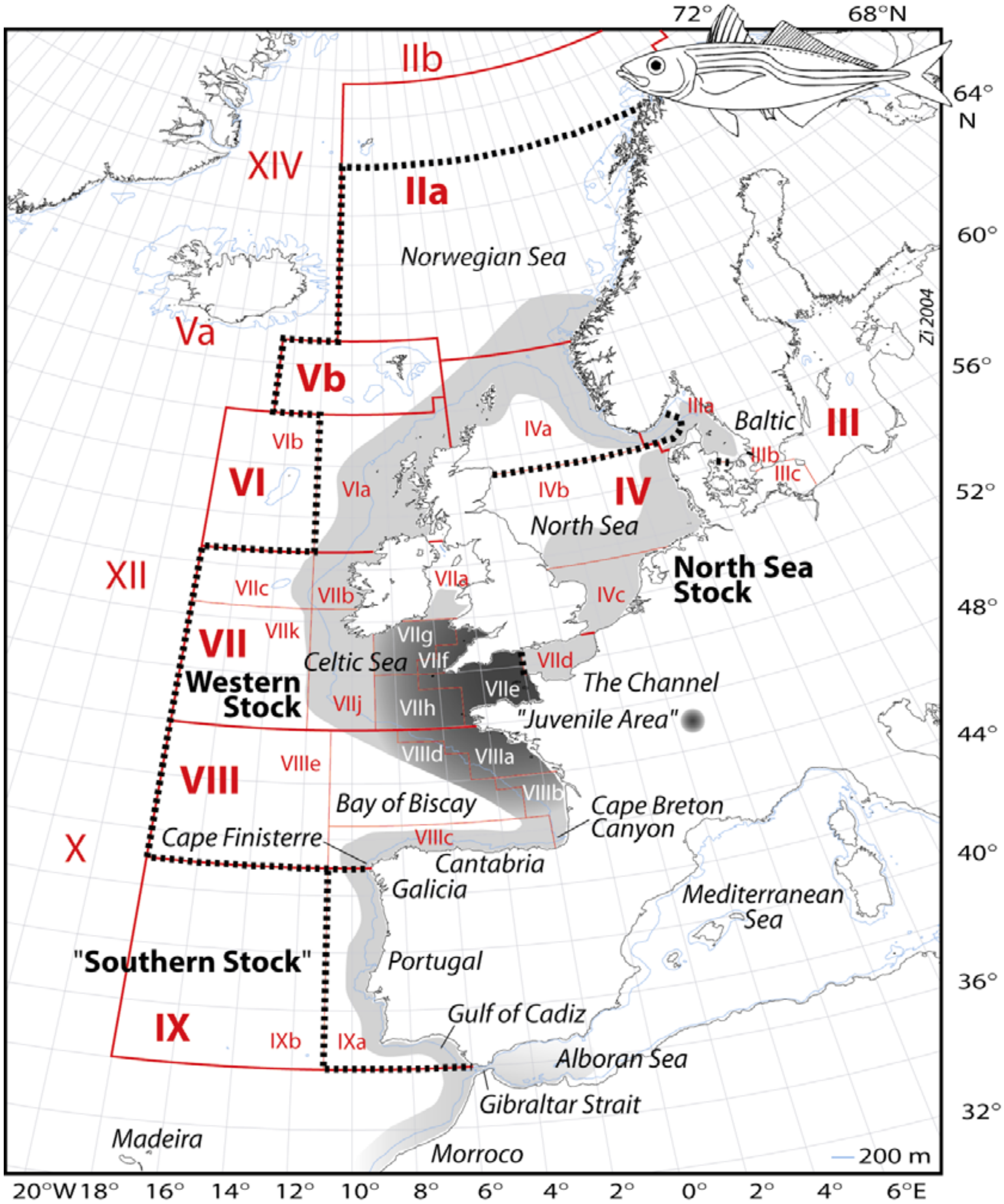


Figure 3.2.1: Distribution of Horse Mackerel in the Northeast-Atlantic: Stock definitions as used by the 2004 WG MHSA. Note that the "Juvenile Area" is currently only defined for the Western Stock distribution area – juveniles do also occur in other areas (like in Div. VIId). Map source: GEBCO, polar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

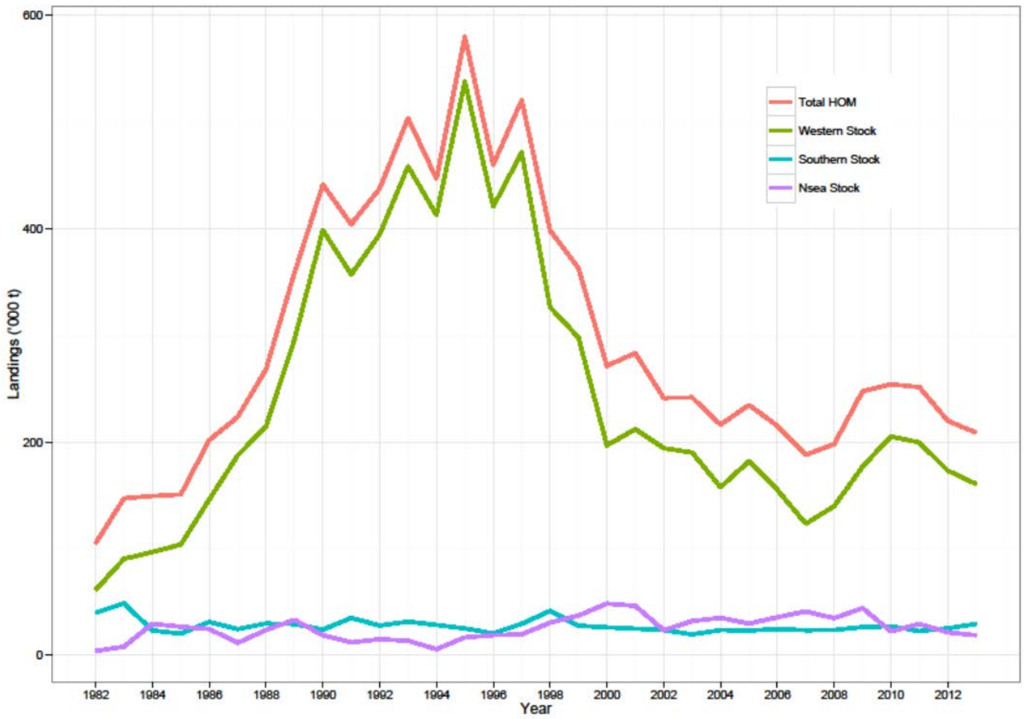


Figure 3.3.1 Horse mackerel general. Total catches in the northeast Atlantic during the period 1982-2013. The catches taken from the southern, western and North Sea horse mackerel stocks are shown in relation to the total catches in the northeast Atlantic. Caches from Div. VIIIc are transferred from southern stock to western stock from 1982 onwards. Southern horse mackerel is assessed by ICES WGHANSA since 2011.

4 North Sea Horse Mackerel: Divisions IVa (Q1 and Q2), IIIa (excluding Western Skagerrak Q3 and Q4), IVb, IVc and VIId

4.1 ICES Advice Applicable to 2014

In 2012, based on ICES approach to data-limited stocks (category 5), ICES advised for 2013 that catches of horse mackerel in Divisions IIIa and VIa first and second quarter, IVb,c, and VIId (North Sea stock) should be no more than 25500 tonnes, which represented a 20% precautionary reduction to recent catch levels. In 2013, new data on survey indices available for this stock were considered to not change the perception of the stock and therefore the advice for the fishery in 2014 was the same as the advice for 2013: no more than 25500 t. Discards are known to take place but cannot be quantified; therefore total catches could not be calculated.

The TAC for IVbc and VIId in 2014 was 31,720 tonnes.

4.2 The Fishery in 2013 on the North Sea horse mackerel stock

Catches by the Danish industrial fleet for reduction into fishmeal and fish oil formed the majority of North Sea horse mackerel catches throughout the 1970s and 1980s. Catches were taken in the fourth quarter mainly in Divisions IVb and VIId. The 1990s saw a drop in the value of industrial resources, limited fishing opportunities and steep increases in fuel costs. Since the 1990's, a larger portion of catches has been taken in a directed horse mackerel fishery for human consumption by the Dutch freezer-trawler fleet.

In 2001, an individual quota scheme was introduced in Denmark, the majority quota holder for this stock. Though this individual quota system does not directly apply to the North Sea horse mackerel fishery, it resulted in a rapid restructuring of the Danish fleet. Since then the Danish North Sea horse mackerel catches have diminished. Denmark has traded parts of its quota with the Netherlands for fishing opportunities for other species, however due to the structure of the Danish quota management set-up only a limited amount of quota can be made available for swaps with other countries. These practical implications of the management scheme largely explain the consistent underutilisation of the TAC (approximately 50% in 2010—2013) in recent years (see Figure 4.2.1).

Catches taken in Divisions IVa and IIIa during the two first quarters and all year in divisions IVb, IVc and VIId are regarded North Sea horse mackerel (Section 3, Table 3.3.1). In Section 3, Table 3.3.3 shows the reported national catches of this stock from 1997—2013. The catches were relatively low during the period 1982—1997 (not shown) with an average of 18000 tons. The catches increased between 1998 (30500 tons) and 2000 (4,400 tons). Between 2000 and 2010, the catches varied between 22255 and 46400 tons. In 2013 the catch was 18696 tons, which is 13% less than in 2012. This difference is the same as the percentage decrease in TAC. Landings by ICES division are illustrated in Figure 4.2.2 for the period 1982—2013.

4.2.1 Egg Surveys

No egg surveys for horse mackerel have been carried out in the North Sea since 1991. Such surveys were carried out during the period 1988—1991. SSB estimates are available historically. However, they were calculated assuming horse mackerel to be a determinate spawner. Horse mackerel is now considered an indeterminate spawner, Therefore egg abundance could only be considered a relative index of SSB. The mackerel egg surveys in the North Sea do not cover the spawning area of horse mackerel.

4.3 Biological Data

4.3.1 Catch in Numbers at Age

In 2013, 71% of the landings were sampled. These samples were taken by Germany, Netherlands and the UK (England) in all quarters except Q2 (<7% of the landings occur in this quarter). A total of 30 samples were collected (Section 1.3.1). Sampling coverage in 2013 has improved compared to 2012. The catch at age data remains questionable and, if an analytical assessment is to be carried out in the future, methods for distinguishing landings from the Western stock and the North Sea horse mackerel stock need to be developed.

Table 4.3.1 shows catch numbers by quarter (and annual totals) by area in 2013. Annual catch numbers at age for the whole stock for 1995—2013 are given in Table 4.3.2. Age compositions for the period 1987—1995 are also available and are plotted together with the estimates from 1995—2013 in Figures 4.3.1 and 4.3.2. However, these are based on samples taken from low numbers of Dutch commercial catches and catches from research vessels. These samples cover only a small proportion of the total catch and therefore only give a rough indication of the age composition of the stock. After 1998 catch at age data by area are available (Figure 4.3.3). Since the mid-2000s the majority of the catch has come from VIId.

Cohort structure is generally not clearly detectible in the data. This may partly be due to the shifts in distribution of the fishery. In addition, it may partly be due to age reading difficulties, which are a known to be encountered (e.g. Bolle *et al.* 2011). Most clearly detectable is the relatively large 2001 year class, although it is not clearly present in the catch in all years. There are indications that environmental circumstance may be an important factor (possibly stronger than stock size) contributing to spawning success in horse mackerel. This is for example illustrated by the largest year classes (1982 and 2001) observed in the Western stock which incidentally were produced at the lowest observed stock sizes. Since 2001 is considered to have been a relatively strong year class in the Western stock as well, it is plausible that circumstances in the North Sea were similar to those in Western areas and also allowed for relatively high spawning success in the North Sea.

Lastly, potential mixing of fish from the Western and North Sea stock in area VIId in winter may also confuse the cohort signals. For example, the large recruitment in the Western stock may have led to more of these fish being located in the North Sea stock area as age 1 fish in 2002.

4.3.2 Mean weight at age and mean length at age

Tables 4.3.3 and 4.3.4 show mean weight and length at age by quarter and by area in 2013. The annual average values are also shown in those same tables.

4.3.3 Maturity at age

Peak spawning in the North Sea falls in May and June (Macer, 1974), and spawning occurs in the coastal regions of the southern North Sea along the coasts of Belgium, the Netherlands, Germany, and Denmark.

There is no information available about the maturity at age of the North Sea Horse mackerel stock. Since there is no specific information available for the North Sea horse mackerel stock specifically, for exploratory model fits the maturity ogive used since 1998 in the assessment of the Western horse mackerel stock was used, constant over time (see text table below).

Western horse mackerel maturity ogive (>1998) used in exploratory assessments.

Age:	1	2	3	4	5	6	7	8	9	10+
Proportion Mature	0.00	0.05	0.25	0.70	0.95	1.00	1.00	1.00	1.00	1.00

4.3.4 Natural mortality

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

Two options (see text table below) were explored for inclusion in the exploratory assessments. The first being the natural mortality assumptions used in the assessment for Western horse mackerel (whmM). This stock is geographically closest to the North Sea stock and therefore possible better comparable than the Southern stock. It assumes a constant natural mortality rate of 0.15 for all ages and years, which is almost identical to estimates derived from simple maximum age methods to calculate M (results not shown here). The second option explored included the assumptions used in the assessment of the Southern horse mackerel stock (shmM). This is an age-varying M, highest on the younger ages, decreasing to 0.15 for the older ages. Despite that this stock is geographically further away than the Western stock, predation on younger ages, especially in a more confined area as the North Sea, might be expected to be higher than in a situation like the Western stock where spawning occurs in more open waters, with possibly less threat of predation.

Two alternative natural mortality at age vectors considered for use in the NS horse mackerel exploratory assessments.

Age:	1	2	3	4	5	6	7	8	9	10+
whmM	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
shmM	0.6	0.4	0.3	0.2	0.15	0.15	0.15	0.15	0.15	0.15

4.4 Data Exploration

4.4.1 Catch curves

The log-catch numbers were plotted by cohort to estimate the negative gradient of the slope and get an estimate of total mortality (Z). Fully selected ages 3 to 14 from the 1995 – 2013 period (when catch at age estimates are considered more representative of the whole fishery) provide complete data for the 1992 to 1999 cohorts (Figure 4.4.1). The estimated negative gradients by cohort (Figure 4.4.2) indicate an increasing trend in total mortality for the period examined, however the poor quality of the cohort signals in the data likely make these Z estimates highly uncertain.

An analysis of the catch number at age data carried out in 2011 showed that only the 1 vs 2, 2 vs 3, 7vs 8 and 8 vs 9 age groups were positively and significantly correlated in the catch. This analysis was not updated this year but these results suggest limitations in the catch at age data.

4.4.2 Alternative methods to estimate the biomass

In 2002 Ruckert *et al.* estimated the North Sea horse mackerel biomass based on a ratio estimate that related CPUE data from the IBTS to CPUE data of whiting (Merlangius merlangus). The applied method assumes that length specific catchability of whiting and horse mackerel are the same for the IBTS gear. Subsequently, they use the total biomass of whiting derived from an analytical stock assessment (MSVPA) to estimate the relationship between CPUE and biomass.

Other methods to use information from data-rich stocks to assess the biomass of data poor stocks have recently been suggested by Punt *et al.* (2011). WGWIDE suggests that these methods should be further investigated to enable stock estimates of the North Sea horse mackerel.

4.4.3 IBTS Survey Data

Many pelagic species are frequently found close to the bottom during daytime (which is when the IBTS survey operates) and migrate upwards predominantly during the night they are susceptible to semi-pelagic fishing gear and to bottom trawls (Barange *et al.* 1998). Eaton *et al.* (1983) argued that horse mackerel of 2 years and older are predominantly demersal in habit. Therefore, in the absence of a targeted survey for this stock, the IBTS is considered a reasonable alternative. IBTS data are also used in the assessment of the southern horse mackerel stock.

IBTS data from quarter 3 were obtained from DATRAS and analysed. Based on a comparison of IBTS data from 4 quarters in the period 1991—1996, Ruckert *et al.* (2002) showed that horse mackerel catches in the IBTS were most abundant in the third quarter of the year. In contrast to previous years, when during WGWIDE meetings, three indices were derived: (a) for fish <14 cm, (b) for fish >= 14 cm and <23 cm and (c) for fish >=23 cm, the working group in 2013 considered that using an 'exploitable biomass index' is most appropriate for the purpose of interpreting trend in the stock.

Commercial catch data show that 2-year old fish and older make up 96% of the landings, which roughly coincides with fish of >= 20 cm (see Figure 4.4.3). Index including fish of 20 cm and larger (roughly corresponding to age 2 and older) were therefore derived for the interpretation of stock trend.

To create indices, a subset of ICES rectangles was selected. Rectangles that were not covered by the survey more than once during the period 1991—2012 were excluded from the index area. In 2012, WGWIDE expressed concern that the previously selected index area did not sufficiently cover the distribution area of the stock, especially in years that the stock would be relatively more abundant and spread out more. Ruckert *et al.* (2002) also identified a larger distribution area of the North Sea stock. Based on the above, 61 rectangles were identified to be included in the index area as shown in Figure 4.4.4.

4.4.3.1 General Linear Modelling approach to index

Even though survey trawl hauls in the IBTS are supposed to be directly comparable, there still may exist differences in catchability of between vessels, especially with species for which the survey was not designed. If the proportion or the geographical distribution of the data collected by the different vessels varies among years, then the vessel effect needs to be accounted for in the computation of the abundance index.

A generalized linear model (GLM) approach accounts for the above mentioned issue in establishing the index. Catches from the survey can be modelled as a linear function of explanatory variables, which may be continuous (depth) or factors (year, vessel, gear type) and offer the possibility to specify a distribution different from the normal distribution. The abundance index (corrected for the other potential effects such as vessel effects) can then be obtained from the estimated year effects. Sensitivity tests suggested that the index is robust to the inclusion of new years of data.

In zero inflated GLMs, the zeros (absence of the species) are assumed to result of two different causes: i) the false zeros, corresponding to sampling errors (such as sampling in wrong areas, i.e. outside the distribution area of the species, or using an inadequate technique) and ii) the real zeros, corresponding to sampling in low abundance areas. The zero inflated GLM is then a combination of two models: a model for the probability of occurrence of a false zero multiplied by a model of the count data conditional to not having a false zero.

Where $E(Y_i)$ is the expected catch for the trawl haul *i*, and $var(Y_i)$ is the associated variance, π_i is the probability of having a false zero, μ_i is the expected catch, conditional to not having a false zero, and *k* is the dispersion parameter from the negative binomial distribution.

The probability of having a false zero is modelled by a logistic regression, where

$$logit(\pi_i) = I_{zero} + Depth\ Cathegory_{i,zero} + Vessel_{i,zero} + Year_{i,zero}$$

The expected number of fish, conditional to not having a false zero is modelled as negative binomial regression :

$$log(\mu_i) = I_{count} + Depth\ Cathegory_{i,count} + Vessel_{i,count} + Year_{i,count} + offset\ (\log(haul\ duration))$$

Using $\log(haul\ duration)$ as an offset is a common way of standardizing samples taken by trawl haul of different length and it comes down to modelling the CPUE of the horse mackerel in fish per hour.

The year effect from this model fit then represents an index of the relative changes in stock abundance in the index area over time (Table 4.4.1, Figure 4.4.5)

To convert abundance per length class to biomass per length class, weight per cm length class was calculated using length-weight information from a fitted function to IBTS 2003—2009 weight data:

$$W = 0.0161 * L^{2.86}$$

Where: W=weight in grams

L= length in cm.

The resulting biomass index shows very similar trends to the abundance index (Table 4.4.1, Figure 4.4.5). Index values decreased steadily over the 2000s. Since 2010 there are some signs of a slight increase in abundance/biomass, however the relative increase in the index is small in comparison to the uncertainty range.

4.4.3.2 Delta Log-Normal computation of index

As an alternative approach to deal with the skewed nature of the data together with its relatively large number of zeros, the mean annual cpue was computed assuming a lognormal distribution for the positive values only, together with an additional probability mass at zero. This type of distribution is commonly referred to as the delta-lognormal distribution, and was first discussed by Aitchison (1957). It has been used in various applications since then, and is commonly used in fisheries research (e.g. Pennington, 1996; Fletcher 2008).

The expected annual index values are computed as the product of the proportion of positive (non-zero) hauls and the cpue of the positive hauls:

$$\mu_Y = \pi \exp(\mu_X + \frac{\sigma_X^2}{2})$$

Where: π = the proportion of positive hauls in each year

μ , σ = the mean and variance of the cpue from the positive hauls each year

The proportion of positive hauls, the cpue in the positive hauls and the resultant index values are shown in Table 4.4.1 and Figure 4.4.6. The decrease in the DLN index is more consistent than the GLM index, with no slight recovery in recent years as seen in the GLM index. This is mainly due to the proportion of hauls in which horse mackerel are found decreasing steadily over time, from 74% in 1998 to the lowest observed value of 28% in 2013. Since 2008, cpue in the positive hauls only has increased. This indicates that while the distribution of horse mackerel through the survey area has reduced, in hauls where horse mackerel are encountered, they are found in a higher density than previously.

4.5 Exploratory Assessments

4.5.1 The JAXass assessment model

At the 2014 WGWIDE some exploratory model fits were attempted using the data available. The JAXass (JAX assessment) model is a simple statistical catch at age model fitted to an age-aggregated index of (2+) biomass, total catch data and proportions at age from the catch. It is based on Per Sparre's "separable VPA" model, an ad hoc method tested for the first time at WGWIDE in 2003, and later 2004. A new analysis using this model was also done in 2007 using an IBTS index. In 2014 the model has been coded in ADMB (Fournier et al., 2012) and updated with an improved objective function (dnorm), extra years of data and new methods for calculating the index (see above).

Difficulties in fitting an assessment model for this stock include:

- Unclear stock boundaries
- Difficulty aging horse mackerel
- lack of strong cohort signals in CAA data
- Scientific index derived from a survey not specifically designed for horse mackerel and not covering one of the main fishing grounds for the stock (VIId)

Catches taken in area VIId are close to the management boundary between the (larger) western horse mackerel stock and the NS horse mackerel stock. It is quite possible that given changes in oceanographic condition, or changes in abundance of either of the two stocks, that some proportion of the catches taken in area VIId actually originated from the western horse mackerel stock. Nevertheless, all assessment models used in the MSE assume that 100% of fish caught in area VIId belong to the North Sea horse mackerel stock. This is in agreement with stock and management definitions.

Table 4.5.1 shows the inputs and settings used in the JAXass model. In total the model estimates 60 parameters (for the period 1992—2013):

- Annual F multipliers (*N*=22, one for each year)
- Fishery selectivity parameters (*N*=2, selectivity is time invariant i.e. one selectivity curve)
- Initial population (*N*=9, ages 2-10+ in 1995)
- Annual recruitment (*N*=22, one for each year)
- Sigmas (variances) (*N*=5, one for total catch, one for index and three for CAA)

Annual F values in the model are bound between 0.01 and 1.5. Selectivity is modelled as a logistic curve. For *age* 1 to 10, the selectivity at age (Sel_{age}) is calculated as:

$$Sel_{age} = \frac{1}{1 + e^{\alpha + age \times \beta}}$$

The objective function is the weighted dnorm likelihoods for the total catch, catch at age and IBTS data:

$$objF = wt_C \times f_C + wt_{CAA} \times f_{CAA} + wt_I \times f_I$$

Where:

$$f_C = \sum_{y=1995}^{2012} 0.5 \times \left(\ln(2\pi\sigma_C^2) + \frac{\left(\ln C_y^{obs} - \ln C_y^{exp}\right)^2}{\sigma_C^2} \right)$$

$$f_{CAA} = \sum_{a=1}^{10+} \sum_{y=1995}^{2012} 0.5 \times \left(\ln\left(2\pi\sigma_{CAA,a}^2\right) + \frac{\left(\ln CAA_{a,y}^{obs} - \ln CAA_{a,y}^{est}\right)^2}{\sigma_{CAA,a}^2} \right)$$

$$f_I = \sum_{y=1998}^{2012} 0.5 \times \left(\ln(2\pi\,\sigma_I^2) + \frac{\left(\ln I_y^{obs} - \ln I_y^{exp}\right)^2}{\sigma_I^2} \right)$$

C^{obs} and C^{exp}	= The observed and expected total catch (*C*), over years (*y*)
CAA^{obs} and CAA^{exp}	= The observed and expected catch at age (*CAA*), over years (*y*)
I^{obs} and I^{exp}	= The observed and expected IBTS index (*I*), over ages (*a*) and years (*y*)
σ_C	= Estimated variance in the total catch time series
σ_I	= Estimated variance in the IBTS index time series
$\sigma_{CAA,a}$	= Estimated variance in the catch at age (*CAA*) time series

for ages *a=1*, *a=2-9*, and *a=10*

wt_C / wt_{CAA} / wt_I = Weightings applied to the total catch / catch at age / index

The index and total catch have single sigma (variance) values for the whole time series while the CAA has one for the youngest age (a=1, high variance), one for ages 2—9 (similar variance) and one for age 10 (high variance).

4.5.2 Assessment model results

Four assessment models were fit, using either the GLM index or the DLN index and either the western or southern horse mackerel natural mortality (Figure 4.5.1).

All models fit indicate a sharp reduction in SSB since the start of the time series, with an accompanying increase in mean F. Mean F fluctuates in recent years depending on whether or not there was a Norwegian fishery in IVa. Using the GLM index instead of the DLN index leads to higher SSB and recruitment and lower mean F in 2013 relative to the past.

The alternative natural mortality values do not have a significant impact on either SSB or mean F. Rather, the southern horse mackerel M models, which have higher M on the younger ages, predict more recruits and a slightly lower selectivity of the fleet on these ages. This allows the model to account for the higher natural mortality on the younger ages. As a result the age structure in stock tends towards more young fish with Shm M.

All models under estimate total catch in the recent years and over estimate it in the past. This is because the model is not able to reconcile the sharp decreases seen in the indices with the levels of catch taken. i.e. the model estimates that more catch than observed was required to lead to the sharp reduction in the indices and that the current levels of catch are too high given the recent trends found in the index.

The diagnostics of these models (not shown) indicate significant retrospective patterns, probably due to the assumption of a constant selectivity. It is unlikely that selectivity in this fishery has remained constant over time given changes in fishery location and the frequent reliance on a few large year classes.

The results presented here, are purely exploratory. Much work is required to develop a plausible assessment model for this stock given the data issues involved.

4.6 Basis for 2014 Advice

The exploratory assessment models are not considered acceptable as a basis for advice. As in the previous two years, using an index derived from the IBTS survey can be used to inform on stock status. New methods for calculating indices have been explored. The GLM approach is considered a robust, appropriate treatment of the survey data and provides confidence bounds on the final estimates. This is considered as the best currently available index for the stock.

There remains concerns over the data and knowledge available for the management of this stock. The available survey data do not cover the main fishing grounds for this stock, even though the stock is thought to be present in the survey area at the time of the survey. Cohort signals in the catch are weak, due to aging errors, changes in fishery location and potentially due to mixing of fish from the western stock in the catch. However, the available data all suggest that the North Sea horse mackerel stock is currently at a low biomass in the North Sea, potentially increasing slightly I n the most recent years.

4.6.1 ICES DLS approach

The guidelines for data-limited stocks (DLS) for which a biomass index is available (Category 3) suggest a harvest control rule of index-adjusted status-quo catch. The advice is based on a comparison of the most recent index values (2 or 3) with the preceding values (3 or 5), combined with recent catch or landings data. Knowledge about the exploitation status also influences the advised catch.

For this stock, comparing the most recent two years with the preceding three years of the GLM biomass index estimates a 54% increase. According to the guidelines for DLS this implies an increase of landings of at most 20% in relation to the last three years average landings (23155 t), corresponding to landings of no more than 27786 t.

Comparing the most recent three years with the preceding five years of the GLM biomass index estimates a 4% increase. According to the guidelines for DLS this implies an increase of landings of 4% in relation to the last three years average landings (23155 t), corresponding to landings of no more than 24081 t.

Although the 2:3 harvest control rule indicates a potential increase in biomass >50%, the large confidence bounds indicate a high degree of uncertainty around this increase. In addition there are no clear indications that the stock is not over-exploited. The advice given for this stock in 2012 under category 5 of the ICES DLS approach (25500 t) is considered valid for 3 years unless there are clear indications of a change in stock status. WGWIDE does considers that this advice should remain valid since any potential changes in stock status are highly uncertain.

4.7 Management considerations

In the past, Division VIId was included in the management area for Western horse mackerel together with Divisions IIa, VIIa–c, VIIe–k, VIIIa, VIIIb, VIIId, VIIIe, Subarea VI, EU and international waters of Division Vb, and international waters of Subareas XII and XIV. ICES considers Division VIId to be part of the North Sea horse mackerel distribution area. Since 2010, the EU TAC for the North Sea area has included Divisions IVb,c and VIId. Considering that a majority of the catches are taken in Division VIId, the total of North Sea horse mackerel catches are effectively constrained by the TAC since the realignment of the management areas in 2010.

Catches in Divisions IIIa (Western Skagerrak) and IVa in quarters 3 and 4 are considered to be from the Western horse mackerel stock, while catches in quarters 1 and 2 are considered to be from the North Sea horse mackerel stock. Catches in area IVa and IIIa are variable. In recent years only Norway has had significant catches in this area, but these are only taken in some years (see Figure 4.2.1).

4.8 References

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Table 4.3.1. North Sea Horse Mackerel stock. Catch in numbers (1000) by quarter and area in 2013.

1Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0						
1	0.00	0.00	8.04	2.89	141.29	152.23
2	0.00	0.01	20.14	7.24	353.79	381.18
3	0.00	0.13	249.84	89.81	4388.38	4728.17
4	0.01	0.19	352.73	126.79	6195.53	6675.25
5	0.01	0.34	622.66	223.82	10936.61	11783.43
6	0.00	0.07	132.51	47.63	2327.41	2507.62
7	0.00	0.14	253.08	90.97	4445.17	4789.36
8	0.00	0.06	110.31	39.65	1937.61	2087.64
9	0.00	0.09	163.33	58.71	2868.77	3090.90
10	0.00	0.12	229.13	82.36	4024.54	4336.16
11	0.00	0.08	150.31	54.03	2640.18	2844.61
12	0.00	0.02	28.32	10.18	497.37	535.88
13	0.00	0.01	25.56	9.19	448.99	483.76
14		0.00	2.00	0.72	35.18	37.91
15+	0.00	0.00	4.21	1.51	73.87	79.59
Sum	0.04	1.27	2352.18	845.51	41314.70	44513.70
2Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0	0.00	0.10	0.14	0.00	0.00	0.24
1	0.00	2.82	4.10	8.96	26.40	42.28
2	0.00	0.48	0.70	34.04	101.06	136.29
3	0.00	0.34	0.50	225.87	670.58	897.30
4	0.00	0.38	0.55	284.94	845.96	1131.83
5	0.00	1.52	2.21	484.50	1438.31	1926.53
6	0.00	1.01	1.47	105.75	313.87	422.09
7	0.00	0.38	0.55	196.92	584.58	782.43
8				85.83	254.82	340.65
9	0.00	0.19	0.28	127.08	377.27	504.81
10	0.00	0.57	0.83	178.29	529.26	708.94
11	0.00	0.38	0.55	116.96	347.20	465.10
12	0.00	0.38	0.55	22.04	65.41	88.38
13				19.89	59.05	78.93
14				1.56	4.63	6.19
15+				3.27	9.71	12.99
Sum	0.01	8.55	12.43	1895.89	5628.10	7544.98

Table 4.3.1. North Sea Horse Mackerel stock. Catch in numbers (1000) by quarter and area in 2013. Cont.

3Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0			1.09	0.05		1.14
1			31.82	55.38	157.53	244.72
2			5.46	376.98	1102.70	1485.14
3			3.88	645.98	1890.35	2540.21
4			4.28	215.47	630.12	849.86
5			17.10	0.84		17.94
6			11.39	54.37	157.53	223.29
7			4.28	0.21		4.49
8						
9			2.14	0.10		2.24
10			6.41	0.31		6.73
11			4.28	0.21		4.49
12			4.28	0.21		4.49
13						
14						
15+						
Sum			96.39	1350.12	3938.22	5384.73
4Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0			3.38	0.89	161.66	165.94
1			145.33	38.46	6948.78	7132.57
2			162.15	42.91	7753.05	7958.10
3			268.17	70.97	12822.63	13161.77
4			275.28	72.85	13162.45	13510.57
5			273.14	72.28	13060.27	13405.69
6			58.69	15.53	2806.41	2880.64
7			32.85	8.69	1570.81	1612.36
8			37.25	9.86	1781.07	1828.17
9			8.36	2.21	399.91	410.48
10			6.70	1.77	320.49	328.97
11			7.70	2.04	368.09	377.82
12			8.08	2.14	386.12	396.33
13						
14						
15+			0.19	0.05	9.12	9.37
Sum			1287.26	340.65	61550.85	63178.77

Table 4.3.1. North Sea Horse Mackerel stock. Catch in numbers (1000) by quarter and area in 2013. Cont.

1–4Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0	0.00	0.10	4.61	0.95	161.66	167.32
1	0.00	2.83	189.29	105.68	7274.01	7571.81
2	0.00	0.49	188.45	461.17	9310.60	9960.71
3	0.00	0.48	522.40	1032.62	19771.94	21327.44
4	0.01	0.57	632.84	700.05	20834.06	22167.52
5	0.01	1.85	915.11	781.44	25435.19	27133.59
6	0.00	1.08	204.06	223.28	5605.22	6033.64
7	0.00	0.52	290.76	296.79	6600.56	7188.63
8	0.00	0.06	147.56	135.34	3973.50	4256.47
9	0.00	0.28	174.11	188.11	3645.94	4008.44
10	0.00	0.69	243.07	262.74	4874.29	5380.80
11	0.00	0.46	162.84	173.24	3355.47	3692.01
12	0.00	0.39	41.22	34.57	948.90	1025.08
13	0.00	0.01	25.56	29.08	508.04	562.69
14		0.00	2.00	2.28	39.81	44.09
15+	0.00	0.00	4.40	4.83	92.71	101.94
Sum	0.05	9.82	3748.27	4432.17	112431.88	120622.17

Table 4.3.2. Catch in numbers at age (millions), weight at age (kg) and length at age (cm) for the North Sea horse mackerel 1995-2013.

millions	Catch number																		
Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	1.76	4.58	12.56	2.30	12.42	70.23	12.81	60.42	13.81	15.65	52.39	5.01	3.40	1.73	34.10	3.31	8.14	9.49	7.57
2	3.12	13.78	27.24	22.13	31.45	77.98	36.36	16.82	56.15	17.54	29.82	23.72	15.46	8.84	13.91	22.52	23.30	24.31	9.96
3	7.19	11.04	14.07	36.69	23.13	28.41	174.34	19.27	23.44	34.38	27.80	61.47	22.83	36.13	28.43	10.67	76.51	20.42	21.33
4	10.32	11.87	14.93	38.82	17.59	21.42	87.81	11.90	33.21	14.51	12.58	40.86	82.64	16.72	22.06	15.70	37.27	40.24	22.17
5	12.08	9.64	14.58	20.79	23.12	31.27	18.51	5.61	26.93	27.77	16.66	72.95	71.23	36.35	17.25	23.68	14.58	25.76	27.13
6	13.16	12.49	12.38	12.10	26.19	19.64	11.49	5.83	10.59	20.17	5.19	23.38	30.52	36.10	16.28	15.93	9.93	20.82	6.03
7	11.43	7.96	10.12	13.99	20.64	19.47	18.25	5.54	6.33	10.58	2.86	13.73	23.93	27.33	21.52	27.63	5.75	3.13	7.19
8	12.64	6.60	8.64	10.79	21.75	9.00	14.70	10.48	9.56	3.82	2.43	5.86	17.27	21.90	47.13	5.62	6.03	4.99	4.26
9	7.25	1.48	2.45	8.26	12.91	11.50	10.22	6.33	10.90	5.37	3.80	1.58	7.89	10.16	11.24	6.34	3.36	4.64	4.01
10	5.87	5.31	0.75	4.01	8.21	8.96	9.98	6.75	1.51	10.95	5.76	1.36	1.66	7.52	9.28	8.30	10.13	1.53	5.38
11	0.01	0.29	0.34	2.72	2.14	6.98	9.58	5.12	3.43	6.22	2.31	0.19	0.59	1.92	7.24	2.88	6.90	0.49	3.69
12	8.84	1.28	0.25	0.71	0.43	3.07	5.35	3.02	3.29	4.47	4.13	1.69	0.21	2.10	3.65	0.30	3.61	0.11	1.03
13	0.20	8.92		1.81	1.40	1.61	3.73	2.17	2.25	6.16	2.50	0.62	0.72	0.36	0.30	0.34	0.77		0.56
14	4.37	8.01	1.38	0.31	3.78		1.95	1.29	3.40	2.25	9.86	0.96	0.65	2.42	0.90	0.23	0.33	0.17	0.04
15+				5.11	4.03	12.22	5.81	2.71	4.70	8.52	9.55	0.82		1.03	6.14	1.13	0.53		0.10

kg	weight																		
Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.076	0.107	0.063	0.063	0.063	0.075	0.055	0.066	0.073	0.076	0.079	0.069	0.073	0.063	0.063	0.077	0.060	0.069	0.077
2	0.126	0.123	0.102	0.102	0.102	0.101	0.072	0.095	0.105	0.104	0.077	0.095	0.082	0.096	0.096	0.101	0.092	0.090	0.099
3	0.125	0.143	0.126	0.126	0.126	0.136	0.071	0.129	0.123	0.120	0.103	0.116	0.105	0.109	0.109	0.115	0.098	0.118	0.112
4	0.133	0.156	0.142	0.142	0.142	0.152	0.082	0.154	0.137	0.147	0.132	0.124	0.115	0.125	0.125	0.138	0.116	0.142	0.138
5	0.146	0.177	0.160	0.160	0.160	0.166	0.120	0.172	0.166	0.174	0.158	0.141	0.130	0.145	0.145	0.154	0.146	0.152	0.166

6	0.164	0.187	0.175	0.175	0.175	0.194	0.183	0.195	0.181	0.198	0.196	0.177	0.164	0.161	0.161	0.180	0.167	0.172	0.180
7	0.161	0.203	0.199	0.199	0.199	0.198	0.197	0.216	0.195	0.225	0.251	0.210	0.191	0.194	0.194	0.207	0.188	0.183	0.200
8	0.178	0.195	0.231	0.231	0.231	0.213	0.201	0.227	0.212	0.229	0.270	0.244	0.197	0.221	0.221	0.195	0.206	0.188	0.216
9	0.165	0.218	0.250	0.250	0.250	0.247	0.235	0.228	0.238	0.256	0.280	0.231	0.256	0.286	0.286	0.241	0.300	0.212	0.223
10	0.173	0.241	0.259	0.259	0.259	0.280	0.246	0.251	0.259	0.291	0.291	0.284	0.258	0.296	0.296	0.225	0.324	0.204	0.226
11	0.317	0.307	0.300	0.300	0.300	0.279	0.260	0.302	0.245	0.301	0.344	0.237	0.517	0.273	0.273	0.286	0.341	0.274	0.242
12	0.233	0.211	0.329	0.329	0.329	0.342	0.286	0.292	0.295	0.300	0.361	0.257	0.279	0.309	0.309	0.227	0.402	0.195	0.263
13	0.241	0.258	0.367	0.367	0.367	0.318	0.287	0.318	0.356	0.302	0.332	0.268	0.338	0.375	0.375	0.288	0.405		0.262
14	0.348	0.277	0.299	0.299	0.299	0.325	0.295	0.319	0.319	0.338	0.376	0.291	0.414	0.277	0.277	0.315	0.415	0.187	0.559
15+	0.348	0.277	0.360	0.360	0.360	0.332	0.336	0.390	0.380	0.401	0.367	0.402		0.389	0.389	0.358	0.473		0.339

cm	length																		
Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	19.2	19.2	19.2	19.2	19.2	19.0	18.7	17.1	20.2	19.8	20.54	19.89	20.05	20.00	20.00	20.77	19.17	19.90	20.86
2	22.0	22.0	22.0	22.0	22.0	21.5	20.4	21.4	22.4	22.2	21.49	21.94	20.83	21.62	21.62	22.60	21.70	21.67	22.37
3	23.5	23.5	23.5	23.5	23.5	23.9	20.6	22.9	23.8	23.6	23.00	23.38	22.59	23.20	23.20	23.75	23.06	23.53	23.45
4	24.8	24.8	24.8	24.8	24.8	24.9	21.3	24.9	24.6	25.2	24.69	24.13	23.64	24.11	24.11	24.98	24.48	25.02	25.25
5	25.5	25.5	25.5	25.5	25.5	26.0	25.0	26.2	26.2	26.6	25.53	25.42	24.37	25.61	25.61	25.69	25.87	25.70	26.98
6	26.4	26.4	26.4	26.4	26.4	27.8	27.4	26.6	27.3	27.5	27.77	27.01	26.58	26.33	26.33	27.02	27.54	26.96	27.10
7	27.2	27.2	27.2	27.2	27.2	28.3	28.0	27.4	28.2	28.9	30.42	28.53	27.80	28.07	28.07	28.23	28.02	27.09	28.25
8	29.2	29.2	29.2	29.2	29.2	28.6	28.4	28.2	29.0	29.2	31.19	29.84	28.12	28.77	28.77	28.17	27.71	27.05	28.87
9	29.5	29.5	29.5	29.5	29.5	30.0	29.7	29.2	29.9	30.5	31.82	30.63	30.05	31.16	31.16	30.19	31.88	28.56	29.22
10	29.5	29.5	29.5	29.5	29.5	31.3	30.2	30.8	30.8	31.5	32.32	31.55	31.15	31.79	31.79	29.91	32.45	28.04	29.53
11	30.6	30.6	30.6	30.6	30.6	31.4	30.7	32.5	30.8	32.0	34.41	31.18	39.50	31.60	31.60	32.09	33.30	30.06	30.05
12	32.1	32.1	32.1	32.1	32.1	33.7	32.0	33.8	31.9	31.8	36.16	30.75	31.50	32.24	32.24	29.57	34.49	27.50	30.39
13	33.3	33.3	33.3	33.3	33.3	33.5	31.7	33.8	32.9	32.0	34.20	32.13	33.40	33.90	33.90	31.83	35.21		32.08
14	31.1	31.1	31.1	31.1	31.1	33.4	32.1	32.4	32.7	33.0	34.90	32.15	34.50	32.33	32.33	33.00	36.00	27.50	38.50
15+	32.5	32.5	32.5	32.5	32.5	33.4	33.4	34.4	34.6	34.8	35.39	35.42		35.12	35.12	34.69	36.95		34.22

Table 4.3.3. North Sea Horse Mackerel stock. Mean weight at age (kg) in the catch by quarter and area in 2013.

1Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0						
1	0.062	0.062	0.062	0.062	0.062	0.062
2	0.080	0.080	0.080	0.080	0.080	0.080
3	0.098	0.098	0.098	0.098	0.098	0.098
4	0.118	0.118	0.118	0.118	0.118	0.118
5	0.157	0.157	0.157	0.157	0.157	0.157
6	0.171	0.171	0.171	0.171	0.171	0.171
7	0.189	0.189	0.189	0.189	0.189	0.189
8	0.209	0.209	0.209	0.209	0.209	0.209
9	0.218	0.218	0.218	0.218	0.218	0.218
10	0.225	0.225	0.225	0.225	0.225	0.225
11	0.241	0.241	0.241	0.241	0.241	0.241
12	0.285	0.285	0.285	0.285	0.285	0.285
13	0.262	0.262	0.262	0.262	0.262	0.262
14	0.559	0.559	0.559	0.559	0.559	0.559
15+	0.343	0.343	0.343	0.343	0.343	0.343
Mean	0.214	0.214	0.214	0.214	0.214	0.214
2Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0	0.019	0.019	0.019	0.019	0.060	0.019
1	0.074	0.074	0.074	0.068	0.068	0.069
2	0.091	0.091	0.091	0.096	0.096	0.096
3	0.127	0.127	0.127	0.100	0.100	0.100
4	0.189	0.189	0.189	0.119	0.119	0.119
5	0.205	0.205	0.205	0.157	0.157	0.157
6	0.210	0.210	0.210	0.170	0.170	0.170
7	0.229	0.229	0.229	0.189	0.189	0.189
8				0.209	0.209	0.209
9	0.210	0.210	0.210	0.218	0.218	0.218
10	0.229	0.229	0.229	0.225	0.225	0.225
11	0.267	0.267	0.267	0.241	0.241	0.241
12	0.274	0.274	0.274	0.285	0.285	0.284
13				0.262	0.262	0.262
14				0.559	0.559	0.559
15+				0.343	0.343	0.343
Mean	0.177	0.177	0.177	0.204	0.206	0.204

Table 4.3.3. North Sea Horse Mackerel stock. Mean weight at age (kg) in the catch by quarter and area in 2013. Cont.

3Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0			0.019	0.019		0.019
1			0.074	0.084	0.084	0.083
2			0.091	0.109	0.109	0.109
3			0.127	0.112	0.112	0.112
4			0.189	0.145	0.145	0.145
5			0.205	0.205		0.205
6			0.210	0.155	0.154	0.157
7			0.229	0.229		0.229
8						
9			0.210	0.210		0.210
10			0.229	0.229		0.229
11			0.267	0.267		0.267
12			0.274	0.274		0.274
13						
14						
15+						
Mean			0.177	0.170	0.121	0.170
4Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0			0.060	0.060	0.060	0.060
1			0.077	0.077	0.077	0.077
2			0.098	0.098	0.098	0.098
3			0.118	0.118	0.118	0.118
4			0.150	0.150	0.150	0.150
5			0.174	0.174	0.174	0.174
6			0.191	0.191	0.191	0.191
7			0.237	0.237	0.237	0.237
8			0.226	0.226	0.226	0.226
9			0.265	0.265	0.265	0.265
10			0.248	0.248	0.248	0.248
11			0.251	0.251	0.251	0.251
12			0.230	0.230	0.230	0.230
13						
14						
15+			0.300	0.300	0.300	0.300
Mean			0.187	0.187	0.187	0.187

Table 4.3.3. North Sea Horse Mackerel stock. Mean weight at age (kg) in the catch by quarter and area in 2013. Cont.

1–4Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0	0.019	0.019	0.049	0.058	0.060	0.060
1	0.073	0.074	0.076	0.079	0.077	0.077
2	0.086	0.091	0.096	0.106	0.099	0.099
3	0.099	0.119	0.108	0.108	0.112	0.112
4	0.121	0.165	0.132	0.130	0.139	0.138
5	0.162	0.196	0.163	0.159	0.166	0.166
6	0.180	0.208	0.179	0.168	0.180	0.180
7	0.191	0.218	0.195	0.191	0.201	0.200
8	0.209	0.209	0.213	0.210	0.217	0.216
9	0.218	0.213	0.220	0.219	0.223	0.223
10	0.225	0.229	0.225	0.225	0.226	0.226
11	0.243	0.262	0.242	0.241	0.242	0.242
12	0.281	0.274	0.273	0.281	0.262	0.263
13	0.262	0.262	0.262	0.262	0.262	0.262
14	0.559	0.559	0.559	0.559	0.559	0.559
15+	0.343	0.343	0.341	0.343	0.339	0.339
Mean	0.204	0.215	0.208	0.209	0.210	0.210

Table 4.3.4. North Sea Horse Mackerel stock. Mean length (cm) at age in the catch by quarter and area in 2013.

1Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0						
1	19.34	19.34	19.34	19.34	19.34	19.34
2	21.36	21.36	21.36	21.36	21.36	21.36
3	22.71	22.71	22.71	22.71	22.71	22.71
4	24.46	24.46	24.46	24.46	24.46	24.46
5	26.53	26.53	26.53	26.53	26.53	26.53
6	26.94	26.94	26.94	26.94	26.94	26.94
7	28.01	28.01	28.01	28.01	28.01	28.01
8	28.62	28.62	28.62	28.62	28.62	28.62
9	29.05	29.05	29.05	29.05	29.05	29.05
10	29.52	29.52	29.52	29.52	29.52	29.52
11	30.12	30.12	30.12	30.12	30.12	30.12
12	31.19	31.19	31.19	31.19	31.19	31.19
13	32.08	32.08	32.08	32.08	32.08	32.08
14	38.50	38.50	38.50	38.50	38.50	38.50
15+	34.50	34.50	34.50	34.50	34.50	34.50
Mean	28.20	28.20	28.20	28.20	28.20	28.20
2Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0	12.50	12.50	12.50	12.50	19.50	12.52
1	19.53	19.53	19.53	19.97	19.98	19.90
2	20.90	20.90	20.90	21.90	21.90	21.89
3	23.60	23.60	23.60	22.75	22.75	22.75
4	27.00	27.00	27.00	24.47	24.47	24.47
5	27.25	27.25	27.25	26.53	26.53	26.53
6	27.88	27.88	27.88	26.91	26.91	26.92
7	28.00	28.00	28.00	28.01	28.01	28.01
8				28.62	28.62	28.62
9	28.50	28.50	28.50	29.05	29.05	29.05
10	28.50	28.50	28.50	29.52	29.52	29.52
11	30.00	30.00	30.00	30.12	30.12	30.12
12	30.50	30.50	30.50	31.18	31.19	31.18
13				32.08	32.08	32.08
14				38.50	38.50	38.50
15+				34.50	34.50	34.50
Mean	25.35	25.35	25.35	27.29	27.73	27.29

Table 4.3.4. North Sea Horse Mackerel stock. Mean length (cm) at age in the catch by quarter and area in 2013. Cont.

3Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0			12.50	12.50		12.50
1			19.53	21.44	21.50	21.23
2			20.90	22.36	22.36	22.35
3			23.60	23.00	23.00	23.00
4			27.00	24.75	24.75	24.76
5			27.25	27.25		27.25
6			27.88	25.52	25.50	25.63
7			28.00	28.00		28.00
8						
9			28.50	28.50		28.50
10			28.50	28.50		28.50
11			30.00	30.00		30.00
12			30.50	30.50		30.50
13						
14						
15+						
Mean			25.35	25.19	23.42	25.19
4Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0			19.50	19.50	19.50	19.50
1			20.89	20.89	20.89	20.89
2			22.44	22.44	22.44	22.44
3			23.85	23.85	23.85	23.85
4			25.74	25.74	25.74	25.74
5			27.45	27.45	27.45	27.45
6			27.38	27.38	27.38	27.38
7			29.09	29.09	29.09	29.09
8			29.20	29.20	29.20	29.20
9			30.72	30.72	30.72	30.72
10			29.60	29.60	29.60	29.60
11			29.40	29.40	29.40	29.40
12			29.14	29.14	29.14	29.14
13						
14						
15+			31.50	31.50	31.50	31.50
Mean			26.85	26.85	26.85	26.85

Table 4.3.4. North Sea Horse Mackerel stock. Mean length (cm) at age in the catch by quarter and area in 2013. Cont.

1–4Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0	12.50	12.50	17.63	19.09	19.50	19.44
1	19.52	19.53	20.56	21.06	20.87	20.86
2	21.12	20.91	22.27	22.31	22.38	22.37
3	22.76	23.35	23.30	22.98	23.48	23.45
4	24.57	26.15	25.04	24.69	25.28	25.25
5	26.60	27.12	26.82	26.61	27.00	26.98
6	27.18	27.81	27.13	26.61	27.12	27.10
7	28.01	28.00	28.13	28.04	28.27	28.25
8	28.62	28.62	28.76	28.66	28.88	28.87
9	29.02	28.67	29.12	29.07	29.23	29.22
10	29.42	28.68	29.49	29.52	29.53	29.53
11	30.11	30.02	30.08	30.11	30.04	30.05
12	30.93	30.53	30.71	31.05	30.35	30.39
13	32.08	32.08	32.08	32.08	32.08	32.08
14	38.50	38.50	38.50	38.50	38.50	38.50
15+	34.50	34.50	34.37	34.47	34.20	34.22
Mean	27.22	27.31	27.75	27.80	27.92	27.91

Table 4.4.1. North Sea horse mackerel. Relative indices of abundance and biomass derived from the IBTS Q3 data (North Sea only, no VIId included). The DLN index is derived as the product of the CPUE in the positive (non-zero) hauls and the proportion of positive hauls. The GLM index uses a zero inflated negative binomial model to predict the trend in abundance of exploitable (≥20cm) horse mackerel in the North Sea. This GLM index of abundance is converted to an index of biomass using the observed length frequency in each year together with a length-weight relationship

	DLN Index (age 2+)			GLM Index (20cm+)					
.Year	CPUE (+ve hauls)	Prop. +ve hauls	Relative1 Abundance Index	Relative1 Abundance Index	Lower CI	Upper CI	Relative1 Biomass Index	Lower CI	Upper CI
1998	8.86	0.74	1.60	0.79	0.39	1.59	1.12	0.56	2.25
1999	7.15	0.68	1.19	1.67	0.78	3.55	2.04	0.96	4.34
2000	9.43	0.64	1.48	4.03	1.78	9.13	3.80	1.68	8.61
2001	9.26	0.60	1.36	0.69	0.32	1.51	0.69	0.31	1.50
2002	8.04	0.64	1.27	1.51	0.71	3.21	1.43	0.67	3.05
2003	6.92	0.67	1.13	1.19	0.55	2.54	1.06	0.50	2.27
2004	6.99	0.67	1.14	0.74	0.35	1.60	0.72	0.34	1.55
2005	7.64	0.54	1.01	1.11	0.49	2.54	0.97	0.43	2.21
2006	8.01	0.53	1.05	0.99	0.45	2.18	0.89	0.40	1.96
2007	6.42	0.51	0.80	0.18	0.08	0.41	0.19	0.08	0.44
2008	4.94	0.50	0.61	0.70	0.27	1.82	0.83	0.32	2.15
2009	5.96	0.50	0.72	0.45	0.19	1.08	0.47	0.20	1.11
2010	6.74	0.49	0.80	0.19	0.08	0.43	0.19	0.08	0.45
2011	6.35	0.39	0.61	0.44	0.19	1.05	0.46	0.19	1.09
2012	8.09	0.32	0.64	0.47	0.19	1.20	0.43	0.17	1.09
2013	8.38	0.28	0.58	0.84	0.31	2.28	0.71	0.26	1.93

[1]Relative to the mean of the whole time series.

Table 4.5.1 North Sea horse mackerel. JAXass statistical catch at age model inputs and settings.

Setting/Data	Values/source
Total Catch	Total Landings, 1992-2013. Discards considered negligible.
Catch at age	Landings at age, 1995-2013, ages 1- 10+
Tuning indices	IBTS Q3 (GLM year effect or delta lognormal index); 1998-2013; 20cm+
Weight at age	Weight at age samples from the catch, 1992-2013
Maturity at age	Constant over time, taken from most recent western stock (whm) values
Natural mortality	Constant over time, taken from either the western (whm) or southern (shm) stock
First Age	1
Plus group (last age)	10+
First tuning year	1992
Selectivity	Two parameter (α, β) logistic, constant over years

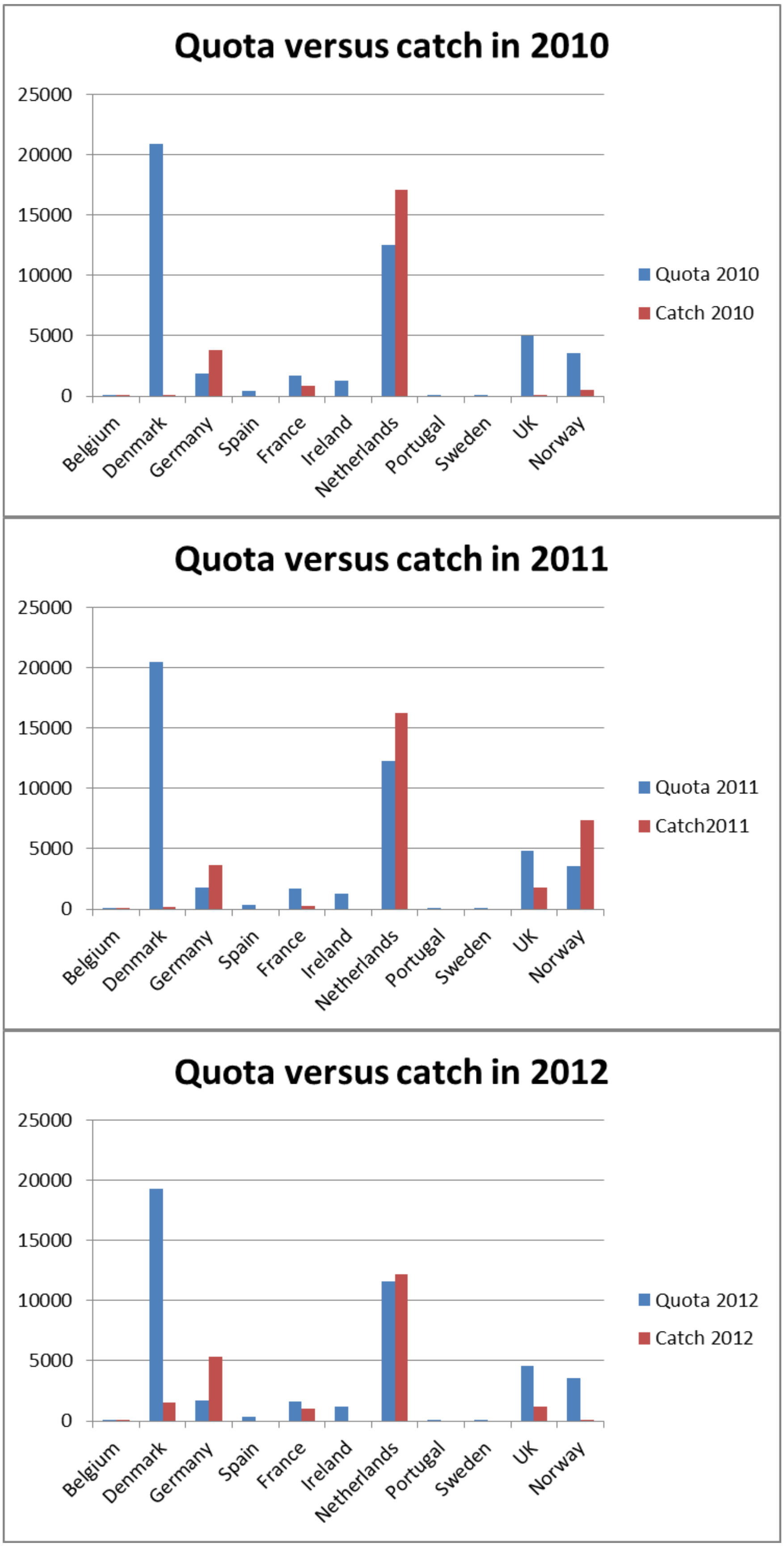


Figure 4.2.1. North Sea horse mackerel. Utilisation of quota by country. Total under-utilisation of EU quota equals 52%, 52% and 49% in 2011, 2012 and 2013 respectively.

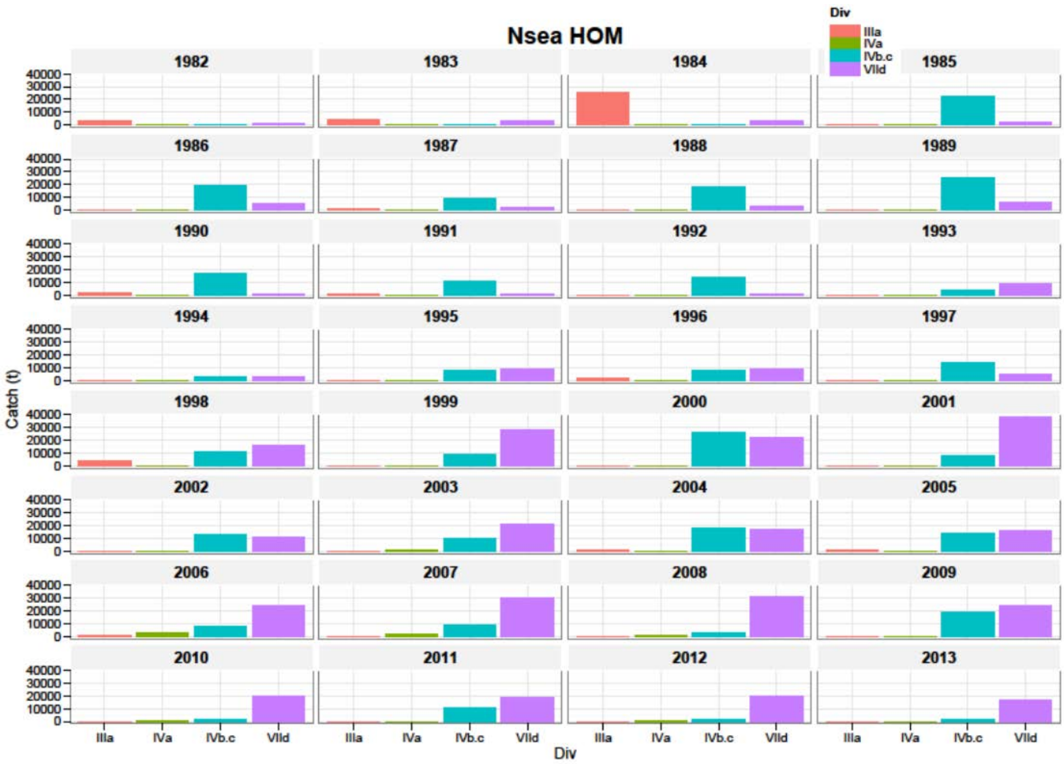


Figure 4.2.2 North Sea horse mackerel. Catch by ICES Division for 1982-2013.

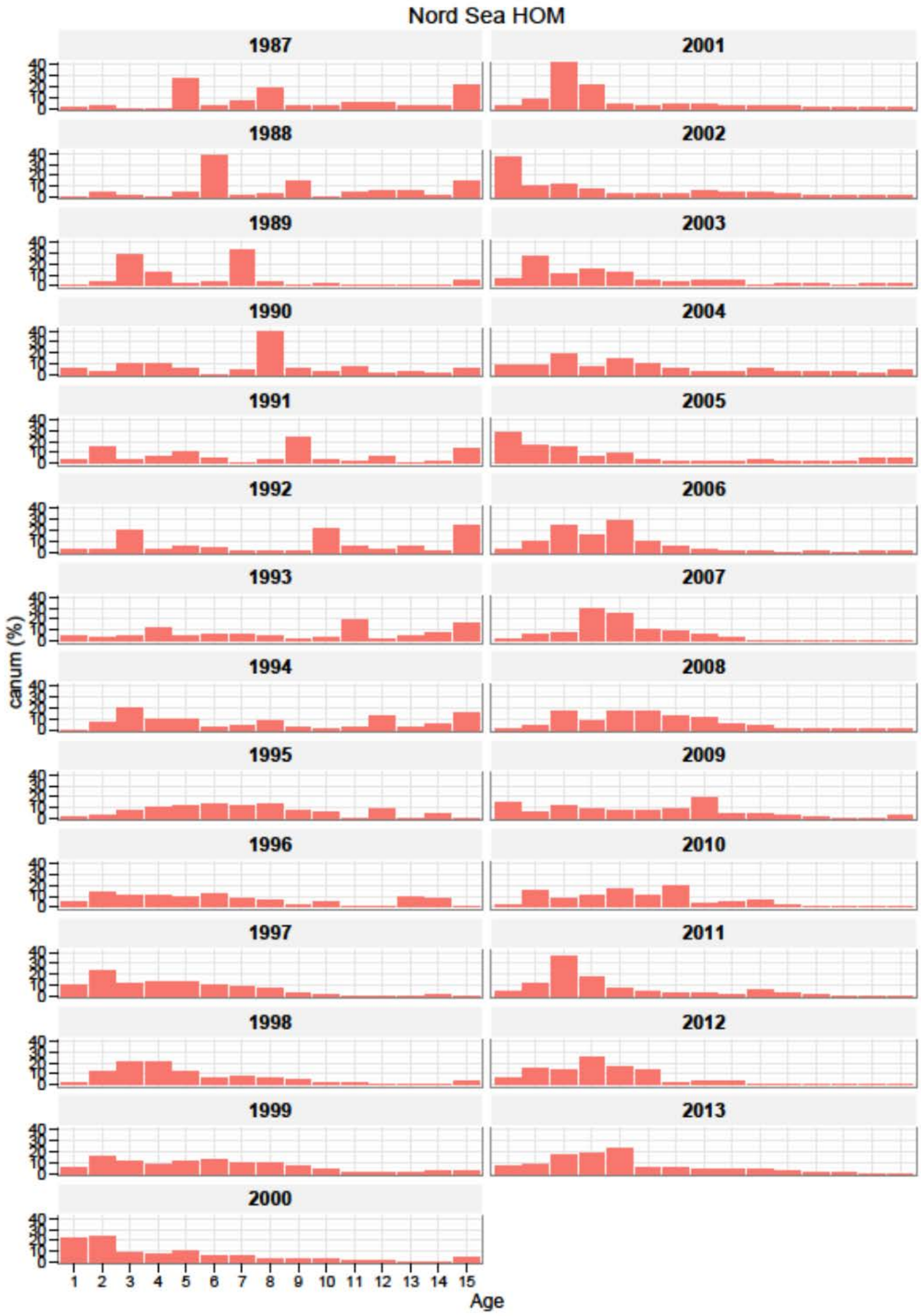


Figure 4.3.1 North Sea horse mackerel. Age distribution in the catch for 1987-2013.

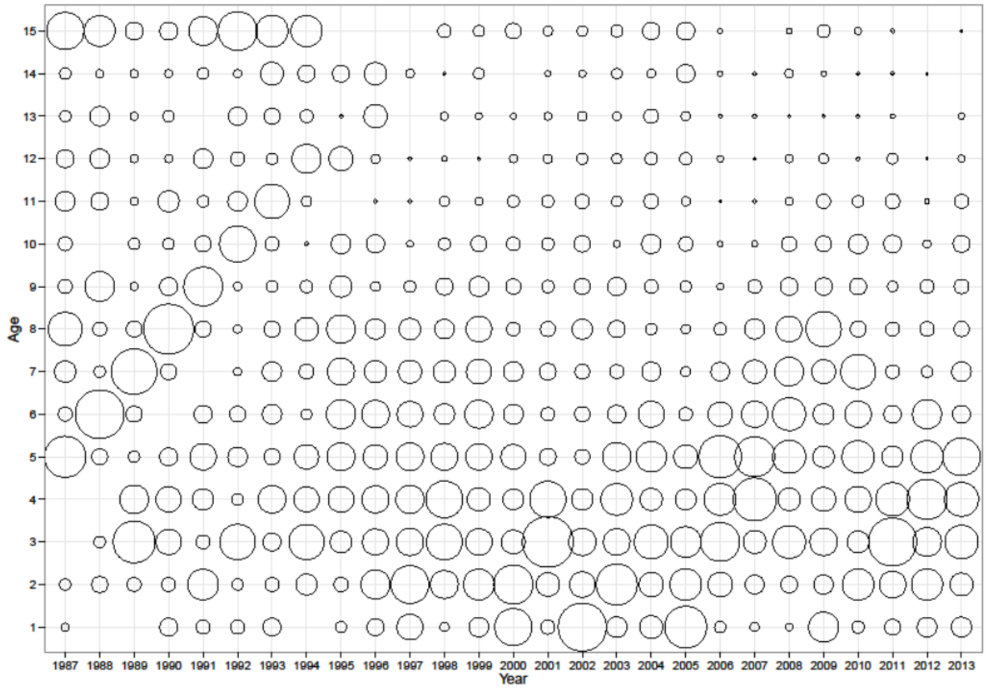


Figure 4.3.2. North Sea horse mackerel. Bubbleplot of age distribution in the catch in all areas for 1987-2013. The area of bubbles is proportional to the catch number. Note that age 15 is a plus group.

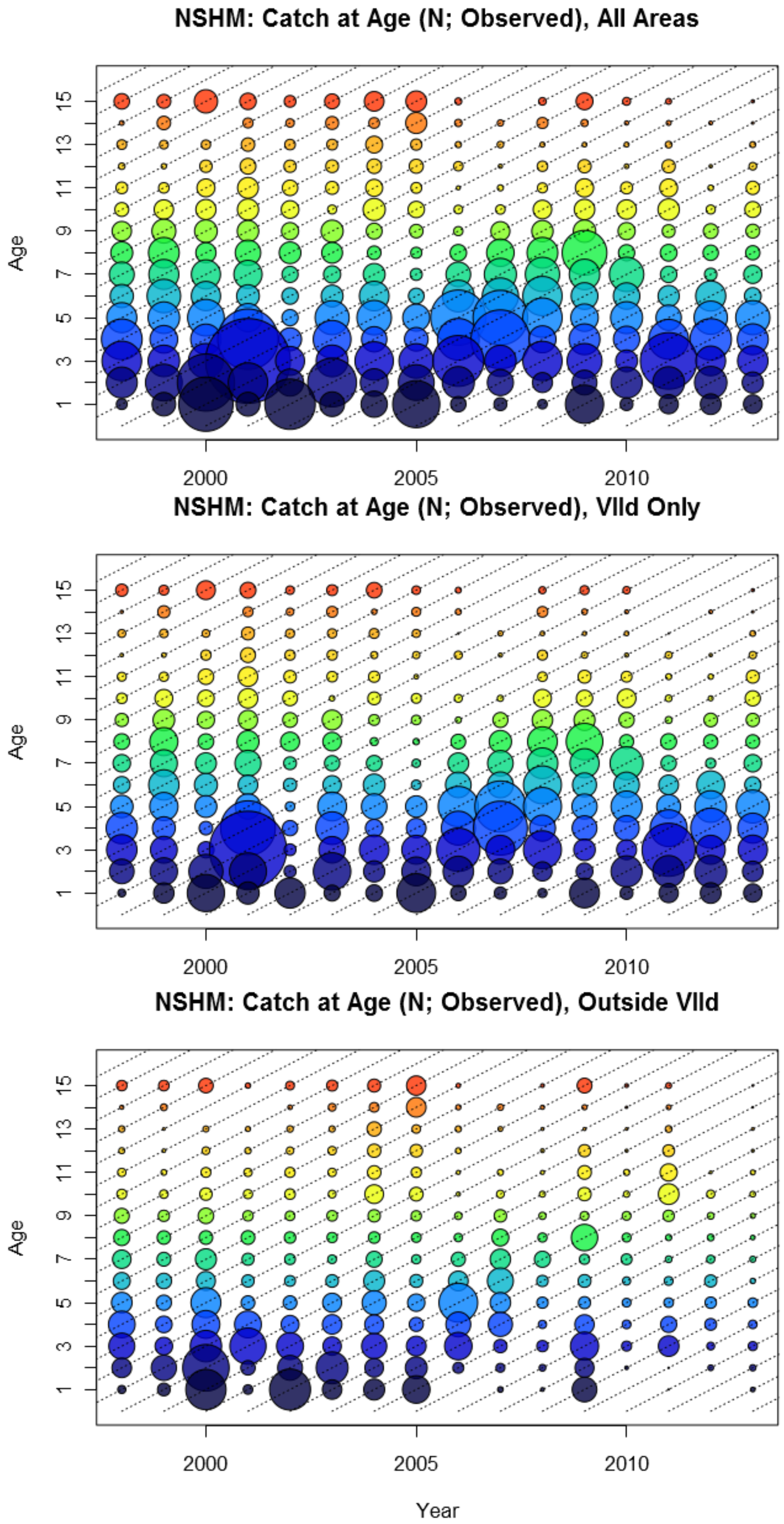


Figure 4.3.3. North Sea horse mackerel. Bubbleplots of age distribution in the catch by area for 1998-2013. The area of bubbles is proportional to the catch number. Note that age 15 is a plus group.

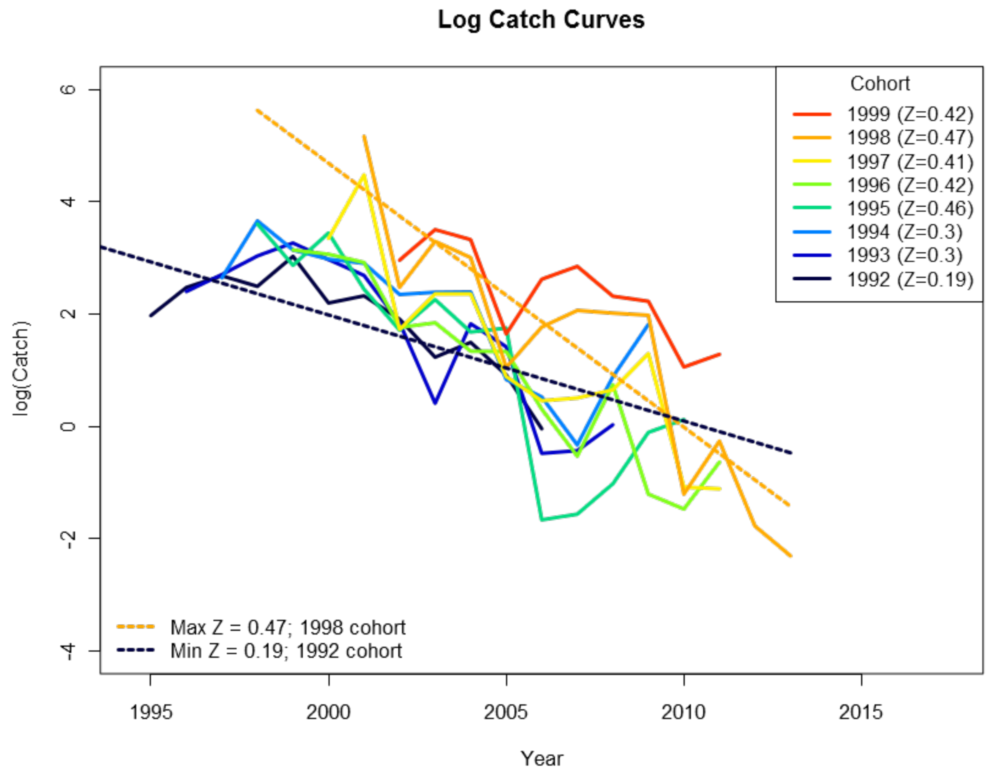


Figure 4.4.1. North Sea Horse Mackerel. Catch curves for the 1992 to 1999 cohorts, ages from 3 to 14. Values plotted are the log(catch) values for each cohort in each year. The negative slope of these curves estimates total mortality (Z) in the cohort.

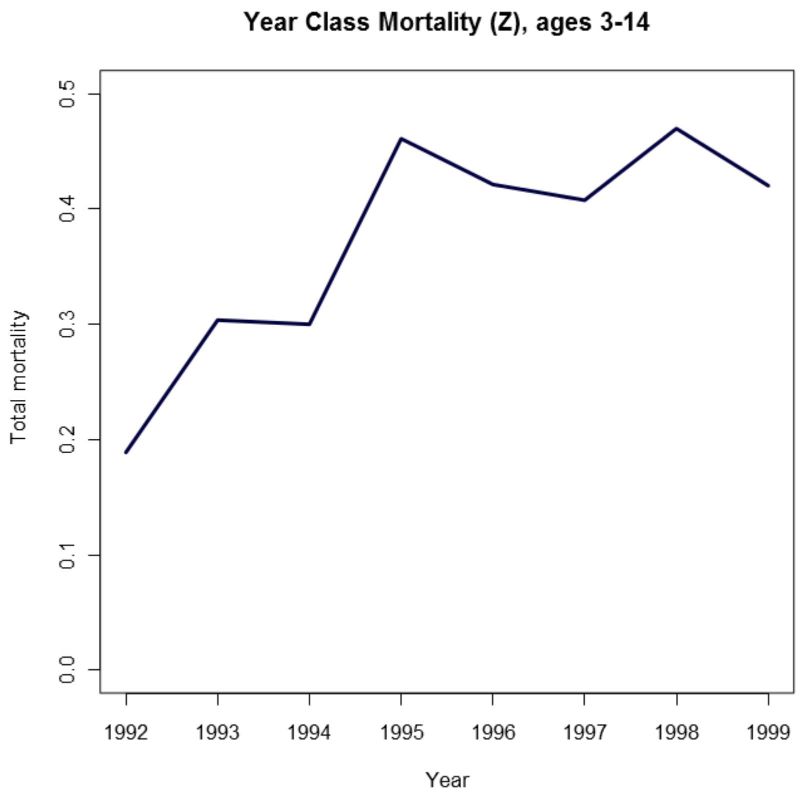


Figure 4.4.2. North Sea Horse Mackerel. Cohort total mortality (Z), negative gradients of the 1992–1999 cohort catch curves.

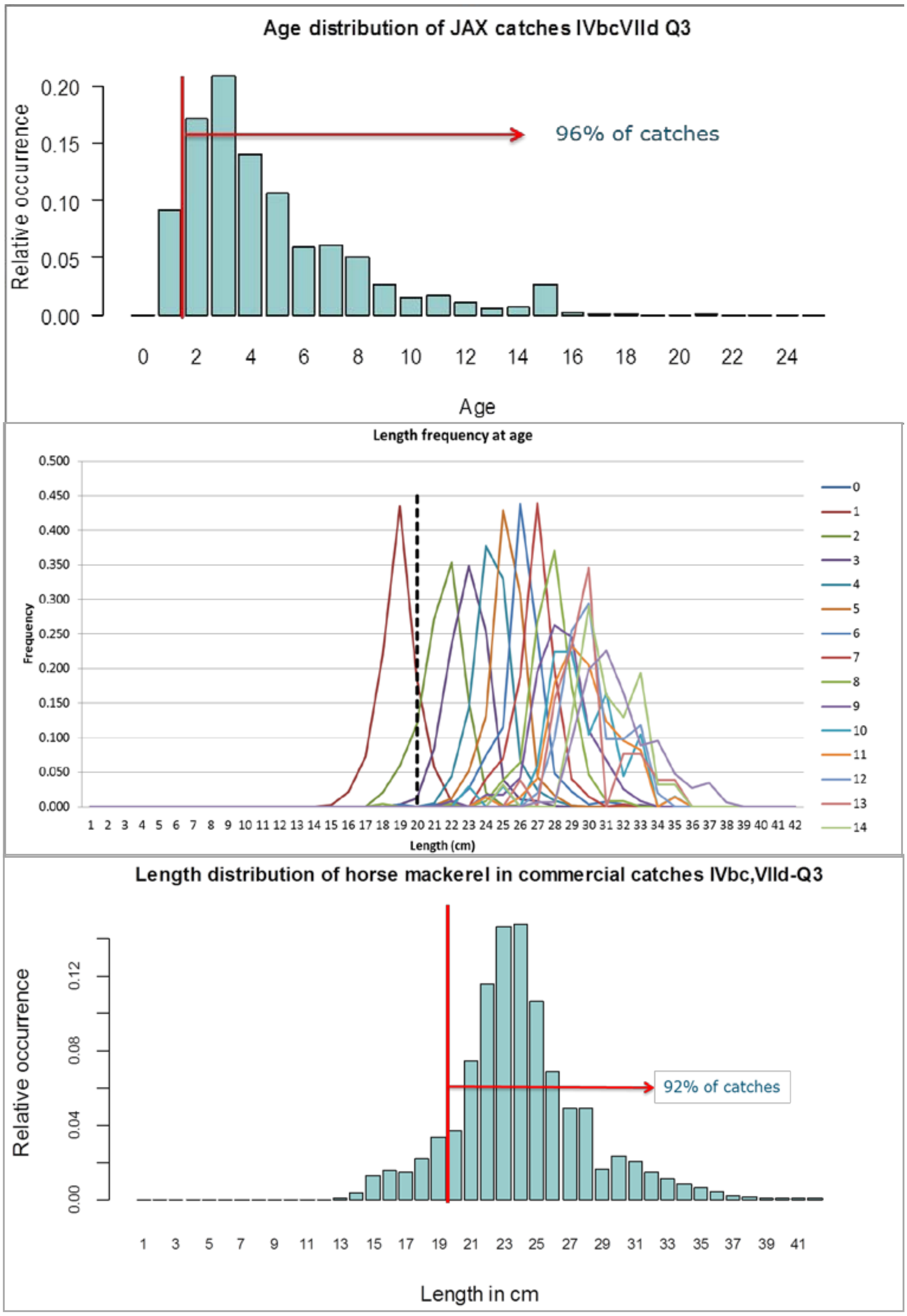


Figure 4.4.3. North Sea horse mackerel. Age distribution of commercial catches in the 3rd quarter (top), length distribution at age in the third quarter (middle) and length distribution of commercial catches in the 3rd quarter (bottom). Data are aggregated from all years up to and including 2012.

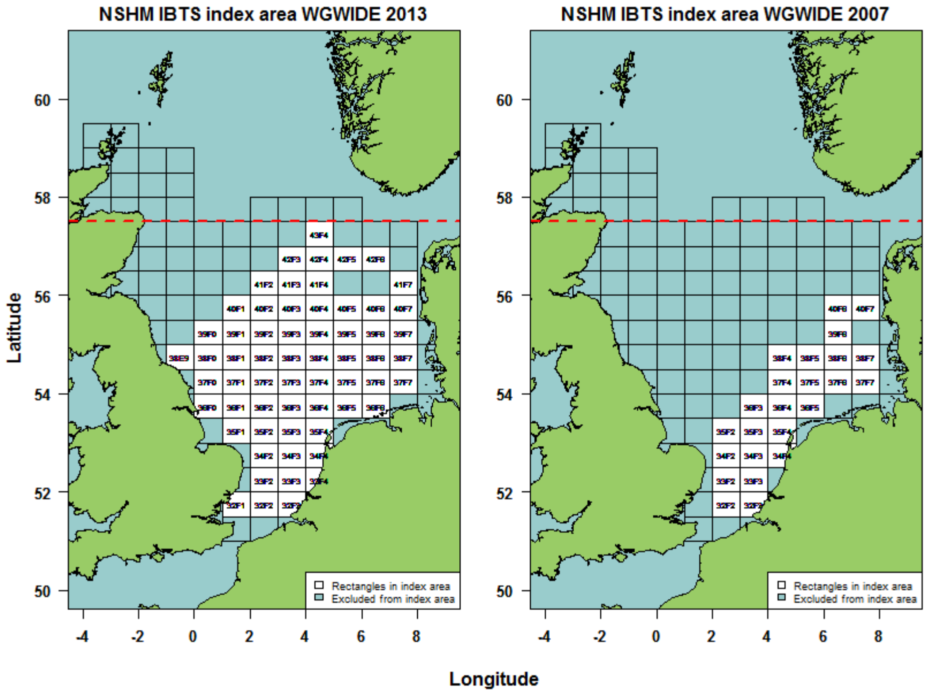
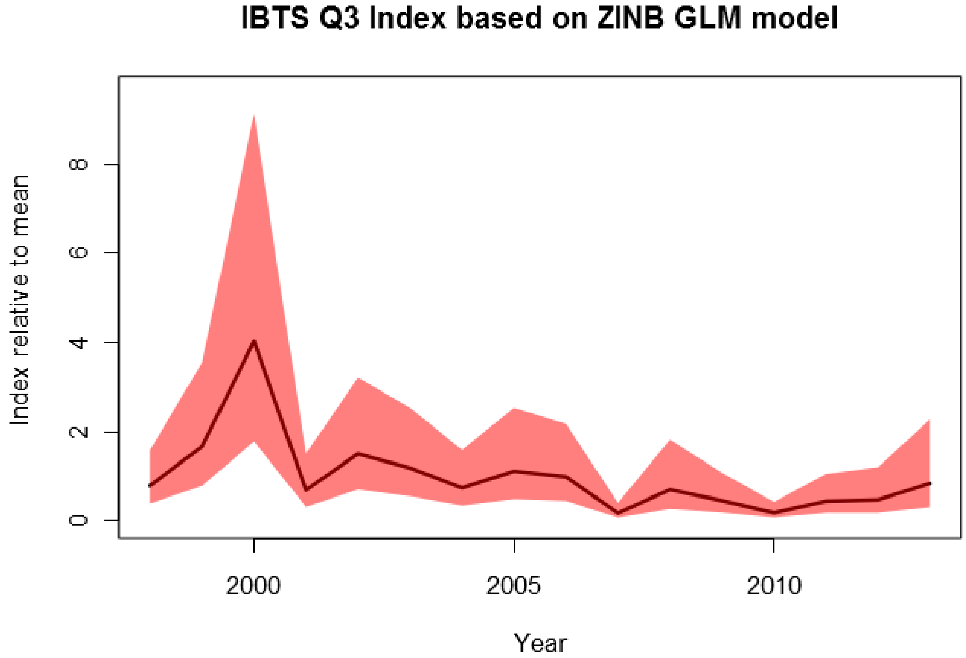


Figure 4.4.4 North Sea horse mackerel. ICES rectangles selected in 2013 and currently used by the working group (left) compared to selection for explorations in previous years (right).



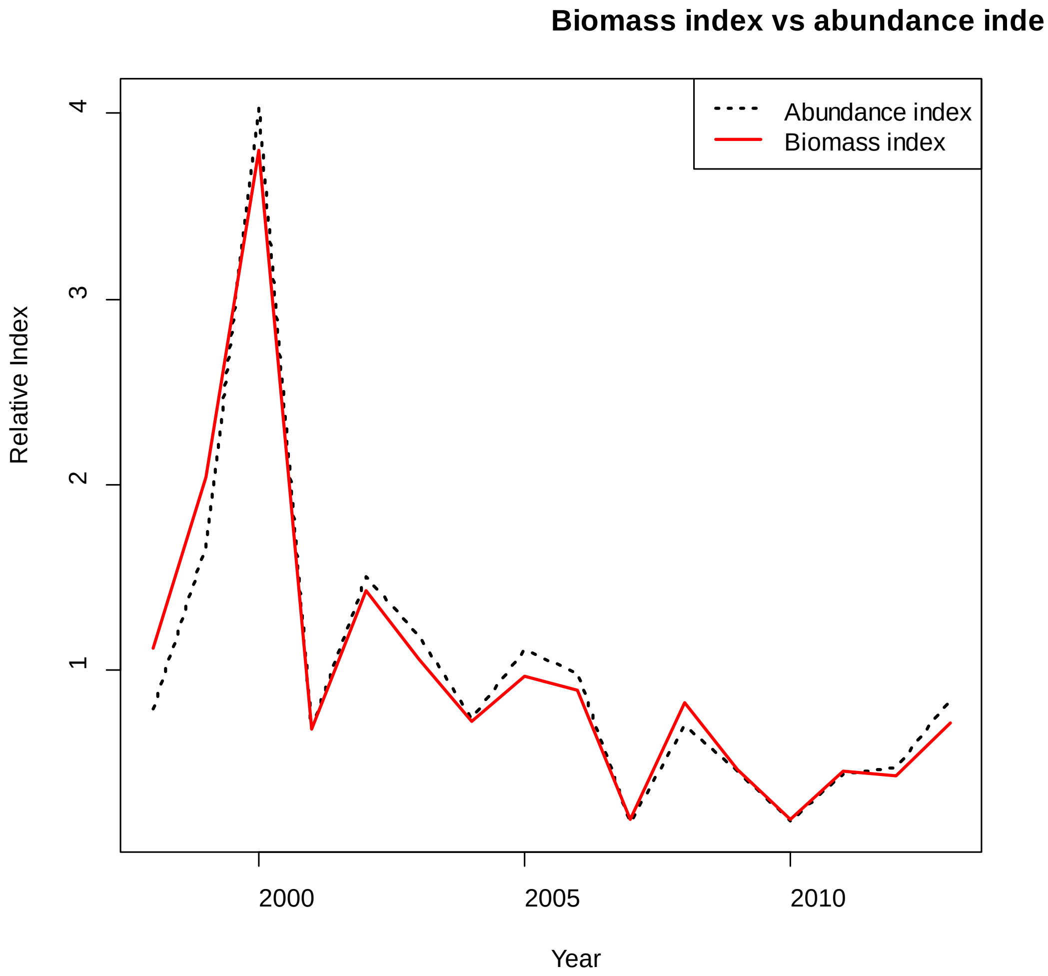


Figure 4.4.5. North Sea horse mackerel. GLM abundance indices. Top: Abundance index, the shaded area indicates the 95% confidence intervals for the estimated index values. Bottom: The abundance and biomass indices compared.

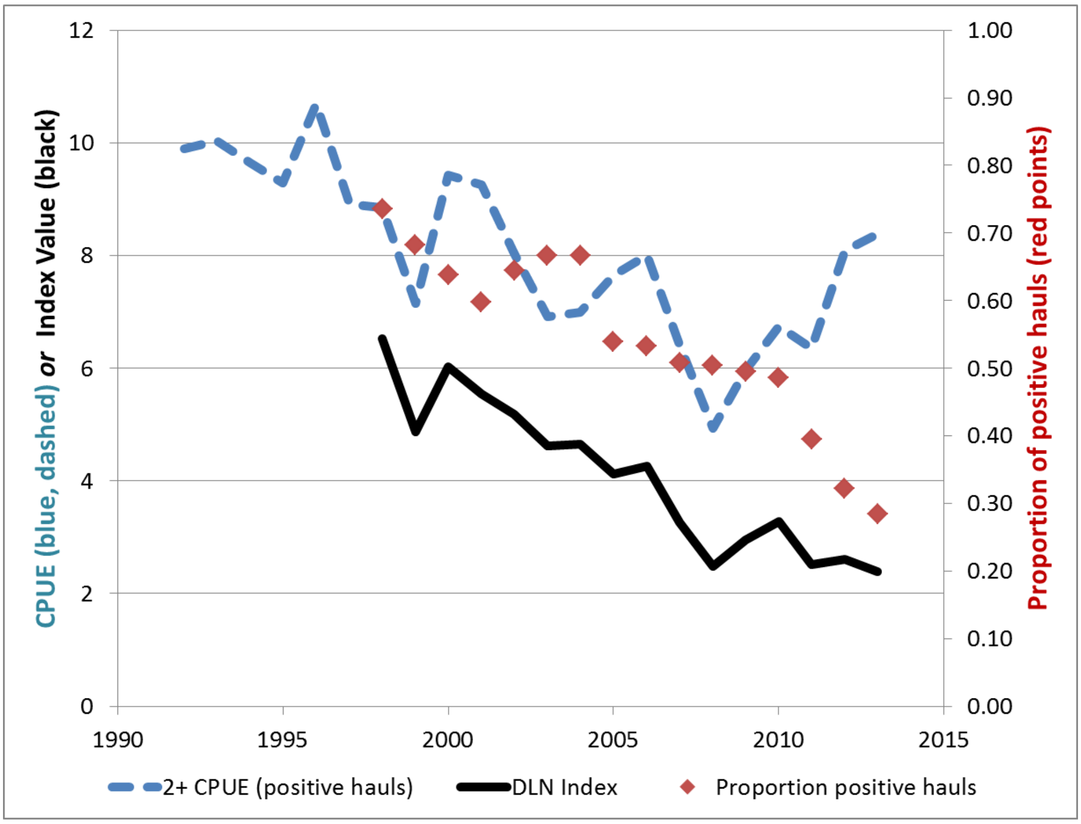


Figure 4.4.6. North Sea horse mackerel. The DLN index (black, solid) and its components: the proportion of positive (non-zero) hauls (red diamonds) and the cpue in the positive hauls (blue, dashed).

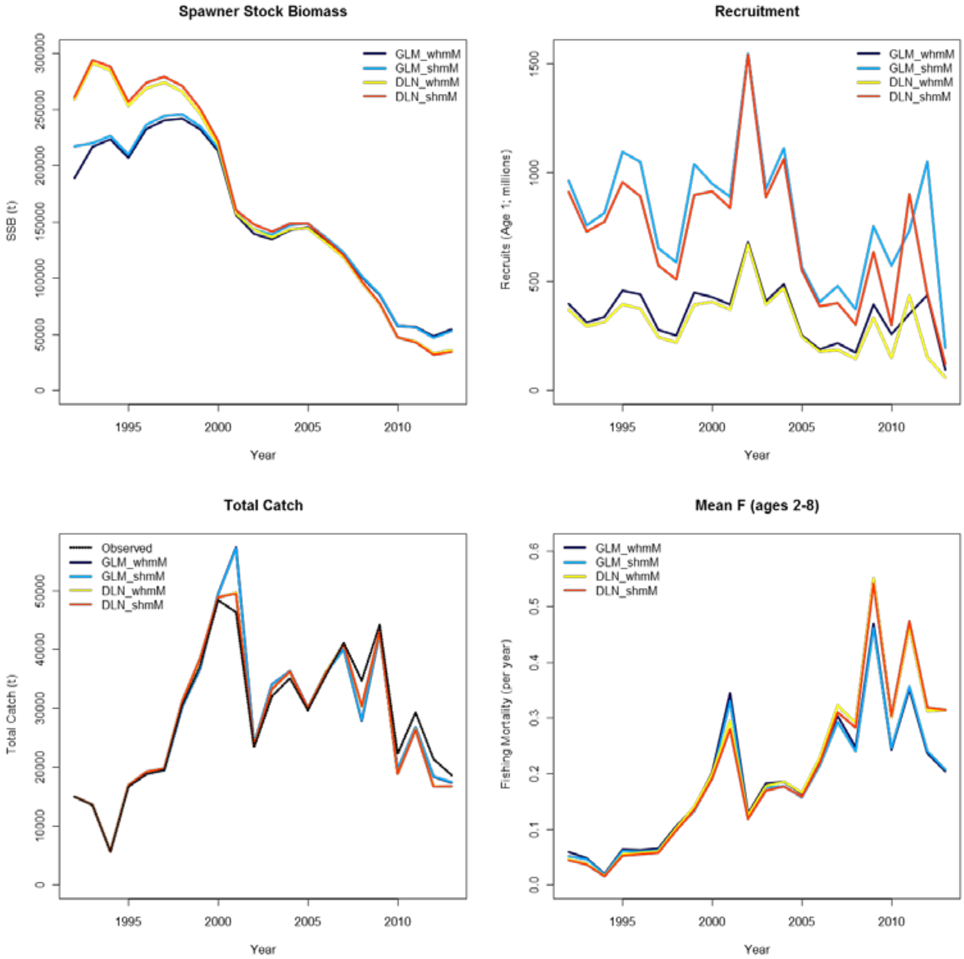


Figure 4.5.1. North Sea horse mackerel. Results of exploratory model fits using the JAXass assessment model. Spawner stock biomass (SSB, top left), Recruitment (top right), total catch (bottom left) and mean fishing mortality (ages 2-8, bottom right) for the four combinations of data used in the assessment model.

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

5.1 ICES advice applicable to 2013 and 2014

Since 2011, the TACs cover areas in line with the distribution areas of the stocks.

For 2013 the TAC set in EU waters (EC 39/2013) was the following:

Areas in EU waters	TAC 2013	Stocks fished in this area
IIa, IVa, Vb, Subareas VI,VIIa-c, VIIe-k, VIIIabde, Vb, XII, XIV	157,989 t	Western stock & North Sea stock in IVa 1-2 quarters
IVb,c, VIId	37,950 t	North Sea stocks
Division VIIIc	25,011 t	Western stock

For 2014 the TAC set in EU waters (EC 43/2014) was the following:

Areas in EU waters	TAC 2014	Stocks fished in this area
IIa, IVa, Vb, Subareas VI,VIIa-c, VIIe-k, VIIIabde, Vb, XII, XIV	114,712 t	Western stock & North Sea stock in IVa 1-2 quarters
IVb,c, VIId	27,815 t	North Sea stocks
Division VIIIc	18,508 t	Western stock

The TAC for the western stock should apply to the distribution area of western horse mackerel as follows:

All Quarters: IIa, Vb, VIa, VIIa-c, VIIe-k, VIIIa-e

Quarters 3&4: IIIa (west), IVa

The TAC for the North Sea stock should apply to the distribution area of North Sea horse mackerel as follows:

All Quarters: IIIa (east), IVb-c, VIId

Quarters 1&2: IIIa (west), IVa

In 2013 ICES adviced on the basis of MSY approach that Western horse mackerel landings in 2014 should be no more than 110546 tonnes. The Western horse mackerel TAC for 2014 is 135420 tonnes, the TAC for EU waters only is 133220. The TAC should apply to the total distribution area of this stock. The EU horse mackerel catches in Division IIIa are taken outside the horse mackerel TACs.

5.1.1 The fishery in 2013

Information on the development of the fisheries by quarter and division is shown in Table 3.1.1 and 3.1.2 and in Figures 3.1.1.a–d. The total catch allocated to western horse mackerel in 2013 was 160686 t which is 12456 t less than in 2012 and 34686 t more than advised by ICES. The catches of horse mackerel by country and area are shown in Tables 5.1.1.1-5.

5.1.2 Estimates of discards

In 2013 discards data were presented by Spain, Germany, Netherlands and Ireland (who provided limited information).

Therefore, the amount of discards given in Table 3.3.1 are not representative of the total fishery. Based on the limited data available it is impossible to estimate the amount of discard in the horse mackerel fisheries (see section 1.3.3). No discard data for 2013 were used in the assessment.

5.1.3 Stock description and management units

The western horse mackerel stock spawns in the Bay of Biscay, and in UK and Irish waters. After spawning, parts of the stock migrate northwards into the Norwegian Sea and the North Sea, where they are fished in the third and fourth quarter. The stock is distributed in Divisions IIa, Vb, IIIa, IVa, VIa, VIIa-c, VIIe-k and VIIIa-e. The stock is caught in these areas following the yearly distribution described in Section 3.3 (Figure 5.1.3.1). The western stock is considered a management unit and advised accordingly. At present there are no international agreed management measures. EU regulates the fishery by TAC. This TAC is now set in accordance with the distribution of the stock although catches in IIIa are taken outside the TAC.

5.2 Scientific data

5.2.1 Egg survey estimates

In 2013 a new egg survey was carried out in the western and southern spawning areas and a working document with preliminary results of the survey was distributed to WGWIDE members (Burns *et al.* 2013). Results were revised slightly by WGMEGS in early 2014.

The mean daily stage I egg production estimates (DEP) for each survey period plotted against the mid-period days is shown in figure 5.2.1. The results from previous surveys are also included in the figure for comparison. Period number and duration are the same as those used to estimate the western mackerel stock, as are the dates defining the start and end of spawning. The shape of the egg production curve suggests that some spawning may have continued after the survey ended. The daily egg production curve revealed a provisional estimate of total annual egg production of 3.97×10^{14}. This is a decrease of almost 64% on that observed in 2010 (1.09×10^{15}) and is one of the lowest estimates of annual egg production ever recorded for this species. The time series of egg production estimates is shown in Table 5.2.1.1.

5.2.2 Other surveys for western horse mackerel

Bottom trawl surveys

No new information was presented on bottom trawl surveys. These surveys could be considered in future to provide indices of recruitment or abundance for western horse mackerel. Further information can be found in the stock annex, and in ICES (2008/ACOM:13) and ICES (2009/RMC:04).

Acoustic surveys

Information was presented on VIIIc acoustic survey from Spain. Further information can be found in the stock annex and in ICES (2008/ACOM:13) and ICES (2006/LRC:18).

5.2.3 Effort and catch per unit effort

No new information was presented on effort and catch per unit effort. Further information can be found in the stock annex.

5.2.4 Catch in numbers

In 2013, the Netherlands (IVa,VIa,VIIb,c,e,h-k, VIIIb), Norway (IVa), Ireland (VIa and VIIb,), Germany (IV, VIa VIIb,c, e, h, j), Spain (VIIIb,c) and UK(England) (IVa, VIa, VIIb,e,h) provided catch in numbers at age. The catch sampled for age readings in 2013 covered 71%, 2012 covered 71% and 62% in 2011.

The total annual and quarterly catches in numbers for western horse mackerel in 2013 are shown in Table 5.2.4.1. The sampling intensity is discussed in Section 1.3.

The catch at age matrix, as used in the assessment, is given in Table 5.2.4.2, and illustrated in Figure 5.2.4.1. It shows the dominance of the 1982 year class in the catches since 1984 until it entered the plus group in 1996. Since 2002 the 2001 year class of horse mackerel which has now entered the plus group in 2012, has been caught in considerable numbers. The 2008 year class can be followed in the catch data suggesting it was stronger than other year classes subsequent to the 2001.

5.2.5 Mean length at age and mean weight at age

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

The mean weight and mean length at age in the catches by area, and by quarter in 2013 are shown in Tables 5.2.5.1 and 5.2.5.2. Weight at age time-series is shown in Figure 5.2.5.1.

Mean weight at age in the stock

Mean weights-at-age in the stock, as used in the assessment, are presented in Table 5.2.5.3. Weights for age two in 2012 and 2013 were assigned as 0.085kg, according to the stock annex as there were no weight samples available for this age group. Weight samples for age 3 were available only for area VIIj period 1, where the mean weight of 0.160 kg is much larger than seen before in the time series. Weight for age three in 2013 was therefore taken as the mean of 1995—2012. Weight at age time-series is shown in Figure 5.2.5.2. Further information can be found in the stock annex.

5.2.6 Maturity ogive

Maturity-at-age, as used in the assessment, is presented in Table 5.2.6.1. Further information can be found in the stock annex.

5.2.7 Natural mortality

A fixed natural mortality of 0.15.year^{-1} is assumed for all ages and years in the assessment. Further information can be found in the stock annex.

5.2.8 Fecundity data

The potential fecundity data used in the assessment is listed in Table 5.2.8.1. The basis for specifying the realised fecundity 'prior', as used in the assessment (mean=1847 eggs per gram spawning female, CV=0.287), is given in the stock annex.

5.2.9 Data exploration

Within-cohort consistency of the catch-at-age matrix is investigated in Figure 5.2.9.1, which shows that the catch-at-age data contains information on year class strength that could form the basis for an age-structured model.

Log-catch curves are shown in Figure 5.2.9.2, along with the negative of the gradients fitted to ages 1—3 (bottom left plot), and ages 4—8 (bottom right plot). The general pattern of log-catches is increasing log-catch with age for the earlier years, indicating cohorts were not fully selected until they reached an advanced age, and the more usual decreasing log-catch for a wider range of ages in the most recent years (compared to earlier years), indicating selection has shifted towards younger fish over time. A requirement for interpreting the negative gradient as a proxy for total mortality is that catchability and selectivity-at-age remains stable within a cohort, so that any changes in the catch of a cohort are explained by changes in total mortality. The prevalence of negative values for the proxy (bottom plots of Figure 5.2.9.2) indicates that this requirement has not always been met for western horse mackerel catch data, and also indicates that a separable model with constant selectivity-at-age for the earliest data would not be appropriate.

5.2.10 Assessment model, diagnostics

The SAD (linked Separable-ADAPT VPA) model is used for the assessment of western horse mackerel. A description of the model can be found in the stock annex. The western horse mackerel assessment is presented as an update assessment and was conducted with a 6-year separable window as in recent assessments.

Fits to the available data are given in Figure 5.2.10.1, and model estimates with associated precision in Figures 5.2.10.2—3. Model estimates and residual patterns are similar to those presented in 2012 and 2013 (ICES 2012/ACOM:15 & ICES2013/ACOM:15). A deterioration of the model fit to the early data is apparent and could be related to the model assumption of constant fecundity. The model estimate of egg production is higher than the survey estimate; this is consistent with the observation that spawning may have continued beyond the survey period. A comparison with the 2013 assessment is discussed in Section 5.6.

Retrospective plots are shown for two cases. In the first case, 3-year retrospective plots were constructed for SSB, recruitment and F trajectories, and for selectivity-at-age, where the length of the separable window is fixed at six years (Figure 5.2.10.4.) Information on the distribution of the Dutch fleet presented to WGHMMP 2014 suggested that constant selection should not be assumed beyond 2006 therefore, only a three-year retrospective assessment is presented. The exclusion of the egg production data as the retrospective analysis is carried out has an effect back in the time-series estimates (not only for this set of retrospective plots, but for the one discussed below).

For the second case, 3-year retrospective plots were constructed as before, but this time the starting year of the separable window (2008) was kept constant, thus resulting in the separable window reducing in length as years were dropped. The reduced length of the separable window only allowed 3 years for the analysis, because a window any shorter than 3 years in length results in a large deterioration in the precision of model estimates. Results for the second set of retrospective plots are shown in Figure 5.2.10.5. The selectivity-at-age retrospective in Figure 5.2.10.5d suggests larger instability of selection as the separable window is shortened, causing greater uncertainty and deterioration in the precision of the model estimates, particularly in the younger age groups.

5.3 State of the Stock

5.3.1 Stock assessment

The SAD model with a separable window of 2008—2013 is presented as the final assessment model. Stock numbers-at-age and fishing mortality-at-age are given in Tables 5.3.1.1 and 5.3.1.2, and a stock-summary is provided in Table 5.3.1.3, and illustrated in Figure 5.3.1.1. SSB peaked in 1988 following the very strong 1982 year class. Subsequently SSB peaked following the moderate year classes in the early- to mid-90s and the moderate-to-strong year class of 2001 (a third of the size of the 1982 year class). Year classes following 2001 have been weak, 2010 recruitment in particular is the lowest in the time-series. 2008 year class is estimated as higher than the recent average. Fishing mortality has been increasing since 2007 as a result of increasing catches and decreasing biomass as the 2001 year-class was reduced. SSB in 2013 is estimated as the third lowest in the time-series.

5.4 Short-term forecast

A deterministic short-term forecast was conducted with the ICES standard software MFDP (Multi Fleet Deterministic Projection) version 1a.

Input

Table 5.4.1 lists the input data for the short term predictions. Weight at age in the stock and weight at age in the catch are the average of the 2011 to 2013. Selection (exploitation pattern) is based on F in 2013 from the most recent assessment and is the average of ages 1 to 10, which assumes a fixed selection in the period 2008—2013. Natural mortality is assumed to be 0.15 across all ages. The proportion mature for this stock has been constant since 1998 and values are copied from the assessment input.

As with last year the expected landings for the intermediate year were set to the level that corresponds to the 2014 TAC in EU waters, 133220t which is considered an appropriate estimate for the forecast.

Output

Detailed age disaggregated tables for an F status quo projection ($F = F_{2013}$) are shown in Table 5.4.2 and a range of predicted catch and SSB options from the short term forecast are presented in Table 5.4.3. The % TAC change in Table 5.4.3 corresponds to the total Western horse mackerel TAC of 135,420 t.

The management plan proposed by the Pelagic RAC in 2007 was recently evaluated (ICES 2013/ACOM:59) and, ICES considered that the HCR and reference points were not consistent with the precautionary approach.

5.5 Uncertainties in the assessment and forecast

Fishery-independent data for this stock is extremely limited, with only a single data point for egg production every three years. In addition, the assessment contains a fecundity model which links the egg production to SSB that could be improved if further evidence was obtained on the spawning biology of this stock which at present is considered an indeterminate spawner.

The reliability of this assessment depends on the reliability of the input data, and the extent to which model assumptions are violated. For example, simulation testing has shown that if there is an increasing trend in the realised fecundity parameter that is not accounted for, then the model over-estimates SSB and recruitment, and underestimates fishing mortality and realised fecundity (ICES 2008/ACOM:13).

The model relies on a 'prior' distribution for realised fecundity (based on published values), which is used for scaling, and the inclusion of any additional information on realised fecundity would help to improve the reliability of the assessment. Estimates of F are considerably lower than the assumed value for natural mortality (M=0.15). Reviewers have commented that the assumed value for M should be investigated. However, there is no data available (such as tagging) that could assist in estimating M more accurately. Nevertheless, total mortality appears to be low, given the persistence of the 1982 year class in the catch data.

Decisions on the length of the separable window need to balance the precision of model estimates (windows that are too short result in less precise model estimates) with considerations of whether the separability assumption continues to hold (by considering information from the fishery and patterns in the log-catch residual plots).

Although some estimates on the uncertainty of the egg input data are available, they are not currently available in a form that can be included in the assessment model. This is one area that might need addressing in the future if a systematic estimation of likely error in the model is to be evaluated. The inclusion of independent estimates of the uncertainty of the egg production would improve the reliability of the assessment.

The precision of recruitment estimates for the most recent years is poor, with CVs of 29—56% for the most recent 5 years. This result is expected given the negligible input the first three age classes make to SSB and the limited catch data for recruits. This uncertainty increases as the assessment is updated without additional egg production survey data. The estimate for the 2001 year class at age 0 is the largest since 1982, with a CV of 21%.

The assessment could be improved by the inclusion of information such as survey tuning indices on the numbers at age in the stock. However, obtaining a reliable tuning series is likely to be hampered by the large geographic area in which the stock occurs and the strong migration patterns. It does not seem that changes to the modelling methodology alone will fundamentally solve this problem.

5.6 Comparison with previous assessment and forecast

A comparison of the update assessment with the 2013 assessment is shown in Figure 5.6.1. SSB, recruitment and F trajectories show a similar pattern. The large decrease in selectivity for younger age groups, particularly for the 1 and 2 year olds (see Figure 5.6.1), is largely due to the lack of information on these age groups which causes instability in the estimated selection pattern.

5.7 Management Options

5.7.1 MSY approach

In 2013 deterministic and stochastic equilibrium analyses were carried out using the 'plotMSY' software (WKFRAME 2010) to re-evaluate the Fmsy value estimated in 2010 for the western horse mackerel stock. With the inclusion of the most recent data the results, similar to those provided in 2010, suggest that the F_{msy} proxy of 0.13 remains valid. See WGWIDE 2011 for details, or refer to the stock annex.

5.7.2 Management plans and evaluations

In 2007 the Pelagic RAC, in collaboration with a group of scientists, developed and proposed a management plan for the Western Horse Mackerel stock. The plan sets a multiannual TAC using a harvest rule that comprises a fixed TAC component and one that varies with the trend in egg production as recorded during the previous 3 egg surveys. The TAC was set according to the following rule:

$$TAC_{y+1\text{ to }y+3} = 1.07\left[\frac{TAC_{ref}}{2} + \frac{TAC_{y-2\text{ to }y}sl}{2}\right]$$

where y is the year an egg survey becomes available, TAC_{ref} = 150kt and sl is a function of the slope of the most recent three egg abundance estimates from surveys such that

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

A request from EU was posed to ICES at the end of 2012 to:

1) Fully evaluate the plan, and ascertain whether it is precautionary in the long term as well as in the short term.

2) Should the plan be found not to be precautionary in the long term, ICES is requested to identify reinforcements in the harvesting rules that would resolve the plan's shortcomings in that respect.

3) ICES is furthermore requested to identify what TAC should apply in 2013 in accordance with a revised harvesting rule under point 2 above.

Upon evaluation in 2013, ICES considered the plan not to be precautionary. However, the request was not fully addressed therefore, in December 2013 EU reiterated the need that ICES fully addressed the initial request (above). ICES convened a group Chaired by Ciaran Kelly (Ireland) and participants from the Marine Institute (Ireland), Cefas (UK England) and IMARES (the Netherlands) in response. Deadline to complete the work is October 2014.

Considerable progress has been made so far. A brief outline of developments follows.

Simulations were developed on two platforms:

Full feedback (FLR , ADMB)

FPRESS Stochastic simulation (R)

Conditioning was derived from the 2013 assessment (WGWIDE 2013) including updated catch information and the finalised 2013 egg survey result. The variance-covariance matrix from the assessment was used to generate 1000 populations, each with their own set of parameters.

Considerable attention was paid to the modelling of the stock and recruitment relationship. The plotMSY software (ICES-WGMG 2013) was used to derive the relative weights given to three stock recruit forms (49% to Beverton-Holt, 28% to Ricker and 23% to Hockeystick), which were then fitted in these proportions to "historic" stock-recruit pairs from 1000 populations; in this way, the stock-recruit parameters (which included recruitment variability and serial correlation) were entirely consistent with the associated population. In this process, the 1982 and 2001 year-classes were considered outliers (to be treated separately when modelling recruitment spikes) and not included in the stock-recruit fits.

In a second step, a spike year was modelled using a boxcar distribution (Skagen 2012) with a mean interval between spikes of 19 years (perios between the historic two high recruitment events). In the event of a spike there is a 50/50 chance of a 1982 or 2001 residual draw. The appropriate residual is added to the stock recruitment form for the current population (model iteration).

Initial simulations were carried out according to the following specifications:

- Long term (200 years), statistics from final 50 years
- Range of fishing mortalities from 0 to 0.2, no HCR
- Excluding/ including spikes
- Including serial correlation
- 100 iterations for full feedback model, 1000 for FPRESS model

Results from both platforms were fully comparable. Predicted yields, SSB and associated risks from population projections are presented in Figure 5.7.2.1 for illustration. The curves correspond to median and confidence intervals of mean values computed over the final 50 years in 200 years population projections. The plots are based on 100 iterations.

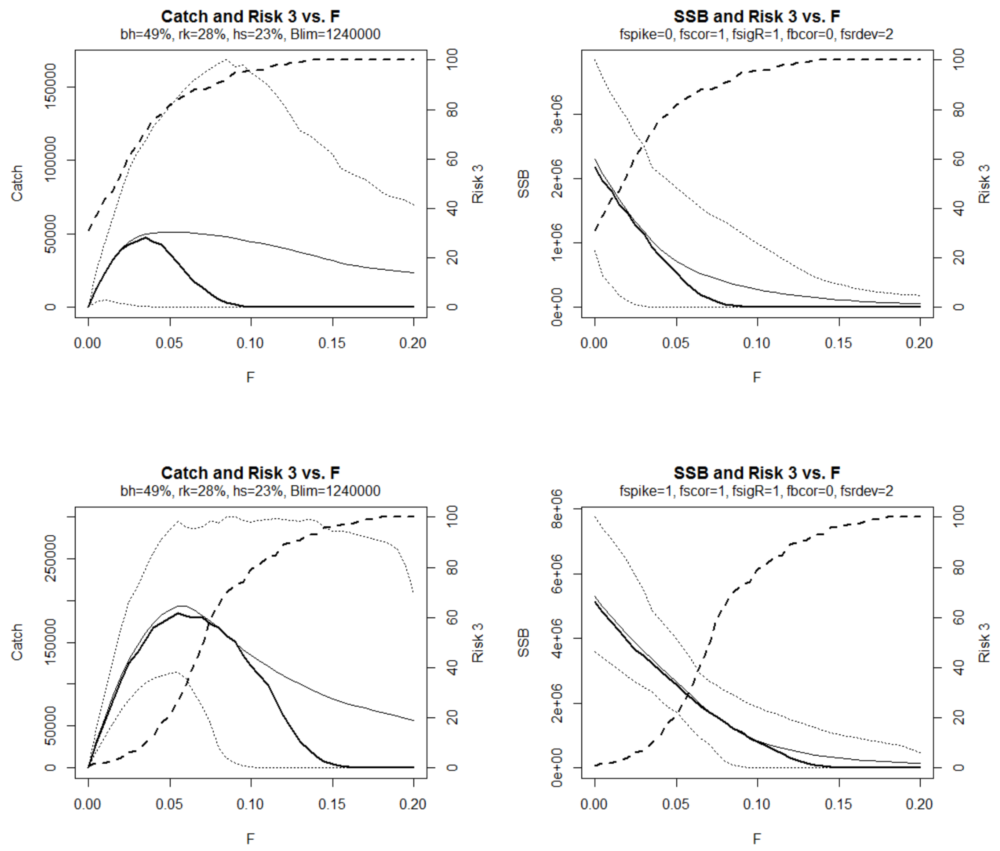


Figure 5.7.2 Western horse mackerel. Model Yield, SSB and Risk 3 vs F (med,10th & 90th pct) from projecting initial conditions forward 200 years, 100 iterations. The upper plots correspond to simulations with no recruitment spikes, results with recruitment spikes are shown on the bottom row.

These preliminary results illustrate that horse mackerel in the NEA Atlantic relies on spasmodic recruitment events to recover from exploitation. Without those recruitments and even in the absence of exploitation, the risk of SSB < B_{lim} can be quite high in particular years.

5.8 Management considerations

The 2001 year class has now entered the plus group and there are no detectable strong year classes entering the fishery. With the inclusion of the new 2013 egg survey estimate the perception of the stock as changed. However the declining trend in SSB and upward trajectory of F_{1-10} remains the same.

SSB in 2014 was estimated by the assessment at 609 865 tonnes, this is below the 1982 SSB previously estimated at 1.4Mt which was previously adopted as B_{lim}. A B_{pa} consistent with this is 1.8Mt and was proposed in 2008. However, B_{pa} is not used as a reference for management but rather the rule in the agreed management plan is used. There are currently no accepted biomass reference points for this stock following the revision of the assessment methodology and acceptance of the assessment in 2011.

The TAC has only been given for parts of the distribution and fishing areas (EU waters). The Working Group advises that the TAC should apply to all areas where western horse mackerel are caught. Note that sub-area VIIIc is now included in the Western stock distribution area. If (as planned) the management area limits are revised, measures should be taken to ensure that misreporting of juvenile catch taken in subareas VIIe,h and VIId (the latter then belonging to the North Sea stock management area) is effectively hindered. The mismatch between TAC and fishing areas and the fact that the TAC is only applied to EU waters has resulted in the catch prior to 2007 exceeding those advised by ICES.

The management plan proposed by the Pelagic RAC in 2007 was evaluated by ICES and considered to be precautionary in the short term. This plan makes use of the information available in the egg production surveys, and bases triennial TACs on the slope of the three previous egg production estimates. The rule proposed by the plan was used to set the TAC for 2008—2010 at 180kt. Using the finalised egg survey time-series the catch advice based on the MSY approach for 2015 is 137534t. It should be noted that the management plan assumes that all catches are taken against the TAC and, should the management and assessment areas be combined in the future, the TAC as set by the EU will not cover all fisheries.

5.9 Ecosystem considerations

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

5.10 Regulations and their effects

There are no horse mackerel management agreements between EU and non EU countries. The TAC set by EU therefore only apply to EU waters and the EU fleet in international waters. The minimum landing size of horse mackerel by the EU fleet is 15cm (10% undersized allowed in the catches).

The stock allocations were changed in 2005 following the results of the HOMSIR project (Abaunza *et al.* 2003) and VIIIc now belongs to the western stock. Landings from VIId are now allocated to the North Sea horse mackerel.

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

5.11 Changes in fishing technology and fishing patterns

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

5.12 Changes in the environment

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

Since the strong 1982 year class of the western stock started to appear in the North Sea in 1987 a good correspondence between the modelled influx of Atlantic water to the North Sea in the first quarter and the horse mackerel catches taken by Norwegian purse seiners in the Norwegian EEZ (NEZ) later (October-November) the same year (Iversen *et al.* 2002, Iversen WD presented in ICES 2007/ACFM:31) has been noted in most years.

5.13 References

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Table 5.1.1.1. Horse mackerel general. Catches (t) in Subarea II. (Data as submitted by Working Group members).

Country	1980	1981	1982	1983	1984	1985	1986	1987
Denmark	-	-	-	-	-	-	-	39
France	-	-	-	-	1	1	-2	-2
Germany Fed.Rep	-	+	-	-	-	-	-	-
Norway	-	-	-	412	22	78	214	3272
USSR	-	-	-	-	-	-	-	-
Total	-	+	-	412	23	79	214	3311

	1988	1989	1990	1991	1992	1993	1994	1995
Faroe Islands	-	-	9643	1115	91573	1068	-	950
Denmark	-	-	-	-	-	-	-	200
France	-2	-	-	-	-	-	55	-
Germany Fed. Rep.	64	12	+	-	-	-	-	-
Norway	6285	4770	9135	3200	4300	2100	4	11300
USSR / Russia (1992 -)	469	27	1298	172	-	-	700	1633
UK (England + Wales)	-	-	17		-	-	-	-
Total	6818	4809	11414	4487	13457	3168	759	14083

	1996	1997	1998	1999	2000	2001	2002	2003
Faroe Islands	1598	7993	1883	1323	2503	-	-	-
Denmark	-	-	17553	-		-	-	-
France	-	-	-	-		-	-	-
Germany	-	-	-	-		-	-	-
Norway	887	1170	234	2304	841	44	1321	22
Russia	881	648	345	121	843	16	3	2
UK (England + Wales)	-	-	-	-	-	-	-	-
Estonia	-	-	22	-	-	-	-	-
Total	3366	2617	2544	2557	1175	60	1324	24

	2004	2005	2006	2007	2008	2009	20101
Faroe Islands	-	-	3	-	-	-	29233
Denmark	-	-	-	-	-	-	-
France	-	-	-	-	-	-	-
Germany	-	-	-	-	-	-	-
Ireland	-	-	-	3664	-	-	-
Norway	42	176	27	-	572	1847	1364
Russia	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-

Total	42	176	30	366	572	1847	1656

[1]Preliminary.

[2]Included in Subarea IV.

[3]Includes catches in Div. Vb.

[4]Taken in Div. Vb

	2011	2012	2013[1]
Faroe Islands	3494	-	
Denmark	-	-	
France	-	+	
Germany	-	-	
Ireland	-		
Netherlands	1	-	
Norway	298	66	30
Russia	-	-	
UK (England + Wales)	-	-	
Estonia	-	-	
Total	648	66	30

[1]Preliminary

[2]Included in IV.

[3]Includes catches in Div. Vb.

[4]Taken in Div. Vb.

Table 5.1.1.2. Horse mackerel general. Catches (t) in North Sea Subarea IV and Skagerrak Division IIIa by country. (Data submitted by Working Group members). Catches partly concern the North Sea horse mackerel.

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
Belgium	8	34	7	55	20	13	13	9	10
Denmark	199	3576	1612	1590	23730	22495	18652	7290	20323
Faroe Islands	260	-	-	-	-	-	-	-	-
France	292	421	567	366	827	298	2312	1892	7842
Germany Fed.Rep.	+	139	30	52	+	+	-	3	153
Ireland	1161	412	-	-	-	-	-	-	-
Netherlands	101	355	559	20293	824	1603	6003	8504	10603
Norway2	119	2292	7	322	3	203	776	117284	344254
Poland	-	-	-	2	94	-	-	-	-
Sweden	-	-	-	-	-	-	2	-	-
UK (Engl. + Wales)	11	15	6	4	-	71	3	339	373
UK (Scotland)	-	-	-	-	3	998	531	487	5749
USSR	-	-	-	-	489	-	-	-	-
Total	2151	7253	2788	4420	25987	24238	20808	20895	62877

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
Belgium	10	13	-	+	74	57	51	28	-
Denmark	23329	20605	6982	7755	6120	3921	2432	1433	648
Estonia	-	-	-	293	-		17	-	-
Faroe Islands	-	942	340	-	360	275	-	-	296
France	248	220	174	162	302		-	-	-
Germany Fed.Rep.	506	24695	5995	2801	1570	1014	1600	7	7603
Ireland	-	687	2657	2600	4086	415	220	1100	8152
Netherlands	14172	1970	3852	3000	2470	1329	5285	6205	37778
Norway	84161	117903	50000	96000	126800	94000	84747	14639	45314
Poland	-	-	-	-	-	-	-	-	-
Sweden	-	102	953	800	697	2087	-	95	232
UK (Engl. + Wales)	10	10	132	4	115	389	478	40	242
UK (N. Ireland)	-	-	350	-	-		-	-	-
UK (Scotland)	2093	458	7309	996	1059	7582	3650	2442	10511
USSR / Russia (1992 -)	-	-	-						
Unallocated + discards	124824	-3174	-7504	-2786	-3270	1511	-28	136	-31615
Total	112047	145062	77904	114133	140383	112580	98452	26125	79161

Country	1998	1999	2000	2001	2002	2003	2004	2005	20061
Belgium	19	21	19	19	1004	5	4	6	3
Denmark	2048	8006	4409	2288	1393	3774	8735	4258	1343
Estonia	22	-	-						
Faroe Islands	28	908	24	-	699	809		35	
France	379	60	49	48	-	392	174	3876	2380
Germany	4620	4071	3115	230	2671	3048	4905	1811	965
Ireland	-	404	103	375	72	93	379	753	2077
Lithuania									2354
Netherlands	3811	3610	3382	4685	6612	17354	21418	24679	20984
Norway	13129	44344	1246	7948	35368	20493	10709	24937	27200
Russia	-	-	2	-	-	-			
Sweden	3411	1957	1141	119	575	1074	665	239	491
UK (Engl. + Wales)	2	11	15	317	1191	1192	2552	1778	423
UK (Scotland)	3041	1658	3465	3161	255	1	1	22	314
Unallocated+discards	737	-325	14613	649	-149	-14009	-19103	-21830	-19623
Total	31247	64725	31583	19839	49691	34226	30435	40564	38911

[1]-Preliminary.

[2] Includes Division IIa.

[3] Estimated from biological sampling.

[4] Assumed to be misreported.

[5] Includes 13 t from the German Democratic Republic.

[6] Includes a negative unallocated catch of -4,000 t.

Country	2007	2008	2009	2010	2011	2012	20131
Belgium	5	2	4	12	-	-	0
Denmark	329	59	279	75	20	9	9
Faroe Islands	3	55	-	81	-	-	-
France	457	943	-	173	2682	-	-
Germany, Fed.Rep.	93	1,167	1,299	242	-	--	20
Ireland	652	1,186	342	12	755	25	7
Netherlands	20,027	9,400	10,077	1,342	81	92	0
Lithuania	98	-	-	-	-	-	-
Norway	5.423	11652	70,745	11,082	13,409	3,183	6,566
Sweden	130	45	660	2	90	-	0
UK (Engl. + Wales)	2,966	-	-	-	-	-	16
UK (Scotland)	626	20	51	646	101	12	102
Unallocated +discards	-14,403	-9,151	-5,898	0	-	-	-
Total	16,407	15,377	78,595	13,667	14,725	3,321	6,721

[1]-Preliminary.

[2]French catches landed in the Netherlands

Table 5.1.1.3 Horse mackerel general. Catches (t) in Subarea VI by country. (Data submitted by Working Group members).

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
Denmark	734	341	2785	7	-	-	-	769	1655
Faroe Islands	-	-	1248	-	-	4014	1992	44503	40003
France	45	454	4	10	14	13	12	20	10
Germany Fed. Rep.	5550	10212	2113	4146	130	191	354	174	615
Ireland	-	-	-	15086	13858	27102	28125	29743	27872
Netherlands	2385	100	50	94	17500	18450	3450	5750	3340
Norway	-	5	-	-	-		83	75	41
Spain	-	-	-	-	-		-2	-2	-2
UK (Engl. + Wales)	9	5	+	38	+	996	198	404	475
UK (N. Ireland)						-	-	-	-
UK (Scotland)	1	17	83	-	214	1427	138	1027	7834
USSR.	-	-	-		-	-	-	-	-
Unallocated + disc						-19168	-13897	-7255	-
Total	8724	11134	6283	19381	31716	33025	20455	35157	45842

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
Denmark	973	615	-	42	-	294	106	114	780
Faroe Islands	3059	628	255	-	820	80	-	-	-
France	2	17	4	3	+	-	-	-	52
Germany Fed. Rep.	1162	2474	2500	6281	10023	1430	1368	943	229
Ireland	19493	15911	24766	32994	44802	65564	120124	87872	22474
Netherlands	1907	660	3369	2150	590	341	2326	572	498
Norway	-	-	-	-	-	-	-	-	-
Spain	-2	-2	1	3	-	-	-	-	-
UK (Engl. + Wales)	44	145	1229	577	144	109	208	612	56
UK (N.Ireland)	-	-	1970	273	-	-	-	-	767
UK (Scotland)	1737	267	1640	86	4523	1760	789	2669	14452
USSR/Russia (1992-)	-	44	-	-	-	-	-	-	-
Unallocated + disc.	6493	143	-1278	-1940	-69604	-51	-41326	-11523	837
Total	34870	20904	34456	40469	53942	69527	83595	81259	40145

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006
Denmark	-	-	-	-	-	-	-	-	-
Faroe Islands	-	-	-	-	-	-	-	-	-
France	221	25007	-	428	55	209	172	41	411
Germany	414	1031	209	265	149	1337	1413	1958	1025
Ireland	21608	31736	15843	20162	12341	20915	15702	12395	9780
Lithuania									2822

Netherlands	885	1139	687	600	450	847	3701	6039	1892
Spain	-	-	-	-	-	-	-	-	-
UK (Engl.+Wales)	10	344	41	91	-	46	5	52	-
UK (N.Ireland)	1132	-	-			453		210	82
UK (Scotland)	10447	4544	1839	3111	1192		377	62	43
Unallocated+disc.	98	1507	2038	-21	3	-553	559	1298	-304
Total	34815	65308	20657	24636	14190	23254	21929	22055	15751

Country	2007	2008	2009	2010	2011	2012	2013[1]
Denmark	-	-	-	-	58	1131	433
Faroe Islands	-	573	-	1	-	-	-
France	-	74	-	-	2465	-	-
Germany	1835	5097	635	773	6508	672	8616
Ireland	20341	18786	16565	19985	23556	29283	19979
Lithuania	80	641	-	-	-	-	-
Netherlands	2177	3904	2332	1685	6353	12653	11078
Norway	2	20	27	18	48	2	-
Russia	-	-	-	-	-	-	-
Spain	-	-	-	-	-	-	-
UK (Engl. + Wales)	232	-	-	-	-	-	451
UK (Scotland)	38	588	243	89	2528	1232	2325
Unallocated+disc.	1474	-3781	-2057	62	230	2	0
Total	26279	25902	17776	22613	39528	44975	43266

[1]Preliminary. [2]Included in Subarea VII. [3]Includes Divisions IIIa, IVa,b and VIb.

[4]Includes a negative unallocated catch of -7000 t. [5]French catches landed in the Netherlands

Table 5.1.1.4. Horse mackerel general . Catches (t) in Subarea VII by country. (Data submitted by the Working Group members).

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
Belgium	-	1	1	-	-	+	+	2	-
Denmark	5045	3099	877	993	732	14772	304082	27368	33202
France	1983	2800	2314	1834	2387	1881	3801	2197	1523
Germany Fed.Rep.	2289	1079	12	1977	228	-	5	374	4705
Ireland	-	16	-	-	65	100	703	15	481
Netherlands	23002	25000	275002	34350	38700	33550	40750	69400	43560
Norway	394	-	-	-	-	-	-	-	-
Spain	50	234	104	142	560	275	137	148	150
UK (Engl. + Wales)	12933	2520	2670	1230	279	1630	1824	1228	3759
UK (Scotland)	1	-	-	-	1	1	+	2	2873
USSR	-	-	-	-	-	120	-	-	-
Total	45697	34749	33478	40526	42952	39034	77628	100734	90253

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
Faroe Islands	-	28	-	-	-	-	-	-	-
Belgium	-	+	-	-	-	1	-	-	18
Denmark	34474	30594	28888	18984	16978	41605	28300	43330	60412
France	4576	2538	1230	1198	1001	-	-	-	27201
Germany Fed.Rep.	7743	8109	12919	12951	15684	14828	17436	15949	28549
Ireland	12645	17887	19074	15568	16363	15281	58011	38455	43624
Netherlands	43582	111900	104107	109197	157110	92903	116126	114692	81464
Norway	-	-	-	-	-	-	-	-	-
Spain	14	16	113	106	54	29	25	33	-
UK (Engl. + Wales)	4488	13371	6436	7870	6090	12418	31641	28605	17464
UK (N.Ireland)	-	-	2026	1690	587	119	-	-	1093
UK (Scotland)	+	139	1992	5008	3123	9015	10522	11241	7931
USSR / Russia (1992-)	-	-	-	-	-	-	-	-	-
Unallocated + discards	28368	7614	24541	15563	40103	14057	68644	26795	58718
Total	135890	192196	201326	188135	221000	200256	330705	279100	326474

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006
Faroe Islands	-	-	550	-	-	-	-	3660	1201
Belgium	18	-	-	-	1	-	+	+	+
Denmark	25492	19223	13946	20574	10094	10867	11529	9939	6838
France	24223	-	20401	11049	6466	7199	8083	8469	7928
Germany	25414	15247	9692	8320	10812	13873	16352	10437	7139
Ireland	51720	25843	32999	30192	23366	13533	8470	20406	16841
Lithuania									3569
Netherlands	91946	56223	50120	46196	37605	48.222	41123	31156	35467

Spain	-	-	50	7	0	1	27	12	60
UK (Engl. + Wales)	12832	8885	2972	8901	5525	4186	7178	4752	2935
UK (N.Ireland)	-	-	-	-	-			217	142
UK (Scotland)	5095	4994	5152	1757	1461	268	1146	59	413
Unallocated+discards	12706	31239	1884	11046	2576	24897	18485	18368	19379
Total	249446	161654	137766	138042	97906	123046	112393	107475	101912

Country	2007	2008	2009	2010	2011	2012	2013[1]
Faroe Islands	475	212	-	-	-	-	-
Belgium	+	+	1	24	2	+	14
Denmark	4806	1970	2710	5247	5831	2281	6373
France	6844	11008	-	899	74312	579	744
Germany	3.943	5700	14204	20404	14545	16391	15781
Ireland	8039	16293	23841	24490	14154	15893	15805
Lithuania	5585	4907	-	-	-	-	-
Netherlands	38034	43514	47741	75475	49207	53644	41562
Norway	-	-	-	40	-	-	-
Spain	-	11	6	6	-	58	-
Sweden	55	-	-	-	-	-	-
UK (Engl. + Wales)	9105	-	-	-	11688	12122	3388
UK (Scotland)	738	476	1123	1723	299	91	17
Unallocated+discards	15460	14656	-61	17534	-	3039	4401
Total	93084	98746	89565	145839	103156	104098	88085

[1]Preliminary.

[2]French catches landed in the Netherlands

Table 5.1.1.5. Horse mackerel general. Catches (t) in Subarea VIII by country. (Data submitted by Working Group members).

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
Denmark	-	-	-	-	-	-	446	3283	2793
France	3361	3711	3.073	2643	2489	4305	3534	3983	4502
Netherlands	-	-	-	-	-2	-2	-2	-2	-
Spain	34134	36362	19610	25580	23119	23292	40334	30098	26629
UK (Engl.+Wales)	-	+	1	-	1	143	392	339	253
USSR	-	-	-	-	20	-	656	-	-
Total	37495	40073	22684	28223	25629	27740	45362	37703	34177

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
Denmark	6729	5726	1349	5778	1955	-	340	140	729
France	4719	5082	6164	6220	4010	28	-	7	8690
Germany Fed. Rep.	-	-	80	62	-		-	-	-
Netherlands	-	6000	12437	9339	19000	7272	-	14187	2944
Spain	27170	25182	23733	27688	27921	25409	28349	29428	31081
UK (Engl.+Wales)	68	6	70	88	123	753	20	924	430
USSR/Russia (1992-)	-	-	-	-	-	-	-	-	-
Unallocated+discards	-	1500	2563	5011	700	2038	-	3583	-2944
Total	38686	43496	46396	54186	53709	35500	28709	48269	40930

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006
Denmark	1728	4818	2584	582	-	-		-	1513
France	1844	74	7	5316	13676	-	2161	3540	3944
Germany	3268	3197	3760	3645	2249	4908	72	4776	3325
Ireland	-	-	6485	1483	704	504	1882	1808	158
Lithuania									401
Netherlands	6604	22479	11768	36106	12538	1314	1047	6607	6073
Russia	-	-	-	-	-	6620			-
Spain	23599	24190	24154	23531	22110	24598	16245	16624	13874
UK (Engl. + Wales)	9	29	112	1092	157	982	516	838	821
UK (Scotland)	-	-	249	-	-	-		-	-
Unallocated+discards	1884	-8658	5093	4365	1705	2785	2202	7302	4013
Total	38936	46129	54212	76120	54560	41711	24125	41495	34122

Country	2007	2008	2009	2010	2011	2012	2013[1]
Denmark	2687	3289	3109	632	200	581	14
France	10741	2848	-	-	3263	1216	2849
Germany	-	918	281	64	61	-	417
Ireland	694	246	-	-	-	39	-
Lithuania	-	-	-	-	-	-	-
Netherland	-	6269	1849	97	49		1057

Russia	-	-	-	-	-	7	-
Spain	13853	19840	21071	38740	34581	13502	22541
UK (Engl. + Wales)	-	-	-	-	28		104
UK (Scotland)	-	-	-	-	-	-	
Unallocated+discards	412	482	7045	3694		2057	0
Total	28387	33892	33355	43227	35245	17402	26983

[1]Preliminary.

[2]Included in Subarea VII.

[3]French catches landed in the Netherlands

Table 5.2.1.1. Western horse mackerel. The time series of egg production estimates (10^{-12} eggs).

Year	Total egg production
1983	513
1989	1762
1992	1712
1995	1265
1998	1136
2001	821
2004	889
2007	1640
2010	1093
2013	397

Table 5.2.4.1. Western Horse Mackerel stock. Catch in numbers (1000) at age by quarter and area in 2013

1Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0																				0
1									166	0	0				191	490	724	16015	0	17586
2									6690	0	0				20	51	258	881	0	7900
3							653		9508	0	0	414	173		90	37	326	523	0	11725
4					558		4364	12	11928	0	0	10020	1313		2293	1188	261	229	1	32167
5					5894		32006	897	13530	0	0	33463	4456		6556	1141	177	30	2	98151
6					2153		4175	12	1773	0	0	6333	1803		1346	486	136	6	0	18224
7					1076		2655	968	4135	0	0	1491	1286	10	319	119	87	5	0	12153
8					1039		2333	103	1506	0	0	2523	2184		465	11	79	7	0	10250
9					1615		3720	104	2324	0	0	450	1700		85	8	79	12	0	10099
10					1505		3332	1146	2879	0	0	2505	3035		486	73	66	30	0	15057
11					2415		1409	2485	957	0	0	1135	1347	41	242	88	48	41	0	10208
12					25791		19282	4566	1013	0	0	1145	4295	102	242	85	52	119	0	56693
13					3139		2500	2196	148	0	0	225	1278	41	52	28	34	190	0	9831
14					3572		4131	163	563	0	0		829	20	7	18	27	130	0	9461
15+					6912		1804	1188	207	0	0	347	1528	41	90	69	119	468	0	12776
Sum					55669		82366	13840	57326	0	1	60051	25227	256	12486	3893	2475	18685	5	332281

2Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0																				0
1									1287	1					768	6823	3877	20013	0	32770
2									443	0					236	2094	706	1124	0	4603
3									314	0					309	2743	509	744	0	4619
4					2		5	253	376	0	0	1	5210	31	148	1314	336	502	0	8178
5					18		29	1344	557	1	1	5	27589	263	50	445	293	300	1	30898
6					7		13	593	147	1	1	2	12275	15	52	458	384	270	1	14220
7					3		2	95	122	0	0	0	1913	46	29	261	291	254	0	3018
8					3		1	41	49	0	0	0	832	15	24	211	308	237	0	1721
9					5		1	24	66	0	0	0	500		22	197	351	213	0	1379
10					5		3	135	98	0	0	1	2790		21	190	371	245	0	3858
11					7		3	118	47	0	0	0	2454		19	171	316	184	0	3321
12					78		10	457	105	0	0	2	9461	15	21	188	345	278	0	10962
13					9		2	85	23	0	0	0	1762		17	148	264	302	0	2613
14					11		1	69	29	0	0	0	1431		12	109	195	207	0	2065
15+					21		1	65	31	0	0	0	1346		45	401	742	888	0	3541
Sum					168		71	3280	3694	5	3	13	67563	387	1773	15754	9287	25763	4	127766

3Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0													382		82	249	2086	63082	7	65887
1									31753	67	14	141	259		232	704	1129	11479	1	45779
2									7600	16	3	34	47		63	193	43	344	0	8342
3									1717	4	1	8	14		143	434	85	237	0	2642
4	0	0	71		77	0	17	11	920	2	0	4	10		149	452	104	304	0	2122
5	2	1	588		668	3	147	99	67	0	0	0	8		149	452	332	518	0	3037
6	2	1	534		336	2	74	50	13	0	0	0	7		124	376	463	367	0	2349
7	1	0	196		43	0	10	6	1	0	0	0	7		97	296	610	266	0	1533
8	1	0	196		10	0	2	2					5		60	183	469	206	0	1134
9	0	0	55		33	0	7	5	1	0	0	0	6		54	164	652	218	0	1196
10	0	0	125						1	0	0	0	12		73	221	1459	463	0	2355
11	0	0	109		33	0	7	5					10		41	126	1151	370	0	1854
12	4	2	1026		53	0	12	8					7		14	42	685	382	0	2235
13	1	0	180										5		9	28	583	311	0	1118
14	0	0	55										4		7	21	410	299	0	796
15+													20		27	83	1756	1548	0	3435
Sum	12	5	3136		1253	6	276	185	42074	89	18	187	802		1325	4022	12015	80395	10	145812

4Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0															137	1214	1337	24899	0	27586
1									16252	0	0	454	2		729	5949	798	16890	0	41075
2	0	0	41		74			0	6213	0	0	3679	17		658	1606	68	1370	0	13726
3	0	0	39		225		772	0	6286	0	0	1743	10		695	4136	140	1011	0	15056
4	3	2	672		7805		8106	0	9723	0	0	1299	31		641	3667	121	398	0	32468
5	15	10	3274		52337		30745	0	12364	0	0	6313	120		1230	1118	242	132	0	107901
6	16	11	3578		15473		6056	0	1942	0	0	1053	23		255	537	298	153	0	29395
7	5	3	1073		2954		2050	0		0	0	456	8		129	446	382	118	0	7625
8	2	2	544		1817		1359	0	317	0	0	4	4		47	293	291	97	0	4776
9	4	3	987		3318		2254	0			0	20	7		66	350	407	100	0	7516
10	5	3	1077		4017		1901	0					6		87	613	926	219	0	8854
11	8	5	1650		1119		528	0					2		58	476	738	186	0	4769
12	14	9	2993		17155		11561	0		0	0	4	34		145	249	441	177	0	32783
13	10	7	2253		2731		1357	0					4		35	191	379	140	0	7107
14	2	1	455		1557		928	0					3		21	121	266	133	0	3488
15+	2	1	418		852		658	0					2		59	462	1138	624	0	4216
Sum	87	58	19053		111433		68274	0	53098	2	1	15025	270		4991	21428	7971	46648	0	348340

1-4Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Total
0													382		219	1463	3423	87981	7	93473
1									49459	69	14	595	261		1919	13966	6528	64397	2	137210
2	0	0	41		74			0	20945	16	4	3713	63		977	3944	1074	3718	0	34571
3	0	0	39		225		1425	0	17826	4	1	2165	197		1237	7350	1059	2515	0	34042
4	3	2	743		8442	0	12492	277	22947	3	1	11324	6564	31	3231	6620	822	1432	1	74935
5	17	11	3862		58917	3	62927	2340	26518	2	2	39782	32173	263	7986	3156	1043	981	4	239987
6	18	12	4112		17969	2	10317	655	3876	1	1	7388	14108	15	1777	1857	1282	797	1	64187
7	6	4	1269		4077	0	4716	1069	4258	0	0	1947	3214	57	575	1122	1371	643	0	24328
8	3	2	740		2869	0	3695	145	1872	0	0	2528	3025	15	596	697	1146	547	0	17881
9	5	3	1041		4971	0	5982	133	2392	0	0	470	2212		228	720	1490	543	0	20190
10	5	3	1203		5527		5236	1281	2978	0	0	2505	5842		667	1096	2822	958	1	30125
11	8	5	1759		3574	0	1948	2608	1004	0	0	1135	3812	41	361	861	2254	781	0	20152
12	18	11	4019		43078	0	30865	5031	1117	0	0	1150	13796	118	422	564	1522	957	1	102672
13	11	7	2433		5880		3859	2281	170	0	0	225	3050	41	113	395	1260	943	0	20668
14	2	1	510		5139		5061	232	592	0	0	0	2267	20	47	270	898	769	0	15809
15+	2	1	418		7785		2463	1253	238	0	0	348	2896	41	222	1015	3755	3529	1	23967
Sum	99	63	22189		168524	6	150987	17305	156191	96	23	75276	93863	643	20575	45097	31748	171490	19	954198

Table 5.2.4.2. Western horse mackerel. Catch-at-age (thousands of fish).

	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0	3713	21072	134743	11515	13197	11741	8848	1651	414	1651	81385
1983	0	7903	2269	32900	53508	15345	44539	52673	17923	3291	5505	129139
1984	0	0	241360	4439	36294	149798	22350	38244	34020	14756	4101	58370
1985	0	1633	4901	602992	4463	41822	100376	12644	16172	6200	9224	40976
1986	0	0	0	1548	676208	8727	65147	109747	25712	21179	15271	56824
1987	0	99	493	0	2950	891660	2061	41564	90814	11740	9549	62776
1988	876	27369	6112	2099	4402	18968	941725	12115	39913	67869	9739	76096
1989	0	0	0	20766	18282	5308	14500	1276731	12046	59357	83125	78951
1990	0	20406	45036	138929	61442	33298	10549	20607	1384850	37011	70512	226294
1991	20632	33560	89715	23034	207751	143072	73730	25369	25584	1219646	23987	137131
1992	14887	229703	36331	80552	56275	256085	127048	49020	19053	23449	1103480	152305
1993	46	109152	94500	16738	62714	94711	317337	144610	70717	32693	4822	1309609
1994	3686	60759	911713	115729	53132	44692	38769	221970	106512	40799	42302	998180
1995	2702	165382	470498	424563	215468	59035	90832	35654	245230	119117	99495	1362342
1996	10729	19774	658727	860992	186306	85508	51365	55229	53379	57131	56962	729283
1997	4860	110145	465350	735919	410638	244328	119062	127658	134488	109962	109165	601196
1998	744	91505	184443	488662	360116	219650	157396	122583	81499	68264	50555	389594
1999	14822	97561	83714	176919	265820	254516	212225	187250	147328	77691	35635	252044
2000	637	78856	131112	52716	71779	150869	170393	177995	133290	61578	18010	168770
2001	58685	69430	246525	151707	98454	101344	116952	234832	203823	103968	36076	132706
2002	13707	461055	120106	164977	126329	64449	69828	94429	130285	85325	45798	150103
2003	1843	303721	585700	165666	152117	88944	57445	45596	49476	92758	50503	109994
2004	21246	140299	110976	474273	76136	103011	69844	43981	31618	49188	56109	63823
2005	1260	71508	170936	310085	531221	68559	74392	61641	43454	22304	27127	99898
2006	1901	49396	39439	41585	73860	501168	57299	39424	43667	17148	12274	102329
2007	4583	37208	39743	46218	63337	105042	336626	48066	27637	20155	8801	59268
2008	29912	76358	19219	41715	46963	74125	47740	294659	50621	36873	25725	73986
2009	46167	117519	46258	39576	33781	38393	55696	53917	248299	66292	41751	107948
2010	6806	82287	159023	93764	32789	31381	52379	104625	72210	269930	68571	129653
2011	1094	18864	59027	93167	46347	41372	35607	60798	63676	78422	246442	177090
2012	5350	48100	42654	64222	171285	56012	37917	28132	25608	45490	41255	278872
2013	93473	137210	34571	34042	74935	239987	64187	24328	17881	20190	30125	183268

Table 5.2.5.1. Western horse mackerel stock. Mean weight (kg) in catch at age by quarter and area in 2013

1Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Mean
0																				
1									0.08	0.08	0.08				0.05	0.05	0.06	0.05	0.05	0.06
2									0.08	0.08	0.08				0.06	0.06	0.09	0.09	0.06	0.08
3					0.09		0.09		0.09	0.09	0.09	0.09	0.16		0.09	0.08	0.11	0.10	0.12	0.10
4			0.13		0.13		0.13	0.17	0.12	0.12	0.12	0.13	0.15		0.13	0.12	0.12	0.11	0.13	0.13
5			0.16		0.16		0.16	0.20	0.14	0.14	0.14	0.13	0.16		0.13	0.14	0.15	0.13	0.14	0.15
6			0.21		0.20		0.20	0.17	0.16	0.16	0.17	0.16	0.18		0.16	0.16	0.18	0.17	0.17	0.17
7			0.24		0.23		0.25	0.23	0.19	0.19	0.20	0.18	0.23	0.21	0.19	0.22	0.21	0.21	0.22	0.21
8			0.27		0.24		0.24	0.24	0.18	0.19	0.22	0.19	0.25		0.19	0.35	0.24	0.23	0.23	0.23
9			0.28		0.25		0.25	0.29	0.22	0.23	0.23	0.27	0.23		0.27	0.33	0.25	0.26	0.23	0.26
10			0.30		0.28		0.21	0.25	0.21	0.20	0.22	0.18	0.24		0.19	0.30	0.28	0.32	0.23	0.24
11			0.37		0.29		0.28	0.25	0.29	0.27	0.25	0.25	0.24	0.34	0.25	0.24	0.30	0.35	0.24	0.28
12			0.34		0.33		0.30	0.26	0.28	0.28	0.25	0.27	0.24	0.23	0.26	0.24	0.30	0.43	0.24	0.29
13			0.39		0.37		0.31	0.27	0.29	0.32	0.26	0.34	0.25	0.28	0.35	0.37	0.34	0.43	0.26	0.33
14			0.43		0.38		0.42	0.31	0.35	0.35	0.30		0.27	0.27	0.36	0.36	0.32	0.44	0.27	0.35
15+			0.46		0.41		0.42	0.24	0.49	0.37	0.33	0.24	0.32	0.31	0.28	0.37	0.38	0.48	0.31	0.36
Mean			0.30		0.26		0.25	0.24	0.21	0.20	0.19	0.20	0.23	0.27	0.20	0.22	0.22	0.25	0.19	

2Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Mean
0																				
1									0.05	0.05					0.06	0.06	0.06	0.05	0.06	0.05
2									0.08	0.08					0.08	0.08	0.09	0.09	0.08	0.08
3									0.10	0.09					0.09	0.09	0.10	0.10	0.09	0.10
4					0.13		0.13	0.13	0.12	0.13	0.13	0.13	0.13	0.11	0.11	0.11	0.12	0.12	0.13	0.12
5					0.16		0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.16	0.15	0.14	0.15
6					0.21		0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.19	0.18	0.18	0.19	0.18	0.16	0.17
7					0.24		0.21	0.21	0.19	0.21	0.21	0.21	0.21	0.20	0.21	0.21	0.21	0.21	0.21	0.21
8					0.27		0.23	0.23	0.20	0.23	0.23	0.23	0.23	0.21	0.26	0.26	0.26	0.22	0.23	0.23
9					0.28		0.24	0.24	0.23	0.25	0.24	0.24	0.24		0.26	0.26	0.27	0.25	0.24	0.25
10					0.30		0.26	0.26	0.23	0.27	0.26	0.26	0.26		0.29	0.29	0.29	0.28	0.26	0.27
11					0.37		0.25	0.25	0.27	0.26	0.25	0.25	0.25		0.32	0.32	0.32	0.31	0.25	0.29
12					0.34		0.24	0.24	0.25	0.24	0.24	0.24	0.24	0.24	0.32	0.32	0.32	0.35	0.24	0.28
13					0.39		0.25	0.25	0.28	0.28	0.25	0.25	0.25		0.35	0.35	0.36	0.39	0.25	0.30
14					0.43		0.26	0.26	0.31	0.28	0.26	0.26	0.26		0.34	0.34	0.34	0.39	0.26	0.31
15+					0.46		0.23	0.23	0.36	0.33	0.23	0.23	0.23		0.35	0.35	0.36	0.44	0.25	0.32
Mean					0.30		0.22	0.22	0.20	0.20		0.22	0.22	0.18	0.23	0.23	0.23	0.24		

3Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Mean
0													0.04		0.06	0.06	0.03	0.04	0.04	0.05
1									0.05	0.05	0.05	0.05	0.05		0.09	0.09	0.07	0.06	0.06	0.06
2									0.08	0.08	0.08	0.08	0.08		0.11	0.11	0.11	0.10	0.10	0.09
3									0.14	0.14	0.14	0.14	0.13		0.13	0.13	0.13	0.11	0.13	0.13
4	0.20	0.20	0.20		0.18	0.18	0.18	0.18	0.17	0.17	0.17	0.17	0.16		0.15	0.15	0.17	0.13	0.15	0.17
5	0.19	0.19	0.19		0.18	0.18	0.18	0.18	0.17	0.17	0.17	0.17	0.18		0.20	0.20	0.19	0.16	0.18	0.18
6	0.21	0.21	0.21		0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.21		0.24	0.24	0.20	0.19	0.21	0.20
7	0.22	0.22	0.22		0.22	0.22	0.22	0.22	0.26	0.26	0.26	0.26	0.23		0.25	0.25	0.22	0.21	0.23	0.23
8	0.23	0.23	0.23		0.23	0.23	0.23	0.23					0.23		0.27	0.27	0.23	0.22	0.23	0.24
9	0.25	0.25	0.25		0.22	0.22	0.22	0.22	0.24	0.24	0.24	0.24	0.26		0.29	0.29	0.25	0.25	0.26	0.25
10	0.25	0.25	0.25						0.33	0.33	0.33	0.33	0.27		0.30	0.30	0.27	0.27	0.27	0.29
11	0.29	0.29	0.29		0.22	0.22	0.22	0.22					0.30		0.32	0.32	0.30	0.32	0.30	0.28
12	0.30	0.30	0.30		0.22	0.22	0.22	0.22					0.34		0.36	0.36	0.33	0.37	0.34	0.29
13	0.24	0.24	0.24										0.37		0.39	0.39	0.35	0.39	0.37	0.33
14	0.31	0.31	0.31										0.38		0.38	0.38	0.36	0.41	0.38	0.35
15+													0.42		0.36	0.36	0.38	0.47	0.42	0.40
Mean	0.24	0.24	0.24		0.21	0.21	0.21	0.21	0.18	0.18	0.18	0.18	0.23		0.24	0.24	0.22	0.23	0.23	

4Q

Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Mean
0															0.07	0.07	0.03	0.05	0.05	0.05
1									0.06	0.06	0.06	0.09	0.09		0.09	0.10	0.07	0.07	0.07	0.08
2	0.17	0.17	0.17		0.11			0.11	0.10	0.10	0.10	0.10	0.10		0.10	0.11	0.11	0.10	0.10	0.12
3	0.21	0.21	0.21		0.12		0.14	0.13	0.14	0.14	0.14	0.13	0.13		0.13	0.13	0.13	0.11	0.12	0.15
4	0.23	0.23	0.23		0.15		0.17	0.16	0.18	0.17	0.17	0.15	0.16		0.14	0.13	0.15	0.11	0.14	0.17
5	0.25	0.25	0.25		0.18		0.19	0.19	0.18	0.17	0.17	0.16	0.18		0.17	0.17	0.18	0.17	0.16	0.19
6	0.27	0.27	0.27		0.21		0.21	0.21	0.21	0.19	0.19	0.15	0.19		0.18	0.24	0.20	0.19	0.18	0.21
7	0.30	0.30	0.30		0.26		0.24	0.25		0.16	0.16	0.16	0.22		0.21	0.26	0.22	0.21	0.21	0.23
8	0.33	0.33	0.33		0.26		0.25	0.25	0.27	0.26	0.26	0.21	0.25		0.27	0.27	0.23	0.22	0.24	0.27
9	0.33	0.33	0.33		0.25		0.25	0.25			0.19	0.19	0.25		0.28	0.30	0.25	0.25	0.27	0.26
10	0.33	0.33	0.33		0.27		0.25	0.26					0.25		0.31	0.32	0.27	0.27	0.29	0.29
11	0.33	0.33	0.33		0.29		0.26	0.28					0.26		0.34	0.35	0.30	0.31	0.31	0.31
12	0.36	0.36	0.36		0.30		0.25	0.28		0.25	0.23	0.23	0.25		0.27	0.38	0.33	0.36	0.35	0.30
13	0.37	0.37	0.37		0.31		0.24	0.28					0.24		0.34	0.40	0.36	0.39	0.37	0.33
14	0.46	0.46	0.46		0.33		0.25	0.29					0.24		0.35	0.41	0.36	0.41	0.38	0.37
15+	0.40	0.40	0.40		0.33		0.25	0.29					0.25		0.38	0.39	0.38	0.46	0.40	0.36
Mean	0.31	0.31	0.31		0.24		0.23	0.23	0.16	0.17	0.17	0.16	0.20		0.23	0.25	0.22	0.23	0.23	

1-4Q

Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Mean
0													0.04		0.07	0.07	0.03	0.04	0.04	0.05
1									0.05	0.05	0.05	0.08	0.05		0.08	0.08	0.06	0.05	0.06	0.06
2	0.17	0.17	0.17					0.11	0.08	0.08	0.08	0.10	0.09		0.10	0.09	0.09	0.09	0.09	0.11
3	0.21	0.21	0.21				0.11	0.13	0.11	0.14	0.14	0.12	0.16		0.12	0.11	0.11	0.11	0.11	0.14
4	0.23	0.23	0.23		0.18		0.15	0.13	0.14	0.16	0.15	0.13	0.14	0.11	0.13	0.13	0.13	0.12	0.13	0.16
5	0.24	0.24	0.24		0.18		0.17	0.17	0.16	0.15	0.15	0.14	0.15	0.14	0.14	0.16	0.17	0.16	0.14	0.17
6	0.26	0.26	0.26		0.19		0.20	0.16	0.18	0.17	0.16	0.16	0.16	0.19	0.17	0.20	0.20	0.18	0.17	0.20
7	0.29	0.29	0.28		0.22		0.25	0.23	0.19	0.20	0.20	0.18	0.22	0.20	0.21	0.24	0.22	0.21	0.22	0.23
8	0.31	0.31	0.30		0.23		0.25	0.23	0.20	0.23	0.22	0.19	0.24	0.21	0.21	0.27	0.24	0.22	0.23	0.24
9	0.32	0.32	0.32		0.22		0.25	0.28	0.22	0.25	0.23	0.26	0.23		0.28	0.29	0.26	0.25	0.24	0.27
10	0.32	0.33	0.32				0.22	0.25	0.21	0.26	0.25	0.18	0.25		0.22	0.31	0.28	0.27	0.25	0.26
11	0.33	0.33	0.33		0.22		0.27	0.25	0.29	0.26	0.25	0.25	0.25	0.34	0.28	0.33	0.30	0.32	0.27	0.29
12	0.34	0.35	0.34		0.22		0.28	0.25	0.28	0.24	0.24	0.27	0.24	0.23	0.27	0.34	0.33	0.37	0.25	0.29
13	0.36	0.36	0.36				0.28	0.27	0.29	0.28	0.25	0.34	0.25	0.28	0.35	0.38	0.36	0.40	0.29	0.32
14	0.45	0.45	0.45				0.39	0.29	0.34	0.29	0.26	0.26	0.26	0.27	0.36	0.37	0.36	0.41	0.30	0.35
15+	0.40	0.40	0.40				0.37	0.24	0.48	0.33	0.25	0.24	0.28	0.31	0.33	0.37	0.37	0.46	0.37	0.35
Mean	0.30	0.30	0.30		0.21		0.25	0.21	0.22	0.21	0.19	0.19	0.19	0.23	0.21	0.23	0.22	0.23	0.20	

Table 5.2.5.2. Western horse mackerel stock. Mean length (cm) in catch at age by quarter and area in 2013

1Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIId	Mean
0					0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
1					0.00		0.00	0.00	21.31	21.31	21.31	0.00	0.00	0.00	17.47	17.47	18.88	17.28	17.47	10.89
2					0.00		0.00	0.00	21.77	21.80	21.77	0.00	0.00	0.00	19.66	19.66	22.51	21.84	19.66	12.05
3					0.00		22.45	0.00	22.79	22.83	22.87	22.50	26.50	0.00	22.25	20.96	23.57	23.10	24.14	18.14
4					25.69		25.56	27.50	24.86	25.07	25.24	25.47	27.17	0.00	25.35	24.87	24.64	24.09	25.70	23.66
5					27.58		27.27	29.47	25.79	25.91	26.24	26.00	28.08	0.00	26.05	26.73	26.64	25.07	26.49	24.81
6					30.11		29.45	27.50	26.87	26.98	27.54	27.04	28.81	0.00	27.09	27.39	28.20	27.93	27.70	25.90
7					31.17		31.99	32.00	27.95	27.88	28.73	27.58	31.25	30.50	28.01	30.55	29.86	29.83	30.04	29.81
8					32.43		31.29	30.95	28.27	28.40	30.08	28.56	31.81	0.00	28.63	35.61	31.31	30.72	30.73	28.49
9					32.80		32.09	33.43	29.75	29.92	30.51	31.50	31.20	0.00	31.63	34.98	31.85	32.34	31.25	29.52
10					33.58		30.35	32.19	29.10	28.89	30.13	28.50	31.48	0.00	28.76	33.01	32.78	34.52	30.72	28.86
11					35.63		32.70	31.60	31.42	31.04	31.42	30.49	31.77	35.00	30.59	31.18	33.87	35.63	31.41	32.41
12					34.90		33.64	32.71	31.37	31.79	31.73	32.39	31.71	31.40	32.25	31.38	33.81	38.24	31.78	32.79
13					36.47		33.88	32.98	31.50	32.90	32.37	34.50	32.28	33.00	34.88	36.31	35.12	38.30	32.52	34.07
14					37.40		37.42	33.89	33.67	33.67	33.26	0.00	33.05	33.50	36.11	36.11	34.39	38.61	33.11	32.44
15+					38.19		37.19	32.13	37.92	34.75	34.75	31.50	34.74	34.00	32.95	36.38	36.21	39.77	34.52	35.36
Mean					24.75		25.33	23.52	26.52	26.45	26.75	21.63	24.99	12.34	26.36	27.66	27.73	30.42	26.70	

2Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIIc west	Mean
					0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
1					0.00		0.00	0.00	17.69	17.75	0.00	0.00	0.00	0.00	19.09	19.09	18.52	17.27	19.09	9.18
2					0.00		0.00	0.00	21.17	21.60	0.00	0.00	0.00	0.00	21.25	21.25	21.91	21.87	21.25	10.74
3					0.00		0.00	0.00	23.08	22.52	0.00	0.00	0.00	0.00	22.06	22.06	23.24	23.23	22.06	11.30
4					25.76		26.06	26.06	25.17	25.59	26.06	26.06	26.06	25.50	23.82	23.82	24.74	24.55	25.71	25.35
5					27.60		27.26	27.26	26.38	27.24	27.26	27.26	27.26	26.79	26.80	26.80	27.03	26.48	27.26	27.05
6					30.08		28.39	28.39	27.95	28.40	28.39	28.39	28.39	29.50	28.48	28.48	28.70	28.38	28.39	28.59
7					31.17		29.97	29.97	28.29	29.93	29.98	29.98	29.98	29.83	29.78	29.78	30.04	29.64	29.96	29.88
8					32.43		30.96	30.96	28.99	31.19	30.97	30.97	30.97	30.50	31.84	31.84	32.05	30.48	31.11	31.09
9					32.79		29.50	29.50	29.94	31.06	29.50	29.50	29.50	0.00	32.25	32.25	32.37	31.77	30.11	28.57
10					33.58		32.36	32.36	30.08	32.55	32.36	32.36	32.36	0.00	33.21	33.21	33.38	33.11	32.40	30.24
11					35.62		31.71	31.71	31.85	32.26	31.71	31.71	31.71	0.00	34.59	34.59	34.55	34.17	31.85	30.57
12					34.90		31.26	31.26	31.50	31.53	31.26	31.26	31.26	31.50	34.45	34.45	34.65	35.49	31.31	32.58
13					36.47		31.98	31.98	32.93	33.20	31.98	31.98	31.98	0.00	35.70	35.70	35.83	37.13	32.20	31.36
14					37.40		33.31	33.31	33.83	33.97	33.31	33.31	33.31	0.00	35.18	35.18	35.36	36.79	33.41	31.98
15+					38.19		32.01	32.01	35.41	34.90	32.01	32.01	32.01	0.00	35.45	35.45	35.90	38.31	32.62	31.88
Mean					24.75		22.80	22.80	26.52	27.11		22.80	22.80	10.85	27.75	27.75	28.02	29.46	26.80	

3Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIIc west	Mean
	0.00	0.00	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	16.02		19.36	19.36	15.34	16.04	16.02	6.38
1	0.00	0.00	0.00		0.00		0.00	0.00	17.67	17.67	17.67	17.67	17.99		22.01	22.01	19.66	18.49	18.76	11.85
2	0.00	0.00	0.00		0.00		0.00	0.00	20.74	20.74	20.74	20.74	20.91		23.47	23.47	23.44	23.15	23.27	13.79
3	0.00	0.00	0.00		0.00		0.00	0.00	24.49	24.49	24.49	24.49	24.58		25.33	25.33	25.05	23.86	24.80	15.43
4	28.50	28.50	28.50		28.50		28.50	28.50	27.35	27.35	27.35	27.35	26.84		26.44	26.44	27.59	25.53	26.25	27.47
5	28.51	28.51	28.51		28.58		28.58	28.58	26.57	26.57	26.57	26.57	28.23		29.49	29.49	28.66	27.11	28.29	28.05
6	29.41	29.41	29.41		29.27		29.27	29.27	27.17	27.17	27.17	27.17	29.61		31.06	31.06	29.42	28.64	29.65	29.01
7	30.70	30.70	30.70		30.74		30.74	30.74	30.50	30.50	30.50	30.50	30.58		31.90	31.90	30.39	29.69	30.58	30.71
8	31.22	31.22	31.22		31.50		31.50	31.50	0.00	0.00	0.00	0.00	30.93		32.55	32.55	30.62	30.34	30.93	23.51
9	32.50	32.50	32.50		30.50		30.50	30.50	29.50	29.50	29.50	29.50	32.06		33.42	33.42	31.84	31.82	32.07	31.35
10	30.94	30.94	30.94		0.00		0.00	0.00	33.50	33.50	33.50	33.50	32.75		33.88	33.88	32.70	32.41	32.75	26.57
11	33.50	33.50	33.50		30.50		30.50	30.50	0.00	0.00	0.00	0.00	33.89		34.63	34.63	33.69	34.34	33.90	24.82
12	33.44	33.44	33.44		30.88		30.88	30.88	0.00	0.00	0.00	0.00	35.31		35.90	35.90	34.80	36.25	35.34	25.40
13	31.37	31.37	31.37		0.00		0.00	0.00	0.00	0.00	0.00	0.00	36.31		36.88	36.88	35.84	37.14	36.31	19.59
14	32.50	32.50	32.50		0.00		0.00	0.00	0.00	0.00	0.00	0.00	36.66		36.77	36.77	35.99	37.57	36.66	19.87
15+	0.00	0.00	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	37.82		35.83	35.83	36.52	39.40	37.82	13.95
Mean	21.41	21.41	21.41		15.03		15.03	15.03	14.84	14.84	14.84	14.84	29.41		30.56	30.56	29.47	30.52	29.59	

4Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIIc west	Mean
	0.00	0.00	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00		19.70	19.70	15.40	17.37	17.36	5.60
1	0.00	0.00	0.00		0.00		0.00	0.00	19.43	19.52	19.53	22.45	22.45		22.50	22.51	19.76	19.70	20.37	13.01
2	24.50	24.50	24.50		24.50		0.00	24.50	22.21	22.42	22.46	22.82	22.82		23.07	23.72	23.66	23.23	23.11	22.00
3	28.00	28.00	28.00		24.52		25.59	25.38	25.04	25.03	24.98	24.77	24.96		24.84	24.87	24.83	23.94	24.70	25.47
4	27.60	27.60	27.60		26.83		27.53	27.21	27.25	27.23	27.13	26.28	27.28		25.85	25.42	26.55	24.15	25.57	26.69
5	28.90	28.90	28.90		28.58		28.77	28.65	27.80	27.55	27.53	27.06	28.35		27.54	27.71	28.38	27.43	27.19	28.08
6	29.80	29.80	29.80		29.89		29.87	29.88	28.75	28.33	28.32	27.63	29.39		28.96	31.06	29.37	28.65	28.79	29.27
7	30.80	30.80	30.80		32.23		31.48	31.88	0.00	27.50	27.53	27.53	30.45		29.93	32.08	30.37	29.73	29.84	28.31
8	32.50	32.50	32.50		31.77		32.08	31.90	30.50	30.49	30.49	29.50	32.04		32.57	32.75	30.62	30.35	31.41	31.50
9	32.10	32.10	32.10		31.72		31.95	31.82	0.00	0.00	28.86	28.86	31.91		32.95	33.82	31.86	31.86	32.50	27.78
10	32.30	32.30	32.30		32.58		31.85	32.31	0.00	0.00	0.00	0.00	31.84		34.03	34.56	32.71	32.55	33.28	24.54
11	32.30	32.30	32.30		33.21		32.61	32.99	0.00	0.00	0.00	0.00	32.60		35.29	35.52	33.71	34.28	34.35	25.09
12	33.40	33.40	33.40		33.40		31.86	32.73	0.00	30.50	30.04	30.00	31.85		32.84	36.65	34.81	36.08	35.53	31.03
13	33.40	33.40	33.40		34.01		31.29	33.02	0.00	0.00	0.00	0.00	31.30		35.04	37.45	35.87	37.00	36.48	25.73
14	35.50	35.50	35.50		34.25		31.66	33.15	0.00	0.00	0.00	0.00	31.61		35.71	37.58	36.03	37.59	36.76	26.30
15+	34.70	34.70	34.70		34.37		32.10	33.31	0.00	0.00	0.00	0.00	32.11		36.55	37.12	36.50	39.09	37.36	26.41
Mean	27.24	27.24	27.24		26.99		24.92	26.80	11.31	14.91	16.68	16.68	27.56		29.84	30.78	29.40	30.48	29.66	

1-4Q Ages	IIa	IIIa	IVa	Vb	VIa	VIIa	VIIb	VIIc	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc east	VIIIc west	VIIIc west	Mean
	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.02	0.00	19.57	19.64	15.36	16.41	16.05	5.73
1	0.00	0.00	0.00		0.00	0.00	0.00	0.00	18.26	17.68	17.70	21.32	18.03	0.00	20.58	20.64	18.91	18.13	18.87	10.56
2	24.50	24.50	24.50		24.50	0.00	0.00	24.50	21.51	20.77	20.83	22.81	21.42	0.00	22.59	22.34	22.23	22.48	22.22	18.98
3	28.00	28.00	28.00		24.52	0.00	24.15	25.38	23.75	24.43	24.47	24.33	26.28	0.00	24.02	23.83	23.70	23.55	23.54	22.22
4	27.67	27.65	27.69		26.77	28.50	26.84	26.22	25.98	27.07	26.75	25.56	26.29	25.50	25.43	25.07	25.34	24.57	25.74	26.37
5	28.85	28.86	28.84		28.48	28.58	28.00	28.16	26.74	27.18	27.20	26.16	27.38	26.79	26.34	27.48	27.80	26.90	26.87	27.59
6	29.76	29.77	29.75		29.90	29.27	29.69	28.44	27.85	28.30	28.32	27.12	28.44	29.50	27.67	29.47	29.06	28.55	28.24	28.84
7	30.79	30.79	30.78		31.94	30.74	31.76	31.81	27.96	29.48	29.53	27.57	30.49	29.95	29.19	31.33	30.28	29.68	30.16	30.24
8	32.20	32.28	32.16		32.01	31.50	31.58	30.96	28.67	30.76	30.60	28.57	31.58	30.50	29.46	32.46	31.05	30.41	30.81	30.98
9	32.12	32.11	32.12		32.06	30.50	32.03	32.61	29.76	30.82	29.98	31.38	30.82	0.00	32.50	33.31	31.97	31.82	31.41	29.85
10	32.18	32.22	32.16		32.85	0.00	30.89	32.21	29.13	32.21	31.87	28.50	31.90	0.00	30.15	34.09	32.79	32.69	31.62	28.19
11	32.36	32.34	32.37		34.83	30.50	32.66	31.60	31.44	32.20	31.67	30.49	31.73	35.00	32.03	34.76	33.82	34.35	32.41	32.59
12	33.41	33.41	33.41		34.30	30.88	32.97	32.57	31.39	31.54	31.30	32.38	31.41	31.41	32.69	35.07	34.74	36.25	31.95	32.84
13	33.27	33.31	33.25		35.33	0.00	32.97	32.94	31.69	33.19	32.02	34.50	32.12	33.00	35.21	36.67	35.83	37.35	33.54	32.01
14	35.22	35.31	35.18		36.44	0.00	36.36	33.72	33.68	33.97	33.31	33.31	33.22	33.50	35.79	36.45	35.82	37.54	34.36	32.95
15+	34.70	34.70	34.70		37.77	0.00	35.83	32.12	37.60	34.90	32.41	31.50	33.49	34.00	34.77	36.31	36.38	39.12	36.18	33.14
Mean	27.19	27.20	27.18		27.61		25.36	26.45	26.59	27.16	26.75	26.59	28.16	19.32	28.62	29.93	29.07	29.50	28.37	

Table 5.2.5.3. Western horse mackerel. Stock weights-at-age (kg).

	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.000	0.000	0.050	0.080	0.207	0.232	0.269	0.280	0.292	0.305	0.369	0.352
1983	0.000	0.000	0.050	0.080	0.171	0.227	0.257	0.276	0.270	0.243	0.390	0.311
1984	0.000	0.000	0.050	0.077	0.122	0.155	0.201	0.223	0.253	0.246	0.338	0.287
1985	0.000	0.000	0.050	0.081	0.148	0.140	0.193	0.236	0.242	0.289	0.247	0.306
1986	0.000	0.000	0.050	0.080	0.105	0.134	0.169	0.195	0.242	0.292	0.262	0.342
1987	0.000	0.000	0.050	0.080	0.105	0.126	0.150	0.171	0.218	0.254	0.281	0.317
1988	0.000	0.000	0.050	0.080	0.105	0.126	0.141	0.143	0.217	0.274	0.305	0.366
1989	0.000	0.000	0.050	0.080	0.105	0.103	0.131	0.159	0.127	0.210	0.252	0.336
1990	0.000	0.000	0.050	0.080	0.105	0.127	0.135	0.124	0.154	0.174	0.282	0.345
1991	0.000	0.000	0.050	0.080	0.121	0.137	0.143	0.144	0.150	0.182	0.189	0.333
1992	0.000	0.000	0.050	0.080	0.105	0.133	0.151	0.150	0.158	0.160	0.182	0.287
1993	0.000	0.000	0.050	0.080	0.105	0.153	0.166	0.173	0.172	0.170	0.206	0.222
1994	0.000	0.000	0.050	0.080	0.105	0.147	0.185	0.169	0.191	0.191	0.190	0.235
1995	0.000	0.000	0.050	0.066	0.119	0.096	0.152	0.166	0.178	0.187	0.197	0.233
1996	0.000	0.000	0.050	0.095	0.118	0.129	0.148	0.172	0.183	0.185	0.202	0.238
1997	0.000	0.000	0.050	0.080	0.112	0.124	0.162	0.169	0.184	0.188	0.208	0.238
1998	0.000	0.000	0.050	0.090	0.108	0.129	0.142	0.151	0.162	0.174	0.191	0.215
1999	0.000	0.000	0.050	0.110	0.120	0.130	0.160	0.170	0.180	0.190	0.210	0.222
2000	0.000	0.000	0.050	0.087	0.108	0.148	0.170	0.173	0.193	0.202	0.257	0.260
2001	0.000	0.000	0.070	0.074	0.082	0.100	0.121	0.131	0.142	0.161	0.187	0.268
2002	0.000	0.000	0.050	0.109	0.120	0.135	0.146	0.153	0.177	0.206	0.216	0.275
2003	0.000	0.000	0.050	0.110	0.142	0.139	0.161	0.169	0.169	0.176	0.176	0.206
2004	0.000	0.000	0.050	0.104	0.114	0.127	0.142	0.157	0.168	0.166	0.178	0.213
2005	0.000	0.000	0.085	0.095	0.110	0.141	0.163	0.182	0.197	0.181	0.209	0.243
2006	0.000	0.000	0.085	0.098	0.095	0.113	0.167	0.157	0.164	0.205	0.195	0.229
2007	0.000	0.000	0.085	0.098	0.095	0.118	0.128	0.137	0.168	0.180	0.173	0.181
2008	0.000	0.000	0.085	0.107	0.128	0.142	0.153	0.160	0.169	0.188	0.263	0.217
2009	0.000	0.000	0.085	0.125	0.15	0.177	0.168	0.169	0.205	0.223	0.217	0.316
2010	0.000	0.050	0.070	0.084	0.114	0.149	0.171	0.182	0.187	0.206	0.221	0.268
2011	0.000	0.070	0.075	0.086	0.119	0.151	0.171	0.190	0.203	0.220	0.238	0.278
2012	0.000	0.000	0.085	0.077	0.093	0.138	0.165	0.185	0.207	0.236	0.231	0.274
2013	0.000	0.000	0.085	0.0941	0.135	0.147	0.163	0.218	0.240	0.231	0.249	0.248

Weight at age 3 is the average of the time series 1995-2012.

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

	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0	0	0.40	0.80	1	1	1	1	1	1	1	1
1983	0	0	0.30	0.70	1	1	1	1	1	1	1	1
1984	0	0	0.10	0.60	0.85	1	1	1	1	1	1	1
1985	0	0	0.10	0.40	0.80	0.95	1	1	1	1	1	1
1986	0	0	0.10	0.40	0.60	0.90	1	1	1	1	1	1
1987	0	0	0.10	0.40	0.60	0.80	1	1	1	1	1	1
1988	0	0	0.10	0.40	0.60	0.80	1	1	1	1	1	1
1989	0	0	0.10	0.40	0.60	0.80	1	1	1	1	1	1
1990	0	0	0.10	0.40	0.60	0.80	1	1	1	1	1	1
1991	0	0	0.10	0.40	0.60	0.80	1	1	1	1	1	1
1992	0	0	0.10	0.40	0.60	0.80	1	1	1	1	1	1
1993	0	0	0.10	0.40	0.60	0.80	1	1	1	1	1	1
1994	0	0	0.10	0.40	0.60	0.80	1	1	1	1	1	1
1995	0	0	0.10	0.40	0.60	0.80	1	1	1	1	1	1
1996	0	0	0.10	0.40	0.60	0.80	1	1	1	1	1	1
1997	0	0	0.10	0.40	0.60	0.80	1	1	1	1	1	1
1998	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
1999	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2000	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2001	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2002	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2003	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2004	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2005	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2006	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2007	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2008	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2009	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2010	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2011	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2012	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1
2013	0	0	0.05	0.25	0.70	0.95	1	1	1	1	1	1

Table 5.2.8.1. Western horse mackerel. Potential fecundity (10^6 eggs) per kg spawning female vs. weight in kg.

	1987		1992		1995		1998		2000		2001		2001 (contd)	
	w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.
1	0.168	1.524	0.105	1.317	0.13	1.307	0.172	1.318	0.258	0.841	0.086	0.688	0.165	1.382
2	0.179	0.916	0.109	2.056	0.157	1.246	0.104	0.867	0.268	0.747	0.08	0.812	0.166	1.579
3	0.192	2.083	0.11	1.869	0.168	1.699	0.112	1.312	0.304	1.188	0.081	0.535	0.167	1.479
4	0.233	1.644	0.112	1.772	0.179	1.135	0.206	0.382	0.311	1.411	0.095	0.88	0.113	0.527
5	0.213	1.066	0.115	1.188	0.189	1.529	0.207	0.78	0.337	0.613	0.11	1.164	0.14	0.876
6	0.217	2.392	0.119	1.317	0.168	1.1	0.109	1.133	0.339	1.571	0.113	1.106	0.122	0.589
7	0.277	1.617	0.12	1.413	0.209	1.497	0.132	1.02	0.341	1.522	0.095	0.823	0.12	0.68
8	0.279	1.018	0.123	1.293	0.215	1.524	0.2	1.088	0.355	1.056	0.11	0.883	0.121	0.578
9	0.274	1.62	0.123	1.991	0.218	1.616	0.152	1.417	0.357	0.604	0.108	0.823	0.139	0.723
10	0.3	1.513	0.131	1.617	0.226	1.883	0.149	1.004	0.367	1.15	0.097	0.741	0.144	1.213
11	0.32	1.647	0.135	0.793	0.22	1.324			0.393	1.279	0.101	0.853	0.144	1.265
12	0.273	1.956	0.131	1.039	0.236	1.221			0.393	0.668	0.106	1.133	0.171	0.956
13	0.212	2.83	0.136	1.06	0.261	1.21			0.413	0.694	0.107	0.935	0.121	0.607
14	0.268	1.687	0.138	1.489	0.245	1.445			0.421	1.339	0.107	0.494	0.122	0.689
15	0.32	1.088	0.147	1.214	0.306	1.693			0.423	0.798	0.11	0.85	0.139	0.915
16	0.318	1.208	0.151	1.158	0.314	1.312			0.445	1.03	0.111	0.67	0.153	0.943
17	0.343	1.933	0.16	1.349	0.46	1.575			0.446	1.208	0.103	0.632	0.154	0.709
18	0.378	1.429	0.165	1.359	0.449	1.43			0.152	0.643	0.111	0.547	0.156	0.773
19	0.404	1.849	0.165	0.945					0.165	0.579	0.118	0.88	0.162	1.158
20	0.428	2.236	0.167	1					0.175	0.596	0.107	0.944	0.174	1.389
21	0.398	1.538	0.168	1.545					0.179	0.997	0.104	0.724	0.175	1.426
22	0.431	1.223	0.18	1.299					0.19	0.744	0.111	0.86	0.179	1.248
23	0.432	1.465	0.174	1.487					0.197	0.613	0.11	0.728	0.179	1.236
24	0.421	1.843	0.178	1.594					0.203	0.702	0.111	0.544	0.18	2.353
25	0.481	1.757	0.185	1.475					0.219	0.472	0.129	0.935	0.184	2.255
26	0.494	1.611	0.195	1.41					0.223	0.806	0.114	0.901	0.139	0.931
27	0.54	1.754	0.203	1.937					0.227	0.606	0.114	0.557	0.161	1.037
28	0.564	2.255	0.205	1.534					0.289	1.273	0.151	1.377	0.162	0.893
29	0.585	1.221	0.213	1.577					0.294	1.395	0.153	1.596	0.169	0.691
30			0.222	0.958					0.3	1.305	0.154	1.699	0.18	1.609
31			0.275	2.444							0.103	0.679	0.185	1.776
32											0.12	1.14	0.211	2.102
33											0.12	0.631	0.224	1.466
34											0.121	0.834	0.162	0.849
35											0.144	0.626	0.17	0.668
36											0.116	0.668	0.187	1.453
37											0.118	1.194	0.198	1.371
38											0.112	0.779	0.219	1.847
39											0.126	0.782	0.22	1.578
40											0.139	1.244	0.201	0.878
41											0.119	1.212	0.206	1.196

42	0.109	0.755	0.223	1.115
43	0.122	0.841	0.225	1.43
44	0.131	0.929	0.233	1.724
45	0.135	0.862	0.241	1.131
46	0.142	1.834	0.219	0.96
47	0.146	1.689	0.237	1.33
48	0.148	1.357	0.241	0.918
49	0.151	1.817	0.34	0.605
50	0.164	1.631	0.407	1.189
51	0.164	1.052		

Table 5.3.1.1. Western horse mackerel. Final assessment. Numbers-at-age (thousands).

	0	1	2	3	4	5	6	7	8	9	10	11+
1982	67966200	810830	2034690	3854670	566839	508234	416305	329657	51916.3	58365.8	66774	3291580
1983	525368	58499000	694444	1731720	3192730	477200	425197	347425	275529	43153.1	49851.9	2813630
1984	1544370	452188	50343300	595608	1459980	2698370	396494	324650	250164	220522	34089	2172000
1985	2779520	1329250	389202	43106900	508526	1222950	2183530	320530	243948	183757	176116	1653230
1986	3906540	2392360	1142580	330442	36543100	433552	1013800	1786260	264152	194965	152409	1485790
1987	5209060	3362390	2059120	983428	282978	30825500	365065	812147	1435630	203504	148159	1258090
1988	2001600	4483480	2893940	1771840	846444	240825	25704600	312303	660461	1151410	164266	1126440
1989	2115060	1721980	3833580	2485170	1523090	724458	189682	21250400	257562	531435	928062	1040050
1990	1844010	1820450	1482120	3299590	2119740	1293980	618622	149809	17105900	210510	402342	1530790
1991	3364770	1587150	1547950	1233890	2711090	1767470	1082840	522666	109824	13438400	146851	1350660
1992	6183280	2876940	1334940	1249100	1040650	2140720	1388550	863610	426327	70790.7	10435100	1062740
1993	7327610	5308190	2263100	1115290	1000380	843490	1604950	1077260	697838	349267	39175.4	8770990
1994	7669080	6306890	4467530	1860200	944410	802849	638131	1086990	793049	535028	270286	6579640
1995	4471940	6597420	5372020	2999410	1493720	763568	649556	513277	729649	583768	422652	4904390
1996	2445460	3846530	5525020	4187240	2187730	1085760	602440	474809	408703	400504	391943	3426920
1997	2096320	2094870	3292390	4144300	2805210	1710150	855190	470871	357433	302252	291714	2773600
1998	3506020	1799810	1700890	2402060	2884280	2033500	1245270	625610	286849	182875	158134	1581850
1999	4177640	3016970	1464220	1292850	1614120	2148430	1546470	925788	424742	171283	94070.9	984714
2000	4422700	3581980	2506220	1182600	948633	1142680	1613050	1134170	623113	228896	75347.2	552183
2001	17247600	3806060	3009880	2035480	968967	749903	843543	1230280	811056	412659	139884	401605
2002	3785950	14790700	3211500	2361910	1611210	742657	551426	617543	841052	508990	258727	337151
2003	2788270	3245880	12302700	2652730	1879860	1269580	579419	409835	443919	603029	358932	415369
2004	1458000	2398180	2511980	10045700	2129530	1476890	1010220	445416	310447	336183	432976	565673
2005	959001	1235200	1934020	2059510	8206530	1762350	1175580	804696	342552	237854	243701	739591
2006	808081	824250	1002720	1509920	1484590	6567640	1453220	942810	635413	254514	184036	745040
2007	1355850	693758	663612	826456	1261020	1209270	5187860	1197640	774909	506393	203154	742284
2008	2770940	1162740	562604	534305	668459	1026610	943378	4152930	986226	641330	417158	775806
2009	1172140	2357220	952757	460830	429737	536981	813307	748119	3265080	790982	512492	957942
2010	438369	966041	1914330	773404	366099	340907	419043	635433	578573	2585270	623600	1165940
2011	530138	370993	756871	1498760	584752	276155	250410	308396	459998	435096	1930650	1348850
2012	1493810	455279	291760	594817	1139070	443422	204137	185447	224802	347798	326774	2485060
2013	2378928[1]	1280770	351249	224907	440279	840845	317362	146430	130494	165357	253760	2073830
2014		2015845	975384	267250	163524	319146	588787	222783	100608	94216.4	118308	1685550

1. Age 0 in 2013 is the geometric mean of the time-series 1983 to 2012

Table 5.3.1.2. Western horse mackerel. Final assessment. Fishing mortality-at-age.

	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0.000	0.005	0.011	0.038	0.022	0.028	0.031	0.029	0.035	0.008	0.027	0.027
1983	0.000	0.000	0.004	0.021	0.018	0.035	0.120	0.178	0.073	0.086	0.126	0.126
1984	0.000	0.000	0.005	0.008	0.027	0.062	0.063	0.136	0.159	0.075	0.138	0.138
1985	0.000	0.001	0.014	0.015	0.010	0.038	0.051	0.043	0.074	0.037	0.058	0.058
1986	0.000	0.000	0.000	0.005	0.020	0.022	0.072	0.069	0.111	0.125	0.114	0.114
1987	0.000	0.000	0.000	0.000	0.011	0.032	0.006	0.057	0.071	0.064	0.072	0.072
1988	0.000	0.007	0.002	0.001	0.006	0.089	0.040	0.043	0.067	0.066	0.066	0.066
1989	0.000	0.000	0.000	0.009	0.013	0.008	0.086	0.067	0.052	0.128	0.101	0.101
1990	0.000	0.012	0.033	0.046	0.032	0.028	0.019	0.160	0.091	0.210	0.209	0.209
1991	0.007	0.023	0.065	0.020	0.086	0.091	0.076	0.054	0.289	0.103	0.193	0.193
1992	0.003	0.090	0.030	0.072	0.060	0.138	0.104	0.063	0.049	0.442	0.121	0.121
1993	0.000	0.022	0.046	0.016	0.070	0.129	0.240	0.156	0.116	0.106	0.142	0.142
1994	0.001	0.010	0.248	0.069	0.063	0.062	0.068	0.249	0.156	0.086	0.184	0.184
1995	0.001	0.027	0.099	0.166	0.169	0.087	0.163	0.078	0.450	0.248	0.291	0.291
1996	0.005	0.006	0.138	0.251	0.096	0.089	0.096	0.134	0.152	0.167	0.170	0.170
1997	0.003	0.058	0.165	0.212	0.172	0.167	0.163	0.346	0.520	0.498	0.512	0.512
1998	0.000	0.056	0.124	0.248	0.145	0.124	0.146	0.237	0.366	0.515	0.419	0.419
1999	0.004	0.035	0.064	0.160	0.195	0.137	0.160	0.246	0.468	0.671	0.520	0.520
2000	0.000	0.024	0.058	0.049	0.085	0.154	0.121	0.185	0.262	0.342	0.296	0.296
2001	0.004	0.020	0.092	0.084	0.116	0.157	0.162	0.230	0.316	0.317	0.324	0.324
2002	0.004	0.034	0.041	0.078	0.088	0.098	0.147	0.180	0.183	0.199	0.211	0.211
2003	0.001	0.106	0.053	0.070	0.091	0.079	0.113	0.128	0.128	0.181	0.164	0.164
2004	0.016	0.065	0.049	0.052	0.039	0.078	0.077	0.113	0.116	0.172	0.150	0.150
2005	0.001	0.059	0.098	0.177	0.073	0.043	0.071	0.086	0.147	0.107	0.127	0.127
2006	0.003	0.067	0.043	0.030	0.055	0.086	0.043	0.046	0.077	0.075	0.074	0.074
2007	0.004	0.060	0.067	0.062	0.056	0.098	0.073	0.044	0.039	0.044	0.048	0.048
2008	0.012	0.049	0.050	0.068	0.069	0.083	0.082	0.091	0.071	0.074	0.069	0.069
2009	0.043	0.058	0.059	0.080	0.082	0.098	0.097	0.107	0.083	0.088	0.082	0.082
2010	0.017	0.094	0.095	0.130	0.132	0.159	0.157	0.173	0.135	0.142	0.133	0.133
2011	0.002	0.090	0.091	0.124	0.127	0.152	0.150	0.166	0.130	0.136	0.127	0.127
2012	0.004	0.109	0.110	0.151	0.154	0.184	0.182	0.201	0.157	0.165	0.154	0.154
2013	0.000	0.122	0.123	0.169	0.172	0.206	0.204	0.225	0.176	0.185	0.173	0.173

Table 5.3.1.3. Western horse mackerel. Final assessment. Stock summary table.

	R (age 0) (thousands)	SSB (tons)	TSB (tons)	Catch (tons)	Yield/SSB	F(1-3)	F(4-8)	F(1-10)
1982	67966200	1793500	2065881	61197	0.034	0.018	0.029	0.023
1983	525368	1751440	2012066	90442	0.052	0.008	0.085	0.066
1984	1544370	1578190	4063910	96744	0.061	0.004	0.089	0.067
1985	2779520	2560780	4916190	103843	0.041	0.010	0.043	0.034
1986	3906540	3260710	5167265	145999	0.045	0.002	0.059	0.054
1987	5209060	3825420	5094097	187338	0.049	0.000	0.035	0.031
1988	2001600	4341700	4995857	214729	0.049	0.003	0.049	0.039
1989	2115060	3972900	4756338	296037	0.075	0.003	0.045	0.046
1990	1844010	3381820	4139592	398645	0.118	0.031	0.066	0.084
1991	3364770	3208300	3916191	357288	0.111	0.036	0.119	0.100
1992	6183280	2628440	3182752	394793	0.150	0.064	0.083	0.117
1993	7327610	2451510	3023893	458628	0.187	0.028	0.142	0.104
1994	7669080	2071500	2742362	413022	0.199	0.109	0.119	0.120
1995	4471940	1596110	2366581	538131	0.337	0.097	0.189	0.178
1996	2445460	1452480	2286748	420942	0.290	0.131	0.113	0.130
1997	2096320	1247460	2083908	471700	0.378	0.145	0.273	0.281
1998	3506020	1041410	1594940	326443	0.313	0.143	0.204	0.238
1999	4177640	987174	1440593	298076	0.302	0.086	0.241	0.266
2000	4422700	915603	1299626	196911	0.215	0.044	0.161	0.158
2001	17247600	634577	1094395	212090	0.334	0.065	0.196	0.182
2002	3785950	768187	1288939	194292	0.253	0.051	0.139	0.126
2003	2788270	843833	1842789	190183	0.225	0.076	0.108	0.111
2004	1458000	1019840	2119584	157627	0.155	0.055	0.085	0.091
2005	959001	1443810	2190517	181994	0.126	0.111	0.084	0.099
2006	808081	1447960	1869976	155094	0.107	0.047	0.061	0.060
2007	1355850	1327920	1618848	123408	0.093	0.063	0.062	0.059
2008	2770940	1432300	1710835	143106	0.100	0.056	0.079	0.071
2009	1172140	1506950	1821528	183400	0.122	0.066	0.093	0.083
2010	438369	1209140	1618153	218143	0.180	0.106	0.151	0.135
2011	530138	1099880	1447828	199593	0.181	0.102	0.145	0.129
2012	1493810	955397	1190722	173141	0.181	0.124	0.176	0.157
2013	2378928[1]	772334	964703	160686	0.208	0.138	0.197	0.175
2014		609865						

Note: the final estimate of SSB assumes the same F-at-age as in the preceding year

1. R(age 0) in 2013 is the geometric mean of the time series 1983 to 2012

Table 5.4.1. Western Horse Mackerel. Short term prediction: INPUT DATA

2014	Stock abundance	Natural mortality	Maturity ogive	Prop. Of F before spw.	Prop. Of M before spw.	Weights in the stock	Explotation pattern	Weights in the catch
0	2378928	0.15	0	0.45	0.45	0.000	0	0.033
1	2047562	0.15	0	0.45	0.45	0.023	0.122	0.062
2	975384	0.15	0.05	0.45	0.45	0.082	0.123	0.082
3	267250	0.15	0.25	0.45	0.45	0.086	0.169	0.102
4	163524	0.15	0.7	0.45	0.45	0.116	0.172	0.136
5	319146	0.15	0.95	0.45	0.45	0.145	0.206	0.16
6	588787	0.15	1	0.45	0.45	0.166	0.204	0.182
7	222783	0.15	1	0.45	0.45	0.198	0.225	0.208
8	100608	0.15	1	0.45	0.45	0.217	0.176	0.222
9	94216	0.15	1	0.45	0.45	0.229	0.185	0.239
10	118308	0.15	1	0.45	0.45	0.239	0.173	0.251
11	1685550	0.15	1	0.45	0.45	0.267	0.173	0.295

2015	Stock abundance	Natural mortality	Maturity ogive	Prop. Of F before spw.	Prop. Of M before spw.	Weights in the stock	Explotation pattern	Weights in the catch
0	2378928	0.15	0	0.45	0.45	0.000	0	0.033
1	.	0.15	0	0.45	0.45	0.023	0.122	0.062
2	.	0.15	0.05	0.45	0.45	0.082	0.123	0.082
3	.	0.15	0.25	0.45	0.45	0.086	0.169	0.102
4	.	0.15	0.7	0.45	0.45	0.116	0.172	0.136
5	.	0.15	0.95	0.45	0.45	0.145	0.206	0.16
6	.	0.15	1	0.45	0.45	0.166	0.204	0.182
7	.	0.15	1	0.45	0.45	0.198	0.225	0.208
8	.	0.15	1	0.45	0.45	0.217	0.176	0.222
9	.	0.15	1	0.45	0.45	0.229	0.185	0.239
10	.	0.15	1	0.45	0.45	0.239	0.173	0.251
11	.	0.15	1	0.45	0.45	0.267	0.173	0.295

2016	Stock abundance	Natural mortality	Maturity ogive	Prop. Of F before spw.	Prop. Of M before spw.	Weights in the stock	Explotation pattern	Weights in the catch
0	2378928	0.15	0	0.45	0.45	0.000	0	0.033
1	.	0.15	0	0.45	0.45	0.023	0.122	0.062
2	.	0.15	0.05	0.45	0.45	0.082	0.123	0.082
3	.	0.15	0.25	0.45	0.45	0.086	0.169	0.102
4	.	0.15	0.7	0.45	0.45	0.116	0.172	0.136
5	.	0.15	0.95	0.45	0.45	0.145	0.206	0.16
6	.	0.15	1	0.45	0.45	0.166	0.204	0.182
7	.	0.15	1	0.45	0.45	0.198	0.225	0.208
8	.	0.15	1	0.45	0.45	0.217	0.176	0.222
9	.	0.15	1	0.45	0.45	0.229	0.185	0.239
10	.	0.15	1	0.45	0.45	0.239	0.173	0.251
11	.	0.15	1	0.45	0.45	0.267	0.173	0.295

Table 5.4.2. Western Horse Mackerel Short term prediction single option table. Catch constraint of 133220 t in 2014 and F for 2015 and 2016. = F2013

Year:	2014	F multiplier	0.8785	Fbar:	0.1542				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0	0	0	2378928	0	0	0	0	0
1	0.1072	193496	11997	2047562	47094	0	0	0	0
2	0.1081	92891	7617	975384	79981	48769	3999	43422	3561
3	0.1485	34303	3499	267250	22984	66813	5746	58416	5024
4	0.1511	21335	2902	163524	18969	114467	13278	99962	11596
5	0.181	49169	7867	319146	46276	303189	43962	261235	37879
6	0.1792	89905	16363	588787	97739	588787	97739	507716	84281
7	0.1977	37195	7737	222783	44111	222783	44111	190519	37723
8	0.1546	13409	2977	100608	21832	100608	21832	87721	19035
9	0.1625	13150	3143	94216	21575	94216	21575	81856	18745
10	0.152	15519	3895	118308	28276	118308	28276	103276	24683
11	0.152	221100	65224	1685550	450042	1685550	450042	1471384	392860
Total		781472	133220	8962046	878878	3343489	730560	2905507	635385

Year:	2015	F multiplier	1	Fbar:	0.1755				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0	0	0	2378928	0	0	0	0	0
1	0.122	218711	13560	2047562	47094	0	0	0	0
2	0.123	170420	13974	1583246	129826	79162	6491	70011	5741
3	0.169	109034	11121	753538	64804	188385	16201	163193	14035
4	0.172	29159	3966	198289	23001	138802	16101	120079	13929
5	0.206	20974	3356	121009	17546	114958	16669	97942	14202
6	0.204	39380	7167	229221	38051	229221	38051	195466	32447
7	0.225	79484	16533	423629	83879	423629	83879	357848	70854
8	0.176	23634	5247	157361	34147	157361	34147	135890	29488
9	0.185	11663	2787	74189	16989	74189	16989	63808	14612
10	0.173	10190	2558	68929	16474	68929	16474	59604	14245
11	0.173	197174	58166	1333695	356097	1333695	356097	1153272	307924
Total		909824	138436	9369596	827909	2808331	601099	2417112	517476

Year:	2016	F multiplier	1	Fbar:	0.1755				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
0	0	0	0	2378928	0	0	0	0	0
1	0.122	218711	13560	2047562	47094	0	0	0	0
2	0.123	167912	13769	1559944	127915	77997	6396	68980	5656
3	0.169	174358	17785	1204997	103630	301249	25907	260965	22443
4	0.172	80547	10954	547729	63537	383410	44476	331691	38476
5	0.206	24906	3985	143699	20836	136514	19795	116307	16864
6	0.204	14562	2650	84763	14071	84763	14071	72281	11999
7	0.225	30186	6279	160884	31855	160884	31855	135902	26909
8	0.176	43729	9708	291156	63181	291156	63181	251428	54560
9	0.185	17856	4267	113584	26011	113584	26011	97689	22371
10	0.173	7846	1969	53071	12684	53071	12684	45891	10968
11	0.173	150127	44287	1015463	271129	1015463	271129	878091	234450
Total		930740	129214	9601780	781942	2618092	515503	2259227	444696

Table 5.4.3. Western Horse Mackerel. Short term prediction; single area management option table. OPTION: Catch constraint 133220 t in 2014 (EU TAC). The % TAC change corresponds to the total Western horse mackerel TAC of 135420 t.

2014				
Biomass	SSB	FMult	FBar	Landings
878878	635385	0.8785	0.1542	133220

2015					2016			
TSB	SSB	FMult	FBar	Landings	Biomass	SSB	SSB	TAC
827909	561864	0	0	0	912871	576528	3%	-100%
.	557257	0.1	0.0176	14909	898752	561734	1%	-89%
.	552688	0.2	0.0351	29569	884872	547323	-1%	-78%
.	548157	0.3	0.0527	43987	871227	533286	-3%	-68%
.	543664	0.4	0.0702	58165	857812	519612	-5%	-57%
.	539208	0.5	0.0878	72108	844623	506293	-7%	-47%
.	534789	0.6	0.1053	85820	831657	493319	-8%	-37%
.	530407	0.7	0.1229	99304	818910	480681	-10%	-27%
.	528664	0.74	0.1299	104636	813871	475718	-11%	-23%
.	527361	0.77	0.1351	108611	810115	472030	-12%	-20%
.	526061	0.8	0.1404	112566	806377	468370	-12%	-17%
.	525196	0.82	0.1439	115192	803896	465947	-13%	-15%
.	521751	0.9	0.158	125609	794056	456378	-14%	-7%
.	518328	0.98	0.172	135887	784348	447008	-16%	0%
.	517476	1	0.1755	138436	781942	444696	-16%	2%
.	513238	1.1	0.1931	151051	770032	433317	-18%	12%
.	511552	1.14	0.2001	156039	765324	428848	-19%	15%
.	509453	1.19	0.2088	162227	759484	423327	-20%	20%
.	509034	1.2	0.2106	163458	758321	422232	-21%	21%
.	504865	1.3	0.2282	175661	746808	411433	-23%	30%
.	500731	1.4	0.2457	187662	735488	400913	-25%	39%
.	496631	1.5	0.2633	199467	724358	390666	-27%	47%
.	492564	1.6	0.2808	211077	713415	380683	-29%	56%
.	488532	1.7	0.2984	222496	702655	370958	-32%	64%
.	484533	1.8	0.3159	233727	692076	361484	-34%	73%
.	480567	1.9	0.3335	244775	681673	352254	-36%	81%
.	476634	2	0.351	255641	671445	343263	-39%	89%

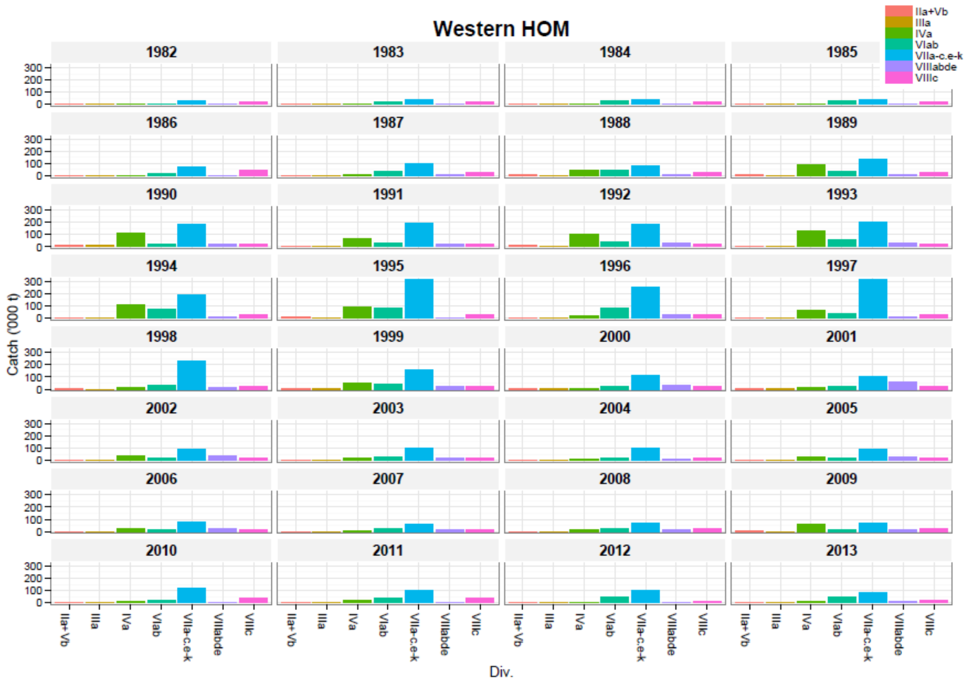

Figure 5.1.3.1. Western horse mackerel. Catch by ICES Division for 1982-2013

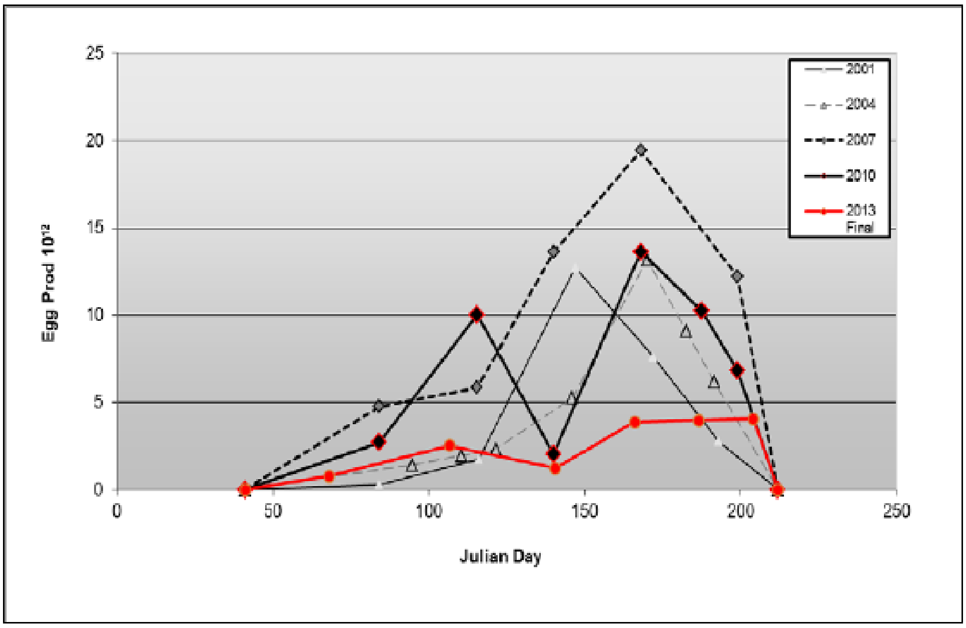

Figure 5.2.1: Western horse mackerel. Provisional annual egg production curve for western horse mackerel. The curves for 2001, 2004, 2007 and 2010 are included for comparison.

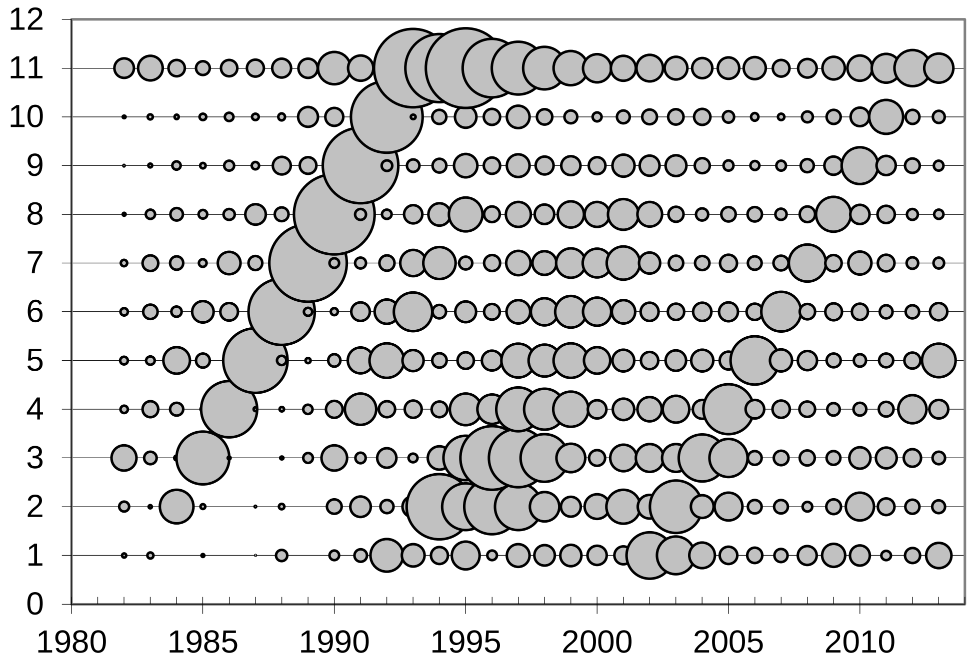

Figure 5.2.4.1: Western horse mackerel. Catch-at-age matrix, expressed as numbers (thousands). The area of bubbles is proportional to the catch number. Note that age 11 is a plus group.

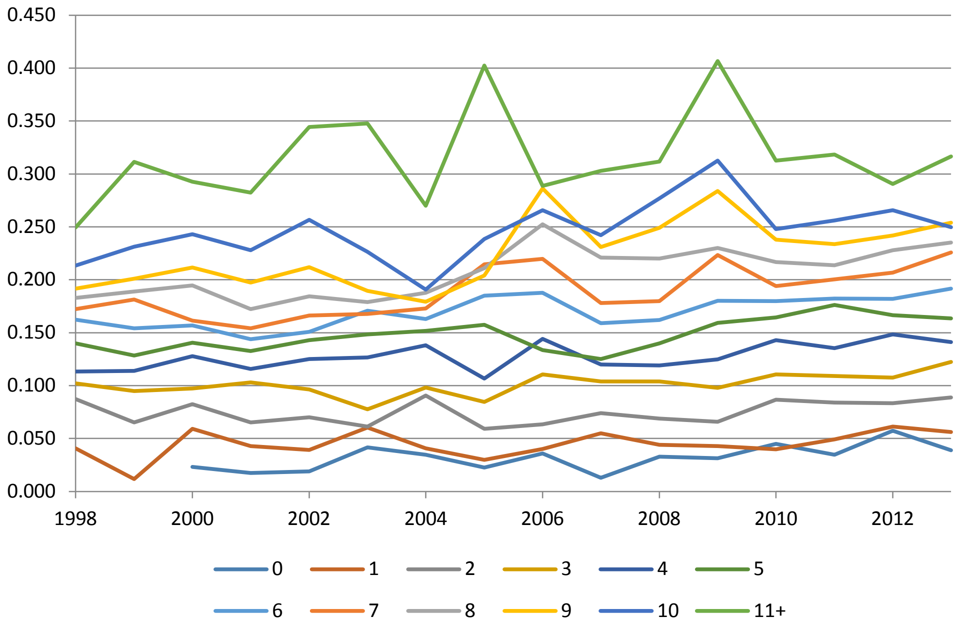

Figure 5.2.5.1: Western horse mackerel. Weight in the catch (kg) by year.

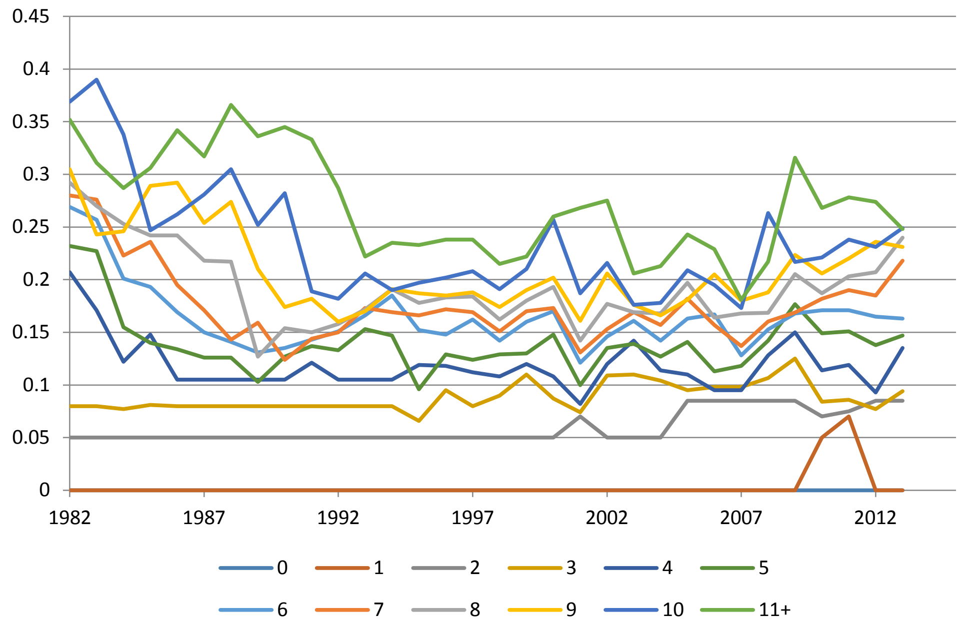

Figure 5.2.5.2: Western horse mackerel. Weight in the stock (kg) by year.

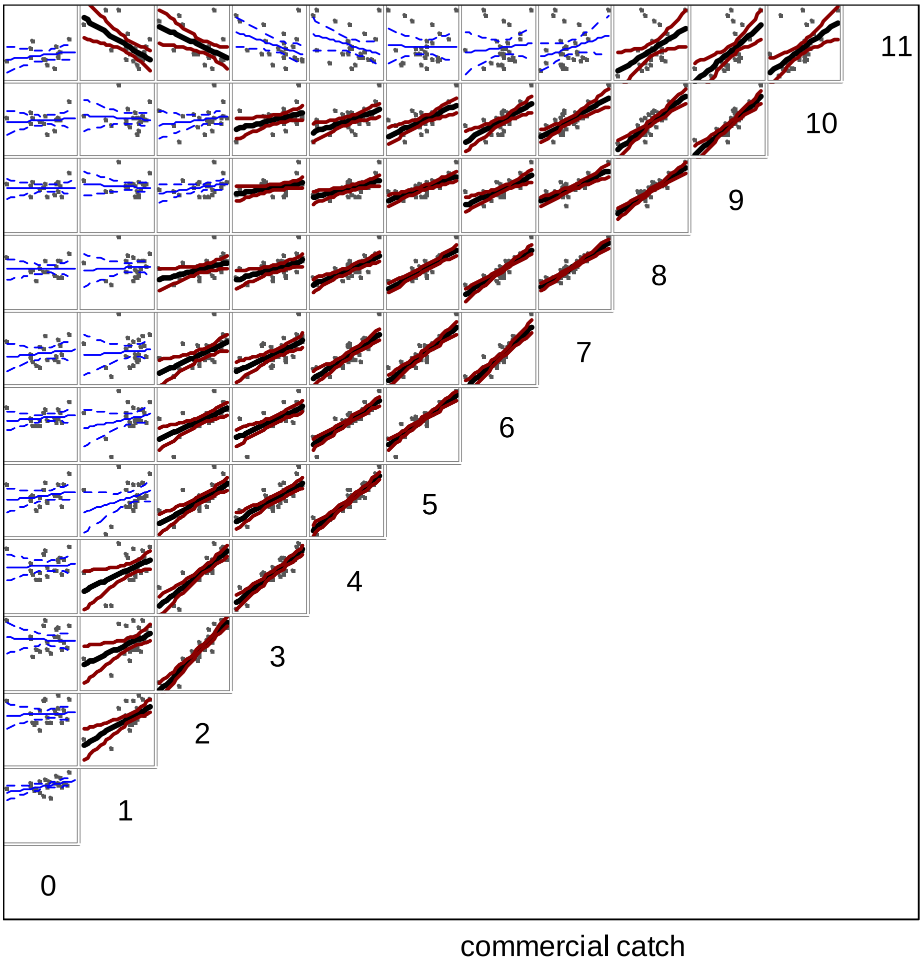

Figure 5.2.9.1: Western horse mackerel. Data exploration. Within-cohort consistency in the catch-at-age matrix, shown by plotting the log-catch of a cohort at a particular age against the log-catch of the same cohort at subsequent ages. Thick lines represent a significant (p<0.05) regression and the curved lines are approximate 95% confidence intervals.

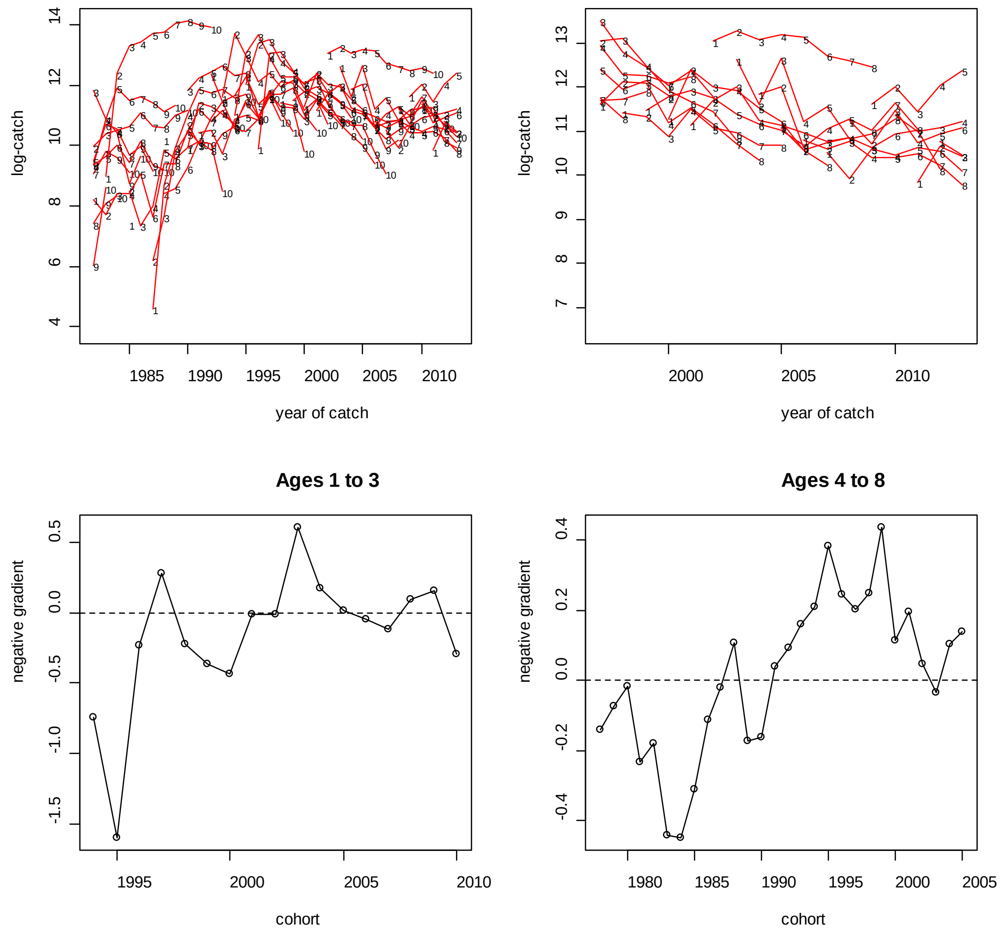

Figure 5.2.9.2: Western horse mackerel. Data exploration. Log-catch cohort curves (top row shows the full time series on the left, and the most recent period for ages 1-8 on the right) and the associated negative gradients for each cohort across the reference fishing mortality of ages 1-3 (bottom left) and 4-8 (bottom right).

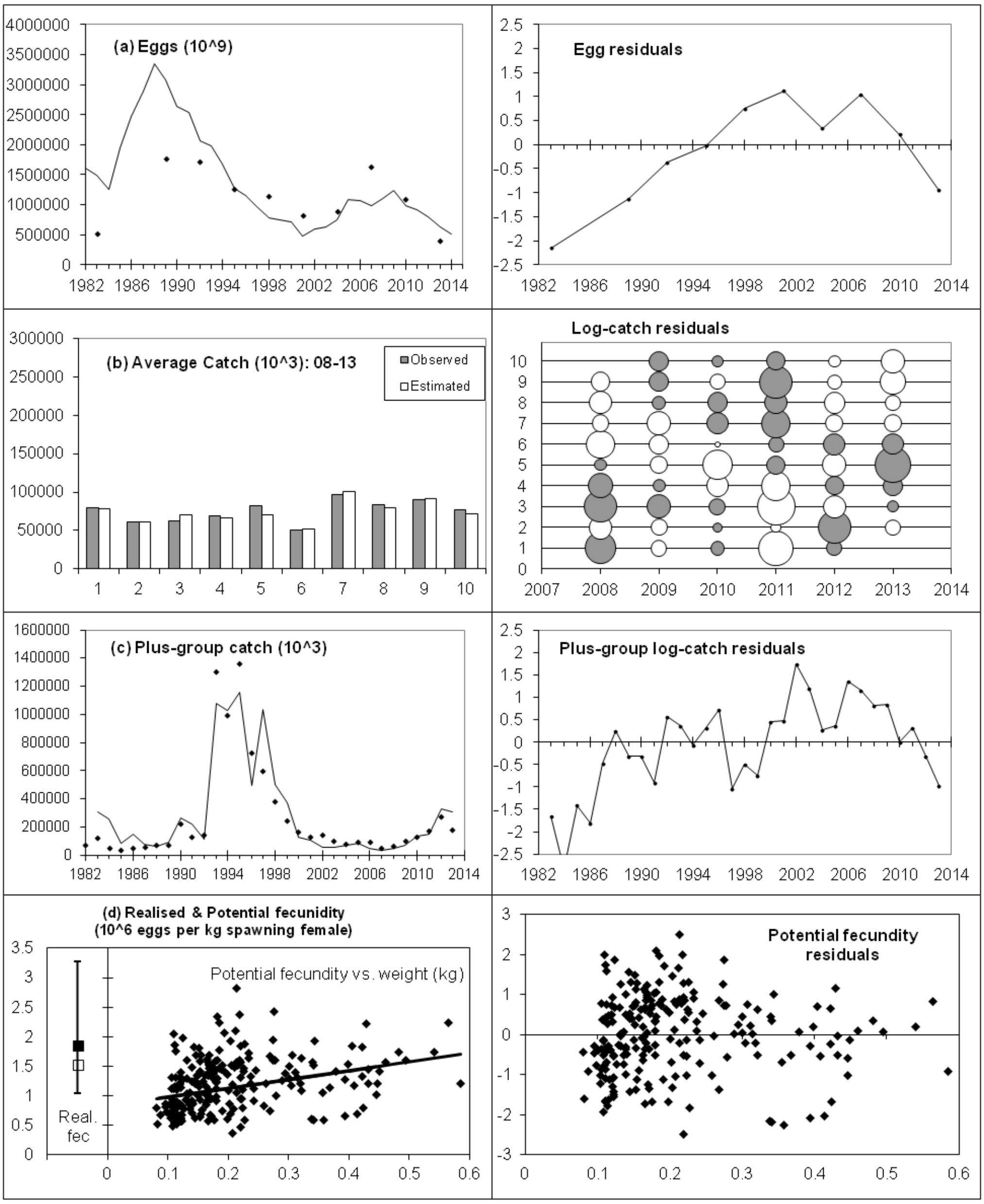

Figure 5.2.10.1: Western horse mackerel. SAD model with 2008-2013 separable window. Model fits to data for the five components of the likelihood, corresponding to (a) the egg estimates, (b) the catches in the separable period, (c) to the catches in the plus-group, and (d) population-mean realised fecundity (left of y-axis) and potential fecundity (right of y-axis). The left-hand column of plots shows the actual fit to the data (average catches are shown in (b) for ease of presentation), and the right-hand column normalised residuals, of the form: ln X – ln X̂ / σ. In the residual plot for (b), the area of a bubble reflects the size of the residual, with the maximum absolute size given in the top right of the plot. In the residual plot for (d), only the potential fecundity residuals are shown (there is only one residual for the population-mean realised fecundity). The final SSB estimate assumes the same fishing mortality as in the previous year.

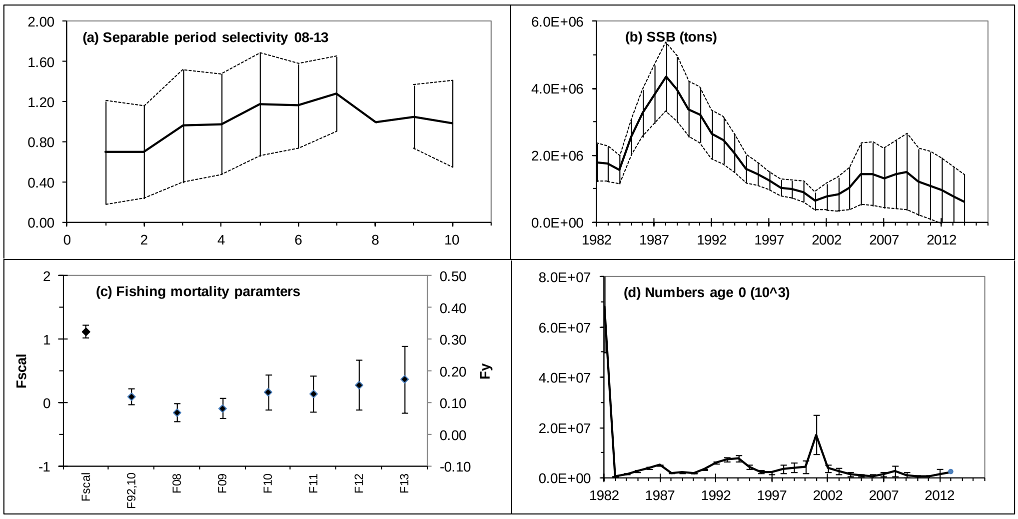

Figure 5.2.10.2: Western horse mackerel. Model with 2008-2013 separable window. Plots of (a) the selectivity pattern, (b) the SSB trajectory, (c) fishing mortality parameters (the scaling parameter F_{scal}, fishing mortality at age 10 in 1992, $F_{92,10}$, and the fishing mortality year effects for the separable period, F_y), and (d) numbers at age 0. The error bars are two standard deviations (indicating roughly 95% confidence bounds). The final SSB estimate assumes the same fishing mortality as in the previous year.

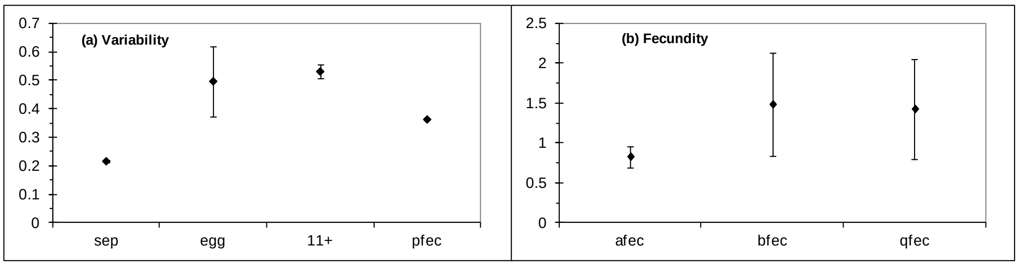

Figure 5.2.10.3: Western horse mackerel. Model with 2008-2013 separable window. Estimates for some key parameters, with (a) corresponding to variability parameters, plotted as standard deviations, for four components of the likelihood (σ_{sep}, σ_{egg}, σ_{11+} and σ_{pfec}), and (b) the fecundity parameters a_{fec}, b_{fec}, q_{fec}. The error bars are two standard deviations (indicating roughly 95% confidence bounds).

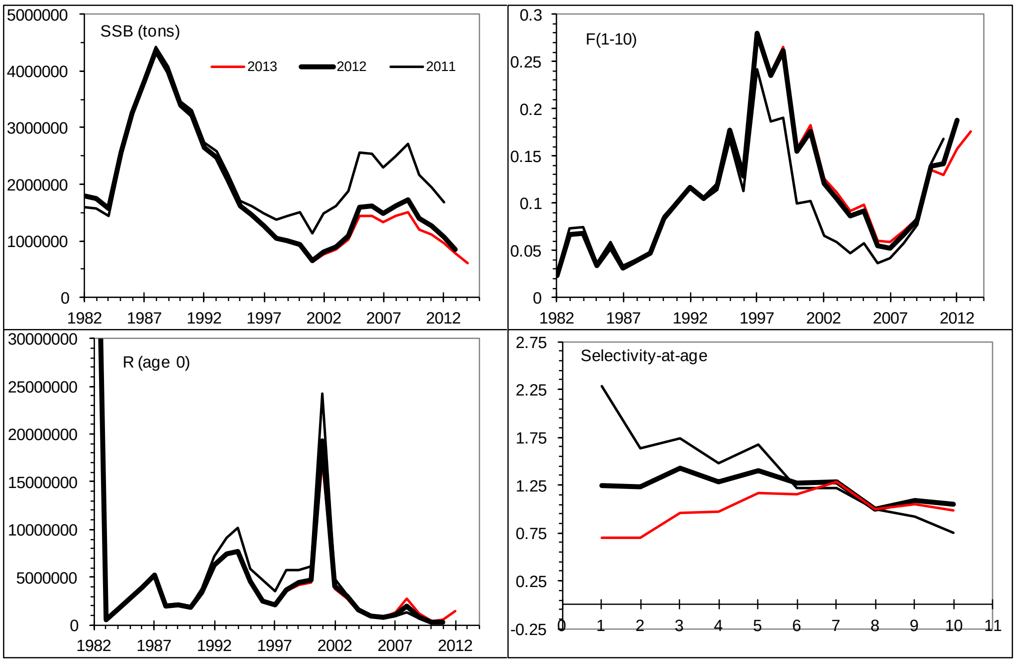

Figure 5.2.10.4: Western horse mackerel. 2-year retrospective bias for the case where the length of the separable window is kept at 6 years (the year shown is the final year shown of the window). Trajectories of SSB, F(1-10), Recruitment (age 0) and selectivity-at-age.

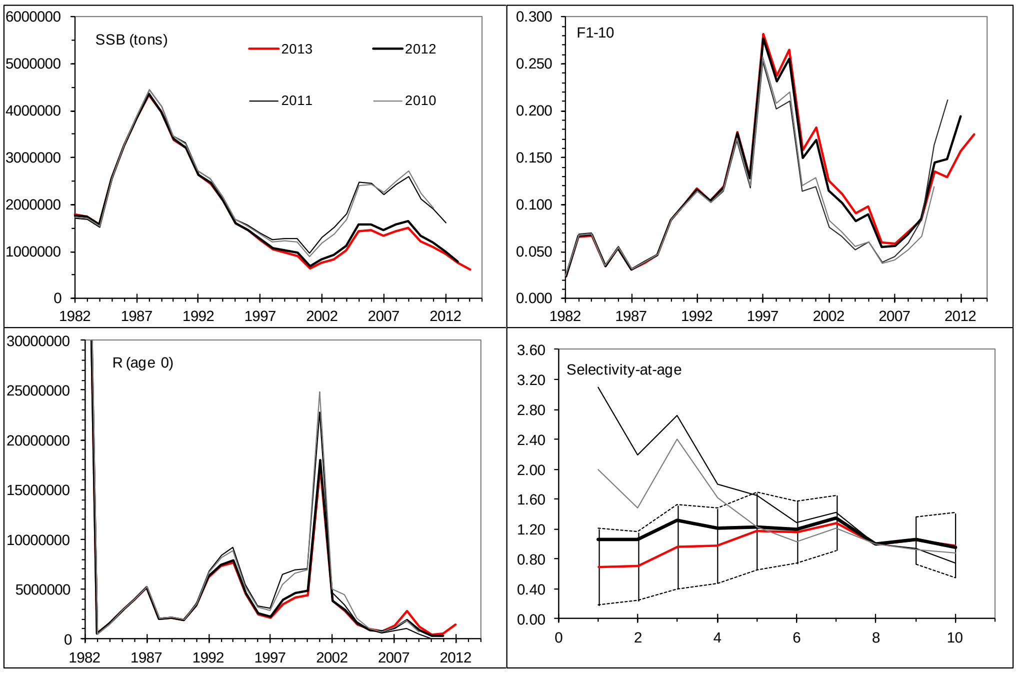

Figure 5.2.10.5: Western horse mackerel. 3-year retrospective bias for the case where the starting year of the separable window is kept at 2008, so that the window decreases in length as more years are dropped (the year shown is the final year of the window). Trajectories of SSB, F(1-10), recruitment (age 0) and selectivity-at-age including confidence bounds from the 2014 assessment.

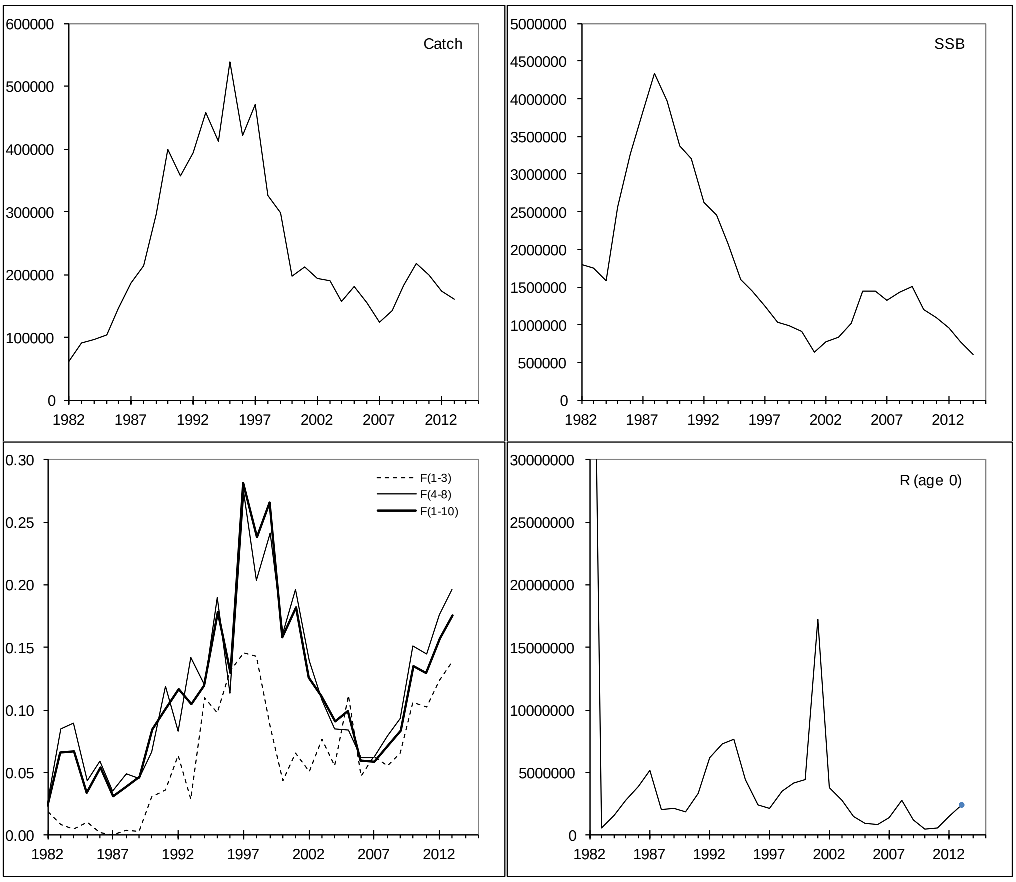

Figure 5.3.1.1: Western horse mackerel. Final assessment stock summary. Plots of catch, SSB, recruitment (age 0) and fishing mortality (average for 1-3, 4-8 and 1-10). SSB and catch are in tons, and recruitment is in thousands. The final SSB estimate assumes the same fishing mortality as in the previous year. Recruitment in 2013 is the geometric mean of the time series excluding 1982.

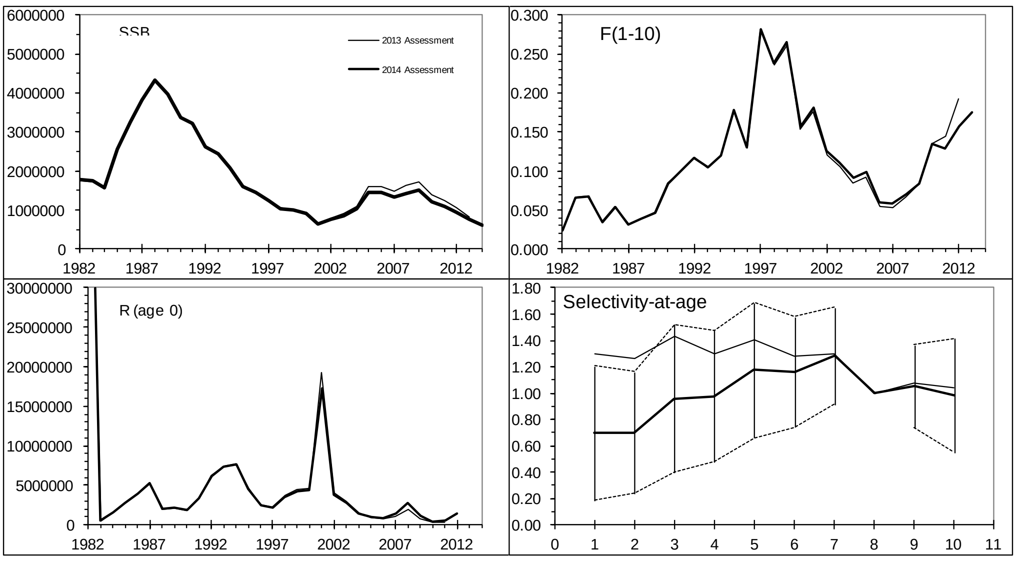

Figure 5.6.1: Western horse mackerel. Comparison of the final assessment this year with that of last year. Plots of SSB, recruitment (age 0), fishing mortality (average for ages 1-10) and selectivity-at-age for the separable period (2007-2012 for the 2013 assessment, and 2008-2013 for the 2014 assessment). SSB values are in tons, and recruitment is in thousands.

6 Northeast Atlantic Boarfish (*Capros aper*)

The boarfish (*Capros aper*, Linnaeus) is a deep bodied, laterally compressed, pelagic shoaling species distributed from Norway to Senegal, including the Mediterranean, Azores, Canaries, Madeira and Great Meteor Seamount (Blanchard and Vandermeirsch, 2005).

Boarfish is targeted in a pelagic trawl fishery for fish meal, to the southwest of Ireland. The boarfish fishery is conducted primarily in shelf waters and the first landings were reported in 2001. Landings were at very low levels from 2001-2005. The main expansion period of the fishery was 2006-2010 when unrestricted landings increased from 2 772 t to 137 503 t. A restrictive TAC of 33 000 t was implemented in 2011. In 2011, ICES was asked by the European Commission to provide advice for 2012. In 2014, ICES is considering this stock for the fourth year.

An analysis of bottom trawl survey data suggests a continuity of distribution spanning ICES Subareas IV, VI, VII, VIII and IX (Figure 6.1). Isolated small occurrences appear in the North Sea (ICES Subarea IV) in some years indicating spill-over into this region. A hiatus in distribution was suggested between ICES Divisions VIIIc and IXa as boarfish were considered very rare in northern Portuguese waters but abundant further south (Cardador and Chaves, 2010), however it is unclear if this suggested hiatus represents a true stock separation. Based on these data, a single stock is considered to exist in ICES Subareas IV, VI, VII, VIII and IXa. This distribution is broader than the current EC TAC area: VI, VII and VIII and for the purposes of assessment in 2014 only data from these areas were utilised. A dedicated study on the stock structure of boarfish within the Northeast Atlantic and Mediterranean Sea commenced in October 2013, the results of which will feed into future assessments.

6.1 The Fishery

6.1.1 Advice and management applicable to 2011, 2012 and 2013

In 2011 a TAC was set for this species for the first time, covering ICES Subareas VI, VII and VIII. This TAC was set at 33 000 t. Before 2010, the fishery was unregulated. In October 2010, the European Commission notified national authorities that under the terms of Annex 1 of Regulation 850/1998, industrial fisheries for this species should not proceed with mesh sizes of less than 100 mm. In 2011, the European Parliament voted to change Regulation 850/1998 to allow fishing using mesh sizes ranging from 32 to 54 mm.

For 2012, ICES advised that catches of boarfish should not increase, based on precautionary considerations. As supporting information, ICES noted that it would be cautious that landings did not increase above 82 000 t, the average over the period 2008-2010, during which the stock did not appear to be overexploited. In 2012 the TAC was set at 82 000 t by the Council of the European Union.

For 2013, ICES advised that catches of boarfish should not be more than 82,000 t. This was based on applying a harvest ratio of 12.2% ($F_{0.1}$, as an F_{msy} proxy). For 2013, the TAC was set at 82 000 t by the Council of the European Union.

For 2014, ICES advised that, based on F_{MSY} (0.23), catches of boarfish should not be more than 133 957t, or 127 509t when the average discard rate of the previous ten years

(6 448t) is taken into account. For 2014 the TAC was set at 127 509t by the Council of the European Union.

By-catch of boarfish in the horse mackerel pelagic fishery is regulated by a provision in the TAC for the latter species. This allows a certain percentage of boarfish, and other species, to be retained and deducted from the horse mackerel quota.

In 2010, an interim management plan was proposed by Ireland, which included a number of measures to mitigate potential bycatch of other TAC species in the boarfish fishery. A closed season from the 15th March to 31st August was proposed, as anecdotal evidence suggests that mackerel and boarfish are caught in mixed aggregations during this period. A closed season was proposed in ICES Division VIIg from 1st September to 31st October, in order to prevent catches of Celtic Sea herring, which is known to form feeding aggregations in this region at these times. Finally, if catches of a species covered by a TAC, other than boarfish, amount to more than 5% of the total catch by day by ICES statistical rectangle, then fishing must cease in that rectangle.

In August 2012 the Pelagic RAC proposed a long term management plan for boarfish. The management plan has not been fully evaluated by ICES. However, in 2013, ICES advised that Tier 1 of the plan can be considered precautionary if a Category 1 assessment is available.

Since 2011, there has been a provision for by-catch of boarfish (also whiting, haddock and mackerel) to be taken from the western and North Sea horse mackerel EC quotas. These provisions are shown in the text table below. The effect of this is that a quantity not exceeding the value indicated of these 4 species combined may be landed legally and subtracted from quotas for horse mackerel.

Year	North Sea (t)	Western (t)
2011	2031	7779
2012	2148	7829
2013	1702	7799
2014	1392	5736

6.1.2 The fishery in recent years

The first landings of boarfish were reported in 2001. Landings fluctuated between 100 and 700 t per year up to 2005 (Table 6.1.2.1). In 2006 the landings began to increase considerably as a target fishery developed. Cumulative landings since 2001 are now in excess of 380 000 t. The fishery targets dense shoals of boarfish from September to March. Catches are generally free from bycatch from September to February. From March onwards a bycatch of mackerel can be found in the catches and the fishery generally ceases at this time. Information on the bycatch of other species in the boarfish fishery is sparse, though thought to be minimal. The fishery uses typical pelagic trawl nets with mesh sizes ranging from 32 to 54 mm. Preliminary information suggests that only the smallest boarfish escape this gear.

From 2001 to 2006 only Ireland reported landings of boarfish. In 2007 UK-Scotland reported landings of less than 1 000 t. Scottish landings peaked at 9 241 t in 2010. Denmark joined the fishery in 2008 and landed 3 098 t. Danish landings then increased to 39 805 t in 2010. In all years the vast majority of catches have come from ICES Division VIIj (Figure 6.2 and Tables 6.1.2.2 and 6.1.2.3). Since 2011 landings have been regulated by TAC.

Previous to the development of the target fishery, boarfish was a discarded bycatch in pelagic fisheries for mackerel in ICES Subareas VII and VIII. A study by Borges *et al*. (2008) found that boarfish may have accounted for as much as 5% of the total catch of Dutch pelagic freezer trawlers. Boarfish are also discarded in whitefish fisheries, particularly by Spanish demersal trawlers (Tables 6.1.2.1 and 6.1.2.4).

6.1.3 The fishery in 2013

In 2013 a total of 69 812 t of boarfish were landed (Tables 6.1.2.1, 6.1.2.2 and 6.1.2.3). Ireland continued to be the main participant (52 250 t), with Denmark taking 13 182 t and Scotland 4 380 t. Forty one Irish registered fishing vessels reported landings with the majority made in Q1 (25 884 t) and Q4 (19 339 t). The Q3 landings of 7 026 t were all made in September. Figure 6.2 shows the majority of the Irish catch was taken in ICES divisions VIIb, g, and j. Scottish pelagic vessels reported landings of boarfish in Q1 (2 547 t), Q3 (468 t) and Q4 (1 365 t) with the majority from VIIh (1 728 t) and VIIj (1 653 t). The 2013 Danish boarfish fishery occurred solely in Q1 in division VIIj (10 873 t), VIIIa (1 356 t), and VIIh (945 t) and was significantly (6 941 t) under quota. The number of Danish vessels participating in the fishery is unknown.

6.1.4 Regulations and their effects

In 2010, the fishery finished early when the European Commission notified member states that mesh sizes of less than 100 mm were illegal. However, in 2011, the European Parliament voted to change Regulation 850/1998 to allow fishing for boarfish using mesh sizes ranging from 32 to 54 mm. The TAC (33 000 t) that was introduced in 2011 significantly reduced landings.

6.1.5 Changes in fishing technology and fishing patterns

The expansion of the fishery in the mid 2000s was associated with developments in the pumping and processing technology for boarfish catches. These changes made it easier to pump boarfish ashore. Efforts are underway to develop a human consumption market and fishery for boarfish. To date the majority of boarfish landings by Danish, Irish and Scottish vessels have been made into Skagen, Denmark and Fuglafjørður, Faroe Islands to be processed into fishmeal. A small number of Irish vessels have landed into Killybegs and Castletownbere, Ireland. These landings into Irish ports are expected to increase with the development of a human consumption fishery

6.1.6 Discards

Discard data were available from Dutch and German pelagic freezer trawlers (van Overzee and van Helmond, 2014; areas not specified) and from Irish demersal fleets. No discard data from the Spanish demersal fleet was available before the 2014 working group meeting so an estimate (average of previous 10 years Spanish discards) was used in the assessment. Table 6.1.2.4 shows available data.

Discards were not obtained from UK or French freezer trawlers, though discard patterns in these fleets are likely to be similar to the Dutch fleet. It is to be expected that discarding occurred before 2003, in demersal fisheries, however it is difficult to predict what the levels may have been. 46 t of boarfish were also discarded by the Portuguese bottom otter trawl fleet in ICES Division IXa in 2013 (Prista et al., 2014).

Discard data were included in the calculation of catch numbers at age. All discards were raised as one métier using the same age length keys and sampling information as for the landed catches. In the absence of better sampling information on discards, this was considered the best approach. This placed the stock in Category A2 for the ICES Advice in October 2013: Discards 'topped up' onto landings calculations. With the introduction of the discard ban in 2015 this stock will now be in A4: Discards known, with discard ban in place in year +1. As such the advice will be given for catch in ICES Advice October 2014.

6.2 Biological composition of the catch

6.2.1 Catches in numbers-at-age

For 2013 catch number-at-age were prepared for Irish, Danish and Scottish landings using the ALK in table 6.2.1.1. This general ALK was constructed based on 814 aged fish from Irish, Danish and Scottish caught samples from 2012. Allocations to unsampled métiers were made according to table 6.2.1.2. In total 62 Irish and 14 Danish samples were collected in 2013, comprising 8 818 and 1 221 fish measured for length frequency, respectively. This equated to one sample per 919 t landed.

ALKs were applied to commercial length-frequency data available for the years 2007-2013 to produce a proxy catch numbers-at-age (Figure 6.2.1.1 and Table 6.2.1.3) (see the stock annex for a description of ALKs prior to 2012). It can be seen that many older fish are still present in catches, though there appears to be a reduction of older ages since 2007. There have been no strong year classes since the 2005 year class, with the possible exception of 2010, now at age 3, although it is too early to say for certain. The modal age from 2007-2011 was 6 and in 2012-2013 it was 7. It should be noted that in WGWIDE 2011 and 2012 the +group for boarfish was 20+. This was reduced to 15+ in WGWIDE 2013 due to potential inaccuracy of the age readings of older fish. Ageing was based on the method that has been validated for ages 0-7 by Hüssy *et al*. (2012a; 2012b). The age range is similar to the published growth information presented by White *et al*. (2011).

6.2.2 Quality of catch and biological data

Table 6.2.1.2 shows the number of samples available per year and allocations that were made to un-sampled métiers (Division*Quarter*Country). Length-frequencies of the international commercial landings by year are presented in Table 6.2.2.1.

Sampling in the early years of the fishery (2006-2009) was sparse as there was no dedicated sampling programme in place. The sampling programme was initiated in 2010 and good coverage of the landings has been achieved since then (Table 6.2.1.2). There is no DCF funded sampling of the fishery and all Irish sampling is industry funded. Irish sampling comprises only samples from Irish registered vessels. Samples are collected onboard directly from the fish pump during fishing operations and are frozen until returning to port, which ensures high quality samples. Each sample consists of approximately 6kg of boarfish. This equates to approximately 150 fish which, given the limited size range of boarfish, is sufficient for determining a representative length frequency. The established sampling target is one sample per 1 000 t of landings per ICES Division, which is also standard in other pelagic fisheries such as mackerel. All fish in each sample are measured to the 0.5cm below for length frequency. Following standard protocols 5 fish per 0.5cm length class are randomly selected from each sample for biological data collection i.e. otolith extraction, measurement to the 1mm below and sex and maturity determination. To date all Irish sample and data processing has been conducted by one person and the quality and consistency can be ensured.

There is no sampling programme in place for Scottish catches.

6.3 Fishery Independent Information

6.3.1 Acoustic Surveys

The Boarfish Acoustic Survey (BFAS) series was initiated in July 2011 and is now in its fourth year. The 2011 survey, the first in the series, was conducted by Marine Institute scientists aboard the Irish pelagic RSW vessel FV "Felucca'' with a towed body system with a calibrated 38 kHz split beam transducer (O'Donnell *et al.*, 2012a). The survey was designed to extend the Malin Shelf Herring Acoustic Survey (MSHAS) conducted aboard the RV "Celtic Explorer" to the south, which increased the range of continuous coverage from approximately 58.5°N to 47.5°N (Figure 6.3.1.1). The 2011 BFAS operated on a 24 hour basis as it was an exploratory survey and the distribution and behaviour of boarfish during this time of year were unknown prior to the survey. The combined surveys resulted in a continuous coverage over 33 days, 90 000 nmi^2 and transect coverage over 4 500 nmi. 24 trawls were sampled and lengths, weights, maturity data, and otoliths of boarfish were collected. In 2011 the total biomass of boarfish in the survey area was estimated at 456 115 t. Estimates of boarfish biomass by category are presented in Table 6.6.4.1 and the spatial distribution of the echotraces attributed to boarfish in each year can be seen in Figure 6.3.1.1.

The text table below explains the categories used to report estimated biomass from all BFASs. Following standard acoustic survey protocols the Total Biomass estimate includes the '*Definitely*', '*Probably*' and '*Mixture*' categories but excludes the '*Possibly*' category.

Category	Definition
Definite	"Definitely" echotraces were identified on the basis of captures of boarfish from the fishing trawls which were sampled directly. Based on the directly sampled schools echotraces were also characterised as definitely boarfish which appeared very similar on the echogram i.e. large marks which showed as very high intensity (red), located high in the water column(day) and as strong circular schools.
Probably	"Probably" was attributed to smaller echotraces that had not been fished but which had similar characteristics to "definite" boarfish traces.
Mixture	"Mixture" was attributed to NASC values arising from all fish traces in which boarfish were contained, based on the presence of a proportion of boarfish in the catch or within the nearest trawl haul. Boarfish were often taken during trawling in mixed species layers during the hours of darkness.
Possibly	"Possibly" was attributed to small echotraces outside areas where fishing was carried out, but which had the characteristics of definite boarfish traces.

In 2012 the survey methodology was refined by switching to daylight only (04:00-00:00) surveying. This change in protocol was a result of the observation during the 2011 BFAS that boarfish shoals were observed to break up during the night (00:00-04:00) and could not be acoustically detected or quantified. The 2012 total biomass estimate was 863 446 t (O' Donnell *et al*., 2012b; Table 6.6.4.1), with the increase partially attributable to the protocol change.

In July 2013 the BFAS series was continued, with the survey being conducted again aboard the FV "Felucca" (O'Donnell *et al.*, 2013). The survey used the same equipment and followed the same protocol as the 2012 survey and the survey track was broadly similar (Figure 6.3.1.1). In total 4,295nmi (nautical miles) of cruise track was undertaken by both vessels over 53 transects relating to a total area coverage of 57,020nmi^2. Transect spacing was set at 15nmi for the *Felucca* and 15 and 7.5nmi for the *Explorer* component. Coverage extended in coastal areas from the c.50m contour to the shelf slope (250m). The survey was carried out from 04:00–00:00 each day. In 2013 thirty three hauls were carried out during the survey, 19 of which contained boarfish. A total of 1,074 boarfish echotraces were identified during the survey. Of this 98% were categorised as '*Definitely*' boarfish, 1.6% as '*Probably*' and 0.3% '*Boarfish in a mixture*'. The total estimated biomass of the survey area was 423 158 t (Table 6.6.4.1).

As no species-specific target strength (TS) previously existed for boarfish, an industry funded project was conducted to model boarfish TS. Samples were collected during the 2011 survey and MRI scans were taken of the swim bladders from the observed size range of boarfish. 3D swimbladder dimensions of each fish sample were used as input to a KRM model. An estimated TS-L relationship of -65.98dB was derived based on model calculations. This TS was used in 2012 to produce biomass estimates for the 2012 and 2011 survey. In 2013 this TS was reviewed and revised to -66.2dB (Fässler *et al.*, 2013; O'Donnell, 2013). This new TS (-66.2dB) was applied to the 2013 survey data and retrospectively to the 2012 and 2011 BFAS survey data for use in the boarfish assessment.

The July 2014 BFAS again comprised acoustic and trawl data recorded from the FV "Felucca" and RV "Celtic Explorer" (Figure 6.3.1.1). Temporal and spatially coverage were almost identical to 2013 and the revised TS was used in the biomass calculation. Twenty one hauls were carried out during the survey, 11 of which contained boarfish. A total of 3 160 boarfish lengths, 1 102 length/weight measurements and 397 otolith were collected during the survey. The total estimated biomass was 187 779 t, 57% less than the 2013 BFAS estimate. Of this total estimate 71% were categorised as 'definitely' boarfish, 27% as 'probably' and 1.4% 'boarfish in a mixture' (Table 6.6.4.1). It should be noted that the higher percentage of '*Probably*' boarfish this year was mainly due to technical difficulties with the trawl gear that prevented sampling of some schools that had all the characterisitcs of '*Definitely*' boarfish. A full breakdown of school categorisation, abundance and biomass by ICES statistical rectangle is available in O'Donnell and Nolan (2014).

The large change in biomass observed between the surveys cannot be easily explained and is no doubt the result of multiple factors (O'Donnell *et al.*, 2013). Expected interannual variation between successive acoustic estimates is in part responsible. However, factors outside survey effects should also be considered including hydrographic conditions and prey availability. As boarfish continue to feed during spawning the availability of prey will also determine spatial distribution of schools locally and clusters of schools at larger scales. If conditions for spawning are not optimum then the prey availability will drive distribution. As the survey covered the same area using the same survey design and good trawl sampling was achieved it is methodologically a replicate of that performed in 2012. However, factors outside of the survey have no doubt influenced the distribution of the stock both in the large scale (how it was distributed over the greater survey area) and at the smaller scale (in terms of schooling behaviour). The latter being directly related to how available boarfish were to the acoustic recording equipment. As no bottom trawl was available during the survey it was not possible to target the seabed within the acoustic dead zone (ADZ) for presence/absence of boarfish. Unquantified sonar observations and off track investigations indicated that echosounder observations were indeed representative of aggregations present in the wider area. This raises the possibility that boarfish could have also been distributed within the ADZ and out of the range of echosounder and midwater trawl sampling.

It should be noted that the survey does not contain the stock fully, given that concentrations of boarfish are likely to be found southward of the survey area as evidenced by both IBTS data and information from the PELACUS survey on the northern Spanish Shelf (Carrera *et al.*, 2013). However, low abundances of boarfish were observed by the IFREMER PELGAS 2014 acoustic survey in the Bay of Biscay (May-June), particularly in northern Biscay (Pettigas *pers. comm.* reported in O'Donnell and Nolan, 2014). Carrera *et al.* (2014) recorded an increase in boarfish abundance on the northern Spanish Shelf but the same length frequency distribution was apparent in 2014 as in the same survey in 2013, just in much greater abundance. The more northern BFAS area is characterised by older, larger fish and if fish had moved south in 2014 it would likely result in a different size range in PELACUS 2014.

6.3.2 International bottom trawl survey (IBTS)

The western IBTS data and CEFAS English Celtic Sea Groundfish Survey were investigated for their utility as abundance indices. An index of abundance was constructed from the following surveys:

- EVHOE, French Celtic Sea and Biscay Survey, (Q4) 1997 to 2013
- IGFS, Irish Groundfish Survey, (Q4) 2003 to 2013
- WCSGFS, West of Scotland, (Q1 and Q4) 1986 to 2013 (no Q4 survey in 2010)
- SPPGFS, Spanish Porcupine Bank Survey, (Q3) 2001 to 2013
- SPNGFS, Spanish North Coast Survey, (Q3/Q4) 1991 to 2013
- ECSGFS, CEFAS English Celtic Sea Groundfish Survey, (Q4) 1982 to 2003

From the IBTS data CPUE was computed as the number of boarfish per 30 minute haul. The abundance of boarfish per year per ICES Rectangle (used for visualisation only) was then calculated by summing the boarfish in a given rectangle and dividing by the total number of hauls in that rectangle. Length frequencies are presented in Table 6.3.2.2 for each survey. The spatial extent of each constituent survey of the IBTS is shown in Figures 6.3.2.1, 6.3.2.2a and 6.3.2.2b. These surveys cover the majority of the observed range of boarfish in the ICES Area (Figure 6.1). Figure 6.3.2.1 also includes the spatial range of the Portuguese Groundfish Survey (1990-2011), however this survey is outside the current EC TAC area and was not included in the index of abundance in 2014.

Anecdotal evidence from the fisheries indicates that from September to March boarfish are found on the shelf in dense shoals often in close proximity to the bottom. These shoals are particularly abundant around the banks in ICES Division VIIj in the Celtic Sea. Therefore boarfish are likely effectively sampled by the demersal gear of the IBTS despite being a pelagic species. However the shoaling nature of the species results in occasional large hauls.

The IBTS appears to give a relative index of abundance, with good resolution between periods of high and low abundance. The main centres of abundance in the survey (Figure 6.3.2.3) correspond to the main fishing grounds (Figure 6.2). Figure 6.3.2.4 shows the signal in abundance, increasing in the 1990s, declining again in the early 2000s, before increasing again. These trends have been reported by (Farina *et al.*, 1997; Pinnegar *et al.*, 2002; Blanchard and Vandermeirsch, 2005). These authors used IBTS and other trawl survey data to show the increased abundance of the species in this area.

The preliminary results of a GAM modelling project of the IBTS data up to 2011, including the Portuguese data, are presented to illustrate the temporal and spatial distribution of boarfish in the ICES Area. A GAM based on the probability of occurrence of boarfish in a surveyed area was developed based on presence absence data from over 13,000 individual fishing hauls in 7 groundfish surveys over a 30 year period (Figures 6.3.2.2a, 6.3.2.2b, 6.3.2.5a and 6.3.2.5b). The GAM models clearly illustrate that boarfish are distributed on the shelf and have a wide area of distribution. In recent years (2003 onwards) there has been an increase in the northerly distribution of boarfish. The depth distribution profile of boarfish within these hauls was also calculated, which shows that boarfish have a depth distribution preference of approximately 100-300m and the probability of occurrence in deeper water decreases sharply (Figure 6.3.2.6). The proportion of each region over which boarfish were distributed per year was also investigated and shows an increasing trend over time (Figure 6.3.2.7). This indicates that the area of spread of boarfish within the surveyed area has increased during the period.

For subsequent surplus production modelling, biomass indices were extracted from each of the IBTS surveys using a delta-lognormal model (Stefánsson, 1996). Many of the surveys exhibited a large proportion of zero tows (Figure 6.3.2.8) with occasionally very large tows, hence the decision to explicitly model the probability of a non-zero tow and the mean of the positive tows. A delta-lognormal fit comprises fitting two generalized linear models (GLMs). The first model (binomial GLM) is used to obtain the proportion of non-zero tows and is fit to the data coded as 1 or 0 if the tow contained a positive or zero CPUE, respectively. The second model is fit to the positive only CPUE data using a lognormal GLM. Both GLMs were fit using ICES rectangle and year as explanatory factor variables. Where the number of tows per rectangle was less than 5 over the entire series, they are grouped into an "others" rectangle. An index per rectangle and year is constructed, according to Stefánsson (1996), by the product of the estimated probability of a positive tow times the mean of the positive tows. The station indices are aggregated by taking estimated average across all rectangles within a year. To propagate the uncertainty, all survey index analyses were conducted in a Bayesian framework using MCMC sampling in WinBUGS (Spiegelhalter *et al.*, 2004; Kéry, 2010).

6.4 Mean weights-at-age, maturity-at-age and natural mortality

Mean weight-at-age was obtained from the ageing studies of Hüssy *et al.* (2012b). These mean weights are presented in the text table below. The variation in weight-at-age is due to small sample size and seasonal variation in weight and maturity stage.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
MW g	0.84	6.65	14.65	19.49	23.71	26.75	33.29	37.73	40.03	47.11	50.24	51.16	62.75	56.44	62.25
Age	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
MW g	68.86	50.52	86.69	77.94	64.56	63.52	75.02	86.05	71.01	76.97	84.42	79.38	-	67.60	52.77

Maturity-at-age was obtained from the ageing studies of Hüssy *et al.* (2012a; 2012b) and the reproductive study by Farrell *et al.* (2012).

Age	0	1	2	3	4	5	6+
Prop mature	0	0	0.07	0.25	0.81	0.97	1

Natural mortality (M) was estimated over the life span of the stock using the method described by King (1995). This method assumes that M is the mortality that will reduce a population to 1% of its initial size over the lifespan of the stock. Based on a maximum age of 31, M is calculated as follows:

M = -ln (0.01) / 31

Following this procedure M = 0.16 year^{-1}. M=0.16 is considered a good estimate of natural mortality over the life span of this boarfish stock, as it is similar to the total mortality estimate from 2007, (Z= 0.19, see Section 6.6.3). Given that catches in 2007 were relatively low, this estimate of total mortality might be considered a good estimate of natural mortality, assuming negligible fishing mortality in previous years.

Similarly, total mortality was estimated from age-structured IBTS data from 2003 to -2006 (years from which data was available for all areas). The total mortality may be considered a good estimate of natural mortality as fishing mortality was assumed to be negligible during this period. Total mortality ranged from 0.09 – 0.2 with a mean of 0.16.

The special review of Chapter 6, in 2012, questioned the validity of a single estimate of M across the entire age range. If an age based assessment is possible in the future, age specific estimates of natural mortality are required. However, the current estimate of M, which covers the whole age range, is considered appropriate in the context of the current situation where age data are used as an indicator approach, rather than as a full assessment method. Given that Z and F are also calculated over the entire (fully selected) range (Section 6.6.3) a single value of M is considered appropriate.

6.5 Recruitment

The IBTS data were explored as indices of abundance of 1 year olds, and 1-5 year olds as a composite recruitment index (Figures 6.5.1 & 6.5.2). The EVHOE and SPNGFS surveys provide the best indices of recruitment as this is where the juveniles appear to be most abundant (Table 6.3.2.2). It appears that recruitment was high in the late 1990s but declined to a low in 2003, before increasing again. However, this apparent dip in recruitment was not observed in the commercial catch-at-age data (Figure 6.2.1.1). Recruitment has fluctuated in recent years with an overall slightly negative slope in the EVHOE and SPNGFS indices since 2010.

6.6 Assessment

In 2012, a new stock assessment method was tested. In 2013 this Bayesian state space surplus production model (BSP; Meyer and Millar 1999) was further developed following reviewers recommendations in 2012. Different applications of a Bayesian biomass dynamic model were run in 2013 incorporating combinations of catch data, abundance data from the groundfish surveys, and the two estimates of biomass (and associated uncertainty) from the acoustic surveys in 2012 and 2013 (see stock annex for more details of the sensitivity runs). The model and settings from the final accepted run in 2013 were used once again in 2014.

6.6.1 Historical literature sources

In the Northeast Atlantic region it is suggested that boarfish have historically undergone fluctuations in abundance. It should be noted that these apparent fluctuations in abundance occurred during periods when fisheries and fishery independent sampling were less widespread that the present day. The primary distribution areas of boarfish, on the Celtic Sea shelf in winter and along the shelf edge in summer, were rarely if ever sampled during this time. Therefore, the observations of peaks in abundance are only related to inshore areas. There is no evidence that boarfish were not also abundant in offshore waters throughout these periods. A literature review of historical sources suggests increases in abundance in the following periods:

- 1840s to 1880s
- 1950s
- Mid 1980s to 1990s

From the 1840s to 1880s large abundances were periodically observed in the western English Channel (Day, 1880-1884; Couch, 1844; Cunningham, 1888). Gatcombe, writing in 1879, stated that they had become an extreme nuisance in trawl fisheries. In the early 1900s boarfish were noted for their sporadic occurrence in the English Channel and were scarce or absent for many years in the area around Plymouth where they had previously been abundant (Cooper, 1952). In the mid 1900s there was another apparent increase in abundance in the English Channel, which Cooper (1952) hypothesised was caused by a 'submarine eagre' that swept shoals of boarfish from submarine canyons in the southern edge of the Celtic Sea onto the continental shelf. There was no sound basis for this untested hypothesis and it is at odds with more reliable survey and fisheries data which indicates boarfish are a shelf species, which migrate to the shelf edge for spawning (see below).

Increases in abundance were observed in the Bay of Biscay, Galician continental shelf waters and the Celtic Sea between the 1980s and 2000 (Farina et al., 1997; Pinnegar *et al.*, 2002; Blanchard and Vandermeirsch, 2005). Based on EVHOE data the relative abundance in the Bay of Biscay was reported to have increased from 0.3% in 1973 to 16% in 2000 resulting in boarfish becoming one of the dominant species in the fish community in this region (Blanchard and Vandermeirsch, 2005).

Based on the above information the external reviewers in 2012 noted the possibility that boarfish was a deep-water species that had undergone a shoreward range extension onto the shelf in the late 1980's. In 2013 this was deemed not to be the case; see stock annex for full descriptions of both arguments.

6.6.2 IBTS Data

The common ALK (Table 6.2.1.5) was applied to the number-at-length data. The length-frequency is presented in Table 6.3.2.2 and the age-structured index in Table 6.6.2.1 and Figure 6.6.2.1. A cohort effect can be seen with those cohorts from the early 2000s appearing weak. This coincides with a decline in overall abundance in the early 2000s. From the mid 2000s onwards recruitment improved as observed in the abundance of 1-5 year olds in the EVHOE and Spanish northern shelf surveys (see section 6.5 and Figures 6.5.1 & 6.5.2). It should be noted however that the IBTS data is measured to the 1.0cm not the 0.5cm. Therefore application of the common ALK to this data must be viewed with caution.

Some of the IBTS CPUE indices displayed marked variability with a large proportion of zero tows and occasionally very large tows (e.g., West of Scotland survey, Figure 6.3.2.8). More southern surveys, displayed a consistently higher proportion of positive tows (Figure 6.3.2.8). The variability of the data is reflected in the estimated mean CPUE indices (Figure 6.6.2.2). The West of Scotland survey index has been increasing since 2000 but is highly uncertain, whereas the estimate indices from the other series are typically less variable (Figure 6.6.2.2). The Spanish North Coast, EVHOE, and Irish Groundfish surveys display broadly consistent trend in periods of overlap. The Spanish Porcupine Bank Survey fluctuates with a peak in 2005, a decrease and a recent increase in the years 2009-2011. The CEFAS English Celtic Sea Groundfish Survey displays a steady increase from the mid-1980s to 2002 with a large but somewhat uncertain estimate in 2003 (Figures 6.6.2.2 and 6.6.2.3). The spatial extent of each survey is shown in Figures 6.3.2.1.

Diagnostics from the positive component of the delta-lognormal fits indicate relatively good agreement with a normal distribution on the natural logarithmic scale (Figure 6.6.2.4). There is an indication of longer tails in some of the surveys (e.g., WCSGFS, SPPGFS).

Pair-wise correlation between the annual mean survey indices varied. The IGFS, EVHOE and SPNGFS displayed positive correlation (Figure 6.6.2.5). The WCSGFS also displayed positive correlation with most other surveys except for a weakly negative correlation with the SPNGFS survey. The SPPGFS and ECSFS displayed slightly negative correlations with EVHOE (Figure 6.6.2.5). Weighting the correlations by the sum of the pair-wise variances resulted in a largely similar correlation structure, though the WCSGFS and SPPGFS were more strongly correlated with the ECSGFS (Figure 6.6.2.6). Note that though some surveys displayed weak or no correlation, we did not a-priori exclude any surveys from the assessment. Sensitivity tests were conducted in 2013, which led to the exclusion of certain surveys as explained in the section 6.6.5.

6.6.3 Pseudo-cohort Analysis

Pseudo-cohort analysis is a procedure where mortality is calculated by means of catch curves derived from catch-at-age from a single year. This is in contrast to cohort analysis, which is the basis of VPA-type assessments. In cohort analysis, mortality is calculated across the ages of a year class, not within a single year. Because only seven years of sampling data were available and owing to the large age range currently in the catches a cohort analysis would only yield information for a very limited age and year range. Therefore, pseudo-cohort analysis was performed to supplement the Bayesian state space model.

Pseudo-cohort Z estimates increased with the rapid expansion of the fishery but decreased in 2011 due to the introduction of the first boarfish TAC (Table 6.6.3.1). By subtracting M (=0.16), an estimate of F was obtained for each year (ages 7-14). This series was revised to represent ages 7-14, rather than 6-14 as in previous years, because in 2013 age 6 boarfish were not fully selected, i.e. age 7 had higher abundance at age.

It can be seen from the text table below that Z ≈ M in 2007, the initial year of the expanded fishery, while F is negligible. F increased to a high of 0.26 in 2012 and has reduced to 0.19 in 2013. There was a weak correlation between catches and pseudo-cohort F ($r^2 = 0.54$). Recent F estimated in this way is above F_{MSY} (0.17) and $F_{0.1}$ (0.13).

Year	Z (7-14)	F (Z-M)	Catch (t)
2007	0.18	0.02	21 576
2008	0.32	0.16	34 751
2009	0.32	0.16	90 370
2010	0.32	0.16	144 047
2011	0.28	0.12	37 096
2012	0.42	0.26	87 355
2013	0.35	0.19	75 409

6.6.4 Biomass estimates from acoustic surveys

The Boarfish Acoustic Survey (BFAS) series was initiated in July 2011 and is now in its fourth year. Due to the change in survey protocol between the 2011 and 2012 acoustic surveys, the 2011 survey is not directly comparable with the others because data was collected during both day and night (24hrs). Three acoustic surveys are therefore appropriate for inclusion in the assessment model: 2012-2014. The revised modelled TS of -66.2dB (Fässler *et al.*, 2013; O'Donnell, 2013) was applied to the 2012 BFAS data to produce a new biomass estimate comparable to 2013 and 2014 (Table 6.6.4.1). This table also includes the CV for each estimate. Over the four years of the survey, biomass has been estimated in the range 187,779t to 863 446 t. The 2014 survey biomass estimate is 57% lower than that in 2013, which was in turn lower than that in 2012. The precision on the estimates has been good, with coefficients of variation in the range 10.7 to 16.7. In all model runs in 2014 the '*Total'* estimate of boarfish biomass was used for all years; see section 6.3.1 for more details and an explanation of the reported categories.

6.6.5 Biomass dynamic model

In 2012 an exploratory biomass dynamic model was developed. This was a Bayesian state space surplus production model (Meyer and Millar, 1999), incorporating the catch data, IBTS data, and acoustic biomass data. This assessment was then peer-reviewed by two independent experts on behalf of ICES. In 2013 a new assessment was provided, which was based on the previous year's work and the reviewers' comments. Details of the review and the associated changes can be found in the stock annex.

In 2014 the Bayesian state space surplus production model (Meyer and Millar, 1999) was again fit using the catch data, delta-lognormal estimated IBTS survey indices, and the acoustic survey estimates. The biomass dynamics are given by a difference form of a Schaefer biomass dynamic model:

$$B_t = B_{t-1} + rB_{t-1}\left(1 - \frac{B_{t-1}}{K}\right) - C_{t-1}$$

where B_t is the biomass at time t, r is the intrinsic rate of population growth, K is the carrying capacity, and C_t is the catch, assumed known exactly. To assist the estimation the biomass is scaled by the carrying capacity, denoting the scaled biomass $P_t = B_t/K$. Lognormal error structure is assumed giving the scaled biomass dynamics (process) model:

$$P_t = \left(P_{t-1} + rP_{t-1}(1 - P_{t-1}) - \frac{C_{t-1}}{K}\right)e^{u_t}$$

where the logarithm of process deviations are assumed normal $u_t \sim N(0, \sigma_u^2)$; σ_u^2 is the process error variance.

The starting year biomass is given by aK, where α is the proportion of the carrying capacity in the first year. The biomass dynamics process is related to the observations on the indices through the measurement error equation:

$$I_{j,t} = q_j P_t K e^{\varepsilon_{j,t}}$$

where $I_{j,t}$ is the value of abundance index j in year t, q_j is survey-specific catchability, $B_t = P_t K$, and the measurement errors are assumed lognormally distributed with ; $\varepsilon_t \sim N(0, \sigma^2_{\varepsilon,j,t})$; where $\sigma^2_{\varepsilon,j,t}$ is the index-specific measurement error variance $\mathrm{Var}(I_{j,t})$ obtained from the delta-lognormal survey fits. That is, the variance of the mean annual estimate per survey is inputted directly from the delta-lognormal fits (Figure 6.6.2.2) as opposed to estimating a measurement error within the assessment. The measurement error is obtained from:

$$\sigma^2_{\varepsilon,j,t} = \ln\left(1 + \frac{\mathrm{Var}(I_{j,t})}{(I_{j,t})^2}\right)$$

For the acoustic survey, the CV of the survey was transformed into a lognormal variance via

$$\sigma^2_{\varepsilon,acoustic,t} = \ln\left(CV^2_{acoustic,t} + 1\right).$$

Prior assumptions on the parameter distributions were:

- Intrinsic rate of population growth: $r \sim U(0.001,2)$
- Natural logarithm of the carrying capacity ln $K \sim U$(ln max(C), ln 10xsum C)=U(ln 144,047t, ln 4,450,407t)
- Proportion of carrying capacity in first year of assessment: $a \sim U(0.001, 1.0)$
- Natural logarithm of the survey-specific catchabilities ln $q_i \sim U(-16,0)$ (for IBTS only). Acoustic survey is discussed below when separate runs are described.
- Process error precision $1/\sigma^2_u \sim$Gamma(0.001,0.001)

Specifications

During the 2013 WGWIDE meeting a number of different iterations of the model were run to discern the best parameters for the assessment. After four initial runs and four sensitivity runs the settings for the final run (run 2.2) were chosen. These settings are shown below and were used for the assessment model in 2014. (More details of the trial runs in 2013 can be found in the stock annex.)

Specifications for final 2013 and 2014 boarfish assessment model; $q_{acoustic}$ is the catchability of the acoustic survey, $I_{acoustic}$ is the acoustic index value used:

Acoustic survey

Years: 2012-2014

$I_{acoustic,year}$: 'Total' in tonnes (i.e. Definitely Boarfish + Probably Boarfish + Boarfish in a Mix)

$q_{acoustic}$: Free but strong prior (i.e. the acoustic survey is treated as a relative index but is strongly informed, this allows the survey to cover <100% of the stock)

IBTS surveys

6 delta log normal indices (WCSGFS, SPPGFS, IGFS, ECSGFS, SPNGFS, EVHOE)

First 5 years omitted from WCSGFS

First 9 years omitted from ECSGFS

- Discards: average of 2003-2013 (6 371t in 2014)

The final run assumes a strong prior ln $q_{acoustic}$ ~ N(1,1/4) (standard deviation of 1/4), which has 95% of the density between 0.5 and 2. Given the short acoustic series (3 years) it is not possible to estimate this parameter freely (using an uninformative prior) but assuming a strong prior removes the assumption of an absolute index from the acoustic survey and will be continually updated as data accrue.

Following plenary discussion of the sensitivity runs in 2013, it was decided that the final run be based on a run that includes all surveys with the omission of the first 5 years of the WCSGFS and first 9 years of the ECSGFS. The reasons for this decision were:

- It is unclear whether boarfish were consistently recorded in the early part of the ECSGFS
- The WCSGFS is thought to be at the northern extreme of the distribution and may not be an appropriate index for the whole stock.
- The SPNGFS commences in 1991 such that running the assessment from 1991 onwards includes at least three surveys without relying solely on the ECSGFS and WCSGFS.
- Surveys are internally weighted such that highly uncertain values receive lower weight.

Run convergence

Parameters for the 2014 model run converged with good mixing of the chains and Rhat values lower than 1.1 indicating convergence (Figures 6.6.5.1, 6.6.5.2). MCMC chain autocorrelation was also low indicating good sampling of the parameter posteriors (Figures 6.6.5.3).

Diagnostic plots are provided in Figures 6.6.5.4 showing residuals about the model fit. A fairly balanced residual pattern is evident. In some cases outliers are apparent, for instance in the English survey in the final year (2003). However, these points are down-weighted according to the inverse of their variance and hence to not contribute much to the model fit. The west of Scotland IBTS survey, located at the northern extreme of the stock distribution underestimates the stock in the early period (years) and overestimates it in the recent period from all fits. This could be indicative of stock expansion into this area at higher stock sizes and suggests that this index is not representative of the whole stock. Figure 6.6.5.5 shows the prior and posterior distributions of the parameters of the biomass dynamic model. The estimate of q is less than 1.0, leading to a higher estimate of final stock biomass than the acoustic survey.

Results

Trajectories of observed and expected indices are shown in Figure 6.6.5.6, along with the stock size over time and a harvest ratio (total catch divided by estimated biomass). Parameter estimates from the model run are summarized in Table 6.6.5.1. F_{MSY} has been recalculated by the model (r/2) as 0.17, down from 0.23 in 2013. Biomass in 2014 is estimated to be 261 003 t, a decrease on the 2013 estimate of 653 668 t. Retrospective plots of TSB and F, presented in Figure 6.6.5.7, show that the model has revised the perception of the stock considerably with the addition of the new data. This revision is in large part due to the low biomass estimate of the 2014 acoustic survey. As the acoustic survey does not span the entire range of the stock, assuming its catchability and treating it as an absolute index is likely incorrect, hence the decision to use a strong prior on the acoustic survey catchability 2013. A free but strong prior, i.e. the acoustic survey is treated as a relative index but is strongly informed), allows the survey to cover <100% of the stock.

Review

ACOM ADGWIDE discussed some aspects of the assessment model as a basis for providing management advice in 2013, and details are available in the minutes of the advice drafting group. The working group provides feedback on these comments below.

ADGWIDE Comment	Response
Two acoustic survey data points and IBTS surveys. Model handles model uncertainty. Recent re-distribution of the stock appears to be the result of increasing abundance. However big decrease in acoustic estimate of abundance between 2012 and 2013. Final model uses strong prior on acoustic survey with q around 1.0.	A strong prior on the acoustic survey index centred on 1.0 is necessary to include this short survey index. As the number of years of the survey increases, the posterior for that catchability will update based on the accruing data. A strong prior allows for the inclusion of this important though short survey. This is somewhat similar to how ICES treated the egg survey in the mackerel assessment for many years. In the early years, the survey was treated as an absolute index (catchability "q" = 1) to allow it to fit. As the series extended this was changed to relative (q was allowed to be estimated). In new survey situations this is the only tenable approach.
Discussion about the validity of using Schaefer model. Reviewers and assessment audit both endorse use of the model. ADG questioned whether there was enough contrast in the catch, biomass and exploitation to properly parameterize production model. Also assumption that K is constant over time series may not be supported. However since reviewers have agreed with approach difficult to reject model.	The short series of catches is of concern. The acoustic survey, however, provides an anchor for the assessment, which would be very difficult to fit otherwise. Time-varying K would be very difficult to estimate given the shortness of the catch series and contrast in exploitation. Alternative formulations of production models, including Pella-Tomlinson could be trialled in future. The assessment as formulated makes the best use of the available data. The acoustic series, though short, is the main piece of information; the short catch series precludes many classical methods, though it does make the estimation of K less reliable; the trawl surveys are included though they would not be easily included in an age structured model, given their temporal asymmetry with the catch series.

Applicability of production model outputs for advice in the MSY context	The application of the HCR based on a production model estimate of BMSY is following the procedure used for several other stocks in the ICES area, including VIa megrim and IXa anglerfish. In these data limited stocks, a production model is used in the ICES MSY generic harvest control rule context.

6.6.6 State of the stock

According to the latest assessment total stock biomass appeared to increase from low levels from the early to mid 1990s (Figure 6.6.5.6). The stock fluctuated around this level until 2009. Biomass then greatly increased to a new level in 2010 and fluctuated around this elevated level until 2012. Since 2012 there has been a sharp decline in the estimated total stock biomass of boarfish in the North East Atlantic. This decline is exacerbated by the downward revision of the modelled perception of the stock with the addition of the latest year's catch and survey data (Figure 6.6.5.7 shows retrospective plots compared to the 2013 assessment). TSB in 2014 (261 003t) is still considerably higher than the proposed B_{lim} but has fallen below the proposed $B_{trigger}$ (Table 6.6.5.1; see section 6.9 for further information on reference points). The uncertainty surrounding the estimates of biomass in the final year are not as high as previous years but there is still a wide 95% credible interval (Table 6.6.5.2), this reflects the uncertainty in the survey indices, and short exploitation history of the stock and the fact that we treat the acoustic survey as a relative biomass index. As more data accumulates from this survey, we expect that the prior will become increasingly updated, and potentially less variable. Reflective of the uncertainty, short-term forecasts are presented with associated probabilities of crossing reference points for given levels of fishing mortality (see Section 6.7).

Catch data are available from 2001, the first year of commercial landings, and reasonably comprehensive discard data are available from 2003. Peak catches were recorded in 2010, when over 140 000 t were taken. Elevated fishing mortality was observed, associated with the highest recorded catch in 2010. Fishing mortality, expressed as a harvest ratio (catch divided by total biomass), was first recorded in 2003. Before that time, it is to be expected that some discarding took place, and there were some commercial landings. Fishing mortality increased measurably from 2006, reaching a peak in 2009 - 2010. F declined in 2011 as catches became regulated by the precautionary TAC but has increased since then in line with the larger TACs. In 2013 F was still below F_{msy}. The considerable catches in recent years do not appear to have significantly truncated the size or age structure of the stock and 15+ group fish are still abundant (Figure 6.2.1.1).

Estimates of recruitment are not available from the stock assessment. However, an independent index of recruitment is available from groundfish surveys (section 6.5). Observations from the survey recruitment of 1 year olds show an overall slightly negative trend since 2010 (Figures 6.5.1 and 6.5.2).

6.7 Short term projections

A short term forecast was performed by projecting the model run forward by one year. However, as there is no recruitment estimate it is not possible to construct a traditional style catch forecast for management purposes. Instead, short term projections over a range of fishing mortality and catch options are provided on a risk based approach. An intermediate year catch constraint was applied (2014 TAC, 127 509 t + average discards of 6 371 t). The population is then projected forward within the assessment under a range of management objectives that included the yield at:

- F_{MSY} = 0.17 based on *r*/2 from model run (Table 6.6.5.1)
- $F_{MP} = B_{2014}\ (F_{MSY} / B_{trigger}) = 0.129$
- $F_{ICES\ HCR} = B_{2015}\ (F_{MSY} / B_{trigger}) = 0.132$
- $F_{0.1}$ = 0.13 based on yield-per-recruit analysis
- F_{lim} = 0.274 based on the F associated with a long-term biomass of *K*/5

(0.2 carrying capacity used for B_{lim})

- F_{pa} = exp(-1.645*CV(TSB_{2014}))*F_{lim} = exp(-1.645*0.381)* 0.367 = 0.146
- C_{2015} = 0 (zero catch option)
- C_{2015} = C_{2014}

Where F_{MP} is the F according to Rule 1.1b in the proposed management plan (section 6.14) and $F_{ICES\ HCR}$ is the reduced F according to the generic ICES harvest control rules.

A forward projection on the risk of the stock falling below B_{msy} ($B_{trigger}$), B_{lim} and fishing mortality exceeding F_{lim} are estimated. Fishing mortality for the fixed catch projections is calculated as -ln(1-C_{2015}/TSB_{2015}). Catch options are presented in Table 6.7.1.

Given that F (0.134) is below F_{MSY} (0.171) but mean total stock biomass in 2014 (261 003 t) is less than $B_{trigger}$ (347 063 t) but greater than B_{lim} (138 825 t) (Tables 6.6.5.1 and 6.6.5.2; section 6.9 for reference points), fishing at a reduced F is required. This reduced F is calculated as $B_{2015}\ (F_{MSY} / B_{trigger})$ and is consistent with the ICES MSY approach. It results in an advised catch of 33 875 t for 2015. There is a high level of uncertainty associated with this F and a wide 95% CI for the biomass in 2016, which is reflected in a 12.9% probability of falling below B_{lim} in 2016 (Table 6.7.1). Fishing at F_{lim} elevates this probability to 17.2%. However, we note that the probability of dropping below B_{lim} even at zero catch is 9.9%, again reflecting the uncertainty of the biomass trajectory.

6.7.1 Yield per Recruit

A yield per recruit analysis was conducted in 2011 (Minto *et al.*, WD 2011) and $F_{0.1}$ was estimated to be 0.13 whilst F_{max} was estimated in the range 0.23 to 0.33 (Figure 6.7.1.1). $F_{0.1}$ was considered to be well estimated (Figure 6.7.1.2). No new yield per recruit analyses were performed in 2012, 2013, or 2014.

6.8 Long term simulations

No long term simulations were conducted.

6.9 Precautionary and yield based reference points

6.9.1 Precautionary reference points

It does not appear that boarfish is an important prey species in the NE Atlantic (Section 6.12). ICES (1997) considered that precautionary F targets (F_{pa}) should be consistent with F<M for prey species, and F = M for non-prey species. This approach would ensure that fishing does not out-compete natural predators for their prey. This would suggest that a good candidate precautionary F_{pa} is F = M = 0.16y^{-1}. This is considered appropriate because boarfish is not an important prey in the NE Atlantic. B_{lim} may be defined from the stock size estimates available from the stock assessment. It is proposed that B_{lim} be set at 0.2* *K*, (0.2 * 694 127 t = 138 825 t), based on the results of model run (Table 6.6.5.1).

6.9.2 Yield based reference points

Yield per recruit analysis, following the method of Beverton and Holt (1957), found $F_{0.1}$ to be robustly estimated at 0.13 (ICES WGWIDE, 2011; Minto et al., WD 2011).

An estimate of F_{msy} is available from the stock assessment model as 0.171.

An estimate of B_{msy} is available from stock assessment model (347 063 t). This is proposed as a conservative basis for MSY $B_{trigger}$.

It should be noted that these values have changed since 2013. The new value is output from the surplus production model, which has revised the perception of the stock after the inclusion of the latest data.

6.10 Quality of the Assessment

This is the second year that a full stock assessment has been conducted for this stock. A considerable amount of data has been collected and analysed. The stock assessment method makes use of all available fisheries independent data, as well as landings and discard data too. Age data have been collected and analysed, but the time series is still too short to be useful for an age-based assessment of this long lived species.

The bottom trawl survey data are considered to be a good index of abundance given that boarfish aggregate on the bottom at this time of year. The trawl surveys record high abundances of the species, but with many zero hauls. The delta-log normal error structure used in the analyses is considered to be a good means of dealing with such data. The biomass dynamic model used in the stock assessment is based on the recent Benchmark of megrim in Sub-divisions IV and VI. The model was further developed by including acoustic survey biomass estimates. One drawback of the model is that it does not provide estimates of recruitment. However, an estimate of recruitment strength is available from the Spanish and French trawl surveys.

Boarfish cannot be considered a data poor stock, and the group considers that the stock assessment is a good indicator of stock status. However, in view of the new and developing nature of the fishery, uncertainty surrounding the final estimates, and considering that the biological information on the stock is constantly being updated, precaution is warranted when considering catch options for 2015.

6.11 Management Considerations

The available data suggests that this is still a large stock. Even accounting for the downward revision of the stock's perception (Figure 6.6.5.7), stock size in 2014 is estimated to be 261 003 t, though at this stage of the development of the assessment absolute estimates of stock size are uncertain. Trends in abundance over time indicate that the stock has increased from very low levels in the 1980s, to high levels in the 1990s. It declined somewhat in the early 2000s and recruitment weakened. The stock increased again in 2010 but has sharply declined from 2012-2014. Total stock biomass in 2014 is below the proposed $B_{trigger}$ (which equals B_{MSY}; Ssection 6.9).

Fishing mortality is estimated to have increased from a negligible rate in 2007 to a peak of 0.216 in 2010 and was 0.134 in 2013. This is lower than F_{MSY}. The large reduction in catch, resulting from the 2011 TAC (75% decrease in landings from 2010) reduced F considerably.

The management plan, proposed by the Pelagic RAC in 2012, has not been fully evaluated by ICES. However ICES advised in 2013 that the HCR in tier 1 of the plan can be considered in accordance with the precautionary approach if a Category 1 assessment is available (ICES, 2013). Though the ICES advice for 2015 will be based on the ICES generic HCR, the WG provides a catch option based on the proposed management plan. Applying tier 1.1b of the proposed plan implies catches in 2015 that are 2% lower than the ICES generic HCR. In order to be faithful to the precautionary approach and FAO guidelines on new and developing fisheries, it is appropriate to obey the signals from the assessment and other indicators and to reduce the catch.

Following the MSY approach implies reducing fishing mortality, where the reduced F from the generic ICES HCR is 0.132. On this basis, the proposed TAC in 2015 would be not more than 33 875 t. Various scenarios and the associated probabilities of attaining reference points are presented in Table 6.7.1.

6.12 Ecosystem considerations

The ecological role and significance of boarfish in the NE Atlantic is largely unknown. However, in the south-east North Atlantic, in Portuguese waters, they are considered to have an important position in the marine food web (Lopes *et al.*, 2006). The diet has been investigated in the eastern Mediterranean, Portuguese waters and at Great Meteor Seamount and consists primarily of copepods, specifically *Calanus helgolandicus*, with some mysid shrimp and euphausiids (MacPherson, 1979; Fock *et al.*, 2002; Lopes *et al.*, 2006). This contrasted with the morphologically similar species, the slender snipefish, *Macroramphosus gracilis* and the longspine snipefish, *M. scolopax*, whose diet comprised *Temora* spp., copepods and mysid shrimps, respectively (Lopes *et al.*, 2006). Despite the obvious potential for these species to feed on fish eggs and larvae, there was no evidence to support this conclusion in Portuguese waters and they were not considered predators of commercial fishes and thus their increase in abundance was unlikely to affect recruitment of commercial fish species (Lopes *et al.*, 2006). If the NE Atlantic population of boarfish is sufficiently large then there exists the possibility of competition for food with other widely distributed planktivorous species.

Both seasonal and diurnal variations were observed in the diet of boarfish in all three regions. In the eastern Mediterranean and Portuguese waters, mysids become an important component of the diet in autumn, which correlates with their increased abundance in these regions at this time (MacPherson, 1979; Lopes *et al.*, 2006). Fock *et al.* (2002) found that boarfish at Great Meteor Seamount fed mainly on copepods and euphausiids diurnally and on decapods nocturnally, indicating habitat dependent resource utilisation.

Boarfish appear an unlikely target of predation given their array of strong dorsal and anal fin spines and covering of ctenoid scales. However, there is evidence to suggest that they may be an important component of some species' diets. Most studies have focused in the Azores and few have mentioned the NE Atlantic, probably due to the relatively low abundance in the region until recent years. In the Azores, boarfish was found to be one of the most important prey items for tope (*Galeorhinus galeus*), thornback ray (*Raja clavata*), conger eel (*Conger conger*), forkbeard (*Phycis phycis*), bigeye tuna (*Thunnus obesus*), yellowmouth barracuda (*Sphyraena viridensis*), swordfish (*Xiphias gladius*), blackspot seabream (*Pagellus bogaraveo)*, axillary seabream (*Pagellus acarne*) and blacktail comber (*Serranus atricauda*) (Clarke *et al*., 1995; Morato *et al*., 1999; Morato *et al*., 2000; Morato *et al*., 2001; Barreiros *et al*., 2002; Morato *et al*., 2003; Arrizabalaga *et al*., 2008). Many of these species also occur in the NE Atlantic shelf waters although it is unknown whether boarfish represent a significant component of the diet in this region.

In the NE Atlantic boarfish have not previously been recorded in the diets of tope or thornback ray (Holden and Tucker, 1974; Ellis *et al*., 1996,). However, this does not prove that they are currently not a prey item. A study of conger eel diet in Irish waters from 1998-1999 failed to find boarfish in the diet (O'Sullivan *et al.*, 2004). However, in Portuguese waters a recent study has found boarfish to be the most numerous species in the diet of conger eels (Xavier *et al*., 2010). It has been suggested that boarfish are an important component of the diet of hake (*Merluccius merluccius*), as they are sometimes caught together. However, a recent study of the diet of hake in the Celtic Sea and Bay of Biscay did not report any boarfish in the stomachs of hake caught during the 2001 EVHOE survey (Mahe *et al.*, 2007).

The conspicuous presence of boarfish in the diet of so many fish species in the Azores is perhaps more related to the lack of other available food sources than to the palatability of boarfish themselves. Given the large abundance in NE Atlantic shelf waters it is likely that they would have been recorded more frequently if they were a significant and important prey item.

Boarfish are also an important component of the diet a number of sea birds in the Azores, most notably the common tern (*Sterna hirundo*) and Cory's shearwater (*Calonectris diomedea*) (Granadeiro *et al*., 1998; Granadeiro *et al*., 2002). This is surprising given that in the Mediterranean discarded boarfish were rejected by seabirds whereas in the Azores they were actively preyed on (Oro and Ruiz, 1997). Cory's shearwaters are capable of diving up to 15 m whilst the common tern is a plunge-diver and may only reach 2-3 m. It is therefore surprising that boarfish are such a significant component of their diet given that it is generally considered a deeper water fish. In the Azores boarfish shoals are sometimes driven to the surface by horse mackerel and barracuda where they are also attacked by diving sea birds (J. Hart, CW Azores, pers. comm.). Anecdotal reports from the Irish fishery indicate that boarfish are rarely found in waters shallower than 40 m. This may suggest that they are outside the range of shearwaters and gannets, the latter having a mean diving depth of 19.7±7.5 m (Brierley and Fernandes, 2001). However, the upper depth range of boarfish is within maximum diving depth recorded for auks (50 m) as recorded by Barrett and Furness (1990). Given their frequency in the diets of marine and bird life in the Azores, boarfish appear to be an important component of the marine ecosystem in that region. There is currently insufficient evidence to draw similar conclusions in the NE Atlantic.

The length-frequency distribution of boarfish may be important to consider. IBTS data shows an increase in mean total length with latitude (Table 6.3.2.2) and perhaps the smaller boarfish in the southern regions are more easily preyed upon. Length data of boarfish from stomach contents studies of both fish and sea birds in the Azores indicate that the boarfish found are generally < 10 cm (Granadeiro *et al*., 1998; Granadeiro *et al*., 2002).

6.13 Changes in the environment

Studies are underway to investigate if the increase in abundance of boarfish in the 1990s and 2000s is related to changes in the environment. Blanchard and Vandermeirsch (2005) attributed the increase in abundance of boarfish in the EVHOE survey during this time to a concurrent increase in water temperature during the spawning season which may have enhanced recruitment.

The reproductive biology of the species goes some way to supporting and developing this theory. Evidence suggests that the boarfish is an asynchronous batch spawner with indeterminate fecundity (Farrell *et al*., 2012). Given suitable conditions (i.e. suitable temperature and abundant prey) boarfish are capable of spawning repeatedly over an extended period of time. In aquarium conditions, spawning has been observed daily for males and every 2-3 days for females over a period of nine consecutive months. Natural conditions are more variable and Farrell *et al.* (2012) indicated that spawning was restricted to the summer months with a peak in July. Spawning had ceased by September and remaining oocytes were resorbed at this time.

If conditions remain favourable for an extended period of time in a particular year then boarfish are likely to continue spawning, possibly leading to enhanced recruitment. Analysis of length at age data showed recruitment to have a positive correlation with adult growth the previous year for the Spanish north coast survey index only, and that complex climate related mechanisms are responsible for the boarfish stock expansion in the Northeast Atlantic (Coad et al. 2014).

6.14 Proposed management plan

A management plan has been proposed by the Pelagic RAC. This management plan has not yet been fully evaluated by ICES. However, ICES identifies that Tier 1 of the proposed plan coincides with the ICES generic approach to giving advice for data-rich situations. Given that a Category 1 assessment is now being used for advice, ICES recommends that Tier 1.1 of the plan be considered consistent with the PA and MSY approaches for as long as a Category 1 assessment is available (ICES, 2013). This plan is presented below.

The TAC setting rules 1.1-1.6 shall apply. Precedence is in decreasing order from Rule 1.1. These are shown in the table below. The decision year for TAC setting is the last year in the assessment, and not the TAC year.

Rule	Assessment	Uncertainty	Condition	Procedure
1.1.a	SSB and F	Low	SSB > Btrigger	Ftarget
1.1.b			SSB < Btrigger	SSB * (Ftarget / Btrigger)
1.2.a	SSB and F	Higher	SSB > Btrigger	Ftarget
1.2.b			SSB < Btrigger	SSB * (Ftarget / Btrigger) * G
1.3.a	F	Any	F < Ftarget	Reference TAC * G
1.3.b			F > Ftarget,	RTAC + (-RTAC / Flim-Fpa)*(F-Fpa) * G
1.4.a	U	Any	U > Upa, TAC =	Reference TAC * G
1.4.b			U < Upa, TAC =	U * (Reference TAC / Upa) * G
1.5.	Survey biomass	Any	TAC y,q3,4 = TACy+1, q1 =	ASB * 1-exp-F0.1_ * G * 0.62 ASB * 1-exp-F0.1_ * G * 0.38
1.6	None		No information on stock status and no risk of recruitment impairment	TAC = 33,000 t (interim management plan TAC)

SSB = Spawning stock biomass, F = Fishing mortality in units per year, U = Fisheries independent abundance index, from IBTS survey, C = Commercial catch in tonnes, TSB = Total stock biomass in tonnes

Notwithstanding Paragraph 1, if in the opinion of ICES, the stock is at risk of recruitment impairment, a TAC shall be based on advice given by ICES, and at a lower level than provided for in Paragraph 1, rules 1.1 to 1.6.

Closed seasons, closed areas and moving on procedures shall apply to all directed boarfish fisheries as follows:

i) A closed season shall operate from 15th March to the 31st August. This is because it is known that herring and mackerel are present in these areas and may be caught with boarfish.

ii) A closed area shall be implemented inside the Irish 12 mile limit south of 52°30 from 12th February to 31st October, in order to prevent catches of Celtic Sea herring, known to form aggregations at these times.

iii) If catches of other species covered by TAC, amount to more than 5% of the total catch by day by ICES statistical rectangle, then all fishing must cease in that rectangle for 5 consecutive days.

6.15 References

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Table 6.1.2.1. Boarfish in Subareas VI, VII, VIII. Landings, discards and TAC by year (t), 2001–2013. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	Ireland	Denmark	Scotland	Total landings	Estimated Discards	Total Catch incl. Discards	TAC
2001	120	0	0	120	NA	120	-
2002	91	0	0	91	NA	91	-
2003	458	0	0	458	10929	11387	-
2004	675	0	0	675	4476	5151	-
2005	165	0	0	165	5795	5959	-
2006	2772	0	0	2772	4365	7137	-
2007	17615	0	772	18387	3189	21576	-
2008	21585	3098	0.45	24683	10068	34751	-
2009	68629	15059	0	83688	6682	90370	-
2010	88457	39805	9241	137503	6544	144047	-
2011	20685	7797	2813	31295	5802	37096	33000
2012	55949	19888	4884	80720	6634	87355	82000
2013	52250	13182	4380	69812	5598	75409	82000

Table 6.1.2.2 Boarfish in ICES Subareas VI, VII, VIII. Landings by year (t), 2001–2013 and Subarea where available. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

	Denmark	Ireland	Scotland	Total
2001	0	120	0	120
2002	0	91	0	91
2003	0	458	0	458
VI		65		65
VII		393		393
2004	0	675	0	675
VI		292		292
VII		345		345
VIII		38		38
2005	0	165	0	165
VI		10		10
VII		117		117
VIII		38		38
2006	0	2772	0	2772
VI		21		21
VII		2750		2750
VIII		1		1
2007	0	17615	772	18386
V		6		6
VI		93		93
VII		17510	772	18282
VIII		5		5
2008	3098	21584	0	24683
VI		28	0	28
VII		21557		21557
2009	15059	68629	0	83688
VI		45		45
VII		68584		68584
2010	39805	88457	9241	137503
VI		1355	10	1365
VII	39805	87101	9231	136138
2011	7797	20685	2813	31295
VI		26		26
VII	7779	20659	2813	31251
VIII	18			
2012	19888	55949	4884	80720
VI		125		125
VII	18283	55731	4884	78898
VIII	1604	93		1697
2013	13182	52250	4380	69811
VI		538	15	553
VII	11828	50572	4365	66764
VIII	1354	1140		2494
Total	**98829**	**329449**	**22090**	**450367**

Table 6.1.2.3. Boarfish in ICES Areas VI, VII, VIII. Landings by year (t), 2001–2013 and subarea where available. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	Denmark	Ireland	Scotland	Total
2001	0	120	0	120
2002	0	91	0	91
2003	0	458		458
VIa		65		65
VIIb		214		214
VIIj		179		179
2004	0	675	0	675
VIa		292		292
VIIb		224		224
VIIId		38		38
VIIj		122		122
2005	0	165	0	165
VIa		10		10
VIIb		105		105
VIIIa		38		38
VIIj		12		12
2006	0	2772	0	2772
VIa		21		21
VIIb		15		15
VIIg		375		375
VIIIa		1		1
VIIj		2360		2360
2007	0	17615	772	18386
Vb2		6		6
VIa		93		93
VIIb		1259		1259
VIIg		120		120
VIIIa		5		5
VIIj		16131	772	16903
2008	3098	21584	0	24683
VIa		28	0	28
VIIb		3		3
VIIg		184		184
VIIj		21370		21370
2009	15059	68629	0	83688
VIa		45		45
VIIb		73		73
VIIc		1		1
VIIg		4912		4912
VIIh		18225		18225
VIIj		45372		45372

Table 6.1.2.3 continued.

Year	Denmark	Ireland	Scotland	Total
2010	39805	88457	9241	137503
VIa		1349	10	1359
VIaS		7		7
VIIb		2258		2258
VIIc		35	4	39
VIIe	2			2
VIIg	672	3649		4321
VIIh	1465	8453	1712	11629
VIIj	37667	72707	7515	117889
2011	7797	20685	2813	31295
VIa		26		26
VIIb		274		274
VIIc		9		9
VIIg		811		811
VIIh	4155	8540	2813	15508
VIIIa	18			18
VIIj	3624	11025		14648
2012	19888	55949	4884	80720
VIa		125		125
VIIb	80	4501	838	5419
VIIc		108	907	1015
VIIg		616		616
VIIh	5837	10579	3139	19554
VIIIa	1604	93		1697
VIIj	12366	39928		52294
2013	13182	52250	4380	69811
VIa		538	15	553
VIIb		10405	100	10505
VIIe			883	883
VIIg		1808		1808
VIIh	955	11355	1728	14038
VIIIa	1354	870		2224
VIIId		270		270
VIIj	10873	27003	1653	39529
Total	98829	329449	22090	450367

Table 6.1.2.4. Boarfish in ICES Areas VI, VII, VIII. Discards of boarfish in demersal and non-target pelagic fisheries by year (t), 2003–2013. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	Germany	Ireland	Netherlands	Spain	Total
2003		119	1998	8812	10929
2004		60	837	3579	4476
2005		55	733	5007	5795
2006		22	411	3933	4365
2007		549	23	2617	3189
2008		920	738	8410	10068
2009		377	1258	5047	6682
2010		85	512	5947	6544
2011	49	107	185	5461	5802
2012		181	88	6365	6634
2013	22	47	11	5518*	5598

***No Spanish discard data received prior to WG. Estimated (mean 2003-2012)**

Table 6.2.1.1. Boarfish in ICES Subareas VI, VII, VIII. General boarfish age length key produced from 2012 commercial samples. Figures highlighted in grey are estimated.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
7	1	1													
7.5	1	1													
8		1													
8.5		1	1												
9		1	1												
9.5			1												
10			1												
10.5			2	10	3										
11			1	29	14	2	2								
11.5				9	21	21	18	2	2	1					
12				4	17	22	38	12	8						1
12.5					5	9	42	37	14	6	2		1	1	1
13					2	4	31	28	24	12	6	2	3	1	5
13.5					1	3	25	22	21	14	6	5	4	2	11
14							6	8	18	22	8	3	7	1	20
14.5						1	1	2	3	8	1	6	6	6	30
15							1	1		2	2	2	5	2	19
15.5										2				2	19
16															8
16.5															1
17															1
17.5															1
18															1
18.5															1

Table 6.2.1.2. Boarfish in ICES Subareas VI, VII, VIII. Sampling intensity by country of commercial landings.

			DK				IRL				SCT			
Year	Q	Area	Landings	Samples	Measured	Allocated	Landings	Samples	Measured	Allocated	Landings	Samples	Measured	Allocated
2007	1	VIa					12	0	0	VIIj_Q2 and VIa_Q4				
	1	VIIIa					5	0	0	VIIj_Q2 and VIa_Q4				
	1	VIIj					5253	0	0	VIIj_Q2 and VIa_Q4	772	0	0	Irish 2007 combined
	2	VIIg					120	0	0	VIIj_Q2 and VIa_Q4				
	2	VIIj					4130	2	197	VIIj_Q2 and VIa_Q4				
	3	VIIb					0	0	0	VIIj_Q2 and VIa_Q4				
	4	Vb2					6	0	0	VIIj_Q2 and VIa_Q4				
	4	VIa					82	1	20	VIIj_Q2 and VIa_Q4				
	4	VIIb					1259	0	0	VIIj_Q2 and VIa_Q4				
	4	VIIj					6748	0	0	VIIj_Q2 and VIa_Q4				
	Total		0	0	0		17615	3	217		772	0	0	
2008	1	VIa					5	0	0	VIIj_Q4				
	1	VIIg					184	0	0	VIIj_Q4				
	1	VIIj					5041	0	0	VIIj_Q4				
	2	VIIj					46	0	0	VIIj_Q4				
	3	VIIj					4067	0	0	VIIj_Q4				
	4	VIa					23	0	0	VIIj_Q4	0.5	0	0	Irish 2008 combined
	4	VIIb					3	0	0	VIIj_Q4				
	4	VIIj					12216	1	152	VIIj_Q4				
	Total		3098	0	0		21584	1	152		0.5	0	0	
2009	1	VIIb					55	0	0	VIIj_Q3				
	1	VIIg					2979	0	0	VIIj_Q3				
	1	VIIh					1971	0	0	VIIj_Q3				
	1	VIIj					10901	2	359	VIIj_Q3				
	2	VIIg					1933	0	0	VIIj_Q3				
	2	VIIh					3169	0	0	VIIj_Q3				
	2	VIIj					2727	0	0	VIIj_Q3				
	3	VIIh					10378	0	0	VIIj_Q3				
	3	VIIj					11423	1	175					
	4	VIa					45	0	0	VIIj_Q4				
	4	VIIb					18	0	0	VIIj_Q4				
	4	VIIh					2707	0	0	VIIj_Q4				
	4	VIIj					20321	6	941					
	Total		15059	0	0		68629	9	1475		0	0	0	
2010	1	VIa									10	0	0	Irish 2010 VIIb_Q1
	1	VIIb					1069	1	102					
	1	VIIg	577	1	77		2392	0	0	VIIj_Q1				
	1	VIIh	1079	0	0	VIIg+VIIj_Q1	326	1	94					
	1	VIIj	32422	2	193		34466	12	1447		2504	0	0	Irish 2010 VIIj_Q1
	2	VIIh					102	0	0	VIIh_Q3				
	2	VIIj	344	0	0	VIIj_Q1								
	3	VIIg					338	0	0	VIIh_Q3				
	3	VIIh	377	0	0	VIIh_Q4	5540	8	1316		548	0	0	Irish 2010 VIIh_Q3
	3	VIIj	2660	0	0	VIIj_Q4	11531	31	3275		2171	0	0	Irish 2010 VIIj_Q3
	4	VIa					1355	1	117					
	4	VIIb					1189	0	0	VIIj_Q4				
	4	VIIc					35	0	0	VIIj_Q4	4	0	0	Irish 2010 VIIj_Q4
	4	VIIe	2	0	0	VIIh_Q4								
	4	VIIg	94	0	0	VIIh+VIIj_Q4	920	0	0	VIIh_Q4				
	4	VIIh	9	3	384		2484	6	715		1165	0	0	Irish 2010 VIIh_Q4
	4	VIIj	2241	2	217		26710	27	2738		2840	0	0	Irish 2010 VIIj_Q4
	Total		39805	8	871		88457	87	9804		9241	0	0	

Table 6.2.1.2 continued.

			DK				IRL				SCT			
Year	Q	Area	Landings	Samples	Measured	Allocated	Landings	Samples	Measured	Allocated	Landings	Samples	Measured	Allocated
2011	1	VIIb					39	0	0	VIIj_Q4				
	1	VIIh	32	0	0	VIIh_Q4								
	1	VIIIa	18	0	0	VIIh_Q4								
	1	VIIj	1	0	0	VIIj_Q4	38	0	0	VIIj_Q4				
	2	VIIb					1	0	0	VIIj_Q4				
	3	VIIh					820	0	0	VIIh_Q4	434	0	0	Irish 2011 VIIh_Q4
	3	VIIj					1092	0	0	VIIj_Q4				
	4	VIa					26	0	0	VIIj_Q4				
	4	VIIb					235	0	0	VIIj_Q4				
	4	VIIc					9	0	0	VIIj_Q4				
	4	VIIg					811	0	0	VIIj_Q4				
	4	VIIh	4123	11	1347		7720	3	319		2379	0	0	Irish 2011 VIIh_Q4
	4	VIIj	3623	5	611		9894	8	1789					
	Total		7797	16	1958		20685	11	2108		2813	0	0	
2012	1	VIIb					4365	3	339					
	1	VIIg					616	0	0	IRL_Q3_VIIh				
	1	VIIh	3789	1	150	IRL_Q3_VIIh	1005	0	0	IRL_Q3_VIIh				
	1	VIIj	11403	3	102	IRL_Q1_VIIj	27812	42	4987					
	1	VIIIa	1330	2	214	IRL_Q3_VIIh								
	2	VIIh	208	0	0	IRL_Q3_VIIh								
	3	VIIb					49	0	0	IRL_Q1_VIIb				
	3	VIIh					3176	5	682		1537	0	0	IRL_Q3_VIIh
	3	VIIj					834	2	341					
	4	VIa					125	1	96					
	4	VIIb	80	0	0	IRL_Q1_VIIb	87	0	0	IRL_Q1_VIIb	838	0	0	IRL_Q1_VIIb
	4	VIIc					108	0	0	IRL_Q1_VIIb	907	0	0	IRL_Q1_VIIb
	4	VIIh	1840	4	445	IRL_Q4_VIIh	6398	7	945		1602	0	0	IRL_Q4_VIIh
	4	VIIIa	274	0	0	IRL_Q4_VIIj	93	0	0	IRL_Q4_VIIh				
	4	VIIj	963	2	180	IRL_Q4_VIIj	11281	8	1175					
Total			19888	12	1091		55949	68	8565		4884	0	0	
2013	1	VIa					370	0	0	IRL_Q1_VIIb	15	0	0	IRL_Q1_VIIb
	1	VIIb					8314	15	2037		100	0	0	IRL_Q1_VIIb
	1	VIIe									883	0	0	IRL_Q1_VIIh
	1	VIIg					1443	0	0	IRL_Q1_VIIh				
	1	VIIh	955	0	0	IRL_Q1_VIIh	1319	1	113		828	0	0	IRL_Q1_VIIh
	1	VIIIa	1354	3	369		100	1	147					
	1	VIIj	10873	11	852		14338	21	2984		721	0	0	IRL_Q1_VIIj
	3	VIIb					11	0	0	IRL_Q4_VIIb				
	3	VIIg					46	0	0	IRL_Q3_VIIh				
	3	VIIh					2307	3	480					
	3	VIIIa					770	0	0	IRL_Q3_VIIh				
	3	VIIj					3892	2	436		468	0	0	IRL_Q3_VIIj
	4	VIa					167.262	1	123					
	4	VIIb					2080	2	198					
	4	VIIg					320	0	0	IRL_Q4_VIIh				
	4	VIIh					7729	10	1467		901	0	0	IRL_Q4_VIIh
	4	VIIId					270	0	0	IRL_Q4_VIIh				
	4	VIIj					8773	6	833		464	0	0	IRLQ4_VIIj
Total			13182	14	1221		52250	62	8818		4380	0	0	

Table 6.2.1.3. Boarfish in ICES Subareas VI, VII, VIII. Proxy catch numbers-at-age of the international catches (raised numbers in '000s) for the years 2007-2013.

	2007	2008	2009	2010	2011	2012	2013
1	0	0	1575	2415	0	28	301
2	352	5488	15043	11229	2894	893	7148
3	2114	21140	65744	72709	41913	5467	156680
4	40851	105575	338931	294382	28148	41278	58522
5	48915	141300	475619	567689	30116	110272	59797
6	62713	195339	543707	878363	175696	146582	68949
7	26132	104031	307333	522703	143967	492078	302967
8	29766	66570	172783	293719	107126	365840	250341
9	56075	53159	155477	276672	77861	271916	212318
10	44875	46893	130148	232122	60022	173486	160137
11	14019	15289	42521	78588	46079	69396	63025
12	32359	21178	61350	114600	40468	40968	41490
13	4848	11854	39609	59932	24352	58888	59380
14	16837	13570	31569	59060	19724	30277	30355
15+	109481	112947	196967	349320	157707	217260	239366

Table 6.2.2.1. Boarfish in ICES Subareas VI, VII, VIII. Length-frequency distributions of the international catches (raised numbers in '000s) for the years 2007-2013.

TL (cm)	2007	2008	2009	2010	2011	2012	2013	Total
6	0	0	0	156	0	0	0	156
6.5	0	0	0	439	0	0	0	439
7	0	0	0	1090	522	56	52	1719
7.5	0	0	1354	1574	0	0	551	3479
8	0	0	677	375	1345	185	1419	4000
8.5	0	0	0	1082	0	555	3592	5229
9	0	0	677	5382	851	555	7263	14727
9.5	0	7473	17367	7883	7012	641	47509	87884
10	9609	11209	54130	29410	33243	2791	94702	235094
10.5	0	52308	174796	130889	15848	6132	59833	439807
11	84555	63517	343283	361774	70615	24571	18359	966675
11.5	0	59781	321637	655875	93487	81928	20938	1233646
12	44199	119561	297737	739025	189434	264888	98564	1753408
12.5	0	70990	207739	564347	114904	398772	204868	1561619
13	82633	52308	147965	353484	133539	419060	315063	1504052
13.5	0	29890	149314	246146	51235	307533	285688	1069806
14	117224	22418	105782	224611	50857	176710	210137	907739
14.5	0	14945	71273	127711	25309	89726	105571	434534
15	65338	33627	47816	125463	25569	52791	62175	412778
15.5	0	11209	13082	81386	5473	25065	31122	167337
16	13452	11209	19397	24256	4181	13149	14990	100634
16.5	0	3736	4061	6209	2280	2738	4918	23942
17	0	3736	677	1913	456	827	1109	8718
17.5	0	0	0	0	0	0	407	407
18	0	0	0	283	0	0	296	579
18.5	**0**	**0**	**0**	**0**	**0**	**0**	592	592

Table 6.3.2.2 Boarfish in ICES Subareas VI, VII, VIII. IBTS length-frequency data.

WCSGFS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML mature	Total	Total mature
1986								1													8.0		1	0
1987								1	1	2	1										9.7	10.2	4	3
1988				1																	4.0		1	0
1989							1														7.0		1	0
1990				1		1	1	2	24	55	50	43	12	1							10.7	11.1	188	160
1991						1	1	9	38	183	267	317	48	16							11.2	11.3	877	829
1992						1		10	39	468	1145	4001	1627	486							12.0	12.1	7775	7726
1993							4		3	9	60	155	73	16		1					12.0	12.1	319	313
1994									1	1	1			1							11.0	11.7	2	2
1995									8	37	194	294	398	199	22						12.5	12.5	1150	1143
1996				2		4	3				1	55	610	1575	304						13.8	13.8	2553	2544
1997			4			1	7	9	4	6	25	109	203	157	41	4					12.9	13.1	568	544
1998				1		1	5	2		1	2		3								8.8	11.8	15	6
1999			1			2	5	1	1		1	2	1								8.2	12.0	14	4
2000							2	2	39	110	216	288	183	93	46	6					12.0	12.1	983	940
2001		1						1	4	15	28	59	134	240	103	10	4				13.5	13.6	599	593
2002						1	8	2	1	82	742	3211	5601	5772	1497	167	1				13.2	13.3	17085	17073
2003			1				3	52		53	281	1473	3066	4895	3083	309	28				13.7	13.8	13244	13188
2004				1			2	2	43	82	743	4569	8600	9514	5693	948	84				13.6	13.6	30280	30232
2005		2					24	3	23	25	110	435	1085	1708	792	130	6				13.6	13.7	4343	4291
2006		1	2	1		1	4		10	218	232	452	1396	2853	2051	435	72				13.9	13.9	7726	7707
2007			2	2		2	1	3	21	159	780	2923	5194	6888	5283	1523	116				13.8	13.8	22897	22866
2008		1	1			16	37	36	187	468	1395	3213	9893	22758	18399	6288	575	71			14.1	14.2	63338	63060
2009			1			1		5	53	2443	2093	441	331	287	246	129	10				11.2	11.2	6038	5979
2010											530	1443	1384	1357	828	149	29				13.2	13.2	5720	5720
2011		1	4	1		1	5	254	1015	2034	7613	18918	14479	6445	2006	237	23				12.4	12.4	53034	51753
2012			1			1	2		103	9	1267	6545	26337	29361	27333	15857	1505	497			14.2	14.2	108817	108710
2013				1			1			1	143	3201	15282	11288	3935	858	6	1			13.5	13.5	34716	34714
SPPGFS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**ML**	**ML mature**	**Total**	**Total mature**
2001		2		2	2	4		88	10	104	266	323	1334	2259	460	81					13.3	13.5	4934	4827
2002									1	4	90	212	791	843	313	60					13.5	13.5	2314	2313
2003						1		3	15	22	21	62	268	426	249	51	2	1			13.8	13.8	1121	1102
2004		1				5	2		4	5	18	100	312	483	319	43	1				13.8	13.9	1293	1281
2005		1		1	6	1	18	10	9	14	7	101	530	935	705	226	18				14.0	14.2	2581	2536
2006			1	1	6	91	89	21	34	75	27	45	335	670	555	197	10	1			13.3	14.1	2158	1914
2007					3	4	9	15	12	9	27	25	72	151	144	26	4				13.4	13.9	501	458
2008		1				1	13	7	16	13	55	106	237	457	302	78	5				13.7	13.8	1292	1254
2009		6	5		2	7	8	1		1	154	318	924	1201	1172	324	7				13.9	14.0	4130	4101
2010	1			1	5	14	3	1	5	2	31	284	521	717	459	123	10				13.7	13.8	2178	2148
2011								3	16	18	5	147	671	792	429	122	13		2		13.8	13.8	2220	2200
2012				1	1			2	2	1	8	70	369	468	218	66	3				13.8	13.9	1208	1202
2013				1		7	22	6	9		1	42	435	889	480	141	12	1			14.0	14.1	2045	2000
IGFS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**ML**	**ML mature**	**Total**	**Total mature**
2003		1	32	22	7	22	129	172	879	2942	2322	1325	3822	4628	2898	896	163	38			12.7	13.0	20299	19035
2004		23	63	34	8	96	532	1431	369	344	410	2253	4320	4698	3966	1017	87	2	1		12.9	13.7	19654	17098
2005		8	59	52	20	203	1024	585	288	636	341	3463	11457	11348	7955	1744	382	2	1		13.4	13.7	39569	37330
2006	5	60	68	48	35	212	969	621	2046	4190	8044	7946	24208	42119	32168	12296	2454	532			13.7	13.9	138021	133957
2007	1	6	44	18	31	501	923	1251	1638	1166	2510	3581	8275	10740	7093	1934	92				12.9	13.5	39804	35391
2008			26	18	23	127	672	531	2095	13780	17664	19268	16980	19484	15953	8789	1747	76	1		12.8	12.9	117231	113741
2009		3	80	76	25	94	228	486	1000	1139	9081	7749	5138	6921	5592	1084	68	1			12.5	12.8	38763	36772
2010		6	42	3	18	199	272	463	920	393	7914	34236	28611	16063	8161	1974	433				12.8	12.9	99709	97784
2011		6	14	5	4	189	772	586	555	670	2578	20171	22082	10829	5298	2207	266	9	6		12.9	13.0	66247	64116
2012		7	36	20	10	131	271	378	702	2144	1183	11105	34010	22742	10906	3903	525	4			13.3	13.4	88077	86521
2013	1	3	9	9	20	127	352	340	1321	2833	3971	15572	51637	52868	20485	6560	492	20			13.5	13.5	156620	154439
EVHOE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**ML**	**ML mature**	**Total**	**Total mature**
1997		5	11	7	17	197	2659	5020	3719	3598	4429	12065	16651	7198	3455	501	18	1			11.8	12.7	59548	47915
1998		1	4	26	76	2093	18283	8631	6125	5966	7095	11730	14078	9260	5076	934	8			1	10.6	12.6	89387	54148
1999			13	52	33	245	11177	26610	23947	6684	2899	4709	7868	6160	1353	267	7				9.5	12.3	92023	29947
2000		17	79	120	8	1504	26894	17674	9836	21967	16382	29585	36853	16522	5397	989	75				10.8	12.2	183903	127769
2001		1	45	687	489	913	21297	37171	13276	28355	31514	18309	12232	6471	3186	1270	81	4			10.0	11.5	175303	101422
2002		2	18	23	11	547	9631	29874	17777	13290	9470	9697	9751	6268	2484	641	37	1	1		9.9	11.9	109522	51639
2003			17	47	17	57	426	1655	7142	20018	24842	20989	21263	14493	7086	1550	36				11.8	12.1	119639	110277
2004			33	512	378	123	1248	1419	1307	1083	3102	7308	7224	6353	7866	3630	241	5			12.7	13.5	41833	36813
2005		2	93	975	1285	146	1100	2326	1229	1553	3183	13398	15758	9834	6010	1658	117	70			12.3	13.1	58738	51580
2006	1	26	112	79	75	15510	37566	10750	3622	2127	1521	1955	4131	3955	2535	921	94	2	12		8.2	13.1	84994	17253
2007		8	187	467	234	1503	22689	126065	64536	6341	6731	5431	6004	5911	4238	1409	118	11			8.8	12.5	251882	36193
2008		3	434	2807	827	5341	53189	247297	165392	163200	69382	38434	18390	17258	9178	3490	745	6	1		9.3	11.1	795371	320083
2009		6	128	194	72	1496	19769	35819	5264	3913	9556	12269	9402	10831	6720	775	38	1			10.0	12.7	116252	53505
2010		21	529	116	154	5755	46438	74986	27175	11952	37420	58313	34737	33774	14626	1561	249	8	1		10.4	12.5	347814	192641
2011		60	95	215	5	541	2247	8368	15256	33221	30237	50384	56559	36673	11867	3082	573	159	47		12.0	12.4	249590	222803
2012		9	145	584	137	2922	28865	26816	6124	11739	13606	22369	37135	44082	19963	4893	127	1			11.4	13.1	219516	153914
2013		3	48	91	10	306	2185	2165	2542	13649	9932	14987	37755	40524	20107	6918	666		2		12.9	13.2	151890	144540
SPNGFS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**ML**	**ML mature**	**Total**	**Total mature**
1991		1			31	690	1311	313	49	9	6	7	7	4				6			7.0	12.7	2433	39
1992		57	38	9	178	3290	2743	282	48	10	8	69	162	390	779	246	95				8.2	14.7	8404	1760
1993		57	1206	488	97	3730	3753	421	105	54	7	4	8	3	2						6.0	10.8	9934	77
1994	1	40	33		342	4789	10162	8920	3195	53	106	20	9	12	1						7.4	11.1	27685	202
1995		84	108	4	342	3063	2157	220	84	65	58	105	105	90	20	4					6.7	12.4	6510	447
1996		218	537	143	245	4457	4449	267	820	722	82	145	126	219	96	39	2				7.0	11.6	12566	1431
1997	2	102	809	441	235	3458	6824	2189	1923	534	156	353	161	88	3						7.2	11.3	17277	1295
1998	3	2	7	4	49	1920	4685	1815	337	153	125	88	147	135	86	13	2	3			7.5	12.4	9573	752
1999		6	59	13	134	2736	3010	193	106	83	109	143	390	645	402	69					8.1	13.6	8098	1841
2000		7	3729	2046	17	554	1947	489	277	486	756	1252	999	1021	199	34	13				7.4	12.4	13827	4760
2001		68	4	1	153	3241	5085	659	225	206	205	236	692	407	120	22	9				7.7	12.7	11331	1896
2002		4	20		133	2333	2013	284	50	58	54	60	231	314	72	9					7.5	13.2	5634	798
2003		4	950	567	4	77	221	57	39	28	16	22	17	23	16	5	1				4.7	12.5	2047	128
2004		6	22	4	43	2289	3808	443	110	83	58	219	931	776	303	2	1				8.5	13.3	9097	2372
2005		16	451	25	9	754	1007	207	85	102	30	54	257	218	90	44	2				7.8	13.1	3349	797
2006		14	156	160	50	2238	8913	4507	175	94	9	36	229	419	169	9	2				7.4	13.5	17181	968
2007		49	40	1	111	3025	6620	1099	129	260	81	7	93	215	89	21	3				7.2	12.4	11843	768
2008	7	4	92	247	1	936	1561	1326	234	1483	304	537	11	833	201	186	11				9.2	11.9	7974	3566
2009	1	17	53	125	9	2582	3816	4105	119	250	45	142	59	819	120	17	1	1			7.8	13.1	12283	1456
2010		55	102	5	232	13090	22032	3169	1160	1056	89	82	179	1007	1981	518	9				7.5	13.6	44766	4920
2011		29	260	105	46	2805	5511	1278	148	340	145	100	144	591	724	134	3	1			7.9	13.5	12364	2182
2012		29	132	35	556	7550	7844	1364	88	53	59	170	1051	2394	1553	432	21				8.4	14.1	23331	5734
2013			2	11	126	2163	4664	854	302	609	251	61	110	123	140	64	7				7.6	11.7	9486	1364

Table 6.6.2.1. Boarfish in ICES Subareas VI, VII and VIII. IBTS length-frequency data converted to age-structured index by application of the 2010 common ALK rounded down to 1cm length classes.

All	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1997	9186	11460	5356	4603	4209	7331	6050	4331	4970	4375	1498	2491	1741	1248	635	1242	161	676	635	3814
1998	17475	19641	6886	6423	5693	7515	5791	3814	4860	4439	1481	2883	1654	1644	685	1240	236	917	685	4965
1999	11838	33029	20031	8826	3580	3421	2837	1990	2911	2552	804	1716	1045	1010	320	705	80	539	320	2435
2000	19340	29071	12974	18627	16220	19669	14950	10117	11553	9928	3345	5427	3955	2717	1310	2709	265	1470	1310	7757
2001	20344	44451	20694	25753	22184	16593	9665	4839	5137	4484	1492	2471	1545	1362	643	1109	175	824	643	4482
2002	10040	33131	18597	13158	9120	9171	6846	4380	6006	5313	1699	3476	2053	2046	696	1430	202	1115	696	5313
2003	840	4714	8356	20850	19443	18478	13092	7863	10801	10051	3279	7063	3662	4270	1598	2792	629	2439	1598	12890
2004	5958	5660	2092	2537	3567	8255	7560	5288	8479	8618	2871	6954	2968	4378	1924	2576	866	2794	1924	16191
2005	4201	4323	2012	2784	3836	9869	9393	6931	10296	9875	3269	7332	3684	4419	1814	2913	759	2642	1814	14728
2006	44120	35631	8054	7238	6703	8802	9417	6528	14774	15648	4994	14441	5398	9659	3847	4781	1967	6478	3847	37015
2007	24531	128029	67188	19124	7326	8707	7376	4824	8405	8454	2739	7014	2967	4520	1748	2495	799	2784	1748	15325
2008	43985	262478	172674	148047	91323	53729	31280	15702	23250	22959	7433	17778	7213	11602	5022	6177	2310	7992	5022	45589
2009	18107	42788	14748	10829	12257	14366	9760	5252	7847	7656	2476	5816	2443	3766	1259	2049	642	2128	1259	11324
2010	58552	98227	37475	25665	30828	52503	37174	21833	27440	24593	8035	15093	8215	8983	3253	6110	1257	4997	3253	25820
2011	8615	17617	17110	34003	34910	52378	39952	26259	31789	27728	9181	16113	10503	8764	3850	7350	1012	5048	3850	26631
2012	32050	40410	12771	13406	14205	27201	28554	21680	36693	35756	11588	28599	13608	17833	7714	10766	2944	11650	7714	64807
2013	6803	7520	5505	13956	13771	24883	28094	22103	38364	35844	11307	27931	14497	17316	6137	10616	2170	10230	6137	51394
EVHOE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20+**
1997	1876	6003	3741	3911	3938	7065	5867	4218	4832	4259	1461	2428	1699	1214	623	1215	159	659	623	3737
1998	12977	15997	6248	6247	5591	7435	5732	3777	4806	4386	1463	2843	1635	1619	676	1224	232	904	676	4888
1999	7576	31223	19915	8732	3499	3308	2715	1905	2720	2357	743	1540	975	893	285	647	62	474	285	2102
2000	17676	27730	12586	17986	15525	18740	14297	9737	11041	9490	3208	5160	3797	2556	1266	2604	253	1384	1266	7385
2001	14389	41313	20357	25467	21921	16211	9247	4525	4543	3951	1332	2057	1322	1098	578	959	153	684	578	3884
2002	6719	31728	18455	12784	8389	7115	4767	2851	3429	3018	994	1806	1123	1009	421	796	117	573	421	2964
2003	509	3993	7348	18371	17276	16113	10798	6270	7620	6852	2267	4294	2501	2456	1009	1838	326	1387	1009	7340
2004	1265	1976	1261	1722	2227	4124	3228	2061	2871	3058	1066	2426	939	1509	901	917	382	1142	901	7311
2005	2102	2603	1497	2098	3015	7160	5992	4177	5301	4873	1642	3144	1796	1776	833	1368	285	1065	833	6107
2006	35834	26593	4803	2199	1386	1489	1332	947	1521	1484	485	1170	557	725	311	445	125	464	311	2596
2007	16818	122140	65369	16986	4919	4316	2967	1715	2452	2392	788	1802	820	1124	484	678	204	715	484	4049
2008	41611	258758	168378	134061	77106	37738	18750	8277	9132	8183	2660	4868	2458	2992	1226	1876	492	1919	1226	10417
2009	13338	36829	12194	5626	5982	7788	5443	3054	4443	4230	1364	3079	1382	1965	618	1114	309	1064	618	5485
2010	33601	83903	35048	21678	23503	34210	23037	12643	16303	14519	4647	9008	4716	5551	1689	3457	690	2957	1689	14298
2011	2212	12471	14982	28729	26114	31844	23915	15535	19473	16964	5542	10176	6534	5663	2262	4513	597	3197	2262	16235
2012	20089	34348	11535	11098	10795	14979	13308	9004	15662	14714	4598	11467	5540	7325	2325	4142	920	4164	2325	20439
2013	1647	3695.1	3805.3	10388	9207	11385	11271	8299	14485	13797	4374	10961	5364	6893	2550	4068	981	4205	2550	21823
IGFS+WCSGFS+EVHOE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20+**
2003	636	4552	8306	20803	19406	18414	13013	7804	10668	9916	3237	6942	3612	4190	1573	2752	617	2393	1573	12654
2004	1685	3414	1912	2444	3481	8017	7255	5037	8031	8189	2735	6610	2796	4164	1860	2446	838	2683	1860	15644
2005	2930	3604	1895	2694	3773	9738	9200	6777	9949	9514	3154	7004	3553	4203	1731	2801	721	2505	1731	13978
2006	36687	28176	6830	7100	6633	8714	9277	6421	14479	15337	4898	14144	5288	9457	3779	4686	1933	6356	3779	36365
2007	17873	124020	66810	18929	7205	8648	7322	4790	8309	8353	2708	6917	2932	4453	1729	2464	788	2746	1729	15126
2008	42240	260577	172031	147113	90691	53328	31023	15587	22918	22641	7344	17496	7113	11395	4967	6101	2285	7861	4967	44972
2009	13607	37705	13658	10616	12063	14060	9426	5030	7283	7072	2296	5275	2243	3396	1141	1878	582	1909	1141	10185
2010	33976	84649	35967	24858	30441	52245	36921	21671	26982	23992	7828	14456	8055	8546	3060	5910	1145	4712	3060	24053
2011	2884	13954	16666	33742	34724	52174	39716	26089	31387	27290	9039	15699	10356	8486	3752	7213	958	4882	3752	25707
2012	20395	35049	12386	13340	14140	26984	28191	21406	35924	34955	11342	27840	13323	17314	7548	10525	2861	11338	7548	63197
2013	2021	4557.2	5053.5	13515	13490	24723	27933	21993	38084	35555	11218	27662	14393	17133	6074	10529	2140	10116	6074	50796
SPNGFS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20+**
1997	7306	5446	1609	681	249	203	121	67	69	56	18	22	18	11	4	11	0	6	4	23
1998	4493	3640	638	175	101	79	58	37	54	53	17	40	19	25	9	15	4	14	9	77
1999	4258	1802	116	93	80	112	121	85	191	195	61	175	70	117	35	58	18	65	35	333
2000	1661	1325	347	518	553	750	537	315	443	379	116	237	139	146	37	91	10	78	37	325
2001	5952	3099	308	205	161	197	190	148	199	175	58	114	77	62	25	53	6	34	25	169
2002	3315	1395	104	54	43	55	63	47	98	88	26	71	37	46	10	25	3	24	10	97
2003	203	155	38	26	16	14	10	5	9	9	3	7	3	4	2	2	1	3	2	15
2004	4267	2243	177	82	68	171	219	186	303	279	89	209	118	124	37	85	14	63	37	294
2005	1253	701	108	78	46	50	60	51	84	78	25	59	33	35	15	24	4	22	15	116
2006	7297	7378	1191	85	34	36	56	44	116	112	33	100	43	68	14	32	8	35	14	154
2007	6646	3990	367	180	106	37	30	18	55	54	16	50	20	35	8	15	4	20	8	92
2008	1736	1886	629	908	597	329	178	62	202	183	47	158	53	122	28	36	10	81	28	352
2009	4487	5077	1085	168	104	79	71	26	174	155	37	147	56	113	9	34	6	58	9	194
2010	24558	13572	1504	792	346	101	85	41	222	365	132	436	76	306	146	130	91	206	146	1347
2011	5730	3656	432	244	163	94	77	38	140	182	61	198	48	140	50	59	33	84	50	493
2012	11653	5359	383	62	55	160	276	202	620	657	201	638	228	441	140	198	73	266	140	1382
2013	4763	2947	446	439	276	110	59	30	44	49	17	44	16	28	15	16	7	21	15	132

Table 6.6.3.1. Boarfish in ICES Subareas VI, VII, VIII. Pseudo-cohort derived estimates of fishing mortality (F) and total mortality (Z), in comparison with total catch per year. Pearson correlation coefficient of F vs. catch (tonnes) indicated.

Age	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013
	Raised numbers							ln (raised numbers)						
1	0	0	1575	2415	0	28	301	0	0	7	8	0	3	6
2	352	5488	15043	11229	2894	893	7148	6	9	10	9	8	7	9
3	2114	21140	65744	72709	41913	5467	156680	8	10	11	11	11	9	12
4	40851	105575	338931	294382	28148	41278	58522	11	12	13	13	10	11	11
5	48915	141300	475619	567689	30116	110272	59797	11	12	13	13	10	12	11
6	62713	195339	543707	878363	175696	146582	68949	11	12	13	14	12	12	11
7	26132	104031	307333	522703	143967	492078	302967	10	12	13	13	12	13	13
8	29766	66570	172783	293719	107126	365840	250341	10	11	12	13	12	13	12
9	56075	53159	155477	276672	77861	271916	212318	11	11	12	13	11	13	12
10	44875	46893	130148	232122	60022	173486	160137	11	11	12	12	11	12	12
11	14019	15289	42521	78588	46079	69396	63025	10	10	11	11	11	11	11
12	32359	21178	61350	114600	40468	40968	41490	10	10	11	12	11	11	11
13	4848	11854	39609	59932	24352	58888	59380	8	9	11	11	10	11	11
14	16837	13570	31569	59060	19724	30277	30355	10	10	10	11	10	10	10
15+	109481	112947	196967	349320	157707	217260	239366	12	12	12	13	12	12	12
Z (age 7-14)								0.18	0.32	0.32	0.32	0.28	0.42	0.35
F (Z-M), where M = 0.16								0.02	0.16	0.16	0.16	0.12	0.26	0.19
Catches (t)								21576	34751	90370	144047	36937	86414	75409
Correllation coefficient landings vs. F								0.54						

Table 6.6.4.1. Boarfish in ICES Subareas VI, VII, VIII. Acoustic survey biomass estimates for 2011 - 2014.

2011 *MFV Felucca* - 24 hour operations

	Abun (mil)	Biomass (t)	%
Total estimate			
Definitely	7,049	393,893	86.4
Probably	1,134	62,222	13.6
Mixture	-	-	-
Total estimate	**8,183**	**456,115**	**100**
Possibly			
CV TSB	17.5	17.6	
SSB Estimate			
Definelty	7,019	393,312	86.4
Probably	1,126	62,063	13.6
Mixture	0	0	0.0
SSB estimate	**8,145**	**455,375**	**100**
Possibly	-	-	

2012 *MFV Father McKee* - daylight only (04:00 - 24:00) operations

	Abun (mil)	Biomass (t)	%
Total estimate			
Definitely	11,684	708,019	82.0
Probably	2,072	123,723	14.3
Mixture	501	31,704	3.7
Total estimate	**14,257**	**863,446**	**100**
Possibly	16	1,017	
CV TSB	10.6	10.7	
SSB Estimate			
Definelty	11,615	706,582	82.0
Probably	2,050	123,286	14.3
Mixture	500	31,676	3.7
SSB estimate	**14,165**	**861,544**	**100**
Possibly	16	1,017	

2013 *MFV Felucca* - daylight only (04:00 - 24:00) operations

	Abun (mil)	Biomass (t)	%
Total estimate			
Definitely	8,834	431,571	98.1
Probably	240	7,187	1.6
Mixture	17	1,139	0.3
Total estimate	**9,091**	**439,897**	**100**
Possibly	-	-	
CV TSB	17.5	16.7	
SSB Estimate			
Definelty	8,120	416,124	98.3
Probably	179	5,895	1.4
Mixture	17	1,139	0.3
SSB estimate	**8,316**	**423,158**	**100**
Possibly	-	-	

Biomass derived using a modelled boarfish TS-Length relationship (-66.2dB).

2014 *MFV Felucca* - daylight only (04:00 - 24:00) operations

	Abun (mil)	Biomass (t)	%
Total estimate			
Definitely	2,227	133,713	71.2
Probably	830	51,461	27.4
Mixture	41	2,605	1.4
Total estimate	**3,098**	**187,779**	**100**
Possibly	-	-	
CV TSB	15.1	15.1	
SSB Estimate			
Definelty	2,223	133,600	71.2
Probably	829	51,449	27.4
Mixture	41	2,605	1.4
SSB estimate	**3,093**	**187,654**	**100**
Possibly	-	-	

Biomass derived using a modelled boarfish TS-Length relationship (-66.2dB).

Table 6.6.5.1. Boarfish in ICES Subareas VI, VII, VIII. Key parameter estimates from final run. CV(TSB_{2014}) is the coefficient of variation of the estimated total stock biomass in 2014. Posterior parameter distributions are provided in Figure 6.6.5.5.

Run	r	K	FMSY	BMSY	TSB2014	CV(TSB2014)
1	0.343	694127	0.171	347063	261003	0.381

Table 6.6.5.2. Boarfish in ICES Subareas VI, VII, VIII. Estimates of total stock biomass and F.

Year	Low TSB	Mean TSB	High TSB	Low F	Mean F	High F
1991	120302	242343	482648	0	0	0
1992	200600	385082	763798	0	0	0
1993	235500	464690	926990	0	0	0
1994	268602	538698	1084975	0	0	0
1995	237808	472397	942688	0	0	0
1996	249802	482913	969268	0	0	0
1997	213402	407993	797973	0	0	0
1998	292808	569625	1142000	0	0	0
1999	223405	433785	855868	0	0	0
2000	187600	361979	714373	0	0	0
2001	193602	364120	708700	0	0	0
2002	176200	327015	633300	0	0	0
2003	168002	309117	597243	0.019	0.042	0.07
2004	252300	469763	930195	0.006	0.012	0.021
2005	226802	421489	819848	0.007	0.016	0.027
2006	267700	490674	940488	0.008	0.016	0.027
2007	228205	419437	806883	0.027	0.059	0.099
2008	300802	547163	1045975	0.034	0.073	0.123
2009	303802	547028	1046975	0.09	0.204	0.353
2010	457102	830052	1587000	0.095	0.216	0.379
2011	355218	657557	1276975	0.029	0.065	0.11
2012	515808	873575	1650975	0.054	0.116	0.186
2013	379502	665634	1270975	0.061	0.134	0.222
2014	140800	261003	513893	-	-	-

Table 6.7.1. Boarfish in ICES Subareas VI, VII, VIII. Projection table. Basis: Catch (2014) = 133 880 thousand tonnes (EU TAC = 127 509 t and average discards 2003-2013 = 6 371 t). Note that for F projections, the fishing mortality is fixed and the credible intervals for catch (95% CI) represent the uncertainty in biomass; for fixed catch projections credible intervals on F represent the uncertainty in biomass. F_{MP} is based rule 1.1b of the proposed management plan. $F_{ICES\ HCR}$ is based on the generic ICES MSY harvest control rule.

Projection	F_{2015}	F_{2015} 95% CI	Catch 2015	Catch 2015 95% CI	TSB_{2016}	TSB_{2016} 95% CI	Probability $TSB_{2016}<B_{trigger}$	Probability $TSB_{2016}<B_{lim}$
F_{lim}	0.274	-	65680	25780-200300	282115	77040-915400	0.777	0.172
F_{MSY}	0.171	-	43132	16930-131500	306969	87440-960100	0.712	0.145
F_{pa}	0.146	-	37305	14640-113800	310681	87190-983200	0.702	0.141
$F_{ICES\ HCR}$	0.132	-	33875	13300-103300	312637	88460-998100	0.700	0.129
$F_{0.1}$	0.13	-	33394	13110-101800	315563	87920-986300	0.703	0.128
F_{MP}	0.129	-	33154	13010-101100	318207	88450-992900	0.697	0.132
Zero catch	0	0-0	0	-	352984	98120-1095000	0.621	0.099
Status quo catch	0.671	-	133880	-	211826	5180-939000	0.867	0.511

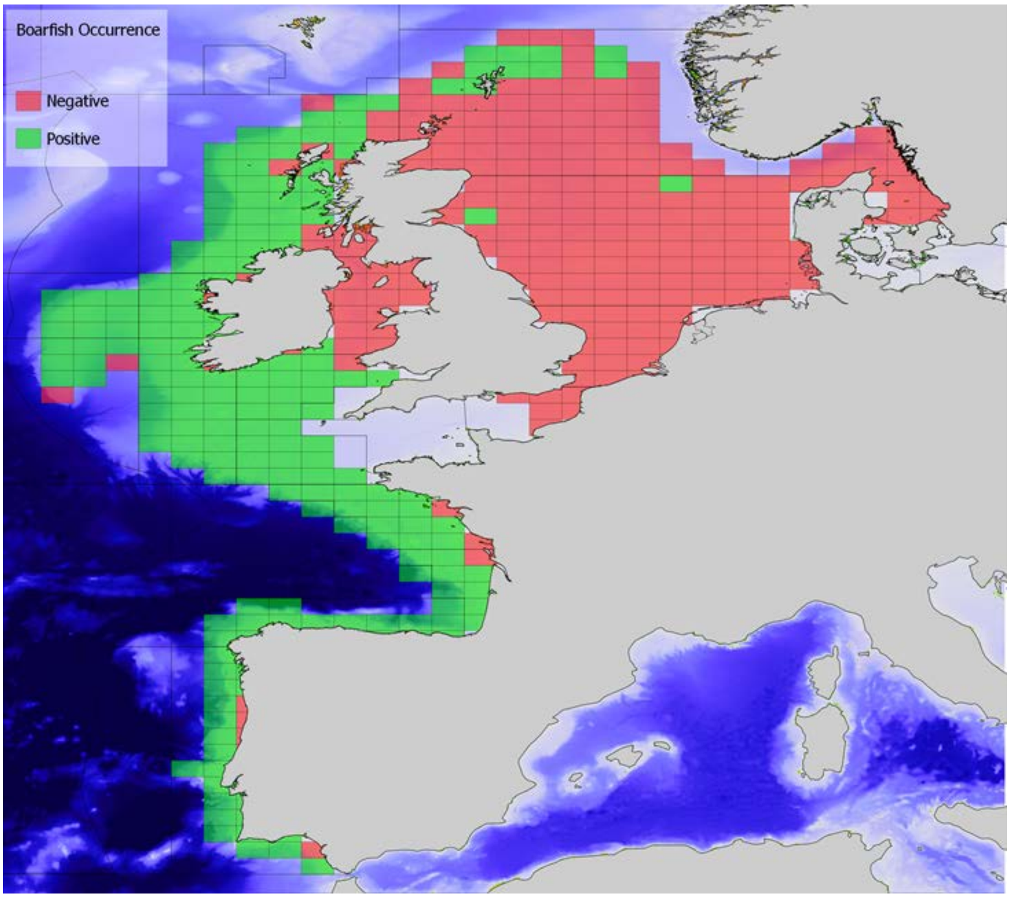
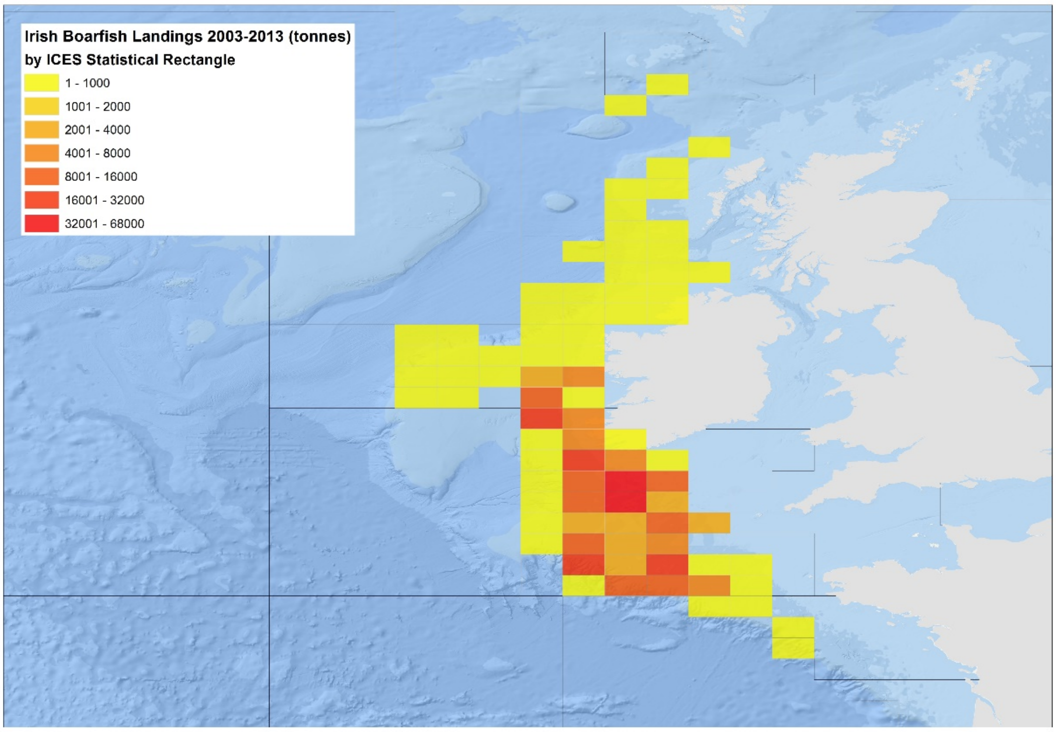


Figure 6.1. Boarfish in ICES Subareas VI, VII, VIII. Distribution of boarfish in the NE Atlantic area based on presence and absence in IBTS surveys (all years).



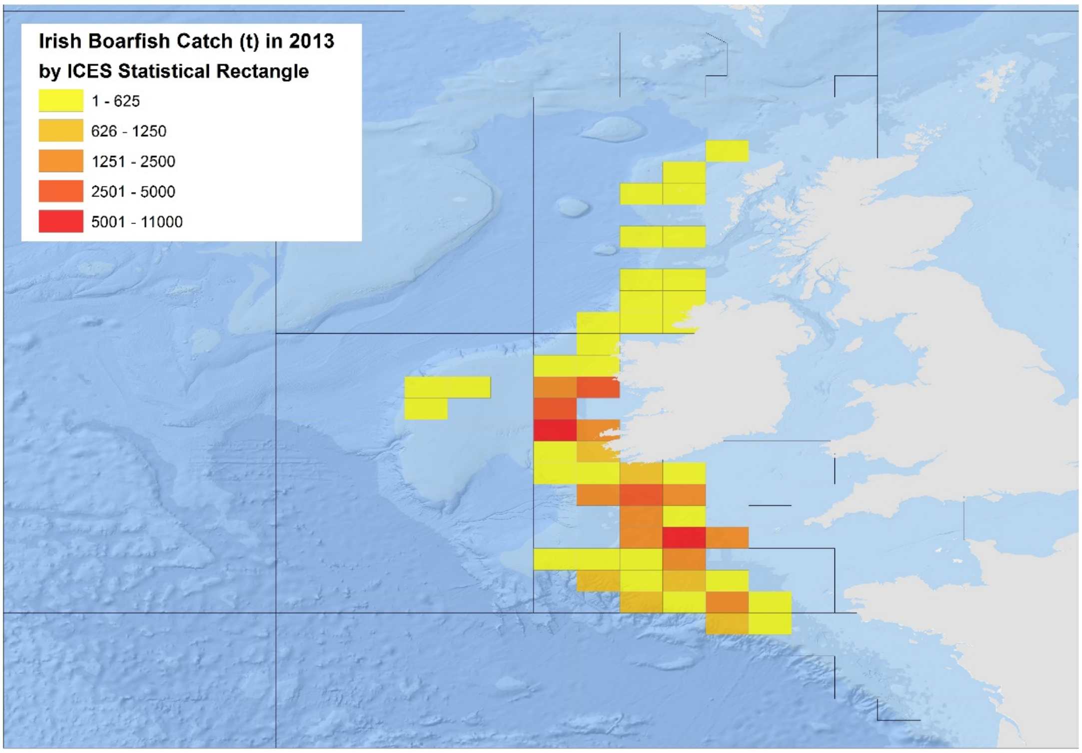


Figure 6.2. Boarfish in ICES Subareas VI, VII, VIII. Combined Irish boarfish landings 2003-2013 by ICES rectangle (Above). Irish boarfish landings 2013 by ICES rectangle (Below).

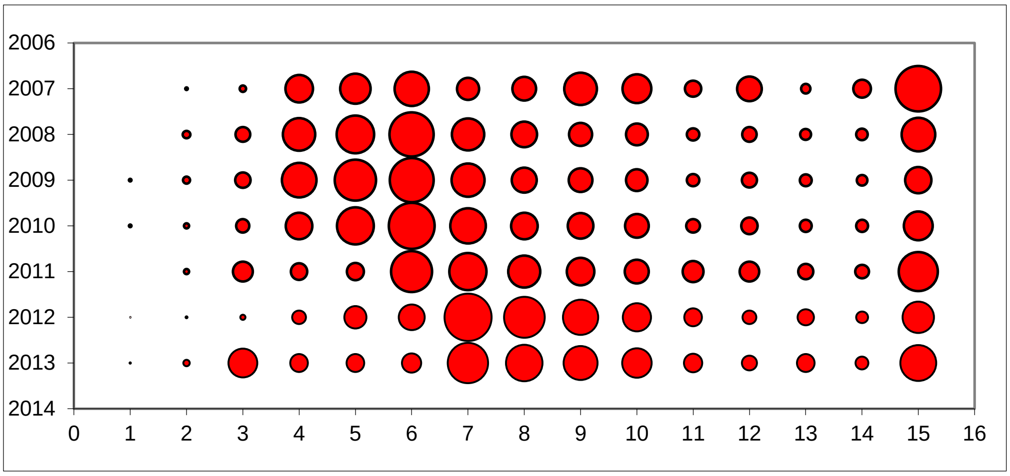


Figure 6.2.1.1. Boarfish in ICES Subareas VI, VII, VIII. Catch numbers-at-age standardised by yearly mean. 15+ is the plus group.

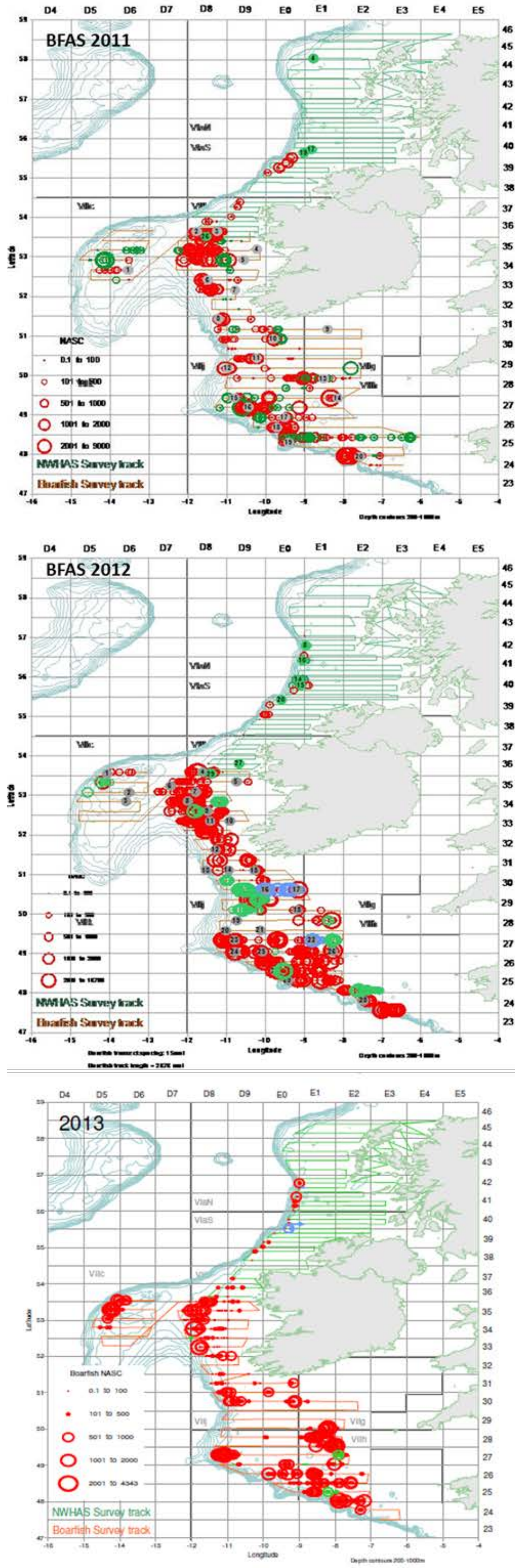


Figure 6.3.1.1a. Boarfish in ICES Subareas VI, VII, VIII. Boarfish acoustic survey track and haul positions from acoustic survey 2011-2013. Red circles represent 'definitely' boarfish, green: 'probably boarfish', blue: 'boarfish mix'.

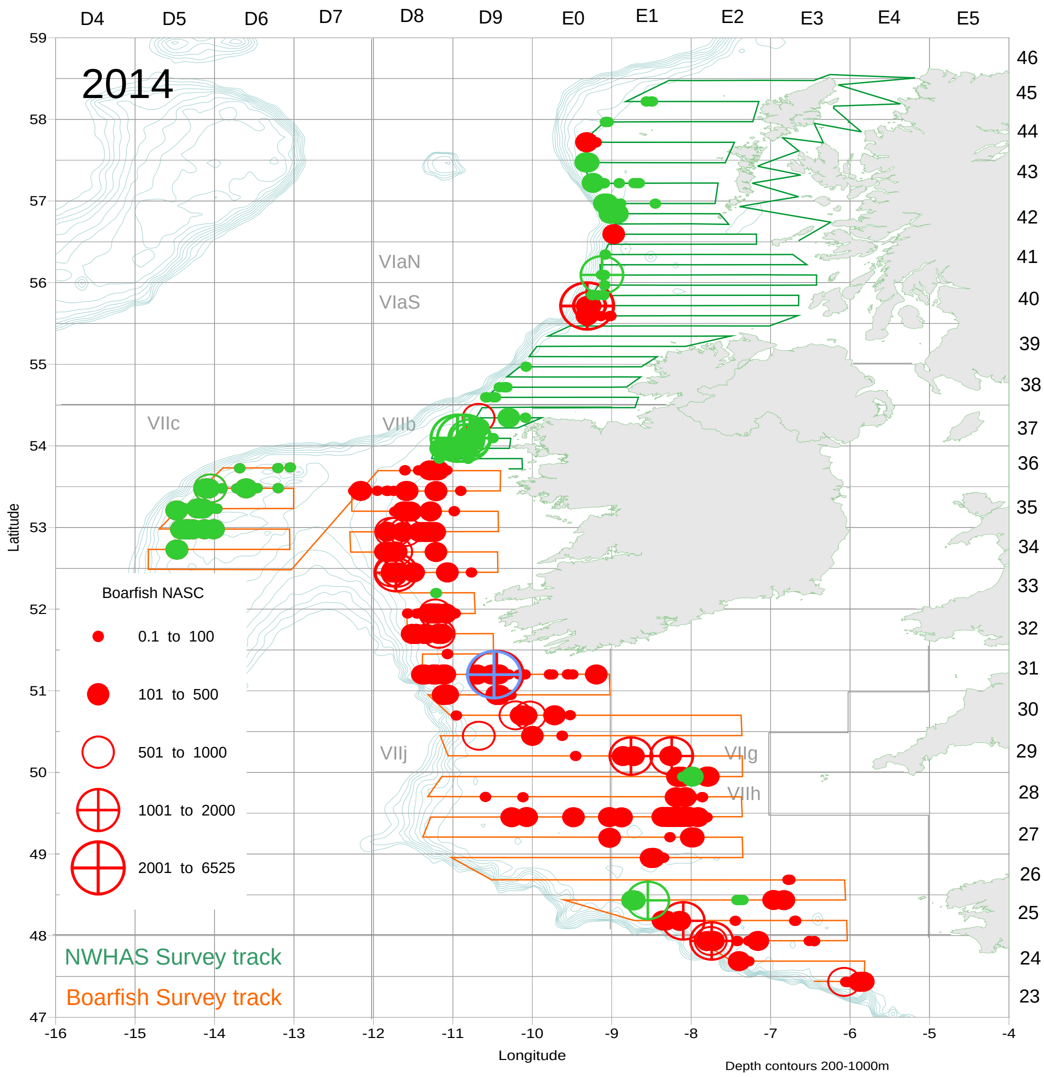


Figure 6.3.1.1b. Boarfish in ICES Subareas VI, VII, VIII. Boarfish acoustic survey track and haul positions from acoustic survey 2014. Red circles represent 'definitely' boarfish, green: 'probably boarfish', blue: 'boarfish mix'.

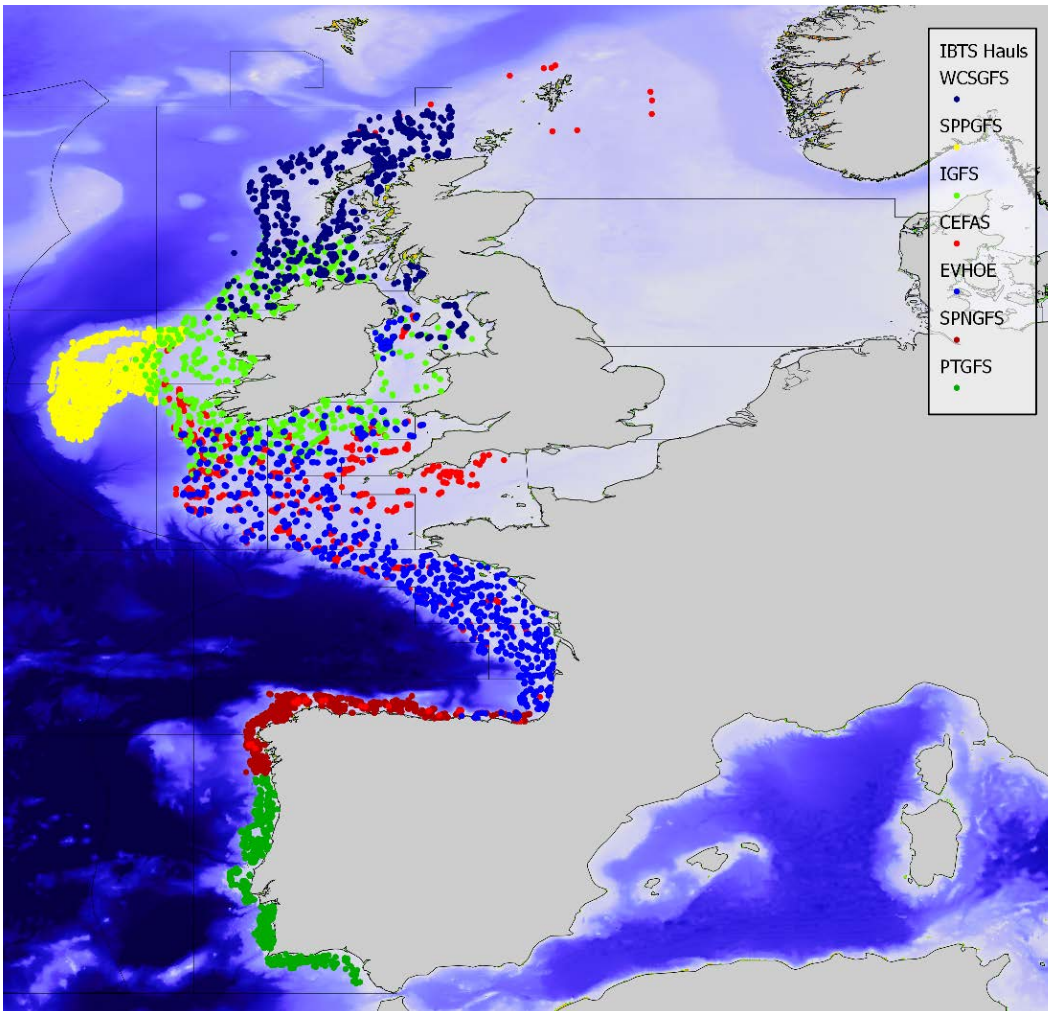


Figure 6.3.2.1. Boarfish in ICES Subareas VI, VII, VIII. The haul positions of bottom trawl surveys analysed as an index for boarfish abundance. Note the Portuguese Groundfish survey included here was not included in the 2014 assessment.

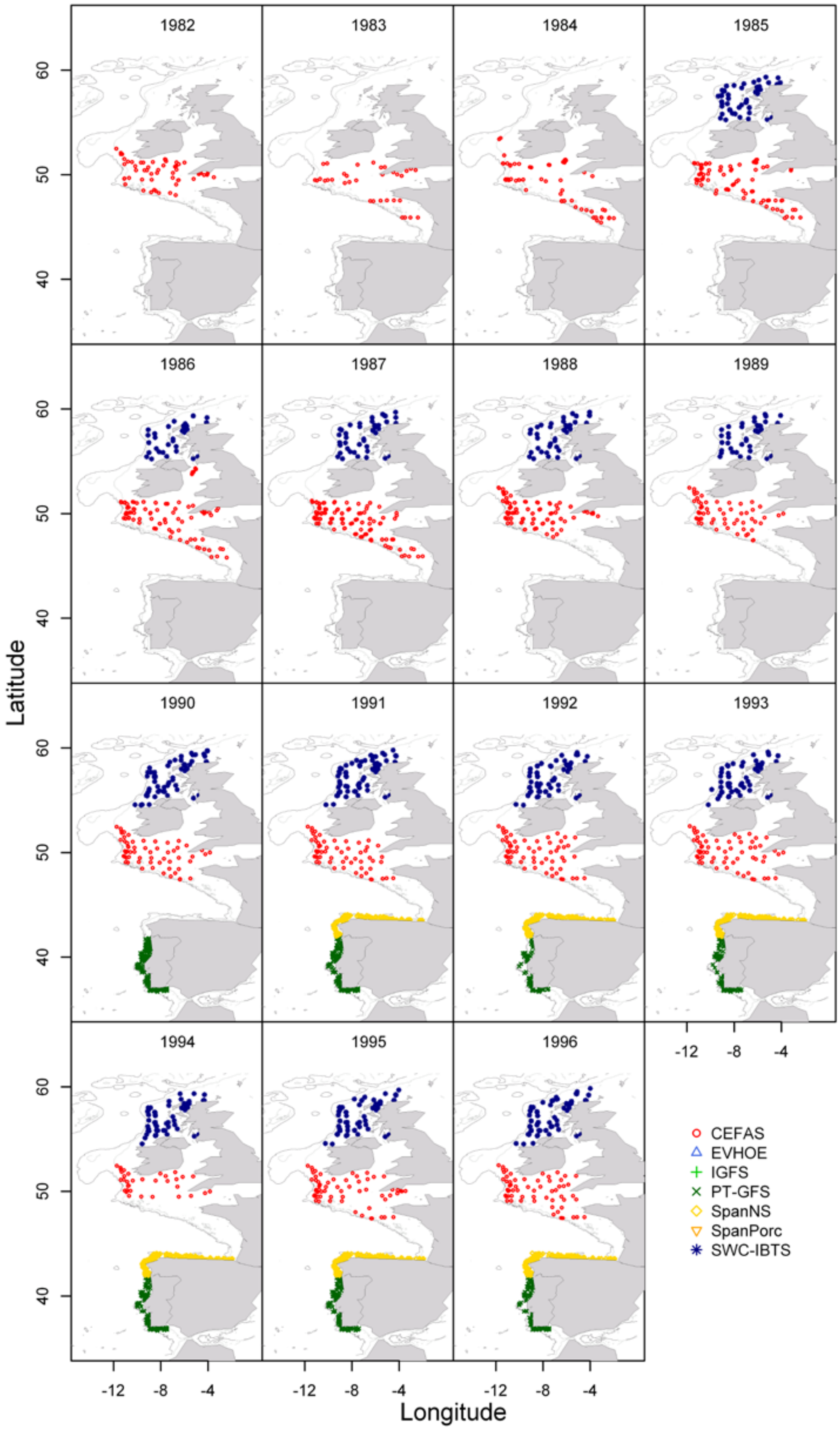


Figure 6.3.2.2a. Boarfish in ICES Subareas VI, VII, VIII. The haul positions of bottom trawl surveys by year analysed as part of the GAM modelling.

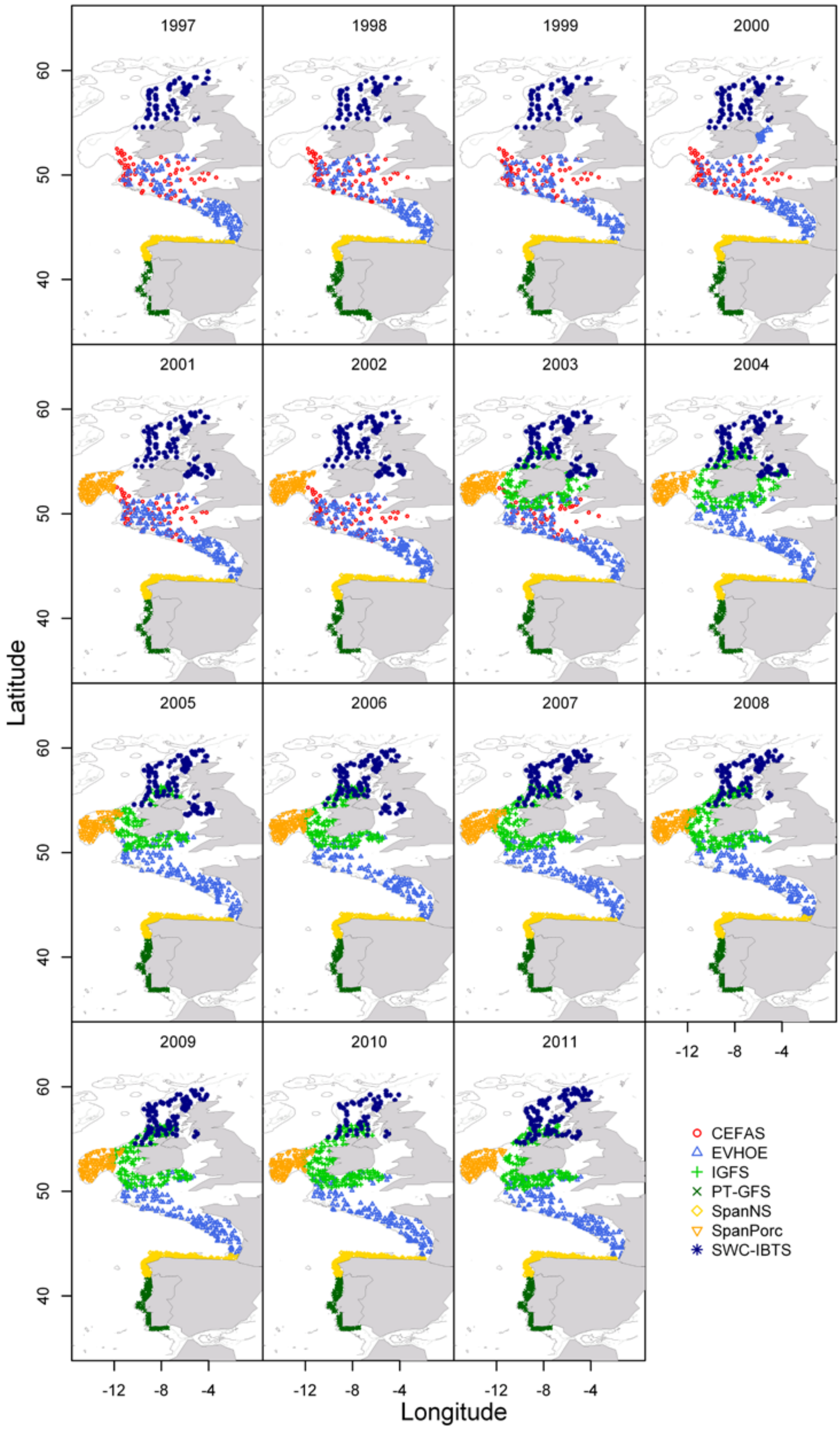


Figure 6.3.2.2b. Boarfish in ICES Subareas VI, VII, VIII. The haul positions of bottom trawl surveys by year analysed as part of the GAM modelling.

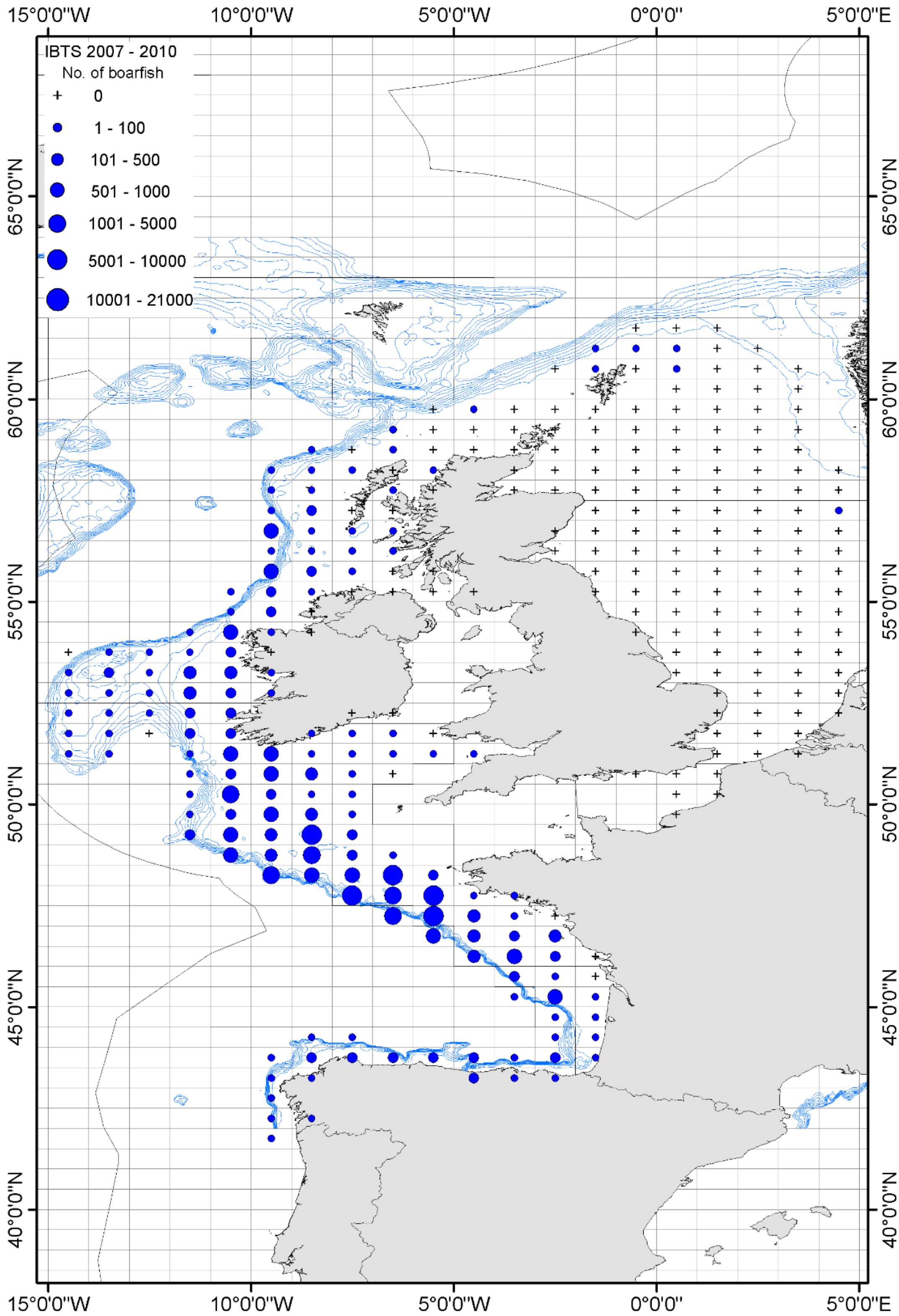


Figure 6.3.2.3. Boarfish in ICES Subareas VI, VII, VIII. Distribution of boarfish in the NE Atlantic showing proposed management area.

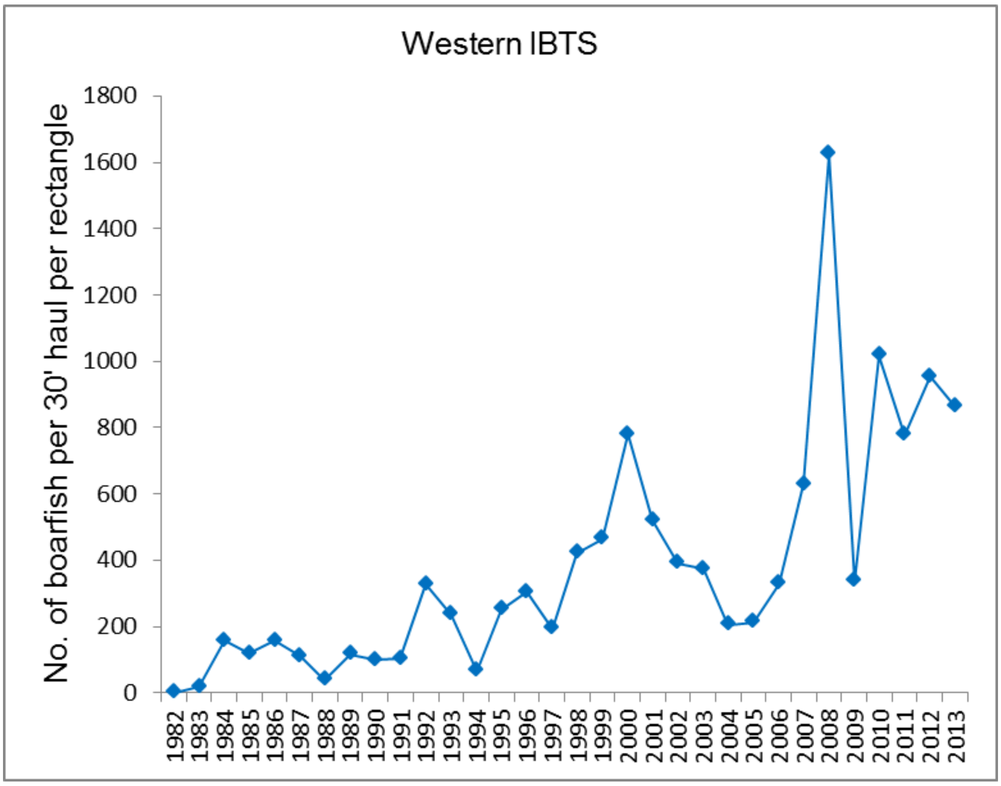


Figure 6.3.2.4. Boarfish in ICES Subareas VI, VII, VIII. CPUE in number per 30 minute haul of boarfish per rectangle in the western IBTS survey 1982 to 2013.

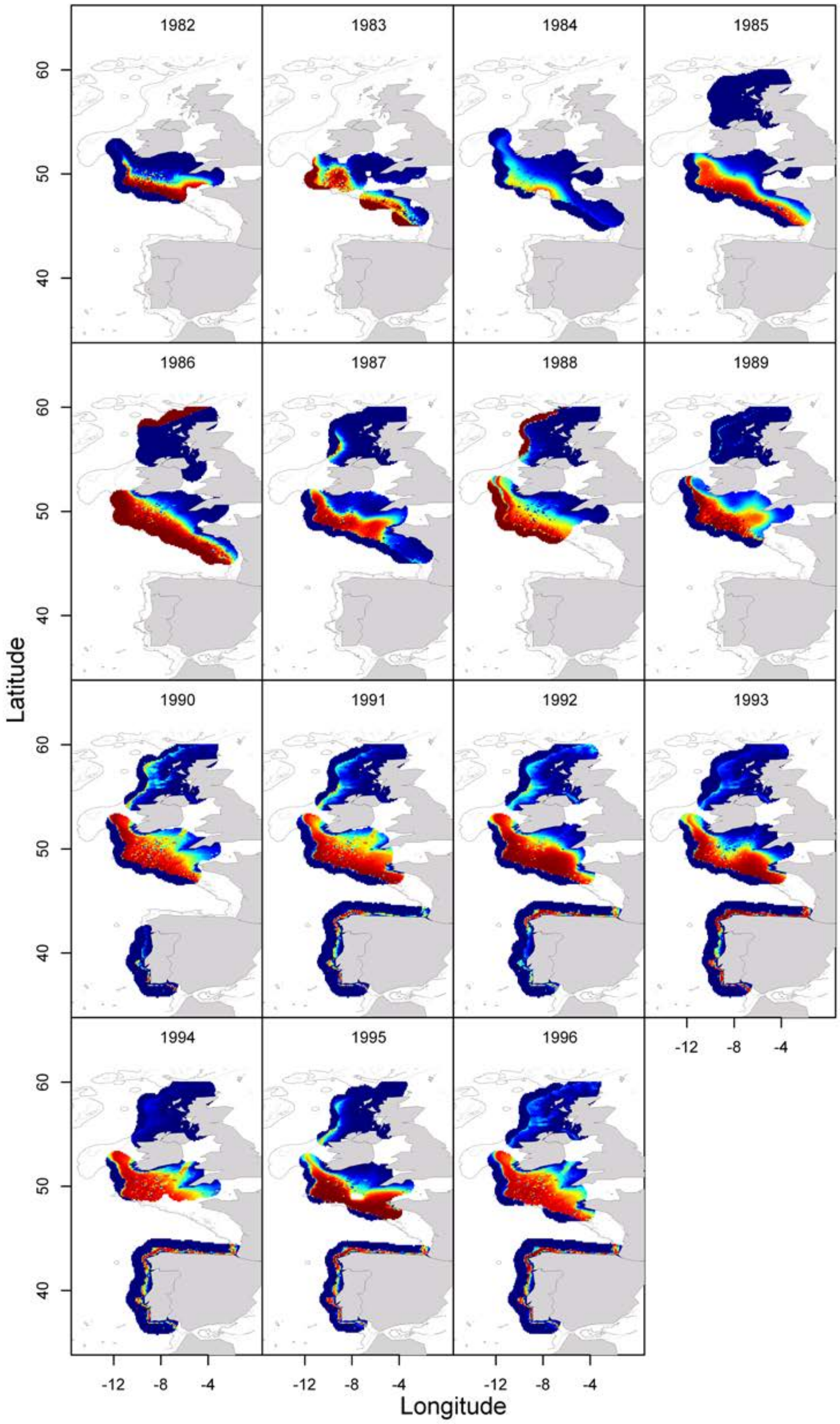


Figure 6.3.2.5a. Boarfish in ICES Subareas VI, VII, VIII. The occurrence GAM of the probability of occurrence of boarfish in a survey area 1982 – 1996. Red indicates definite occurrence and blue indicates absence.

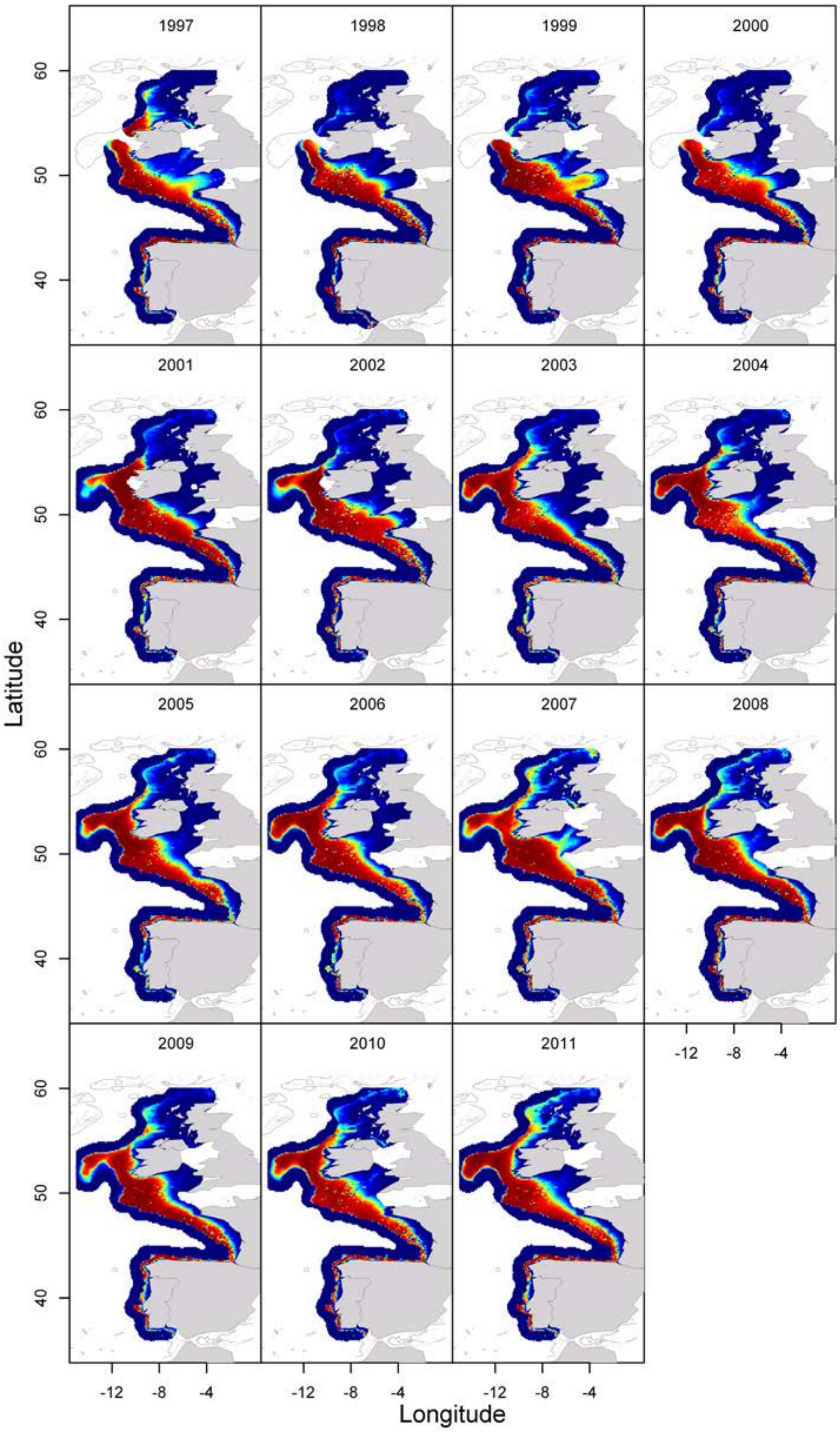


Figure 6.3.2.5b. Boarfish in ICES Subareas VI, VII, VIII. The occurrence GAM of the probability of occurrence of boarfish in a survey area 1997 – 2011. Red indicates definite occurrence and blue indicates absence.

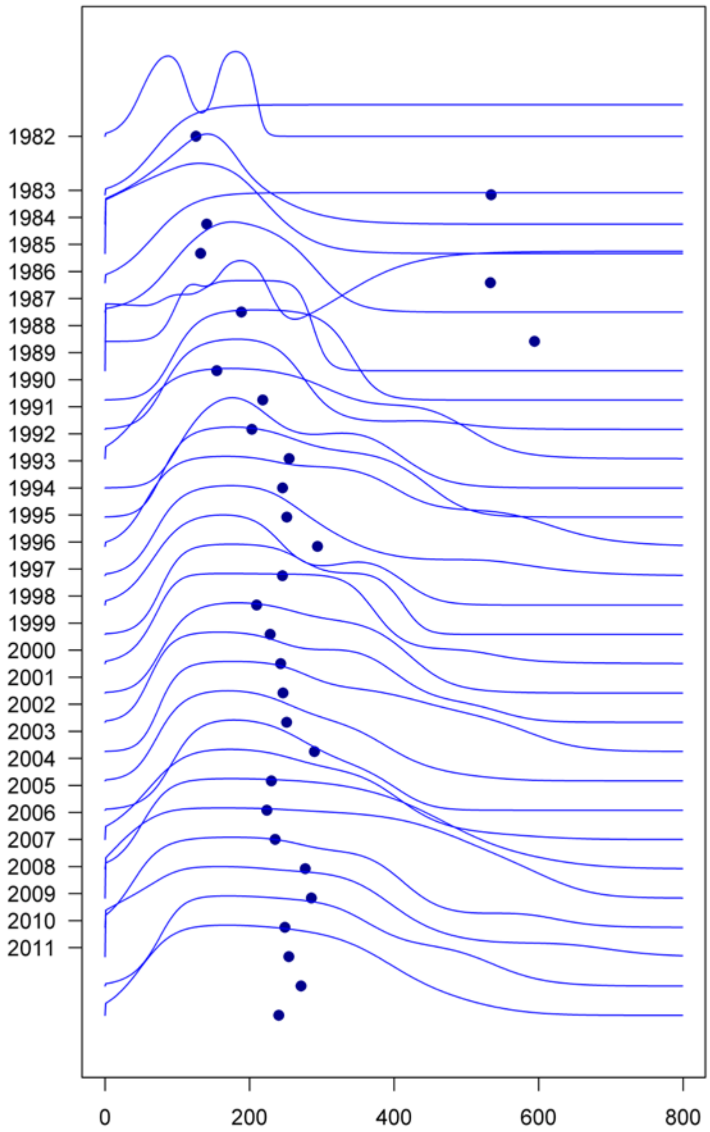


Figure 6.3.2.6. Boarfish in ICES Subareas VI, VII, VIII. The depth distribution profile of boarfish within the IBTS surveys.

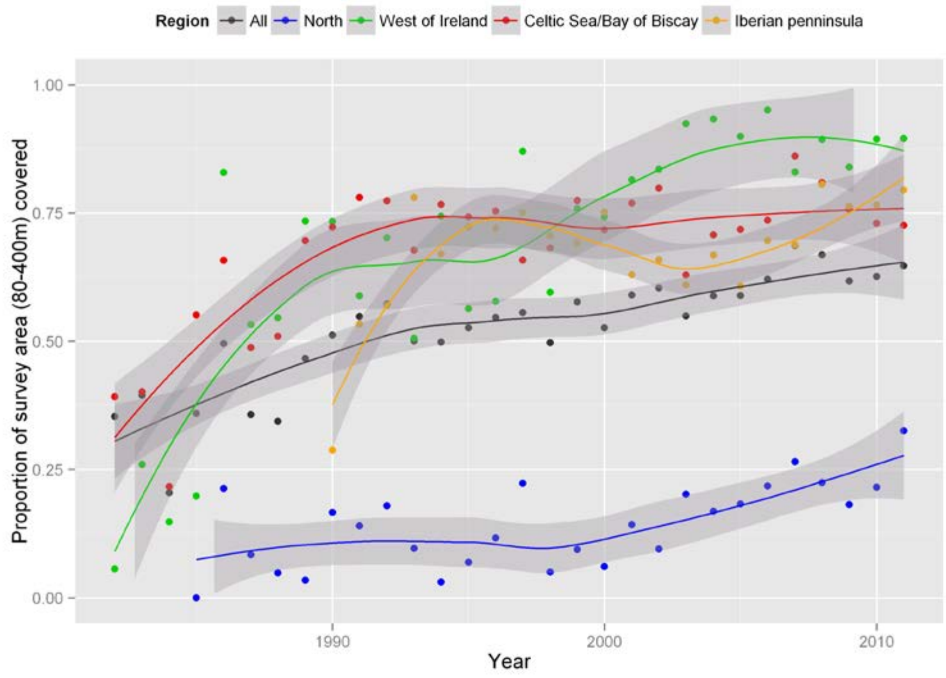


Figure 6.3.2.7. Boarfish in ICES Subareas VI, VII, VIII. The proportion of survey area covered by boarfish per region and per year.

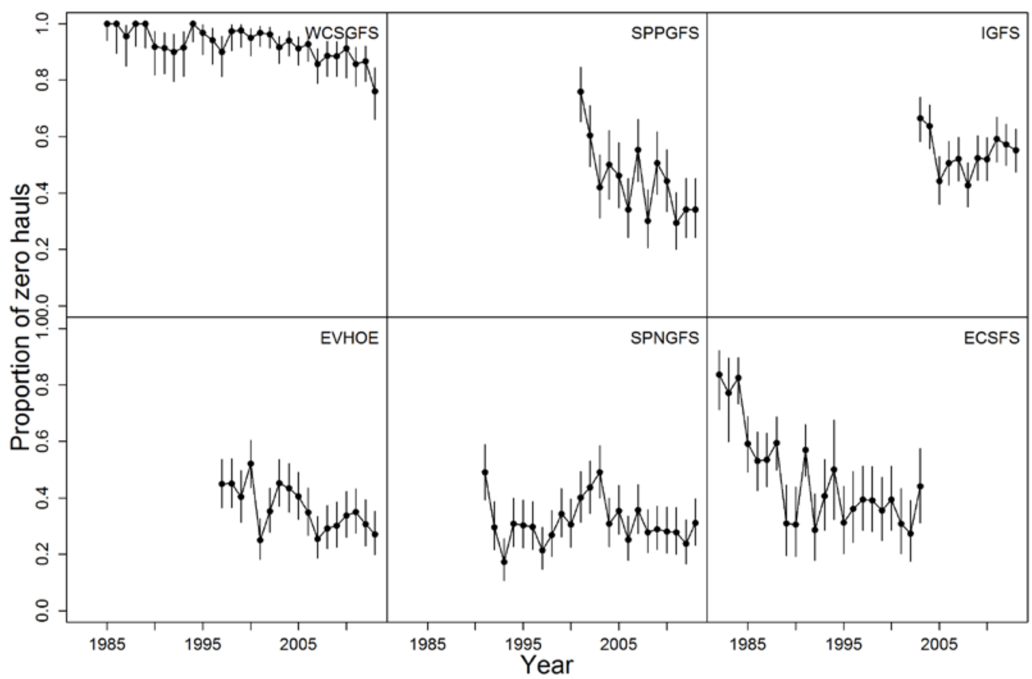


Figure 6.3.2.8. Boarfish in ICES Subareas VI, VII, VIII. The proportion of zero hauls per IBTS survey.

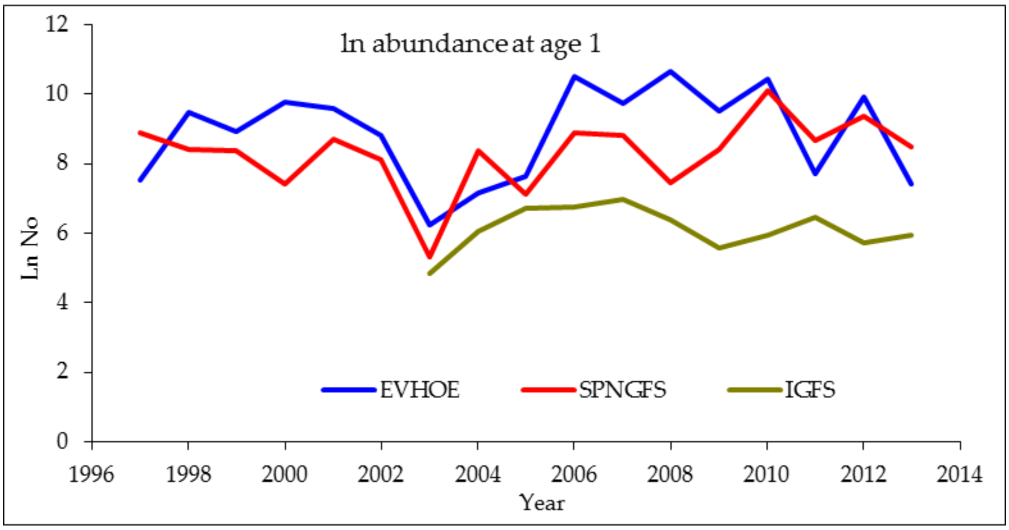


Figure 6.5.1. Boarfish in ICES Subareas VI, VII, VIII. Recruitment-at-age 1, from various IBTS.

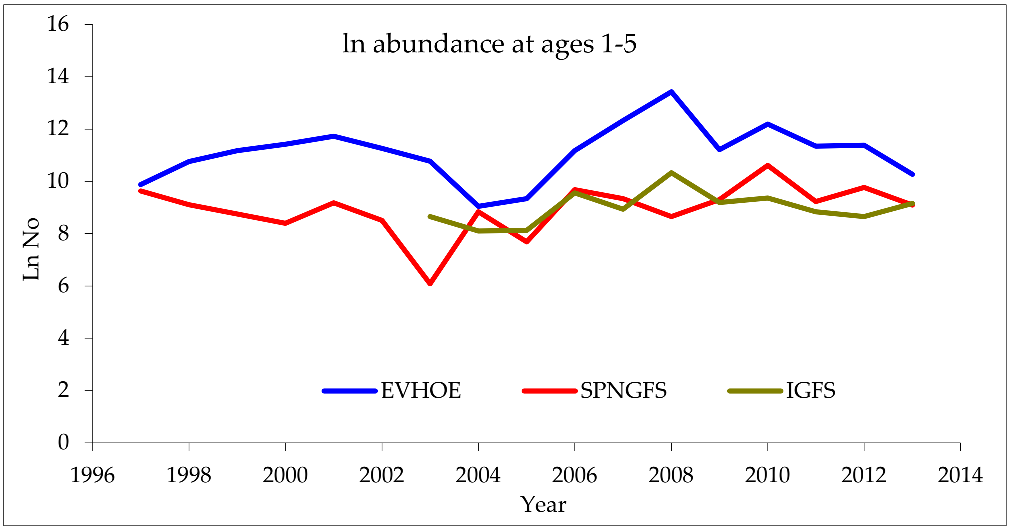


Figure 6.5.2. Boarfish in ICES Subareas VI, VII, VIII. Recruitment-at-ages 1-5, from various IBTS.

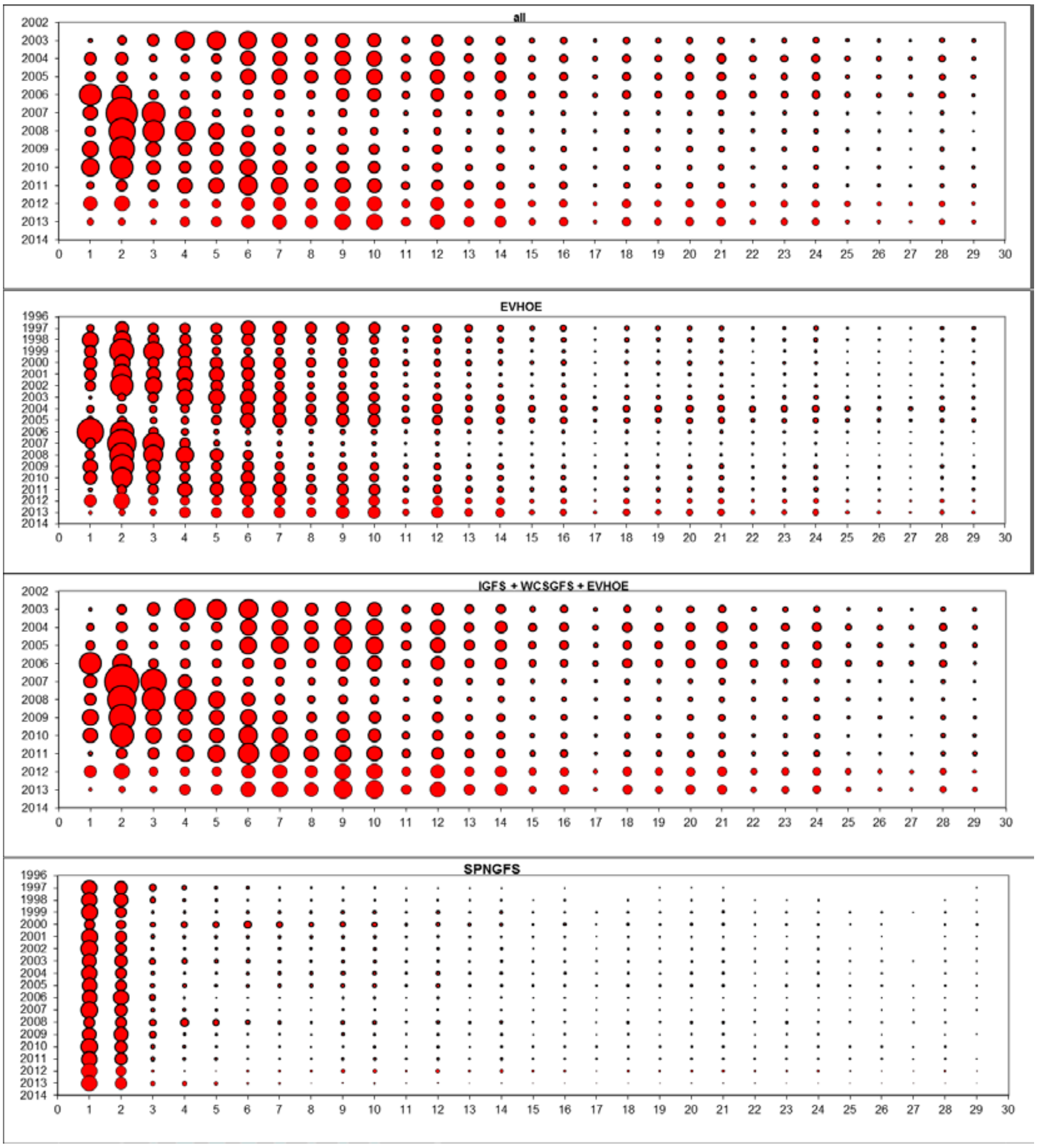


Figure 6.6.2.1. Boarfish in ICES Subareas VI, VII, VIII. Abundance-at-age in constituent western IBTS. Yearly mean standardised abundance-at-age.

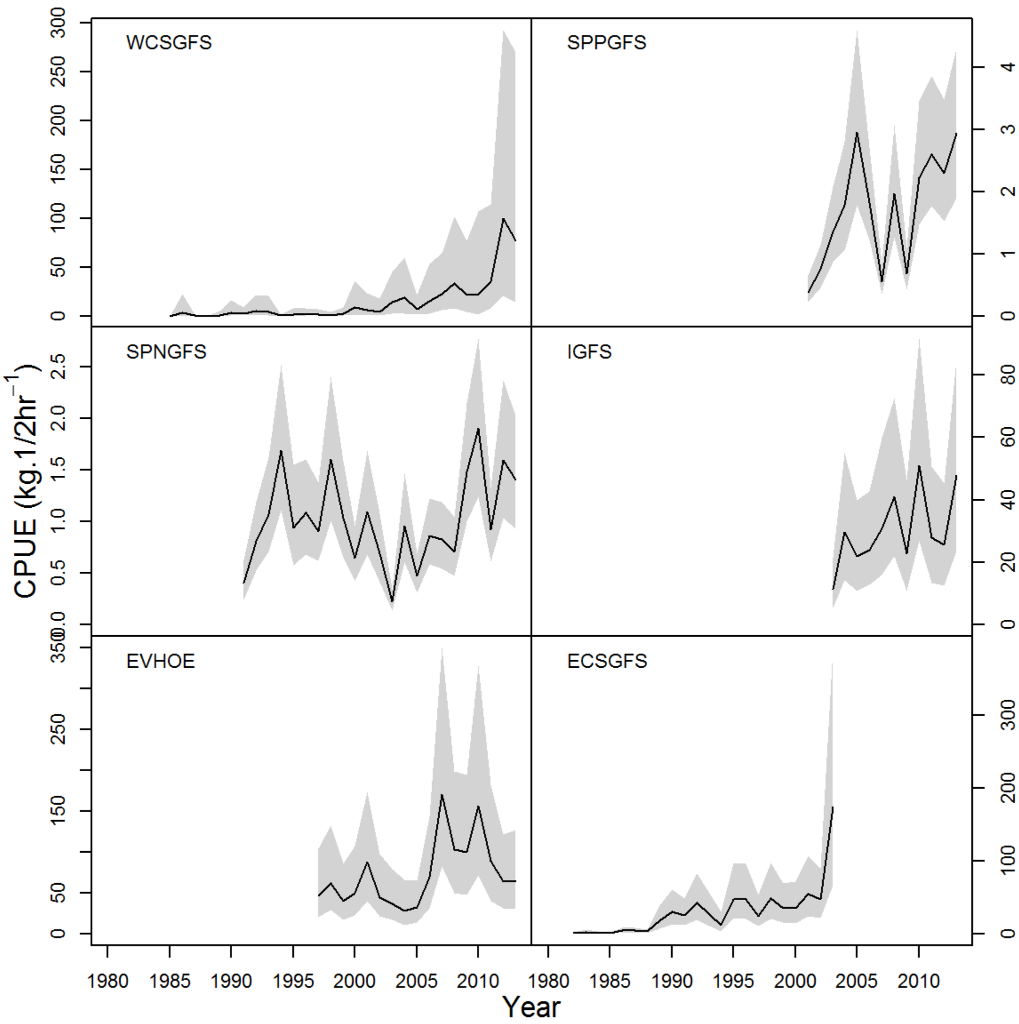


Figure 6.6.2.2. Boarfish in ICES Subareas VI, VII, VIII. Boarfish IBTS survey CPUE fitted delta-lognormal mean (solid line) and 95% credible intervals (grey region).

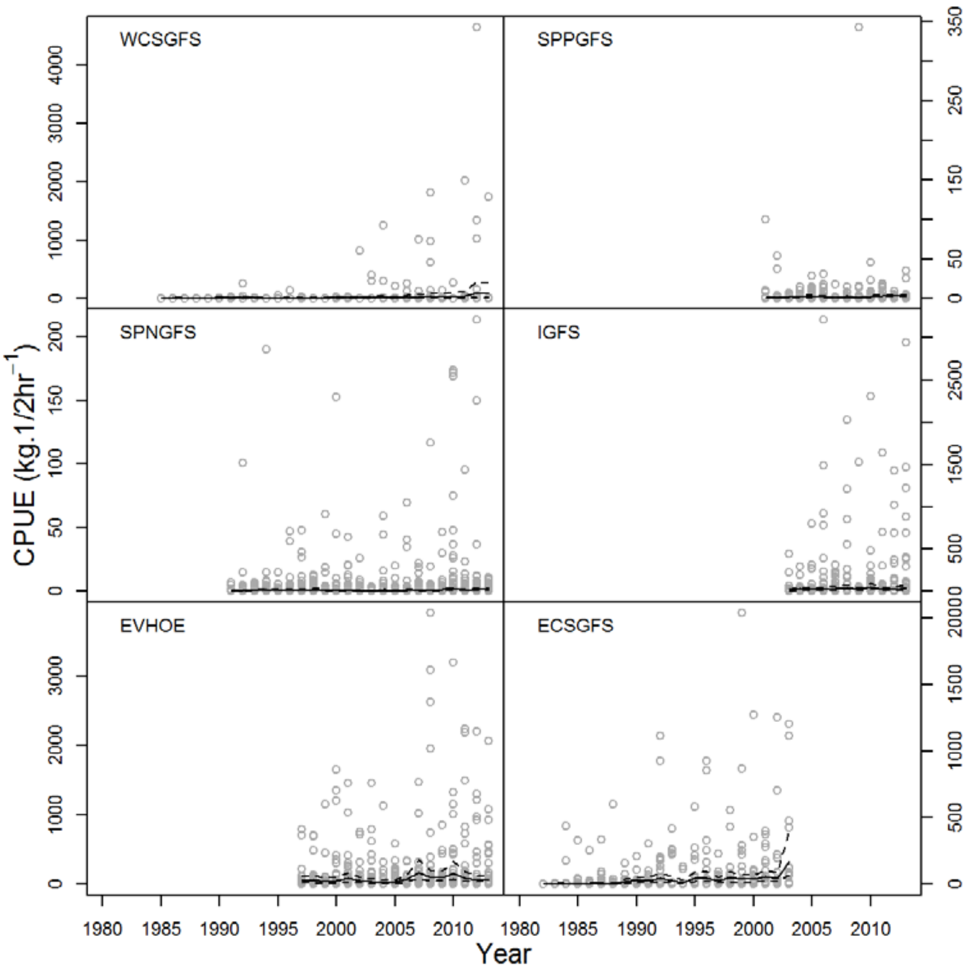


Figure 6.6.2.3. Boarfish in ICES Subareas VI, VII, VIII. Boarfish IBTS survey CPUE data (grey points) and fitted delta-lognormal mean (solid line) and 95% credible intervals (dashed lines).

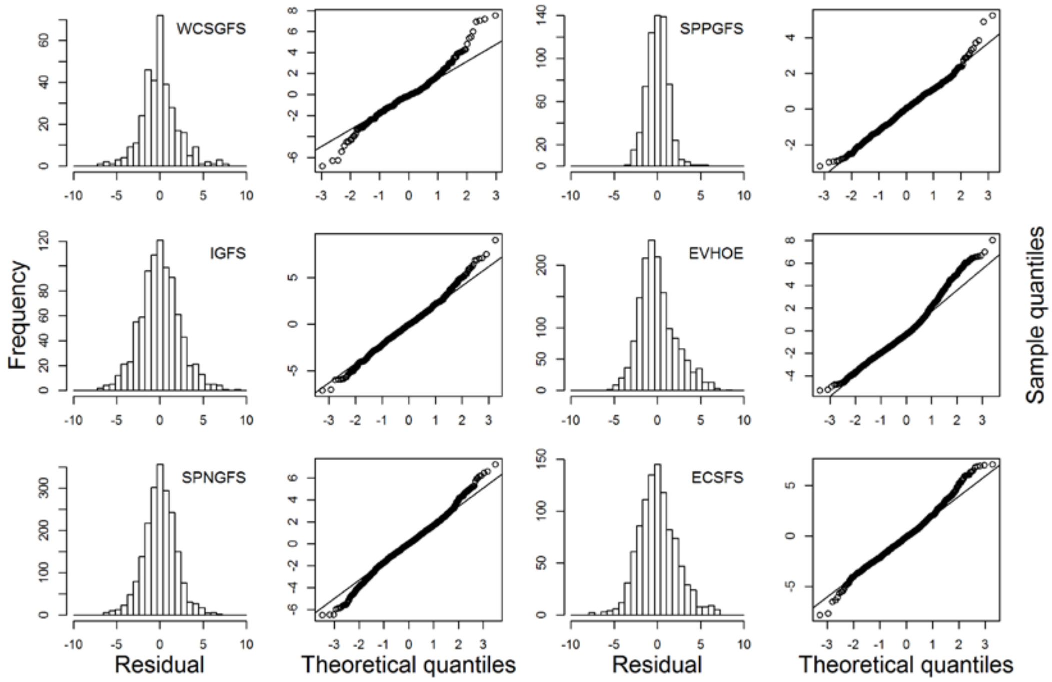


Figure 6.6.2.4. Boarfish in ICES Subareas VI, VII, VIII. Diagnostics from the positive component of the delta-lognormal fits.

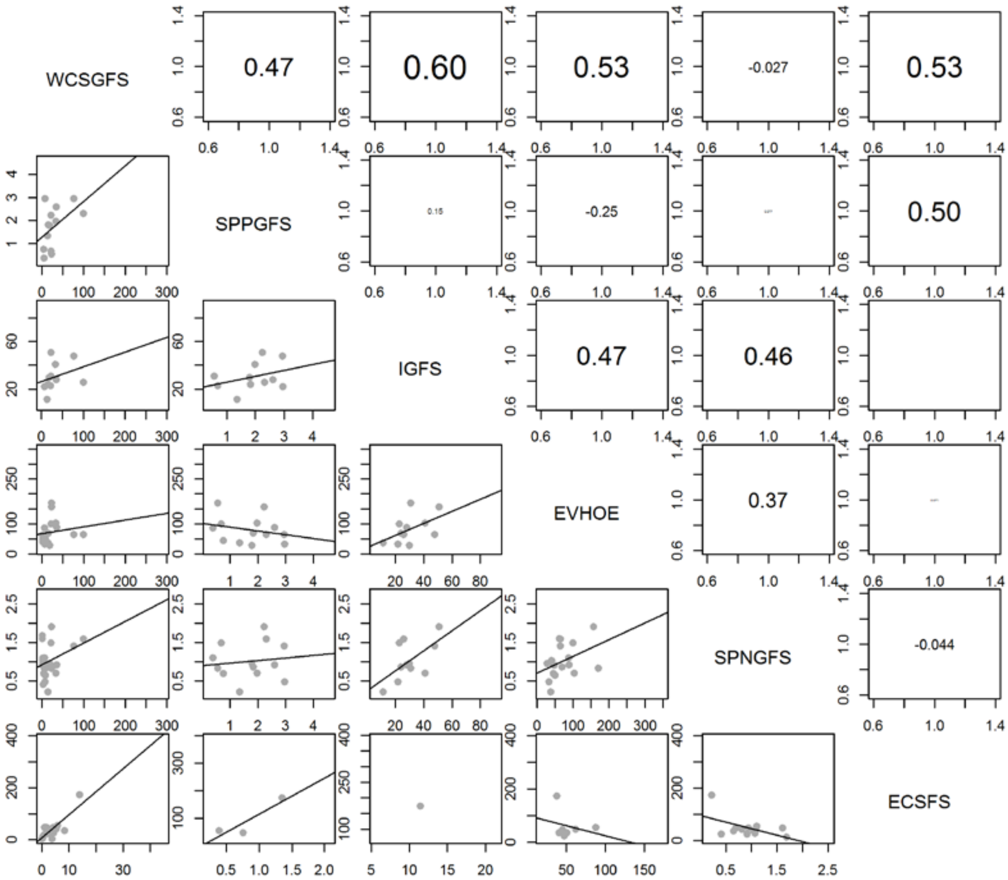


Figure 6.6.2.5. Boarfish in ICES Subareas VI, VII, VIII. Pair-wise correlation between the annual mean survey indices.

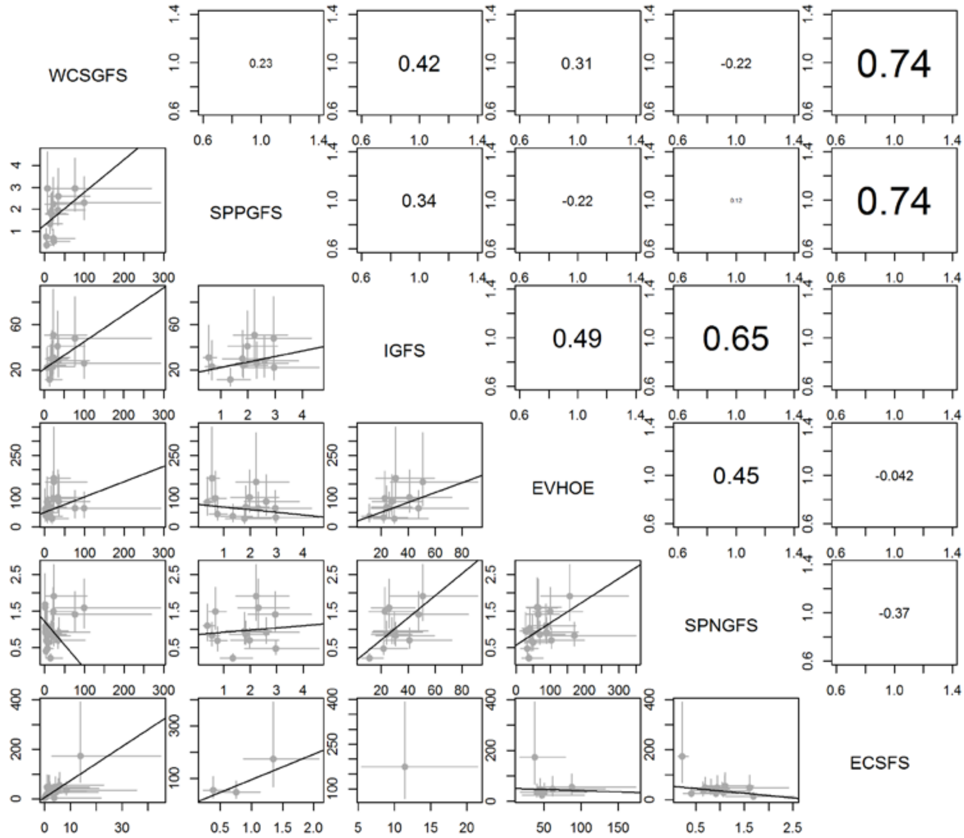


Figure 6.6.2.6. Boarfish in ICES Subareas VI, VII, VIII. Weighted correlation between the annual mean survey indices. Correlations are weighted by the sum of the pair-wise variances.

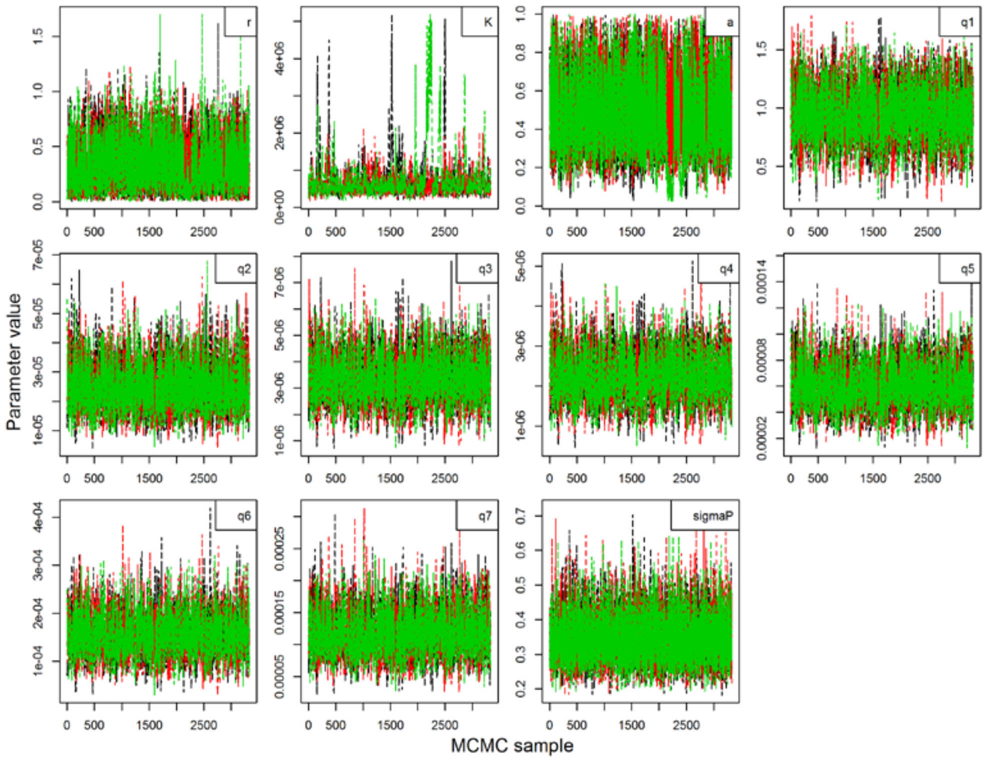


Figure 6.6.5.1. Boarfish in ICES Subareas VI, VII, VIII. Parameters for final run converged with good mixing of the chains.

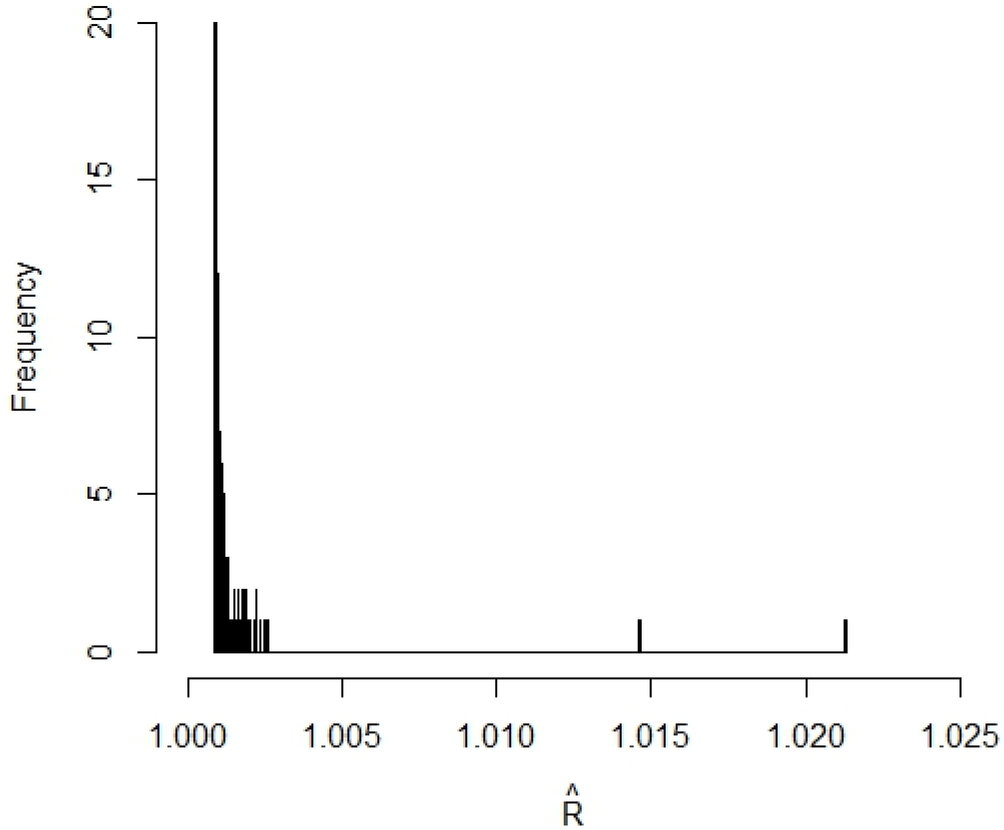


Figure 6.6.5.2. Boarfish in ICES Subareas VI, VII, VIII. Rhat values lower than 1.1 indicating convergence.

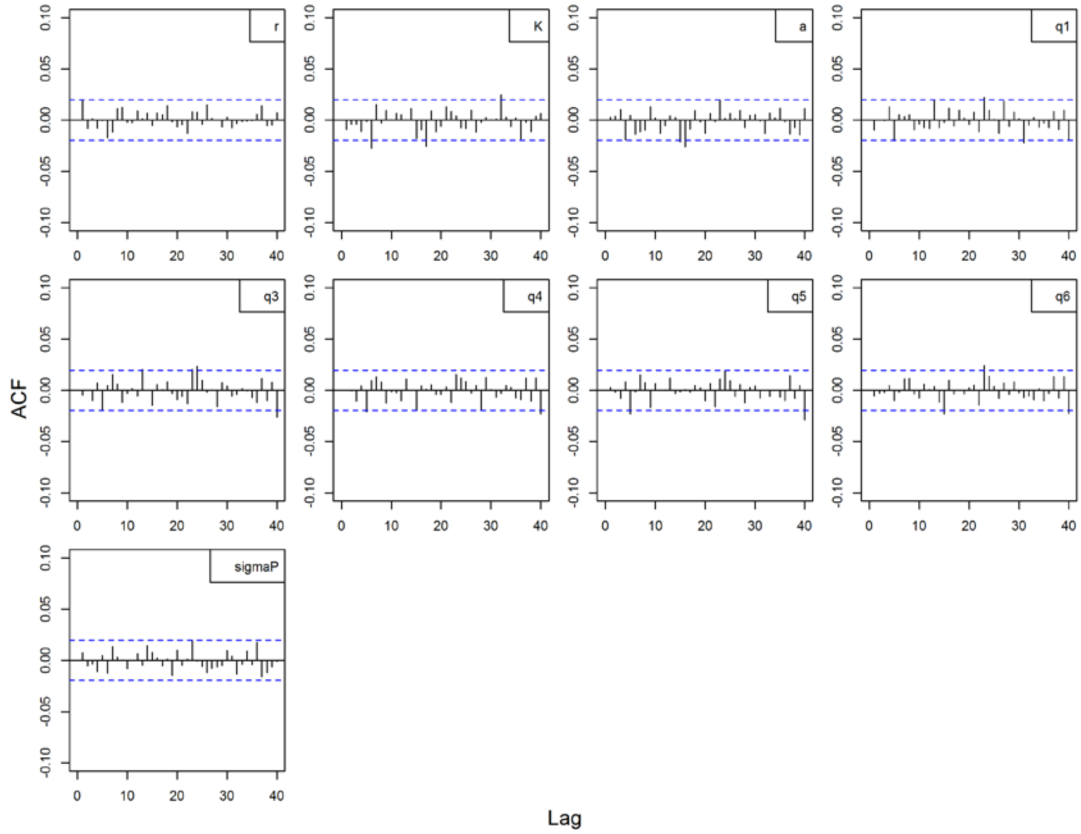


Figure 6.6.5.3. Boarfish in ICES Subareas VI, VII, VIII. MCMC chain autocorrelation for final run.

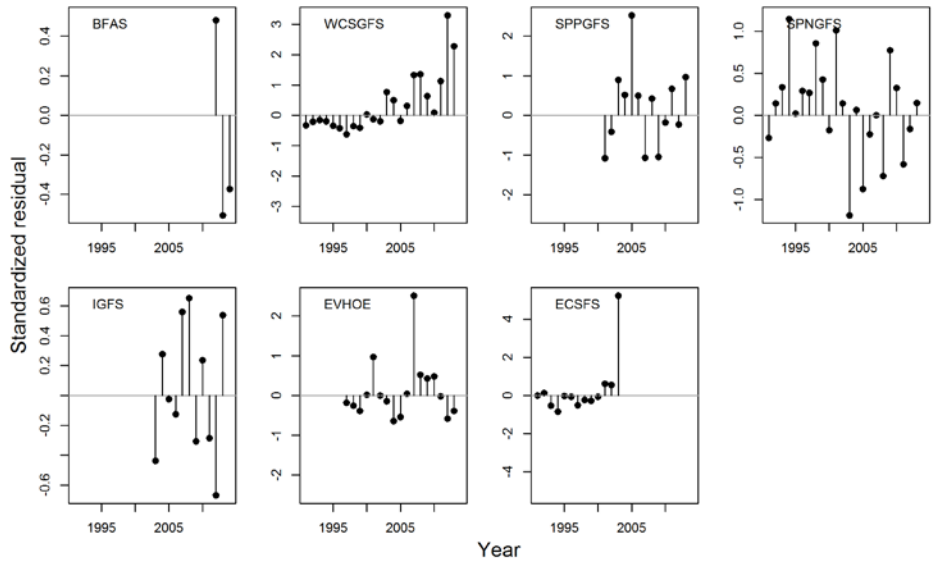


Figure 6.6.5.4. Boarfish in ICES Subareas VI, VII, VIII. Residuals around the model fit for the final assessment run.

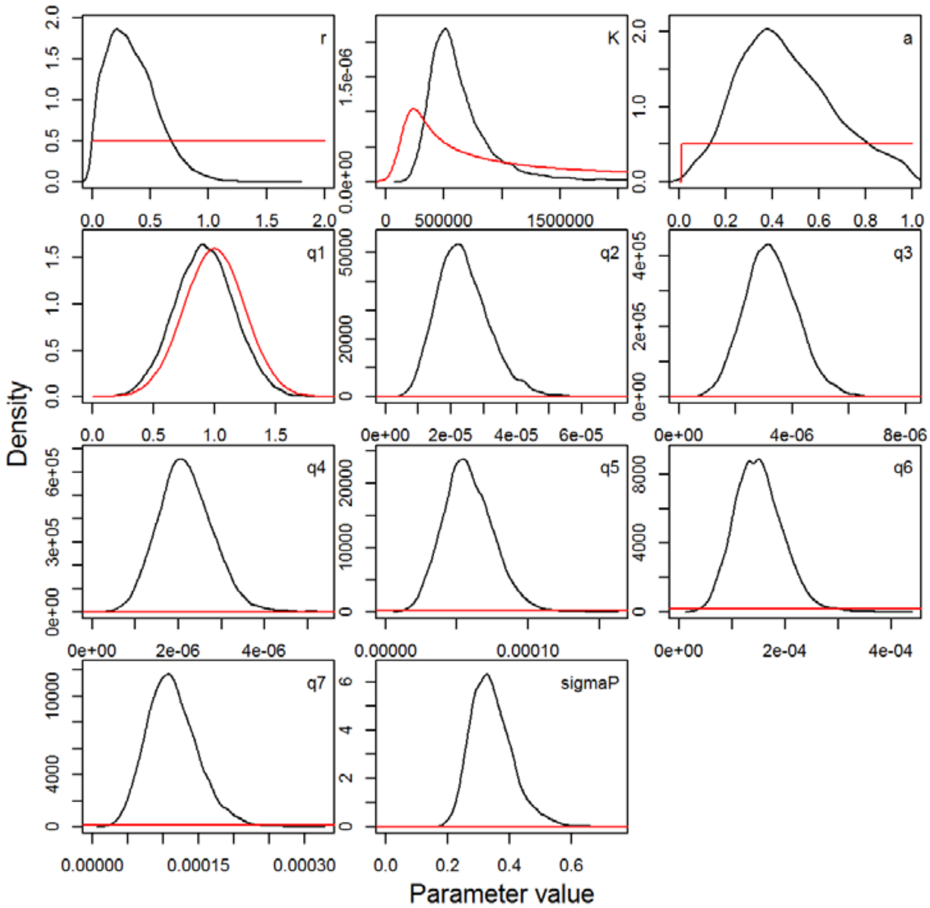


Figure 6.6.5.5. Boarfish in ICES Subareas VI, VII, VIII. Prior (red) and posterior (black) distributions of the parameters of the biomass dynamic model.

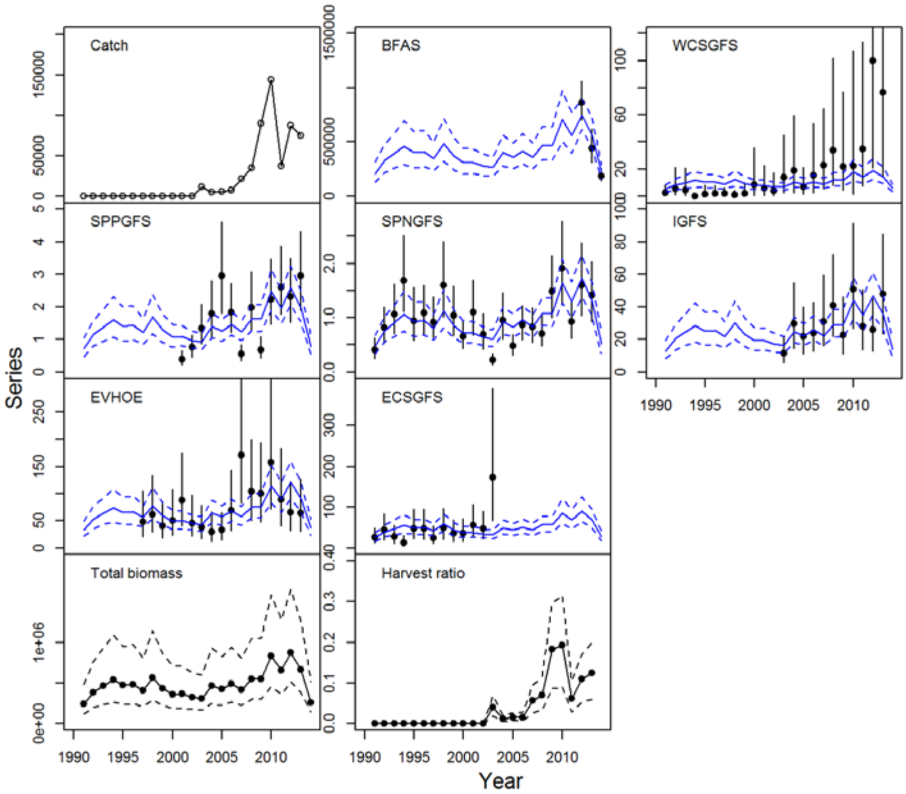


Figure 6.6.5.6. Boarfish in ICES Subareas VI, VII, VIII. Trajectories of observed and expected indices for the final assessment run. The stock size over time and a harvest ratio (total catch divided by estimated biomass) are also shown.

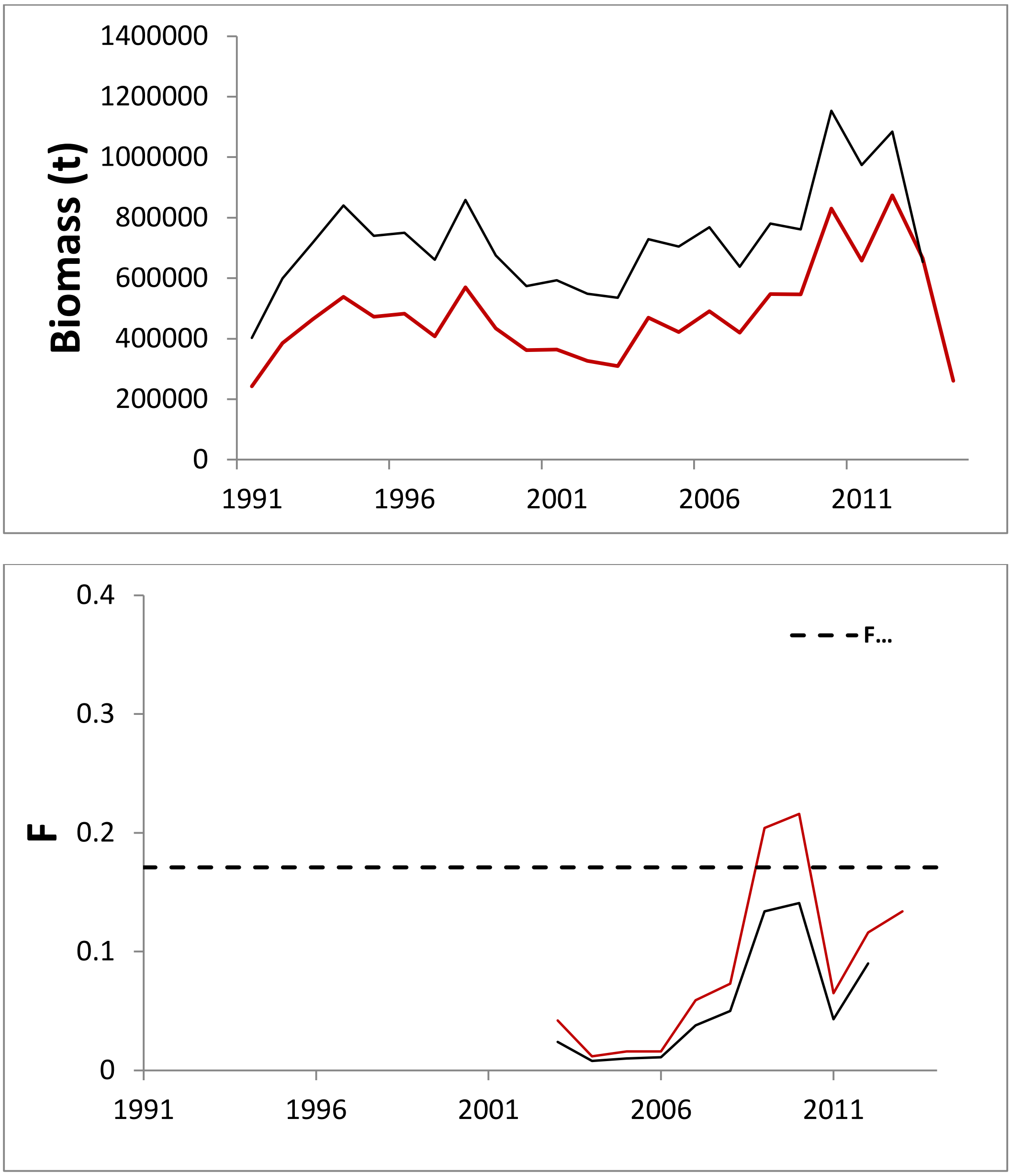


Figure 6.X.X.X. Boarfish in ICES Subareas VI, VII, VIII. Retrospective plot of total stock biomass (above) and fishing mortality (below) from the surplus production model in 2013 and 2014. Red line is current assessment.

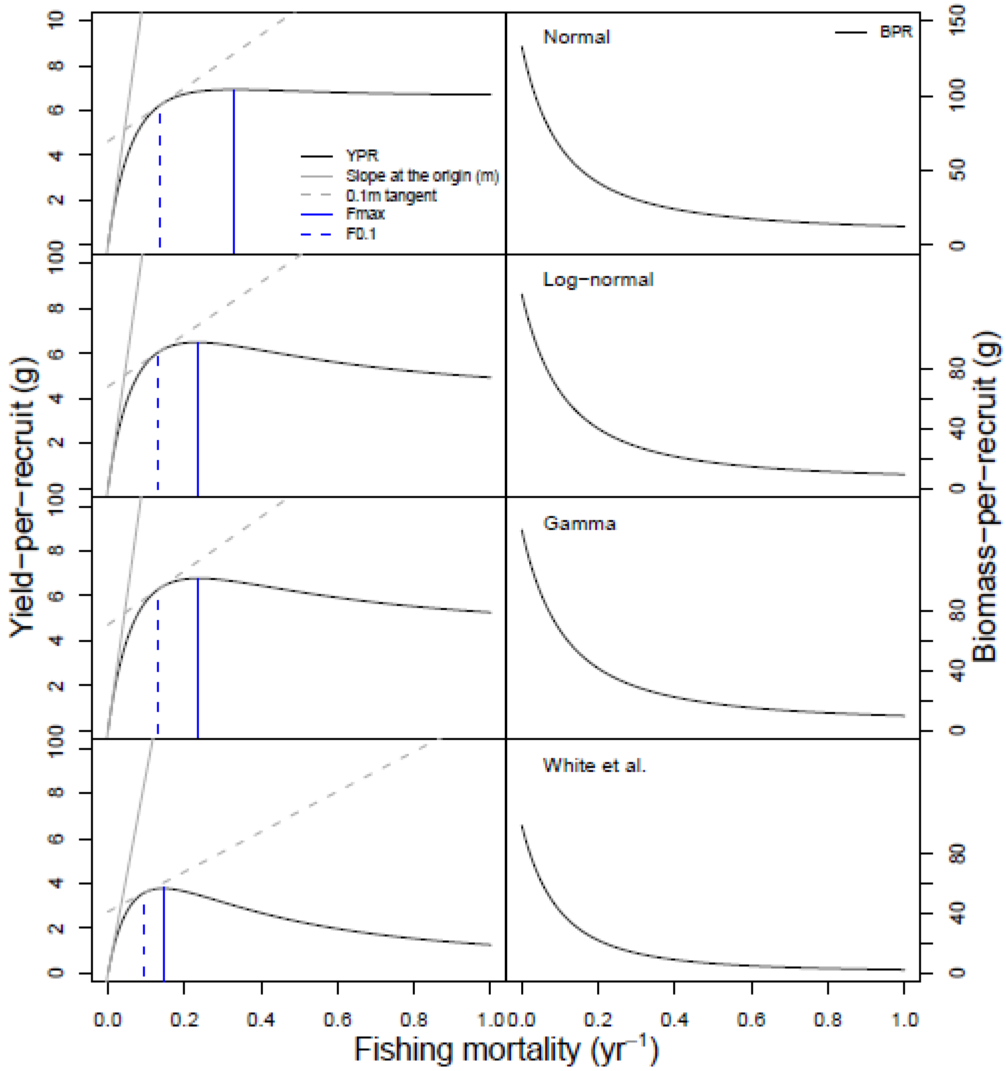


Figure 6.7.1.1. Boarfish in ICES Subareas VI, VII, VIII. Results of exploratory yield per recruit analysis. Beverton and Holt model applied to various fits of the VBGF and for comparison with the VBGF parameters provided by White *et al.* 2011.

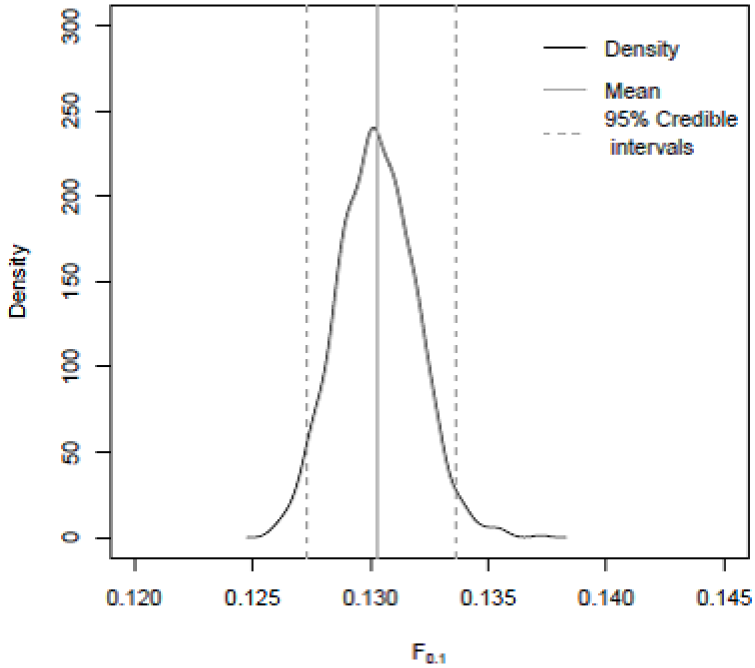


Figure 6.7.1.2. Boarfish in ICES Subareas VI, VII, VIII. Sensitivity of estimation of $F_{0.1}$.

7 Norwegian Spring Spawning Herring

7.1 ICES advice in 2013

Based on the most recent estimates of fishing mortality in 2011, ICES stated that the stock is being harvested below F_{MSY} but above the management target. The SSB is declining but still above B_{pa} and MSY $B_{trigger}$ in 2012. Presently three large year classes (2002, 2003, and 2004) dominate the stock. All year classes from 2005 onwards have been small, generally less than half the geometric mean.

A long term management plan, agreed by the EU, Faroe Islands, Iceland, Norway and Russia, is operational since 1999. ICES has evaluated the plan and concludes that it is in accordance with the precautionary approach. The management plan implies maximum catches of 619000 t in 2013.

7.2 Management in 2013 and 2014

EU, Faroe Islands, Iceland, Norway, and Russia agreed in 1996 to implement a long-term management plan for Norwegian spring-spawning herring. The management plan was part of the international agreement on total quota setting and sharing of the quota during the years 1997—2002. In the years 2003—2006 there was no agreement between the Coastal States regarding the allocation of the quota. In this period quotas were set unilaterally and in some countries quota were raised during the course of a year. In the years 2007—2012 the Coastal States have agreed to set a TAC in accordance with the management plan. For the fishing years 2013 and 2014, Faroe Islands have withdrawn from the Coastal States agreement on the allocation of the quota.

The management plan in use contains the following elements:

- Every effort shall be made to maintain a level of Spawning Stock Biomass (SSB) greater than the critical level (B_{lim}) of 2500000 t.
- For 2012 and subsequent years, the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality rate of less than 0.125 for appropriate age groups as defined by ICES, unless future scientific advice requires modification of this fishing mortality rate.
- Should the SSB fall below a reference point of 5000000 t (B_{pa}), the fishing mortality rate, referred under Paragraph 2, shall be adapted in the light of scientific estimates of the conditions then prevailing to ensure a safe and rapid recovery of the SSB to a level in excess of 5000000 t. The basis for such adaptation should be at least a linear reduction in the fishing mortality rate from 0.125 at B_{pa} (5000000 t) to 0.05 at B_{lim} (2500000 t).
- The Parties shall, as appropriate, review and revise these management measures and strategies on the basis of any new advice provided by ICES.

The agreed TAC for 2013[1] was 619000 tonnes. The agreed shares of the Parties (excluding the Faroe Islands) are 40297 tonnes for the European Community, 89817 tonnes for Iceland, 377590 tonnes for Norway and 79356 tonnes for the Russian Federation. In

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1 Agreed record of conclusions of fisheries consultations on the management of the Norwegian spring-spawning (Atlanto-scandian) herring stock in the north-east Atlantic for 2013 (London, 23 January 2013).

addition the Parties agreed to set aside a quantity of 31940 tonnes for the Faroe Islands based on the sharing arrangement agreed between the Parties in Oslo 18 January 2007.

Unilaterally, the Faroe Islands has decided[2] to fix a national catch ceiling at 17 per cent of the TAC of 619000 tonnes as advised by ICES for 2013. This corresponds to 105230 tonnes in 2013.

The agreed TAC for 2014[3] was 418487 tonnes. The agreed shares of the Parties (excluding the Faroe Islands) are 27244 tonnes for the European Community, 60722 tonnes for Iceland, 255277 tonnes for Norway and 53650 tonnes for the Russian Federation. In addition the Parties agreed to set aside a quantity of 21594 tonnes for the Faroe Islands based on the sharing arrangement agreed between the Parties in Oslo 18 January 2007.

Unilaterally, the Faroe Islands has decided[4] to fix a national catch ceiling at 40000 tonnes in 2014.

Each Party may transfer unutilised quantities of up to 10% of the quota allocated to the Party for 2014 to the quota allocated to that Party for 2015. Such transfer shall be an addition to the quota allocated to that Party for 2015. Each Party may also authorise fishing by its vessels of up to 10% beyond the quota allocated. All quantities fished beyond the allocated quota for 2014 shall be deducted from the Party's allocation for 2015. Further arrangements, including arrangements for access and other conditions for fishing in the respective zones of fisheries jurisdiction of the Parties, are regulated by bilateral arrangements.

7.3 The fishery in 2013

7.3.1 Description and development of the fisheries

Distribution of the 2013 Norwegian spring-spawning herring fishery for all countries by ICES rectangles per year is shown in Figure 7.3.1.1 and for annual quarter in Figure 7.3.1.2.

The 2013 herring fishing pattern was similar to recent years, i.e. clockwise movement of the fishing fleet in the Norwegian Sea as the year progressed. The fishery began in January on the Norwegian shelf and focused on pre-spawning, spawning and post-spawning fish (Figure 7.3.1.2 quarter I). By spring, fishing effort had shifted south to especially Faroese waters (Figure 7.3.1.2 quarter II). In summer the fishery expanded into Icelandic waters and north to Jan Mayen and Svalbard, hence, covering the whole western part of the Norwegian Sea (Figure 7.3.1.2 quarter III). In autumn, the fishery shifted to the eastern part of the Norwegian Sea (Figure 7.3.1.2 quarter IV). The largest proportion of the catches was taken in the fourth quarter (51 %).

The NSSH changed wintering areas from fjordic to oceanic during the years 2002—2006. The new wintering pattern caused a large change in fishing pattern as more catches were taken during the spawning migration and spawning instead of during

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2 Press release by the Faroese Ministry of Fisheries 26-03-2013 | The Faroese fishery for Atlanto-Scandian herring in 2013

3 Agreed record of conclusions of fisheries consultations on the management of the Norwegian spring-spawning (Atlanto-scandian) herring stock in the north-east Atlantic for 2014 (Reykjavík, 28 March 2014).

4 Press release by the Faroese Ministry of Fisheries 12-06-2014 | Prime Minister welcomes understanding to resolve dispute on EU's economic measures

the wintering period. These changes apply mostly to the Norwegian fleet and are described in section 7.3.1.8. A further change in recent years, is that before 2010 the fishery in fourth quarter tended to be primarily in the wintering area in the Norwegian zone, but in the last years there have also been fisheries in the international (<68°N), Icelandic and Faroese EEZs.

In 2013, there were limitations by some countries to enter the EEZs of other countries regarding Norwegian spring-spawning herring. Therefore, the fisheries do not necessarily depict the distribution of herring in the Norwegian Sea and the preferred fishing pattern of the fleets given free access to all zones.

7.3.1.1 Denmark

The Danish fishery of Norwegian spring spawning herring in 2013 took place in IIa during January and February, by purse seiners and trawlers. A total sum of 17160 tonnes was caught, corresponding to 99.9% of the Danish quota. All catches were from Norwegian EEZ.

7.3.1.2 Germany

The vessels targeting Norwegian spring spawning herring belong to the pelagic freezer trawler fleet owned by a Dutch company and operating under the German flag. Depending on season and the economic situation these vessels are targeting other pelagic species in European and international waters. This fleet consists of four large pelagic freezer-trawlers with power ratings between 4200 and 12000 hp and crews of about 35 to 40 men. The vessels are purpose built for pelagic fisheries. The catch is pumped into large storage tanks filled with cool water to keep the catch fresh until it is processed. The reported landings in 2013 were 4244 tonnes taken in IIa and IIb.

7.3.1.3 Greenland

The bulk of the catches was taken in Division IIa in fourth quarter, while the remaining was caught in both Division Va (fourth quarter) and Subarea XIV (late summer), partly as an exploratory fishery.

7.3.1.4 Faroe Islands

Faroese vessels landed 105 038 of Norwegian spring spawning herring in 2013. The majority of the landings were caught within the Faroese EEZ (93 %), and the rest in international waters (7 %). Approximately two thirds of the catches were taken in May to September in a mixed fishery for Norwegian spring spawning herring and mackerel. The remaining catches were taken in the direct herring fishery, which occurred in autumn (October to November). Herring was caught within the Faroese EEZ from May to November but the location of the fishery shifted between seasons. In early summer, the fishery was concentrated between latitudes 62 °N to 65 °N, just north of the Faroe Islands. In August the fishery was across the Faroese EEZ around 63 °N. In autumn the fishery shifted to the north eastern part of the Faroese EEZ and, to a lesser extent, the international zone in the Norwegian Sea. Faroese fishing vessels did not catch any herring in winter (January – April).

The 2013 herring fishing season in Faroese waters lasted six months – from May to November. This trend of prolonged herring fishery in the Faroese EEZ has been observed since 2008.

7.3.1.5 Iceland

The Icelandic TAC for Norwegian spring spawning herring in 2013 was set at 90000 tonnes. The majority of the catch, 64000 tonnes, was caught, as in last years, within the Icelandic EEZ in the period July to October. The prolonged existence of the stock on feeding grounds in the west into the autumn in recent years therefore continues, whereas in the years before the fishery moved to International or Norwegian waters already in September-October. The remaining catch of 18200 tonnes was caught within the Faeroese EEZ and 8500 tonnes in International waters in September to November. The total catch of the Icelandic fleet in 2013 came to 90729 t.

Since 2007 the entire fishery of the Icelandic summer-spawning herring has been west and south off Iceland and therefore Norwegian spring-spawning herring was not caught in that fishery, different from the east coast fishery during 2004—2005.

7.3.1.6 Ireland

The Irish fishery for Norwegian spring spawning herring took place in February off the Norwegian coast. A total of 7 vessels (23—63 m) participated in the fishery and recorded landings of 3815 tonnes. Norwegian spring spawning herring from the Irish fleet are landed primarily for reduction to fishmeal and processed for human consumption. All landings were made into Norwegian ports.

7.3.1.7 Netherlands

Two Dutch freezer trawlers participated in the fishery for Norwegian spring spawning herring in 2013. The fishery took place in late October to early November, in ICES Division II. The Dutch catch of 5626 tonnes was taken in 2 trips. The fishery is carried out with large pelagic trawls.

7.3.1.8 Norway

The Norwegian quota for 2013 was shared with about 50% to the large oceanic purse seiners, 10% to trawlers and 40% to smaller coastal purse seiners. The total catch during the first quarter in 2013 was 130323 tonnes. The Norwegian fleet hardly fish herring in the oceanic feeding area during the second quarter. There are some catches reported from the coastal areas during this period, amounting to 1005 tonnes in 2013. This herring consists of a mix of NSSH, a summer spawning oceanic stock and local fjordic herring stocks, of which the two latter are allocated to the Norwegian spring spawning herring quota for practical reasons. The Norwegian fishery in quarter 3 was 2802 tonnes. The fisheries in the fourth quarter took place in the migration route from the feeding areas in the Norwegian Sea to the wintering areas west and northwest of Vesterålen and in fjords in Troms, and the total catch was 225322 tonnes.

7.3.1.9 Russia

The Russian fishery started within the wintering area of the Norwegian spring spawning herring (approximately 10—13°E) in the Vesteralen (Norwegian EEZ) at the beginning of January, then progressed in the south-western direction along the Norwegian coast and was finished on south banks of the Norwegian shallow water (approximately 63°N) at the second half of February. In January-February the total catch was 8511 t.

During the II quarter the Russian fleet did not target fishery of herring almost. Major part of herring was caught in the mackerel fishery. But several vessels started target fishery at the end of June. The total catch was 670 t.

In III quarter, Russian fishery started at the beginning of July. The vessels caught herring in the international water and in areas of Spitsbergen and Jan-Mayen westward from 17° E. 29648 t of herring was taken in the III quarter.

In IV quarter, the fishery was continued in area of Spitsbergen, Jan-Mayen and international water. At the end of October the Russian fishery started in the Norwegian EEZ. Catch was finished in December. 39692 t was taken in that period.

The Russian fishery is carried out by different types of trawl vessels. Total Russian catch of Norwegian spring spawning herring was 78521 t. The entire Russian catch was utilized for human consumption.

7.3.1.10 UK (Scotland)

UK vessels (all of which were Scottish) landed 1965 tonnes of Norwegian spring spawning herring from Division IIa into Scotland in 2013. Scottish vessels also landed 6377 tonnes of herring from Division IIa into Norway. The fishery took place in first quarter only. In total ten Scottish trawlers ranging in size from 62—73m, participated in the fishery.

7.3.2 Information on by-catch

In recent years the Faroes have reported on problems with mackerel caught as by-catch in the directed herring fishery north of the Faroes. However, since 2010 the fishery has been directed towards herring and mackerel in the Faroese zone, and has thus been a result of legal activity.

7.4 Stock Description and management units

7.4.1 Stock description

A description of the stock is given in section A.1.1 in the stock annex.

7.4.2 Changes in migration

A characteristic feature of this herring stock is a very flexible and varying migration pattern. A detailed description of the migration pattern is given in the stock annex.

Information about changes in migration of the stock in recent years is mainly derived from the ecosystem surveys Nordic Seas in May (ICES 2014c) and July/August (Nøttestad *et al.* 2014). The May survey takes place when the stock is still, in part, migrating to the feeding grounds and there are no major changes in migration pattern and distribution of the stock observed in recent years. The main concentration has been in the mid Norwegian Sea with a tail reaching southwest into Faroese and Icelandic waters and typically a smaller concentration further north towards Lofoten in Norway. The July/August survey shows a further westwards and northwards migration, with the main concentrations in the south-western to north-western fringes of the Norwegian Sea and herring being relatively absent from the mid Norwegian Sea. However, the main changes in the stock's migration pattern observed in recent times derive from information from the commercial fishery. They indicate that herring have prolonged the stay on the feeding grounds in the western part, with fishery ongoing in Faroese and Icelandic waters reaching into November in recent three years, in contrast to September and October earlier. Such indications resulting from fishing activity have to be interpreted carefully as the behaviour of the fleet can also have changed, causing the changes in distribution of catch from one year to another.

It is not clear what drives the changes in the migration, but the biomass and production of zooplankton is a likely factor, as well as feeding competition with other pelagic fish species (e.g. mackerel) and oceanographic features (e.g. limitations due to cold areas). However, it should be noted that beside the environmental forces the age distribution in the stock is also likely to influence the centre of gravity of the stock during summer (Figure 7.4.2.1). At present the stock consists of old individuals due to poor recruitment in a number of years, and as the largest fish move farthest west, the stock should be in the western areas at the time being while the opposite should be expected when rich year-classes join the adult stock from the nursery areas in the Barents Sea.

7.5 Data available

7.5.1 Catch data

Catches in tonnes by ICES division, ICES rectangle and quarter in 2013 were available from Denmark, Faroe Islands, Germany, Greenland, Iceland, Ireland, The Netherlands, Norway, Russia, Scotland and Sweden. The total working group catch in 2013 was 684743 tonnes (Table 7.5.1.1) compared to the ICES-recommended catch of 619000 tonnes.

Table 7.5.1.2 shows catches and number of age samples by country, ICES division and quarter together with the samples used as fill-in for unsampled catches (when calculating the catch and weight at age). Sampled catches accounted for 91% of the total catches, which is similar to previous years. The majority of the catches (>80 %) were taken in division IIa.

This year Intercatch was used for the first time to calculate age and size distributions, so all countries were requested to deliver catch and sample data both as the old data delivery sheets and as Intercatch files. Table 7.5.1.3 shows a comparison of catch at age and weight at age in 2013 estimated with the SALLOC software and with Intercatch. The differences are negligible. However, a problem with intercatch is that it is not possible to record catch data from the same species and two different stocks in the same area. This problem applies to catches of Norwegian spring spawning herring in area IVa as catches of North Sea herring are also recorded from this area. The solution to the problem was to sum all the countries catches in IVa and allocate this total catch to area XIVa and to use “other” as country code.

7.5.2 Discards

In 2008, the Working Group noted that in this fishery an unaccounted mortality caused by fishing operations and underreporting probably exists. It was not possible to assess the magnitude of these extra removals from the stock, and taking into account the large catches taken in recent years, the relative importance of such additional mortality is probably low. Therefore, no extra amount to account for these factors has been added in 1994 and later years. In previous years, when the stock and the quotas were much smaller, an estimated amount of fish was added to the catches.

The Working Group has no comprehensive data to estimate discards of the herring. Although discarding may occur on this stock, it is considered to be low and a minor problem to the assessment. This is confirmed by estimates from sampling programmes carried out by some EU countries in the Data Collection Framework. Estimates on discarding in 2008 and 2009 of about 2% in weight were provided for the trawl fishery carried out by the Netherlands. In 2010 and 2012, this metier was sampled by Germany. No discarding of herring was observed (0%) in either of the two years.

During the Norwegian fishery in the first quarter the stock is migrating fast southward in dense aggregations. This is a challenge to the fleet by increasing the risk of slipping of the catch or breaking of the net during fishing operations due to extremely large catches. There are no data to estimate the amount of slipping. However, the Coastguard maintains a close presence with the pelagic fishing fleet during the season with several vessels and a plane. IMR has cooperation with a number of reference vessels in the pelagic fleet, primarily for the purposes of biological sampling but also recording losses through gear damage or slipping. These data indicate that the frequency of slipping and the total quantities of fish slipped are low and, although the quantity remains unknown, are too small to have a significant effect on the reliability of the assessment.

7.5.3 Length and age composition of the catch

The catch at age data are given in Table 7.5.3.1. The numbers are calculated with Intercatch for 2013 and SALLOC before 2013. In 2013, about 30% of the catches (in numbers) were taken from the 2004 year class, followed by the 2006 and 2009 year classes that each contributed around 15%. Lengths at age data are not used in the assessment.

7.5.4 Weight at age in catch and in the stock

The weight-at-age in the catches in 2013 was computed from the sampled catches in 2013 using Intercatch. SALLOC was used for the years before 2013. Trends in weight-at-age in the catch are presented in Figure 7.5.4.1 and Table 7.5.4.1. The mean weights at age for most of the age groups have generally been increasing from 2011 onwards.

A similar pattern is observed for some age groups (age 5—9) in weight-at-age in the stock which is presented in Figure 7.5.4.2 and Table 7.5.4.2. These data have been taken from the survey in the wintering area until the year 2008. The mean weight at age in the stock for age groups 4—11 in the years 2009—2014 was derived from samples taken in the fishery in the same area and at the same time as the wintering surveys were conducted in.

7.5.5 Maturity at age

The maturity data used in the assessment were revised in 2010 following a recommendation from WKHERMAT[5]. This Workshop evaluated the existing maturity at age data because they were not available or considered in the benchmark assessment in 2008.

WGWIDE adopted the maturity ogives derived from back calculation of scales for the historical time period (years 1950-2007) in the assessment. WGWIDE recommends that this data set remains updated in future years. For the years after 2007 for which no data are available from this method (including the years considered in the forecast) the following default maturity ogives will be assumed. For ‘normal’ classes (average, median and weak year classes), an average maturity at age will be assumed from the periods 1983—2007 from the back calculation data set excluding the strong year classes 1983, 1991, 1992, 1998, 1999, 2002. For year classes which are considered strong, preliminary estimates will be assumed to be the average of the recent strong year classes 1983, 1991, 1992, 1998, 1999, 2002 in the data set.

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5 Report of the Workshop on estimation of maturity ogive in Norwegian spring spawning herring (WKHERMAT). 1-3 March 2010 Bergen, Norway. ICES CM 2010/ACOM:51 REF. PGCCDBS

The default maturity o-gives used for 'normal' and strong year classes are given in the text table below.

age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
normal yc	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
strong yc	0	0	0	0	0.1	0.6	0.9	1	1	1	1	1	1	1	1	1

The maturity ogives used in the present assessment are presented in Table 7.7.5.1.

7.5.6 Natural mortality

In this year's (2013) assessment, the natural mortality M=0.15 was used for ages 3 and older and M=0.9 was used for ages 0—2. These levels of M are in accordance to previous years and their justification is provided in the stock annex. Information about deviations from these levels in the time series, e.g. due to diseases, are also provided in the stock annex.

7.5.7 Survey data updated

The description of the surveys and use of them for tuning in the assessment are given in the Stock Annex 2. This section contains and discusses the survey results from some recent years. Several surveys were stopped many years ago, but are still used for tuning of the assessment models because they were included in the benchmark. The influence of these surveys on the assessment and the need to use them in the future should be investigated in the next benchmark assessment.

7.5.7.1 Survey 1 Norwegian acoustic survey on spawning grounds in February/March (NASF)

No new information but the years 1994—2005 are used in the tuning (see stock annex 2).

7.5.7.2 Survey 2 Norwegian acoustic survey in November/December (NASN)

No new information but the years 1992—2001 are used in the tuning (see stock annex 2).

7.5.7.3 Survey 3 Norwegian acoustic survey in January (NASJ)

No new information but the years 1991—1999 are used in the tuning (see stock annex 2).

7.5.7.4 Survey 4 and 5 International ecosystem survey in the Nordic Seas (IESNS)

The international ecosystem survey in the Nordic Seas aims for exploring the pelagic ecosystem, with a special focus on herring, blue whiting, zooplankton and hydrography. Survey coverage in the Norwegian Sea was considered adequate in 2014 and in line with previous years. It is therefore recommended that the results can be used for assessment purpose. The herring distribution in 2014 was similar to the 2013 distribution. (Figure 7.5.7.4.1). The highest concentrations were found in the central to southwestern part of the Norwegian Sea and consisted mainly of older part of the stock (age 8 and older). A dense concentration was also found in the northeast (around 69°N and 5°E) and consisted of a mixture of all age classes from age 2—14. Overall the herring density was relatively low and herring was never observed in big schools. In 2014, like in previous three years, almost no herring were observed north of 70°N, while it was found further north in 2010. The center of gravity of the acoustic recordings of herring reflects the distribution and shifted in a southwesterly direction compared to 2013.

As in previous years the smallest fish were found in the eastern area of the Norwegian Sea whereas size and age were found to increase to the west and south. Correspondingly, it was mainly older herring that appeared in the southwestern areas (area III).

The herring stock is now dominated by 10 year old herring (2004 year class) in numbers but 5, 8, 9, 11 and 12 year old herring (the 2009, 2006, 2005, 2003 and 2002 year classes) are also numerous (Table 7.5.7.4.2), which is similar to previous years. (Figure 7.5.7.4.2). The 2009 year class appears to be the largest of the younger age groups even it appears to be only around 50% of average size of five year olds in the times series since 1997. The six year classes from 2002 to 2006 and 2009 contribute to 6%, 10%, 22%, 14%, 12% and 14%, respectively, of the total biomass.

The total biomass estimate of herring in the Norwegian Sea from the 2014 survey was 5.1 million tons. This estimate is 0.3 million tons lower than in 2013. The biomass estimates in the last six years has fluctuated, with 10.7 million tons in 2009, 5.8 million tons in 2010, 7.4 million tons in 2011, 4.6 million tons in 2012, 5.4 million tons in 2013 and now 5.1 million tons in 2014.

The investigations of herring in the Barents Sea covered the area from 44°E to the 20°30′ E. The total abundance estimate was higher than in the last two years, with 5876 million individuals of age 1 (mean length of 11.5 cm and weight of 8.7 g), 2185 million individuals of age 2 (mean length of 17.8 cm and mean weight of 32.4 g), 2156 million individuals of age 3 herring (mean length of 23.8 cm and mean weight of 76.3 g) and 242 million individuals of age 4 herring (mean length of 25.7 cm and mean weight of 95.9 g). Only very few older herring were observed.

The total number of herring recorded in the Norwegian Sea was 9.6 billion in the northeastern area and 10.4 billion in the southwestern area, compared to 12.8 and 13.0 billion in the northeastern and 7.2 and 7.4 billion in the southwestern area in 2012 and 2013, respectively.

The age-disaggregated time-series of abundance for the Barents and Norwegian Sea are presented in Table 7.5.7.4.1 and 7.5.7.4.2, respectively.

7.5.7.5 Survey 6 and 7 Ecosystem survey in the Barents Sea (Eco-NoRu-Q3 (Aco))

The age groups 1 and 4 are used in the assessment. The log index of 0–group herring has been used in the assessment up to 2004 and then replaced by a new abundance index, which was included in the assessment since 2006.

The results from these surveys on 0–group herring are given in Table 7.5.7.5.2; those of the 1 to 4 age groups are given in Table 7.5.7.5.1.

The total abundance of herring aged 1-4 years covered during the survey was estimated at 12.8 billion individuals (about 3 times higher than the value estimated in 2012). The biomass of 0.5 million tonnes is about 80% higher than in 2012, since the overall mean weight is much lower this year. This is first of all an effect of a younger age distribution in 2013. During recent years, the amount of young herring entering the Barents Sea has been low, and the estimated stock size in 2013, though being much higher than last year, is only about half of the average stock size during the period 1999 to 2013.

In 2013, only very scattered concentrations of herring were found from Nordkapp eastwards to Novaya Zemlya. Herring of ages between 1 and 4 was registered, with 1-year-olds being dominant in numbers and 2-year-olds in biomass. The distribution of young herring is shown in Figure 7.5.7.5.1. 0-group herring were distributed as in 2012 from southeast to northwest of the Barents Sea in 2013. However, herring has widely distribution in the central part of the sea in comparison to 2012. The main dense concentration of herring was located in the central area: between 71—75° N and 24—35° E. Distribution of 0–group herring is presented in Figure 7.5.7.5.2.

7.5.7.6 Survey 8 Norwegian herring larvae survey on the Norwegian shelf (NHLS)

A description of this survey is given in stock annex 4. Two indices are available from this survey (Table 7.5.7.6.1). The "Index 1" is used in the assessment as representative for the size of the spawning stock except for 2003 and 2009 due to incomplete coverage in these years.

In 2014 the survey was carried out from 31 March to 14 April. The number of herring larvae was estimated to be 75.6*10^{12}. The number of larvae is slightly higher than last year (Table 7.5.7.6.1).

As shown in figure (Figure 7.5.7.6.1), herring larvae were observed throughout the sampling area. Zero values were found on the southernmost and northernmost sections. The offshore extent of the larval distributions were found on all transects. The highest abundance of herring larvae were found relatively close inshore, on the northern part of the Møre spawning grounds and northward to Sklinnabanken. Relatively low concentrations of larvae were found on the northern spawning banks of Lofoten, Vesterålen and Troms.

7.5.7.7 Survey 9 International ecosystem survey in the Norwegian Sea in July–August (IESSNS)

The IESSN survey (formerly called "Norwegian ecosystem survey and SALSEA salmon project in the Norwegian Sea in July-August") has been carried out on the Norwegian shelf since 2004 for the exception 2008 but was extended to the whole Norwegian Sea, Icelandic waters, and Faroese waters in 2009. The objectives of the survey are to obtain estimates of abundance, spatiotemporal distribution, aggregation and feeding ecology of Northeast Atlantic mackerel, Norwegian spring-spawning herring, blue whiting and Atlantic salmon in relation to oceanographic conditions, prey communities and marine mammals.

The survey has not been used in the assessment of NSS herring but the results from the surveys, with regards to herring, plankton and hydrographical investigation, has been presented to the WG every year. Four vessels from Norway (2), Iceland (1) and Faroe Island (1) participated in the survey in 2014 during 2 July to 12 August. The acoustic estimate of NSSH in the survey came to only 4.6 million tonnes compared to 8.6 million tonnes in 2013, 7.3 million tonnes in 2012, 10.7 million tonnes in 2010 and 13.6 million tonnes in 2009. There is no estimate from 2011 due to insufficient coverage. There are two likely explanations for the drop in the biomass index in 2014. First, the survey did probably not cover the whole distribution area of the stock, especially north of Iceland and west of Jan Mayen. Secondly, there is a strong indication that herring were in the acoustic dead-zone above the transducer or in the surface 10—15m, (e.g. in the Jan Mayen area).

7.6 Methods

7.6.1 TASACS stock assessment

This year's assessment was classified as an update assessment and was run according to the benchmark in 2008 using the VPA population model in the TASACS toolbox with the same model options as the benchmark (see stock annex 4). The information used in the assessment is catch data and survey data from eight surveys. The analysis was restricted to the years 1988—2014, which is regarded as the period representative of the present production and exploitation regimes, and is presumed to be of main interest for the management.

As a result of the data exploration WGWIDE in 2013 implemented an updated algorithm for calculating the terminal F-values for last age classes where no data supporting the estimate of terminal stock numbers was available. The same procedure was used this year.

The model was run with catch data 1988—2013, and projected forwards through 2014 assuming Fs in 2014 equal to those in 2013, to include survey data from 2014.

7.6.2 Short-term forecast

A detailed description of the short term forecast procedure is given in the stock annex. Since the standard software cannot cope with Management Option Tables based on average fishing mortality weighted over stock numbers, calculations are carried out using a spread sheet.

7.7 Data Exploration

7.7.1 Catch curve analyses

Figure 7.7.1.1 shows the age disaggregated catch in numbers by years. In the years 2009—2011 the year classes from 2002—2004 were the most prominent year classes in the catches, whereas in 2012 and 2013 it is the 2004 year class. Figure 7.7.1.2 shows the disaggregated catch in numbers plotted on a log scale. For comparison, lines corresponding to Z=0.3 are drawn in the background. It is tempting to draw the conclusion that the catch curves shows the exploitation of the big year classes in the periods of relatively constant effort, but the poor year classes exhibit just noise. For year classes 2005 and younger these curves provide hardly any information.

For survey 5 Figure 7.7.1.3 shows the age disaggregated abundance indices in numbers plotted on a log scale. The same arguments are valid for the interpretation of the catch curves from the survey as from the catches. In 2010 the number of all age groups decreased suddenly and this is seen as a drop in the catch curves that year. This drop has continued for some of the year classes and the year classes 1998 and 1999 are disappearing faster from the stock than expected. This observed fast reduction in these age classes may also be influenced by the changes in the Survey 5 catchability, with seemingly higher catchability in years 2006—2009. Like for the catch data these provide hardly any information for year classes 2005 and younger.

7.7.2 data exploration with TISVPA

WGWIDE 2014 carried out some exploratory assessments with the TISVPA model, using the same version which was used by the Working Group in 2006 and later years. The main model settings were the same as in previous assessments.

The surveys data are the same as in the TASACS model run: the survey on spawning grounds along the Norwegian coast (survey 1); in wintering area in Vestfjorden in November-December (survey 2); in wintering area in Vestfjorden in January (survey 3); of young herring in the Barents Sea in May (survey 4); in feeding areas in the Norwegian Sea in May (survey 5); joint IMR-PINRO ecosystem survey in August-September (survey 6); Indices for 0 group (survey 7); and larvae index of SSB (survey 8). In contrast to the benchmark assessment, no data points were down-weighted.

Profiles of the components of the TISVPA loss function with respect to SSB in 2014 are shown on Figure 7.7.2.1. The same way as in previous years, only catch-at-age data and survey 5 give any clear indications about the SSB value in 2014: about 5.5 million tons from catch-at-age data, while survey 5 gives two local minima corresponding to 4 and 5.8 million tons. When information from catches and survey 5 are used the SSB is estimated to be around 5.8 million tones (Table 7.7.2.1). Survey 7 (indices for 0-group) a weak indication for SSB in 2014 to be between 3 and 5 million tons. The remaining surveys give unclear and contradicting indications. When input from all data sources are used the overall objective function indicates the SSB in 2013 to be about 6 million tones (curve 9 in figure 7.7.2.1).

Since surveys 1—3 were not conducted in recent years and their influence on the solution is rather indirect and weak, the same way as in last year assessment these three surveys were excluded from the consideration, as well as the other surveys giving no proper indication about the stock in 2014. When only catch-at-age and survey 5 are retained in the objective function of the model, the indication for SSB value in 2014 is dubious the same way as the signal from survey 5: 4 or 5.8 million tones (curve 10 in figure 7.7.2.1), but minimum corresponding to SSB(2014)=5.8 million tones is somewhat lower.

Retrospective runs made using inputs only from catch-at-age and survey 5 data again reveal a historical bias in the results of the assessment by TISVPA (figure 7.7.2.2), generally similar to what is observed in the TASACS results.

As it was shown in previous (2013) assessment, the above mentioned historical bias in the stock biomass estimates can be somewhat diminished if the survey 5 data are used as the only source of auxiliary data and if only one component is included in the objective function of the model. This component corresponds to the median of the distribution of weighted squared residuals between logarithmic age proportions in the data of the survey 5 and the respective values, coming from the cohort part of the model. Using proportions of the stock at age rather than of survey derived abundance values helps to diminish the impact of possible year-to-year changes in survey catchability (see figure 7.7.2.3)

The same way as in the previous assessment (2013), negative residuals are prevailing for survey 5 in the final years, especially in the terminal year (see figure 7.7.2.4), which supports the suggestion that the "effective" catchability for this survey continues to rise in the recent years due to, for example, a more compact stock distribution, which is easier to survey, as a result of lower number of different age classes in the stock. Estimates of average catchability from retrospective runs are shown in figure 7.7.2.5

The above mentioned can also suggest that the option of triple-separabilization used by default (reflecting within-year "selection-redistribution") may not be optimal for this case and it could be better to change it into the option of "gain in selection". For Norwegian spring-spawning herring the traditionally used option assumed that in each year more fishing-attractive cohorts borrow some amount of fishing effort from other cohorts by increasing its selection at the expense of diminished selections for other age groups in this year. The suggested settings assumes that some cohorts has increased (or reduced) selections, but it does not cause direct change in selections for others.

The profiles of the components of the objective function for this modified model are shown in figure 7.7.2.6. In comparison to figure 7.7.2.1, it can be seen that in figure 7.7.2.6 for survey 5 the indication of SSB(2014) to be about 4 million tons is more strong, as well as for survey 7, and even for survey 3, which diminishes contradictions among signals from different sources of data

In general, the results of the TISVPA runs support the conclusions drown from previous investigations of the bias in historical runs of the TASACS model.

7.7.3 TASACS assessment

7.7.3.1 Update benchmark assessment

This year's assessment was classified as an update assessment and was run according to the benchmark in 2008 using the VPA population model in the TASACS toolbox with the same model options as the benchmark (see stock annex 4). Relatively strong retrospective pattern has, however, been observed in the NSSH assessment since the assessment year 2010. In WGWIDE 2013, an updated algorithm to estimate terminal F-values for weak year-classes was implemented in TASACS which improved the consistency of the assessment (ICES, 2013). This algorithm was used also in this year's assessment.

7.7.3.2 data exploration with TASACS

The model fit to the tuning data is shown with Q-Q plots in Figure 7.7.3.2.1. Surveys 2—3 seem to fit rather well to the assumed linear relationship assumed in the TASACS model but surveys 4 and 6—8 have rather poor fit. In addition, the fitting of survey data to the model in different assessment years is not in all cases very good. Particularly Surveys 7 (0-group) and 8 (larval survey) seems to disagree a lot with the assessment (Figure 7.7.3.2.1). This can also be seen as a block of negative residuals for these surveys in later years (Figure 7.7.3.2.2). The residual plot for survey 5 (IESNS) also shows some pattern with a series of negative residuals during the early 2000s followed by a period of positive residuals. This was thoroughly discussed in last year's WGWIDE report.

During the benchmark in 2008, exploration of the survey data was carried out in order to investigate whether the survey contributes information to the assessment or whether there is no or little information in the survey data. Within TASACS, the development of the individual cohorts (year classes) was explored for each survey separately. This was done cohort by cohort by translating each survey index into population numbers. This allows comparing what each survey indicates that the population numbers should be, and thus identify conflicting signals between surveys and outliers in the survey data. This was done year class by year class. Included in this analysis was also catch data at age, translated into N-values assuming a separable model for the fishing mortalities. Such comparisons allow identification of outliers in the surveys, contradicting signals, or may indicate that the survey provides mostly noise (Figure 7.7.3.2.3). This year, no new survey data were excluded from further analysis.

This year, new information was available for surveys 4, 5, 6, 7 and 8.

7.7.3.3 Final assessment

The final results of the assessment are presented in Tables 7.7.3.3.1 (stock in numbers) and 7.7.3.3.2 (fishing mortality) and Figures 7.7.3.3.1 . Table 7.7.3.3.3 is the summary table of the assessment.

The assessment indicates that the fishing mortality (F5—14weighted weighted by stock numbers) in recent years has fluctuated between 0.13 and 0.20 and is estimated in 2013 at 0.146. The SSB in 2014 is estimated to 4.1 million tonnes.

7.7.4 Bootstrap

The uncertainty of the assessments was examined by bootstrap (1000 replicas). For the data where residuals are generated by the modelling, the bootstrap was made by adding randomly drawn residuals from the same source of data to the modelled observations. For catches at age in the VPA, log-normally distributed random noise with a CV of 0.1 was added to the observations. The results are shown in Figure 7.7.4.1.

7.7.5 Retrospective analyses

The retrospective analyses of the final assessment are shown in Figure 7.7.5.1. It shows that there is a retrospective pattern since the 2009 assessment, but the retrospective pattern previously observed in the earlier parts of the SSB time series has been considerably improved with the implementation of the new algorithm for terminal F-values in 2013.

7.8 NSSH reference points

ICES reviewed the reference points of Norwegian spring spawning herring in 2013 in combination with the NEAFC request to evaluate of alternative management plans for this stock (ICES 2013d). ICES concluded that B_{lim} should remain unchanged at 2.5 million tonnes. B_{pa} is not to be revised as it is defined based on B_{lim}. ICES has evaluated F_{MSY} and considers it should remain unchanged at F_{MSY} = 0.15[6].

7.8.1 PA reference points

The PA reference points for the stock originate from an analysis carried out in 1998, as detailed in the stock annex. According to it, ICES considers the precautionary reference points B_{lim}=2.5 million t and proposes that B_{pa}=5.0 million t. and F_{pa}=0.150.

7.8.2 MSY reference points

The MSY reference points originate from an analysis carried out by WGWIDE in 2010 and confirmed by reanalysis by WKBWNNSH in 2013 (ICES 2013d). A detailed report of the analysis is provided in the stock annex. F_{MSY} is estimated at 0.15 and is based on the weighted mean of age groups 5—14. In the ICES MSY framework B_{pa} is proposed/adopted as the default trigger biomass $B_{trigger}$.

7.8.3 Management reference points

In the long term management plan the Coastal States have then agreed a target reference point defined at F_{target}=0.125 when the stock is above B_{pa}. If the SSB is below B_{pa}, a

6 Norwegian spring spawning herring management plan operates on F values weighted with stock numbers, thus the unweighted F_{msy} is likely higher than 0.15.

linear reduction in the fishing mortality rate will be applied from 0.125 at B_{pa} to 0.05 at B_{lim}.

7.9 State of the stock

The stock is declining and below B_{pa} in 2014. In the last 15 years, five large year classes have been produced (1998, 1999, 2002, 2003, and 2004). The available information indicates that year classes born in 2004—2012 have all been small. However, the 0-group index from the Barents Sea in 2013 was well above the average of the time series. Fishing mortality in 2013 is slightly below F_{pa} and F_{MSY}, but above the management plan F.

7.10 NSSH Catch predictions for 2013

7.10.1.1 Input data for the forecast

The input stock numbers at age 1 and older have been taken from the final assessment as last year. No attempt was made to estimate recent year classes separately because the available information of these year classes from surveys had already be included in the VPA. It should be noted that recent year classes are estimated poor and have little influence on predicted catches and SSB. For age 0 a geometric mean (1988—2010) has been used as in previous years.

The catch weight-at-age, used in the forecast, is the average of the observed catch weights over the last 3 years (2011——2013). For the weight-at-age in the stock, the values for 2014 were obtained from the commercial fisheries in the wintering areas. For the years 2015 and 2016 the average of the last 3 years (2012—2014) was used.

Standard values for natural mortality were used. Maturity at age was based on the information presented in section 7.4.5. For all year classes born after 2004 the default maturity ogive for normal year classes were used

Like in 2013 the exploitation pattern used in the forecast was taken as the average of the last 5 years (2009—2013). The average fishing mortality defined as the average over the ages 5 to 14 and is weighted over the population numbers in the relevant year.

$$\overline{F}_y = \sum_{a=5}^{a=14} F_{y,a} N_{y,a} / \sum_{a=5}^{a=14} N_{y,a}$$

Where $F_{y,a}$ and $N_{y,a}$ are fishing mortalities and numbers by year and age. This procedure is the same as applied in previous years for this stock.

Input data for the short term forecast are given in Table 7.10.1.1.

7.10.2 Results of the forecast

The Management Options Table with the results of the forecast is presented in Table 7.10.2.1. Detailed output of the forecast, with options corresponding to the management plan is given in Table 7.10.2.2. Assuming a total catch of 436893 tonnes is taken in 2013, it is expected that the SSB will decline from 4.1 million tonnes in 2014 to 3.5 million tonnes in 2015. The assumed catch in 2014 takes account for the fact that the Coastal States did not agree on a share of the stock resulting in catches higher than the TAC indicated by the management plan. Furthermore, it does not account for possible catches taken by Greenland.

As the spawning stock biomass in 2015 is below the trigger reference point of 5 million tonnes, paragraph 3 of the management plan applies. This paragraph states that "*Should the SBB fall below the reference point of 5 million tonnes, the fishing mortality rate* *referred to under paragraph 2, shall be adapted in the light of scientific estimates of the conditions then prevailing to ensure a safe and rapid recovery of the SSB to a level in excess of 5 million tonnes. The basis for such adaptation should be at least a linear reduction in the fishing mortality rate from 0.125 at B_{pa} to 0.05 at B_{lim}".* The resulting fishing mortality used for predicting the TAC in 2015 = 0.080 and the corresponding TAC in 2015 is 283013 tonnes. The expected remaining SSB in 2016 is about 3.2 million tonnes.

Due to the quota flexibility in the management plan each Party may transfer up to 10% of the quota allocated to the Party in 2014 to 2015. Both EU and Norway indicated that they might use this clause in 2014. Therefore two additional catch options for the year 2014 are presented along with the standard option described above. It was assumed the Faroes, Iceland and Russia would take their quotas in 2014, and that EU and Norway would have the possibility to use this clause. A transfer of 10% of the catches for EU and Norway in 2014 corresponds to a decrease of 6% of the total assumed catches in 2014. Just for exploration a transfer of 20% for the same Parties was assumed, corresponding to a 13% decrease of the total assumed catches in 2014. Both of these options had only minor influence on the TAC in 2015 and the SSB in 2016 (table 7.10.2.2 b and c).

7.11 Uncertainties in assessment and forecast

7.11.1 Uncertainty in the assessment

The population dynamics of Norwegian spring spawning herring is characterized by occasional strong year classes that at turns dominate the stock. The occurrence of such high recruitment is impossible to foresee, and this increases the uncertainty in the assessment of this stock. This characteristic population structure also seems to have consequences for how well the surveys represent the overall stock – in the presence of strong year classes they are also dominating the survey sampling. There seems to be marked changes in the survey catchability, the stock at times appearing to be more easily available for the survey leading to discrepancies between the signal given by the survey and the one given by catch statistics. This obviously increases the uncertainty in the assessment. Exploratory runs conducted (ICES, 2013) where the survey 5 catchability was changed for the period where we have a reason to assume higher catchability show smaller retrospective pattern in the latest years, which can be considered as decreasing the uncertainty of the assessment.

Final assessment in 2014 includes an updated algorithm for estimating the terminal F values for year classes where no supporting data is available, according to a decision made in WGWIDE 2013. In these cases there is no information from the surveys and the catch statistics have a lot of stochastic noise. This update significantly reduced the uncertainty in the assessment, as it makes it more robust to the noise caused by small year classes entering age 14.

7.11.2 Uncertainty in the forecast

In the past, the retrospective behaviour of the assessment, which is the basis for the forecast, has contributed to the uncertainty in the forecast and predicted catches have been taken with a higher fishing mortality than intended. This retrospective behaviour of the assessment is still present but is less between in the assessments in 2012 and 2013 compared to previous years. The present assessment is quite similar to last years.,

There is little uncertainty about the fact that year classes 2011-2012 are low. The 0-group survey in the Barents Sea in the autumn 2013 indicated an abundant 2013 year class but the first reliable survey estimates of the strength of the year class can not be expected to appear until surveyed at age-1 in the autumn 2014. However, recent recruitment estimates do not have a large influence on the predicted yields and SSBs in the short-term forecasts. The fishery is mainly concentrating on the older age groups, which is apparent from the catch composition and the exploitation patterns in recent years. Assumptions on the actual size of recent year classes have little impact on the prediction of the catch and the SSB in the projected period.

Uncertainty in the forecast arises from the assumption of the catch which will be taken in the intermediate year in the forecast (2014). In previous years it was assumed that the agreed TAC, following from the management plan, will be taken in the intermediate year. This assumption appeared to be realistic. In 2013 and 2014, however, the Coastal States did not agree on a share of the stock with the consequence that the sum of the quota of all participants in the fishery was higher than the TAC indicated by the management plan. In the forecast it has been assumed that the sum of the national quota will be taken in 2014.

7.12 Comparison with previous assessment and forecast

A comparison between the assessments 2008—2014 is shown in Figure 7.12.1. The assessment in 2014 was conducted in the same way as last year.

This year's assessment is consistent with last years' assessment. Fishing mortality is estimated slightly higher and SSB slightly lower tan last year. The table below shows the SSB (thousand tones) in 2013 and F in 2012 estimated in 2013 and 2014.

	ICES2013	WG2014	%difference
SSB(2013)	5 006	4 726	-6%
F(2012)	0.144	0.147	+2%

The observed decline in the stock is consistent with previous assessments and forecasts. Last year it was expected that the SSB in 2014 would decline to 4.123 million tonnes compared to this year's estimate of 4.066 million tonnes. In the forecast for 2015, paragraph 3 of the Management Agreement has been applied for the 2nd time. This paragraph applies when the SSB is estimated below B_{pa}.

7.13 Management plans and evaluations

The long term management plan of Norwegian spring spawning herring (re-evaluated in 2013) aims for exploitation at a target fishing mortality below F_{pa} and is considered by ICES in accordance with the precautionary approach (WKBWNSSH, ICES 2013d). The present management plan is described in section 7.2. A brief history of it is in the stock annex. In general, the stock has been managed in compliance with the management plan. However, the realized fishing mortalities have been higher than intended under the plan due to the persistent overestimation of the stock during the last years, on average by 20% (ICES 2013d OR section 7.11.1). It is estimated that with the current management plan, the short-term probability of SSB < B_{lim} increases from 0.061 with no bias to 0.6 when a 20% bias is included (WKBWNSSH 2013).

7.14 Management considerations

Historically, the size of the stock has shown large variations and dependency on the irregular occurrence of very strong year classes. Between 1998 and 2004 the stock has produced a number of strong year classes which lead to an increase in SSB. The SSB for the year 2009 was estimated at its highest level in the last 20 years. Since 1999 catches have been regulated through an agreed management plan. The management plan is considered to be precautionary. However, since 2013, total declared catches are higher than the management plan.

In the absence of strong year classes after 2004, the stock has declined since 2009 and is expected to decline further in the near future even when fishing according to the management plan. Norwegian spring spawning herring mature between age 4 and 6. This means that it will take at least 4 years after they are born until they can contribute to an increase in the SSB. Surveys carried out in recent years in the Norwegian Sea and Barents Sea show no signs of new strong year classes in the period 2005—2012. The 0-group index from the Barents Sea in 2013 was well above average, but there is high uncertainty associated with this index.

The short term prognoses indicate a decline of SSB from 4 million tonnes in 2014 to 3.5 and 3.3 million tonnes in 2015 and 2016, respectively, assuming that declared catches will be taken in 2014 and exploitation in 2015 is according the management plan. SSB in 2015 is below B_{pa} and $B_{trigger}$. In that situation, article 3 of the management plan will be applied, to set TACs for 2015 and future years as long as SSB remains below B_{pa}. Given the low recruitment in recent years, it is expected that SSB will remain below B_{pa} in the short term. This situation will continue until large year classes appear and recruit in the spawning stock.

The results of the evaluation of a management plan are conditional to a number of assumptions which have to be made in any modelling exercise. The expected recruitment is one of these assumptions. In general, it is assumed that future recruitment patterns are similar as observed in the past. Under this assumption, the present management plan for Norwegian spring spawning herring is considered precautionary. However, the present extended period of low recruitment is an exceptional situation for this stock but may continue for a number of years. In the ICES advice, released in 2013, on the NEAFC request to evaluate possible modifications of the management plan, an evaluation was presented of the expected dynamics of the stock under continued poor recruitment conditions. This evaluation indicates that in the absence of strong year classes entering SSB, under the present management plan SSB is expected to fluctuate around 4 million tonnes and catches will vary between 300 and 400 thousand tonnes.

Since 2013, a lack of agreement by the Coastal States on their share in the TAC has lead to unilateral set quota's which together are higher than the TAC indicated by the management plan. If this situation continues, the high catches will accelerate the present decline of the stock and increase the risk of a depletion of the stock.

In recent years the distribution area of mackerel has expanded to the north and west and overlaps the distribution area of the herring in summer. As a consequence mackerel catches have been taken in that area as by-catch in the herring fisheries and in directed and mixed fisheries.

7.15 Regulations and their effects

The NSSH has been fished moderately for the last six years with an intended fishing mortality of 0.125. This is in accordance with the international management plan and below F_{pa}. Thus the stock is moderately harvested as compared to most other stocks.

7.16 Ecosystem considerations

The Norwegian spring-spawning herring is characterized by large dynamics with regard to migration pattern. This applies to the wintering, spawning and feeding area. Juvenile and adults of this stock form an important part of the ecosystems in the Barents Sea, the Norwegian Sea, and the Norwegian coast. The herring stock is a significant part of the ecosystem in Nordic Seas, both as predator on zooplankton but also as food resource to higher trophic levels (e.g. cod, saithe, seabirds, and marine mammals).

Compare to the early 2000s, the older part of the herring stock have had more westerly feeding migration pattern in recent years according to the IESNS survey in May (ICES 2014c), which has been more pronounced in July/August according to the IESSNS survey (Nøttestad *et al.* 2014). With the absent of large recruiting year classes in the stock in recent years and thereby small amount of young herring, less amount have been feeding in the northeastern part of the Norwegian Sea. Thus herring have been mainly found in the fringe of the Norwegian Sea; i.e. from north of the Faroese, the east and northeast Icelandic area and north in the Jan Mayen area, with negligible concentrations in the central areas and small in the eastern areas. Whether this distribution pattern is a response to feeding competition with mackerel, which is distributed over the whole Norwegian Sea and adjacent waters (Nøttestad *et al.* 2014), is unknown. A spatial overlap of herring and mackerel has been, large in the southern most areas of the herring distribution, but less further north (e.g. in the Jan Mayen area), even if the overlap was less pronounced 2014 compared to preceding two years (Nøttestad *et al.* 2014). Spatial overlap between herring and mackerel causes bycatch of mackerel in the targeted herring fishery and vice versa in the mackerel fishery. In addition, fishery patterns suggest that herring appears to reside longer through out the autumn in the south-western area close to Faroe Islands.

Analyses of stomach content of herring and mackerel overlapping spatially show that they are competing for food to some extent (Debes *et al.* 2012; Langøy *et al.* 2012; Óskarsson *et al.* 2012). Since mackerel is more effective feeder as for example indicated by the stomach content weight, herring might be partly outcompeted by the faster and more efficient mackerel in areas where they co-exist. Thus, the competition could be forcing the herring to the fringe of Norwegian Sea, though also higher zooplankton biomass there (Nøttestad *et al.* 2014) could attract the herring.

The average biomass of zooplankton in the total area in May had a decreasing trend from around 2002 until 2009, but an upward trend since then and is now at similar level as prior to the decline (ICES 2014c). An upward trend of zooplankton abundance is also observed in the IESSNS surveys in the Norwegian Sea for the years 2011—2014 (Nøttestad *et al.* 2014). At the same time (2011—2014), weight-at-age (this report) and length-at-age (ICES 2014b) in the stock are showing increasing trend. Thus, there are neither signs that the Norwegian Sea is being overgrazed at present by the pelagic fish stocks in the area, nor that the herring stock is suffering from a lack of food. If the increase in zooplankton is related to decreasing stock size of herring is unknown but will be explored further by WGINOR. Further work on the zooplankton index is also needed and is planned to be addressed by WGINOR (ICES 2014b) as well as exploring the biological and stock related variables of herring and other pelagic fish stocks in relation to environmental and ecological variables. It involves revision of the data and producing indices for the different areas, as well as explorations of their relation to growth, abundance and spatial distribution of pelagic fish stocks feeding in the area.

7.17 Changes in fishing patterns

No major changes were observed in the fishing patterns in 2013 relative to recent years (see section 7.3). Minor changes observed include an extended period of the fishery in the southern and south-western areas in the Norwegian Sea during in 3rd and especially 4th quarters. Minor changes observed include more easterly distributed catches in the fourth quarter.

Mixture of mackerel and herring was again apparent in the 2013 summer fishery of the Icelandic and Faroese fleets, but the preliminary information from the fishery in 2014 suggests less overlap between the two species.

7.18 Changes in the environment

In the Norwegian Sea, where the herring stock is grazing, the two main features of the circulation are the Norwegian Atlantic Current (NWAC) and the East Iceland Current (EIC). The NWAC with its offshoots forms the northern limb of the North Atlantic current system and carries relatively warm and salty water from the North Atlantic into the Nordic Seas. The EIC, on the other hand, carries Arctic waters.

The Arctic front is a central feeding area for Norwegian spring-spawning herring. During periods when the Arctic front is shifted westwards it is likely that the part of the stock feeding in the western Norwegian Sea will also be shifted westward. In May 2014, the Arctic front was encountered slightly below 65°N east of Iceland extending eastwards towards the 0° Meridian where it turned almost straight northwards up 70°N. The front was visible throughout the observed water column. The warmer North Atlantic water formed a broad tongue that stretched far northwards along the Norwegian coast with temperatures > 7 °C to 70° N in the surface layers and to 68 ° N at 200 m depth (ICES 2014c).

Relative to a 19 years long-term mean, from 1995 to 2013, the temperature at 20 m depth northeast of Iceland was considerable higher in 2014 compared to the long-term mean, or up to 2°C warmer. At deeper depths the difference between 2014 and the long term mean was smaller. In general, at 200 m and shallower depths the western part of the Norwegian Sea and the Iceland Sea was somewhat warmer than the long-term mean (ICES 2014c). This general pattern was also observed in IESSNS in July-August 2014 from CTD data (Nøttestad *et al.* 2014). Moreover, SST anomaly for July (satellite data relative to a 20 year average) showed that the surface layer in the northeastern part of the North Atlantic was warm in 2014. The SST was more than 3°C warmer north of Iceland and between 2—2.5°C warmer in the central Norwegian Sea. This is in contrast to 2013 when the surface layer was close to the long-term average. The anomaly pattern in 2014 resembles that of 2012 with the exception that in 2012 the Irminger Sea was considerably (more than 3°C) warmer than the average (Nøttestad *et al.* 2014).

Relative to an 16 years long-term mean, from 1995 to 2010, the average temperatures 0—200 m depth north of Iceland and northeast of the Faroese were considerable higher (~1°C) in 2013 compared to the long-term mean (ICES 2013c). At the surface this difference was larger north of Iceland but was less northeast of the Faroese. At larger depths, the anomaly northeast of the Faroese was higher or up to 2°C at 300m depth. In the central Norwegian Sea the temperature was mainly close to or lower than the long term mean at all depths. A comparison of the sea temperatures in 2013 and 2012 showed particularly warmer waters northeast of the Faroese in 2013, while colder waters (0.5° - 0°C) in the central Norwegian Sea.

7.19 Recommendation

In the last years there have been concerns regarding age reading of herring, because the age distribution from the different participants have showed differences. This is also the case in 2014. Partly, the differences may reflect differing spatial distribution of age groups, and partly, they may reflect variable growth conditions for the stock, and consequently growth rate as seen on the fish scales and otoliths. In spring 2014 an otolith and scale exchange was conducted, as was suggested by the IESNS survey group in last year's survey report to address these issues. The otolith exchange was done in spring 2014 and reported in June 2014 (Godiksen 2014).

The results show that the percentage agreement in all the comparisons in the exchange was quite low compared to what could be expected. The results comparing age readings of the readers reading for assessment purposes the percent agreement was 69.1% with a CV of 9.4%. Further there was a trend by most readers in underestimating the otoliths older than 9 years modal age, while scale readings tend to overestimate these age classes. They concluded that it was important to continue this type of as a large scale exchange including both images and the real structures of both otoliths and scales from the same fish. The WGWIDE recommends that an age reading workshop as stated above on NSS herring be held as soon as possible.

7.20 References

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Table 7.5.1.1 Total catch of Norwegian spring-spawning herring (tons) since 1972. Data provided by Working Group members.

Year	Norway	USSR/ Russia	Denmark	Faroes	Iceland	Ireland	Netherlands	Greenland	UK (Scotland)	Germany	France	Poland	Sweden	Total
1972	13161	-	-	-	-	-	-	-	-	-	-	-	-	13161
1973	7017	-	-	-	-	-	-	-	-	-	-	-	-	7017
1974	7619	-	-	-	-	-	-	-	-	-	-	-	-	7619
1975	13713	-	-	-	-	-	-	-	-	-	-	-	-	13713
1976	10436	-	-	-	-	-	-	-	-	-	-	-	-	10436
1977	22706	-	-	-	-	-	-	-	-	-	-	-	-	22706
1978	19824	-	-	-	-	-	-	-	-	-	-	-	-	19824
1979	12864	-	-	-	-	-	-	-	-	-	-	-	-	12864
1980	18577	-	-	-	-	-	-	-	-	-	-	-	-	18577
1981	13736	-	-	-	-	-	-	-	-	-	-	-	-	13736
1982	16655	-	-	-	-	-	-	-	-	-	-	-	-	16655
1983	23054	-	-	-	-	-	-	-	-	-	-	-	-	23054
1984	53532	-	-	-	-	-	-	-	-	-	-	-	-	53532
1985	167272	2600	-	-	-	-	-	-	-	-	-	-	-	169872
1986	199256	26000	-	-	-	-	-	-	-	-	-	-	-	225256
1987	108417	18889	-	-	-	-	-	-	-	-	-	-	-	127306
1988	115076	20225	-	-	-	-	-	-	-	-	-	-	-	135301
1989	88707	15123	-	-	-	-	-	-	-	-	-	-	-	103830
1990	74604	11807	-	-	-	-	-	-	-	-	-	-	-	86411
1991	73683	11000	-	-	-	-	-	-	-	-	-	-	-	84683
1992	91111	13337	-	-	-	-	-	-	-	-	-	-	-	104448
1993	199771	32645	-	-	-	-	-	-	-	-	-	-	-	232457
1994	380771	74400	-	2911	21146	-	-	-	-	-	-	-	-	479228
1995	529838	101987	30577	57084	174109	-	7969	2500	881	556	-	-	-	905501
1996	699161	119290	60681	52788	164957	19541	19664	-	46131	11978	-	-	22424	1220283
1997	860963	168900	44292	59987	220154	11179	8694	-	25149	6190	1500	-	19499	1426507
1998	743925	124049	35519	68136	197789	2437	12827	-	15971	7003	605	-	14863	1223131

Year	Norway	USSR/ Russia	Denmark	Faroes	Iceland	Ireland	Netherlands	Greenland	UK (Scotland)	Germany	France	Poland	Sweden	Total
1999	740640	157328	37010	55527	203381	2412	5871	-	19207	-	-	-	14057	1235433
2000	713500	163261	34968	68625	186035	8939	-	-	14096	3298	-	-	14749	1207201
2001	495036	109054	24038	34170	77693	6070	6439	-	12230	1588	-	-	9818	766136
2002	487233	113763	18998	32302	127197	1699	9392	-	3482	3017	-	1226	9486	807795
2003*	477573	122846	14144	27943	117910	1400	8678	-	9214	3371	-	-	6431	789510
2004	477076	115876	23111	42771	102787	11	17369	-	1869	4810	400	-	7986	794066
2005	580804	132099	28368	65071	156467	-	21517	-	-	17676	0	561	680	1003243
2006*	567237	120836	18449	63137	157474	4693	11625	-	12523	9958	80	-	2946	968958
2007	779089	162434	22911	64251	173621	6411	29764	4897	13244	6038	0	4333	0	1266993
2008	961603	193119	31128	74261	217602	7903	28155	3810	19737	8338	0	0	0	1545656
2009	1016675	210105	32320	85098	265479	10014	24021	3730	25477	14452	0	0	0	1687371
2010	871113	199472	26792	80281	205864	8061	26695	3453	24151	11133	0	0	0	1457015
2011	572641	144428	26740	53271	151074	5727	8348	3426	14045	13296	0	0	0	992997
2012	491005	118595	21754	36190	120956	4813	6237	1490	12310	11945	0	0	705	826000
2013	359458	78521	17160	105038	90729	3815	5626	11788	8342	4244	0	0	23	684743

***In 2003 the Norwegian catches were raised of 39433 to account for changes in percentages of water content.**

Table 7.5.1.2. Norwegian spring spawning herring. Catch and sample data provided by Working Group members, and samples allocated to unsampled catches in Intercatch.

Country	Div.	Quarter	Catch (t)	No of age samples	Samples allocated ('fill-in')
DE	2a	3	1444.3		RU_2a_q3, IS_2a_q3, FO_2a_q3
DE	2a	4	477.9		IS_2a_q4, NO_2a_q4, RU_2a_q4, DK_2a_q4, FO_2a_q4
DE	2b	4	2321.6	4	
DK	2a	1	14759.8	2	
DK	2a	3	0.9		RU_2a_q3, IS_2a_q3, FO_2a_q3
DK	2a	4	2398.8	1	
FO	2a	2	1673.1	1	
FO	2a	3	43094.1	6	
FO	2a	4	30273.3	2	

Country	Div.	Quarter	Catch (t)	No of age samples	Samples allocated ('fill-in')
FO	4a	2	33.0		FO_2a_q2, IS_2a_q2
FO	5a	2	30.0		IS_5b_q2, IS_5a_q2
FO	5b	1	0.0		IS_5b_q2, IS_5a_q2
FO	5b	2	3784.8		IS_5b_q2, IS_5a_q3
FO	5b	3	15048.6		IS_5a_q3
FO	5b	4	11101.0		IS_5a_q4
GL	2a	3	830.0		RU_2a_q3, IS_2a_q3, FO_2a_q3
GL	2a	4	7780.0		IS_2a_q4, NO_2a_q4, RU_2a_q4, DK_2a_q4, FO_2a_q4
GL	5a	1	2.5		IS_5b_q2, IS_5a_q2
GL	5a	4	1300.0		IS_5a_q4
GL	XIVa	3	1368.9		IS_5a_q3
GL	XIVa	4	506.3		IS_5a_q4
IE	2a	1	3593.6	2	
IE	4a	4	221.2		IS_2a_q4, NO_2a_q4, RU_2a_q4, DK_2a_q4, FO_2a_q4
IS	2a	2	342.0	1	
IS	2a	3	22571.0	18	
IS	2a	4	23279.0	11	
IS	5a	2	442.0	1	
IS	5a	3	41434.0	62	
IS	5a	4	2602.0	6	
IS	5b	2	59.0	1	
NL	2a	4	2338.5	6	
NL	2b	4	3287.4		NL_2a_q4
NO	2a	1	127180.0	73	
NO	2a	2	1005.0		NO_2a_q1
NO	2a	3	2802.0	21	
NO	2a	4	225322.0	50	
NO	4a	1	3143.0		NO_2a_q1
NO	4a	2	6.0		FO_2a_q2, IS_2a_q2
RU	1	2	16.0		RU_2b_q3
RU	2a	1	8510.0	12	

Country	Div.	Quarter	Catch (t)	No of age samples	Samples allocated ('fill-in')
RU	2a	2	655.0	12	
RU	2a	3	13269.0	65	
RU	2a	4	22776.0	17	
RU	2b	3	15225.0	4	
RU	2b	4	16856.0	24	
RU	XIVa	3	1154.0		IS_5a_q3
RU	XIVa	4	60.0		IS_5a_q4
SE	2a	3	23.0		RU_2a_q3, IS_2a_q3, FO_2a_q3
UKS	2a	1	8342.1		NO_2a_q1, DK_2a_q1

Table 7.5.1.3. Norwegian spring spawning herring. Comparison of catch at age and weight at age in 2013 estimated with the SALLOC software and Intercatch.

	Catch numbers (thousands)			Catch weights (kg)		
	SALLOC	Intercatch	Difference (%)	SALLOC	Intercatch	Difference (%)
1	1.2	1.20	-0.34	0.0476	0.0476	0.04
2	20715.36	20715.41	0.00	0.1631	0.1631	-0.01
3	60565.76	60364.15	0.33	0.2372	0.2370	0.08
4	276568.56	276900.65	-0.12	0.2763	0.2762	0.04
5	71069.05	71286.51	-0.31	0.3002	0.3000	0.05
6	112419.29	112558.25	-0.12	0.3315	0.3313	0.07
7	283440.97	283657.85	-0.08	0.3391	0.3389	0.06
8	242017.33	242242.93	-0.09	0.3514	0.3511	0.08
9	591719.69	591912.14	-0.03	0.3574	0.3572	0.06
10	169468.3	169524.71	-0.03	0.3703	0.3700	0.09
11	145271.31	145317.75	-0.03	0.3733	0.3731	0.06
12	25010.84	24936.17	0.30	0.3938	0.3937	0.04
13	10631.47	10613.94	0.16	0.3906	0.3905	0.02
14	9733.47	9725.22	0.08	0.3888	0.3888	0.00
15	2293.78	2299.15	-0.23	0.3675	0.3674	0.03

Table 7.5.3.1. Norwegian spring spawning herring. Catch in numbers (thousands).

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	5112600	2000000	600000	276200	184800	185500	547000	628600	79500	88600	109500	86900	194500	368300	66400	344300
1951	1635500	7607700	400000	6600	383800	172400	164400	515600	602000	77100	82700	103100	107600	253500	348000	352500
1952	13721600	9149700	1232900	39300	60500	602300	136300	204500	380200	377900	79200	85700	107700	106800	186500	564400
1953	5697200	5055000	581300	740100	46600	100900	355600	81900	110900	314100	394900	61700	91200	94100	98800	730400
1954	10675990	7071090	855400	266300	1435500	142900	236000	490300	128100	199800	440400	460700	88400	100600	133000	803200
1955	5175600	2871100	510100	93000	276400	2045100	114300	189600	274700	85300	193400	295600	203200	58700	84600	580600
1956	5363900	2023700	627100	116500	251600	314200	2555100	110000	203900	264200	130700	198300	272800	163300	63000	565100
1957	5001900	3290800	219500	23300	373300	153800	228500	1985300	72000	127300	182500	88400	121200	149300	131600	281400
1958	9666990	2798100	666400	17500	17900	110900	89300	194400	973500	70700	123000	200900	98700	77400	70900	255600
1959	17896280	198530	325500	15100	26800	25900	146600	114800	240700	1103800	88600	124300	198000	88500	77400	235900
1960	12884310	13580790	392500	121700	18200	28100	24400	96200	73300	203900	1163000	85200	129700	153500	56700	168900
1961	6207500	16075600	2884800	31200	8100	4100	15000	19400	61600	49200	136100	728100	49700	45000	63000	60100
1962	3693200	4081100	1041300	1843800	8000	3100	7200	20200	11900	59100	52600	117000	813500	44200	54700	152300
1963	4807000	2119200	2045300	760400	835800	5300	1800	3600	18300	9300	107700	92500	174100	923700	79600	185300
1964	3613000	2728300	220300	114600	399000	2045800	13700	1500	3000	24900	29300	95600	82400	153000	772800	336800
1965	2303000	3780900	2853600	89900	256200	571100	2199700	19500	14900	7400	19100	40000	100500	107800	138700	883100
1966	3926500	662800	1678000	2048700	26900	466600	1306000	2884500	37900	14300	17400	26200	11000	69100	72100	556700
1967	426800	9877100	70400	1392300	3254000	26600	421300	1132000	1720800	8900	5700	3500	8500	8900	17500	104400
1968	1783600	437000	388300	99100	1880500	1387400	14220	94000	134100	345100	2000	1100	830	2500	2600	17000
1969	561200	507100	141900	188200	800	8800	4700	700	11700	33600	36000	300	200	200	200	2400
1970	119300	529400	33200	6300	18600	600	3300	3300	1000	13400	26200	28100	300	100	200	2000
1971	30500	42900	85100	1820	1020	1240	360	1110	1130	360	4410	6910	5450	0	20	120
1972	347100	41000	20400	35376	3476	3583	2481	694	1486	198	0	494	593	593	0	0
1973	29300	3500	1700	2389	25200	651	1506	278	178	0	0	0	0	0	180	0
1974	65900	7800	3900	100	241	24505	257	196	0	0	0	0	0	0	0	0
1975	30600	3600	1800	3268	132	910	30667	5	2	0	0	0	0	0	0	0
1976	.20100	2400	1200	23248	5436	0	0	13086	0	0	0	0	0	0	0	0
1977	43000	6200	3100	22103	23595	336	0	419	10766	0	0	0	0	0	0	0

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978	20100	2400	1200	3019	12164	20315	870	0	620	5027	0	0	0	0	0	0
1979	32600	3800	1900	6352	1866	6865	11216	326	0	0	2534	0	0	0	0	0
1980	6900	800	400	6407	5814	2278	8165	15838	441	8	0	2688	0	0	0	0
1981	8300	1100	11900	4166	4591	8596	2200	4512	8280	345	103	114	964	0	0	0
1982	22600	1100	200	13817	7892	4507	6258	1960	5075	6047	121	37	37	121	0	0
1983	127000	4680	1670	3183	21191	9521	6181	6823	1293	4598	7329	143	40	143	860	0
1984	33860	1700	2490	4483	5388	61543	18202	12638	15608	7215	16338	6478	0	0	0	1650
1985	28570	13150	207220	21500	15500	16500	130000	59000	55000	63000	10000	31000	50000	0	0	2640
1986	13810	1380	3090	539785	17594	14500	15500	105000	75000	42000	77000	19469	66000	80000	0	2470
1987	13850	6330	35770	19776	501393	18672	3502	7058	28000	12000	9500	4500	7834	6500	7000	450
1988	15490	2790	9110	62923	25059	550367	9452	3679	5964	14583	8872	2818	3356	2682	1560	540
1989	7120	1930	25200	2890	3623	5650	324290	3469	800	679	3297	1375	679	321	260	0
1990	1020	400	15540	18633	2658	11875	10854	226280	1289	1519	2036	2415	646	179	590	480
1991	100	3370	3330	8438	2780	1410	14698	8867	218851	2499	461	87	690	103	260	540
1992	1630	150	1340	12586	33100	4980	1193	11981	5748	225677	2483	639	247	1236	0	0
1993	6570	130	7240	28408	106866	87269	8625	3648	29603	18631	410110	0	0	0	0	0
1994	430	20	8100	32500	110090	363920	164800	15580	8140	37330	35660	645410	2830	460	100	2070
1995	0	0	1130	57590	346460	622810	637840	231090	15510	15850	69750	83740	911880	4070	250	450
1996	0	0	30140	34360	713620	1571000	940580	406280	103410	5680	7370	66090	17570	836550	0	0
1997	0	0	21820	130450	270950	1795780	1993620	761210	326490	60870	20020	32400	90520	19120	370330	300
1998	0	0	82891	70323	242365	368310	1760319	1263750	381482	129971	42502	25343	3478	112604	5633	108514
1999	0	0	5029	137626	35820	134813	429433	1604959	1164263	291394	106005	14524	40040	7202	88598	63983
2000	0	0	14395	84016	560379	34933	110719	404460	1299253	1045001	216980	71589	16260	22701	23321	71811
2001	0	0	2076	102293	160678	426822	38749	95991	296460	839136	507106	73673	23722	3505	3356	22164
2002	0	0	62031	198360	643161	255516	326495	29843	93530	264675	663059	339326	52922	12437	7000	10087
2003	0	3461	4524	75243	323958	730468	175878	167776	22866	74494	217108	567253	219097	38555	8111	6192
2004	125	1846	43800	24299	92300	429510	714433	111022	137940	26656	52467	169196	401564	210547	28028	11883
2005	0	442	20411	447788	94206	170547	643600	930309	121856	123291	37967	65289	139331	344822	126879	15697
2006	0	1968	45438	75824	729898	82107	171370	726041	772217	88701	77115	30339	57882	133665	142240	49128

	AGE														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2007	0	4475	8450	224636	366983	1804495	152916	242923	728836	511664	47215	25384	15316	24488	64755	58465
2008	0	39898	123949	36630	550274	670681	2295912	199592	256132	586583	369620	29633	36025	23775	25195	63176
2009	0	3468	113424	192641	149075	1193781	914748	1929631	142931	262037	423972	238174	45519	9337	10153	70538
2010	0	75981	61673	101948	209295	189784	1064866	711951	1421939	175010	180164	340781	179039	12558	11602	49773
2011	0	126972	249809	61706	104634	234330	210165	755382	543212	642787	90515	117230	136509	45082	6628	11638
2012	0	2680	13083	211630	49999	119627	281908	263330	747839	314694	357902	53109	44982	64273	12420	3604
2013	0	1	20715	60364	276901	71287	112558	283658	242243	591912	169525	145318	24936	10614	9725	2299

Table 7.5.4.1. Norwegian spring spawning herring. Weight at age in the catch (kg).

	age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	0.007	0.025	0.058	0.110	0.188	0.211	0.234	0.253	0.266	0.280	0.294	0.303	0.312	0.32	0.323	0.334
1951	0.009	0.029	0.068	0.130	0.222	0.249	0.276	0.298	0.314	0.330	0.346	0.357	0.368	0.377	0.381	0.394
1952	0.008	0.026	0.061	0.115	0.197	0.221	0.245	0.265	0.279	0.293	0.308	0.317	0.327	0.335	0.339	0.349
1953	0.008	0.027	0.063	0.120	0.205	0.230	0.255	0.275	0.290	0.305	0.320	0.330	0.34	0.347	0.351	0.363
1954	0.008	0.026	0.062	0.117	0.201	0.225	0.250	0.269	0.284	0.299	0.313	0.323	0.333	0.341	0.345	0.356
1955	0.008	0.027	0.063	0.119	0.204	0.229	0.254	0.274	0.289	0.304	0.318	0.328	0.338	0.346	0.350	0.362
1956	0.008	0.028	0.066	0.126	0.215	0.241	0.268	0.289	0.304	0.320	0.336	0.346	0.357	0.365	0.369	0.382
1957	0.008	0.028	0.066	0.127	0.216	0.243	0.269	0.290	0.306	0.322	0.338	0.348	0.359	0.367	0.371	0.384
1958	0.009	0.030	0.070	0.133	0.227	0.255	0.283	0.305	0.321	0.338	0.355	0.366	0.377	0.386	0.390	0.403
1959	0.009	0.030	0.071	0.135	0.231	0.259	0.287	0.310	0.327	0.344	0.360	0.372	0.383	0.392	0.397	0.409
1960	0.006	0.011	0.074	0.119	0.188	0.277	0.337	0.318	0.363	0.379	0.360	0.420	0.411	0.439	0.450	0.447
1961	0.006	0.010	0.045	0.087	0.159	0.276	0.322	0.372	0.363	0.393	0.407	0.397	0.422	0.447	0.465	0.452
1962	0.009	0.023	0.055	0.085	0.148	0.288	0.333	0.360	0.352	0.350	0.374	0.384	0.374	0.394	0.399	0.414
1963	0.008	0.026	0.047	0.098	0.171	0.275	0.268	0.323	0.329	0.336	0.341	0.358	0.385	0.353	0.381	0.386
1964	0.009	0.024	0.059	0.139	0.219	0.239	0.298	0.295	0.339	0.350	0.358	0.351	0.367	0.375	0.372	0.433
1965	0.009	0.016	0.048	0.089	0.217	0.234	0.262	0.331	0.360	0.367	0.386	0.395	0.393	0.404	0.401	0.431
1966	0.008	0.017	0.040	0.063	0.246	0.260	0.265	0.301	0.410	0.425	0.456	0.460	0.467	0.446	0.459	0.472
1967	0.009	0.015	0.036	0.066	0.093	0.305	0.305	0.310	0.333	0.359	0.413	0.446	0.401	0.408	0.439	0.430
1968	0.010	0.027	0.049	0.075	0.108	0.158	0.375	0.383	0.364	0.382	0.441	0.410		0.517	0.491	0.485
1969	0.009	0.021	0.047	0.072		0.152	0.296		0.329	0.329	0.341					0.429
1970	0.008	0.058	0.085	0.105	0.171		0.216	0.277	0.298	0.304	0.305	0.309				0.376
1971	0.011	0.053	0.121	0.177	0.216	0.250		0.305	0.333		0.366	0.377	0.388			
1972	0.011	0.029	0.062	0.103	0.154	0.215	0.258		0.322							
1973	0.006	0.053	0.106	0.161	0.213		0.255									
1974	0.006	0.055	0.117			0.249										
1975	0.009	0.079	0.169	0.241			0.381									
1976	0.007	0.062	0.132	0.189	0.250			0.323								

	age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1977	0.011	0.091	0.193	0.316	0.350				0.511							
1978	0.012	0.100	0.210	0.274	0.424	0.454				0.613						
1979	0.010	0.088	0.181	0.293	0.359	0.416	0.436				0.553					
1980	0.012			0.266	0.399	0.449	0.460	0.485				0.608				
1981	0.010	0.082	0.163	0.196	0.291	0.341	0.368	0.380	0.397							
1982	0.010	0.087	0.159	0.256	0.312	0.378	0.415	0.435	0.449	0.448						
1983	0.011	0.090	0.165	0.217	0.265	0.337	0.378	0.410	0.426	0.435	0.444					
1984	0.009	0.047	0.145	0.218	0.262	0.325	0.346	0.381	0.400	0.413	0.405	0.426				0.415
1985	0.009	0.022	0.022	0.214	0.277	0.295	0.338	0.360	0.381	0.397	0.409	0.417	0.435			0.435
1986	0.007	0.077	0.097	0.055	0.249	0.294	0.312	0.352	0.374	0.398	0.402	0.401	0.410	0.410		0.410
1987	0.010	0.075	0.091	0.124	0.173	0.253	0.232	0.312	0.328	0.349	0.353	0.370	0.385	0.385	0.385	
1988	0.008	0.062	0.075	0.124	0.154	0.194	0.241	0.265	0.304	0.305	0.317	0.308	0.334	0.334	0.334	
1989	0.010	0.060	0.204	0.188	0.264	0.260	0.282	0.306			0.422	0.364				
1990	0.007		0.102	0.230	0.239	0.266	0.305	0.308	0.376	0.407	0.412	0.424				
1991		0.015	0.104	0.208	0.250	0.288	0.312	0.316	0.330	0.344						
1992	0.007		0.103	0.191	0.233	0.304	0.337	0.365	0.361	0.371	0.403			0.404		
1993	0.007		0.106	0.153	0.243	0.282	0.320	0.330	0.365	0.373	0.379					
1994			0.102	0.194	0.239	0.280	0.317	0.328	0.356	0.372	0.390	0.379	0.399	0.403		
1995			0.102	0.153	0.192	0.234	0.283	0.328	0.349	0.356	0.374	0.366	0.393	0.387		
1996			0.136	0.136	0.168	0.206	0.262	0.309	0.337	0.366	0.360	0.361	0.367	0.379		
1997			0.089	0.167	0.184	0.207	0.232	0.277	0.305	0.331	0.328	0.344	0.343	0.397	0.357	
1998			0.111	0.150	0.216	0.221	0.249	0.277	0.316	0.338	0.374	0.372	0.366	0.396	0.377	0.406
1999			0.096	0.173	0.228	0.262	0.274	0.292	0.307	0.335	0.362	0.371	0.399	0.396	0.400	0.404
2000			0.124	0.175	0.222	0.242	0.289	0.303	0.310	0.328	0.349	0.383	0.411	0.410	0.419	0.409
2001			0.105	0.166	0.214	0.252	0.268	0.305	0.308	0.322	0.337	0.363	0.353	0.378	0.400	0.427
2002			0.056	0.128	0.198	0.255	0.281	0.303	0.322	0.323	0.334	0.345	0.369	0.407	0.410	0.435
2003		0.062	0.068	0.169	0.218	0.257	0.288	0.316	0.323	0.348	0.354	0.351	0.363	0.372	0.376	0.429
2004	0.022	0.066	0.143	0.18	0.227	0.26	0.29	0.323	0.355	0.375	0.383	0.399	0.395	0.405	0.429	0.439
2005		0.092	0.106	0.181	0.235	0.266	0.290	0.315	0.344	0.367	0.384	0.372	0.384	0.398	0.402	0.413

	age														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2006		0.055	0.102	0.171	0.238	0.268	0.292	0.311	0.330	0.365	0.374	0.376	0.388	0.396	0.398	0.407
2007	0.000	0.074	0.137	0.162	0.228	0.271	0.316	0.332	0.342	0.358	0.361	0.381	0.390	0.400	0.405	0.399
2008	0.000	0.026	0.106	0.145	0.209	0.254	0.296	0.318	0.341	0.353	0.363	0.367	0.395	0.396	0.386	0.413
2009	0	0.040	0.156	0.184	0.220	0.251	0.291	0.311	0.338	0.347	0.363	0.375	0.382	0.375	0.375	0.387
2010	0	0.059	0.107	0.177	0.218	0.261	0.279	0.311	0.325	0.343	0.362	0.370	0.388	0.391	0.376	0.441
2011	0	0.011	0.098	0.200	0.257	0.273	0.300	0.316	0.340	0.348	0.365	0.371	0.387	0.374	0.403	0.401
2012	0	0.034	0.126	0.211	0.272	0.301	0.308	0.331	0.335	0.351	0.354	0.370	0.389	0.389	0.382	0.388
2013	0	0.048	0.163	0.237	0.276	0.300	0.331	0.339	0.351	0.357	0.370	0.373	0.394	0.391	0.389	0.367

Table 7.5.4.2. Norwegian spring spawning herring. Weight at age in the stock (kg).

	AGE														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1951	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1952	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1953	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1954	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1955	0.001	0.008	0.047	0.100	0.195	0.213	0.260	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1956	0.001	0.008	0.047	0.100	0.205	0.230	0.249	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1957	0.001	0.008	0.047	0.100	0.136	0.228	0.255	0.262	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1958	0.001	0.008	0.047	0.100	0.204	0.242	0.292	0.295	0.293	0.305	0.315	0.330	0.340	0.345	0.352	0.363
1959	0.001	0.008	0.047	0.100	0.204	0.252	0.260	0.290	0.300	0.305	0.315	0.325	0.330	0.340	0.345	0.358
1960	0.001	0.008	0.047	0.100	0.204	0.270	0.291	0.293	0.321	0.318	0.320	0.344	0.349	0.370	0.379	0.378
1961	0.001	0.008	0.047	0.100	0.232	0.250	0.292	0.302	0.304	0.323	0.322	0.321	0.344	0.357	0.363	0.368
1962	0.001	0.008	0.047	0.100	0.219	0.291	0.300	0.316	0.324	0.326	0.335	0.338	0.334	0.347	0.354	0.358
1963	0.001	0.008	0.047	0.100	0.185	0.253	0.294	0.312	0.329	0.327	0.334	0.341	0.349	0.341	0.358	0.375
1964	0.001	0.008	0.047	0.100	0.194	0.213	0.264	0.317	0.363	0.353	0.349	0.354	0.357	0.359	0.365	0.402
1965	0.001	0.008	0.047	0.100	0.186	0.199	0.236	0.260	0.363	0.350	0.370	0.360	0.378	0.387	0.390	0.394
1966	0.001	0.008	0.047	0.100	0.185	0.219	0.222	0.249	0.306	0.354	0.377	0.391	0.379	0.378	0.361	0.383
1967	0.001	0.008	0.047	0.100	0.180	0.228	0.269	0.270	0.294	0.324	0.420	0.430	0.366	0.368	0.433	0.414
1968	0.001	0.008	0.047	0.100	0.115	0.206	0.266	0.275	0.274	0.285	0.350	0.325	0.363	0.408	0.388	0.378
1969	0.001	0.008	0.047	0.100	0.115	0.145	0.270	0.300	0.306	0.308	0.318	0.340	0.368	0.360	0.393	0.397
1970	0.001	0.008	0.047	0.100	0.209	0.272	0.230	0.295	0.317	0.323	0.325	0.329	0.380	0.370	0.380	0.391
1971	0.001	0.015	0.080	0.100	0.190	0.225	0.250	0.275	0.290	0.310	0.325	0.335	0.345	0.355	0.365	0.390
1972	0.001	0.010	0.070	0.150	0.150	0.140	0.210	0.240	0.270	0.300	0.325	0.335	0.345	0.355	0.365	0.390
1973	0.001	0.010	0.085	0.170	0.259	0.342	0.384	0.409	0.404	0.461	0.520	0.534	0.500	0.500	0.500	0.500
1974	0.001	0.010	0.085	0.170	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1975	0.001	0.010	0.085	0.181	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1976	0.001	0.010	0.085	0.181	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1977	0.001	0.010	0.085	0.181	0.259	0.343	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482

	AGE														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978	0.001	0.010	0.085	0.180	0.294	0.326	0.371	0.409	0.461	0.476	0.520	0.543	0.500	0.500	0.500	0.500
1979	0.001	0.010	0.085	0.178	0.232	0.359	0.385	0.420	0.444	0.505	0.520	0.551	0.500	0.500	0.500	0.500
1980	0.001	0.010	0.085	0.175	0.283	0.347	0.402	0.421	0.465	0.465	0.520	0.534	0.500	0.500	0.500	0.500
1981	0.001	0.010	0.085	0.170	0.224	0.336	0.378	0.387	0.408	0.397	0.520	0.543	0.512	0.512	0.512	0.512
1982	0.001	0.010	0.085	0.170	0.204	0.303	0.355	0.383	0.395	0.413	0.453	0.468	0.506	0.506	0.506	0.506
1983	0.001	0.010	0.085	0.155	0.249	0.304	0.368	0.404	0.424	0.437	0.436	0.493	0.495	0.495	0.495	0.495
1984	0.001	0.010	0.085	0.140	0.204	0.295	0.338	0.376	0.395	0.407	0.413	0.422	0.437	0.437	0.437	0.437
1985	0.001	0.010	0.085	0.148	0.234	0.265	0.312	0.346	0.370	0.395	0.397	0.428	0.428	0.428	0.428	0.428
1986	0.001	0.010	0.085	0.054	0.206	0.265	0.289	0.339	0.368	0.391	0.382	0.388	0.395	0.395	0.395	0.395
1987	0.001	0.010	0.055	0.090	0.143	0.241	0.279	0.299	0.316	0.342	0.343	0.362	0.376	0.376	0.376	0.376
1988	0.001	0.015	0.050	0.098	0.135	0.197	0.277	0.315	0.339	0.343	0.359	0.365	0.376	0.376	0.376	0.376
1989	0.001	0.015	0.100	0.154	0.175	0.209	0.252	0.305	0.367	0.377	0.359	0.395	0.396	0.396	0.396	0.396
1990	0.001	0.008	0.048	0.219	0.198	0.258	0.288	0.309	0.428	0.370	0.403	0.387	0.440	0.440	0.440	0.44
1991	0.001	0.011	0.037	0.147	0.210	0.244	0.300	0.324	0.336	0.343	0.382	0.366	0.425	0.425	0.425	0.425
1992	0.001	0.007	0.030	0.128	0.224	0.296	0.327	0.355	0.345	0.367	0.341	0.361	0.430	0.470	0.470	0.46
1993	0.001	0.008	0.025	0.081	0.201	0.265	0.323	0.354	0.358	0.381	0.369	0.396	0.393	0.374	0.403	0.4
1994	0.001	0.010	0.025	0.075	0.151	0.254	0.318	0.371	0.347	0.412	0.382	0.407	0.410	0.410	0.410	0.41
1995	0.001	0.018	0.025	0.066	0.138	0.230	0.296	0.346	0.388	0.363	0.409	0.414	0.422	0.410	0.410	0.426
1996	0.001	0.018	0.025	0.076	0.118	0.188	0.261	0.316	0.346	0.374	0.390	0.390	0.384	0.398	0.398	0.398
1997	0.001	0.018	0.025	0.096	0.118	0.174	0.229	0.286	0.323	0.370	0.378	0.386	0.360	0.393	0.391	0.391
1998	0.001	0.018	0.025	0.074	0.147	0.174	0.217	0.242	0.278	0.304	0.310	0.359	0.340	0.344	0.385	0.369
1999	0.001	0.018	0.025	0.102	0.150	0.223	0.240	0.264	0.283	0.315	0.345	0.386	0.386	0.386	0.382	0.395
2000	0.001	0.018	0.025	0.119	0.178	0.225	0.271	0.285	0.298	0.311	0.339	0.390	0.398	0.406	0.414	0.427
2001	0.001	0.018	0.025	0.075	0.178	0.238	0.247	0.296	0.307	0.314	0.328	0.351	0.376	0.406	0.414	0.425
2002	0.001	0.010	0.023	0.057	0.177	0.241	0.275	0.302	0.311	0.314	0.328	0.341	0.372	0.405	0.415	0.438
2003	0.001	0.010	0.055	0.098	0.159	0.211	0.272	0.305	0.292	0.331	0.337	0.347	0.356	0.381	0.414	0.433
2004	0.001	0.010	0.055	0.106	0.149	0.212	0.241	0.279	0.302	0.337	0.354	0.355	0.360	0.371	0.400	0.429
2005	0.001	0.010	0.046	0.112	0.156	0.234	0.267	0.295	0.330	0.363	0.377	0.414	0.406	0.308	0.420	0.452
2006	0.001	0.010	0.042	0.107	0.179	0.232	0.272	0.297	0.318	0.371	0.365	0.393	0.395	0.399	0.415	0.428

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2007	0.001	0.010	0.036	0.086	0.155	0.226	0.265	0.312	0.310	0.364	0.384	0.352	0.386	0.304	0.420	0.412
2008**	0.001	0.010	0.044	0.077	0.146	0.212	0.269	0.289	0.327	0.351	0.358	0.372	0.411	0.353	0.389	0.393
2009***	0.001	0.010	0.044	0.077	0.141	0.215	0.270	0.306	0.336	0.346	0.364	0.369	0.411	0.353	0.389	0.393
2010****	0.001	0.01	0.044	0.077	0.188	0.22	0.251	0.286	0.308	0.333	0.344	0.354	0.373	0.353	0.389	0.393
2011	0.001	0.01	0.044	0.118	0.185	0.209	0.246	0.277	0.310	0.322	0.339	0.349	0.364	0.363	0.389	0.393
2012	0.001	0.01	0.044	0.138	0.185	0.256	0.273	0.290	0.305	0.330	0.342	0.361	0.390	0.377	0.389	0.393
2013	0.001	0.01	0.044	0.138	0.204	0.267	0.305	0.309	0.320	0.328	0.346	0.350	0.390	0.377	0.389	0.393
2014	0.001	0.01	0.044	0.138	0.198	0.274	0.301	0.326	0.333	0.339	0.347	0.344	0.362	0.362	0.389	0.393

**** mean weight at ages 11 and 13 are mean of 5 previous years at the same age. These age groups were not present in the catches of the wintering survey from which the stock weight are derived.**

****** derived from catch data from the wintering area north of 69°N during December 2008 – January 2009 for age groups 4-11.**

********derived from catch data from the wintering area north of 69°N during January 2010 for age groups 4-12**

Table 7.5.7.4.1. Norwegian spring-spawning herring. Acoustic estimates (billion individuals) of immature herring in the Barents Sea in May/June. No survey in 2003, 1990—2002. See footnotes. Shaded data are not used in the TASACS assessment. ***Survey 4.***

	survey 4 age				
Year	1	2	3	4	5
1991	24.3	5.2			
1992	32.6	14	5.7		
1993	102.7	25.8	1.5		
1994	6.6	59.2	18	1.7	
1995	0.5	7.7	8	1.1	
1996[1]	0.1	0.25	1.8	0.6	0.03
1997[2]	2.6	0.04	0.4	0.35	0.05
1998	9.5	4.7	0.01	0.01	0
1999	49.5	4.9	0	0	0
2000	105.4	27.9	0	0	0
2001	0.3	7.6	8.8	0	0
2002	0.5	3.9	0	0	0
2003[3]					
2004[3]					
2005	23.3	4.5	2.5	0.4	0.3
2006	3.7	35.0	5.3	0.87	0
2007	2.1	3.7	12.5	1.9	0
2008[4]	0.043	0.38	0.2	0.28	0
2009	0.19	0.47	0.67	0.39	0.41
2010	7.724	1.966	0.091	0	0
2011	0.6	3.6	0.02	0	0
2012	0.370	0.120	0	0	0
2013	0.036	1.912	0.377	0.024	
2014	5.876	2.185	2.156	0.242	0.045

[1] **Average of Norwegian and Russian estimates**

[2] **Combination of Norwegian and Russian estimates as described in 1998 WG report, since then only Russian estimates**

[3] **No surveys**

[4] **Not a full survey**

Table 7.5.7.4.2. Norwegian spring spawning herring. Estimates from the international acoustic surveys on the feeding areas in the Norwegian Sea in May. Numbers in millions. Biomass in thousands. Biomass in thousands. Shaded data are not used in the TASACS assessment. ***Survey 5.***

	survey 5 Age															Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
1996	0	0	4114	22461	13244	4916	2045	424	14	7	155	0	3134			50514	8532
1997	0	0	1169	3599	18867	13546	2473	1771	178	77	288	190	60	2697		44915	9435
1998	24	1404	367	1099	4410	16378	10160	2059	804	183	0	0	35	0	492	37415	8004
1999	0	215	2191	322	965	3067	11763	6077	853	258	5	14	0	158	128	26016	6299
2000	0	157	1353	2783	92	384	1302	7194	5344	1689	271	0	114	0	75	20758	6001
2001	0	1540	8312	1430	1463	179	204	3215	5433	1220	94	178	0	0	6	23274	3937
2002	0	677	6343	9619	1418	779	375	847	1941	2500	1423	61	78	28	0	26089	4628
2003	32073	8115	6561	9985	9961	1499	732	146	228	1865	2359	1769		287	0	75580	6653
2004	0	13735	1543	5227	12571	10710	1075	580	76	313	362	1294	1120	10	88	48704	7687
2005	0	1293	19679	1353	1765	6205	5371	651	388	139	262	526	1003	364	115	39114	5109
2006	0	19	306	14560	1396	2011	6521	6978	679	713	173	407	921	618	243	35545	9100
2007	0	411	2889	5877	20292	1260	1992	6780	5582	647	488	372	403	1048	1010	49051	12161
2008	0	1193	587	8332	8270	16345	1381	1920	3958	2500	416	242	159	217	408	45928	9996
2009	0	410	2316	2314	13545	8937	12025	1335	1334	2696	1488	208	175	65	232	47080	10406
2010	81	364	1195	3329	2156	8282	4146	4519	390	513	804	331	45	17	25	26857	5777
2011	0	1058	1576	1753	4550	2692	8693	2879	4830	572	898	837	281	13	34	30666	7298
2012	0	1588	2995	415	844	1835	2321	4346	1890	2338	329	615	344	112	54	20026	4629
2013	0	395	653	2900	496	1120	1923	2794	4311	2600	1782	538	573	209	62	20356	5291
2014	62	673	1632	1106	3146	548	930	2161	2357	3667	1656	1062	489	192	193	19874	5064

Table 7.5.7.5.1. Norwegian spring-spawning herring. Acoustic estimates (billion individuals) of immature herring in the Barents Sea in August-October. Data in black boxes used in the assessment. *Survey 6.*

survey 6			
	Age		
Year	1	2	3
2000	14.7	11.5	0
2001	0.5	10.5	1.7
2002	1.3	0	0
2003	99.9	4.3	2.5
2004	14.3	36.5	0.9
2005	46.4	16.1	7.0
2006	1.6	5.5	1.3
2007	3.9	2.6	6.3
2008	0.03	1.62	3.99
2009	1.5	0.4	
2010	1.0	0.3	
2011	0.10	1.50	0.01
2012	2.0	1.1	
2013	7.7	5.0	

Table 7.5.7.5.2. Norwegian spring-spawning herring. Abundance indices for 0-group herring since 1980 in the Barents Sea, August-October. This index has been recalculated since 2006. Data in shaded cells are not used in the assessment *Survey 7*.

survey 7	
Year	Abundance index
1980	4
1981	3
1982	202
1983	40557
1984	6313
1985	7237
1986	7
1987	2
1988	8686
1989	4196
1990	9508
1991	81175
1992	37183
1993	61508
1994	14884
1995	1308
1996	57169
1997	45808
1998	79492
1999	15931
2000	49614
2001	844
2002	23354
2003	28579
2004	133350
2005	26332
2006	66819
2007	22481
2008	15727
2009	18916
2010	20367
2011	13674
2012	26480
2013	70972

Table 7.5.7.6.1. Norwegian Spring-spawning herring. The indices for herring larvae on the Norwegian shelf for the period 1981-2007 ($N*10^{-12}$). Data in shaded cells are not used in the assessment. ***Survey 8.***

survey 8		
Year	Index1	Index 2
1981	0.3	
1982	0.7	
1983	2.5	
1984	1.4	
1985	2.3	
1986	1	
1987	1.3	4
1988	9.2	25.5
1989	13.4	28.7
1990	18.3	29.2
1991	8.6	23.5
1992	6.3	27.8
1993	24.7	78
1994	19.5	48.6
1995	18.2	36.3
1996	27.7	81.7
1997	66.6	147.5
1998	42.4	138.6
1999	19.9	73
2000	19.8	89.4
2001	40.7	135.9
2002	27.1	138.6
2003*	3.7	18.8
2004	56.4	215.1
2005	73.91	196.7
2006	98.9	389.0
2007**	90.6	
2008	107.9	393.3
2009	8.4	53.8
2010	42.7	140.2
2011	73.4	192.1
2012	65.6	224.4
2013	71.6	345.3
2014	75.9	

Index 1. The total number of herring larvae found during the cruise.

Index 2. Back-calculated number of newly hatched larvae with 10% daily moratlity. The larval age is estimated from the duration of the yolksac stages and the size of the larvae.

*** Poor weather conditions and survey was late in April**

**** only representative for the area 62-66°N**

Table 7.7.5.1. Norwegian Spring-spawning herring. Mature at age. The time series was provided by WKHERMAT in 2010 and are used in the assessment since 2010.

	age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1950	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
1951	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
1952	0	0	0	0	0.1	0.6	1	1	1	1	1	1	1	1	1	1
1953	0	0	0	0	0.3	0.4	0.9	1	1	1	1	1	1	1	1	1
1954	0	0	0	0	0.1	0.7	0.9	1	1	1	1	1	1	1	1	1
1955	0	0	0	0.1	0.4	0.4	1	1	1	1	1	1	1	1	1	1
1956	0	0	0	0	0.5	0.7	0.6	1	1	1	1	1	1	1	1	1
1957	0	0	0	0	0.3	0.8	0.8	0.7	1	1	1	1	1	1	1	1
1958	0	0	0	0	0.3	0.5	0.9	0.9	1	1	1	1	1	1	1	1
1959	0	0	0	0	0.7	0.8	1	0.9	1	1	1	1	1	1	1	1
1960	0	0	0	0	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
1961	0	0	0	0	0.1	0.8	1	0.9	1	1	1	1	1	1	1	1
1962	0	0	0	0	0.1	0.7	1	1	1	1	1	1	1	1	1	1
1963	0	0	0	0	0.1	0.4	1	1	1	1	1	1	1	1	1	1
1964	0	0	0	0	0.1	0.4	0.8	1	1	1	1	1	1	1	1	1
1965	0	0	0	0	0.5	0.4	0.9	0.8	1	1	1	1	1	1	1	1
1966	0	0	0	0	0.5	0.7	0.9	1	1	1	1	1	1	1	1	1
1967	0	0	0	0	0.3	0.8	1	1	1	1	1	1	1	1	1	1
1968	0	0	0	0	0	0.7	0.9	1	1	1	1	1	1	1	1	1
1969	0	0	0	0.1	0.2	0.3	1	1	1	1	1	1	1	1	1	1
1970	0	0	0	0	0.4	0.3	0.4	1	1	1	1	1	1	1	1	1
1971	0	0	0	0	0.1	0.7	1	1	1	1	1	1	1	1	1	1
1972	0	0	0	0	0.4	0.3	1	1	1	1	1	1	1	1	1	1
1973	0	0	0	0.1	0.6	1	1	1	1	1	1	1	1	1	1	1
1974	0	0	0	0	0.6	0.9	1	1	1	1	1	1	1	1	1	1
1975	0	0	0	0.1	0.5	0.9	1	1	1	1	1	1	1	1	1	1
1976	0	0	0	0.1	0.9	0.9	1	1	1	1	1	1	1	1	1	1
1977	0	0	0	0.3	0.8	1	1	1	1	1	1	1	1	1	1	1
1978	0	0	0	0.2	0.9	1	1	1	1	1	1	1	1	1	1	1
1979	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1	1
1980	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1	1
1981	0	0	0	0.1	1	1	1	1	1	1	1	1	1	1	1	1
1982	0	0	0	0.1	0.8	1	1	1	1	1	1	1	1	1	1	1
1983	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1	1
1984	0	0	0	0.1	0.7	1	1	1	1	1	1	1	1	1	1	1
1985	0	0	0	0.1	0.8	0.9	1	1	1	1	1	1	1	1	1	1
1986	0	0	0	0	0.5	0.9	0.9	1	1	1	1	1	1	1	1	1
1987	0	0	0	0	0.1	0.8	0.9	0.9	1	1	1	1	1	1	1	1
1988	0	0	0	0	0.2	0.7	0.9	1	1	1	1	1	1	1	1	1
1989	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
1990	0	0	0	0.2	0.5	0.9	1	1	1	1	1	1	1	1	1	1

	age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1991	0	0	0	0	0.9	0.9	1	1	1	1	1	1	1	1	1	1
1992	0	0	0	0	0.8	1	1	1	1	1	1	1	1	1	1	1
1993	0	0	0	0	0.5	1	1	1	1	1	1	1	1	1	1	1
1994	0	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1
1995	0	0	0	0	0	0.6	1	1	1	1	1	1	1	1	1	1
1996	0	0	0	0	0	0.5	0.9	1	1	1	1	1	1	1	1	1
1997	0	0	0	0.1	0	0.4	0.9	1	1	1	1	1	1	1	1	1
1998	0	0	0	0	0.6	0.4	0.9	1	1	1	1	1	1	1	1	1
1999	0	0	0	0	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
2000	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2001	0	0	0	0	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
2002	0	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1
2003	0	0	0	0	0.2	0.7	1	1	1	1	1	1	1	1	1	1
2004	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1
2005	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1
2006	0	0	0	0	0.3	0.8	1	1	1	1	1	1	1	1	1	1
2007	0	0	0	0	0.1	0.7	0.9	1	1	1	1	1	1	1	1	1
2008	0	0	0	0	0.1	0.6	0.9	1	1	1	1	1	1	1	1	1
2009	0	0	0	0	0.4	0.6	0.9	1	1	1	1	1	1	1	1	1
2010	0	0	0	0	0.4	0.8	0.9	1	1	1	1	1	1	1	1	1
2011	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2012	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2013	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2014	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1

Table 7.7.2.1. Norwegian spring-spawning herring. The stock summary of the exploratory TISVPA run. (R(0): recruits at age 0 in millions, B(0+) and SSB in thous. tonnes)

year	R(0)	B(0+)	SSB	F(5-14) weighted by abundance
1986	12605	1916	344	0.975
1987	10456	3311	385	0.268
1988	25613	3636	2113	0.044
1989	67814	4335	3425	0.028
1990	124850	4909	4093	0.020
1991	332243	5602	4018	0.022
1992	382331	6687	4092	0.025
1993	116671	7773	3968	0.060
1994	38173	8923	4096	0.125
1995	12234	9799	4121	0.210
1996	53194	9884	4739	0.176
1997	32777	9802	6114	0.168
1998	164100	8487	6796	0.142
1999	155360	9045	6985	0.173
2000	58368	8466	5893	0.200
2001	40268	7003	4783	0.173
2002	302522	6875	4062	0.189
2003	140437	8082	4369	0.154
2004	278988	9542	5159	0.134
2005	90019	9979	5097	0.185
2006	96853	10722	5086	0.198
2007	40757	10044	5348	0.181
2008	27902	10001	5705	0.234
2009	164567	9530	6746	0.214
2010	87549	8843	6618	0.216
2011	122801	8193	5870	0.151
2012	37	8314	5413	0.144
2013		8289	5395	0.126
2014		8003	5854	

Table 7.7.3.3.1. Norwegian spring spawning herring. Stock in numbers (billions).

	Age (in years)															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1988	26.068	4.006	1.627	3.494	0.731	14.032	0.046	0.013	0.012	0.027	0.012	0.008	0.006	0.004	0.003	0.001
1989	71.488	10.589	1.627	0.656	2.949	0.606	11.567	0.030	0.008	0.005	0.010	0.002	0.004	0.002	0.001	0.001
1990	109.322	29.060	4.304	0.645	0.562	2.535	0.516	9.655	0.023	0.006	0.004	0.005	0.001	0.003	0.002	0.002
1991	308.608	44.446	11.815	1.740	0.538	0.481	2.171	0.434	8.100	0.019	0.004	0.001	0.002	0.000	0.002	0.002
1992	367.743	125.471	18.068	4.801	1.490	0.461	0.413	1.855	0.366	6.769	0.014	0.003	0.001	0.001	0.000	0.003
1993	113.032	149.512	51.013	7.345	4.121	1.252	0.392	0.354	1.585	0.309	5.617	0.010	0.002	0.001	0.000	0.002
1994	38.651	45.951	60.787	20.736	6.296	3.448	0.996	0.329	0.301	1.337	0.249	4.454	0.008	0.002	0.001	0.002
1995	19.595	15.714	18.682	24.709	17.817	5.317	2.630	0.705	0.269	0.252	1.116	0.181	3.235	0.004	0.001	0.002
1996	58.595	7.967	6.389	7.595	21.214	15.014	3.998	1.672	0.392	0.217	0.202	0.896	0.078	1.938	0.000	0.002
1997	33.527	23.823	3.239	2.578	6.505	17.597	11.465	2.569	1.062	0.242	0.182	0.167	0.710	0.051	0.892	0.001
1998	208.090	13.631	9.686	1.303	2.098	5.348	13.480	8.019	1.505	0.611	0.151	0.138	0.114	0.527	0.026	0.425
1999	167.194	84.603	5.542	3.885	1.056	1.581	4.261	9.969	5.729	0.941	0.406	0.091	0.095	0.095	0.349	0.299
2000	57.634	67.976	34.397	2.250	3.216	0.876	1.236	3.269	7.091	3.851	0.540	0.251	0.065	0.045	0.075	0.406
2001	34.588	23.432	27.637	13.976	1.859	2.248	0.722	0.961	2.439	4.898	2.345	0.263	0.149	0.041	0.017	0.275
2002	355.123	14.063	9.527	11.235	11.934	1.451	1.539	0.585	0.738	1.824	3.437	1.548	0.158	0.107	0.032	0.200
2003	163.350	144.382	5.717	3.834	9.486	9.675	1.012	1.022	0.476	0.548	1.324	2.344	1.018	0.087	0.080	0.152
2004	286.094	66.413	58.699	2.322	3.230	7.864	7.650	0.708	0.724	0.388	0.403	0.938	1.491	0.673	0.039	0.178
2005	67.518	116.317	27.001	23.837	1.976	2.694	6.370	5.921	0.506	0.495	0.310	0.298	0.651	0.911	0.384	0.043
2006	73.226	27.451	47.291	10.965	20.102	1.613	2.161	4.886	4.233	0.322	0.312	0.231	0.196	0.431	0.464	0.236
2007	26.620	29.772	11.159	19.198	9.367	16.625	1.312	1.701	3.532	2.927	0.195	0.197	0.171	0.115	0.247	0.403
2008	16.645	10.823	12.101	4.532	16.316	7.722	12.635	0.988	1.239	2.364	2.045	0.124	0.146	0.133	0.076	0.401

	Age (in years)															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2009	53.913	6.767	4.375	4.841	3.867	13.532	6.024	8.745	0.665	0.828	1.490	1.417	0.079	0.092	0.092	0.265
2010	10.159	21.919	2.749	1.706	3.988	3.190	10.540	4.336	5.737	0.440	0.470	0.889	0.999	0.026	0.071	0.271
2011	28.169	4.130	8.863	1.078	1.374	3.238	2.569	8.084	3.072	3.618	0.216	0.237	0.449	0.694	0.011	0.242
2012	19.187	11.453	1.598	3.444	0.871	1.086	2.570	2.016	6.257	2.140	2.518	0.102	0.096	0.260	0.555	0.074
2013	130.288	7.801	4.655	0.642	2.768	0.703	0.823	1.950	1.491	4.692	1.550	1.835	0.039	0.041	0.164	0.529
2014		52.971	3.172	1.879	0.496	2.126	0.539	0.604	1.416	1.059	3.489	1.177	1.445	0.010	0.025	0.558

Table 7.7.3.3.2. Norwegian spring spawning herring. Fishing mortality.

	Age (in years)															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1988	0.001	0.001	0.009	0.020	0.038	0.043	0.253	0.360	0.750	0.875	1.475	0.500	0.920	1.221	0.897	0.897
1989	0.000	0.000	0.025	0.005	0.001	0.010	0.031	0.131	0.116	0.160	0.458	0.934	0.201	0.184	0.312	0.312
1990	0.000	0.000	0.006	0.032	0.005	0.005	0.023	0.026	0.062	0.316	0.928	0.682	1.856	0.070	0.557	0.557
1991	0.000	0.000	0.000	0.005	0.006	0.003	0.007	0.022	0.030	0.157	0.141	0.079	0.392	-1.000	0.131	0.131
1992	0.000	0.000	0.000	0.003	0.024	0.012	0.003	0.007	0.017	0.037	0.218	0.279	0.316	-1.000	0.140	0.140
1993	0.000	0.000	0.000	0.004	0.028	0.078	0.024	0.011	0.020	0.067	0.082	0.000	0.000	0.000	0.060	0.060
1994	0.000	0.000	0.000	0.002	0.019	0.121	0.196	0.052	0.030	0.031	0.168	0.170	0.469	0.375	0.226	0.226
1995	0.000	0.000	0.000	0.003	0.021	0.135	0.303	0.436	0.064	0.070	0.070	0.690	0.362	-1.000	0.336	0.336
1996	0.000	0.000	0.007	0.005	0.037	0.120	0.293	0.304	0.335	0.029	0.040	0.083	0.277	0.626	0.295	0.295
1997	0.000	0.000	0.011	0.056	0.046	0.117	0.208	0.385	0.403	0.317	0.127	0.235	0.148	0.517	0.593	0.593
1998	0.000	0.000	0.014	0.060	0.133	0.077	0.152	0.186	0.319	0.260	0.361	0.221	0.034	0.262	0.262	0.262

1999	0.000	0.000	0.001	0.039	0.037	0.096	0.115	0.191	0.247	0.406	0.331	0.189	0.605	0.086	0.318	0.318
2000	0.000	0.000	0.001	0.041	0.208	0.044	0.102	0.143	0.220	0.346	0.568	0.368	0.316	0.794	0.407	0.407
2001	0.000	0.000	0.000	0.008	0.098	0.229	0.060	0.114	0.141	0.204	0.265	0.359	0.188	0.098	0.232	0.232
2002	0.000	0.000	0.010	0.019	0.060	0.211	0.260	0.057	0.147	0.170	0.233	0.270	0.447	0.135	0.270	0.270
2003	0.000	0.000	0.001	0.021	0.038	0.085	0.208	0.195	0.053	0.158	0.195	0.302	0.264	0.648	0.116	0.116
2004	0.000	0.000	0.001	0.011	0.031	0.061	0.106	0.185	0.230	0.077	0.151	0.216	0.343	0.412	1.473	1.473
2005	0.000	0.000	0.001	0.021	0.053	0.071	0.115	0.186	0.301	0.313	0.142	0.269	0.262	0.525	0.441	0.441
2006	0.000	0.000	0.002	0.008	0.040	0.056	0.089	0.175	0.219	0.352	0.310	0.153	0.383	0.407	0.401	0.401
2007	0.000	0.000	0.001	0.013	0.043	0.124	0.134	0.167	0.252	0.209	0.302	0.150	0.102	0.261	0.333	0.333
2008	0.000	0.006	0.016	0.009	0.037	0.098	0.218	0.246	0.252	0.311	0.217	0.297	0.310	0.214	0.440	0.440
2009	0.000	0.001	0.042	0.044	0.042	0.100	0.179	0.272	0.264	0.417	0.366	0.200	0.962	0.116	0.126	0.126
2010	0.000	0.006	0.036	0.067	0.058	0.066	0.115	0.195	0.311	0.561	0.533	0.533	0.215	0.730	0.195	0.195
2011	0.000	0.049	0.045	0.064	0.086	0.081	0.092	0.106	0.212	0.213	0.601	0.760	0.397	0.073	1.075	1.075
2012	0.000	0.000	0.013	0.069	0.064	0.126	0.126	0.152	0.138	0.173	0.166	0.824	0.708	0.310	0.024	0.024
2013	0.000	0.000	0.007	0.107	0.114	0.116	0.159	0.171	0.193	0.146	0.126	0.089	1.198	0.332	0.066	0.066

Negative fishing mortality -1 means that the fishing mortality was not defined, see TASACS manual

Table 7.7.3.3.3 Norwegian spring spawning herring. Final stock summary table.

Summary	output					
Run	id:	20140828	114812.1			
Process:	Ordinary	assessment				
Model:	VPA					
Year	Recruit	TSB	SSB	Landings	Unweighted	Weighted F with stock numbers
	Age 0 in billions	Million tonnes	Million tonnes	tonnes	F5-14	WF5-14
1988	26.068	3.416	1.996	135301	0.730	0.049
1989	71.488	4.073	3.244	103830	0.254	0.031
1990	109.322	4.605	3.823	86411	0.452	0.022
1991	308.608	5.245	3.732	84683	0.107	0.024
1992	367.743	6.284	3.814	104448	0.114	0.028
1993	113.032	7.355	3.761	232457	0.034	0.066
1994	38.651	8.406	3.890	479228	0.184	0.133
1995	19.595	9.197	3.849	905501	0.274	0.236
1996	58.595	9.284	4.326	1220283	0.240	0.202
1997	33.527	9.171	5.537	1426507	0.305	0.190
1998	208.090	7.984	6.218	1223131	0.213	0.161
1999	167.194	8.808	6.334	1235433	0.258	0.199
2000	57.634	8.285	5.378	1207201	0.331	0.232
2001	34.588	6.869	4.371	766136	0.189	0.196
2002	355.123	7.077	3.786	807795	0.220	0.216
2003	163.350	8.508	4.392	789510	0.222	0.150
2004	286.094	10.318	5.389	794066	0.325	0.131
2005	67.518	10.841	5.419	1003243	0.262	0.176
2006	73.226	11.732	5.631	968958	0.255	0.185
2007	26.620	11.140	6.294	1266993	0.203	0.157
2008	16.645	11.017	6.872	1545656	0.260	0.196
2009	53.913	10.224	7.884	1687373	0.300	0.190
2010	10.159	8.724	7.388	1457014	0.345	0.198
2011	28.169	7.177	6.302	992998	0.361	0.150
2012	19.187	6.298	5.466	825999	0.275	0.151
2013	130.288	5.604	4.726	684743	0.260	0.147
2014		5.171	4.066			

The GM recruitment over the years 1988-2010 is 72 billion

Table 7.10.1.1 Norwegian Spring-spawning herring. Input to short-term prediction. Stock size is in millions and weight in kg.

2014								
Age	Stock size	Natural mortality	Maturity ogive	Prop. of M bef. spaw.	Prop. of F bef. spaw.	Weight in stock	Exploit. pattern	Weight in catch
0	72000	0.90	0	0	0	0.001	0.000	0.000
1	52971	0.90	0	0	0	0.010	0.011	0.031
2	3172	0.90	0	0	0	0.044	0.028	0.129
3	1879	0.15	0	0	0	0.138	0.070	0.216
4	496	0.15	0.4	0	0	0.198	0.073	0.268
5	2126	0.15	0.8	0	0	0.274	0.098	0.291
6	539	0.15	1	0	0	0.301	0.134	0.313
7	604	0.15	1	0	0	0.326	0.179	0.328
8	1416	0.15	1	0	0	0.333	0.223	0.342
9	1059	0.15	1	0	0	0.339	0.302	0.352
10	3489	0.15	1	0	0	0.347	0.358	0.363
11	1177	0.15	1	0	0	0.344	0.481	0.371
12	1445	0.15	1	0	0	0.362	0.696	0.390
13	10	0.15	1	0	0	0.362	0.312	0.385
14	25	0.15	1	0	0	0.389	0.297	0.391
15	558	0.15	1	0	0	0.393	0.297	0.386

2015 and 2016								
Age	Stock size	Natural mortality	Maturity ogive	Prop. of M bef. spaw.	Prop. of F bef. spaw.	Weight in stock	Exploit. pattern	Weight in catch
0	72000	0.90	0	0	0	0.001	0.000	0.000
1		0.90	0	0	0	0.010	0.011	0.031
2		0.90	0	0	0	0.044	0.028	0.129
3		0.15	0	0	0	0.138	0.070	0.216
4		0.15	0.4	0	0	0.196	0.073	0.268
5		0.15	0.8	0	0	0.266	0.098	0.291
6		0.15	1	0	0	0.293	0.134	0.313
7		0.15	1	0	0	0.308	0.179	0.328
8		0.15	1	0	0	0.319	0.223	0.342
9		0.15	1	0	0	0.332	0.302	0.352
10		0.15	1	0	0	0.345	0.358	0.363
11		0.15	1	0	0	0.352	0.481	0.371
12		0.15	1	0	0	0.381	0.696	0.390
13		0.15	1	0	0	0.372	0.312	0.385
14		0.15	1	0	0	0.389	0.297	0.391
15		0.15	1	0	0	0.393	0.297	0.386

Table 7.10.2.1. Norwegian spring spawning herring. Short term prediction.

a)
Basis:
SSB(2014)=4.066 million t
Landings (2014)=436 thous. t (sum of national quota)
Fw(2014)=0.107
SSB(2015)=3.502 million t
The fishing mortality applies according to the agreed management plan (F(management plan)) is 0.08

Rationale	Catch (2015)	Basis	F(2015)	SSB(2016)	%SSB char	%TAC change
Zero catch	0	F=0	0.000	3.437	-2	-100
Status quo	373	F(2014)	0.107	3.115	-11	-11
Agreed Management Plan	181	Management plan, if SSB < 2.5 mt	0.050	3.280	-6	-57
	216		0.060	3.250	-7	-48
	251		0.070	3.219	-8	-40
	283	Management plan	0.080	3.192	-9	-32
	318		0.090	3.162	-10	-24
	350		0.100	3.134	-11	-16
	434	Management plan, if SSB > 5.0 mt	0.125	3.062	-13	4
	512		0.150	2.995	-14	22
MSY	367	0.7*Fmsy	0.105	3.120	-11	-12

b)
Basis:
SSB(2014)=4.066 million t
Landings (2014)=409 thous. (sum of national quota decreased by 6%)*
Fw(2014)=0.100
SSB(2015)=3.527 million t
The fishing mortality applies according to the agreed management plan (F(management plan)) is 0.081

Rationale	Catch (2015)	Basis	F(2015)	SSB(2016)	%SSB char	%TAC change
	289		0.081	3210	-9	-31

*see chapter 7.4.2

c)
Basis:
SSB(2014)=4.066 million t
Landings (2014)=380 thous. (sum of national quota decreased by 13%)*
Fw(2014)=0.092
SSB(2015)=3.552 million t
The fishing mortality applies according to the agreed management plan (F(management plan)) is 0.082

Rationale	Catch (2015)	Basis	F(2015)	SSB(2016)	%SSB char	%TAC change
	293		0.082	3228	-9	-30

*see chapter 7.4.2

Landings weights in thousand tonnes, stock biomass weight in million tonnes.

F_w=Fishing mortality weighted by population numbers (age groups 5-14).

Table 7.10.2. 2 Norwegian spring-spawning herring. Detailed short term prediction

2014

Age	Stockno. 1-Jan.	Stockno. spawning time	Biomass 1-Jan	Biomass spawning time	SSB 1-Jan	SSB spawning time	F	Catches in numbers	Catches in weight
0	72000	72000	72	72	0	0	0.000	0	0
1	52971	52971	530	530	0	0	0.004	129	4
2	3172	3172	140	140	0	0	0.009	20	3
3	1879	1879	259	259	0	0	0.023	40	9
4	496	496	98	98	39	39	0.024	11	3
5	2126	2126	582	582	466	466	0.032	63	18
6	539	539	162	162	162	162	0.044	22	7
7	604	604	197	197	197	197	0.059	32	11
8	1416	1416	471	471	471	471	0.074	93	32
9	1059	1059	359	359	359	359	0.100	93	33
10	3489	3489	1211	1211	1211	1211	0.118	362	131
11	1177	1177	405	405	405	405	0.159	161	60
12	1445	1445	523	523	523	523	0.230	276	108
13	10	10	4	4	4	4	0.103	1	0
14	25	25	10	10	10	10	0.098	2	1
15	558	558	219	219	219	219	0.098	48	19
	142965	142965	5242	5242	4066	4066	0.107	1353	437
	(millions)	(millions)	(thous.)	(thous.)	(thous.)	(thous.)	WF5-14	(millions)	(thous.)

2015

Age	Stockno. 1-Jan.	Stockno. spawningtime	Biomass 1-Jan	Biomass spawningtime	SSB 1-Jan	SSB spawningtime	F	Catches in numbers	Catches in weight
0	72000	72000	72	72	0	0	0.000	0	0
1	29273	29273	293	293	0	0	0.003	50	2
2	21457	21457	944	944	0	0	0.007	93	12
3	1277	1277	176	176	0	0	0.016	19	4
4	1581	1581	309	309	124	124	0.017	25	7
5	417	417	111	111	89	89	0.023	9	3
6	1771	1771	519	519	519	519	0.031	50	16
7	444	444	137	137	137	137	0.042	17	6
8	490	490	157	157	157	157	0.052	23	8
9	1132	1132	376	376	376	376	0.070	71	25
10	825	825	285	285	285	285	0.083	61	22
11	2668	2668	938	938	938	938	0.112	262	97
12	864	864	329	329	329	329	0.161	120	47
13	988	988	368	368	368	368	0.072	64	25
14	8	8	3	3	3	3	0.069	0	0
15	455	455	179	179	179	179	0.069	28	11
	135651	135651	5195	5195	3502	3502	0.080	893	283
	(millions)	(millions)	(thous.)	(thous.)	(thous.)	(thous.)	WF5-14	(millions)	(thous.)

2016

Age	Stockno. 1-Jan.	Stockno. spawningtime	Biomass 1-Jan	Biomass spawningtime	SSB 1-Jan	SSB spawningtime	F	Catches in numbers	Catches in weight
0	72000	72000	72	72	0	0	0.000	0	0
1	29273	29273	293	293	0	0	0.002	44	1
2	11871	11871	522	522	0	0	0.006	45	6
3	8666	8666	1196	1196	0	0	0.014	113	24
4	1082	1082	212	212	85	85	0.015	15	4
5	1338	1338	355	355	284	284	0.020	24	7
6	351	351	103	103	103	103	0.027	9	3
7	1478	1478	456	456	456	456	0.036	49	16
8	367	367	117	117	117	117	0.045	15	5
9	401	401	133	133	133	133	0.061	22	8
10	908	908	313	313	313	313	0.072	59	21
11	653	653	230	230	230	230	0.097	56	21
12	2054	2054	782	782	782	782	0.141	251	98
13	633	633	235	235	235	235	0.063	36	14
14	791	791	308	308	308	308	0.060	43	17
15	372	372	146	146	146	146	0.060	20	8
	132237	132237	5473	5473	3192	3192	0.071	800	253
	(millions)	(millions)	(thous.)	(thous.)	(thous.)	(thous.)	WF5-14	(millions)	(thous.)

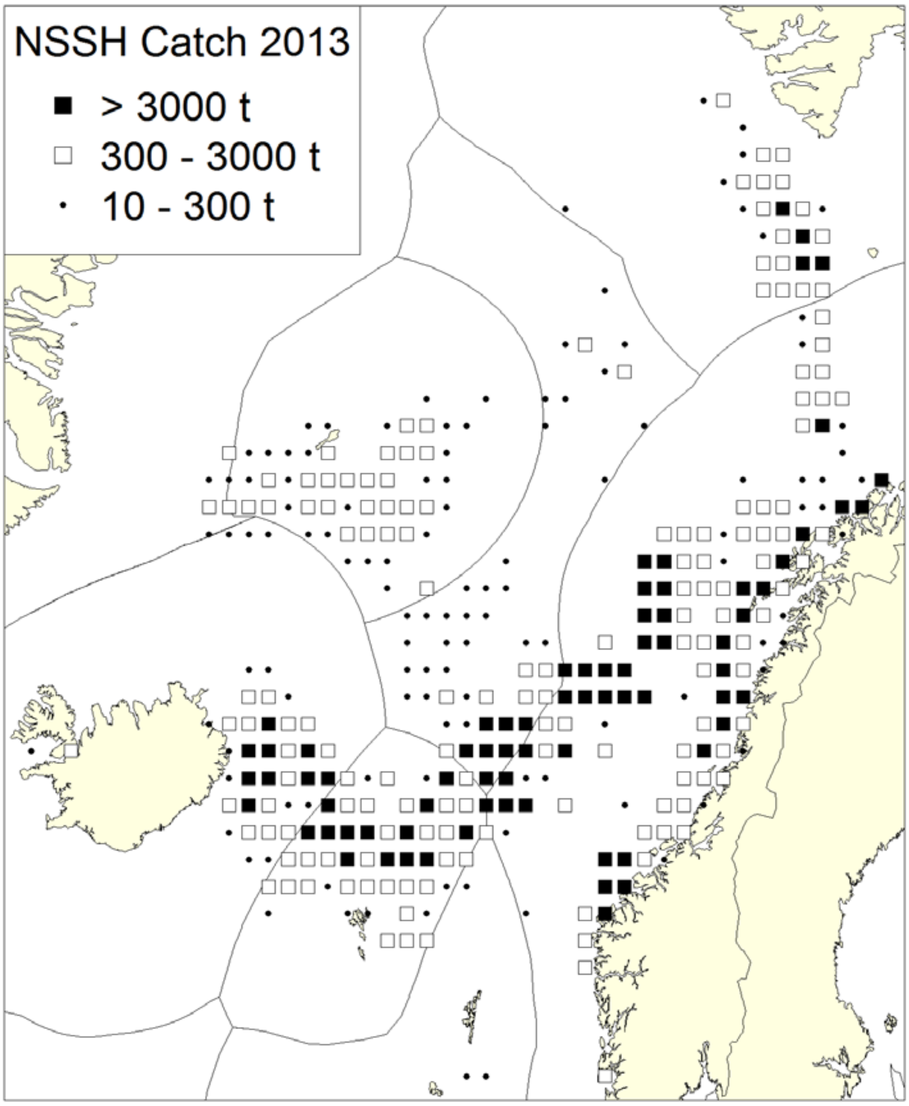


Figure 7.3.1.1. Total reported catches of Norwegian spring-spawning herring in 2013 by ICES rectangle. Grading of the symbols: black dots less than 300 t, open squares 300–3000 t, and black squares > 3000 t.

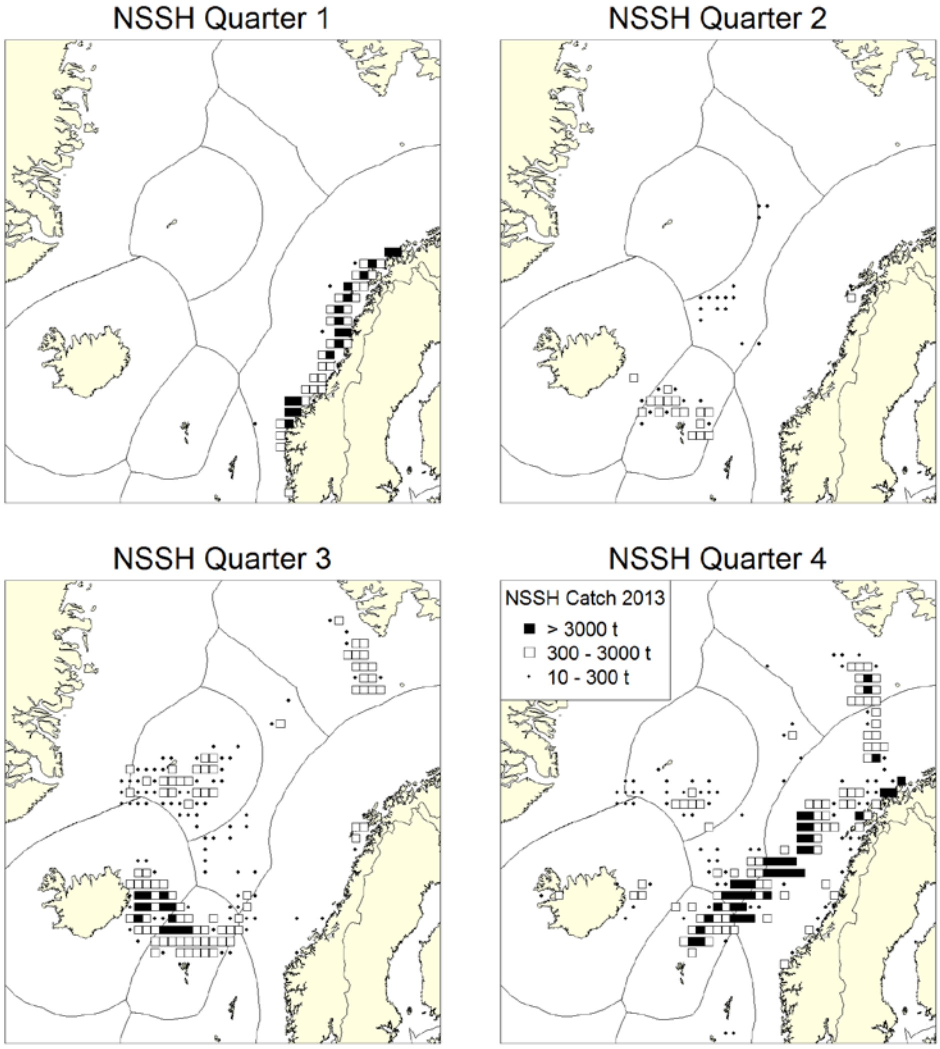


Figure 7.3.1.2. Total reported catches of Norwegian spring-spawning herring in 2013 by quarter and ICES rectangle. Grading of the symbols: black dots less than 300 t, open squares 300–3000 t, and black squares > 3000 t.

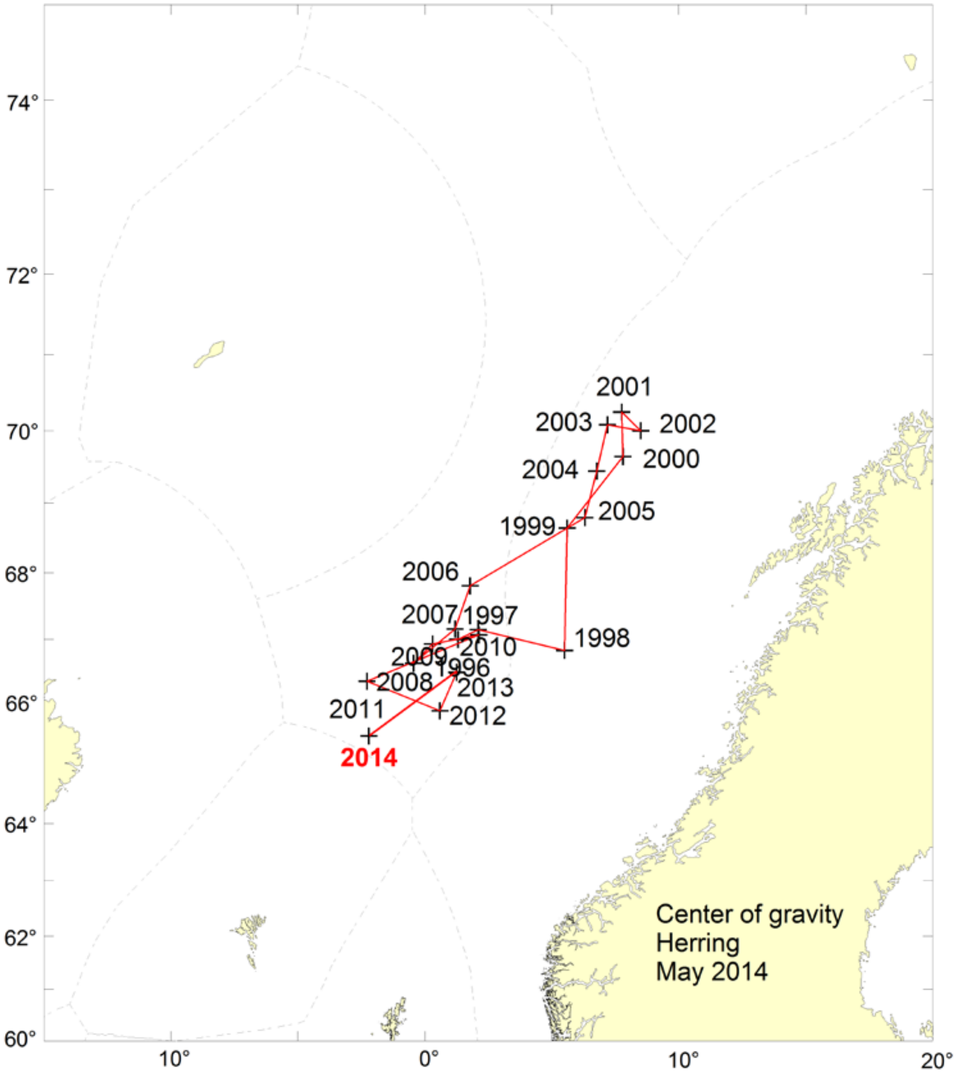


Figure 7.4.2.1 Norwegian spring spawning herring: Centre of gravity of herring during the period 1996-2014 derived from acoustic. Acoustic data from area II and III only, i.e. west of 20°E.

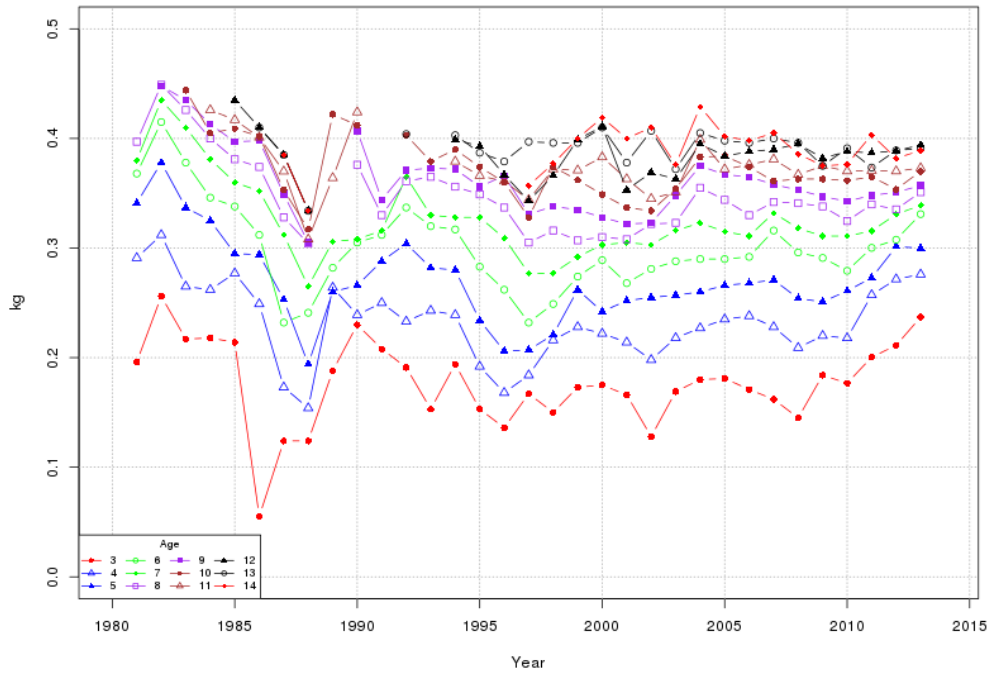


Figure 7.5.4.1. Norwegian spring spawning herring. Mean weight at age by age groups 3-14 in the years 1980-2013 in the catch (weight at age for zero catch numbers were omitted).

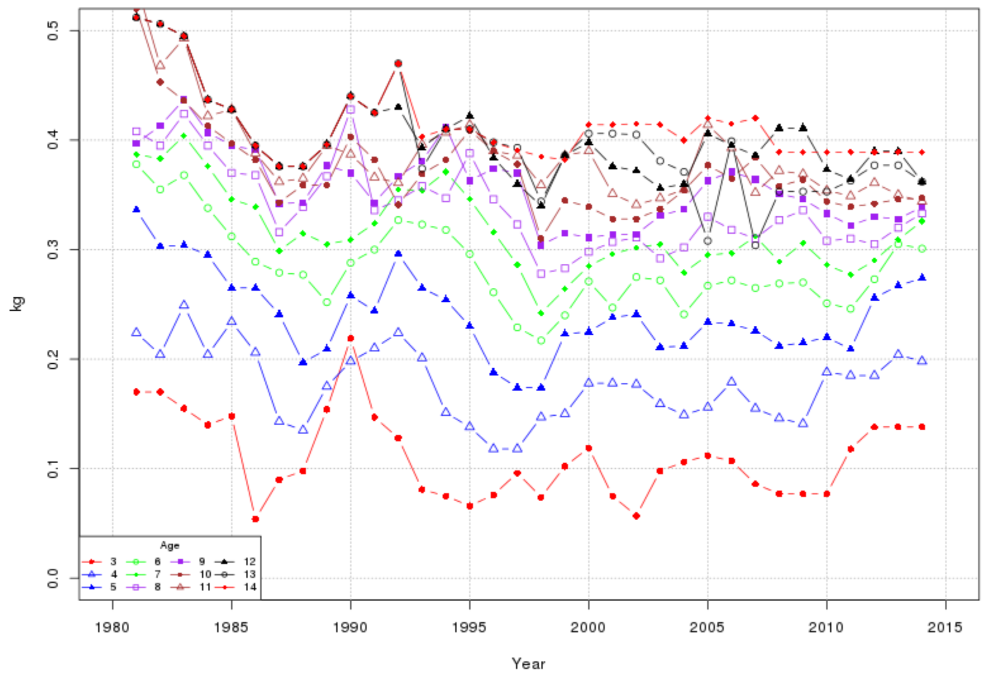
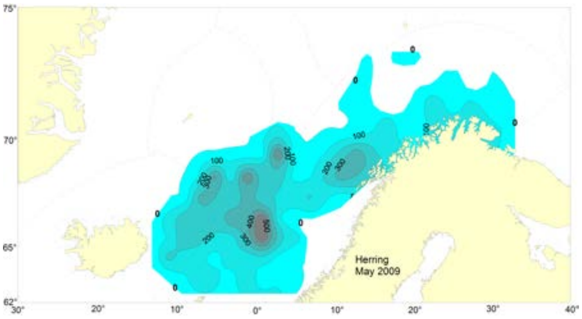
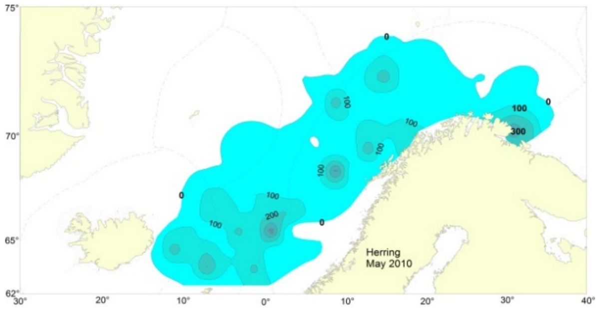


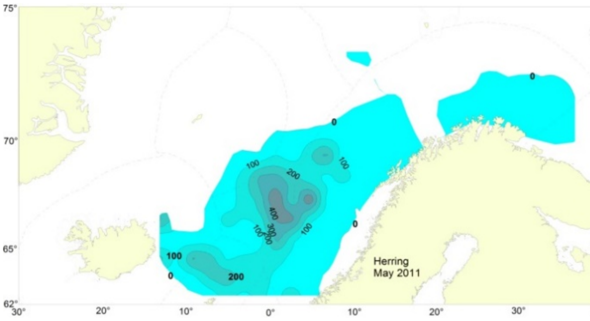
Figure 7.5.4.2. Norwegian spring-spawning herring. Mean weight at age in the stock 1981-2014.



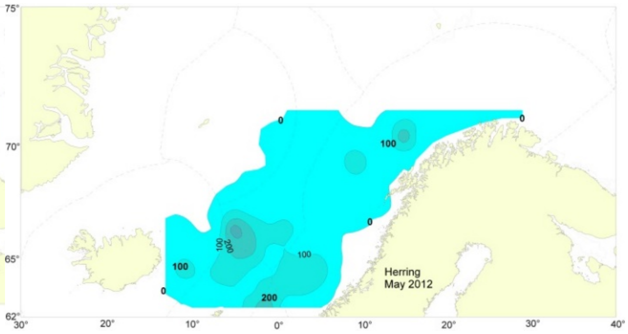
2009



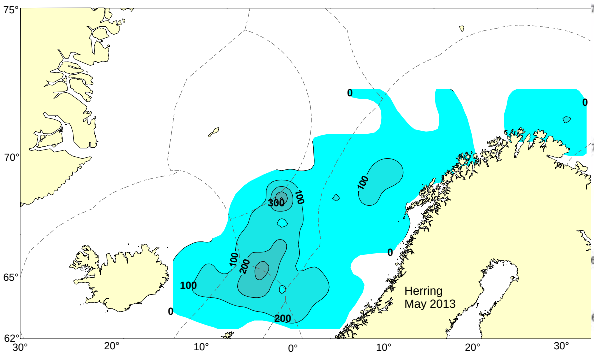
2010



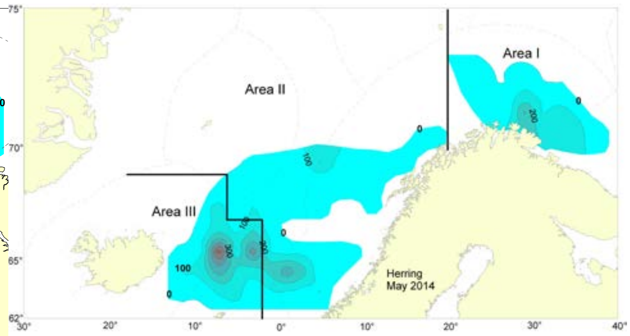
2011



2012



2013



2014

Figure 7.5.7.4.1. Norwegian Spring-Spawning herring. Schematic map of herring acoustic density (sA, m^2/nm^2) found during the survey in May 2009 to 2014.

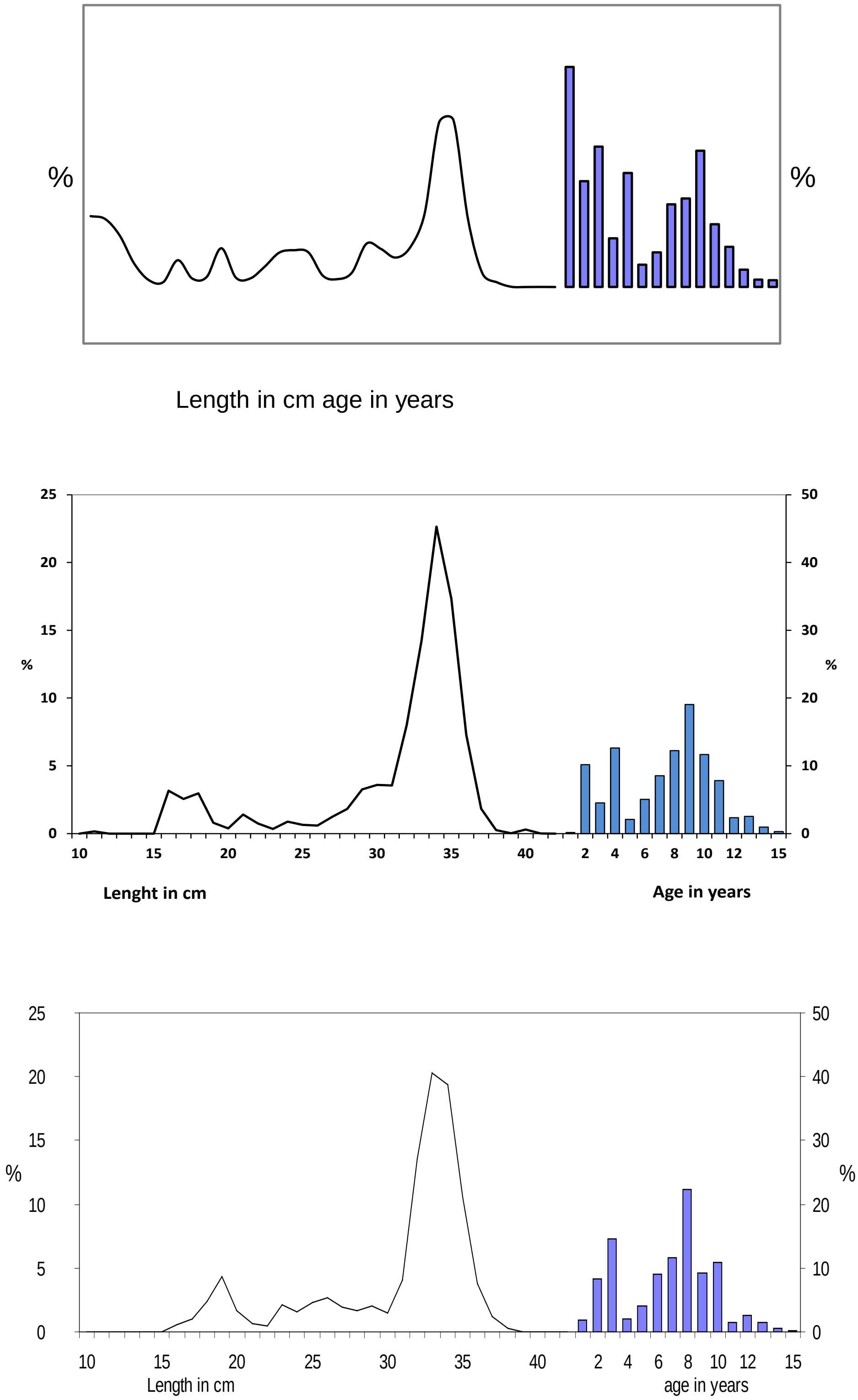


Figure 7.5.7.4.2. Length and age distribution of Norwegian spring spawning herring in the area in the Norwegian Sea and Barents Sea in May 2014 (upper most panel), in 2013 (mid panel) and in 2012 (lowest panel).

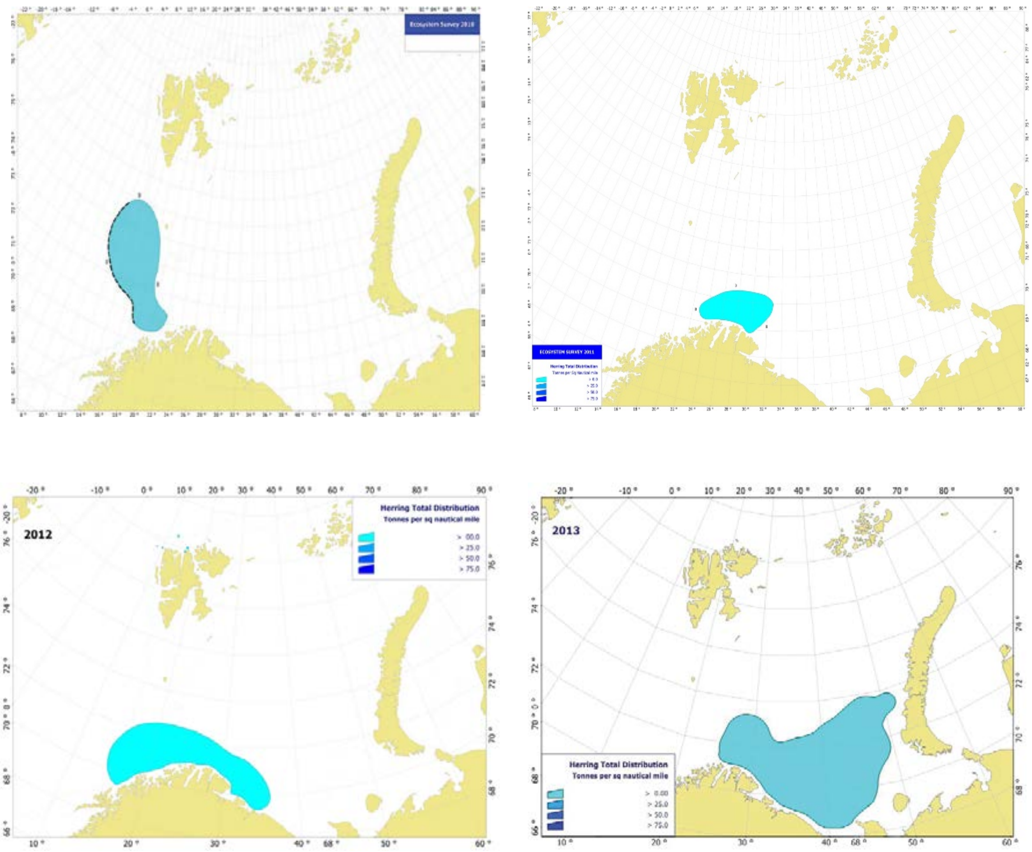


Figure 7.5.7.5.1. Norwegian Spring-Spawning herring. Estimated total density of herring (tonnes/nautical mile²) in August-September 2010 (upper left panel), 2011 (upper right panel) and 2012 (lower left panel), 2013 (lower right panel) in Barents Sea. *Survey 6*.

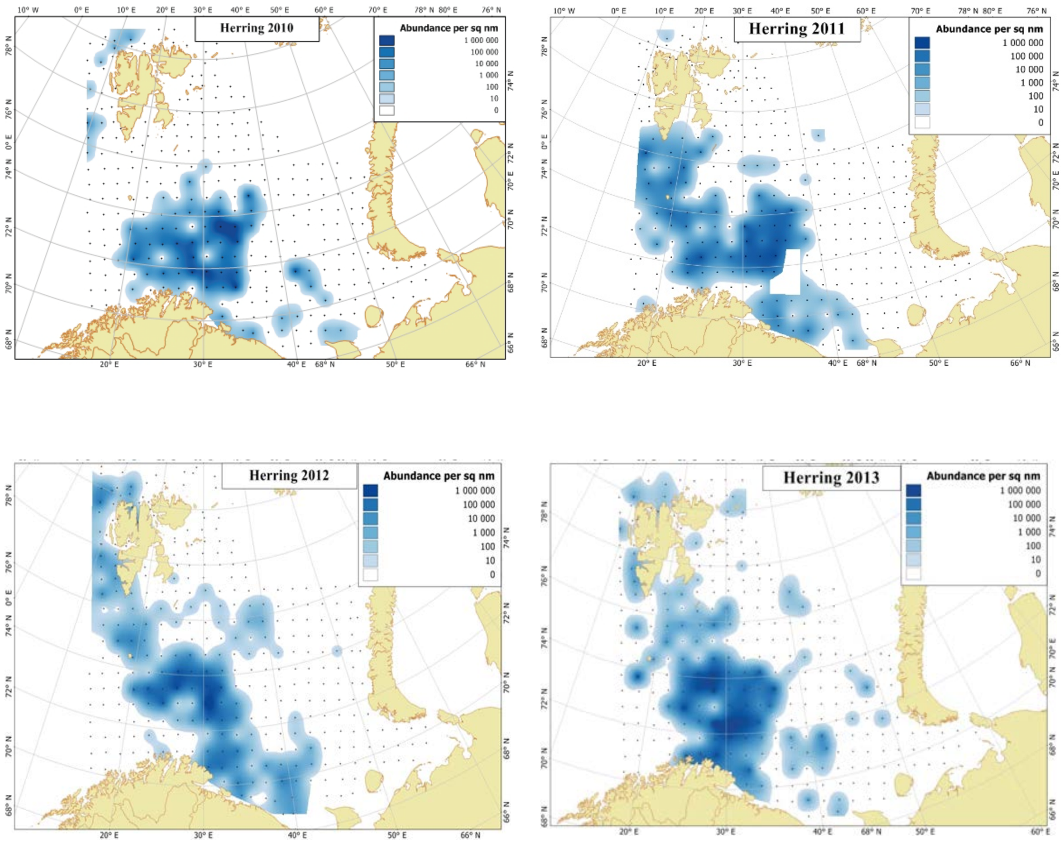


Figure 7.5.7.5.2. Norwegian Spring-Spawning herring. O–group surveys in August/September in the Barents Sea in 2010 to 2013. ***Survey 7.***

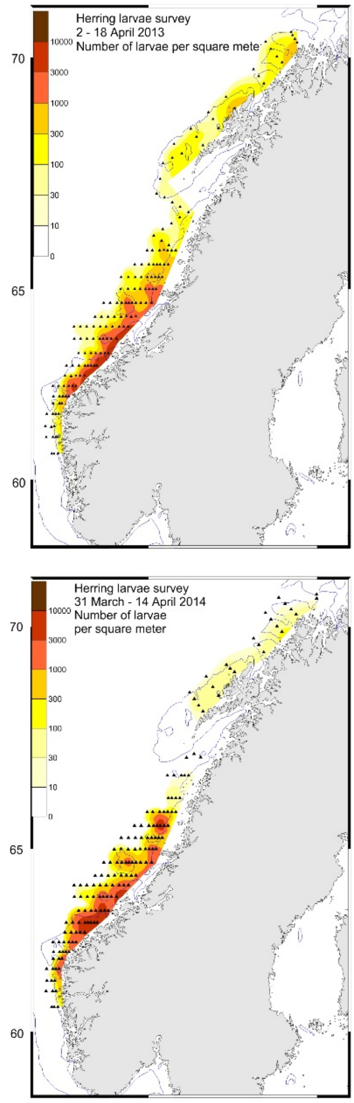


Figure 7.5.7.6.1. Norwegian Spring-Spawning herring. Distribution of herring larvae on the Norwegian shelf in 2013 (left panel) and 2014 (right panel). The 200 m depth line is also shown. ***Survey 8.***

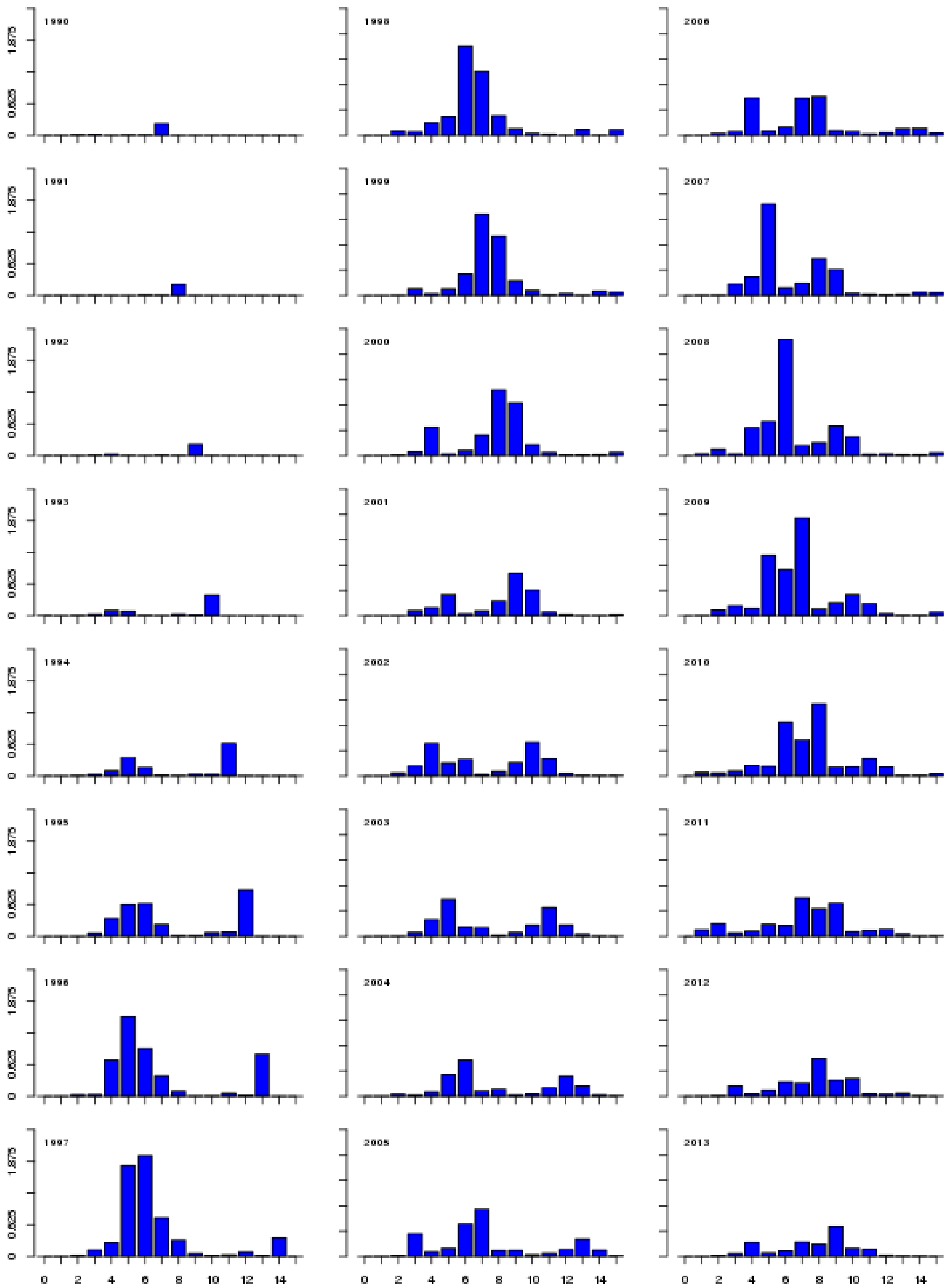


Figure 7.7.1.1. Norwegian spring spawning herring. Age disaggregated catch in numbers plotted. Age is on x-axis. The labels indicate years.

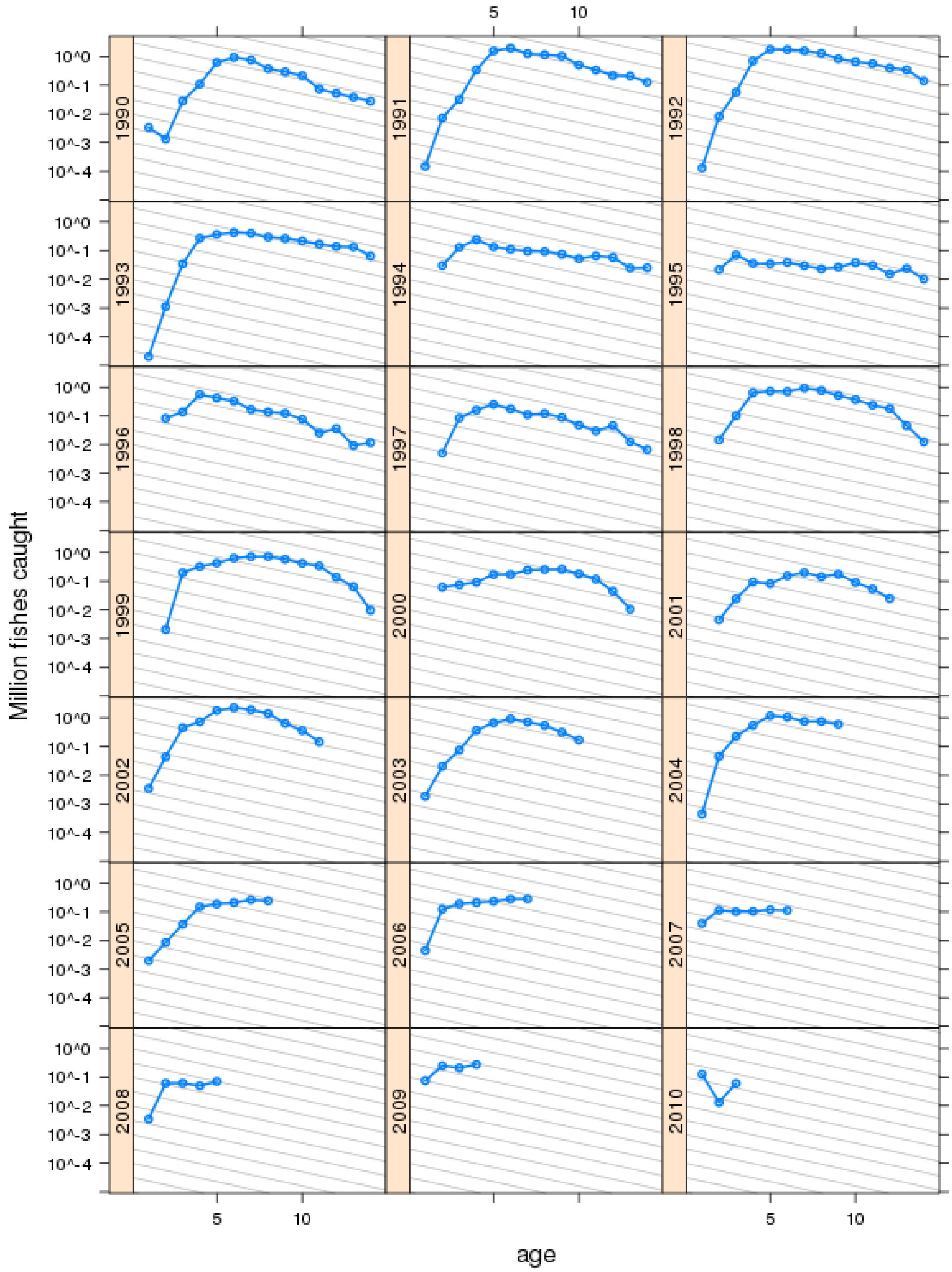


Figure 7.7.1.2. Norwegian spring spawning herring. Age disaggregated catch in numbers plotted on a log scale. Age is on x-axis. The labels indicate year classes and grey lines correspond to Z=0.3.

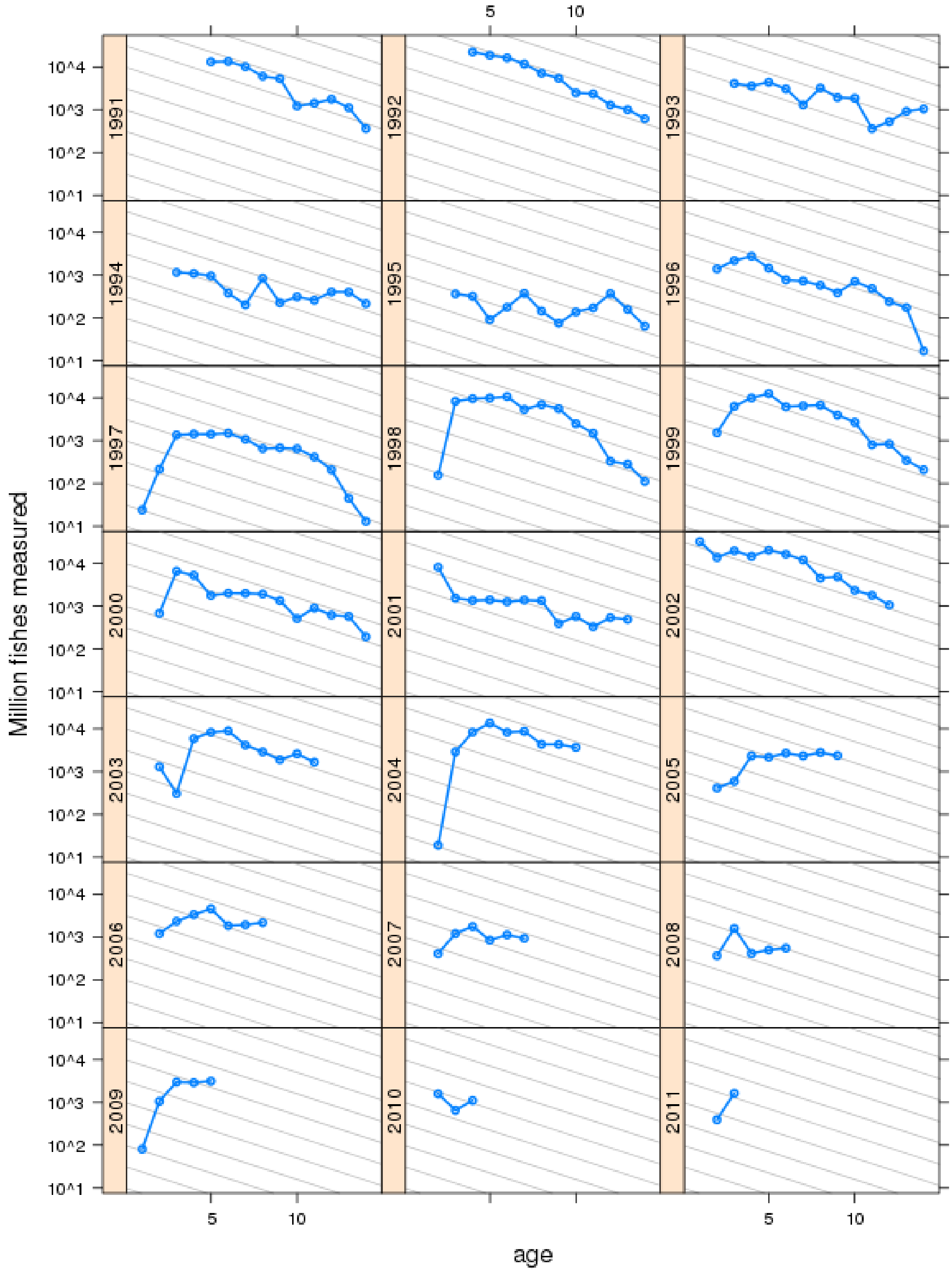
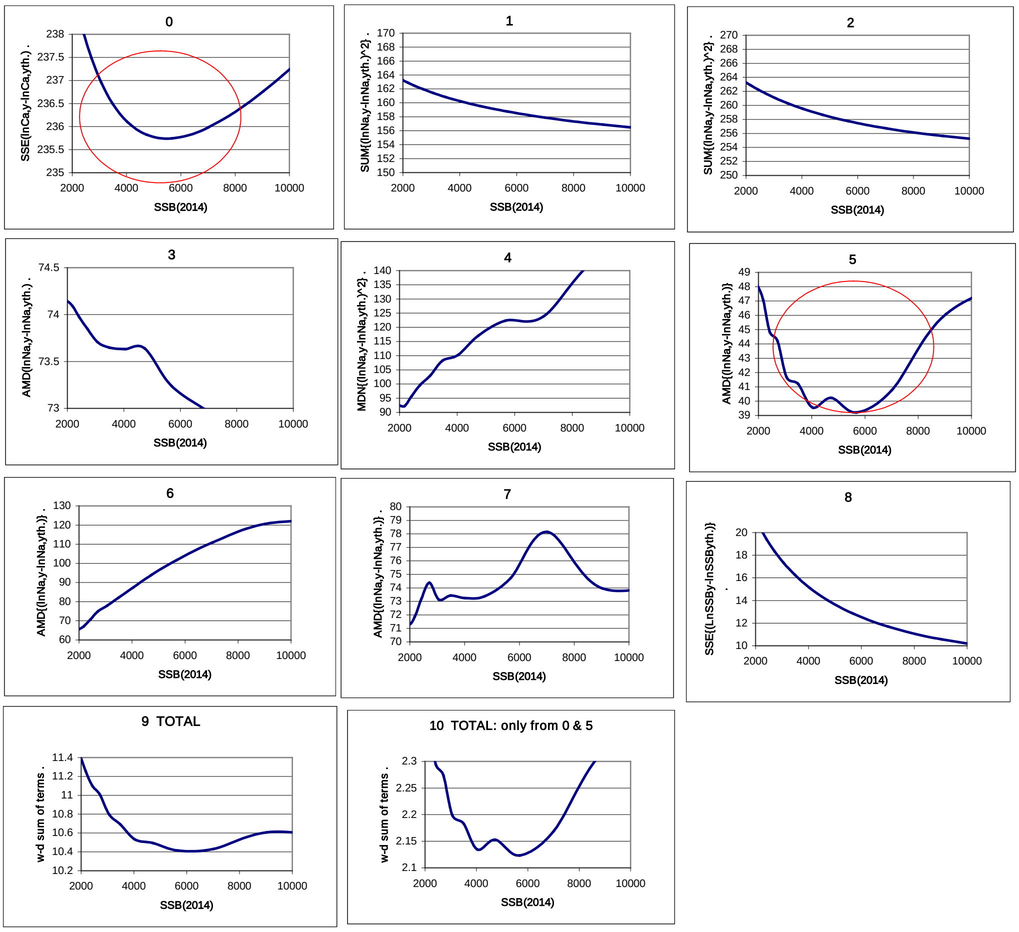


Figure 7.7.1.3. Norwegian spring spawning herring. Age disaggregated abundance indices (billions) from the acoustic survey on the feeding area in the Norwegian Sea in May (survey 5) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z=0.3.



0- catch-at-age
1- spawning grounds acoustic in Febr.-March
2-acoust. surv. in wint. area Nov.-December
3- acust. in wintering areas, January
4- Young herring in the Barents Sea (June)
5- Feeding areas, May
6-Young herring in the Barents Sea, September survey
7-index for 0-group
8-SSB indices
9-All data
10-catch-at-age + survey 5

Figure 7.7.2.1. Norwegian spring spawning herring. Profiles of components of the TISVPA objective function : 0 - signal from catch-at-age alone; 1-8 - signals from "surveys" from 1 to 8 respectively.

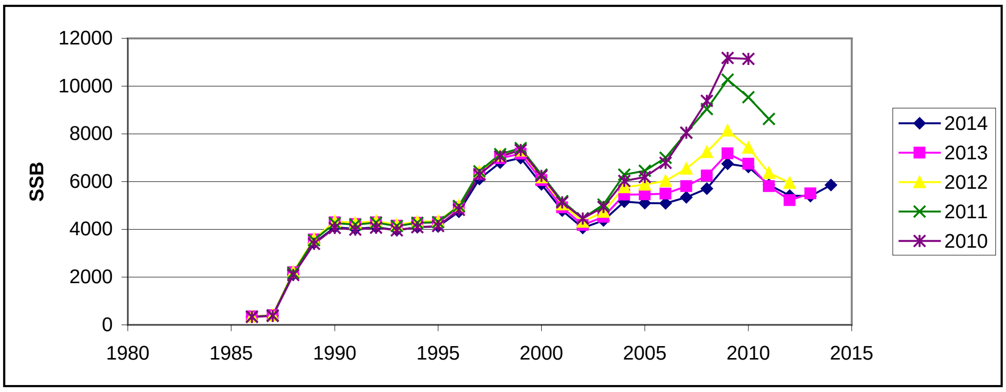


Figure 7.7.2.2. Norwegian spring spawning herring. Results of the TISVPA retrospective runs obtained when inputs only from catch-at-age and survey 5 were used.

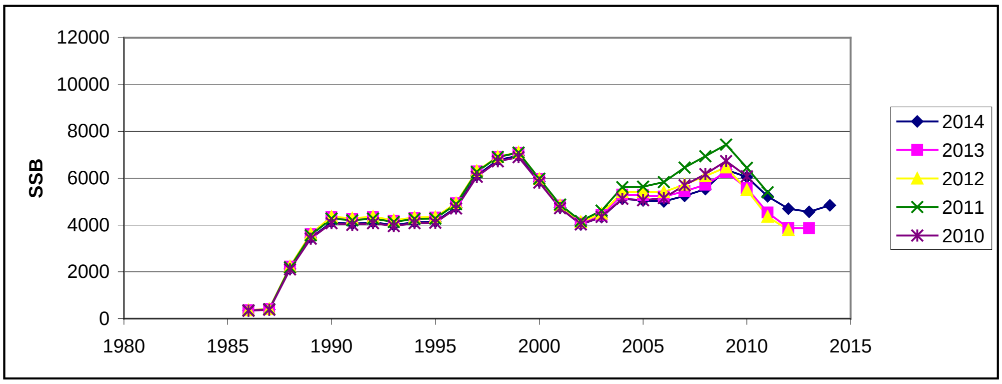


Figure 7.7.2.3. Norwegian spring spawning herring. Results of the TISVPA retrospective runs obtained when input only from age proportions in the data of survey 5 was used.

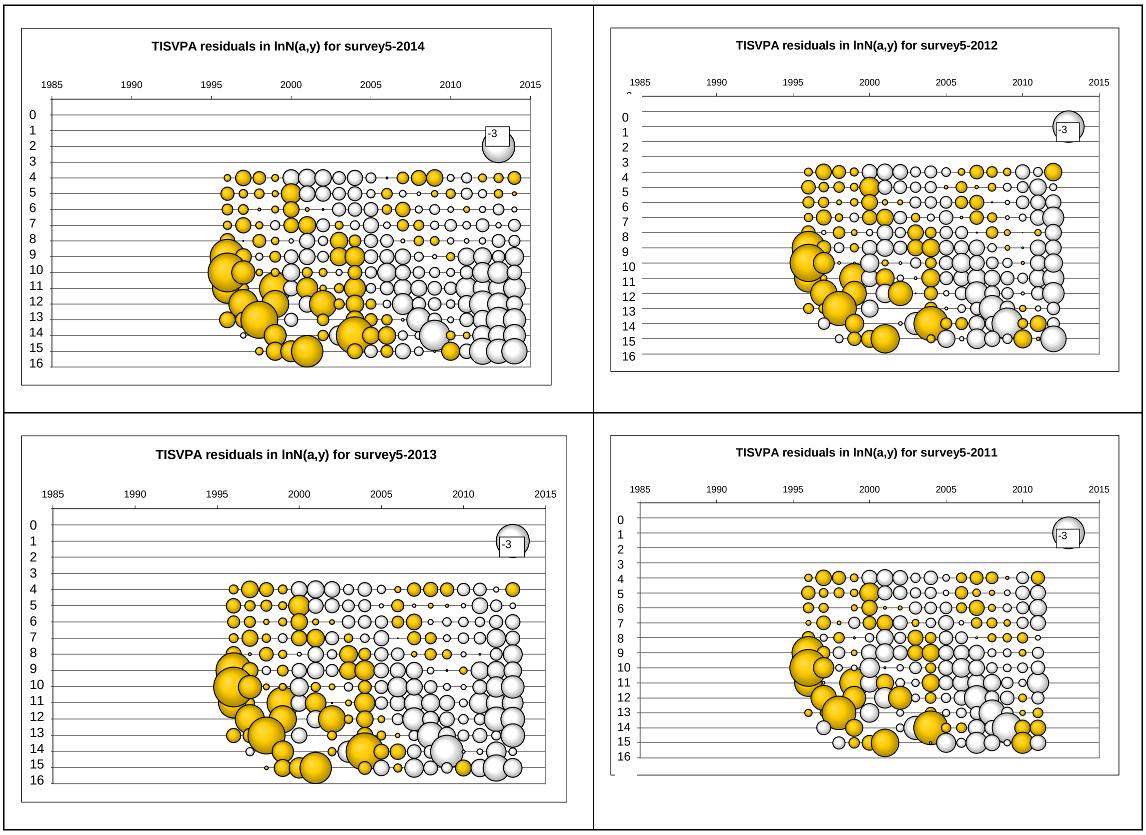


Figure 7.7.2.4. Norwegian spring spawning herring. Residuals of the TISVPA retrospective runs obtained when the model was tuned only at age proportions of survey 5.

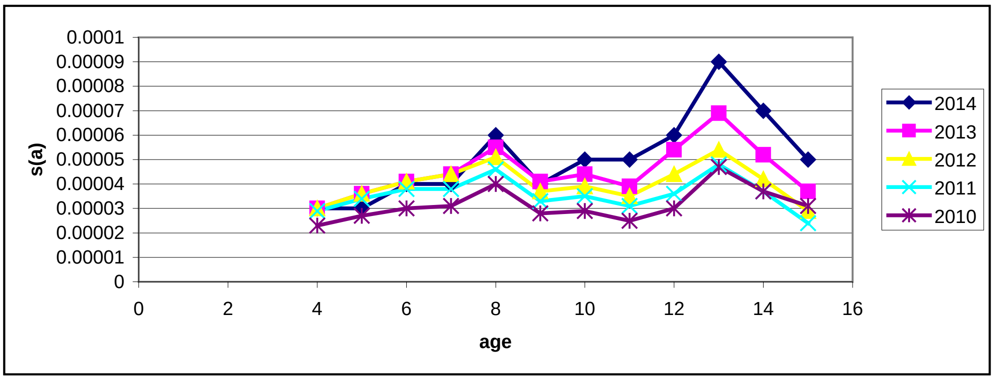
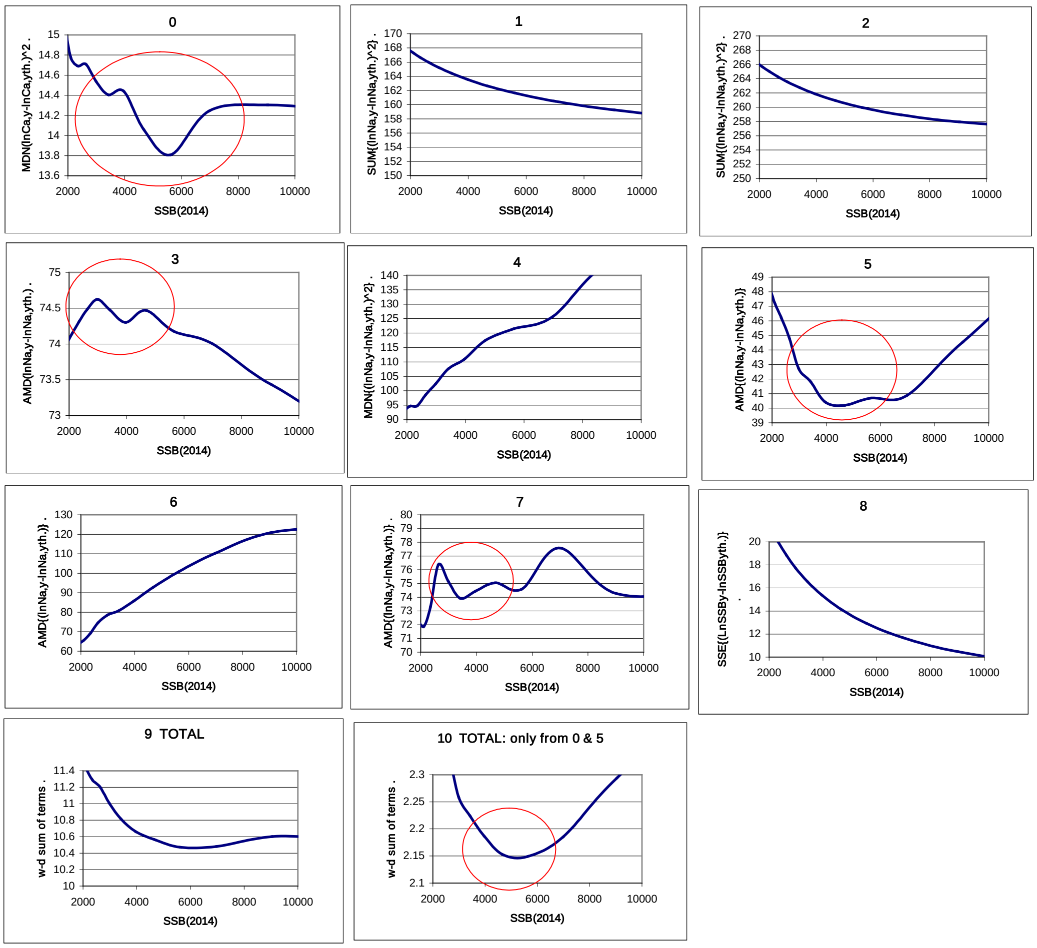


Figure 7.7.2.5. Norwegian spring spawning herring. The TISVPA-derived estimates of average catchability by ages for survey 5 obtained in retrospective runs.



0- catch-at-age
1- spawning grounds acoustic in Febr.-March
2-acoust. surv. in wint. area Nov.-December
3- acust. in wintering areas, January
4- Young herring in the Barents Sea (June)
5- Feeding areas, May
6-Young herring in the Barents Sea, September survey
7-index for 0-group
8-SSB indices
9-All data
10-catch-at-age + survey 5

Figure 7.7.2.6. Norwegian spring spawning herring. Profiles of components of the TISVPA objective function with modified model of "triple-separabilization" : 0 - signal from catch-at-age alone; 1-8 - signals from "surveys" from 1 to 8 respectively.

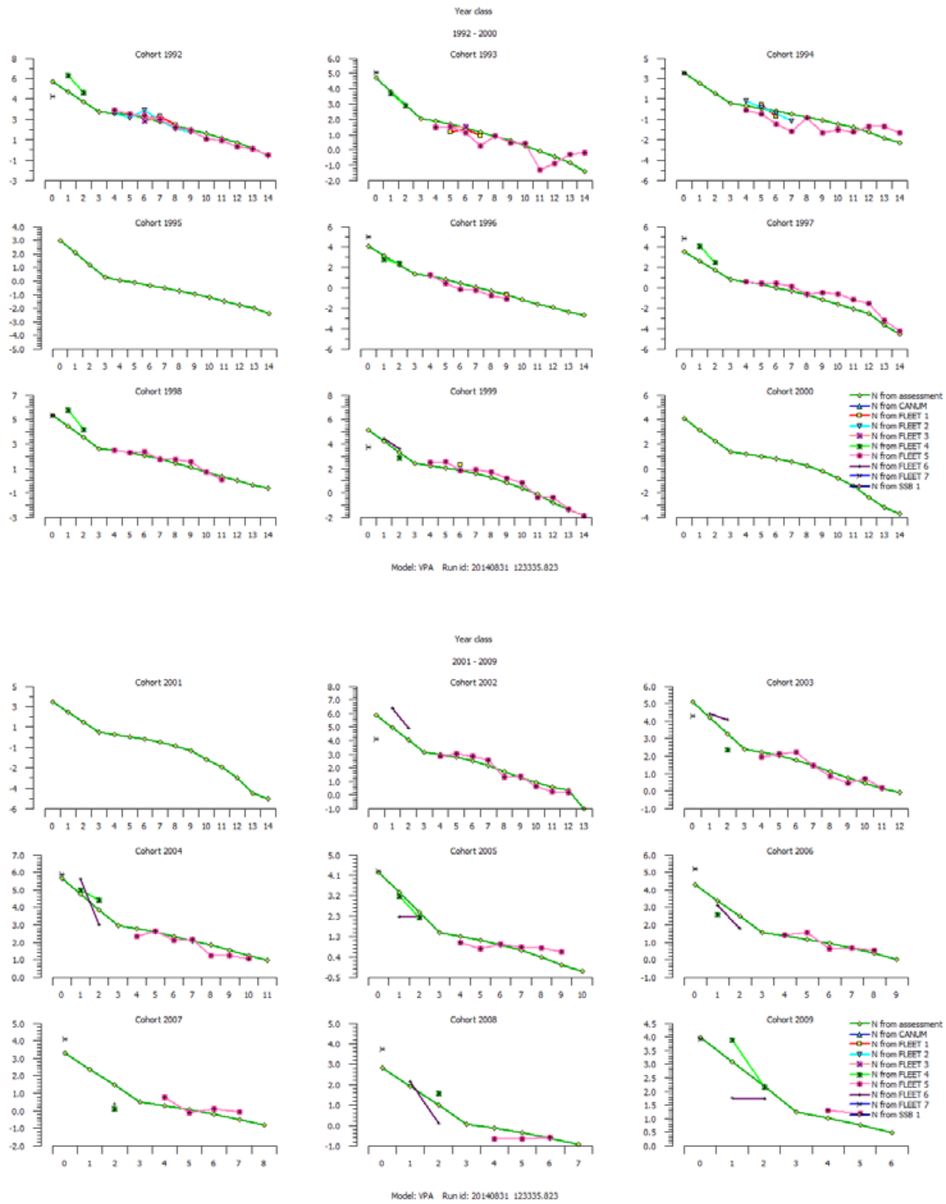


Figure 7.7.3.2.3 Norwegian spring spawning herring. Year class Ns, excluding values with zero weight.

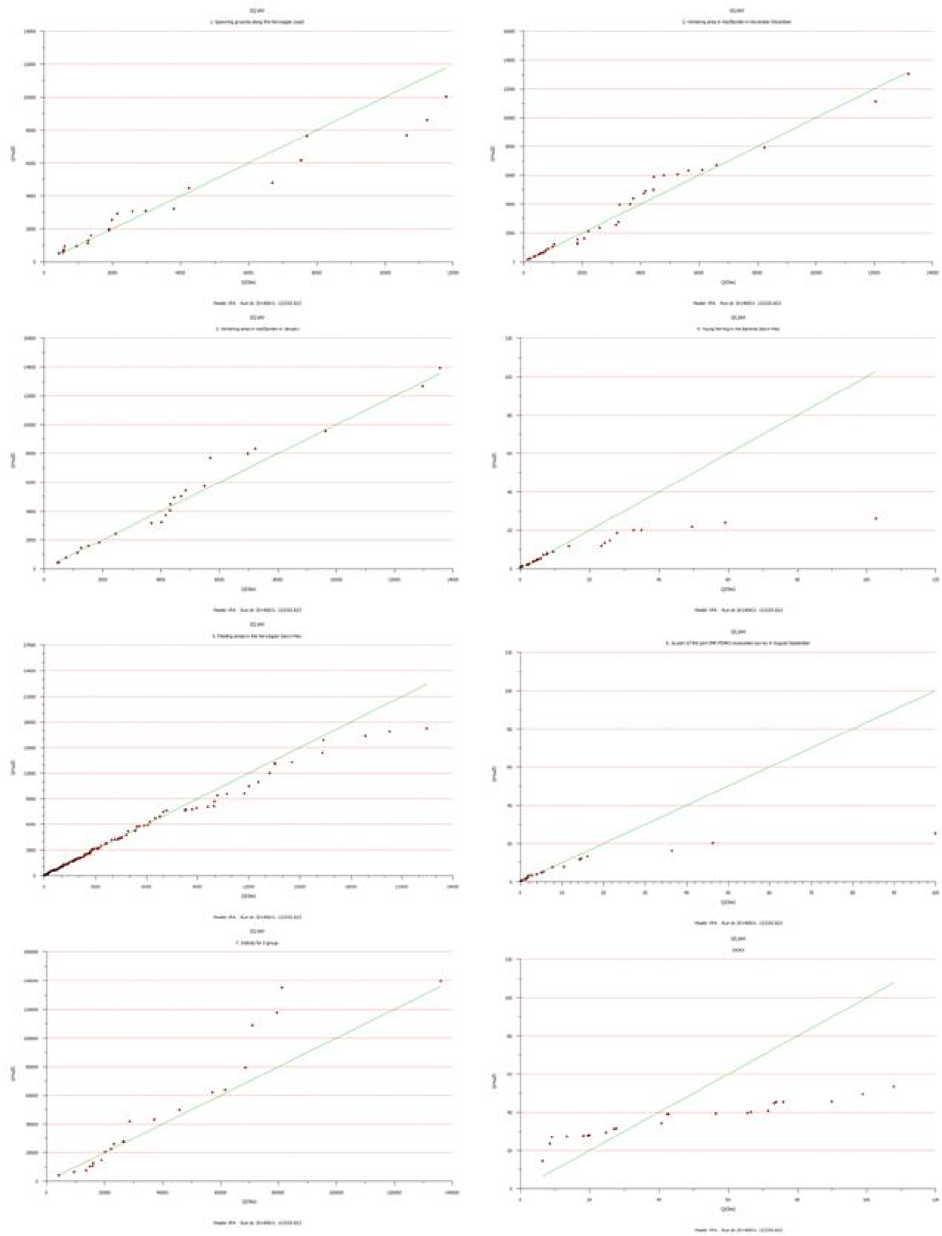


Figure 7.7.3.2.1. Norwegian spring spawning herring. Q-Q plot from the eight different surveys used in tuning in TASACS. First row starts with survey 1 and the last one in row four is larval survey.

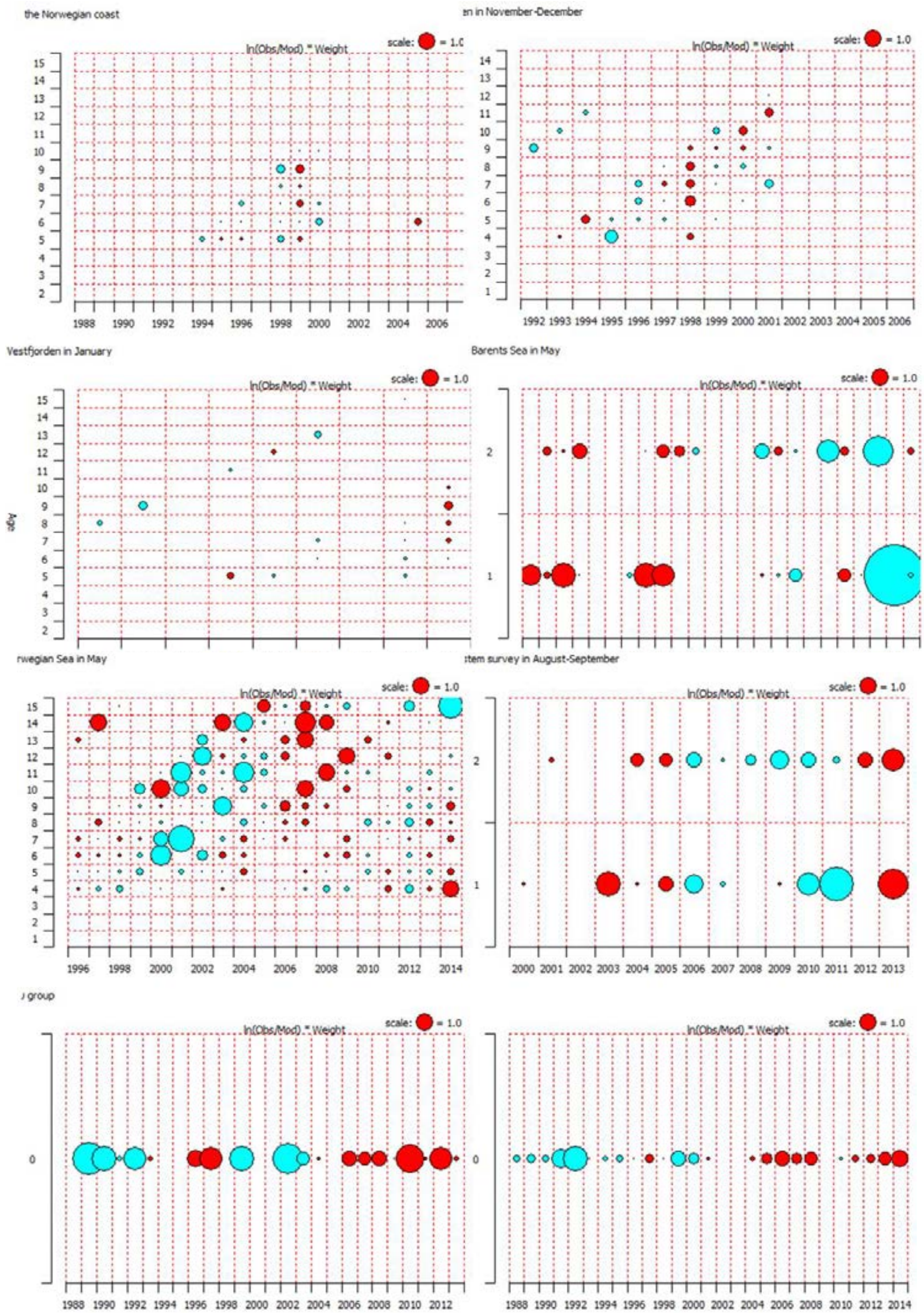


Figure 7.7.3.2.2. Norwegian spring-spawning herring. Residual sum of squares in the surveys separately from TASACS. First row starts with survey 1 and the last one in row four is larval survey.

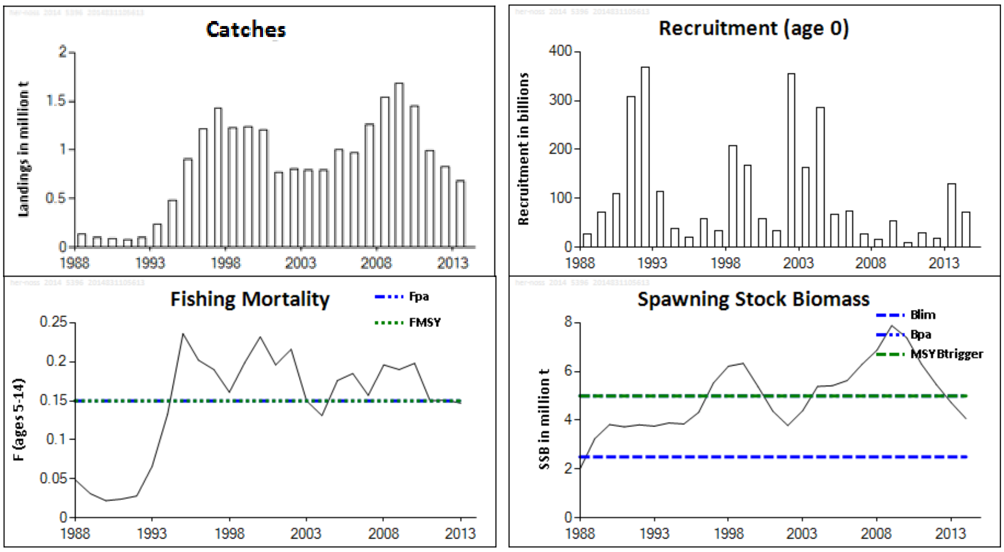


Figure 7.7.3.3.1. Norwegian spring-spawning herring. Standard plots from final assessment (TASACS VPA) in 2014.

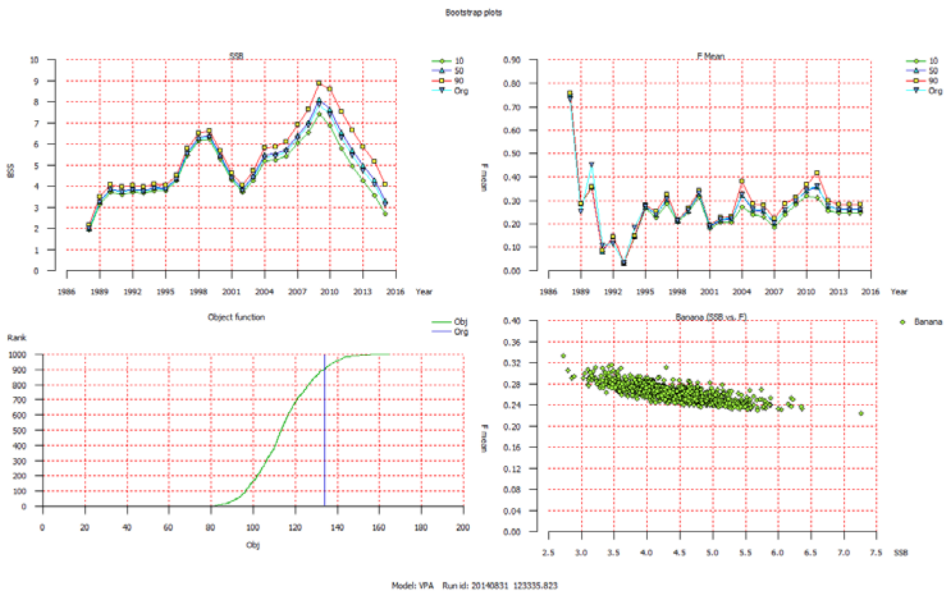


Figure 7.7.4.1. Norwegian spring-spawning herring. Percentiles for spawning stock biomass (top left), mean F 5-10 (top right), SSQ (bottom left) and “Banana”-plot (bottom right) from bootstrap results for final assessment.

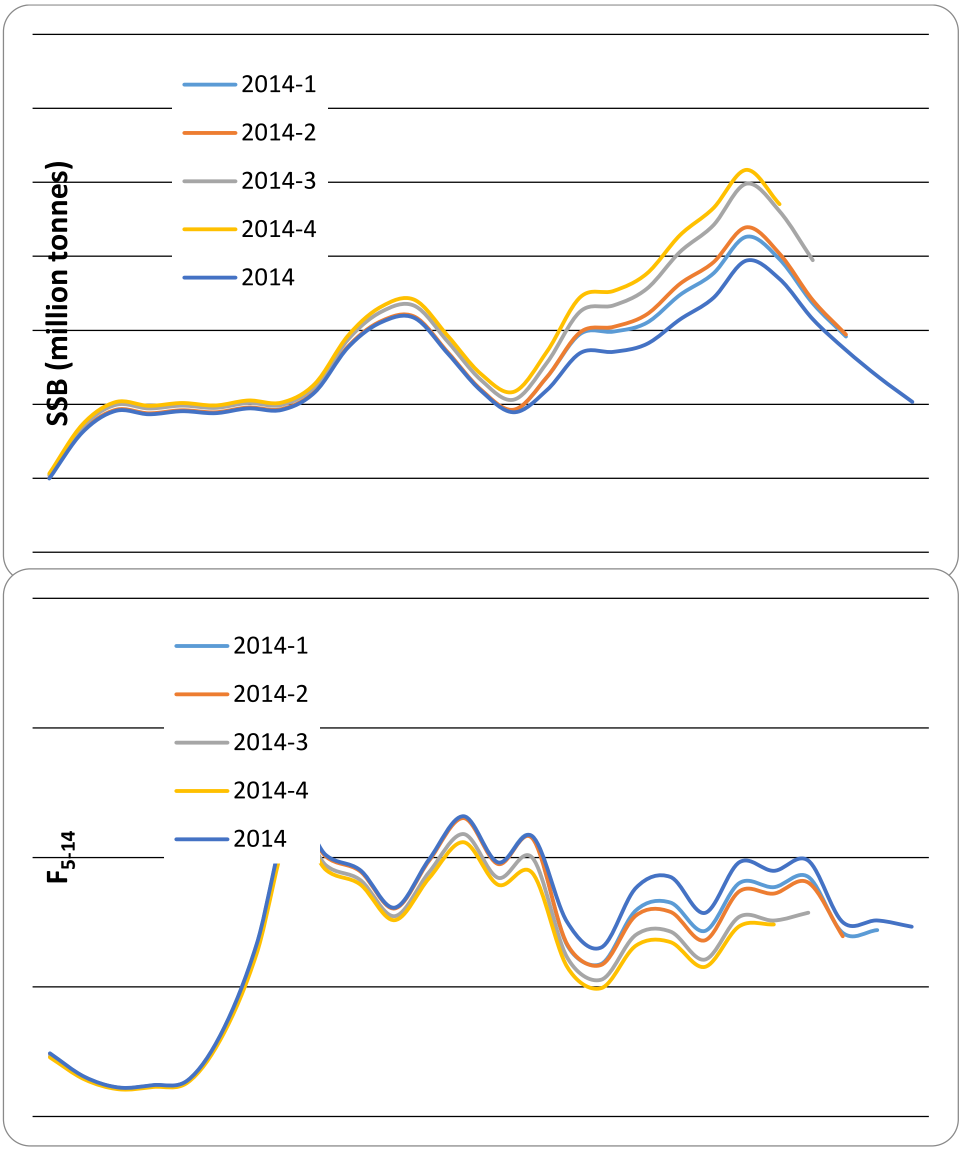


Figure 7.7.5.1 Norwegian spring-spawning herring. Retrospective run for SSB and F.

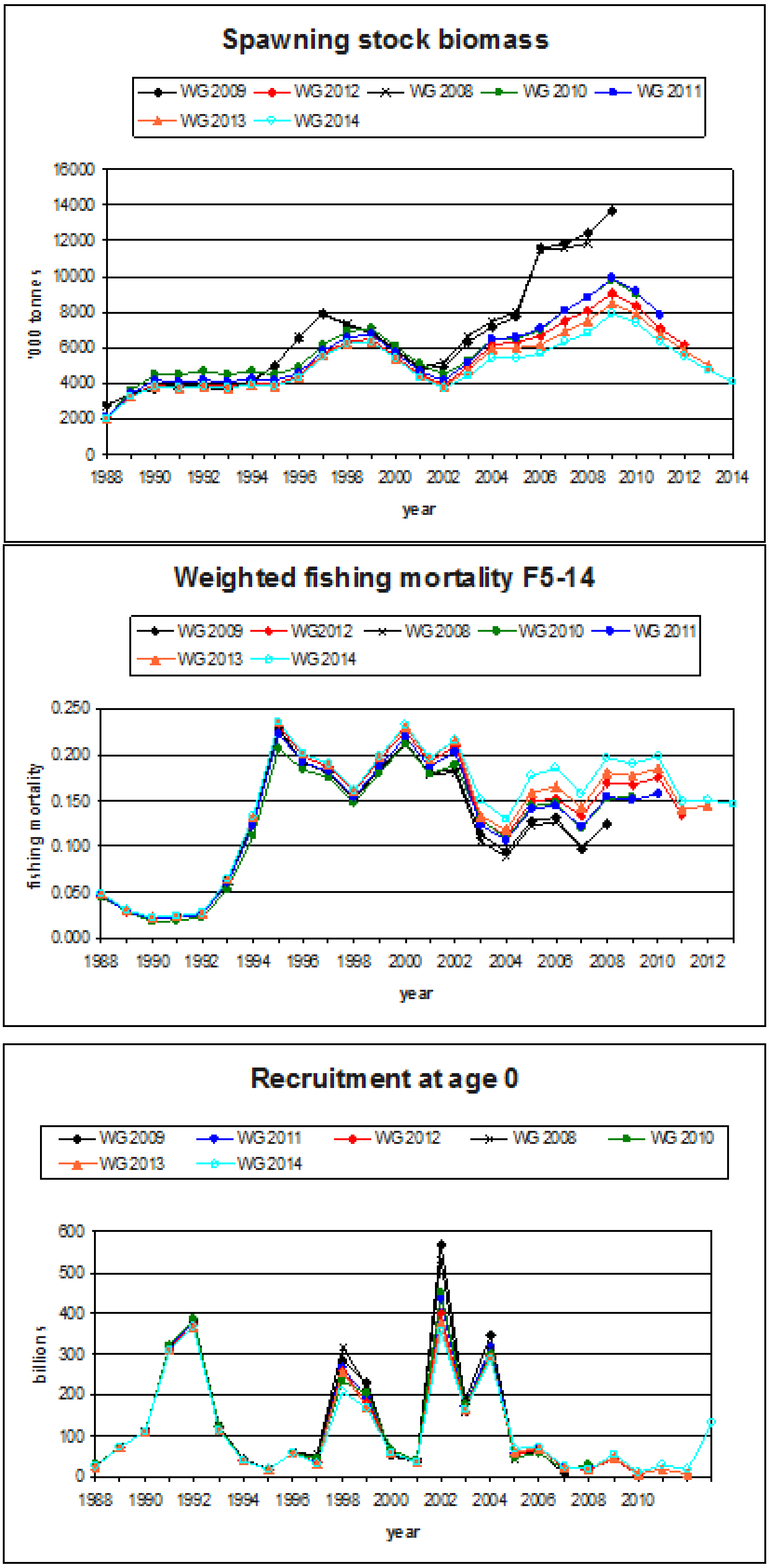


Figure 7.12.1. Norwegian spring spawning herring. Comparisons of spawning stock, weighted fishing mortality F5-14 and recruitment at age 0 with previous assessments.

8 Blue Whiting - Subareas I-IX, XII and XIV

Blue whiting (*Micromesistius poutassou*) is a small pelagic gadoid that is widely distributed in the eastern part of the North Atlantic. The highest concentrations are found along the edge of the continental shelf in areas west of the British Isles and on the Rockall Bank plateau where it occurs in large schools at depths ranging between 300 and 600 meters but is also present in almost all other management areas between the Barents Sea and the Strait of Gibraltar and west to the Irminger Sea. Blue whiting reaches maturation at 2—7 years of age. Adults undertake long annual migrations from the feeding grounds to the spawning grounds. Most of the spawning takes place between March and April, along the shelf edge and banks west of the British Isles. Juveniles are abundant in many areas, with the main nursery area believed to be the Norwegian Sea. See the stock Annex for further details on stock biology.

8.1 ICES advice in 2013

ICES notes that SSB has almost doubled from 2010 (2.9 million tonnes) to 2013 (5.5 million tonnes) and is well above Bpa (2.25 million tonnes). This increase is due to the lowest Fs in the time-series in 2011 and 2012, in combination with increased recruitment since 2010.

ICES advises on the basis of the management plan agreed by Norway, the EU, the Faroe Islands, and Iceland (target F=0.18) that landings in 2014 should be no more than 948 950 tonnes.

8.2 The fishery in 2013

The total catch was 626036 tonnes while the agreed TAC was 643000 tonnes. The main fisheries on blue whiting were targeting spawning and post-spawning fish in the EU region, International waters west of Porcupine Bank/Rockall Bank areas, west of Scotland and the Faroese region (Figure 8.3.1.2-8.3.1.3). Most of the catches (91%) were taken in the first two quarters of the year. The multi-national fleet currently targeting blue whiting consists of several types of vessels but the bulk of the catch is caught with large pelagic trawlers. Thirteen countries reported blue whiting landings in 2013. Specific details from some of these fisheries are provided below. Even though the majority of the blue whiting quotas for most national fleets are landed in the first half of the year, detailed information on the timing and location of catches in the current year are not always available by the time of the WGWIDE meeting.

8.2.1 Denmark

Danish landings of blue whiting in 2013 were just 2167 tonnes as the main part of the Danish quota was swapped with other species.

8.2.2 Germany

The vessels targeting blue whiting belong to the pelagic freezer trawler fleet and are owned by a Dutch company and operating under German flag. Depending on season and the economic situation these vessels are targeting other pelagic species in European and international waters. This fleet consists of four large pelagic freezer-trawlers with power ratings between 4200 and 12000 hp and crews of about 35 to 40 men. The vessels are purpose built for pelagic fisheries. The catch is pumped into large storage tanks filled with cool water to keep the catch fresh until it is processed. Total landings increased from 278 tonnes in 2011 to 6 238 tonnes in 2012 to 11418 tonnes in 2013. The majority of catches was taken in areas VIa,b and VIIc.

8.2.3 Faroe Islands

The reported landings of blue whiting from Faroese vessels were 85768 tonnes in 2013. Approximately 98 % of the blue whiting was caught within the Faroese EEZ and 2 % in international waters. The majority (96 %) of the blue whiting fishery occurred near the southern boundary of the Faroese EEZ in winter and early spring, January to May, and began again in December. In March, however, the catches were taken in international waters west of the British Isles. Later in the year scattered catches (4 %) were taken as bycatch in the herring and mackerel fisheries in the northern part of the Faroese EEZ. The fishing fleet consists of seven large trawlers/purse-seiners and one factory freezer utilizing pelagic trawls.

8.2.4 Iceland

The Icelandic landings in 2013 amounted around 105 000 t. Around 92% of the catches were taken in the Faroes EEZ during April and May, and 3% there in December. The remaining catches were taken in the Icelandic EEZ during July-December. A negligible amount was taken in international waters. The catches in the Icelandic EEZ were mainly from a mixed fishery with mackerel and Norwegian spring-spawning herring.

8.2.5 Ireland

The Irish Fishery in 2013 took place mainly in the first quarter, with a catch of 12428 t landed. In quarter two 777 t was landed. The fishery was concentrated on spawning aggregations to the west and northwest of Ireland. The majority of the catch was from VIIc (6813 t), VIa (2731 t) and VIb (2583 t), followed by small catches in VIIk (930 t) and VIIb (148t). Fifteen vessels participated in the fishery.

8.2.6 Netherlands

The Dutch catches of blue whiting in 2013 were mostly taken in the period February-May, with some catches in November-December, mainly in area VIa and VIIc by freezer trawlers. The total catch was 51600 tonnes. The majority of the catch (>95%) was recorded from 18 fishing trips. The remaining catches (<5%) are by-catch in the fisheries directed to other pelagic species. Estimated discards of blue whiting in 2013 are 1% in weight originating from non-directed fisheries.

8.2.7 Norway

After the coastal states agreement in 2012 and quota transfers in other international agreements, the Norwegian TAC for 2013 was set to 189132 t (up to 144408 t could be taken in the EU zone). The majority of the Norwegian catches (186000 t) were taken in a directed pelagic trawl fishery west of the British Isles and south of the Faroe Islands during the first half of the year. The remaining catches were mainly taken by the industrial trawl fleet (which uses both pelagic and demersal trawls) in the Norwegian deeps and Tampen area (east of 4ºW).

8.2.8 Russia

Two Russian trawlers operated in the Faroese area since the beginning of the year until February 11, and then on March 20—21. Five other vessels started to work here on April 3. The number of trawlers increased gradually to 18 but decreased to 2 in May.

The fishery was finished in that area on June 22 and resumed on December 22. In the first half of July, 11 trawlers were operating in the central part of Norwegian Sea when later in October one vessel carried out the directed BW fishery until the total catch in the international waters closed to the allowed value 48879 t. Majority of this amount refers to the spring fishery in the spawning area west of British islands. That fishery was from February 7 to April 4. The total Russian landings of blue whiting in 2013 were 120674 tonnes.

8.2.9 Spain

The Spanish blue whiting fishery is carried out mainly by bottom pair trawlers in a directed fishery (approx. one third of the fleet) and by single bottom otter trawlers in a by-catch fishery (approx. two thirds of the fleet). The fleet operates throughout the year. Small quantities are also caught by longliners. These coastal fisheries have trip durations of 1 or 2 days and catches are for human consumption. Thus, coastal landings are driven mainly by market forces, and are rather stable. The Spanish fleet has decreased from 279 vessels in the early 1990s to 135 vessels in 2008. After a period of decreasing trend, Spanish landings increased in 2013 to a total landing of 15273 tonnes, and 99% of it was obtained in Spanish waters.

8.2.10 Portugal

Blue whiting is commonly caught as by-catch by the Portuguese bottom-trawl fleets targeting finfish and crustaceans, which comprises around 100 vessels under 30 meters long. Some vessels of the artisanal fishing fleet also catch blue whiting as by-catch, although this is mostly discarded it is rarely used for human consumption in Portugal and there is no market demand for industrial transformation. Total landings in 2013 were about 2056 tonnes.

8.2.11 UK

The whole catch, 13498 tonnes was obtained in the first half of 2013. The vessels from Northern Ireland caught 1232 tonnes in the area VIIk. The Scottish trawlers operated in VIa-b and VIIc landing 8166 tonnes. The rest of the catch was taken by English trawlers in the same areas in the 2nd quarter.

8.2.12 France

The total French catch in 2013 was 8981 tonnes, and 80% of it was obtained in the first half of year west of the British Isles.

8.3 Input to the assessment

8.3.1 Catch data

Total landings in 2013 were about 626 036 tonnes. Total catches in 2013 were provided by members of the WG. The data provided as catch by rectangle represented more than 96% of the total WG catch in 2013. Total catch by country for the period 1988 to 2013 is presented in Table 8.3.1.1.

After a minimum of 104000 tonnes in 2011, catches increased to around 384000 tonnes in 2012 and around 626000 tonnes in 2013. The spatial and temporal distribution in 2013 (Figure 8.3.1.1, 8.3.1.2 and 8.3.1.3 and Table 8.3.1.2), is quite similar to the distribution in previous years. The majority of catches is coming from the spawning area, but compared to previous years, the 2013 catches have a much larger contribution from

Division Vb (Figure 8.3.1.4 and 8.3.1.5). The temporal allocation of catches has been relatively stable in recent years (Figure 8.3.1.6) however with an increase of the proportion of catches from the second quarter that was also observed in 2013. In the first two quarters catches are taken over a broad area while later in the year catches are mainly taken further north in sub-area II and in the North Sea (Division IVa) and Division V. The proportion of landings originating from the Norwegian Sea has been decreasing steadily over the recent period to less than 10% of the total catch in 2013.

8.3.1.1 Discards

Discards of blue whiting are thought to be small. Most of these discards are by-catch in fisheries not directed to blue whiting. Most of the blue whiting is caught in directed fisheries for reduction purposes.

Discards information for blue whiting in 2013, are presented in Table 8.3.1.1.1. Only a few countries have supplied quantitative discards information for 2013.

The main fishing nations, Faroe Islands, Iceland, Norway and Russia have already a discard ban in place and discards are assumed zero or negligible.

Germany and Netherlands presented a discard percentage of 1 and 2% (respectively) in the total amount of catches. Discards estimates from Germany are based on a single trip operation in ICES Division VIIj in a fishery directed on horse mackerel.

The 99.8% of blue whiting French landings are mainly from one industrial boat targeting the species to producing surimi. Although no information is available by observer programmes on this fishery, the industry confirms that there are no discards. Discards could however occur at a very low level, in case of the total catch is too low to process the fish or if other species are mixed with blue whiting.

Blue whiting discards in Portugal are relatively high and mostly due to by-catch and a reduced market-demand. In 2013, the discards were around 700 ton, corresponding to 25% of the total Portuguese catches.

The discard scenery observed in Spain is similar, with a 26% of the blue whiting total catches being discarded. By-catch, undersized fish, and market-demand dynamics are the driving forces to discard this species in Spain.

The Portuguese and Spanish landings contribute by less than 2.8 % of the total international landings. At a stock level, discards are considered negligible as most of the blue whiting landings are from directed fisheries for reduction purposes by nations where a discards ban already is in force.

8.3.1.2 Sampling intensity

Sampling intensity for blue whiting from the commercial catches by fishery and quarter is shown in Table 8.3.1.2.1, while detailed information on the number of samples, number of fish measured, and number of fish aged by country and quarter is given in Table 8.3.1.2.2 and are presented and described by year, country and area in section 1.3 (Quality and Adequacy of fishery and sampling data). In total 915 samples were collected from the fisheries in 2013. 111079 fish were measured and 14633 were aged. Sampled fish were not evenly distributed throughout the fisheries (Table 8.3.1.2.2). Considering the proportion of samples per catch, the most intensive sampling took place in the mixed fishery with one sample for every 62 tonnes, followed by the southern fishery of Spain and Portugal. Here one sample was taken for every 69 tonnes, and lastly the directed fishery where there was one sample for every 1028 tonnes caught. In this context it should be noted that implementation of the EU Collection of Fisheries

Data, Fisheries Regulation 1639/2001, requires EU Member States to take a minimum of one sample for every 1000 t landed in their country. As can be seen, no sampling data were submitted by France and UK (England, Wales and Northern Ireland), all with relatively small landings. Sampling intensity for age and weight of herring and blue whiting are made in proportion to landings according to CR 1639/2001 and apply to EU member states. For other countries there are no guidelines. Current precision levels of the sampling intensity are unknown and the group recommends reviewing the sampling frequency and intensity on a scientific basis and provide guidelines for sampling intensity.

8.3.1.3 Length and age compositions

Data on the combined length composition of the 2013 commercial catch by quarter of the year from the directed fisheries in the Norwegian Sea and from the stock's main spawning area were provided by the Faroes, France, Germany, Iceland, Ireland, the Netherlands, Norway, Russia and Scotland (Table 8.3.1.3.1). Length composition of blue whiting varied from 10 to 46 cm, with 95% of fish ranging from 21—36 cm in length, a size range similar to that observed last year. The mean length in the fishery was 28.6, which is 0.5 cm smaller than last year, confirming the decreasing trend in the mean length observed last year, after a period of increasing trend in the mean length observed in recent years.

Length compositions of the blue whiting catch and by-catch from "mixed fisheries" in the Norwegian Sea and the North Sea and Skagerrak were presented by Norway (Table 8.3.1.3.2). The catches of blue whiting from the mixed industrial fisheries consisted of fish with lengths of 18—38 cm with 95% of fish ranging from 19—34 cm. The mean length was 23.6 cm, 5 cm shorter than last year.

The Spanish and Portuguese length distribution of catches showed a length range of 13—40 cm with 95% of fish ranging from 16 to 28cm (Table 8.3.1.3.3). This distribution is similar as last year. The mean length was 22.1, 0.8 cm shorter than the previous year.

The combined age composition for the directed fisheries in the Northern area, i.e. the spawning area and the Norwegian Sea, as well as for the by-catch of blue whiting in "other fisheries" and for landings in the Southern area, were assumed to represent the overall age composition of the total landings for the blue whiting stock. The InterCatch program was used to calculate the total international catch-at-age, and to document how it was done. The catch numbers-at-age used in the stock assessment are given in Table 8.3.1.3.4. The calculation of mean age assigns an age of 10 to all fish in the plus group. Therefore in years of high plus group abundance the mean age could be significantly underestimated. The mean age of the catch (and stock) has been increasing in the period 2001-2010, followed by a drop in 2011, due to the relatively high catches of one and two groups this year. There was also a high increase to a mean age of 5 years in 2013.

Catch proportions at age plotted in Figure 8.3.1.3.1. Strong year classes can be clearly seen in the early 1980s, 1990 and the late 1990s. Poor recruitment over the recent period is clearly seen in the decreasing proportion of younger fish. This pattern was different in 2011 onwards, where stronger year classes can also be observed.

Catch curves made on the basis of the international catch-at-age (Figure 8.3.1.3.2) indicate a consistent decline in catch number by cohort and thereby reasonably good quality catch-at-age data, especially for year classes since 1995.

8.3.1.4 Weight at age

Table 8.3.1.4.1 and Figure 8.3.1.4.1 show the mean weight-at-age for the total catch during 1983—2013 used in the stock assessment. Compared to the 2007 mean weights, the values from the succeeding years are higher for most ages, which show that the decreasing trend in mean weight for the period 1995—2005 (2007) has ended.

The weight-at-age for the stock is assumed to be the same as the weight-at-age for the catch.

8.3.2 Information from the fishing industry

No comprehensive information has been received from the fishing industry this year.

8.3.3 Maturity and natural mortality

Blue whiting natural mortality and proportion of maturation-at-age is shown in Table 8.3.3.1. See the Stock Annex for further details. A new working document shows a higher proportion mature for age 1 (from 11% to 22%) and slightly higher for ages 2—6 (Heino, 2014, WD to WGWIDE 2014). These values have not fully been evaluated by the WG and as the assessment is an update assessment they have not been used in this year's assessment.

8.3.4 Fisheries independent data

8.3.4.1 International Blue Whiting spawning stock survey

Background and status

The International Blue Whiting Spawning Stock Survey (IBWSS) is carried out on the spawning grounds west of the British Isles in March-April. The survey started in 2004 and is carried out by Norway, Russia, the Faroe Islands and the EU. This international survey, allowed for broad spatial coverage of the stock as well as a relatively dense amount of trawl and hydrographical stations. The survey is coordinated by WGIPS (ICES CM 2014/ SSGESS:01).

Use of this survey in stock assessment

Indices of age 3—8 from the IBWSS survey have been used in the assessment since 2007.

Quality of the survey

WGIPS decided that in 2014, the survey design should follow the principle of the one used during the two previous surveys. The focus was still on a good coverage of the shelf slope in areas II and III. However, given the increasing stock biomass observed over recent years, it was expected that the distribution was more extended over the whole survey area as well. In previous years when larger stock sizes were observed (2004—2011), blue whiting aggregations were distributed more evenly over the whole survey area, including the Rockall Bank and Rockall Trough. Therefore, the survey design in 2014 was to allocate more effort in these areas as well. The design was the same as in the previous two years and the design is based on variable transect spacing, ranging from 30 nmi in areas containing less dense aggregation (e.g. subarea I, south Porcupine), to 7.5 nmi in the core survey area (subarea III, Hebrides). To ensure transect coverage was not replicated, transects were allocated systematically with a random start location.

Due to acceptable - good weather conditions throughout the survey period, the survey resulted in high quality coverage of the stock. Transects of all vessels were consistent in spatial coverage and timing, delivering full coverage of the respective distribution areas within 14 days

A post-cruise meeting held in Torshavn 22—24 April 2014 compiled a joint survey report. This will be reviewed in the next WGIPS meeting. The post-cruise meeting concluded that the estimate is a valid extension of the survey time series.

Uncertainties in spawning stock estimates based on bootstrapping of available data have been assessed again in 2014 (Figure 8.3.4.1.1 A). At present, only one source of uncertainty is considered namely the spatio-temporal variability in acoustic re-cordings. The overall trend indicates a continued decrease year-on-year in biomass from 2007—2011 for this stock. The uncertainty around the decline in biomass from 2008 to 2011 is more than could be accounted for from spatial heterogeneity alone and is regarded as statistically significant. The biomass estimate from 2010 was omitted in the assessment process due to coverage problems in the survey and a resulting possibility of biomass underestimation. The 2014 estimate shows a slightly decreasing trend in biomass again when compared to the previous two years.

The International spawning stock survey shows good internal consistency for the main age groups in the fishery (Figure 8.3.4.1.1 B).

Results

The distribution of acoustic backscattering densities for blue whiting for the last 4 years is shown in Figure 8.3.4.1.2. The highest concentrations of blue whiting were recorded in the Hebrides area but the observed biomass there was 37% less than in the previous year. Due to the perceived later northward migration of the stock as compared to 2013 the centre of gravity was located further south within the northern Porcupine Bank area. This area saw an increase in biomass of 310% as compared to 2013. Compared to the last year, more high density aggregations were found on the Rockall Bank. The blue whiting spawning stock estimates based on the international survey are given in Table 8.3.4.1.1

The estimated total abundance of blue whiting for the 2014 international survey on the spawning grounds was 3.25 million tonnes, representing an abundance of 31.1x109 individuals. The spawning stock was estimated at 3 million tonnes and 26.4x109 individuals. In comparison to the results in 2013, there is a decrease (-3%) in the observed stock biomass and a related increase in stock numbers (+15%).

The stock biomass within the survey area is dominated by age classes 3, 4, and 5 and 1 years of the 2010, 2009, 2008 and 2013 year classes respectively. The main contribution (76%) to the spawning stock biomass was the age groups 4, 3, 5 and 6.

Mean length (27 cm) and weight (104.6 g) are lower than in 2013 and in previous years. This can be attributed to the increasing contribution of young fish to the total stock biomass (Figure 8.3.4.1.3). A positive signal of 3 and 4-year old fish (strong 2010 & 2011 year classes) continues to be observed across all areas and the 2009 and 2010 year classes are now considered fully recruited to the spawning stock. Signs of a potentially strong 2013 year class could be seen in the survey. However, it is too early to predict the magnitude of that year class yet with any degree of accuracy until it can be confirmed in upcoming surveys.

8.3.4.2 International ecosystem survey in the Nordic Seas

Background and status

The international ecosystem survey in the Nordic Seas (IESNS) is aimed at observing the pelagic ecosystem with particular focus on Norwegian spring-spawning herring and blue whiting (mainly immature fish) in the Norwegian Sea. Estimates in 2000—2014 are available both for the total survey area and for a "standardized" survey area (Figure 8.3.4.2.1). The latter is more meaningful as the survey coverage has been rather variable in the non-standard areas. However, the historical time series has not been recalculated using the new TS-value for blue whiting, thus the estimates are not directly comparable. The new TS-value gives estimates of roughly 1/3 of the old cal-culations (i.e. around 3.1 times the current values corresponds to the old value).

The survey is carried out in May since 1995 by the Faroes, Iceland, Norway, and Russia, and since 1997 (except 2002 and 2003) the EU. The high effort in this survey with such a broad international participation allowed for broad spatial coverage as well as a relatively dense net of trawl and hydrographic stations.

Since 2005 this survey has extended into the Barents Sea where the main focus of investigations has been young herring. Low numbers of blue whiting found in the Norwegian bottom trawl survey in this area suggest that this gap would not signifi-cantly change the estimate for blue whiting. The survey is coordinated by WGIPS (ICES CM 2014/ SSGESS:01).

Use of this survey in stock assessment

After the benchmark in February 2012 (ICES 2012b) it was decided to not use this survey in the assessment, but it is used as basis for a qualitative estimate of recruitment

Results for blue whiting

The total biomass of blue whiting registered during the May 2014 survey was 0.63 million tons, which is somewhat less than the biomass estimate in 2013. The stock estimate in number for 2014 is 8.9 billion, which is approximately the same number as in 2012 estimate. The decrease in biomass without a decrease in abundance is caused by more young fish in the stock. Age one is dominating the estimate whereas in 2013 the 1-group was more or less absent. The estimate of 1-group in 2014 is 3.7 billion compared to only 0.6 billion in 2013. The number of 2 year olds was lower than in 2013, 2.5 billion compared to 6.3 billion. These results confirm the weak 2012 year class and suggest that the 2013 year class is stronger. This year class constituted to 41% of the total number and 26% of the total biomass.

An estimate was also made from a subset of the data or a "standard survey area" between 8°W–20°E and north of 63°N, which has been used as an indicator of the abundance of blue whiting in the Norwegian Sea because the spatial coverage in this area provides a coherent time-series with adequate spatial coverage. This standard survey area estimate is used as an abundance index in WGWIDE. The age-disaggregated total stock estimate in the "standard area" is presented in Table 8.3.4.2.1, showing that the blue whiting in this index area was dominated by fish at age 2 in terms of numbers and age 3 in terms of biomass, i.e. the youngest fish (age 1) is mostly found outside the "standard survey area".

The distribution of blue whiting in 2014 was similar to 2013, but the strong concentration found in the north eastern corner of the Norwegian Sea in 2013 was absent in 2014. The main concentrations were observed both in connection with the continental slopes of Norway and south and southwest Iceland and in the open sea in the southern part of the Norwegian Sea (Figure 8.3.4.2.1). It should be noted that the spatial survey design was not intended to cover the whole blue whiting stock during this period.

Age and length distributions from the last five years are shown in Figure 8.3.4.2.2.

8.3.4.3 Norwegian bottom trawl survey in the Barents Sea (BS-NoRu-Q1(Btr))

Background and status

Norway has conducted bottom trawl surveys targeting cod and other demersal fish in the Barents Sea since late 1970s. From 1981 onwards there have been systematically designed surveys carried out during the winter months (usually late January-early March) by at least two Norwegian vessels. In some years the survey has been conducted in co-operation with Russia. Blue whiting are regularly caught as a by-catch species in these surveys, and have in some years been among the numerically dominant species (Heino et al., 2003). This survey has in earlier years given the first reliable indication of year class strength of blue whiting.

Most of the blue whiting catches (or samples thereof) have been measured for body length, but very few age readings are available (from 2004 onwards otoliths are systematically collected). The existing age readings suggest that virtually all blue whiting less than 19 cm in length belong to 1–group and that while some 1–group blue whiting are larger, the resulting underestimation is not significant. An abundance index of all blue whiting and putative 1–group blue whiting from 1981 onwards is given in Table 8.3.4.3.1 and follows methods described in Heino *et al.* (2003).

In 2014 1-group blue whiting were again found in this survey, but not at the same level as in 2012. The catch rate was ranked as the seventh highest in the time series.

Use of this survey in blue whiting assessment

The survey is not used in the assessment, but as basis for a qualitative estimate of recruitment.

8.3.4.4 Other surveys

The stock Annex provides information and time series from surveys covering just a small fraction of the stock area. The International Survey in Nordic Seas and adjacent waters in July-August (IESSNS) is an expansion of the Norwegian Sea summer survey (Stock Annex), however the coverage and main focus has changed. Blue whiting is not main target, but the survey gives useful information of the stock in this period. This survey started in 2009.

8.4 Stock assessment

Blue whiting was benchmarked February 2012 (ICES 2012b) and the SAM model (Nielsen and Berg, 2014) was chosen as the default assessment model for the stock. ICES has classified the assessment this year as an update assessment, and no new methods were applied at this year's WG. The results from the SAM model were however compared with the results from methods previously applied for the stock (SMS and XSA). The two models gave similar results. This report will just present the results from the SAM method.

The configuration of the SAM model (see the Stock annex for details) is the same as agreed during the Benchmark WK (ICES 2012b). Residuals from the catch at age observation and survey indices are shown in figure 8.4.1. The catch residuals for 2012—2013 show a tendency for a higher observed catch of older fish than estimated by the model.

The SAM model allows a gradually change in exploitation pattern, however it might not fully adapt to the changes in the individual years. Residuals from the IBWSS survey showed a "year effect" with higher indices for ages 3—7 than estimated by the model using all data sources. This however, is often seen time series from acoustic surveys. The IBWSS residuals for 2014 show a tendency to overestimate the age 3—4 and underestimate age 5—8.

The diagnostic output from the SAM model is limited. There is only 13 parameter estimated within the model of which the uncertainties of catch and survey observations are shown in Table 8.4.2. The CV of the catch and survey observations of the main age groups in the fishery are low for both catch observations (0.15) and suvey (0.22-0.29). The fit for other age groups is also quite good. Compared to noise estimated last year the observation noise for catches is practically the same, while the noise for the survey is shlightly lower.

Figure 8.4.2 presents estimated F at age and exploitation pattern for the whole time series. There are no abrupt changes in the exploitation pattern from 2010 to 2013, even though the landings in 2011 were just 19% of the landings in 2010, which might have given a different fishing practice. The estimated rather stable exploitation pattern might be due to the use of correlated random walks for F at age with a high estimated correlation coefficient (0.98).

The retrospective analysis shows a stable estimate of F and SSB (Figures 8.4.3). The use of the SAM option for correlated random walks for F at age (and a high estimated correlation coefficient at 0.98) limits the changes in exploitation pattern when a new year's data are added to the time series, which probably stabilize the estimate of F and SSB. Recruitment in the terminal year is determined from catch data and an assumption on random walk in recruitment as there is no survey indices for age 1 and 2. This gives variable recruitment estimate in the terminal year, but the available short time series indicates that recruitment estimates have been in the range of the final (more converged) model estimate.

Stock summary results with added 95% confidence limits (Figure 8.4.4 and Table 8.4.5) show a decreasing trend in fishing mortality since 2004, with a historical low F in 2011 at 0.04, and an increase in F to 0.161 in 2013. Recruitment decreased substantially in the period 2000—2009 with a resulting strong decreasing SSB up to 2010. SSB has almost doubled from 2010 (2.9 million tonnes) to 2014 (5.5 million tonnes) and is estimated to be above Bpa. The year classes 2005—2008 are at historic low levels, but information from catches and survey show an increase in recruitment since 2009. However, the uncertainty around the recruitment in the most recent year is high. The rather high estimates are however confirmed by qualitative analysis of recruitment indices from surveys not used in the SAM assessment.

8.5 Final assessment

Input data are catch numbers at age (Table 8.3.1.4.1), mean weight-at-age in the stock and in the catch (Table 8.3.3.1) and natural mortality and proportion mature in Table 8.3.3.2. Applied survey data are presented in Table 8.3.4.1.1.

This is the third year that the SAM model has been applied for this stock. The model settings can be found in the Stock annex.

The model was run until 2013. The SSB January 1st in 2014 is estimated from survivors and estimated recruits (with an assumption of random walks for recruitment, which in this case give recruitment in 2014 as estimated for 2013). 11% of age-group 1 is assumed mature thus the recruitment influences the size of SSB. The key results are presented in Tables 8.4.3–8.4.4 and summarized in Table 8.4.5 and Figure 8.4.4. Residuals of the model fit are shown in Figures 8.4.1.

8.6 State of the Stock

SSB has almost doubled from 2010 (2.9 million tonnes) to 2014 (5.5 million tonnes) and is clearly above Bpa (2.25 million tonnes). This increase is due to historical low F since 2011 in combination with a higher recruitment (age 1) since 2010. The uncertainty around the recruitment in the most recent year is high.

The year classes 2005—2008 are in the very low end of the historical recruitments, but recruitment since 2009 and 2010 year class are estimated higher. Information on the 2012 and 2013 year classes is uncertain, but the level is confirmed from qualitative analysis of survey indices.

8.7 Biological reference points

As a response to a special request from NEAFC, ICES re-evaluated in May 2013 (ICES advice, 2013) the reference points for the stock. ICES concluded that Blim and Bpa should remain unchanged. Fpa and Flim were undefined. Equilibrium stochastic simulations have been used to give a new value for Flim = 0.48. On the basis of this and the uncertainty in the assessment, a corresponding value for Fpa = 0.32 was derived. Currently MSY advice is based on a management strategy evaluation which used F0.1 as a proxy for FMSY and an MSY Btrigger = Bpa. The new simulations provide estimates of FMSY = 0.30. There are no scientific reasons to reduce MSY Btrigger below Bpa, and no estimates of MSY Btrigger are above Bpa. Under these circumstances it is proposed that Bpa be retained as MSY Btrigger for the MSY framework.

In a new request from NEAFC, June 2013, ICES was requested to confirm the suggested reference points, more specifically to confirm:

a) That the value of F0.1 is considered to be 0.22 rather than 0.18, as stated in the advice of September 2012

b) That the value of Fmsy is considered to be 0.30 rather than 0.18, as stated in the advice of September 2012

ICES confirmed (ICES advice October 2013) that the value of F0.1 is currently estimated to be 0.22. ICES advises that the value of FMSY is considered to be 0.30 and this replaces the F0.1 proxy for FMSY of 0.18 from the advice of September 2012.

The present reference points and their technical basis are:

Reference point	Blim	Bpa	Flim	Fpa
Value	1.5 mill t	2.25 mill. t	0.48	0.32
Basis	Bloss	Blim* exp(1.645* σ), with σ= 0.25.	Equilibrium stochastic simulations, (ICES advice, 2013)	Based on Flim and assessment uncertainties (ICES advice, 2013)

Reference point	FMAX	F0.1	FMSY	MSY Btrigger
Value	NA	0.22	0.30	2.25 mill. t
Basis	FMAX is poorly defined	Yield per recruit (ICES advice, 2013 and WGWIDE, 2013)	Equilibrium stochastic simulations, (ICES advice, 2013)	Bpa

8.8 Short term forecast

8.8.1 Recruitment estimates

The benchmark WKPELA in February 2012 concluded that the available survey indices should be used in a qualitative way to estimate recruitment, rather than using them in a strict quantitative model framework. The WGWIDE has followed this rec-ommendation and investigated several survey time series indices with the potential to give quantitative or semi-quantitative information of blue whiting recruitment. The investigated survey series were standardized by dividing with their mean and are shown in Figure 8.8.1.1.

The International Ecosystem Survey in the Nordic Seas (IESNS) only partially covers the known distribution of recruitment from this stock. Both the 1-group (2013 year class) and 2-group (2012 year class) indices from the survey in 2013 were near the middle of the historical range.

The International Blue Whiting Spawning Stock Survey (IBWSS) is not designed to give a representative estimate of immature blue whiting. However, the 1-group indices appear to be fairly consistent with corresponding indices from older ages. The 1-group (2013 year class) index from the survey in 2014 were the highest in the time series.

The Norwegian bottom trawl survey in the Barents Sea (BS-NoRu-Q1(Btr)) in February-March 2014, showed that 1-group blue whiting was present and the index was close to the mean value in the time series (Table 8.3.4.3.1). This index should be used as a presence/absence index, in the way that when blue whiting is present in the Barents Sea this is usually a sign of a strong year-class (Heino *et al.* 2008), as all known strong year classes have been strong also in the Barents Sea.

The Icelandic bottom trawl survey (March) has a time series from 1996 to present. This survey is aimed at demersal species, but blue whiting juveniles are caught as bycatch. Some signals in recruitment are evident in the time series. The recruitment index of age 1 fish was obtained by a cut-off length at 22 cm. The 1-group estimate in 2014 (2013 year class) was the highest observed in the time series.

The Faroese Plateau spring (March) bottom trawl survey has a time series from 1994 to present. While this survey is not specifically aimed at blue whiting, nor has it been used in any assessments, there are some signals in recruitment evident in the time series. An index (number per trawl hour) was created based on a length split at 22 cm as an estimate of the abundance of age 1 blue whiting. The 1-group estimate in 2014 (2013 year class) was the highest observed in the time series.

In conclusion, the indices from available survey time series indicate that the 2012 year class is around or lower than average. Moreover, the new information regarding the 2011 year class suggests that this is above average. The WG therefore decided to use the estimate from the assessment for the 2011 year class (approximately at the 70th percentile), and the geometric mean of the whole period (1981—2011) for the 2012 yearclass. The 2013 year classes is assumed to be strong from the survey series and the WG deceided to use the 75th percentile as input (26.94 billion at age 1 in 2014). No information is available for the 2014 and 2015 yearclasses and the geometric mean of the whole period (1981—2011) was used for these yearclasses (13.77 billion at age 1 in 2015 and 2016) (Table 8.8.1.1).

8.8.2 Short term forecast

The SAM model provides uncertainty of fishing mortality and stock numbers in the final year estimates which only can be fully applied in a stochastic short-term forecast. The default stochastic projections applied for SAM assessments are carried out by projecting the final year's SAM estimates of stock numbers (log(N)) and fishing mortality (log(F)). Using the variance-covariance matrix of those estimates, a high number (1000) of replicates of the initial stock numbers and fishing mortalities are randomly drawn, such that the variance and co-variance between stock N and F are maintained. Due to additional information affecting recruitment (qualitative use of recruitment indices from surveys not used by SAM), the initial stock estimate for age 1 and age 2 can optionally be changed by an input factor. The 1000 replicates are then simulated forward according to the management options. The presented forecast result in the option table is finally derived from the median of the 1000 replicates.

Compared to a deterministic forecast the stochastic forecast gives slightly higher estimates of TAC and SSB. For this year's advice the TAC for 2015 is estimated 4-5% higher and SSB in 2016 8-9% higher. The difference is due to the assumed log-normal distributed stock number. The median of the projected stock N is unbiased compared to the stock N from a deterministic forecast, but the median of quantities like yield and SSB, which is the sum of several age groups N weighted by e.g. F, mean weight and proportion mature, will be higher. The difference increases by increasing uncertainty of the initial stock numbers used for the forecast.

The default stochastic forecast has been applied for the last two years. For this year however, a deterministic version was applied for advice. The MSE evaluation (ICES advice 2014) used a deterministic forecast in the evaluation. The conclusion, that a HCR with target F=0.30 is precautionary is sensitive to the choice of forecast model. With a TAC estimated 4-5% lower in the MSE than actually applied in the MSE will give a too high target F for precautionary management. Due to time constraint it is not possible to correct the MSE and re-estimate a precautionary target F. Therefore the WGWIDE concluded to use the other alternative, to use a deterministic forecast this year.

8.8.2.1 Input

Table 8.8.2.1.1 lists the input data for the short term predictions. Mean weight at age in the stock and mean weight in the catch are the same and are calculated as three year averages (2011—2013). Selection (exploitation pattern) is based on average F in the most recent three years. The proportion mature for this stock is assumed constant over the years and values are copied from the assessment input.

Recruitment (age 1) in 2012 is assumed as estimated by the SAM model. Recruitment in 2013 is assumed to be somewhat lower than the SAM estimate and is thus assumed at the long term average (GM 1981—2011). The recruitment in 2014 is believed to be stronger and is thus assumed to be at the 75th percentile of SAM the estimated recruitment 1981—2011. The recruitment in 2015 and 2016 are assumed at the long term average (GM 1981—2011).

The "Agreed Records of conclusion of fisheries consultations between the European Union, the Faroe Islands, , Iceland and Norway on the management of blue-whiting in the North East Atlantic in 2014" a limitation of 1200000 tonnes of blue whiting in 2014 was set in accordance to the management plan. Information from the WG members indicates a full quota uptake in 2014. F in 2014 is calculated on the basis of this TAC.

8.8.2.2 Output

A range of predicted catch and SSB options from the deterministic short term forecast used for advice are presented in Table 8.8.2.2.1. For comparison the stochastic forecast is presented in Table 8.8.2.2.2.

The existing management plan has a target F of 0.18 which applies once SSB is above B_{pa} (2.250 million tonnes) on the 1st January of the year in which the TAC is to be set. SSB in 2015 is estimated to be 5.7 million tonnes (above B_{pa}) such that F in 2015 should be 0.18. This will lead to a TAC in 2015 of 840000 tonnes (an decrease of 30%). This is expected to lead to an SSB of 5.904 million tonnes in 2015, which is high above B_{pa}.

The option table provides TAC calculation for F in the range 0.18 to 0.32 (Fpa). All of them will produce a SSB in 2016 higher than Bpa.

Following the ICES MSY framework implies fishing mortality to be at FMSY = 0.30 which will give a TAC in 2015 at 1.326 million tonnes (11% increase).

8.9 Comparison with previous assessment and forecast

Comparison of the final assessment results from the last 6 years (Figure 8.9.1) show stable and consistent output, except for the 2010 assessment. In 2010 the survey results from the IBWSS 2010 survey were applied, which gave a too low stock estimate and a corresponding too high F. An evaluation of the survey coverage led to a later exclusion of the 2010 observations.

This year's assessment gave a decrease in SSB for 2013. This is mainly due to the applied mean weight at age, where the last year's estimate of SSB for 2013 was calculated using the 2012 set of mean weight. Appling the observed mean weight available this year, the calculated SSB 2013 decreases.

8.10 Quality considerations

The assessment shows a low to moderate uncertainty of the absolute estimate of F and SSB, and a higher uncertainty on the recruiting year-classes. The assessment presented this year should be considered to be at the same quality as the assessment presented last year with respect to the absolute estimates of stock metrics, and certain in the conclusion on the steep decline in F in the most recent two years and an increase in SSB. Recruitment (age 1) is estimated significantly higher in 2011—2014 than in the years (2007—2009) with the historically low recruitments.

The quality of age readings of blue whiting was evaluated at a workshop (WKARBLUE) on age reading of blue whiting which took place in Bergen, Norway, from 10—14 June 2013 chaired by Jane Amtoft Godiksen and Manuel Meixide. Blue whiting otoliths have proven to be quite difficult to age, and though guidelines has been constructed, the experience of the reader determines the interpretation of the otolith structure. This strongly indicates that biased readings might have been present in many cases for the historical data used in the assessment, even for experienced age-readers. **It is therefore recommended** to have regular exchanges and workshops in order to improve the agreement between readers. WKARBLUE recommends a new workshop in 2017, and the survey group recommended that the age readers look closer into a discrepancy problem for ages 1—3 in the 2014 blue whiting age reading material. **It is therefore recommended** that an age reading workshop will be held as soon as possible.

The population structure of blue whiting in the NE Atlantic appears to be more complex than the current single-stock structure used for management purposes. The ICES SIMWG (Stock Identification Methods Working Group) has concluded "Blue whiting in the NE Atlantic should be considered as two stock units: Northern and Southern". WGWIDE **therefore recommends** that during the next "Age Reading Workshop for Blue Whiting", otoliths from the whole distribution area of this stock should be collected to perform shape analysis, aiming to clarify the blue whiting stock structure composition.

Assessment results for blue whiting are highly dependent on the quality of the only survey that covers the spawning stock (IBWSS). A post-cruise meeting compiled a joint survey report (Anon 2014) where it was concluded that the quality of the survey was high this year. The post-cruise meeting noted that the favourable weather conditions allowed the five survey vessels to successfully cover the entire planned area within the time available and achieved good containment of the stock. Estimated uncertainty around the mean acoustic density is low and comparable to the previous two years.

The assessment model SAM was applied for the third time for blue whiting. The two assessment models (SMS and XSA) previously applied for the stock gave a similar result as SAM and a consistent picture of the state of the stock.

8.11 Management considerations

The assessment shows a low to moderate uncertainty of the absolute estimate of F and SSB, and a higher uncertainty on the recruiting year-classes. SSB and F are estimated from a fairly good quality catch data and from only one survey giving information on the spawning stock (IBWSS). It is essential that this survey be maintained and it is important to maintain good geographical survey coverage within the agreed time window to avoid increases in assessment uncertainty. A continuous lack of one or more vessels (Norway did not take part of the 2013 survey) will put the survey quality at risk. Due to good planning and favourable weather conditions the implementation of the survey in 2014 resulted in good quality data.

Recruitment (age 1) is estimated significantly higher in 2011—2014 than in the years (2007—2009) with the historically low recruitments. Information from surveys and the fishery suggest a good recruitment in 2014 as well.

8.12 Ecosystem considerations

An extensive overview of ecosystem considerations relevant for blue whiting can be found in the stock annex. A more general overview of the pelagic complex in the NE Atlantic can be found in Chapter 1 of this report.

8.13 Regulations and their effects

Existing TAC are based on annual agreement between the "Coastal States" EU, Norway, Iceland and the Faroe Island. No minimum landing size is associated with blue whiting.

8.13.1 Management plans and evaluations

A meeting was held in 2008 (Anon, 2008) at which a number of potential management strategies for blue whiting were examined through simulations. Following this meeting a new management plan was proposed by the Coastal States. The full text of this plan is also presented in the stock annex. ICES was requested by the coastal states to evaluate this proposed management plan and this evaluation was carried out by WGWIDE in 2008. ICES considers that this plan is precautionary if fishing mortality in the first year is immediately reduced to the fishing mortality that is implied by the harvest control rule. The reduction to F=0.18 was followed by managers for setting the 2010 TAC. Likewise an F=0.05 according to the management plan was applied for 2011. The full text of the management plan is presented in the stock annex.

In May 2013 ICES answered (ICES advice May 2013) a request from NEAFC to review a potential new HCR function:

ICES considered that the current management plan is precautionary. A number of alternative F targets in the range of 0.1—0.35 were evaluated for the current harvest control rule (HCR) form and found to be precautionary up to an F target of 0.32 (corresponding to Fpa), with only a minimal increase in mean TAC for F targets above 0.3.

Inclusion of catch stabilization mechanisms have been tested in the current HCR and are considered precautionary as they do not increase the probability of SSB< Blim above 0.05. Over the entire time period examined there are no significant differences in catch either with or without the stabilizers.

Initial evaluations indicate that a number of options for the newly proposed HCR form (with increasing F at high biomass) have been found to be precautionary. However, these preliminary evaluations are not considered sufficiently robust. Based on the results presented, ICES suggests that a small subset of such rules should be selected and tested further with greater rigour before they are judged suitable for precautionary management. This suggestion led to a new request from NEAFC to evaluate a specified HCR. The conclusion of this new evaluation was not finalised during the WGWIDE meeting

Testing of banking and borrowing scenarios showed very little impact of either extreme banking or borrowing. Allowing a maximum of 10% to be banked or borrowed any year is considered precautionary when used with the existing HCR.

In October 2013 ICES answered (ICES advice October 2013) a request from NEAFC to elaborate the advice from May. ICES confirmed the advice from May. The request proposes also a new multistage HCR with two optional values for a slope parameter that determine the target F as function of SSB. The results of the evaluations showed that the HCRs gave similar performance with both values and no differences could be seen in the plots of SSB and F. The increase in F at high biomass leads to greater catch variability and 4% higher yields over the 40-year period simulated (particularly during periods of high recruitment). The multistage HCR leads to higher interannual variability (IAV) in TAC during the period of declining stock as recruitment changes from the high to the low regime. IAV for the multistage HCR is 33% compared to 25% for the F target of 0.22.

No international agreement has been obtained with respect a specific HCR to be used for a new management plan for blue whiting. The TAC for 2014 was set to 1.2 million tons equivalent to an F of around 0.23.

8.14 References

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ICES advice 2013. NEAFC request to ICES to evaluate the harvest control rule element of the long-term management plan for blue whiting. Special request, Advice May 2013. Section 9.3.3.1 of ICES advice Book 9.

ICES advice 2013. NEAFC request to ICES to evaluate the extra harvest control rule options for the long-term management plan for blue whiting, Advice October 2013. Section 9.3.3.7 of ICES advice Book 9.

Nielsen, A., and Berg, C.W. 2014. Estimation of time-varying selectivity in stock assessments using state-space models. Fisheries Research, 158: 96-101.

Table 8.3.1.1. Blue whiting landings (tonnes) by country for the period 1988–2013, as estimated by the Working Group.

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Denmark	18 941	26 630	27 052	15 538	34 356	41 053	20 456	12 439	52 101	26 270	61 523	64 653	57 686	53 333	51 279	82 935
Estonia					6 156	1 033	4 342	7 754	10 982	5 678	6 320					
Faroes	79 831	75 083	48 686	10 563	13 436	16 506	24 342	26 009	24 671	28 546	71 218	105 006	147 991	259 761	205 421	329 895
France		2 191				1 195		720	6 442	12 446	7 984	6 662	13 481	13 480	14 688	14 149
Germany	5 546	5 417	1 699	349	1 332	100	2	6 313	6 876	4 724	17 969	3 170	12 655	19 060	17 050	22 803
Iceland		4 977						369	302	10 464	68 681	160 430	260 857	365 101	287 336	501 493
Ireland	4 646	2 014			781		3	222	1 709	25 785	45 635	35 240	25 200	29 854	17 825	22 580
Japan					918	1 742	2 574									
Latvia					10 742	10 626	2 582									
Lithuania						2 046										
Netherlands	800	2 078	7 750	17 369	11 036	18 482	21 076	26 775	17 669	24 469	27 957	35 843	46 128	73 595	37 529	45 832
Norway	233 314	301 342	310 938	137 610	181 622	211 489	229 643	339 837	394 950	347 311	560 568	528 797	533 280	573 311	571 479	834 540
Poland	10															
Portugal	5 979	3 557	2 864	2 813	4 928	1 236	1 350	2 285	3 561	2 439	1 900	2 625	2 032	1 746	1 659	2 651
Spain	24 847	30 108	29 490	29 180	23 794	31 020	28 118	25 379	21 538	27 683	27 490	23 777	22 622	23 218	17 506	13 825
Sweden ***	1 229	3 062	1 503	1 000	2 058	2 867	3 675	13 000	4 000	4 568	9 299	12 993	3 319	2 086	18 549	65 532
UK (England)****																
UK (Scotland)	5 183	8 056	6 019	3 876	6 867	2 284	4 470	10 583	14 326	33 398	92 383	98 853	42 478	50 147	26 403	27 382
USSR / Russia *	177 521	162 932	125 609	151 226	177 000	139 000	116 781	107 220	86 855	118 656	130 042	178 179	245 198	315 478	290 068	355 319
TOTAL	557 847	627 447	561 610	369 524	475 026	480 679	459 414	578 905	645 982	672 437	1 128 969	1 256 228	1 412 927	1 780 170	1 556 792	2 318 935

Table 8.3.1.1 (continued). Blue whiting landings (tonnes) by country for the period 1988–2013, as estimated by the Working Group.

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark	89 500	41 450	56 979	48 659	18 134	248	140	165	340	2 167
Estonia	**									
Faroes	322 322	266 799	321 013	317 859	225 003	58 354	49979	16405	43290	85 768
France		8 046	18 009	16 638	11 723	8 831	7839	4337	9799	8 978
Germany	15 293	22 823	36 437	34 404	25 259	5 044	9108	278	6239	11 418
Iceland	379 643	265 516	309 508	236 538	159 307	120 202	87942	5887	63056	104 918
Ireland	75 393	73 488	54 910	31 132	22 852	8 776	8324	1195	7557	13 205
Japan										
Latvia										
Lithuania			4 635	9 812	5 338					
Netherlands	95 311	147 783	102 711	79 875	78 684	35 686	33762	4595	26526	51 635
Norway	957 684	738 490	642 451	539 587	418 289	225 995	194317	20539	118832	196 246
Poland										
Portugal	3 937	5 190	5 323	3 897	4 220	2 043	1482	603	1955	2 056
Spain	15 612	17 643	15 173	13 557	14 342	20 637	12891	2416	6726	15 274
Sweden ***	19 083	2 960	101	467	4	3	50	1	4	199
UK (England + Wales)	2 593	7 356	10 035	12 926	14 147	6 176	2475	27	2866	4 100
UK (Northern Ireland)										1 232
UK (Scotland)	57 028	104 539	72 106	43 540	38 150	173	5496	1331	6305	8 166
USSR / Russia *	346 762	332 226	329 100	236 369	225 163	149 650	112553	45841	88303	120 674
Greenland***										2 133
Unallocated									3 499	

TOTAL	2377568	2026953	1968456	1612330	1246465	635639	523832	103592	385297	626036

*** From 1992 only Russia**

**** Reported to the EU but not to the ICES WGNPBW. (Landings of 19,467 tonnes)**

***** Estimates from Sweden and Greenland: are not included in the Catch at Age Number**

****** From 2012**

Table 8.3.1.2. Blue whiting total landings by country and area for 2013 in tonnes, as estimated by the Working Group.

Area	Denmark	Faroe Islands	France	Germany	Iceland	Ireland	Netherlands	Norway	Portugal	Russia	Spain	UK (England + Wales)	UK (Scotland)	UK (Northern Ireland)	Grand Total
IIa	14	3904		38	1096		18	1589		20669					27 328
IIb				40			13			870					922
IIIa	89														89
IVa	144	10	12					8265		158					8 590
IVb	30							40							70
IVc															0
IXa									2056		2997				5 053
Va					3322			2							3 324
Vb		78396	3		89715					58798					226 911
VIa	1033	2456	2222	3624	10775	2731	21406	29521		12163		705	1370		88 008
VIb	811	804	684			2584	5204	19086		12832		1540	3147		46 690
VIIb			988	5120		148	83				148				6 485
VIIc	46	19	948	2341		6813	24193	67931		5213		1856	3649		113 009
VIIg															0
VIIh															0
VIIIa			1110								25				1 136
VIIIb							619				50				669
VIIIc											12051				12 051
VIIId			683								2				685
VIIj			10	256			30								296
VIIk		180	2319			930	69	69810		9544				1232	84 084
XII										253					253
XIVa										174					174
XIVb					10										10
Grand Total	**2 167**	**85 768**	**8 978**	**11 418**	**104 918**	**13 205**	**51 635**	**196 246**	**2 056**	**120 674**	**15 274**	**4 100**	**8 166**	**1 232**	**625 837**

*** Note: the value for area IXa is summed across CN, CS and S subdivisions of this area.**

Table 8.3.1.3. Blue whiting total landings of by quarter and area for 2013 in tonnes, as estimated by the Working Group.

Area	1	2	3	4	Total
IIa	844	9699	11439	5346	27328
IIb			239	683	922
IIIa			74	15	89
IVa	165	3304	4750	371	8590
IVb		16	25	29	70
IVc					0
IXa	580	1740	1984	749	5053
Va	29	1119	1822	354	3324
Vb	39025	168874	487	18525	226911
VIa	3249	84672	86	1	88008
VIb	36185	10505			46690
VIIb	5286	1199			6485
VIIc	109801	3207			113009
VIIg					0
VIIh					0
VIIIa	4	7	44	1081	1136
VIIIb	14	13	13	629	669
VIIIc	1785	2061	3534	4672	12051
VIIId	1	0	327	356	685
VIIj	4	252	10	30	296
VIIk	84084				84084
XII	253				253
XIVa			174		174
XIVb	8			2	10
Total	281318	286669	25009	32842	625837

Table 8.3.1.1.1. Blue whiting total catches (tonnes), total landings (tonnes) and discards (tonnes) for 2013.

Country	Catches	Landings	Discards	% Discards	Comments
Denmark	2167	2167	-	no sampling, discard assumed zero	
Faroe Islands	85768	85768	-	no sampling, discard assumed zero	Discard ban in place
France*	8978	8978	-	no discards	
Germany**	11655	11418	237	2%	Discards due to by-catch
Iceland	104918	104918	-	no sampling, discard assumed zero	Discard ban in place
Ireland	13205	13205	-	0	
Netherlands	51750	51635	115	1%	
Norway	196246	196246	-	no sampling, discard assumed zero	Discard ban in place
Portugal***	2756	2056	700	25%	Discards mainly reason: by-catch/market-forces/offer-demand dynamics
Russia	120674	120674	-	no sampling, discard assumed zero	Discard ban in place
Spain****	20680	15274	5406	26%	Discards mainly reason: by-catch/market-forces/offer-demand dynamics/undersized fish
UK (England + Wales)		4100	non available		
UK (Scotland)		8166	non available		
UK (Northern Ireland)		1232	non available		

*** Working Document (Tetard, 2014)**

**** Working Document (Ulleweit, 2014)**

***** Working Document (Prista *et al.* 2014)**

****** Working Document (Pérez *et al.* 2014)**

Table 8.3.1.2.1. Sampling intensity for blue whiting from the commercial catches by fishery in 2013.

Quarter	Fisheries	Directed	Mixed*	Southern	Total
1	No. of samples	217	39	48	304
	WG Catch	278509	277	2532	281318
2	No. Of samples	229	12	82	323
	WG Catch	279489	3358	3821	286669
3	No. of samples	48	87	58	193
	WG Catch	14764	4699	5546	25009
4	No. of samples	33	0	62	95
	WG Catch	27199	212	5431	32842
Total No. of samples		527	138	250	915
Total WG Catch		599961	8546	17329	625837
tonnes per sample		1138	62	69	684

* Norwegian mixed fishery only.

Table 8.3.1.2.2 Blue whiting. Total landings, No. of samples, No. of fish measured and No. of fish aged by country and quarter for 2013.

Country	Quarter	Landings (t)	No. Samples	No. Fish Measured	No. Fish Aged
Denmark	1	84	2	59	59
	2	1760	1	53	53
	3	273			
	4	50			
	Total	**2167**	**3**	**112**	**112**
Faroe Islands	1	36170	3	235	200
	2	30177	3	410	299
	3	2690	1	50	20
	4	16730	2	150	125
	Total	**85768**	**9**	**845**	**644**
France	1	5073			
	2	2103			
	3	366			
	4	1436			
	Total	**8978**	**0**	**0**	**0**
Germany	1	6403			
	2	4938	29	2033	155
	3	14			
	4	64			
	Total	**11418**	**29**	**2033**	**155**
Iceland	1	35	1	97	50
	2	98506	34	1752	2593
	3	2694			
	4	3683	2	200	100
	Total	**104918**	**37**	**2049**	**2743**
Ireland	1	12428	11	3751	900
	2	777			
	3	0			
	4	0			
	Total	**13205**	**11**	**3751**	**900**
Netherlands	1	23191	70	11263	1749
	2	27764	5	827	125
	3	0			
	4	680			
	Total	**51635**	**75**	**12090**	**1874**
Norway	1	156320	99	3140	544
	2	34705	28	2254	596
	3	4699	87	2467	200
	4	521			
	Total	**196246**	**214**	**7861**	**1340**
Portugal	1	143	9	705	269
	2	580	8	852	279
	3	987	3	351	93
	4	346	3	197	84
	Total	**2056**	**23**	**2105**	**725**
Russia	1	30488	64	12212	692
	2	77212	140	27958	2161
	3	8728	47	11016	801
	4	4246	29	5765	484
	Total	**120674**	**280**	**56951**	**4138**
Spain	1	2389	39	3765	471
	2	3242	74	7741	274
	3	4558	55	5930	529
	4	5085	59	4887	492
	Total	**15274**	**227**	**22323**	**1766**
UK (England + Wales)	1				
	2	4100			
	3				
	4				
	Total	**4100**	**0**	**0**	**0**
UK (Scotland)	1	7362	6	827	178
	2	804	1	132	58
	3				
	4				
	Total	**8166**	**7**	**959**	**236**
UK (Northern Ireland)	1	1232			
	2				
	3				
	4				
	Total	**1232**	**0**	**0**	**0**
	Grand Total	**625837**	**915**	**111079**	**14633**

Table 8.3.1.3.1. Blue whiting landings in numbers ('000) by length group (cm) and quarter for the directed fishery in 2013

Length (cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
5					
6					
7					
8					
9					
10			13		13
11			63		63
12			254		254
13			390		380
14			456		444
15			5 665	1	5 652
16	314		12 453	82	12 835
17	2 535	281	11 323	97	14 224
18	5 876	3 314	5 292	51	14 461
19	8 858	9 922	1 098	97	19 900
20	11 666	28 609	282	509	40 705
21	18 894	30 875	847	2 209	50 868
22	60 107	41 471	2 108	4 299	101 850
23	79 347	66 012	3 691	6 580	148 195
24	62 396	108 991	5 558	7 622	175 360
25	71 377	108 331	5 252	7 797	181 412
26	123 554	111 253	3 515	6 138	223 079
27	210 961	125 266	1 831	4 985	311 743
28	191 392	119 038	1 136	3 078	281 605
29	137 182	109 059	853	2 044	227 473
30	135 909	150 096	1 029	1 821	266 625
31	112 469	167 888	1 089	1 458	260 429
32	117 856	178 831	1 268	2 104	278 192
33	92 798	142 778	951	1 432	218 036
34	86 647	117 239	761	1 591	188 386
35	58 070	69 166	571	1 051	116 644
36	29 130	26 169	317	606	51 722
37	19 617	13 680	190	323	30 893
38	11 045	4 769	63	202	14 386
39	2 629	2 305	25	40	4 923
40	2 695	673	13		3 122
41	599	328	13		940
42	140	688			828
43	8	322		20	350
44	78	322			400
45	5				5
46		322			322
47					
48					
49					
50					
51					
52					
53					
54					
55					
TOTAL numbers	1654 153	1737 997	68 369	56 238	3246 720

Table 8.3.1.3.2. Blue whiting landings in numbers ('000) by length group (cm) and quarter for the mixed fishery in 2013.

Length (cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18	29				29
19	117	1			118
20	427	2	1		430
21	494	16	6		516
22	310	52	23		385
23	139	110	47		296
24	64	114	47		225
25	20	99	34		153
26	10	58	21		89
27	18	18	8		44
28	18	7	8		33
29	8	10	9		27
30	20	10	15		45
31	12	17	11		40
32	23	15	18		56
33	23	18	13		54
34	33	13	11		57
35	39	21	9		69
36	20	5	5		30
37	2	3	4		9
38			1		1
39					
40					
41					
42					
43					
44					
45					
46					
47					
48					
49					
50					
51					
52					
53					
54					
55					
TOTAL numbers	1 826	589	291		2 706

Table 8.3.1.3.3. Blue whiting landings in numbers ('000) by length group (cm) and quarter for the southern fishery in 2013.

Length (cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
5					
6					
7					
8					
9					
10					
11					
12					
13					
14	2				2
15	1 327	3	979		2 309
16	5 670	223	840		6 734
17	7 358	974	2 278	38	10 648
18	6 353	2 946	2 435	140	11 874
19	2 741	5 726	3 663	1 668	13 798
20	1 384	6 204	7 121	4 947	19 656
21	1 136	7 111	10 903	9 550	28 699
22	1 590	7 250	14 991	11 160	34 990
23	1 662	5 936	10 853	11 564	30 016
24	2 417	5 565	8 124	9 525	25 631
25	1 779	4 155	4 546	5 972	16 453
26	1 565	2 940	2 983	3 589	11 077
27	1 042	1 692	1 523	1 632	5 888
28	920	1 164	1 304	1 571	4 959
29	737	661	675	680	2 753
30	472	347	614	367	1 800
31	298	162	279	172	911
32	233	50	117	214	615
33	196	35	26	57	314
34	114	20	30	27	191
35	16	13	7	17	52
36	43	2	3	16	63
37		1			1
38	36		1	5	42
39		3		2	6
40					
41					
42					
43					
44					
45					
46					
47					
48					
49					
50					
51					
52					
53					
54					
55					
TOTAL numbers	39 092	53 183	74 297	62 911	229 483

Table 8.3.1.4.1. Blue whiting. Catch at age numbers (millions)

Year/Age	1	2	3	4	5	6	7	8	9	10+
1981	258	348	681	334	548	559	466	634	578	1460
1982	148	274	326	548	264	276	266	272	284	673
1983	2283	567	270	286	299	304	287	286	225	334
1984	2291	2331	455	260	285	445	262	193	154	255
1985	1305	2044	1933	303	188	321	257	174	93	259
1986	650	816	1862	1717	393	187	201	198	174	398
1987	838	578	728	1897	726	137	105	123	103	195
1988	425	721	614	683	1303	618	84	53	33	50
1989	865	718	1340	791	837	708	139	50	25	38
1990	1611	703	672	753	520	577	299	78	27	95
1991	267	1024	514	302	363	258	159	49	5	10
1992	408	654	1642	569	217	154	110	80	32	12
1993	263	305	621	1571	411	191	107	65	38	17
1994	307	108	368	389	1222	281	174	90	79	31
1995	296	354	422	465	616	800	254	160	60	42
1996	1893	534	632	537	323	497	663	232	98	83
1997	2131	1519	904	578	296	252	282	407	104	169
1998	1657	4181	3541	1045	384	323	303	264	212	86
1999	788	1549	5821	3461	413	207	151	153	69	140
2000	1815	1193	3466	5015	1550	514	213	151	58	140
2001	4364	4486	2962	3807	2593	586	170	97	77	66
2002	1821	3232	3292	2243	1824	1647	344	169	103	143
2003	3743	4074	8379	4825	2035	1117	400	121	20	27
2004	2156	4426	6724	6698	3045	1276	650	249	75	37
2005	1427	1519	5084	5871	4450	1419	518	249	100	55
2006	413	940	4206	6151	3834	1719	506	181	68	37
2007	167	307	1795	4211	3867	2353	936	321	130	89
2008	409	179	545	2917	3263	1919	736	316	113	127
2009	61	156	232	595	1596	1157	592	252	89	49
2010	350	223	160	208	646	992	703	257	70	44
2011	163	102	64	54	70	116	120	55	26	13
2012	240	352	663	142	107	203	364	357	212	158
2013	228	508	849	897	463	224	321	398	344	384

Table 8.3.1.4. Blue whiting landings (tonnes) from the main fisheries, 1988–2013, as estimated by the Working Group.

Area	Norwegian Sea fishery (SAs 1+2; Divs. Va, XIVa-b)	Fishery in the spawning area (SA XII; Divs. Vb, VIa-b, VIIa-c)	Directed- and mixed fisheries in the North Sea (SA IV; Div. IIIa)	**Total northern areas**	Total southern areas (SAs VIII+IX; Divs. VIId-k)	**Grand total**
1988	55 829	426 037	45 143	**527 009**	30 838	**557 847**
1989	42 615	475 179	75 958	**593 752**	33 695	**627 447**
1990	2 106	463 495	63 192	**528 793**	32 817	**561 610**
1991	78 703	218 946	39 872	**337 521**	32 003	**369 524**
1992	62 312	318 081	65 974	**446 367**	28 722	**475 089**
1993	43 240	347 101	58 082	**448 423**	32 256	**480 679**
1994	22 674	378 704	28 563	**429 941**	29 473	**459 414**
1995	23 733	423 504	104 004	**551 241**	27 664	**578 905**
1996	23 447	478 077	119 359	**620 883**	25 099	**645 982**
1997	62 570	514 654	65 091	**642 315**	30 122	**672 437**
1998	177 494	827 194	94 881	**1 099 569**	29 400	**1 128 969**
1999	179 639	943 578	106 609	**1 229 826**	26 402	**1 256 228**
2000	284 666	989 131	114 477	**1 388 274**	24 654	**1 412 928**
2001	591 583	1 045 100	118 523	**1 755 206**	24 964	**1 780 170**
2002	541 467	846 602	145 652	**1 533 721**	23 071	**1 556 792**
2003	931 508	1 211 621	158 180	**2 301 309**	20 097	**2 321 406**
2004	921 349	1 232 534	138 593	**2 292 476**	85 093	**2 377 569**
2005	405 577	1 465 735	128 033	**1 999 345**	27 608	**2 026 953**
2006	404 362	1 428 208	105 239	**1 937 809**	28 331	**1 966 140**
2007	172 709	1 360 882	61 105	**1 594 695**	17 634	**1 612 330**
2008	68 352	1 111 292	36 061	**1 215 704**	30 761	**1 246 465**
2009	46 629	533 996	22 387	**603 012**	32 627	**635 639**
2011	20 599	72 279	7 524	**100 401**	3 191	**103 592**
2012	24 391	324 545	5678.346	**354 614**	29401.78	**384 016**
2013	31 759	481 356	8 749	**521 864**	103 973	**625 837**

Table 8.3.3.1. Blue whiting: Individual mean weight (Kg) at age in the catch

Year/Age	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1981	0.052	0.065	0.103	0.125	0.141	0.155	0.170	0.178	0.187	0.213
1982	0.045	0.072	0.111	0.143	0.156	0.177	0.195	0.200	0.204	0.231
1983	0.046	0.074	0.118	0.140	0.153	0.176	0.195	0.200	0.204	0.228
1984	0.035	0.078	0.089	0.132	0.153	0.161	0.175	0.189	0.186	0.206
1985	0.038	0.074	0.097	0.114	0.157	0.177	0.199	0.208	0.218	0.237
1986	0.040	0.073	0.108	0.130	0.165	0.199	0.209	0.243	0.246	0.257
1987	0.048	0.086	0.106	0.124	0.147	0.177	0.208	0.221	0.222	0.254
1988	0.053	0.076	0.097	0.128	0.142	0.157	0.179	0.199	0.222	0.260
1989	0.059	0.079	0.103	0.126	0.148	0.158	0.171	0.203	0.224	0.253
1990	0.045	0.070	0.106	0.123	0.147	0.168	0.175	0.214	0.217	0.256
1991	0.055	0.091	0.107	0.136	0.174	0.190	0.206	0.230	0.232	0.266
1992	0.057	0.083	0.119	0.140	0.167	0.193	0.226	0.235	0.284	0.294
1993	0.066	0.082	0.109	0.137	0.163	0.177	0.200	0.217	0.225	0.281
1994	0.061	0.087	0.108	0.137	0.164	0.189	0.207	0.217	0.247	0.254
1995	0.064	0.091	0.118	0.143	0.154	0.167	0.203	0.206	0.236	0.256
1996	0.041	0.080	0.102	0.116	0.147	0.170	0.214	0.230	0.238	0.279
1997	0.047	0.072	0.102	0.121	0.140	0.166	0.177	0.183	0.203	0.232
1998	0.048	0.072	0.094	0.125	0.149	0.178	0.183	0.188	0.221	0.248
1999	0.063	0.078	0.088	0.109	0.142	0.170	0.199	0.193	0.192	0.245
2000	0.057	0.075	0.086	0.104	0.133	0.156	0.179	0.187	0.232	0.241
2001	0.050	0.078	0.094	0.108	0.129	0.163	0.186	0.193	0.231	0.243
2002	0.054	0.074	0.093	0.115	0.132	0.155	0.173	0.233	0.224	0.262
2003	0.049	0.075	0.098	0.108	0.131	0.148	0.168	0.193	0.232	0.258
2004	0.042	0.066	0.089	0.102	0.123	0.146	0.160	0.173	0.209	0.347
2005	0.039	0.068	0.084	0.099	0.113	0.137	0.156	0.166	0.195	0.217
2006	0.049	0.072	0.089	0.105	0.122	0.138	0.163	0.190	0.212	0.328
2007	0.050	0.064	0.091	0.103	0.115	0.130	0.146	0.169	0.182	0.249
2008	0.055	0.075	0.100	0.106	0.120	0.133	0.146	0.160	0.193	0.209
2009	0.056	0.085	0.105	0.119	0.124	0.138	0.149	0.179	0.214	0.251
2010	0.052	0.064	0.110	0.154	0.154	0.163	0.175	0.187	0.200	0.272
2011	0.055	0.079	0.107	0.136	0.169	0.169	0.179	0.189	0.214	0.270
2012	0.041	0.072	0.098	0.140	0.158	0.172	0.180	0.185	0.189	0.203
2013	0.051	0.077	0.094	0.117	0.139	0.162	0.185	0.188	0.198	0.197
arith. mean	0.050	0.076	0.101	0.123	0.145	0.164	0.183	0.198	0.216	0.251

Table 8.3.3.2. Blue whiting natural mortality and proportion of maturation-at-age

AGE	0	1	2	3	4	5	6	7-10+
Proportion mature	0.00	0.11	0.40	0.82	0.86	0.91	0.94	1.00
Natural mortality	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Table 8.3.4.1.1 Blue whiting age composition (millions) from the IBWSS for 2004–2014.

Year\Age	1	2	3	4	5	6	7	8	9	10+	Total
2004	1559	5 650	11086	14353	5426	1785	1007	635	367	40	41908
2005	1159	1427	6034	8178	8526	2657	646	233	105	1	28967
2006	1010	1 775	10332	12504	5338	2570	798	261	95	0	34685
2007	552	855	5 270	10606	8001	4501	2348	810	308	135	33461
2008	301	566	1440	5668	6516	3845	2122	1050	248	299	20943
2009	245	620	373	2057	5066	4181	2037	516	125	15	15238
2010*	580	648	212	452	982	2264	2456	1242	352	47	9311
2011	202	2617	942	912	1647	2301	1767	1221	430	31	12075
2012	1178	1832	6678	1013	544	1343	2077	1444	1078	1025	18393
2013	502	1682	7056	7776	3122	1287	1327	1515	867	1892	27026
2014	2886	1502	8396	7771	5927	1468	532	536	599	1468	31085

*** The quality of the survey was regarded as not satisfactory**

Total stock biomass (kt)

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
TSB (1000t)	3612	2557	3357	3583	2458	1981	1266	1578	2219	3347	3251

2008	1440	5668	6516	3845	2122	1050

Table 8.3.4.2.1. Estimated blue whiting stock numbers from the International Norwegian Sea ecosystem survey, 2000–2014. The estimates are for the standard area, north of 63°N and between 8°W–20°E.

Year\Age	1	2	3	4	5	6	7	8	9	10	11	Total
2000*	48927	3133	3580	1668	201	5						57514
2001*	85772	25110	7533	3020	2066							123501
2002*	15251	46656	14672	4357	513	445		15		6		81915
2003*	35688	21487	35372	4354	639	201	43	3				97787
2004*	49254	22086	13292	8290	1495	533	83	39				95072
2005*	54660	19904	13828	4714	1886	326	103	43	8	3	11	95486
2006*	570	18300	15324	6550	1566	384	246	80	47	2	8	43077
2007*	21	552	5846	3639	1674	531	178	49	19			12509
2008*	29	75	534	2151	715	287	116	44				3951
2009*	0	14	56	617	963	621	296	84	13			2664
2010*	0	0	0	10	107	165	68	96				446
2011*	1447	3138	1	43	204	226	431	120	84			5694
2012	9425	3142	427	153	87	169	98	31				13532
2013	241	5723	457	81	22	42	62	125	102	26	42	6938
2014	1402	1966	1024	438	97	33	28	50	37	22	11	5112

*** Using the old TS-value. To compare the results with 2012 all values should be divided by approximately 3.1**

Table 8.3.4.3.1 1-group indices of blue whiting from the Norwegian winter survey (late January-early March) in the Barents Sea. (Blue whiting <19 cm in total body length which most likely belong to 1-group.)

	Catch Rate	
Year	All	<19cm
1981	0.13	0
1982	0.17	0.01
1983	4.46	0.46
1984	6.97	2.47
1985	32.51	0.77
1986	17.51	0.89
1987	8.32	0.02
1988	6.38	0.97
1989	1.65	0.18
1990	17.81	16.37
1991	48.87	2.11
1992	30.05	0.06
1993	5.8	0.01
1994	3.02	0
1995	1.65	0.10
1996	9.88	5.81
1997	187.24	175.26
1998	7.14	0.21
1999	5.98	0.71
2000	129.23	120.90
2001	329.04	233.76
2002	102.63	9.69
2003	75.25	15.15
2004	124.01	36.74
2005	206.18	90.23
2006	269.2	3.52
2007	80.38	0.16
2008	17.03	0.04
2009	4.5	0.01
2010	3.3	0.08
2011	1.48	0.01
2012	127.89	126.83
2013	39.54	2.33
2014	31.95	25.2

Table 8.4.1. Blue Whiting: Survey indices used in the assessment.

IBWSS

	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8
2004	11086	14353	5426	1785	1007	635
2005	6034	8178	8526	2657	646	233
2006	10332	12504	5338	2570	798	261
2007	5270	10606	8001	4501	2348	810
2008	1440	5668	6516	3845	2122	1050
2009	373	2057	5066	4181	2037	516
2010	-1	-1	-1	-1	-1	-1
2011	942	912	1647	2301	1767	1221
2012	6678	1013	544	1343	2077	1444
2013	7056	7776	3122	1287	1327	1515
2014	8396	7771	5927	1468	532	536

Table 8.4.2. Blue Whiting: Estimated observation noise.

Index	Age	log(observation noise) ~ CV
Catch	1	0.42
Catch	2	0.28
Catch	3-8	0.15
Catch	9-10	0.43
IBWSS	3	0.39
IBWSS	4-6	0.22
IBWSS	7-8	0.29

Table 8.4.3. Blue whiting. Estimated fishing mortalities.

Year\Age	1	2	3	4	5	6	7	8	9+	F37
1981	0.070	0.118	0.174	0.218	0.262	0.346	0.375	0.477	0.488	0.275
1982	0.057	0.095	0.140	0.178	0.208	0.278	0.303	0.383	0.389	0.222
1983	0.067	0.112	0.164	0.209	0.243	0.334	0.362	0.451	0.452	0.262
1984	0.082	0.133	0.198	0.255	0.301	0.414	0.440	0.543	0.540	0.322
1985	0.085	0.136	0.207	0.271	0.330	0.444	0.465	0.572	0.567	0.343
1986	0.110	0.172	0.266	0.364	0.453	0.587	0.614	0.756	0.749	0.457
1987	0.098	0.152	0.242	0.337	0.421	0.550	0.572	0.699	0.684	0.424
1988	0.097	0.149	0.248	0.339	0.437	0.581	0.583	0.704	0.678	0.438
1989	0.110	0.169	0.296	0.399	0.508	0.669	0.682	0.816	0.779	0.511
1990	0.112	0.170	0.309	0.419	0.529	0.685	0.726	0.851	0.815	0.534
1991	0.054	0.083	0.156	0.215	0.269	0.338	0.363	0.418	0.402	0.268
1992	0.047	0.071	0.140	0.193	0.234	0.284	0.314	0.366	0.353	0.233
1993	0.041	0.061	0.127	0.176	0.212	0.249	0.278	0.328	0.315	0.209
1994	0.037	0.054	0.119	0.166	0.199	0.230	0.259	0.311	0.294	0.195
1995	0.046	0.068	0.153	0.221	0.252	0.291	0.328	0.401	0.371	0.249
1996	0.055	0.082	0.189	0.282	0.302	0.358	0.401	0.497	0.455	0.307
1997	0.053	0.078	0.185	0.284	0.294	0.349	0.389	0.486	0.443	0.300
1998	0.070	0.105	0.253	0.399	0.406	0.487	0.533	0.669	0.600	0.415
1999	0.058	0.088	0.214	0.348	0.354	0.424	0.451	0.570	0.510	0.358
2000	0.074	0.111	0.269	0.444	0.478	0.573	0.588	0.729	0.660	0.470
2001	0.069	0.105	0.252	0.421	0.472	0.564	0.562	0.691	0.633	0.454
2002	0.073	0.109	0.259	0.437	0.518	0.629	0.617	0.742	0.681	0.492
2003	0.067	0.099	0.238	0.403	0.499	0.590	0.578	0.666	0.617	0.462
2004	0.075	0.109	0.263	0.451	0.585	0.686	0.682	0.750	0.700	0.533
2005	0.070	0.099	0.237	0.419	0.563	0.650	0.652	0.700	0.652	0.504
2006	0.056	0.080	0.191	0.341	0.472	0.544	0.544	0.572	0.532	0.418
2007	0.055	0.079	0.184	0.332	0.476	0.555	0.559	0.572	0.533	0.421
2008	0.050	0.072	0.164	0.294	0.432	0.502	0.514	0.513	0.480	0.381
2009	0.030	0.045	0.103	0.176	0.268	0.311	0.328	0.321	0.294	0.237
2010	0.023	0.035	0.078	0.130	0.203	0.239	0.257	0.243	0.221	0.181
2011	0.005	0.008	0.017	0.028	0.044	0.053	0.057	0.054	0.049	0.040
2012	0.013	0.020	0.045	0.070	0.115	0.138	0.153	0.144	0.130	0.104
2013	0.020	0.030	0.068	0.106	0.178	0.213	0.240	0.224	0.201	0.161

Table 8.4.4. Blue Whiting. Estimated stock numbers at age (million).

Year\Age	1	2	3	4	5	6	7	8	9	10+
1981	4013	3563	4718	2037	2461	2087	1651	1807	1463	3227
1982	5417	2946	2639	3269	1540	1403	1200	945	899	2187
1983	21232	4278	1993	1790	1852	1171	955	810	545	1520
1984	20625	16453	2744	1289	1274	1356	781	521	425	1029
1985	10089	15173	10724	1572	779	909	759	444	252	737
1986	7018	6517	9811	5891	1011	481	497	407	227	516
1987	8589	4887	4123	6696	2566	419	247	244	163	296
1988	6224	6524	3389	2879	3715	1253	207	117	95	176
1989	8495	4538	5015	2511	2150	1630	374	98	50	116
1990	17505	5885	2917	2671	1478	1213	594	140	38	73
1991	9295	14798	4172	1769	1488	850	534	185	41	38
1992	7181	7741	13125	3338	1238	782	463	290	101	43
1993	5283	5278	5471	10069	2318	968	504	274	160	80
1994	7393	3649	3693	3392	6756	1527	767	350	181	140
1995	9781	5593	3138	2531	2769	3783	1012	521	214	190
1996	29006	7527	3997	2294	1521	1776	2211	623	297	238
1997	45947	22499	5604	2498	1370	1010	993	1168	303	300
1998	28488	39153	17176	3482	1357	908	724	568	575	294
1999	21338	21596	29326	10756	1746	738	488	365	229	391
2000	37393	16240	16535	16079	4543	1147	477	304	162	307
2001	57887	30554	13270	11029	7580	1731	503	224	132	199
2002	49131	44902	19211	8049	5390	3510	777	285	104	158
2003	52746	40956	37920	14218	5163	2761	1189	305	96	100
2004	34518	40792	30892	22522	7557	2671	1336	568	137	87
2005	20379	26776	28205	18256	11117	3375	1106	510	218	95
2006	7641	15823	24643	21147	9989	4538	1394	462	212	130
2007	4235	5593	13111	17039	11206	5521	2327	777	240	179
2008	5257	3172	4466	11106	9742	5299	2202	968	338	216
2009	5833	3671	2461	3985	7167	5030	2424	942	428	257
2010	18403	5091	2500	2029	3570	4676	2967	1340	503	368
2011	25393	16240	3745	1823	1839	2733	2701	1475	838	520
2012	23347	20075	15203	2629	1180	1736	2637	2481	1278	1136
2013	15433	20075	15697	11195	2905	1203	1475	2041	1810	1823
2014	15433*	12385	17505	12865	8032	1967	767	868	1336	2431

***Replaced by the 75% percentile of recruitment 1981-2011 in forecast**

Table 8.4.5. Blue whiting. Estimated recruitment in millions, total stock biomass (TBS) in 1000 tonnes, spawning stock biomass (SSB) in 1000 tonnes, and average fishing mortality for ages 3 to 7 (F37).

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F37	Low	High
1981	4013	2509	6419	3413	2782	4186	2917	2338	3638	0.275	0.217	0.349
1982	5417	3378	8687	2816	2325	3412	2318	1884	2851	0.222	0.176	0.279
1983	21232	13378	33695	3076	2518	3757	1899	1588	2272	0.262	0.212	0.325
1984	20625	13201	32224	3358	2711	4161	1849	1557	2194	0.322	0.263	0.394
1985	10089	6482	15705	3482	2867	4227	2233	1870	2667	0.343	0.283	0.417
1986	7018	4581	10751	3236	2753	3805	2381	2025	2800	0.457	0.379	0.550
1987	8589	5613	13144	2769	2359	3251	1916	1637	2243	0.424	0.351	0.513
1988	6224	4050	9566	2374	2029	2777	1614	1392	1870	0.438	0.362	0.529
1989	8495	5516	13084	2393	2027	2825	1550	1338	1797	0.511	0.423	0.617
1990	17505	11143	27500	2419	1959	2988	1338	1141	1570	0.534	0.432	0.660
1991	9295	5878	14699	3138	2474	3979	1727	1399	2132	0.268	0.211	0.342
1992	7181	4587	11243	3653	2928	4557	2528	2023	3160	0.233	0.183	0.297
1993	5283	3353	8325	3527	2865	4342	2610	2110	3229	0.209	0.165	0.265
1994	7393	4754	11495	3345	2762	4051	2498	2054	3039	0.195	0.155	0.245
1995	9781	6299	15189	3338	2788	3997	2281	1922	2706	0.249	0.201	0.309
1996	29006	18773	44816	3745	3074	4563	2176	1855	2553	0.307	0.249	0.377
1997	45947	29778	70896	5532	4382	6983	2466	2077	2927	0.300	0.246	0.367
1998	28488	18605	43622	7039	5694	8702	3753	3113	4525	0.415	0.343	0.503
1999	21338	13815	32959	7460	6159	9034	4597	3789	5578	0.358	0.295	0.434
2000	37393	24162	57869	7482	6225	8993	4299	3675	5030	0.470	0.390	0.567
2001	57887	37532	89281	9193	7535	11217	4690	4011	5485	0.454	0.377	0.547
2002	49131	31716	76108	10211	8348	12490	5304	4508	6241	0.492	0.408	0.593
2003	52746	34151	81466	12299	10199	14831	7189	6057	8531	0.462	0.384	0.555
2004	34518	21894	54422	10875	9137	12945	7053	6021	8262	0.533	0.442	0.643
2005	20379	12882	32239	8833	7368	10589	6212	5256	7343	0.504	0.413	0.616
2006	7641	4817	12119	8170	6848	9748	6306	5308	7492	0.418	0.340	0.515
2007	4235	2651	6767	6083	5104	7249	5061	4252	6023	0.421	0.335	0.529
2008	5257	3260	8475	4607	3802	5581	3817	3153	4620	0.381	0.296	0.491
2009	5833	3490	9747	3645	2915	4559	2931	2343	3667	0.237	0.180	0.312
2010	18403	11147	30382	4143	3206	5354	2914	2268	3744	0.181	0.136	0.242
2011	25393	15361	41977	5194	3919	6884	3009	2330	3885	0.040	0.030	0.053
2012	23347	13294	41002	6156	4716	8036	4078	3195	5204	0.104	0.081	0.135
2013	15433	6655	35789	7082	5306	9451	4960	3847	6396	0.161	0.122	0.213

2014	5471	4024	7438

Table 8.8.1.1. Blue Whiting. Upper part: Recruitment candidates (R_1, number at age 1, millions) to be used in the forecast section. Lower part: Geometric means of age 1 blue whiting from the final assessment run.

Year	Number at age 1
2013	13770
2014	26940
2015	13770
2016	13770
Year range	Geometric mean
1981-1995, 2006-2009	7974
1981-2011	13770
1996-2005	35520

Table 8.8.2.1.1. Blue Whiting. Input to short term projection (median values for exploitation pattern and stock numbers).

Table X1. Blue Whiting. Input to short term projection.

Age	Mean weight in the stock (kg)	Mean weight in the catch (kg)	Proportion mature	Natural mortality	Exploitation pattern	Stock numbers (millions)
1	0.049	0.049	0.11	0.20	0.125	26939*
2	0.076	0.076	0.40	0.20	0.188	11050**
3	0.099	0.099	0.82	0.20	0.429	17505
4	0.131	0.131	0.86	0.20	0.670	12865
5	0.156	0.156	0.91	0.20	1.105	8032
6	0.168	0.168	0.94	0.20	1.321	1967
7	0.181	0.181	1.00	0.20	1.474	767
8	0.188	0.188	1.00	0.20	1.380	868
9	0.201	0.201	1.00	0.20	1.244	1336
10	0.223	0.223	1.00	0.20	1.244	2431

***Changed to 75% percentile of recruitment 1981-2011 .**

****Changed to match GM(1981-2011)**

Table 8.8.2.2.1. Blue whiting. Deterministic forecast, used for the ICES advice

Basis: F(2014) = 0.273 (catch constraint = 1200 = TAC). SSB(2015) = 5738. R(2013), R(2015) and R(2016) = GM(1981-2011) = 13770 million at age 1, R(2014)=75% percentile of recruitment 1981-2011 .

Rationale	Catch 2015	Basis	F 2015	SSB 2016	% SSB change1	% TAC change2
Management plan F=0.18	839.886	Management Plan	0.18	5904.242	3	-30
F=0.19	882.497		0.19	5864.151	2	-26
F=0.20	924.713		0.20	5824.446	2	-23
F=0.21	966.538		0.21	5785.123	1	-19
F=0.22	1007.975		0.22	5746.177	0	-16
F=0.23	1049.030		0.23	5707.604	-1	-13
F=0.24	1089.705		0.24	5669.400	-1	-9
F=0.25	1130.007		0.25	5631.561	-2	-6
F=0.26	1169.938		0.26	5594.083	-3	-2
F=0.27	1209.502		0.27	5556.961	-3	1
F=0.22	1248.704		0.28	5520.193	-4	4
F=0.29	1287.547		0.29	5483.774	-4	7
F=0.30	1326.035		0.30	5447.701	-5	11
F=0.31	1364.173		0.31	5411.968	-6	14
Fpa 0.32	1401.963	Fpa	0.32	5376.574	-6	17
Flim 0.48	1962.330	Flim	0.48	4853.303	-15	64
MSY framework 0.30	1326.035	Fmsy=0.30	0.30	5447.701	-5	11
Zero catch	0	F=0	0.00	6696.989	17	-100
0.50*F(2014)	650.489		0.14	6082.598	6	-46
1.00*F(2014)	1222.488		0.27	5544.780	-3	2
1.50*F(2014)	1726.900		0.41	5072.776	-12	44
2.00*F(2014)	2173.016		0.55	4657.393	-19	81

Weights in thousand tonnes.

1) SSB 2016 relative to SSB 2015.

2) Catch 2015 relative to TAC 2014 (1200.000).

Table 8.8.2.2.2. Blue whiting. Stochastic forecast (NOT used for advice).

Basis: F(2014) = 0.266 (catch constraint = 1200 = TAC). SSB(2015) = 6066. R(2013), R(2015) and R(2016) = GM(1981-2011) = 13770 million at age 1, R(2014)=75% percentile of recruitment 1981-2011 .

Rationale	Catch 2015	Basis	F 2015	SSB 2016	% SSB change1	% TAC change2
Management plan F=0.18	884.578	Management Plan	0.18	6464.584	7	-26
F=0.19	929.173		0.19	6421.030	6	-23
F=0.20	973.024		0.20	6379.514	5	-19
F=0.21	1017.094		0.21	6335.471	4	-15
F=0.22	1059.853		0.22	6292.610	4	-12
F=0.23	1102.983		0.23	6248.048	3	-8
F=0.24	1145.596		0.24	6203.954	2	-5
F=0.25	1187.505		0.25	6159.985	2	-1
F=0.26	1229.191		0.26	6116.272	1	2
F=0.27	1270.822		0.27	6076.063	0	6
F=0.22	1312.301		0.28	6036.214	-0	9
F=0.29	1353.018		0.29	5996.563	-1	13
F=0.30	1393.140		0.30	5957.596	-2	16
F=0.31	1433.369		0.31	5919.978	-2	20
Fpa 0.32	1472.969	Fpa	0.32	5882.726	-3	23
Flim 0.48	2067.402	Flim	0.48	5314.122	-12	72
MSY framework	1393.140	Fmsy=0.30	0.30	5957.596	-2	16
Zero catch	0	F=0	0.00	7302.251	20	-100
0.50*F(2014)	667.786		0.13	6670.156	10	-44
1.00*F(2014)	1254.183		0.27	6092.236	0	5
1.50*F(2014)	1775.884		0.40	5588.546	-8	48
2.00*F(2014)	2240.720		0.53	5147.044	-15	87

Weights in thousand tonnes.

1) SSB 2016 relative to SSB 2015.

2) Catch 2015 relative to TAC 2014 (1200.000).

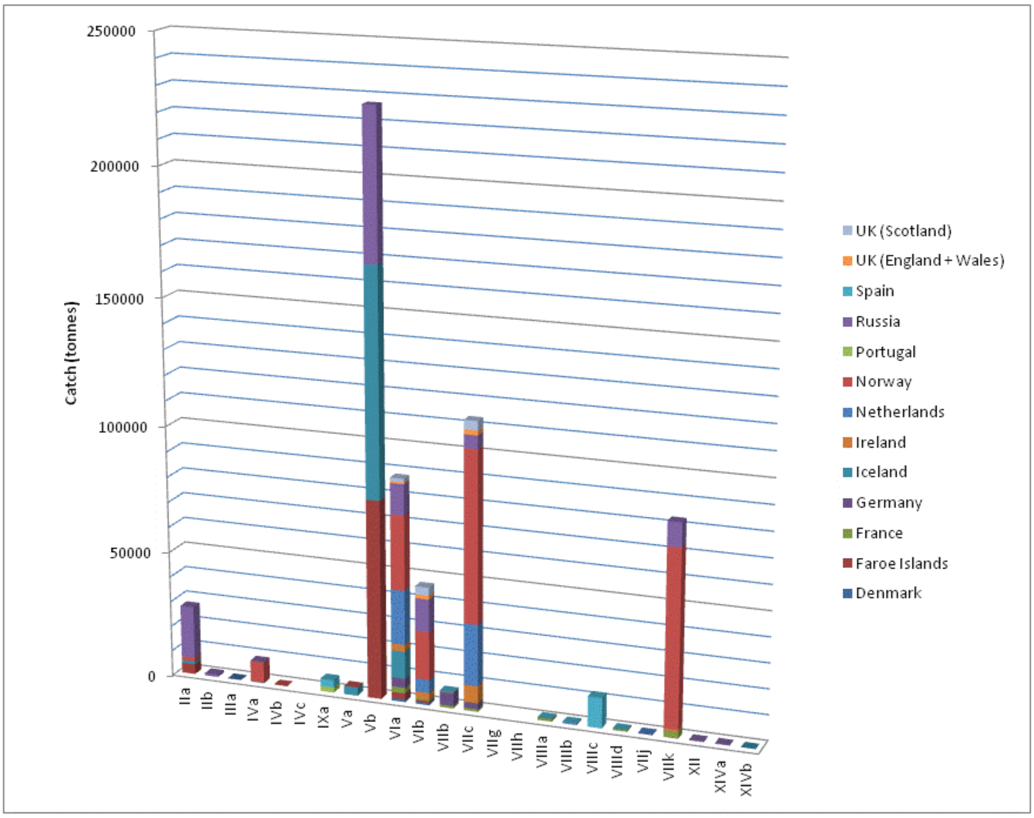


Figure 8.3.1.1 Blue whiting landings (tonnes) in 2013 presented by ICES area and country.

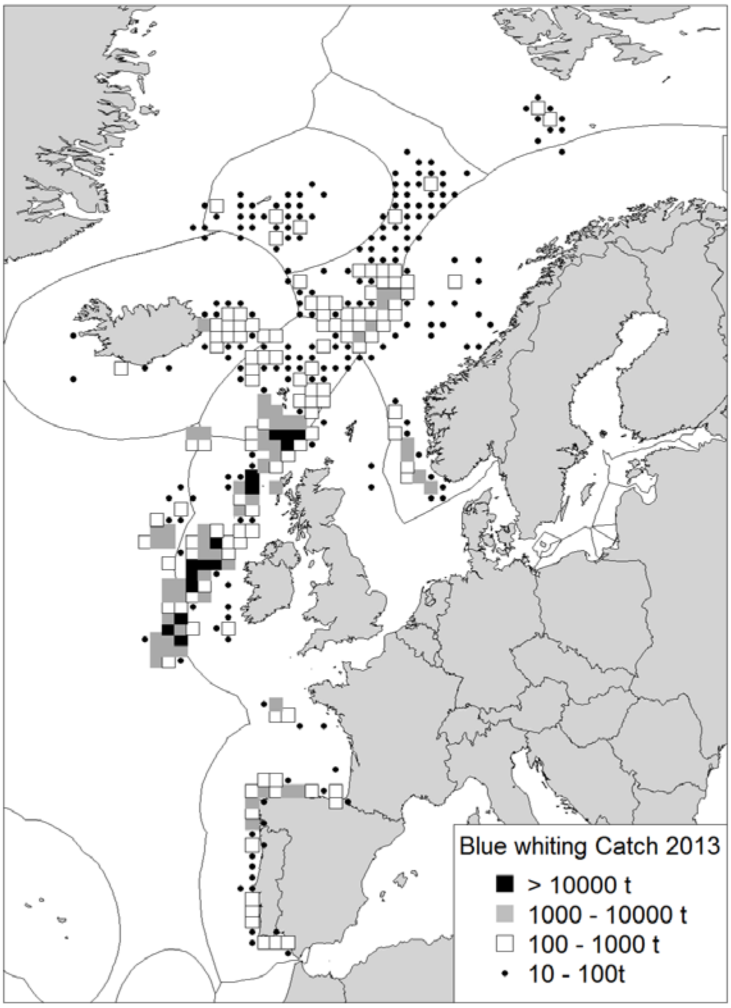


Figure 8.3.1.2. Total blue whiting catches (t) in 2013 by ICES rectangle. Catches below 10 t are not shown on the map. The catches on the map constitute close to 100 % of the total catches.

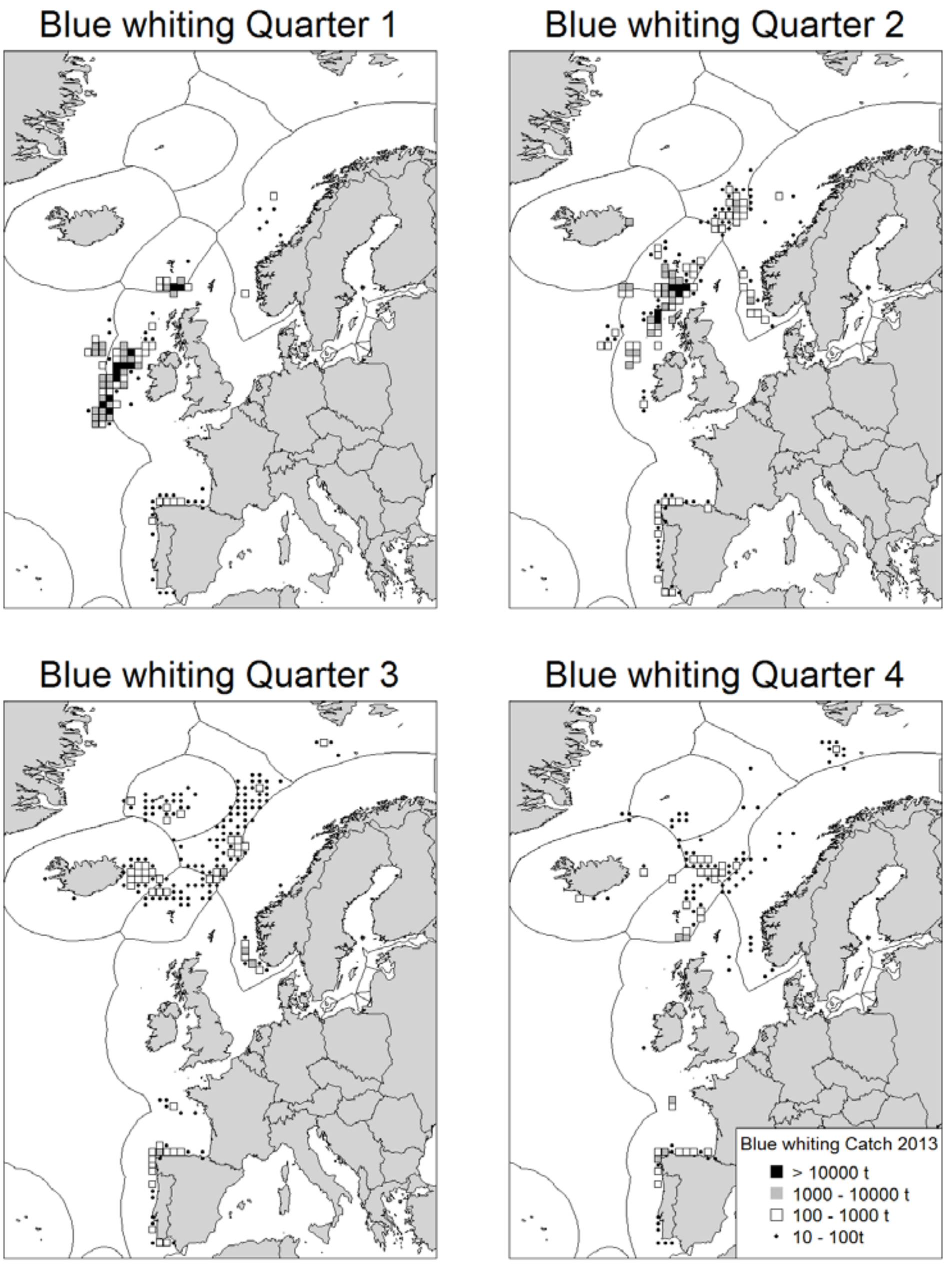
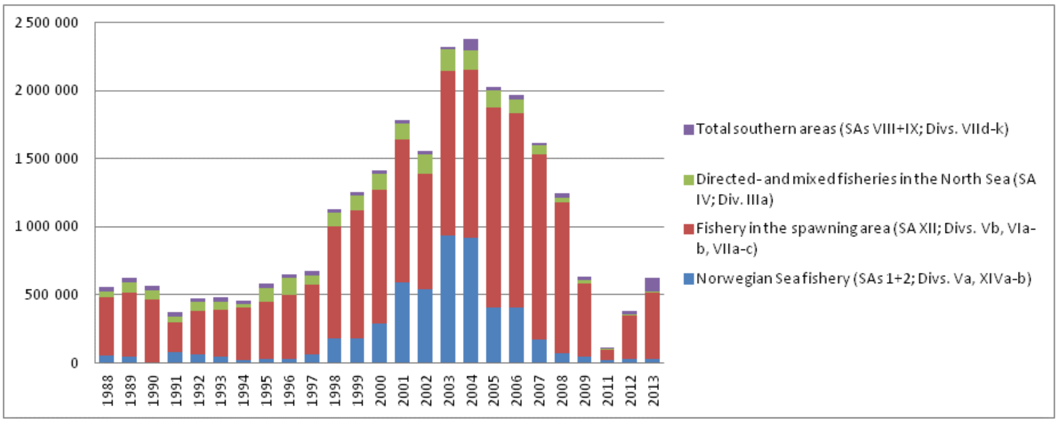


Figure 8.3.1.3. Blue whiting total catches (t) in 2013 by quarter and ICES rectangle. The catches on the maps constitute close to 100 % of the total catches.

A



B

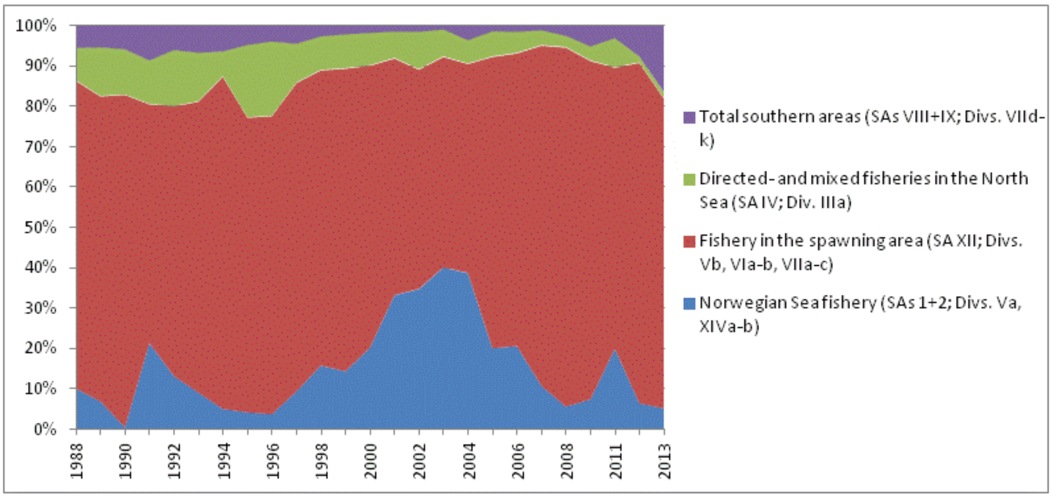


Figure 8.3.1.4. (A) Annual catch (tonnes) of blue whiting by fishery sub-areas from 1988-2013 and (B) the percentage contribution to the overall catch by fishery sub-area over the same period.

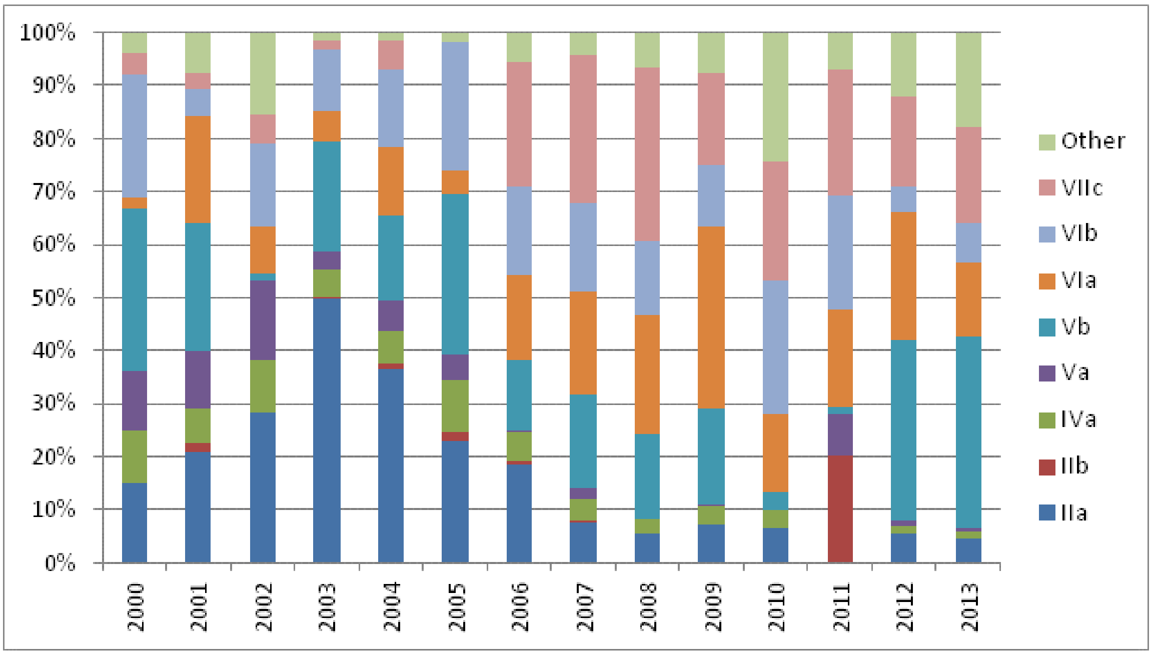


Figure 8.3.1.5. Distribution of total landings of blue whiting by ICES sub-area.

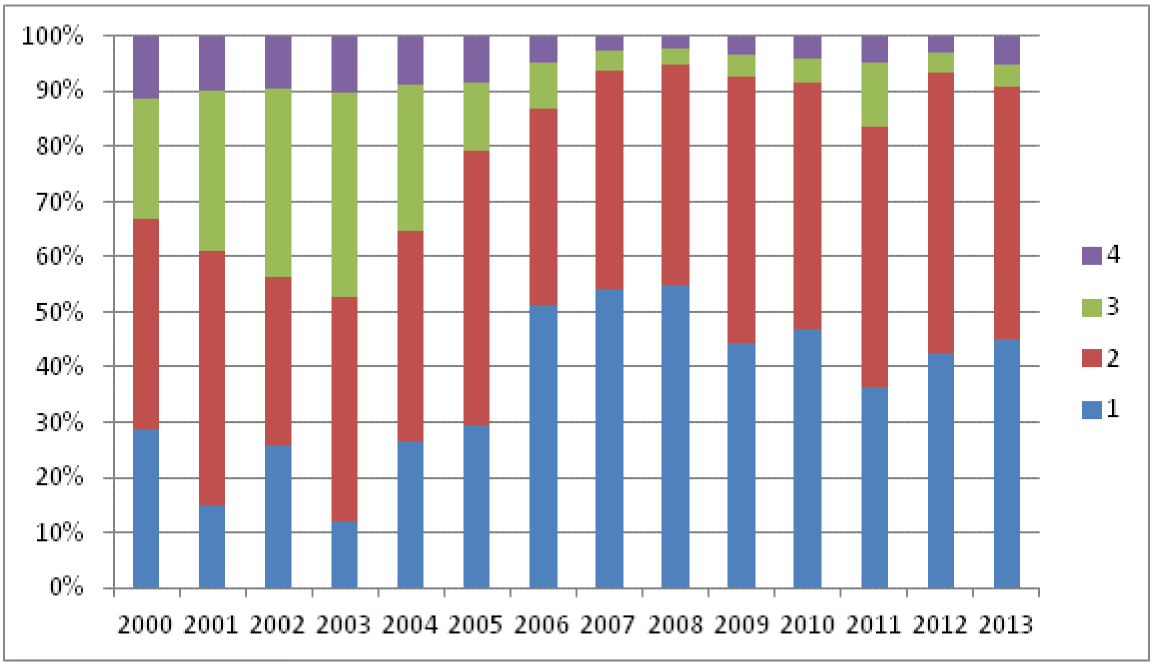


Figure 8.3.1.6. Distribution of total landings of blue whiting by quarter.

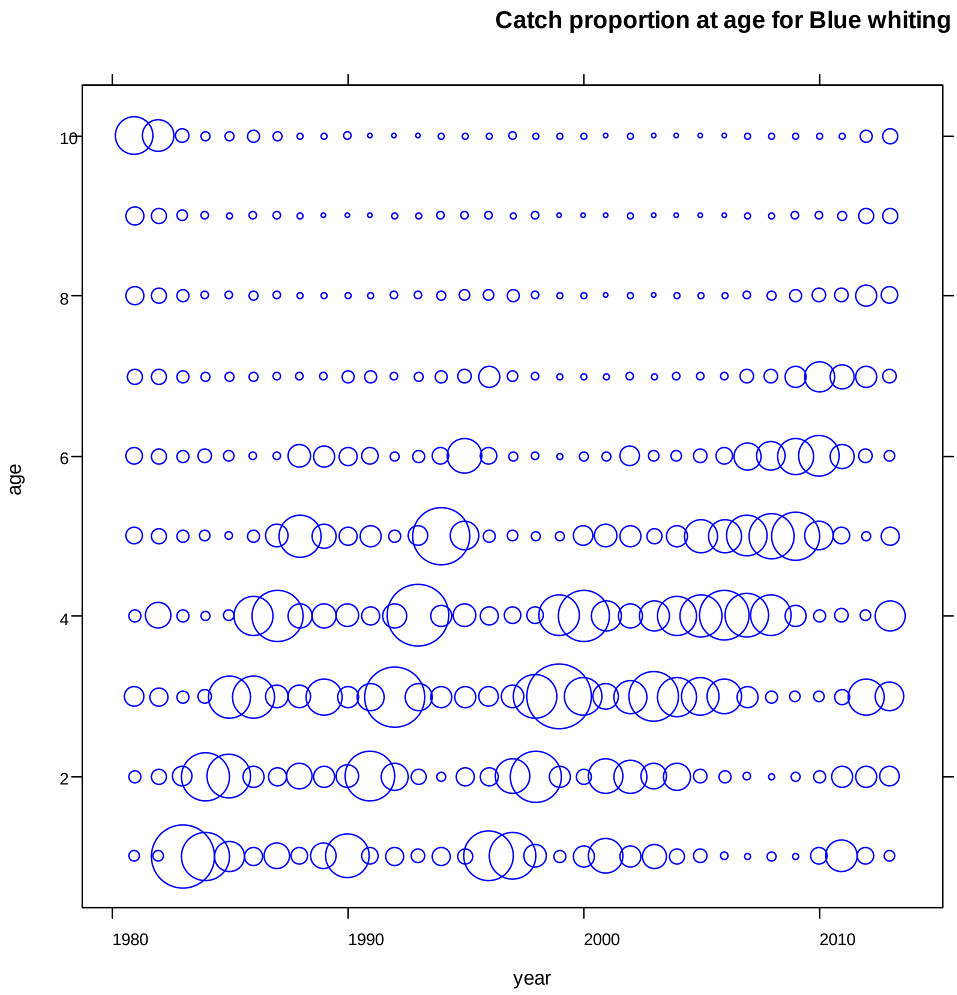


Figure 8.3.1.3.1 Catch proportion at age of blue whiting in the International catch from 1981-2013.

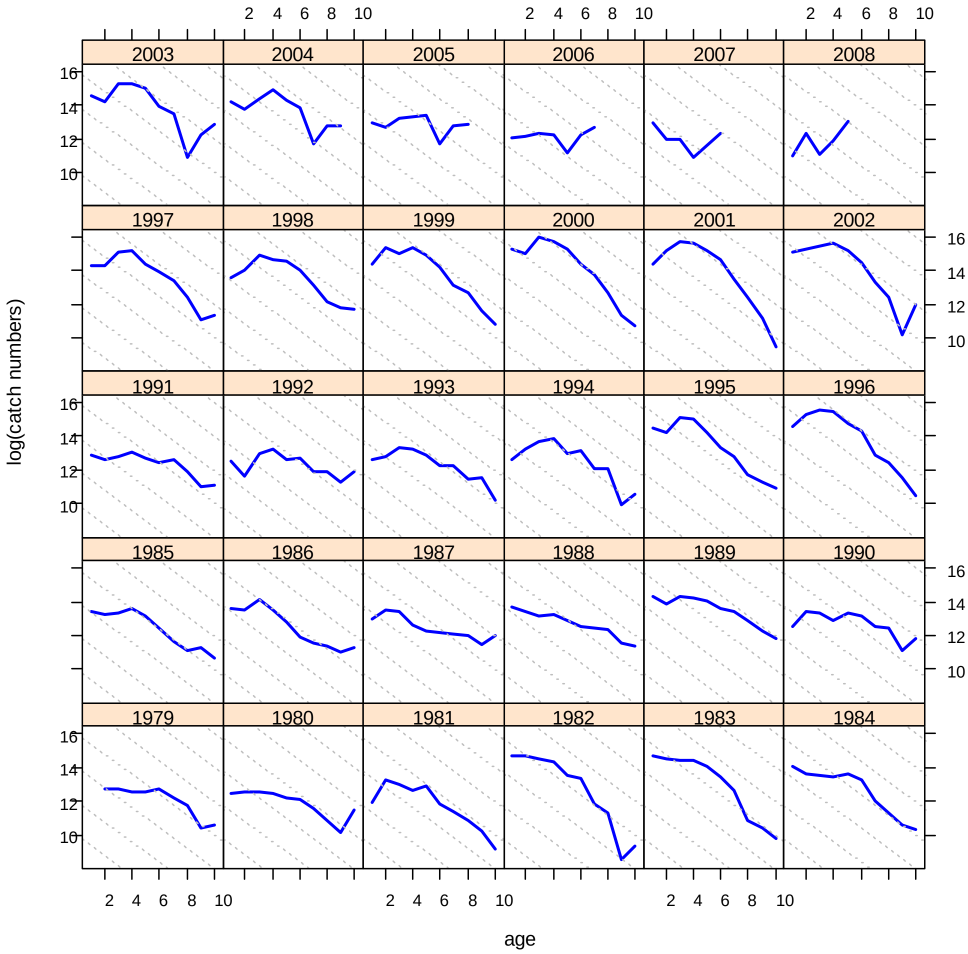


Figure 8.3.1.3.2. Blue whiting. Age disaggregated blue whiting catch (numbers) plotted on log scale. The labels behind each panel indicate year classes. The grey dotted lines correspond to *Z*=0.6.

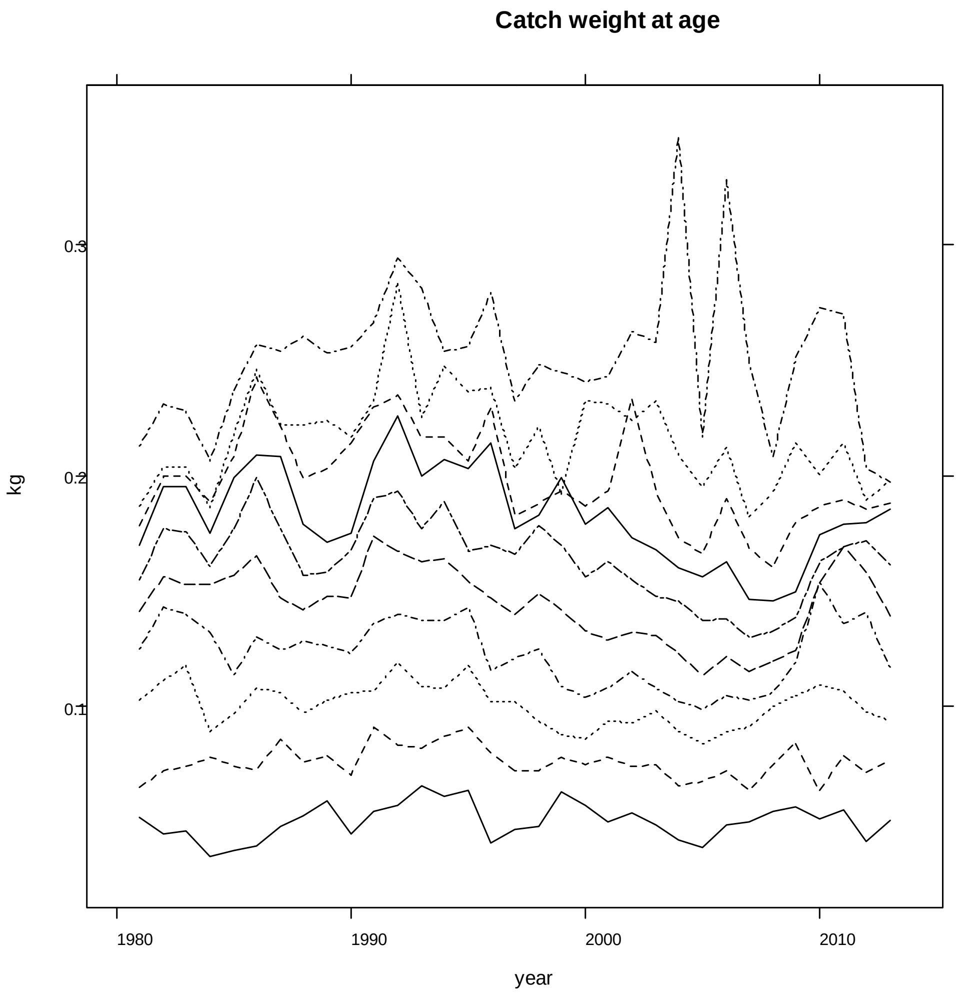


Figure 8.3.1.4.1. Mean catch weight (kg) at age of blue whiting by year.

A **B**

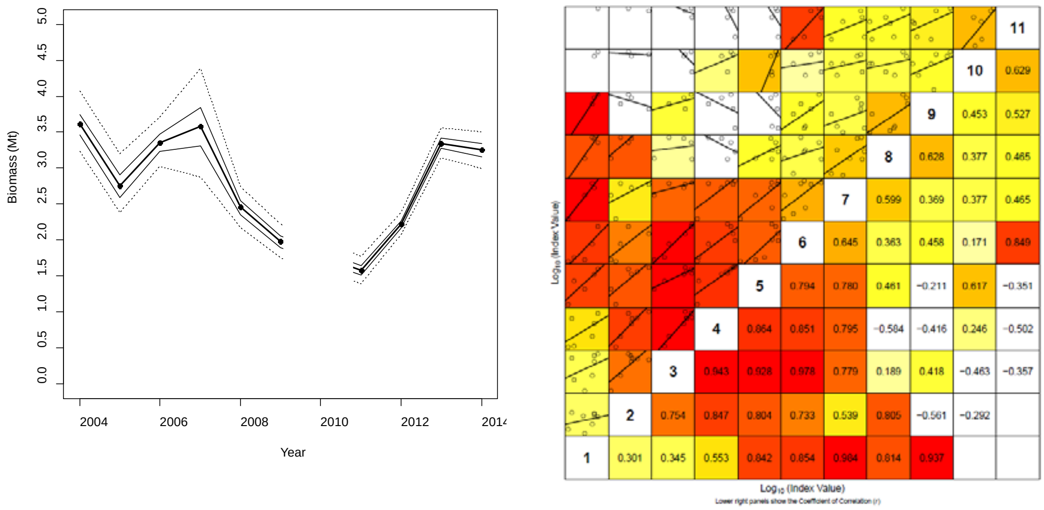
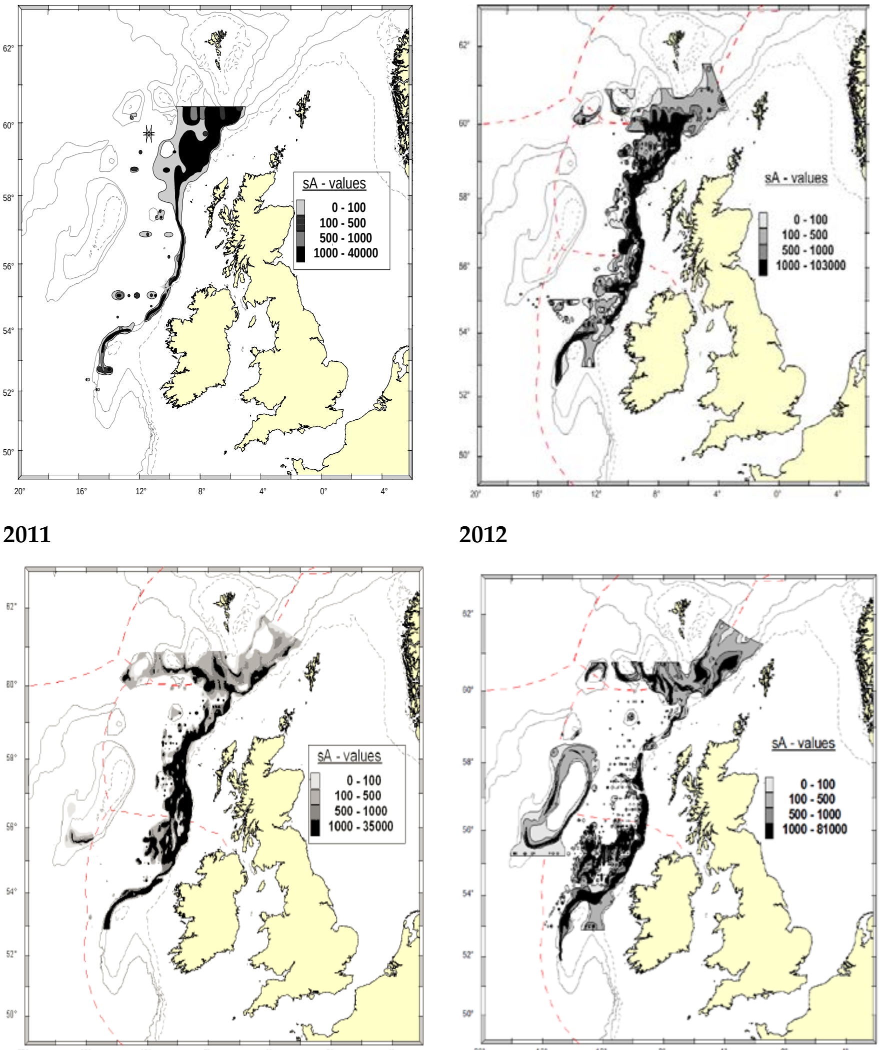


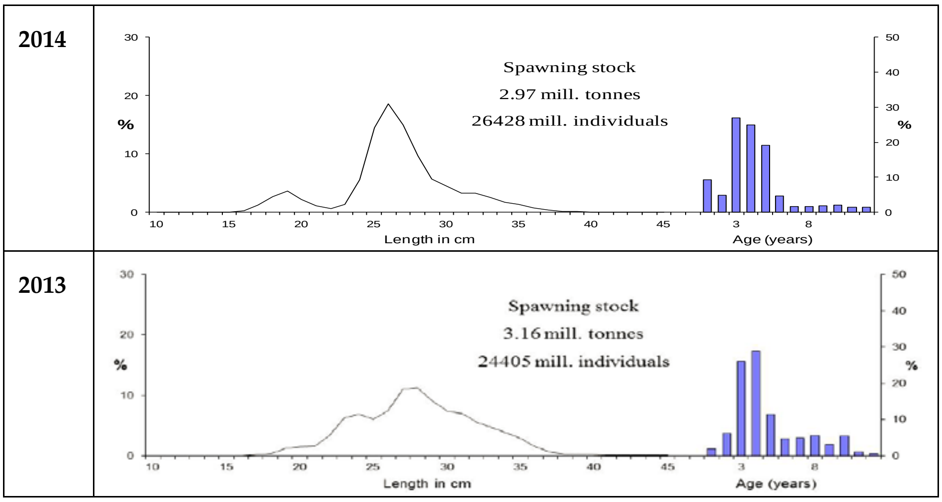
Figure 8.3.4.1.1 (A) Approximate 50% and 95% confidence limits for blue whiting biomass estimates. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations from the mean values. These confidence limits only account for spatio-temporal variability in acoustic observations. (B) Internal consistency within the International blue whiting spawning stock survey. The upper left part of the plots shows the relationship between log index-at-age within a cohort. Linear regression line shows the best fit to the log-transformed indices. The lower-right part of the plots shows the correlation coefficient (r) for the two ages plotted in that panel. The background colour of each panel is determined by the r value, where red equates to r=1 and white to r<0.



2011 **2012**

2013 **2014**

Figure 8.3.4.1.2. Schematic map of blue whiting acoustic density (sA, m2/nm2) found during the spawning survey in spring 2011-2014.



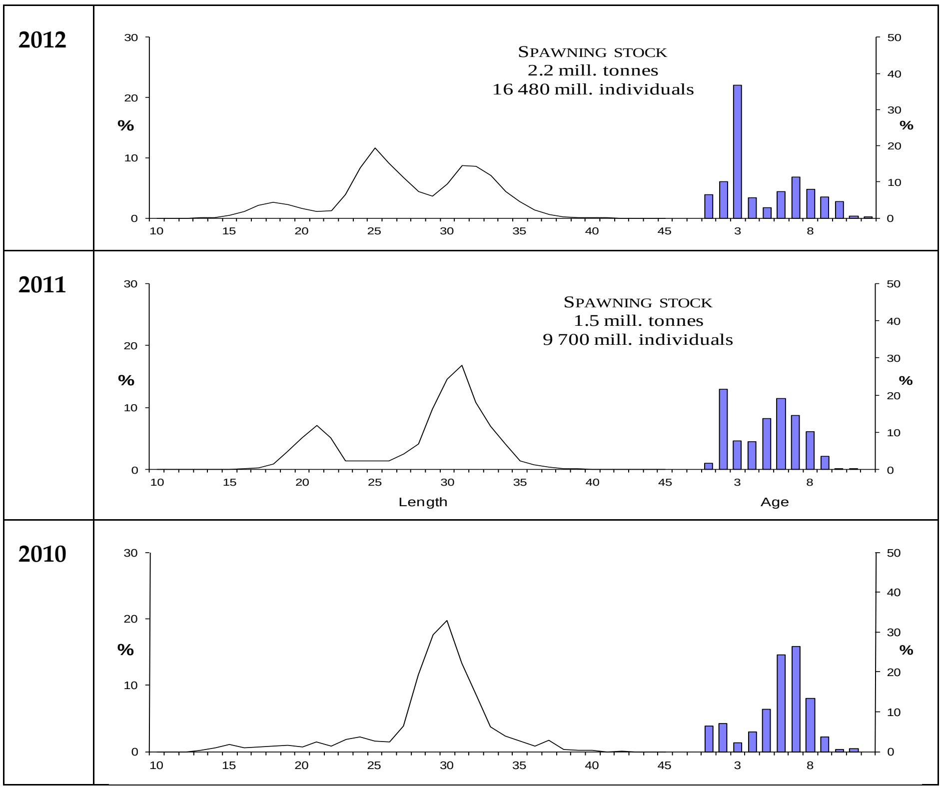


Figure 8.3.4.1.3 Length (line) and age (bars) distribution of the blue whiting stock in the area to the west of the British Isles, spring 2010 (lower panel) to 2014 (upper panel). Spawning stock biomass and numbers are given.

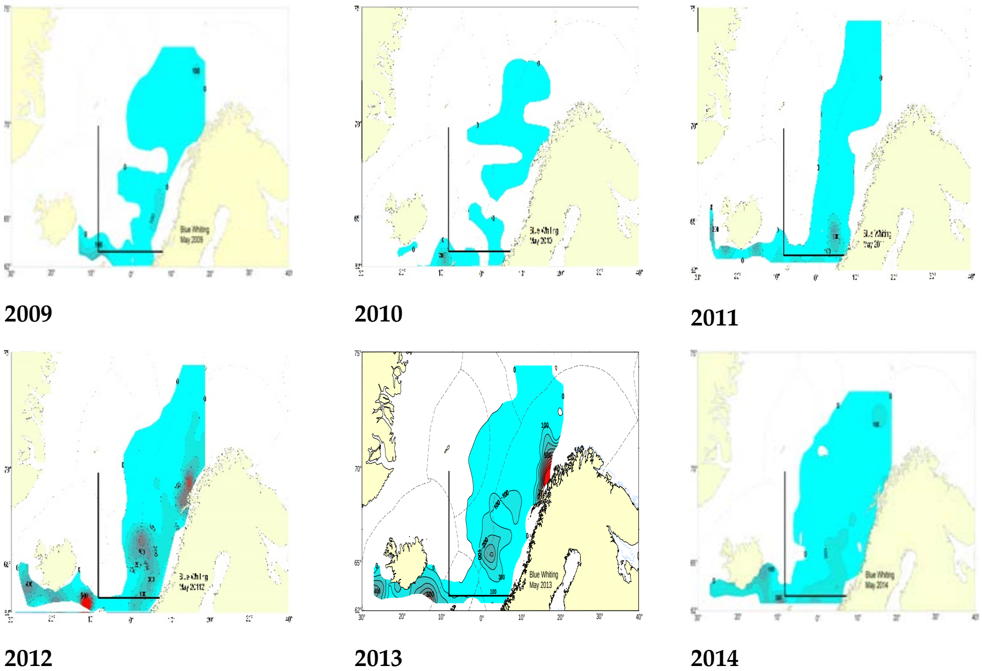


Figure 8.3.4.2.1. Schematic map of blue whiting acoustic density (sA, m2/nm2) found during the International Ecosystem survey in the Nordic Seas in spring 2009–2014.

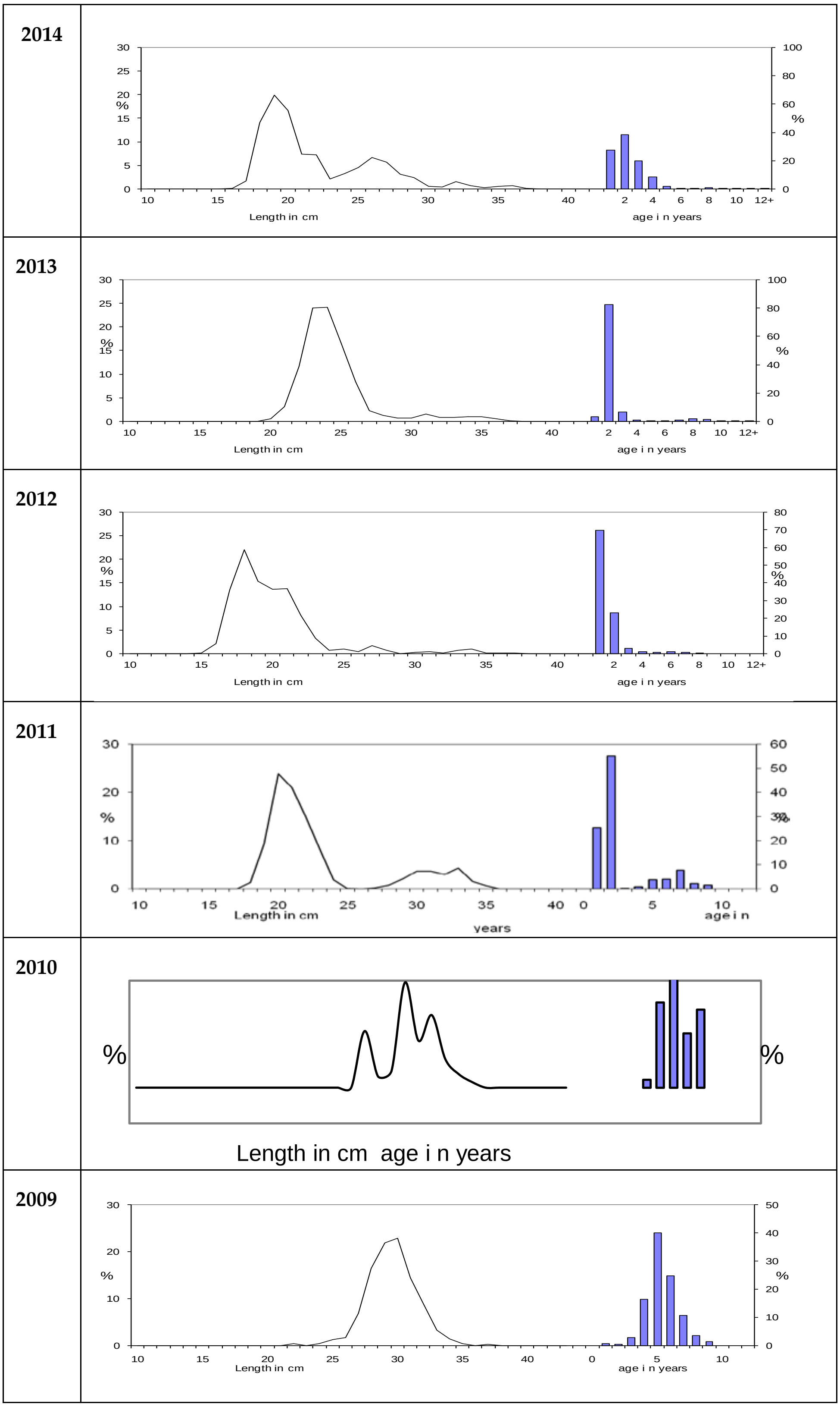


Figure 8.3.4.2.2 Estimated length (line) and age (bar) distributions of blue whiting in the International Ecosystem Survey in the Nordic Seas in May–June for 2009-2014 based on the "standard survey area" between 8°W-20°E and north of 63°N.

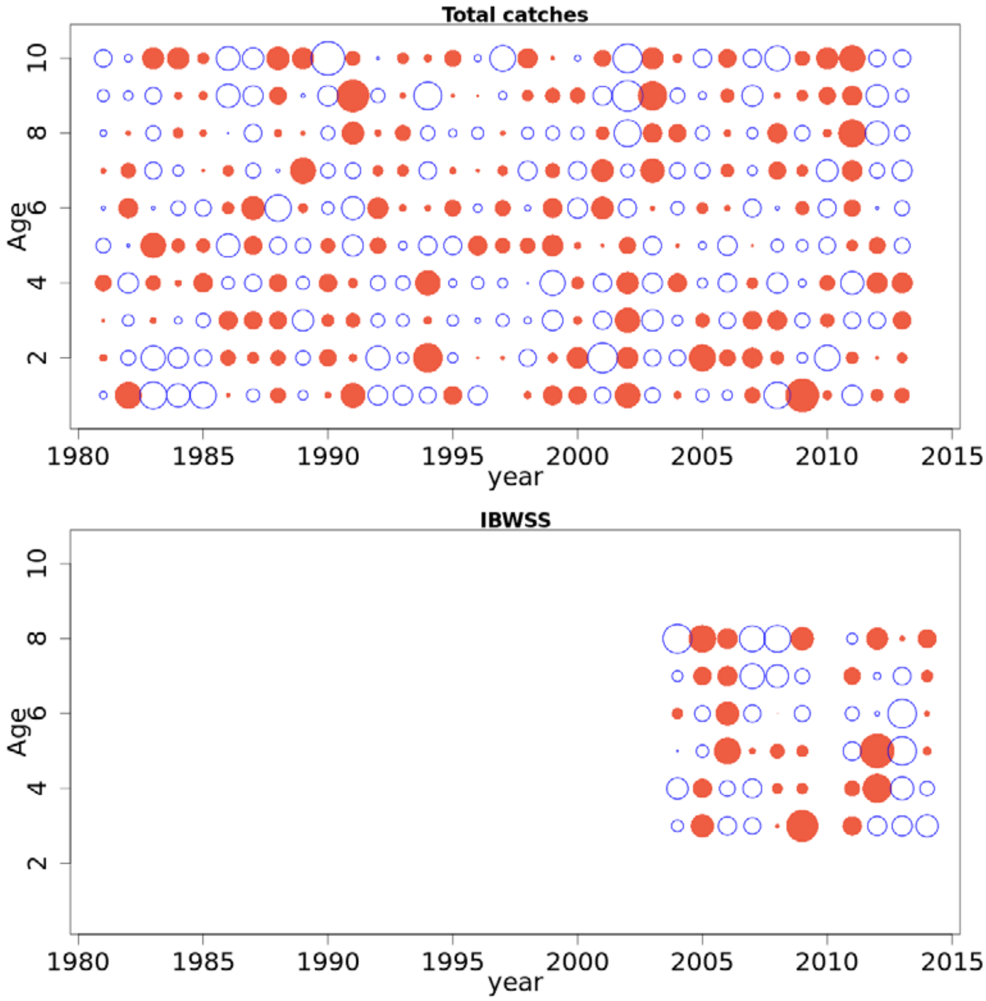


Figure 8.4.1 Blue Whiting. Standardized residuals from catch at age and the IBWSS survey. red (dark) bubbles show that the observed value is less than the expected value

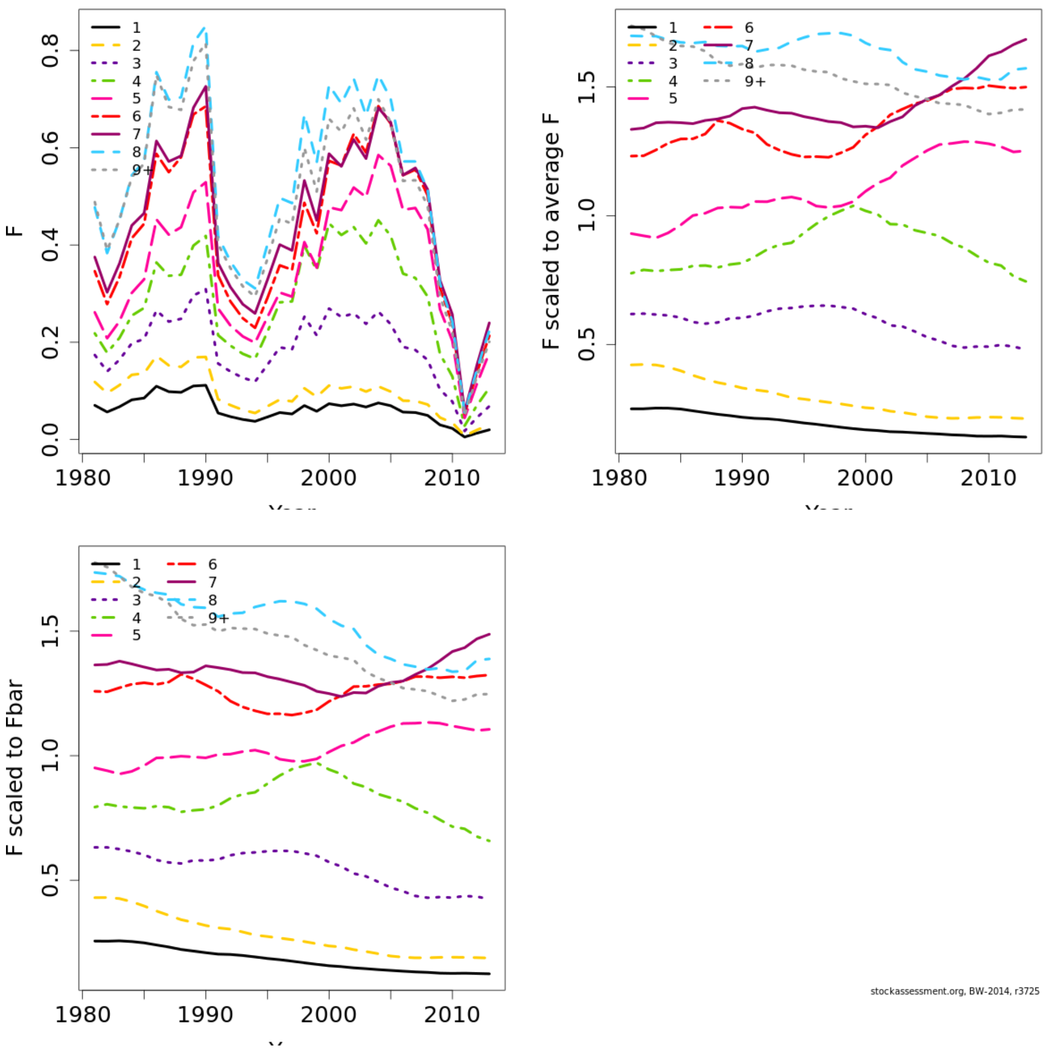


Figure 8.4.2. Blue Whiting. F at age and exploitation pattern (F scaled to mean F all ages, and F scaled to mean F ages 3-7).

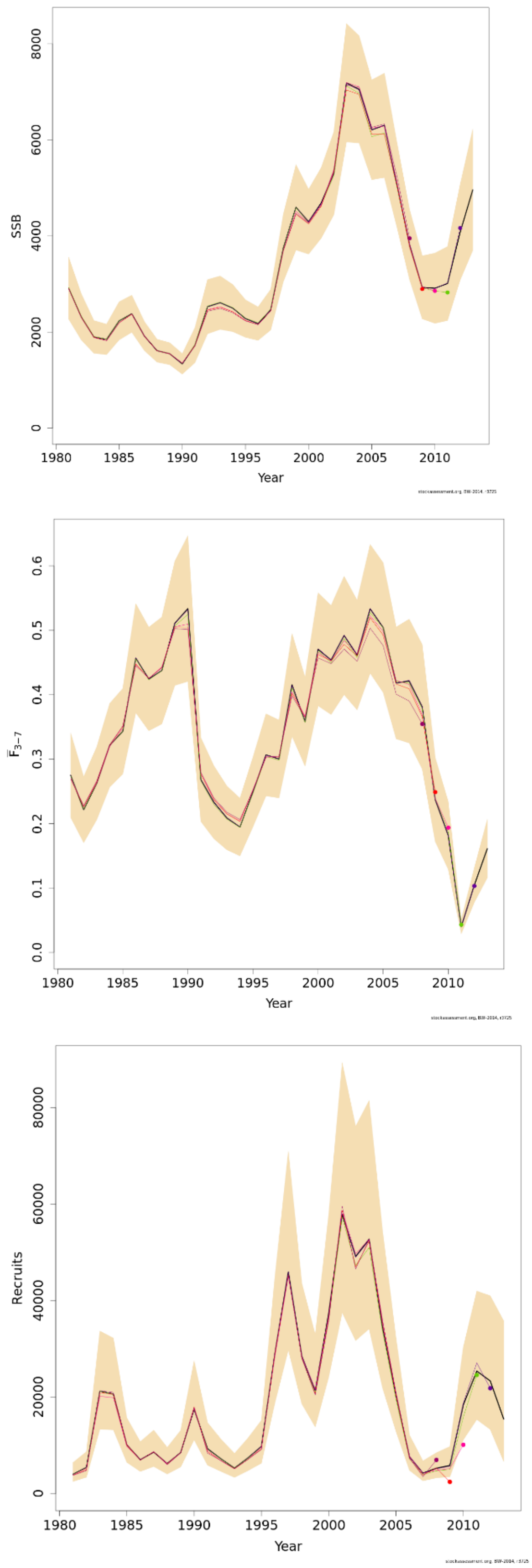


Figure 8.4.3 Blue Whiting. Retrospective analysis of SSB, F and recruitment (age 1) using the SAM model. The 95% confidence interval is shown for the most recent assessment.

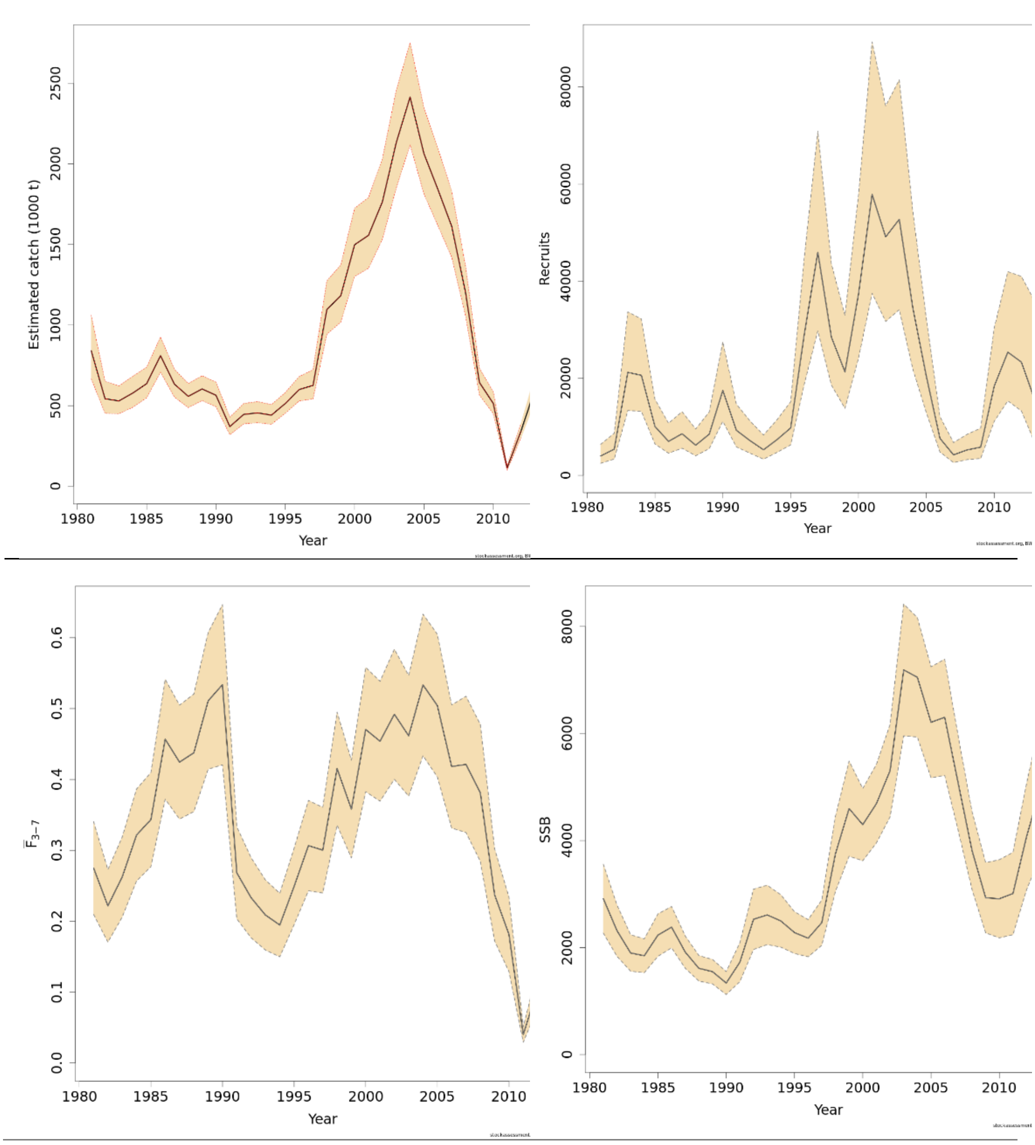


Figure 8.4.4 Blue whiting. SAM final run: Stock summary landings, recruitment (age 1), F and SSB. The graphs show the median value and the 95% confidence interval.

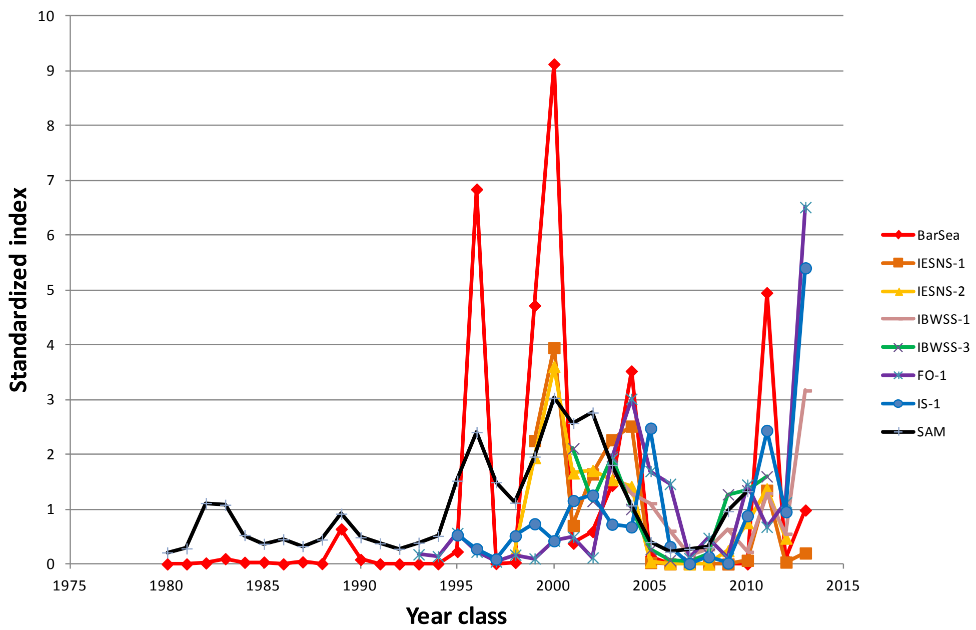


Figure 8.8.1.1. Blue whiting young fish indices from five different surveys and recruitment index from the assessment, standardized by dividing each series by their mean. BarSea - Norwegian bottom trawl survey in the Barents Sea, IESNS: International Ecosystem Survey in the Nordic Seas in May (1 and 2 is the age groups), IBWSS: Internationl Blue Whiting Spawning Stock survey (1 and 3 is the age groups), FO: the Faroese bottom trawl surveys in spring, IS: the Icelandic bottom trawl survey in spring, SAM: recruits from the assessment.

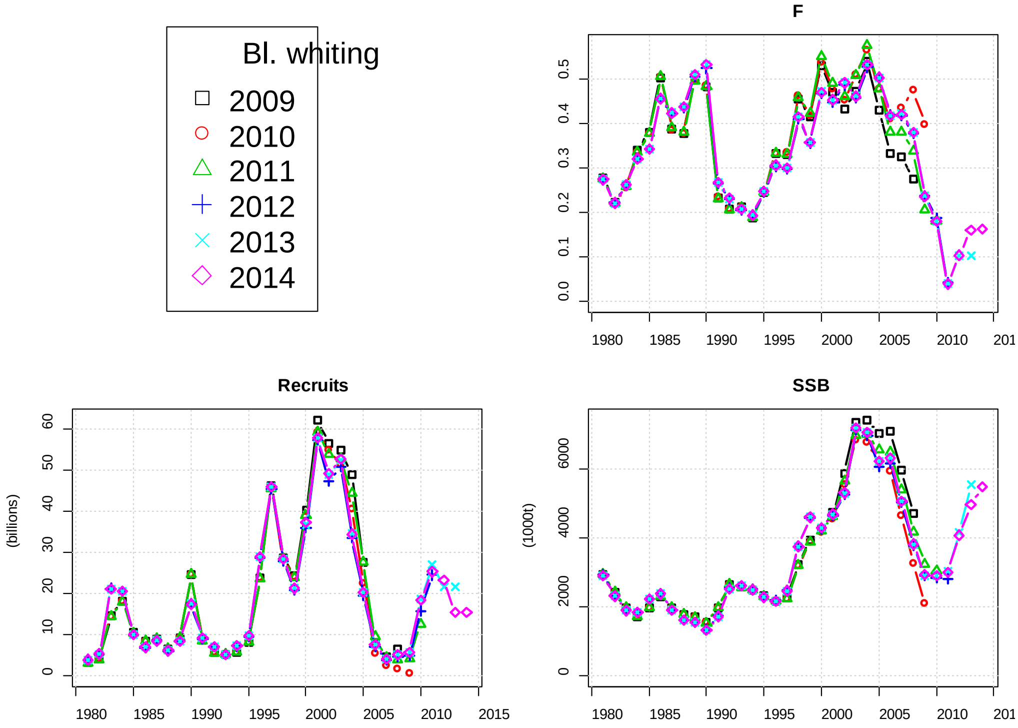


Figure 8.9.1. Blue whiting. Comparison of the 2009 - 2014 assessments.

9 Recommendations

9.1 NE Atlantic mackerel

IBTS survey and the derived recruit index

WGWIDE regards the addition of the first quarter survey data as an improvement over the version implemented during the 2014 WKPELA benchmark workshop (ICES CM 2014 / ACOM:43). However, the analysis suggested a possible difference in catchability between first and fourth quarter surveys, so this should be further explored before the new index is implemented in the assessment.

IESSNS survey

- Cover the NEA mackerel stock completely during the summer feeding
- Increase the survey effort in Greenlandic and international waters in the western part of the survey area.
- Develop a method that can sample the mackerel representatively in the North West European shelf Seas south of 58.5N, where mackerel tend to dive under surface trawls.

9.2 Blue whiting stock structure

The ICES Stock Identification Methods Working Group (SIMWG) reviewed this evidence in 2014 (ICES SIMWG 2014) and concluded that the perception of blue whiting in the NE Atlantic as a single-stock unit is not supported by the best available science. SIMWG further recommended that blue whiting be considered as two units. However, there is currently no information available that can be used as the basis for generating advice on the status of the individual stocks. There is therefore a need to begin to collate information on these stocks:

- Otolith-shape analysis has recently been shown to be able to reliably identify the stock-origin of sampled fish Keating et al (2014). Use of this method in conjunction with age-reading in both scientific surveys and catch sampling can therefore provide a valuable source of information about the individual stocks. WGWIDE therefore recommends that during the next "Age Reading Workshop for Blue Whiting", otoliths from the whole area of this stock distribution should be collected to perform shape analysis, and used to both standardize the technique and plan for its roll-out.
- The spatial and temporal coverage of the International Blue-whiting spawning stock survey (IBWSS) currently does not include the southern component, which spawns in the Porcupine Seabight in February-March (Pointin and Payne 2014). WGWIDE therefore recommends expansion of this survey to cover this component. [WGIPS]
- This Mackerel Egg Survey (MEGS) survey has previously been shown to provide valuable information about the distribution of fish spawning, including blue whiting (Ibaibarriaga et al 2007). This survey covers the spatial and temporal distribution of spawning in both blue whiting stocks extremely well, and can therefore provide valuable information about their relative abundances. WGWIDE therefore recommends that WGMEGS checks the possibility of identifying and counting the blue

whiting larval per haul during the 2016 version of this survey. [WGMEGS]

- Seek/provide statistical advice on how to bias correct log-normally distributed SSB values used to predict future catches in stochastic simulations. TO METHODS WG.

10 Working Documents

Results on Atlantic mackerel Spanish Discard Sampling Programme

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Abstract

Quarterly discards per ICES Divisions estimates for the Spanish bottom otter trawl fleet fishing in the Northeast Atlantic ICES Subareas VI, VII, VIII and IX are presented for Atlantic mackerel (Scomber scombrus). Information was obtained by observers on board under DCF discard sampling program carried out by the Spanish research institute IEO. Raising based on effort (number of trips) was used to estimate discards in weight and number for the most important fleets of Bottom Otter Trawlers. Discards age distributions are also presented.

No trend is observed in discards volume only a great seasonality with higher discards values generally in the 1st and 4th quarter in Subarea VI_VII, and in the 1º in VIIIc and IXa Divisions. Thus, discards are highly variable throughout the series, both in weight and in number ranging from 30 to 4 580 tonnes per quarter and from 2 to 70 million fish. The highest discard weights are in Divisions VIIj, VIIIc and IXaN. 100% catches are discarded in Sub-areas VI-VII.

Ages modes can, to some extent, be followed from one quarter to the next, especially in Divisions VIIIc-IXaN, although the signal is not very strong.

Keywords: Mackerel, Discards, Northeast Atlantic waters, Bottom Otter Trawl.

1. Introduction

The "Spanish Discards Sampling Programme" was started in 1988. It does not cover every year because its implementation has depended on funding from several national and European research projects, which have not had an annual continuity. For this reason information is presented only since 2003:

Year	Project
1988-1989	National project
1994	EC Project: Pem/93/005
1997	EC Project: 95/ 094
1999-2000	EC Project: 98/095
2001	EC Project: 99/063
2003-2014	Data Collection Regulation Programme (Spain)

Spanish data on Atlantic mackerel discards have been provided to ICES WGWIDE in the past, but it was aggregated by year till 2010 and by Northern and Southern regions for all available series (2003 to 2013).

The main objective of this working document is to present the Spanish Atlantic mackerel discards estimates since 2003 by quarter and Division. Information on sampling discard strategy and discard reasons is also presented.

2. Material and methods

The sampling strategy and the estimation methodology used in the "Spanish Discards Sampling Programme" are similar since 1988, and are in accordance with the "*Workshop on Discard Sampling Methodology and Raising Procedures*" guidelines (ICES, 2003). The observers-on-board programme is based on a stratified random sampling design. Métier is the stratum and trips (the sampling units) are randomly selected for sampling within métiers. Until 2009 the DCR asked for annual estimates and, hence, sampling was organised so as to obtain annual results.

The differences between the discards estimates presented here and those previously presented to the ICES WGWIDE are that now estimates are presented by quarter (instead of annually) and by ICES Divisions. The raising is done based on quarterly effort per métier. Total fleet discard per division are estimations from the total métier discard raising to the effort in each Division. This is because there are Division with no discard sampling per quarter.

Only the trawl fleet is considered for this species from the Spanish Discards Sampling Programme. This is because previous observations carried out on long line vessels showed low discarding levels for this species and area (Pérez et al., 1996). No information is available for gillnet in Sub-areas VI-VII, but discards of Atlantic mackerel in this gear are considered low. Information from the IXaS subdivision is available, but discarded weight is only presented because the samples are very irregular and sampled period shorter.

For discards sampling purposes, two métiers (Castro et al., 2012) are considered within the Spanish trawl fleet operating in the ICES Sub-areas VI and VII, taking into account fishing area, gear and target: One métier OTB_DEF_100-119_0_0 to target mainly hake (*Merluccius merluccius*) and anglerfish (*Lophius piscatorius and L. budegassa*) and the other one métier OTB_DEF_70-99_0_0 targeting megrims (*Lepidorhombus whiffiagonis and L. boscii*) and anglerfish. It was not possible sampled métier OTB_DEF_100-119_0_0 in 2013 so; discard in the métier OTB_DEF_70-99_0_0 was raised to the both métiers efforts.

Three métiers are considered (Punzón et al., 2010) within the Spanish trawl fleet operating in the ICES Sub-areas VIII and IXa, Northern Spanish coastal bottom otter trawl fleet: One métier OTB_DEF_>=55_0_0 targeting a variety of demersal species in ICES Divisions VIIIc and IXa-North, other coastal bottom otter trawl fleet but with higher vertical open gear OTB_MPD_>=55_0_0 targeting horse mackerel (*Trachurus trachurus*) and/or Atlantic mackerel and a Pair trawler fleet PTB_MPD_>=55_0_0 targeting blue whiting (*Micromesistius poutassou*) and/or hake and/or Atlantic mackerel. Results here are showed for the entire trawl fleet, with metiers combined. Indices are presented for all period and per métier.

For each trip sampled, several hauls are, in turn, sampled as follows. A random sample of discarded species is selected. Atlantic mackerel in the discards sample is measured for length and the weight is calculated using a length/weight relationship (Dorel, 1986; Cull et al., 1989; Pereda and Pérez, 1995). The resulting Atlantic mackerel weight in the discards sample is raised to haul level according to the total discarded weight of the haul and the proportion of Atlantic mackerel in the sample. Haul-raised data are further raised to trip level taking into account the total number of hauls in the trip. Trip-raised weight and length values are subsequently raised to quarterly métier level using the number of trips per métier. Total discard per division are estimated raising the métiers values to total division effort (logbooks values since 2012). Effort per divisions, in years previous to 2012, where information disaggregated per division were not available, was estimated with the proportion of number of trip on division logbook effort, to obtain effort estimates for the fleet.

3. Results

Sampling during 1988 to 2000 was not systematic, thus information are not used for assessment. The sampling level varies depending on the year (Table 1). The information can be considered representative of the discard behaviour of the whole Spanish trawl fishery exploiting the Atlantic mackerel stock.

Discard estimates by ICES Division and quarter are shown in weight and number in Table 2 and Figure 1-2, and per year in Figure 3. Sub-areas VI_VII show high variability along the series, with low discard in years 2005, 2009 and in 2013 (Figure 3). The discard rate does not explain this decrease because 100% of catches are always discarded. Observer on board indices (kg caught per haul) could explain the decrease in 2005 and 2009 (Figure 4). However, the strong effort reduction in 2012 and 2013 period could be the mayor reason for the discard observed decrease in 2013 (Figure 5).

Divisions VIIIc and IXa show two extremely high discard values in 2006 and 2010 (Figure 3) with a sharp drop in the middle. In these both years the three métiers operating in the area present high catch indices (kg caught per haul) in some of the both years (Figure 6). The behaviour patterns of catch indices are highly variable depending on the métier analyzed (Figure 6). Only the OTB_DEF_>=55_0_0 métier shows a gradually decrees in abundance indices since 2004-2006, due probably the specialization of this métiers in high value species as hake, megrims or anglerfishes (Santos et al, 2012). Both métiers (OTB_MPD_>=55_0_0 and PTB_MPD_>=55_0_0) show an increasing trend in catch per haul along the series. The discard rates also vary widely in the zone (Figure 7) but no patter is observed. No effort strong reduction in the period is observed (Figure 8).

Observer on board catch and discard indices (kg per haul) for all métiers show, in general, a gradually increase throughout the series but especially in recent years (Figure 9).

Figures 10 and 11 show the quarterly age composition of the discards. Discards are concentrated in Divisions VIIj, VIIIc and IXaN, what are the areas with the greatest effort of the fleet. Modes can, to some extent, be followed from one quarter to the next, especially in VIIIc and IXa divisions, although the signal is not very strong. High recruitment is observed at age 0 in 2005 in Division VIIIc, which can be followed, moderately well, throughout the series.

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Table 1. Quarterly discard sampling level. Haul observation on board.

Year	Quarter	VIa	VIb	VIIb	VIIc	VIIg	VIIh	VIIj	VIIk	VIIIc	IXaN	IXaS
2003	1											
	2				18		5	64	20	36	29	
	3						6	87		37	24	
	4				3			147	19	30	11	
2004	1				30			48	12	41	8	
	2				4			123	3	39	9	
	3		19		20			13	7	30	10	
	4				26			90		34	6	
2005	1				33			38		46	31	5
	2			11	5	5	30	52	2	57	10	20
	3						21	67		63	17	1
	4				4	7		52	9	33	11	
2006	1				2	27		69	10	40	19	
	2			4	20		45	61	15	40	20	9
	3			22	46			41		52	23	20
	4							14		14	7	
2007	1				1	5		65	11	43	4	
	2				27		14	41	17	54	12	12
	3				30			34	2	34	33	16
	4			22	16			75	8	47	29	
2008	1							32		71	14	
	2			9	24	5	29	46	5	56	32	3
	3		32	11	24		11	60	7	49	46	15
	4			1	27			89	14	38	23	
2009	1							60	29	46	16	2
	2			20	48		17	43	26	69	32	6
	3				14	2	5	105	4	81	28	9
	4				59			16	10	57	36	12
2010	1				11			29	24	27	14	2
	2					6	1	91	13	118	15	10
	3				57			10		71	19	10
	4			15	2	1		99	23	59	14	8
2011	1				18			46	10	74	13	5
	2						9	60		91	6	11
	3							92		103	12	12
	4		11		10		20	9	8	88	7	5
2012	1					5	17	88	14	83	15	7
	2					18	4	81		100	18	16
	3							34		75	23	8
	4				7		28	38	6	45	17	9
2013	1					1	41	62		69	5	6
	2						8	93		114	22	12
	3			10	9	4	2	8	1	56	9	8
	4				14		22	40	1	41	8	7

Table 2. Atlantic mackerel quarterly discard estimates in weight (tonnes) derived from the total discard number for the Spanish trawl fishery operating in Sub-areas VI-VII-VIII and IXa per Divisions, according to weight/length relationship.

Year	Quarter	VIa	VIb	VIIb	VIIc	VIIg	VIIh	VIIj	VIIk	VIIIc	IXa	IXaS
2003	1	0	0	1	4	1	20	57	1	0	0	
	2	0	3	0	10	5	17	43	5	305	170	
	3	0	3	1	4	0	5	24	3	34	19	
	4	0	0	1	2	2	8	25	1	1	1	
2004	1	0	4	8	110	44	261	838	59	439	396	
	2	10	94	50	210	159	328	902	91	23	23	
	3	0	0	0	0	0	0	0	0	17	17	
	4	0	37	48	111	63	179	617	54	6	5	
2005	1	0	9	26	72	22	78	380	34	86	25	
	2	0	2	1	12	3	10	41	14	11	3	
	3	0	2	0	5	1	8	29	4	22	5	
	4	1	5	2	13	3	14	50	6	180	58	
2006	1	0	7	27	73	53	61	310	68	1614	1225	
	2	0	9	11	45	12	38	130	33	363	249	
	3	1	8	9	27	5	28	118	20	41	31	
	4	1	9	12	34	9	27	123	11	48	32	
2007	1	0	28	106	194	37	203	934	62	26	22	
	2	1	5	7	23	4	15	79	12	32	26	
	3	0	1	0	3	0	2	11	2	21	16	
	4	0	2	2	7	3	4	26	3	8	5	
2008	1	0	22	113	326	51	181	1089	166	28	17	
	2	0	4	5	19	5	9	52	15	11	7	
	3	0	2	3	11	5	10	36	5	3	2	
	4	1	1	8	12	4	6	38	5	3	2	
2009	1	1	6	12	27	5	20	121	5	323	222	43
	2	0	9	14	42	11	42	202	20	21	16	24
	3	0	2	3	12	11	22	69	5	65	45	22
	4	0	0	0	0	0	0	0	0	19	13	8
2010	1	0	0	0	9	0	118	1042	110	1793	873	4
	2	25	24	2	39	0	162	823	63	957	685	190
	3	0	0	0	0	0	1	11	1	11	5	26
	4	0	3	0	3	0	31	313	33	32	54	25
2011	1	6	6	15	82	0	28	560	58	176	104	0
	2	108	3	18	84	0	9	254	13	143	63	881
	3	0	0	20	71	4	51	676	0	11	10	363
	4	0	8	9	4	1	20	213	0	31	26	0
2012	1	0	0	0	26	0	184	2526	184	1777	47	26
	2	0	0	0	25	0	25	625	75	64	23	136
	3	0	0	0	2	0	2	58	6	240	40	553
	4	0	0	1	0	0	0	62	5	22	2	154
2013	1	0	0	6	13	16	74	378	0	742	110	47
	2	0	0	4	8	0	12	108	0	141	21	70
	3	0	0	0	0	0	0	7	0	113	3	266
	4	0	0	0	0	0	0	2	0	201	29	5

Figure 1. Atlantic mackerel quarterly discard estimates in weight (tonnes) for the Spanish trawl fishery in ICES Sub-area.

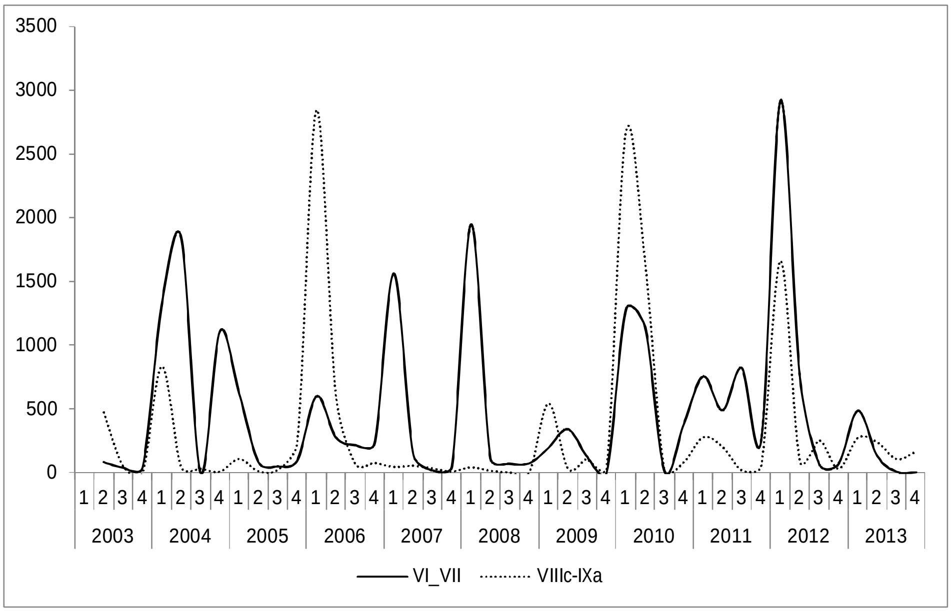


Figure 2. Atlantic mackerel quarterly discard estimates in number (thousands) for the Spanish trawl fishery in ICES Sub-areas.

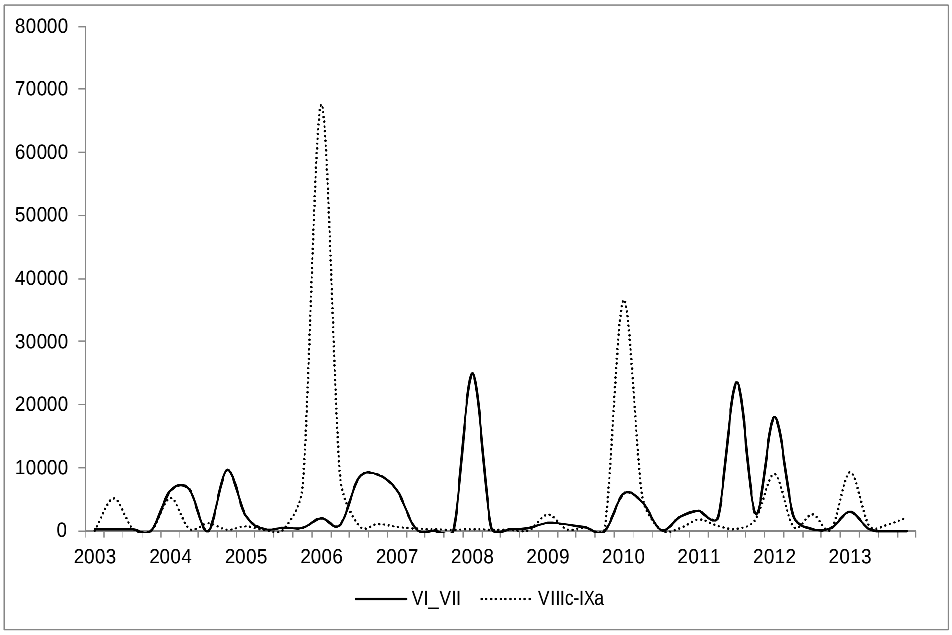


Figure 3. Atlantic mackerel yearly discard estimates in weight (tonnes) for the Spanish trawl fishery in ICES Sub-areas

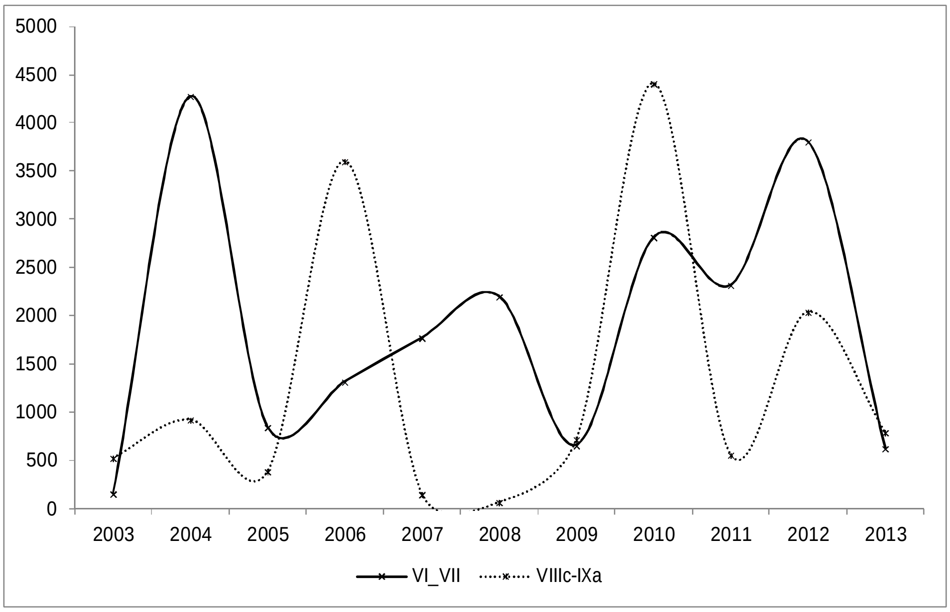


Figure 4. Observer on board indices (kg caught per haul) from métiers operated in Sub-areas VI_VII

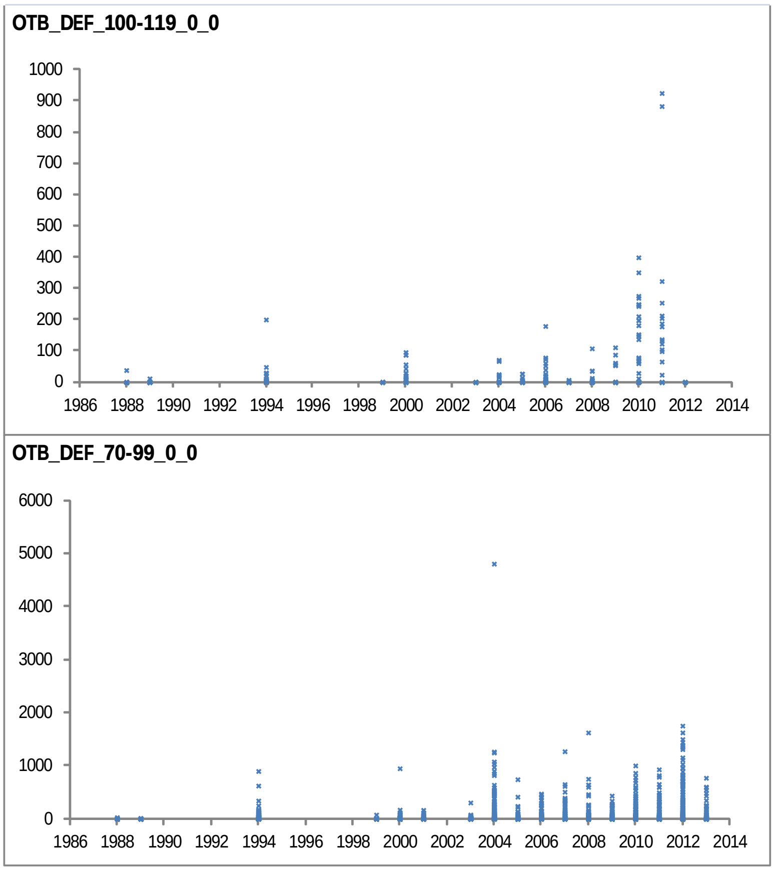


Figure 5. Effort in number of trips in Sub-areas VI_VII

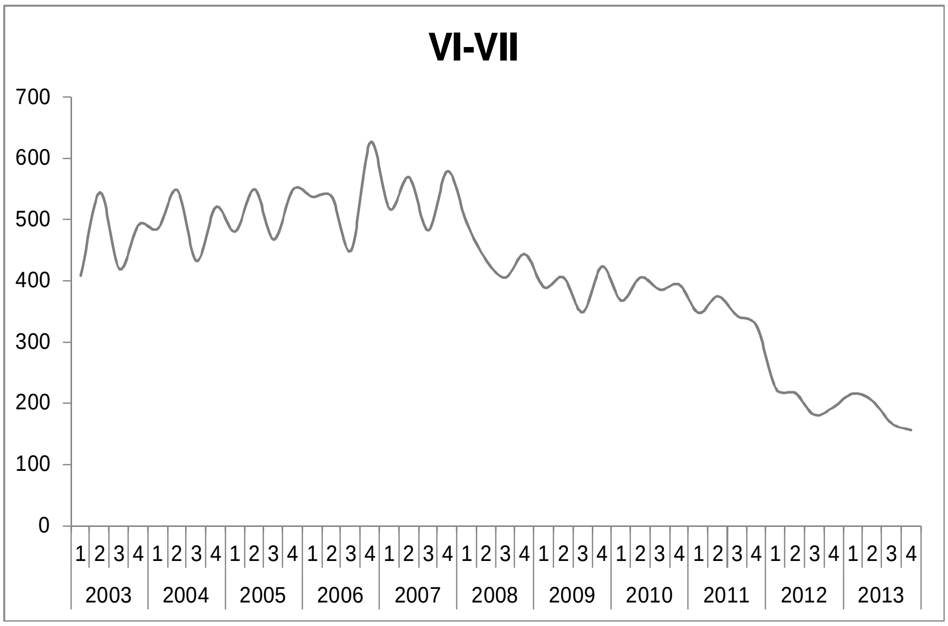


Figure 6. Catch indices, Total Catch per Haul (kg) in observed trips of OTB_DEF_>=55_0_0, OTB_MPD_>=55_0_0 and PTB_MPD_>=55_0_0

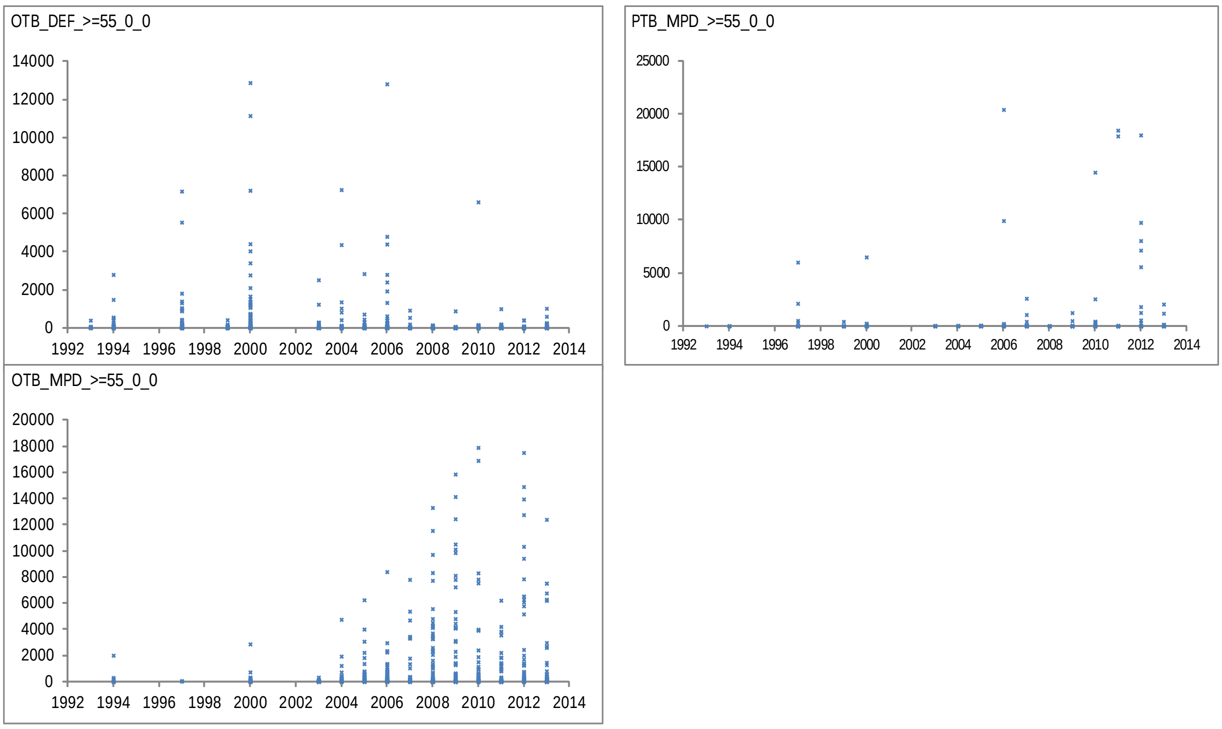


Figure 7. Discard rate (discard weight/catch weight) by métier in Divisions VIIIc and IXa. 1994-2013

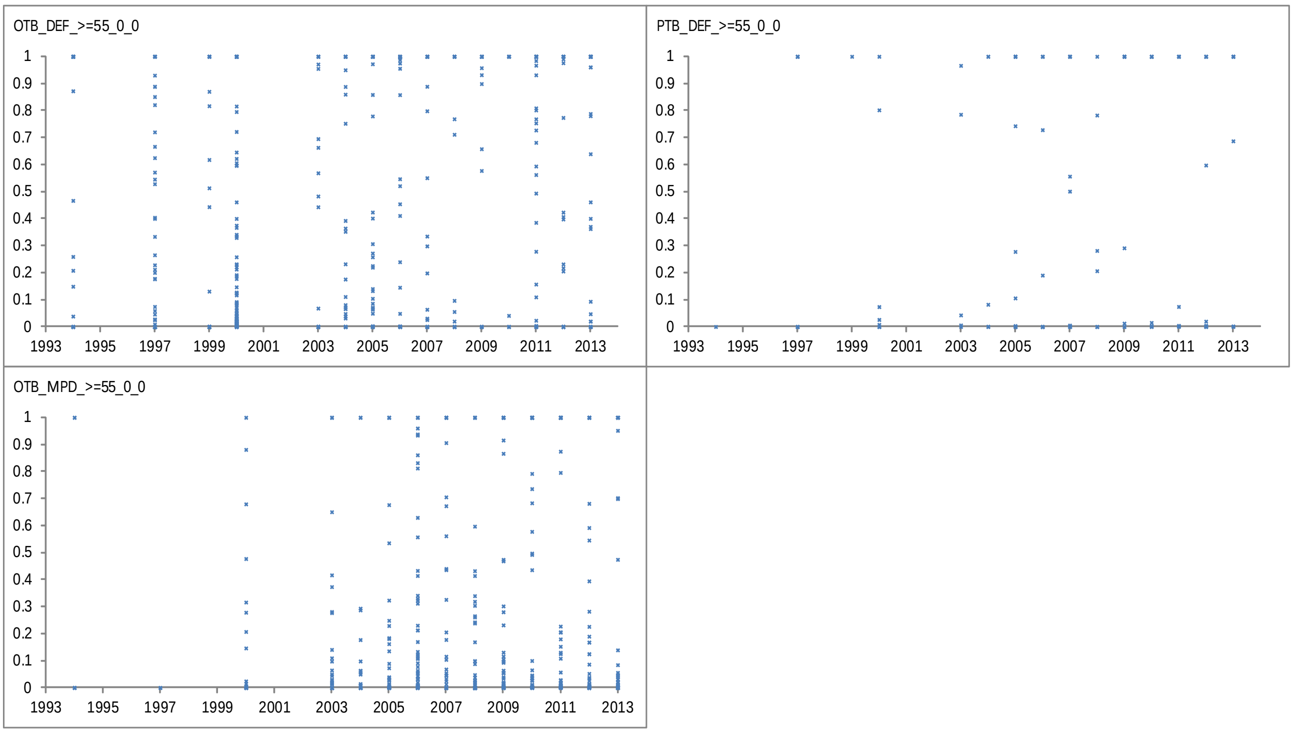


Figure 8. Effort in number of trips in Divisions VIIIc, IXaN

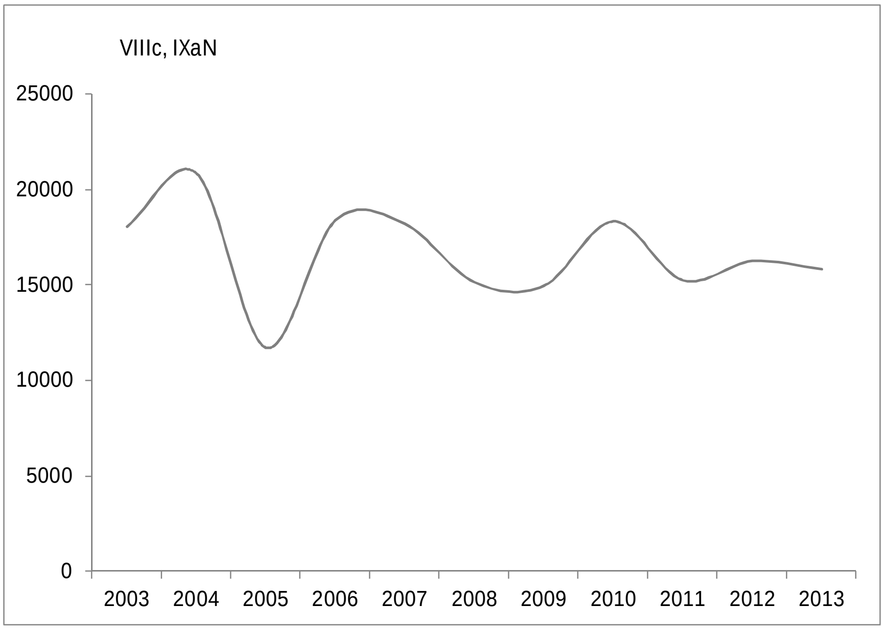


Figure 9. Observer on board indices; kg caught/haul (points, on the left axis) and mean kg caught/haul (line, on the right axis) from all métiers, upper figure and discard indices in lower.

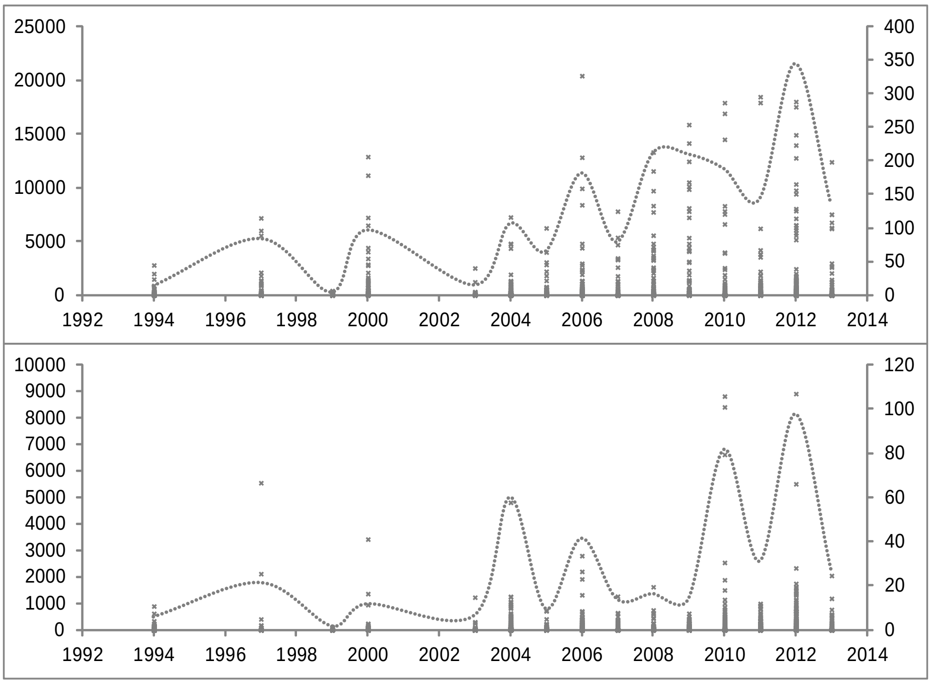


Figure 10. Quarterly age composition of Spanish trawl discards of Atlantic mackerel in ICES Sub-areas VI and VII.

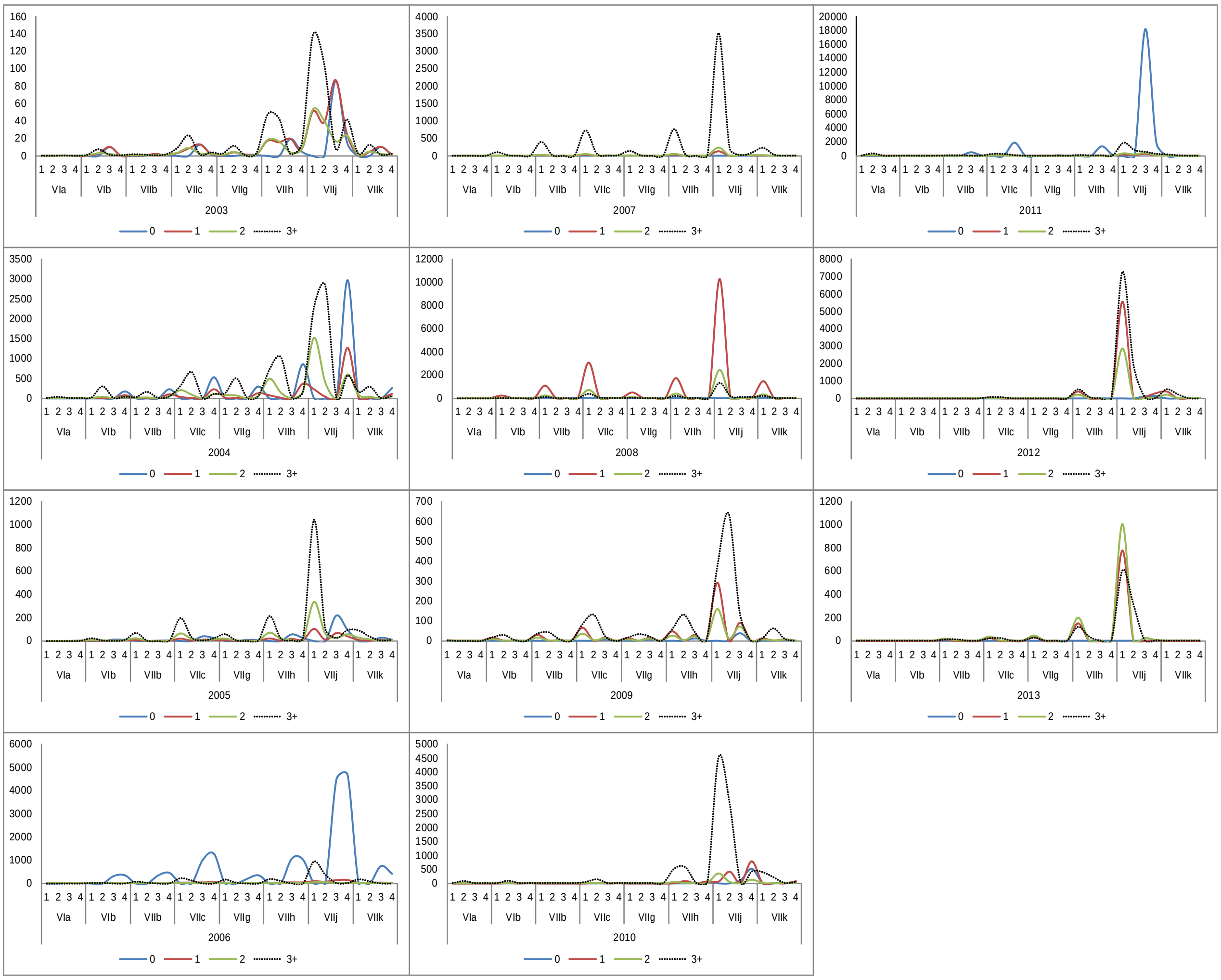
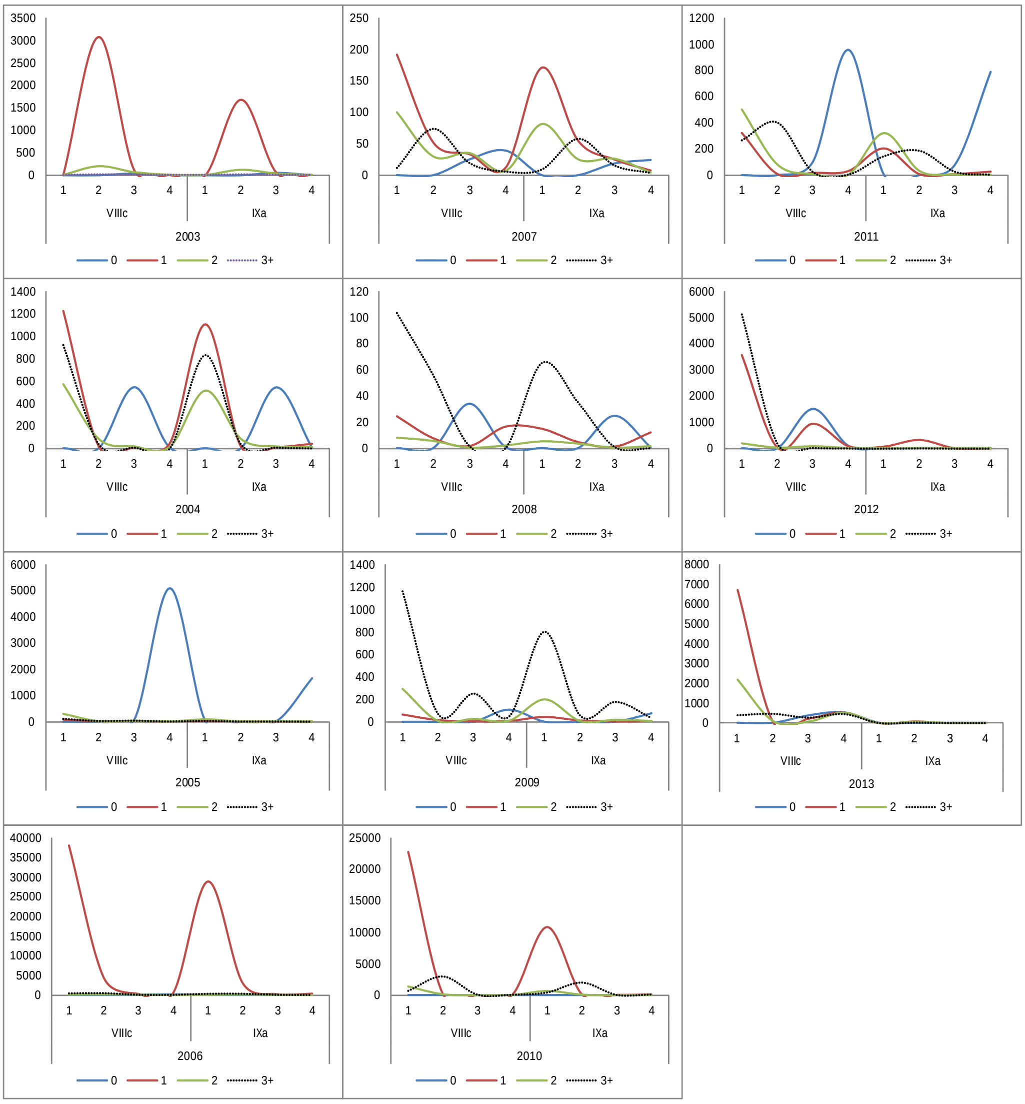


Figure 11. Quarterly age composition of Spanish trawl discards of Atlantic mackerel in ICES Divisions VIIIc-IXaN.



Working Document on Working Group on Widely Distributed Stocks (WGWIDE-2014).
26th August-1st September 2014.Copenhagen.

REVIEW OF THE MACKEREL SSB ESTIMATED FROM THE EGG SURVEY DATA APPLYING THE UPDATED METHODOLOGY.

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Introduction

The international mackerel and horse mackerel egg surveys take place every 3 years and cover the spawning grounds in the NE Atlantic. It typically takes place between January and July and aims to cover the entire spawning area from Cadiz in the south up as far as NW Scotland in the north and since 2010, up to the waters around the Faroe Islands and southeast of Iceland.

The surveys are divided into three geographical component areas, the western, southern and the North Sea. In the western area, the mackerel egg survey has been running continuously on a triennial basis since 1977 and since 1992 has also sampled the southern spawning component. The egg survey in the North Sea has been running since 1968.

The objective of the triennial surveys is to cover the entire spawning area in space and time and produce both an index and a direct estimate of the biomass of the north east Atlantic mackerel stock and an index for the southern and western horse mackerel stocks. The results have been used in the assessment for mackerel since 1977. The mackerel egg survey has been the only source of data providing fisheries independent information for these stocks. The general method is to quantify the freshly spawned eggs in the water column on the spawning grounds to estimate the spawning stock biomass. To be able to establish a relationship between eggs and biomass of the spawning stock, the fecundity of the females must also be determined.

The general methodology used to estimate the spawning stock biomass for NEA Mackerel stock is the Annual egg Production Method (AEPM) (ICES, 1996).

Material and Methods

For the estimation of daily egg production by AEPM only the counts of stage I mackerel eggs are used. To convert abundance of eggs into daily egg production data (egg/m2/day) a rate of egg development is required. The rate of egg development described by Lockwood et al. (1977) has been used for calculating daily production stage I mackerel eggs on all surveys from 1977.

The rate of mackerel egg development was updated (ICES, 2013) according to the new findings of Mendiola et al. (2006) in 2013 and has been used to recalculate the Total Annual Egg Production (TAEP) for mackerel. In this new equation rate, the mackerel eggs developed more rapidly at low temperatures than previous rate (Lockwood eq.).

In 2014 a depth review of the estimates and data collected from 1992 to 2013 by the International Mackerel Egg Surveys has been carried out. Moreover over this revised time series was applied the Mendiola rate of mackerel egg development instead of Lockwood consistently across the whole time-series

The Total egg production for mackerel has been recalculated with the new egg development equation. And using the realized fecundity data it has been estimated the Spawning Stock Biomass for NEA mackerel stock.

This work shows the differences in the TAEP and SSB in the time-series between reported values and the new update in the methodology (applying the Mendiola egg development equation) over the revised Egg production database from 1992 to 2013.

Results

As a result of this exercise a new time-series of Total egg production and SSB was produced. The main results using Mendiola mackerel egg development equation in the temporal series are presented in Table 1 and Table 2. When these values are compared with SSB and TAEP values that were published in the WGMEGGS Reports (ICES, 1993; ICES, 1996; ICES, 2000; ICES, 2002; ICES, 2005; ICES, 2008; ICES, 2011; ICES, 2014) (Table 3 & 4) a significant difference is observed (Figure 2). It should be noted that SSB and TAEP values reported in the WGMEGS reports has been estimated using the Lockwood egg development equation (Traditional methodology) with exception of TAEP in 2013 that was used Mendiola egg development equation.

In general these differences were around 15 % for the TAEP and 12 % for SSB. Although the estimates presented substantial changes and higher differences in 1992, 1995 and 2013.

The causes for bigger divergences in 1992, 1995 and 2013 were explained as:

- The 1992 reported TAEP estimate had not included the egg production from the Southern area of the survey (ICES, 1993) so that was corrected to include those. In addition, during 1992 egg survey was no covered the entire distribution area of the mackerel eggs, as it was only sampled the standard survey area defined previously.

- The 1995 survey had covered the whole distribution of the mackerel eggs because it was adopted an adaptative sampling procedure but in the calculation of the reported 1995 estimate only data from the standard area corresponding to that used in 1992 were used (ICES, 1996). In this revised estimate were incorporated data from the entire surveyed area.

- Finally, the 2013 data was revised substantially from the one presented by WGMEGS 2014. The new estimate was based on a reallocation of some stations from western area to survey periods according to the initial plan. In this case the result was that these stations in the South and Western Bay of Biscay were moved forward into period 2. One mayor reason for this revision was that in 2013 one individual survey which was supposed exclusively to take place in the survey period 3 started 4 days earlier in period 2 than what was planned. In itself this was not unusual and WGMEGS had assessed the impact of removing such stations. In the case of the period 3 survey stations that were out of period (22/3 - 26/3) the daily egg production for these stations were very low so they were removed from the analysis for the first calculation which had negligible impact on the overall total annual egg production (0.12%). The aim was to avoid the disruption of the overall survey plan for that period. With the overall revision of the egg production data those production values were reallocated into their correct period by date which in this case meant moving those forwards into period 2. The same stations were also sampled by another survey earlier in period 2 which yielded very large numbers of stage 1 mackerel eggs. By including the low density stations (previously in period 3) to period 2 now an average is used which is significantly reducing the DEP values for these previously high abundance stations leading to an overall reduction of SSB compared to the previous estimate Figure 1.

Plotting results are shown in figures 2-5.

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TAEP	1992	1995	1998	2001	2004	2007	2010	2013
southern	3.67 e14	2.26 e14	5.61 e14	3.61 e14	1.62 e14	3.50 e14	4.68 e14	6.76 e14
western	2.22 e15	2.04 e15	1.57 e15	1.34 e15	1.37 e15	1.50 e15	1.93 e15	2.14 e15
combined	2.59 e15	2.27 e15	2.13 e15	1.70 e15	1.53 e15	1.85 e15	2.40 e15	2.81 e15

Table 1.- Results of TAEP by component and combined components using Mendiola mackerel egg development equation across the whole temporal-series of the International Mackerel Egg Surveys (1992-2013).

SSB	1992	1995	1998	2001	2004	2007	2010	2013
southern	5.54 e5	4.51 e5	1.04 e6	4.73 e5	3.63 e5	7.50 e5	9.45 e5	1.21 e6
western	3.35 e6	3.39 e6	3.38 e6	2.80 e6	2.80 e6	3.22 e6	3.89 e6	3.82 e6
combined	3.90 e6	3.84 e6	4.42 e6	3.27 e6	3.17 e6	3.97 e6	4.84 e6	5.03 e6

Table 2.- Results of SSB by component and combined components using Mendiola mackerel egg development equation across the whole temporal-series of the International Mackerel Egg Surveys (1992-2013).

TAEP	1992	1995	1998	2001	2004	2007	2010	2013
southern	-	1.69 e14	4.34 e14	2.83 e14	1.20 e14	3.27 e14	4.25 e14	6.12 e14*
western	1.94 e15	1.49 e15	1.37 e15	1.21 e15	1.20 e15	1.21 e15	1.70 e15	1.86 e15*
combined	-	1.66 e15	1.80 e15	1.49 e15	1.32 e15	1.54 e15	2.13 e15	2.47 e15*

Table 3.- Results of reported mackerel egg production by WGMEGS from 1992 to 2013. Egg productions were estimated using Lockwood egg development equation (Traditional Methodology) with exception in 2013. * means that egg production was estimated using Mendiola equation.

SSB	1992	1995	1998	2001	2004	2007	2010	2013
southern	-	3.09 e5	8.00 e5	3.70 e5	2.80 e5	7.01 e5	8.58 e5	1.28 e6*
western	2.93 e6	2.47 e6	2.95 e6	2.53 e6	2.47 e6	2.95 e6	3.43 e6	4.29 e6*
combined	2.93 e6**	2.78 e6	3.75 e6	2.90 e6	2.75 e6	3.65 e6	4.29 e6	5.57 e6*

Table 3.- Results of reported SSB by WGMEGS from 1992 to 2013. SSB were estimated using Traditional Methodology (use Lockwood egg development equation). * means that egg production was estimated using Mendiola equation.

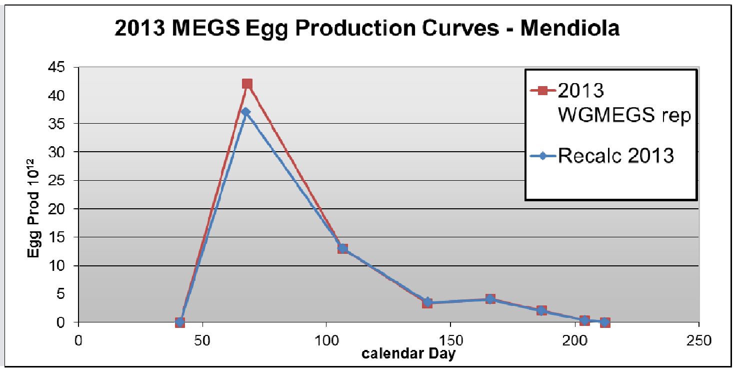

Figure 1.-. Comparison of the originally reported and revised mackerel egg production curve for the Western area.

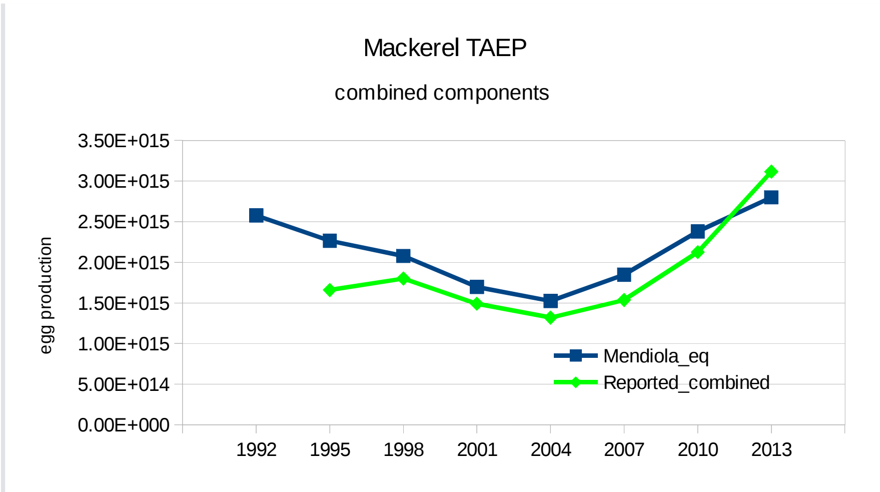

Figure 2.-. Mackerel TAEP estimates derived from the mackerel egg surveys. The green line represents the Annual egg Production for the mackerel reported by WGMEGS. The blue line represents the recalculated egg production using Mendiola equation. It should be noted that reported egg production in 2013 was estimated using Mendiola equation.

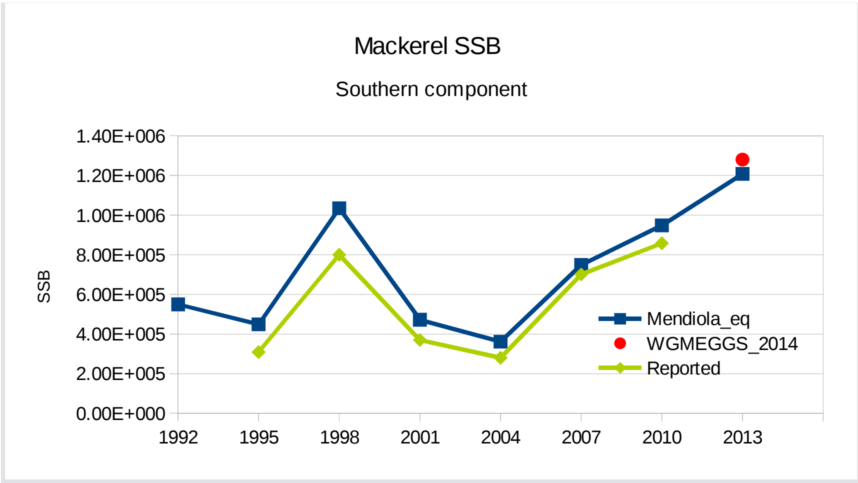

Figure 3.-.. Mackerel SSB estimates derived from annual egg production for the southern area only. The green line represents the reported estimates by WGMEGS until 2012. The red spot is the estimate given by WGMEGS for the updated advice. The blue line represents the recalculate SSB using Mendiola egg development equation.

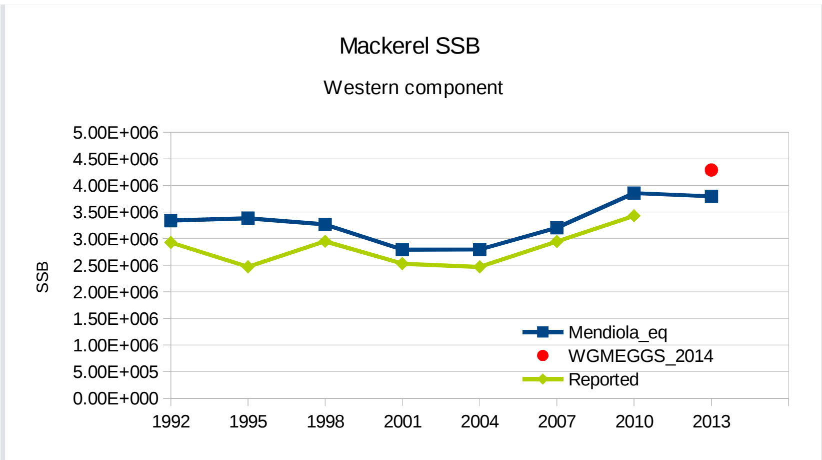

Figure 4.-.. Mackerel SSB estimates derived from annual egg production for the western area only. The green line represents the reported estimates by WGMEGS until 2012. The red spot is the estimate given by WGMEGS for the updated advice. The blue line represents the recalculate SSB using Mendiola egg development equation

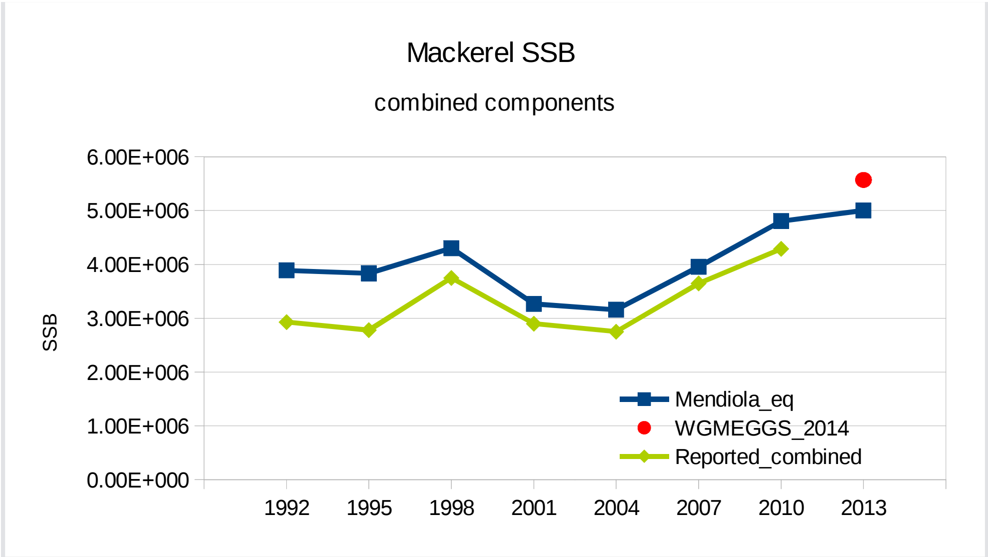

Figure 5.-. Mackerel SSB estimates derived from the mackerel egg surveys for the combined survey area. The green line represents the reported estimates by WGMEGS until 2012. The red spot is the estimate given by WGMEGS for the updated advice. The blue line represents the recalculate SSB using Mendiola egg development equation.

Exploratory assessments of Norwegian spring-spawning herring with two assessment models and two different sets of survey data

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Introduction

The assessment of Norwegian spring-spawning herring is basically carried out using the model, model configuration and data sources agreed upon during the last benchmark assessment in 2008 (ICES, 2008). The assessment model used is the VPA population model in TASACS (A Toolbox for Age-structured Stock Assessment using Catch and Survey data) (ICES, 2013a).

The next benchmark assessment of Norwegian spring-spawning herring is planned to occur in 2016. A new assessment model candidate is SAM (State-space Stock Assessment) (Nielsen and Berg, 2014). This model framework is currently used on many other herring stocks in the ICES system (see e.g. ICES, 2013b). As opposed to TASACS, SAM is statistical model, see Nielsen and Berg (2014) for more details.

In another working document for WGWIDE 2014 (Salthaug and Johnsen, 2014), it is evaluated whether different time series of survey indices provide valid signals of trends in abundance of Norwegian spring-spawning herring. The authors claim that the methods used are more systematic and statistical compared to the methods that was used to exclude/include survey data during the benchmark assessment in 2008.

The objectives of this work are:

- Explore the effect of using the survey data recommended by Salthaug and Johnsen (2014) on stock assessments of Norwegian spawning-spawning herring.
- Compare the outcome of the presently used assessment model TASACS with the possible takeover candidate SAM.

Methods

The following four assessment runs are carried out:

1. ***TASACS_update***; same settings and data as in the final assessment in 2013 (ICES, 2013a) with some minor exceptions: the 2013 indices from the Ecosystem survey in the Barents Sea (age 0-2) are added to the survey data, and the 0-group time series from the same survey is taken from the cruise report (Prokhorova, 2013).
2. ***TASACS_new***; almost the same settings and catch data as the final assessment in 2013, but the survey data used are those recommended in Salthaug and Johnsen (2014) except that age 11 time series from the IESNS survey ("May survey") is included. Though this age was recommended excluded it was decided to use in the assessment due to lack of other survey data for this age in recent years and since it almost passed the inclusion criteria. The survey data used are given in Salthaug and Johnsen (2014). Another difference is that the 2000 and 2001 year classes for which the N-values in 2012 were set to fixed in the update assessment are now set to be estimated by the model.
3. ***SAM_update***; same input data as in Run 1. The configuration file is shown in Appendix A1. The model was run on stockassessment.org, and the stock is available for all users under the name "her_noss3".
4. ***SAM_new***; same input data as in Run 2. The configuration file is shown in Appendix A2. The model was run on stockassessment.org, and the stock is available for all users under the name "her_noss9".

The acronyms in bold are used when describing the different runs below.

Results and discussion

Figure 1 shows the trend in spawning stock biomass (SSB) from the four assessment runs. The trend is quite similar in the four runs but both in TASACS and SAM, inclusion of new survey data leads to higher SSB over the entire time period. In 2013 the difference is about 2.5 million tonnes for TASACS and 1.6 million tonnes for SAM. It should also be noted that SAM gives a higher SSB than TASACS in the period 2004-2009. Figure 2 shows the trend in average fishing mortality from the four assessment runs. The trends are quite similar except for *TASACS_new* which shows a large drop after 2009. The F-level differences correspond (inversely) to the differences in SSB. The negative log likelihood value is 745.13 in *SAM_update* and 1120.07 in *SAM_new*.

The stock summaries of the four assessment runs are shown in and tables 1-4 and figures 3-5. The trend in recruitment is quite different in SAM and TASACS since a stock-recruit function is used in SAM which restricts the amount of permitted change from one year to the next.

Residuals for the survey fleets in the assessment runs are shown in figures 6-9. *TASACS_new* has more large residuals than *TASACS_update*. However, most indices which give rise to large residuals in *TASACS_new* are excluded in *TASACS_update*. The residual plots look more similar for the two SAM runs.

The retrospective plots from the assessment runs are shown in figures 10-12. They all generally show a downward revision of SSB and an upward revision of F as more data years are added. This revision is most systematic in TASACS. Figure 13 shows the average yearly revision of SSB in the retrospective analyses. SSBs in the most recent years are revised more in TASACS while the revision is largest in SAM in the first years. The revision in SAM is more constant from year to year compared to TASACS. Inclusion of new survey data leads to a stronger retrospective pattern in both assessment models.

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Table 1. Stock summary from *TASACS_update*.

Year	Recruits*	TSB**	SSB**	F514
1988	26	3.42	2.00	0.730
1989	71	4.07	3.25	0.254
1990	109	4.61	3.82	0.452
1991	308	5.24	3.73	0.107
1992	367	6.28	3.81	0.114
1993	113	7.35	3.76	0.034
1994	39	8.40	3.89	0.184
1995	20	9.19	3.85	0.274
1996	59	9.27	4.32	0.240
1997	34	9.16	5.53	0.305
1998	248	8.01	6.21	0.214
1999	169	9.09	6.32	0.259
2000	58	8.45	5.37	0.332
2001	35	7.07	4.36	0.190
2002	367	7.49	3.82	0.220
2003	160	8.98	4.68	0.222
2004	277	10.82	5.81	0.326
2005	59	11.30	5.87	0.260
2006	66	12.13	6.08	0.250
2007	23	11.51	6.79	0.197
2008	15	11.27	7.31	0.252
2009	43	10.37	8.20	0.289
2010	7	8.71	7.53	0.330
2011	25	7.06	6.33	0.347
2012	14	6.09	5.42	0.276
2013			4.59	

*age 0 in billions

**million tonnes

Table 2. Stock summary from *TASACS_new*.

Year	Recruits*	TSB**	SSB**	F514
1988	26	3.53	2.05	0.728
1989	80	4.22	3.35	0.253
1990	110	4.79	3.96	0.45
1991	345	5.48	3.88	0.106
1992	405	6.64	3.96	0.112
1993	129	7.87	3.94	0.033
1994	42	9.04	4.11	0.178
1995	13	9.96	4.06	0.261
1996	62	10.12	4.68	0.222
1997	41	10.15	6.15	0.274
1998	205	8.99	7.06	0.191
1999	214	9.85	7.32	0.227
2000	92	9.66	6.32	0.284
2001	51	8.26	5.26	0.16
2002	449	8.37	4.63	0.183
2003	181	10.46	5.24	0.183
2004	369	12.90	6.59	0.261
2005	69	13.66	6.92	0.191
2006	88	15.06	7.52	0.195
2007	20	14.38	8.51	0.156
2008	11	14.40	9.35	0.255
2009	76	13.57	10.82	0.358
2010	14	11.65	10.10	0.159
2011	39	9.93	8.92	0.112
2012	23	9.00	7.94	0.107
2013			7.00	

*age 0 in billions

**million tonnes

Table 3. Stock summary from *SAM_update*.

Year	Recruits*	TSB**	SSB**	F514
1988	59115280	1854267	1067681	0.722
1989	42372071	2505503	1657797	0.249
1990	90875410	2722334	1874776	0.229
1991	104845668	3239728	1841332	0.124
1992	116453196	3591211	2055439	0.122
1993	58527073	4652894	2641876	0.181
1994	71270995	5438425	2928497	0.245
1995	57771146	6550160	3090984	0.359
1996	105687798	7944576	3446949	0.341
1997	70844649	8948532	5168019	0.385
1998	120721887	8153844	6144083	0.301
1999	70632434	8580476	6465559	0.342
2000	89701675	6955199	4699657	0.432
2001	57196313	5891375	3555478	0.254
2002	159571076	6331198	3147125	0.295
2003	104218478	8227560	4164055	0.236
2004	111775170	10324187	6034479	0.238
2005	53919352	10929761	6382051	0.24
2006	78924322	12237310	6997056	0.221
2007	62708026	12916292	8368624	0.185
2008	25984220	12335601	8418986	0.274
2009	59709399	11285170	8841791	0.300
2010	37505570	8832953	7275332	0.347
2011	28459711	7481920	6199629	0.262
2012	50173623	6343873	5106373	0.167
2013			4690267	

*age 0 in thousands

**thousand tonnes

Table 4. Stock summary from *SAM_new*.

Year	Recruits*	TSB**	SSB	F514
1988	54898688	2280716	1383324	0.633
1989	45172543	2905163	2092772	0.217
1990	106111395	3060228	2251259	0.189
1991	106430208	3499043	2037023	0.106
1992	117036920	3867040	2331448	0.107
1993	60249209	5157693	3106477	0.197
1994	60128831	5974434	3409240	0.254
1995	29918872	7138406	3311792	0.385
1996	122301516	9351058	4184928	0.408
1997	80518699	10907923	6543613	0.424
1998	159252253	10262428	7897051	0.333
1999	96784750	10029086	7444604	0.337
2000	110884536	9002384	6052609	0.398
2001	37206722	7452052	4713777	0.239
2002	197846097	7889158	3945160	0.259
2003	113919202	10427947	5282975	0.202
2004	117623570	12981035	7787263	0.197
2005	62770765	13230033	7904952	0.197
2006	99334152	14665377	8753814	0.178
2007	73809647	16159198	10767038	0.148
2008	30219561	15510069	10799388	0.220
2009	85241588	14090340	11094943	0.254
2010	53543234	10617350	8692751	0.310
2011	34969961	9568624	7865526	0.220
2012	63401622	8170168	6550160	0.131
2013			6343873	

* Age 0 in thousands

** Thousand tonnes

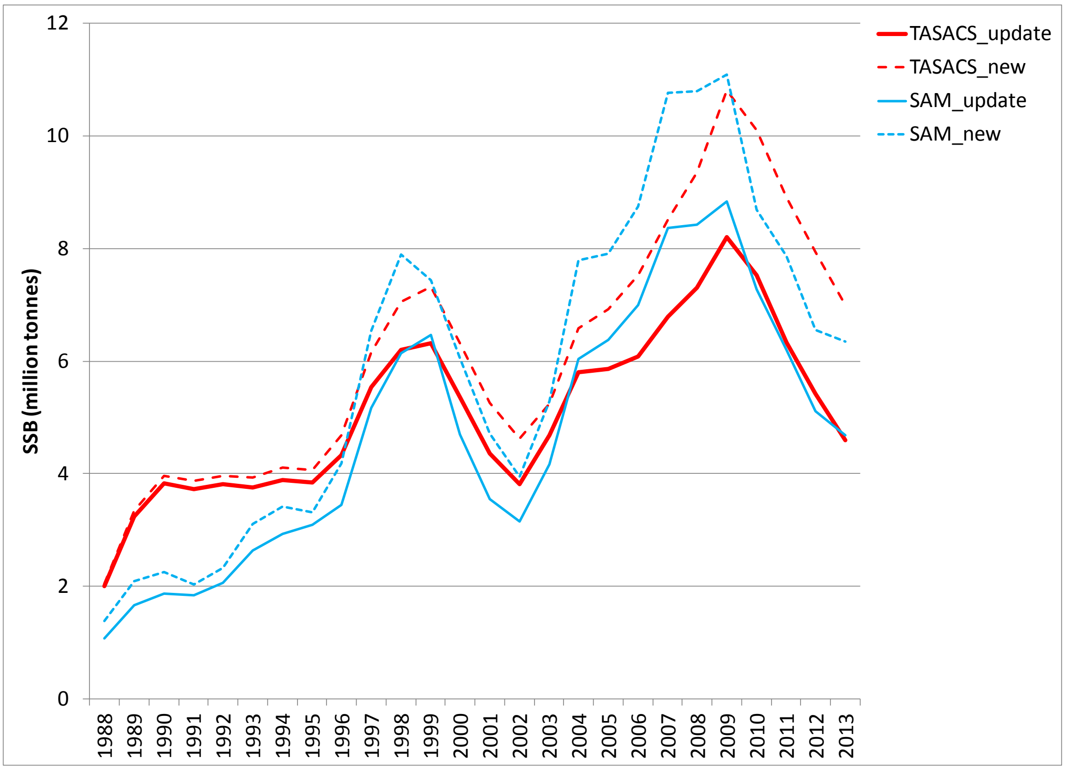

Figure 1. Comparison of SSB from TASACS and SAM using approximately the same survey data as in the final ICES assessment from 2013 (*TASACS_update* and *SAM_update*) and using the survey data recommended by Salthaug and Johnsen (2014) (*TASACS_new* and *SAM_new*).

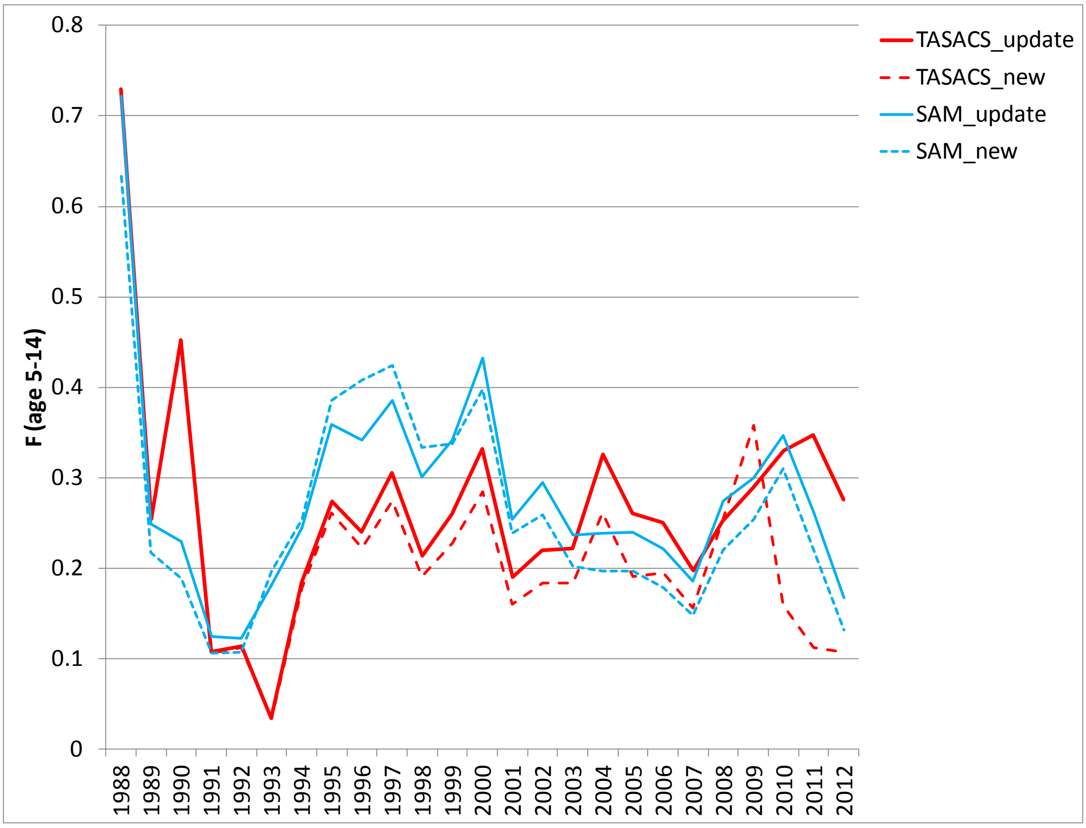

Figure 2. Comparison of mean F from TASACS and SAM using approximately the same survey data as in the final ICES assessment from 2013 (*TASACS_update* and *SAM_update*) and using the survey data recommended by Salthaug and Johnsen (2014) (*TASACS_new* and *SAM_new*).

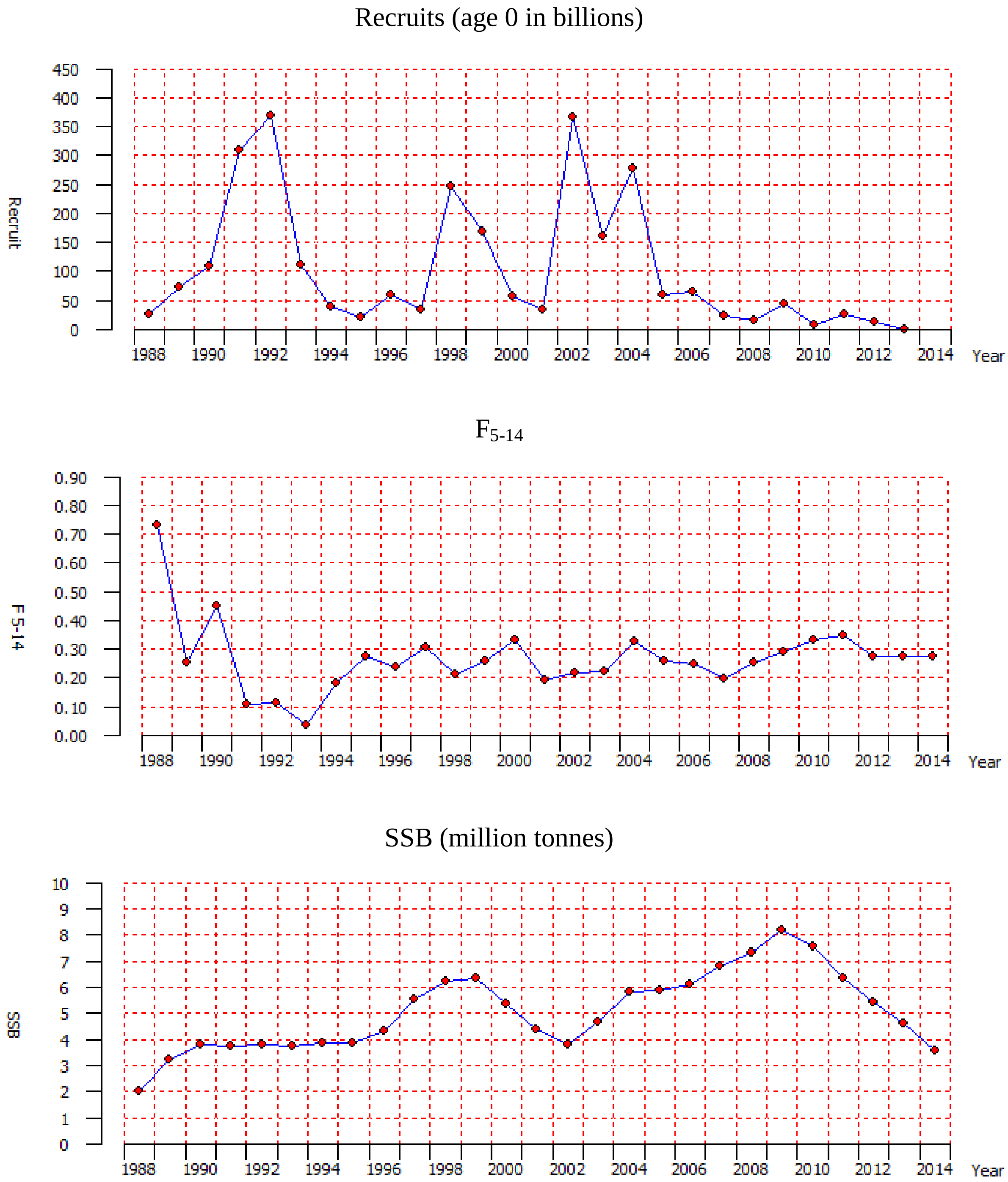

Figure 3. Stock summary of *TASACS_update*.

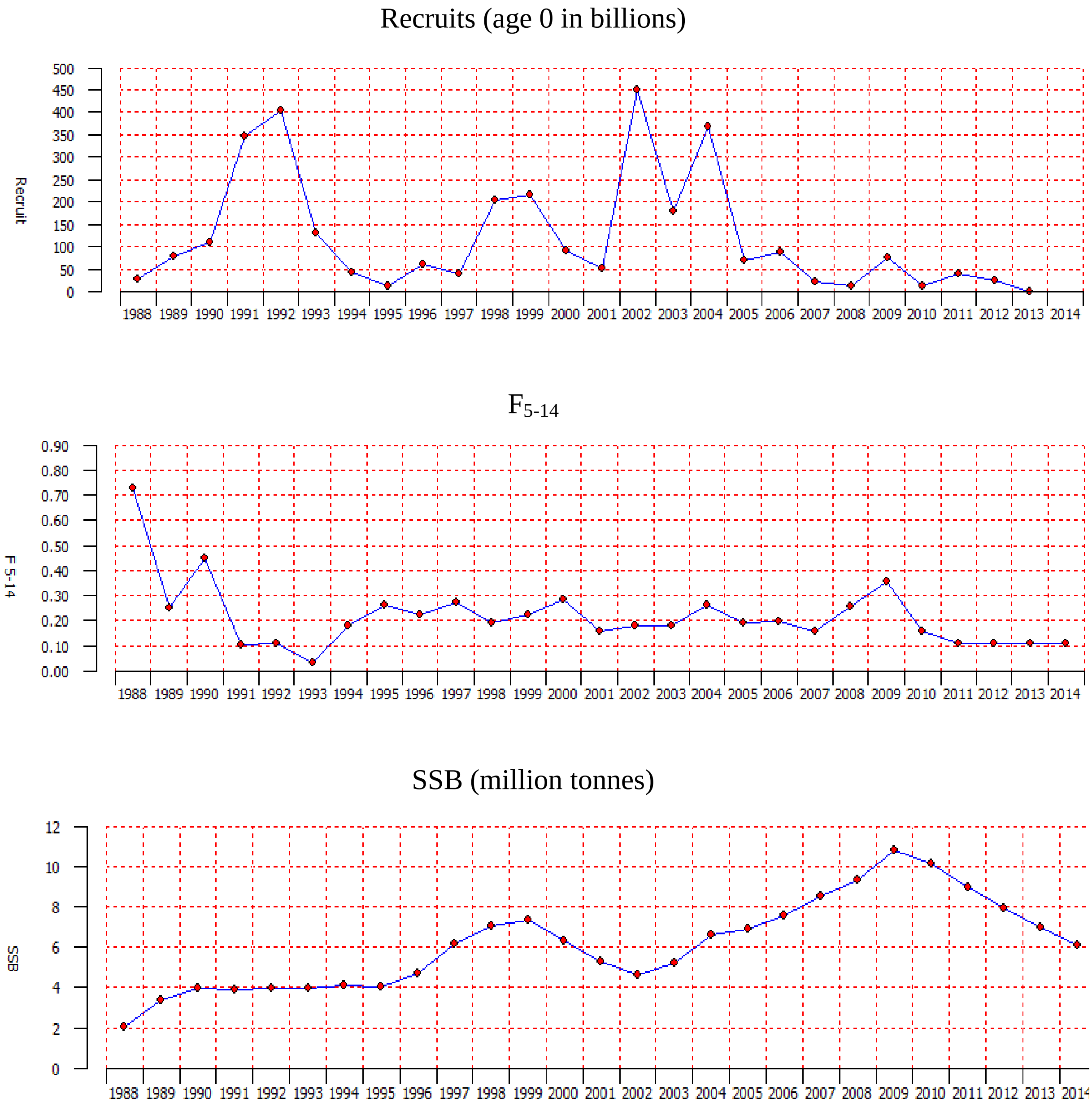

Figure 4. Stock summary of *TASACS_new*.

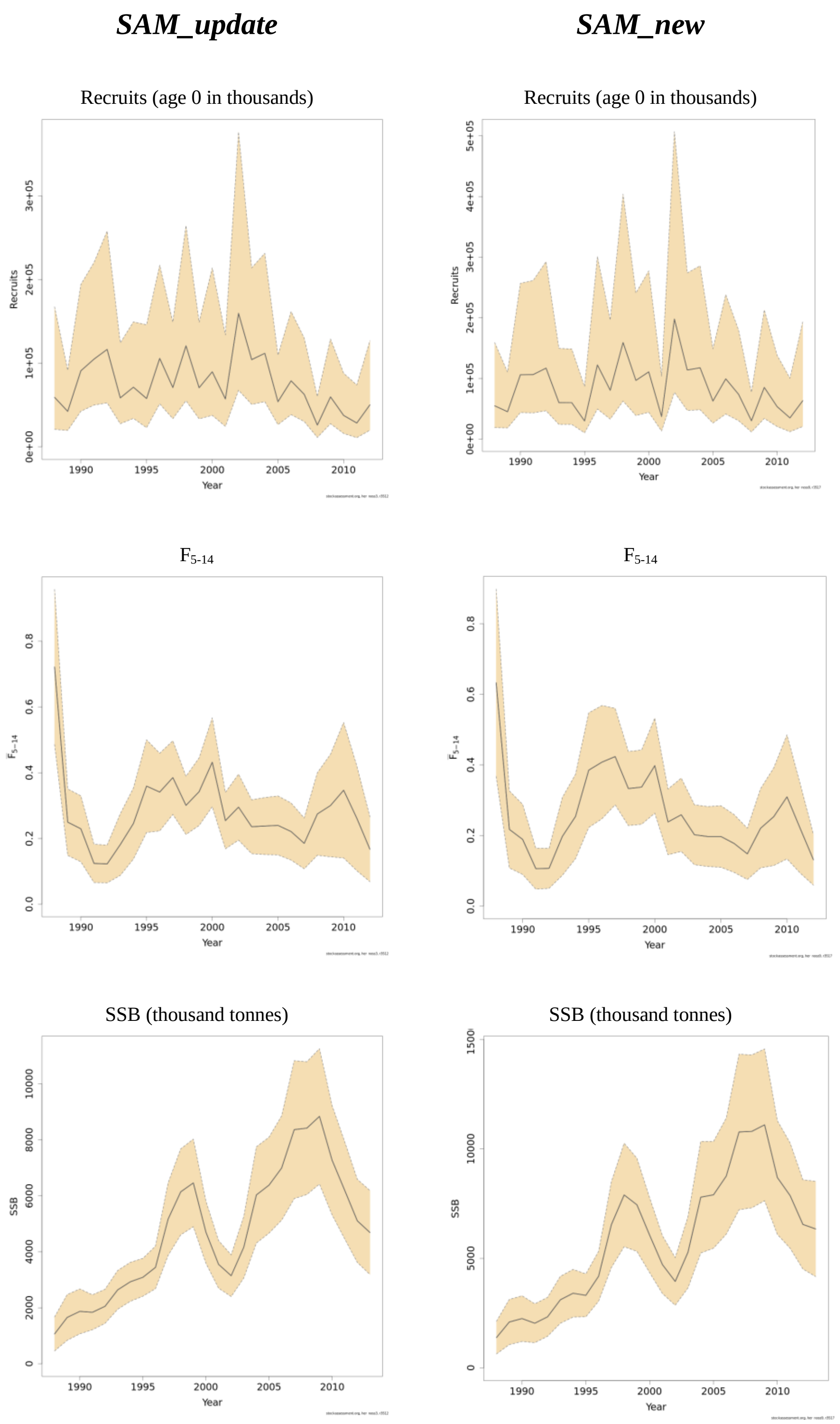

Figure 5. Stock summary of *SAM_update* (left) and *SAM_new* (right).

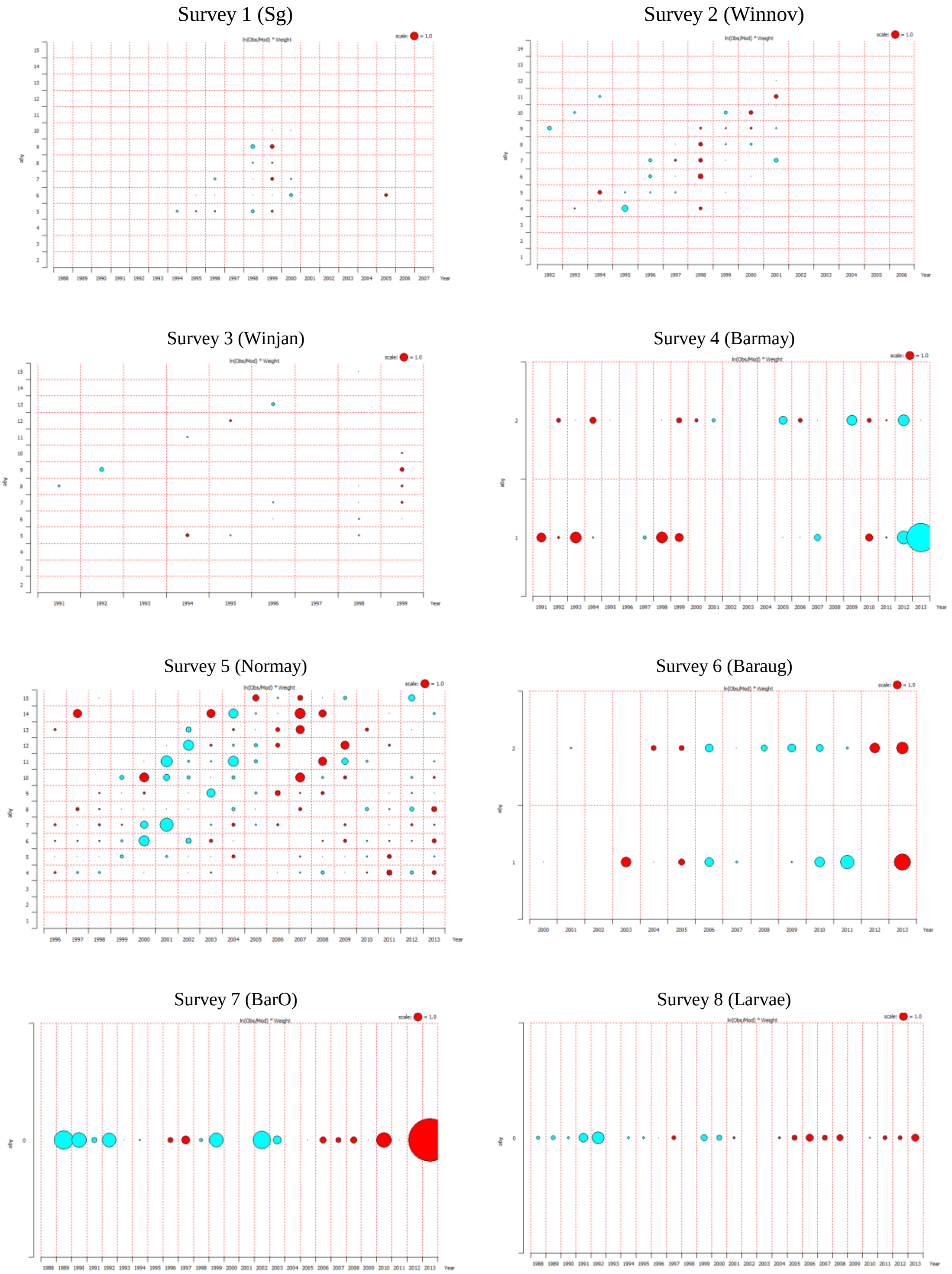

Figure 6. Residuals for the surveys in *TASACS_update*. A red bubble shows that the observed value is higher than the expected value.

Figure 7. Residuals for the surveys in *TASACS_new*. A red bubble shows that the observed value is higher than the expected value.

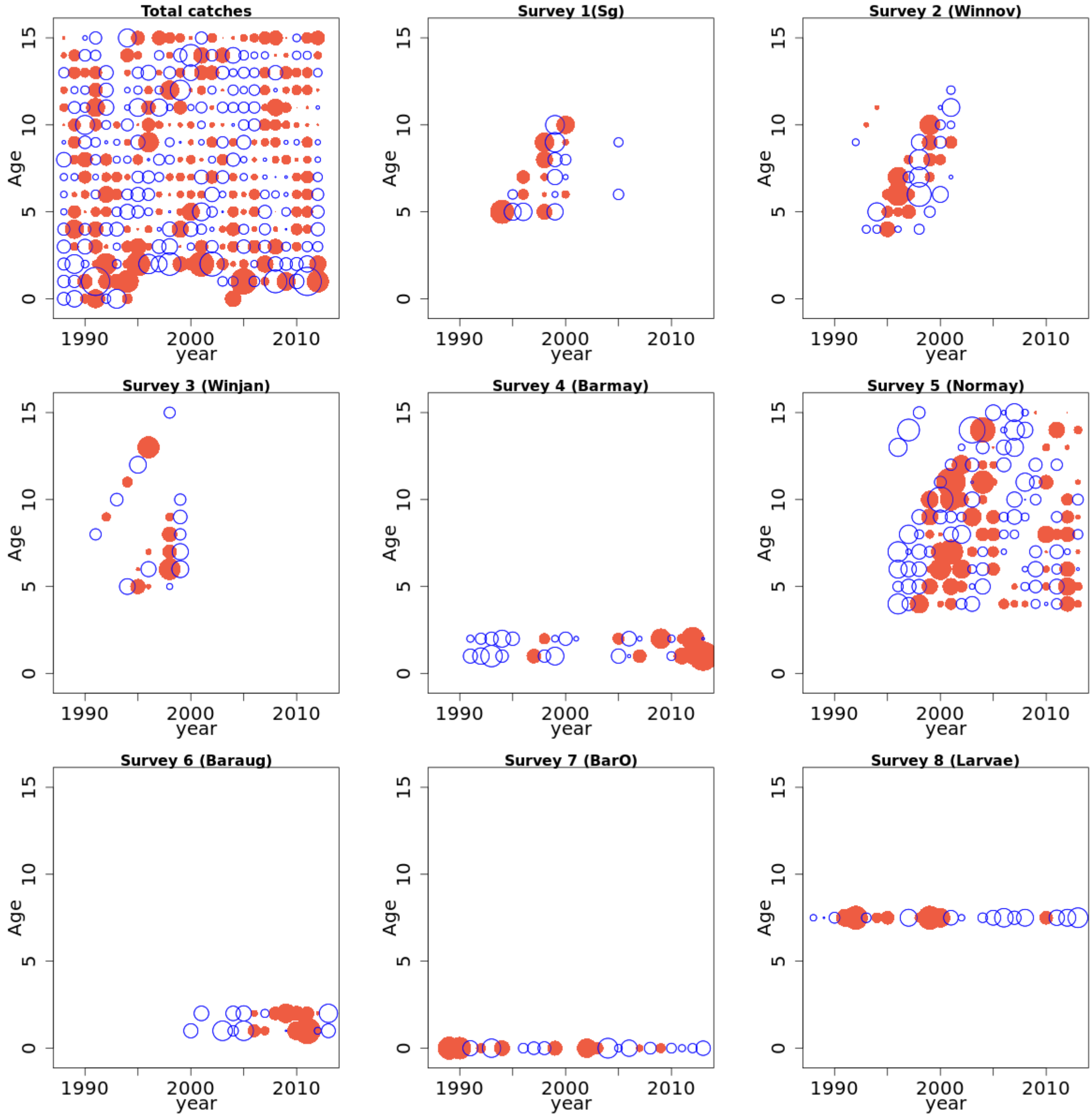

Figure 8. Residuals for the surveys in *SAM_update*. A red (filled) bubble shows that the observed value is less than the expected value.

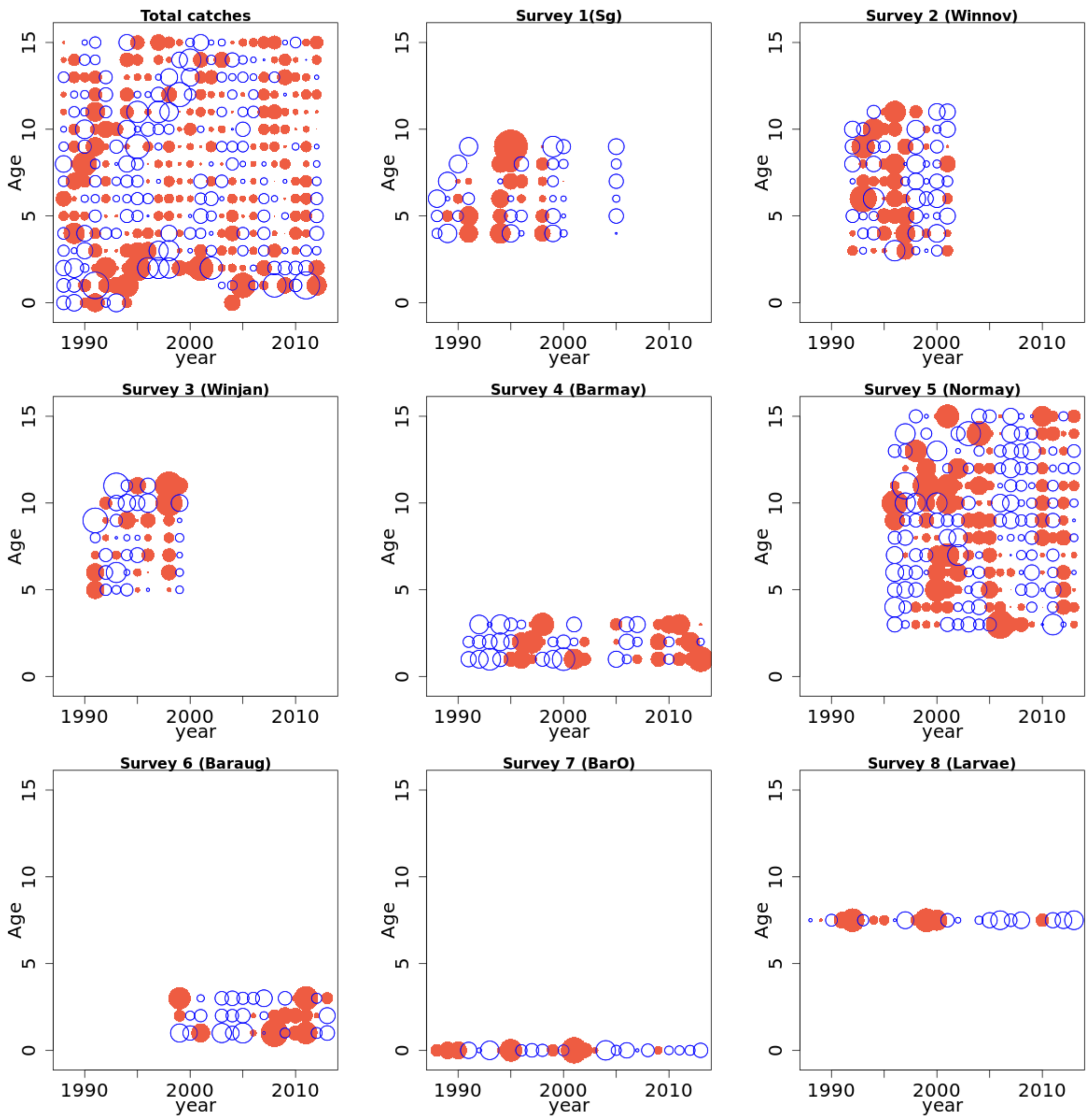

Figure 9. Residuals for the surveys in *SAM_new*. A red (filled) bubble shows that the observed value is less than the expected value.

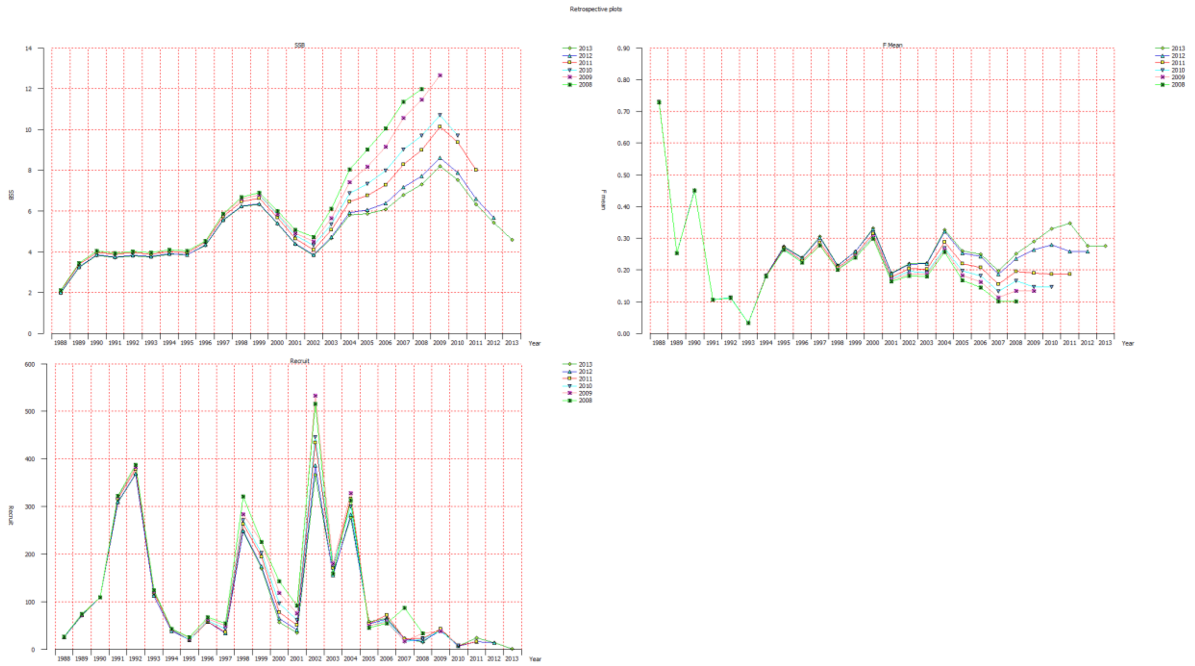

Figure 10. Retrospective analysis of SSB, F and recruits using *TASACS_update*. SSB is in million tonnes and recruits in billions.

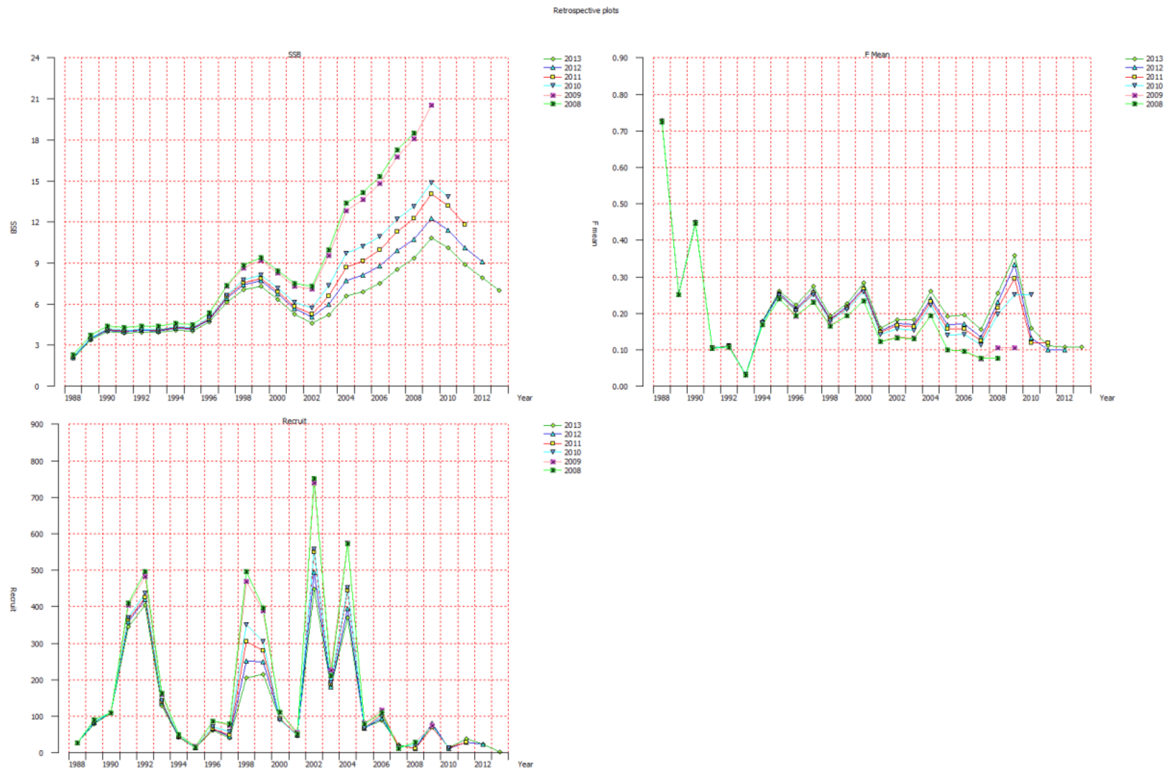

Figure 11. Retrospective analysis of SSB, F and recruits using *TASACS_new*. SSB is in million tonnes and recruits in billions.

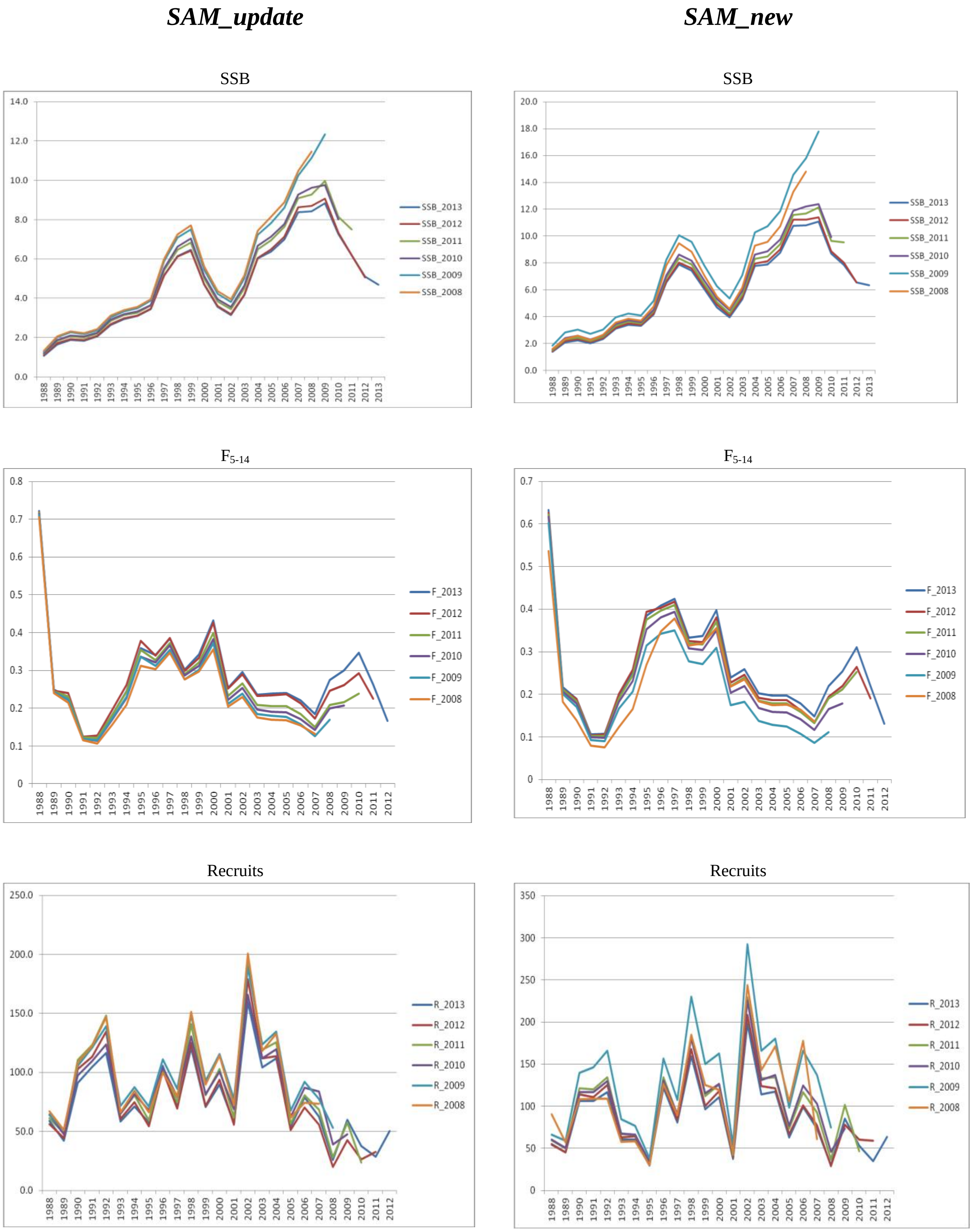

Figure 12. Retrospective analysis of SSB, F and recruits using *SAM_update* (left) and *SAM_new* (right). SSB is in million tonnes and recruits in billions.

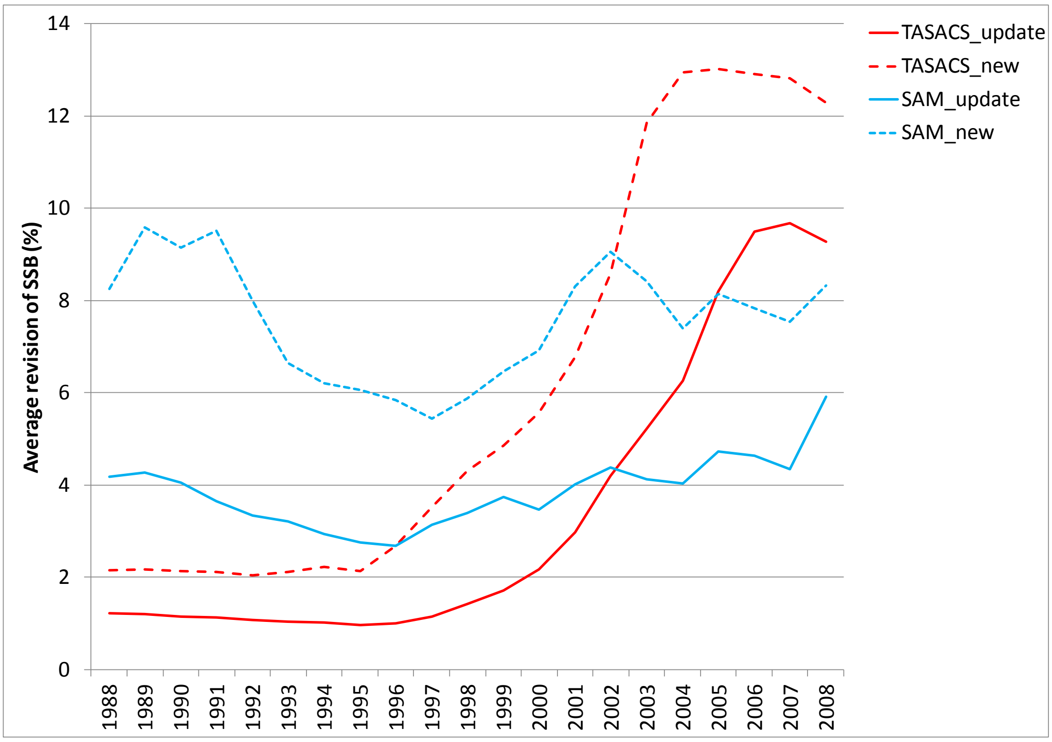

Figure 13. Average yearly revision of SSB in the retrospective analyses.

Appendix

A1. The SAM-configuration file used in Run 3 (*SAM_update*).

```
# Min Age (should not be modified unless data is modified accordingly)
0
# Max Age (should not be modified unless data is modified accordingly)
15
# Max Age considered a plus group (0=No, 1=Yes)
1
# The following matrix describes the coupling
# of fishing mortality STATES
# Rows represent fleets.
# Columns represent ages.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
# Use correlated random walks for the fishing mortalities
# ( 0 = independent, 1 = correlation estimated)
1
# Coupling of catchability PARAMETERS
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	2	3	4	5	6	0	0	0	0	0
0	0	0	0	7	8	9	10	11	12	13	13	13	0	0	0
0	0	0	0	0	14	15	16	17	18	19	19	19	19	0	19
0	20	21	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	22	23	24	25	26	27	28	29	29	29	29	29
0	30	31	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
# Coupling of power law model EXPONENTS (if used)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
# Coupling of fishing mortality RW VARIANCES
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
# Coupling of log N RW VARIANCES
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
# Coupling of OBSERVATION VARIANCES
1	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3
0	0	0	0	0	4	4	4	4	4	4	0	0	0	0	0
0	0	0	0	5	5	5	5	5	5	5	5	5	0	0	0
0	0	0	0	0	6	6	6	6	6	6	6	6	6	0	6
0	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	8	8	8	8	8	8	8	8	9	9	9	9
0	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
# Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time)
1
# Years in which catch data are to be scaled by an estimated parameter
0
# first the number of years
# Then the actual years
# Them the model config lines years cols ages
# Define Fbar range
5	14
```

A2. The SAM-configuration file used in Run 4 (*SAM_new*).

```
# Min Age (should not be modified unless data is modified accordingly)
0
# Max Age (should not be modified unless data is modified accordingly)
15
# Max Age considered a plus group (0=No, 1=Yes)
1
# The following matrix describes the coupling
# of fishing mortality STATES
# Rows represent fleets.
# Columns represent ages.
1    2    3    4    5    6    7    8    9    10   11   12   13   14   15   15
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
# Use correlated random walks for the fishing mortalities
# ( 0 = independent, 1 = correlation estimated)
1
# Coupling of catchability PARAMETERS
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    1    2    3    4    5    6    0    0    0    0    0    0
0    0    0    7    8    9    10   11   12   13   14   14   0    0    0    0
0    0    0    0    0    15   16   17   18   19   20   20   0    0    0    0
0    21   22   23   0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    24   25   26   27   28   29   30   31   32   32   32   32   32
0    33   34   35   0    0    0    0    0    0    0    0    0    0    0    0
36   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
# Coupling of power law model EXPONENTS (if used)
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
# Coupling of fishing mortality RW VARIANCES
1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
# Coupling of log N RW VARIANCES
1    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
# Coupling of OBSERVATION VARIANCES
1    2    2    2    2    2    2    2    2    2    2    2    3    3    3    3
0    0    0    0    4    4    4    4    4    4    0    0    0    0    0    0
0    0    0    5    6    6    6    6    6    6    6    6    0    0    0    0
0    0    0    0    0    7    7    7    7    7    7    7    0    0    0    0
0    8    8    9    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    10   11   11   11   11   11   11   11   12   12   12   12   12
0    13   13   14   0    0    0    0    0    0    0    0    0    0    0    0
15   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
# Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time)
1
# Years in which catch data are to be scaled by an estimated parameter
0
# first the number of years
# Then the actual years
# Them the model config lines years cols ages
# Define Fbar range
5    14
```

Validation of Norwegian spring-spawning herring surveys

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Abstract

This work presents an objective method for evaluating whether abundance estimates from different Norwegian spring-spawning herring surveys provide valid signals of trends in stock abundance. The suggested criteria for valid signal in a survey-age time series are: (1) internal consistency with ages before or after within cohorts and (2) external consistency with at least one set of independent estimates of the same age group (from other surveys or VPA). Compared with the conclusions drawn in the last benchmark assessment of Norwegian spring-spawning herring in 2008, this work recommends to include more survey data in the stock assessment models.

Introduction

No standardized objective criteria exist for selection of input data in stock assessments, and the basis for inclusion or exclusion of available data in a particular assessment is often difficult to find in retrospect (Payne et al., 2009). Inclusion of inappropriate data may mask the underlying signal from other data sources, leading to more uncertain results. Moreover, exclusion of appropriate data may also have costs in terms of increased uncertainty and/or bias.

The last benchmark assessment of Norwegian spring-spawning herring was carried out in 2008 (ICES, 2008). Since then, five years with survey and catch information have been added. As a preparation to the next benchmark, which is planned for 2016, the present study aims to evaluate available survey abundance indices. In the 2008 assessment, survey indices were evaluated using analyses of (1) consistency within and between surveys and (2) N-values by year class for each survey as estimated with the VPA assessment model in the TASACS toolbox. The decision to include or exclude ages from the different surveys in the final assessment was mainly based on a subjective evaluation of the scatter plots showing consistency within and between surveys and the belonging coefficients of determination for fitted lines forced through the origin (ICES, 2008). Moreover, survey indices were also excluded on the basis of visual inspections of the N-values plots mentioned above. Year classes for which these curves showed a noisy pattern were excluded from the survey data. The ages and year classes that were excluded in the final assessment in 2008 have also been removed in later assessments.

As in the benchmark assessment in 2008, the present study uses consistency within and between surveys as suggested selection criteria, but the approach is to establish a more objective and systematic approach using Pearson and Spearman's correlation coefficients to validate the quality of survey time series. All available survey time series are examined, however, if previous working groups have decided to exclude indices due to bad survey coverage these were not included in the analyses.

Material and methods

Description of the surveys

Abundance estimates from nine herring surveys are analyzed. These surveys cover different life stages, areas, time periods and different parts of the season. The surveys are here categorized according to data structure, e.g. the survey with the official name International ecosystem survey in the Nordic seas is viewed as two surveys since two independent sets of age-disaggregated abundance indices are provided (one set from the Norwegian Sea and one from the Barents Sea). Abbreviations that are used later in the analyses are given in brackets after the survey name. The terms 'working groups' and 'assessments' refer to the ICES stock assessments of Norwegian spring-spawning herring. The working group name was Working group on northern pelagic and blue whiting fisheries (WGNPBW) before 2008 and Working group of widely distributed stocks (WGWIDE) from 2008 onwards. All the time series used in the analyses are given in the Appendix, and the exact sources are also given in the text. Zero-values are not used and the reasons for this are stated below.

Norwegian acoustic survey on spawning grounds (Sg). This survey provides abundance estimates by age at the spawning grounds during spawning. The shelf along the Norwegian coast from Møre to Vesterålen is covered, and the survey is carried out in late February and early March. The survey started in 1988 and has not been carried out since 2008. In some of the years in this period the survey was not conducted. Estimates from the years 2006-2008 have not been used in assessments since the spatial and/or temporal coverage was considered inadequate by the working group in these years. Thus these years are excluded from the analyses. For unknown reasons, the first years of the survey have not always been used in the assessments. These years are used in the present analyses. The data are taken from ICES (2008).

Norwegian acoustic survey in wintering areas I (Winnov). This survey provides abundance estimates by age at the wintering areas in November and December. During the period from 1992, when the survey started, to 2002 the Norwegian fjords east of Lofoten were covered. From 2003 onwards the herring started to winter in oceanic areas west of Vesterålen, so the survey coverage was extended to these areas during the period 2003 to 2007. The survey has not been carried out from 2008 onwards. The working group decided in 2008 to not use the years 2003-2007 in the assessment due to possible incomplete coverage. These years are also excluded from the present analysis. The data are taken from ICES (2008).

Norwegian acoustic survey in wintering areas II (Winjan). This survey provides abundance estimates by age at the wintering areas in January. The Norwegian fjords east of Lofoten were covered. The survey was conducted in the period 1991-1999, except in 1997 due to poor weather conditions. The data are taken from ICES (2008).

International acoustic survey in the Norwegian Sea I (Normay). This survey provides abundance estimates by age at the feeding grounds in the Norwegian Sea in April-June, but mainly in May. The eastern limit of the Norwegian Sea is here defined as 20° East. The survey in its present form was started in 1996 and is still conducted annually. The data are taken from ICES (2013).

International acoustic survey in the Barents Sea (Barmay). This survey provides abundance estimates by age at the juvenile feeding area in the Barents Sea in April-June, but mainly in May. The survey has been conducted from 1991 till present, except in 2003 and 2004. The area covered in 2008 was considered inadequate by the working group, so this year is excluded from the present analyses. The data are taken from ICES (2013).

Joint Russian-Norwegian acoustic survey in the Barents Sea (Baraug). This survey provides abundance estimates by age at the juvenile feeding area in the Barents Sea in August-October. Age disaggregated herring data are available from 1999 onwards except for 2002 when large amounts of 0-group herring prevented adequate sampling and measurement of older fish. The data are taken from Prokhorova et al. (2013) (Table 5.1.1).

International acoustic survey in the Norwegian Sea II (Norjul). This survey provides abundance estimates by age at the feeding grounds in the Norwegian Sea in July-August. The survey in its present form was started in 2009. The herring indices from this cruise have not been published elsewhere.

Joint Russian-Norwegian 0-group trawl survey in the Barents Sea (Ogroup). This survey provides 0-group indices from the juvenile feeding areas in the Barents Sea in August-October. Indices are available from 1980 onwards. The data are taken from Prokhorova et al. (2013) (Table 5.2.3.3).

Norwegian herring larvae survey on the Norwegian shelf (Larvae). This survey provides indices of herring larvae abundance on the shelf along the Norwegian coast between approximately 60°N and 71°N. The abundance of larvae is assumed to be an index of spawning stock biomass. The survey is carried out in March-April and started in 1981. The years 2003 and 2009 are excluded from the analysis due to probable inadequate coverage (following the working group decision). The data are taken from ICES (2013).

VPA

In order to obtain survey-independent estimates of abundance at age and spawning stock biomass, a Virtual Population Analysis (VPA) was carried out using the Fisheries Library in R (FLR) environment (Kell et al. 2007). More specifically, the VPA function in the FLAssess package version 2.5.0 was used, with R version 2.15.3 and FLcore version 2.5.0. The only input data in VPA is estimated catch at age, and these data can be found in the ICES (2013). Since VPA is a cohort back-calculation method, the most recent years with estimates of numbers at age in the stock change when data from a new year is added, i.e. these recent estimates are unstable. However, the estimates for a given year converge with time (number of years passed to the last year with data). Thus, a convergence criterion can be used to decide whether to exclude data from a given year. In this work years where selected for a given age group if the estimates changed less than 10 % between the last data year (running VPA from 2012) and the year before (running VPA from 2011). VPA-based estimates of spawning stock biomass were also calculated using the estimated mean weights in the stock and the maturity ogive from ICES (2013), and the above mentioned convergence criterion was used for SSB as well. The VPA estimates are given in the Appendix.

Internal consistency

If a survey picks up a strong year class, it is a good sign for the survey quality if the same year class also turns out strong in following year's survey. Internal consistency, also termed within-survey correlation, is the strength of the relationship between the abundance estimates for the same cohorts at consecutive ages. For theoretical reasons (see Payne et al., 2009), a linear relationship between the natural logarithm of the abundance at subsequent ages is expected. In this work, the time series with abundance estimates for a given survey and age group is therefore evaluated by exploring the internal consistency with both the previous and the following age. Both correlations mentioned below are calculated, and a survey-age time series is deemed internally consistent if these correlations are significant for the age before or the age after. Zero-values are not used in analysis due to the log-transformation.

External consistency

A measuring instrument, like a survey, can also be evaluated by checking whether measures are related to independent measures of the same construct. This can be termed the degree of external consistency. In this work, the two correlations mentioned below are calculated between all available time series with abundance estimates for the same age group. A survey-age time series is deemed externally consistent if significantly correlated with one or more independent time series with abundance estimates of the same age group (from other surveys or VPA). Zero-values are excluded since these provide little information and also lead to artificially high correlations for the youngest and oldest age groups (due to many corresponding zero-values).

Correlation analysis

Correlation refers to the degree of statistical relationship between two variables. The most familiar measure is Pearson product-moment correlation coefficient which indicates the degree of linear relationship. A problem with the Pearson correlation is that one extreme outlier may lead to a statistically significant correlation even if all the other observations are totally unrelated. This situation can be detected by also using Spearman's rank correlation which is non-parametric and thereby not affected by outliers. In this work we conclude that two time series are related if both the Pearson and Spearman's correlation coefficients are significant at the 5 % level.

Results

All surveys, except Norjul, show a high degree of internal consistency between adjacent ages of the same cohorts (Table 1). The youngest age groups are poorly related to adjacent ages in the surveys designed to measure the adult part of the population (Sg, Winnov, Winjan, Normay) while the surveys targeting juveniles (Barmay and Baraug) show high degree of internal consistency for these age groups (Table 1). External consistencies for each age group and SSB are shown in Tables 2-18. The O-group index time series from the Barents Sea (BarO) is significantly ($p<0.05$) related to age 0 from VPA (Table 2). For ages 1-2 only Barmay and Baraug are externally consistent, as both are significantly ($p<0.05$) related to VPA. For age 3, Winnov, Normay, Barmay and Baraug are externally consistent as these are significantly ($p<0.05$) related to one or more independent measures. For ages 4-9 all surveys designed to measure these age groups are externally consistent, except Norjul. For age 10 and older, various surveys start to lose external consistency. The larvae index of spawning stock biomass (Larvae) is significantly ($p<0.05$) related to the VPA-based spawning stock biomass estimate (Table 18). Results of the analyses of both internal and external consistency for all surveys and ages are summarized in Table 19.

Figures 1-17 show mean standardized survey time series for each age group. These figures only include time series with both internal and external consistency. In addition, the O-group (BarO), SSB indices (Larvae), and age 15+ from Normay are included since it is not possible to evaluate internal consistency for these. This also applies to age 12 and older in the Sg survey, however, due to lack of internal consistency in ages 10-11 the older ages are ignored. It was not possible to evaluate internal or external consistency for age 13 and older in Winnov and Winjan so these were also ignored. The abundance trend signals are most conflicting for ages 0-3 (Fig. 1-4), and the relationship between the SSB indices (Larvae) and the VPA based SSB estimate looks noisy and not linear (Fig. 17).

Figure 18 shows the observations in the different survey datasets that were excluded/included in the latest ICES stock assessment, together with the suggested inclusion/exclusion based on the present analysis.

Discussion

Compared to the benchmark assessment in 2008 (ICES, 2008), the results from the present work suggest including more survey-age time series in the assessment. This applies in particular to the youngest age groups. Some of the older age groups that are presently used in the assessment are also suggested deleted. The approach used in 2008 to exclude entire cohorts from surveys was not investigated since this is rather uncommon in other ICES assessments. In our opinion, deletion of observations should be based on good reasons. Poor fit in an assessment model may be a reason to exclude entire surveys or ages from a survey, but not single observations from these.

In this work we use more objective criteria for inclusion of survey data compared with the benchmark assessment in 2008. Some of the same basic methods were also used in 2008, like analyses of internal and external consistency but it is not clear how the results of these analyses were used to make decisions of whether to exclude/exclude ages from surveys. The use of internal and external consistency to evaluate the quality of surveys and assessments is also used for other herring stocks (see e.g. Payne et al. 2009; Simmonds 2009). However, some subjective evaluations are still required, e.g., whether to include survey-age components for which it is not possible to estimate the degree of internal consistency, like the O-group and SSB indices in this work. Exploratory runs with the chosen assessment model may aid in such decisions, for example use the retrospective pattern to evaluate the quality of data sources (Payne et al. 2009; Simmonds 2009). Another approach for evaluation of survey time series would have been to explore the uncertainty within each survey and year. However, most of the surveys are presently not designed to make uncertainty calculations possible.

Conclusion: include the following surveys and ages in the assessment of Norwegian spring-spawning herring; Sg: ages 4-9, Winnov: ages 3-11, Winjan: ages 5-11, Normay: ages 3-10 and 12-15+, Barmay: ages 1-3, Baraug: ages 1-3, BarO and Larvae.

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Table 1. Internal consistency in the surveys. Pearson (r) and Sperman's (r_s) correlation coefficients of the same cohorts at consecutive and adjacent ages. The natural logarithm of the abundance indices is used. If both correlations are significant at the 5 % level the correlations are emboldened.

Age step		1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
Sg	r		-0.85	0.41	**0.87***	**0.95****	**0.98****	**0.98****	**0.97***	0.82	0.05			
	r_s		-0.80	0.40	**1.00****	**0.96****	**1.00****	**1.00****	**1.00****	0.50	0.20			
Winnov	r	-0.03	-0.13	**0.81****	**0.86****	**0.95****	**0.95****	**0.97****	**0.96****	**0.97****	**0.97****	**0.96***		
	r_s	0.03	-0.02	**0.70***	**0.78***	**0.93****	**0.85****	**0.93****	**0.95****	**0.99****	**1.00****	**0.97****		
Winjan	r		0.88	-0.43	0.90*	**0.98****	**0.94****	**0.96****	**0.98****	0.82*	**0.89***	**1.00***		
	r_s		1.00**	-0.26	0.71	**0.83***	**0.94****	**1.00****	**0.89***	0.77	**0.90***	**1.00****		
Normay	r	0.97	0.13	**0.66****	**0.95****	**0.95****	**0.95****	**0.86****	**0.96****	**0.90****	0.45	**0.77****	**0.67***	**0.74****
	r_s	1.00**	0.01	**0.70****	**0.95****	**0.94****	**0.95****	**0.88****	**0.97****	**0.84****	0.69**	**0.67****	**0.90****	**0.77****
Barmay	r	**0.82****	**0.82****											
	r_s	**0.83****	**0.85****											
Baraug	r	**0.80****	**0.82****											
	r_s	**0.89****	**0.82****											
Norjul	r		0.23	0.78	0.36	0.74	0.72	0.65	0.53	0.95*	0.24	0.37	0.33	0.24
	r_s		0.40	0.60	0.40	0.20	0.60	0.40	0.40	0.80	0.20	0.40	0.50	0.32

$^{*}p<0.05$, $^{**}p<0.01$

Table 2. External consistency for age 0. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		BarO
VPA	r	**0.57****
	r_s	**0.78****

$^{*}p<0.05$, $^{**}p<0.01$

Table 3. External consistency for age 1. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Winnov	Barmay	Baraug
VPA	r	-0.38	**0.75****	**0.94***
	r_s	0.00	**0.80****	**1.00****
Winnov	r		-0.48	-0.69
	r_s		-0.50	-0.50
Barmay	r			0.47
	r_s			0.50

$^{*}p<0.05$, $^{**}p<0.01$

Table 4. External consistency for age 2. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Winnov	Winjan	Normay	Barmay	Baraug	Norjul
VPA	r	0.12	0.02	-0.62	0.54	**0.91****	**0.90***	
	r_s	-0.14	0.02	-1.00**	0.19	**0.89****	**0.83***	
Sg	r		0.07		-0.54	0.11	0.22	
	r_s		0.80		-1.00**	-0.37	-0.50	
Winnov	r				0.73	-0.22	0.79	
	r_s				0.60	-0.22	0.50	
Winjan	r					-0.60		
	r_s					-1.00**		
Normay	r					-0.46	0.75**	0.79
	r_s					-0.33	0.26	0.80
Barmay	r						0.37	0.26
	r_s						0.62*	0.10
Baraug	r							-0.42
	r_s							0.00

$^{*}p<0.05$, $^{**}p<0.01$

Table 5. External consistency for age 3. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Winnov	Winjan	Normay	Barmay	Baraug	Norjul
VPA	r	0.39	**0.89****	-0.18	**0.89****	**0.64***	0.86*	
	r_s	0.56	**0.88****	-0.24	**0.74****	**0.71***	0.77	
Sg	r		0.37	0.16	-0.53	-0.04		
	r_s		0.10	-0.10	-0.60	-0.20		
Winnov	r			-0.12	**0.91***	0.63		
	r_s			-0.07	**1.00****	0.83*		
Winjan	r				0.02	0.64		
	r_s				0.50	0.37		
Normay	r					0.18	**0.70***	0.86
	r_s					0.50	**0.64***	0.80
Barmay	r						0.56	0.73
	r_s						0.71*	0.40
Baraug	r							**0.98****
	r_s							**0.90***

$^{*}p<0.05$, $^{**}p<0.01$

Table 6. External consistency for age 4. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Winnov	Winjan	Normay	Norjul
VPA	r	**0.97****	**0.84****	**0.89****	**0.98****	
	r_s	**0.89****	**0.83****	**0.98****	**0.94****	
Sg	r		0.78	0.78	**0.99****	
	r_s		1.00**	1.00**	**1.00****	
Winnov	r			**0.99****	0.95**	
	r_s			**0.96****	0.60	
Winjan	r				0.99	
	r_s				1.00**	
Normay	r					0.63
	r_s					0.50

$^{*}p<0.05$, $^{**}p<0.01$

Table 7. External consistency for age 5. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Winnov	Winjan	Normay	Norjul
VPA	r	**0.95****	**0.92****	**0.98****	**0.94****	
	r_s	**0.96****	**0.89****	**0.88****	**0.96****	
Sg	r		0.81	0.95**	**0.96***	
	r_s		0.83*	0.77	**0.90***	
Winnov	r			**0.92****	**0.91***	
	r_s			**0.96****	**1.00****	
Winjan	r				**1.00***	
	r_s				**1.00****	
Normay	r					0.93*
	r_s					0.30

$^{*}p<0.05$, $^{**}p<0.01$

Table 8. External consistency for age 6. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Winnov	Winjan	Normay	Norjul
VPA	r	**0.92****	**0.90****	**0.97****	**0.96****	
	r_s	**0.95****	**0.90****	**0.93****	**0.95****	
Sg	r		0.98**	**0.97****	**0.92***	
	r_s		0.60	**1.00****	**0.90***	
Winnov	r			**0.91****	**0.89***	
	r_s			**0.82***	**0.94****	
Winjan	r				0.99	
	r_s				0.50	
Normay	r					0.93*
	r_s					0.60

$^{*}p<0.05$, $^{**}p<0.01$

Table 9. External consistency for age 7. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Winnov	Winjan	Normay	Norjul
VPA	r	**0.80****	**0.96****	**0.97****	**0.94****	
	r_s	**0.92****	**0.95****	**0.98****	**0.91****	
Sg	r		**0.88***	**1.00****	0.79	
	r_s		**0.94****	**1.00****	0.80	
Winnov	r			**0.88****	0.95**	
	r_s			**0.96****	0.77	
Winjan	r				0.93	
	r_s				1.00**	
Normay	r					0.78
	r_s					0.90*

$^{*}p<0.05$, $^{**}p<0.01$

Table 10. External consistency for age 8. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Winnov	Winjan	Normay	Norjul
VPA	r	**0.89****	**0.96****	**0.93****	**0.89****	
	r_s	**0.90****	**0.95****	**0.95****	**0.97****	
Sg	r		**0.97****	**0.98****	**0.99****	
	r_s		**0.94****	**1.00****	**1.00****	
Winnov	r			**0.96****	**0.94****	
	r_s			**0.86***	**0.94****	
Winjan	r				0.99	
	r_s				1.00**	
Normay						**0.91***
						0.90*

$^{*}p<0.05$, $^{**}p<0.01$

Table 11. External consistency for age 9. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Winnov	Winjan	Normay	Norjul
VPA	r	**0.94****	**0.95****	0.95**	**0.89****	
	r_s	**0.82***	**0.95****	0.64	**0.93****	
Sg	r		**0.96***	**0.98****	0.94	
	r_s		**1.00****	**0.90***	0.80	
Winnov	r			**0.98****	**0.99****	
	r_s			**0.94****	**0.90***	
Winjan	r				0.83	
	r_s				1.00**	
Normay	r					0.51
	r_s					0.40

$^{*}p<0.05$, $^{**}p<0.01$

Table 12. External consistency for age 10. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Winnov	Winjan	Normay	Norjul
VPA	r	0.20	**0.98****	**0.99****	**0.73****	
	r_s	0.09	**0.78***	**0.86***	**0.87****	
Sg	r		0.76	0.85	0.60	
	r_s		0.87	0.40	0.60	
Winnov	r			1.00**	0.64	
	r_s			0.68	0.90*	
Winjan	r				0.72	
	r_s				0.50	
Normay	r					0.59
	r_s					0.20

$^{*}p<0.05$, $^{**}p<0.01$

Table 13. External consistency for age 11. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Winnov	Winjan	Normay	Norjul
VPA	r	1.00**	**0.99****	0.99**	0.83**	0.44
	r_s	0.64	**0.83***	0.60	0.51	0.50
Sg	r		**1.00****	**1.00****	-0.51	
	r_s		**0.90***	**0.90***	-0.80	
Winnov	r			**1.00****	-0.36	
	r_s			**1.00****	-0.50	
Normay	r					0.53
	r_s					0.00

$^{*}p<0.05$, $^{**}p<0.01$

Table 14. External consistency for age 12. Pearson (r) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Winnov	Winjan	Normay	Norjul
VPA	r	**1.00***	0.99**	1.00**	**0.83****	
	r_s	**1.00****	0.62	0.50	**0.59***	
Winnov	r			1.00**	0.79	
	r_s			0.87	0.50	
Normay	r					-0.24
	r_s					-0.40

$^{*}p<0.05$, $^{**}p<0.01$

Table 15. External consistency for age 13. Pearson (*r*) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Normay	Norjul
VPA	r	0.97	**0.97****	-1.00*
	r_s	1.00**	**0.73****	-1.00**
Sg	r		0.98	
	r_s		1.00**	
Normay	r			0.84
	r_s			0.60

$^{*}p<0.05$, $^{**}p<0.01$

Table 16. External consistency for age 14. Pearson (*r*) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Normay	Norjul
VPA	r	0.99	**0.93****	
	r_s	1.00**	**0.83****	
Normay	r			0.86
	r_s			0.82

$^{*}p<0.05$, $^{**}p<0.01$

Table 17. External consistency for age 15+. Pearson (*r*) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Sg	Normay	Norjul
VPA	r	**0.99****	**0.64***	
	r_s	**1.00****	**0.76****	
Sg	r		0.81	
	r_s		0.80	
Normay	r			0.97**
	r_s			0.40

$^{*}p<0.05$, $^{**}p<0.1$

Table 18. External consistency for the spawning stock biomass (SSB). Pearson (*r*) and Sperman's (r_s) correlation coefficients between time series with abundance estimates. If both correlations are significant at the 5 % level the correlations are emboldened.

		Larvae
VPA	r	**0.69****
	r_s	**0.86****

$^{**}p<0.05$, $^{*}p<0.1$

Table 19. Summary of the correlation analyses. Each cell in the table indicates whether a survey-age component is internally and/or externally consistent, Int=1: internal consistency, Int=0: not internal consistent, Ext=1: external consistency, Ext=0: not external consistency. Green: both internal and external consistency, red: either not external consistency, internal consistency or none, yellow: not possible to evaluate internal consistency.

	Survey																	
	Sg		Winnov		Winjan		Normay		Barmay		Baraug		Norjul		BarO		Larvae	
Age	Int	Ext	Int	Ext	Int	Ext	Int	Ext	Int	Ext	Int	Ext	Int	Ext	Int	Ext	Int	Ext
0																1		
1			0	0			0		1	1	1	1						
2	0	0	0	0	0	0	0	0	1	1	1	1	0	0				
3	0	0	1	1	0	0	1	1	1	1	1	1	0	1				
4	1	1	1	1	0	1	1	1					0	0				
5	1	1	1	1	1	1	1	1					0	0				
6	1	1	1	1	1	1	1	1					0	0				
7	1	1	1	1	1	1	1	1					0	0				
8	1	1	1	1	1	1	1	1					0	1				
9	1	1	1	1	1	1	1	1					0	0				
10	0	0	1	1	1	1	1	1					0	0				
11	0	1	1	1	1	1	1	0					0	1				
12		1	1	0	1	0	1	1					0	0				
13		0					1	1					0	0				
14		0					1	1					0	0				
15+		1						1					0	0				
SSB																		1

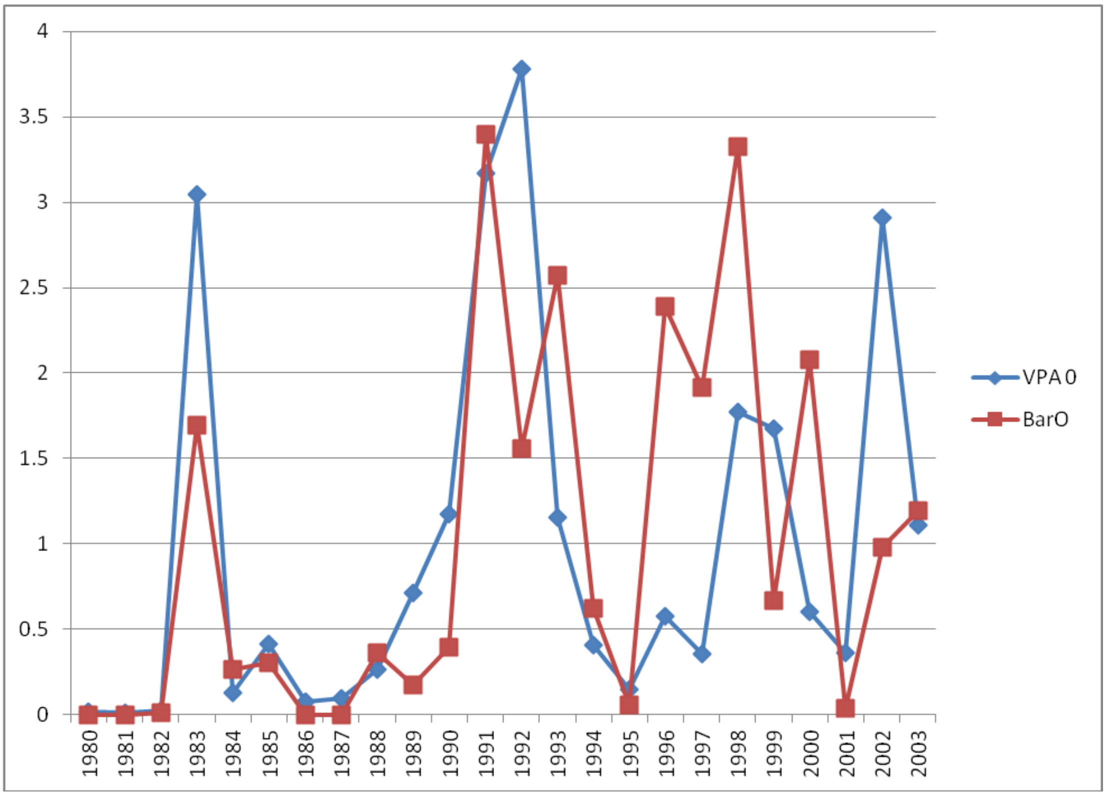

Figure 1. Mean standardised time series with abundance estimates of age 0.

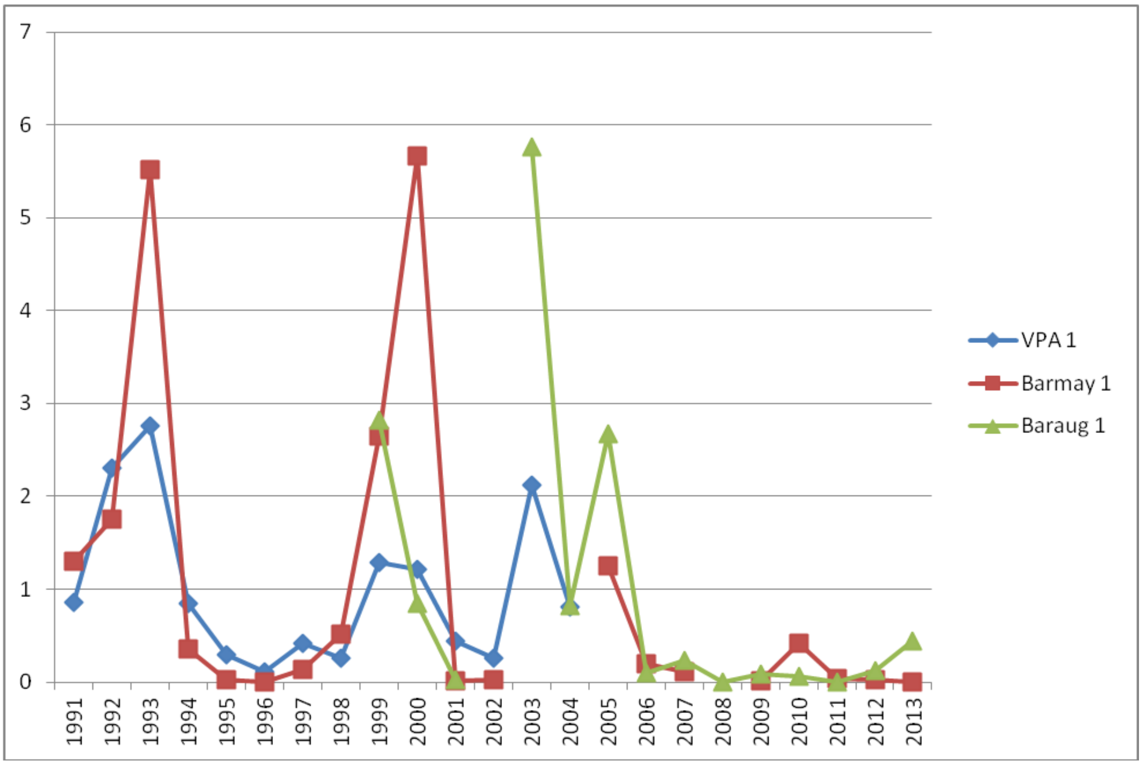

Figure 2. Mean standardised time series with abundance estimates of age 1. Only the survey time series with both internal and external consistency are shown.

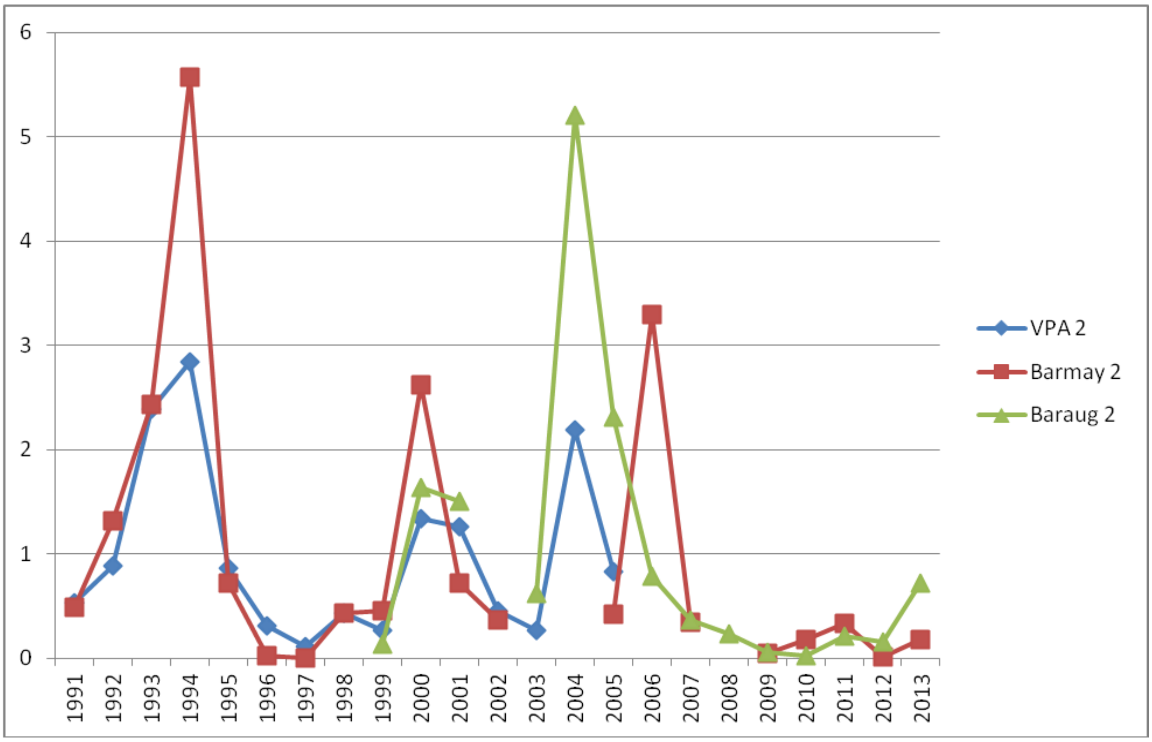

Figure 3. Mean standardised time series with abundance estimates of age 2. Only the survey time series with both internal and external consistency are shown.

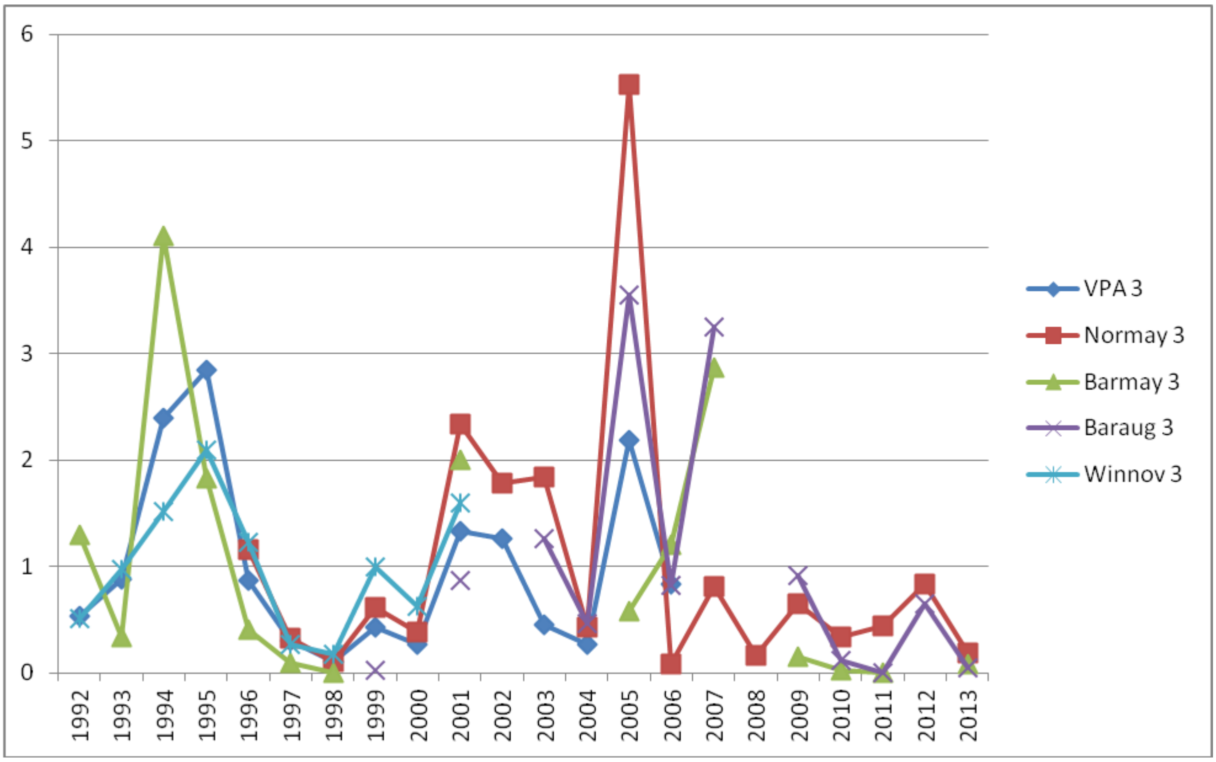

Figure 4. Mean standardised time series with abundance estimates of age 3. Only the survey time series with both internal and external consistency are shown.

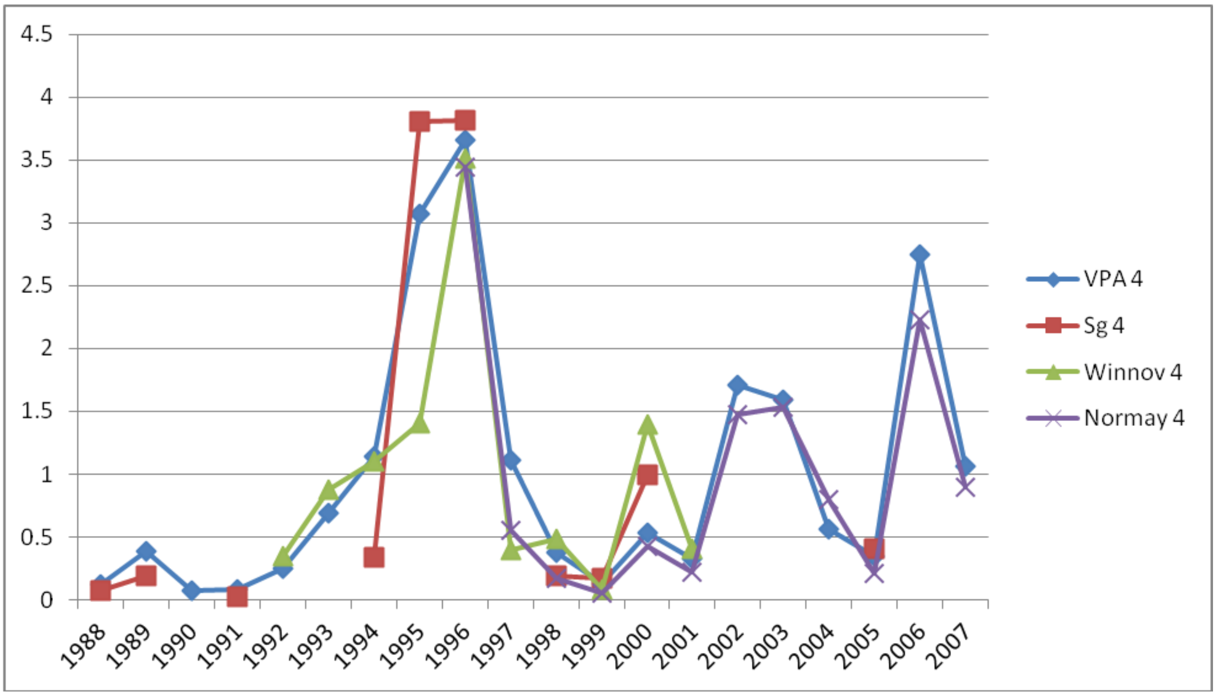

Figure 5. Mean standardised time series with abundance estimates of age 4. Only the survey time series with both internal and external consistency are shown.

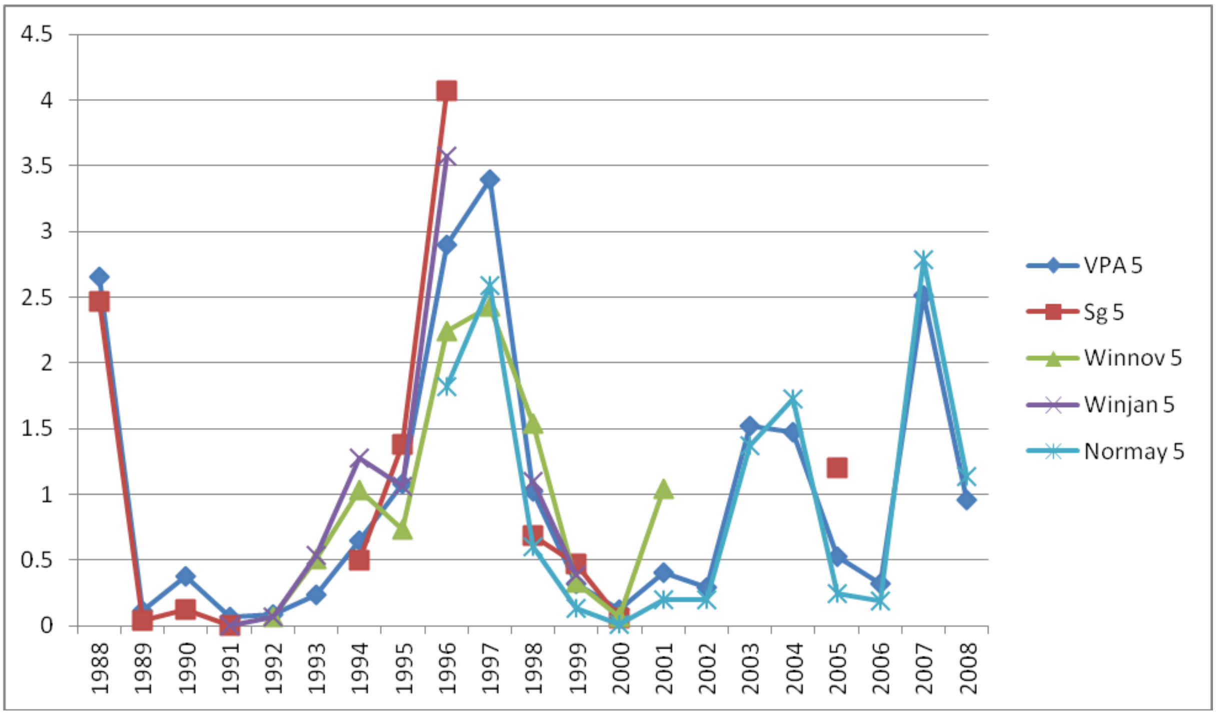

Figure 6. Mean standardised time series with abundance estimates of age 5. Only the survey time series with both internal and external consistency are shown.

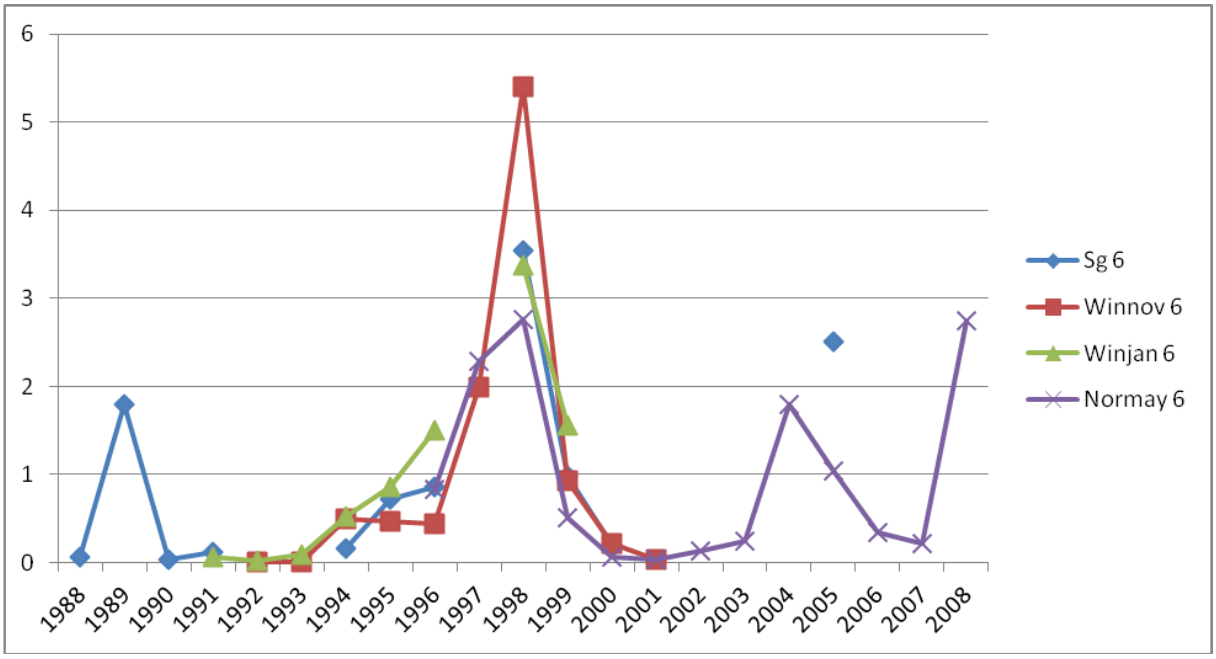

Figure 7. Mean standardised time series with abundance estimates of age 6. Only the survey time series with both internal and external consistency are shown.

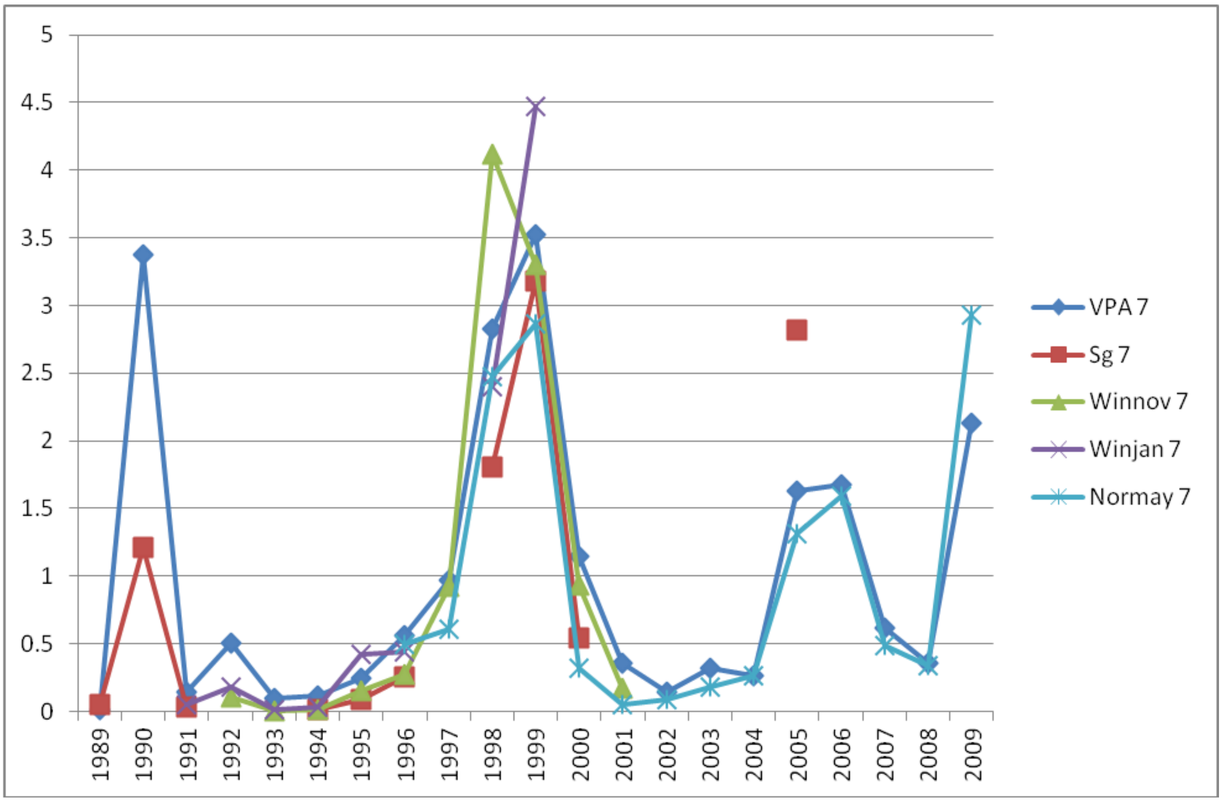

Figure 8. Mean standardised time series with abundance estimates of age 7. Only the survey time series with both internal and external consistency are shown.

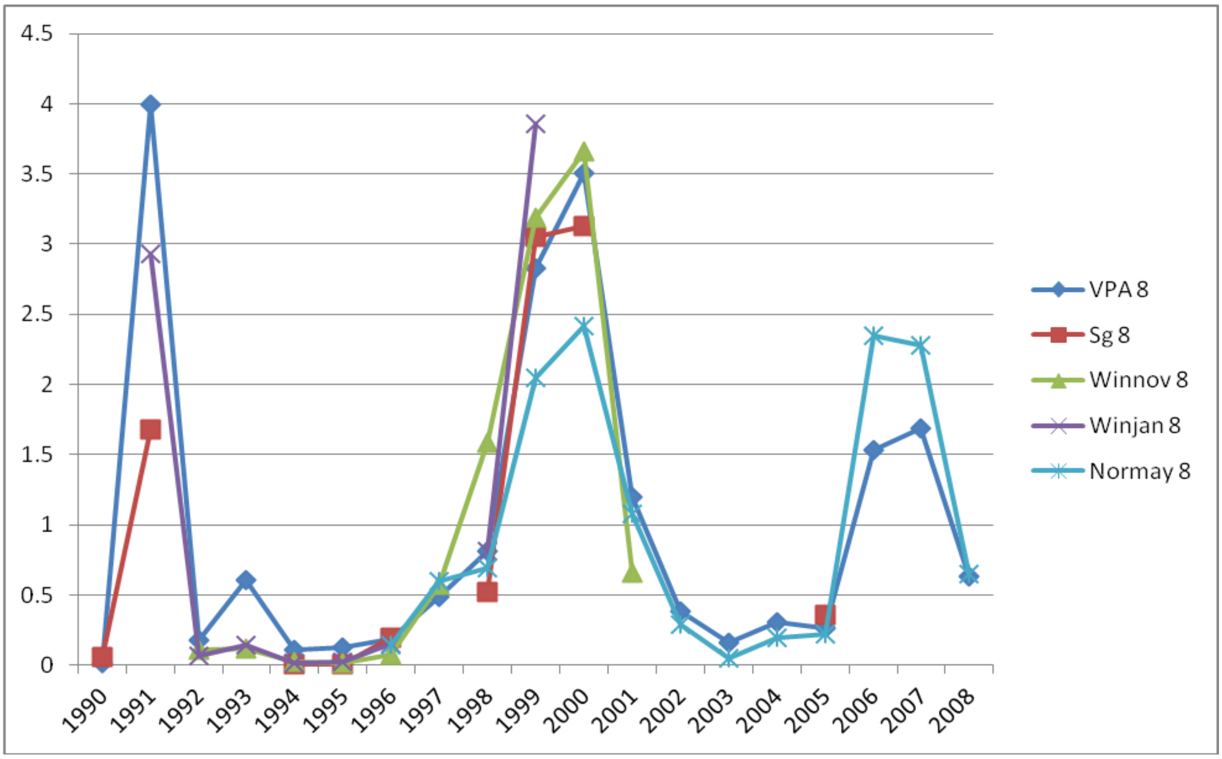

Figure 9. Mean standardised time series with abundance estimates of age 8. Only the survey time series with both internal and external consistency are shown.

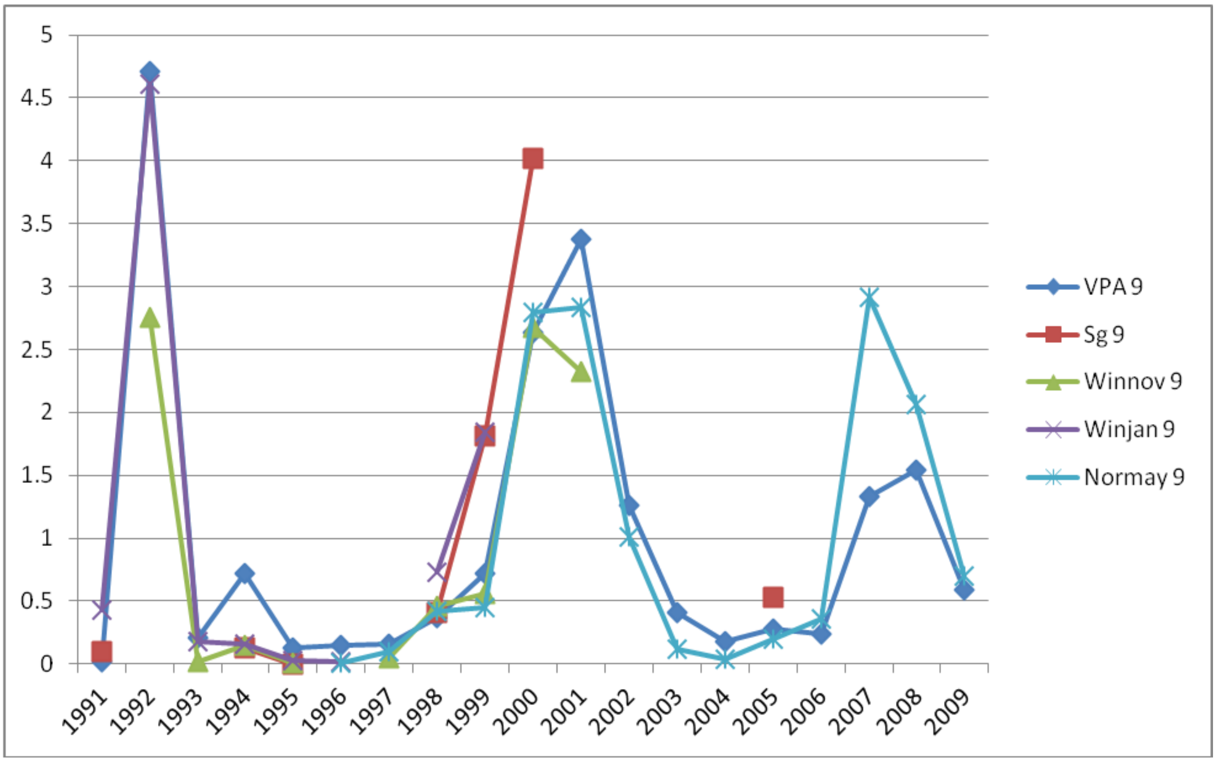

Figure 10. Mean standardised time series with abundance estimates of age 9. Only the survey time series with both internal and external consistency are shown.

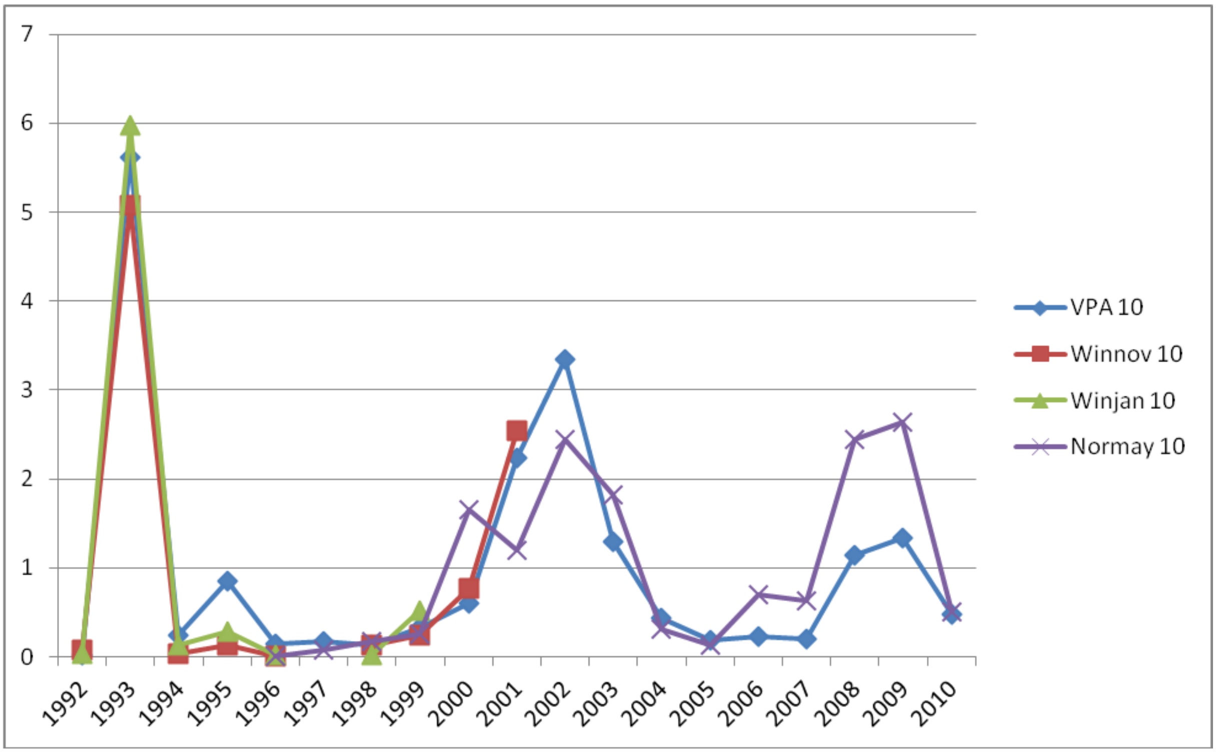

Figure 11. Mean standardised time series with abundance estimates of age 10. Only the survey time series with both internal and external consistency are shown.

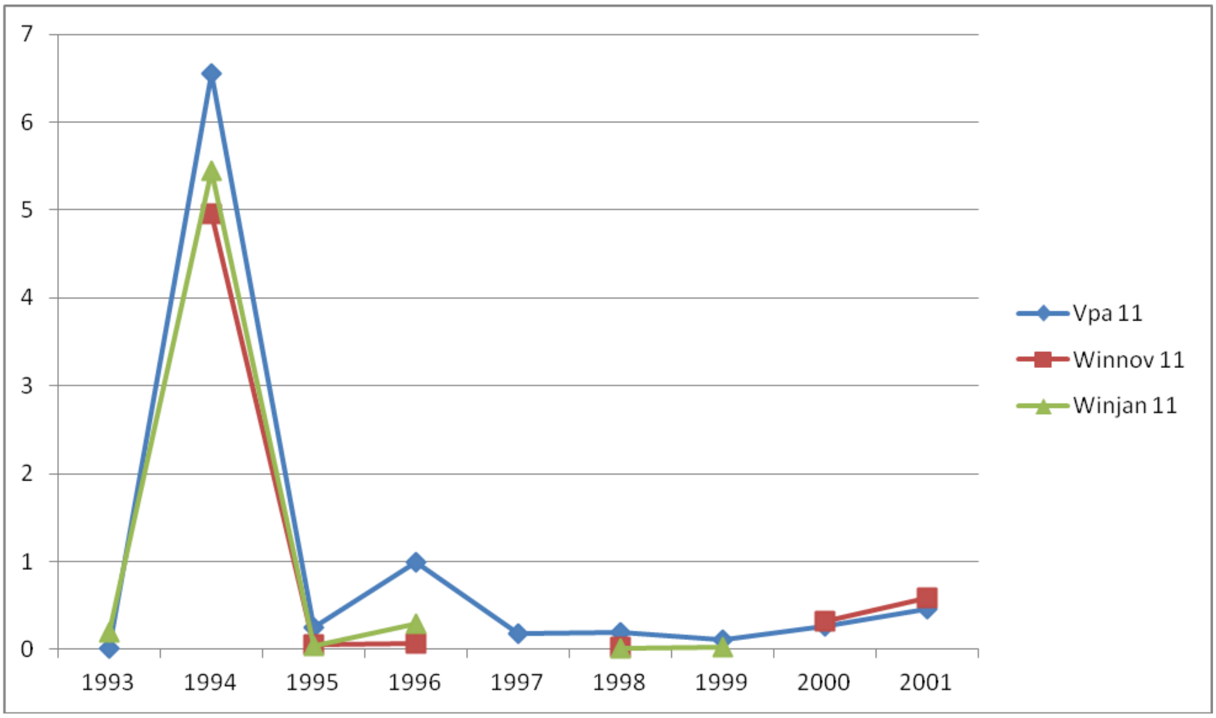

Figure 12. Mean standardised time series with abundance estimates of age 11. Only the survey time series with both internal and external consistency are shown.

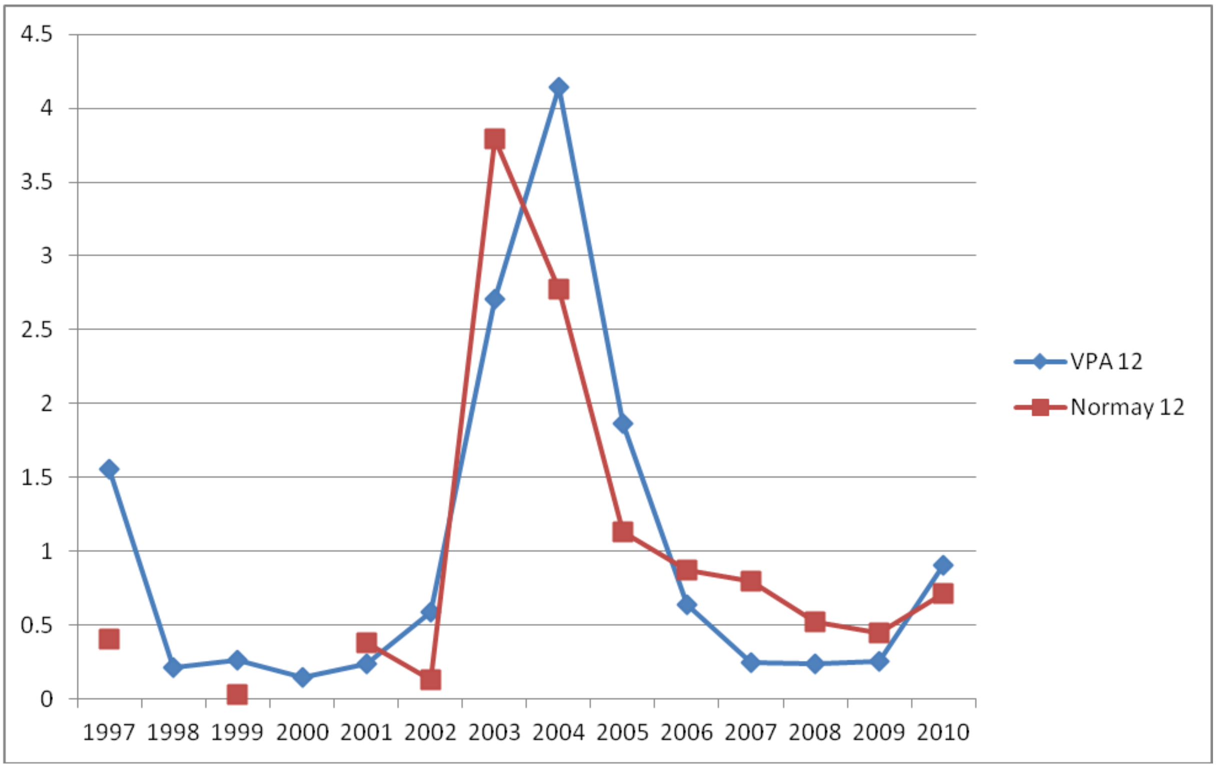

Figure 13. Mean standardised time series with abundance estimates of age 12. Only the survey time series with both internal and external consistency are shown.

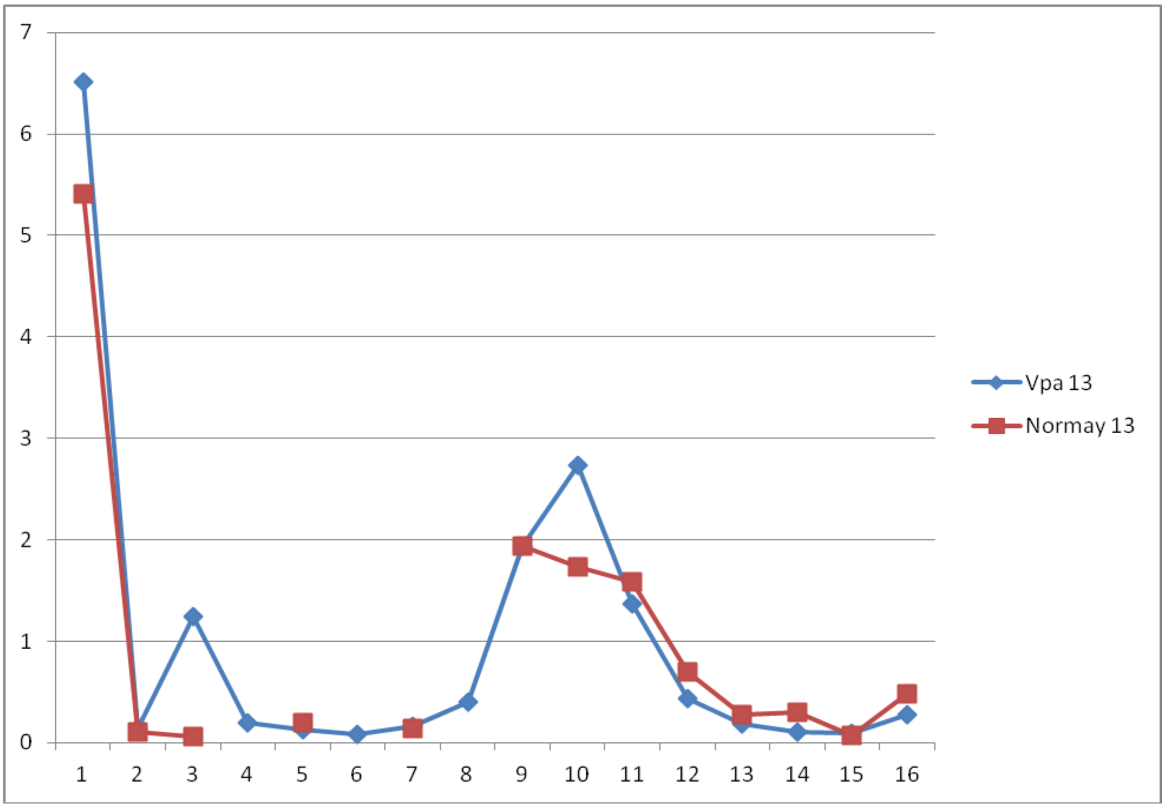

Figure 14. Mean standardised time series with abundance estimates of age 13. Only the survey time series with both internal and external consistency are shown.

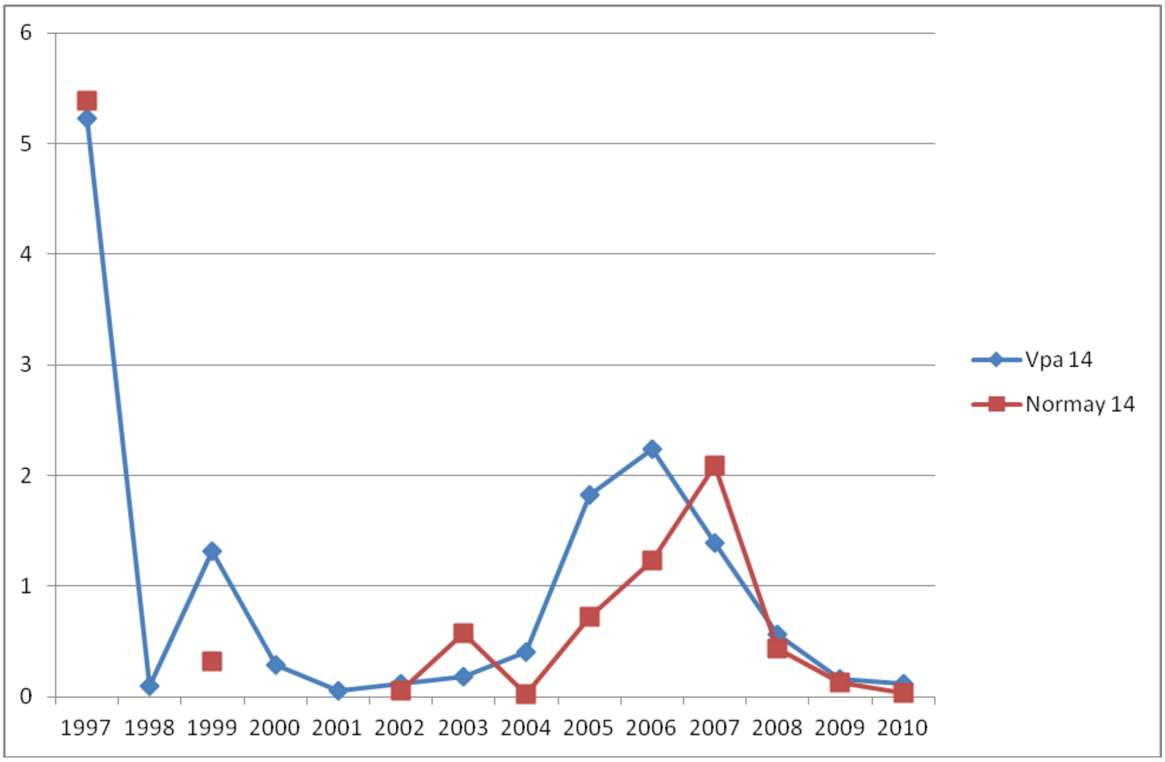

Figure 15. Mean standardised time series with abundance estimates of age 14. Only the survey time series with both internal and external consistency are shown.

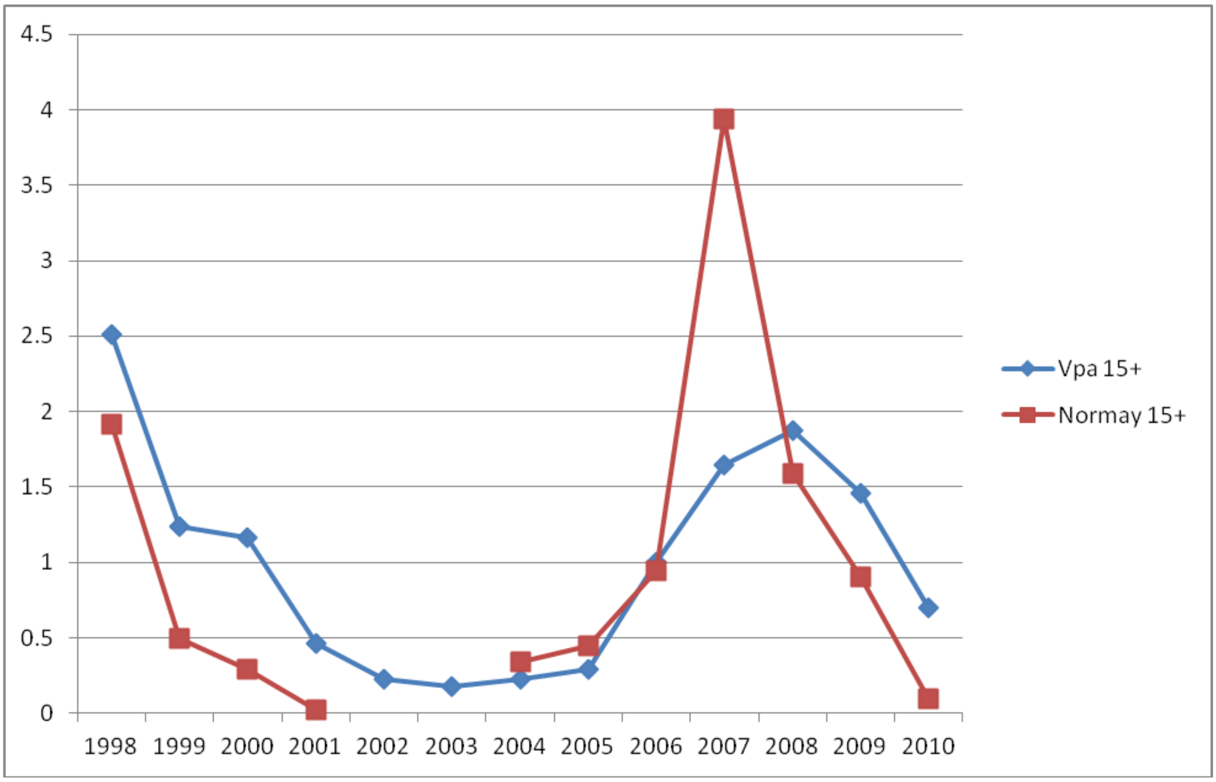

Figure 16. Mean standardised time series with abundance estimates of age 15+. Only the survey time series with external consistency are shown.

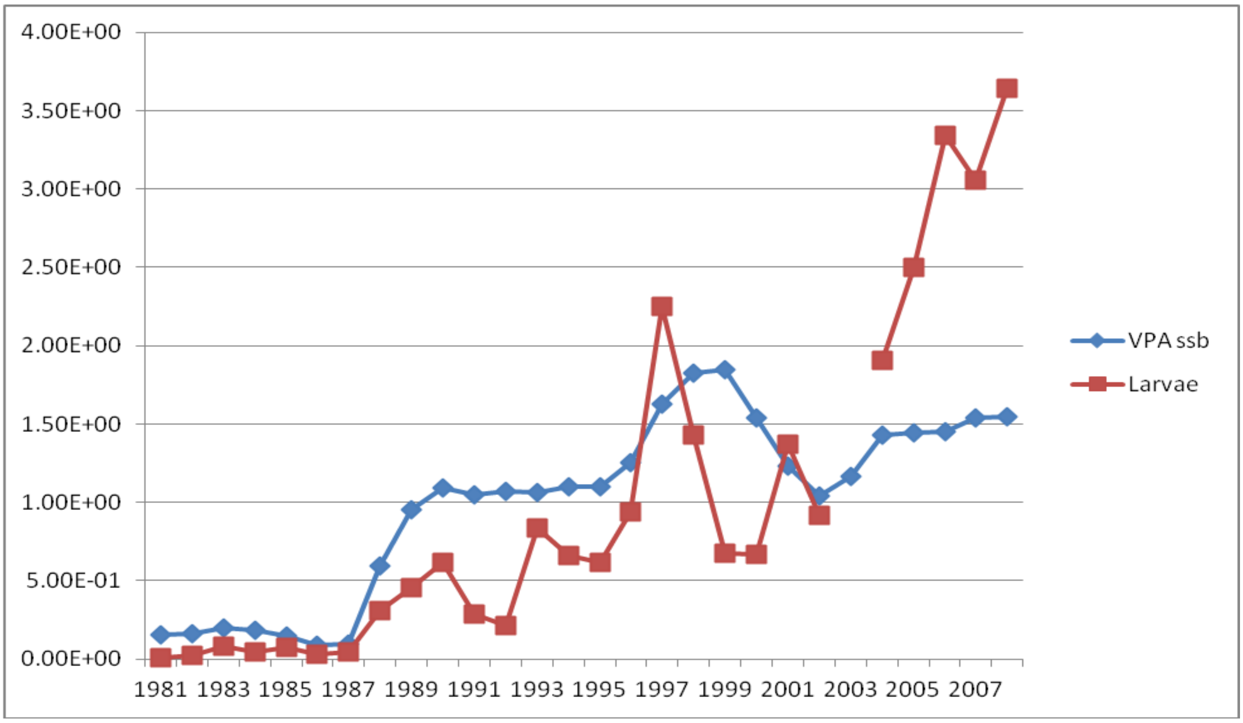

Figure 17. Mean standardised time series with SSB estimates.

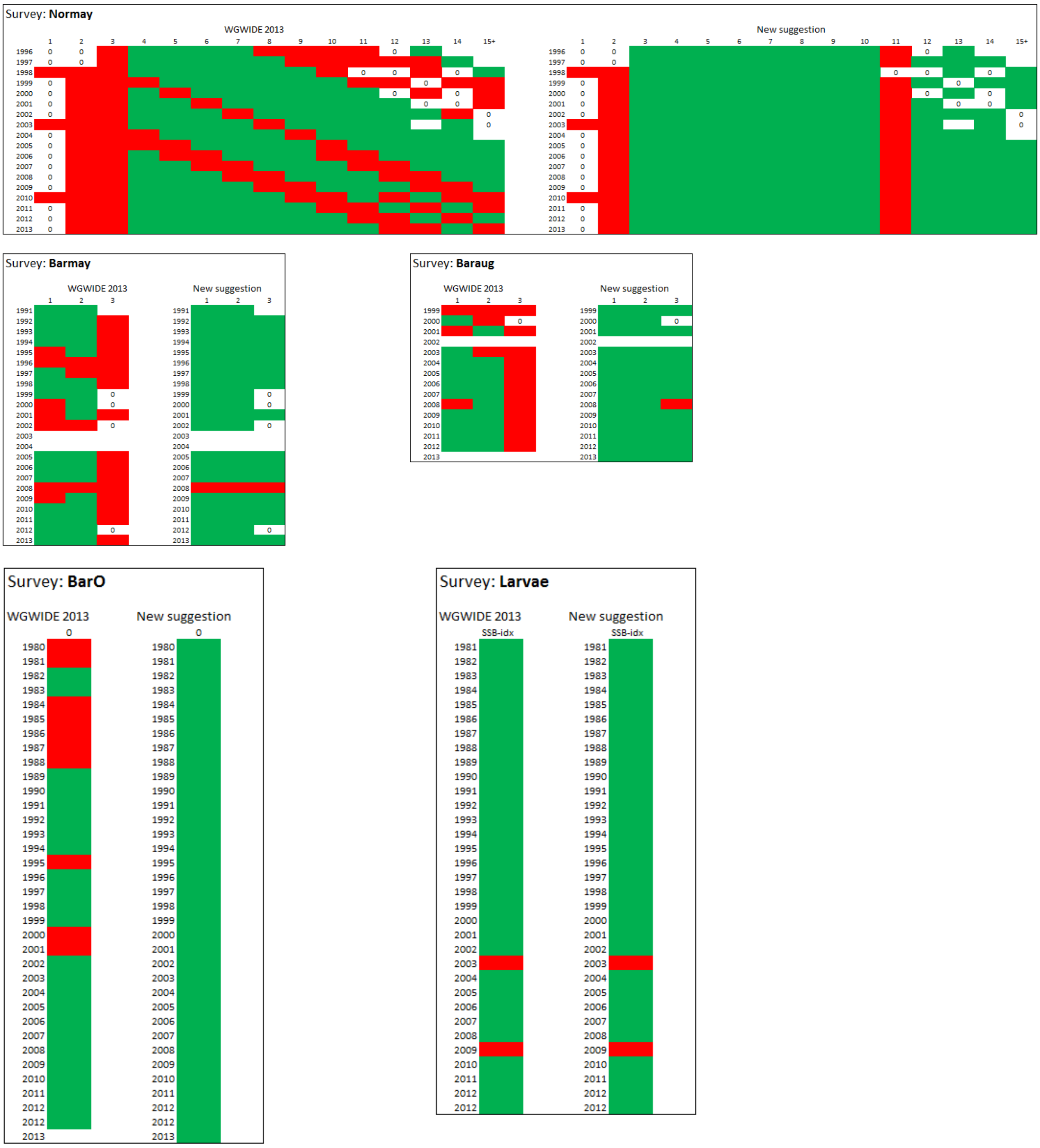

Figure 18. Comparison of excluded and included survey indices in the latest ICES stock assessment ('WGWIDE 2013') and the suggestion based on the present work ('New suggestion'). Green: included, red: excluded, white: no observation (blank) or zero-value (0). The top rows with numbers in each survey are age groups.

Appendix

Data used in the analyses (survey indices and VPA estimates).

Survey: **Sg**

Age→	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1988		255	146	6805	202									
1989	101	5	373	103	5402	182								
1990	183	187		345	112	4489	146							
1991	44	59	54	12	354	122	4148	102						
1992														
1993														
1994	16	128	676	1375	476	63	13	140	35	1820				
1995		1792	7621	3807	2151	322	20	1	124	63	2573			
1996	407	231	7638	11243	2586	957	471			165		2024		
1997														
1998			381	1905	10640	6708	1280	434	130	39		175		804
1999	106	1366	337	1286	2979	11791	7534	1912	568	132			392	437
2000	1516	690	1996	164	592	1997	7714	4240	553	71	3		6	361
2001														
2002														
2003														
2004														
2005	103	281	811	3310	7545	10453	887	563	159	122	610	1100	686	17

Survey: **Winnov**

Age→	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
1992		36	1247	1317	173	16	208	139	3742	69				
1993	72	1518	2389	3287	1267	13	13	158	26	4435				
1994		16	3708	4124	2593	1096	34	25	196	29	3239			
1995	380	183	5133	5274	1839	1040	308	19	13	111	39	907		
1996		1465	3008	13180	5637	994	552	92		7	41	15	393	
1997	9	73	661	1480	6110	4458	1843	743	66			64		904
1998	65	1207	441	1833	3869	12052	8242	2068	629	111	14		40	573
1999	74	159	2425	296	837	2066	6601	4168	755	212		15		146
2000	56	322	1522	5260	165	497	1869	4785	3635	668	205			11
2001	362	522	3916	1528	2615	82	338	864	3160	2216	384	127		1

Survey: **Winjan**

Age→	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1991	90	220	70	20	180	150	5500	440						
1992		410	820	260	60	510	120	4690	30					
1993		61	1905	2048	256	27	269	182	5691	128				
1994	73	642	3431	4847	1503	102	29	161	131	3679				
1995		47	3781	4013	2445	1215	42	24	267	29	4326			
1996		315	10442	13557	4312	1271	290	22	25	200	58	1146		
1997														
1998	214	267	1938	4162	9647	6974	1518	743	16	4		33	7	462
1999		1358	199	1455	4452	12971	7226	1876	499	16	16		156	220

Survey: **Normay**

Age→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1996			4114	22461	13244	4916	2045	424	14	7	155		3134		
1997			1169	3599	18867	13546	2473	1771	178	77	288	190	60	2697	
1998	24	1404	367	1099	4410	16378	10160	2059	804	183			35		492
1999		215	2191	322	965	3067	11763	6077	853	258	5	14		158	128
2000		157	1353	2783	92	384	1302	7194	5344	1689	271		114		75
2001		1540	8312	1430	1463	179	204	3215	5433	1220	94	178			6
2002		677	6343	9619	1418	779	375	847	1941	2500	1423	61	78	28	
2003	32073	8115	6561	9985	9961	1499	732	146	228	1865	2359	1769		287	
2004		13735	1543	5227	12571	10710	1075	580	76	313	362	1294	1120	10	88
2005		1293	19679	1353	1765	6205	5371	651	388	139	262	526	1003	364	115
2006		19	306	14560	1396	2011	6521	6978	679	713	173	407	921	618	243
2007		411	2889	5877	20292	1260	1992	6780	5582	647	488	372	403	1048	1010
2008		1193	587	8332	8270	16345	1381	1920	3958	2500	416	242	159	217	408
2009		410	2316	2314	13545	8937	12025	1335	1334	2696	1488	208	175	65	232
2010	81	364	1195	3329	2156	8282	4146	4519	390	513	804	331	45	17	25
2011		1058	1576	1753	4550	2692	8693	2879	4830	572	898	837	281	13	34
2012		1588	2995	415	844	1835	2321	4346	1890	2338	329	615	344	112	54
2013		395	653	2900	496	1120	1923	2794	4311	2600	1782	538	573	209	62

Survey: **Barmay**

Age→	1	2	3
1991	24.3	5.2	
1992	32.6	14	5.7
1993	102.7	25.8	1.5
1994	6.6	59.2	18
1995	0.5	7.7	8
1996	0.1	0.25	1.8
1997	2.6	0.04	0.4
1998	9.5	4.7	0.01
1999	49.5	4.9	
2000	105.4	27.9	
2001	0.3	7.6	8.8
2002	0.5	3.9	
2003			
2004			
2005	23.3	4.5	2.5
2006	3.7	35.0	5.3
2007	2.1	3.7	12.5
2008			
2009	0.19	0.47	0.67
2010	7.724	1.966	0.091
2011	0.6	3.6	0.02
2012	0.370	0.120	
2013	0.036	1.912	0.377

Survey: **Baraug**

Age→	1	2	3
1999	48759	986	51
2000	14731	11499	
2001	525	10544	1714
2002			
2003	99786	4336	2476
2004	14265	36495	901
2005	46380	16167	6973
2006	1618	5535	1620
2007	3941	2595	6378
2008	30	1626	
2009	1538*	433	1807
2010	1047	215	234
2011	95	1504	6
2012	2031	1078	1285
2013	7657	5027	91

This value has been corrected: It is wrong in Prokhorova et al. (2013).

Survey: **Norjul**

Age→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2009		414	4134	3522	12449	7479	12361	1224	2144	1761	410		157	75	756
2010	544	326	1307	2630	2501	10139	6620	6470	1165	2308	805	422	166	87	143
2011		1042	1122	368	969	1008	3441	2710	2052	395	523	313	87	22	14
2012	108	794	3197	1256	1203	2674	2255	3999	3495	2923	907	554	301	87	57
2013		95	469	3261	1878	1251	2221	2949	4580	4989	2518	1087	606	151	73

Survey: **BarO**

Age→	0
1980	4
1981	3
1982	202
1983	40557
1984	6313
1985	7237
1986	7
1987	2
1988	8686
1989	4196
1990	9508
1991	81175
1992	37183
1993	61508
1994	14884
1995	1308
1996	57169
1997	45808
1998	79492
1999	15931
2000	49614
2001	844
2002	23354
2003	28579
2004	136053
2005	26531
2006	68531
2007	22319
2008	15915
2009	18916
2010	20367
2011	13674
2012	26480
2013	70972

Survey: **Larvae**

	SSB-index
1981	0.3
1982	0.7
1983	2.5
1984	1.4
1985	2.3
1986	1
1987	1.3
1988	9.2
1989	13.4
1990	18.3
1991	8.6
1992	6.3
1993	24.7
1994	19.5
1995	18.2
1996	27.7
1997	66.6
1998	42.4
1999	19.9
2000	19.8
2001	40.7
2002	27.1
2003	
2004	56.4
2005	73.91
2006	98.9
2007	90.6
2008	107.9
2009	
2010	42.7
2011	73.4
2012	65.6
2013	71.6

VPA (numbers at age in thousands, SSB in million tons)

Age→	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	SSB
1980	1460000	4220000	1020000	334000	444000	138000	327000	404000	1320	263	440	22800	14.5	8.42	4.75	4.75	0.482
1981	1100000	591000	1720000	414000	282000	377000	117000	274000	333000	725	219	378	17100	11.6	6.33	6.33	0.492
1982	2220000	443000	240000	691000	353000	238000	316000	98400	232000	279000	307	93.6	220	13800	9.04	9.04	0.506
1983	2.85E+08	890000	179000	97300	582000	296000	201000	267000	82900	195000	234000	153	46.5	155	11800	13.7	0.632
1984	12000000	1.16E+08	359000	71900	80800	481000	246000	167000	223000	70100	164000	195000	4.06	3.95	5.67	9360	0.571
1985	38700000	4860000	47100000	144000	57800	64600	357000	195000	132000	178000	53700	126000	162000	2.57	2.48	6540	0.473
1986	7040000	15700000	1970000	19000000	104000	35400	40300	188000	114000	63200	94800	37000	79500	93100	1.29	3200	0.28
1987	9010000	2850000	6390000	798000	15900000	73600	17100	20500	65300	29200	16100	11800	14000	8690	7910	509	0.303
1988	24732000	3653900	1155600	2575100	668200	13197000	46139	11517	11098	30424	14089	5141.2	6012.5	4832.6	1564.9	542	1.88
1989	66774000	10046000	1483800	464210	2158100	551910	10849000	30979	6520	4082	12789	4013.3	1841.2	2098.7	1700.7	6.54	3
1990	1.1E+08	27144000	4083200	587770	396870	1854100	469800	9037100	23454	4872	2886	7963.9	2187.1	959.27	1509.5	1230	3.44
1991	2.96E+08	44702000	11036000	1650500	488640	339120	1584900	394300	7568600	18993	2792.5	627.58	4627.1	1286.5	660.2	1370	3.32
1992	3.53E+08	1.2E+08	18172000	4484700	1412800	418000	290580	1350500	331160	6311600	14035	1977.3	459.69	3344.5	1011.9	1010	3.39
1993	1.08E+08	1.44E+08	48986000	7387500	3848300	1185300	355160	249000	1151300	279710	5223400	9785	1112.7	169.1	1740.1	1740	3.36
1994	38439000	43843000	58400000	19912000	6332200	3213300	939420	297700	210930	963470	223500	4116100	8421.1	956.77	144.62	2990	3.48
1995	14006000	15628000	17825000	23739000	17108000	5348100	2428900	656210	241800	174010	794690	159390	2945900	4639.6	400.91	722	3.48
1996	54088000	5694300	6353800	7246500	20379000	14404000	4026900	1501800	351870	193760	135100	619420	60353	1694600	325.93	326	3.96
1997	33271000	21991000	2315100	2564700	6205300	16879000	10944000	2597300	917680	207460	161500	109460	471980	35737	690310	559	5.13
1998	1.66E+08	13527000	8940700	927820	2086600	5090000	12866000	7576500	1533300	489030	122410	120480	64322	322580	13220	255000	5.77
1999	1.56E+08	67407000	5499700	3584000	733470	1571700	4039900	9445500	5352700	967470	300950	66193	80287	52141	173880	126000	5.83
2000	56193000	63542000	27406000	2232900	2957200	598130	1228000	3079800	6646000	3531600	563930	161350	43556	32338	38216	118000	4.85
2001	33809000	22846000	25834000	11133000	1844000	2027400	482460	954420	2276600	4519500	2075600	285590	73050	22513	7136	47100	3.88
2002	2.72E+08	13746000	9288600	10502000	9487900	1438400	1350700	379380	732640	1685200	3114400	1318300	177800	41004	16136	23300	3.29
2003	1.04E+08	1.11E+08	5588600	3738200	8855500	7570700	1001900	861030	298910	544060	1205700	2068000	821400	104210	23821	18200	3.68
2004		42258000	44989000	2269400	3147800	7321900	5840000	699730	586040	236100	399360	837100	1256400	504760	54185	23000	4.51
2005			17179000	18264000	1930700	2623800	5904200	4365500	499600	377020	178550	295200	564150	711160	240720	29800	4.56
2006				6972100	15305000	1574500	2100400	4486200	2898000	317490	210840	118600	193770	356920	295350	102000	4.57
2007					5930700	12497000	1279200	1649200	3190000	1781500	191410	110430	74072	113390	184100	167000	4.85
2008						4764700	9087400	959500	1194800	2072500	1061300	121160	71607	49603	74969	190000	4.88
2009								5702000		791740	1242500	572870	76918	28557	20851	148000	
2010											439900	678700	273920	24524	15971	71200	
2011												212830		72190			

Update on the discards of WGWIDE species by the Portuguese bottom otter trawl fisheries in ICES Division IXa (2004-2013)

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Abstract

We compile and update the information available on the discards of boarfish, herring, chub mackerel, Atlantic mackerel and blue whiting produced by Portuguese vessels operating with bottom otter trawl in Portuguese ICES Division IXa. The data was collected by the Portuguese on-board sampling programme (EU DCR/NP) between 2004 and 2013. Estimates of discard volume and discard length composition at fleet level are provided for most years × species × fisheries combinations. Final remarks are made on the importance of results from a WGWIDE perspective.

1 Introduction

This working document compiles the information available on the discards of WGWIDE stocks (boarfish, herring, Atlantic mackerel and blue whiting) and chub mackerel produced by the Portuguese bottom otter trawl fisheries in Portuguese ICES Division IXa. The data were collected by the Portuguese on-board sampling programme (EU DCR/NP) between 2004 and 2013. The document starts with a description of the on-board sampling programme and details of the estimation algorithms and quality assurance procedures (Section 2). Then, results are presented on the annual frequencies of occurrence and numbers sampled in discards of the different taxa and, for some years × species combinations, also fleet-level estimates of discard volume, length composition and age structure (Section 3). The document ends with a set of final remarks that highlight the importance of the results from a WGWIDE perspective (Section 4)

2 Onboard sampling and data analysis

2.1 Trip selection

Please refer to Prista et al. (2012).

2.2 Catch sampling

Please refer to Prista et al. (2012).

2.3 Estimates of discards (haul and set level)

Please refer to Prista et al. (2012).

2.4 Estimates of discards (fleet level)

Haul estimates are raised to fleet level using a raising algorithm adapted from Fernandes et al. (2010) (see also Jardim and Fernandes, 2013). Broadly, the raising algorithm combines haul level discard data (discards per hour) with total effort data derived from logbooks and sales slips to obtain annual fleet level discard estimates for different vessel-length strata. The procedure was developed for hake, which is a very frequent catch of the Portuguese OTB fisheries (Jardim and Fernandes, 2013); however, it has the drawback that it cannot reliably estimate discards from species with low frequency of occurrence in discard samples, namely those discarded in <30% of the hauls sampled (Jardim et al., 2011). To our knowledge the conversions of total discards in weight (and total discard numbers-at-length) to age are still to be standartized at European level. In this work, age length keys were used to convert annual discards-at-length to annual discards-at-age and quarterly estimates of discard weights (and numbers-at-age) were calculated by splitting total annual discards in weight (or numbers-at-age) proportionally to the number of trips registered in each quarter (as determined from sales slips). Discards-at-age were not sop-corrected.

2.5 Age determination

Age determination is carried out for Atlantic mackerel, chub mackerel and blue whiting according to standardized protocols and validated procedures (ICES 2010; ICES 2013; Martins et al., 2014). Otoliths used in to build the age-length keys come from port sampling, discards and research surveys. Annual age-length keys derived from quarterly age-length keys are used in discard estimation. The ages of Atlantic mackerel and chub mackerel were determined by Maria Manuel Martins, Delfina Morais and Andreia Silva. The ages of blue whiting were determined by Adelaíde Resende and Ana Luísa Ferreira. Boarfish is not aged at IPMA.

2.6 Quality assurance procedures

Data involved in the calculation of discard estimates from Portuguese waters comes from an IPMA database (on-board sampling data) and a DGRM database (logbook and sales data). The IPMA onboard database is programmed in Oracle and contains internal routines for the detection of very basic errors (e.g., in dates). Quality checks involving the manual checking of (at least) 10% of annual trawl records have been carried out since the beginning of the on-board sampling programme and in 2010-2011 a semi-automated R quality assurance procedure was designed and the entire OTB data checked for (so far) undetected errors. Since that time, routine quality assurance procedures include: quarterly checks using the semi-automated R routine and an annual check of 10% of the trawl records that detects observer-related biases, with only minor updates and data reviews being performed in previous data. DGRM effort and commercial data (sales records) are supplied to IPMA on an annual basis. The 2004-2011 logbook data supplied by DGRM are based on paper logbooks and display increasing fleet coverage across the period. From 2012 onwards, logbook data consist of both paper and electronic logbook records. IPMA and DGRM have been working on methods that improve the way paper and electronic records are combined and generate raising factors for discard estimation that are consistent through time. At present, these efforts are still ongoing so discard estimates should be considered provisional until a final review is made. The data used in the current estimates were extracted from the IPMA database in 21/06/2014. The DGRM data were supplied in 18/03/2014 and 23/04/2014.

2.7 Note on species identification

Please refer to Prista et al. (2012).

3 Species discards

3.1 Sampling levels

Sampling levels attained by the Portuguese onboard sampling programme on the OTB fisheries are presented in Table 1.

Table 1: Sampling levels achieved by the onboard sampling programme of Portuguese OTB fisheries in ICES Division IXa (2004-2013). "OTB_CRU" = crustacean fishery, "OTB_DEF" = demersal fish fishery

	Trips sampled		Hauls sampled		Hours fished	
Year	OTB_CRU	OTB_DEF	OTB_CRU	OTB_DEF	OTB_CRU	OTB_DEF
2004	17	24	111	125	479	315
2005	15	39	74	159	372	349
2006	7	42	30	194	133	380
2007	12	38	73	162	263	287
2008	12	34	66	128	255	254
2009	16	38	84	135	314	264
2010	16	31	103	116	375	208
2011	13	30	56	83	217	161
2012	13	31	68	60	302	130
2013	6	27	28	50	118	108

3.2 Selected species

Species codes and common names used in the present report are displayed in Table 2.

Table 2: Species codes (FAO), scientific and common names, and ICES stock abbreviations

3-alpha code	Species	Common name (EN)	Common name (PT)	ICES stock
BOC	*Capros aper*	Boarfish	Mini-saia	boc-nea
HER	*Clupea harengus*	Atlantic herring	Arenque	her-nea
MAC	*Scomber scombrus*	Atlantic mackerel	Sarda	mac-nea
MAS	*Scomber colias*	Chub mackerel	Cavala	—
WHB	*Micromesistius poutassou*	Blue whiting	Verdinho	whb-comb

3.3 Frequency of occurrence

The annual frequencies of occurrence of boarfish, herring, chub mackerel, Atlantic mackerel and blue whiting in discards of the Portuguese OTB fisheries are displayed in Table 3 and Table 4. The number of individuals sampled in each year is displayed in Table 5 and Table 6.

Table 3: Frequency of occurrence (%) of boarfish (BOC), herring (HER), chub mackerel (MAS), Atlantic mackerel (MAC) and blue whiting (WHB) in the discards of the hauls sampled onboard the Portuguese OTB_CRU fishery (2004-2013). "—" indicates no occurrence; "bold" numbers indicates frequency of occurrence ≥30%

YEAR	BOC	HER	MAC	MAS	WHB
2004	**32**	—	10	9	**83**
2005	16	—	11	7	**86**
2006	**47**	—	10	13	**73**
2007	**34**	—	22	19	**68**
2008	17	—	18	**35**	**56**
2009	**57**	—	1	7	**67**
2010	29	—	4	**31**	**84**
2011	**39**	—	25	**30**	**91**
2012	**32**	—	22	12	**72**
2013	**36**	—	18	7	**93**

Table 4: Frequency of occurrence (%) of boarfish (BOC), herring (HER), chub mackerel (MAS), Atlantic mackerel (MAC) and blue whiting (WHB) in the discards of the hauls sampled onboard the Portuguese OTB_DEF fishery (2004-2013). "—" indicates no occurrence; "bold" numbers indicates frequency of occurrence ≥30%

YEAR	BOC	HER	MAC	MAS	WHB
2004	**33**	—	22	**38**	**44**
2005	26	—	18	**36**	26
2006	**52**	—	17	**45**	**35**
2007	**46**	—	**31**	**69**	26
2008	**42**	—	20	**75**	15
2009	**47**	—	23	**70**	19
2010	27	—	22	**67**	**37**
2011	25	—	29	**71**	18
2012	**47**	—	**37**	23	**33**
2013	**34**	—	**44**	**44**	22

Table 5: Number of boarfish (BOC), herring (HER), chub mackerel (MAS), Atlantic mackerel (MAC) and blue whiting (WHB) sampled in the discards of the Portuguese OTB_CRU fishery (2004-2013)

YEAR	BOC	HER	MAC	MAS	WHB
2004	377	0	49	37	7057
2005	235	0	74	15	1685
2006	173	0	7	19	825
2007	706	0	257	47	1385
2008	52	0	46	62	514
2009	549	0	2	11	1197
2010	481	0	4	69	2216
2011	117	0	106	64	1509
2012	183	0	92	40	1337
2013	25	0	9	3	1054

Table 6: Number of boarfish (BOC), herring (HER), chub mackerel (MAS), Atlantic mackerel (MAC) and blue whiting (WHB) sampled in the discards of the Portuguese OTB_DEF fishery (2004-2013)

YEAR	BOC	HER	MAC	MAS	WHB
2004	1016	0	249	977	2682
2005	660	0	160	1085	1569
2006	5156	0	225	2704	1356
2007	1809	0	818	3061	632
2008	1345	0	153	3858	86
2009	1264	0	333	2434	1770
2010	201	0	70	3235	2180
2011	331	0	257	1642	605
2012	315	0	740	923	1219
2013	106	0	315	349	305

3.4 Total discards

Total discards of boarfish, herring, chub mackerel, Atlantic mackerel and blue whiting produced by the Portuguese OTB fisheries are displayed in Table 7 and Table 8. Quarterly estimates of discard weights of Atlantic mackerel and blue withing are provided in Annex. Due to limitations of the current estimation algorithm, discard volumes were not estimated when frequency of occurrence was lower than 30% (Prista et al., 2012; also Section 2.4). For that reason, numbers discarded per haul are also presented (Table 9 and Table 10).

Table 7: Volume (in metric tons) and CVs (%, in brackets) of boarfish (BOC), herring (HER), chub mackerel (MAS), Atlantic mackerel (MAC) and blue whiting (WHB) species discarded in the Portuguese OTB_CRU fishery (2004-2013). "(a)" = low frequency of occurrence

YEAR	BOC	HER	MAC	MAS	WHB
2004	25 (43%)	0 (0%)	(a)	(a)	2491 (38%)
2005	(a)	0 (0%)	(a)	(a)	676 (33%)
2006	73 (30%)	0 (0%)	(a)	(a)	3558 (4%)
2007	89 (66%)	0 (0%)	(a)	(a)	324 (48%)
2008	(a)	0 (0%)	(a)	25 (27%)	161 (41%)
2009	166 (35%)	0 (0%)	(a)	(a)	291 (18%)
2010	(a)	0 (0%)	(a)	33 (46%)	376 (22%)
2011	9 (36%)	0 (0%)	(a)	52 (39%)	507 (39%)
2012	32 (85%)	0 (0%)	(a)	(a)	278 (60%)
2013	3 (66%)	0 (0%)	(a)	(a)	633 (43%)

Table 8: Volume (in metric tons) and CVs (%, in brackets) of boarfish (BOC), herring (HER), chub mackerel (MAS), Atlantic mackerel (MAC) and blue whiting (WHB) discarded in the Portuguese OTB_DEF fishery (2004-2013). "(a)" = low frequency of occurrence

YEAR	BOC	HER	MAC	MAS	WHB
2004	222 (58%)	0 (0%)	(a)	413 (210%)	933 (39%)
2005	(a)	0 (0%)	(a)	463 (27%)	(a)
2006	938 (24%)	0 (0%)	(a)	1122 (35%)	170 (37%)
2007	394 (24%)	0 (0%)	815 (61%)	3476 (34%)	(a)
2008	225 (66%)	0 (0%)	(a)	4212 (24%)	(a)
2009	252 (60%)	0 (0%)	(a)	1844 (21%)	(a)
2010	(a)	0 (0%)	(a)	3727 (31%)	418 (45%)
2011	(a)	0 (0%)	(a)	1113 (23%)	(a)
2012	48 (28%)	0 (0%)	482 (65%)	(a)	191 (56%)
2013	42 (37%)	0 (0%)	617 (60%)	936 (70%)	(a)

Table 9: Discards (in number per haul) of boarfish (BOC), chub mackerel (MAS), Atlantic mackerel (MAC) and blue whiting (WHB) in the OTB_CRU fishery (2004-2013). "—" indicates no occurrence.

	BOC		MAC		MAS		WHB	
year	mean (sd)	range	mean (sd)	range	mean (sd)	range	mean (sd)	range
2004	60.7 (168.1)	0-1096	21 (170.6)	0-1788	7.2 (37.2)	0-358	2473.4 (5388.5)	0-35768
2005	127.4 (594.8)	0-4386	28.3 (183)	0-1556	7.7 (46.3)	0-387	701.6 (1420.3)	0-7419
2006	169.1 (394.2)	0-1838	6.5 (20.6)	0-88	50.2 (213.5)	0-1148	1538.3 (3330.1)	0-16250
2007	687.1 (3531.7)	0-29593	205.8 (857.2)	0-6014	50.4 (304.4)	0-2573	784.3 (2092.6)	0-12410
2008	86.2 (607.2)	0-4936	14.6 (42.6)	0-243	30.2 (62.7)	0-305	260.3 (522.5)	0-3910
2009	306.5 (598.8)	0-2965	1.4 (12.7)	0-117	10.4 (42.9)	0-283	528.5 (1080.9)	0-6961
2010	114 (387)	0-3082	1.2 (7.7)	0-73	46.7 (151.4)	0-1333	974.6 (1717.6)	0-13290
2011	74.9 (167.6)	0-776	56.5 (168.9)	0-990	55.3 (203.2)	0-1299	1063.1 (1583.8)	0-6559
2012	77.6 (246.9)	0-1624	42.2 (162.1)	0-1225	14.3 (53.6)	0-312	499.7 (1252.9)	0-8274
2013	24.9 (72.1)	0-333	6.4 (25.3)	0-132	6.7 (26.1)	0-125	1859.1 (4605.5)	0-23331

Table 10: Discards (in number per haul) of boarfish (BOC), chub mackerel (MAS), Atlantic mackerel (MAC) and blue whiting (WHB) in the OTB_DEF fishery (2004-2013). "—" indicates no occurrence.

	BOC		MAC		MAS		WHB	
year	mean (sd)	range	mean (sd)	range	mean (sd)	range	mean (sd)	range
2004	531.8 (3188.5)	0-32590	43.4 (137.1)	0-850	266.8 (957.5)	0-8032	929.1 (3809.7)	0-29195
2005	148 (590)	0-5782	29.7 (135.8)	0-1308	353.4 (1408.4)	0-12236	487.4 (2347.7)	0-17469
2006	1310.8 (3936.3)	0-34732	65.4 (386.5)	0-4080	1015.5 (3574.1)	0-24688	434.9 (2535.1)	0-27962
2007	613.6 (3121.9)	0-37181	437.5 (1936.7)	0-16744	1218.7 (3083.4)	0-26405	248.8 (1162.7)	0-12833
2008	598.6 (2373.6)	0-23407	103.7 (560.4)	0-4650	2091 (4857)	0-34187	26.6 (83.5)	0-479
2009	621.1 (2951.7)	0-30655	193.3 (961)	0-7960	1395.8 (4612.6)	0-36464	619.2 (3007.8)	0-24880
2010	140.7 (458.5)	0-3186	55.9 (349.3)	0-3713	2015.8 (4614)	0-28913	1221.3 (4541.7)	0-31342
2011	177.3 (646)	0-3640	299.3 (2226.5)	0-20150	614.7 (1198.8)	0-5613	233.5 (710.6)	0-3616
2012	126.4 (578.1)	0-4431	1020.4 (5452.4)	0-40388	314.6 (904.3)	0-4633	459.3 (1662.6)	0-11832
2013	156.5 (653.2)	0-4309	597.7 (2710.9)	0-18836	375.1 (990.1)	0-5405	519 (2304.2)	0-12290

3.5 Length frequency of discards

Length composition of discards of boarfish, chub mackerel, Atlantic mackerel and blue whiting produced by the Portuguese OTB fisheries are presented in Table 11 to 14. Due to limitations of the estimation algorithm (see Sections 2.4 and 3.4), length composition at fleet level is only provided for the year × species combinations where total discards could be reliably calculated. Overall summary statistics of length samples are provided in Table 15 and Table 16

Table 11: Length composition of boarfish (BOC) discards (no.x1000) produced by the Portuguese OTB fisheries (2004-2013). Years not shown displayed low frequency of occurrence (see Sections 2.4, 3.3 and 3.4)

	OTB_CRU							OTB_DEF						
Class (0.5 cm)	2004	2006	2007	2009	2011	2012	2013	2004	2006	2007	2008	2009	2012	2013
1.5	16.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	16.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.2	0.0	0.0	0.0
3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3	26.8	0.0	17.6	0.0	0.0
4	8.2	0.0	0.0	0.0	37.7	0.0	0.0	53.0	0.0	145.1	139.0	0.0	0.0	0.0
4.5	30.2	0.0	3.3	0.0	37.7	0.0	0.0	198.3	54.6	321.9	3.6	17.6	0.0	0.0
5	24.1	0.0	0.0	0.0	25.1	0.0	0.0	83.2	88.8	798.5	0.0	72.4	0.0	0.0
5.5	2.2	0.0	0.0	0.0	0.0	0.0	0.0	24.7	54.1	455.2	0.0	580.5	6.5	0.0
6	0.0	0.0	0.0	0.0	12.6	0.0	0.0	48.2	37.9	198.9	205.6	492.6	2.7	32.5
6.5	0.0	22.5	5.6	0.0	12.0	2.6	4.8	65.5	29.7	137.7	716.8	186.0	8.1	76.0
7	0.0	27.2	9.1	0.0	63.7	0.0	6.7	145.2	44.5	35.1	404.2	101.4	0.0	14.6
7.5	9.4	0.0	57.3	31.3	126.3	0.0	17.1	168.8	3.7	23.2	285.5	261.9	0.0	784.7
8	0.0	0.0	22.5	13.4	75.5	4.7	3.4	15.3	37.3	0.0	386.1	132.5	60.8	130.0
8.5	0.6	0.0	5.6	19.9	44.8	0.0	20.7	2.9	0.0	65.2	437.8	183.9	18.4	34.3
9	5.0	19.9	5.2	58.4	0.0	0.0	23.6	0.0	37.0	37.5	97.4	257.7	11.4	0.0
9.5	23.4	6.2	0.0	55.9	0.0	0.0	16.2	61.5	164.1	199.6	74.1	163.4	11.3	0.0
10	60.5	281.5	147.6	86.8	24.4	23.7	13.2	482.2	1738.7	823.2	578.4	290.8	12.5	29.6
10.5	101.8	186.8	422.8	520.9	22.2	30.9	20.0	1428.9	5055.8	1817.0	1565.9	456.1	9.5	38.9
11	102.3	296.5	863.3	719.5	38.8	163.0	2.9	2299.2	8042.2	3672.4	2918.6	1081.0	63.1	109.0
11.5	85.5	243.5	556.2	1188.2	38.1	213.1	49.1	1490.4	7739.9	2765.3	1813.0	1784.7	72.7	206.9
12	168.2	1163.2	396.6	1285.6	12.9	249.3	0.0	808.5	5418.4	2259.5	810.9	1469.4	44.4	104.6
12.5	96.3	179.3	208.9	875.1	2.9	104.5	2.9	317.3	2940.9	1346.1	502.2	1178.1	52.8	116.3
13	40.8	99.7	96.3	296.8	2.9	75.4	0.0	132.3	1151.1	661.8	232.2	589.5	96.1	61.4
13.5	15.0	80.7	33.5	41.0	10.0	41.0	0.0	47.6	489.4	230.5	120.1	219.0	140.7	58.2
14	0.0	23.7	0.0	27.3	0.0	18.7	0.0	8.6	55.2	17.7	25.9	69.9	83.3	0.0
14.5	0.0	0.0	0.0	16.8	0.0	10.6	0.0	62.2	9.3	4.3	0.0	33.1	58.2	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.2	18.8	0.0	0.0	0.0	62.8	6.2
15.5	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.8	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2	0.0	0.0	0.0	27.3	0.0
16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	6.2
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2
19.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0

Table 12: Length composition of Atlantic mackerel (MAC) discards (no.x1000) produced by the Portuguese OTB fisheries (2004-2013). Years not shown displayed low frequency of occurrence (see Sections 2.4, 3.3 and 3.4)

	OTB_DEF		
Class (1 cm)	2007	2012	2013
11	0.0	0.0	0.0
13	0.0	0.0	0.0
14	0.0	0.0	0.0
15	0.0	0.0	18.3
16	0.0	0.0	18.3
17	31.2	0.0	0.0
18	0.0	210.9	81.2
19	754.7	524.6	162.4
20	3971.6	653.6	155.7
21	2146.7	1736.3	1295.7
22	429.6	2124.9	2644.1
23	1732.4	603.0	810.2
24	1157.5	125.4	529.1
25	629.1	91.5	532.6
26	50.4	25.7	151.6
27	30.3	14.8	33.4
28	5.3	11.8	45.6
29	21.5	6.4	56.6
30	5.5	8.9	0.0
31	44.1	0.0	0.0
32	0.0	0.0	0.0
33	0.0	0.0	0.0
34	0.0	0.0	39.4
35	0.0	0.0	0.0
36	0.0	6.4	0.0
37	0.0	6.4	13.6
38	0.0	12.9	0.0
39	0.0	6.4	0.0
40	0.0	20.3	0.0
42	0.0	12.9	0.0

Table 13: Length composition of chub mackerel (MAS) discards (no.x1000) produced by the Portuguese OTB fisheries (2004-2013). Years not shown displayed low frequency of occurrence (see Sections 2.4, 3.3 and 3.4)

	OTB_CRU			OTB_DEF								
Class (1 cm)	2008	2010	2011	2004	2005	2006	2007	2008	2009	2010	2011	2013
12	0.0	0.0	0.0	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	13.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.6	0.0
15	0.0	0.0	0.0	0.0	8.2	39.6	0.0	61.1	0.0	0.0	111.8	0.0
16	0.0	0.0	6.4	0.0	59.0	11.3	0.0	632.8	532.4	0.0	65.6	0.0
17	0.0	0.0	0.0	0.0	427.5	742.6	30.8	2162.2	1699.7	139.1	255.3	0.0
18	0.0	0.0	9.4	0.0	1451.2	4047.4	1923.3	2946.0	1983.1	2783.2	864.4	0.0
19	0.0	0.0	114.9	0.0	1463.3	4898.6	5505.2	4374.8	1622.6	5866.0	1072.7	66.1
20	8.1	0.0	50.7	28.0	402.3	3379.3	6903.4	5995.5	1421.4	5944.8	866.3	576.2
21	0.0	3.6	34.7	99.6	154.4	2198.4	7359.5	9252.4	1839.3	6632.0	1162.6	1146.4
22	26.4	51.8	9.4	203.5	128.3	782.1	5837.8	11998.2	2166.6	7325.3	1064.5	1595.2
23	9.2	58.3	4.8	668.0	446.0	662.2	3713.6	6189.0	2795.1	5569.8	1513.5	1168.5
24	22.7	54.0	19.8	1314.0	716.7	414.1	2189.1	3082.5	3094.0	3062.7	1183.2	361.8
25	22.0	40.6	20.2	461.4	486.9	458.9	2135.0	1123.6	2675.1	2809.6	868.6	304.5
26	25.3	9.8	43.2	261.5	218.2	327.0	1693.4	1299.4	1261.8	1845.0	856.0	150.3
27	20.7	27.3	34.2	135.5	209.3	229.2	947.3	997.1	446.9	966.1	392.3	181.1
28	25.6	30.8	63.8	242.8	46.5	113.9	797.2	464.8	98.7	612.3	293.7	763.8
29	9.1	5.7	46.9	193.0	39.8	52.2	336.9	322.8	51.3	381.2	376.0	212.8
30	7.9	0.0	7.1	17.1	2.1	20.9	123.3	95.6	55.6	128.8	98.0	0.0
31	15.6	1.9	6.8	5.6	0.0	24.9	43.5	31.9	10.7	19.9	32.6	0.0
32	0.0	0.0	0.0	0.0	0.0	10.6	38.9	26.2	45.0	0.0	5.0	0.0
33	0.0	1.9	0.0	0.0	0.0	0.0	6.4	4.3	0.0	4.8	38.2	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	7.3	4.3	22.1	0.0	5.0	173.2
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	26.9	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	2.1	12.2	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	0.0	0.0	0.0	0.0

Table 14: Length composition of blue whiting (WHB) discards (no.x1000) produced by the Portuguese OTB fisheries (2004-2013). Years not shown displayed low frequency of occurrence (see Sections 2.4, 3.3 and 3.4)

	OTB_CRU										OTB_DEF			
Class (1 cm)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2004	2006	2010	2012
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.6	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	230.3	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	189.7	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	49.8	0.0	0.0	25.1	0.0	0.0	42.7	0.0	13.5
12	0.0	0.0	0.0	0.0	0.0	378.9	3.3	0.0	61.7	0.0	0.0	35.1	0.0	0.0
13	1.5	0.0	55.6	0.0	0.0	757.1	63.4	0.0	90.3	0.0	0.0	106.7	77.8	26.9
14	1284.7	0.0	289.7	0.0	0.0	730.2	324.7	0.0	200.4	0.0	0.0	241.5	60.4	324.3
15	7985.2	0.0	1453.0	3.9	0.0	745.1	521.7	6.9	368.0	0.0	954.0	852.1	1682.2	1351.1
16	6781.8	442.4	582.5	3.5	0.0	924.6	520.9	339.1	487.8	75.3	4145.3	724.7	4636.0	2293.2
17	1353.7	1098.3	1750.8	7.7	0.0	1168.9	611.6	682.0	342.9	1320.7	8214.6	313.5	5538.5	1166.6
18	304.1	777.3	372.2	11.3	0.0	1273.6	815.5	791.8	304.1	2969.1	3306.7	212.5	1839.9	356.5
19	721.2	363.7	759.2	7.7	6.5	1134.1	1143.9	1763.0	363.3	1753.1	1265.9	370.6	532.2	495.3
20	2968.8	146.8	877.6	22.3	50.5	529.0	726.6	1800.4	588.2	786.5	2476.3	596.2	268.4	370.8
21	5828.6	164.1	1603.7	115.5	94.1	106.6	458.5	1206.1	613.1	429.8	1951.0	302.8	159.8	203.6
22	4672.6	233.0	1014.7	526.9	236.0	0.0	725.5	1010.4	327.0	781.3	1058.4	180.6	182.9	83.5
23	3493.3	391.9	4773.1	1089.6	125.0	0.0	522.6	723.2	118.1	1281.0	394.9	202.3	317.4	56.9
24	2926.7	533.1	2450.5	728.4	413.3	14.6	428.4	428.1	78.2	1297.6	202.4	128.6	139.1	23.8
25	2120.9	774.4	6346.8	273.2	244.2	31.1	194.8	163.3	64.9	587.9	203.9	92.3	103.1	17.9
26	756.0	747.6	8273.6	218.2	385.5	118.8	80.7	57.4	41.1	109.2	98.5	68.0	0.0	14.7
27	533.6	611.1	1409.1	107.3	81.1	166.4	19.3	36.2	81.4	18.7	33.9	38.8	0.0	13.5
28	435.0	476.3	1338.9	107.5	36.1	128.4	10.1	30.2	80.2	2.2	10.8	2.0	0.0	0.0
29	107.3	313.9	322.5	46.8	12.2	42.3	8.4	30.0	45.7	7.9	0.0	2.0	4.3	0.0
30	91.8	232.2	345.4	20.3	16.4	43.0	5.7	23.9	38.7	0.0	0.0	0.0	0.0	0.0
31	56.8	119.4	1206.6	15.1	8.2	0.0	2.3	6.9	6.0	0.0	0.0	0.0	0.0	0.0
32	62.0	81.5	118.4	1.2	4.6	0.0	0.0	9.5	10.4	2.0	0.0	0.0	0.0	0.0
33	9.9	18.3	68.9	5.0	4.7	0.0	0.7	1.6	2.6	0.0	8.2	0.0	0.0	0.0
34	9.9	23.8	39.2	8.6	1.6	8.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0
35	14.0	13.7	7.9	2.5	0.0	0.0	0.0	2.1	6.5	0.0	0.0	0.0	0.0	0.0
36	9.4	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	9.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 15: Length frequency of discards (in cm) of WGWIDE species sampled onboard the Portuguese OTB_CRU fishery (2004-2013). See Table 2 for species codes

Taxa	n	Mean	SD	Range
BOC	2910	11.3	1.4	2-15.5
MAC	619	21.7	2.9	14-33
MAS	371	25.2	3.9	16-42
WHB	18777	20.9	4.2	10-38

Table 16: Length frequency of discards (in cm) of WGWIDE species sampled onboard the Portuguese OTB_DEF fishery (2004-2013). See Table 2 for species codes

Taxa	n	Mean	SD	Range
BOC	12118	11.1	1.5	3-19.5
MAC	3423	21.9	2.8	11-42
MAS	20343	21.3	2.8	12-43
WHB	12487	17.1	2.7	5-33

3.6 Age composition of discards

The fleet level age composition (in numbers) of Atlantic mackerel and blue whiting discards are displayed in Tables 17 and 18. Quarterly estimates of numbers-at-age of Atlantic mackerel and blue withing discarded in the Portuguese fisheries are provided in Annex. Due to limitations of the estimation algorithm (see Section 3.4), age composition at fleet level is only provided for the year $\times$ fishery $\times$ species combinations where total discards were not null *and* above the 30% frequency of occurrence threshold (see Section 2.4). At the time of the present report, the age composition of chub mackerel was still being processed. Boarfish is not aged at IPMA.

Table 17: Age composition of Atlantic mackerel (MAC) discarded by the Portuguese OTB_DEF fishery (no.x1000) (2007, 2012, 2013). Age compositions were not estimated in the remaining year $\times$ fishery combinations (see Section 3.4)

	OTB_DEF		
age class	2007	2012	2013
0	3411	2070	3080
1	5317	3945	2538
2	2251	121	829
3	20	2	12
4	7	5	14
5	4	9	7
6	0	11	15
7	0	12	3
8	0	9	0
9	0	7	0
10	0	11	0
11+	0	0	0

Table 18: Age composition of blue whiting (WHB) discarded by the Portuguese OTB_CRU and OTB_DEF fisheries (no.x1000) (2004-2013). Age compositions were not estimated in the remaining year × fishery combinations (see Section 3.4)

	OTB_CRU										OTB_DEF			
Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2004	2006	2010	2012
0	757	2043	2896	0	3	7471	1578	2208	176	886	1217	2256	9238	1133
1	23240	789	9482	937	661	324	2805	2499	2196	1765	17777	1618	4041	1895
2	10381	2219	8874	810	691	211	1577	3962	886	6994	4374	272	1832	695
3	5471	1176	5870	675	203	268	1071	352	794	1433	821	118	271	12
4	1055	725	3622	479	60	47	142	37	227	335	115	43	22	0
5	200	463	2865	258	56	14	8	37	52	5	12	18	0	0
6	34	96	1330	116	32	5	1	10	3	3	0	4	0	0
7	0	15	354	43	11	4	1	6	3	0	0	0	0	0
8	10	38	80	5	2	3	1	6	3	0	0	0	0	0
9	0	0	80	0	0	3	0	2	0	0	0	0	0	0
10	0	0	0	0	0	1	0	2	0	0	0	0	0	0
11+	0	0	0	0	0	0	0	0	0	0	0	0	0	0

4 Final remarks

Due to limitations of the current estimation algorithm, discard volumes were only estimated in the years and fisheries where discards were most frequent (>30% of sampled hauls). Results available indicate discard volumes were <100 tonnes/year of boarfish, < 700 tonnes/year of Atlantic mackerel, <1200 tonnes/year of chub mackerel and <700 tonnes/year of blue whiting in the most recent years (2011-2013). Discards of herring did not take place. The latter values are (with exception of blue whiting in recent years) relatively high when compared to mortality accounted in fisheries landings (Table 19) and are worth considering within WGWIDE assessments. IPMA is currently improving its discard raising algorithm to extend the estimation of OTB discards to all years × species × fisheries combinations. The main motives for discards are: no commercial value (boarfish), market-forces/offer-demand dynamics (blue whiting), quota restrictions (Atlantic mackerel) and undersized fish or low price of smaller specimens (chub mackerel and atlantic mackerel). In the OTB_CRU fishery the main motive for discarding is the existence of a by-catch limit on all fish species except blue whiting.

Table 19: Volume (in metric tons) of boarfish (BOC), herring (HER), chub mackerel (MAS), Atlantic mackerel (MAC) and blue whiting (WHB) landed by Portuguese vessels operating in ICES Division IXa (2004-2013). Landings made by both the Portuguese trawl fleet and the total Portuguese fleet are displayed. The trawl values of MAC include only the landings of Portuguese vessels when these operated in Portuguese ICES Division IXa

	Trawl landings from ICES IXa					Total landings from ICES IXa				
YEAR	BOC	HER	MAC	MAS	WHB	BOC	HER	MAC	MAS	WHB
2004	0	0	1127	1934	3545	0	0	1381	14714	4308
2005	0	0	1310	1830	4440	0	0	1509	14906	5190
2006	0	0	2428	797	1886	0	0	2620	13031	2447
2007	0	0	391	954	3216	0	0	2605	20222	3897
2008	0	0	444	540	3599	0	0	2381	23286	4221
2009	0	0	441	328	1855	0	0	1753	14428	2045
2010	0	0	351	426	1272	0	0	2363	22283	1484
2011	0	0	632	1098	641	0	0	962	30635	694
2012	0	0	148	688	1955	0	0	824	37191	1968
2013	0	0	206	803	2034	0	0	254	39250	2056

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Annexes

Quarterly volume (in metric tons) of Atlantic mackerel (MAC) discarded in the Portuguese OTB_DEF fishery (2004-2013)

QUARTER	2007	2012	2013
Q1	210.354	123.768	141.251
Q2	207.908	119.915	160.989
Q3	214.430	133.400	181.343
Q4	182.633	104.986	132.615

Quarterly volume (in metric tons) of blue whiting (WHB) discarded in the Portuguese OTB_CRU fishery (2004-2013)

QUARTER	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Q1	538.051	68.942	640.468	60.941	26.99	55.276	81.621	104.011	53.859	95.024
Q2	802.094	220.343	1067.446	99.192	42.573	88.442	98.547	152.211	73.571	195.75
Q3	625.235	215.612	1078.120	85.253	46.911	86.114	101.180	130.395	79.401	205.252
Q4	525.596	171.679	772.119	78.770	44.180	61.095	94.786	120.754	70.794	137.468

Quarterly volume (in metric tons) of blue whiting (WHB) discarded in the Portuguese OTB_DEF fishery (2004-2013)

QUARTER	2004	2006	2010	2012
Q1	249.181	49.570	106.597	48.976
Q2	248.248	40.542	106.597	47.451
Q3	223.983	43.438	105.761	52.787
Q4	211.851	36.794	99.072	41.543

Quarterly numbers-at-age (no.x1000) of Atlantic mackerel (MAC) discarded in the Portuguese OTB_DEF fishery (2004-2013)

QUARTER	AGE	2007	2012	2013
Q1	0	880.078	531.995	705.206
Q1	1	1371.696	1013.875	581.180
Q1	2	580.749	30.976	189.876
Q1	3	5.258	0.569	2.712
Q1	4	1.903	1.257	3.160
Q1	5	0.906	2.306	1.574
Q1	6	0	2.941	3.482
Q1	7	0	3.169	0.672
Q1	8	0	2.354	0.112
Q1	9	0	1.871	0
Q1	10	0	2.913	0
Q1	11	0	0	0
Q2	0	869.845	515.435	803.750
Q2	1	1355.746	982.315	662.393
Q2	2	573.996	30.011	216.409
Q2	3	5.197	0.552	3.091
Q2	4	1.880	1.218	3.602
Q2	5	0.896	2.234	1.794
Q2	6	0	2.850	3.969
Q2	7	0	3.070	0.766
Q2	8	0	2.281	0.128
Q2	9	0	1.813	0
Q2	10	0	2.823	0
Q2	11	0	0	0
Q3	0	897.134	573.396	905.374
Q3	1	1398.279	1092.776	746.144
Q3	2	592.004	33.386	243.771
Q3	3	5.360	0.614	3.482
Q3	4	1.939	1.354	4.057
Q3	5	0.924	2.486	2.021
Q3	6	0	3.170	4.471
Q3	7	0	3.416	0.863
Q3	8	0	2.538	0.144
Q3	9	0	2.017	0
Q3	10	0	3.140	0
Q3	11	0	0	0
Q4	0	764.099	451.265	662.093
Q4	1	1190.93	860.019	545.650
Q4	2	504.216	26.275	178.268
Q4	3	4.565	0.483	2.546
Q4	4	1.652	1.066	2.967
Q4	5	0.787	1.956	1.478
Q4	6	0	2.495	3.269
Q4	7	0	2.688	0.631
Q4	8	0	1.997	0.105
Q4	9	0	1.587	0
Q4	10	0	2.471	0
Q4	11	0	0	0

Quarterly numbers-at-age (no.x1000) of blue whiting (WHB) discarded in the Portuguese OTB_CRU fishery (2004-2013)

QUARTER	AGE	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Q1	0	163.421	208.38	521.264	0	0.533	1419.584	342.493	452.668	34.197	132.898
Q1	1	5019.754	80.507	1706.722	176.141	111.047	61.49	608.656	512.255	426.003	264.74
Q1	2	2242.281	226.388	1597.268	152.333	116.104	40.057	342.27	812.216	171.882	1049.078
Q1	3	1181.708	119.916	1056.561	126.822	34.149	50.86	232.492	72.100	153.981	214.962
Q1	4	227.891	73.946	651.901	90.068	10.078	8.959	30.913	7.548	44.07	50.32
Q1	5	43.257	47.19	515.668	48.431	9.386	2.616	1.803	7.507	10.085	0.795
Q1	6	7.350	9.748	239.39	21.750	5.441	0.927	0.180	2.082	0.554	0.489
Q1	7	0	1.525	63.664	8.131	1.88	0.736	0.113	1.233	0.500	0.044
Q1	8	2.132	3.832	14.479	0.955	0.364	0.570	0.154	1.158	0.504	0
Q1	9	0	0	14.479	0	0	0.570	0.102	0.41	0	0
Q1	10	0	0	0	0	0	0.190	0.043	0.479	0	0
Q1	11+	0	0	0	0	0	0	0	0	0	0
Q2	0	243.618	665.998	868.774	0	0.840	2271.335	413.517	662.441	46.712	273.770
Q2	1	7483.152	257.308	2844.537	286.697	175.163	98.384	734.874	749.642	581.911	545.364
Q2	2	3342.659	723.554	2662.114	247.947	183.14	64.091	413.247	1188.609	234.787	2161.101
Q2	3	1761.62	383.26	1760.935	206.423	53.866	81.376	280.705	105.512	210.335	442.822
Q2	4	339.726	236.336	1086.502	146.6	15.897	14.334	37.324	11.045	60.199	103.66
Q2	5	64.485	150.822	859.447	78.829	14.806	4.185	2.177	10.986	13.776	1.639
Q2	6	10.957	31.156	398.983	35.401	8.582	1.483	0.217	3.047	0.756	1.008
Q2	7	0	4.873	106.106	13.235	2.966	1.177	0.136	1.804	0.683	0.091
Q2	8	3.178	12.248	24.131	1.555	0.574	0.912	0.186	1.695	0.689	0
Q2	9	0	0	24.131	0	0	0.912	0.123	0.600	0	0
Q2	10	0	0	0	0	0	0.304	0.052	0.701	0	0
Q2	11+	0	0	0	0	0	0	0	0	0	0
Q3	0	189.901	651.697	877.461	0	0.926	2211.563	424.566	567.491	50.414	287.06
Q3	1	5833.14	251.783	2872.983	246.41	193.009	95.795	754.508	642.193	628.025	571.838
Q3	2	2605.613	708.018	2688.735	213.104	201.8	62.404	424.288	1018.242	253.393	2266.009
Q3	3	1373.188	375.031	1778.544	177.416	59.354	79.234	288.204	90.388	227.003	464.318
Q3	4	264.818	231.262	1097.367	125.999	17.516	13.957	38.321	9.462	64.969	108.692
Q3	5	50.266	147.583	868.042	67.752	16.314	4.075	2.235	9.412	14.868	1.718
Q3	6	8.541	30.487	402.972	30.427	9.456	1.444	0.223	2.611	0.816	1.057
Q3	7	0	4.768	107.167	11.375	3.268	1.146	0.140	1.545	0.737	0.096
Q3	8	2.477	11.985	24.373	1.336	0.632	0.888	0.191	1.452	0.743	0
Q3	9	0	0	24.373	0	0	0.888	0.126	0.514	0	0
Q3	10	0	0	0	0	0	0.296	0.054	0.600	0	0
Q3	11+	0	0	0	0	0	0	0	0	0	0
Q4	0	159.638	518.906	628.413	0	0.872	1569.014	397.734	525.536	44.95	192.259
Q4	1	4903.556	200.479	2057.549	227.671	181.773	67.963	706.826	594.716	559.952	382.99
Q4	2	2190.376	563.751	1925.596	196.899	190.051	44.273	397.474	942.963	225.927	1517.666
Q4	3	1154.354	298.614	1273.743	163.925	55.899	56.213	269.991	83.706	202.398	310.979
Q4	4	222.616	184.139	785.903	116.418	16.497	9.902	35.899	8.763	57.927	72.797
Q4	5	42.256	117.512	621.667	62.600	15.365	2.891	2.094	8.716	13.256	1.151
Q4	6	7.180	24.275	288.597	28.113	8.906	1.025	0.209	2.418	0.728	0.708
Q4	7	0	3.797	76.75	10.51	3.078	0.813	0.131	1.431	0.657	0.064
Q4	8	2.083	9.543	17.455	1.234	0.595	0.630	0.179	1.345	0.663	0
Q4	9	0	0	17.455	0	0	0.630	0.118	0.476	0	0
Q4	10	0	0	0	0	0	0.210	0.05	0.556	0	0
Q4	11+	0	0	0	0	0	0	0	0	0	0

Quarterly numbers-at-age (no.x1000) of blue whiting (WHB) discarded in the Portuguese OTB_DEF fishery (2004-2013)

QUARTER	AGE	2004	2006	2010	2012
Q1	0	325.071	656.503	2355.735	68.37
Q1	1	4746.464	470.797	1030.37	1502.899
Q1	2	1167.944	79.036	467.09	136.919
Q1	3	219.29	34.245	68.988	34.411
Q1	4	30.605	12.417	5.695	4.361
Q1	5	3.153	5.306	0.042	0.295
Q1	6	0	1.273	0.007	0
Q1	7	0	0.01	0	0
Q1	8	0	0	0	0
Q1	9	0	0	0	0
Q1	10	0	0	0	0
Q1	11+	0	0	0	0
Q2	0	323.853	536.934	2355.735	66.241
Q2	1	4728.687	385.05	1030.37	1456.116
Q2	2	1163.57	64.641	467.09	132.657
Q2	3	218.468	28.008	68.988	33.34
Q2	4	30.49	10.155	5.695	4.226
Q2	5	3.142	4.34	0.042	0.286
Q2	6	0	1.041	0.007	0
Q2	7	0	0.008	0	0
Q2	8	0	0	0	0
Q2	9	0	0	0	0
Q2	10	0	0	0	0
Q2	11+	0	0	0	0
Q3	0	292.198	575.286	2337.259	73.69
Q3	1	4266.485	412.554	1022.288	1619.856
Q3	2	1049.837	69.258	463.427	147.574
Q3	3	197.114	30.008	68.447	37.089
Q3	4	27.51	10.881	5.65	4.701
Q3	5	2.835	4.65	0.041	0.318
Q3	6	0	1.115	0.007	0
Q3	7	0	0.009	0	0
Q3	8	0	0	0	0
Q3	9	0	0	0	0
Q3	10	0	0	0	0
Q3	11+	0	0	0	0
Q4	0	276.371	487.301	2189.448	57.995
Q4	1	4035.383	349.458	957.638	1274.833
Q4	2	992.971	58.666	434.119	116.142
Q4	3	186.437	25.419	64.119	29.189
Q4	4	26.02	9.217	5.293	3.7
Q4	5	2.681	3.939	0.039	0.251
Q4	6	0	0.945	0.006	0
Q4	7	0	0.007	0	0
Q4	8	0	0	0	0
Q4	9	0	0	0	0
Q4	10	0	0	0	0
Q4	11+	0	0	0	0

Results on Blue Whiting Spanish Discard Sampling Programme

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Abstract

Quarterly discards per ICES Divisions estimates for the Spanish bottom otter trawl fleet fishing in the Northeast Atlantic ICES Subareas VI, VII, VIII and IX are presented for blue whiting (Micromesistius poutassou). Information was obtained by observers on board under DCF discard sampling program carried out by the Spanish research institute IEO. Raising based on effort (number of trips) was used to estimate total quarterly discards in weight and number for the most important fleets of Bottom Otter Trawlers. Discards age distributions are also presented.
Discards are highly variable throughout the series, both in weight and in number ranging from 680 to 6 800 tonnes per quarter and from 1 to 68 million fish. 100% catches are discarded in Sub-areas VI-VII. The highest discards weights are in Divisions VIIIc and VIIj. There is a seasonal pattern of discard being generally higher in the second quarter, although there are years with high values in other quarters.
Age distributions of blue whiting discards in Divisions VIIIc and IXaN show that most of the individuals are juveniles (ages 0 to 3), however older than are also discarded.

Keywords: Blue whiting, Discards, Northeast Atlantic waters, Bottom Otter Trawl.

1. Introduction

The "Spanish Discards Sampling Programme" was started in 1988. It does not cover every year because its implementation has depended on funding from several national and European research projects, which have not had an annual continuity. For this reason information is presented only since 2003:

Year	Project
1988-1989	National project
1994	EC Project: Pem/93/005
1997	EC Project: 95/ 094
1999-2000	EC Project: 98/095
2001	EC Project: 99/063
2003-2014	Data Collection Regulation Programme (Spain)

Spanish data on blue whiting discards have been provided to ICES WGWIDE in the past, but it was aggregated by year till 2010 and by Northern and Southern regions for all available series (2003 to 2012).

The main objective of this working document is to present the Spanish blue whiting discards estimates since 2003 by quarter and Division. Information on sampling discard strategy and discard reasons is also presented.

2. Material and methods

The sampling strategy and the estimation methodology used in the "Spanish Discards Sampling Programme" are similar since 1994, and are in accordance with the "*Workshop on Discard Sampling Methodology and Raising Procedures*" guidelines (ICES, 2003). The observers-on-board programme is based on a stratified random or cooperative sampling design. Métier is the stratum and trips (the sampling units) are randomly selected for sampling within of some métiers. Until 2009 the DCR asked for annual estimates and, hence, sampling was organised so as to obtain annual results.

The differences between the discards estimates presented here and those previously presented to the ICES WGWIDE are that now estimates are presented by quarter (instead of annually) and by ICES Divisions. The raising is done based on quarterly effort per métier. Total fleet discard per division are estimations from the total métier discard raising to the effort in each Division. This is because there are Division with no discard sampling per quarter.

Only the trawl fleet is considered for this species from the Spanish Discards Sampling Programme. This is because previous observations carried out on long line vessels showed low discarding levels for this species and area (Pérez et al., 1996). No information is available for gillnet in Sub-areas VI-VII, but discards of blue whiting in this gear are considered low. Information from the IXaS subdivision is available, but discarded weight is only presented because the samples are very irregular and sampled period shorter.

For discards sampling purposes, two métiers are considered within the Spanish trawl fleet operating in the ICES Sub-areas VI and VII, taking into account fishing area, gear and target. One métier -OTB_DEF_100-119_0_0- is considered to target mainly hake (*Merluccius merluccius*) and anglerfish (*Lophius piscatorius and L. budegassa*) and the other one métier OTB_DEF_70-99_0_0 megrim (*Lepidorhombus whiffiagonis and L. boscii*) and anglerfish. It was not possible sampled métier OTB_DEF_100-119_0_0 in 2013 so; discard in the métier OTB_DEF_70-99_0_0 was raised to the both métiers effort.

Three métiers are considered within the Spanish trawl fleet operating in the ICES Sub-areas VIII and IX, Northern Spanish coastal bottom otter trawl fleet: One métier OTB_DEF_>=55_0_0 targeting a variety of demersal species in ICES Divisions VIIIc and IXa-North, other coastal bottom otter trawl fleet but with higher vertical open gear -OTB_MPD_>=55_0_0- targeting horse mackerel (*Trachurus trachurus*) and/or Atlantic mackerel (*Scomber scumbrus*) and a Pair-trawler fleet PTB_MPD_>=55_0_0 targeting blue whiting and/or hake and/or Atlantic mackerel. Results here are showed for the entire trawl fleet, with metiers combined.

For each trip sampled, several hauls are, in turn, sampled as follows. A random sample of all discarded species is selected. Blue whiting in the discards sample is measured for length and the weight is calculated using a length/weight relationship (Dorel, 1986; Cull et al., 1989; Pereda and Pérez, 1995). The resulting blue whiting weight in the discards sample is raised to haul level according to the total discarded weight of the haul and the proportion of blue whiting in the sample. Haul-raised data are further raised to trip level taking into account the total number of hauls in the trip. Trip-raised weight and length values are subsequently raised to quarterly métier level using the number of trips per métier. Total discard per division are estimated raising the métiers values to total division effort (logbooks values since 2012). Effort per divisions, in years previous to 2012, where information disaggregated per division were not available, was estimated with the proportion of number of trip on division logbook effort, to obtain effort estimates for the fleet.

3. Results

Between 1988 and 2001, the sampling has had irregular coverage, with significantly higher levels of sampling in 1988 and 1994. However due sampling during 1988 to 2000 was not systematic information are not used for assessment. The sampling level varies depending on the year (Table 1). The information can be considered representative of the discard behaviour of the whole Spanish trawl fishery exploiting the blue whiting stock.

Discard estimates by quarter are shown in weight and number in Table 2 and Figure 1-2, and per year in Figure 3. Sub-areas VI_VII show low discard levels in 2012 and the lowest of the series in 2013 (Figure 3). The discard rate does not explain this decrease because 100% of catches are always discarded. Observer on board indices (kg caught per haul in OTB_DEF_70-99_0_0) show a small decrease in these both years (Figure 4), however, the strong effort reduction in that period is probably the mayor reason for the discard observed decrease (Figure 5).

Divisions VIIIc and IXa show a gradually declined in discards weight since 2006 increasing slightly in the last 3 years (Figure 3). The discard rates vary widely in these zones (Figure 6) but only PTB_MPD_>=55_0_0 métier show some diminution in discard rates. Observer on board indices of kg caught per haul show different patter according to métier (Figure 7). Only the OTB_DEF_>=55_0_0 métier shows a gradually decrees in abundance indices since 2003, due probably the specialization of this métiers in high commercial value species as hake, megrims or anglerfishes (Santos et al, 2012). Only the métier (PTB_MPD_>=55_0_0) shows higher catch indices in the last years which may explain the slight increase in discards in recent years, because is the métier with the highest weights of discards in the area. No effort reduction in that period is observed (Figure 8).

Observer on board indices (kg caught per haul) for all métiers show a relatively stable values since 2004 after a pick in 1997 (Figure 9).

Figures 10 and 11 show the quarterly age composition of the discards. Discards are concentrated in Divisions VIIj and VIIIc. Age distributions of blue whiting discards in Divisions VIIIc and IXaN show that most of the individuals are juveniles (ages 0 to 3), however older than are also discarded

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Table 1. Quarterly discard sampling level. Haul observation on board

Year	Quarter	VIa	VIb	VIIb	VIIc	VIIg	VIIh	VIIj	VIIk	VIIIc	IXaN	IXaS
2003	1											
	2				18		5	64	20	36	29	
	3						6	87		37	24	
	4				3			147	19	30	11	
2004	1				30			48	12	41	8	
	2				4			123	3	39	9	
	3		19		20			13	7	30	10	
	4				26			90		34	6	
2005	1				33			38		46	31	5
	2			11	5	5	30	52	2	57	10	20
	3						21	67		63	17	1
	4				4	7		52	9	33	11	
2006	1				2	27		69	10	40	19	
	2			4	20		45	61	15	40	20	9
	3			22	46			41		52	23	20
	4							14		14	7	
2007	1				1	5		65	11	43	4	
	2				27		14	41	17	54	12	12
	3				30			34	2	34	33	16
	4			22	16			75	8	47	29	
2008	1							32		71	14	
	2			9	24	5	29	46	5	56	32	3
	3		32	11	24		11	60	7	49	46	15
	4			1	27			89	14	38	23	
2009	1							60	29	46	16	2
	2			20	48		17	43	26	69	32	6
	3				14	2	5	105	4	81	28	9
	4				59			16	10	57	36	12
2010	1				11			29	24	27	14	2
	2					6	1	91	13	118	15	10
	3				57			10		71	19	10
	4			15	2	1		99	23	59	14	8
2011	1				18			46	10	74	13	5
	2						9	60		91	6	11
	3							92		103	12	12
	4		11		10		20	9	8	88	7	5
2012	1					5	17	88	14	83	15	7
	2					18	4	81		100	18	16
	3							34		75	23	8
	4				7		28	38	6	45	17	9
2013	1					1	41	62		69	5	6
	2						8	93		114	22	12
	3			10	9	4	2	8	1	56	9	8
	4				14		22	40	1	41	8	7

Table 2. Blue whiting quarterly discard estimates in weight (tonnes) and number (in thousands) for the Spanish trawl fishery, operating in Sub-areas VI-VII-VIII and Division IXa per Divisions

		VIa	VIb	VIIb	VIIc	VIIg	VIIh	VIIj	VIIk	VIIIc	IXaN	IXaS
2003	1									0	0	
	2	0	33	34	400	27	217	755	469	1766	1129	
	3	2	30	7	55	5	56	286	53	806	673	
	4	0	1	2	16	4	18	108	38	636	542	
2004	1	0	2	3	55	17	99	563	126	704	639	
	2	4	40	35	134	67	148	498	129	623	626	
	3	0	36	17	148	40	188	727	169	386	402	
	4	0	11	14	64	18	51	390	155	385	342	
2005	1	0	29	86	272	71	260	1575	230	338	91	
	2	0	51	38	315	59	231	1014	386	414	67	
	3	0	16	10	146	18	79	537	223	966	172	
	4	1	3	3	14	2	9	68	35	352	64	
2006	1	0	0	1	24	2	14	200	138	834	830	
	2	0	6	17	66	9	34	179	89	271	267	
	3	4	46	51	155	30	156	659	120	331	327	
	4	4	66	85	244	66	189	878	91	626	751	
2007	1	0	4	24	95	5	38	494	311	83	82	
	2	1	5	66	236	4	33	414	335	635	706	
	3	3	20	28	150	10	64	477	109	618	559	
	4	1	5	14	43	8	11	134	63	238	203	
2008	1	0	0	8	73	1	15	226	180	269	227	
	2	0	2	23	78	2	16	167	123	109	97	
	3	0	13	21	257	17	28	347	262	364	319	
	4	5	14	119	379	66	88	953	491	341	284	
2009	1	18	1	38	332	37	2	1074	861	139	109	0
	2	0	20	81	228	27	129	726	182	263	260	299
	3	0	2	35	147	17	58	405	131	180	153	154
	4	0	1	37	185	9	32	482	227	166	126	18
2010	1	0	0	0	0	0	1	173	166	116	108	0
	2	362	10	33	32	0	66	969	506	246	247	10
	3	30	14	6	12	0	33	457	122	280	263	85
	4	5	5	1	5	0	48	574	135	88	59	59
2011	1	6	2	13	68	0	7	352	57	173	111	75
	2	106	8	17	101	0	21	375	13	385	220	0
	3	154	0	57	385	7	97	1965	183	318	362	7
	4	10	5	27	86	1	13	861	471	193	222	44
2012	1	161	0	22	31	0	30	711	404	277	101	0
	2	420	0	26	97	0	43	291	131	368	170	2
	3	1	0	0	27	0	22	221	4	507	211	0
	4	0	7	20	7	0	22	185	10	153	82	0
2013	1	6	0	2	6	5	22	149	19	187	73	49
	2	55	0	11	21	0	26	298	21	743	318	72
	3	31	4	0	37	0	15	255	20	895	371	5
	4	0	1	5	2	0	6	41	1	387	166	22

Figure 1. Blue whiting quarterly discard estimates in weight (tonnes) for the Spanish trawl fishery in ICES Sub-area

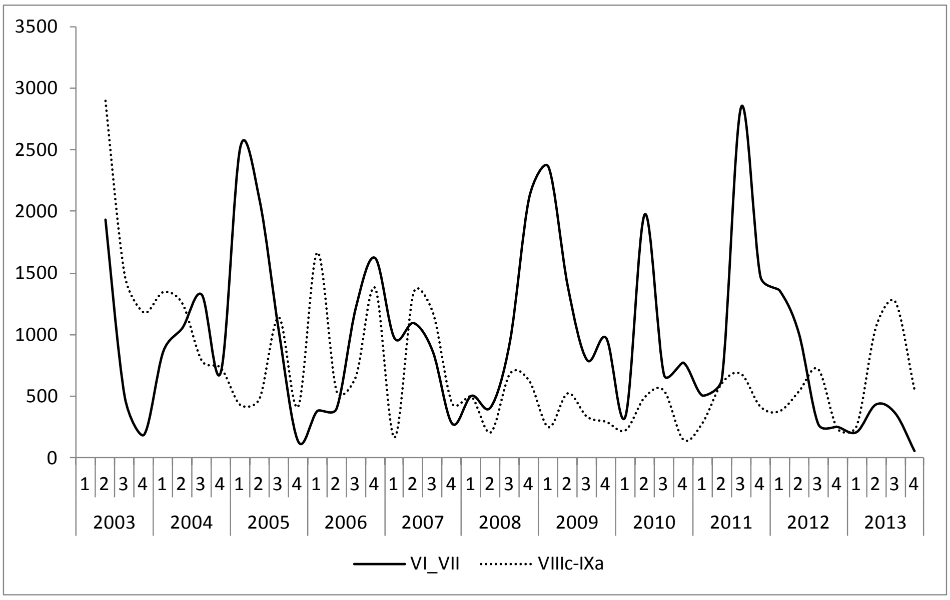


Figure 2. Blue whiting quarterly discard estimates in number (thousands) for the Spanish trawl fishery in ICES Sub-areas

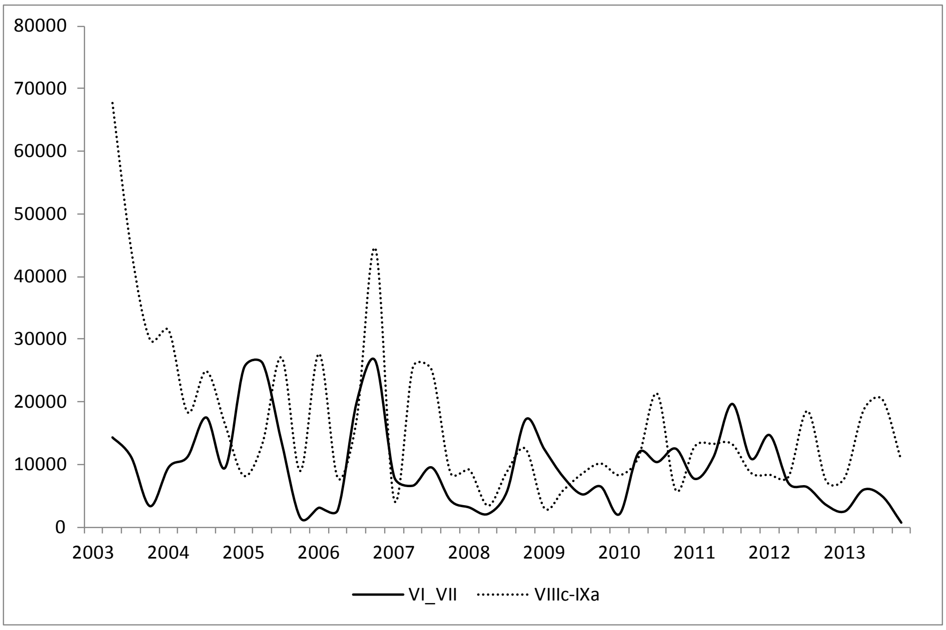


Figure 3. Blue whiting yearly discard estimates in weight (tonnes) for the Spanish trawl fishery in ICES Sub-areas

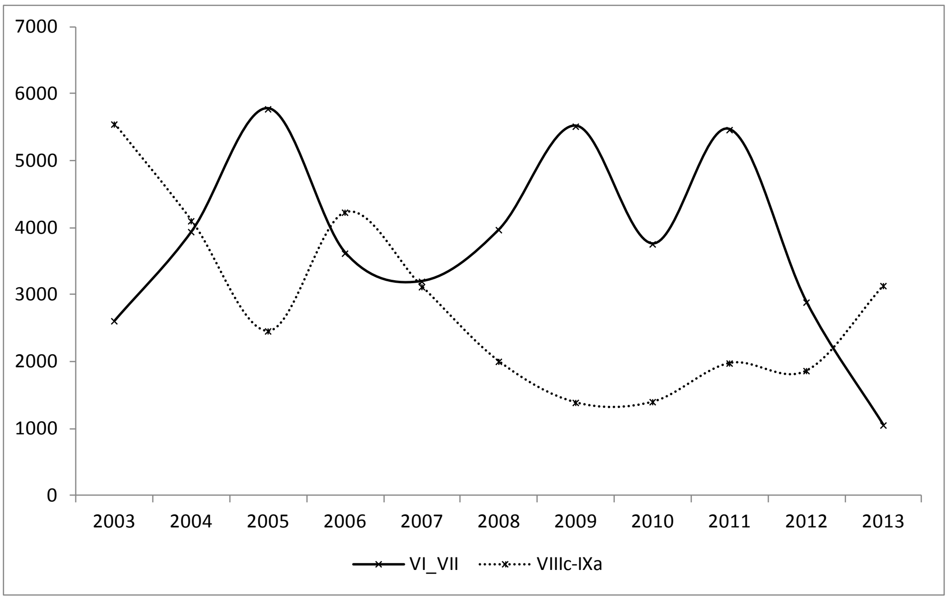


Figure 4. Observer on board indices (kg caught per haul) from métiers operated in Sub-areas VI_VII

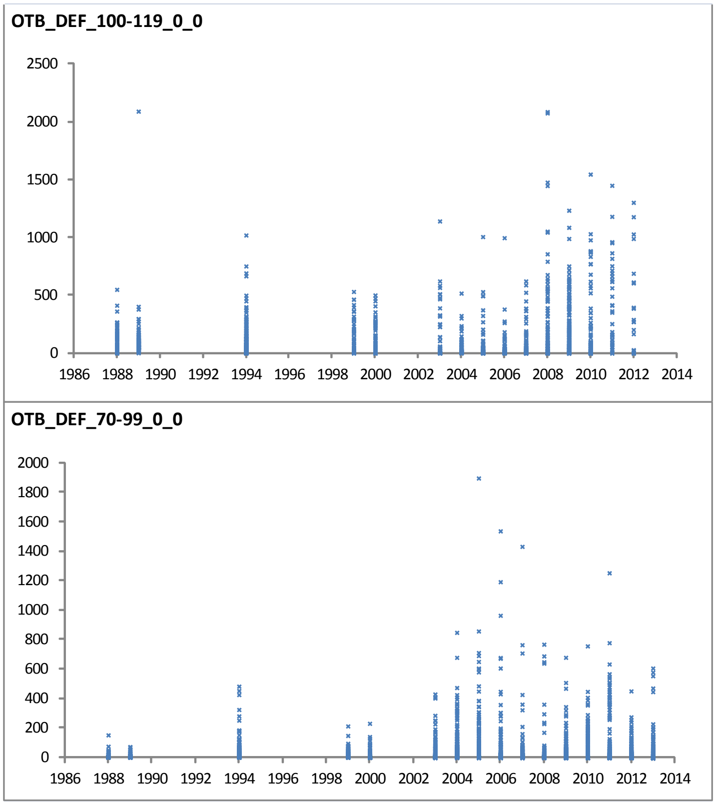


Figure 5. Effort in number of trips in Sub-areas VI_VII

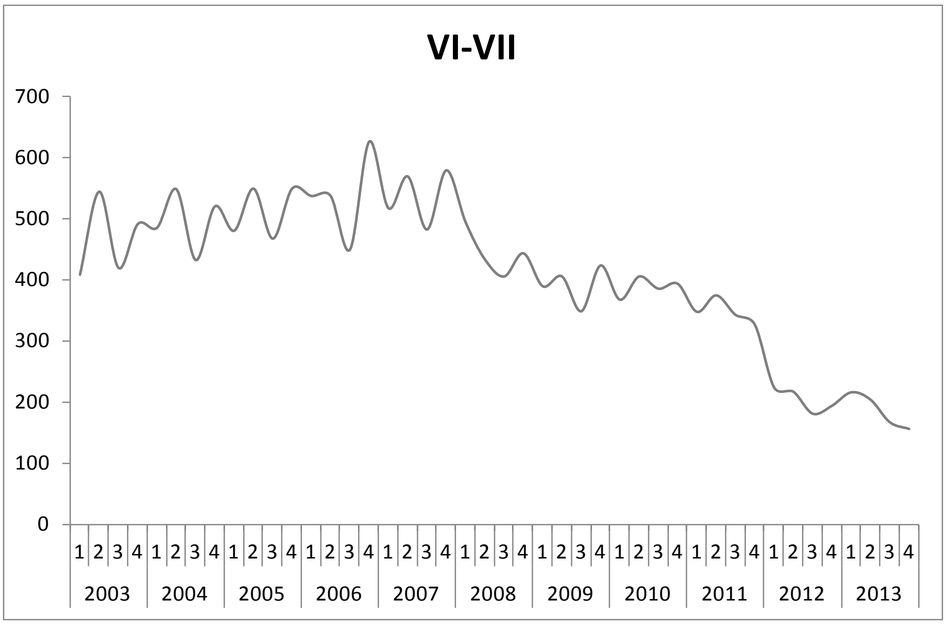


Figure 6. Discard rate (discard weight/catch weight) by métier in Divisions VIIIc and IXa. 1994-2013

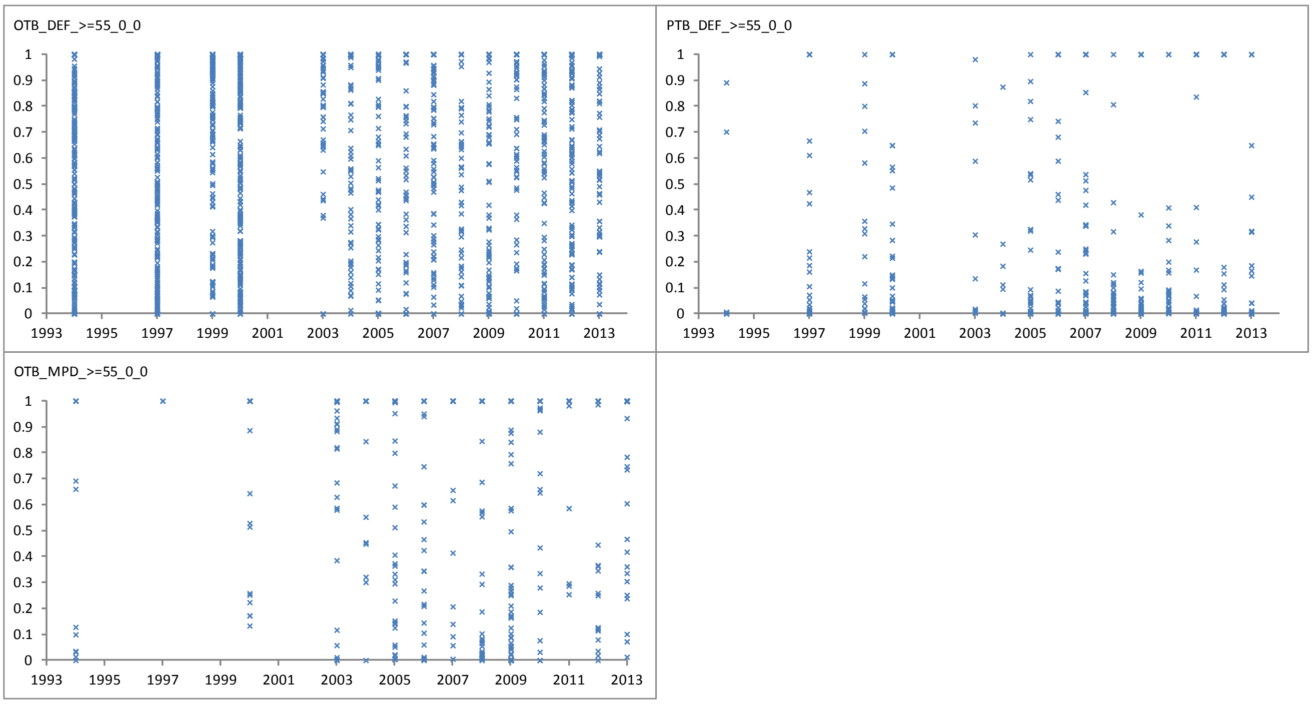


Figure 7. Total catch per haul (kg) in observed trips of OTB_DEF_>=55_0_0, OTB_MPD_>=55_0_0 and PTB_MPD_>=55_0_0

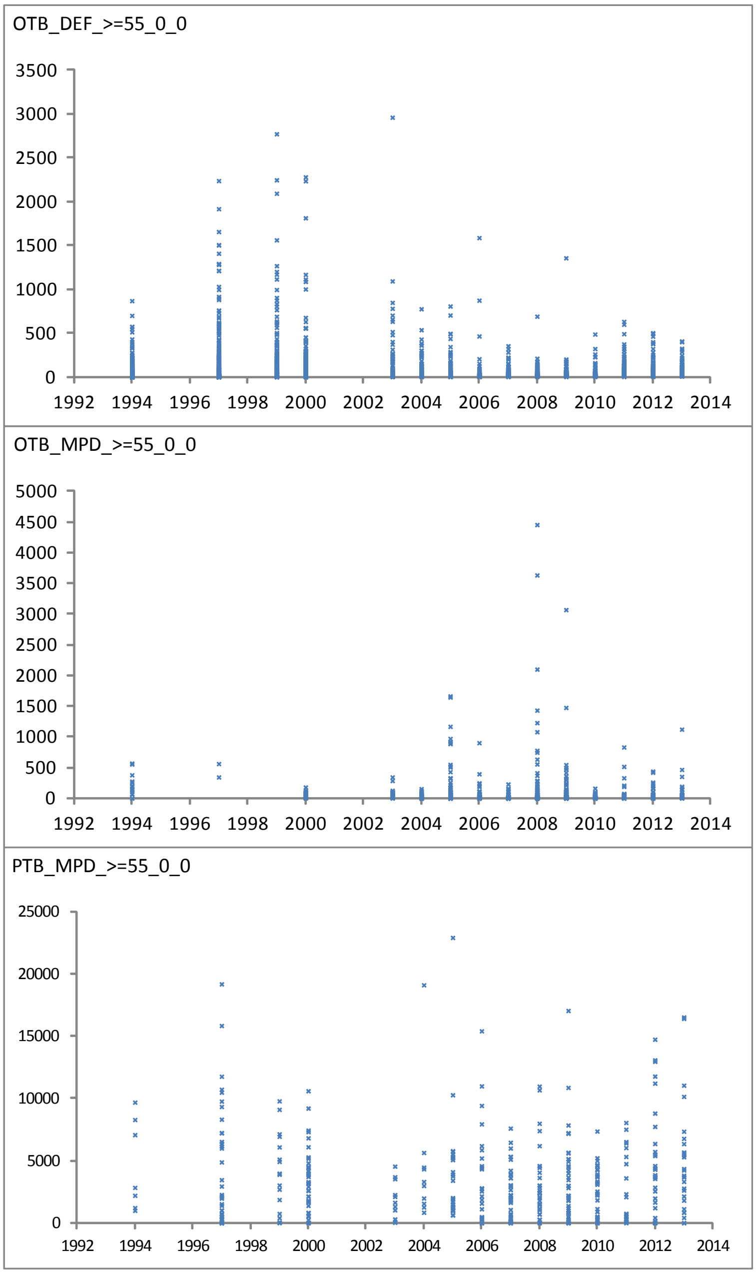


Figure 8. Effort in number of trips in Divisions VIIIc, IXaN

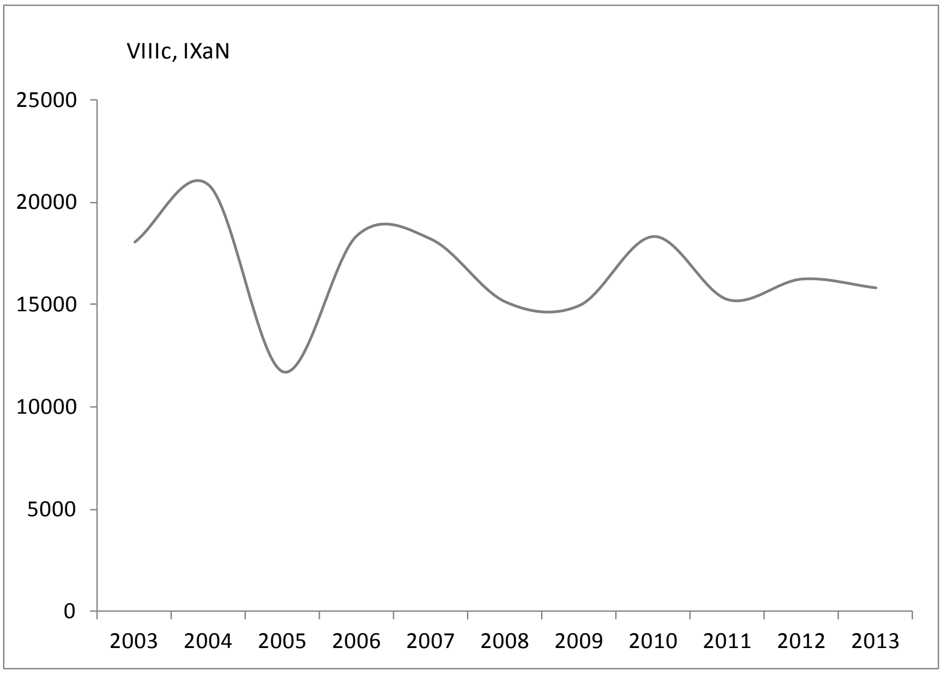


Figure 9. Observer on board indices; kg caught/ haul (points, on the left axis) and mean kg caught/haul (line, on the right axis) from all métiers.

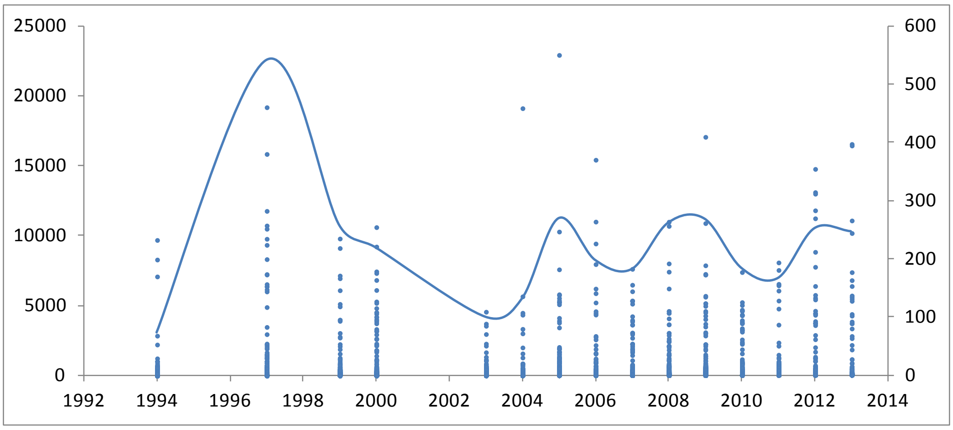


Figure 10. Quarterly age composition of Spanish trawl discards of blue whiting in ICES Sub-areas VI and VII.

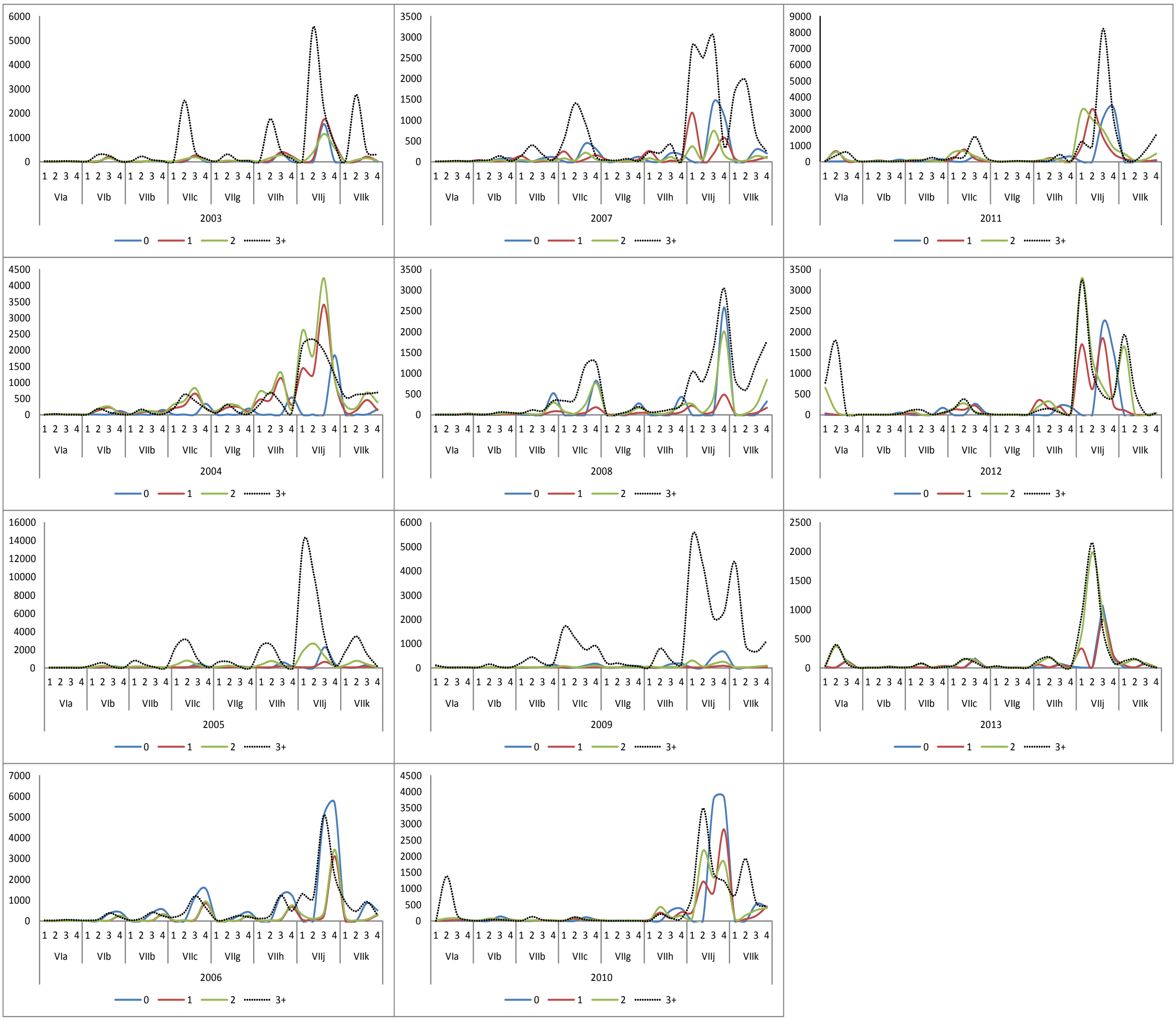
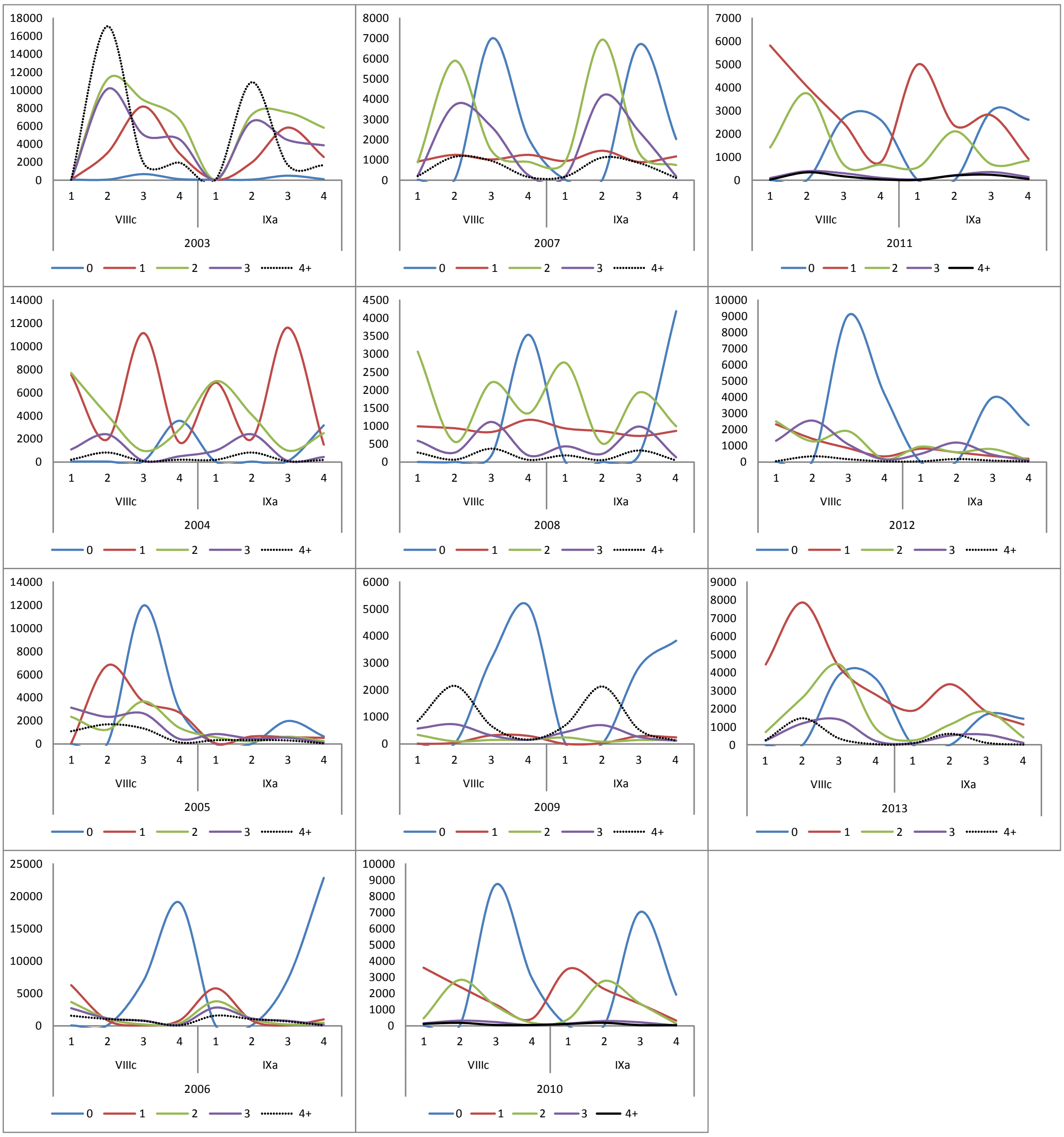


Figure 11. Quarterly age composition of Spanish trawl discards of blue whiting in ICES Divisions VIIIc-IXaN.



MULTIDISCIPLINARY ACOUSTIC SURVEY PELACUS0314: PRELIMINARY RESULTS ON FISH ABUNDANCE ESTIMATES AND DISTRIBUTION

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Abstract

PELACUS 0314 was characterised by relative stable weather conditions along the surveyed area. Besides, there was an important increase in backscattering energy as compared with the previous year. This resulted in an increase of the biomass estimated for the majority of the fish species, but still sardine is at lowest productivity ever recorded. Good recruitment would be observed in horse mackerel, but for the rest of the fish species, no strong signals for age group 1 have been detected.

The reasons for this increase would be related to the weather stability which could have increased the fish availability either for a change in the behaviour (i.e. spatial pattern distribution) or for an increase in the food availability. This is relevant accounting the increase of the occurrence of mackerel subsurface layers observed this year. As PELACUS is a multidisciplinary survey series (we collect environmental and biological ancillary information, stomach contents, including CTD cats, plankton tows or continuous records of plankton, eggs, S, T and flourometry), we will try to explain this change of behaviour. Our main hypothesis is that these species could follow mackerel when is undertaking vertical migration, probably related with the spawning activity, just for feeding eggs and, therefore, changing the expected schooling behaviour by the dispersed one, used during the feeding activity.

Material and methods

The methodology was similar to that of the previous surveys (see Iglesias et al. 2010 for further details). Survey design consisted in a grid with systematic parallel transects with random start, separated by 8 nm, perpendicular to the coastline, covering the continental shelf from 40 to 1000 m depth and from Portuguese-Spanish border to the Spanish -French one. (Figure 1)

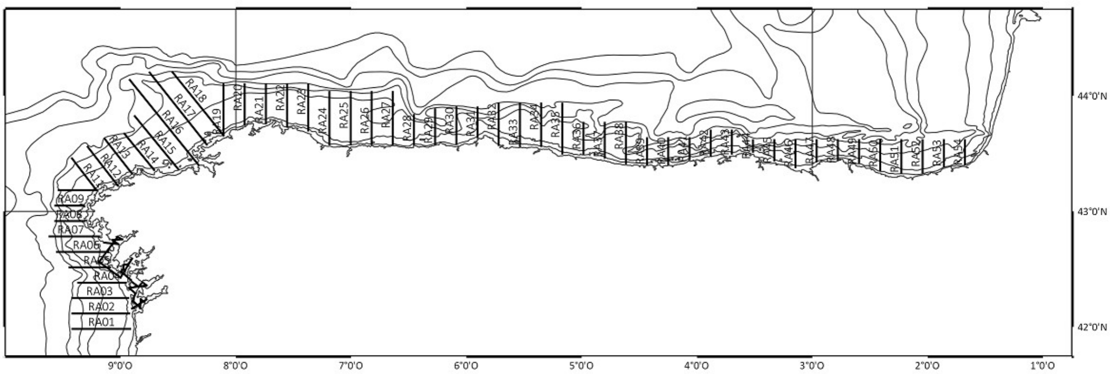


Figure 1 Survey track

The backscattering acoustic energy from marine organisms is measured continuously during daylight. Pelagic trawls are carried out whenever possible to help identify the species (and size classes) that reflect the acoustic energy. A continuous underwater fish egg sampler with an internal water intake located at 5 m depth is used to sample the composition of the ichthyoplankton while trained observers record marine mammal, seabird, floating litter and vessel presence and abundance. At night, data on the hydrography and hydrodynamics of the water masses are collected via the deployment of rosettes and conductivity, temperature and depth sensors. Information on the composition, distribution and biomass of phytoplankton and zooplankton is derived from the analyses of samples taken by plankton nets.

Acoustic equipment

Acoustic equipment consisted on a Simrad EK-60 scientific echosounder, operating at 18, 38, 120 and 200 kHz. All frequencies were calibrated according to the standard procedures (Foote et al 1987). The elementary distance sampling unit (EDSU) was fixed at 1 nm. Acoustic data were obtained only during daytime at a survey speed of 8-10 knots. Data were stored in raw format and post-processed using SonarData Echoview software (Myriax Ltd.) (Higginbottom et al , 2000). All echograms were first scrutinized and also background noise was removed according to De Robertis and Higginbottom (2007). Fish abundance was calculated with the 38 kHz frequency as recommended at the PGAAM (ICES 2002), although echograms from 18, 120 and 200 kHz frequencies were used to visually discriminate between fish and other scatter-producing objects such as plankton or bubbles, and to distinguish different fish species according to the strength of their echo at each frequency. The 18, 120 and 200 kHz frequencies have been also used to create a mask allowing a better discrimination between fish species and plankton. The threshold used to scrutinize the echograms was –70 dB. The integration values were expressed as nautical area scattering coefficient (NASC) units or s_A values (m^2 nm^{-2}) (MacLennan *et al*., 2002).

NASC Allocation

Two pelagic gears have been used to identify the species and size classes responsible for the acoustic energy detected and to provide samples. Choice of net was also dependant on the availability of enough unobstructed ground for the net to be deployed and recovered and for effective fishing to occur. Haul duration is variable and ultimately depends on the number of fish that enters the net and the conditions where fishing takes place although a minimum duration of 20 minutes is always attempted. The quality of the hauls for ground-truthing of the acoustic data was classified on account of weather condition, haul performance and the catch composition in numbers and the length distribution of the fish caught as follows:

	0	1	2	3
Gear performance **Fish behaviour**	Crash	Bad geometry Fish escaping	Bad geometry No escaping	God geometry No escaping
Weather conditions	Swell >4 m height Wind >30 knots	Swell: 2 -4 m Wind: 30-20 knots	Swell: 1-2m Wind 20-10 knots	Swell <1 m Wind < 10 knots
Fish number	total fish caught <100	Main species >100 Second species <25	Main species > 100 Second species< 50	Main species > 100 Second species > 50
Fish length distribu-tion	No bell shape	Main species bell shape	Main species bell shape Seconds: almost bell shape	Main species bell shape Seconds: bell shape

Hauls considered as the best representation of the fish community for a specific area were used to allocate NASC of each EDSU within this area. This process involved the application of the Nakken and Dommasnes (1975, 1977) method for multiple species, but instead of using the mean backscattering cross section, the full length class distribution (1 cm length classes) has been used, as follows:

$$s_{A_i} = s_A \frac{w_{li} \cdot \sigma_{bs}}{\sum_{li} w_{li} \cdot \sigma_{bs}}$$

where w_{li} is the proportion in number of *l* length class and species *i* in the hauls, and σ_{bs} is its correspondent proportion of backscattering cross section. The target strength (TS) is also taken into account as follows:

$$\sigma_{bs} = 10^{TS/10} \quad \text{(in dB)}$$

This is computed from the formula TS =20 $\log L_T$+ b_{20} (Simmonds and MacLennan, 2005), where L_T is the length class (0.5 cm). The b_{20} values for the most important species present in the surveyed area are shown in following table:

Table 1.- b_{20} values from the length target strength relationship of the main fish species assessed in PELACUS survey (WHB is blue whiting; MAC-mackerel; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel (Trachurus picturatus); BOG-bogue (Boops boops); MAS-chub mackerel (Scomber colias); BOC-board fish (Capros aper); and HMM-Mediterranean horse mackerel (Trachurus mediterraneus))

Species	WHB	MAC	HOM	PIL	JAA	ANE	BOG	MAS	BOC	HMM
b_{20}	-67.5	-84.9	-68.7	-72.6	-68.7	-72.6	-67.0	-68.7	-72.6	-68.7

In addition and according with Fässler et al (2013) a new b_{20} = -66.20 value for boarfish was also used.

When possible, direct allocation was also done, accounting for the shape of the schools and also the relative frequency response (Korneliussen and Ona, 2003, De Robertis et al, 2010).

Echointegration estimates

Once backscattering energy was allocated to fish species, the spatial distribution for each species was analysed taking into account both the NASC values and the length frequency distributions (LFD) to provide homogeneous assessment polygons. These are calculated as follows: an empty track determine the along-coast limit of the polygon, whilst three consecutive empty ESDU determine a gap or the across-coast limit. Within each polygon, the LDF is analysed.

LFD were obtained for all positive hauls for a particular species (either from the total catch or from a representative random sample of 100-200 fish). For the purpose of acoustic assessment, only those LFD which were based on a minimum of 30 individuals were considered. Differences in probability density functions (PDF) were tested using Kolmogorov-Smirnov test. PDF distributions without significant differences were joined, providing a homogeneous PDF strata. Spatial distribution was then analysed within each stratum and finally mean s_A value and surface (square nautical miles) were calculated using a GIS based system. These values, together with the length distributions, are used to calculate the fish abundance in number as described in Nakken and Dommasnes (1975). Numbers were converted into biomass using the length weight relationships derived from the fish measured on board. Biomass estimation was carried out on each strata (polygon) using the arithmetic mean of the backscattering energy (NASC, s_A) attributed to each fish species and the surface expressed in square nautical miles. For purposes of comparison, results are given by ICES Sub-Divisions (IXaN, VIIIcW, VIIIcEw , VIIIcEe and VIIIb)

Otoliths are taken from anchovy, sardine, horse mackerel, blue whiting, mackerel and hake (*Merluccius merluccius*) in order to determine age and to obtain the age-length key (ALK) for each species and area.

CUFES counts

Samples from CUFES are collected every three nmi while acoustically prospecting the transects. Once the sample is taken it is fixed in a buffered 4% formaldehyde solution. Anchovy and sardine eggs are sorted out and counted before being preserved in the same solution. The remaining ichthyoplankton (other eggs and larvae) are also preserved in the same way.

Plankton and hydrological characterisation

Continuous records of SSS, SST and flourometry are taken using a SeaBird Thermosalinograph coupled with a Turner Flourometer. Plankton and CTD and bottle rosette for water samples casts are performed at night. Five stations are placed over the transects, which are those of the acoustic prospection but that are extended onto open waters until the 1000-2000 m isobaths. The stations are evenly distributed over the surveyed area at a distance of 16-24 nmi.

Plankton was sampled using several nets (Bongo, WP2 and CalVet). Fractionated dried biomass at 53-200, 200-500, 500-1000 and >2000 µm fractions was calculated together with species composition and groups at fixed strata from samples collected at the CTD+bottle rosette carousel (pico and nanoplankton, microplankton and mesozooplankton). For this purpose, FlowCAM, LOPC and ZooImage techniques were used.

Water samples were stored at -20°C for further dissolved nutrients analysis (NO_3, NO_2, P, NH_4^+, SiO_4).

Top predator observations

Three observers placed above the bridge of the vessel at a height of 16 m above sea level work in turns of two prospecting an area of 180° (each observer cover a field of 90°). Observations are carried out with the naked eye although binoculars are used (7x50) to confirm species identification and determine predator behaviour. Observations are carried out during daylight while the vessel prospects the transects and while it covers the distance between transects at an average speed of 10 knots. Observers record species, number of individuals, behaviour, distance to the vessel and angle to the trackline and observation conditions (wind speed and direction, sea state, visibility, etc.). Observers also record presence, number and type of boats and type, size and number of floating litter. The same methodology is used on the PELGAS surveys and both observer teams shared a common database.

Centre of gravity

For each main specie, a centre of gravity (Woillez et al. 2007) was calculated as a weighted average of each sample location (allocated NASC value as weighting factor). Due to the particular topography of the NW Spanish area, instead longitude and latitude, we have used depth and a new variable called “distance from the origin” calculated as follows:

- Locations below 43º10 N: distance is calculated as (Lat-41.5)*60, being *Lat* the latitude of the middle point of any particular EDSU within this region.

- Location between 43º10’ N and 8ºW (i.e. NW corner): distance is calculated as ((I.Lat-43.18333)^2+ (*I.Lon**(cos(I.Lat*pi()/180))-6.714441)^2)$^{0.5}$)*60+(43.1833-41.5)*60, being *I.Lat* and *I.Lon* the coordinates at which a normal straight line from middle point of any particular EDSU within this region intercepts a line defined by the following geographical coordinates: 43º11N-9º12.50’W and 43º39.50’N-8º06’W.

- Location between 8ºW and the Spanish-French border: distance is calculated as 158.329+ (Lon+5.8755324052)*60, being *Lon* the corrected longitude (longitude multiplied by the cosine of latitude) of the middle point of any particular EDSU within this region.

Besides each fish was measured and weighed to obtain a length-weight relationship. Otoliths were also extracted from anchovy, sardine, horse mackerel, blue whiting and mackerel in order to estimate age and to obtain the age-length key (ALK) for each species for each area.

Results

The survey started on 9th March and ended on 6th April. A total of 3260 nautical miles were steamed, 1075 of them corresponding to the survey track. Contrary to the previous year, weather conditions were in general good, although three tracks were interrupted due to the presence on air bubble. Besides, some pings were also removed due to the presence of bubbles sweep down. Also most of the tracks located in the NW corner (i.e. VIIIc-west), were sternway steamed in order to avoid bubbles sweep down. The last track, located in the French waters was not surveyed.

Calibration

All frequencies were calibrated on 9th March, with the following results:

Table 2: Acoustic equipment calibration. Main in and outputs for each frequency.

		200 kHz	120 kHz	38 kHz	18 kHz
Main	TS	-39.10 dB	-39.50 dB	-42.30 dB	-42.70 dB
	Gain	27.00 dB	27.00 dB	26.50 dB	22.40 dB
	Two way Beam Angle	-20.70 dB	-21.00 dB	-20.60 dB	-17.00 dB
	Angles (deg)	7.0 x 7.0	7.0 x 7.0	7.1 x 7.1	11.0 x 11.0
	Pulse Duration	1.024 ms	1.024 ms	1.024 ms	1.024 ms
	Power	90 W	200 W	2000 W	2000 W
	Sample Interval	0.193 m	0.193 m	0.193 m	0.193 m
	Rec. Bandwidth	3.09 kHz	3.03 kHz	2.43 kHz	1.57 kHz
Beam Model Results	Transducer Gain	26.03 dB	26.73 dB	24.73 dB	22.94 dB
	Sa Corr	-0.27 dB	-0.37 dB	-0.58 dB	-0.80 dB
	Athw Beam Angle	6.57 deg	6.38 deg	6.95 deg	10.97 deg
	Along. Beam Angle	6.53 deg	6.51 deg	7.12 deg	10.63 deg
	Athw Offset Angle	-0.29 deg	-0.05 deg	0.05 deg	0.19 deg
	Along. Offset Angle	-0.09 deg	-0.01 deg	-0.17 deg	0.31 deg
Data dev from beam model	RMS	0.60 dB	0.52 dB	0.20 dB	0.55 dB
Data dev polynomial model	RMS	0.56 dB	0.44 dB	0.18 dB	0.51 dB

Main oceanographic conditions

Figure 2a-c shows the sea surface temperature, salinity and flourometry from the continuous records. In the western areas (i.e. IXa-N) temperatures ranged from 13.18º to 22.27ºC, with a mean value of 14.13º (median, 14.07º). In the same way salinity ranged from 28.28 to 36.31 ppm (mean 33.70 and median 33.91 ppm), with a strong correlation with longitude, being waters less salted and warmer close to the coast due to the river flows. Fluorescence ranged from 0.84 to 2.75 (mean 1.20, median , 1.12). In the northern areas (VIIIc) temperature ranged from 12.58º to 14.92ºC (mean, 13.26º, median 13.18º) being 0.75º colder than that of the western area. In addition, salinity ranged from 31.64 to 36.04 ppm (mean 35.23, median 35.34 ppm), thus more salted than those from the western area. Fluorescence ranged from 0.94 to 3.63 (mean 1,64, median 1.52); complementary, all variables were correlated with latitude. Thus, interpolation was made using this two areas . The surveyed area can be divided in several areas according to the surface continuous records. IXaN area with low salinity, warmer waters and weak flourometry (i.e. chlorophyll); NW corner (VIIIc-W) with high flourometry values, salty waters from the coast to the self-beak, and temperatures in transition from warmer waters in the south to colder waters in the north ; from Cape Ortegal to Llanes Canyon, with lesser salty waters in coastal areas than in open waters, colder temperature through all the area and a weak chlorophyll density ; from Llanes Canyon to Suances , with warmer waters than that of the surrounded areas, but with almost same salinity as found in the surrounded areas, with a clear influence from the river flows and the chlorophyll increasing eastwards; from Suances to Laredo, characterised by an intrusion of colder waters, low salinity in coastal waters, and a moderate concentration of chlorophyll; and the inner part where both sea surface temperature and flourometry showed a clear west-eastward cline, and, as in the rest of the surveyed area except in VIIIc-west, an influence of the river flows in the coastal areas.

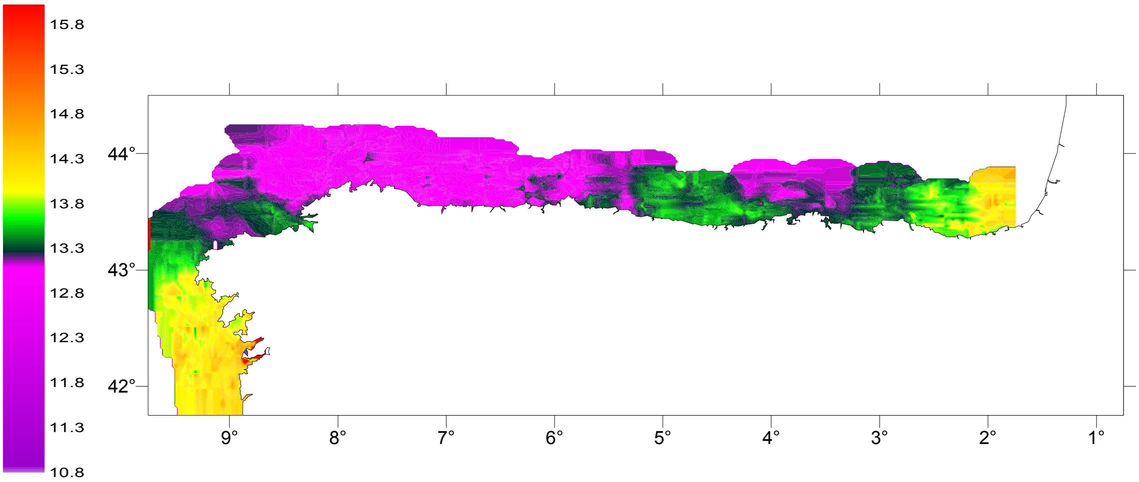


Figure 2a: Sea Surface Temperature during PELACUS 0314 survey

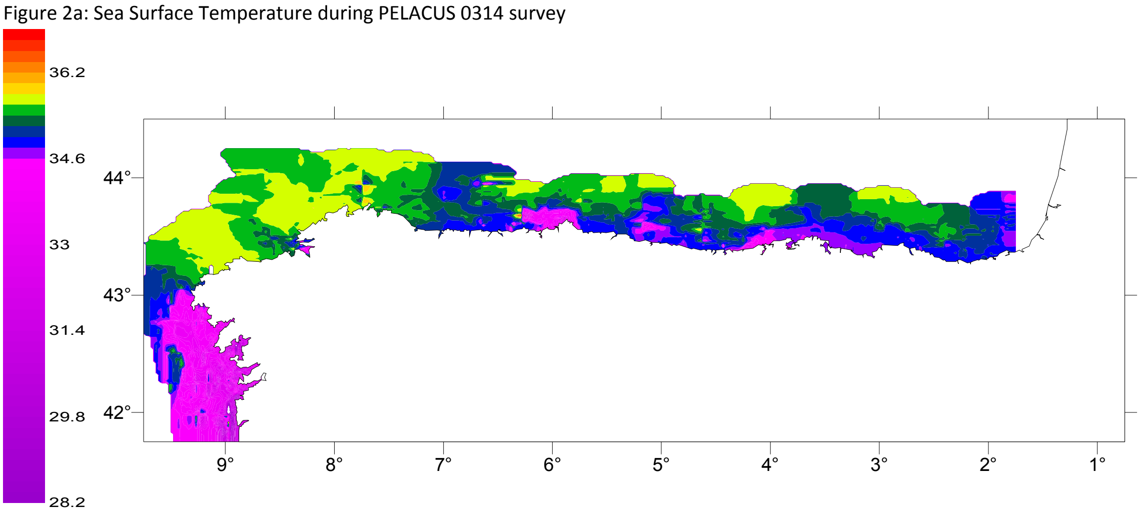


Figure 2b: Sea Surface Salinity during PELACUS 0314 survey

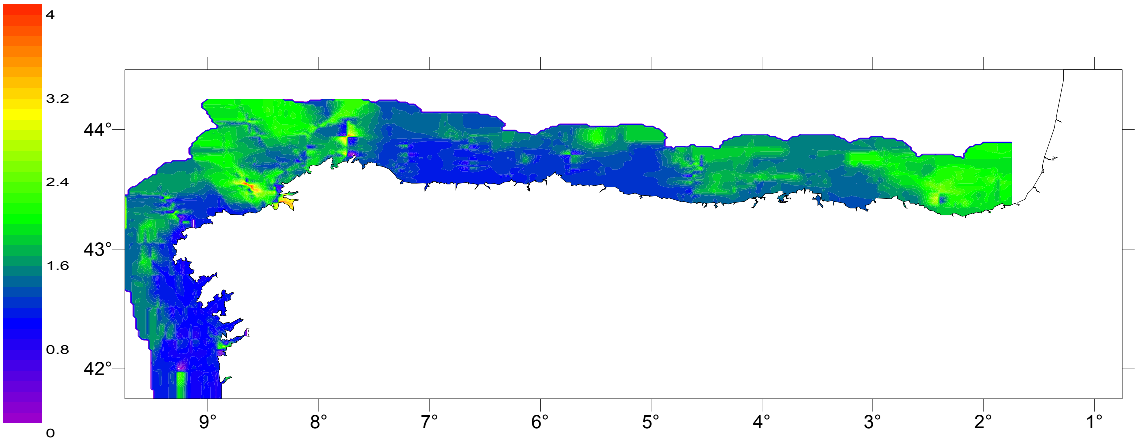


Figure 2c: Sea Surface Fluorescence during PELACUS 0314 survey

Fishing stations

Without including the trawl hauls done at the beginning of the survey for checking and setting up purposes, 52 fishing station were performed, one of them was removed. Figure 3 shows the location and the value for each ground-truth criteria (from 0 to 3).

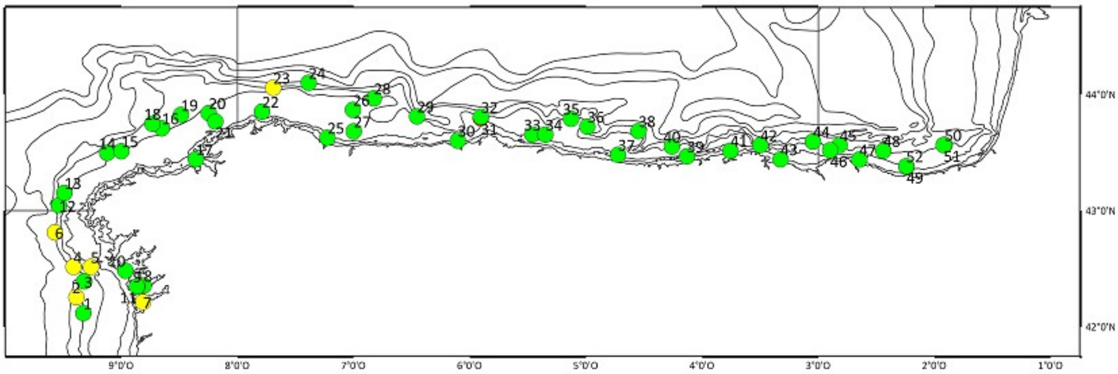


Figure 3: Fishing station and colour system according to ground-truth criteria (red bad; yellow, acceptable; and green good)

As it can be seen most of the fishing stations were performed under good conditions. Mackerel was the most abundant fish species (34% of the total catch in number) and was also present in the 88% of the fishing hauls. Horse mackerel was also abundant (29% of the total catch in number) and a 67% of haul presence. Finally, blue whiting accounted the 21% of the total catch in number and was present in the 61% of the trawl hauls. Mackerel mainly occurred in the Cantabrian Sea although some adults together with juveniles has been caught in IXa-N and VIIIc-west; in these areas mean length was around 24 cm, without significant differences in length distribution (Kolmogorov Smirnov test) whilst in the Cantabrian Sea mean length increased up to 35cm, thus spawners, with a slight differences, but significant, in both mean length and length distribution between those hauls performed in shallower waters (<140 m depth) and those located close to the shelf edge. Horse mackerel showed a great variety in both mean lengths and length distributions along the surveyed area. On the contrary, the mean length of blue whiting samples was around of 22.5 cm in almost all the hauls and only in two samples obtained near the Llanes Canyon (4º30'W) mean length was lower (21.3 cm).

Figure 4 shows the fish proportion in number obtained in each trawl haul. Boarfish, sardine and bogue, although less representative, were also important. Boarfish mainly occurred in the Cantabrian Sea with a small patch located in the northern coastal waters of VIIIc-west (i.e. close to the Estaca de Bares Cape -8º W-). In the former area was found round Estaca de Bares Cape and in the inner part of the Bay of Biscay. Mean length was similar in almost the whole area (14.09 cm), and only small fish (8.76 cm) were found in the shelf-edge close to the Galicia Asturias border. Juvenile bogue, as shown in mackerel, were mainly located in IXaN whilst adults occurred in the Cantabrian Sea. For Sardine as well mean length in IXaN was 17.03 and in the Cantabrian Sea, except one single haul performed close to the Bilbao harbour the mean length was around 20 cm.

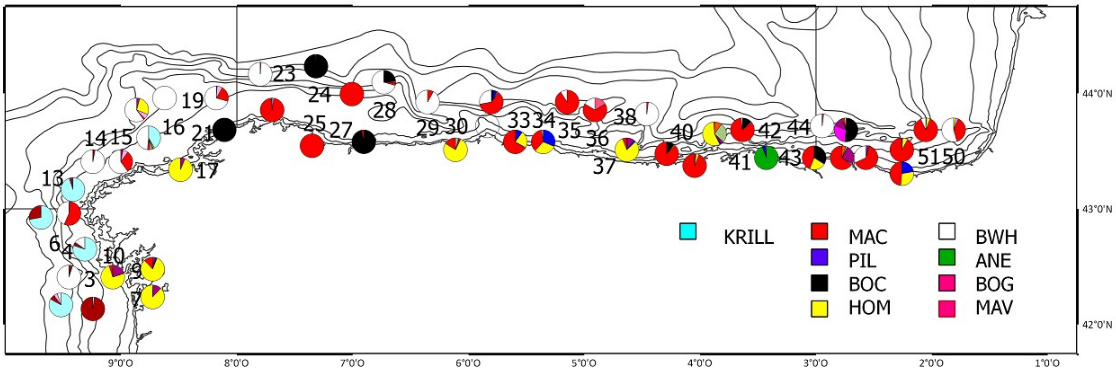


Figure 4: Fish proportion (% in number) at each fishing station. (KRILL -M. norvegica; MAC-mackerel; PIL-sardine; BOC-boarfish; HOM- horse mackerel; WHB-blue whiting; ANE- anchovy; BOG-bogue; and MAV-M. muelleri)

Finally it should be noted the presence of lantern fish, *Maurulicus muelleri*, over the shelf of IXaN. This fish species occurred in small schools during day time as shown in figure 5.

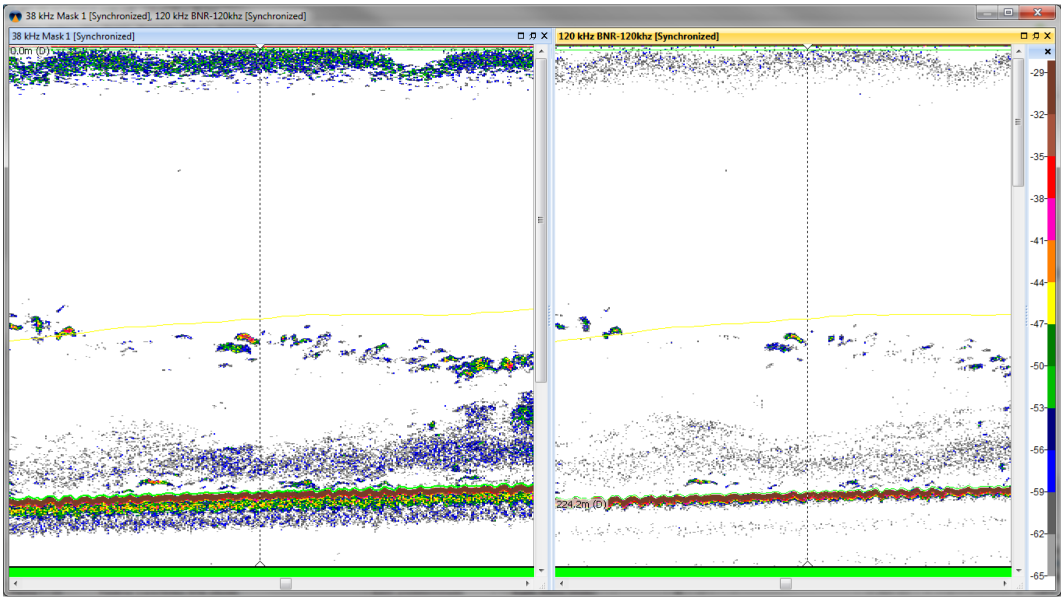


Figure 5: M. muelleri schools located at 140 m depth (total depth is 200). The yellow line is the depth sensor of the trawl door. M. muelleri represented 98% of the catch and 2% was krill (Meganyctiphanes norvegica).The fishing station was performed on 12th March at 13:30 GMT.

CUFES sardine egg counts

658 CUFES stations were done and 4214 were collected in 117 samples (33% positive stations). Last year the total egg number collected was 5936 but the number of positive stations was 105 (28% positive stations). Figure 6 shows the sardine egg counts

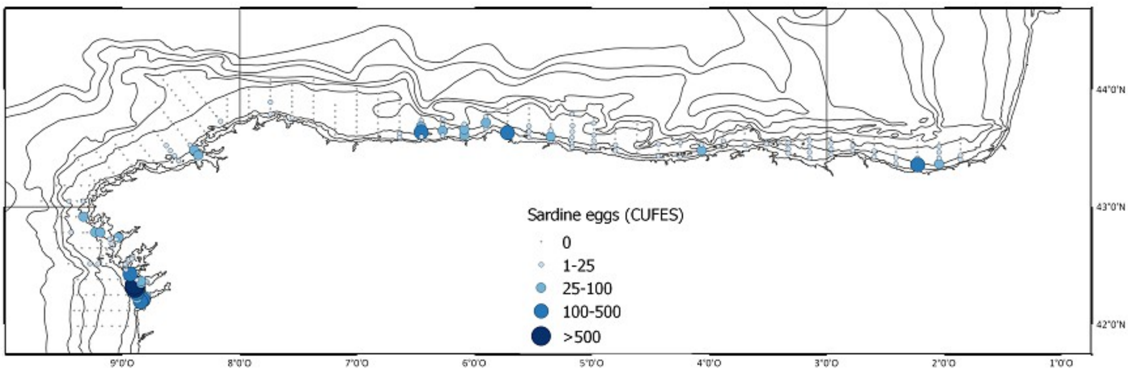


Figure 6. Number of sardine egg collected at the CUFES stations

Acoustic

A total of 251.893,2 s_A were attributed to fish species which is is 2.4 times higher than that of the previous year when only 105.384,67 s_A were attributed to fish species. Table 3 shows the fishing station used to allocate backscattering energy when echotraces were similar to those found around these fishing station.

Table 3: Fishing station used for backscattering energy allocation and transects

Fishing station	Transects
PE01	RA02
PE02	RA01, RA02
PE03	RA03, RA04
PE04	RA05, RA06, RA07, RA08
PE05	RA04, RA05, RA06, RA07
PE06	RA06, RA07, RA08, RA09, RA11, RA13
PE10	RA06, RA07, RIAS
PE11	RIAS
PE12	RA09, RA10, RA11
PE13	RA10
PE15-16	RA15, RA16
PE15-18	RA15, RA16
PE15	RA12, RA13, RA14
PE19-18	RA17
PE17	RA12, RA16, RA17
PE19	RA18
PE20	RA17, RA18, RA19
PE22	RA21, RA22
PE23	RA20, RA21, RA22, RA23
PE24	RA23
PE26	RA25, RA27
PE27	RA23, RA24, RA25, RA26, RA27
PE28	RA23, RA24, RA25, RA26, RA27
PE29	RA28, RA29, RA30, RA31, RA32
PE30	RA27, RA28, RA29, RA30, RA31, RA32, RA33
PE32	RA28, RA29, RA30, RA31, RA32, RA33
PE33	RA31, RA32, RA33, RA36
P33-P30	RA34, RA35
PE34	RA33, RA34, RA35, RA36, RA37, RA38
PE35	RA32, RA33, RA34, RA35, RA36,
PE36	RA34, RA36
PE37	RA35, RA36, RA37, RA38, RA39,
PE38	RA37, RA38, RA39, RA43
PE39	RA40, RA42
PE40	RA40, RA43, RA45, RA46
PE41	RA37, RA40, RA41, RA43, RA44,
PE42	RA41, RA42, RA44, RA45, RA46
PE43	RA45, RA46
PE44	RA46, RA47, RA48
PE45	RA48, RA49
PE46	RA47, RA48, RA49
PE47	RA48, RA49, RA50, RA51
PE48	RA50, RA51
PE49	RA49, RA50, RA51
P49-P52	RA52, RA53
P50-P51	RA50, RA51, RA52, RA53

Table 4 shows the backscattering energy distributed by species and ICES subdivision, either by direct allocation (DA) or through the proportion found at the fishing stations (Fst). Direct assignation was feasible accounting for its special acoustic properties, morphology and geographical characteristics for some board fish, horse mackerel and especially, mackerel. On the other hand, only a 1.19% of the total energy attributed to fish remained unallocated.

Table 4: Backscattering energy (s_A) allocated by species, both by direct allocation (DA) and by the fish proportion found at the ground-truth fishing stations, and by ICES Sub-Division (WHB-blue whiting; MAC-mackerel; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel; BOG-bogue; MAS-chub mackerel; BOC-boarfish; SBR-sea breams and similar specie; HMM-mediterranean horse mackerel; Other species and- unallocated NASC)

		WHB	MAC	HAK	HOM	PIL	JAA	BOG	MAS	BOC	SBR	HMM	Other	total
IXa	**DA**	0	16	0	4543	0	0	0	0	0	0	0	174	4733
	Fst	5540	94	2213	56324	340	407	18209	14	0	1612	0	1087	85841
VIIIc-W	**DA**	0	5	0	84	0	0	0	0	3420	0	0	168	3677
	Fst	12278	77	1086	4456	1	4	775	1	0	54	0	124	18858
VIIIc-Ew	**DA**	0	7967	0	0	0	0	0	0	3096	0	0	2689	11063
	Fst	32385	6395	1286	29357	4989	400	4058	323	18048	3963	669	1	101874
VIIIc-Ee	**DA**	0	1400	0	0	0	0	0	0	0	0	0	0	1400
	Fst	5127	1749	294	2914	711	4	1917	962	6955	242	229	655	21758
Total	**DA**	0	9388	0	4627	0	0	0	0	6515	0	0	3030	23561
	Fst	55330	8315	4879	93052	6042	815	24959	1300	25003	5872	899	1867	228332
Total		55330	17703	4879	97679	6042	815	24959	1300	31518	5872	899	4897	251893

Spatial patterns

Table 5 and figure 7 summarizes the spatial indices of the main fish species.

Table 5: Center of gravity according to the weighting average calculated using Distance to the Origin (Dist.Org.; expressed in nautical miles), distance to 200 m isobath (Dist 200) and depth (DEPTH, expressed in meters) together with its standard deviation and confidence interval. (WHB-blue whiting; MAC-mackerel; HAK -hake; HOM- horse mackerel; PIL-sardine; JAA-blue jack mackerel; BOG-bogue; MAS-chub mackerel; BOC-boarfish; ANE-anchovy ; HMM-mediterranean horse mackerel.

	BWH	MAC	HAK	HOM	PIL	JAA	BOG	MAS	BOC	ANE	HMM
Depth	246.79	163.18	182.37	67.16	136.98	100.06	57.50	197.11	165.79	54.60	94.30
s.d.	312.95	189.00	99.77	236.16	52.46	29.59	113.57	52.97	192.52	3.29	18.61
c. i.	37.36	22.56	11.91	28.20	6.26	3.53	13.56	6.32	22.99	0.39	2.22
Dist 200	3.90	4.84	5.53	8.38	5.38	6.10	7.81	3.11	5.61	8.70	4.27
s.d.	10.02	7.47	3.21	22.89	4.55	1.94	11.06	1.50	15.43	0.44	1.21
c. i.	1.20	0.89	0.38	2.73	0.54	0.23	1.32	0.18	1.84	0.05	0.14
Dist. Or	226.42	284.62	149.87	144.04	295.46	176.95	127.71	373.37	250.86	373.78	354.52
s.d.	353.30	147.04	114.13	570.87	86.91	50.76	285.73	29.69	219.17	0.70	14.13
c. i.	42.16	17.55	13.62	68.13	10.37	6.06	34.10	3.54	26.16	0.08	1.69

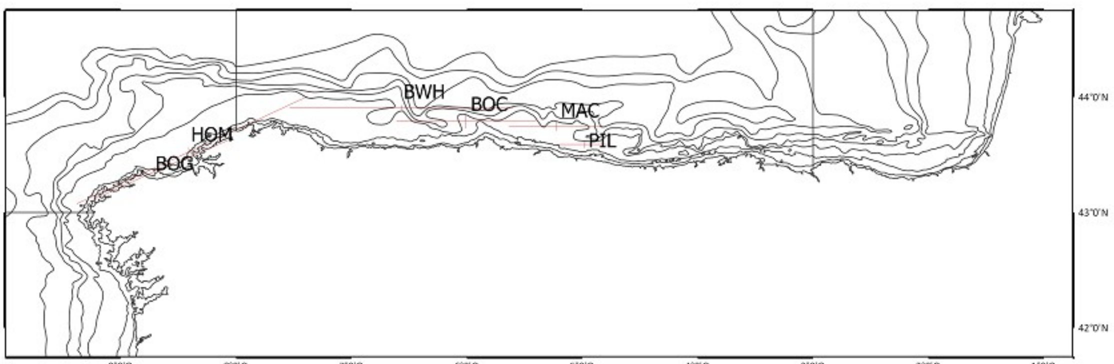


Figure 7 Centre of gravity of NASC distribution for the main fish species. Lines are proportional to the confidence intervals for both variables, Distance to the Origin (D.O.) and Depth

That of horse mackerel reflects the high abundance found within the Rías in IXaN and, in general in shallower waters. The center of gravity of mackerel remains more or less in the position as in the previous year. For blue whiting, although some fish have been detected over the continental shelf, the bulk of the distribution is still located on the self-edge, but this year the center has been estimated eastward than the previous year. On the other hand, sardine distribution, although the schools detected in the Rias, remains as well in more or less the same position as in the previous year.

Mackerel distribution and assessment

Mackerel was the most important fish species, both in number and spatial distribution. Figure 8 shows the spatial distribution.

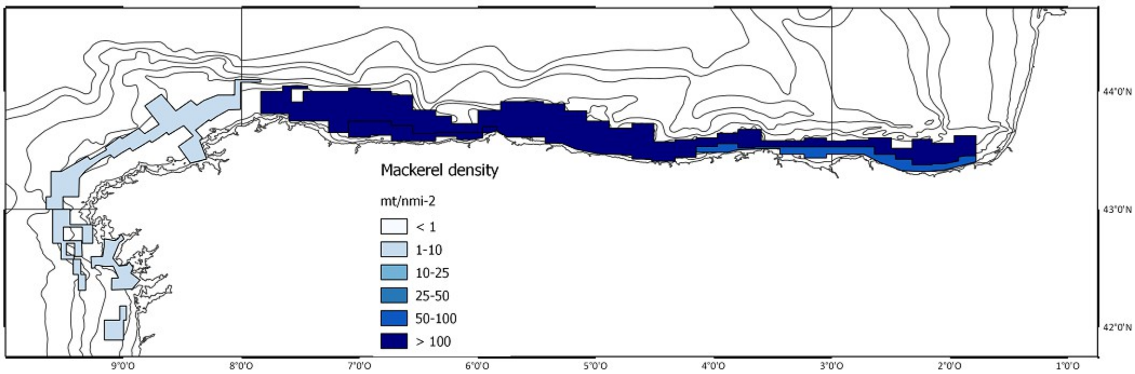


Figure 8. Mackerel: spatial distribution PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >500)

Table 6 shows the mackerel assessment. 808 422 mt has been estimated, corresponding to 2.802 million fish. The bulk of the distribution occurred in the central part of the Cantabrian Sea. In western areas (IXaN and VIIIc-west), where the juvenile mackerel fraction was distributed, density was scarce and, in some cases, very difficult to observe at 38 kHz and probably both abundance and distribution area would be greater; in these areas age group 1 was predominant (84% in number and 63% in weight). On the contrary, in the Cantabrian Sea (VIIIc-East), where the bulk of the biomass occurs, age groups 5, 6 and 7 where predominant and accounted for the 65% of the biomass (64% in weight)

Table 6 Mackerel acoustic assessment

		SURVEY:	PELACUS 0314 MACKEREL					
Zone	**Area**	**No**	**Mean**	**Surface**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**
Ixa-N	Ixa-N-South	9	0.84	92.24	P03-P05-P08-P10-P12-P13-P15-P20	ST01	3	326
	Ixa-N-Rias Baixas	55	1.36	189.90	P03-P05-P08-P10-P12-P13-P15-P20	ST01	11	1081
	Ixa-N-North	25	1.07	229.58	P03-P05-P08-P10-P12-P13-P15-P20	ST01	10	1026
	Total	***89***	***1***	***512***			***24***	***2433***
VIIIc-w	Artabro	100	0.81	899.84	P03-P05-P08-P10-P12-P13-P15-P20	ST01	30	3040
	Total	***100***	***1***	***900***			***30***	***3040***
VIIIc-E	VIIIc-Ew-Coast	37	19.10	277.93	P18-P20-P22	ST02	108	29735
	VIIIc-Ee-Coast	48	14.64	382.41		ST02	114	31366
	VIIIc-offshore	365	44.11	2926.46	P32-P33-P34-P35-P36-P37-P38-P39-P40-P42-P44	ST03	2525	741848
	Total	***450***	***39***	***3587***			***2748***	***802949***
	Total VIIIc	***550***	***32***	***4998***			***2778***	***805989***
	Total Spain	***639***	***28***	***4998***			***2802***	***808422***

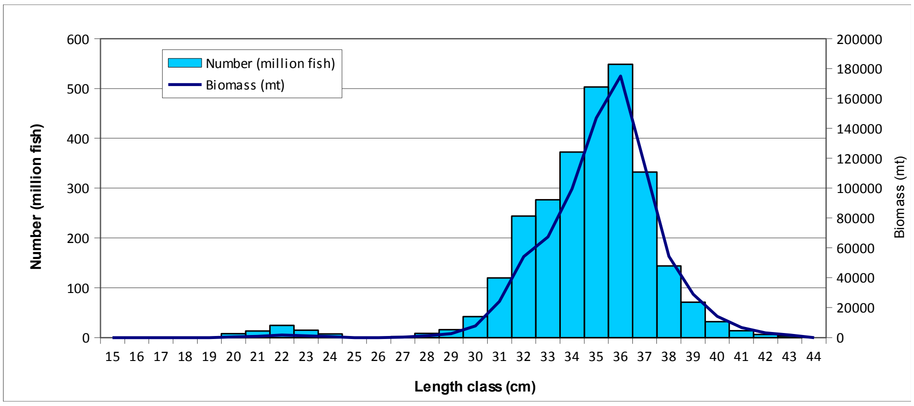
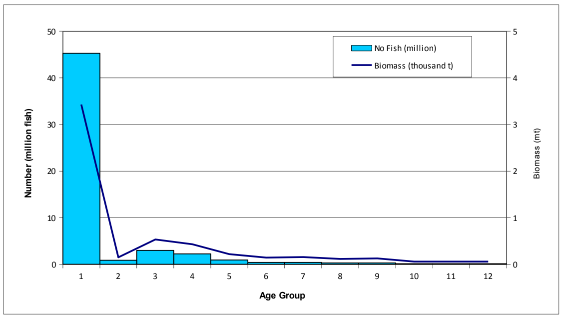
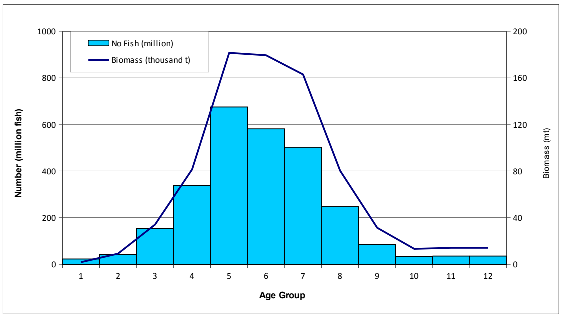


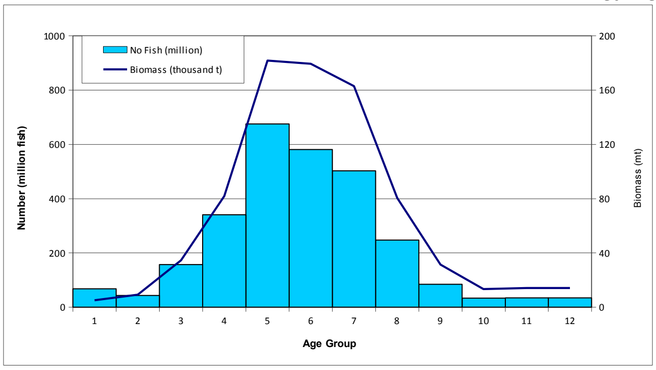
Figure 9. Mackerel length distribution in both number and biomass during PELACUS0314 survey.



Biomass: 5.47 thousand mt
Mean weight: 87.65 g
Number: 54 million fish
Mean length: 24.03 cm (s.d. 3.96)



Biomass: 802.95 thousand mt
Mean weight: 296.75 g
Number: 2748 million fish
Mean length: 35.31 cm (s.d. 2.51)



Biomass: 808.42 thousand mt
Mean weight: 290.99 g
Number: 2802 million fish
Mean length: 35.09 cm (s.d. 2.98)

Figure 10. Mackerel abundance and biomass by age group during PELACUS0314 survey.

Comparing with the previous year, the total mackerel biomass assessed is 47 % higher (379 149 t corresponding to 1,725 million fish). As in previous year juveniles were mainly located in the west part (VIIIc-w and IXaN), where age group 1 accounted for the 83% of total fish number and the 63% of the total biomass. In Cantabrian Sea (VIIIc-East), were the bulk of the population was located (97% of the fish number and 99% of the total biomass), age groups 4, 5 and 6 accounted for the 65% of the total biomass. On the other hand, age group 2 only represents the 1% of the total abundance. This result is consistent with that obtained the previous year when the strength of age class 1 was weak.

Table 7. Mackerel abundance in number (thousand fish) and biomass (tons) by age group and ICES sub-area in PELACUS0314.

SURVEY: PELACUS 0314. MACKEREL

BIOMASS (thousand tonnes). ZONE: VIIIc+IXaN

Length	AGE GROUPS 1	2	3	4	5	6	7	8	9	10	11	12	Total	No fish (milli
10														
11														
12														
13														
14														
15														
16														
17														
18														
19	0.01												0.01	0
20	0.43												0.43	8
21	0.84												0.84	13
22	1.80												1.80	24
23	1.27												1.27	15
24	0.66												0.66	7
25	0.03												0.03	0
26														
27	0.05	0.14	0.05										0.23	2
28		0.32	0.95										1.27	9
29		0.23	0.70	1.64									2.58	16
30		0.64	3.53	2.25	1.28								7.70	42
31		1.34	10.72	8.04	4.02								24.11	120
32		3.87	3.87	23.19	23.19								54.11	244
33		2.59	5.18	20.74	36.29	2.59							67.40	276
34			7.11	10.67	35.57	24.90	17.78	3.56					99.59	372
35			2.49	4.98	42.36	52.33	24.92	19.94					147.03	503
36				7.00	24.50	56.01	52.51	28.00	7.00				175.03	549
37				3.39	10.17	33.91	37.30	13.57	6.78	3.39	3.39	3.39	115.30	332
38					4.34	6.51	21.70	8.68	6.51	2.17	2.17	2.17	54.26	144
39						3.23	6.45	3.23	6.45	3.23	3.23	3.23	29.03	71
40							2.36	2.36	2.36	2.36	2.36	2.36	14.15	32
41								1.11	2.22	1.11	1.11	1.11	6.65	14
42										1.06	1.06	1.06	3.18	6
43											0.88	0.88	1.75	3
44														
Biomass (thousand t)	5	9	35	82	182	179	163	80	31	13	14	14	808.42	2802
%	0.63	1.13	4.28	10.13	22.48	22.20	20.17	9.95	3.87	1.65	1.76	1.76		
M. weight	71.47	217.42	223.71	245.54	275.29	318.01	333.93	335.23	381.81	414.30	420.87	420.87	290.99	
No Fish (million)	68	43	157	340	676	581	502	247	85	33	35	35	2802	
%	2.43	1.53	5.62	12.15	24.12	20.74	17.93	8.81	3.02	1.18	1.24	1.24		
M. length	22.53	32.01	32.30	33.26	34.48	36.09	36.65	36.69	38.23	39.22	39.42	39.42	35.09	
s.d.	1.21	1.48	1.74	1.69	1.61	1.16	1.34	1.36	1.46	1.51	1.72	1.72	2.98	

On the other hand given that in some cases NASC direct allocation was not feasible and, therefore, this was done using the Nakken and Dommasnes method, the change in the TS length relationship for boarfish, would result in a small decrease of a 1.29 % in the total abundance (i.e. from 808 to 798 thousand tonnes)

Behaviour:

This year, most of the mackerel occurs in a pelagic layer, at around 30-50 m depth. In some cases schools were also seen in the surface and, in general, they showed strong diving reaction from the upper layers to the bottom, especially when marine mammals were present, but also raising reaction from the bottom to the upper layers, as shown in figures 10 and 11. Yet, the relationship between this raising behaviour and explanatory variables was not studied. On the other hand the main difference between this year and the previous is both the thickness and the continuity of the subsurface layer. Until now, rather than a subsurface layer, mackerel occurred in scarce patches while the bulk of the distribution was located near the sea bottom. Over the subsurface patches, the spring artisanal hand-line fleet is concentrated (figure 12).

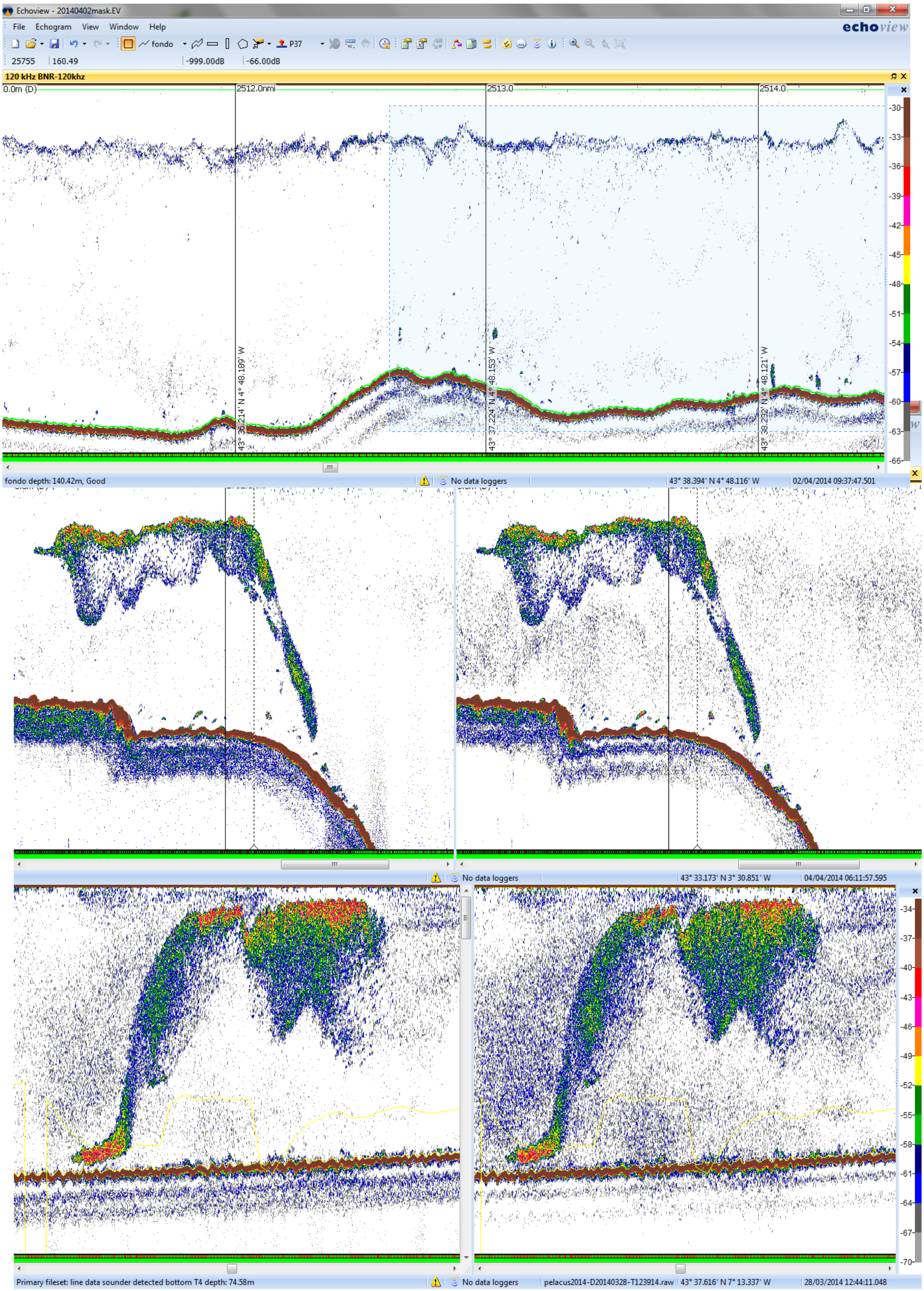


Figure 10. Mackerel occurrence during PELACUS 0314. Top panel subsurface layer (120 kHz echogram; threshold set at -70dB); Mid panel, diving reactions close to the self-edge(200 kHz left and, 120 kHz, right). Bottom panel, raising reaction.

Figure 11: Mackerel schools at the surface

Figure 12: Hand-line working over a mackerel schools.

Mackerel diet

The times series of mackerel stomach contents (1999-2014) has been presented this year. Data came from the biological samples obtained in different trawls hauls during PELACUS (i.e. only day time data). Figure 13 shows the percentage of non empty stomachs. 75% of stomachs analysed, ranging from to 56 to 92%, were full or partial full. Main prey has varied along time series, but copepods and mackerel eggs were the most important preys in number along the time series. In volume, three periods can be distinguished; from 2001 to 2004 salps accounted for around 54% of the stomach volume; 2006 to 2011 when copepods accounted for the 40% of the total stomach volume, reaching the maximum in 2009 and then showing a continuous declining trend; and since 2011 when crustacean became more important (Euphausiacea, Mysidacea, Decapoda, both adult and larvae) (figure 14). Since no long-term trends or cycles were detected in any zooplankton species (Bode et al, 2012) and only an increase in the zooplankton diversity related with inter-seasonal variability, the variability observed in the mackerel diet would be rather related to a variability in the zooplankton diversity which ultimately depends on the seasonal temperature.

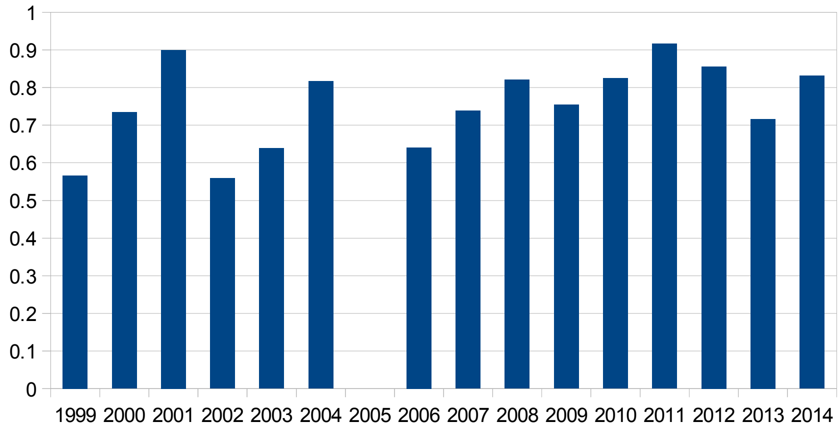
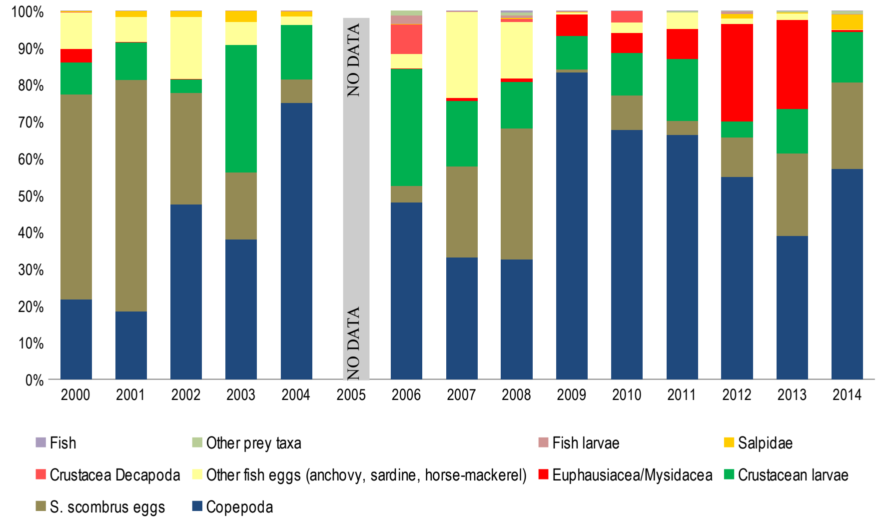


Figure 13:Percentage of non-empty mackerel stomachs taken during PELACUS time series (1999-2014)



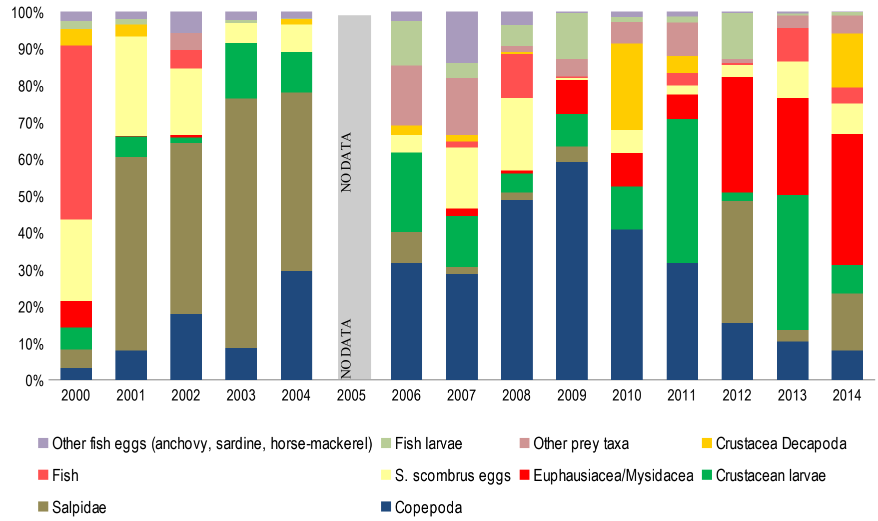


Figure 14: Mackerel diet in number (top panel) and in volume (bottom panel). All figures are in percentage.

Blue whiting distribution and assessment

As stated previously, main blue whiting distribution area is located around the self-edge at 247 m depth. Besides is the closest fish species to the 200 m isobath, occurring with lantern fish (*Maurolicus muelleri*) and krill (*Meganyctiphanes norvegica)*.Besides, the density was in general low and no extension of the distribution area into open waters in pelagic layers has been detected. Instead, comparing to the previous year, it seems that the distribution is spreading through the continental shelf (figure 15). Mean length was rather homogeneous along the surveyed area at around 22.5 cm and only smaller fish were found, close to Santander.

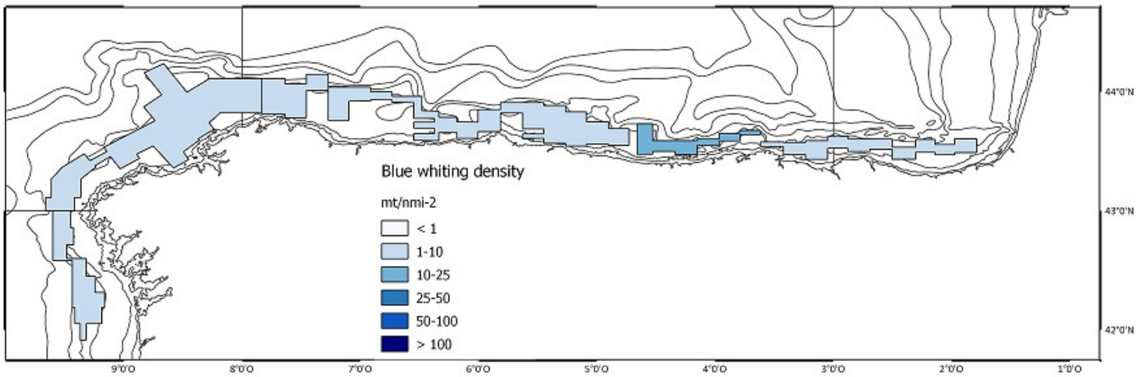


Figure 15. Blue whiting spatial distribution PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100)

Table 8 shows the blue whiting assessment. A total of 24.117 tonnes corresponding to 414 million fish has been estimated. Comparing to previous years, blue whiting is increasing its biomass from 7146 mt (123 million fish) assessed in 2012, and 13.488 mt (corresponding to 299 million fish) in 2013. Beside length structured, as show in figure 16 was significant different from that found in the previous year. According to the information got at the fishing station which as it has been stayed was similar along the surveyed area (up to 20 fishing stations with more than 31 sampled specimens), no signal of younger fish (length < 18cm) has been found.

Table 8: Blue whiting assessment

		SURVEY:	PELACUS 0314 BLUE WHITING						
Zone	**Area**	**No**	**Mean**	**δ^2**	**Area**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**
IXa	Ixa_N	58	95.52	235	479	P02-P03-P04-P06	S01	40	2407
	Total	**58**	**95.52**		**479**			**40**	**2407**
VIIIc-W	VIIIc_W	182	67.46	104	1643	P12-P14-P15-P16-P18-P19-P20	S02	94.37	5891.61
	Total	***182***	***67***		***1643***			***94***	***5892***
VIIIc-E	Estaca	43	84.00	215	351	P23-P24	S03	26	1548
	Asturias	136	150.80	457	1177	P24-P28-P29-P32-P34-P35-P36	S04	159	9201
	Cantabria	37	223.28	409	263	P38-P40	S05	58	2919
	Euskadi	59	86.89	158	477	P42-P44-P48	S06	38	2150
	Total	***275***	***136.39***		***2268***			***280***	***15818***
Total IXa		***58***	***96***		***479***			***40***	***2407***
Total VIIIc		***457***	***109***		***3910***			***374***	***21710***
Total Spain		***515***	***107.43***		***4389***			***414***	***24117***

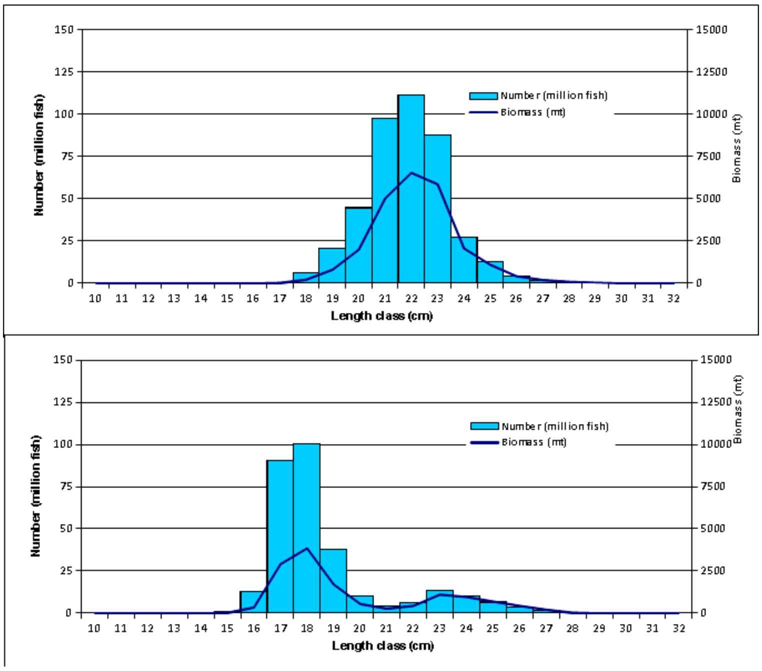


Figure 16. Blue whiting length distribution in both number and biomass during the PELACUS0314 (above) and PELACUS 0313 (below) surveys.

As in the case of mackerel, when the new TS length relationship is applied in multispecific areas, the total biomass decreases up to 22870 mt (5.5%).

Horse mackerel distribution and assessment

Horse mackerel density was higher than that found the previous year. In IXaN, the bulk of the distribution occurred within the Rías Baixas in a very dense and near bottom schools (figure 17).

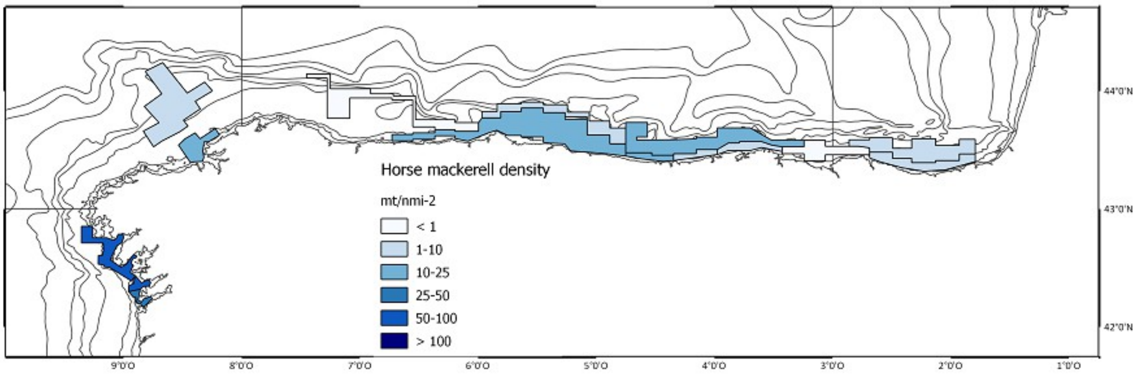


Figure 17. Horse mackerel spatial distribution PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100

Total biomass was estimated to be 44.356 mt (556 million fish), 13024 of those located in IXaN (217 millions fish) and the remaining 31.332 in VIIIc (340 million fish). (table 9, figure 18)

Table 9: Horse mackerel assessment

SURVEY: PELACUS 0314 HORSE MACKEREL

Zone	Area	No	Mean	δ^2	Area	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
IXa	R Vigo	22	556.67	674.99	27.20	P07	S01	22	1307
	R Pontevedra	16	773.98	1259.80	31.13	P08-P11	S02	41	1907
	R Arousa	57	635.74	1446.86	173.65	P10	S03	154	9810
	Total	***95***	***641***		***232***			***217***	***13024***
VIIIc-W	Artabro_ Coast	15	262.10	451.09	116.91	P17	S04	43.39	2704.57
	Artabro_Shelf	59	7.79	9.56	494.24	P18-P19	S05	2.50	610.23
	Total	***74***	***59***		***611***			***46***	***3315***
VIIIc-E	VIIIcE_west_Coast	98	171.52	288.11	748.83	P30-P33-P34	S06	164	12046
	VIIIcE_west_Shelf	33	9.37	20.36	336.88	P30-P33-P34	S06	4	296
	VIIIcE_mid_Coast	32	25.35	75.07	244.75	P32-P36-P45	S07	3	978
	Llanes	6	182.38	179.84	50.03	P37	S08	16	718
	San Vicente	6	114.14	132.90	48.48	P39	S09	8	480
	Santander	11	85.72	104.78	81.59	P41	S10	16	499
	Abra Bilbao	22	1.42	3.71	180.29	P46	S11	0	22
	Donostia_Shelf	25	51.39	114.14	177.57	P49-P52	S12	16	715
	Donostia_Coast	44	33.32	46.14	343.45	P50-P51	S13	8	1542
	Cantabria_Shelf	52	169.91	732.69	471.35	P40	S14	57	10722
	Total	***329***	***98.08***		***2683***			***294***	***28017***
	Total IXa	***95***	***641***		***232***			***217***	***13024***
	Total VIIIc	***403***	***91***		***3294***			***340***	***31332***
	Total Spain	***498***	***195.84***		***3526***			***556***	***44356***

As in the previous years, length distribution showed a great heterogeneity along the surveyed although a clear mode around 20 cm has been found in almost all the fishing stations.

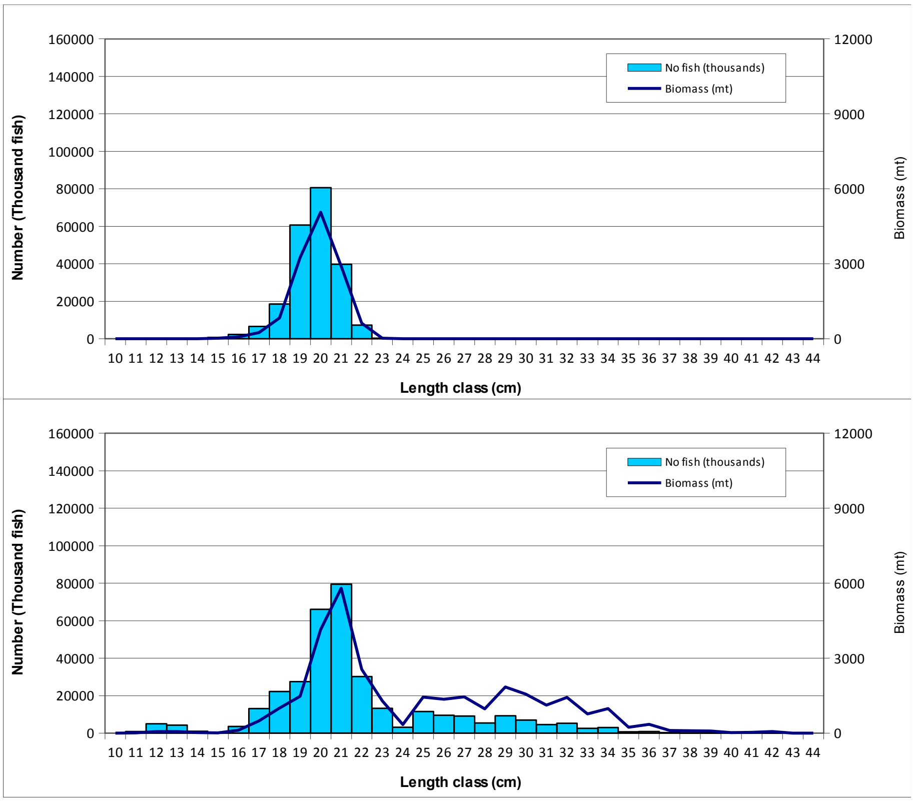


Figure 18. Horse mackerel length distribution in both number and biomass during the PELACUS0314 in IXaN (above) and VIIIc (below).

The total biomass assessed in Pelacus 0314 was significantly higher than that estimated last year (6.362 mt corresponding to 44 million fish). A total of 6.372 mt has been estimated, corresponding to 44million fish, which was smaller than that assessed the last year (18264 mt corresponding to 110 million fish). The bad weather conditions found last year as well as the behaviour observed of near-coast schools, mainly concentrated in shallower waters in a very hard and rough sea bed, thus no accessible to the pelagic year, which represented the 33% of the total backscattering energy and left as unallocated, would be a plausible explanation for such increase. On the other hand, as shown in figure 19, the main difference between both surveys is the lack of a 20 cm mode (mainly age group 1) during the previous survey as compared with 2014 survey. Given the presence of this length mode through the whole surveyed area, it seems that the strength of the 2013 recruitment would be higher than that of the previous ones.

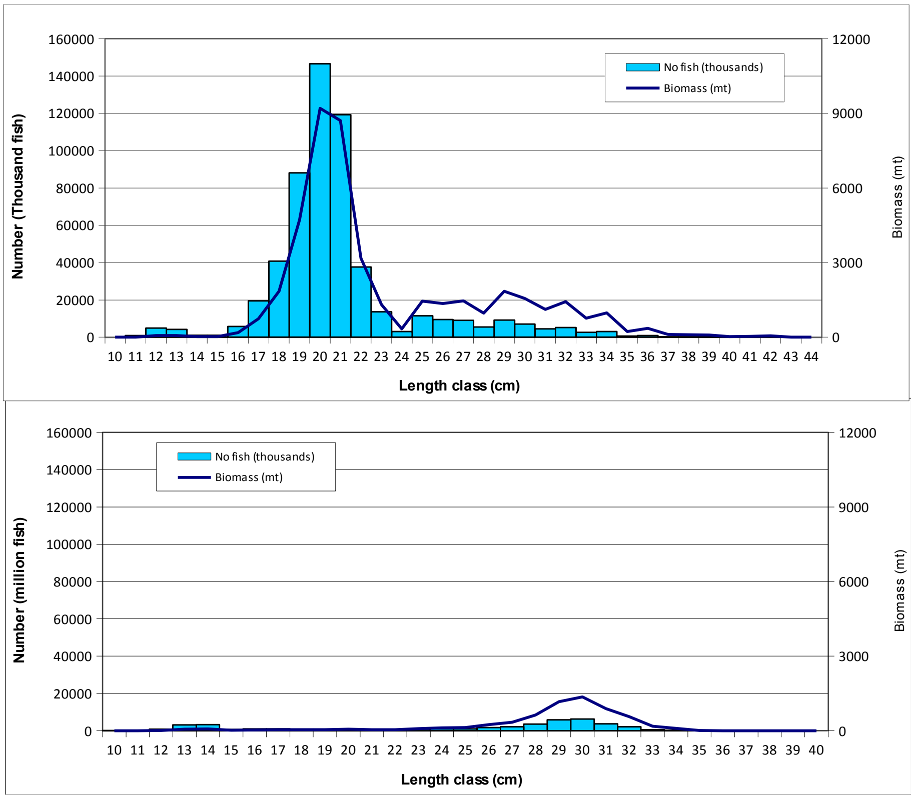


Figure 19: Horse mackerel length distribution in both number and biomass during the PELACUS0314 (above) and PELACUS 0313 (below) surveys.

On the other hand the differences between this assessment and that derived from the application of the new boarfish TS length relationship is almost negligible (0.25%)

Boarfish distribution and assessment

Boarfish spatial distribution and length structure remained very similar to those observed last year (figure 20). Smaller size was detected in the eastern part of Cape Ortegal (7ºW) with a principal mode located at 8 cm, while for the rest of the areas the main mode was estimated at 14 cm. Besides, as in previous years, boarfish occurred either in isolate, thick schools, mainly located in the western part and in near bottom layer, sometimes mixed with other fish species.

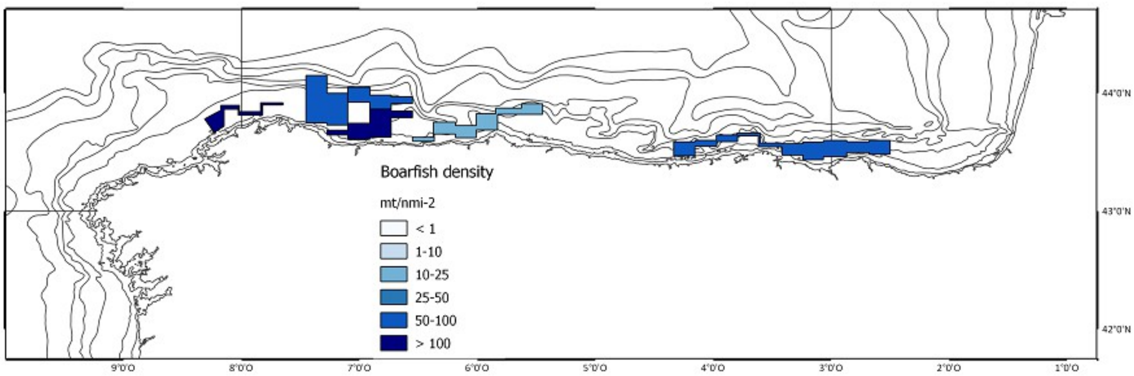


Figure 20. Board fish spatial distribution PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100)

For the assessment we have kept the old TS/length relation ship for comparison purposes, but, together with this, we have used the new one estimation.

Accordingly, using the new TS estimation, a total of 25344 has been estimated corresponding to 581 million fish. (table 10). In the same way, using the old TS estimation which was so much lower than the new one (6.4 dB), the total biomass reached 98220 mt (2167 million fish), which was 6 times higher than that of the previous year (16067 tonnes, corresponding to 437 million fish), but still far from the maximum assessed in 2011 when more than 220 thousand tonnes were estimated. In 2012 the total biomass assessed were 33.238 corresponding to 518 million fish.

Table 12: Boarfish acoustic assessment

		SURVEY:	PELACUS 0314 BOAR FISH					
Zone	**Area**	**No**	**Mean**	**Area**	**Fishing st.**	**PDF**	**No (million fish)**	**Biomass (tonnes)**
VIIIc-W	Capelada	13	264.57	93.92	P21	S01	39.10	2321.75
	Total	***13***	***265***	***94***			***39***	***2322***
VIIIc-E	Estaca	34	136.59	310.86	P24	S02	74	3790
	Masma Coast	28	315.74	225.18	P27	S03	107	6763
	Masma Off-shore	17	301.03	144.32	P28	S04	184	2643
	Asturias_Occ	30	112.63	251.50	P32-P40-P42-P44-P45-P46	S05	47	2590
	Cantabria	55	186.94	423.37	P32-P40-P42-P44-P45-P46	S05	131	7235
	Total	***164***	***196.73***	***1355***			***542***	***23022***
Total VIIIc		***177***	***202***	***1449***			***581***	***25344***
Total Spain		***177***	***202***	***1449***			***581***	***25344***

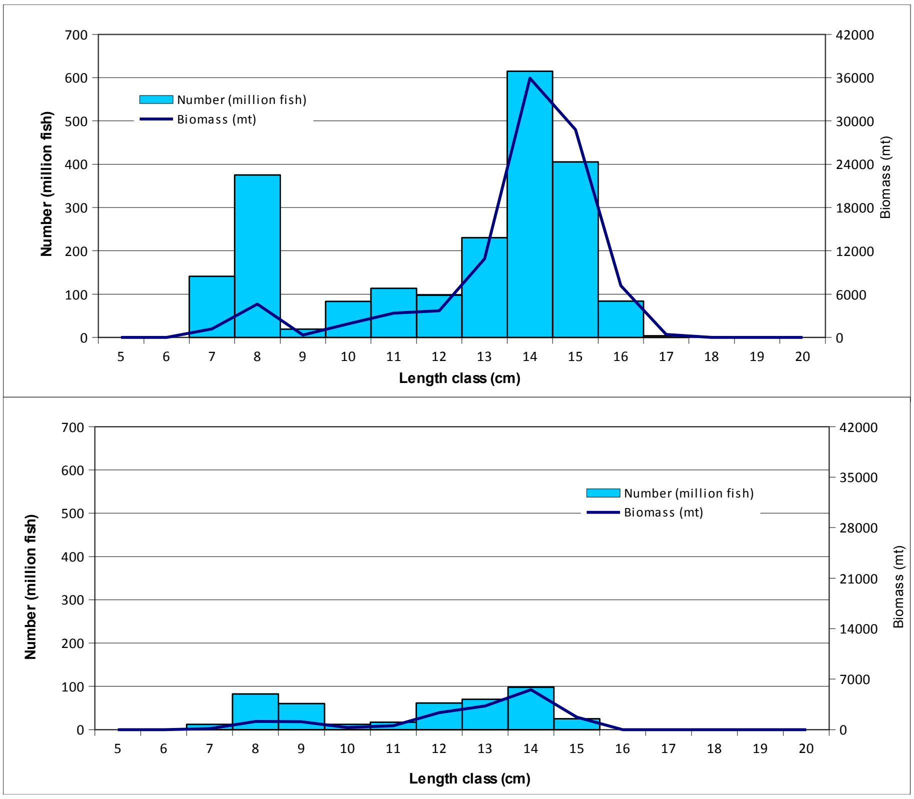


Figure 21. Boarfish length distribution in both number and biomass during the PELACUS0314 (above) and PELACUS 0313 (below) surveys.

When possible boarfish schools were directly allocated. Nevertheless, relative frequency response seems to be highly variable, and, although there is a clear pattern with a weak response at high frequencies, specially at 200 kHz, in some cases responses at 18 kHz or at 120 kHz were higher than those reported by Fässler et al (2013), as shown in figure 22a-b. Whether this changes are related to the fish size (i.e. different frequency resonant in relation total size) or to physiological condition or behaviour (i.e. spawning) should be further investigated.

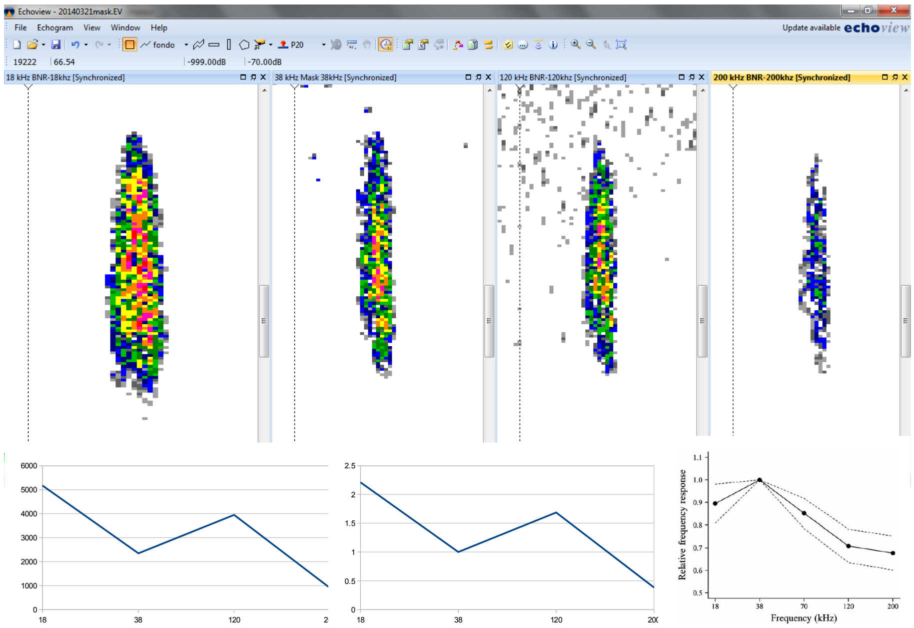


Figure 22a. Boarfish school as observed at 18, 38, 120 and 200 kHz and its absolute frequency response (left plot), relative one (middle plot) and the observed relative frequency response as found in Fässler et al (2003) (right plot).

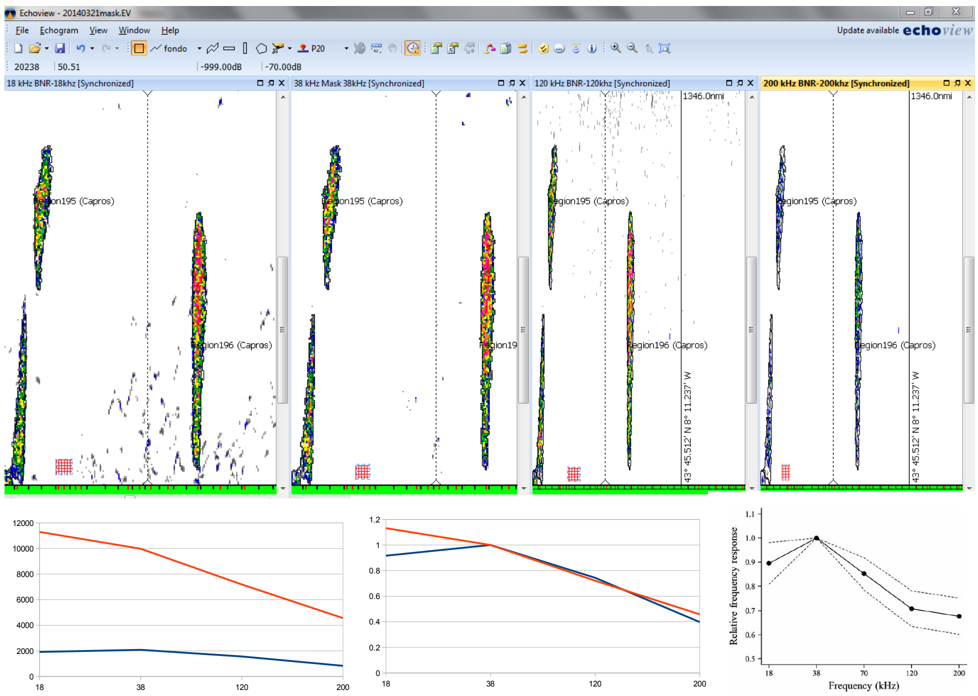


Figure 22b. Ib. Boarfish schools as observed at 18, 38, 120 and 200 kHz and its absolute frequency response (left plot), relative one (middle plot) and the observed relative frequency response as found in Fässler et al (2003) (right plot).

Sardine distribution and assessment

A total of 9,669 tons of sardine (157 million fish) was estimated to be present in the surveyed area. That represents an important increase in relation to 2013 abundance and biomass, but still at the lower levels of the time series. Fish were mainly found in Cantabrian area (mainly in VIIIc East-West subdivision) and inside Rias Baixas (South Galicia, ICES sub-areas IXa-N) and was almost absent from the rest of the surveyed area (figure 23). Most fish in the entire surveyed area were assigned as belonging to the age 2 (38% of the abundance and 43% of the biomass) and age 3 (24.5% of the abundance and 25.5 % of the biomass) years classes. By subdivisions, the IXaN (South of Galicia) population was dominated by age 1 fish whilst the Cantabrian area was mainly composed by a population of age 2 and age 3 individuals.

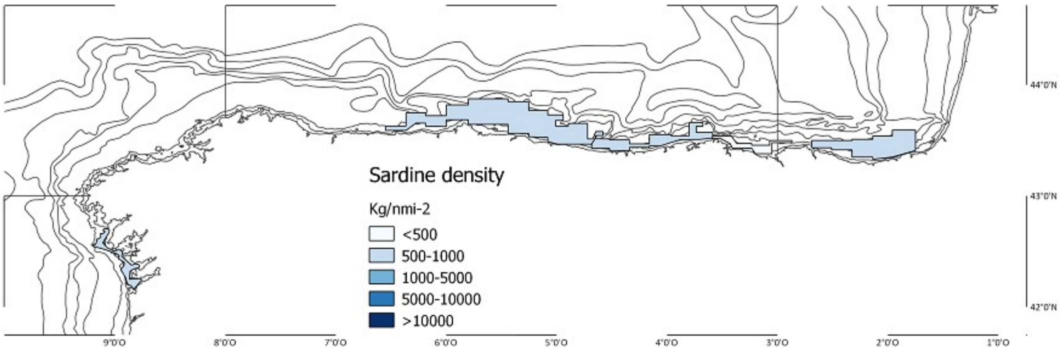


Figure 23. Sardine spatial distribution in PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as kilograms per squared nautical mile (<500,; 500-1000; 1000-5000; 5000-10000; and >10000)

The distribution of sardine eggs (obtained from the analysis of 358 CUFES stations) indicates a very coastal distribution, agreeing with that observed in previous years The percentage of positive stations was very similar in both surveys, but total number of sardine eggs detected in Spanish waters was 4214, which represents an important decrease from the 2013 value.

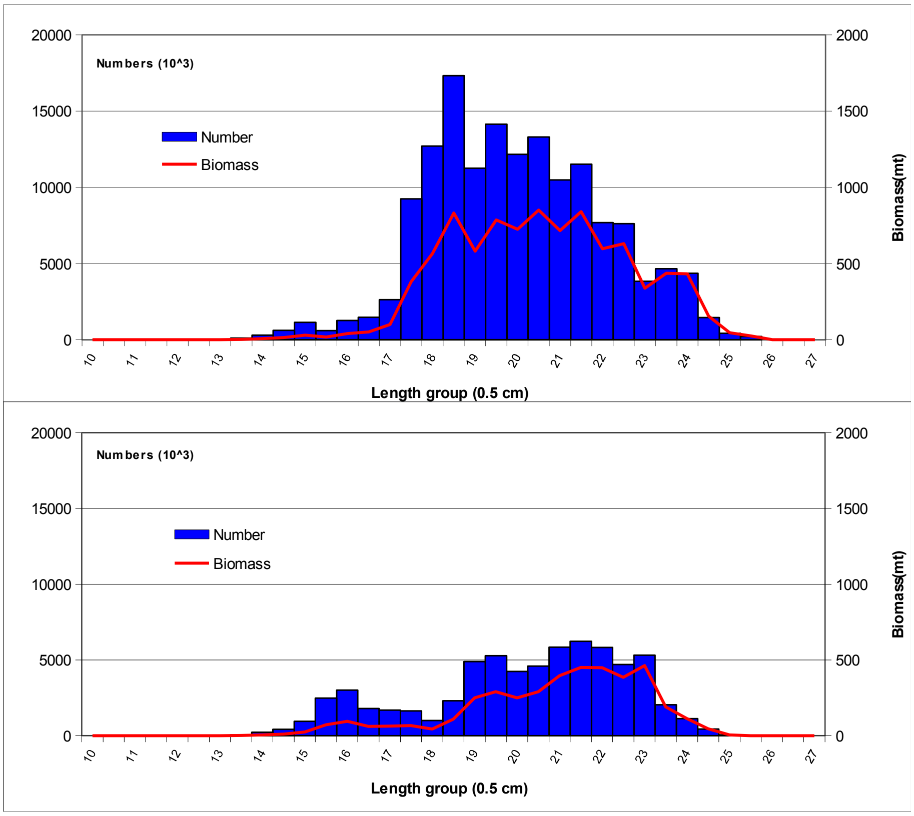


Figure 24. Sardine length distribution in both number and biomass during the PELACUS0314 (above) and PELACUS 0313 (below) surveys.

Other fish species

Only bogue (Boops boops) has an important contribution to the pelagic community; on the contrary, anchovy or Mediterranean horse mackerel had a lesser contribution, with only few tonnes.

Discussion and conclusions

PELACUS 0314 was characterised by relative stable weather conditions along the surveyed area. Besides, there was an important increase in backscattering energy as compared with the previous year. This resulted in an increase of the biomass estimated in the majority of the fish species, but still sardine is at lowest productivity ever recorded. Good recruitment would be observed in horse mackerel, but for the rest of the fish species, no strong signals for age group 1 have been detected.

The reasons for this increase would be related to the weather stability which could have increased the fish availability either for a change in the behaviour (i.e. spatial pattern distribution) or for an increase in the food availability. This is relevant accounting the increase of the occurrence of mackerel subsurface layers observed this year. As PELACUS is a multidisciplinary survey series (we collect environmental and biological ancillary information, stomach contents, including CTD cats, plankton tows or continuous records of plankton, eggs, S, T and flourometry), we will try to explain this change of behaviour. Our main hypothesis is that these species could follow mackerel when is undertaking vertical migration, probably related with the spawning activity, just for feeding eggs and, therefore, changing the expected schooling behaviour by the dispersed one, used during the feeding activity.

The challenges for the next years are to increase the number of school directly allocated accounting the relative frequency response and to investigate and also to update the list of TS/length relationship for the most important fish species.

Acknowledgements

We would like to thank all the participants and crew of the PELACUS surveys. Mackerel diet data were provided by our colleague Izaskun Preciado and her team. We wish to thank to our colleague and friend Pepe Zabala, now retired for the extraordinary effort in providing all the diet analysis from the beginning up to 2013.

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Revising the maturity ogive for blue whiting

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Introduction

This document presents an approach to revise the maturity ogive for blue whiting, and the new maturity ogive obtained with this approach. The current maturity ogive for blue whiting dates from 1994. The stock annex states the following:

> "Maturity at age used in the assessment was obtained by combining maturity ogives from the southern and northern areas, weighted by catch in numbers at age (ICES, 1995). These values have been used since 1994. Although the values of maturity at age may be too low, sufficient information for estimating new ogives is not available." (ICES 2013, p. 842)

This leaves open when and how the ogives for the southern and northern areas were derived in the first place, so it is rather difficult to make any judgements regarding how good (or bad) the ogives were 20 years ago or are now[1].

Errors in maturity-at-age are directly reflected in estimates of spawning stock biomass based on stock numbers and weight, and thereby it is important to try to understand how much bias and error may be entering the SSB estimate this way.

When the ogive for the northern stock component was estimated, there were two surveys covering larger parts of the stock: the Norwegian and Russian spawning stock surveys (March–April), and the Norwegian pelagic survey in the Norwegian Sea in July–August. The first survey represents almost only spawning fish, whereas the latter survey represents both immature and mature fish. Because the surveys are far apart in time, mature fish have ample time to move from one survey area to another, and the "same" fish could be observed in both surveys. This is problematic if data from these surveys were combined.

However, the situation has changed. The spawning stock survey has developed into an international, coordinated survey (starting 2004). The survey in the Norwegian Sea in July–August became supplemented by another survey conducted in late spring, gradually becoming a coordinated survey with broad international participation (from about 1997, and further improving over time) and eventually replacing the old survey in July–August (discontinued in 2001). Thus, since about 2004, there has been coordinated, international survey coverage of the stock at both the spawning and feeding areas. The surveys are now only 1–2 months apart, reducing (but not totally eradicating) the problem of counting the same fish twice. This gives a much better basis for estimating maturity-at-age by combining survey data from spawning and feeding areas.

[1] I do not have the reports, but I seem to remember that the northern ogive was derived in early 1980's.

Methods

Data from 2004 to 2013 corresponding to the spawning stock survey in March–April and the pelagic ecosystem survey in May–June were extracted from the PGNAPES database[2].

Estimated numbers-at-age corresponding to the aforementioned surveys were extracted from the 2013 assessment report (ICES 2013, Tables 8.3.5.1.1 and 8.3.5.2.1). Numbers-at-age for the pelagic ecosystem survey before 2012 were divided by 3.1 to account for the change in the target strength (Pedersen et al. 2011, ICES 2013). A weighting factor for each individual observation was calculated as $w_{a,y,s} = N_{a,y,s}^{estimated} / N_{a,y,s}^{sampled}$ where the numerator is numbers per age per year per survey in the acoustic survey estimate and denominator is the total sampled numbers per age per year per survey. Individuals in macroscopic maturity stage 1 ("immature", coded as 0) were considered immature and all above (stages 2–8, coded as 1) mature (cf. Mjanger et al. 2010). Maturity-at-age can then be calculated as a mean maturity-at-age, weighted by the factor defined above.

Results

The ogive derived using the Norwegian survey data combined with estimated numbers-at-age suggests that the current ogive underestimates maturity by about 10 per cent points in age groups 2 to 6 years (Figure 1, Table 1). Recalculating SSB using the estimated stock numbers-at-age and weights-at-age from the 2013 assessment shows, as expected, that SSB is revised upwards. Looking at the absolute estimates gives an impression that the revision amounts to a mere re-scaling. However, a closer look on the results shows that the upward revision has fluctuated between 4% and 18%, with an average of about 11% (assuming that the new ogive is representative for years before 2004, which can of course be questioned). The bias is strongly correlated with the mean age in the stock ($r = -0.83$, the 10+ group being given nominal age 10 years), that is the bias is largest when stock is dominated by young fish.

[2] IBWSS data provided by Leon Smith 15/08/2014. IESNS data provided by Leon Smith 26/08/2014.

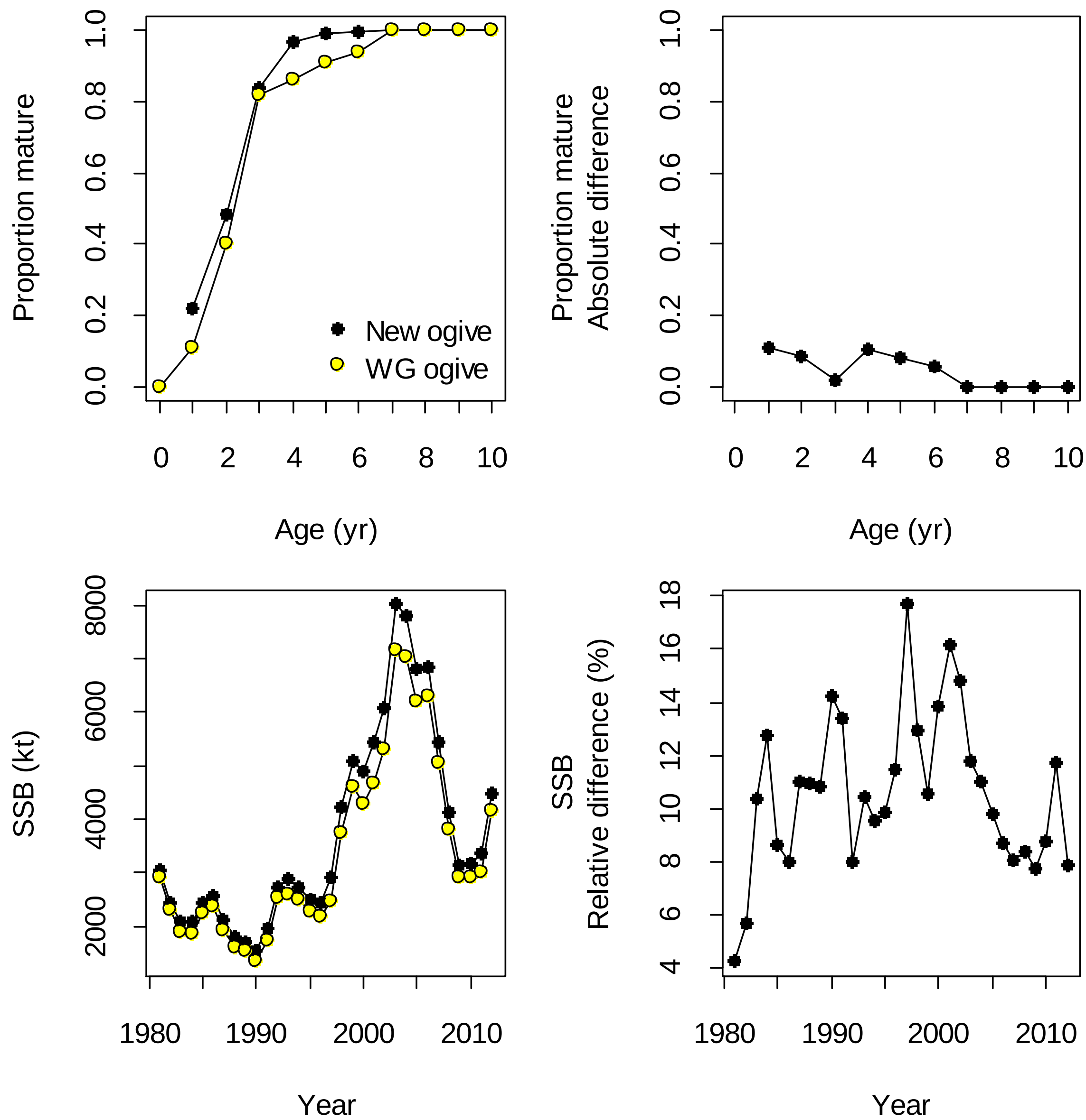

Figure 1. The provisional revised maturity ogive and its consequence for SSB.

Table 1. The current maturity ogive used in WGWIDE and the provisional revised maturity ogive.

Age	0	1	2	3	4	5	6	7	8	9	10
WG ogive	0	0.11	0.40	0.82	0.86	0.91	0.94	1.00	1.00	1.00	1.00
New ogive	0	0.22	0.48	0.83	0.97	0.99	1.00	1.00	1.00	1.00	1.00

Concluding remarks

Some of the hidden assumptions above are:

- Both surveys have the same relative observability. This is not true (if not for any other reason) because the estimate in Table 8.3.5.2.1 is for the "standard survey area", so numbers-at-age are underestimated. This probably leads to overestimation of maturity-at-age.

- The same fish are not observed twice. This is probably not true either because some spawning fish will have moved to the area surveyed in May by that time. This probably leads to overestimation of maturity-at-age.
- Years receive relative weight that is proportional to stock numbers. Giving equal weight to each years is easily done but unlikely to have much effect.

The considerations above suggest that the provisional ogive represents the worst case—that the "true" ogive might lie somewhere between the old and new ogive.

The results here suggest that there is a significant downward bias by about 11% in current SSB estimates. Assessments are relatively immune to a constant bias, but because the bias is correlated with the mean age in the stock, there is an error that varies from year to year, as long as incoming year classes differ in strength.

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Otolith shape analysis of blue whiting suggests a complex stock structure at their spawning grounds in the Northeast Atlantic

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ABSTRACT

Evidence from morphometric, meristic, oceanographic, genetic and otolith microstructure studies suggest complexity in the structure of the blue whiting (*Micromesistius poutassou*) population in the Northeast Atlantic. However the boundaries between stock components and the degree to which they overlap on the spawning grounds are uncertain. Blue whiting are therefore currently assessed and managed as a single stock. This study uses otolith shape analysis to provide further insight into the stock structure of blue whiting in the NE Atlantic at a critical period of their life history: spawning. Otolith shape analysis is useful for stock discrimination as it can identify groups of fish which may have been spatially or temporally discrete at some stage in their life history. In this study, blue whiting were sampled in 2003 and 2010, from the northern and southern extremes of the spawning ground and from around the Porcupine Bank and Rockall Trough. Spatial variation in otolith shape was examined in an attempt to elucidate boundaries between stock components. Cluster analysis of the otolith shape data revealed two distinct morphotypes; although some overlap did occur, fish of morphotype I occupied a more northerly distribution than fish of morphotype II. These findings are consistent with previous observations from otolith microstructure and oceanographic modelling, and support the hypothesis of northern and southern components in the blue whiting population which may overlap to varying degrees in the centre of the spawning distribution.

1. Introduction

Fisheries assessment models typically work under the assumption that populations are discrete groups with homogenous ecological characteristics (Begg et al., 1999; Kell et al., 2009; Stephenson, 1999). Failure to recognize underlying stock structure in a fishery can result in a reduction or collapse of less productive components (Frank and Brickman, 2000). Furthermore, when varying fishing pressures are applied to different components this can result in loss of genetic diversity and reduced ability to adapt to local conditions, with consequences for long term viability (Hutchinson, 2008; Stephenson, 1999). It is especially crucial for widely distributed species such as blue whiting, which undertake long migrations to separate feeding grounds, that accurate information on stock identity is incorporated into the stock assessment. Stock assessors must rely on this information to help managers generate appropriately scaled plans which are legislated to incorporate precautionary tactics to sustainably harvest the species (Begg et al., 1999). It is therefore recommended that the possible presence of discrete components be analyzed and assessed due to its implications to the management of fish stocks (Stephenson, 1999).

The distribution of blue whiting has been described from the Mediterranean Sea, north to the Barents Sea and west to the Mid-Atlantic ridge and east coast of North America (Bailey, 1982; Monstad, 1990; Payne et al., 2012). There are feeding grounds in the Bay of Biscay, Celtic Sea, and all along the continental slope as far as the Norwegian Sea. From January–May, the population makes an extensive migration to the spawning ground west of the British Isles (Skogen et al., 1999). Early research on the blue whiting population described sub-stocks in the NE Atlantic, with a main spawning area along the shelf-edge NW of the British Isles, and a smaller aggregation at the Porcupine Bank, with these sub-stocks migrating to different feeding grounds north and south of the spawning area (Pawson, 1979). Fisheries scientists have consistently questioned

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the stock identification for blue whiting; however, no sufficient management structures have been put in place to unequivocally delineate the stock for assessment purposes (ICES, 2012).

In 1980, catches south of the Porcupine bank were excluded from the assessment due to uncertainty of the stock structure. Length-at-age relationships and maturity ogives indicated some degree of stock delineation in this southern region (ICES, 1981). The following year, maturity ogives for fish caught in different areas to the west of Britain and Ireland suggested the existence of several populations in these areas (Ehric and Robles, 1982; Giedz, 1983). Analysis of von Bertalanffy growth curves showed a growth difference between the Hebridean/Porcupine areas and the North Sea/Norwegian Sea areas (Monstad, 1990). Based on otolith width and fish length relationships, Giedz (1982) proposed that juvenile blue whiting found on the Porcupine Bank did not migrate North with the rest of the stock. Otolith microstructure analysis has shown that adult blue whiting collected from the south of the spawning grounds grew significantly faster as larvae than those spawning to the north. This suggests that the spawning assemblage is not a randomly mixing unit, and that larval dispersal histories influence the subsequent adult distributions (Brophy and King, 2007). This is consistent with the results of oceanographic modelling studies which suggest that blue whiting larvae released on the Northeast Atlantic spawning grounds split into two branches, one following a northerly drift trajectory and the second drifting towards the south (Skogen et al., 1999).

Otolith shape is species specific but also shows intra-specific variation (Lombarte and Castellón, 1991). Due to the combined effects of genetics and environment, fish with different life histories often show variation in otolith morphology (Vignon and Morat, 2010). This has led to the development of otolith shape analysis as a tool in stock identification. The technique has been used to discriminate between fish populations for species such as Georges Bank haddock (*Melanogrammus aeglefinus*; Begg et al., 2001), Icelandic cod (*Gadus morhua*; Petursdottir et al., 2006), Atlantic herring (*Clupea harengus*; Burke et al., 2008), Atlantic saury (*Scomberesox saurus*; Agüera and Brophy, 2011), southern blue whiting (*Micromesistius australis*; Leguá et al., 2013) and Baltic Sea cod (*Gadus morhua*; Paul et al., 2013). The aim of this study was to examine the stock structure of blue whiting at their spawning grounds in the NE Atlantic using otolith shape analysis, and discuss how the results can influence the sustainable management of this population.

2. Methods

2.1. Sampling

Blue whiting otoliths were collected from the Irish Marine Institute port sampling operations at Killybegs, Co. Donegal, Ireland (Table 1). The fish were randomly sampled from commercial catch, and stored at the Marine Institute Fisheries Laboratory in Killybegs. All samples were collected during the fishing season on the spawning grounds in March 2003 and between February and April 2010. The catch was distributed between longitudes of 8.5 W and 17.5 W and latitudes of 49.25 N and 57.75 N. These locations correspond with the Porcupine Bank and the Rockall Trough. The most Northerly sample was located near St Kilda, off the West coast of Scotland.

A total of 249 fish were used in this study. The age of each fish was estimated by counting annuli on the whole otolith and was carried out by one experienced age reader to avoid potential inter-reader bias which has been noted for this species (ICES, 2013; Power et al., 2006). To avoid the potentially confounding influence of inter-annual and age related variability in otolith shape, fish from a restricted number of age classes were used in the analysis (ages 6 and 7 in 2003, age 7 in 2010) (Stransky and MacLellan, 2005). The selected age classes provided the largest sample size available from the commercially caught samples. Catch locations (longitude/latitude) were selected in order to maximize the spatial coverage; however samples from the northern and southern extremes of the spawning area were not available in 2003. Total body length was measured to the nearest half centimetre and weight was recorded to the nearest 0.1 g. The saggital otolith was removed, cleaned and stored dry. The otolith was soaked in water over 24 h to aid age reading. Whilst confounding effects of using both left and right otoliths are not noted in the literature for gadoids; the collected otoliths (left and right) for this study where in excellent condition and it was decided *a priori* to conduct the analysis on left otoliths only (Cardinale et al., 2004).

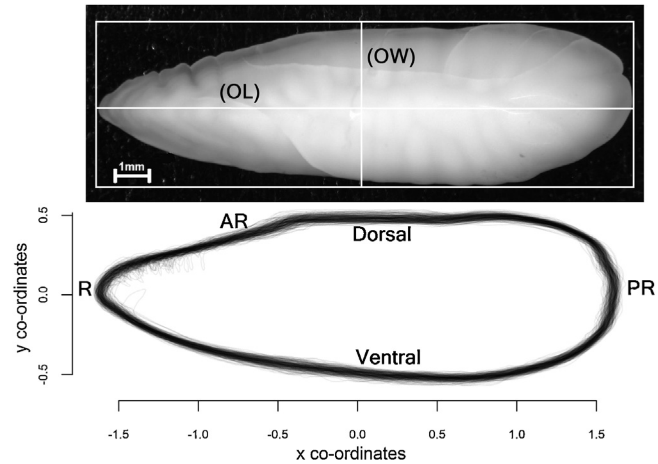

Fig. 1. (Above) otolith is digitized against a black background to emphasize the outline. A rectangle is placed around the otolith, from which otolith width (OW) and otolith length (OL) are measured. (Below) the 249 combined otolith outlines are centred, scaled and aligned. The notation R, AR and PR refer to the rostrum, anti-rostrum and post-rostrum on the otolith.

2.2. Image acquisition, digitisation and measurement of shape indices

Otolith orientation was standardized by positioning each otolith with the sulcus side facing up and the rostrum to the left (Fig. 1). The otoliths were digitized against a black background using a QImaging 2000R camera mounted to an Olympus SZX10 stereo microscope at 0.63× magnification. Image Pro-Plus (v6.3) was used for taking measurements of otolith width (OW), otolith length (OL), otolith area (A) and perimeter (P) (Fig. 1). Six common shape indices were calculated using ratios of OW, OL, A and P (Agüera and Brophy, 2011; Burke et al., 2008);

$$\text{Circularity} = \frac{P^2}{A} \qquad \text{Roundness} = \frac{4A}{\pi(\text{OL})^2}$$

$$\text{Rectangularity} = \frac{A}{\text{OL} \times \text{OW}} \qquad \text{Form Factor} = \frac{4\pi A}{P^2}$$

$$\text{Aspect Ratio} = \frac{\text{OL}}{\text{OW}} \qquad \text{Ellipticity} = \frac{\text{OL} - \text{OW}}{\text{OL} + \text{OW}}$$

2.3. Elliptical Fourier descriptors

Elliptic Fourier Descriptor's (EFD) describe a shape in terms of cosine waves (Campana and Casselman, 1993). Each turn or bend in the otolith outline is described by a series of cosine waves; with the degree of the bend relating to the height/depth of the wave.

Table 1
Capture dates and locations and summary of the biological data for each sample of blue whiting used in the analysis.

Year	Date	Long. (W)	Lat. (N)	*n*	Ages	Average length (cm)	Standard deviation (cm)
2003	04-Mar	16.5	51.25	12	6 + 7	30.3	±1.6
2003	14-Mar	16.5	54.25	10	6 + 7	31.8	±3.01
2003	16-Mar	15.5	52.25	16	6 + 7	30.4	±2.78
2003	18-Mar	17.5	53.25	21	6 + 7	30.9	±3.35
2010	10-Feb	15.5	53.25	29	7	31.34	±1.84
2010	17-Feb	14.5	52.75	26	7	31.35	±2.35
2010	23-Feb	15.5	49.25	33	7	31.1	±1.67
2010	15-Mar	16.5	55.25	40	7	30.1	±1.73
2010	18-Mar	11.5	55.75	36	7	29.9	±1.58
2010	19-Apr	8.5	57.75	26	7	29.5	±1.06

Subsequent cosines can be added to the model to improve the shape description, until a point when the number of cosines is enough to describe 99.9% of the otolith and any extra are superfluous (Crampton, 1995).

The otolith outline was traced from the digitized image and saved as *x, y* co-ordinates (TPS files) using TpsDig (F.J. Rohlf, http://life.bio.sunysb.edu/morph/index.html). There were 3131 (±150) co-ordinates per outline. TPS files for all the otolith outlines were combined into one data file and passed to the R package *Momocs* (Bonhomme et al., 2013). The *x,y* co-ordinates for each otolith outline were centred, scaled and aligned (Fig. 1). The Fourier power equation indicated the first 10 harmonics as being sufficient to describe 99.9% of the otolith shape (Crampton, 1995). EFDs were calculated using the 'eFourier' function in *Momocs*, specifying the first 10 harmonics, thus reducing the number of parameters in the subsequent analysis.

2.4. Data analysis

Shape indices were tested for normality and homogeneity of variance. Shape indices that did not satisfy normality following transformation were discarded from subsequent analyses. The remaining shape indices were corrected for size effects (fish length (cm)) using a linear regression. Using the slope of the regression, the remaining shape indices were corrected for size effects using the equation:

$$Y_c = Y - b \times L$$

where Y_c is the corrected shape parameter, Y is the original shape parameter, b is the common within group slope of the shape-size relationship (from ANCOVA), and L is the measurement of size (fish length (cm)).

Circularity, Rectangularity, Form Factor and Roundness were not normally distributed and did not show any improvement following transformation (*Anderson–Darling*, $P < 0.01$). They all showed significant correlation with the other shape variables it was decided to exclude them from further analysis. Therefore, Ellipticity and Aspect Ratio were corrected for size effects and selected for the analysis. The subsequent analysis was therefore based on 2 shape indicators, and 10 Harmonics; each harmonic was comprised of four coefficients.

K-means cluster analysis was carried out on the EFDs and shape indices, to partition the data into two groups such that the sum of squares of the assigned cluster centres is minimized. The algorithm iteratively estimates the cluster means and assigns each case to its respective cluster. K-means allows for *a priori* assumptions on the number of clusters to compute, and from the knowledge of the species in the literature, two morphotypes (*i.e.* hypothetical North and South stock components) were specified.

Principal Component Analysis (PCA) was carried out using the corrected shape indices and EFDs based on the correlation matrix, which render the variables independent of the order of magnitude

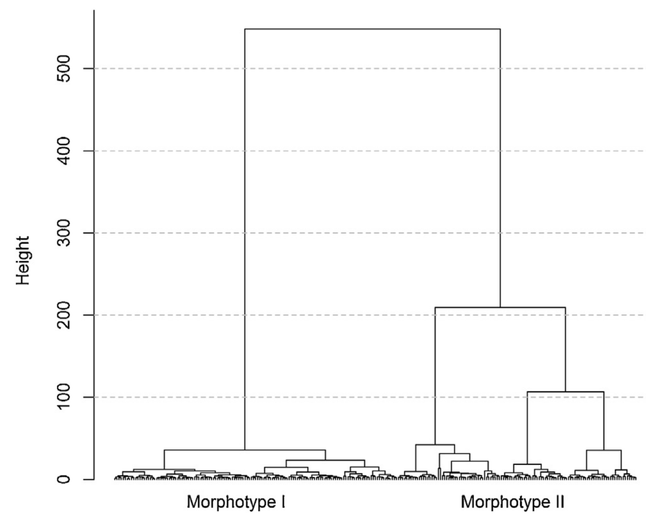

Fig. 2. K-means clustering based on the euclidean distance (height) of the elliptic fourier descriptors. The tree is split into two clusters according to morphotype.

of the measurements (R Core Team, 2013). This allows for examination of variance in multivariate data, by retaining the maximum amount of information through linear transformations of the shape parameters. PCA scores were plotted to visualize regional clustering in the data. The PCA scores were tested for normality (Anderson–Darling) and for homogeneity of the covariance matrices using Box's M test, prior to being included in a Discriminant Function Analysis (DFA) to classify them to separate morphotypes (PAST v3). The DFA was applied to the scores from the PCA with Jackknife classification to assign fish to morphotype (as defined from cluster analysis) (SYSTAT v11).

3. Results

K-means clustering supported the hypothesis that two morphotypes occurred within the samples (Fig. 2). The average outline for each morphotype, according to K-means clustering was recreated and plotted to show the differences in shape (Fig. 3). Morphotype II, on average appears to be wider at a given otolith length than morphotype I, especially at the anti-rostrum.

The first five principal components (PC1–5) explained 99.9% of the variability in otolith shape, so these were retained in the analysis. 20.3% and 8.4% of the variance was described by PC1 and PC2 respectively. The contribution of the EFDs to the PC loadings was somewhat homogenous for all coefficients, with higher loading values towards the latter harmonics. Two distinct clusters (morphotype I and morphotype II) emerged from the PCA. A latitudinal trend in the distribution of the two morphotypes was observed; with the exception of one fish (Fig. 4).

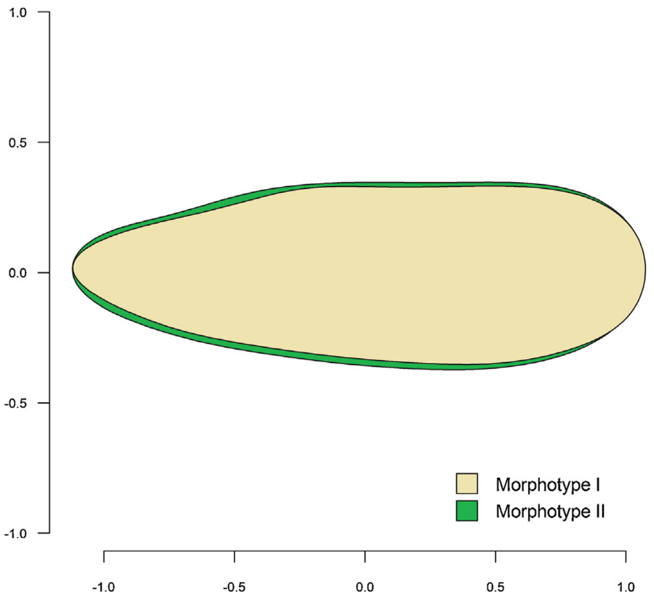

Fig. 3. The recreated average outline of the two otolith morphotypes, overlaid to demonstrate shape differences.

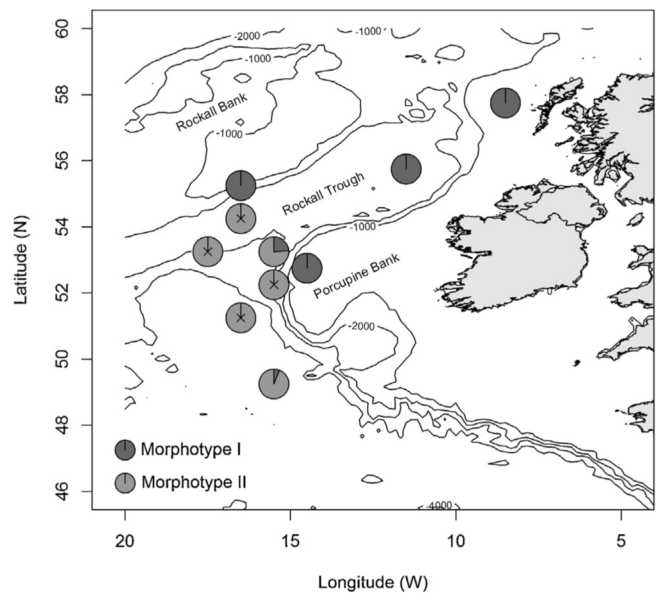

Fig. 5. The distribution of otolith morphotypes across the spawning area. Pie charts represent proportions of morphotype I and II found in each sample. 2003 samples are represented by an "x" in the centre of the pie chart.

Fish of morphotype I generally occurred to the north of 52 N while fish of morphotype II occurred to the south of 54.25 N (Fig. 5). Between these limits there was overlap in the distributions; however individual hauls were largely predominated by one or other of the two morphotypes. Fish from samples collected in 2003 were exclusively of morphotype II while both morphotypes were sampled in 2010 (Fig. 5). This most likely reflects the more restricted spatial and temporal distribution of sampling in 2003 compared to 2010.

Stepwise DFA of the PCA scores, showed 99% and 100% classification success in assigning fish to morphotype I (North) and II (South) respectively with one fish misclassified out of the entire sample of 249 (Table 2).

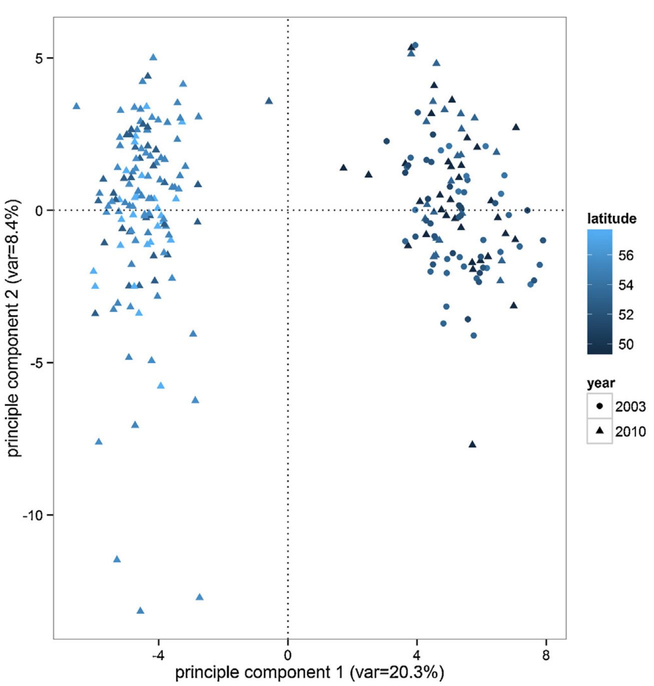

Fig. 4. Scores from Principle Component Analysis. The colour of the points reflect a latitudinal gradient, whereby points from Southern latitudes are dark blue, becoming a lighter shade of blue from more Northern latitudes. The percentage variance described by each component is listed on the axes.

4. Discussion

The otolith shape analysis revealed the existence of two very distinct groups within the blue whiting spawning aggregations. The study relied on opportunistic sampling of the commercial catches. The fishery targets a dynamic assemblage of fish as blue whiting migrate to and from the spawning area throughout the main spawning period (February to April) (ICES, 2012). In this regard, the samples merely provide a "snapshot" of the temporal and spatial distribution of the two groups. However at the times and locations examined, fish of Morphotype I occupied a more northerly distribution than fish of Morphotype II with limited mixing between the two types (two of the ten hauls examined contained individuals of both types). These northerly and southerly components therefore appear not to mix randomly during the spawning season, providing additional evidence of stock structure within the blue whiting fishery.

The results of this study are consistent with previous observations from otolith microstructure (Brophy and King, 2007) and oceanographic modelling (Skogen et al., 1999). The findings lend support to the hypothesis that a southern component of the blue whiting stock arrives at the spawning grounds (Porcupine Bank/Seabight area) between January and March, with a larger northern component arriving later (Feb-April) in the Rockall Trough area. This hypothesis is supported by a recent long term analysis of the distribution of blue whiting larvae between 1948 and 2005 from the Continuous Plankton Recorder which indicates the

Table 2
Jackknife classification results from the stepwise Discriminatory Function Analysis.

	Predicted group		%correct
	North	South	
North	134	2	99
South	0	113	100
Total n	134	115	

occurrence of two key blue whiting spawning events separated in space and time. The first occurs at the Porcupine Bank, almost a month earlier than the second, which occurs in the Rockall Trough (Fabien Pointin and Mark R. Payne, in review).

The hypothesis of two stock components should be considered in the context of the drivers of otolith shape. The morphology of the otolith is determined by the genetics of the stock, but also by ontogeny and environment (Vignon and Morat, 2010; Vignon, 2012). In field studies, otolith shape variation appears to coincide with geographical differences in temperature (Bolles and Begg, 2000), water depth (Lombarte, 1992), salinity (Capoccioni, 2011) and substrate type (Mérigot et al., 2007). Experimental studies provide empirical evidence of the influence of feeding rates on otolith shape (Gagliano and McCormick, 2004; Hüssy, 2008) and are also helping to segregate the genetic, ontogenetic and environmental components of otolith shape determination (Cardinale et al., 2004; Hüssy, 2008). The response of otolith shape to temperature and food availability appears to be mediated *via* the effects of these variables on growth rate (Campana and Casselman, 1993; Hüssy, 2008). The mechanism of this association between otolith growth rate and shape is not certain; however Gauldie and Nelson (1990) observed long, thin crystals in the otoliths of fast growing fish compared to the shorter more compacted crystals in slower growing fish, with possible consequences for overall shape.

In light of what is known about how otolith morphology is determined, the observed variation in the otolith shape of blue whiting may reflect differences in the genetics or the environmental histories of the northern and southern components, or may occur due to the interactive influence of both factors. Previous studies have revealed some degree of genetic heterogeneity among blue whiting spawning assemblages in the Hebridean Shelf and the Porcupine Bank area, although this variability is largely temporal rather than spatial (Ryan et al., 2005; Was et al., 2008, 2006) and the high probability of genetic mixing on the spawning grounds is acknowledged (Mork and Giaever, 1995). While it is difficult to unravel the phenotypic and genotypic drivers of otolith shape, genetic variation across the spawning ground is not as marked as the observed variability in otolith shape, suggesting some degree of phenotypic control. The blue whiting stock occupies an extensive distribution throughout its life cycle and groups of fish are therefore likely to occupy a wide range of environmental conditions which could produce variation in growth and otolith shape. Indeed, experienced otolith readers note the northern fish tend to have more split and false ring deposition, with Southern fish displaying more uniformity in ring structure.

Blue whiting distribution and recruitment rates are intrinsically linked to hydrography in the region such as the North Atlantic Sub Polar Gyre (Hátún et al., 2009; Payne et al., 2012). The cohorts used in this study were obtained during a period of large recruitment events (ICES, 2011). Oceanographic studies suggest that the phase of the sub-polar gyre regulates the distribution of blue whiting during these recruitment events (Hátún et al., 2009). During the period of our sampling, the gyre was in a negative phase (Gao and Yu, 2008), which according to Hátún et al. (2009) should coincide with a westward shift in spawning of blue whiting. This leads to an expansion of the spawning grounds; introducing eggs and larvae to areas of differing hydrography (as opposed to during a positive gyre phase), and subsequently differing drift patterns which can vary up to 200 km over short periods (1976–1979) (Skogen et al., 1999). Should two components exist in the NE Atlantic, the relationship between hydrography and blue whiting distribution would add temporal complexity when attempting to elucidate stock structure.

The otolith shape analysis method presented here provides a powerful tool that if applied correctly, could be used to produce a quantitative index to inform the assessment of this widely distributed stock of blue whiting. The method is relatively quick and inexpensive and could be easily incorporated into routine sampling of blue whiting during scientific surveys and from the commercial catch to track the movements of the two putative components throughout the spawning season and during migrations to and from feeding areas. Special emphasis should be placed on the collection of otoliths from as far south and north as possible, which could be accommodated during the existing acoustic survey (ICES, 2011). This approach could help to define the distributional boundaries of the northern and southern components and establish the degree to which mixing occurs. The complexity of stock structuring could thus be reduced to a few parameters which in turn could facilitate its incorporation into stock assessment. By adding this utility to the existing toolkit for managers, we hope to remove some of the difficulties made during key management decisions, and lead towards a more sustainable harvest for blue whiting.

5. Conclusion

Otolith shape analysis provides evidence that the blue whiting population in the NE Atlantic displays complex stock structuring at the spawning grounds. Blue whiting were classified into two morphotypes according to their otolith shape, with a strong latitudinal effect. Consistent with previous studies of stock separation in blue whiting, the results strengthen the argument for blue whiting to be considered as a series of separate stocks; based around distinct feeding grounds and undergoing varying degrees mixing on common spawning grounds.

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Working Document to

ICES Working Group on Widely distributed Stocks (WGWIDE), ICES Headquarters, Copenhagen, Denmark, 26 August - 1 September 2014

Cruise report from the coordinated ecosystem survey (IESSNS) with M/V ”Brennholm”, M/V “Vendla”, M/V “Finnur Fríði” and R/V “Árni Friðriksson” in the Norwegian Sea and surrounding waters, 2 July - 12 August 2014

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Abstract

The international coordinated ecosystem survey in the Norwegian Sea and adjacent areas (IESSNS) was performed during 2 July to 12 August 2014 on four vessels from Norway (2), Iceland (1) and Faroes (1). Greenland leased the Icelandic vessel for 12 days to cover the East Greenland area. A standardised pelagic trawl swept area method was used to estimate abundance of NEA mackerel in the Nordic Seas in recent years.

One of the main objectives of the IESSNS is to provide reliable and consistent age-disaggregated abundance indices of NEA mackerel. The WKPELA meeting held at ICES in Copenhagen in February 2014 benchmarked the assessment of mackerel in the Northeast Atlantic (ICES 2014c). It was agreed during the meeting to include age-disaggregated indices for age group 6+ scaled by the coverage each year from the IESSNS into the assessment.

The total swept area estimate of NEA mackerel in summer 2014 was 9.0 million tonnes distributed over an area of 2.45 million square kilometres in the Nordic Seas from about 58°30'N up to 76°10'N and from 22°E on the Norwegian coast to 43°W in the Irminger Sea south of Cape Farewell in Greenland waters. The 2011-year class contributed with 32.0% in number followed by the 2010-year class with 21.1%. The 2007, 2008 and 2009 year classes contributed then to around 11% each. Altogether 66.2% of the estimated number of mackerel was less than 6 years old. The internal consistency plot for age-disaggregated year classes has greatly improved since 2013 especially for younger year classes. There is now good internal consistency between year classes 1-10 years old, except between the less abundant 5 and 6 year old. The improved consistency in younger year classes for NEA mackerel in the IESSNS survey should be taken into consideration by ICES, specifically by including also younger mackerel 1-5 years of age, and not only age 6+ mackerel, into the tuning series as input on abundance of NEA mackerel to the assessment.

Mackerel was observed in most of the surveyed area, and the zero boundaries were found in most areas, except in the southwestern border of the East Greenland zone. Approximately 8% of the mature mackerel sampled during the survey had not yet spawned based on maturity on each trawl haul and all the vessels.

The geographical coverage and survey effort was 2.45 million km2 in 2014 which was very similar to 2013 (2.41 million km2). The area coverage in 2013 and 2014 is larger than previous years mapping from 2007 to 2012.

Norwegian spring-spawning (NSS) herring was measured acoustically during the survey and the total biomass came to 4.6 million tonnes. The 2004 and 2005 year classes were most abundant in the survey. The NSS herring was mainly found in the southwestern and western part of the Norwegian Sea; i.e. from north of the Faroe Islands and to the east and north off Iceland. Small concentrations were found in the northern and eastern areas, while herring was mostly absent in the mid Norwegian Sea. The biomass estimate is considerably lower than from the 2013 survey (8.6 million tonnes). This is partly due to insufficient coverage north of Iceland and west of Jan Mayen, and partly due to the very shallow distribution in the Jan Mayen area, with apparently high proportions of NSS herring being in the acoustic deadzone above the transducers.

The spatio-temporal overlap between NEA mackerel and NSS herring in July-August 2014 was highest in the southern and south-western part of the Norwegian Sea. Herring was most densely aggregated in areas where zooplankton concentrations where high. Mackerel, on the other hand, was found in most of the surveyed area, and in areas with varying zooplankton concentrations.

No deep trawl hauls were taken on acoustic registrations of blue whiting, and acoustic registrations deeper than 200 m were not scrutinized in part of the survey area in 2014. Thus the results of the survey can neither be used to quantify nor map the distribution of blue whiting in the Nordic Seas in the summer 2014.

The surface temperatures in the Nordic Seas in July-August 2014 were generally higher in all areas compared to July-August 2013. The SST anomaly map showed considerably higher average surface temperatures in July 2014 or 1-3°C higher compared to the average temperature in July during the last 20 years. This is thought to be due to the unusual calm weather conditions during this summer.

The average concentration of zooplankton in the Nordic Seas in July-August 2014 was at the same level as in 2013, 8.3 g/m^2 and 8.6 g/m^2, respectively. However, in the western areas, i.e. west of 14 degrees west (Iceland and East Greenland areas), the zooplankton biomass was markedly lower in 2014.

Whale observations were done by the two Norwegian vessels during the survey. The number of marine mammal sightings was generally very low in the central and eastern part of the Norwegian Sea but considerably higher numbers, especially of fin whales, were observed in the northern Norwegian Sea and into the Barents Sea. Many groups of killer whales were observed in central and northern Norwegian Sea feeding on mackerel, whereas fin whales where mainly observed near Jan Mayen, Bear Island and the southwestern part of the Barents Sea and off the coast of Finnmark.

All vessels that participated in the IESSNS 2014 used the same pelagic sampling trawl design (Multpelt 832) and followed the protocol agreed upon in Hirtshals in February 2013 for both rigging and operation (ICES 2013). Systematic underwater video recordings of mackerel swimming behaviour in relation to the catching process were also conducted. Results from those exercises are not available yet.

Introduction

In July-August 2014, four vessels; the chartered trawler/purse seiners M/V "Brennholm" and M/V "Vendla" from Norway, and M/V "Finnur Fríði" from Faroe Islands, and the research vessel R/V "Arni Friðriksson" from Iceland, participated in the joint ecosystem survey (IESSNS) in the Norwegian Sea and surrounding waters. The five weeks coordinated survey from 2nd of July to 11th of August 2014 is part of a long-term project to collect updated and relevant data on abundance, distribution, aggregation, migration and ecology of northeast Atlantic mackerel and other major pelagic species. Major aims of the survey were to quantify abundance, spatio-temporal distribution, aggregation and feeding ecology of Northeast Atlantic mackerel in relation to distribution of other pelagic fish species such as Norwegian spring-spawning herring, oceanographic conditions and prey communities. Whale observations were conducted on the Norwegian vessels in order to collect data on distribution and aggregation of marine mammals in relation to potential prey species and the physical environment. The pelagic trawl survey was initiated by Norway in the Norwegian Sea in the beginning of the 1990's. Faroe Islands and Iceland have been participating on the joint mackerel-ecosystem survey since 2009, but the Icelandic survey results for 2009 were not included in a joint cruise report that year.

The main objective of the IESSNS survey in relation to quantitative assessment purposes is to provide reliable and consistent age-disaggregated abundance indices of NEA mackerel. WKPELA meeting was held in ICES HQ in Copenhagen from the 21-27 February 2014, to benchmark the assessment of mackerel in the Northeast Atlantic. In the case of NEA mackerel the previous assessment was not considered to give a reliable estimate of the development of the stock, and this assessment was limited by lack of independent age-structured indices. There was an agreement during the benchmark meeting to include age-structured indices on adults from the IESSNS swept-area trawl survey. It was decided that an age-disaggregated time-series for analytical assessment should be restricted to adult mackerel at age 6 years and older for the years 2007, 2010-2013. We furthermore aim to extend the existing time series with annual updates from 2014 on abundance indices from the IESSNS swept-area trawl survey as input to the analytical assessment on NEA mackerel. Based on results on coefficient of correlation from updated internal consistency plots in the age-disaggregated data between year classes when extending the time series, we will test whether younger year classes (2, 3, 4 and 5 year olds) can be included in the age-disaggregated time-series from the IESSNS survey.

It must be noted that even if the IESSNS covers the spatial distribution of blue whiting adequately no dedicated deep trawl hauls were taken on likely acoustic registrations of blue whiting and acoustic registrations deeper than 200m were not scrutinized in part of the survey area. Thus the results of the survey can neither be used to quantify nor map the distribution of blue whiting in the Nordic Seas in the summer 2014.

Material and methods

Coordination of the survey was done by correspondence during the spring and summer 2013 and in relation to the international ICES WKNAMMM workshop in February 2013 in Hirtshals, Denmark and input and recommendations from the mackerel benchmark in February 2014 (ICES 2014c). The participating vessels together with their effective survey periods are listed in Table 1.

In general, the weather conditions were predominantly very calm with good survey conditions for the two Norwegian vessels “Brennholm” and “Vendla” related to oceanographic monitoring, plankton sampling, acoustic registrations and pelagic trawling. The same was the case with the Faroese chartered vessel “Finnur Fridi” experiencing very good weather conditions in Faroese waters. Although “Arni Fridriksson” experienced some bad weather in the northwestern part of the Iceland in the beginning of the survey, and a few days in Greenland waters at the end of the survey the weather conditions did not affect the quality to any extent of the various scientific data collection during the survey for the involved survey vessels. Only a few plankton stations could not be taken due to bad weather.

During this year’s survey the special designed pelagic trawl, Multpelt 832, was used by all four participating vessels for the third consecutive year. This trawl is a product of a cooperation of participating institutes in designing and construction of a standardized sampling trawl for this survey in the future for all participants. The work lead by trawl gear scientist John Willy Valdemarsen, Institute of Marine Research (IMR), Bergen, Norway, has been in good progress for four years. The design of the trawl was finalized during meetings of fishing gear experts and skippers at meetings in January and May 2011. Further discussions on modifications in standardization between the rigging and operation of Multpelt 832 was done during a trawl expert meeting in Copenhagen 17-18 August 2012, in parallel with the post-cruise meeting for the joint ecosystem survey, and then at the WKNAMMM workshop and tank experiments on a prototype (1:32) of the Multpelt 832 pelagic trawl, conducted as a sequence of trials in Hirtshals, Denmark from 26 to 28 February 2013 (ICES 2013). The standardization and quantification of catchability from the Multpelt 832 pelagic trawl was further discussed during the mackerel benchmark in Copenhagen in February 2014. Recommendations and requests coming out of the mackerel benchmark have further been implemented and improved on all the four vessels involved during the IESSNS survey in July-August 2014.

Table 1. Survey effort by each of the four vessels in the July-August survey in 2014.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton stations
Arni Friðriksson	11/7-12/8	6080	117	117	108
Finnur Fríði	10/7- 21/7	2247	33	33	32
Brennholm	2/7-28/7	4283	77	77	77
Vendla	2/7-28/7	3462	55	54	55
Total	2/7-12/8	16072	282	281	272

Hydrography and Zooplankton

The hydrographical and plankton stations by all vessels combined are shown in Figure 2. Arni Fridriksson was equipped with a SEABIRD CTD sensor with a water rosette that was applied during the entire cruise. Finnur Fríði was equipped with a mini SEABIRD SBE 25+ CTD sensor, and Brennholm and Vendla were equipped with a SAIV SD200 CTD sensor, recording temperature, salinity and pressure (depth) from the surface down to 500 m, or when applicable as linked to maximum bottom depth.

All vessels collected and recorded also oceanographic data from the surface either applying a thermosalinograph (temperature and salinity) placed at approximately 6 m depth underneath the surface or a thermograph logging temperatures continuously near the surface throughout the survey.

Zooplankton was sampled with a WP2-net on all vessels. Mesh sizes were 180 μm (Brennholm and Vendla) and 200 μm (Arni Fridriksson and Finnur Fríði). The net was hauled vertically from a depth of 200 m (or bottom depth at shallower stations) to the surface at a speed of 0.5 m/s. All samples were split in two, one half preserved for species identification and enumeration, and the other half dried and weighed. Detailed description of the zooplankton and CTD sampling is provided in the survey manual (ICES 2014b).

The number of stations taken by the different vessels is provided in Table 1. The lower number of plankton stations in comparison to the trawl and CTD stations (e.g. on Árni Friðriksson) is usually due to bad weather preventing plankton sampling.

Trawl sampling

Trawl catches were sorted and weighed; fish were identified to species level, when possible, and other taxa to higher taxonomic levels. The full biological sampling at each trawl station varied between nations and is presented in Table 2. On Finnur Fríði, trawl hauls were sub-sampled, 100 kg to 300 kg, and the same sample processing protocol follow as used on the other three vessels. Smaller sub-sample (approximately 100 kg) was taken when either mackerel or herring was visible in catch but if both species were in catch a large sub-sample is taken (300 kg).

Table 2. Summary of biological sampling in the survey from 2nd of July to 11th of August 2014 by the four participating countries. Numbers denote the maximum number of individuals sampled for each species for the different determinations.

	Species	Faroes	Iceland	Norway
Length measurements	Mackerel	100*	100	100
	Herring	100*	200	100
	Blue whiting	100*	100	100
	Other fish sp.	0	50	25
Weighed, sexed and maturity determination	Mackerel	15	50	25
	Herring	15	50	25
	Blue whiting	15	50	25
	Other fish sp.	10	10*	0
Otoliths/scales collected	Mackerel	15	25	25
	Herring	15	50	25
	Blue whiting	50	50	25
	Other fish sp.	0	0	0
Stomach sampling	Mackerel	10	10	10
	Herring	10	10	10
	Blue whiting	10	10	10
	Other fish sp.	0	0	10*
Tissue for genotyping	Mackerel	210	400	1125

*are also weighted

All vessels used the Multpelt 832 pelagic trawl aimed for further strict standardization of fishing gear used in the survey (see ICES 2013; ICES 2014c). Standardization and documentation/quantification on effective trawl width, trawl depth and catch efficiency was improved according to requests during the mackerel benchmark (ICES 2014c). The most important properties of the Multpelt 832 trawls during the survey and their operation were as shown in Table 3.

Table 3. Trawl settings and operation details during the international mackerel survey in the Nordic Seas in July-August 2014. The column for influence indicates observed differences between vessels likely to influence performance. Influence is categorized as 0 (no influence) and + (some influence).

Properties	Brennholm	Arni Fridriksson	Vendla	Finnur Fríði	Influence
Trawl producer	Egersund Trawl AS	Tornet/Hampiðjan (50:50)	Egersund Trawl AS	Vónin	0
Warp in front of doors	Dyneema – 32 mm	Dynex-34 mm	Dyneema -32 mm	Dynex – 34mm	+
Warp length during towing	350 m	350 m	350 m	350 m	0
Difference in warp length port/starboard	0-4 m	3-12 m	0-4 m	5-12 m	0
Weight at the lower wing ends	400 kg	400 kg	300 kg	400 kg	0
Setback in metres	6 m	6 m	6 m	6 m	+
Type of trawl door	Seaflex adjustable hatches	Jupiter	Seaflex adjustable hatches	Injector F-15	0
Weight of traw door	2000 kg	2200 kg	1700 kg	2000 kg	+
Area trawl door	9 m² 75% hatches (effective 6.5m²)	7 m²	7.5 m² 25% hatches (effective 6.5m²)	6 m²	+
Towing speed (GPS) in knots	4.8 (4.5-5.2)	5.0 (4.5-5.5)	4.8 (4.5-5.2)	4.9 (4.1-5.1)	+
Trawl height	28-35	27-30	29-35	~ 35	+
Door distance	110-117 m	110-114 m	110-117 m	105-110	+
Trawl width*	-	-	-	-	+
Turn radius	5-8 degrees turn	5-10 degrees turn	5-8 degrees turn	5-10 degrees turn	+
A fish lock in front end of cod-end	Yes	Yes	Yes	Yes	+
Trawl door depth (port and starboard)	5-15, 7-17 m	8-13, 10-15 m	5-15, 8-18 m	5-15 m	+
Headline depth	0-1 m	0-1 m	0-1 m	0-1 m	+
Float arrangements on the headline	Kite +2 buoys on each wing	Kite + 2 buoys on wings	Kite + 2 buoys on each wingtip	Kite + 2 buoys on wings and 1 in middle	+
Weighing of catch	All weighted	All weighted	All weighted	All weighted	+

Marine mammal observations

Observations of marine mammals were conducted by trained scientific personnel and crew members from the bridge between 2nd and 28th of July 2014 onboard the Norwegian chartered vessels M/V "Brennholm" and M/V "Vendla" respectively. The priority periods of observing were during the transport stretches from one trawl station to another. Observations were done 24 h per day if the visibility was sufficient for marine mammal sightings. Digital filming and photos were taken whenever possible on each registration from scientists onboard.

Underwater camera observations during trawling

All vessels employed an underwater video camera (GoPro HD Hero 3 Black Edition, www.gopro.com) or high definition Sony camera in the trawl to observe mackerel behaviour during trawling. The camera was put in a waterproof box which tolerated pressure to 40 m or 60 m, and mounted on a small steel frame (approximately 20 cm by 30 cm, weight < 1 kg) with protective bars preventing entanglement of camera in trawl (see Photo 1 and 2). The small and light frame enabled camera employment at many different locations in trawl. The camera was employed inside (except at one station) the trawl where the steel frame was tied to trawl using a rope. It proved a quick and secure method of attaching frame to trawl.

The goal video recordings was to observe and assess: if the fish lock successfully prevents mackerel/herring from escaping the cod end when effective trawl time ends and speed slows below 5 nmi, and escapement of mackerel/herring at meshes from 16 m to 8 cm (Table 9). No light source was employed with camera, hence, recordings were limited to day light hours. Video recordings were collected at 30 % of trawl stations from eleven different locations in the trawl.

Photo 1. GoPro camera inside a waterproof box, mounted on steel frame and ready for employment in trawl on Finnur Fríði.

Photo 2. GoPro camera attached to inside of trawl by fish lock on Finnur Fríði. The steel frame was tied to trawl, at the each corner using a rope.

Acoustics

Multifrequency echosounder

The acoustic equipment onboard Brennholm and Vendla were calibrated 30th of June and 1st of July 2014 for 18, 38, 70, 120, 200 and 333 kHz. Arni Fridriksson was also calibrated on 31st of March 2014 for all frequencies 18, 38, 120 and 200 kHz, whereas Finnur Fridi was calibrated on 9th July 2014 for 38, 120 and 200 kHz prior to the cruise. All vessels used standard hydro-acoustic calibration procedure for each operating frequency (Foote, 1987). CTD measurements were taken in order to get the correct sound velocity as input to the echosounder calibration settings.

Generally, acoustic recordings were scrutinized on daily basis using the softwares LSSS onboard Vendla, Brennholm and Arni Fridriksson, and Echoview onboard Finnur Friði. Species were identified and partitioned using catch information, characteristic of the recordings, and frequency between integration on 38 kHz and on other frequencies by a scientist experienced in viewing echograms.

The survey was based on scientific echosounders using 38 kHz frequency as the main frequency for the abundance estimate. Also 200 kHz was used as frequency for acoustic registrations of NEA mackerel. A summary of acoustic settings is given in Table 4.

Acoustic estimates of herring and blue whiting abundance were obtained during the surveys in a same way as e.g. done in the International ecosystem survey in the Nordic Seas in May (ICES 2014a) and detailed in the manual for the surveys (ICES 2014b).

Table 4. Acoustic instruments and settings for the primary frequency in the July/August survey in 2014.

	M/V Brennholm	R/V Arni Friðriksson	M/V Vendla	M/V Finnur Friði
Echo sounder	Simrad EK60	Simrad EK 60	Simrad EK 60	Simrad EK 60
Frequency (kHz)	18, 38, 70, 120, 200	18, 38, 120, 200	18, 38, 70, 120, 200	38,120, 200
Primary transducer	ES38B	ES38B	ES38B	ES38B
Transducer installation	Drop keel	Drop keel	Drop keel	Hull
Transducer depth (m)	9	8	9	5
Upper integration limit (m)	15	15	15	12
Absorption coeff. (dB/km)	9.9	10	9.9	9.7
Pulse length (ms)	1.024	1.024	1.024	1.024
Band width (kHz)	2.43	2.425	2.425	2.43
Transmitter power (W)	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-21.1	-20.9	-20.6	-20.7
TS Transducer gain (dB)	24.87	24.64	23.27	24.37
s_A correction (dB)	-0.60	-0.84	-0.65	-0.63
alongship:	6.89	7.31	7.01	7.06
athw. ship:	6.87	6.95	7.11	7.16
Maximum range (m)	500	750	500	500
Post processing software	LSSS	LSSS	LSSS	Sonardata Echoview 5.1

Multibeam sonar

M/V “Brennholm” and M/V “Vendla” were equipped with the Simrad fisheries sonars SX90 (frequency range: 111.5-115.5 kHz), with a scientific output incorporated which allow the storing of the beam data for post-processing. One of the objectives in this survey was to continue the test of the software module “Processing system for fisheries omni-directional sonar, PROFOS” in LSSS at the Institute of Marine Research in Norway. The first test was done during the 2010 survey, and the basic processing was described in the cruise report (Nøttestad et al., 2010). The PROFOS module is in a late development phase and for this survey, functionalities for school enhancement by image processing techniques and for automatic school detection have been incorporated (Nøttestad et al., 2012; 2013).

Acoustic doppler current profiler (ADCP)

M/V "Brennholm" are equipped with a scientific ADCP, RDI Ocean surveyor, operating at 75 kHz and/or 150 kHz. The data collected during the survey will be quality checked and used for later analysis.

Intercalibration of Multpelt 832 pelagic trawl

No intercalibration of the Multpelt 832 pelagic trawl was performed during the 2014 survey.

Cruise tracks

M/V "Brennholm", M/V "Vendla", M/V "Finnur Friði" and R/V "Arni Fridriksson" followed predetermined survey lines with pre-selected pelagic trawl stations (Figure 1). An adaptive survey design was also adopted although to a small extent, due to uncertain geographical distribution of our main pelagic planktivorous schooling fish species. The cruising speed was between 10-12.0 knots if the weather permitted otherwise the cruising speed was adapted to the weather situation.

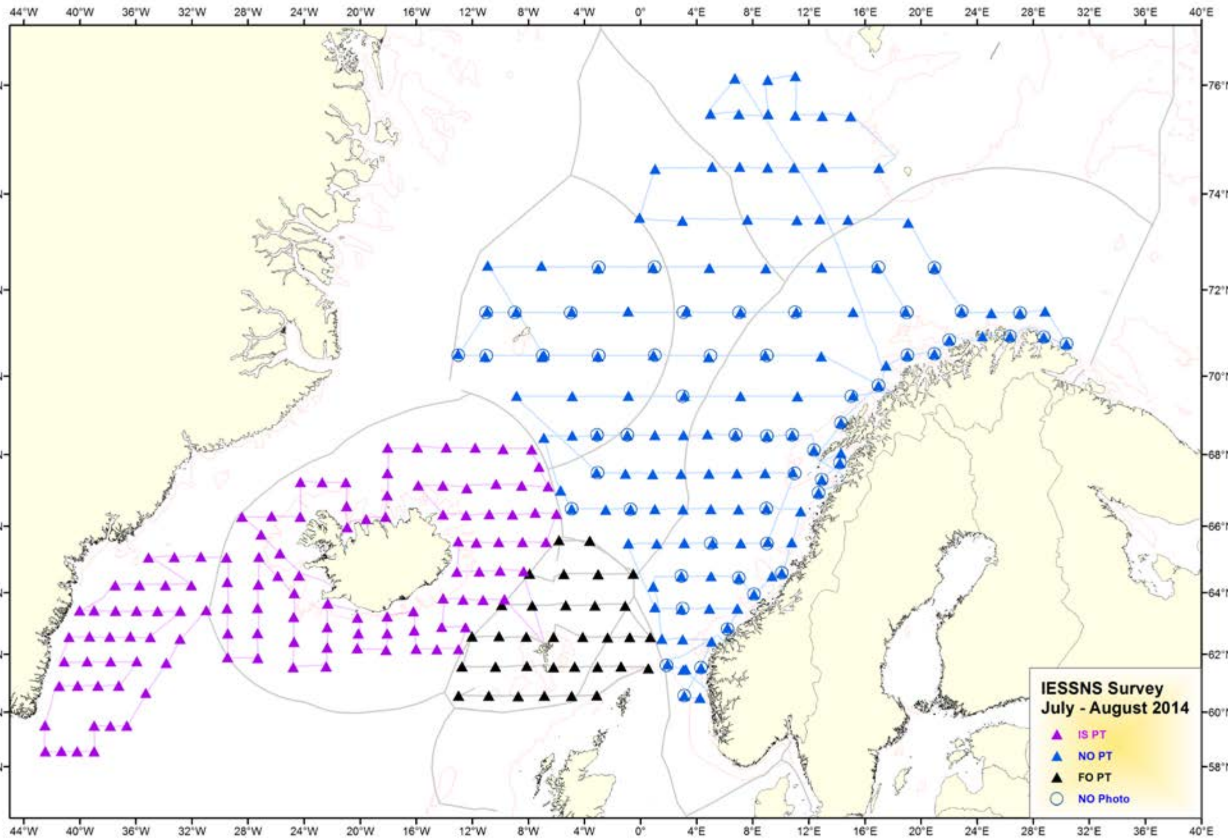


Figure 1. Cruise tracks and pelagic trawl stations shown for M/V "Brennholm" and "Vendla" (Norway) in blue, M/V "Finnur Friði" (Faroe Islands) in black and R/V "Arni Fridriksson" (Iceland/Greenland) in purple within the covered areas of the Norwegian Sea and surrounding waters from 2nd of July to 11th of August 2014.

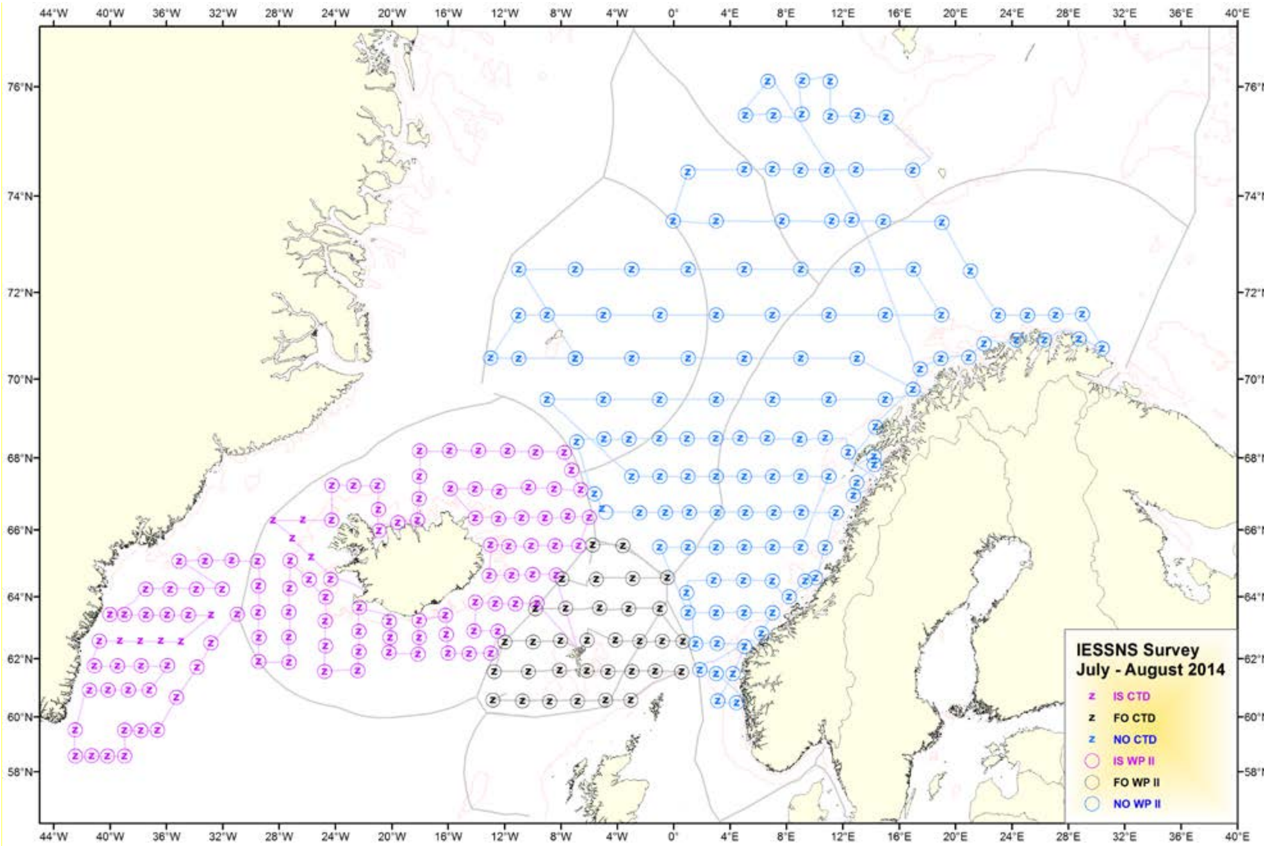


Figure 2. CTD stations (0-500 m) using SEABIRD SBE 37 (Arni Fridriksson) SEABIRD SB 25+ (Finnur Friði) and SAIV SD200 (Brennholm and Vendla) CTD sensors and WP2 plankton net samples (0-200 m depth). These were taken systematically on every pelagic trawl station on all four vessels

Swept area index and biomass estimation

The swept area estimate is based on catches in the whole area covered in the survey, or between 58°N and 77°N and 43°W and 22°E. Rectangle dimensions were 1° latitude by 2° longitude as in the estimates from previous years. Allocation of the biomass to exclusive economic zones (EEZs) was done in the same way as in 2010-2013 (see Annex 1).

In order to calculate a swept area estimate, the horizontal width of the trawl opening is required. It is assumed that no mackerel is distributed below the ground rope (vertical opening of the trawl). Average trawl door spread, vertical trawl opening and tow speed were sampled on each vessel for all stations. Two different kinds of data are available, manually reported values from log books (one value per station) and digitally recorded data from trawl sensors. The digtally recorded data were analysed as follows: Average door spread and vertical opening were calculated for each station, then the average values per station were used to calculate mean, maximum (max), minimum (min) and standard deviation (st.dev.) for each vessel. Horizontal opening of the trawl was calculated by a formula using average values of trawl door horizontal spread and tow speed for each vessel. The results of the measurements and estimations for the four vessels are given in Table 5. Based on these results average horizontal trawl opening used in the swept area calculations was set at the following vessel specific values given as 'Horizontal trawl opening (m)' in Table 5.

Table 5. Descriptive statistics for trawl door spread, vertical trawl opening and tow speed for each vessel. Two different kinds of data were analyzed, manually reported values from log books (one value per station) and digitally recorded data from trawl sensors (*). Digitally recorded data were filtered prior to calculations; for trawl door spread all values < 80 m and > 140 m were deleted, and for opening vertical spread all values < 20 m and > 50 were deleted. Next, average door spread and vertical opening was calculated for each station, then the average values per station were used to calculate overall mean, maximum (max), minimum (min) and standard deviation (st.dev.) for each vessel. Number of trawl stations used in calculations is also reported. For Árni Friðriksson, trawl door spread is reported both for log book data and digital trawl sensor data (*). Horizontal trawl opening (**) was calculated using average vessel values for trawl door spread and tow speed (details in Table 6).

	Finnur Fríði	RV Árni Friðriksson		Brennholm	Vendla
Trawl doors horizontal spread (m)					
Number of stations	31*	44*	110	76	56
mean	109*	113*	113	117	117
max	116*	118 *	120	133	127
min	102*	102*	97	100	110
st. dev.	3*	3*	3	4	4
Vertical trawl opening (m)					
Number of stations	27*	110		77	56
mean	35*	31		33	33
max	43*	38		40	41
min	27*	30		24	29
st. dev.	3*	2		2	5
Horizontal trawl opening (m) **					
mean	63	65		65	66
Speed (over ground, nmi)					
Number of stations	33	115		77	56
mean	5	5.0		4.7	4.8
max	5.5	5.4		5.7	6.0
min	4.6	4.5		4.0	4.2
st. dev.	0.2	0.2		0.2	0.2

Horizontal trawl opening was calculated using average vessel values for trawl door spread and tow speed (Table 6). The estimates in the formulae were based on a flume tank simulations in 2013 (Hirtshals, Denmark) where formulas were developed from the for the horizontal trawl opening as a function of door spread, for two towing speeds, 4.5 and 5 knots:

Towing speed 4.5 knots: Horizontal opening (m) = 0.441 * Doorspread (m) + 13.094

Towing speed 5.0 knots: Horizontal opening (m) = 0.3959 * Doorspread (m) + 20.094

Table 6. Horizontal trawl opening as a function of trawl door spread and towing speed. Relationship based on simulations of horizontal opening of the Multpelt 832 trawl towed at 4.5 and 5 knots, representing the speed range in the 2014 survey, for various door spread. See text for details.

Door	Towing speed (knots)					
spread (m)	4.5	4.6	4.7	4.8	4.9	5
100	57.2	57.7	58.2	58.7	59.2	59.7
101	57.6	58.1	58.6	59.1	59.6	60.1
102	58.1	58.6	59.0	59.5	60.0	60.5
103	58.5	59.0	59.5	59.9	60.4	60.9
104	59.0	59.4	59.9	60.3	60.8	61.3
105	59.4	59.9	60.3	60.8	61.2	61.7
106	59.8	60.3	60.7	61.2	61.6	62.1
107	60.3	60.7	61.2	61.6	62.0	62.5
108	60.7	61.1	61.6	62.0	62.4	62.9
109	61.2	61.6	62.0	62.4	62.8	63.2
110	61.6	62.0	62.4	62.8	63.2	63.6
111	62.0	62.4	62.8	63.2	63.6	64.0
112	62.5	62.9	63.3	63.7	64.0	64.4
113	62.9	63.3	63.7	64.1	64.4	64.8
114	63.4	63.7	64.1	64.5	64.9	65.2
115	63.8	64.2	64.5	64.9	65.3	65.6
116	64.3	64.6	65.0	65.3	65.7	66.0
117	64.7	65.0	65.4	65.7	66.1	66.4
118	65.1	65.5	65.8	66.1	66.5	66.8
119	65.6	65.9	66.2	66.6	66.9	67.2
120	66.0	66.3	66.6	67.0	67.3	67.6

Results

Hydrography

The surface layer in the northeastern part of the North Atlantic was warm in July 2014, as seen from the SST anomaly (one week in mid July 2014 relative to a 20 year average, Figure 3). The SST was more than 3°C warmer north of Iceland and between 2-2.5°C warmer in the central Norwegian Sea. This is in contrast to 2013 when the surface layer was close to the long-term average (Figure 4). The anomaly pattern in 2014 resembles that of 2012 with the exception that in 2012 the Irminger Sea was considerably (more than 3°C) warmer than the average.

It must be mentioned that the NOAA sea surface temperature measurements (SST) are sensitive to the weather condition (i.e. wind and cloudiness) prior to and during the observations and do therefore not necessarily reflect the oceanographic condition of the water masses in the areas, as seen when comparing detailed features of SSTs between years (Figures 3 and 4). However, since the anomaly is now based on averages values over whole July, it should give representative results of the surface temperature.

The upper layer (< 20 m depth) in the southern and mid area surveyed, i.e. from East Greenland extending to the Norwegian coast, was 1-2°C warmer in 2014 compared to 2013 (Figures 5-6). In the northern part of the surveyed area (Jan Mayen towards the northern Norwegian coast) the temperatures was at the 2013 level (Figures 5-6). One exceptional feature of the upper layer in 2014 is the very low signal of the cold East Icelandic Current (EIC) north of Iceland. The usual cool water of the EIC originating from the East Greenland Current (EGC) extending in a southeasterly direction was very weak (Figures 5-6). The temperature was up to 2°C warmer in the surface portion of the EIC in 2014 compared to 2013. The temperature distribution at 50 m depth was similar to the surface layers but with cooler water (Figure 7).

In the deeper layers (below 100 m depth), however, the hydrographic features in the area were similar to those in 2013, with a very clear signal of the EIC extending progressively farter eastwards with depth, towards the Norwegian coast at 400 m depth (Figures 8-10).

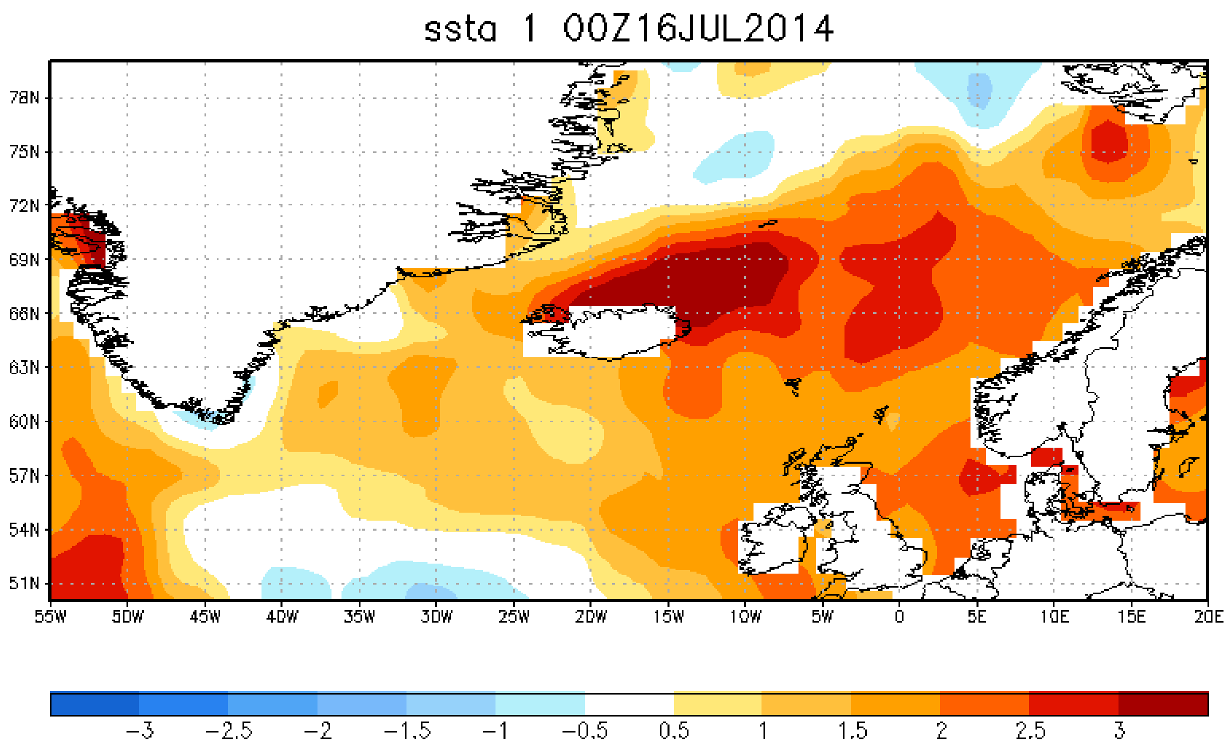


Figure 3. Sea surface temperature anomaly in July (°C; centered for mid July 2014) showing warm and cold conditions in comparison to a 20 year average.

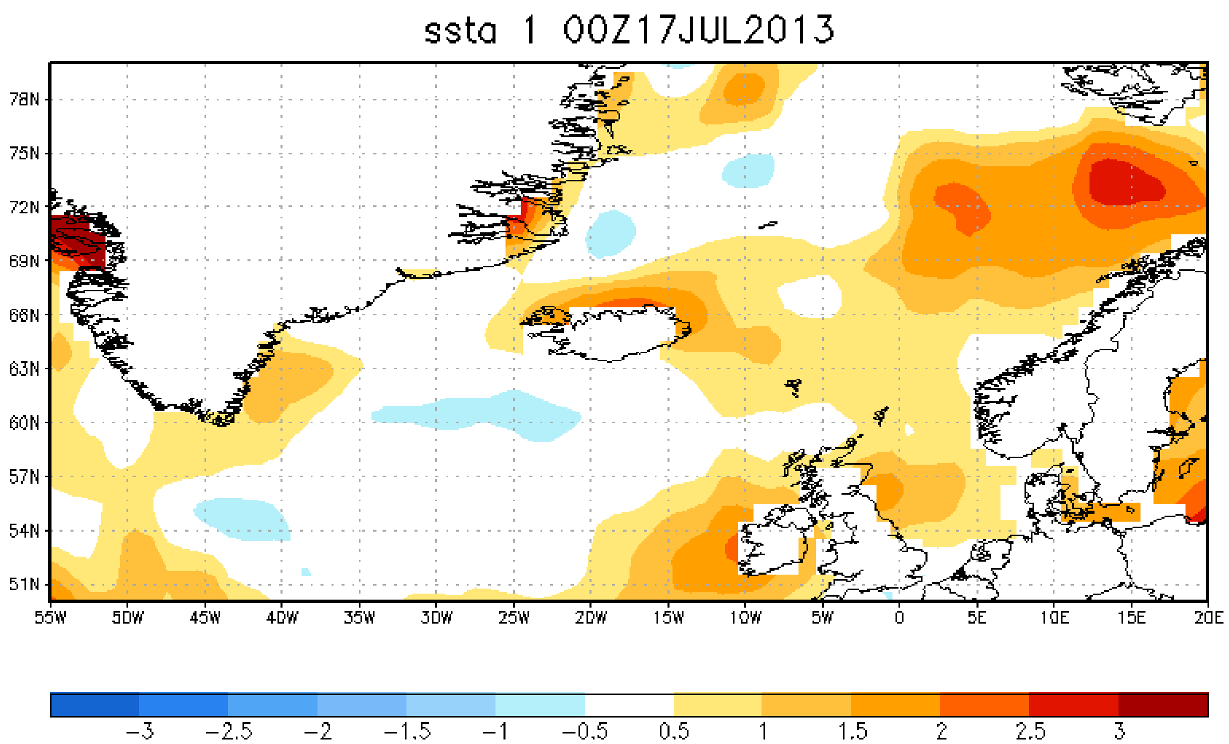


Figure 4. Sea surface temperature anomaly in July (°C; centered for mid July 2013) showing warm and cold conditions in comparison to a 20 year average.

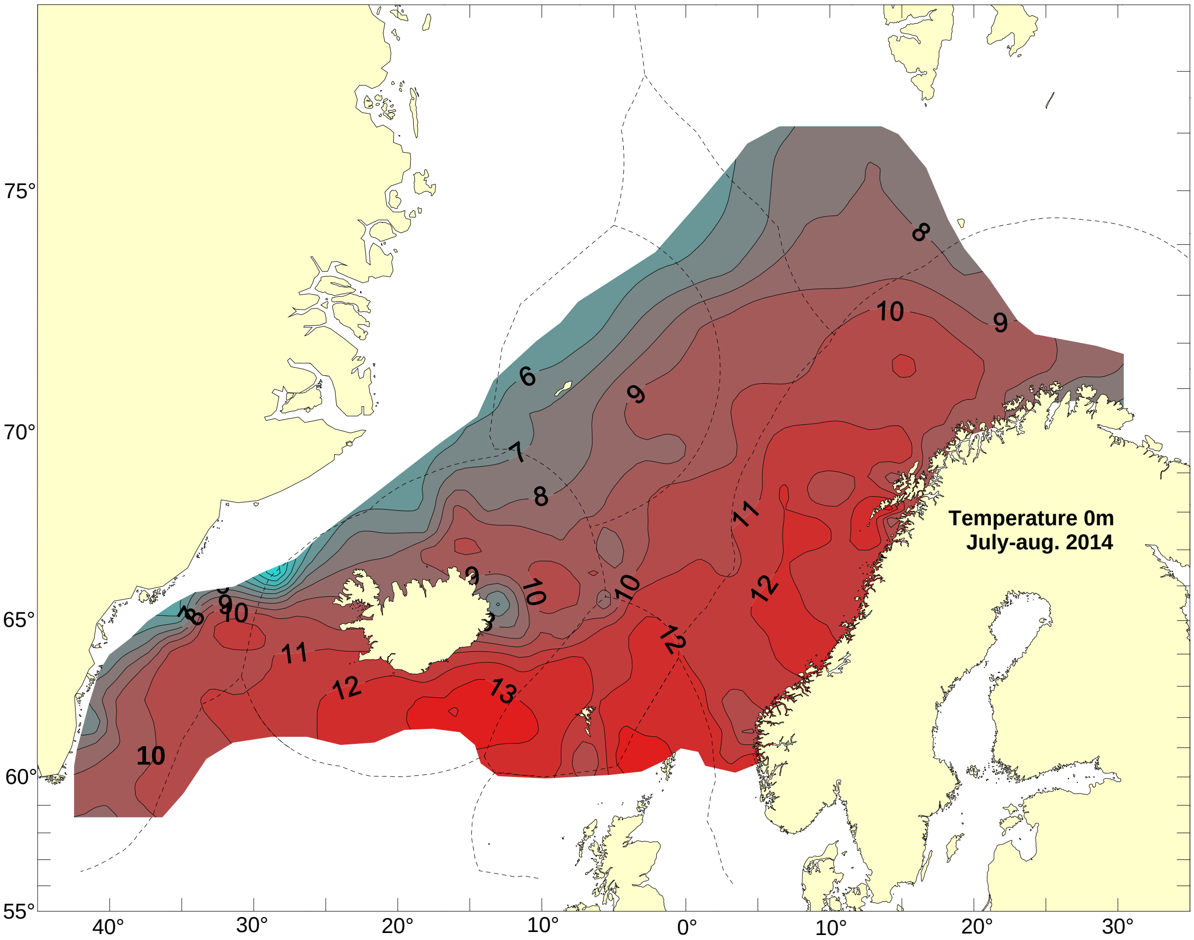


Figure 5. Temperature (°C) at 10 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

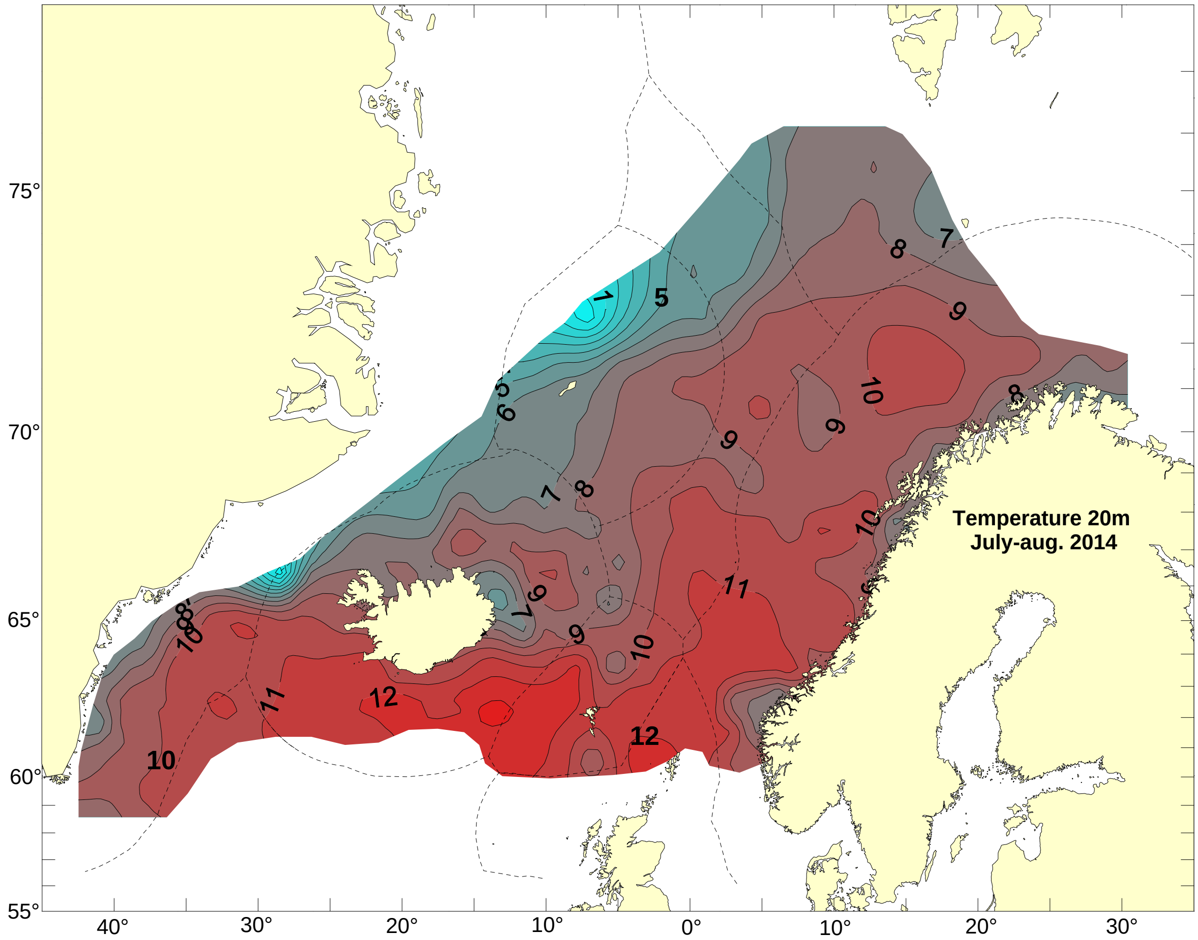


Figure 6. Temperature (°C) at 20 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

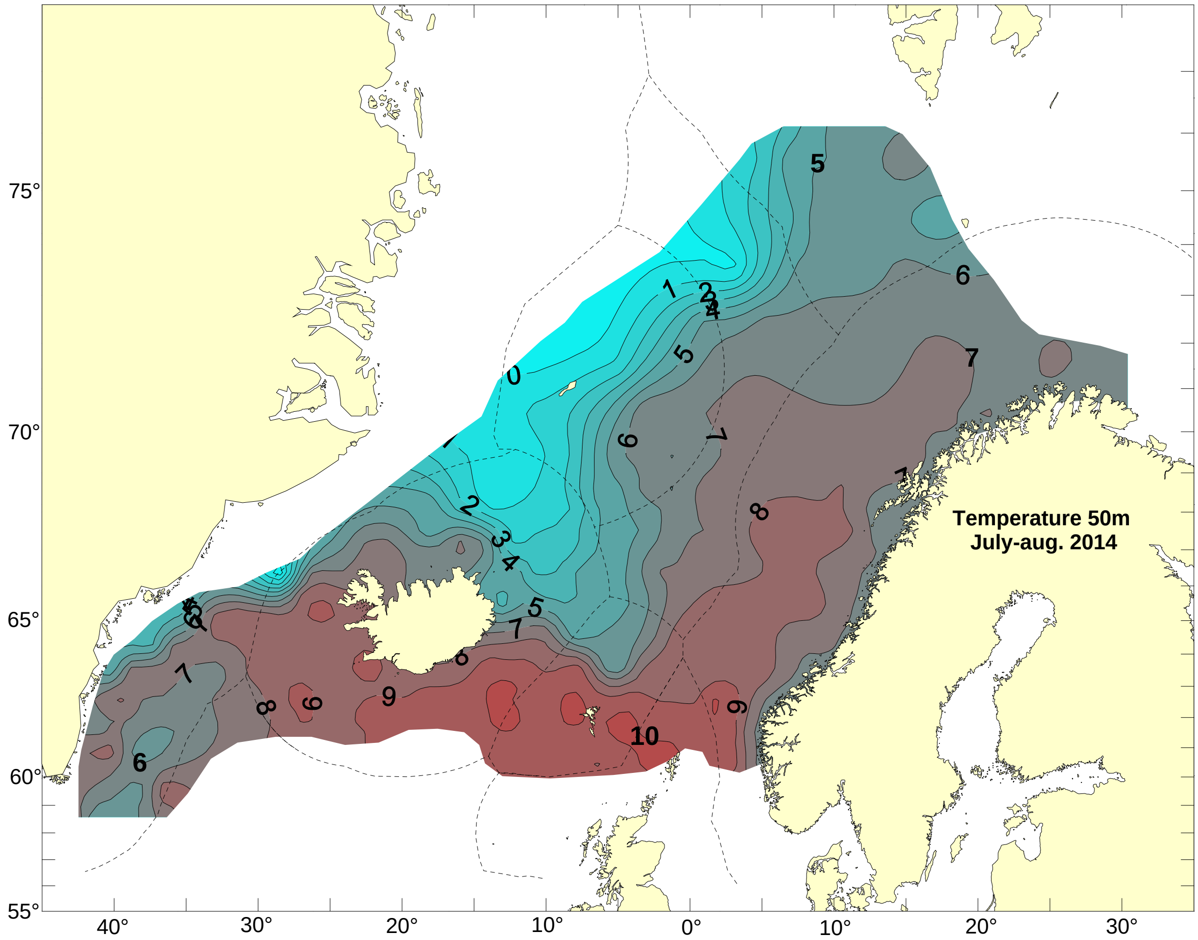


Figure 7. Temperature (°C) at 50 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

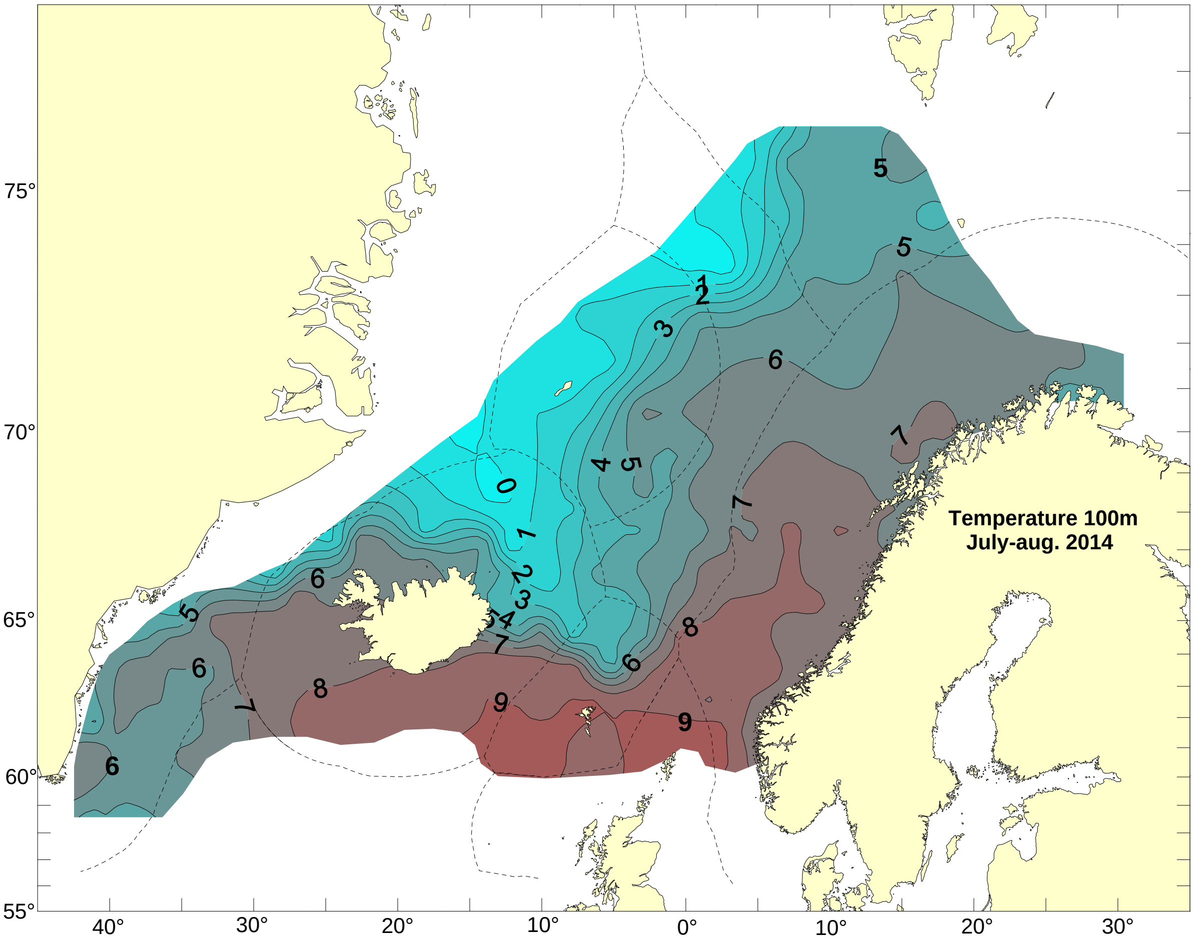


Figure 8. Temperature (°C) at 100 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

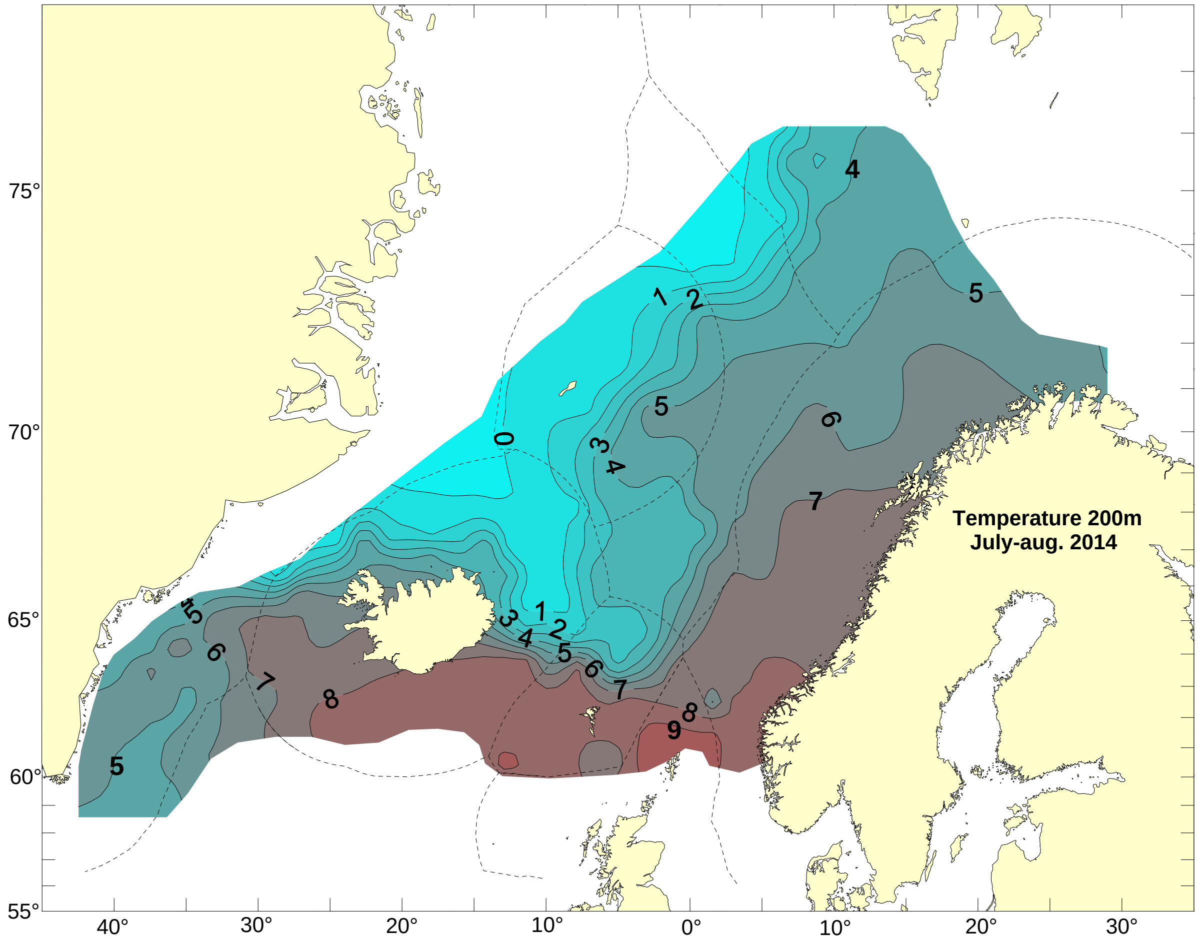


Figure 9. Temperature (°C) at 200 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

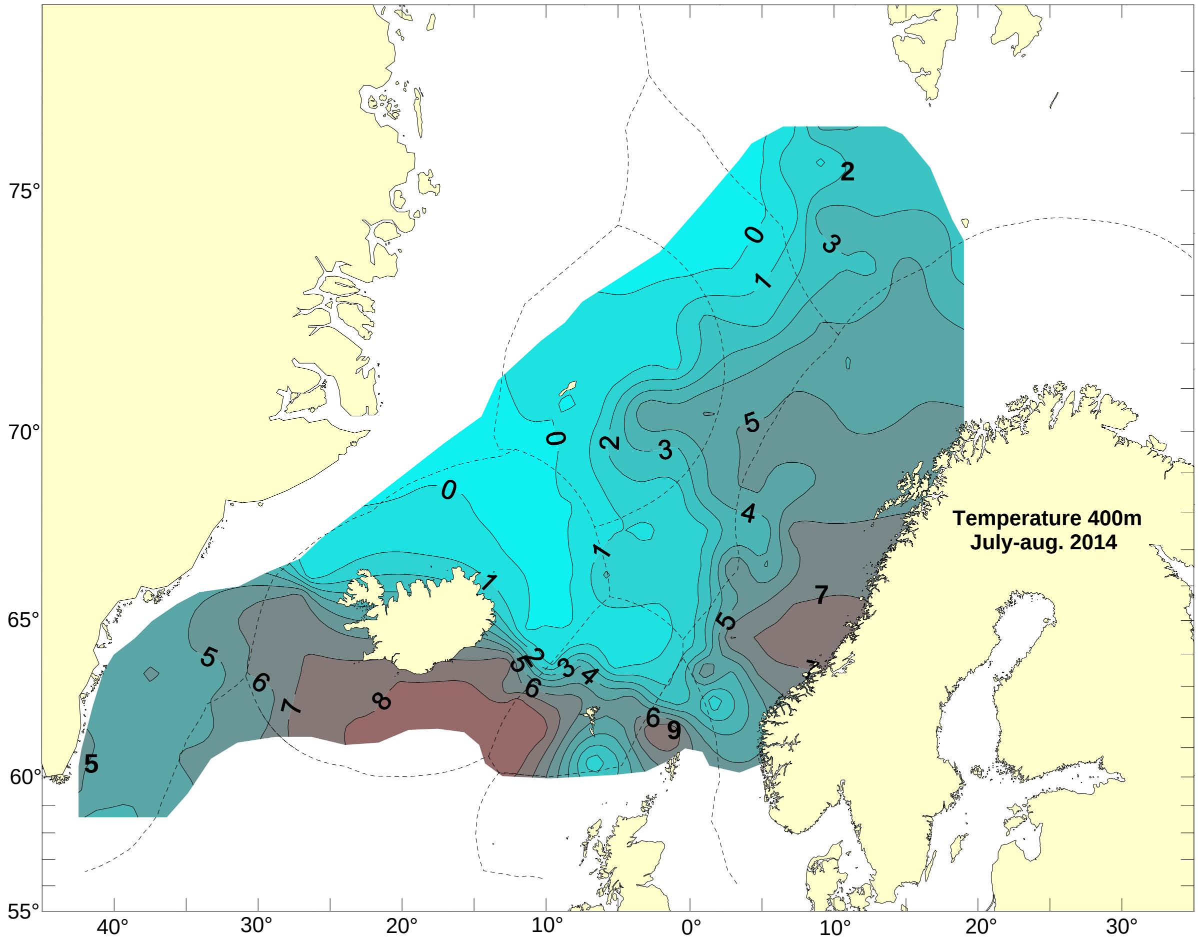


Figure 10. Temperature (°C) at 400 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

Zooplankton

The average plankton biomass in the Norwegian Sea (north of 61°N and between 14°W and 17°E) in July-August was at the same level in 2014 as in 2013 or 8.4 g/m² and 8.2 g/m² respectively (Table 7). This is a substantial increase from 2012 when the average biomass was 6 g/m². The plankton concentrations were high in the northeastern part of the Icelandic area and the northern part of the Faroese area, as in 2013 (Figure 11). However, in 2014 the concentrations in the central part of the Norwegian Sea were higher than in 2013, as well as in the northeastern part (Svalbard area) (Figure 11).

In 2014 the average zooplankton concentration the Icelandic area (between 14°W and 30°W) was only 4.8 g/m², or only half of the biomass observed in 2013 (Table 7).

This year additional and extensive area in East Greenland waters was surveyed. The area was first surveyed in a limited area east of Greenland in 2013 (between 62-66°N). In 2014 this survey was expanded to cover the area from 65°30′ N to 58°30′ N. The average plankton biomass in this area was 13.8 g/m² in 2013 and only 5.3 g/ m² in 2014. This is considerably lower than last year, but the area covered in 2014 was extending much farther south in East Greenland waters, and therefore cannot be compared directly. The level in East Greenland waters is at the same levels as in the Icelandic area. Overall, the impression is that the concentration in the western part of the surveyed area is lower than last year.

The zooplankton samples for species identification have not been examined in detail.

The increased biomass of zooplankton in the Norwegian Sea is in agreement with the increase that has been observed in the zooplankton biomass in the area in the May survey from 2010 to 2014 (ICES 2014a) after a decade with a decreasing trend in zooplankton biomass. These data need nevertheless to be treated with some care, due to various amounts of phytoplankton between years and areas in the samples influencing the total amount of zooplankton (g dry weight/m^2) which is relevant and valuable as available food for pelagic planktivorous fish.

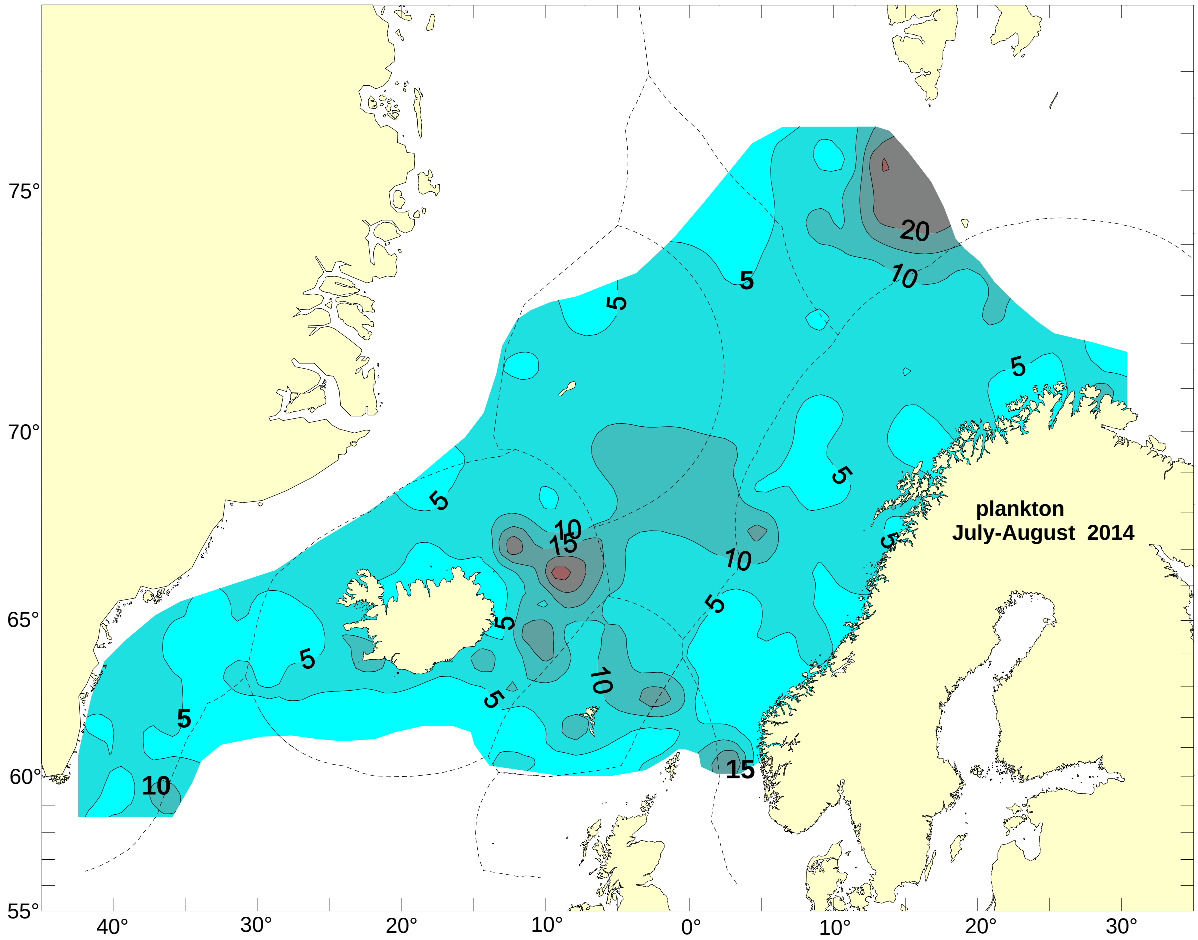


Figure 11. Zooplankton biomass (g dw/m², 0-200 m) in the Norwegian Sea and surrounding waters, 2nd of July -9th of August 2014.

Table 7. The time-series of zooplankton dry weight in IESSNS during 2010 to 2014 for Norwegian Sea (between 17°E and 14°W and north of 61°N), Icelandic waters (between 14°W and 30°W) and Greenlandic waters (west of 30°W). The number of samples is given in parentheses.

	Dry weight of zooplankton (mg/m²)		
Year	Norwegian Sea	Icelandic waters	Greenlandic waters
2010	4911 (167)	9276 (8)*	
2011	4622 (110)	7058 (61)	
2012	6033 (134)	5926 (55)	10086 (2)
2013	8360 (163)	9990 (49)	13787 (14)
2014	8242 (167)	4834 (47)	5308 (33)

*No plankton samples on the Icelandic vessel, only by Norwegian vessel north off Iceland.

Pelagic fish species

Mackerel

The total mackerel catches (kg) taken during the joint mackerel-ecosystem survey with the Multpelt 832 quantitative sampling trawl is presented in standardized rectangles in Figure 12. The map is showing different concentrations of mackerel from zero catch to more than 5000 kg.

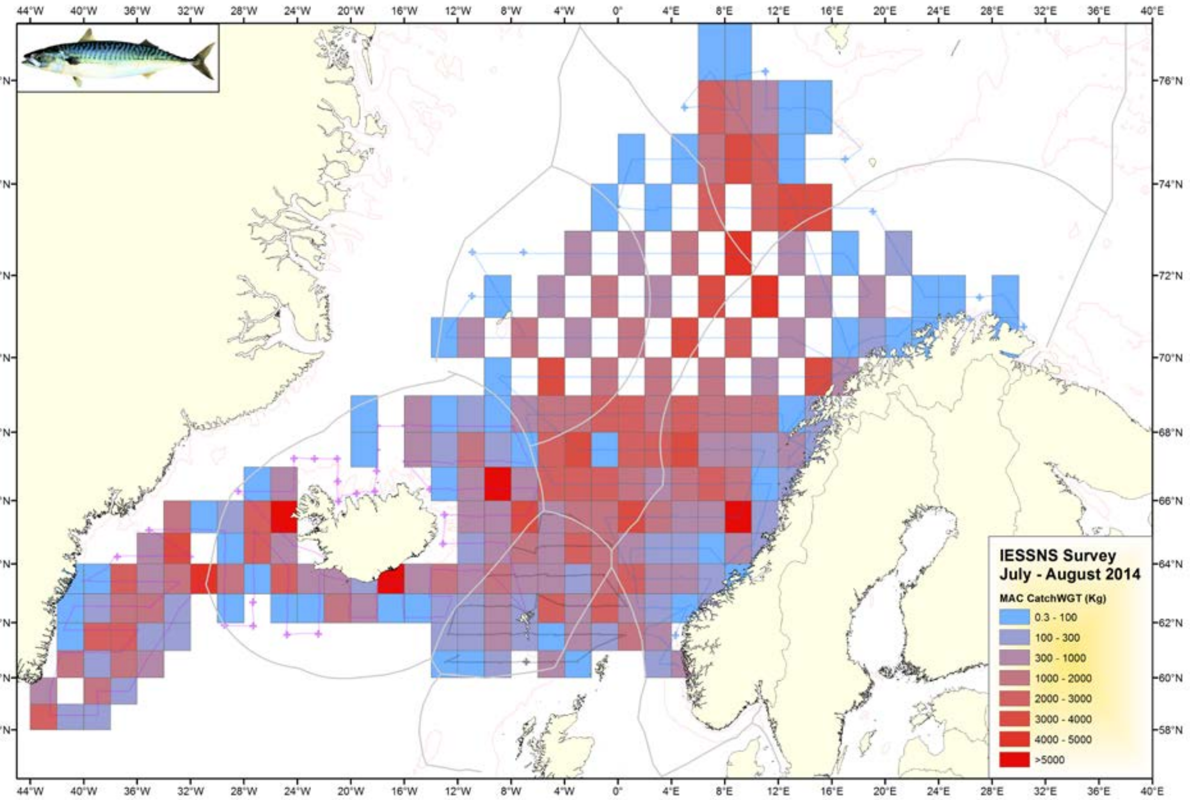


Figure 12. Catches of mackerel in kg represented in standardized rectangles. Light blue represents small catches (0.3-100 kg), while dark red represents catches of more than 5000 kg mackerel after 30 min standardized towing with the Multpelt 832 pelagic trawl. Vessel tracks are shown as continuous lines. Trawl stations are marked as small crosses for each vessel. Empty rectangles surrounded by three or more were interpolated in the calculations on biomass/abundance and density indices.

The length distribution of NEA mackerel during the joint ecosystem survey showed a pronounced length-dependent distribution pattern both with regard to latitude and longitude. The largest mackerel were found in the northernmost and westernmost part of the covered area in July-August 2014 (Figure 13).

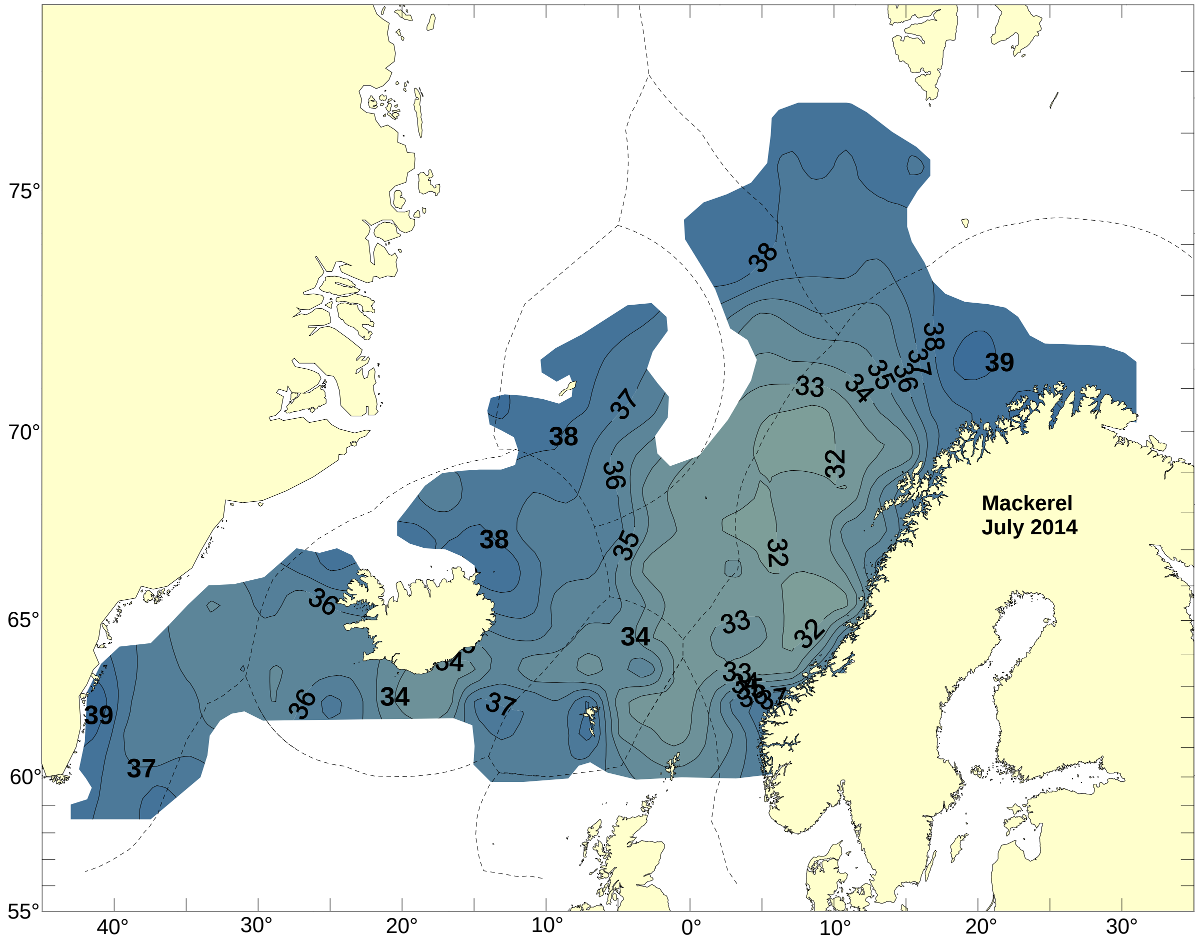


Figure 13. Average length distribution of NEA mackerel from the joint ecosystem survey with M/V "Brennholm", M/V "Vendla", M/V "Finnur Friði" and R/V "Arni Fridriksson" in the Norwegian Sea and surrounding waters between 2nd of July and 12th of August 2014.

Mackerel caught in the pelagic trawl hauls on the four vessels varied from 24 cm to 46 cm in length with the individuals between 30-33 cm and 35-38 cm dominating in the abundance. The mackerel weight (g) varied between 180 to 820 g (Figure 14). Very few juvenile mackerel were caught in 2014.

The spatial distribution and overlap between the major pelagic fish species from the joint ecosystem survey in the Nordic Seas according to the catches are shown in Figure 15.

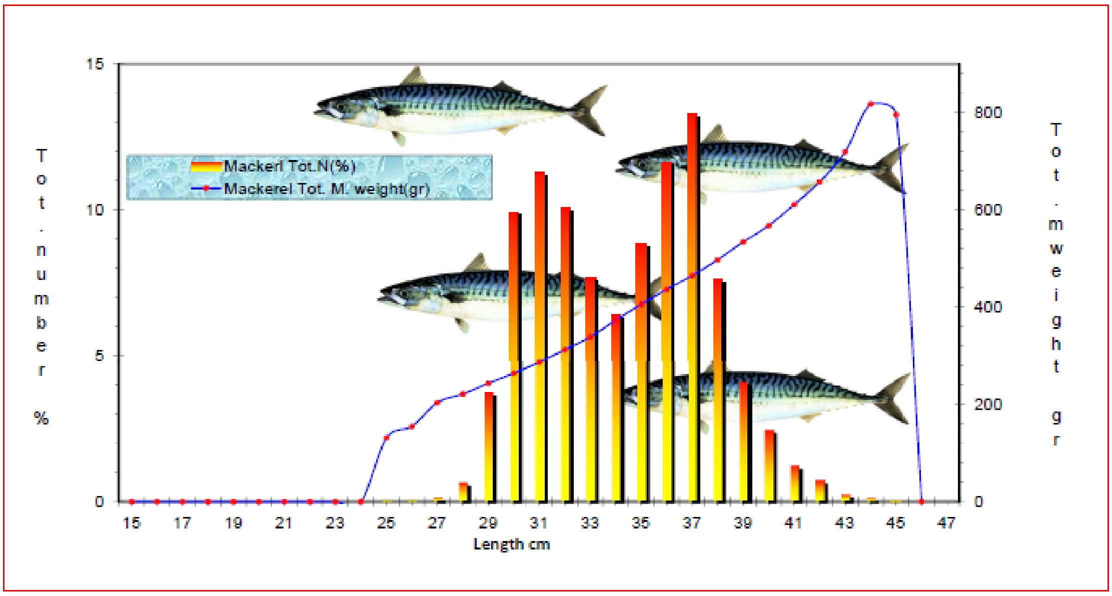


Figure 14. Length (cm) and weight (g) distribution in percent (%) for mackerel sampled in the trawl catches. Note that these values are not weighed with catch or area size and can therefore divide from the estimation of length distribution in the stock (not provided).

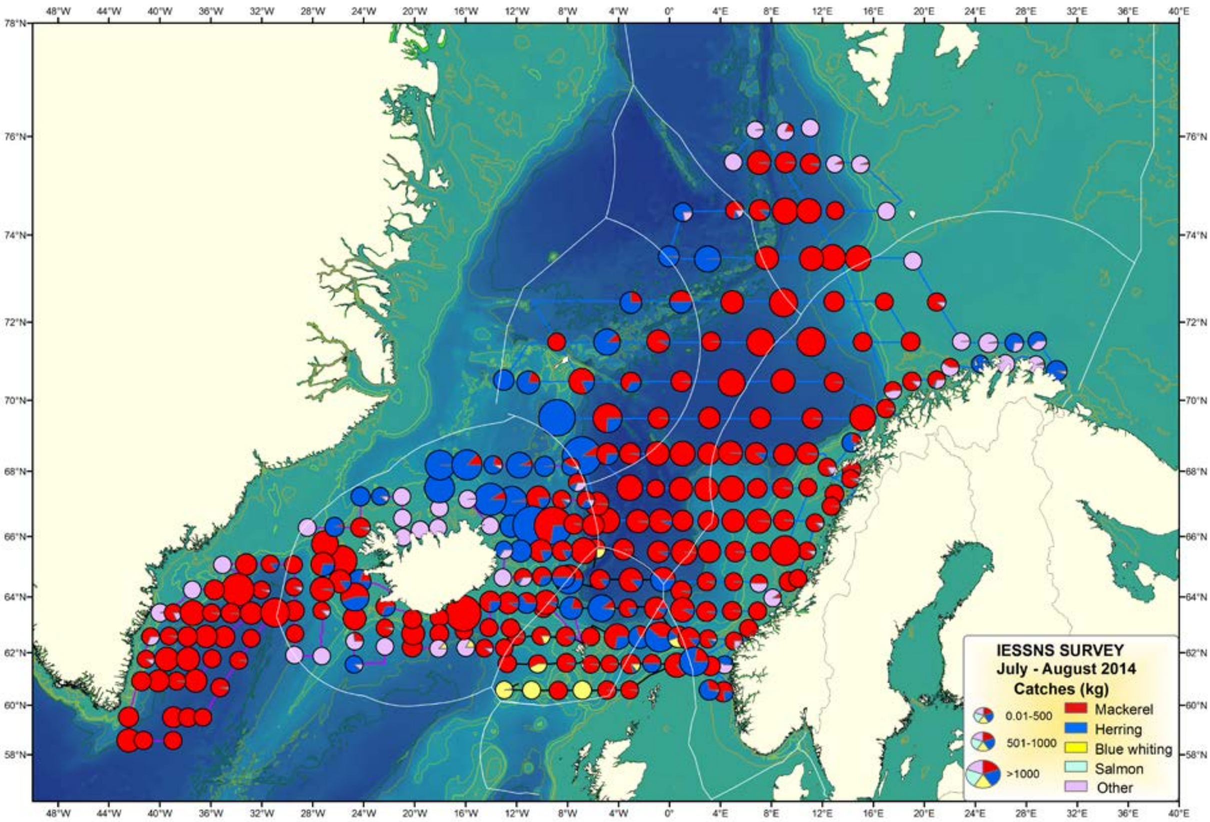


Figure 15. Distribution and spatial overlap between mackerel (red), herring (blue), blue whiting (yellow) and salmon (violet) from joint ecosystem surveys conducted onboard M/V "Brennholm" and M/V "Vendla" (Norway), M/V "Finnur Friði" (Faroe Islands) and R/V "Arni Fridriksson" (Iceland) in the Norwegian Sea and surrounding waters between 2nd of July and 12th of August 2014. Vessel tracks are shown as continuous lines.

Swept area analyses from standardized pelagic trawling with Multpelt 832

The swept area estimates of mackerel biomass in July-August 2014 were based on average catches of mackerel within rectangles of 1° latitude and 2° longitude and measurements of horizontal opening of the trawls (Table 5), which gave catch indices (kg/km^2; Fig. 16). An interpolation for rectangles not covered on the edges of area covered was only done for those that had adjacent rectangles with one or more tows on three or four sides. Total number of rectangles interpolated was 38 (Fig. 17). The interpolation was done by taking the average values of all adjacent rectangles. The swept area estimates for the different rectangles is shown in Fig. 17 and in a different graphical way in Fig. 18. The total biomass estimate came to 9.0 million tons, which was allocated to the different EEZs as in previous years (Annex 1). This estimate was based on the standard method using the average horizontal trawl opening by each participating vessel (around 65 m, see Table 5). A further assumption was that all mackerel inside the trawl opening are caught, i.e. no escape through the meshes.

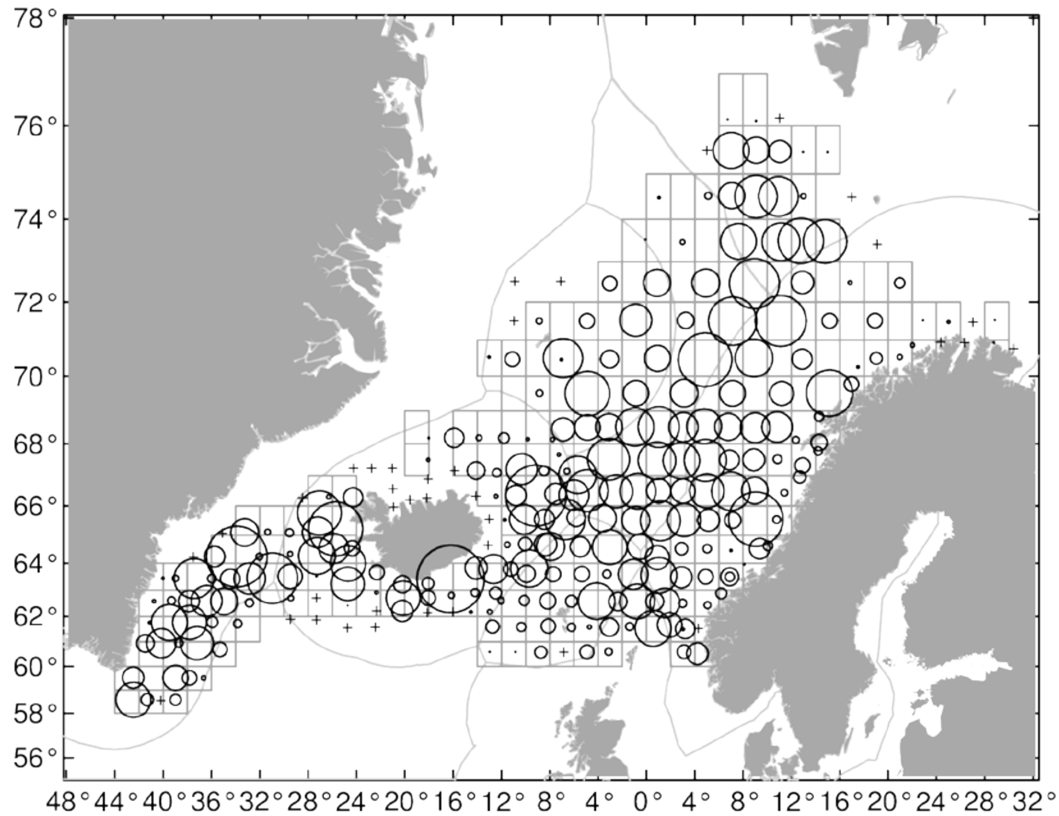


Figure 16. Stations and catches of mackerel in July/August 2014 where the circles size is proportional to square root of catch (kg/km^2) and stations with zero catches are denoted with +.

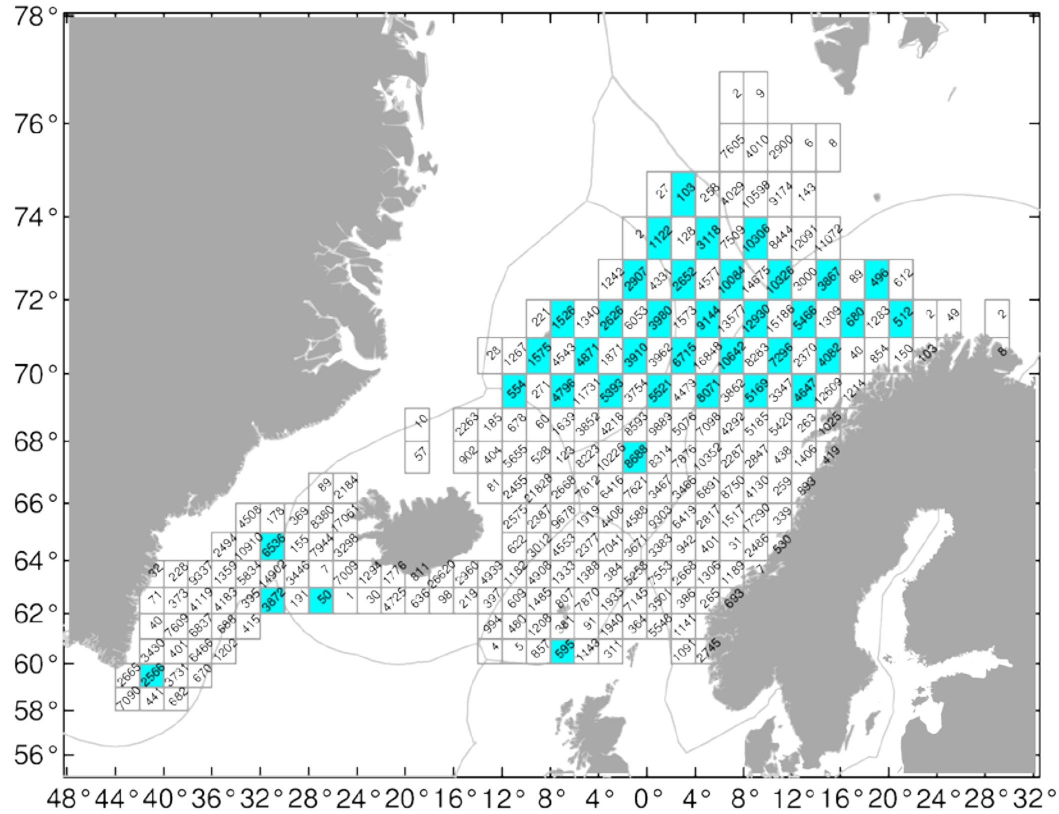


Figure 17. Standardized mackerel catch rates (kg/km²) in 1° lat. by 2° lon. rectangles from swept area estimates in July/August 2014 where interpolated rectangles are denoted with blue shading.

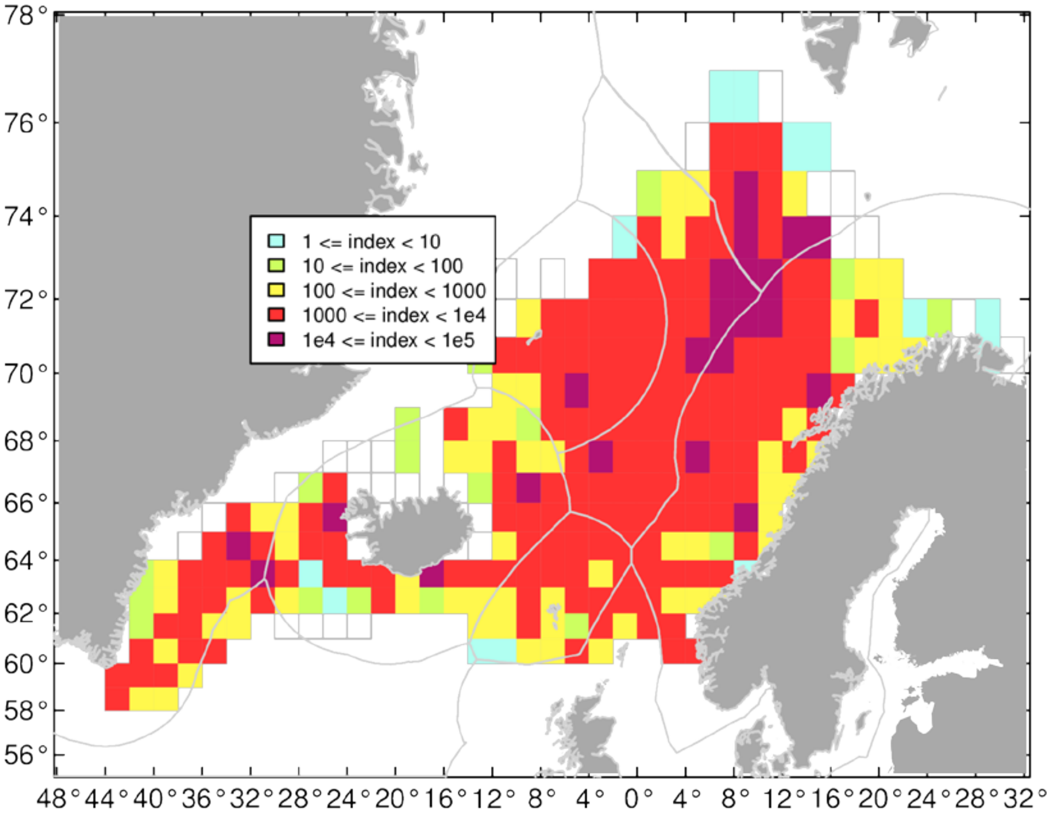


Figure 18. Standardized mackerel catch rates (kg/km²) for mackerel in the July/August 2014 survey represented graphically. Colouring of levels is the same as in the 2013 IESSNS survey report (Nøttestad et al. 2013).

Age-disaggregated indices from IESSNS obtained using the swept-area methodology were first estimated and introduced in the Benchmark assessment of the mackerel stock in 2014 (Nøttestad et al. 2014). The same methodology was used now and the series updated with the 2014 data to be used in the analytical assessment of the stock (Table 8). The 2014 results show that 2011-year class contributed with 32.0% in number followed by the 2010-year class with 21.1% (Fig. 19). The 2007, 2008 and 2009 year classes contributed then to around 11% each. Altogether 66.2% of the estimated number of mackerel was less than 6 years old. The consistency between years for the different age groups is shown in Fig. 20. A good consistency was observed for all age groups from age 1-10, except for age 5. That might be explained by that the 2009 year class (age 5) is a rather weak and has a similar low strength in abundance as the 2008 year class (age 6) providing low contrast in the consistency plot, compared to many of the surrounding very strong year classes (2005, 2006, 2010, 2011), and could be more difficult to track over time compared to the much stronger year classes within the mackerel stock.

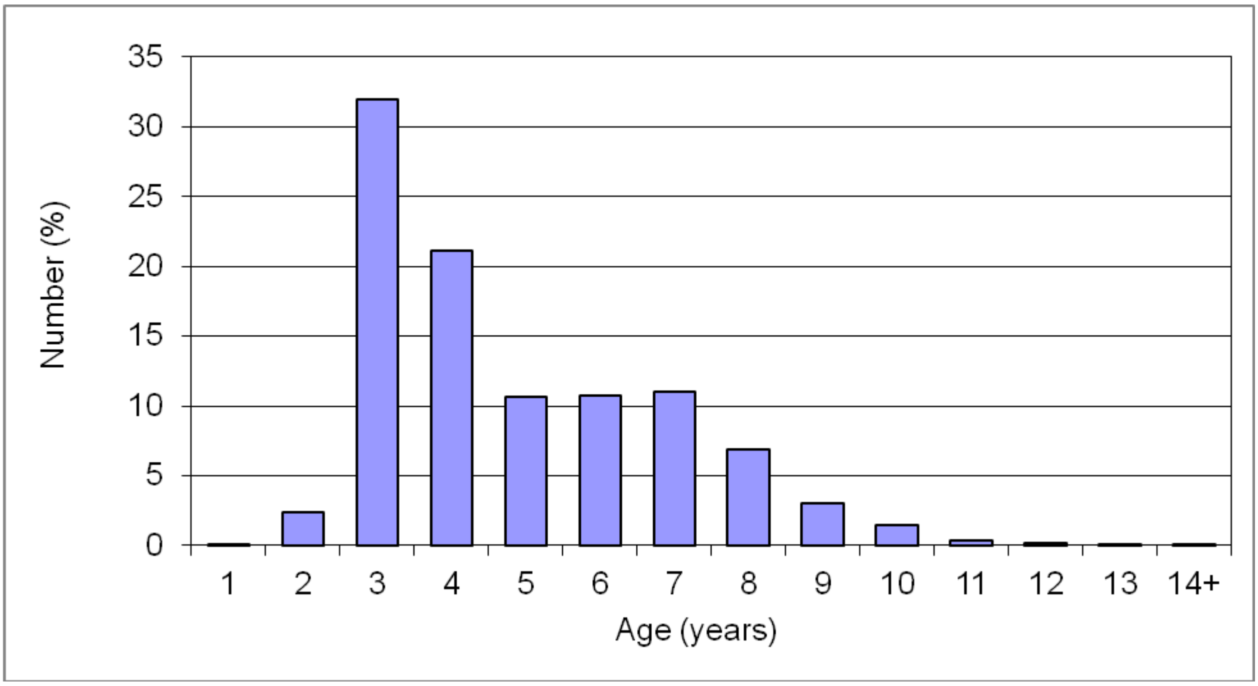


Figure 19. Age distribution in percent (%) of Atlantic mackerel scaled to the total catches, in the Norwegian Sea and surrounding waters from 2nd of July to 12th of August 2014.

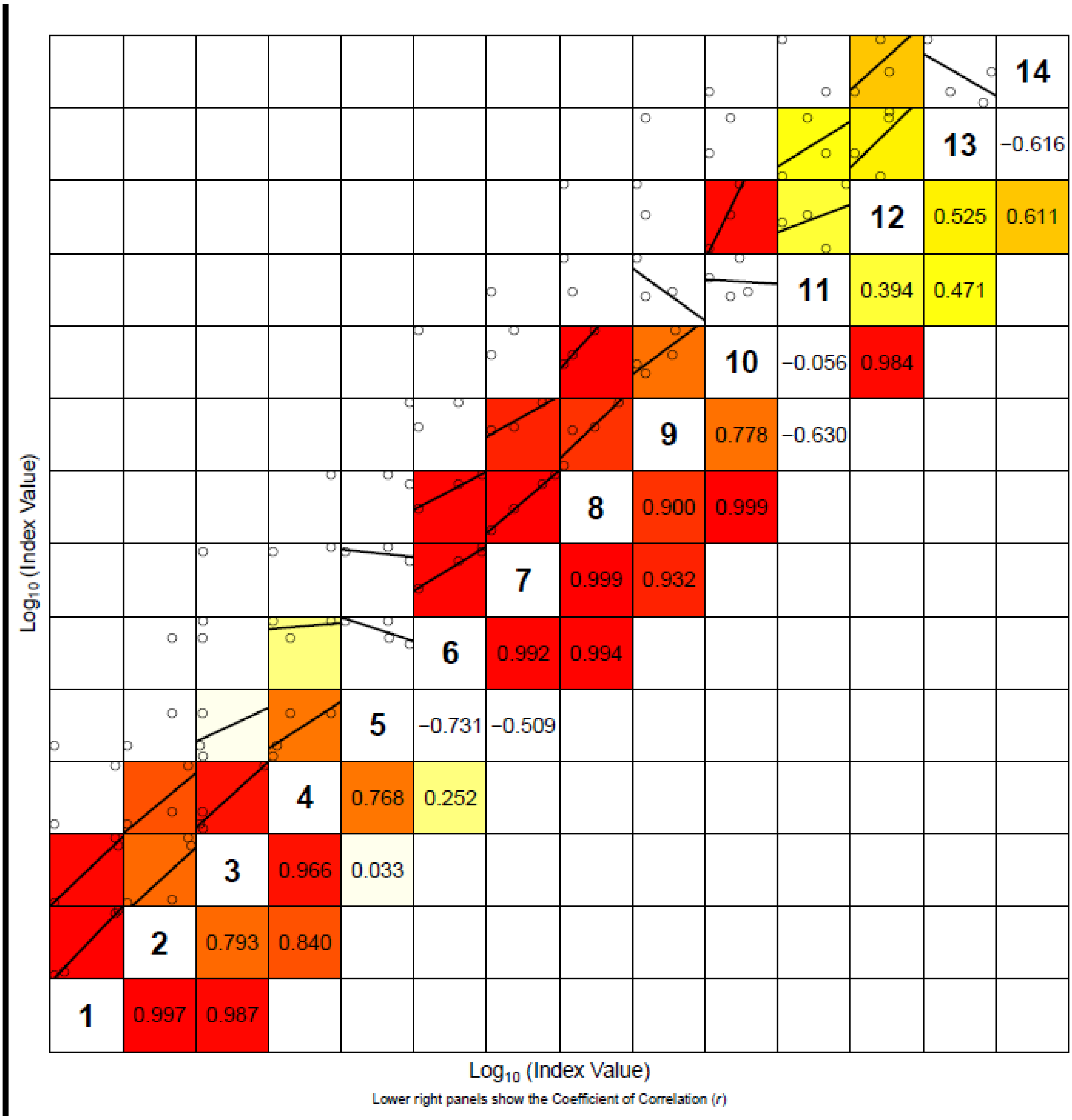


Figure 20a. Consistency plot of mackerel from the July/August 2014 survey (IESSNS).

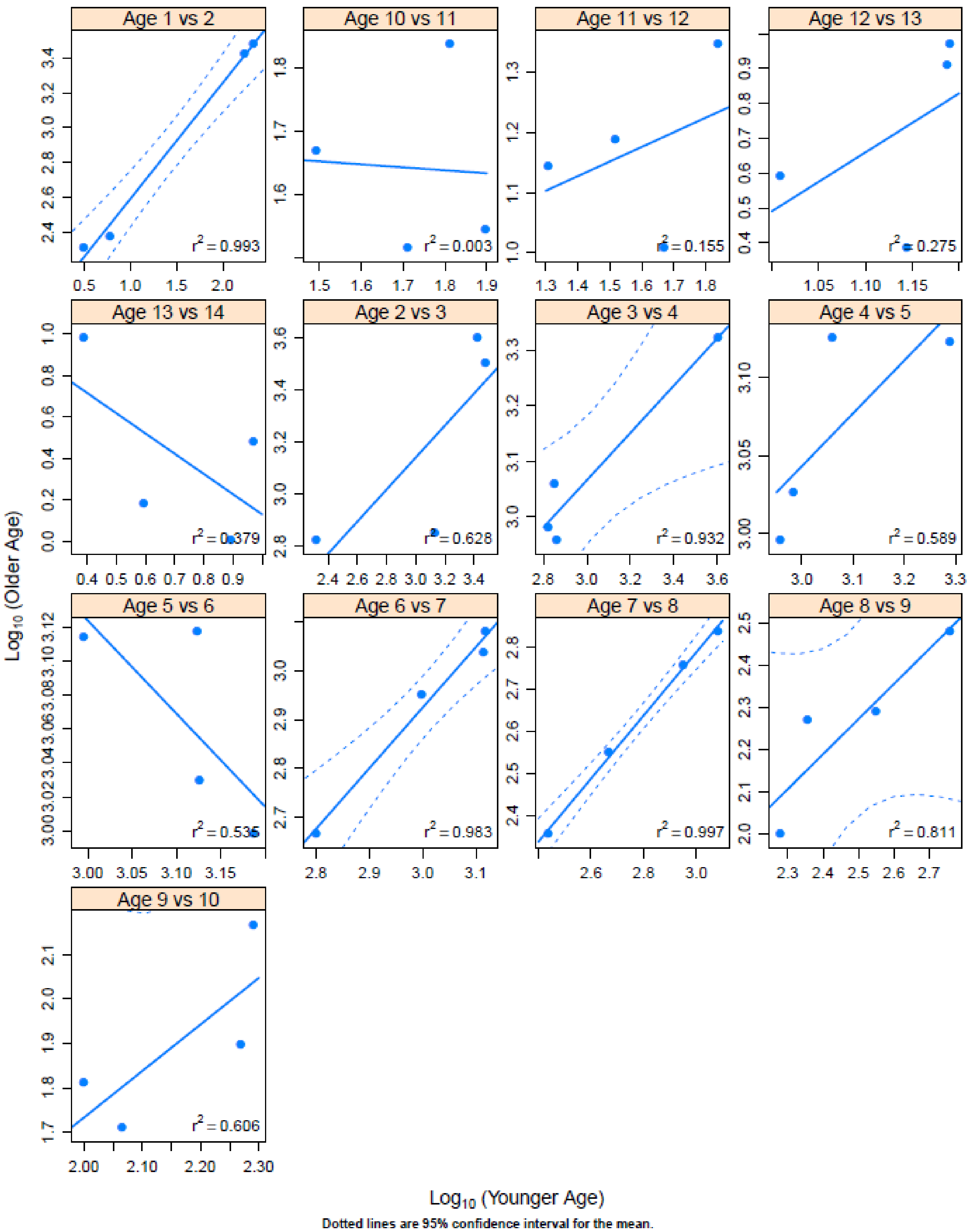


Figure 20b. Consistancy plot (Log_{10} transformed on the x- and y axis) for each year class 1-14+. The correlation is given as r^2 for each year class. Dotted lines are 95% confidence interval for the mean.

Table 8. Time series of the IESSNS showing (a) age-disaggregated abundance indices of mackerel, (b) survey area covered where each age class is observed, and (c) swept-area density index (km^{-2}), which is applied in the analytical assessment of mackerel (limited to age 6+).

(a) Number of individuals (billions)															Habitat range (mill. km^2)
Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14(+)	
2007	1.331	1.861	0.896	0.238	1.000	0.16	0.055	0.039	0.029	0.011	0.009	0.003	0.011	0.002	0.99
2010	0.019	2.768	1.485	3.954	3.123	1.277	0.555	0.385	0.236	0.063	0.041	0.031	0.016	0.005	1.75
2011	0.209	0.251	0.861	1.103	1.616	1.211	0.564	0.276	0.121	0.062	0.057	0.017	0.011	0.001	1.20
2012	0.497	4.991	1.223	2.111	1.822	2.415	1.642	0.652	0.342	0.119	0.067	0.019	0.006	0.006	1.50
2013	0.064	7.776	8.987	2.137	2.906	2.874	2.679	1.266	0.451	0.192	0.161	0.042	0.008	0.022	2.41
2014	0.008	0.579	7.795	5.138	2.605	2.624	2.673	1.686	0.739	0.360	0.086	0.054	0.020	0.004	2.45
(b) Area covered where an age class is observed (km2)															
2007	0.832	0.832	0.832	0.832	0.832	0.830	0.831	0.829	0.820	0.847	0.865	0.720	0.834	0.788	
2010	6.128	2.059	2.052	2.034	2.032	2.028	2.030	2.027	2.032	2.034	2.023	2.002	2.050	2.039	
2011	1.217	1.216	1.218	1.217	1.217	1.217	1.216	1.219	1.212	1.208	1.223	1.220	1.182	0.992	
2012	2.330	1.892	1.846	1.845	1.842	1.842	1.844	1.842	1.842	1.838	2.041	1.861	2.463	1.974	
2013	10.748	2.596	2.255	2.224	2.175	2.209	2.228	2.210	2.313	2.438	2.344	2.730	2.048	2.302	
2014	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	2.450	
(c) Density index (millions per km^2)															
2007	1.599	2.236	1.077	0.286	1.202	0.193	0.066	0.047	0.035	0.013	0.010	0.004	0.013	0.003	
2010	0.003	1.345	0.724	1.944	1.537	0.630	0.273	0.190	0.116	0.031	0.020	0.015	0.008	0.002	
2011	0.172	0.206	0.707	0.907	1.328	0.995	0.464	0.226	0.100	0.051	0.047	0.014	0.009	0.001	
2012	0.213	2.637	0.663	1.144	0.989	1.311	0.890	0.354	0.186	0.065	0.033	0.010	0.002	0.003	
2013	0.006	2.995	3.985	0.961	1.336	1.301	1.202	0.573	0.195	0.079	0.069	0.015	0.004	0.010	
2014	0.003	0.236	3.182	2.097	1.063	1.071	1.091	0.688	0.302	0.147	0.035	0.022	0.008	0.002	

Underwater camera observations

Video recordings have not been quantitatively analysed. However, all recordings have been qualitatively evaluated with regards to research questions stated for employment of camera at each trawl location (Table 9). Quantitative analysis is here defined as viewing of video tape at recorded speed (no stopping and zooming in on details, etc), and writing down comments on fish abundance, swimming direction and escapement. The results of qualitative analysis are that the fish lock is successful in preventing mackerel from escaping the cod end when the towing ends and trawl speed declines to values below 5 knots. Trawl mesh sizes from 8 cm to 16 m were observed. The only location reporting escapement of fish was at the 4 m mesh, herring was confirmed escaping but the video recordings need more detailed analysis before escapement of mackerel can be confirmed.

Table 9. Location of video camera in trawl, number of stations camera was employed and type of video tape analyses completed to date for each vessel. All vessels used a GoPro camera and Árni Friðriksson also used high definition Sony camera. All analyses are qualitative not quantitative.

Vessel	Location of camera	Number of stations	Qualitative results
Finnur Fríði	Junction of 9cm/18cm meshes: facing codend	3	Mackerel swam in direction of towing and no escapement observed. Herring falling back towards cod-end, hence, not swimming with trawl.
	Fish lock: facing codend	5	Negligible amount of mackerel observed escaping but large numbers observed trapped in cod-end by the fish lock at the end of effective tow time.
	Headline	2	Turbulence, no fish observed.
Brennholm	8 m meshes: facing trawl opening	29	No escapement of mackerel observed.
Vendla	8 m meshes: facing trawl opening	27	No escapement of mackerel observed.
Árni Friðriksson	Fish lock: facing codend or trawl opening	5	No escapement of mackerel observed.
	16 m mesh	3	Lots of turbulence.
	4 m mesh	2	Lots of escaping fish observed, herring confirmed escaping but no mackerel confirmed escaping, needs further analysis.
	2 m mesh	4	Fish observed swimming in direction of trawling, and possible escapement of fish observed in 1 of 4 stations.
	40 cm mesh	1	Few fish seen.
	20 cm mesh	1	Mackerel swam direction of trawl, avoided panels and no escaping observed.
	8 cm mesh (mounted outside trawl)	1	No fish observed.
	Headline	1	No fish observed.
	Footrope	1	No fish observed.

Multibeam sonar recordings

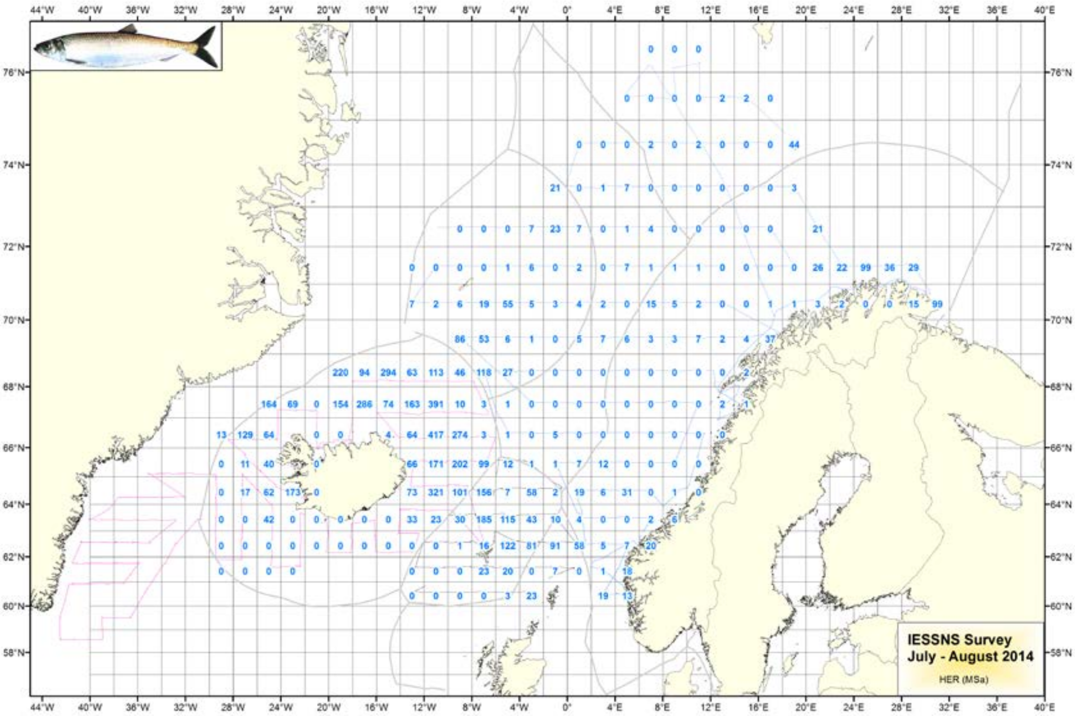
The mackerel schools detected were of small size, predominantly with low density and appeared in the upper 20-30 m of the water column throughout the day, on Simrad SH80 and Simrad SX90 operated within large geographical areas. Only small and loose mackerel schools were recorded on the multibeam sonars at all onboard M/V "Brennholm" and M/V "Vendla". Further quantitative sonar analyses on NEA mackerel will be done in the months ahead. Even if we maximized the ping rate on both the multibeam sonars and multi-frequency echosounders, the mackerel were practically invisible for the multibeam sonars. The main reason is probably due to very loose aggregations/shoals close to the surface thereby providing extremely low detection probability on any acoustic instrumentation including multi-frequency echosounder and high and low frequency multibeam sonars. We could sometimes detect nothing or very little on the sonars but still got medium to high catches of mackerel during surface trawling with the Multpelt 832 pelagic sampling trawl, also suggesting very dispersed mackerel concentrations.

Norwegian spring-spawning herring

Norwegian spring-spawning herring (NSS) was recorded in the eastern part of the area surveyed. The western boundary of its distribution was at 14°W south of Iceland and 20°W north of Iceland. The herring observed west of these boundaries belonged to the Icelandic summer-spawning herring according to trawl samples. The acoustic values indicated that NSS herring had the highest density in the western periphery of its distribution, or north of the Faroes and east and north of Iceland (Figure 21). The concentrations were low in the northern and eastern areas, and herring was relatively absent from the mid Norwegian Sea. The periphery of the distribution of NSS herring towards north were probably not reached between 20°W and 8°E, as in the years 2012 and 2013 (Figure 21 and 15).

The biomass estimate of NSS herring came to 4.6 million tons in July-August 2014 based on the acoustic recordings using the primary frequency of 38 kHz and the biological measurements of herring caught in the trawl tows. Herring was in the surface waters in most area feeding and possibly above the transducer (acoustic dead zone) and therefore not fully represented in the acoustic measurements.

(a)



(b)

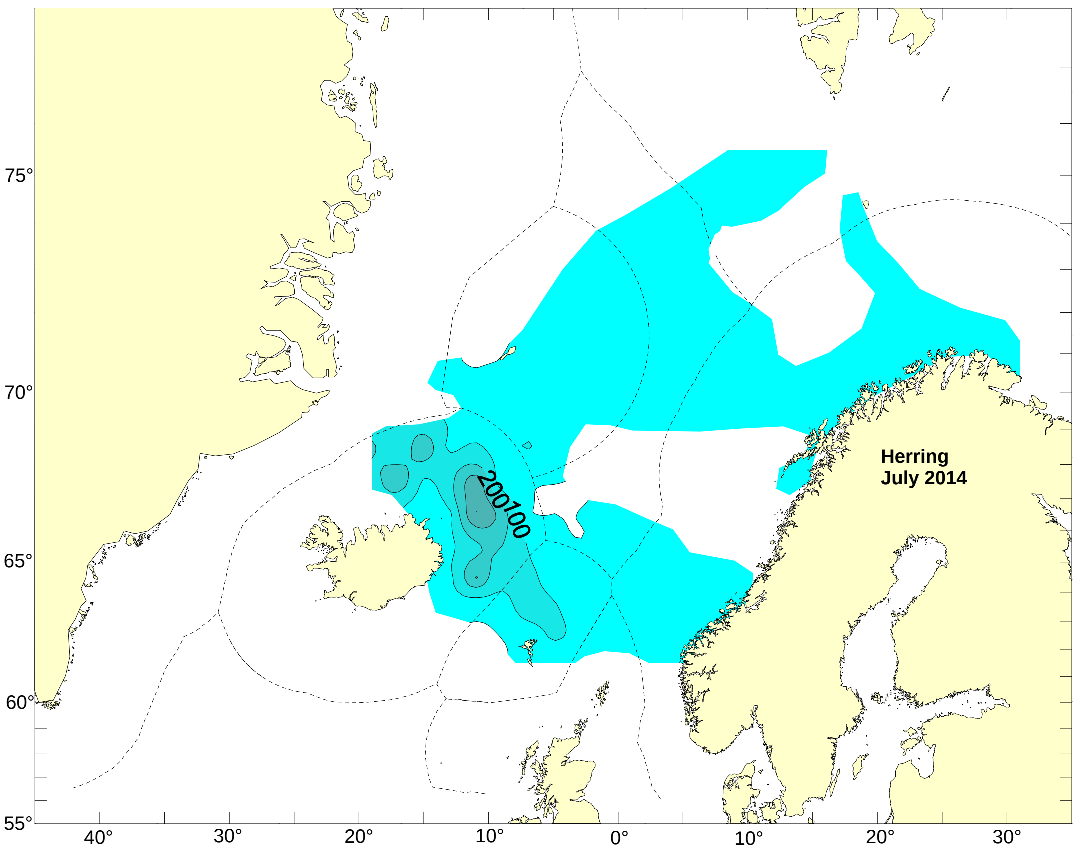


Figure 21. The sA/Nautical Area Scattering Coefficient (NASC) values of herring along the cruise track, 2nd of July to 12th of August 2014 (a) within a rectangles and (b) shown on a contour plot.

Norwegian spring-spawning herring had a length distribution from 18-39 cm with a peak at 35 cm and weighed mean length of 33.4 cm. The weighed mean weight was 329.6 g

The age distribution in NSS herring shows dominance of the 2004 year class with about 22% in numbers of the acoustic estimate, followed by the 2005 year class (16%) (Figure 22).

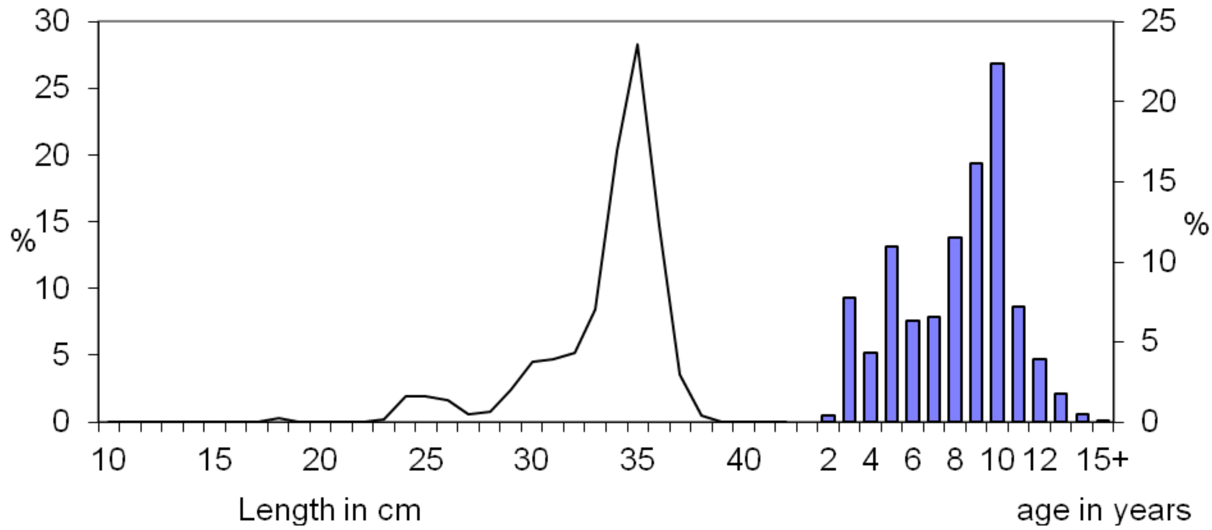


Figure 22. Age and length distribution of Norwegian spring-spawning herring from 2nd to July 11th August 2014.

The length distribution measured on herring showed overall a pronounced length dependent migration pattern, with the largest individuals (>35 cm) swam furthest west and northwest (Figure 23). The large herring observed on the west side of Iceland were Icelandic summer-spawners and the large herring in the Lofoten area were Norwegian autumn-spawners, which are, different from the Icelandic summer-spawners assessed with NSS herring.

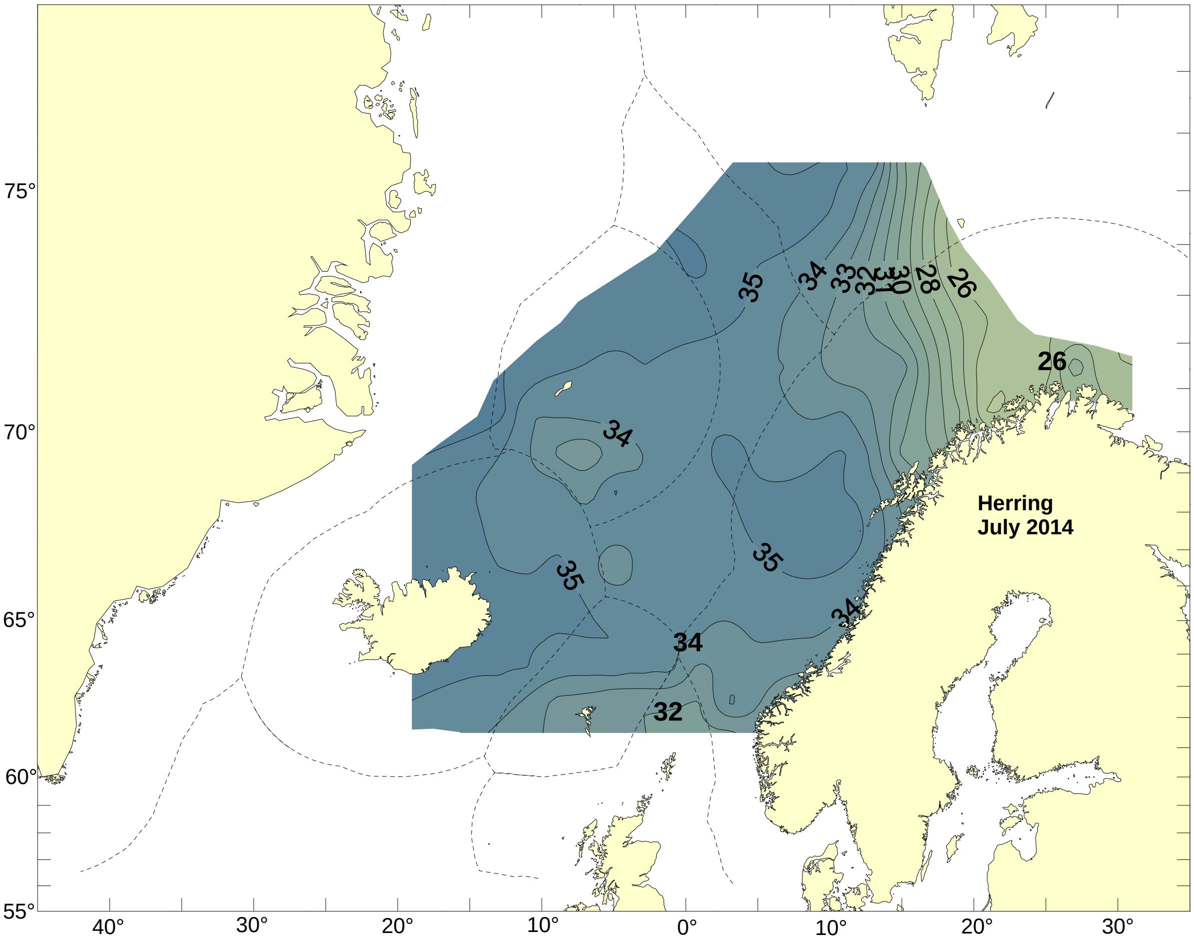


Figure 23. Length distribution of Norwegian spring-spawning herring during the coordinated ecosystem survey 2nd of July to 12th of August 2014.

Blue whiting

No results are presented for blue whiting in 2014 because no dedicated deep trawl hauls were taken on acoustic registrations of blue whiting. See an explanation in the Introduction chapter.

Lumpfish (*Cyclopterus lumpus*)

Lumpfish was caught in 69 % of trawl stations (Fig. 24). Of stations with mackerel present, 60 % of stations had catches < 10 kg. The other 40s% of stations had catches from 25 kg to 95 kg. There was a north-south pattern in lumpfish occurrence. Lumpfish was present at majority of stations north of 65°N, whereas lumpfish was scarce south of 65°N, excluding Greenland waters. Of note, total trawl catch at each trawl station were processed on board Árni Friðriksson, Brennholm and Vendla whereas a subsample of 100 kg to 300 kg was processed on Finnur Fríði. Therefore, small catches (< 10 kg) of lumpfish might be missing from the survey track of Finnur Fríði (black crosses). However, it is unlikely that larger catches of lumpfish would have gone unnoticed by crew during sub-sampling of catch on Finnur Fríði.

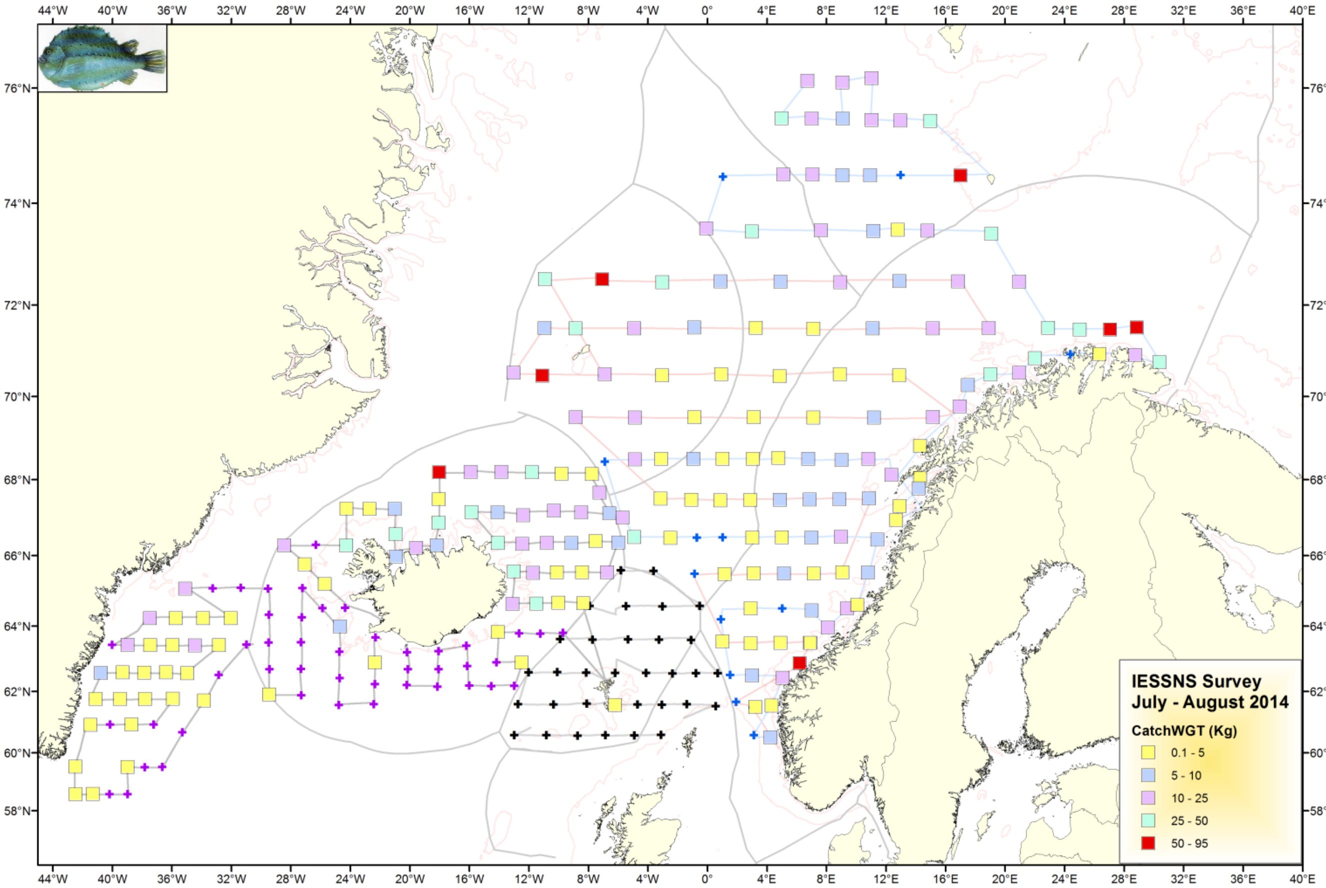


Figure 24. Lumpfish catches at surface trawl stations during the IESSNS survey in July and August 2014.

Marine Mammal Observations

Totally 227 marine mammals and 8 different species were observed onboard M/V "Brennholm" and M/V "Vendla" from 2nd to 28th of July 2014. Altogether 13 groups of killer whales with average group size of 6.6 individuals (N=86, stdev = 8.9) were found in the central and northern part of the Norwegian Sea in close association with small widely distributed shoals of NEA mackerel. A total number of 7 sightings of 9 minke whales were observed east just south of Jan Mayen, in outer part of Vestfjorden and in the central and northern part of the Norwegian Sea. Altogether 10 sightings of 15 fin whales where found concentrated in the northeastern part of the Norwegian Sea and along the coast of Finnmark, just south of Jan Mayen and between Bear Island and Svalbard. Altogether 12 groups of white beaked dolphins with average group size of 7.9 individuals (stdev = 5.2) appeared together with the fin whale observations and in several groups south of Bear Island. Only 2 sightings of 3 humpback whales were mainly found in the northern part of the Norwegian Sea. Very few marine mammals were sighted in the southern part of the covered area including the northern part of the North Sea, and central Norwegian Sea south of 67°N (Figure 25).

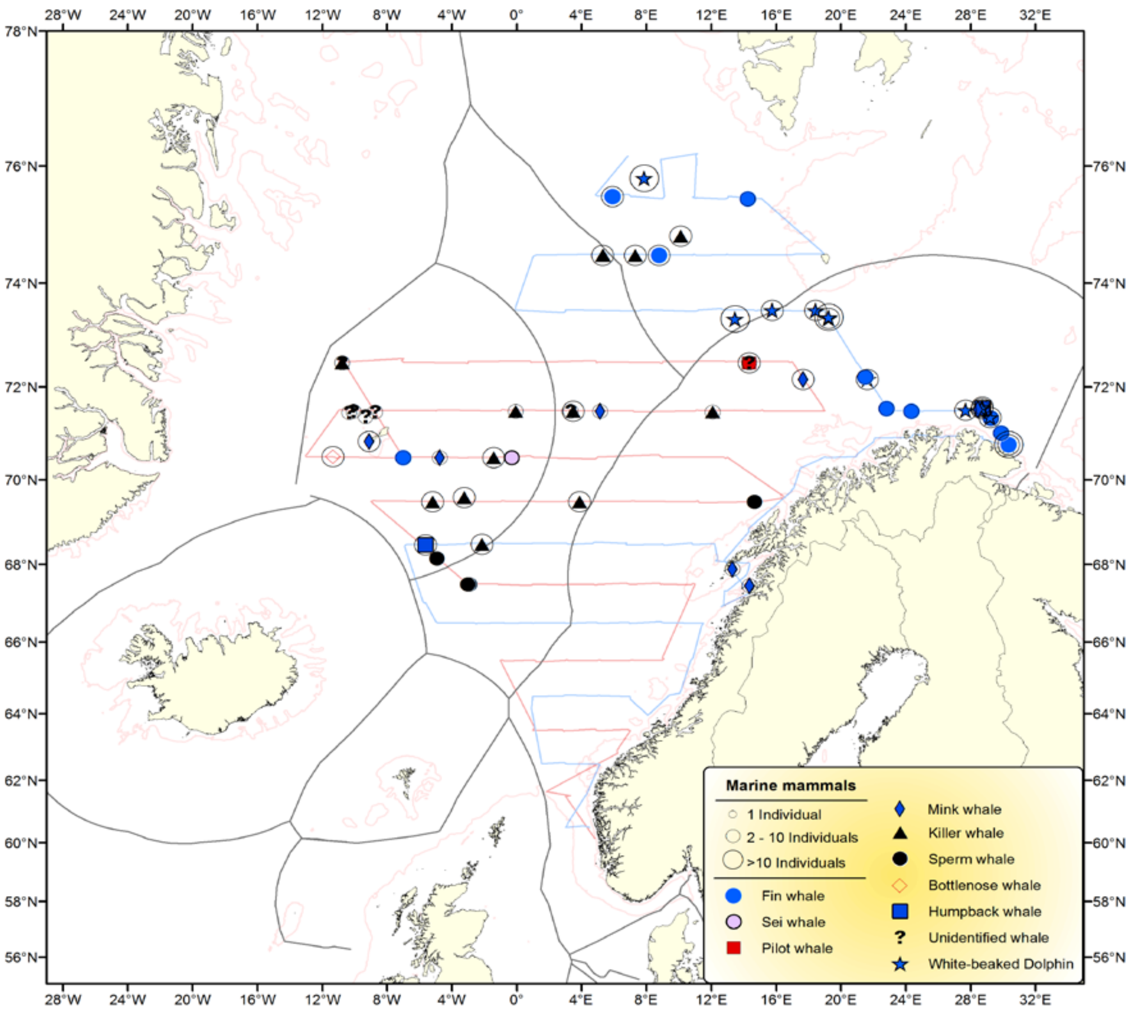


Figure 25. Overview of all marine mammals sighted onboard M/V "Brennholm" and M/V "Vendla" in the Norwegian Sea and surrounding waters from 2nd to 28th of July 2014. No marine mammal sightings were done onboard the Icelandic and Faroese vessels.

Discussion

The international coordinated ecosystem survey in the Norwegian Sea and adjacent areas (IESSNS) was performed during 2 July to 12 August 2014 by four vessels from Norway (2), Iceland (1) and Faroese (1), beside that the Icelandic vessel was rented by Greenland to cover Greenlandic waters. In this year the survey coverage was extended further into Greenlandic waters than in previous years. Furthermore, the area south of 60°N in the eastern part was not covered, including the northern part of North Sea, as in 2013. Otherwise the survey is comparable to previous years and the same protocol was followed (ICES 2014b). A major part of the survey is a standardised surface trawling at predefined locations, which has been used for a swept area abundance estimation of NEA mackerel since 2007, although not in all years. The method is analogous to the various bottom trawl surveys run for many demersal stocks.

The total swept area estimate of mackerel in summer 2014 was 9.0 million tonnes based on a coverage of more than 2.45 million square kilometres in the Nordic Seas from about 58 degrees up to 76 degrees north and from the Norwegian coast in east and west to the Greenlandic continental shelf. This represents average density of 3.66 tonnes/km^2 which is almost identical to last year's estimate of 3.65 tonnes/km^2. Mackerel was distributed over most of the surveyed area, and the zero boundaries for mackerel were not reached towards south and east in the Greenland waters, west of the southernmost tip of Greenland (Cape Farwell) and towards south in the southeastern part of the survey area.

The 2011-year class contributed with 32.0% in number followed by the 2010-year class with 21.1%. The 2007, 2008 and 2009 year classes contributed then to around 11% each. Altogether 66.2% of the estimated number of mackerel was less than 6 years old. The overlap between mackerel and NSS herring was highest in the south-western part of the Norwegian Sea (Faroe and east Icelandic area) according to the catch compositions in the survey (Figure 15), which is similar to 2013 and 2012. However, the overlap is less pronounced now than in the previous two years. In the areas where herring and mackerel overlap an inter-specific competition for food between the species can be expected. According to Langøy *et al*. (2012), Debes *et al*. (2012), and Oskarsson *et al*. (2012) the herring may suffer in this competition, the mackerel had higher stomach fullness index than herring and the herring stomach composition is different from previous periods. Langøy et al (2012) and Debes et al. (2012) also found that mackerel target more prey species compared to herring and mackerel may thus be a stronger competitor and more robust in periods with low zooplankton abundances.

The biomass index of Norwegian spring-spawning herring of 4.6 million tonnes is only 53% of the biomass index in July/August 2013 (8.6 million tonnes). There are two likely explanations for the drop in the biomass index in 2014. First, the survey did probably not cover the whole distribution area of the stock, especially north of Iceland between 20°W and 8°E, as in 2012 and 2013 (Figure 21 and 15). Secondly, there is a strong indication that herring were in the acoustic dead-zone above the transducer or in the surface 10-15m. An example is the Jan Mayen area where the trawl catches at surface was high (Figure 15) but the acoustic registrations were low (Figure 21).

The surface temperatures in the Nordic Seas in July-August 2014 were generally higher in all areas compared to July-August 2013. The SST anomaly map showed considerably higher average surface temperatures in July 2014 or 1-3°C higher compared to the average temperature in July during the last 20 years. This is thought to be due to the unusual calm weather conditions during this summer.

The concentrations of zooplankton was at the same level in 2014 as in 2013 (8.6 g dry weight/m^2 in July-August 2013 to 8.3 g/m^2 in July-August 2014) after more than a decade of decreasing trend in plankton concentrations.

During the 2014 survey, light intensity was measured to meet a request from the mackerel benchmark (ICES 2014c). The request was to use solar elevation angle as measure of daytime instead of a simple two state parameter as used at the benchmark, to test possible diel effects on catch rates of mackerel. A further request was to compare weather conditions (wind and wave height) in relation catch rates.

Environmental data were collected on all vessels during the 2014 IESSNS and results will be reported to the next mackerel benchmark.

Whale observations were done by the two Norwegian vessels during the survey. The number of marine mammal sightings was generally very low in the central and eastern part of the Norwegian Sea but with considerable higher numbers of especially fin whales in the northern Norwegian Sea and into the Barents Sea. Groups of killer whales were mostly observed in central Norwegian Sea, whereas fin and humpback whales where mainly observed near Jan Mayen, Bear Island and the southwestern part of the Barents Sea and off the coast of Finnmark.

The swept-area estimate was as in previous years based on the standard method using the average horizontal trawl opening by each participating vessel (around 65 m), assuming that all mackerel inside the trawl opening are caught, i.e. no escape through the meshes. Further, that no mackerel is distributed below the trawl. Uncertainties in such a method include e.g. possible escape of fish through the meshes leading to an underestimation of the estimate. If, on the other hand, mackerel is herded into the trawl paths by the trawl doors and bridles, the method overestimates the abundance.

The internal consistency plot for age-disaggregated year classes has improved since 2013 especially for younger year classes. There is now good internal consistency for year classes 1-10 years old, except for age 5. The reason for the low consistency around age 5 is unknown. However, the 2009 year class (age 5) is a rather weak year class and has a similar low strength in abundance as the 2008 year class (age 6) providing low contrast in the consistency plot, compared to many of the surrounding very strong year classes (2005, 2006, 2010, 2011), and could be more difficult to track over time compared to the much stronger year classes within the mackerel stock.

The improved consistency in younger year classes for NEA mackerel in the IESSNS survey should be taken into consideration by ICES WGWIDE, specifically by including also younger mackerel 1-5 years of age, and not only age 6+ mackerel, into the tuning series as input on abundance of NEA mackerel to the assessment.

Since altogether 66.2% of the estimated number of mackerel was less than 6 years old and the internal consistency plot for younger year classes has greatly improved in 2014, the value of the assessment would improve considerably by including these consistent and valid density indices for all year classes 1-14+ years old as input data series to the assessment.

Recommendations

General recommendations

Recommendation	To whom
Increase the survey effort in Greenlandic and international waters in the western part of the survey area to cover the NEA mackerel stock completely during the summer feeding.	Greenland
Develop a method that can sample the mackerel representatively in the North West European shelf Seas south of 58.5N, where mackerel tend to dive under surface trawls to cover the NEA mackerel stock completely during the summer feeding.	EU
The age disaggregated indices from IESSNS are considered to give a valid signal about year class sizes from age 1-10 as indicated by the consistency plots (Fig. 20). Therefore it is recommended that WGWIDE consider extending the tuning data from the survey to include younger age groups in the future analytical assessment of the mackerel stock.	WGWIDE
We recommend that observers collect sighting information of marine mammals and birds on all vessels.	Norway, Faroe Island, Iceland, Greenland

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Annex 1

Swept area biomass estimates in the different exclusive economical zones (EEZs)

Allocation of the total swept area estimate of mackerel biomass to exclusive economic zones (EEZs) given in Table A1 was done in R with a selection of spatial packages (see 'Task View: Spatial' on http://cran.r-project.org). These included notably 'rgeos' for polygon clipping, and package 'geo' (http://r-forge.r-project.org), i.e. for rectangle manipulation and graphical presentation (R Development Core Team 2014, Bivand and Rundel 2014, Björnsson et al. 2014). EEZs in the Northeast Atlantic were taken from shape files available on http://marineregions.org (low resolution version, downloaded in late 2012 as: World_EEZ_v7_20121120_LR.zip). Figure A1 shows the steps taken in establishing the framework. The shapefiles did not include the outlines of the EEZ of Svalbard, these were taken from a text file used in NEAFC work (pers. comm. Þorsteinn Sigurðarson, MRI, Iceland). A slight discrepancy between the two is shown in Figure A2, but it was left for later to correct this and get authoritative EEZ boundaries according to international agreements.

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Table A1. Swept area estimates of NEA mackerel biomass in the different Exclusive Economic Zones (EEZs) according to the international coordinated ecosystem (IESSNS) survey in July-August 2014. Area calculated from rectangles where mackerel was present. Note that area calculations in the 2013 were incorrect (included covered rectangles without mackerel).

Exclusive economic zone / international area	Area (in thous. km^2)	Biomass (in thous. tonnes)	Biomass (%)
EU	78	226	2.5
Norwegian	640	2267	25.2
Icelandic	478	1593	17.7
Faroese	268	549	6.1
Jan Mayen	222	732	8.2
International north	275	1759	19.6
International west	52	83	0.9
Greenland	335	1164	13.0
Spitzbergen	105	611	6.8
Total	2453	8984	100.0

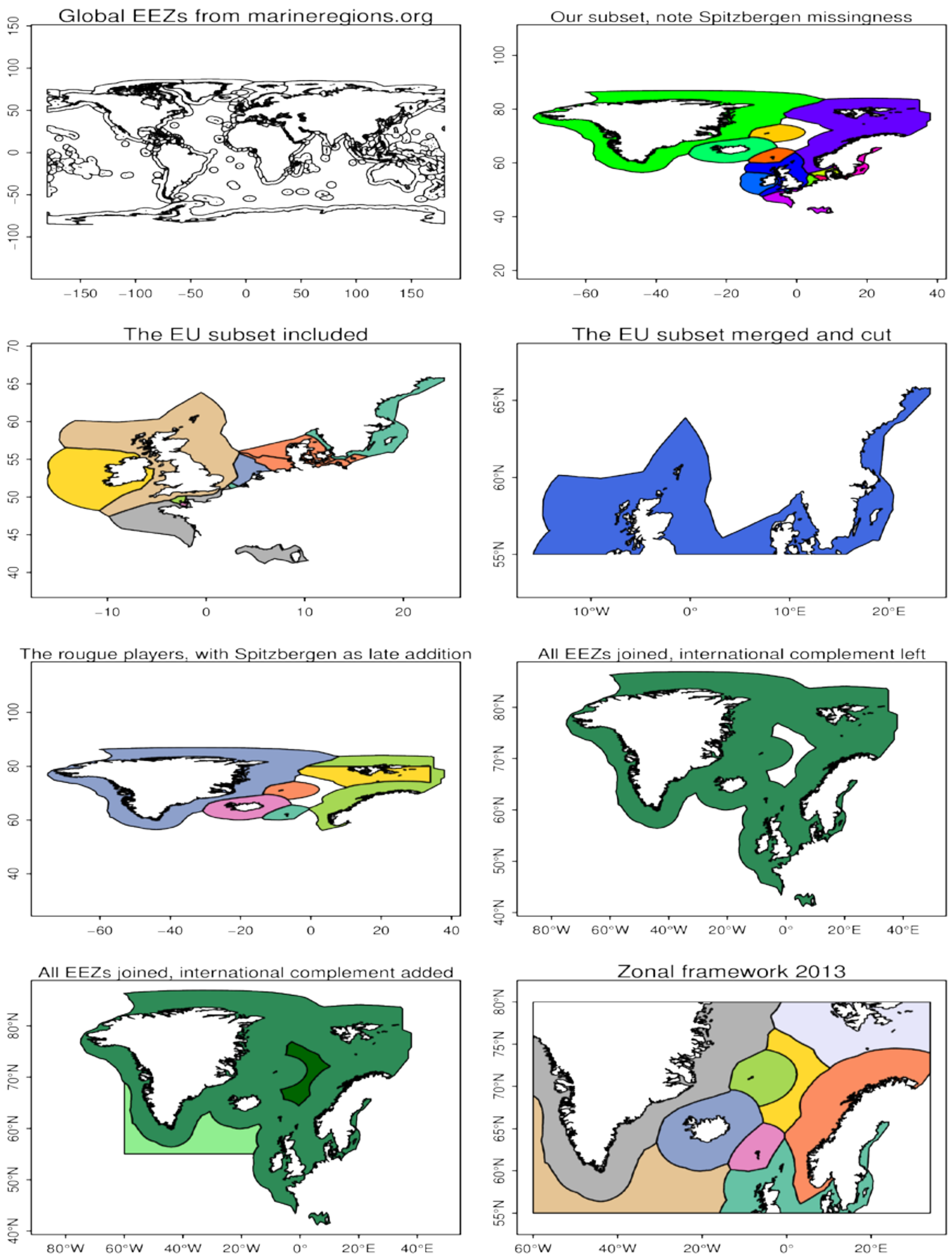

Figure A1. Zonal framework developed and used in 2013, extended and used again in 2014.

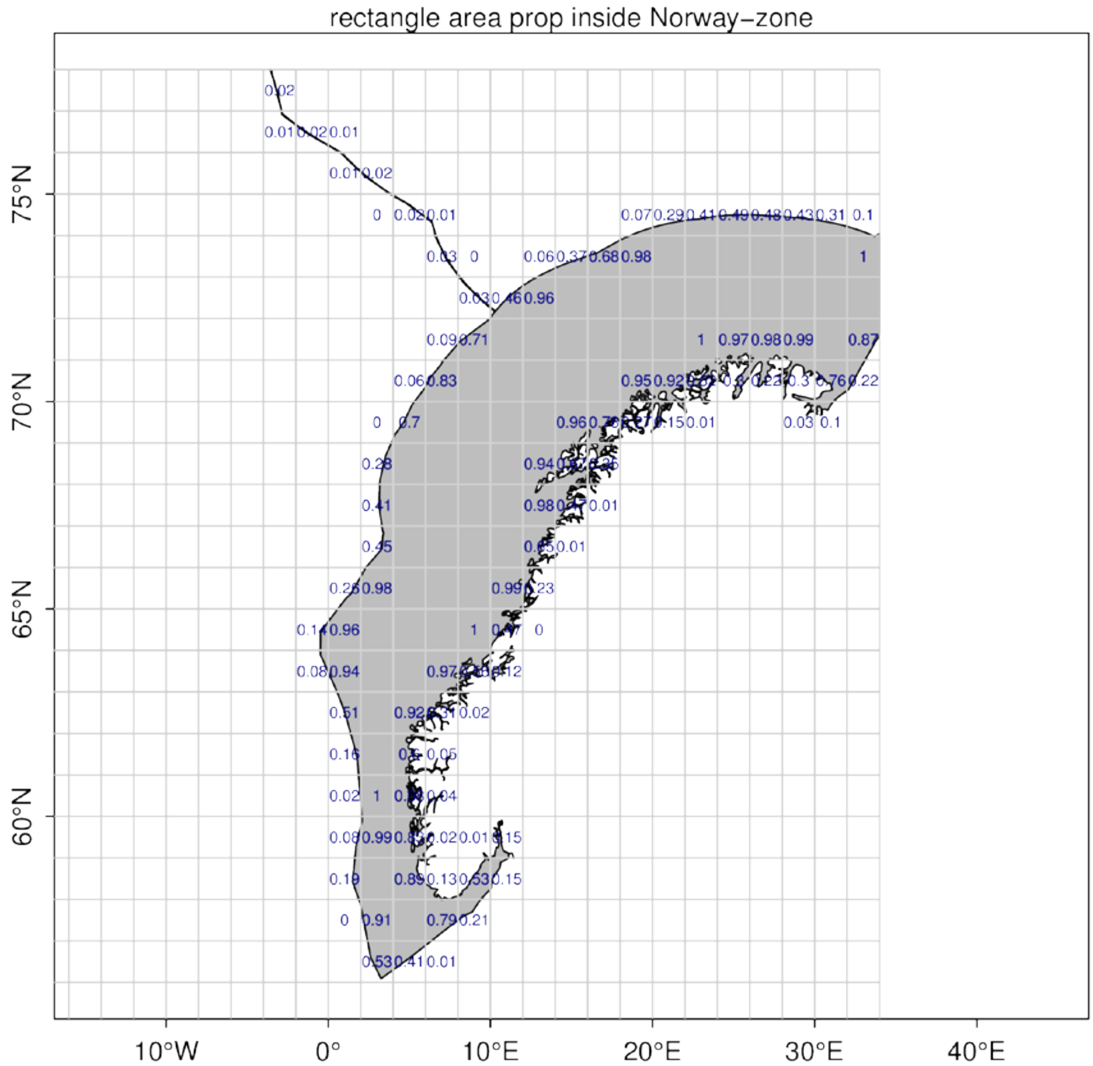

Figure A2. Sea area rectangle (1° latitude by 2° longitude) proportions within the Norway EEZ. The 'outgrowth' is due to discrepancy between the text file used for the Spitzbergen EEZ (pers. comm. Þ. Sigurðsson, MRI, from NEAFC work) and the Norway EEZ according to low-resolution shapefile on htpp://marineregions.org.

Working Document

Working Group on International Pelagic Surveys

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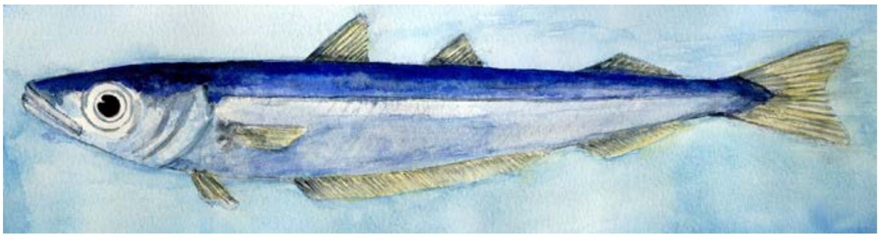

INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY (IBWSS) SPRING 2014

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Material and methods

Survey planning and Coordination

Coordination of the survey was initiated in the meeting of the Working Group on International Pelagic Surveys (WGIPS) and continued by correspondence until the start of the survey. During the survey, updates on vessel positions and trawl activities were collated by the survey coordinator and distributed to the participants twice daily. Participating vessels together with their effective survey periods are listed below:

Vessel	Institute	Survey period
Fritjof Nansen	**PINRO, Murmansk, Russia**	**25/3 – 5/4**
Celtic Explorer	**Marine Institute, Ireland**	**26/3 – 6/4**
Magnus Heinason	**Faroe Marine Research Institute, Faroe Islands**	**29/3 – 6/4**
Tridens	**Institute for Marine Resources & Ecosystem Studies (IMARES), the Netherlands**	**26/3 – 5/4**
G.O. Sars	**Institute of Marine Research, Norway**	**27/3 – 7/4**

The survey design used and described in ICES (2014) allowed for a flexible setup of transects and good coverage of the spawning aggregations. Due to acceptable - good weather conditions throughout the survey period, the survey resulted in a high quality coverage of the stock. Transects of all vessels were consistent in spatial coverage and timing, delivering full coverage of the respective distribution areas within 14 days.

Cruise tracks and trawl stations for each participant vessel are shown in Figure 1. Figure 2 shows combined CTD stations. All vessels worked in a northerly direction (Figure 3). Regular communication between vessels was maintained during the survey (via email and internet weblog) exchanging blue whiting distribution data, echograms, fleet activity and biological information.

Sampling equipment

All vessels employed a midwater trawl for biological sampling, the properties of which are given in Table 5. Acoustic equipment for data collection and processing are presented in Table 2. The survey and abundance estimate are based on acoustic data collected through scientific echo sounders using a frequency of 38 kHz. All transducers were calibrated with a standard calibration sphere (Foote et al. 1987) prior, during or directly after the survey. Acoustic settings by vessel are summarized in Table 2.

Acoustic Intercalibration

Inter-vessel acoustic calibrations are carried out when participant vessels are working within the same general area and time and weather conditions allow for an exercise to be carried out. The procedure follows the methods described by Simmonds & MacLennan 2007. This year, no inter-calibration was carried out due to time constraints.

Biological sampling

All components of the catch from the trawl hauls were sorted and weighed; fish and other taxa were identified to species level. The level of blue whiting sampling by vessel is shown in Table 1.

Hydrographic sampling

Hydrographic sampling by way of vertical CTD cast was carried out by each participant vessel at predetermined locations (Figure 2 and Table 1) with a maximum depth of 1000 m in open water. Hydrographic equipment specifications are summarized in Table 5.

Acoustic data processing

Acoustic scrutiny was mostly based on categorisation by experienced experts aided by trawl composition information. Post-processing software and procedures differed among the vessels:

On Fridtjof Nansen, the FAMAS software was used as the primary post-processing tool for acoustic data. Data were partitioned into the following categories: blue whiting, plankton, mesopelagic species and other species. The acoustic recordings were scrutinized once per day.

On Celtic Explorer, acoustic data were backed up every 24 hrs and scrutinised using Myriax's EchoView (V 4.8) post-processing software for the previous day's work. Data was partitioned into the following categories: plankton (<120 m depth layer), mesopelagic species and blue whiting.

On Magnus Heinason, acoustic data were scrutinised every 24 hrs on board using Myriax's EchoView (V 5.2) post processing software. Data were partitioned into the following categories: plankton (<200 m depth layer), mesopelagic species (pearlside in the upper layer and lanternfish in the deeper layer), blue whiting and krill. Partitioning of data into the above categories was based on trawl samples.

On Tridens, acoustic data were backed up continuously and scrutinized every 24 hrs using the Large Scale Survey System LSSS (V 1.8) post-processing software. Blue whiting were identified and separated from other recordings based on trawl catch information and characteristics of the recordings.

On G.O. Sars, the acoustic recordings were scrutinized using the Large Scale Survey System (LSSS) once or twice per day. Data was partitioned into the following categories: plankton (<120 m depth layer), mesopelagic species and blue whiting.

Acoustic data analysis

The acoustic data were analysed with a SAS based routine called "BEAM" (Totland and Godø 2001) and used to calculate age and length stratified estimates of total biomass and abundance (numbers of individuals) within the survey area as a whole and within sub-areas (i.e., the main areas in the terminology of BEAM). Strata of 1º latitude by 2º longitude were used. The area of a stratum was adjusted, when necessary, to correspond with the area that was representatively covered by the survey track. This was particularly important in the shelf break zone where high densities of blue whiting dropped quickly to zero at depths less than 200 m.

To obtain an estimate of length distribution within each stratum, all length samples within that stratum were used. If the focal stratum was not sampled representatively, additional samples from the adjacent strata were used. In such cases, only samples representing a similar kind of registration that dominated the focal stratum were included. Because this includes a degree of subjectivity, the sensitivity of the estimate with respect to the selected samples was crudely assessed by studying the influence of these samples on the length distribution in the stratum. No weighting of individual trawl samples was used because of differences in trawls and numbers of fish sampled and measurements. The number of fish in the stratum is then calculated from the total acoustic density and the length composition of fish.

The methodology is in general terms described by Toresen et al. (1998). More information on this survey is given by, e.g., Anon. (1982) and Monstad (1986). Following the decisions made at the “Workshop on implementing a new TS relationship for blue whiting abundance estimates (WKTSBLUES)” (ICES 2012), the following target strength (TS)-to-fish length (L) relationship (Pedersen et al. 2011) used is:

$$TS = 20 \log10 (L) - 65.2$$

For conversion from acoustic density (sA, m2/n.m.2) to fish density (ρ) the following relationship was used:

$$\rho = sA / \langle\sigma\rangle,$$

where $\langle\sigma\rangle = 3.795 \cdot 10^{-6} L^{2.00}$ is the average acoustic backscattering cross-section (m^2). The total estimated abundance by stratum is redistributed into length classes using the length distribution estimated from trawl samples. Biomass estimates and age-specific estimates are calculated for main areas using age-length and length-weight keys that are obtained by using estimated numbers in each length class within strata as the weighting variable of individual data.

BEAM does not distinguish between mature and immature individuals, and calculations dealing with only mature fish were therefore carried out separately after the final BEAM run for each sub-area. Proportions of mature individuals at length and age were estimated with logistic regression by weighting individual observations with estimated numbers within length class and stratum (variable ’popw’ in the standard output dataset ’vgear’ of BEAM). The estimates of spawning stock biomass and numbers of mature individuals by age and length were obtained by multiplying the numbers of individuals in each age and length class by estimated proportions of mature individuals. Spawning stock biomass is then obtained by multiplication of numbers at length by mean weight at length; this is valid assuming that immature and mature individuals have the same length-weight relationship.

Results

Distribution of blue whiting

In total 8,231 n.m. (nautical miles) of survey transects were completed and the total area of all the sub-survey areas covered was 125,319 n.m.² (Figure 1, Tables 1 & 3). Covered survey track length was 10% longer and surveyed areas 30% larger than last year as a result of increased and more detailed coverage of the Rockall and Porcupine Bank areas.

Within the Irish EEZ (Exclusive Economic Zone), blue whiting distributions were seen to extend from the shelf edge to the west of the Porcupine Bank. Maximum s_A values observed there reached 64095 m²/mile² with a vertical extension of up to 50-100 m over depths more than 1500 m (near the shelf edge), and 59221 m²/mile² over depths of 770 m in the western area of the Rockall Trough (north of the Porcupine Bank).

Within the UK EEZ, blue whiting were distributed in a continuous layer along the shelf edge up to 58N. The latitudinal width of the aggregation was from 20 to 58 miles. Maximum s_A values observed there reached 41360 m²/mile² with a vertical extension of up to 100 m near the shelf edge.

The highest concentrations of blue whiting were recorded in the Hebrides area but the observed biomass there was 37% less than in the previous year. Due to the perceived later northward migration of the stock as compared to 2013 the centre of gravity was located further south within the northern Porcupine Bank area. This area saw an increase in biomass of 310% as compared to 2013. Medium and high density registrations were concentrated along the shelf slope extending up to 15 nm from the shelf edge (Figures 4 & 5).

Compared to the last year, more high density aggregations were found on the Rockall Bank.

Stock size

The estimated total abundance of blue whiting for the 2014 international survey was 3.25 million tonnes, representing an abundance of 31.1×10^9 individuals (Figure 6, Tables 3 & 4). Spawning stock was estimated at 3.2 million tonnes and 24.4×10^9 individuals. In comparison to the 2013 survey estimate, there is a decrease (-3%) in the observed stock biomass and a related increase in stock numbers (+15%).

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Change from 2013 (%)
Biomass	Total	2.6	3.4	3.6	2.6	2	1.3	1.6	2.2	3.4	3.3	-3%
(mill. t)	Mature	2.4	3.3	3.6	2.6	2	1.3	1.5	2.2	3.2	3	-6%
Numbers	Total	29	34.7	33.5	22.1	15.2	9.3	12.1	18.2	27	31.1	15%
(10^9)	Mature	26.7	33.8	32.9	21.7	15.0	8.9	9.7	16.5	24.4	26.4	8%
Survey area (nm²)		172,000	170,000	135,000	127,000	133,900	109,320	68,851	88,746	87,895	125,319	43%

The Hebrides core area was found to contain 48% of the total biomass observed during the survey, which is lower than seen in previous years (73% of the stock found in this area in 2013 and 71% in 2012). The major part of the biomass recorded in the area was found more towards the southern part, while in previous years, the bulk of the aggregation was observed further north. The North Porcupine and Rockall areas ranked second and third highest contributing 27% and 15% to the total biomass respectively. Compared to the previous year, less biomass was observed in the Hebrides and Faroes/Shetland area, but more in the Northern Porcupine area, reflecting again the more southern distribution seen this year. An increase in absolute blue whiting biomass was observed in the Rockall area, both on the bank itself and in the Rockall Trough as compared to 2013. However, this increase can be attributed primarily to a high density area in the eastern Rockall Trough, as compared to the lower density echotraces found on the Rockall Bank itself. The breakdown of survey biomass by sub area is shown below:

		Biomass (million tonnes)				
		2013		2014		
	Sub-area		% of total		% of total	Change (%)
I	S. Porcupine Bank	-	-	0.03	1	-
II	N. Porcupine Bank	0.21	6	0.86	27	310%
III	Hebrides	2.44	73	1.54	48	-37%
IV	Faroes/Shetland	0.43	13	0.34	10	-21%
V	Rockall	0.27	8	0.47	15	74%

Stock composition

Individuals of ages 1 to 15 years were observed during the survey. A comparison of age reading between nations was carried out and the results are presented in Appendix 2. Results showed less agreement across participants for especially the younger year classes compared to 2013, with a broad spread of lengths for the youngest and oldest fish in the range.

The stock biomass within the survey area is dominated by age classes 3, 4, and 5 and 1 years of the 2010, 2009, 2008 and 2013 year classes respectively (Table 4 and Figure 10). The main contribution (76%) to the spawning stock biomass were the age groups 4, 3, 5 and 6 (Table 4).

The Hebrides area has consistently been the most productive in the current time series with the exception of this year where a slightly lower but still significant proportion of the overall biomass was located in that area (Figure 6). But this year the contribution was 48% while the Porcupine area contained a significant portion of the spawning stock in 2014. Mean lengths and weights of the fish caught in the Hebrides area were also among the highest within the whole survey area (Figures 7 and 8). The Faroe/Shetland subarea was dominated by mainly 1 and 3 year old fish, with some 2 year olds, and Porcupine sub-areas were dominated by 3-5 year old fish. One year old fishes were mainly observed in subarea IV (Faroes-Shetland). Older fish (8+ years) were predominantly observed in sub-area III (Hebrides) and V (Rockall) (Figure 11).

From the survey data, the Faroese/Shetland sub-area was found to contain significant proportion of young blue whiting (1-3 years), consistent with previous years. This together represents 70% (238,000t) of the total biomass and 85% (4183 million individuals) of the total abundance in this area. This is close to the proportions seen in 2012 (75% and 86% respectively), and larger than last year.

The largest blue whiting were observed on the Rockall Bank and here most of the fish were mature (97%).

Immature blue whiting were present to various extents in all sub areas in 2014 (Figure 11). Maturity analysis of survey samples indicate that 14% of 1-year old, 56% of 2-year old and 90% of 3-year old fish were mature as compared to the 2013 estimates, where 18% of 1-year old fish, 54% of 2-year old fish and 82% of 3-year old fish were considered mature (Table 4). Overall, immature blue whiting from the estimate represented 7.4% (242,000t) of the total biomass and 15% (4667 million) of the total abundance recorded during the survey.

Hydrography

A combined total of 167 CTD casts were undertaken over the course of the survey (Table 1). Horizontal plots of temperature and salinity at depths of 50m, 100m, 200m and 500m as derived from vertical CTD casts are displayed in Figures 12-15 respectively.

Concluding remarks

Main results

- The 11th International Blue Whiting Spawning stock Survey 2014 shows a slight decrease in total biomass of -3% (+15% abundance) when compared to the 2013 estimate, with increased area coverage (2013: 88’000 nmi²; 2014: 125’000 nmi²).
- Favourable weather conditions allowed the five survey vessels to successfully cover the entire planned area within the time available and achieved good containment of the stock.
- The survey was carried out over 14 days this year as compared to 19 days in 2013. Temporal progression of the survey was very good and this was achieved through vigilant survey coordination by means of regular updates. Temporal coverage is well within the 21 day time window recommended by the group to cover the spawning stock and was facilitated by good weather conditions.
- Estimated uncertainty around the mean acoustic density is low and comparable to the previous two years. It is about half as large as those observed in earlier years (2004-2011) with the exception of 2007, when a much higher uncertainty was recorded.
- The stock biomass within the survey area is dominated by age classes 4, 3, 5 and 6 of the 2010, 2011, 2009 and 2008 year classes respectively, contributing 74% of total stock biomass
- Mean length (27 cm) and weight (104.6 g) are lower than in 2013 and in previous years. This can be attributed to the increasing contribution of young fish to the total stock biomass.
- A positive signal of 3 and 4-year old fish (strong 2010 & 2011 year classes) continues to be observed across all areas and the 2009 and 2010 year classes are now considered fully recruited to the spawning stock. Signs of a potentially strong 2013 year class could be seen in the survey. However, it is too early to predict the magnitude of that year class yet with any degree of accuracy until it can be confirmed in upcoming surveys.

Interpretation of the results

- The 2014 estimate of abundance can be considered as robust. Stock containment was achieved for the core stock areas, with close temporal progression between vessels and a high amount of supporting biological data contributing to the analysis. 85% of the total biomass was observed in target areas surveyed by more than one vessel.
- The bulk of the stock was once again located in the Hebrides core area. Within this area the stock was located further south than at the same time in previous years indicating a later than normal migration of the stock northwards.
- Cohort tracking through the time series is possible for the most dominant year classes at present (2010 & 2011) and to a lesser extent for older fish. The presence of three successive years of good recruitment is a positive signal after a prolonged period of poor recruitment. The number of 3 year old fish observed in 2014 (2011 year class) is comparable in terms of weight and numbers to that of the strong 2010 year class. The strong 2009 year class has now fully recruited to the stock.

Recommendations

- It is recommended that Norway update the group as soon as possible regarding participation in 2015 to allow for timely planning and allocation of survey effort for the remaining participants.
- It is recommended that all participants with the capacity to do so begin collecting fluorescence data during routine CTD casts in 2015 and submit the data accordingly.
- The 2015 survey will be carried out as detailed in Appendix 3.

- It is the responsibility of individual survey participants to ensure that all data is screened prior to submission to the PGNAPES data base following the details outlined in the WGIPS survey manual.
- Group members should discuss the blue whiting maturity stage key (use of 7 stages or 8 stages) and use of inter-transects during biomass estimation at the next WGIPS meeting to decide on a common standardised method.
- Due to difficulties in confirming vessel availability in recent years, the possibility of limiting participating vessels by use of a rotation system should be investigated at the next WGIPS meeting. Potential reduction of survey precision should be investigated in this process.
- Vessels should adhere to the common survey speed of 10 knots. If this cannot be achieved, relevant participants have to communicate this prior to the survey to facilitate planning.
- Vessels surveying the Rockall area should be able to sample blue whiting that is occurring close to the sea bed there.

Achievements

- The whole survey area (c.125,000nmi^2) was covered within 14 days within the recommended 21 day maximum.
- Comprehensive trawling and hydrographic sampling were carried out.
- Delivery of survey data to Leon Smith (Faroes, data repository) was achieved prior to the post cruise meeting. Most data were quality controlled prior to submitting to the database. Remaining errors were resolved during the post-cruise meeting.

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Table 1. Survey effort by vessel. March-April 2014.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton sampling	Aged fish	Length-measured fish
Celtic Explorer	26/3-6/4	1451	11	24		550	1650
Magnus Heinason	29/3-6/4	1173	10	21	21	337	721
G.O.Sars	27/3- 7/4	1962	8	41	38	204	625
Tridens	26/3-5/4	1997	11	24		1101	1100
Fritjof Nansen	25/3-5/4	1648	12	57		1100	3632
Total	25/3-7/4	8,231	52	167	59	3,292	7,728

Table 2. Acoustic instruments and settings for the primary frequency. March-April 2014.

	Fridtjof Nansen	Celtic Explorer	Magnus Heinason	Tridens	G.O. Sars
Echo sounder	Simrad EK60	Simrad EK 60	Simrad EK60	Simrad EK 60	Simrad EK 60
Frequency (kHz)	**38**	**38**, 18, 120, 200	**38**	**38**, 120	18, 70, **38**, 120, 200,
Primary transducer	ES38B	ES 38B	ES38B	ES 38B	ES 38B
Transducer installation	Hull	Drop keel	Hull	Towed body	Drop keel
Transducer depth (m)	5	8.7	3	7	8.5
Upper integration limit (m)	10	15	7	13	15
Absorption coeff. (dB/km)	10	9.8	10.2	10	10.1
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.425	2.43	2.43	2.43
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-20.6	-20.6	-20.8	-20.6	-20.6
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.52	25.98	25.61	26.18	25.5
s_A correction (dB)	-0.64	-0.69	-0.72	-0.67	-0.65
3 dB beam width (dg)					
alongship:	6.99	6.93	7.02	7.05	6.84
athw. ship:	6.99	7	7.01	7.06	6.85
Maximum range (m)	750	750	750	750	750
Post processing software	FAMAS	Sonardata Echoview	Sonardata Echoview	LSSS	LSSS

Table 3. Assessment factors of blue whiting for IBWSS March-April 2014.

Sub-area			Numbers (10^9)			Biomass (10^6 tonnes)			Mean weight	Mean length	Density
		nmi^2	Mature	Total	%mature	Mature	Total	%mature	g	cm	$ton/n.mile^2$
I	S. Porcupine Bank	7,999	0.28	0.35	80	0.027	0.031	87	85.3	26.3	3.9
II	N. Porcupine Bank	16,175	8.35	9.37	89	0.8	0.865	92	92.3	26.9	53.5
III	Hebrides	37,371	12.07	12.94	93	1.483	1.544	96	119	28.2	41.3
IV	Faroes/Shetland	23,516	2.38	4.92	48	0.237	0.337	70	68.5	22.6	14.3
V	Rockall	40,258	3.35	3.5	96	0.463	0.475	97	135.8	29.2	11.8
Tot.		125,319	26.43	31.08	85	3.01	3.252	93	121.8	28	25.9

Table 4. Survey stock estimate of blue whiting, March-April 2014.

Length	Age in years (year class)										Numbers	Biomass	Mean weight	Prop. mature*
	1	2	3	4	5	6	7	8	9	10+				
(cm)	2012	2011	2010	2009	2008	2007	2006	2005	2004		($*10^{-6}$)	(10^6 kg)	(g)	(%)
11.0 – 12.0											0			
12.0 – 13.0											0			
13.0 – 14.0											0			
14.0 – 15.0											0			
15.0 – 16.0											0			
16.0 – 17.0	77	0	0	0	0	0	0	0	0		77	1.7	22	0
17.0 – 18.0	388	6	0	0	0	0	0	0	0		394	10.1	26	0
18.0 – 19.0	784	49	6	0	0	0	0	0	0		839	26.1	31	13
19.0 – 20.0	993	150	1	0	0	0	0	0	0		1144	42	37	14
20.0 – 21.0	435	246	1	0	0	0	0	0	0		682	28.8	42	14
21.0 – 22.0	164	164	4	0	0	0	0	0	0		332	16.9	51	52
22.0 – 23.0	35	113	46	0	0	0	0	0	0		194	11.2	58	62
23.0 – 24.0	0	154	226	18	1	0	0	0	0		399	26.2	66	74
24.0 – 25.0	10	299	941	411	74	0	0	0	0		1735	128.8	75	75
25.0 – 26.0	0	229	2244	1376	597	41	11	0	0		4498	366.5	82	85
26.0 – 27.0	0	81	2476	1834	1320	61	19	0	0		5791	517.7	90	94
27.0 – 28.0	0	11	1660	1888	987	94	0	0	0		4640	462.8	100	98
28.0 – 29.0	0	0	527	1188	1039	228	10	0	0		2992	334.4	112	100
29.0 – 30.0	0	0	206	557	759	208	24	0	10		1764	219.4	125	100
30.0 – 31.0	0	0	28	352	568	285	84	23	0	55	1395	197.4	142	100
31.0 – 32.0	0	0	0	68	278	234	90	70	115	158	1013	169.2	168	100
32.0 – 33.0	0	0	20	49	142	124	109	167	116	276	1003	184.7	185	100
33.0 – 34.0	0	0	9	30	108	85	51	176	73	269	801	163.1	205	100
34.0 – 35.0	0	0	1	0	47	33	58	38	113	228	518	115.1	224	100
35.0 – 36.0	0	0	0	0	4	43	41	21	84	212	405	99.3	246	100
36.0 – 37.0	0	0	0	0	0	25	8	27	59	112	231	58.3	254	100
37.0 – 38.0	0	0	0	0	0	6	21	6	19	78	130	35.1	273	100
38.0 – 39.0	0	0	0	0	3	1	6	6	3	32	51	14.9	280	100
39.0 – 40.0	0	0	0	0	0	0	0	0	4	22	26	8.4	321	100
40.0 – 41.0	0	0	0	0	0	0	0	0	0	0	0	0	.	100
41.0 – 42.0	0	0	0	0	0	0	0	2	0	2	4	1.4	407	100
42.0 – 43.0	0	0	0	0	0	0	0	0	0	10	10	3.9	383	100
43.0 – 44.0	0	0	0	0	0	0	0	0	3	12	15	6.9	455	100
44.0 – 45.0	0	0	0	0	0	0	0	0	0	2	2	1.1	519	100
TSN (10^6)	2886	1502	8396	7771	5927	1468	532	536	599	1468	31085	3251		
TSB (10^6 kg)	102.1	96	761.2	767.4	660.7	215.3	93.7	106.7	127.7	320.6	3251			
Mean length (cm)	19.2	22.8	26.3	27.3	28.2	30.4	32.3	33.2	33.9	34.5				
Mean weight (g)	35.4	63.8	90.7	98.7	111.4	146.5	176.4	199	212.8	225				
Condition (g/dm^3)														
% mature*	14	56	90	94	97	99	99	100	100	100				
SSB	14.7	53.5	685.2	721.8	637.6	213.6	93.2	106.7	127.7	320.6	2974.6			

* Percentage of mature individuals per age or length class

Table 5. Country and vessel specific details, March-April 2014.

	Fritjof Nansen	Celtic Explorer	Magnus Heinason	Tridens	G.O. Sars
Trawl dimensions					
Circumference (m)	716	768	640	1120	832
Vertical opening (m)	50	50	40	30-70	45
Mesh size in codend (mm)	16	20	40	±20	40
Typical towing speed (kn)	3.0-3.7	3.5-4.0	3.0-4.0	3.5-4.0	3.0-3.5
Plankton sampling	0	0	21	0	38
Sampling net	-	-	WP2 plankton net	-	WP2 plankton net
Standard sampling depth (m)	-	-	200	-	400
Hydrographic sampling					
CTD Unit	SBE19plus	SBE911	SBE911	SBE911	SBE911
Standard sampling depth (m)	1000	1000	1000	1000	1000

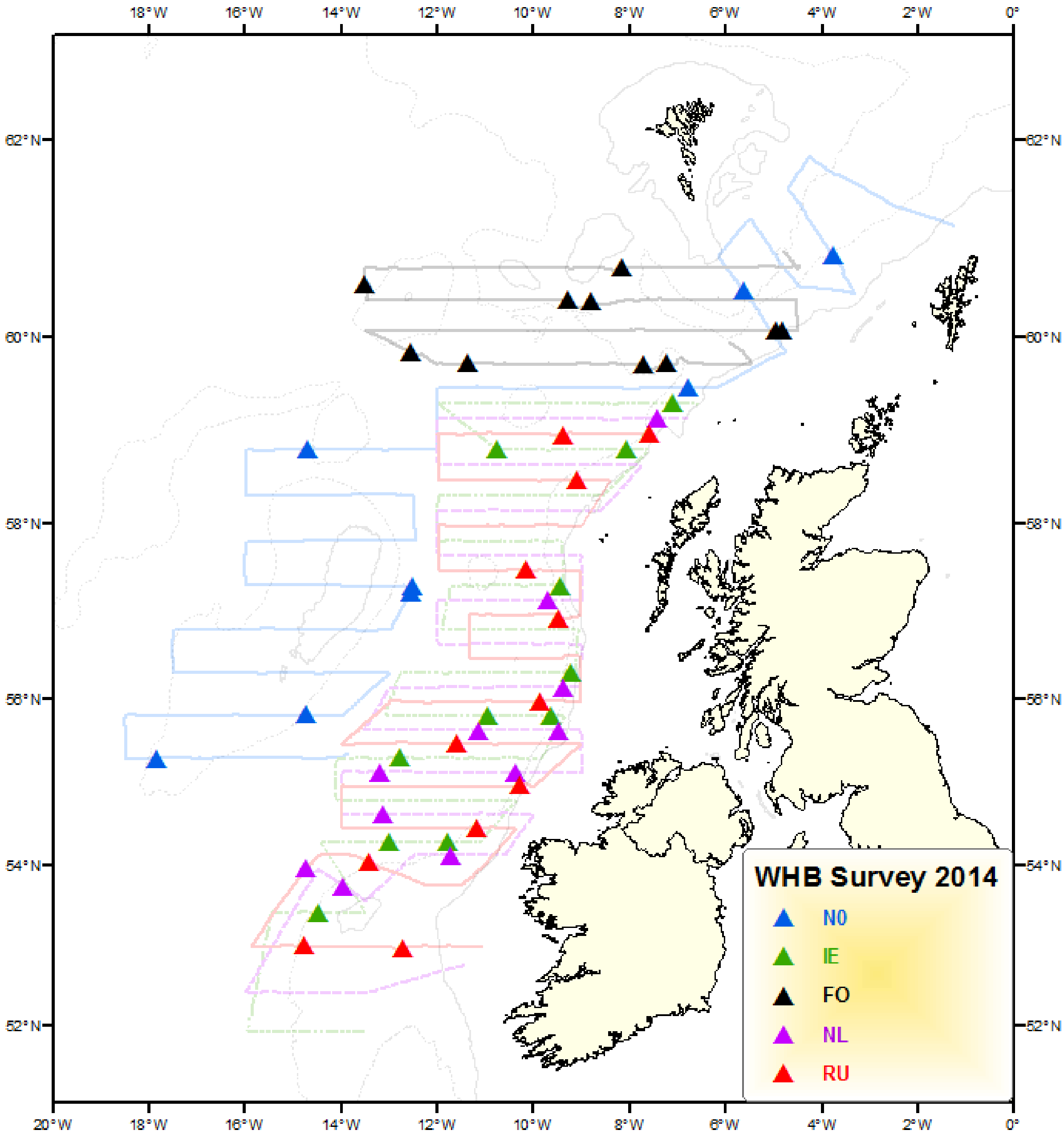


Figure 1. Vessel cruise tracks and trawl stations of the International Blue Whiting Spawning stock Survey (IBWSS) from March-April 2014. IE: Ireland (Celtic Explorer); FO: Faroe Islands (Magnus Heinason); NL: Netherlands (Tridens); RU: Russia (Fritjof Nansen); NO: Norway (G.O. Sars).

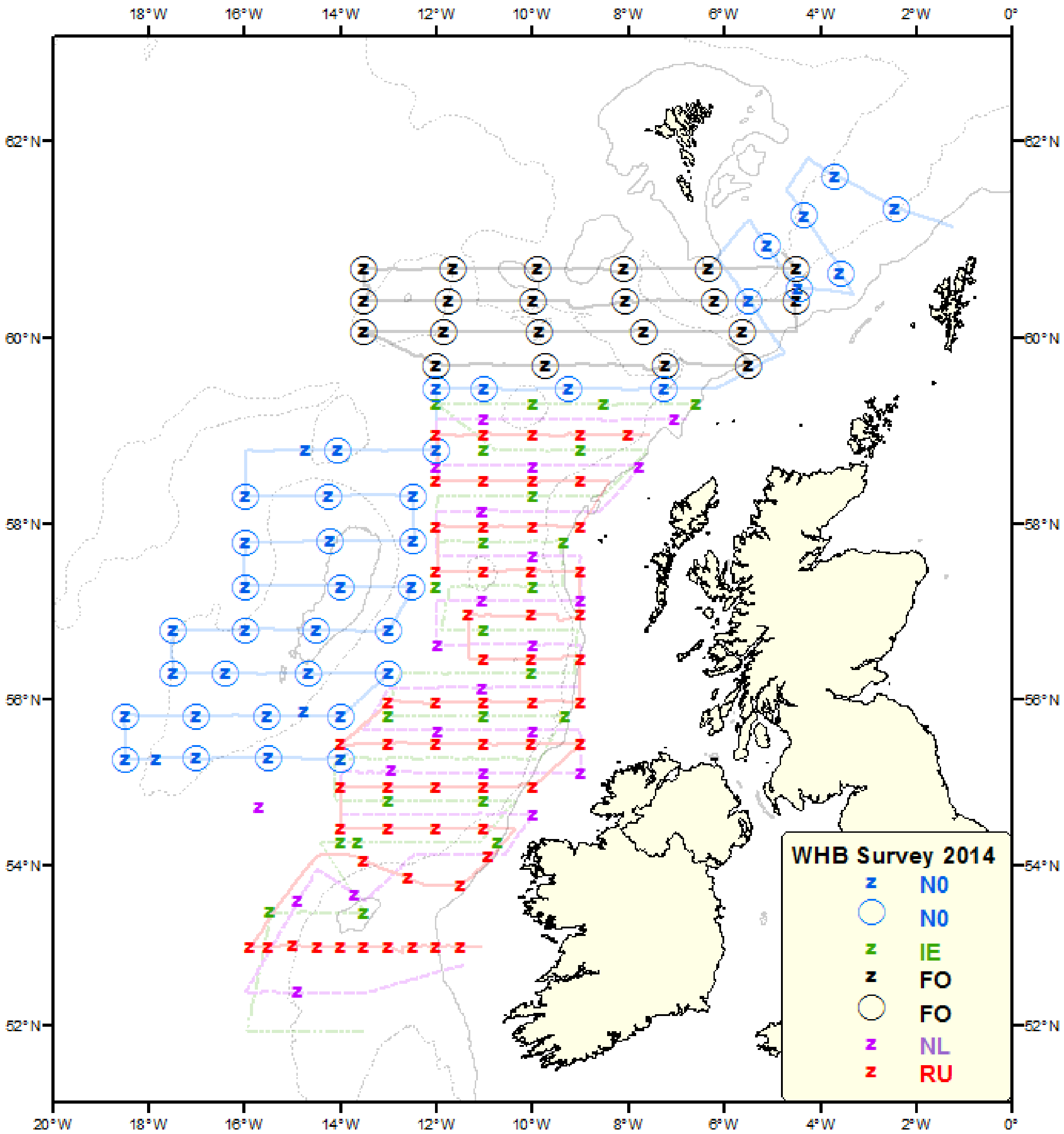


Figure 2. CTD stations overlaid onto vessel cruise tracks for the combined survey (‘z’). Circles represent plankton trawls. green: Celtic Explorer; black: Magnus Heinason; purple: Tridens; red: Fritjof Nansen; blue: G.O. Sars. March-April 2014.

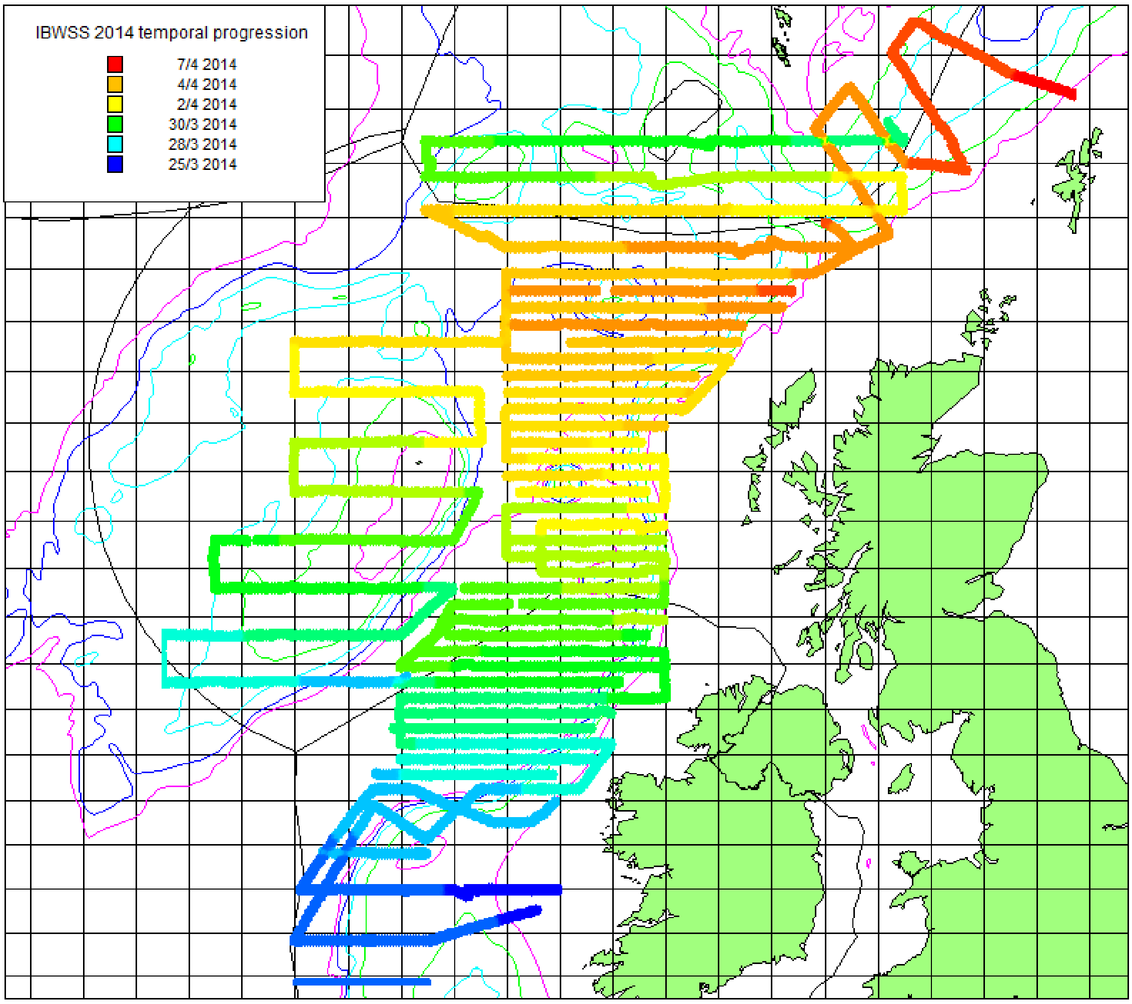


Figure 3. Temporal progression for the International Blue Whiting Spawning stock Survey (IBWSS), 25. March – 7. April 2014.

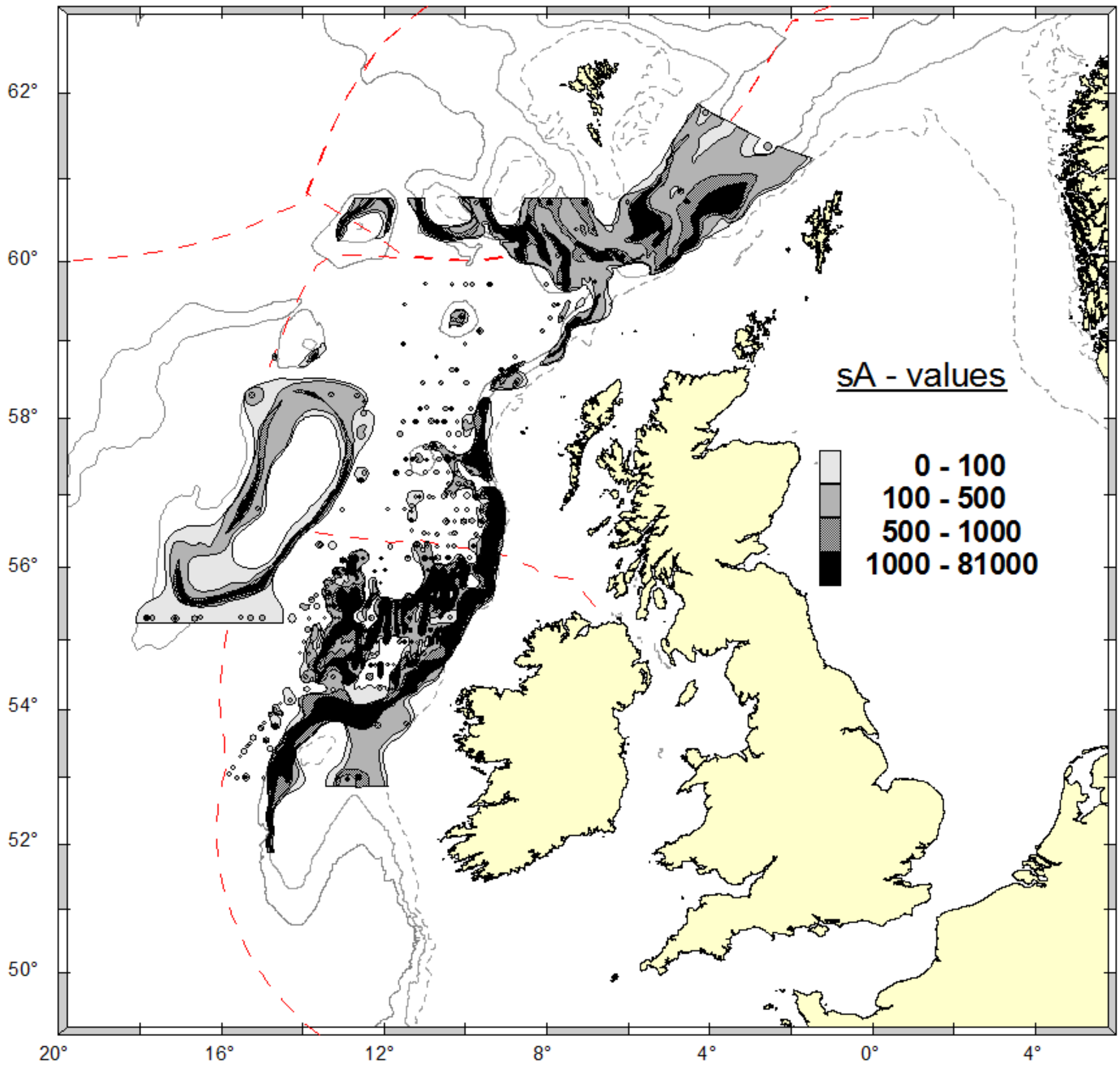


Figure 4. Map of blue whiting acoustic density (s_A, m^2/n.m.^{2}) , 24. March – 07. April 2014.

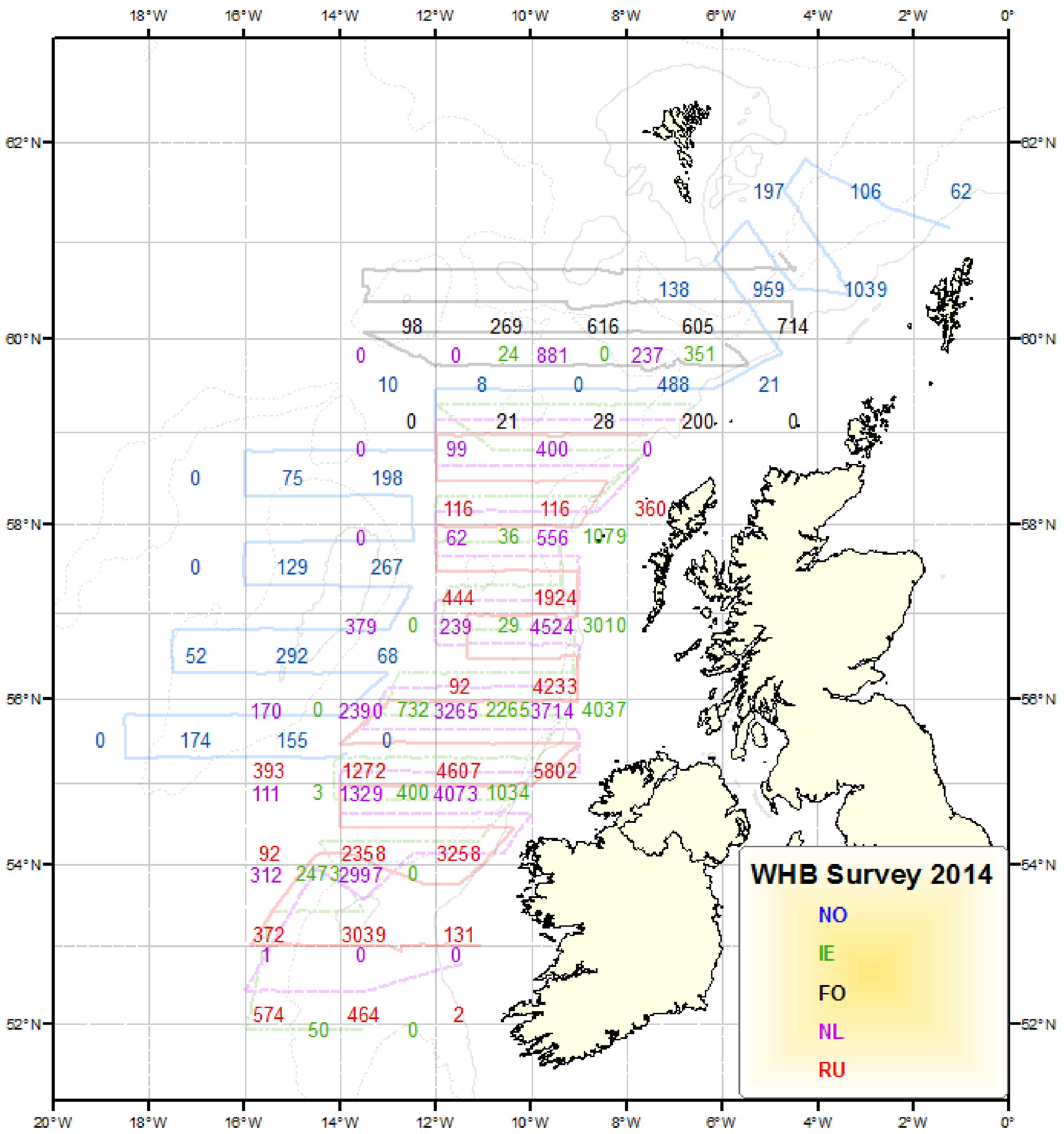


Figure 5. Mean blue whiting acoustic density (s_A, $m^2/n.m.^2$) for IBWSS 2013 by individual vessel: Celtic Explorer: green, Magnus Heinason: black, Tridens: grey, Fritjof Nansen: red, G.O. Sars: blue. March-April 2014.

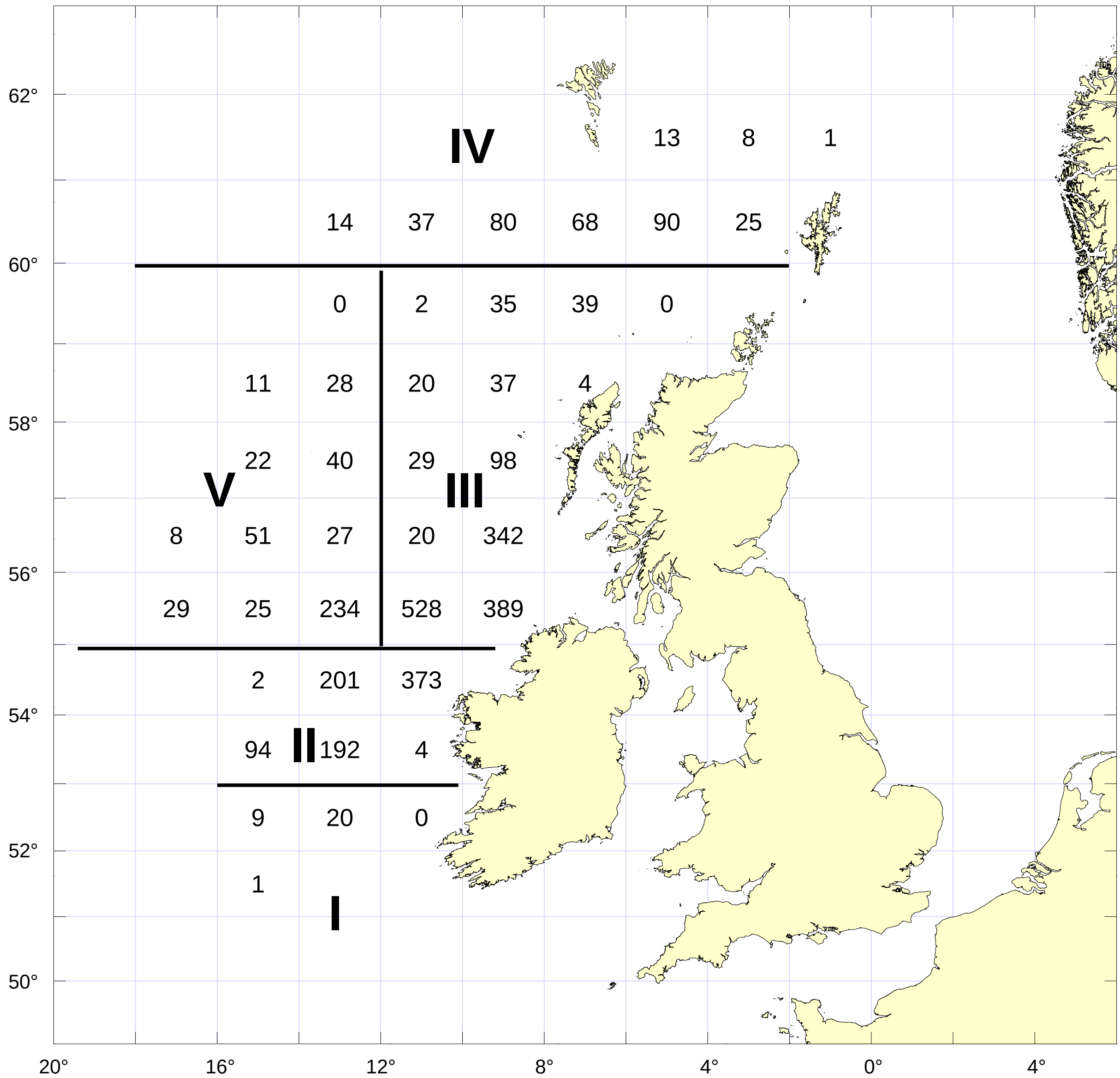


Figure 6. Blue whiting biomass (x1000t) from IBWSS 2014 by sub-area as used in the assessment.

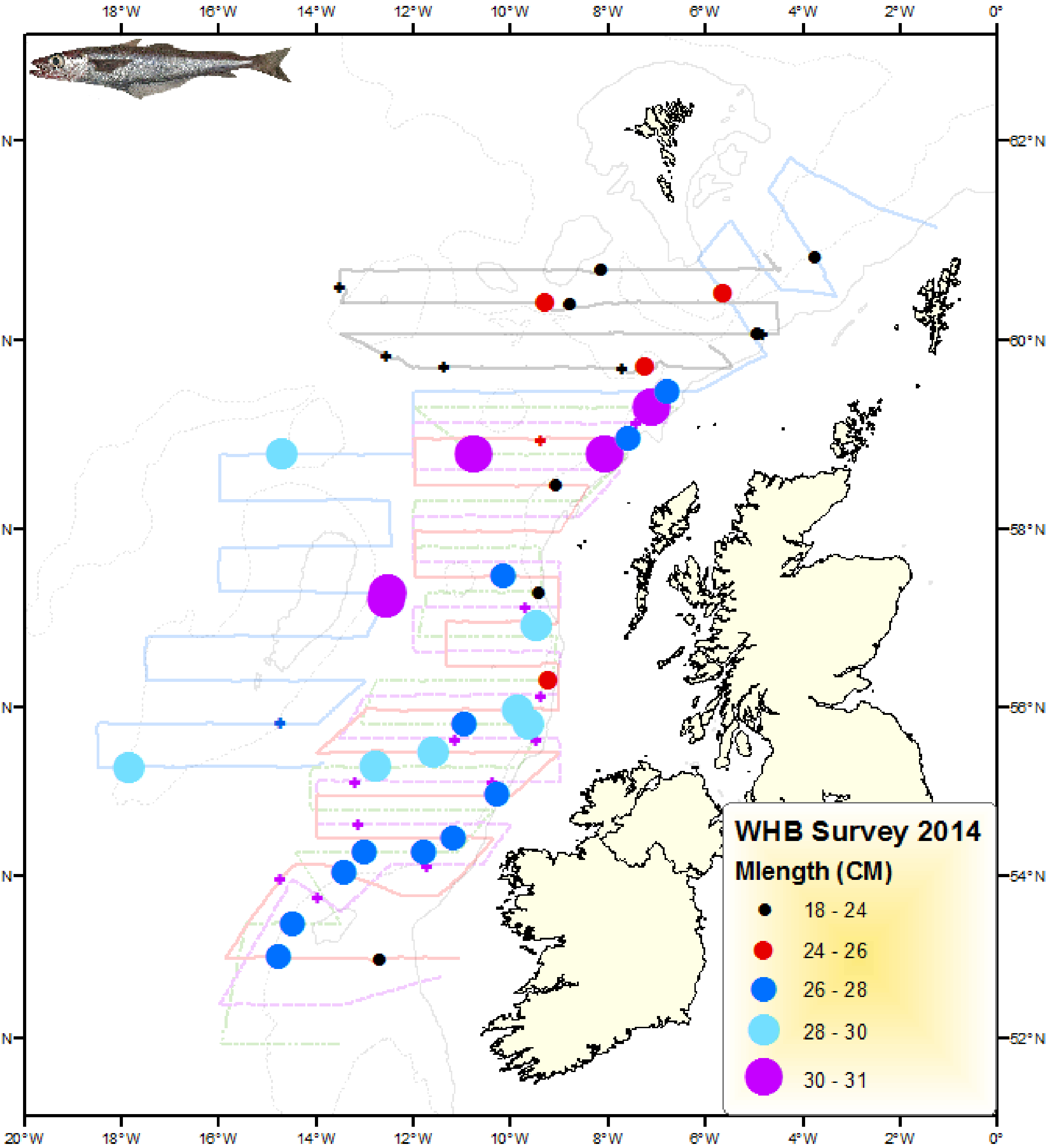


Figure 7. Mean length of blue whiting caught in trawl catches during IBWSS 2014 by individual vessels in March-April 2014. Crosses indicate trawls without any blue whiting catches.

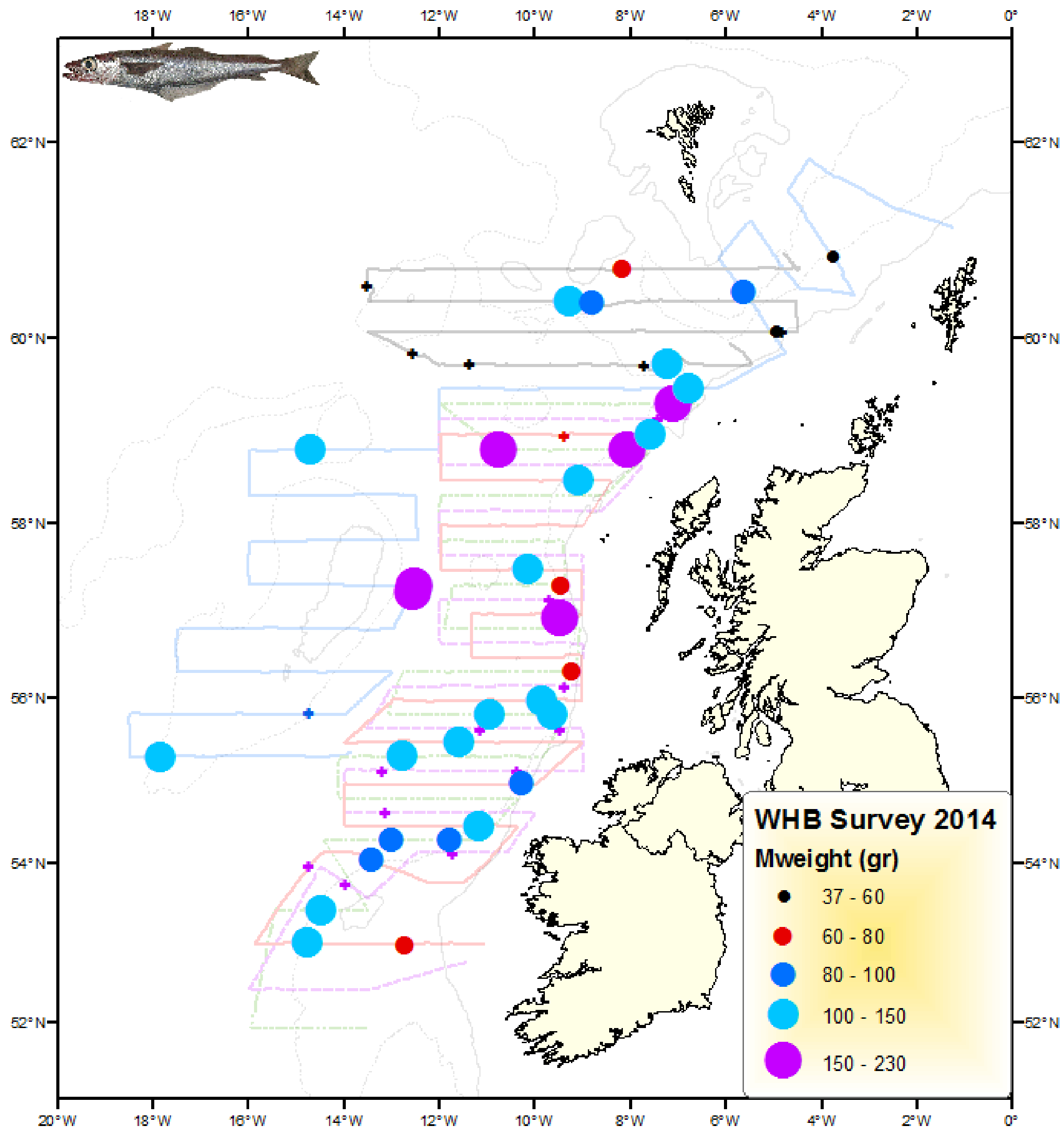
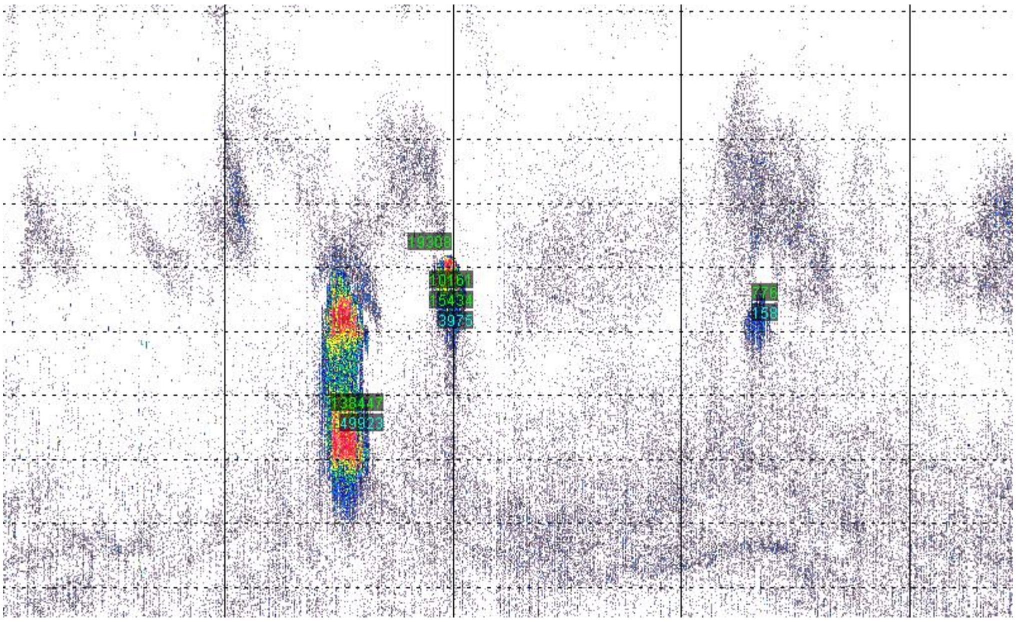
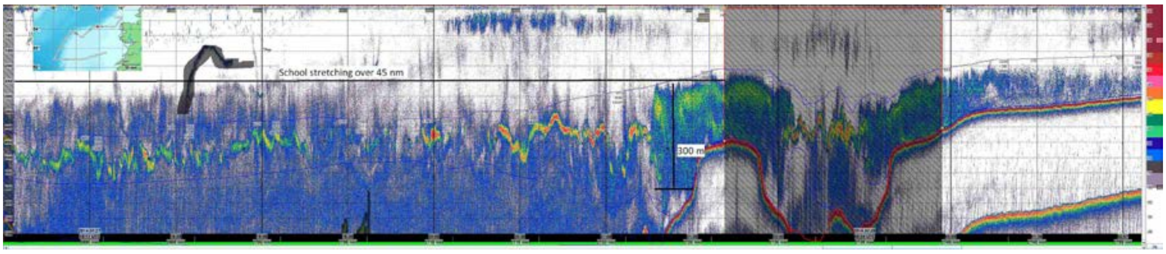


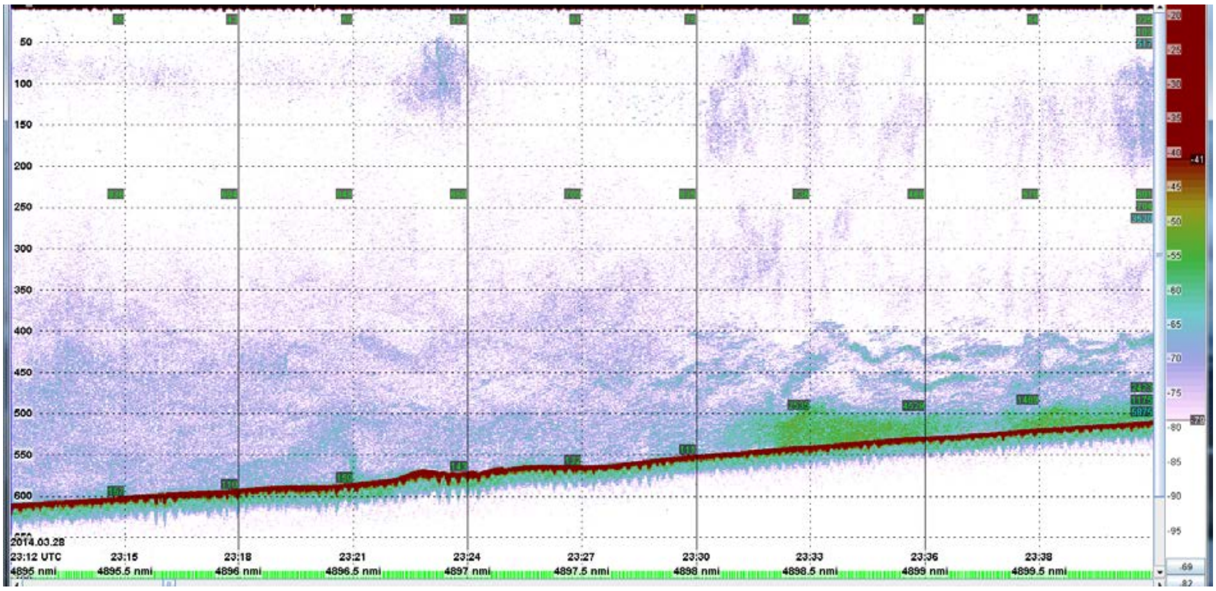
Figure 8. Mean weight of blue whiting caught in trawl catches during IBWSS 2014 by individual vessels in March-April 2014. Crosses indicate trawls without any blue whiting catches.



a). Scattered Double blue whiting echotrace observed by Tridens in the Northern part of the survey area.



b) Long blue whiting school observed onboard Tridens in subarea II (northern Porcupine).



c) Blue whiting schools close to the sea bed on Rockall observed by G.O. Sars.

Figure 9. Echograms of interest encountered during the combined International blue whiting survey in March-April 2014.

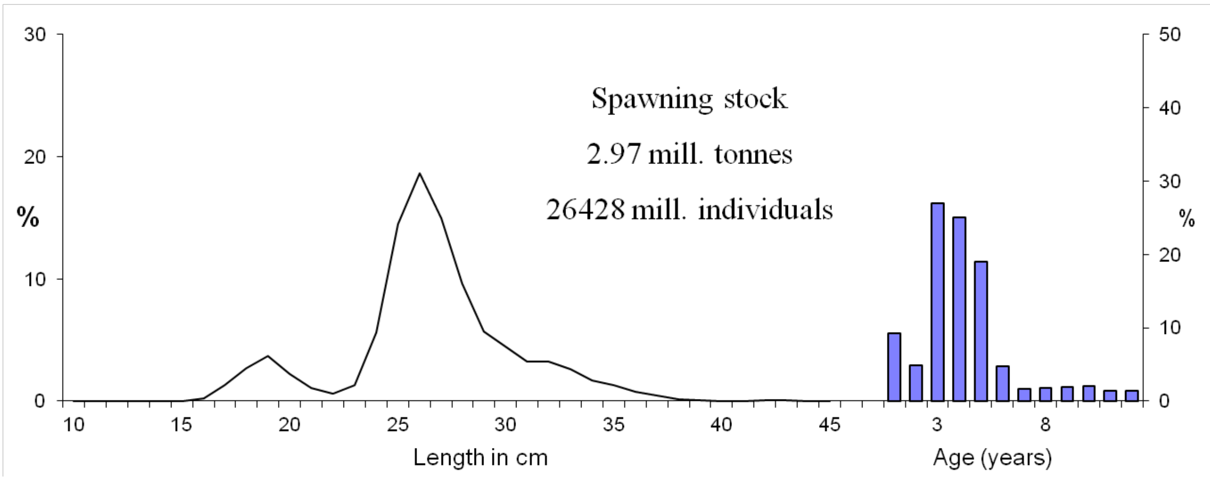


Figure 10. Length and age distributions (numbers) of total stock of blue whiting. Spawning stock biomass is given. March-April 2014.

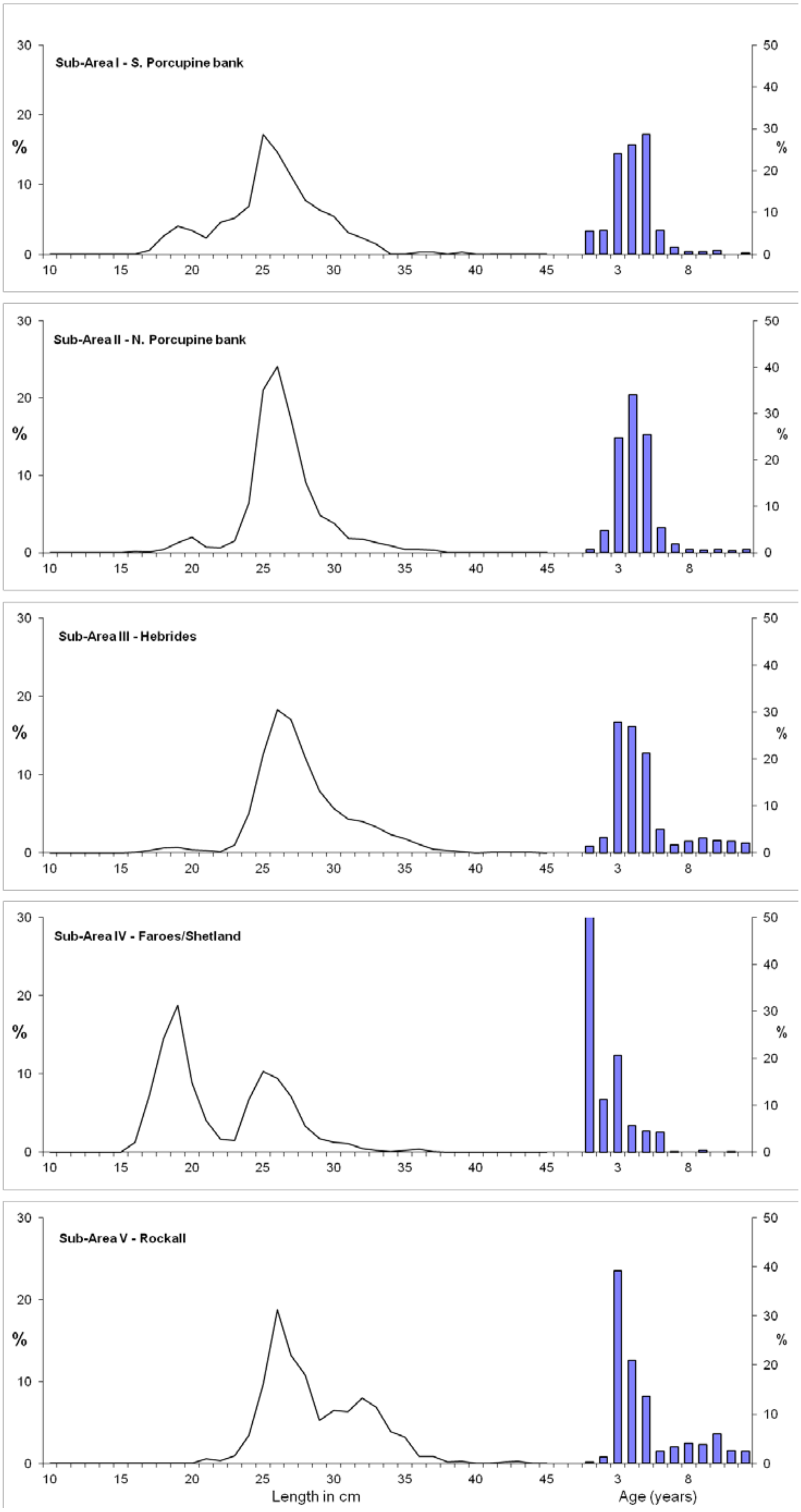


Figure 11. Length and age distribution (numbers) of blue whiting by covered sub-area (I–V). March-April 2014.

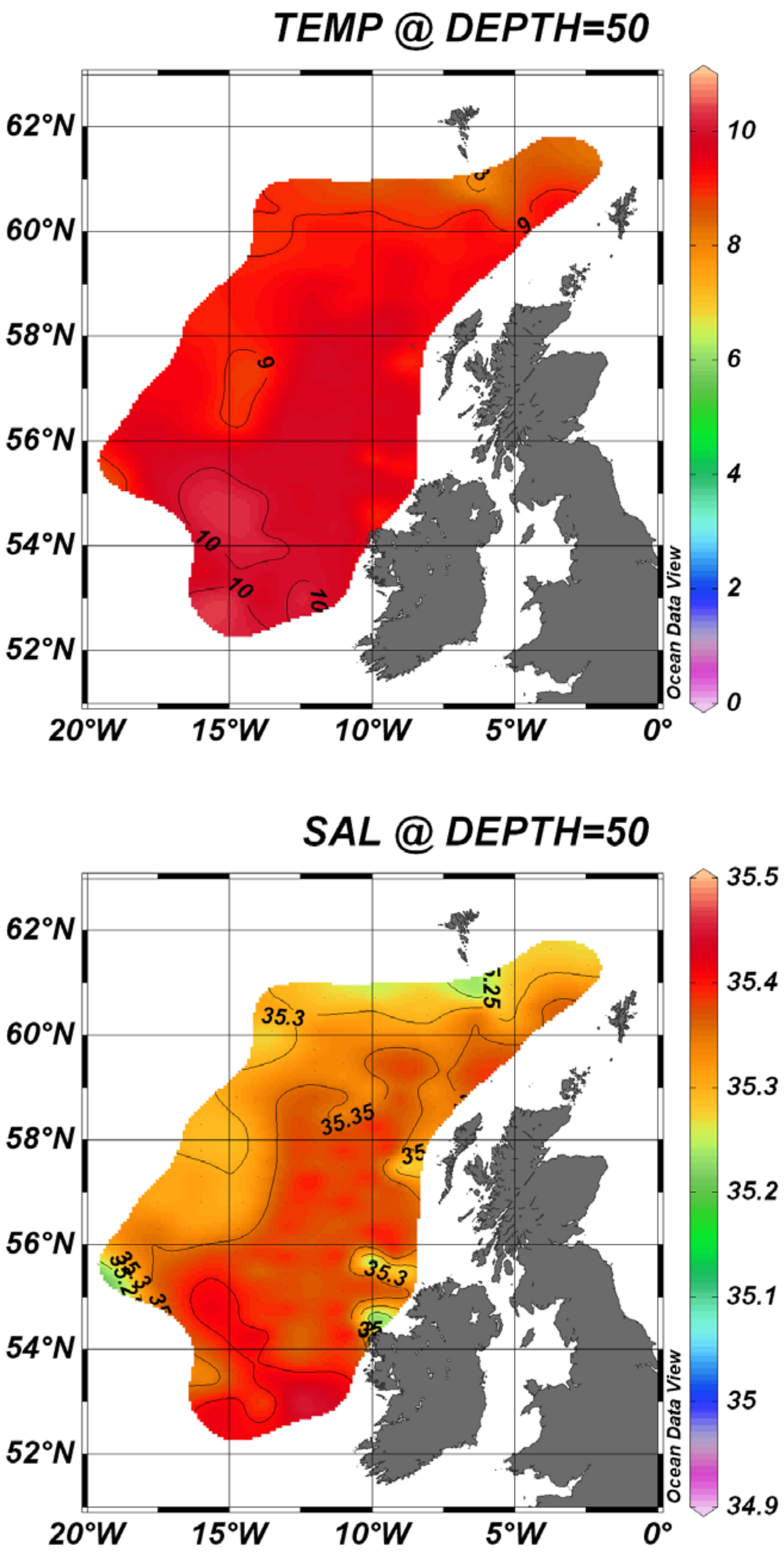


Figure 12. Horizontal temperature (top panel) and salinity (bottom panel) at 50m subsurface as derived from vertical CTD casts. March-April 2014.

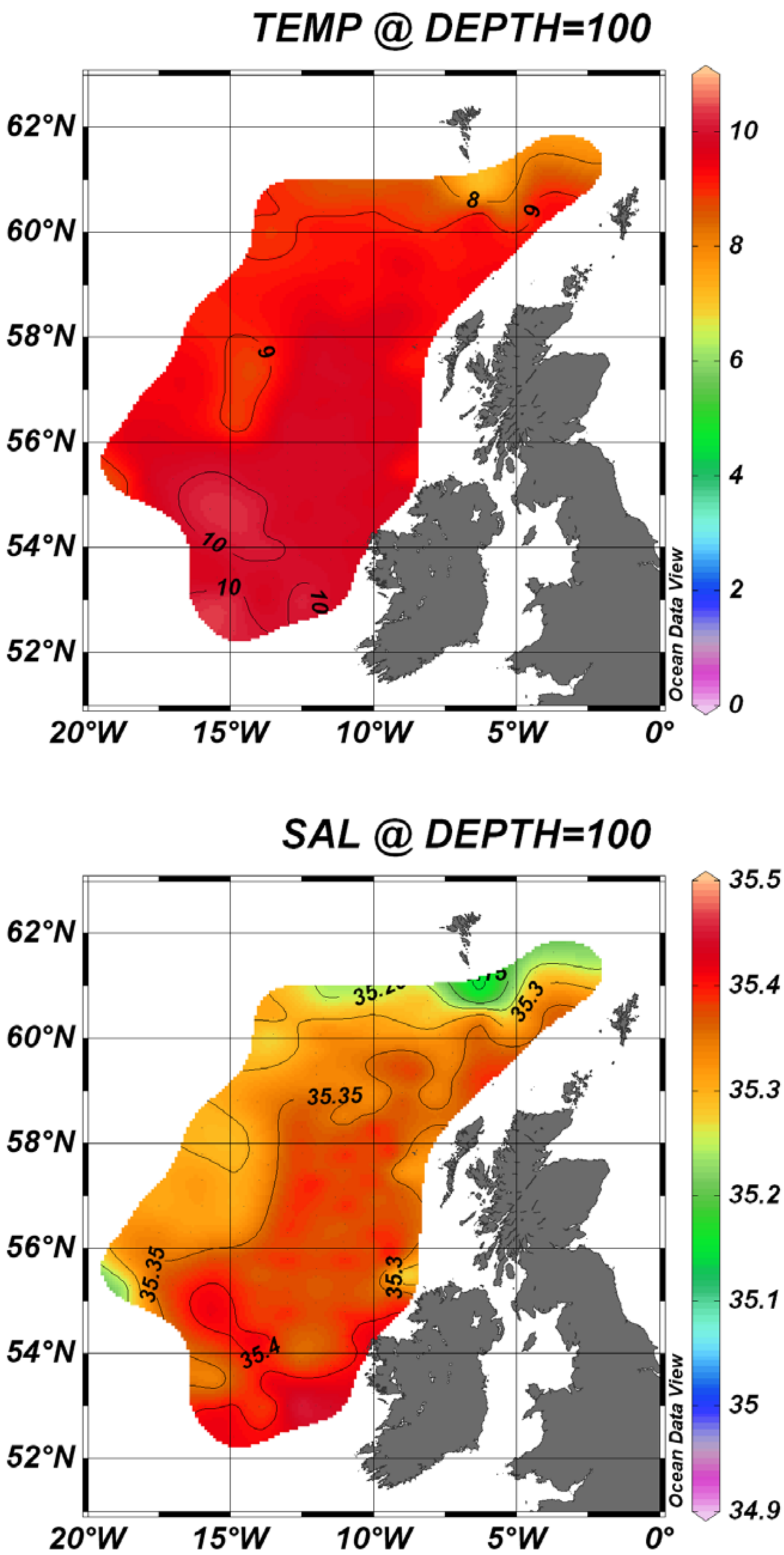


Figure 13. Horizontal temperature (top panel) and salinity (bottom panel) at 100m subsurface as derived from vertical CTD casts. March-April 2014.

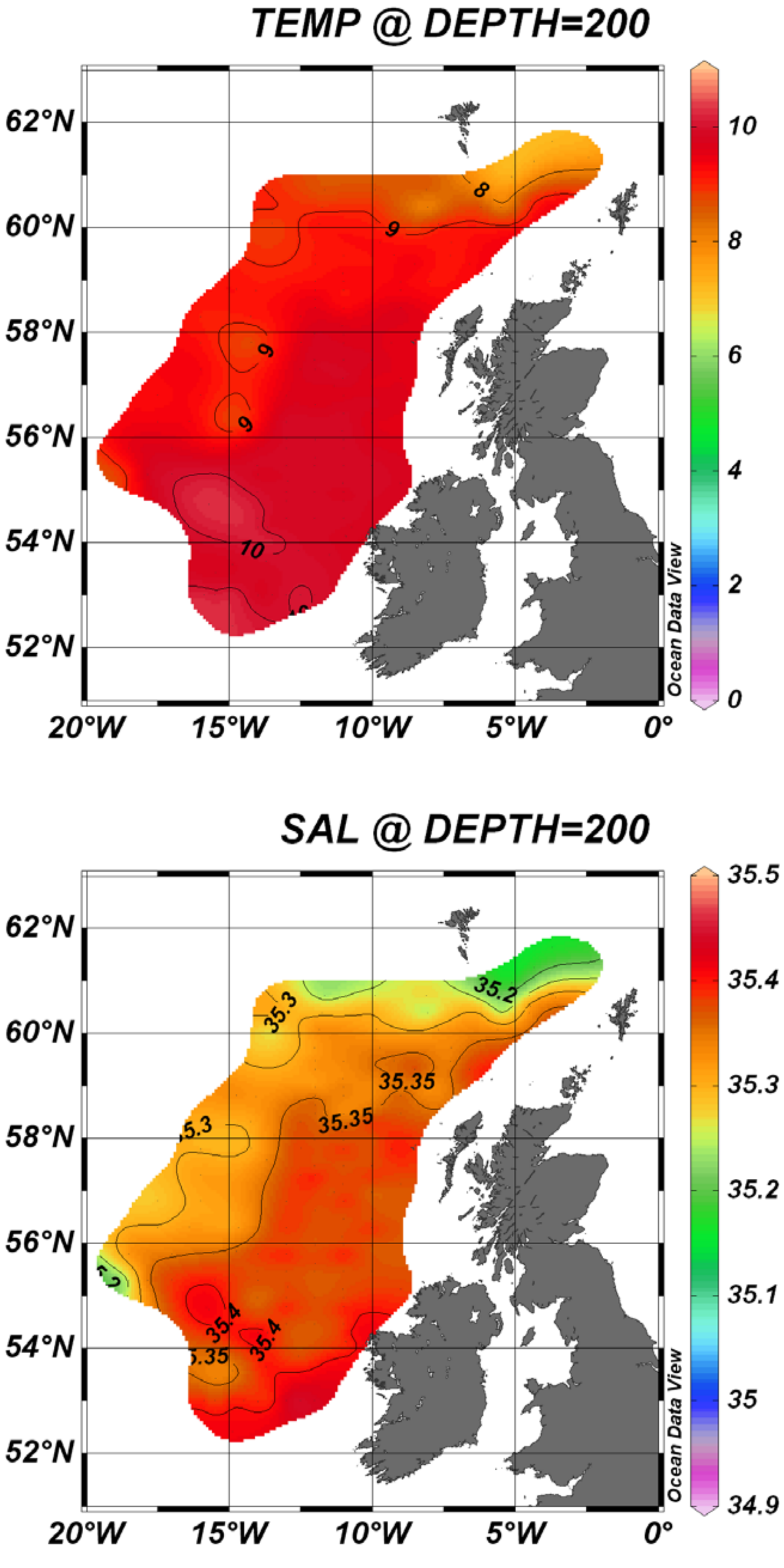


Figure 14. Horizontal temperature (top panel) and salinity (bottom panel) at 200m subsurface as derived from vertical CTD casts. March-April 2014.

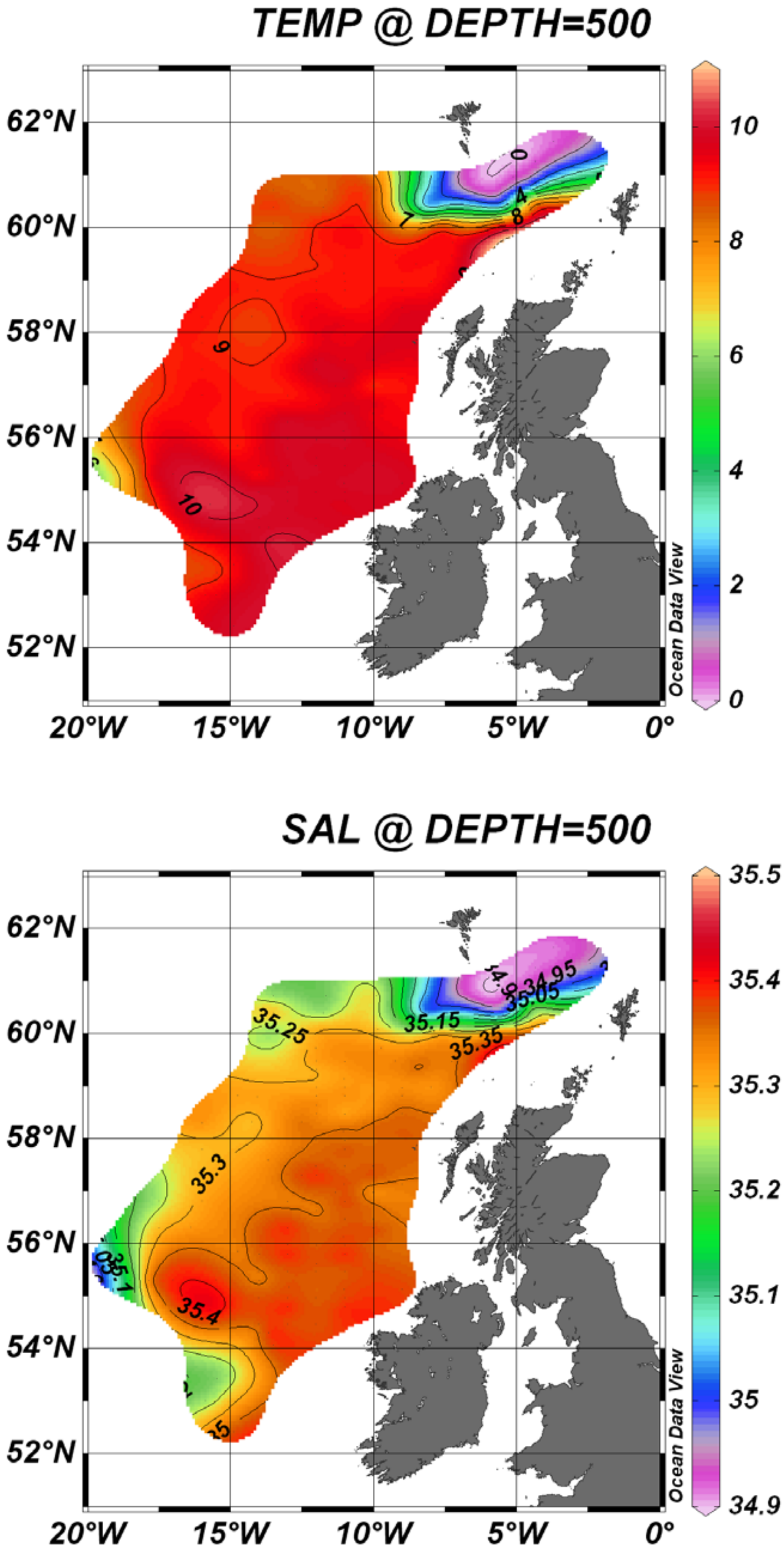


Figure 15. Horizontal temperature (top panel) and salinity (bottom panel) at 500m subsurface as derived from vertical CTD casts. March-April 2014.

Appendix 1. Uncertainty in the acoustic observations and its implications on the stock estimate

The exercise to estimate uncertainty in acoustic blue whiting observations and the consequences of this uncertainty to stock estimates is repeated using the same procedure as in previous years (Appendix 3 in Heino et al. 2007).

When calculating stock estimates from acoustic surveys, the data (acoustics density [s_A] allocated to blue whiting, in units of m^2/n.m.^{2}) from each vessel are expressed as average values over so-called EDSUs (equivalent distance sampling unit) ranging between 1 and 5 n.m. Acoustic density for each survey stratum (subarea with similar fish length distributions) is calculated as an average across all observations (EDSUs) within a stratum, weighted by the length of survey track behind each observation. Normally, these values are then converted to stratum-specific biomass estimates based on information on mean length-at-age of fish in the stratum and the assumed acoustic target strength of the fish; the total survey biomass estimate is the sum of stratum-specific estimates. In the precision estimation exercise routinely performed for the International Blue Whiting Spawning stock Survey (IBWSS), the whole estimation procedure is not repeated, but instead, uncertainty in global mean acoustic density estimates is characterized. As mean size of blue whiting does not vary very much in the survey area, uncertainty in mean acoustic density provides a conservative estimate of uncertainty in total-stock biomass.

Bootstrapping is used to estimate uncertainty in the mean acoustic density. It is calculated by stratum, treating observations from all vessels equally and using lengths of survey track behind each observation as weights when calculating mean density. With 1000 such bootstrap replicates for each stratum, 1000 bootstrap estimates of mean acoustic density, weighted by the stratum areas, are calculated. Bootstrapped mean acoustic density is the mean of these 1000 bootstrap estimates, and confidence limits can be obtained as quantiles of that distribution.

Figure 1 shows the results of this exercise with the data from the 2014 survey as well as ten earlier international surveys. Mean acoustic density over the survey area was 698.5 m^2/n.m.^{2} (as compared to 959.2 m^2/n.m.^{2} in 2013) with 95% confidence interval being 644.1 (lower) and 754.8 (upper) m^2/n.m.^{2}. Relative to the mean, the approximate 95% confidence limits are –7.8% and +8.0%, and 50% confidence limits are –3.0% and +2.9%. This level of uncertainty in acoustic densities is comparable to previous years and among the lowest in the time series so far. Overall, mean acoustic density has shown a consistent decrease annually from 2007 to 2010 and an increase thereafter until 2013. This year, the density has decreased again.

Figure 2 summarises the results and puts them in the biomass context. The overall trend indicates a continued decrease year-on-year in biomass from 2007–2011 for this stock. The uncertainty around the decline in biomass from 2008 to 2011 is more than could be accounted for from spatial heterogeneity alone and is regarded as statistically significant. The biomass estimate from 2010 was omitted in the assessment process due to coverage problems in the survey and a resulting possibility of biomass underestimation. The 2014 estimate shows a slightly decreasing trend in biomass again when compared to the previous two years.

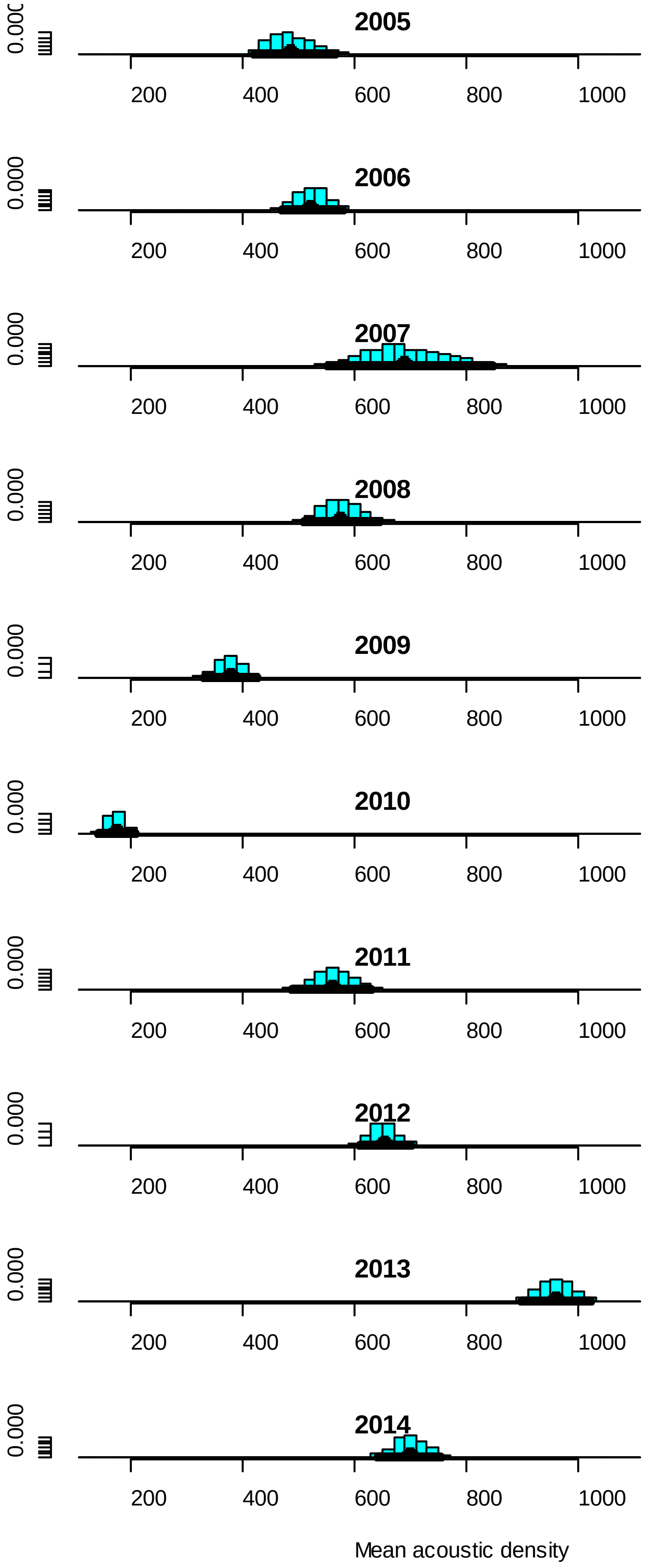


Figure 1. Distribution of mean acoustic density (in $m^2/n.m.^2$) by year based on 1000 bootstrap replicates of acoustic data from blue whiting surveys. Mean acoustic density is indicated with a black dot on the x-axis, while the horizontal bar shows 95% confidence limits.

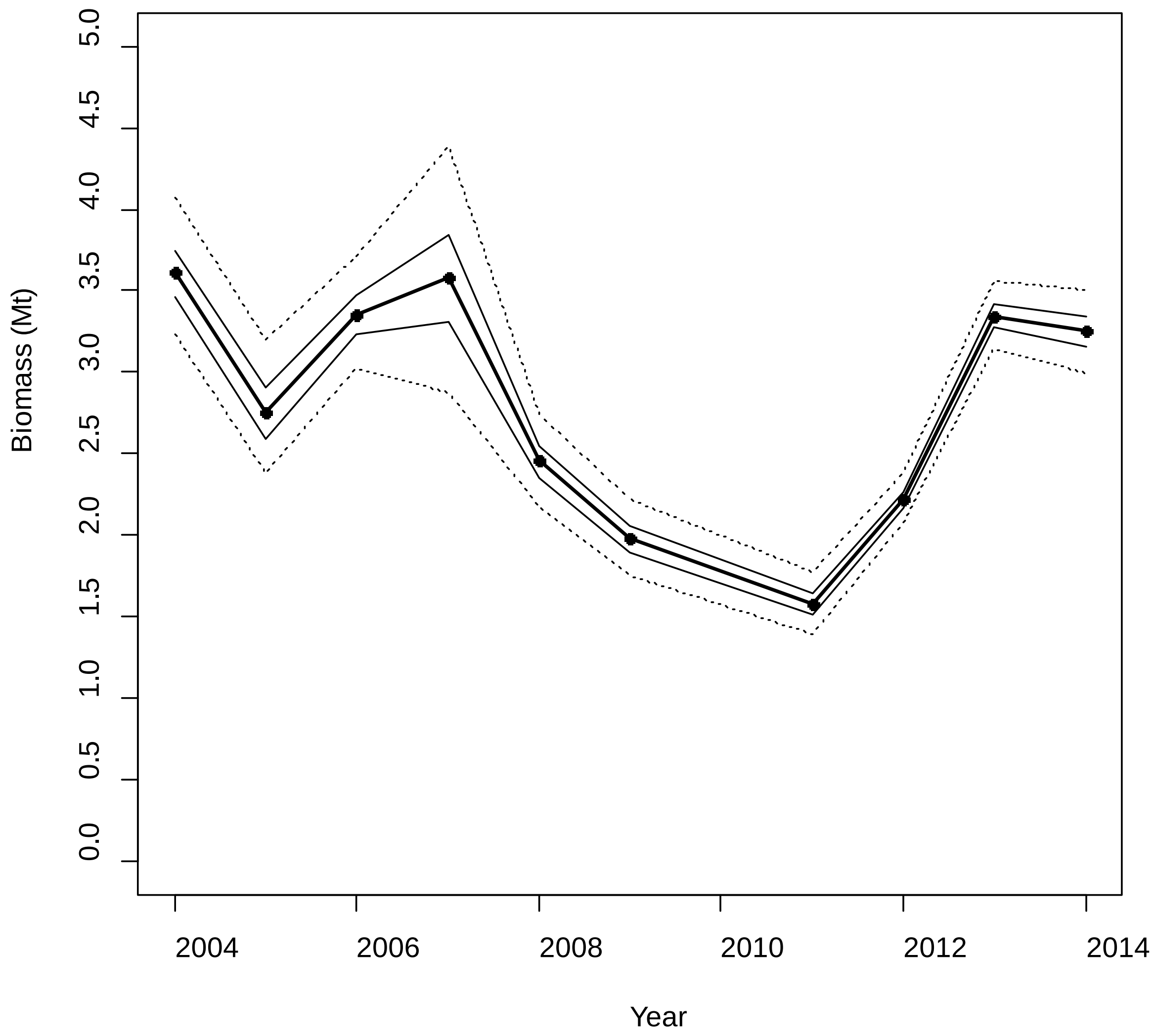


Figure 2. Approximate 50% and 95% confidence limits for blue whiting biomass estimates. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations from the mean values. These confidence limits only account for spatio-temporal variability in acoustic observations.

Appendix 2. Review of age determination of blue whiting by national participants.

A review of consistency of age readings was carried out using data collected from all nations. A broad range of ages were observed from 1 to 15 years from survey data in 2014 with a corresponding length range of 16-46cm.

Results show a relatively good agreement for ages 1-6 years (Figure 1). Some inconsistencies still exist for older age classes (6+ years) which are considered the most difficult to age due to the presence of false rings and the lower number of samples overall. However, for the youngest fish (1-3 year olds) some discrepancies were again observed in 2014. There is an indication that Russia seem to have a lower mean length-at-age for two and three year old fish than the other countries in 2014 (i.e. reading the small fish too old), and perhaps Norway had a higher mean length-at-age that the rest for ages two to four (Figure 1).

A review of data across years (2010-2014) shows a year on year improvement especially for younger age classes up to 2013, however, with some discrepancies again for the youngest fish in 2014 (Figure 2).

Most of the survey age reader personnel participated in the blue whiting age reading workshop (Bergen, June 2013), where otoliths collected during the combined survey in 2013 were used as a worked example for the participants. It is recommended that the age readers look into the discrepancy problem for ages 1-3 in the 2014 blue whiting age reading material.

Figure 1. Profile of length at age by nation of blue whiting collected during individual surveys in 2014 (FO; Faroes, IE; Ireland, NL; Netherlands, NO; Norway and RU; Russia).

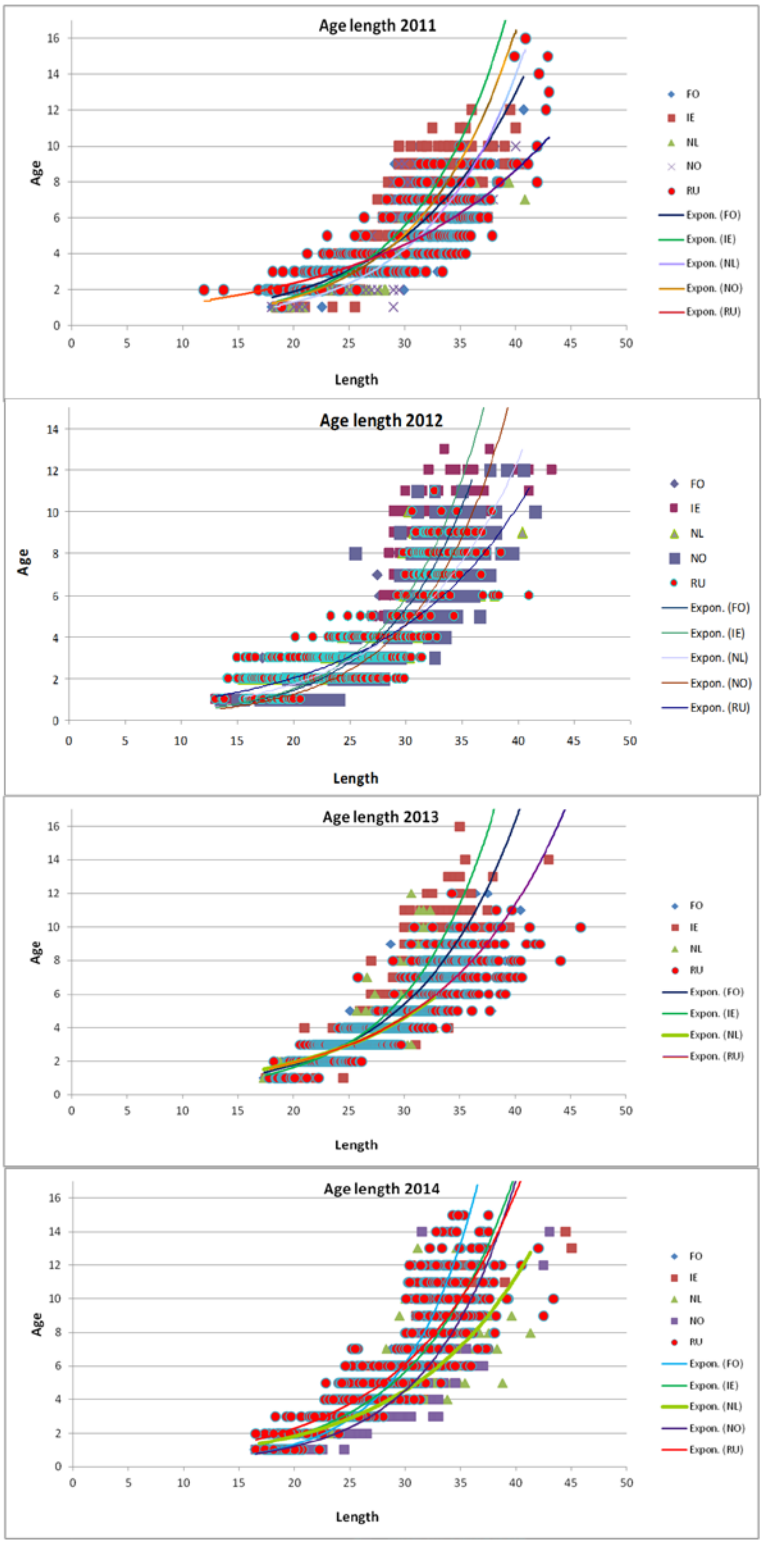


Figure 2. Profile of length at age by nation of blue whiting collected during individual surveys from 2011-2014 (FO; Faroes, IE; Ireland, NL: Netherlands, NO; Norway* and RU; Russia).* No participation from Norway in 2013.

Appendix 3. Planned acoustic survey of the NE Atlantic blue whiting spawning grounds (IBWSS) in 2015

Five vessels representing the Faroe Islands, the Netherlands (EU-coordinated), Ireland (EU-coordinated), Norway and Russia are expected to participate in the 2015 spawning stock survey. There is still uncertainty about the Norwegian participation. Preliminary planning is again based on four vessels at this stage until final participation will be confirmed at the 2015 WGIPS meeting.

Survey timing and design were discussed during the meeting. The group decided that in 2015, the survey design should follow the principle of the one used during the three previous surveys. The focus will still be on a good coverage of the shelf slope in areas II and III. However, given the increasing stock biomass observed over recent years, it can be expected that the distribution will be more extended over the whole survey area as well, as was observed in the 2014 survey. In previous years when larger stock sizes were observed (2004-2007), blue whiting aggregations were distributed more evenly over the whole survey area, including on the Rockall Bank and Rockall Trough. Therefore, the survey design in 2015 will again allocate more effort in these areas as well.

The design is based on variable transect spacing, ranging from 30 nm in areas containing less dense aggregation (e.g. subarea I, south Porcupine), to 10 nm in the core survey area (subarea III, Hebrides) (Figure 4.1). The western borders of the transects in subarea III are extending to 12°W in order to cover potential blue whiting aggregations extending further from the continental slope into the Rockall Trough. To avoid replication, transects will be allocated systematically with a random start location.

The aim is to have three vessels start surveying on their transects just north of subarea II (North Porcupine) at the same time (25.03.2015; Table 1). That way, the core survey subarea III can be covered synoptically by several vessels with a similar temporal progression.

It was decided that the Russian and Irish vessels would start the survey in the southern subareas I and II (Porcupine). 2–4 days after beginning their individual surveys, these vessels will be joint by G.O. Sars and continue surveying the north of subarea II and afterwards area III from the south progressing northwards. Once the Norwegian G.O. Sars vessel has finished surveying subarea III, she will continue northwards into the Faroese-Shetland channel and continue coverage in a north-eastern direction until time allows. The Faroese vessel will primarily survey subarea V (Faroese/Shetland) and join the other vessels in the north of area III once they are present there towards the end of the survey period. The Rockall area will be covered by Tridens, starting in the south on 25.03.2015, progressing northward. Survey extension in terms of coverage (51–61ºN) will be in line with the previous year to ensure containment of the stock and survey timing will also remain fixed as in previous years.

Key will be to achieve coverage of area III in a consistent temporal progression between vessels. It is therefore very important that all vessels covering the core Hebrides area are present on station in the north of subarea II (just north of Porcupine Bank) on 25 March 2015 (Table 1). Nonetheless, if some vessels are found to lag behind others, the tight 10 n.m. transect spacing will allow for adaptation of the survey design without great loss of coverage. For instance, this may mean either skipping or extending some of the horizontal transects to catch up or keep pace with the other vessels. Biological sampling should be carried out following methods normally applied to sampling acoustic registrations.

If registrations of blue whiting marks are continuing at the end of any planned transects, the length of these transects should be extended until no more marks are registered for a distance of 3 n.m. (or 20 minutes at normal survey speed).

Preliminary cruise tracks for the 2015 survey are presented in Figure 1. A new survey coordinator has to be appointed during the next WGIPS meeting, coordinating contact between participants prior to and during the survey. Detailed cruise lines for each ship will be circulated by the coordinator to the group as soon as final vessel availability and dates have been communicated (after WGIPS, latest by the end of January 2015).

As the survey is planned with inter-vessel cooperation in mind it is vitally important that participants stick to the planned transect positioning to ensure that survey effort is evenly allocated and the situation observed in 2010 is not repeated.

Participants are also required to use the logbook system for recording course changes, CTD stations and fishing operations. An example format can be circulated to participants at the 2015 WGIPS meeting. The survey will be carried out according to survey procedures described in the "MANUAL FOR INTERNATIONAL PELAGIC SURVEYS (IPS)" (WGIPS report 2012).

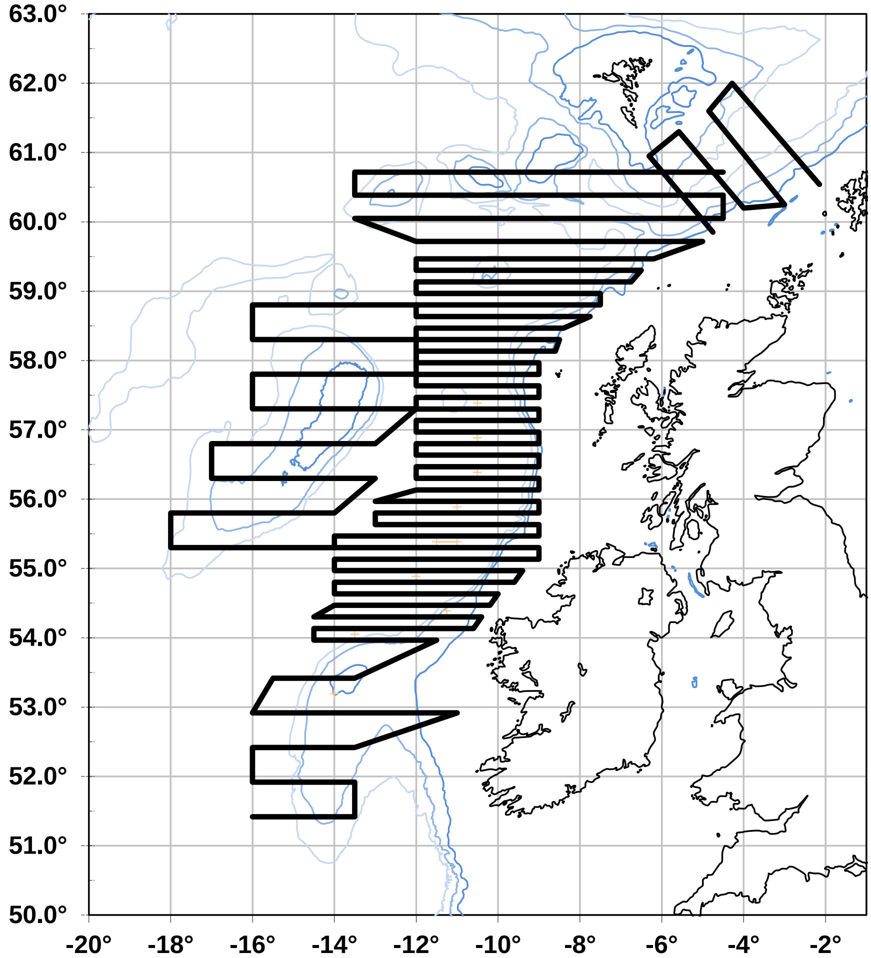


Figure 1. Preliminary survey tracks for the combined 2015 International Blue Whiting Spawning stock Survey (IBWSS).

Table 1. Preliminary individual vessel dates for the 2015 International Blue Whiting Spawning stock Survey (IBWSS).

SHIP	NATION	ACTIVE SURVEY TIME (DAYS)	PRELIMINARY SURVEY DATES
Fritjof Nansen	Russia	19	23.3.2015 – 10.4.2015
Celtic Explorer	Ireland (EU)	19	23.3.2015 – 10.4.2015
G.O. Sars	Norway	14	25.3.2015 – 7.4.2015
Tridens	Netherlands (EU)	17	23.3.2015 – 8.4.2015
Magnus Heinason	Faroe Islands	11	25.3.2015 – 8.4.2015

Working Note to WGWIDE 2014
Blue Whiting Discards in the French Fishery

by Alain Tetard, IFREMER (France)

The French fishery of blue whiting is mainly an industrial one for Surimi. It concerns only one industrial boat targeting the species, JOSEPH ROTY 2. In 2013 it landed 99.8 % of the total French landings. There are no direct information by observer on this fishery, the industry says that there is no discards and this seems true particularly for blue whiting (may be except if the catch is to low for the process of the fish or if species are mixed with blue whiting).

The rest of the landing is done as a by-catch by various métiers not targeting the species. A global analysis of our discard database (2003-2014), in which the industrial JOSEPH ROTY 2 is not sampled, give a discard rate of around 90 %.

The amount of slipping in the French fishery has not been studied.

Working Document

Working Group on International Pelagic Surveys

Copenhagen, Denmark, 24 –26 of June 2014

Working Group on Widely distributed Stocks

Copenhagen, Denmark, 26 August –1 Sept. 2014

INTERNATIONAL ECOSYSTEM SURVEY IN NORDIC SEA (IESNS) IN April – June 2014

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RV G. O. Sars

Karl-Johan Stæhr[3], Bram Couperus[6,] Mathias Kloppmann[8]
RV Dana

Guðmundur J. Óskarsson[7], Sveinn Sveinbjörnsson[7], Héðinn Valdimarsson[7]
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Introduction

In April-June 2014, five research vessels; RV Dana, Denmark (joined survey by Denmark, Germany, Ireland, The Netherlands, Sweden and UK), RV Magnus Heinason, Faroe Islands, RV Arni Friðriksson, Island, RV G.O. Sars, Norway and RV Fridtjof Nansen, Russia participated in the International ecosystem survey in the Nordic Seas (IESNS). The survey area was split into three Subareas: Area I, Barents Sea area, Area II, Northern and central Norwegian Sea Area, and Area III, the South-Western Area (Figure 1). The aim of the survey was to cover the whole distribution area of the Norwegian Spring-spawning herring with the objective of estimating the total biomass of the herring stock, in addition to collect data on plankton and hydrographical conditions in the area. The survey was initiated by the Faroese, Iceland, Norway and Russia in 1995. Since 1997 also the EU participated (except 2002 and 2003) and from 2004 onwards it was more integrated into an ecosystem survey. This report is compilation of data from this International survey stored in the PGNAPES databases and supported by national survey reports from each survey (Dana: Anonymous 2014, Magnus Heinason: Smith & í Homrum FAMRI 1416-2014, Arni Friðriksson: Oskarsson and Sveinbjornsson 2014, Fridtjof Nansen: Rybakov PINRO 2014 and G.O. Sars: not (yet) available.

Material and methods

Coordination of the survey was done only by correspondence as its main platform for discussions, the Working Group on Northeast Atlantic Pelagic Ecosystem Surveys (WGNAPES), was emerged with WGIPS in 2012 and only few scientists involved in this survey attend its meetings. The participating vessels together with their effective survey periods are listed in the table below:

Vessel	Institute	Survey period
Dana	Danish Institute for Fisheries Research, Denmark	13/5–1/6
G. O. Sars	Institute of Marine Research, Bergen, Norway	3/5-31/5
Fridtjof Nansen	PINRO, Russia	14/5–10/6
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	1/5- 12/5
Arni Friðriksson	Marine Research Institute, Island	30/4-22/5

Figure 2 shows the cruise tracks and the CTD/WP-2 stations and Figure 3 the cruise tracks and the trawl stations. Survey effort by each vessel is detailed in Table 1. Frequent contacts were maintained between the vessels during the course of the survey, primarily through electronic mail.

In general, the weather condition did not affect the survey even if there were some days that were not favourable. In the central area the weather conditions were generally excellent during the survey.

The survey was based on scientific echosounders using 38 kHz frequency. Transducers were calibrated with the standard sphere calibration (Foote *et al.*, 1987) prior to the survey. Salient acoustic settings are summarized in the text table below.

Acoustic instruments and settings for the primary frequency (boldface).

	Dana	G.O. Sars	Arni Friðriksson	Magnus Heinason	Fridtjof Nansen
Echo sounder	Simrad EK 60	Simrad EK 60	Simrad EK60	Simrad EK60	Simrad EK60
Frequency (kHz)	**38**	**38**, 18, 70, 120, 200, 333	**38**, 18, 120, 200	**38**,200	**38,** 120
Primary transducer	ES38BP	ES 38B - Serial	ES38B	ES38B	ES38B
Transducer installation	Towed body	Drop keel	Drop keel	Hull	Hull
Transducer depth (m)	3	8.5	8	3	4.5
Upper integration limit (m)	5	15	15	7	10
Absorption coeff. (dB/km)	6.9	10.1	10	10	10
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.425	2.425	2425	2.425
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-20.5	-20.6	-20.9	-20.8	-20.73
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.33	25.5	24.64	25.61	25.72
s_A correction (dB)	-0.55	-0.65	-0.84	-0.72	-0.63
3 dB beam width (dg)					
alongship:	6.73	6.84	7.31	7.02	6.99
athw. ship:	6.77	6.85	6.95	7.01	7.04
Maximum range (m)	500	500	750	500	500
Post processing software	LSSS	LSSS	LSSS	Sonardata Echoview 5.1	LSSS

Post-processing software differed among the vessels but all participants used the same post-processing procedure, which is according to an agreement at a PGNAPES scrutinizing workshop in Bergen in February 2009 (ICES WKCHOSCRU 2009).

Generally, acoustic recordings were scrutinized with the different software (see table above) on daily basis and species identified and partitioned using catch information, characteristic of the recordings, and frequency between integration on 38 kHz and on other frequencies by a scientist experienced in viewing echograms.

All vessels used a large or medium-sized pelagic trawl as the main tool for biological sampling. The salient properties of the trawls are as follows:

	Dana	G.O.Sars	Arni Friðriksson	Magnus Heinason	Fridtjof Nansen
Circumference (m)		832	640	640	500
Vertical opening (m)	25-35	45–50	45–55	45–55	50
Mesh size in codend (mm)		40	40	40	16
Typical towing speed (kn)	3.0-40	4.0–4.5	3.0–4.5	3.0–4.0	3.1–4.3

Catches from trawl hauls was sorted and weighed; fish were identified to species level, when possible, and other taxa to higher taxonomic levels. Normally a subsample of 30–100 herring and blue whiting were sexed, aged, and measured for length and weight, and their maturity status were estimated using established methods. An additional sample of 70–300 fish was measured for length.

Acoustic estimates of herring and blue whiting abundance were obtained during the surveys. This was carried out by visual scrutiny of the echo recordings using post-processing systems. The allocation of sA-values to herring, blue whiting and other acoustic targets were based on the composition of the trawl catches and the appearance of echo recordings. To estimate the abundance, the allocated sA-values were averaged for ICES-squares (0.5° latitude by 1° longitude). For each statistical square, the unit area density of fish (sA) in number per square nautical mile (N*nm-2) was calculated using standard equations (Foote *et al*., 1987; Toresen *et al*., 1998). The following target strength (TS) function was used:

Blue whiting: TS = 20 log(L) – 65.2 dB (rev. acc. ICES CM 2012/SSGESST:01)

Herring: TS = 20.0 log(L) – 71.9 dB

The target strength for herring is the traditionally one used while this target strength for blue whiting was first applied in 2012 (ICES 2012).

To estimate the total abundance of fish, the unit area abundance for each statistical square was multiplied by the number of square nautical miles in each statistical square then summed for all the statistical squares within defined subareas and over the total area. Biomass estimation was calculated by multiplying abundance in numbers by the average weight of the fish in each statistical square then summing all squares within defined subareas and over the total area. The Norwegian BEAM software (Totland and Godø 2001) was used to make estimates of total biomass and numbers of individuals by age and length in the whole survey area and within different subareas.

For the first time, the whole survey area was divided into 5 geographical strata (Figure 4). For each of the strata, east-west transects (except for stratum 6 in the Barents Sea with north-south transects) were decided prior to the survey. Within each stratum, transects were distributed equally apart and the distance was based on available survey time and surveys in previous years. Thus the survey coverage was comparable to previous years, but with more organized interval between transects. This approach will allow for robust statistical analyses of uncertainty of the acoustic estimates in the future.

A new software package (StoX) is under development by IMR, Norway. This is open source software with an infrastructure hosting various types of survey estimation programs for acoustic surveys and trawl surveys (swept area). The program is a stand-alone application build with Java for easy sharing and further development in cooperation with other institutes. The underlying high resolution data matrix structure ensures future implementations of e.g. depth dependent target strength and high resolution length and species information collected with camera systems. Despite this complexity, the execution of an index calculation can easily be governed from user interface and an interactive GIS module, or by accessing the Java function library and parameter set using external software like R. Accessing StoX from external software may be an efficient way to process time series or to perform boot-strapping on one dataset, where for each run, the content of the parameter dataset is altered. In the first version a stratified transect design is assumed (e.g. the IESNS survey plan 2014) and standard statistical methods to estimate mean and variance of abundance will be used. Other methods will be implemented, however, expert specification demands, documentation and statistical rigorousness is essential in the development of "StoX". The software was tested on data collected on this year's IESNS survey.

StoX was used for verification and sensitivity analyses of the biomass estimates of herring. This was done to verify the effect of leaving out transects from Dana because of time-lag of their coverage compare to other vessels (around 10 days later) and obvious nearly lack of herring registrations in parallel adjoining transects with G.O. Sars. This was an exploratory work and the obtained biomass estimates from the program will not be used until a thorough investigation and comparison with the estimates from the BEAM software has taken place. The expectation is that the StoX software will replace the outdated BEAM program in the near future.

Further work on the stratification will take place in the coming years, including defining the most appropriate stratum size and layout of each stratum.

The hydrographical and plankton stations by survey are shown in Figure 2. All vessels collected hydrographical data using a SBE 911 CTD. Maximum sampling depth was 1000 m. Beside the hydrographical sampling from the vessels listed above, hydrographical data from four fixed hydrographical transects (Slétta, Langanes-NE, Langanes-E and Krossanes; Figure 15; total 32 stations) east and north east of Iceland were also used. They were sampled in the spring survey around Iceland by RV Bjarni Sæmundsson during 18-22 May 2014 using the same kind of CTD as the other vessels.

Zooplankton was sampled by a WPII on all vessels except the Russian vessel which used a Djedi net, according to the standard procedure for the surveys. Mesh sizes were 180 or 200 μm. The net was hauled vertically from 200 m or the bottom to the surface. All samples were split in two and one half was preserved in formalin while the other half was dried and weighed. On the Danish, the Icelandic and the Norwegian vessels the samples for dry weight were size fractionated before drying. Data are presented as g dry weight per m^2.

Results

Hydrography

Temperature distribution for April-June 2014

The temperature distributions in the ocean at selected depths between 10 m and 400 m depths are shown in Figures 5-10. The temperatures at the surface ranged between 2°C in the Iceland Sea and 9°C in the southern part of the Norwegian Sea. The Arctic front was encountered slightly below 65°N east of Iceland extending eastwards towards the 0° Meridian where it turned almost straight northwards up 70°N. The front was visible throughout the observed water column. The warmer North Atlantic water formed a broad tongue that stretched far northwards along the Norwegian coast with temperatures > 7 °C to 70° N in the surface layers and to 68 ° N at 200 m depth.

Relative to a 19 years long-term mean, from 1995 to 2013, the temperature at 20 m depth northeast of Iceland was considerable higher in 2014 compared to the long-term mean (Figure 11). There, the anomaly was maximum 2°C. This pattern was also observed at 0-50 m depth at the standard hydrographic sections northeast off Iceland (Figures 15-17). At deeper depths the difference between 2014 and the long term mean was smaller (Figures 12-14). In general, at 200 m and shallower depths the western part of the Norwegian Sea and the Iceland Sea was somewhat warmer than the long-term mean. It was also observed at the standard hydrographic section off northeast Iceland (Figure 18). In the eastern part of the Norwegian Sea the temperature was lower than the mean, particular in the upper layer where it was about 0.5 °C colder than the mean (Figure 11). At 200 m and particular at 400 m depth the temperature was lower than the long-term mean (about 0.25-0.50 °C) in the central Norwegian Basin.

Zooplankton

Biomass of zooplankton and sampling stations are shown in Figure 19. Sampling stations were relatively evenly spread over the area, and most oceanographic regions were covered. The zooplankton biomass was relatively uniform over the whole area, except for higher concentrations off the Norwegian coast around 65°N, and still continues the upwards trend since the lowest recorded value in the time series in 2009 (Figure 20). Recorded zooplankton biomass in the two areas west and east of 2°W equaled 9.4 and 9.8 g dry weight m^{-2}, respectively, while total mean was 9.7 g dry weight m^{-2}. When limiting the area to west of 17°E (eliminating Barents Sea measurements), the biomass indices become 9.4 (west), 9.9 (east) and 9.7 (total) g dry weight m^{-2}. This year, no zooplankton was sampled on the continental slope south and west of Iceland (west of 14°W).

In the Barents Sea, the mean zooplankton biomass was 1.6 g dry weight m^{-2}. It was noted that the Djedy net applied by the Russian vessel in Barents Sea seems to be less effective in catching zooplankton in comparison to WP2 net applied by other vessels in an overlapping area. Thus, the biomass estimates for the Barents Sea are not directly comparable to the other areas, but are comparable among years within the Barents Sea.

Norwegian Spring-spawning herring

Survey coverage in the Norwegian Sea was considered adequate in 2014 and in line with previous years. It is therefore recommended that the results can be used for assessment purpose. The herring distribution in 2014 was similar to the 2013 distribution. The highest concentrations were found in the central to southwestern part of the Norwegian Sea (Figures 21 and 22), and consisted mainly of older part of the stock (age 8 and older; Table 2). A dense concentration was also found in the northeast (around 69°N and 5°E) and consisted of a mixture of all age classes from age 2-14. Overall the herring density was relatively low and herring was never observed in big schools. In 2014, like in previous three years, almost no herring were observed north of 70°N, while it was found further north in 2010. The center of gravity of the acoustic recordings of herring reflects the distribution and shifted in a southwesterly direction compared to 2013 (Figure 23).

As in previous years the smallest fish were found in the eastern area of the Norwegian Sea where size and age were found to increase to the west and south (Figure 24). Correspondingly, it was mainly older herring that appeared in the southwestern areas (area III).

The herring stock is now dominated by 10 year old herring (2004 year class) in numbers but 5, 8, 9, 11 and 12 year old herring (the 2009, 2006, 2005, 2003 and 2002 year classes) are also numerous (Table 2), which is similar to previous years. The 2009 year class appears to be the largest of the younger age groups even it appears to be only around 50% of average size of five year olds in the times series since 1997. The six year classes from 2002 to 2006 and 2009 contribute to 6%, 10%, 22%, 14%, 12% and 14%, respectively, of the total biomass.

The total biomass estimate of herring in the Norwegian Sea from the 2014 survey was 5.1 million tons. This estimate is 0.3 million tons lower than in 2013. The biomass estimates in the last six years has fluctuated, with 10.7 million tons in 2009, 5.8 million tons in 2010, 7.4 million tons in 2011, 4.6 million tons in 2012, 5.4 million tons in 2013 and now 5.1 million tons in 2014.

The investigations of herring in the Barents Sea covered the area from 44°E to the 20°30′ E. The total abundance estimate was higher than in the last two years, with 5876 million individuals of age 1 (mean length of 11.5 cm and weight of 8.7 g), 2185 million individuals of age 2 (mean length of 17.8 cm and mean weight of 32.4 g), 2156 million individuals of age 3 herring (mean length of 23.8 cm and mean weight of 76.3 g) and 242 million individuals of age 4 herring (mean length of 25.7 cm and mean weight of 95.9 g). Only very few older herring were observed.

The total number of herring recorded in the Norwegian Sea was 9.6 billion in the northeastern area and 10.4 billion in the southwestern area, compared to 12.8 and 13.0 billion in the northeastern and 7.2 and 7.4 billion in the southwestern area in 2012 and 2013, respectively.

Blue whiting

The total biomass of blue whiting registered during the May 2014 survey was 0.63 million tons (Table 3), which is somewhat less than the biomass estimate in 2013. The stock estimate in number for 2014 is 8.9 billion, which is approximately the same number as in 2012 estimate. The decrease in biomass without a decrease in abundance is caused by more young fish in the stock. Age one is dominating the estimate whereas in 2013 the 1-group was more or less absent. The estimate of 1-

goup in 2014 is 3.7 billion compared to only 0.6 billion in 2013. The number of 2 year olds was lower than in 2013, 2.5 billion compared to 6.3 billion. These results confirm the weak 2012 year class and suggest that the 2013 year class is stronger. This year class constituted to 41% of the total number and 26% of the total biomass.

An estimate was also made from a subset of the data or a "standard survey area" between 8°W–20°E and north of 63°N, which has been used as an indicator of the abundance of blue whiting in the Norwegian Sea because the spatial coverage in this area provides a coherent time-series with adequate spatial coverage. This standard survey area estimate is used as an abundance index in WGWIDE. The age-disaggregated total stock estimate in the "standard area" is presented in Table 4, showing that the blue whiting in this index area was dominated by fish at age 2 in terms of numbers and age 3 in terms of biomass, i.e. the youngest fish (age 1) is mostly found outside the "standard survey area".

The distribution of blue whiting in 2014 was similar to 2013, but the strong concentration found in the north eastern corner of the Norwegian Sea found in 2013 was absent in 2014. The main concentrations were observed both in connection with the continental slopes of Norway and south and southwest Iceland and in the open sea in the southern part of the Norwegian Sea (Figures 25 and 26). The mean length of blue whiting is shown in Figure 27. It should be noted that the spatial survey design was not intended to cover the whole blue whiting stock during this period.

Mackerel

In later years an increasing amount of mackerel has been observed in the Norwegian Sea during the combined survey in May targeting herring and blue whiting. The edge of the distribution has also been found progressively further north and west. However, the mackerel was mainly found in the eastern part of the survey area up to 67°N in May 2014, with few exceptions at western stations further south. This distribution is comparable to the May surveys in 2012 and 2013. It should be noted, however, that the sampling may not provide a representative picture of mackerel distribution because of its vertical distribution and relatively low trawling speed.

Stomach samples from the three pelagic species (herring, blue whiting and mackerel) were collected by the Norwegian, Icelandic and Faroese vessels. These samples have however, not been analyzed yet and will be reported by other means later.

Discussion

Hydrography

Discussions related to the oceanographic condition in April/July 2014 are provided in the results section above, while more general patterns are introduced in this section.

Two main features of the circulation in the Norwegian Sea, where the herring stock is grazing, are the Norwegian Atlantic Current (NWAC) and the East Icelandic Current (EIC). The NWAC with its offshoots forms the northern limb of the North Atlantic current system and carries relatively warm and salty water from the North Atlantic into the Nordic Seas. The EIC, on the other hand, carries Arctic waters. To a large extent this water derives from the East Greenland Current, but to a varying extent, some of its waters may also have been formed in the Iceland and Greenland Seas. The EIC flows into the southwestern Norwegian Sea where its waters subduct under the Atlantic waters to form an intermediate Arctic layer. While such a layer has long been known in the area north of the Faroes and in the Faroe-Shetland Channel, it is only in the last three decades that a similar layer has been observed all over the Norwegian Sea.

This circulation pattern creates a water mass structure with warm Atlantic Water in the eastern part of the area and more Arctic conditions in the western part. The NWAC is rather narrow in the southern Norwegian Sea, but when meeting the Vøring Plateau off Mid Norway it is deflected westward. The western branch of the NWAC reaches the area of Jan Mayen at about 71°N. Further northward in the Lofoten Basin the lateral extent of the Atlantic water gradually narrows again, apparently under topographic influence of the mid-ocean ridge. It has been shown that atmospheric forcing largely controls the distribution of the water masses in the Nordic Seas. Hence, the lateral extent of the NWAC, and consequently the position of the Arctic Front, that separates the warm North Atlantic waters from the cold Arctic waters, is correlated with the large-scale distribution of the atmospheric sea level pressure.

Plankton

The zooplankton biomass has been estimated since 1997 (Figure 20). After a severe decline from 2003 until 2009 (~4 g/m^2), the biomass has now been showing an upward trend for 5 years and reached 9.7 g/m^2 in 2014. The biomass now is close to what it was in the period prior to 2004 and shows an increase both in the west and particularly in the east. The decrease in zooplankton biomass until 2009 - was dramatic in the sense that biomass in the cold water decreased by 80% since 2003, while in the warmer water, the biomass decreased by 55% since 2002. The reason for this drop in biomass, or the increase since 2010, is not obvious to us. The unusually high biomass of pelagic fish feeding on zooplankton has been suggested to be one of the main causes for the reduction in zooplankton biomass. However, carnivorous zooplankton and not pelagic fish are the main predators of zooplankton in the Norwegian Sea (Skjoldal *et al.*, 2004), and we do not have good data on the development of the carnivorous zoo-plankton stocks. A fairly strong relationship between NAO and zooplankton biomass was observed, particularly during the late 1990s. However, this relationship seems to be less pronounced now. The linkage between sea temperature and zooplankton abundance is also not fully understood and needs further explorations.

The zooplankton biomass in Barents Sea showed an increase from last year, from 1.2 to 1.6 g dry weight m^{-2}, and in 2012 the biomass was 1.7 g dry weight m^{-2}. However, as stated above, the biomass estimates for the Barents Sea taken with the Djedi net are not directly comparable to the other areas taken by WP2 nets, but are comparable among years within the Barents Sea.

Summing up, the reason for the observed changes in zooplankton biomass is not clear to us and more research to reveal this is recommended. Quantitative researches on carnivorous zooplankton stocks (such as krill and amphipods) across the whole survey area, is an important step in that direction and needs a further effort by all participating countries.

The estimations of average biomass of zooplankton, discussed above, have included the whole areas covered by the survey vessels each year. However, it has been noted that the research effort can vary by a lot in the continental slope area south and west off Iceland. For that reason, and to get biomass indices representative for Norwegian Sea it self, it is recommended to re-estimate the whole time series and limit the area to east of 14°W and west of 17°E. The data are not yet all in the NAPES database so this could not be done at the meeting where this report was prepared.

Norwegian spring-spawning herring

The Norwegian spring-spawning herring is characterized by large dynamics with regard to migration pattern. This applies to wintering, spawning and feeding area. The following discussion will mainly concentrate on the distribution and situation in the feeding areas in May, but no attempt was done to draw up the likely feeding migration that is believed to be comparable to recent years.

The amount of herring measured in the 2014 survey was 6% lower than in 2013. The biomass estimates in the last six years has fluctuated, with 10.7 million tons in 2009, 5.8 in 2010, 7.4 in 2011, 4.6 million tons in 2012, 5.4 million tons in 2013 and 5.1 millon tons in 2014. Work is presently being conducted to obtain an estimate of uncertainty in the survey. The uncertainty, or the CV, round the estimates is estimated to be less than 30% for each of the age groups 3-12 for the years 2009 – 2013 (Stenevik, *et.al.*, 2014). However, the downward trend in the biomass is apparent.

The new approach of dividing the survey area into stratum is considered as valid improvements in terms of securing equivalent coverage among years and allow for robust statistical analyses of uncertainty of the acoustic estimates in the future.

In the last years there have been concerns regarding age reading of herring, because the age distribution from the different participants have showed differences. This is also the case in 2014. Partly, the differences may reflect differing spatial distribution of age groups, and partly, they may reflect variable growth conditions for the stock, and consequently growth rate as seen on the fish scales and otoliths. In spring 2014 an otolith and scale exchange was conducted, as was suggested by the survey group in last year's survey report to address these issues. The results have not yet been finally analysed, and therefore possible necessary changes in age reading procedures have not yet been implemented. The survey group recommend that a age reading workshop is held as soon as possible.

There are concerns with the acoustic estimates from Dana during this year's survey, which adds uncertainty to the present acoustic estimates of the herring. The concerns are because of almost zero registrations of herring on their fourth and fifth east-west transects, and also weak registrations on the third, compare to neighbour transects from G.O. Sars with much higher registrations (Figures 21 and 22). The fact that herring was caught by Dana along these transects in areas without herring registrations adds to the concerns that something is wrong with the data from Dana and needs a further attention. Two possible reasons for this discrepancy are of consideration: (1) Time-lag where Dana was around 10 days later compare to other vessels; (2) Problems related to the scrutinizing procedure in Dana. Catches of herring where herring was not recorded acoustically, only blue whiting, supports the second option and calls for re-scrutinizing of the acoustic data where the procedure described in the WGIPS manual is strictly followed. Until the re-scrutinizing has been done there is not much to add to this discussion.

Blue whiting

The abundance estimate of blue whiting confirms that the 2012 year class is weak and that there is a good signal that the 2013 year class is stronger. A positive sign in development of the stock size was first observed in the 2011 survey where blue whiting at age 1 and 2 were in higher numbers than the previous years. The number of 1 year old in the standard area (Table 4) this year is low, but they are found in a higher degree outside the standard area stating that the 2013 year class is stronger than the previous one.

General recommendations and comments

Recommendation	Adressed to
1. A workshop on scrutinizing of acoustic data from the survey is highly recommended by the group. The procedure is to a large extent subjective and therefore it is very important that all scientists responsible for the scrutinization are following the same general procedure. The workshop should preferably take place during the autumn/winter 2013/2014, or prior to the surveys in 2014. The uncertainty regarding the scrutinizing procedure onboard of Dana in this years survey (above), emphasizes the need for the workshop and also involvement of new scientists responsible for the scrutinizing in the survey (e.g. from Iceland, Norway and the Faroes) since the last workshop was held.	ACOM, WGWIDE, WGIPS
2. The survey group recommends that an age reading workshop will be held as soon as possible. This is to follow up on issues identified following analyses of otoliths and scales exchanges in 2014 (preliminary report available from Jane A. Godiksen, IMR, Norway).	ACOM, WGWIDE
3. Establishment of quantitative researches on carnivorous zooplankton stocks (such as krill and amphipods) across the whole survey area are recommended. It would require use of standardized fishing gears, such as the krill trawl used by Norway in recent years and Iceland in 2014.	Participating countries, WGWIDE, WGIPS

Next years post-cruise meeting

Preliminary dates are 16-18 June, in Copenhagen or Murmansk. Will be decided at WGIPS in January 2015.

Concluding remarks

- At 200 m and shallower depths the western part of the Norwegian Sea and the Iceland Sea was somewhat warmer than the 19 years mean. The temperature at 20 m depth northeast of Iceland was up to 2°C higher than the long-term mean, while around and just above mean in other areas.
- The index of plankton biomass in the Norwegian Sea continues to increase and is now close to the level prior to the period of decline (2004-2010.)
- The estimate of NSSH was 6 % lower compared to last year
- NSSH was dominated by the 2004 year class, but also the 2009 year class contributed significantly

- No strong year classes of NSSH were observed in the Barents Sea indicating poor recruitment since 2004.
- The amount of blue whiting measured in the survey area was similar to last year.
- The blue whiting estimate is dominated by three year classes, 2013, 2012 and 2011, and they constitute 28% of the biomass and 87% of the abundance.

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Tables

Table 1. Survey effort by vessel for the International ecosystem survey in the Nordic Seas in April-June 2014.

Vessel	Effective survey period	Effective acoustic cruise track (nm)	Trawl stations	Aged fish (HER)	Length fish (HER)	CTD stations	Plankton station
Dana	13/5-1/6	2539	32	466	1709	35	36
G.O.Sars	4/5-26/5	3332	52	488	1554	66	68
Fridtjof Nansen	15/5-6/6	3525	47	369	2458	104	106
Magnus Heinason	1/5-12/5	1210	12	285	576	20	20
Árni Friðriksson	30/4-22/5	4039	32	690	2646	43	53
Total	1/5-6/6	14645	171	2298	8943	268	284

Table 2. Age and length-stratified abundance estimates of Norwegian spring-spawning herring in April-June 2014 for total area and abstracts of estimates for subareas I, II and III.

Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Number	Biomass	Weight
10																0		
11																0		
12																0		
13																0		
14																0		
15																0		
16																0		
17																0		
18	62	125	0	0	0	0	0	0	0	0	0	0	0	0	0	187	8.4	45
19	0	56	0	0	0	0	0	0	0	0	0	0	0	0	0	56	3.1	55
20	0	248	0	0	0	0	0	0	0	0	0	0	0	0	0	248	15.4	62
21	0	97	63	0	0	0	0	0	0	0	0	0	0	0	0	160	11.6	73
22	0	91	97	0	0	0	0	0	0	0	0	0	0	0	0	188	15.8	84
23	0	27	292	0	0	0	0	0	0	0	0	0	0	0	0	319	30.9	97
24	0	9	195	0	0	0	0	0	0	0	0	0	0	0	0	204	22.4	110
25	0	0	456	15	0	0	0	0	0	0	0	0	0	0	0	471	56	119
26	0	14	254	28	0	0	0	0	0	0	0	0	0	0	0	296	39.9	134
27	0	6	114	72	12	0	0	0	0	0	0	0	0	0	0	204	30.6	150
28	0	0	53	178	125	18	0	0	0	0	0	0	0	0	0	374	62.4	167
29	0	0	64	270	651	79	32	0	0	0	16	0	16	16	0	1144	211.7	185
30	0	0	24	327	533	48	36	24	12	0	0	0	0	0	0	1004	202.8	202
31	0	0	13	91	431	78	26	26	39	13	26	13	0	26	0	782	173.3	221
32	0	0	0	85	693	99	14	85	57	28	0	0	0	0	0	1061	260.9	246
33	0	0	0	29	405	87	260	477	361	246	87	14	0	0	0	1966	529.1	269
34	0	0	0	11	261	109	381	871	828	1275	359	261	54	0	0	4410	1274.1	287
35	0	0	0	0	20	30	163	600	773	1586	763	366	102	41	40	4484	1362.5	303
36	0	0	0	0	9	0	18	71	266	443	363	327	195	62	71	1825	585.6	321
37	0	0	7	0	0	0	0	7	21	63	42	56	91	28	42	357	120	336
38	0	0	0	0	6	0	0	0	0	13	0	25	31	19	32	126	44.9	357
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	2.1	383
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0.8	405
42																0		
Number 10^6	62	673	1632	1106	3146	548	930	2161	2357	3667	1656	1062	489	192	193	19874	5064	
Biomass 10^3 t	5.9	45.1	198.7	214	711.7	138.9	257.1	617.3	686.8	1091	497.2	325.9	153.8	57.1	63.4	5064	5064.2	
Mean length cm	20.8	20.8	25.4	29.9	31.6	32.3	34	34.5	34.8	35.1	35.3	35.7	36.2	35.4	37		32.8	
Mean weight g	79.9	67.1	121.7	193.4	226.1	241	276.4	285.6	291.5	297.6	300.3	306.4	314.3	298.1	332		254.4	

Table 2. (cont'd)

Area 1

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	5876	2185	2156	242	45	2	1	1	0	0	0	0	10508
Biomass 10^3 t	51	70.9	164.6	23.2	6.9	0.6	0.5	0.6					318.3
Mean length cm	11.5	17.8	23.8	25.7	30	31.3	31.9	32.5					15.7
Mean weight g	8.7	32.4	76.3	95.9	151.5	179.6	192.8	202.7					30.3

Area 2

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	63	673	1549	983	2267	262	352	562	660	1117	446	263	214	62	81	9554
Biomass 10^3 t	2.8	45	186.4	186.9	488.9	57.1	93.9	158.4	187.5	327.5	131	79.2	64.2	15	26.5	2050.3
Mean length cm	18.4	20.8	25.3	29.8	31.2	31.3	33.8	34.5	34.7	35.2	35.2	35.5	35.6	32.7	37.1	30.7
Mean weight g	44.2	67.1	120.4	190	215.7	217.3	266.8	281.7	284.1	293.1	293.7	298.6	300.1	245	320	214.5

Area 3

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	0	0	81	86	777	328	582	1664	1724	2556	1244	823	254	136	101	10356
Biomass 10^3 t			24.1	19.1	196.6	83.4	162.2	482.6	512.2	772.2	379.7	256.6	83.7	44.9	33.1	3050.4
Mean length cm			26.9	30.4	32.3	33.2	34	34.4	34.8	35.1	35.3	35.7	36.7	36.8	36.9	34.7
Mean weight g			175.5	221.7	252.3	269.5	284.3	290.1	297.1	302	305.2	312.1	329.6	332.7	340	294.6

Area 2 and 3

(Norwegian Sea)

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	62	673	1632	1106	3146	548	930	2161	2357	3667	1656	1062	489	192	193	19874
Biomass 10^3 t	5.9	45.1	198.7	214	711.7	138.9	257.1	617.3	686.8	1091	497.2	325.9	153.8	57.1	63.4	5063.9
Mean length cm	20.8	20.8	25.4	29.9	31.6	32.3	34	34.5	34.8	35.1	35.3	35.7	36.2	35.4	37	32.8
Mean weight g	79.9	67.1	121.7	193.4	226.1	241	276.4	285.6	291.5	297.6	300.3	306.4	314.3	298.1	332	254.4

Total

(All areas)

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	5939	2858	3787	1312	3080	601	934	2228	2386	3676	1691	1088	468	198	183	30429
Biomass 10^3 t	60	116	365	229.2	689.4	143	260.3	641.3	700.1	1100	510.8	335.9	147.9	59.9	59.6	5418.4
Mean length cm	11.6	18.5	24.5	29.1	31.4	32.3	33.9	34.4	34.8	35.1	35.3	35.7	36.2	35.5	37.1	26.9
Mean weight g	9.6	40.6	96.4	174.7	223.9	245	277.5	287.9	293.5	299.3	302.2	308.8	316.1	305.1	340	178.2

Table 3. Age and length-stratified abundance estimates of blue whiting in April-June 2014, west of 20°E for total area and abstracts of estimates for subareas II and III.

Length	1	2	3	4	5	6	7	8	9	10	11	12+	Number 10^6	Biomass 10^3 t	Mean Weight
10													0		
11													0		
12													0		
13													0		
14													0		
15	0	1	0	0	0	0	0	0	0	0	0	0	1	0	19
16	3	10	0	0	0	0	0	0	0	0	0	0	13	0.3	26
17	63	54	0	0	0	0	0	0	0	0	0	0	117	3.3	28
18	484	403	9	0	0	0	0	0	0	0	0	0	896	29.5	33
19	941	662	10	0	0	0	0	0	0	0	0	0	1613	62.5	39
20	1115	588	4	0	0	0	0	0	0	0	0	0	1707	77.6	46
21	688	250	16	0	0	0	0	0	0	0	0	0	954	50.8	53
22	349	277	48	24	0	0	0	0	0	0	0	0	698	43.1	62
23	22	65	84	15	0	0	0	0	0	0	0	0	186	13.6	73
24	3	36	186	36	0	0	0	0	0	0	0	0	261	21.7	83
25	0	41	229	77	6	0	0	0	0	0	0	0	353	33.5	95
26	0	55	421	122	19	4	0	0	0	0	0	0	621	65.7	106
27	0	28	357	118	34	0	0	0	0	0	0	0	537	64.6	120
28	0	3	181	106	31	0	0	0	0	0	0	0	321	42.5	132
29	5	0	85	113	17	14	0	0	0	0	0	0	234	34.8	150
30	0	0	14	25	27	4	4	2	2	2	0	0	80	13.2	167
31	0	0	0	23	20	13	5	5	3	3	0	0	72	13.3	187
32	0	0	0	17	39	14	5	4	13	8	5	0	105	20.8	200
33	0	0	3	3	0	10	3	15	9	3	0	4	50	10.8	221
34	0	0	0	1	1	5	4	6	1	4	2	2	26	6.3	234
35	0	0	0	0	0	0	12	14	11	1	2	2	42	10.7	257
36	0	0	0	0	1	1	1	1	12	0	12	12	40	12.1	303
37	0	0	0	0	0	1	0	2	0	2	0	0	5	1.8	281
38	0	0	0	0	0	0	2	1	0	0	0	0	3	0.9	282
39													0		
40													0		
41													0		
42													0		
43													0		
Number 10^6	3673	2473	1647	680	195	66	36	50	51	23	21	20	8935	633	
Biomass 10^3 t	167.4	118.3	174.6	83.4	29.8	12.1	7.7	11.5	12.4	4.8	5.7	5.7	633.4	633.4	
Length cm	20.3	20.6	26.4	27.6	29.6	31.7	33.9	34.1	34.3	33.3	35.3	35.5		22.7	
Weight g	45.6	47.9	106.1	122.6	153	187	225.5	230.2	242	216.3	270.6	287		70.9	

Area 2

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	1436	2234	1135	494	85	22	24	39	20	16	0	0	5505
Biomass 10^3 t	59.2	96.6	114.3	57	12.2	3.5	5.5	9	4.7	3.5			365.5
Length cm	19.9	20.1	26	27.1	29	30.4	34.7	34.1	33.7	33.3			22.3
Weight g	41.2	43.2	100.9	115.7	145.1	166.4	240.1	229.7	225	216.8			66.5

Area 3

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	2238	238	514	189	112	45	12	11	31	6	21	20	3437
Biomass 10^3 t	108.2	21.7	60.3	26.4	17.6	8.6	2.2	2.5	7.7	1.3	5.7	5.7	267.9
Length cm	20.6	24.8	27.1	28.8	30	32.3	32.4	34.3	34.6	33.4	35.3	36	23.2
Weight g	48.3	91.5	117.5	140.6	159	197	196	231.9	253.6	214.8	270.6	285	78.1

Area 2 and 3 (Norwegian Sea)

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	3673	2473	1647	680	195	66	36	50	51	23	21	20	8935
Biomass 10^3 t	167.4	118.3	174.6	83.4	29.8	12.1	7.7	11.5	12.4	4.8	5.7	5.7	633.4
Length cm	20.3	20.6	26.4	27.6	29.6	31.7	33.9	34.1	34.3	33.3	35.3	35.5	22.7
Weight g	45.6	47.9	106.1	122.6	153	187	225.5	230.2	242	216.3	270.6	287	70.9

Table 4. Blue whiting in "Standard Area" 8°W - 20°E and north of 63°N in IESNS 2014.

Length	1	2	3	4	5	6	7	8	9	10	11	12+	Number	Biomass	Weight
10													0		
11													0		
12													0		
13													0		
14													0		
15													0		
16	0	10	0	0	0	0	0	0	0	0	0	0	10	0.2	26
17	33	53	0	0	0	0	0	0	0	0	0	0	86	2.3	27
18	334	373	10	0	0	0	0	0	0	0	0	0	717	23.1	32
19	449	559	9	0	0	0	0	0	0	0	0	0	1017	38.6	38
20	356	495	0	0	0	0	0	0	0	0	0	0	851	38	45
21	152	219	8	0	0	0	0	0	0	0	0	0	379	19.9	52
22	74	222	49	25	0	0	0	0	0	0	0	0	370	22.7	61
23	0	18	75	13	0	0	0	0	0	0	0	0	106	7.5	71
24	0	4	141	23	0	0	0	0	0	0	0	0	168	13.4	80
25	0	6	152	69	3	0	0	0	0	0	0	0	230	21.1	92
26	0	7	249	75	14	0	0	0	0	0	0	0	345	35.9	104
27	0	0	200	75	15	0	0	0	0	0	0	0	290	34.8	120
28	0	0	84	62	16	0	0	0	0	0	0	0	162	21.6	134
29	4	0	41	64	4	11	0	0	0	0	0	0	124	18.8	152
30	0	0	3	9	8	2	3	2	0	2	0	0	29	4.7	173
31	0	0	0	5	3	3	3	5	3	0	0	0	22	4.1	196
32	0	0	0	13	25	6	0	6	19	13	0	0	82	17.4	213
33	0	0	3	3	0	3	3	12	9	3	0	0	36	8.2	226
34	0	0	0	2	2	0	2	4	2	2	0	0	14	3.7	258
35	0	0	0	0	0	0	8	11	4	0	4	4	31	8.2	270
36	0	0	0	0	7	7	7	7	0	0	7	0	35	10.3	279
37	0	0	0	0	0	1	0	2	0	2	0	0	5	1.7	279
38	0	0	0	0	0	0	2	1	0	0	0	0	3	0.8	285
39													0		
40													0		
41													0		
42													0		
43													0		
Number 10^6	1402	1966	1024	438	97	33	28	50	37	22	11	4	5112	357.0	
Biomass 10^3 t	57.7	84.9	103.3	51.9	15.9	6.9	6.9	12.5	8.1	4.8	3.1	1	357	357.3	
Length cm	19.9	20.1	26	27.2	30	32.5	34.8	34.3	33.1	33.3	36.2	35.5		22.5	
Weight g	41.1	43.2	101	118.7	166.3	207.3	250.2	243.4	223.4	223.6	275.9	270.3		69.9	

Figures

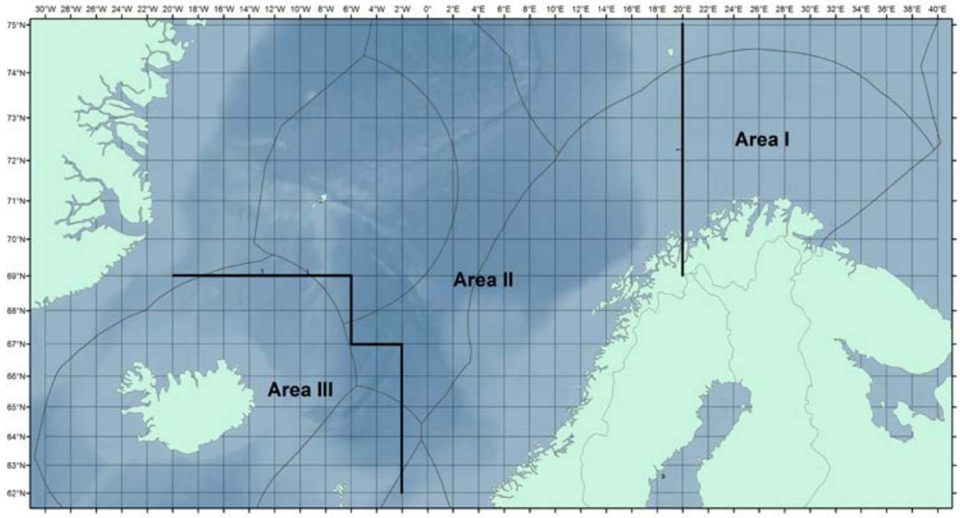

Figure 1. Areas defined for acoustic estimation of blue whiting and Norwegian spring-spawning herring in the Nordic Seas.

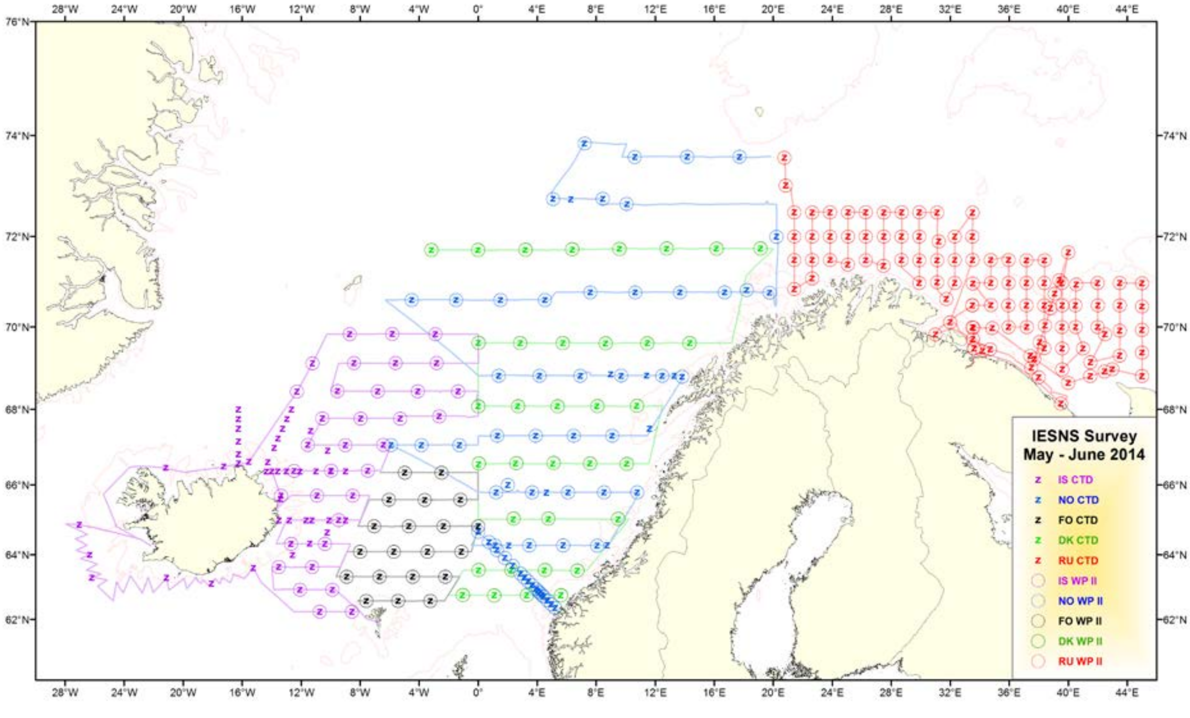

Figure 2. Cruise track, CTD and WP II stations by country for the International ecosystem survey in the Nordic Seas in April-June 2014.

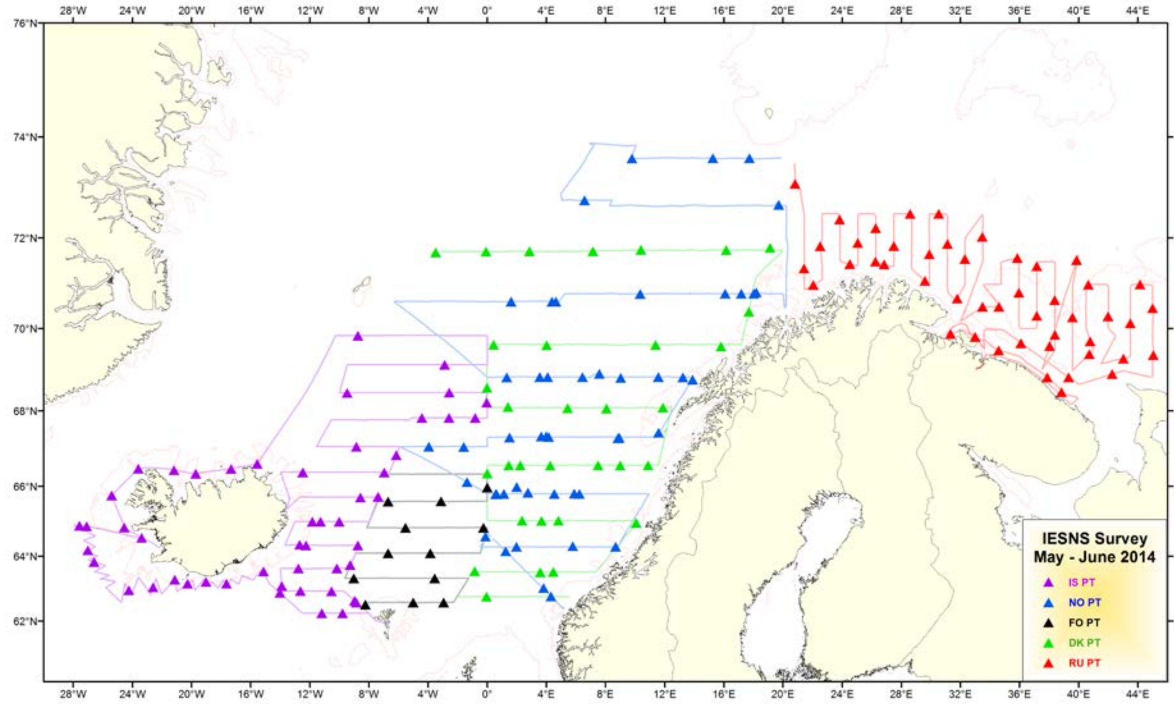

Figure 3. Cruise tracks during the International North East Atlantic Ecosystem Survey in April-May 2014 and location of trawl stations.

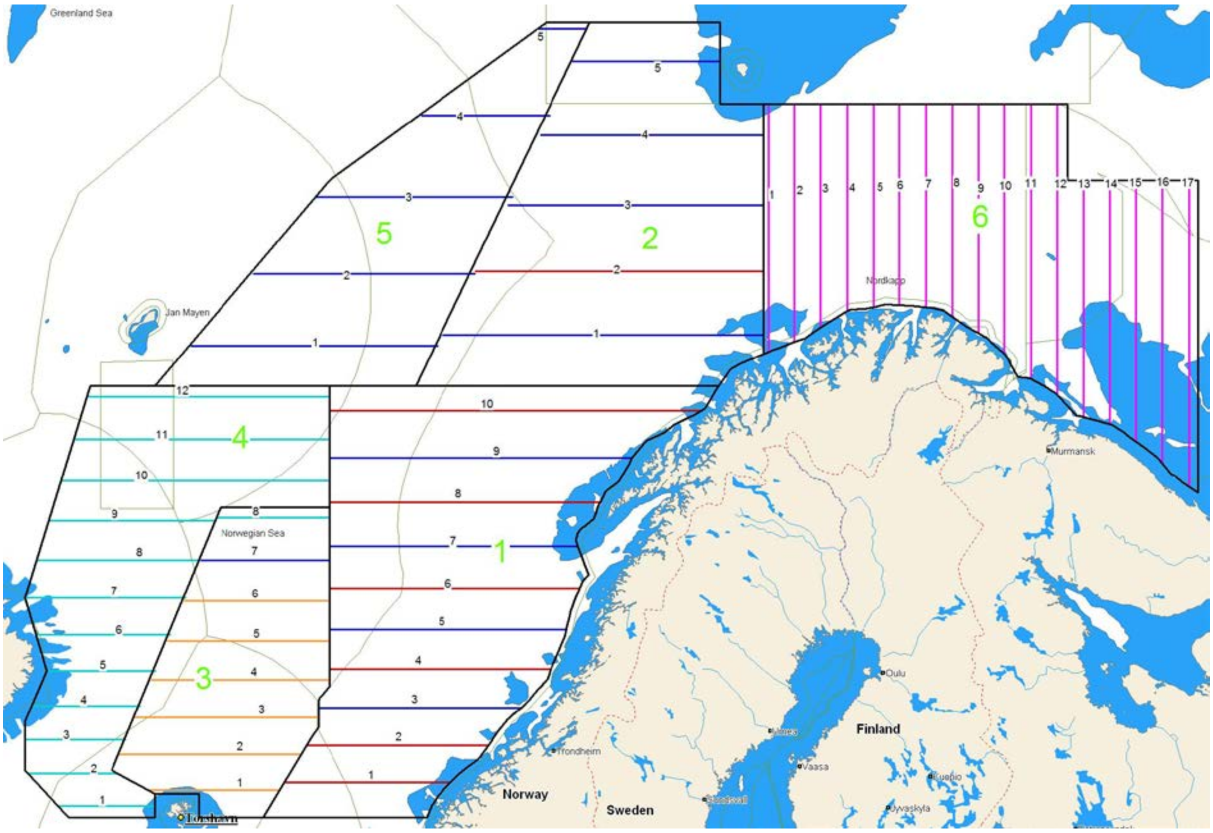

Figure 4. The planed cruise tracks and division of the five stratum used in the IESNS survey 2014.

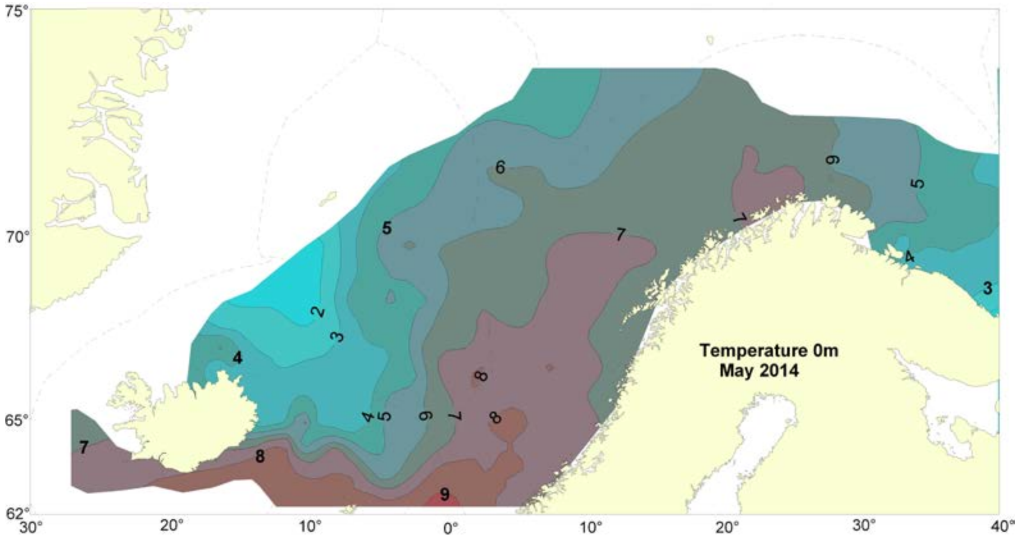

Figure 5. The horizontal sea surface temperature distribution in April-June 2014.

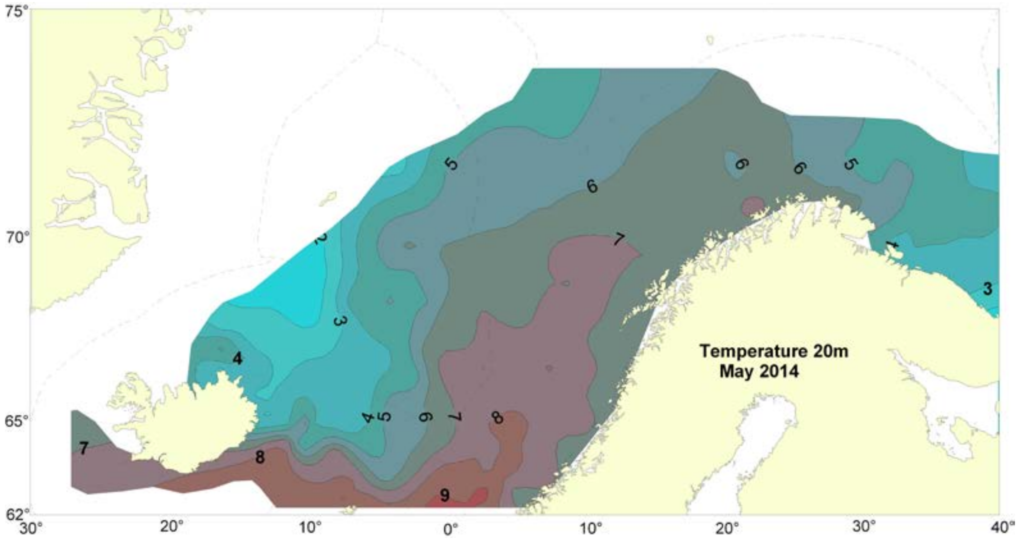

Figure 6. The horizontal distribution of temperatures at 20 m depth in April-June 2014.

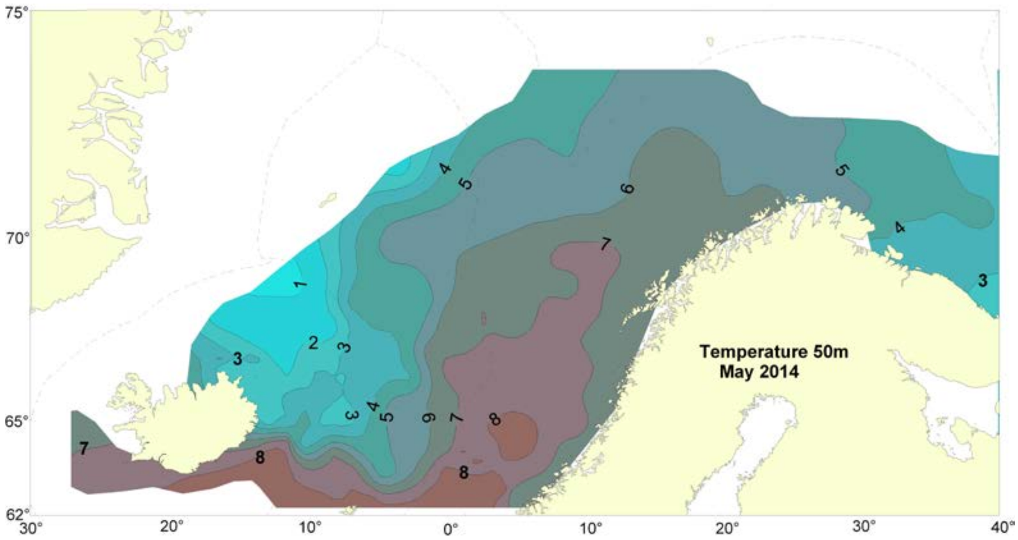

Figure 7. The horizontal distribution of temperatures at 50 m depth in April-June 2014.

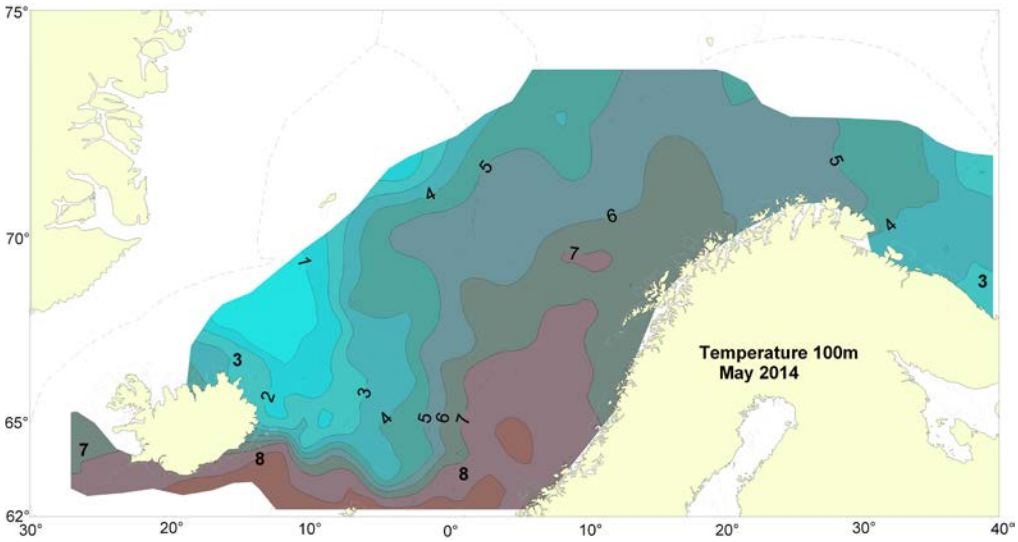

Figure 8. The horizontal distribution of temperatures at 100 m depth in April-June 2014.

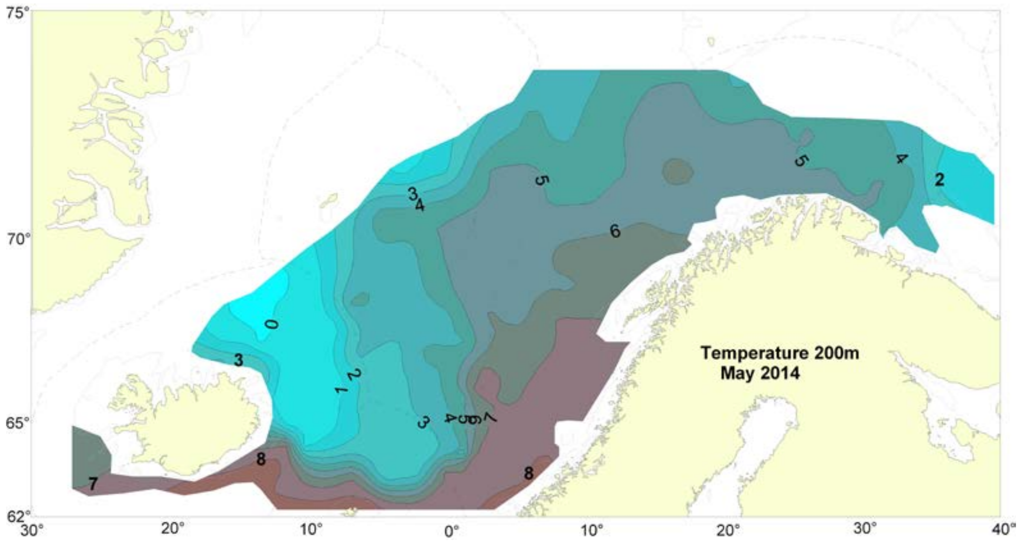

Figure 9. The horizontal distribution of temperatures at 200 m depth in April-June 2014.

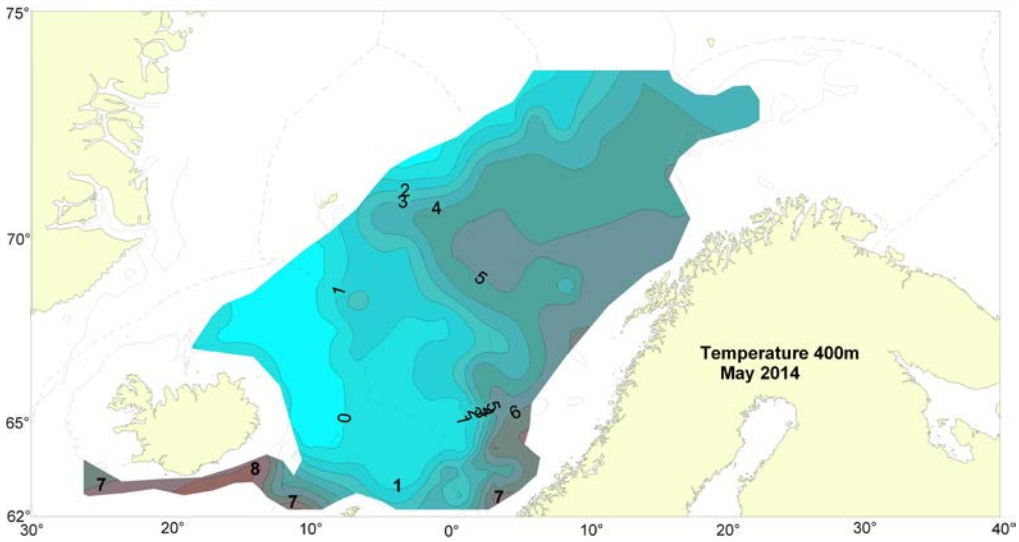

Figure 10. The horizontal distribution of temperatures at 400 m depth in April-June 2014.

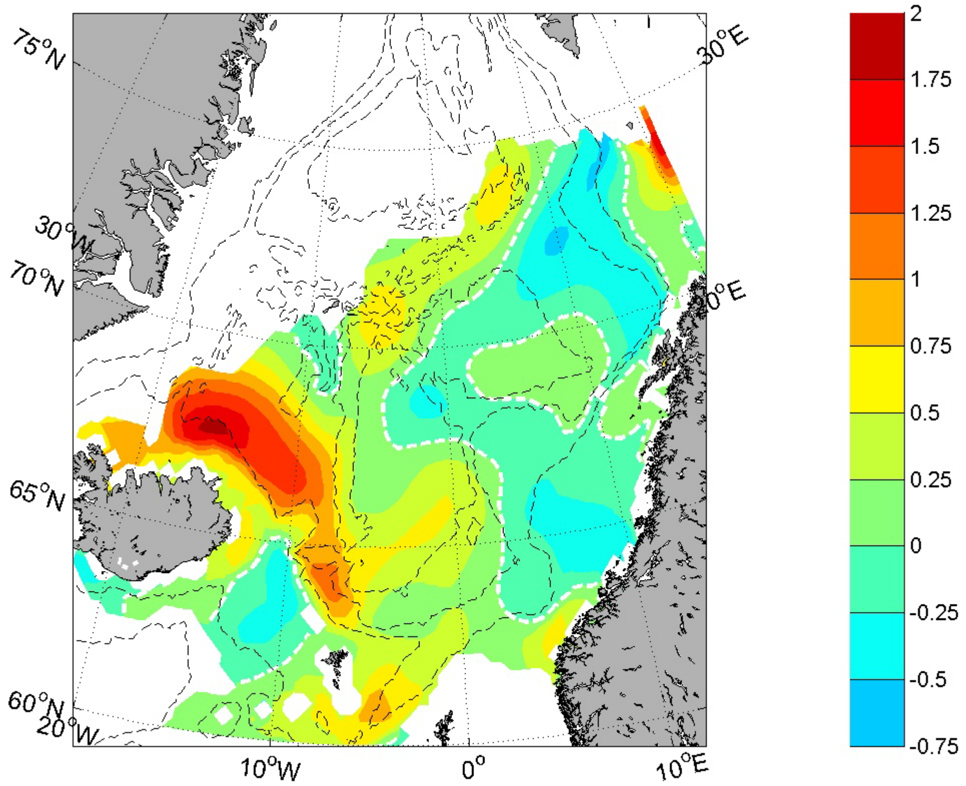

Figure 11. Temperature anomaly at 20 m depth for May 2014. Reference period: 1995-2013.

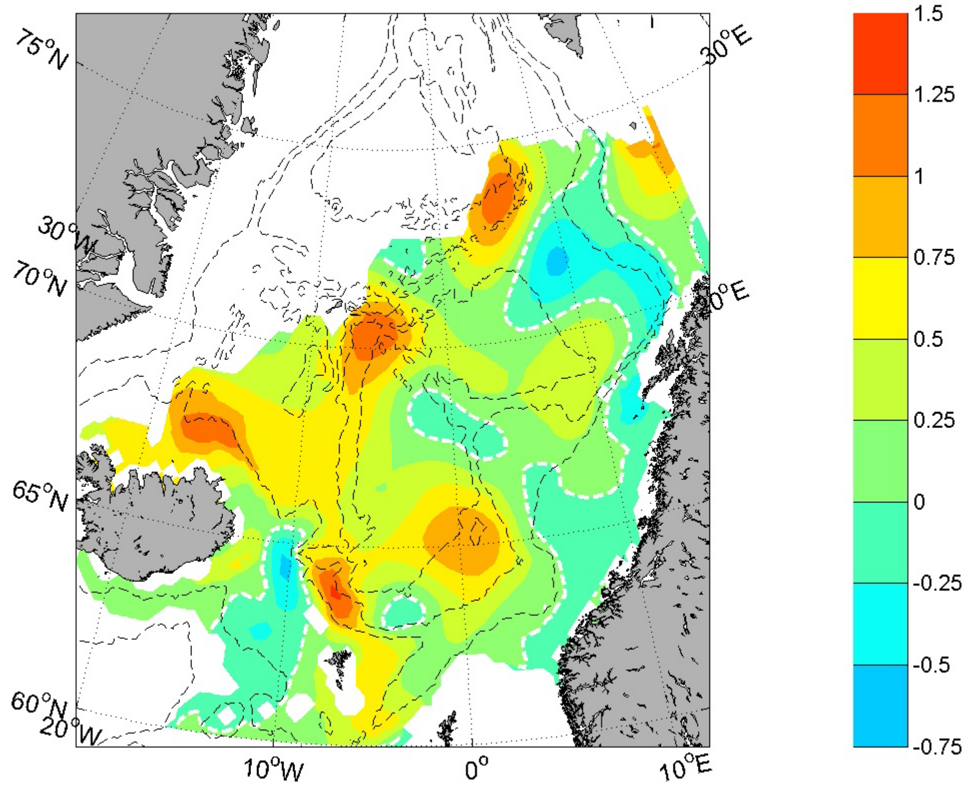

Figure 12. Temperature anomaly at 100 m depth in May 2014. Reference period: 1995-2013.

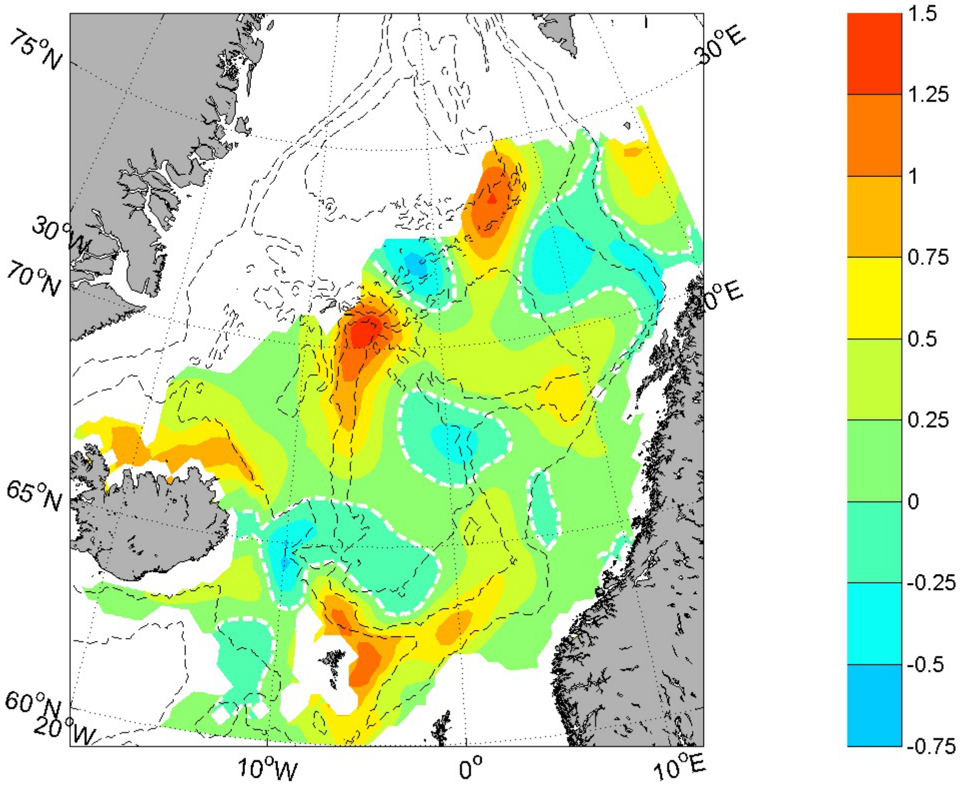

Figure 13. Temperature anomaly at 200 m depth in May 2014. Reference period: 1995-2013.

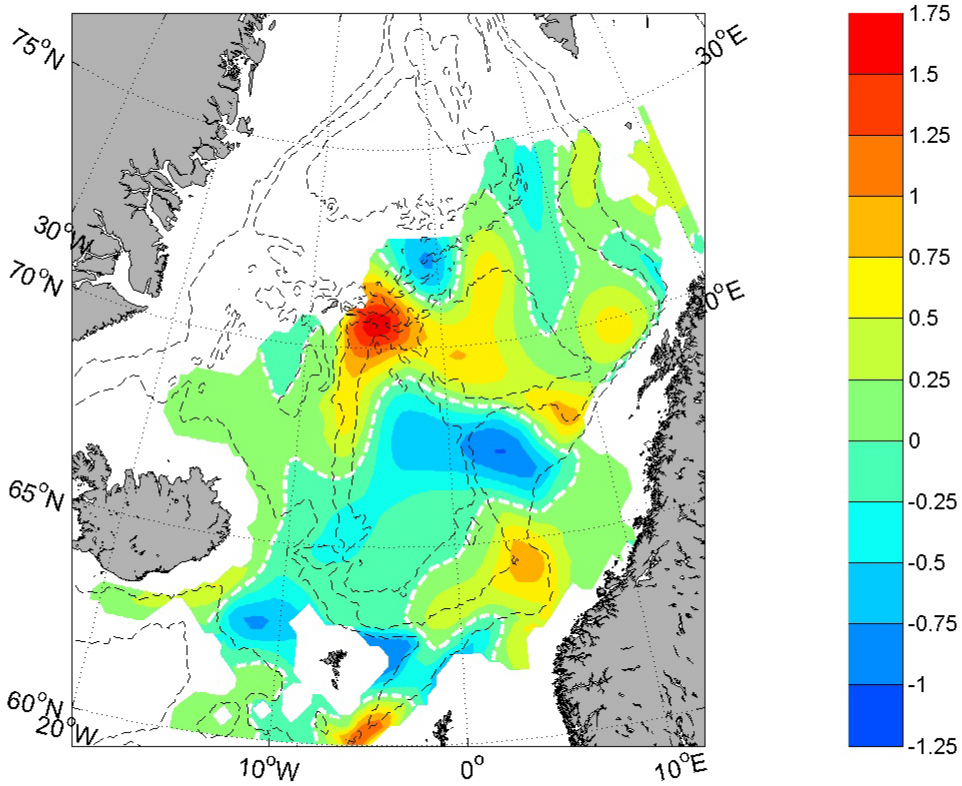

Figure 14. Temperature anomaly at 400 m depth in May 2014. Reference period: 1995-2013.

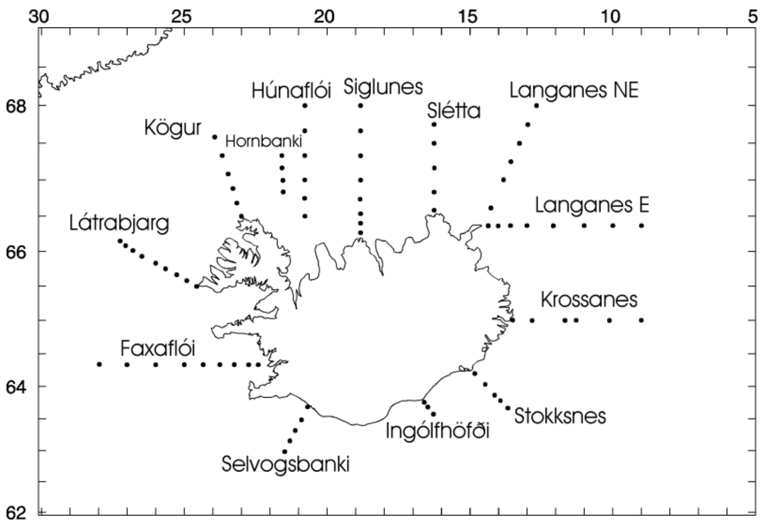

Figure 15. Location of the fixed Icelandic hydrographic sections referred to in the text and Figures 16-18.

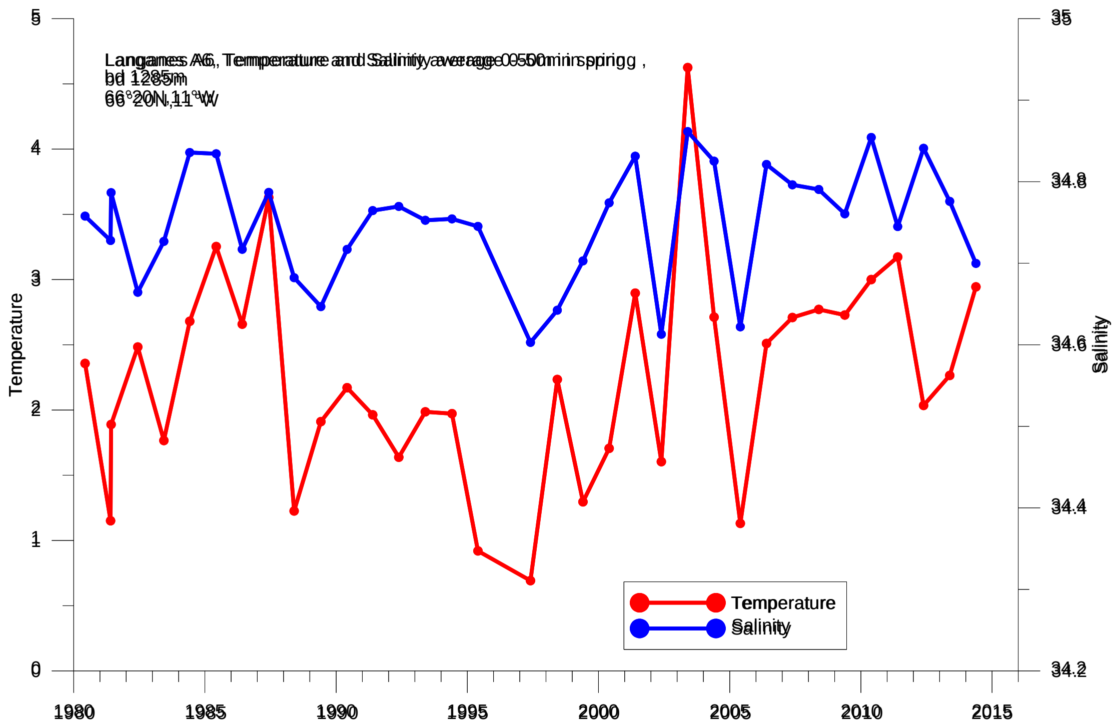

Figure 16. Temperature and salinity in May 2014 east of Iceland, at station Langanes A6 (66°22′N, 11°00′W). Depth averaged 0-50m.

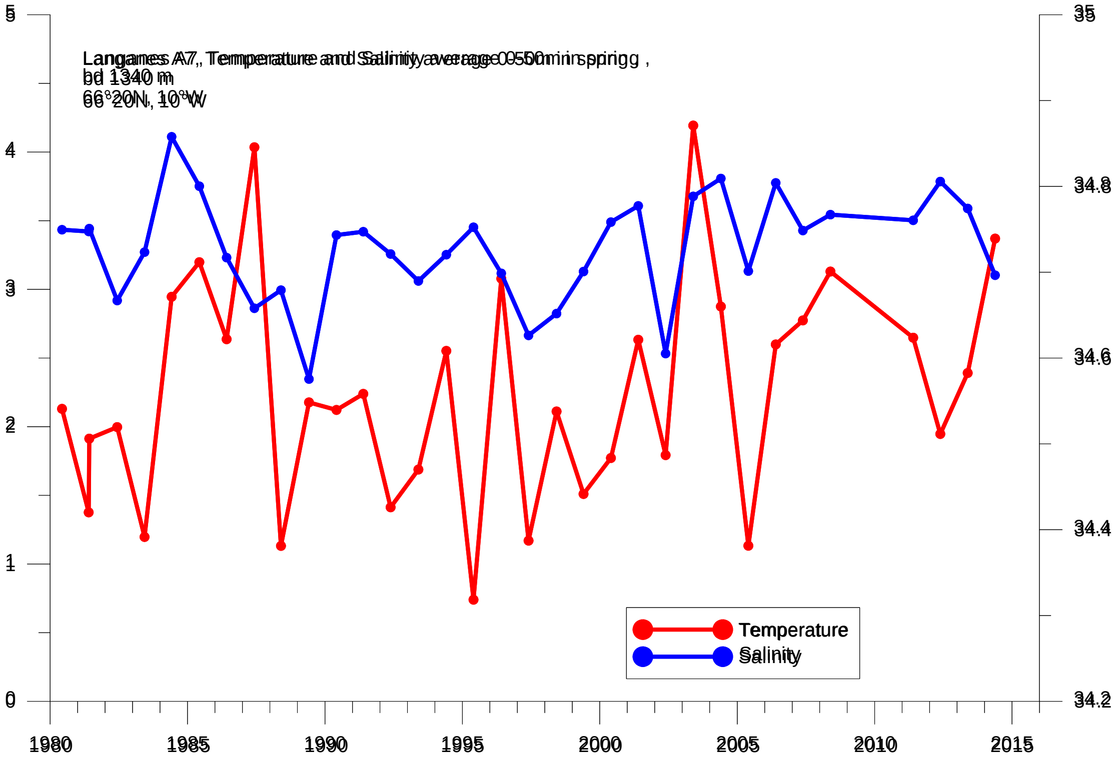

Figure 17. Temperature and salinity in May 2014 east of Iceland, at station Langanes A7 (66°22'N, 10°00'W). Depth average 0-50m.

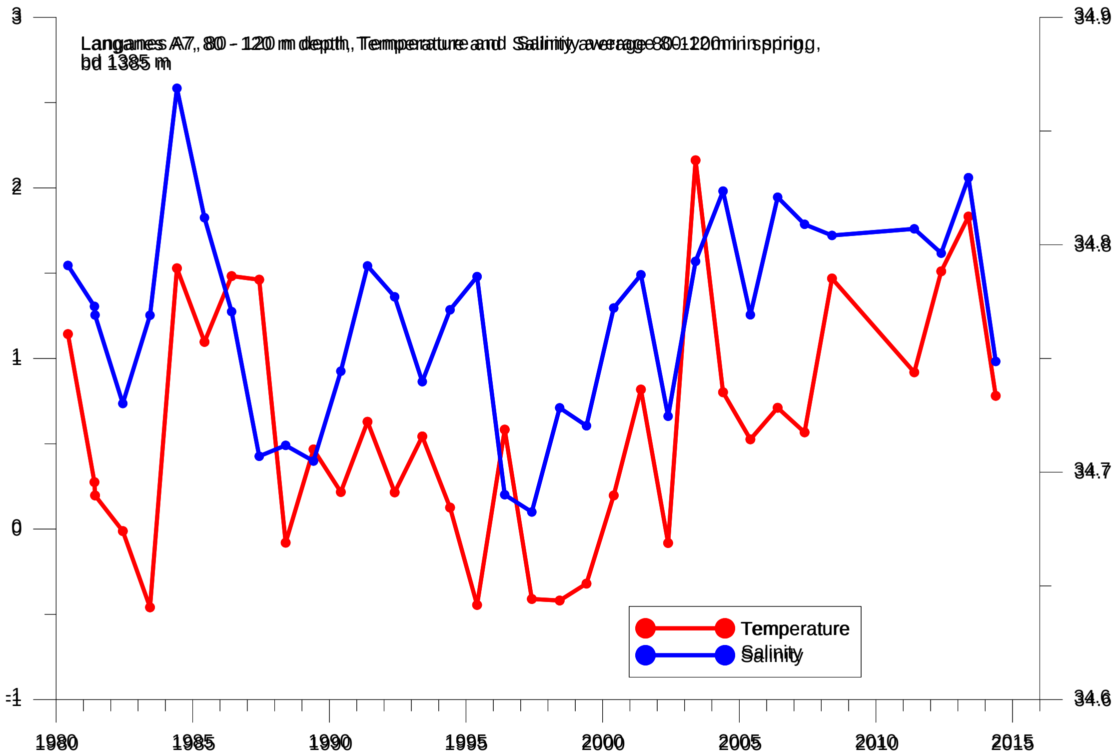

Figure 18. Temperature and salinity in May 2014 east of Iceland at station Langanes A7 (66°22'N, 10°00'W). Depth average 80-120m.

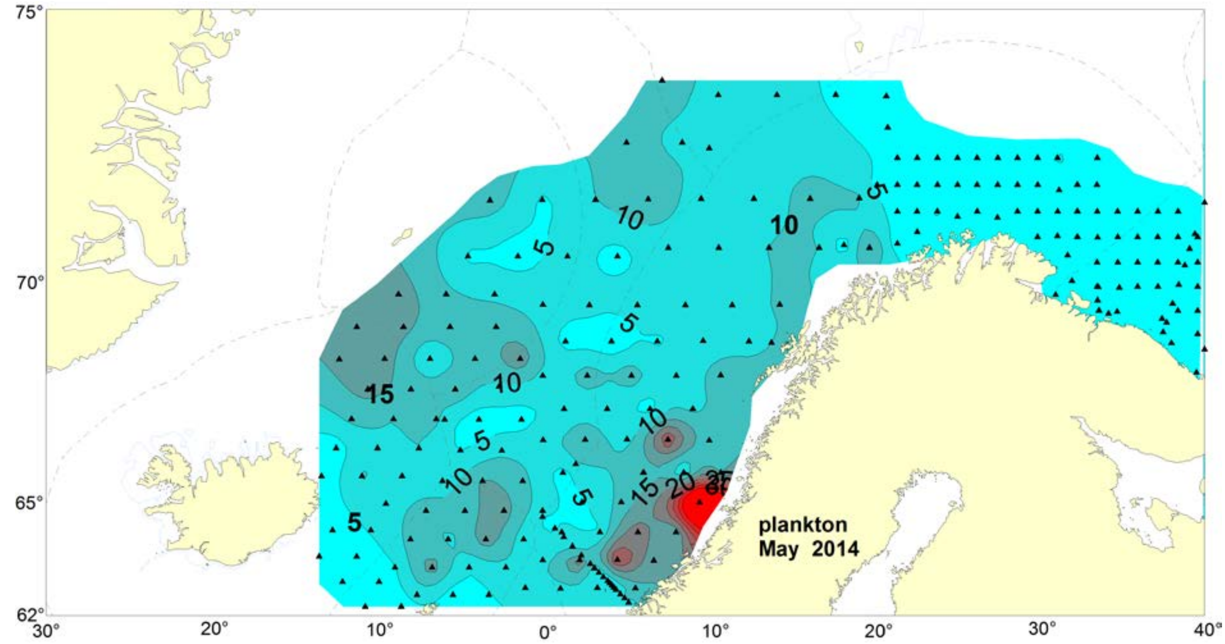

Figure 19. Zooplankton biomass (g dw m-2; 200–0 m in April-June 2014.

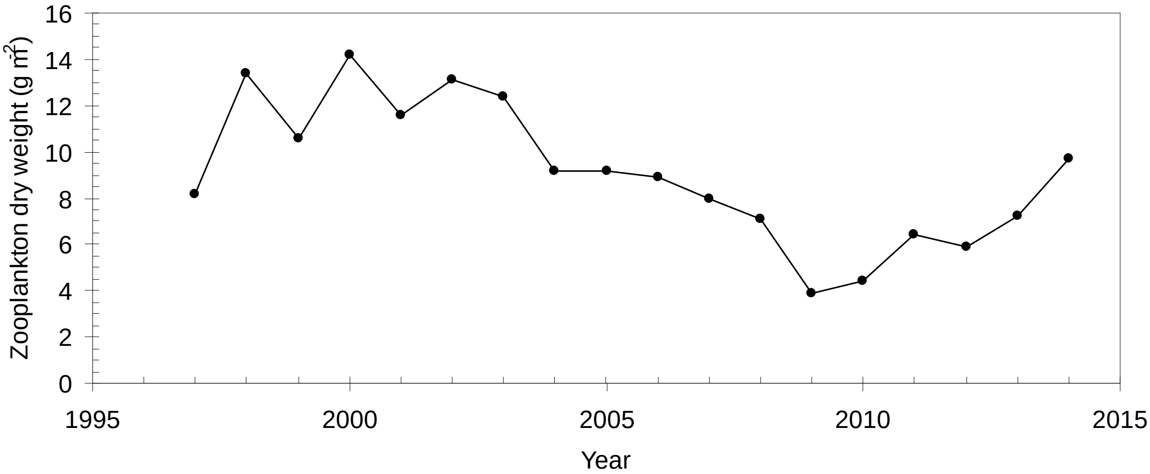

Figure 20. The annual mean dry weight of zooplankton across the whole coverage area in the May surveys in the Norwegian Sea and adjacent waters from 1997 to 2014.

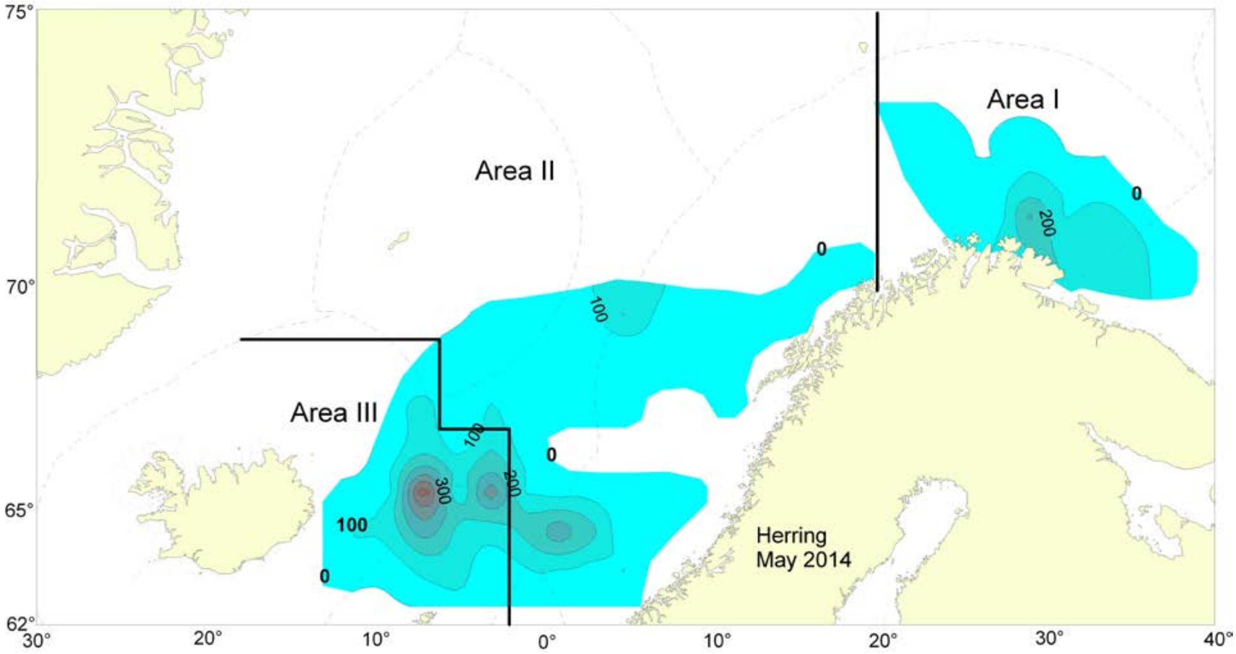

Figure 21. Distribution of Norwegian spring-spawning herring as measured during the International survey in April-June 2014 in terms of s_A-values (m^2/nm^2) based on combined 5 nm values.

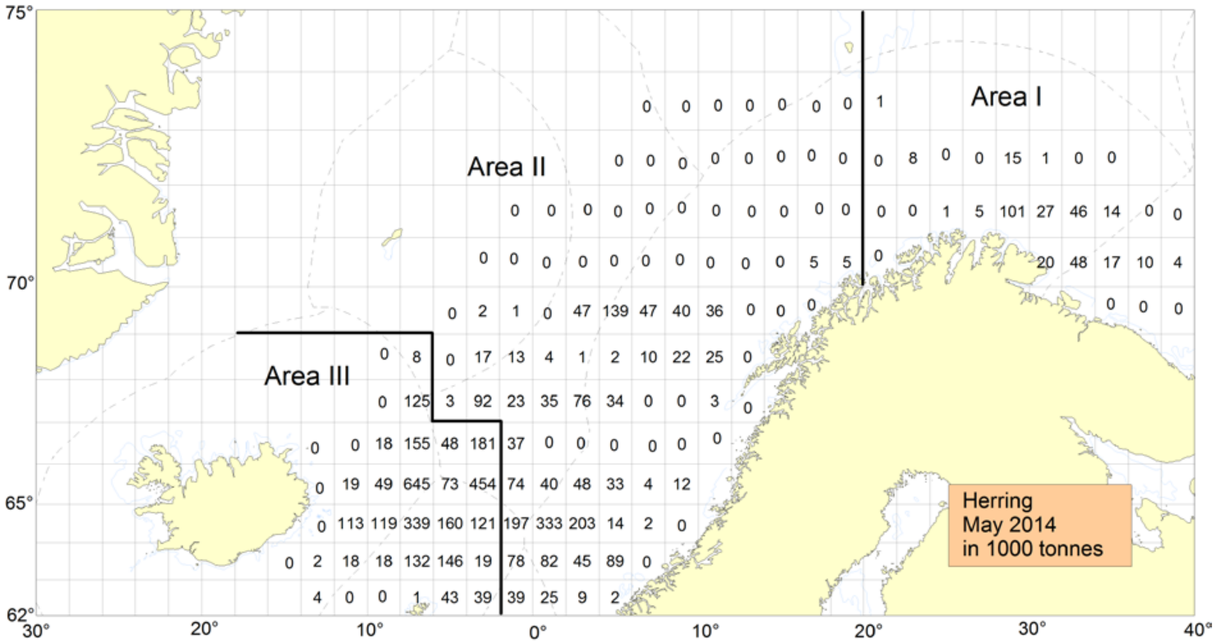

Figure 22. Norwegian spring-spawning herring biomass from IESNS 2014 by sub-area.

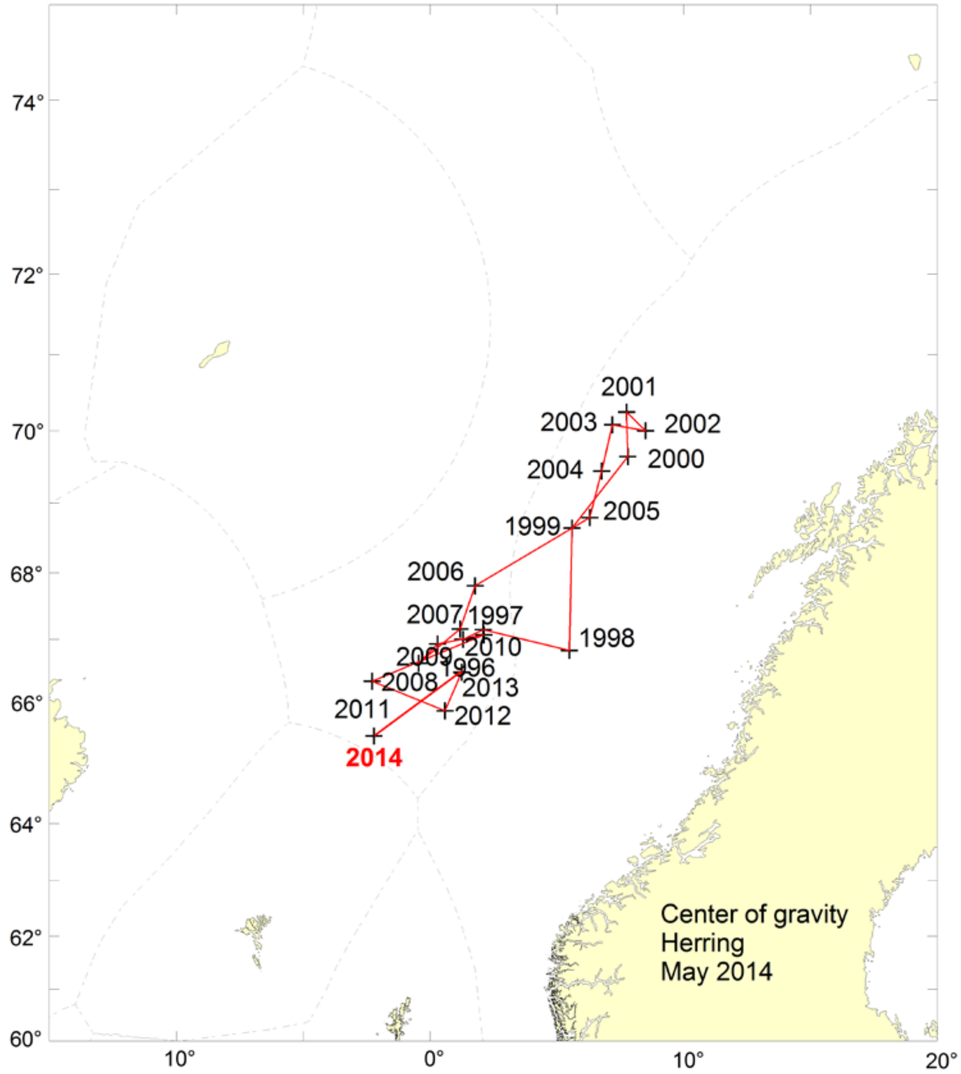

Figure 23. Centre of gravity of herring during the period 1996-2014 derived from acoustic. Acoustic data from area II and III only, i.e. west of 20° E

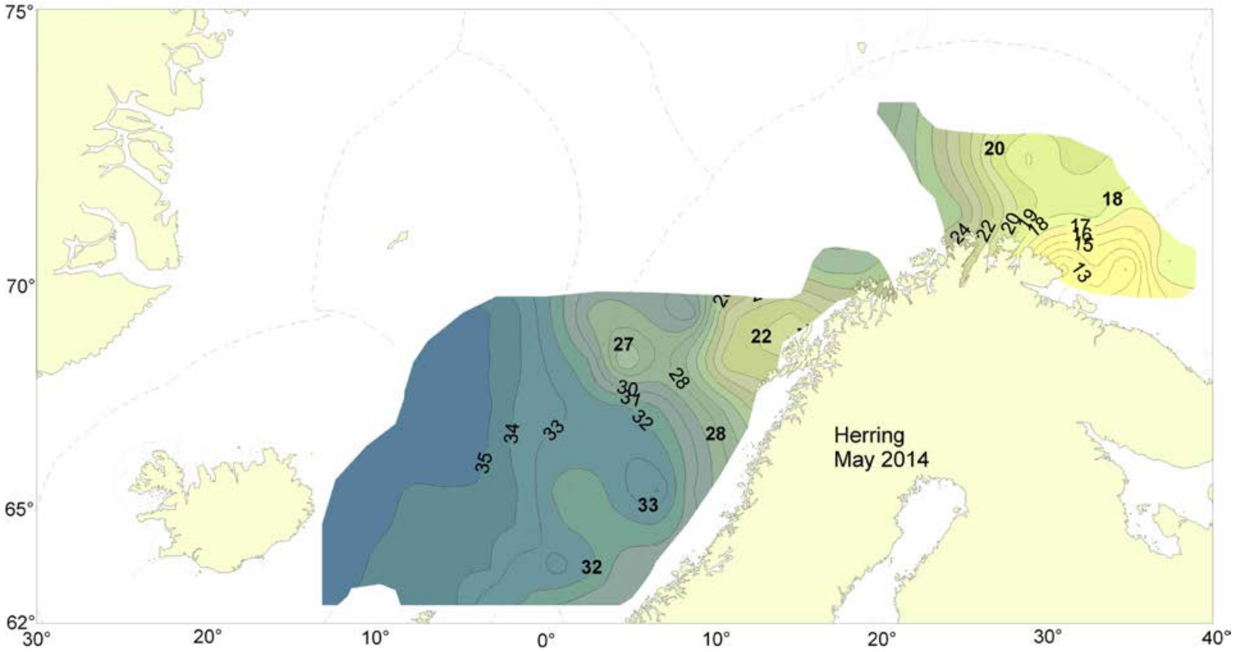

Figure 24. Mean lemgth of Norwegian spring-spawning herring as measured during the International survey in April-June 2014.

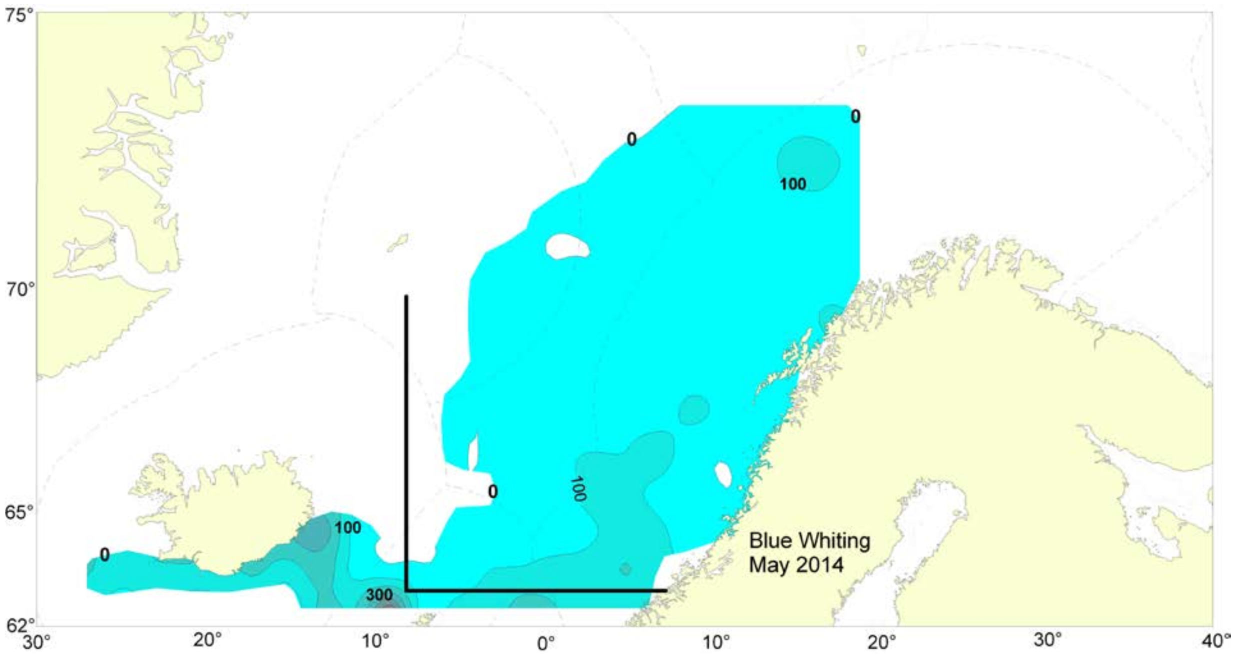

Figure 25. Distribution of blue whiting as measured during the International survey in April-June 2014 in terms of s_A-values (m^2/nm^2) based on combined 5 nm values. The standard area is shown on the map.

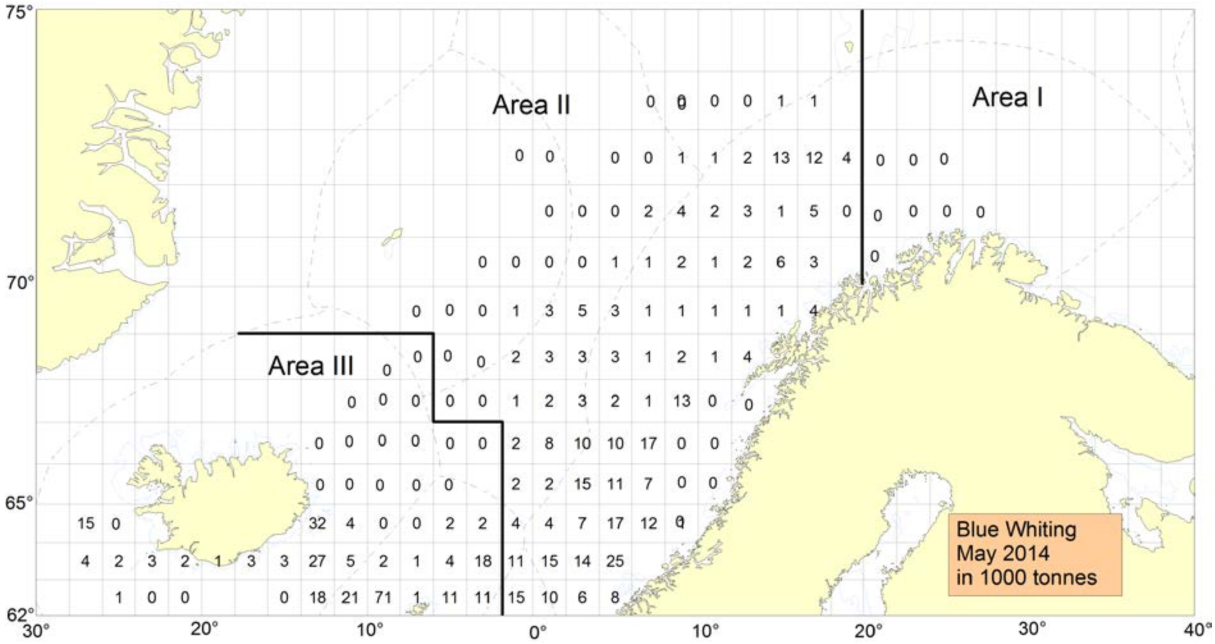

Figure 26. Blue whiting biomass from IESNS 2014 by sub-area.

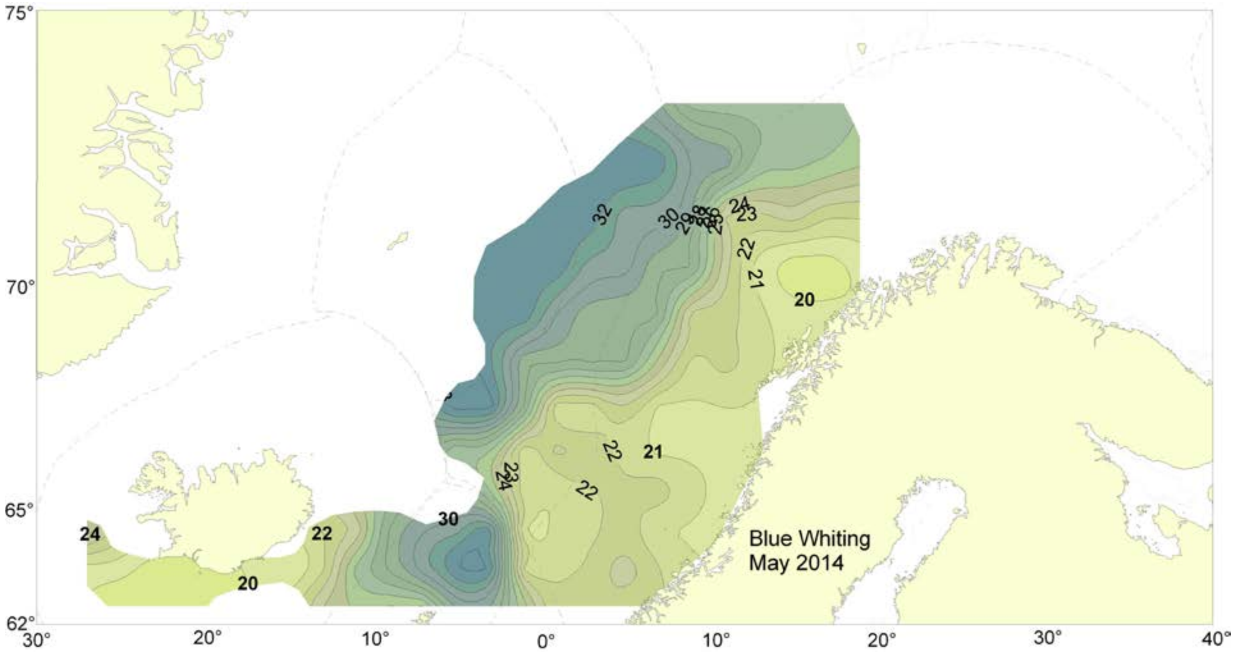

Figure 27. Mean length (cm) of blue whiting recorded in the North-east Atlantic Ecosystem Survey in April–June 2014.

Observations of Blue Whiting Discards in the German Pelagic Fishery

Results of an observer trip on a pelagic freezer trawler in April/May 2013

by Jens Ulleweit, Thünen-Institute of Seafisheries, Hamburg (Germany)

Introduction

The German fleet targeting pelagic fish species currently consists of four freezer trawlers larger than 80m. Depending on season, they were operating in ICES-divisions IIa/b, IVa, VIa, VIIb, VIIe, VIIh and VIIIa, targeting herring, blue whiting, mackerel and horse mackerel. These vessels are similarly managed as the Dutch, French and English freezer trawler fleets. Therefore, discards in those fleets might be similar to those in the German fleet and might be used for calculating the discard rates for all fleets together. In 2013 altogether 5 trips in this métier were observed by scientific personnel in frame of the German part of the EU data collection framework (DCF). This document summarizes the results of one trip on which blue whiting discards occurred.

Material and methods

The observed trip was carried out from 18th April to 23rd May 2013. The trip started and ended in Velsen, the Netherlands The observed vessel was a German flagged freezer trawler with a length of 125m and a loading capacity of 5100 tonnes. Originally the trip should have been directed on blue whiting and argentines but due to the fishing situation on the fishing ground the main target species changed to horse mackerel. The fishing took exclusively place in ICES division VIIj.

Discard and biological data were collected on board the fishing vessels by scientific observes following the German sampling guidelines (http://www.dcf-germany.de/fileadmin/sites/default/downloads/Beprobungsanleitung_2011-12.pdf). Otoliths were taken from mackerel, horse mackerel and blue whiting. The analysed landings data were derived from the official German logbook statistics for 2013.

Results

Altogether 62 hauls were sampled. Table 1 shows an overview with all numbers and weights by the caught species. The column “sample” shows the actual measured and weighted numbers of fish by the observer. The catch composition is also shown in Figure 1. Major share of the catch was horse mackerel with 3524 tonnes of which 309kg (0.01%) was discarded. 316 tonnes of blue whiting were also caught, the percentage of discard was 35,7% (112 tonnes). Other landed species were mackerel (0.9% discard) and argentines (no discard). Caught boarfish, hake, herring, haddock and cod were fully discarded.

Length distribution of blue whiting by landings and discards is shown in figure 2. Most fish was between 24 and 28cm length. Fish between 14 and 37cm length was discarded. The age composition of the caught blue whiting is shown in figure 3.

Conclusion

Although discard rates are mainly low, the results show clearly that in discarding occurs in the pelagic freezer trawler fishery. Discarding in the German pelagic fishery can mostly be explained with the removal of unwanted by-catch of non-target species like boarfish or gadoids. Other reasons might be high grading, bad conditions of fish due to net pressure or other processing reasons. According to the observer, the blue whiting discard of this trip can be explained by bad quality of the fish as the blue whiting was caught together with spiny horse mackerel.

Taken this behavior as typical for the whole fleet, blue whiting discard might be as high as 237 tonnes if raised to the total horse mackerel landings in VIIj, quarter 2 (7405 tonnes). Raised to the total blue whiting landings in VIIj, quarter 2 (256 tonnes) it would be 143 tonnes.

Tab.1: Numbers and weights of caught fish during the observer trip

ICES	Fish Species		Total Catch		Landings		Discards		Sample		Discard prop.	
Division	english	latin	kg	n	kg	n	kg	n	kg	n	% kg	% n
VIIj	Horse Mackerel	*Trachurus trachurus*	3,524,615	18,159,254	3,524,306	18,154,752	309	4,502	4,694.9	23,608	0.01	0.02
VIIj	Blue Whiting	*Micromesistius poutassou*	316,264	3,494,562	203,308	1,695,855	112,956	1,798,707	419	4,617	35.7	51.5
VIIj	Mackerel	*Scomber scombrus*	208,271	544416	206,455	538364	1,816	6052	618.3	1669	0.9	1.1
VIIj	Boarfish	*Capros aper*	16,872	362614	0	0	16,872	362614	20.8	467	100	100
VIIj	Hake	*Merluccius merluccius*	11,364	6843	0	0	11,364	6843	324.3	194	100	100
VIIj	Argentine	*Argentina silus*	4,456	17688	4,456	17688	0	0	219.7	1045	0	0
VIIj	Herring	*Clupea harengus*	1,152	8385	0	0	1,152	8385	1.5	12	100	100
VIIj	Haddock	*Melanogrammus aeglefinu*	38	35	0	0	38	35	8.8	8	100	100
VIIj	Cod	*Gadus morhua*	11	2	0	0	11	2	10.9	2	100	100
		Total	4,083,042	22,593,799	3,938,525	20,406,659	144,517	2,187,140	6,318	31,622	3.54	9.68

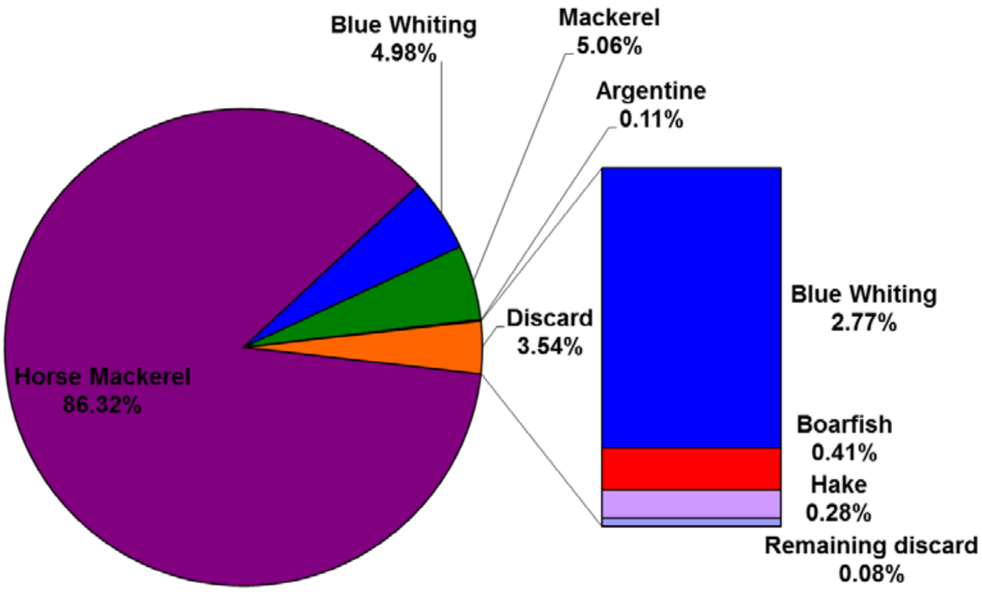

Fig. 1: Catch composition of the observed trip

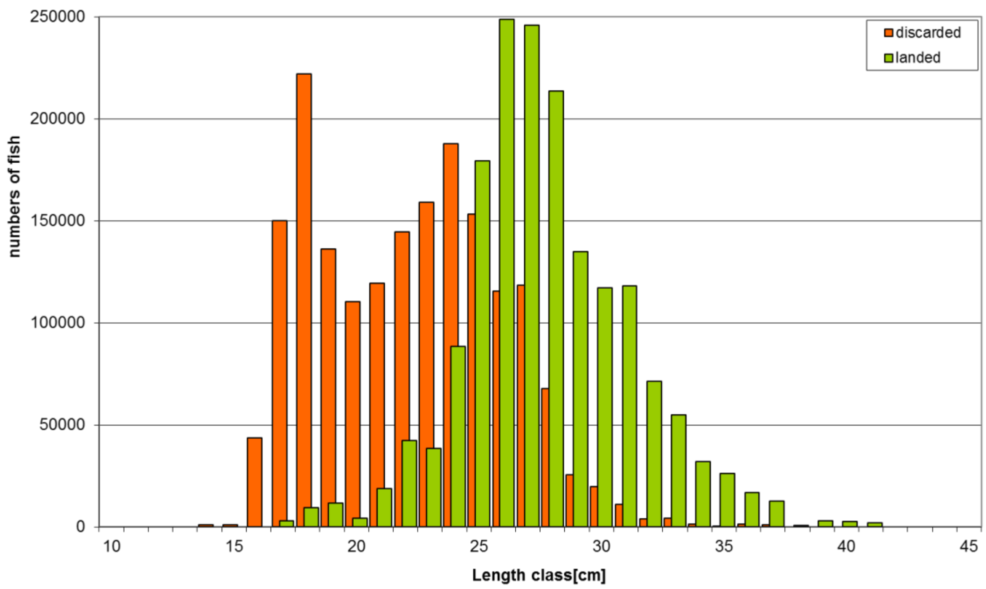

Fig. 2: Length distribution of blue whiting by landings and discards

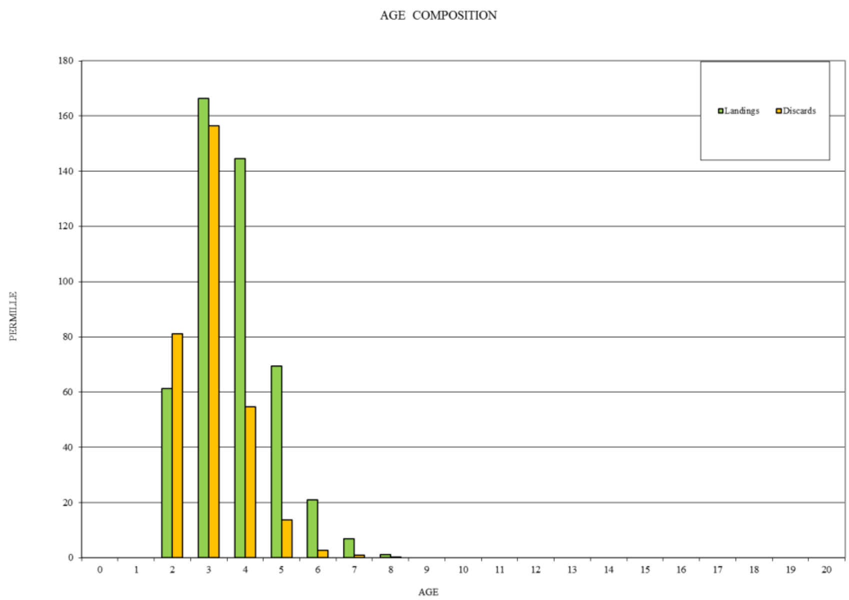

Fig. 3: Age composition of blue whiting by landings and discards

Annex 01 –List of Participants

Working Group on Widely Distributed Stocks (WGWIDE)

26 August – 01 September 2014

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Annex 02A - Stock Annex: Northeast Atlantic mackerel

Stock specific documentation of standard assessment procedures used by ICES.

Stock	**Mackerel in the Northeast Atlantic**
Working Group	**Working Group on Widely Distributed Stocks**
Date	**February 2014**
Revised by	**WKPELA 2014. T. Brunel, E.M.C. Hatfield, T. Jansen, L. Nottestad, A. Campbell**

A. General

A.1. Stock definition

Atlantic mackerel (*Scomber scombrus*) occurs on both sides of the North Atlantic and has traditionally been grouped into five spawning components, some of which have been thought to be isolated natal homing populations. Previous studies have provided no evidence of cross-Atlantic migration and no, or weak, support for isolated spawning components within either side of the North Atlantic (Jansen and Gislason, 2013).

ICES currently uses the term "Northeast Atlantic (NEA) mackerel" to define the mackerel present in the area extending from the Iberian peninsula in the south to the northern Norwegian Sea in the north, and Iceland in the west to the western Baltic Sea in east.

In the Northeast Atlantic, mackerel spawn from the Portuguese waters in the south to Iceland in the north and from Hatton Bank in the west to Kattegat in the east. Spawning starts in January/February in Iberian Peninsula waters and ends in July to the northwest of Scotland and in the North Sea (ICES, 2013a). While spawning varies locally from day to day (Bakken, 1977; Iversen, 1981), it seems to form one large spatio-temporal continuum on the larger scale. However, relatively low levels of spawning in the English and Fair Isle channels separates the main spawning areas in the North Sea from the western areas along the continental shelf edge (Johnston, 1977). Recent studies on distribution, eggs distribution and abundance and mark–recapture experiments (Reid, 1997; Uriarte and Lucio, 2001; Uriarte *et al*., 2001) have questioned the limits of previously established stocks and proposed to consider NEA mackerel as one single stock divided into three spawning components. These components are not completely independent but reproductive exchanges occur, and no differences were observed between these components outside the spawning season. Despite this lack of complete spatial or temporal separation, NEA mackerel is divided into three distinct entities, namely the Southern, Western and North Sea spawning components (ICES 1977; 2013a). Catches cannot be allocated specifically to spawning area components on biological grounds, but by convention; catches from the Southern and Western components are separated according to the areas in which these are taken:

Mackerel in the Northeast Atlantic			
Mainly distributed and fished in ICES Subareas and Divisions IIa, IIIa, IV, V, VI, VII, VIII, and IXa			
Spawning component	Western	Southern	North Sea
Main spawning areas	VI, VII, VIIIa,b,d,e,	VIIIc, IXa	IV, IIIa

The Western component is defined as mackerel spawning in the western area (ICES Divisions and Subareas VI, VII, and VIII a,b,d,e). This component currently accounts for ~75% of the entire Northeast Atlantic stock. Similarly, the Southern component (~22%) is defined as mackerel spawning in the southern area (ICES Divisions VIIIc and IXa). Although the North Sea component has been at an extremely low level since the early 1970s, ICES considers that the North Sea component still exists as a discrete unit (~3%). This component spawns in the North Sea and Skagerrak (ICES Subarea IV and Division IIIaN).

Jansen and Gislason (2013) recently reviewed the concept of spawning components on the basis of spawning and age distribution data. Spawning intensities, proxied by larval abundances, were found to be negatively correlated between the North Sea and Celtic Sea, which indicates that the two spawning components may be connected by substantial straying. This finding was based on unique larvae samples collected before the collapse of North Sea component, thus showing that the exchange is not a recent phenomenon due to the collapse. Furthermore, analyses of old as well as more recent age distributions showed that strong year classes spread into other areas where they spawn as adults (i.e. "twinning"). The authors found that this was in accordance with the lack of solid evidence of stock separation from previous analyses of tagging data, genetics, ectoparasite infections, otolith shapes, and blood phenotypes. Because no method has been able to identify the origin of spawning mackerel unequivocally from any of the traditional spawning components, and in the light of their results, they concluded that straying outweighs spatial segregation. Jansen and Gislason (2013) therefore proposed a new model where the population structure of mackerel was described as a dynamic cline, rather than as connected contingents. Temporal changes in hydrography and mackerel behaviour may affect the steepness of the cline at various locations (Jansen *et al.*, 2013; Jansen and Gislason, 2013; Jansen *et al.*, 2013).

A.2. Fishery

As a widely distributed and migratory species, NEA Mackerel is exploited over a wide geographic range throughout the year. Significant fisheries extend from the Gulf of Cadiz, along the western and northern Iberian costs, through the Bay of Biscay, S, W and N of the United Kingdom and Ireland, into the northern North Sea and the Norwegian Sea and, in more recent years as far north as 72°N and west into Icelandic and east Greenland waters.

The fishery is international and, as such it is exploited by several nations using a variety of techniques determined by both the national fleet structure and the behaviour of the mackerel. At the onset of the spawning migration, large mackerel shoals move out of the northern North Sea initially to the west before moving south down the west coast of Scotland and Ireland. The timing of this migration is variable but generally occurs around the end of quarter 4 and the start of quarter 1. During this time, they are targeted primarily by Scottish and Irish pelagic trawlers with RSW tanks and also freezer (factory) vessels (primarily Dutch and German). Prior to the onset of this migration the mackerel are overwintering, relatively static and are targeted by a large Norwegian purse-seine fleet. During summer the mackerel are more widely dispersed as they feed in Northern waters. At this time Russian pelagic freezer trawlers and in more recent times Icelandic, Faroese and Greenlandic pelagic vessels are active. The southern fishery takes place at the start of the spawning season upon completion of the spawning migration. The Spanish fleet is comprised of both bottom and pelagic trawlers and also a large artisanal fleet. There are other smaller scale fisheries such as a Norwegian gillnet fleet and an English handline fleet that operates in the otherwise restricted area known as the Cornwall box.

There exists a number of national and international agreements to control the exploitation of the NEA Mackerel stock. Targeted fishing is prohibited in the North Sea with the purpose of protecting the North Sea stock component which has failed to recover from extremely heavy exploitation during the 1970s. The Cornwall box is an area off the SW coat of England that is a known juvenile area. It supported a very large fishery prior to its introduction in the early 1980s after which the only permitted fishing in this area is by handliners. A number of countries have discard prohibition. Unfortunately, there has been no overarching agreement in the most recent period which would permit control of the overall exploitation and catches have exceeded advice.

A.3. Ecosystem and behavioural aspects

A.3.1. Feeding

Post larval mackerel feed on a variety of zooplankton and small fish. They prefer larger prey species over smaller prey (Pepin *et al*., 1987; Langoy *et al*., 2006). Feeding patterns vary seasonally, spatially and with size. Mackerel stops feeding almost completely during winter. Main zooplankton prey species in the North Sea are: Copepods (mainly *Calanus finmarchicus*), euphausiids (mainly *Meganyctiphanes norvegica*), while primary fish prey species are: sandeel, herring, sprat, and Norway pout (Walsh and Rankine, 1979; Mehl and Westgård, 1983; ICES, 1989; ICES, 1997a). In the Norwegian Sea euphausiids, copepods (mainly *Calanus finmarchicus* and *Oithona*), *Limacina retroversa, Maurolicus muelleri,* amphipods, Appendicularia and capelin are the main diet during the summer feeding migration (Langoy *et al.,* 2006; Prokopchuk, 2006; Langoy *et al*., 2010).

In the North Sea, mackerel and horse mackerel are responsible for virtually all of the predation on 0-group herring as well as a large part of the consumption of 0-group Norway pout and of all ages of sandeel (ICES, 2008b). Mackerel has also fed opportunistically on available NSS herring larvae along the continental shelf coast of Norway (Skaret *et al*., 2014). This may have a significant impact on the herring larval survival rate, and largely depends upon the degree of overlap in time and space, which can vary from year to year.

Spatial and temporal overlap between NEA mackerel and Norwegian spring-spawning herring particularly in the outskirts or periphery of mackerel distribution (northern Faroese, Icelandic and Jan Mayen waters) may cause increased interspecific competition between mackerel and herring for preferred food such as *Calanus finmarchicus* (Debes *et al*., 2012; Langøy *et al*., 2012; Óskarsson *et al*., 2012). Mackerel may partly outcompete herring during summer because mackerel are generally larger, faster, more enduring when migrating and more effective plankton eaters, including a wider food niche (wider diet breadth) than herring (Nøttestad *et al*., 2012). Mackerel may thus both compete better for preferred zooplankton species and size fractions as well as better utilize smaller plankton species available in the northern part of the Northeast Atlantic Ocean compared with herring.

The mackerel seems to be very opportunistic, and from one year to the next they may exploit any available oceanic areas for feeding purposes (Langøy *et al*., 2012). A westwards and northwards expansion has been observed in the Nordic Seas in recent years (since 2007), as far as Icelandic and south Greenlandic waters in the west and as far north as Spitzbergen (Nøttestad, 2014). Historically, expansions into Icelandic waters are known to coincide with periods of warm waters (Astthorsson *et al.*, 2012).

The dynamics and environmental drivers of the mackerel summer distribution are not yet uncovered. Surveys in recent years indicate substantial interannual variation and provides hypothesis on relations to temperature and food (Holst and Iversen, 1992; Holst and Iversen, 1999; Gill, *et al.*, 2004; ICES, 2006b; ICES, 2007b; ICES, 2009; ICES, 2009). When the mackerel stock is large (as in the recent years) and plankton abundance is low, mackerel has to spread out further to the north and to the west to forage on suitable plankton aggregations. The record high surface temperatures observed in the Nordic Seas during summer in recent years (Hughes *et al.*, 2011; Nøttestad *et al.*, 2012) made this expansion possible and has resulted in an increase in the potential feeding habitat for mackerel (as defined by water temperatures above 6°C).

A.3.2. Spawning

Even though spawning occurs widely on the shelf and shelf edge from the Bay of Biscay to the southern Norwegian Sea, most of the egg production is concentrated in two core spawning areas (Figure A.3.2.1). One elongated area along the shelf break from Spanish and Portuguese waters in January to March, and one around southwest Ireland to the west of Scotland where spawning peaked in April (Beare and Reid, 2002; Iversen, 2002) but the spawning peak has shifted to March in the most recent years. In the central North Sea spawning takes place in May–July.

Spawning activity along the shelf edge has varied to the north and to the south at various times over the decades since the 1980s although the centre of gravity of spawning has remained relatively stable off the southwest of Ireland over this period (Hughes, 2013; Beare and Reid, 2002) In the North Sea there is a westward shift in the main spawning area from the central part of the North Sea in the early 1980s to the western part in recent years (2005 and 2008) (Anon, 2009).

In the recent period (since the 2007 survey) an expansion of the spawning distribution for the western spawning component has been observed (ICES, 2013b). Spawning occurs now further to the west (up to 20° of latitude west) and to the north (up to the southern Norwegian Sea) (ICES, 2013b; Nøttestad *et al.*, 2012; 2013). However, most of the egg production of the western component remains in the traditional spawning grounds, located on the shelf edge in the southwest of Ireland to the west of Scotland. The egg production in the new areas remains marginal. The causes of this geographical expansion of spawning remain unclear, but are suspected to be triggered by the increase in the stock size (i.e. density-dependent space occupation) coupled with changes in the potential spawning habitat linked to environmental conditions (ICES, 2013b). As a consequence of this expansion of spawning to the North, juveniles 0-group mackerel are now found in the Nordic seas (Iceland, Barents sea, ICES 2013a).

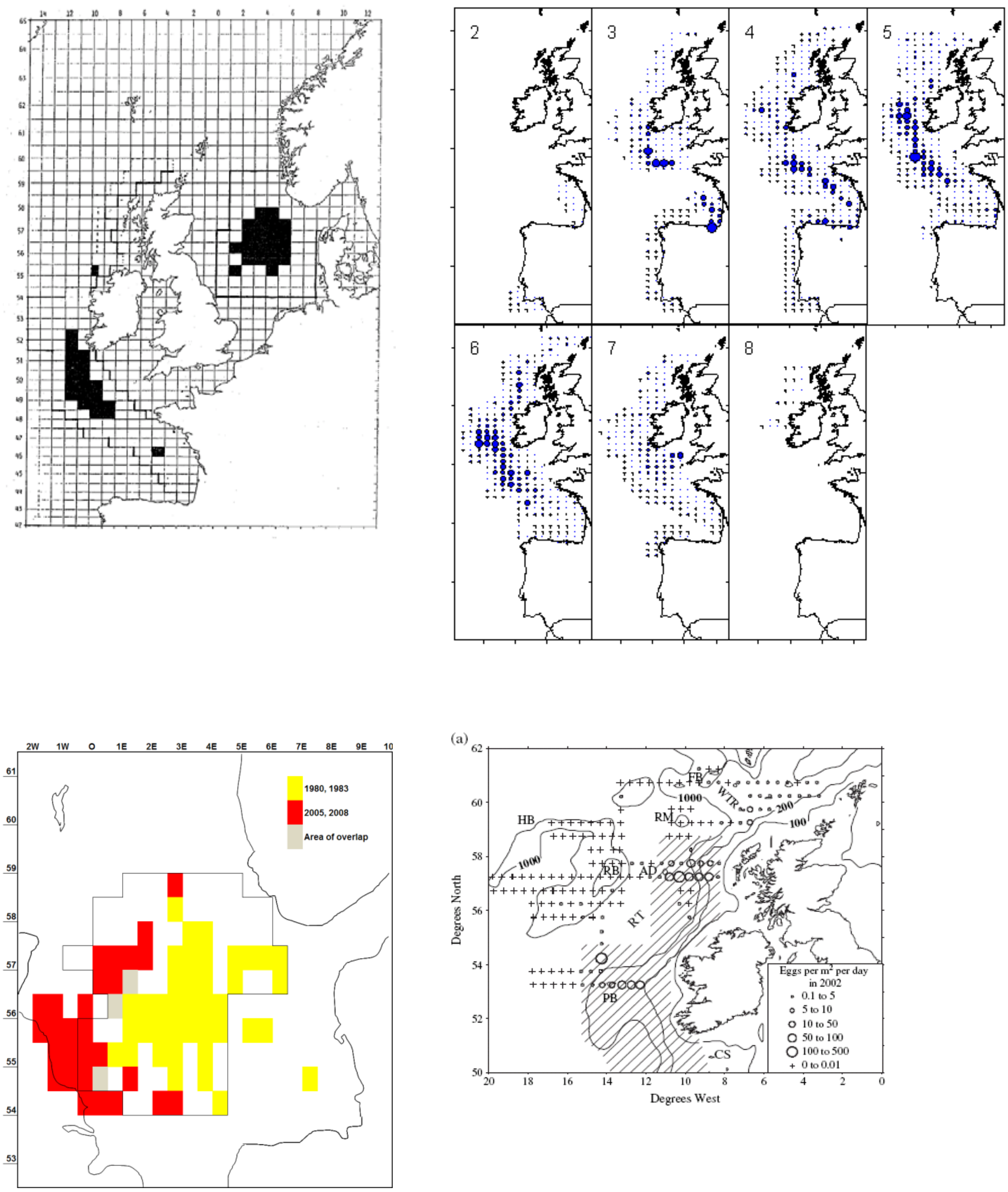


Figure A.3.2.1. NEA mackerel spawning areas. Upper left: Shaded areas indicate 100 eggs/m² in at least two of the years in the period 1977–1988 (from (ICES, 1990)). Upper right: Average distribution of mackerel eggs by ICES statistical rectangle in 1992–2007, each map represents a survey between February and August (from (Anon, 2009)). Lower left: North sea spawning area defined by a daily egg production of at least 50 mackerel eggs per m² of sea surface in any of the years 1980, 1983, 2005 and 2008 (from (Anon, 2009)). Lower right: Experimental survey in May 2002 (from (Dransfeld *et al*., 2005)).

A.3.3. Migration

Mackerel performs extensive migrations between spawning grounds, feeding grounds and overwintering areas. The migration pattern has changed substantially through time.

Tagging studies (Uriarte and Lucio, 1996; Belikov *et al.*, 1998; Uriarte *et al.*, 2001) have demonstrated that mackerel travel from both the western and southern spawning ground north up into the North Sea and Nordic Seas. The migration can be considered as having two elements;

1) A post-spawning migration from the spawning areas along the western European shelf edge (Uriarte *et al.*, 2001);
2) A prespawning migration from feeding grounds in the North and Norwegian Seas (Walsh *et al.*, 1995; Reid *et al.*, 1997). This prespawning migration includes shorter or longer halts that sometimes are referred to as overwintering.

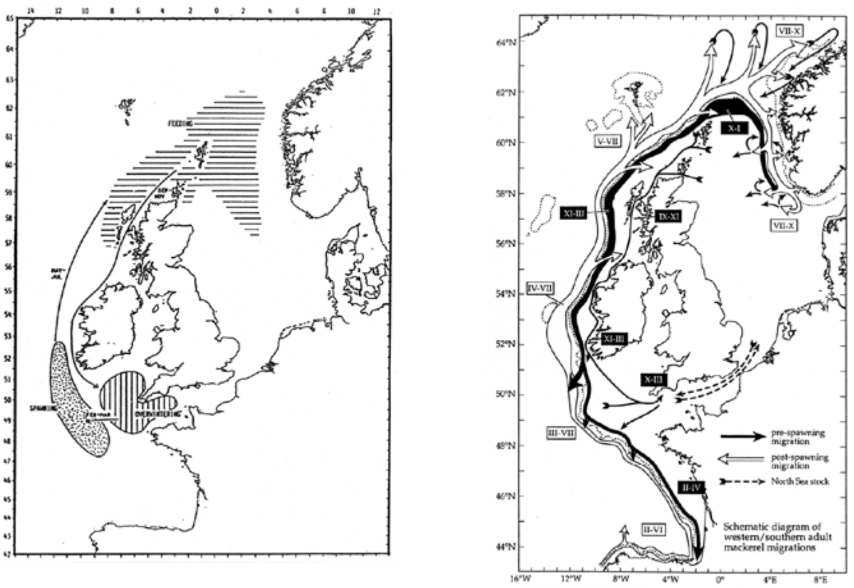
Studies of the timing and the routes for the post-spawning feeding migration are limited. Patterns of food and temperature related distributions in the Norwegian Sea in summer are emerging from summer surveys in the Norwegian Sea in 1992 and 2002–2009. However, the big picture of when and where is the thermal preference dominating/subordinate in relation to other activities like feeding, spawning and predator avoidance remains to be drawn.

Swimming speed during migration is related to fish length (Pepin *et al.*, 1988). Tagging has shown that juveniles of the southern/western component do not migrate as far as the adults (Uriarte *et al.*, 2001). The larger fish reaches furthest to the north and west during the feeding migration in summer (Holst and Iversen, 1992; Nøttestad *et al.*, 1999; Anon 2009; ICES, 2009). This effectively results in a spatial gradient in the mean length of the fish measured during the IESSNS (Nøttestad *et al.*, 2012; 2013), with larger mean length in the north and west, and smaller mean length to the southeast. Similarly, the large mackerel also arrive to the feeding areas (observed in eastern Danish waters) before and leave later than small mackerel (Jansen and Gislason, 2011).

When the NEA mackerel return in late summer and autumn from the feeding areas on the European shelf and in the Nordic Seas, they aggregate through autumn and early winter along the continental shelf edge, where they are targeted by commercial trawlers and purse-seiners. Later in winter the commercial fleets and the fisheries-independent bottom-trawl survey find the mackerel further towards the southwest. The path of the migration, as suggested by the location of commercial and survey catches coincides with the location of the relatively warm high saline eastern Atlantic water flowing northeastwards on and along the continental shelf edge, flanked by cooler water masses. The mackerel population is found further upstream in warmer waters as the current cools through winter and this process is associated via climatic variability, with large impacts on the mackerel migration and fisheries (Jansen *et al.*, 2012; Walsh and Martin, 1986; Reid *et al.*, 2003; Walsh *et al.*, 1995; Reid *et al.*, 1997; Reid *et al.*, 2001). However, other factors than temperature preferences are affecting the mackerel behaviour and can in different scenarios have different weights. D'Amours and Castonguay (1992) showed that mackerel from the northern component of the West Atlantic mackerel migrated into Cabot Straight with approximately 4ºC in order to get to their spawning grounds. They argued that the fish's thermal preferences could be subordinate to their reproductive requirements, a point supported by the fact that this stock always enter the Cabot Straight around the same date (Anonymous, 1896; Castonguay and Beaulieu, 1993).

There are also indications of variation in spawning time: The Spanish spring fishery in the Bay of Biscay has been occurring earlier each year, and since this fishery is targeting spawning mackerel, this indicates that the spawning in the southern component occurs earlier each year (Punzon and Villamor, 2009). In winter 2011–2012 the timing of the spawning migration was even more pronounced in the Cantabrian Sea from early January to February compared to March and April just some years ago. However, the triennial egg survey in 2013 showed that the peak of spawning in the Cantabrian Sea was later than in both 2007 and 2010. Mackerel egg surveys also gave indication of earlier spawning for 2010 and 2013 in the western spawning component with a peak in egg production early in March compared to the earlier years when peak production was in centred on May.

Timing of overwintering, spawning migration and spawning of the NEA mackerel has previously been linked to temperature, with, e.g. earlier overwintering and spawning related to increased temperatures (Reid *et al*., 1997; Jansen *et al*., 2012; Punzón and Villamor, 2009; Jansen and Gislason, 2011). In spring and summer 2012 the measurements of plankton concentrations were among the lowest in the entire time-series since 1996 in the northern and western parts of the Northeast Atlantic.



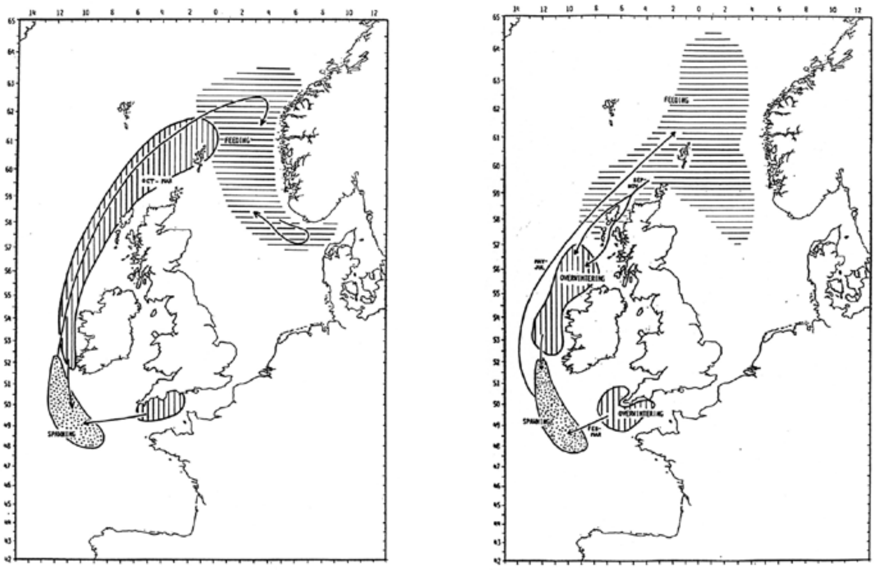


Figure A.3.3.1. Schematic outline of the migration of the western (+ southern in top right map) adult mackerel through time. From left: late 1970s (ICES, 1990), early 1980s (ICES, 1990), latter half of 1980s (ICES, 1990), mid-1990 (Anon, 1997).

B. Data

B.1. Commercial catch

Data Compilation and Archiving

Prior to the annual assessment WG, national data submitters are responsible for submitting details of commercial catch and the associated sampling (carried out under the DCF in EU countries) to the stock coordinator. This information is supplied aggregated to ICES subarea and quarter. The data are usually detailed in an Excel spreadsheet (known as the 'exchange format'). Information on misreported catches, unallocated catches and discards can also be included on the spreadsheet. An up to date fleet description and a breakdown of catch by ICES statistical rectangle are also requested. For nations with minor (and generally unsampled) catches, the stock coordinator will retrieve the data from the Statlant database, hosted by ICES.

Upon completion of error checking, the stock coordinator will compile the data in order that it can be used in the assessment. A key step in this process is the allocation of samples to unsampled catches. The stock coordinator will choose appropriate samples (and their relative weightings) on the basis of fleet type, quarter and geographic area. Once the samples have been assigned the stock coordinator will produce a vector of catch numbers, weights and lengths in addition to the total catch. This was traditionally done using a bespoke software application known as *sallocl* (Patterson, 1998). Presently, a web-based data portal known as InterCatch is used which is hosted by ICES and has the advantage of acting as a central repository for the data. Frequent comparisons are made using both approaches as a quality check.

Discards

The working group has estimated the level of discards since 1978. However, this is based on estimates provided by only a few countries and is routinely identified as being an underestimate. The level of underestimation is variable and unknown.

The primary reason for the discarding or slipping (where the entire catch is released prior to being brought on board) of mackerel is on the basis of size. The discarding of high proportions of the total catch resulted in the establishment of the Cornwall box catch restrictions around the SW coat of England. Small mackerel is also often caught in the horse mackerel directed fishery, primarily in the English Channel, and is subsequently discarded either because of quota restrictions or unfavourable market conditions. Widespread discarding of fish weighing under 600 g also occurred in the early 1990s in response to the high prices paid for large fish which has been proposed as a possible reason for the low abundance of some year classes.

Data quality

If they are in possession of supplementary information, national data submitters can identify misreported catches. Often, catches will be transferred from one ICES area to another to account for information on misreporting. While not considered to be an issue in recent years, there is evidence of large-scale misreporting between ICES Subareas IVa and VIa and IVa and IIa in the past.

A significant proportion of the complete catch time-series is considered to be of relatively poor quality in that it is believed that there is a significant underreporting of catch. A study into unaccounted mortality (Simmonds, 2007) suggested significant unaccounted mortality equivalent to 1.6 to 3.4 times the reported catch. This unaccounted mortality could be the result of unreported discards and slipping, fish that escape but subsequently die or unreported catch. Improved monitoring and stricter reporting requirements have resulted in improved confidence in recent years.

B.2. Biological

B.2.1. Weighting of spawning components

The SSB estimates from the egg surveys in the North Sea and the western/southern area are used to compute the proportion of the NEA mackerel represented by each of the three spawning components. For a complete time-series of proportion of each component, see the report of the 2014 Benchmark Workshop on Pelagic Fish (ICES, 2014) and the WGWIDE reports since then.

B.2.2. Weight-at-age in stock

The mean weights-at-age in the stock are based on available samples from the area and season of spawning of each of the spawning components.

For the southern component, stock weights are based on the samples from the Portuguese and Spanish catch taken in VIIIc and IXa in the 2nd quarter of the year, complemented by egg survey samples when available. For the Western spawning component, samples come from commercial catches, and when available, the egg survey for the areas and months corresponding to spawning (Table 2.2.1). In addition, fish sampled during the May tagging experiments by Norway in the northwest of Ireland are also included. For the North Sea spawning component, mean weights-at-age were calculated from samples of commercial catches collected from Area IVa in June combined with data collected during the North Sea egg survey in May–June when available.

The mean weights-at-age for the total stock are then calculated as weighted mean of the weights in each component, where the weighting is the egg survey based estimate of SSB in the three components. For a complete time-series on mean weights-at-age in the three components see the report of the 2014 Benchmark Workshop on Pelagic Fish (ICES, 2014) and the WGWIDE reports since then.

Table 2.2.1. Areas and month corresponding to the core spawning used for the selection of samples to compute mean stock weights-at-age in the western component. Establish based on egg survey results (see ICES, 2014).

months	ICES subdivision
March	VIIb,j,h,VIIIa,b
April	VIa,VIIb,c,j,h VIIIa
May	VIa,VIIb,c,j,k,VIIIa,d

B.2.3. proportions of individuals mature at age

The proportions of individuals mature at age are based on the following information:

North Sea component: The present proportions mature were calculated in 1984 on the basis of analysis of Norwegian biological samples from June–August 1960–1981. This revealed that 74% of the two year old mackerel, which appeared in the catches, were sexually mature. By comparing fishing mortalities for II-group mackerel with the fishing mortalities for the III-group the year after, when they are fully recruited to the spawning stock, it seems that about 50% of the II-group mackerel are available to the fishery. Assuming that only the spawning component of the stock is available in the fishery, maturity ogive for the North Sea stock was estimated (ICES, 1984).

Western component: Since the 2014 mackerel benchmark (ICES, 2014) time varying proportions of individuals mature at age are calculated based on samples from the Dutch, Irish, German and UK commercial catches collected from February to July. Proportions of mature fish at age were calculated grouping the data in blocks of five years, and moving this five year window from 1980 to the terminal year in the assessment. Due to the scarcity of samples for age 1 fish, the time varying estimate for this age is replaced by the mean across all years.

Southern component: Based on a histological analysis of mackerel samples collected during the 1998 Egg Survey (ICES, 2000; Perez *et al*., 2000).

The proportions of mature mackerel-at-age for the total stock are calculated as the mean of the proportions in the three spawning components weighted by the respective size of each component (as estimated by the egg surveys).

B.2.4. Natural mortality and proportion of F and M before spawning

Natural mortality (M) has been fixed at 0.15 for decades. This value was calculated based on estimates of total mortality derived from tagging data combined with catch data (Hamre, 1980). The first mackerel working group report where this value was given in was 1983 (ICES, 1984).

Given the variability of the time of spawning, time varying proportions of F and M before spawning are used. The time of spawning is calculated for both the western and southern spawning component in each egg survey year as the Julian day where 50% of the total egg production has occurred. The time of spawning for the whole stock is then taken as the average of the time in these two components (weighted by their respective size). Assuming that natural mortality is constant through the year, the proportion of M occurring before spawning is equal to the proportion of the year before spawning time.

The proportion (per age group) of the catches taken before spawning time are calculated for each survey year as the sum of the quarter 1 catches plus the necessary proportion of the quarter 2 catches (if spawning time occurs in the second quarter) or as the necessary proportion of the catches in the first quarter (if spawning time occurs in the first quarter). Proportions of fishing mortality before spawning (F_{prop}) per age group are then estimated using an optimizer to find the F_{prop} value which minimizes the (square of the) difference between the observed proportion of catches before spawning, and the proportion of catches before spawning calculated based on the M_{prop} value and F at age values from the last available assessment. In order to reduce the effect of the noise in the data, average F_{prop} values are calculated by groups of age-classes: ages 1–2, ages 3–4 and ages 5 and older. F_{prop} for age 0 is by convention set to 0.

Time-series of M_{prop} and of F_{prop} at age based on linear interpolation between survey years are used as input to the assessment model. The M_{prop} and F_{prop} values of the latest survey are used for the most recent years, but these values are updated using linear interpolation when a new survey is carried out.

B.3. Surveys

B.3.1. Mackerel Egg surveys (MEGS)

Two mackerel egg surveys have been performed since 1968. Both are triennial survey and are presently only adding new information to the time-series every third year. The Atlantic survey that started in 1977 covers the western–southern spawning grounds in the Northeast Atlantic while the other survey covers the spawning in the North Sea and Skagerrak (Figure A.3.2.1).

Each survey is split into several sampling periods covering the whole spawning area in order to get an egg production curve covering the whole spawning season. Plankton samplers currently used are Gulf VII high speed plankton samplers or Bongo plankton nets with a mesh size of 280 µm. The Gulf samplers are open torpedo-shaped frames with a flowmeter mounted in the nosecone to measure the volume of water sampled. The Bongo's are ringnets with 280 µm mesh size. All samplers are towed in double oblique hauls at a speed of approximately 5 knots. Next to the plankton samples pelagic trawl samples of adult fish are collected in order to determine the sex ratio and collect ovary samples to estimate fecundity and atresia of female fish.

All eggs are sorted out from plankton samples and identified to species. The mackerel eggs in the samples are staged according to development (Lockwood *et al.*, 1981). The stage 1 eggs are used to estimate the daily egg production per sampling period. The total annual egg production is then calculated by integrating all periods in the egg production curve. Spatio-temporal coefficient of variation (CV) of the egg production is estimated. The mackerel SSB is estimated by dividing the total annual egg production by the realized fecundity of the females and multiplying by the sex ratio. The coordination of the surveys and SSB estimation are the responsibility of the working group for mackerel and horse mackerel egg surveys (WGMEGS). Preliminary results are reported by WGMEGS to WGWIDE in the year of the survey, the results of the survey are finalized and reported in the year after the survey.

B.3.2. International Bottom Trawl Surveys (IBTS)

A recruitment index derived from catch data from the International Bottom Trawl Surveys (IBTS) was evaluated during the benchmark process (WKPELA, 2014). The cpue time-series was found to be consistent between first and fourth quarter surveys in the overlapping area. It is therefore used as a relative index of abundance at age 0. Full documentation can be found in Jansen *et al*. (2014. WKPELA WD).

Trawling was done by research vessels from Scotland, Ireland, England, France and Spain collectively known as the international bottom-trawl surveys in October–December (IBTS Q4). The surveys sample the fish community on the continental shelf and upper shelf slope. IBTS Q4 covers the shelf from Spain to Scotland, excluding the North Sea. Trawling was done at 3.5–4.0 knots. Two trawls deviated substantially from the GOV-type, namely the Spanish BAKA trawl and the Irish trawl that was used from 1998 to 2002. The BAKA trawl had a vertical opening of only 2.1–2.2 m and was fished at only 3 knots. This was substantially less suitable for catching juvenile mackerel and therefore excluded from the analysis. The Irish trawl used in 1998 to 2002 was a GOV trawl in reduced dimensions. The reduced wingspread and trawl speed was accounted for in the model.

A geostatistical log-Gaussian Cox process mode model (LGC) with spatio-temporal correlations was used to describe the catch rates of mackerel recruits through space and time.

These catch rates were then averaged by year and expressed in relation to the mean of the time-series as a relative catch rate index.

The information value was examined by fitting similar models to the mackerel catch data in Q4 and Q1 (January–March), in the area where the two surveys overlapped (55–60°N, 4–10°W). The time-series from Q4 and Q1 were compared and found to be strongly positively correlated ($p<0.001$, $R^2=0.66$). The simplest explanation for this correlation is that catch rates in both surveys reflect the same recruitment signal from the mackerel population. It furthermore suggests that the applied method was appropriate to modelling the catch rates and the associated sampling noise.

Field observations during acoustic and trawl surveys in October in the mackerel box (Celtic Sea, Peltic survey) suggested that mackerel catchability may increase exponentially with school size. Although the underlying mechanisms are likely to be complex there are several factors that appear likely. Fish in schools may not be able to successfully avoid an approaching trawl due to high fish densities limited movement; another possibility is that vessel avoidance may propagate through the school from fish in top of the school to those nearer the seabed. Visual exploration of echograms showed that an important contributing factor was density-dependent depth behaviour: small mackerel schools were generally observed in midwater whereas large and high density mackerel schools were consistently associated with the seabed. Schooling mackerel could therefore more easily out-manoeuvre the trawl, given the fact that they can escape in multiple directions. The proximity of larger schools to the seabed would make them more accessible to the bottom-trawl gear. This effect may be further amplified by the reported diving behaviour of the mackerel at the top of the school, in response to an approaching vessel (Slotte *et al*., 2007). Although catchability is a complex process affected by many factors, the above observations suggest that the index should be transformated to account for the density effect.

In conclusion:

The strong correlation between the independent sampled and modelled catch rate in Q1 and Q4 suggests that catch rates in both surveys reflect the same recruitment signal from the mackerel population. It furthermore suggests that the applied method was appropriate to modelling the catch rates and the associated sampling noise.

A hypothesis of positive density-dependant catchability was suggested and acoustic observations supporting the hypothesis were presented. Log transformation of the cpue index as well as modification of the index calculation was done to reduce the density effect. Correlations with the assessment recruitment time-series improved substantially in both cases, further supporting the hypothesis.

Further work on extending the Q4-model with data from IBTS Q1 in the North Sea and other northern areas is recommended.

B.3.3. IESSNS swept-area surveys

The main objective of the IESSNS survey in relation to quantitative assessment purposes is to provide reliable and consistent age-disaggregated abundance indices of NEA mackerel. Research vessels and chartered commercial fishing vessels from Norway (two vessels), Faroe Islands and Iceland (one from each country) were used in the Norwegian Sea and adjacent waters in July–August 2007 and from 2010 to 2013 (Nøttestad *et al*., 2014). In 2007, the surveys were conducted by two Norwegian vessels only. The survey aimed at covering the outer borders (zero lines) of the mackerel distribution each year from 2007 in all directions except in the southern region (south of 62°N in the North Sea). Due to the spatial expansion and increased geographical distribution of mackerel in the Nordic Seas from 2007 to 2013, the survey coverage differed from year to year in an effort to cover an expanding stock and at the same time a dynamically moving zero border lines (Figure A.3.3.1). The temporal coverage was limited to 5–6 weeks period, in order to avoid any double or zero counting during the survey. In 2011 short ship time limited the coverage in both the northern and southern part of the eastern Norwegian Sea. The swept-area survey was designed with predominantly parallel east–west survey lines, and fixed sampling stations approximately 60 nautical miles apart at predetermined geographical positions (ICES, 2013b, c; Nøttestad *et al*., 2014). The methodology of the survey is detailed in ICES (2013c) and Valdemarsen *et al*. (2014).

The catch of the different species was weighed on board and a total of 100 mackerel individuals were sampled from the catch randomly and total length (±1 cm) and whole body weight (±0.1 g) recorded from each trawl haul. The otoliths from the first 25 individuals were retrieved for age reading. On basis of the catch data and operation of the trawling hauls, swept-area estimates of age-disaggregated indices and biomass are calculated for rectangles of 2° longitude and 1° latitude across the survey area (Nøttestad *et al*., 2014). The results from the IESSNS surveys (Figure A.3.3.2) are reported at the working group for widely distributed stocks (WGWIDE) and working group for international pelagic surveys (WGIPS).

The decision of indices constructed and used from this survey took into account issues raised at WKPELA (ICES, 2014) regarding apparent lower catchability of fish at age <6, variable and expanding coverage of the annual surveys, uncertainty in catch efficiency with respect to vertical distribution of the stock in the North Sea, and the fact that the survey is only covering the oceanic part of the stock leaving out mackerel further south. Thus the age-disaggregated indices constructed for analytical assessment purpose was spatially restricted to Nordic Seas, leaving out North Sea south of 62°N, delimited to age 6+ and scaled by the total area covered each year (number per square km; equivalent to cpue).

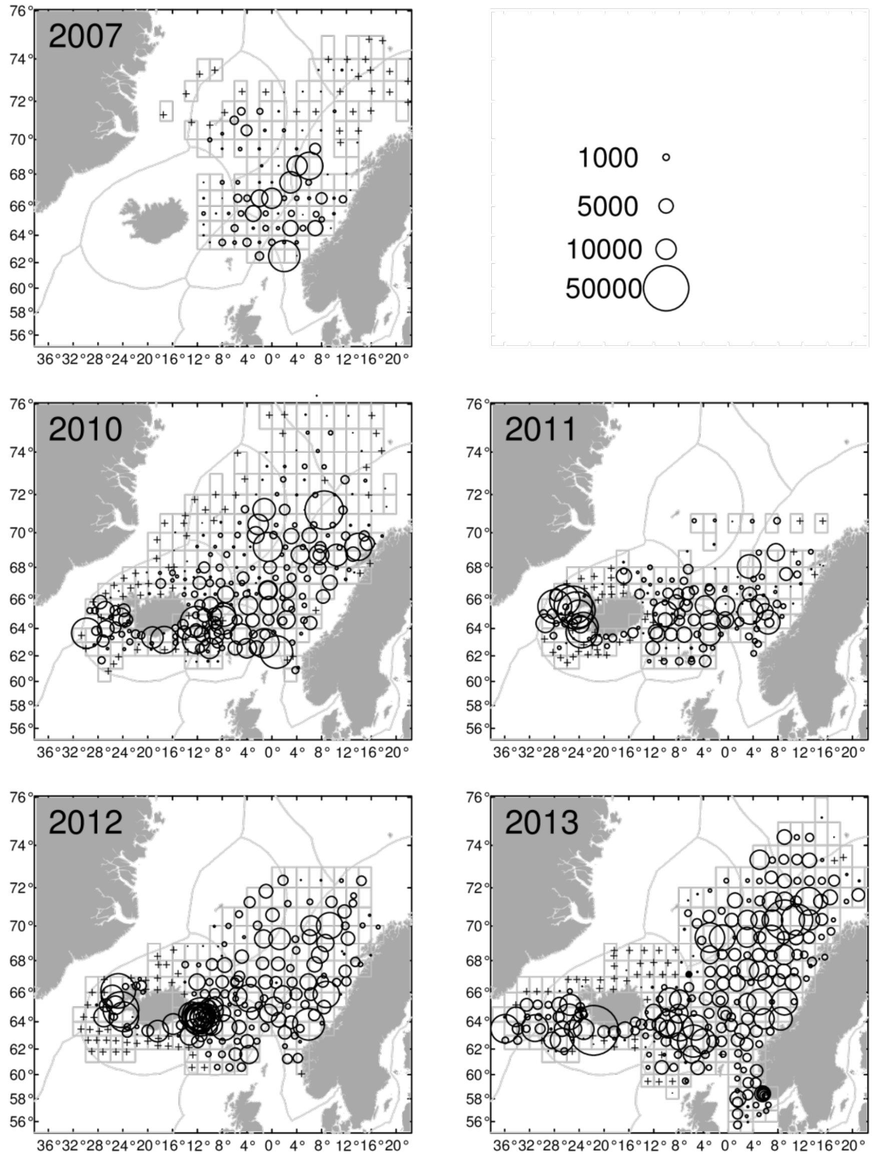


Figure A.3.3.1a–e. Average catch index (kg/km^2) presented as circles ranging from no catch (a +), >1000 kg/km^2 to >50 000 kg/km^2 for NEA mackerel in July–August 2007, 2010–2013. The spatial coverage varied from 0.926 million km^2 in 2007 to 2.410 million kg/km^2 in 2013.

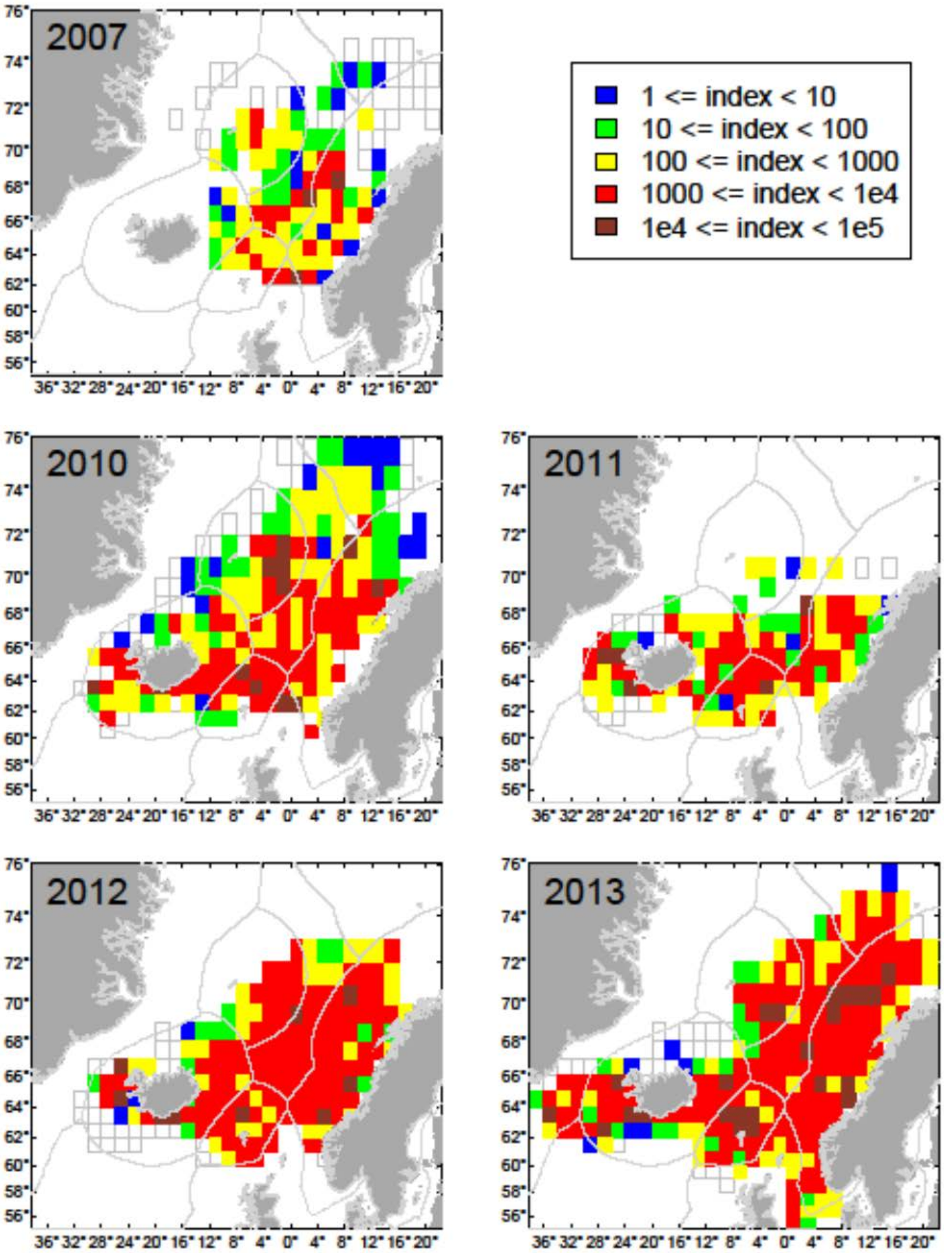


Figure A.3.3.2a–e. Graphical representation of average catch index (kg/km²) for NEA mackerel in July–August in 2007 and 2010–2013. The spatial coverage varied from 0.926 million km² in 2007 to 2.410 million kg/km² in 2013. No catch is represented as open squares.

B.4. Commercial cpue

None.

B.5. Other relevant data: Tagging data

Institute of Marine Research in Bergen has conducted tagging experiments with internal steel tags on mackerel since 1969, both in the North Sea and west of Ireland and the British Isles during the spawning season May–June. In the present assessment the tagging time-series was restricted to releases of the western component during the years 1977–2004 and from screening of commercial catches at factories with metal detectors from 1986–2006. During this period the same methodology was used during both the tagging process and screening, and it was hence suggested to be a very consistent time-series. Tagging with the steel tags continued until 2009 with screening until 2010. However, a change in the fishing process from manual jigging to automatic tagging machines, which could have induced differences in post tagging mortality, as well as some uncertainty regarding screening efficiency at the factories, led to the conclusion that this part of the time-series should be excluded from the assessment. Furthermore, the new effort with tagging using RFID-technology starting in 2011 was considered to be too short, and it is expected that this time-series could be included in the assessment after further evaluation in about three years' time.

The actual format of the tagging data used in the assessment is as numbers tagged of a year class in a specific year, the numbers recovered of this year class from that release year in all successive years, as well as the numbers screened by year class in all years.

C. Historical stock development

The assessment model

SAM

A benchmark assessment for NEA Mackerel was carried out in 2014 during the Benchmark Workshop for Pelagic Stocks (WKPELA, ICES 2014). Following this benchmark investigation, the tool chosen for the assessment is SAM, the state–space assessment model (Nielsen and Berg, 2014). Since 2014, this method has been implemented using the online webpage interface on www.stokassessment.org.

In SAM, the "states" (fishing mortalities and abundances-at-age) are constrained by the survival equation and follow a random walk process. The variances of the random-walk processes on abundances and fishing mortalities are parameters estimated by the model.

SAM is a fully statistical model in which all data sources (including catches) are treated as observations, assuming a lognormal observation model. The corresponding variances, so-called observation variances, are also parameters estimated by the model. Observations variances can be used to describe how well each data source is fitted in the model and effectively correspond to the internal weight given by the model to the difference data sources.

The other parameters estimated are the catchabilities of the surveys.

Uncertainties (standard errors) are estimated for all parameters and for all states (Fs and Ns).

Modifications to SAM for the NEA mackerel assessment

In the SAM mackerel assessment, tagging–recapture data from the Norwegian tagging programme are used as input data. In order to incorporate the tagging–recapture information, tag recoveries (per year and for each year class) were predicted from the model, based on the number of fish screened in the processing factories, the amount of tagged fish of the same year class released in the previous years, and the corresponding abundances of this year class in each release year estimated by the model, conditional to a post-release survival rate (time invariant and for all ages) which is a parameter estimated by the model. Given the nature of these data (count data with overdispersion) a negative binomial observation model is used.

Assessment model configuration

Catches for NEA mackerel for the period prior to 2000 are considered highly unreliable, due to a massive underreporting in the historical period. However, valuable information is available from other data sources (tags, egg survey) for the years before 2000. Instead of discarding all data prior to 2000, it was decided during the 2014 benchmark mackerel assessment to start the assessment in 1980, and reduce as much as possible the influence of the catches until 2000. This was done by arbitrarily down weight the catches for the years prior to 2000, by imposing a high observation variance of these catches (equal to 1.35).

Furthermore, the model incorporates tagging–recapture data until the recovery year 2006, and three survey indices: the IBTS recruitment index, the mackerel egg survey SSB index and abundances indices from the IESSNS.

More details on the input and on the survey indices incorporated in the assessment are given in the tables below (Y being the current year in which the assessment is carried out).

Input data types and characteristics:

Name	Year range	Age range	Variable from year to year
Catch in tonnes	1980–(Y-1)		Yes
Catch-at-age in numbers	1980*–(Y-1)	0–12+	Yes
Weight-at-age in the commercial catch	1980–(Y-1)	0–12+	Yes
Weight-at-age of the spawning stock at spawning time.	1980–(Y-1)	0–12+	Yes
Proportion of natural mortality before spawning	1980–(Y-1)	0–12+	Yes
Proportion of fishing mortality before spawning	1980–(Y-1)	0–12+	Yes (constant before 1989)
Proportion mature-at-age	1980–(Y-1)	0–12+	Yes
Natural mortality	1980–(Y-1)	0–12+	No, fixed at 0.15

*** catches-at-age before 2000 are heavily down weighted which makes that in practice, they have little influence on the assessment.**

Tuning data:

Type	Name	Year range	Age range
Survey (SSB)	ICES Triennial Mackerel and Horse Mackerel Egg Survey	1992, 1995, 1998, 2001, 2004, 2007, 2010, 2013.	Not applicable (gives SSB)
Survey (abundance index)	IBTS Recruitment index (log transformed)	1998–(Y-1)	Age 0
Survey (abundance index)	International Ecosystem Summer Survey in the Nordic Seas (IESSNS)	2007, 2010–Y	Ages 6-11
Tagging/recapture	Norwegian tagging program	1980–2006 (recapture years)	Ages 2 and older

Model configuration as defined during the 2014 benchmark is given in the table below. In addition, the model has an age range from 0 to 12 and a plus group is set at 12 years. The reference fishing mortality, F_{BAR}, is calculated over the ages 4 to 8.

SAM parameter configuration:		
Setting	Value	Description
Coupling of fishing mortality states	1/2/3/4/5/6/7/8/8/8/8/8	Different F states for ages 0 to 6, one same F state for ages 7 and older
Correlated random walks for the fishing mortalities	0	F random walk of different ages are independent
Coupling of catchability parameters	0/0/0/0/0/0/0/0/0/0/0/0 0/0/0/0/0/0/0/0/0/0/0/0 1/0/0/0/0/0/0/0/0/0/0/0 0/0/0/0/0/0/2/2/2/2/2/2/0	No catchability parameter for the catches One catchability parameter estimated for the egg One catchability parameter estimated for the recruitment index One catchability parameter estimated for the IESSNS (same for age 6 to11)
Power law model	0	No power law model used for any of the surveys
Coupling of fishing mortality random walk variances	1/1/1/1/1/1/1/1/1/1/1/1	Same variance used for the F random walk of all ages
Coupling of log abundance random walk variances	1/2/2/2/2/2/2/2/2/2/2/2	Same variance used for the log abundance random walk of all ages except for the recruits (age 0)
Coupling of the observation variances	1/1/1/1/1/1/1/1/1/1/1/1 0/0/0/0/0/0/0/0/0/0/0/0 2/0/0/0/0/0/0/0/0/0/0/0 0/0/0/0/0/0/3/3/3/3/3/0	Same observation variance for all ages in the catches One observation variance for the egg survey One observation variance for the recruitment index One observation variance for the IESSNS (all ages)
Stock–recruitment model	0	No stock–recruiment model

Due to the high uncertainty in the recruitment estimates for the terminal year, Y-1, for the NEA Mackerel, the value estimated by SAM is arbitrarily replaced by the output of RCT 3 (see short-term prediction section).

D. Short-term projection

In a given assessment year Y, advice is given on catches for the following year Y+1 based on deterministic projections three years ahead (Y to Y+2). These projections are based on an assumption of the current year's (also called intermediate year) catch (see section below "Assumptions for the intermediate year catch") from which fishing mortality in the current year Y is inferred, and a range of management options for the advice year, Y+1 (fishing mortality in Y+2 being the same as Y+1), are provided.

Initial abundances at age

The survivors at the 1st of January of year Y estimated by SAM are used as starting abundances at age in the first year of the short-term forecast. The recruitment estimate at age 0 from the assessment in the terminal assessment year (Y-1) is considered too uncertain to be used, because this year class has not yet fully recruited into the fishery. The last (Y-1) SAM recruitment estimate is therefore replaced by predictions from the RCT3 software (Shepherd, 1997). The RCT3 software performs a linear regression between the IBTS recruitment index and the SAM estimates over the period 1998 toY-2, and, based on this regression, predicts the Y-1 recruitment from the Y-1 IBTS index value. The final Y-1 recruitment is the average between the prediction from this regression and a time tapered geometric mean of the SAM recruitments up to Y-2, weighted by the inverse of their respective prediction standard errors. The historic performance of the IBTS index thus determines the influence of the Y-1 index value on the Y-1 recruitment produced by RCT3. A weak correlation of the survey index with the SAM estimates brings the RCT3 estimate close to the SAM geometric mean, while a strong correlation brings it close to recruitment predicted from the IBTS index for the year Y-1. The "time tapered geometric mean" is a weighted geometric mean, where the most recent years are given the highest weights.

The abundance of the survivors-at-age 1 (in Y) used as starting values for the short-term forecast is then estimated by bringing forward recruitment-at-age 0 (in Y-1) applying the total mortality-at-age 0 in year Y-1 estimated by SAM.

Conditioning of the short-term forecast

Recruitment

The recruits at age 0 in year Y, Y+1 and Y+2 are set to the geometric mean.

Exploitation pattern

The exploitation pattern (relative selection pattern) used in the predictions from Y to Y+2 is defined as the average of the exploitation pattern of the last three years in the assessment (Y-3 to Y-1), obtained by dividing the fishing mortalities-at-age of those three years by the value of F_{BAR}4–8 in the corresponding years.

Maturity-at-age, weight-at-age in the catch and weight-at-age in the stock

The three year average of Y-3 to Y-1 is used for the proportion mature-at-age as well as stock and catch weights-at-age.

Proportion of natural and fishing mortality occurring before spawning

The three year average of Y-3 to Y-1 is used for the proportions F_{prop} and M_{prop}.

Assumptions for the intermediate year (Y)

The catch in the intermediate year (Y) is taken as a TAC constraint. The catch is estimated from declared quotas modified by e.g. paybacks (e.g. EU COMMISSION REGULATION (EC) No 147/2007), discards (assumed to be equal to the last reported discards in year Y-1), interannual transfers and expected overcatch. Scientists from the relevant countries present at the WGWIDE each year provide the information on interannual transfers and expected overcatch.

Management Option Tables for the TAC year

The different management options for the catch in Y+1 are tested, covering both the ICES approach to MSY and the management plan implemented for NEA Mackerel in 2009:

Catch$_{Y+1}$ = zero

Catch$_{Y+1}$ = TAC$_Y$ – 20%

Catch$_{Y+1}$ = TAC$_Y$

Catch$_{Y+1}$ = TAC$_Y$ + 20%

$Fbar\,Y+1 = 0.20$

$Fbar\,Y+1 = 0.21$

$Fbar\,Y+1 = 0.22$

$Fbar\,Y+1 = 0.25$ (Fmsy)

$Fbar\,Y+1 =$ Fmsy transition

Software implementation

The short-term forecast will be calculated in MFDP, FLR or StockAssessment.org. Testing and decision will be done during the preparation of the advice for May 2014.

E. Medium-term projections

No medium-term projections.

F. Long-term projections

No long-term projections.

G. Biological reference points

Precautionary reference points.

B_{lim} - There is no evidence of significant reduction in recruitment at low SSB within the time-series (ICES, 2014) hence the previous basis for B_{lim} is retained. B_{lim} is taken as B_{loss}, the lowest estimate of spawning–stock biomass from the revised assessment. This was estimated to have occurred in 2002; B_{loss} = 1 840 000 t.

F_{lim} - F_{lim} is derived from B_{lim} and is determined as the F that on average would bring the stock to B_{lim}; $F_{lim} = 0.39$.

B_{pa} - The ICES basis for advice requires that a precautionary safety margin incorporating the uncertainty in actual stock estimates leads to a precautionary reference point B_{PA}, which is a biomass reference point designed to avoid reaching B_{lim}. Consequently, B_{PA} was calculated as $B_{lim} * \exp(1.645\sigma)$ where $\sigma = 0.15$ was taken as the assessment estimate of spawning biomass uncertainty in the most recent year; B_{PA} = 2 350 000t.

F_{PA} - F_{PA} is derived from B_{PA} and is determined as the F that on average would bring the stock to B_{PA}; $F_{PA} = 0.26$.

MSY reference points

MSY reference points were evaluated using equilibrium stochastic simulations (ICES, 2014 WKMSYREF2). Yield was considered as total catch, which is considered relevant to the situation from 2015 onwards when the fishery will be conducted under a discard ban for almost all participants.

F_{MSY} - Applying the WKMSYREF2 simulation approach the median value of F_{MSY} was F=0.31, above F_{PA}, and resulted in a greater than 5% probability of $SSB<B_{lim}$. Fulfilling the precautionary requirement of SSB having 5% or less probability of being reduced to below B_{lim} results in $F_{MSY} = F \leq 0.26$.

Maximum mean and median catches both occurred at a lower exploitation rate of F=0.25. Following the ICES guidelines (ICES, 2013d WKMSYREF), F=0.25 is an appropriate F_{MSY} target as on average it resulted in the highest mean yields with a low risk of reducing the spawning biomass below B_{lim}.

Type		Value	Technical basis
Management Plan	SSBtrigger	N/A	Revision required
	F target	N/A	Revision required
MSY Approach	MSY Btrigger	2.36 million t	Proxy based on Bpa WKPELA 2014
	MSY target	0.25	Stochastic simulation conducted at WKPELA 2014
Precautionary Approach	Blim	1.84 million t	Bloss in 2002 from WKPELA 2014 benchmark assessment
	Bpa	2.36 million t	exp(1.654*σ)*Bim, σ =0.15
	Flim	0.39	Floss, the F that on average leads to Blim
	Fpa	0.32	F that on average leads to Bpa

H. Other Issues

H.1. Management plans and evaluations

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

An agreed management plan for NE Atlantic mackerel was finalized in October 2008. The management plan is as follows:

"The agreed record of negotiations between Norway, Faroe Islands, and EU in 2008 states that the long-term management plan shall consist of the following elements:

1) For the purpose of this long-term management plan, "SSB" means the estimate according to ICES of the spawning–stock biomass at spawning time in the year in which the TAC applies, taking account of the expected catch.

2) When the SSB is above 2 200 000 tonnes, the TAC shall be fixed according to the expected landings, as advised by ICES, on fishing the stock consistent with a fishing mortality rate in the range of 0.20 to 0.22 for appropriate age groups as defined by ICES.

3) When the SSB is lower than 2 200 000 tonnes, the TAC shall be fixed according to the expected landings as advised by ICES, on fishing the stock at a fishing mortality rate determined by the following:

Fishing mortality F=0.22* SSB/ 2 200 000

4) Notwithstanding paragraph 2, the TAC shall not be changed by more than 20% from one year to the next, including from 2009 to 2010.

5) In the event that the ICES estimate of SSB is less than 1 670 000 tonnes, the Parties shall decide on a TAC which is less than that arising from the application of paragraphs 2 to 4.

6) The Parties may decide on a TAC that is lower than that determined by paragraphs 2 to 4.

7) The Parties shall, as appropriate, review and revise these management measures and strategies on the basis of any new advice provided by ICES."

From (NEAFC, 2008).

ICES consider the agreement to be consistent with the precautionary approach. However, the management plan does not specify measures that would apply under poor stock conditions that preclude further evaluation.

The updated assessment from 2014 (WKPELA 2014) resulted in higher recruitment and fishing mortality estimates that are in historical time similar compared to the old assessment, but lower in recent years. As a consequence, the perception of the level of spawning biomass has changed. Consequently, the current management plan fishing mortality target range is still considered to be precautionary, and ICES can continue to provide advice under this plan if requested to do so. However, the current management plan $B_{trigger}$ is below the revised B_{PA} and consequently the management plan should be re-evaluated prior to the release of advice for 2015 in order to determine the appropriate combination of $B_{trigger}$ and fishing mortality range that are consistent with the precautionary approach.

H.2. Data limited approach for NEA mackerel

Context

In 2013 ICES was required to provide advice for the mackerel stock on the basis of no agreed quantitative assessment and corresponding management target and reference points, an exploitation rate which was potentially above the previous reference levels and no international agreement on catches.

For other stocks for which no quantitative assessment was available ICES had previously employed the WKLIFE Data Limited Stocks (DLS) approach (ICES 2012, CM 2012/ACOM 68) to provide precautionary management advice. ICES considered the DLS Method 3.2 approach, which uses survey trend based scaling of catches, applicable to the NEA mackerel. WKLIFE3 (ICES, 2013e) had evaluated the method using a simulated gadoid stock and concluded that for overexploited stocks without a defined management target, a precautionary buffer which reduced catch levels by 20% would be required to prevent increasing risk to the stock when the control rule was applied over the longer term; however caveat scenarios in which the precautionary buffer might not be required were also discussed.

ICES ACOM eventually gave advice on NEA mackerel based on a recent catch, citing the preliminary nature of the most recent egg survey, the lack of good uncertainty estimates and the lack of agreement on whether a precautionary buffer (20% reduction in catches in the first year of application) should be applied. WKLIFE3 later examined the ICES NEA mackerel advice in 2013 and made the following comment:

"Mackerel in the Northeast Atlantic: In the 2013 advice season, ACOM treated this stock in an *ad hoc* way rather than as a data-limited stock proposed by their own ADG. The rationale for this is neither adequately nor clearly explained in any ICES document.

On balance, WKLIFE do not understand the rejection of the DLS guidance and support the ADG's recommendation to treat this stock with a Category 3 method incorporating the *precautionary buffer*."

As a result of the uncertainty in the application of the ICES DLS Method 3.2 to mackerel, WKPELA (2014) agreed that a more detailed, stock-specific evaluation of the ICES DLS Method 3.2 application to the NEA mackerel should be conducted in order to provide guidance for management advice in the event that a quantitative assessment was not available.

NEA mackerel simulations

WKPELA (2014) used a MSE simulation framework in FLR, R version 2.10.1 (2009-12-14), Core package of FLR, fisheries modelling in R. Version: 2.3-644. Flash Version: 0.7.0. Evaluations were carried out based on a simulated mackerel stock with stock dynamics (growth, recruitment, etc.), single fleet exploitation and a single fishery-independent survey index.

Fishery-independent time-series

WKPELA considered that the triennial egg survey index of SSB with a CV of the order of 24% gave the only, more or less complete, index of SSB (the egg survey does not include egg mortality and so it is not considered an absolute SSB estimate).

Harvest control rule

As the survey is carried out triennially setting the catch for three years as multi-annual advice (y+1 to y+3) is appropriate and the DLS Method 3.2 becomes:

$$C_{(y+1,y+2,y+3)} = C_{(y)} * Fac \qquad \text{Equ. H.2.1}$$

where Fac is derived from DLS Method 3.2 such that with S(y) the survey index in year y

$$Fac = ((S_{(y)} + S_{(y-1)}) /2) / ((S_{(y-2)} + S_{(y-3)} + S_{(y-4)}) /3) \qquad \text{Equ. H.2.2}$$

Mackerel egg survey indices are available every three years so that $S_{(y-1)}$, $S_{(y-2)}$ and $S_{(y-4)}$ are derived by linear interpolation from the surveys in $S_{(y)}$, $S_{(y-3)}$ and $S_{(y-6)}$ such that after simplification:

$$Fac = 3/2 * (5*S_{(y)} + S_{(y-3)}) / (S_{(y)} + 7*S_{(y-3)} + S_{(y-6)}) \qquad \text{Equ. H.2.3}$$

Interannual variability, which could result from noise in the survey index series, is damped by the use of an uncertainty cap, such that:

$$Fac > 1.2 \Rightarrow Fac = 1.2 \qquad \text{Equ H.2.4a}$$

$$Fac < 0.8 \Rightarrow Fac = 0.8 \qquad \text{Equ H.2.4b}$$

In addition to the uncertainty cap, the application of ICES precautionary buffer margin of -20% for the first application of the rule was evaluated.

$$C_{(y+1,y+2,y+3)} = C_{(y)} * 0.8 * Fac \text{ at the first application and} \qquad \text{Equ H.2.5a}$$

$$C_{(y+1,y+2,y+3)} = C_{(y)} * Fac \text{ for subsequent iterations} \qquad \text{Equ H.2.6b}$$

DLS simulation results

Twelve scenarios were evaluated, four rule implementation options (with and without the PA buffer and the uncertainty cap) under three different stock starting conditions: historic fishing mortalities, F=0.22 (~F_{MSY}) and F=0.45 (~2*F_{MSY}). In all cases the stock was conditioned from 1981 to 2009 and DLS management simulated to start in 2009 with first year of catch under this regime in 2010.

The performance of the DLS method was considered in the context of ICES precautionary criteria by comparing the lower 5th percentile of SSB in each forecast year with a B_{lim} proxy (B_{loss}, Figure H.2.1). The inclusion of the precautionary buffer had a major influence on the likelihood that SSB had a greater than 5% probability of falling below B_{lim}. In all cases in which the precautionary buffer was not applied a substantially higher percentage than 5% of the stocks fall below B_{lim} and a significant proportion collapse; the inclusion of the PA buffer appears to prevent collapse in the medium term, independent of the starting conditions in the scenarios examined. This suggests that the application of the ICES DLS Method 3.2 as simulated, using triennial egg surveys to calibrate catch set for a period of three years is precautionary when the buffer is applied; it is not without the application of the buffer.

DLS method conclusions

WKPELA (2014) concluded that the simulations provided very clear guidance that exploitation using the ICES DLS Method 3.2 using the triennial egg survey based on equation H.2.3 would provide precautionary management advice for the provision of triennial multiannual TAC (three years) for the NEA mackerel stock in the absence of an agreed assessment.

The application of the ICES DLS Method 3.2 to the NEA mackerel requires the inclusion of the precautionary buffer at 20% in the first year of implementation (Equation H.2.4ab) and risk of SSB<B_{lim} is also reduced by the application of the uncertainty cap at 20% in each change of three year TAC (Equ H.2.5ab).

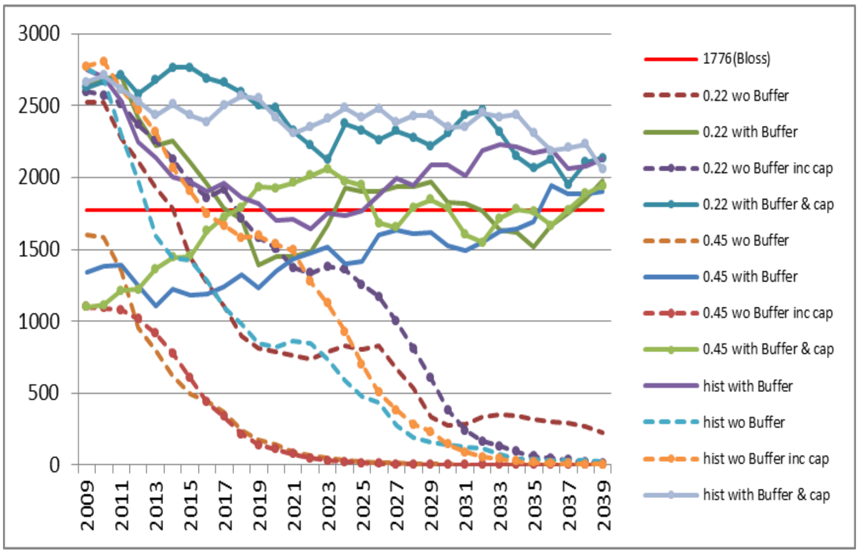


Figure H.2.1. Summary of NEA mackerel DLS Method 3.2 simulations in terms of ICES precautionary criteria. Three starting options 1) stable F=0.22, 2) stable F=0.45 and 3) historic state in 2009. Two options for calculating future catch are tested 1) PA Buffer included (solid lines) or not (dotted lines) 2) +/-20%cap on TAC change included (symbol on the line) or not (no symbol). These results demonstrate that it is essential to include the precautionary buffer if the lower 5% on SSB is to be kept above the assumed B_{lim}.

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Annex 02B – Stock Annex: Western Horse Mackerel

Stock specific documentation of standard assessment procedures used by ICES.

Stock	**Western Horse Mackerel (Divisions IIa, IIIa-west, IVa, Vb, VIa, VIIa-c, VIIe-k, VIIIa-e)**
Working Group:	**Working Group on Widely Distributed Stocks**
Date:	**29 August 2011**
Revised by	**WGWIDE, 02 September 2011**

A. General

A.1. Stock definition

Stock Identity

For many years, ICES considered horse mackerel (*Trachurus trachurus*) in the northeast Atlantic to be separated into three stocks. Prior to the conclusion of the project HOMSIR in 2003, this separation was motivated mainly on the basis of temporal and spatial distributions of the fishery and observed egg and larval distributions (ICES 2008/ACOM:13), but early on was also supported by information from acoustic and trawl surveys, and from parasite infestation rates in horse mackerel (ICES 1989/Assess:19, 1990/Assess:24, 1991/Assess:22). The southern stock was defined as that found in the Atlantic waters of the Iberian Peninsula, the North Sea stock in the eastern English Channel and North Sea area, and the western stock on the northeast continental shelf of Europe, stretching from the Bay of Biscay in the south to Norway in the north.

The occurrence of the large 1982 year class in the eastern part of the North Sea during the latter half of 1987, which resulted in the commencement of a sizeable Norwegian fishery for horse mackerel in the third and fourth quarters from the late 1980s, led to questions about the distribution of the North Sea stock (ICES 1989/Assess:19). A combination of commercial catch and bottom trawl survey data indicated that western horse mackerel had a similar migration pattern to mackerel, so that outside the spawning season bigger fish migrate north to reach the northern North Sea in the latter half of the year (Iversen *et al*. 2002). Differences were also noted in the development of the fishery and in the parasite infestation rates of horse mackerel in Divisions IIa and IVa compared to Divisions IVb-c and the English Channel, suggesting that fisheries in these two areas were exploiting fish from two different spawning areas (ICES 1990/Assess:24, 1991/Assess:22). Therefore, since 1989 ICES has allocated catches taken in Division IIa and in Division IVa (in later years only during the third and fourth quarters of the year for IVa, and including the western part of Division IIIa) to the western stock (ICES 1989/Assess:19).

A Study Group on stock identity held in 1992 (ICES 1992/H:4) found that, although there were clear centres of egg production, there were no major discontinuities in the distribution of eggs between the western and southern areas, bringing into question the separation between these stocks (ICES 1992/Assess:17). It was hoped a tagging program launched in Spain and Portugal in 1994 (ICES 1995/Assess:2), and two studies conducted in 1997 using allozyme differentiation and morphometric characteristics (ICES 1998/Assess:6) would shed further light on stock identity, but none of the tags were ever recovered (ICES 1996/Assess:7, 1997/Assess:3, 1998/Assess:6, 1999/ACFM:6, 2000/ACFM:5, 2001/ACFM:06), and neither study provided a basis for changing the stock separation previously defined (ICES 1998/Assess:6).

Further refinements of the definitions of stock units were made based on the results from HOMSIR (EU-funded project: QLK5-CT1999-01438), which integrated a variety of approaches to investigate horse mackerel stock identification (ICES 2005/ACFM:08, Abaunza *et al*. 2008). The project investigated the stock structure of horse mackerel from a holistic point of view within the western, southern, North Sea and Mediterranean areas. It included various genetic approaches (multilocus allozyme electrophoresis, mitochondrial DNA analysis, microsatellite DNA analysis and single stranded conformation polymorphysm SSCP analysis), the use of parasites as biological tags, body morphometrics, otolith shape analysis and the comparative study of life history traits (growth, reproduction and distribution). The project concluded in June 2003, and some of the main results from this project, which are of relevance to the western stock, were as follows (ICES 2005/ACFM:08):

i) Horse mackerel from the west Iberian Atlantic coast can be distinguished from the rest of the Atlantic areas.

ii) In the Atlantic Ocean, the northern boundary of the so called "southern stock" ought to be revised, and accordingly, the southern boundary of the so called "western stock". The body morphometrics and the otolith shape analysis joined the northwest of the Iberian Peninsula (North Galicia) to the areas located more to the North in the Atlantic Ocean, Bay of Biscay and Celtic Sea. On the other hand, the genetic results from SSCP associated the northwest of Iberian Peninsula to the Portuguese sampling sites. These differences between the techniques suggested that North Galicia may correspond to a transition area between two possible stock units. Therefore, it was proposed to move the actual boundary of the "Southern" and "Western" stocks from Cape Breton Canyon (southeast of Bay of Biscay) to the northwest of Iberian Peninsula (Galician coasts) and specifically to Cape Finisterre at 43º N latitude, which could be considered also as a boundary for certain hydrographic features, like the influence of North-Atlantic Central Water (Fraga *et al*., 1982).

iii) Parasites and body morphometrics indicated that horse mackerel in the North Sea could constitute a stock well differentiated from the rest of adjacent Atlantic areas.

iv) Horse mackerel along western European coasts, from the northwest of Spain to Norway, seem to be a unique stock. This definition is very similar to that previously used for the "western stock", except that, based on results from HOMSIR, the north coast of the Iberian Peninsula should also be included. Neither the SSCP results nor the parasite composition study showed any contradiction with this definition. Anisakid parasite species composition is homogenous throughout this area. Otolith shape analysis and body morphometrics include the sampling sites from this area in the same cluster, showing a great similarity in morphometric characteristics.

v) However, the population structure in the western European coasts could be more complicated and more research is needed to clarify the migration patterns within the Northeast Atlantic Ocean. This is especially relevant to the boundary areas between the North Sea Stock and the Western stock (Northern North Sea and English Channel).

Therefore, in many ways, results from the HOMSIR project largely supported ICES perceptions of stock units. Based on findings from the project, ICES now includes Division VIIIc as part of the distribution area of the western horse mackerel stock. The boundaries for the different stocks are given in Figure B.1.

Allocation of catches to stock

Based on spatial and temporal distribution of the horse mackerel fishery the catches were allocated to the western stock as follows:

Western stock: Quarters 3&4 only: Divisions IIIa (west), IVa
All Quarters: Divisions IIa, Vb, VIa, VIIa-c,e-k and VIIIa-e.

The reason why catches from only the western part of Division IIIa are allocated to the western stock is that these catches are taken in the third and fourth quarter, and are often taken in the neighbouring area of catches from the western stock in Division IVa. ICES is not sure if catches in Divisions IVa and IIIa during the first two quarters are of western or North Sea origin. Usually this is a minor problem because the catches in these areas during this period are small. However, in 2006 and 2007, relatively larger catches, 2 600 and 2 100 tons, were taken in Division IVa during the first half of the year and these catches were allocated to the North Sea stock.

A.2. Fishery

Germany and the Netherlands have a directed trawl fishery and Norway a directed purse seine fishery for horse mackerel. Spain and Portugal have both directed and mixed trawl and purse seine fisheries. In earlier years most of the catches were used for meal and oil while in later years most of the catches have been used for human consumption.

The Dutch and German fleets operated mainly west of the Channel, in the Channel area, and in the southern North Sea. The Spanish and Portuguese fleets operated mainly in their respective waters. Ireland fished mainly west of Ireland and Norway in the north eastern part of the North Sea.

A.3. Ecosystem aspects

Western horse mackerel have a long spawning season with a peak in late spring/early summer (Abaunza *et al.*, 2003). They spawn in the Bay of Biscay and southwest of the British Isles (indicated as the "juvenile area" in Figure B.1). Age and length distributions from around the British Isles suggest that, as for northeast Atlantic mackerel (*Scomber scombrus*), the largest fish tend to travel farthest and may reach areas around the Shetland Islands, the Norwegian coast, and the northern North Sea by September (Eaton, 1983).

Three species of genus Trachurus: *T. trachurus*, *T. mediterraneus* and *T. picturatus* are found together and are commercially exploited in NE Atlantic waters.

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

T. mediterraneus is almost exclusively landed in ports of the Cantabrian Sea in the north of Spain. The fishery for *T. picturatus* takes place in the southern part of Division IXa and in Subarea X. The annual landings of *T. mediterraneus* show substantial variability, ranging from about 500t to 7,000 tones. Since 2004 there has been a decrease in landings reaching the lowest level in 2007.

B. Data

B.1. Commercial catch

Catch in numbers

Since 1998 there has been an increase in age readings compared with previous years, which has improved the quality of the catch at age matrix for western horse mackerel. Catches from some countries were converted to numbers at age using adequate samples from other countries. The procedure has been carried out using the specific software for calculating international catch at age (Patterson WD presented in ICES 1999/ACFM:6). Usually catch at age data are provided by the Netherlands, Norway, Ireland and Spain. In some years also Germany and Scotland have provided such data. Therefore adequate sampling has never been conducted in all fishing areas during the fishing season.

Discards

Over the years, only one, and in later years two, countries have provided data on discards, so that the estimated amount of discards are not representative for the total fishery. During recent years only the Netherlands and Germany have provided discard data. No data on discards were provided during 1998-2001. Based on the limited data available it is impossible to estimate the amount of discard in the horse mackerel fisheries.

B.2. Biological

Mean weight at age in the stock

The mean weight at age is based on mature fish sampled from Dutch freezer trawlers in the first and second quarter in Divisions VIIj,k. In some years there are only data from Division VIIj. Often there are no data for two years olds and then they are given a constant weight of 0.085 kg. The mean weight by age groups in the stock and in the catches were lower than usual in 2001, but returned to normal since 2002.

Maturity ogive

Due to difficulties in estimating a maturity ogive (ICES 2000/ACFM:5, 2000/G:01) the working group has been unable to update the maturity ogive annually. Therefore the same maturity at age has been used since 1998.

Natural mortality

The natural mortalities applied in previous assessments of western horse mackerel are summarised and discussed in ICES (1998/Assess:6). The natural mortality is uncertain but probably low. ICES currently applies M=0.15.year^{-1}.

B.3. Surveys

Egg survey estimates of biomass

The Mackerel and Horse Mackerel Egg Survey takes place triennially with the participation of Portugal, Spain, Scotland, Ireland, The Netherlands, Norway and Germany. It is not possible to convert the horse mackerel egg production to SSB since horse mackerel is considered an indeterminate spawner.

In general the quality and reliability of the egg surveys are good. In contrast to 2007 the 2010 results display a bimodal distribution which is almost identical both in shape and scale to that seen in 1998 with peak spawning occurring in periods 3 and 5 and a significant decline in production during period 4

Since 2003 the ICES working group WGMEGS has held an egg identification and staging workshop prior to the survey. This permits a harmonisation of egg identification and realised fecundity in mackerel as well as spawning rates in horse mackerel across the participating institutes. These activities led to an improvement in the quality of the estimate.

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

Bottom trawl surveys

Bottom trawl surveys are carried out in a systematic and standardized way through the Northeast Atlantic. They cover a significant part of the western horse mackerel distribution area and are carried out mainly during the autumn. These surveys are coordinated in the International Bottom Trawl Surveys Working Group (IBTSWG, ICES 2009/RMC:04) with the main objective of obtaining an index of recruitment for the most important commercial fish species. Horse mackerel is a pelagic species, but its behaviour is closer to that of a demersal species than the rest of typical pelagic species. The IBTS could therefore provide information on horse mackerel distribution, catch rates and length distributions. Taking in to consideration the problems with the abundance index used in the western horse mackerel assessment, it is useful to consider the surveys under IBTSWG in order to analyse whether they could provide an index of recruitment or abundance for western horse mackerel.

Data from the bottom trawl survey carried out in autumn in the Cantabrian Sea and Galician coasts (North of Spain, Division VIIIc) were analysed in relation to horse mackerel. This survey is not used in the assessment because it covers only a small part of the western horse mackerel stock, but it provides valuable information on horse mackerel dynamics. Length distributions show a gap in length range 18-23cm that could be related to the particular exploitation pattern of this species. Juveniles are more abundant in the eastern part of the Cantabrian Sea, although the depth strata <120m, in which the young horse mackerel are also distributed, and are very poorly sampled in the Galician coasts. The recruitment in 1994 appeared to be strong in the data series (ICES 2008/ACOM:13). The evolution of the cohorts through the data matrix compiled from this survey indicated poor information on mortality. This could be due to migration to and from other areas, especially the French continental shelf (Murta *et al*., 2008; Velasco *et al*. 2008). The information provided by this survey will be combined with the results of other bottom trawl surveys carried out in adjacent areas. Traditionally age 0 has been adopted as the recruitment age for horse mackerel in this survey; nevertheless the use of age 1 as a proxy for recruitment may be more appropriate. The years before 1997 have been revised to account for the change in the strata of the sampling design adopted in 1997 (Velasco *et al*. 2008).

The French bottom trawl survey (EVHOE-WIBTS-Q4) covers the Bay of Biscay (French continental shelf) and part of the Celtic Sea. It is carried out in autumn and it is directed at demersal resources. Information on horse mackerel distribution and length distributions are available. The survey is carried out during the recruitment season, and juveniles form the majority in the catches.

It might be useful for the WG to collect all information available about horse mackerel from other bottom trawl surveys carried out in the distribution area of the western horse mackerel stock (e.g. IBTS).

Acoustic surveys

Horse mackerel data from the French acoustic PELGAS surveys are available as independent information on the western horse mackerel stock (ICES 2006/LRC:18). This multidisciplinary survey covers Divisions VIIIa and VIIIb during spring, collecting information on spatial distribution and length distribution. Revised survey estimates were presented in 2008 (Massé et al. WD presented in ICES 2008/ACOM:13).

Horse mackerel data from the Spanish acoustic PELACUS-Q4 surveys are available as independent information on the western horse mackerel stock. This multidisciplinary survey covers Divisions VIIIc and IXa (north) during spring. In some years the survey is extended to the south of Divisions IXa (north) and VIIIb. Information on distribution and abundance estimates are available since 1997, but the biomass estimates of the historical series were calculated considering Divisions IXa (north) (actually belonging to the southern stock) and VIIIc (western stock) until 2006 .The information will be split up by stock in the future.

B.4. Commercial CPUE

Information on effort and catch per unit effort is only available from the southern limit of the stock distribution area. Since Division VIIIc became part of the western stock in 2004 (ICES 2005/ACFM:08), the bottom trawl fleet operating in the western part of Division VIIIc (north of the Galician coast) is exploiting the western stock. This area represents a very small part of the western horse mackerel stock and therefore the fleet has not been used in the assessment.

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

B.5. Other relevant data

None

C. Historical Stock Development

Model used: SAD (linked separable-ADAPT VPA assessment model).

Software used: AD Model Builder, version 2008 (ICES 2008/ACOM:13). The source code is freely available in ICES folders.

Description of SAD

The SAD model has been used by the working group since the 2000 meeting. The WGMHSA Review Group of ACFM in 2005 stated that the SAD model, purposely designed to assess this stock, was the most appropriate tool. A detailed description of the SAD assessment model and rationale for its use is provided in ICES (2003/ACFM:07) and De Oliveira *et al*. (2010). Figure B.2 presents an illustration of the model structure and the "free" parameters estimated by maximum likelihood (i.e. those estimated directly), and the following table summarises its main features.

A summary of the main features of the SAD model used for the assessment of western horse mackerel:

Model	SAD
Version	2009 Working Group (WGWIDE) (ICES 2008/ACOM:13)
Model type	A linked separable VPA and ADAPT VPA model, so that different structural models are applied to the recent and historic periods. The separable component applies to the most recent period, while the ADAPT VPA component applies to the historic period. Model estimates from the separable period initiate a historic VPA for the cohorts in the first year of the separable period. Fishing mortality at the oldest true age (age 10) in the historic VPA is calculated as the average of the three preceding ages (7-9, ignoring the 1982 year-class where applicable), multiplied by a scaling parameter that is estimated in the model. In order to model the directed fishing of the dominant 1982 year-class, fishing mortality on this year-class at age 10 in 1992 is estimated in the model.
Data used	Egg production estimates, used as relative indices of abundance and catch-at-age data (numbers). Weights-at-age in the stock and maturity-at-age vary temporally, but are assumed to be known without error. Natural mortality and the proportions of fishing and natural mortality before spawning are fixed and year-invariant. Fecundity data are potential fecundity vs. fish weight data for the years 1987, 1992, 1995, 1998, 2000 and 2001, and a realised fecundity 'prior' distribution for 1989, with a mean and CV derived from a normal distribution in log-space, which covers (with a 95% probability) the range of realised fecundity values reported by Abaunza et al. (2003).
Selection	The separable period assumes constant selection-at-age, and requires estimation of fishing mortality age- and year-effects (the former reflecting selectivity-at-age) for ages 1-10 and the final x years for which catch data are available (x being the length of the separable period). Selectivity at age 8 is assumed to be equal to 1. The length of the separable period should be balanced against the precision of model estimates and whether there is any indication, from the log-catch residuals, that the separable assumption no longer holds.
Fishing mortality assumptions	The fishing mortality at age 10 (the final true age) is equal to the average of the fishing mortalities at ages 7-9 (ignoring the 1982 year-class where applicable) multiplied by a scaling parameter estimated within the model. The fishing mortality at age 10 in 1992 (applicable to the 1982 year-class) is estimated separately. The plus-group fishing mortality is assumed equal to that of age 10.

Estimated parameters	The parameters treated as "free" in the model (i.e. those estimated directly) are: (1) Fishing mortality year effects for the final four years for which catch data are available; (2) Fishing mortality age effects (selectivities) for ages 1-10 (except for selectivity at age 8 which is set to 1); (3) scaling parameter for fishing mortality at age 10 relative to the average for ages 7-9 (ignoring the 1982 year-class where applicable); (4) fishing mortality on the 1982 year-class at age 10 in 1992; (5) realised fecundity parameter, relating realised fecundity to potential fecundity, and therefore also relating estimated SSB to the egg production estimates; (6) potential fecundity parameters (intercept and slope), relating potential fecundity to fish weight.
Plus-group	A dynamic pool is assumed (plus group this year is the sum of last year's plus group and last year's oldest true age, both depleted by fishing and natural mortality). The plus group modelled in this manner allows the catch in the plus group to be estimated, and making the assumption that log-catches are normally distributed allows an additional component in the likelihood, fitting these estimated catches to the observed plus-group catch.
Objective function	The estimation is based on maximum likelihood. There are five components to the likelihood, corresponding to egg estimates, catches for the separable period, catches for the plus-group, potential fecundity vs. fish weight, and realised fecundity. The variance of each component is estimated, apart from that associated with realised fecundity for which a CV is input.
Variance estimates / uncertainty	Estimates of precision may be calculated by several methods, the simplest (based on the delta method) being used for results shown.
Program language	AD Model Builder (Otter Research Ltd)
References	Description in Working Group reports, De Oliveira et al. (2010).

In 2005 the WG identified aspects of the assessment that warranted further exploration, which included whether there was additional information, particularly in relation to fecundity, that would allow scaling the model (ICES 2006/ACFM:08). Fecundity data (both actual data and estimates from the literature) was subsequently identified for inclusion in the model. Further investigation revealed evidence that potential (i.e. standing stock) fecundity per gram increases with fish weight (ICES 2002/G:06), and total realised fecundity would be expected to follow the same pattern. In line with this argument, the stock average fecundity would have increased as the 1982 year-class matured (as individuals gained weight) and then decreased when the strong year class was fished out. Ignoring these effects could lead to biased population estimates.

The SAD model explicitly incorporates and directly fits potential and realised fecundity data as functions of fish weight, with separate parameters for the two types of fecundity data, thus placing the estimation of fecundity parameters in a self-consistent framework. The model uses a realised fecundity 'prior' distribution (mean=1847 eggs per gram spawning female, CV=0.287), which is derived from a normal distribution, in log-space, which covers (with a 95% probability) the range of realised fecundity values reported by Abaunza *et al*. 2003 (1 040-3 280 eggs per gram spawning female). This allows the incorporation of a realistic level of uncertainty about realised fecundity.

The likelihood function used in SAD is as follows (ICES 2008/ACOM:13):

$$-\ln L = \tfrac{1}{2}\sum_{y\in Y_{egg}}\left\{\frac{\left(\ln N_{egg,y}-\ln(\hat{N}_{egg,y})\right)^2}{\hat{\sigma}^2_{egg}}+\ln\left[2\pi\hat{\sigma}^2_{egg}\right]\right\}$$
$$+\tfrac{1}{2}\sum_{y=2003}^{2007}\sum_{i=1}^{10}\left\{\frac{\left(\ln C_{y,i}-\ln\hat{C}_{y,i}\right)^2}{\hat{\sigma}^2_{sep}}+\ln\left[2\pi\hat{\sigma}^2_{sep}\right]\right\}$$
$$+\tfrac{1}{2}\sum_{y=1983}^{2007}\left\{\frac{\left(\ln C_{y,11+}-\ln\hat{C}_{y,11+}\right)^2}{\hat{\sigma}^2_{11+}}+\ln\left[2\pi\hat{\sigma}^2_{11+}\right]\right\}$$
$$+\tfrac{1}{2}\sum_{y\in Y_{pfec}}\sum_{j=1}^{J_y}\left\{\frac{\left(\ln f^p_{y,j}-\ln\hat{f}^p_{y,j}\right)^2}{\hat{\sigma}^2_{pfec}}+\ln\left[2\pi\hat{\sigma}^2_{pfec}\right]\right\}$$
$$+\tfrac{1}{2}\left\{\frac{\left(\ln\bar{f}^r_{1989}-\ln\hat{\bar{f}}^r_{1989}\right)^2}{\sigma^2_{rfec}}+\ln\left[2\pi\sigma^2_{rfec}\right]\right\}$$

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

The model estimates egg production as follows:

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

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

Potential fecundity is estimated as follows:

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

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

Population-mean realised fecundity is estimated as follows:

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

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

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

1) Fishing mortality year effects (F_y) for the separable period;

2) Fishing mortality age effects (S_a, the selectivities) for ages 1-10 (excluding age 8, which is set at 1);

3) scaling parameter (F_{scal}) for fishing mortality at age 10 relative to the average for ages 7-9 (ignoring the 1982 year-class where applicable);

4) fishing mortality on the 1982 year-class at age 10 in 1992 ($F_{92,10}$);

5) realised fecundity parameter (q_{fec}), relating realised fecundity to potential fecundity, and therefore also relating SSB to egg production; and

6) potential fecundity parameters (a_{fec} and b_{fec}), relating potential fecundity to fish weight

Natural mortality (constant at age and by year at 0.15), maturity-at-age, stock weights-at-age and the proportions of F and M before spawning (0.45), are assumed to be known precisely.

Model Options chosen

For 2011, the separable window was 6 years long (2005-2010). Decisions about whether to shift the window along (keeping it 6 years long) or whether to extend the window (keeping the starting date at 2004) depend on whether the log-catch residuals show the separable assumption to continue to hold or not.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	-	-	Not used
Canum	Catch at age in numbers	1982-present	0-11+	Yes
Weca	Weight at age in the commercial catch	-	-	Not used
West	Weight at age of the spawning stock at spawning time.	1982-present	0-11+	Yes
Mprop	Proportion of natural mortality before spawning			No
Fprop	Proportion of fishing mortality before spawning			No
Matprop	Proportion mature at age	1982-present	0-11+	Yes (but constant since 1998)
Natmor	Natural mortality	-	-	No

Tuning data (data appearing in likelihood function):

Type	Name	Year range	Age range
Western Horse Mackerel egg survey	Total egg production estimates	1983, 1989, 1992,… (every third year)	-
Separable period catch-at-age	Separable catch-at-age	2005-present (but depends on length of separable window)	1-10
Plus-group catch	Plus-group catch	1982-present	11+
Potential fecundity	Potential fecundity vs. fish weight data	1987, 1992, 1995, 1998, 2000 and 2001	-
Realised fecundity	Total realised fecundity, based on Abaunza et al. (2003)	1989	-

D. Short-Term Projection

Software used: MFDP version 1a (Multi Fleet Deterministic Projections)

Initial stock size: Stock numbers from the assessment

Recruitment: At the 2010 working group recruitment estimates for input to the short term forecast were based on the geometric mean of the estimated time series for the period 1983 to 2008. There is no indication that a large recruitment similar to that of 1982 will enter the stock.

Maturity: The proportion mature for this stock is assumed constant over the years. The maturity ogive used in the short term forecast is the same as the ogive used in the assessment for 2009.

F and M before spawning: Spawning is assumed to take place in April/March.

Weight at age in the stock: Weight at age in the stock are the average of the last three years weight at age estimates in the catch for periods 1 and 2 in areas VIIj.

Weight at age in the catch: Weight at age in the catch are the average of the last three years weight at age estimates in the catch for all periods and all areas.

Exploitation pattern: This is based on F in the final year, where the final year of data is calculated from the most recent assessment. The assessment assumes a fixed selection from 2005 to the final year of data.

Natural Mortality: Natural mortality is assumed to be 0.15 across all ages.

E. Medium-Term Projections

A medium-term forecast is not conducted for western horse mackerel because a management plan is in place.

F. Long-Term Projections

Long-term projections are not carried out for western horse mackerel.

G. Biological Reference Points

The stock is characterised by infrequent, extremely large recruitments.

Reference point	Blim	Bpa	Flim	Fpa	F0.1
Value	1.4 mill t	1.8 mill. t			0.13
Basis	Biomass that produced the extraordinary 1982 year class	Blim* exp(1.645* σ), with σ= 0.16.	Not defined	Not defined	Yield per recruit (ICES, 2010/ACOM:15)

Biomass reference points

It could be assumed that the likelihood of a strong year class appearing would decline if stock size were to fall below the stock size at which the only such event has been observed. The WG therefore considers the biomass that produced the extraordinary 1982 yc as a good proxy for B_{lim}. This follows the rationale of SGPRP 2003 (ICES 2003/ACFM:15), proposing to use the stock size in 1982 for B_{lim}. Evaluation of precision of the assessment shows that the CV in SSB is 15%. The ICES procedure for evaluating precautionary reference points from limit points uses a formula based on the CV (ICES 2001/ACFM:11). This formula gives a factor of 30% and an estimate of B_{pa} = 1.8Mt.

Fishing mortality reference points

The age range used in the calculation of mean F was changed in 2003 from F_{4-10} to F_{1-10} to include the ages exploited in both the adult and juvenile fisheries. The management plan currently in place is not based on F (see section 5). There are indications that the assumed natural mortality (0.15) might be too high. However, there is insufficient data to estimate M.

MSY reference points

At WGWIDE 2010 (ICES 2010/ACOM:15) deterministic and stochastic equilibrium analyses were carried out using the 'plot-MSY' software (ICES 2010/ACOM:54) to review the 2010 Fmsy value for the western horse mackerel stock. Stock-recruit pairs from the period 1983-2010, as estimated from the most recent SAD assessment of the stock, were used together with 5-year averages of selectivity, weight and maturity at age , F refers to the mean for ages 1 – 10. Three stock recruit relationships were re-examined, Ricker, Beverton-Holt and the segmented regression ('smooth hockey stick'), and yield-per-recruit (YPR) analyses were also done. For the stochastic analyses, uncertainty (CVs) in the biological and fishery parameters at age were used to create alternative fits to the stock-recruit relationships (N=1000).

The results show a very poor Beverton and Holt fit (Figure 5.7.1.1) to the stock and recruit data. The majority of stochastic stock-recruit model fits fell out of the range of the deterministic fit to the data, and thus it can be concluded that the stock-recruit form is unclear and not suitable for the data and the level of uncertainty associated with the parameters. Given the lack of any clear patterns in the stock-recruit data, a smooth segmented regression model fit, while uncertain around the origin, could provide the most cautious fit to the data. The deterministic segmented regression fit has a shallow slope to the breakpoint, hence the estimated value of Fcrash associated with this function is low. However this slope is determined by very few data points and is therefore poorly estimated. The value for Bmsy is at the breakpoint in the segmented regression, hence Fmsy is estimated to be the same as Fcrash (Table 5.7.1.1). The uncertainty with regards to the slope at the origin makes this stock-recruitment function unsuitable as a basis for advice on Fmsy. The Ricker stock recruit relationship fits the data best, and the median of the stochastic fits is in close agreement with the deterministic fit. If this stock recruit relationship is considered to be biologically reasonable, this function could be used in the calculation of Fmsy. However, there is a very large uncertainty around the fit to the data, as can be seen in the spread of potential stochastic fits. This results in a very high CV around the estimate of Fmsy, again making this function unsuitable as the basis of advice on the selection of Fmsy.

Given the poor fits to stock and recruitment data, a yield-per-recruit analysis remains the conducted (Figure 5.7.1.2). The stochastic analysis shows a well defined Fmax. The uncertainty around this value which results from the associated CVs in the input data and believed to be realistic, provide a potential range of values for consideration of a proxy for FMSY. However, the point estimate of Fmax= 0.22 is close to Fcrash. Alternatively, F0.1= 0.13 is consistent with the findings of the management plan evaluation. This evaluation by simulation showed that in the absence of extraordinary year classes F around 0.1 would result in a risk less than 10% of depleting the stock. On that basis F0.1 = 0.13 is considered a more suitable candidate for Fmsy than Fmax. It is proposed that F0.1 = 0.13 be used as a proxy for Fmsy for this stock. The SSB that produced the extraordinary 1982 year class (1.8Mt) is proposed as MSY Btrigger.

Reference point	MSY Btrigger	FMSY
Value	1.8 mill. t	0.13
Basis	Blim	F0.1

H. Other Issues

None.

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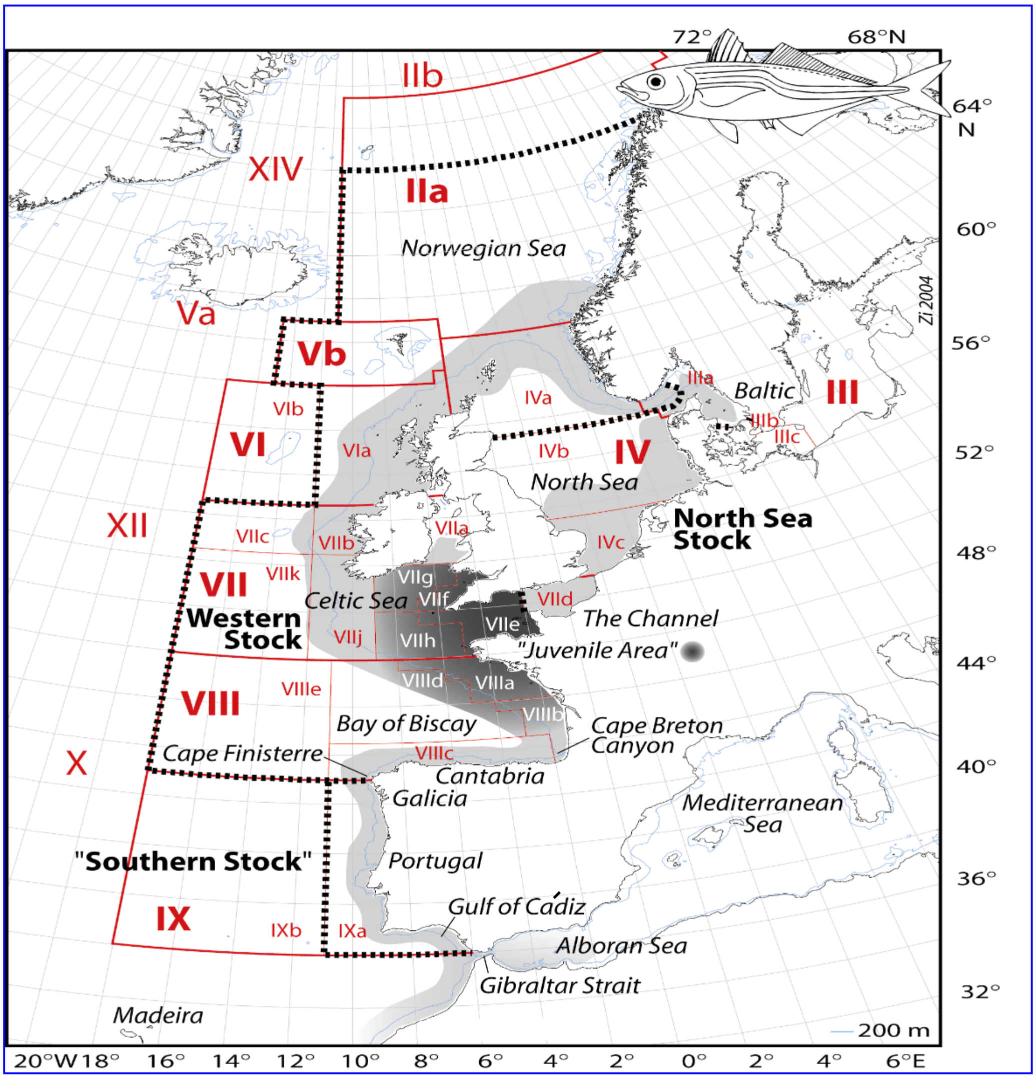

Figure B.1: Distribution of Horse Mackerel in the Northeast-Atlantic: Stock definitions as used by ICES (ICES CM 2005/ACFM:08). Note that the "Juvenile Area" is currently only defined for the Western Stock distribution area – juveniles do also occur in other areas (like in Div. VIId). Map source: GEBCO, polar projection, 200m depth contour drawn.

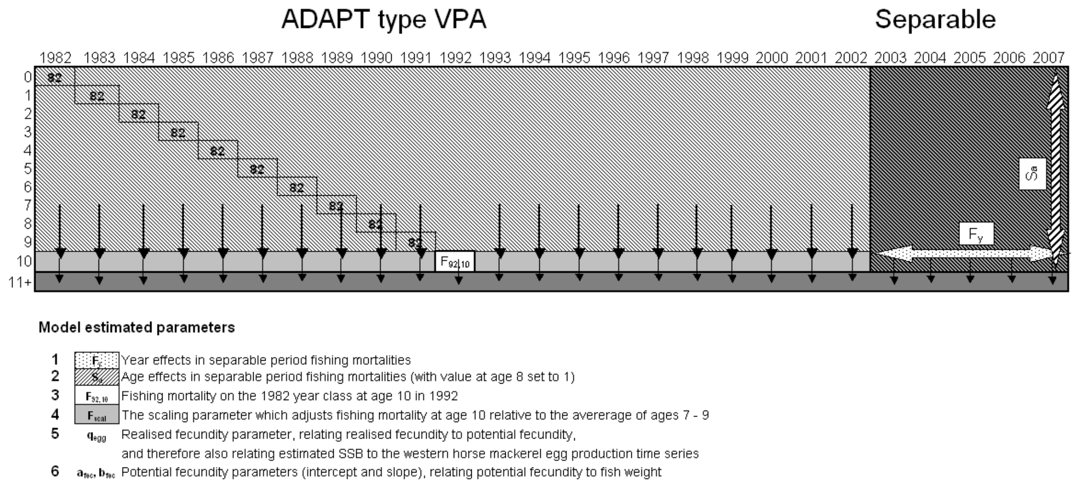

Figure B.2. Western Horse Mackerel. An illustration of the SAD model structure used for the assessment of the Western horse mackerel stock and the "free" parameters estimated by maximum likelihood.

Annex 02C - Stock Annex: Norwegian Spring Spawning Herring

Stock specific documentation of standard assessment procedures used by ICES.

Stock	**Norwegian Spring Spawning herring**
Working Group:	**WGWIDE**
Date:	**13 November 2013 of last revision**
Revised by	**WGWIDE**

A. General

A.1.1 Stock definition

The Norwegian spring spawning herring (*Clupea harengus*) is the largest herring stock in the world. It is widely distributed and highly migratory throughout large parts of the NE Atlantic during its lifespan. Formally, the description of the Norwegian spring spawning herring stock is not linked to specific areas and the ICES advice applies to all areas where it occurs. By far the majority of the stock occurs in Divisions IIa,b Va,b and XIVa. Juveniles of the stock have their nurseries in Division Ia. In some years, small amounts of Norwegian spring spawning herring can be found in adjacent areas mixing with other herring stocks.

It is a herring type with high number of vertebrae, large size at age, large maximum size, different scale characteristics from other herring stocks and large variation in year class strength. The herring spawns along the Norwegian west coast in February-April. Large variations in the north-south distribution of the spawning areas have been observed through the centuries. The larvae drift north and northeast and distribute as 0–group in fjords along the Norwegian coast and in the Barents Sea. The Barents Sea is by far the most important juvenile area for the large year classes, which form the basis for the large production-potential of the stock. Some year classes are in addition distributed into the Norwegian Sea basin as 0–group. Examples of this are the 1950 and 2002 year classes. Most of the young herring leave the Barents Sea as 3 years old and feed in the north-eastern Norwegian Sea for 1–2 years before recruiting to the spawning stock. Large year classes typically mature at a higher mean age due to density dependent distribution and growth. However, exceptions occur and the 2002 year class is a large year class, which has shown quick growth and a relatively early maturation. Juveniles growing up in the Norwegian Sea grow faster than those in the Barents Sea and mature one year earlier. With maturation the young herring start joining the adult feeding migration in the Norwegian Sea. The feeding migration starts just after spawning with the maximum feeding intensity and condition increase occurring from late May until early July. The feeding migration is in general length dependent, meaning that the largest and oldest fish perform longer and typically more western migrations than the younger ones. After the dispersed feeding migration the herring concentrate in one or more wintering areas in September-October. These areas are unstable and since 1950 the stock has used at least 6 different wintering areas in different periods. During the 1950s and 1960s they were situated east of Iceland and since around 1970 in Norwegian fjords. In 2001–2002 a new wintering area was established off the Norwegian coast between 69º30'N and 72ºN and in 2007\2009 no herring was observed in the fiords in winter. After wintering, the spawning migration starts around mid January.

Norwegian spring spawning herring is one the few stocks for which data have been collected over a very long period. Figure A.1.1.1 shows the dynamics of the stock in the past century indicated by assessments which go back to 1907.

A.1.2. Migration

A characteristic feature of this herring stock is a very flexible and varying migration pattern. The migration is characterised as relatively stable periods and periods characterised by large changes occurring at varying time intervals. The changes may or may not be correlated between the major distribution areas: Spawning, feeding and wintering. At present we see a period of large changes in both the wintering and feeding area. Until about 2002 the bulk of the adult herring wintered in fjords in northern Norway. The 1998 and 1999 year classes were expected to enter the fjords around 2002, but were instead observed wintering off the coast in the ocean off Vesterålen/Troms, between 69º30'N–72ºN. This continued in the years to come and in 2005 also the 2002 year class was observed wintering in the same area. During these years, the amount of older herring wintering in the fjords has decreased rapidly and during the winter 2007 and 2008 no herring was observed in the fjords. The survey covering the oceanic wintering area in November have shown a strong decrease in the biomass in the wintering stock in the area, indicating that may be a third and so for unknown wintering area could be under establishment somewhere else. Such a development is supported by the western feeding distribution in recent years, and the fact that the return migration of the smaller herring feeding in the west could be too long compared with comparable return migration distances observed in earlier periods. It is also supported by the fact that the international survey in May did not show any such negative trend in the stock.

In May the herring is migrating westward into the Norwegian Sea to start feeding and main concentrations are found in the central part of this area. In July the herring are spread out over a wide area feeding around the fringes of the Norwegian Sea, particularly in the northern and western region, while almost no herring are observed in the central region.

During the autumn in the period 2004–2008 Norwegian spring spawning herring has been caught as bycatch in smaller concentrations in catches of Icelandic summer spawning herring off the Icelandic east coast. This feature is probably linked to the western movement of the south-western summer feeding area. It is not known whether Norwegian spring spawning herring are wintering in this area.

A.2. Fishery and management

The fishery is regulated and carried out by the Coastal States. The TAC is set by the Coastal States and derived from an agreed long term management plan. The Coastal States also agree on the allocation of the TAC into national quota. The Coastal States involved are the European Union, Faroe Islands, Iceland, Norway and the Russian Federation. The fishery is carried out all year round by purse seines and pelagic trawlers. The catches are used as well for reduction purposes and human consumption. The traditional fishing pattern follows the clockwise migration pattern of the herring. Changes in the migration pattern have occurred in the past and consequently also leading to changes in the fishery, following the fish. The migration pattern, together with environmental factors, was mapped in 2008 during the ICES PGNAPES (Planning Group on Northeast Atlantic Pelagic Ecosystem Surveys) investigations (ICES 2008/RMC:05).

Due to limitations by some countries to enter the EEZs of other countries the fisheries do not necessarily depict the distribution of herring in the Norwegian Sea and the preferred fishing pattern of the fleets given free access to any zone.

Most of the catches consist of herring only and discarding is absent or very low. In recent years increasing amounts of bycatch of mackerel are reported on the traditional fishing grounds, pointing to a change in de distribution of mackerel.

A.3. Ecosystem aspects

Norwegian spring spawning herring is a straddling stock. Juveniles and adults of this stock form an important part of the ecosystems in the Barents Sea, the Norwegian Sea, and the Norwegian coast. Herring has an important role as food resource to higher trophic levels (e.g. large fish, seabirds, and marine mammals), but also as a consumer of zooplankton in the Norwegian Sea and capelin larvae in the Barents Sea. A high stock size will therefore have positive effects on its predators, but the effects on other pelagic fish stocks feeding in the Norwegian Sea such as blue whiting and mackerel may be negative due to competition for food.

Changes in the herring migration in the first decade of the 21th century have led to an increased proportion of the population feeding in Faroese and Icelandic waters. The growth of these herring is faster than those feeding further east and north.

Not much information is available on the impact of the herring fishery on the ecosystem. The fishery is entirely pelagic. There is little quantitative information on the by-catches in the fisheries for herring but these are thought to be small. Therefore unintended effects of the fishery on the ecosystem are probably small or absent. Since herring is a major source of food for some populations of other species, overfishing of the herring stock could affect these populations. This is presently not the case since the herring stock is very abundant and is exploited at a low rate.

B. Data

B.1. Commercial catch

B.1.1. Nominal catch

The catches used in the assessment are the catches provided by the Working Group members.

B.1.2. Catch at age

From each country participating in the herring fishery exists a data delivery sheet containing at minimum information about total catch in tons by quarter of the year and ICES area. If the fleet has taken samples then catch in numbers by age, mean weight at age and mean length at age for each quarter of the year and ICES area are provided. Catch in tonnes by ICES rectangles and quarters are also reported. These sheets are combined into one file, the so called 'disfad' file. None sampled catches have then to be allocated to sampled ones. To do so positions of the catches by fleet are plotted, to see where the fleet was operating. Mean weights and mean lengths behind the sampled catches are also plotted. On the basis on these inspections allocations are done. Then the program SALLOC (ICES 1998/ACFM:18) is used to calculate the total international catch in numbers. Output from SALLOC is total catches in numbers by age as well as by quarters and areas. INTERCATCH is only used for archiving the data used in the assessment.

B.1.3. Weight at age of the catch

Annual weight at age of the catch originate from national sampling programmes of the commercial catches. They are provided by most fishing nations each year on a quarterly basis. The weight at age of the catch used in the assessment is the average of the different nations weighted over the associated catch numbers. Mean weights by age in the catch by age is also output from SALLOC.

B.1.4. Length at age of the catch

Mean length by age in the catch is calculated the same way as mean weight at age of the catch. It is not used in the assessment Mean length by age in the catch is also output from SALLOC.

B.2. Biological parameters

B.2.2. Weight at age of the stock

Up to 2008 weight of age of the stock was taken from the Norwegian survey in the wintering area (reference). The survey has stopped in 2008. From 2009 onwards weight at age of the stock is taken from commercial catches taken in the same area and period as the Norwegian survey. In 2010 sampling of data on weight at age in the stock in this period and area has increased to improve the precision of the estimates.

B.2.3. Natural mortality

B.2.3.1. History of the use of M in the assessment

The back ground of the natural mortality used in the assessment has been reviewed in the 2008 benchmark assessment of this stock. By scanning through the Working Group reports from 1990 to 2007 it was noticed that different values had been used for natural mortality at age through the years. In some years an additional mortality at age had been applied because of a disease. But taken directly from the 1997 WGNPBW-report (ICES 1997): "Values of natural mortality assumed by the Working Group previously (ICES 1996/ASSESS:14) for ages 3 and older were 0.16 for the years 1950 to 1970 and 0.13 for the years 1971 and subsequently. In the previous assessment of this stock it was assumed (on the basis of observations of many diseased and dying fish in catches) that the fish of the 1987 cohorts and older had suffered a higher natural mortality in the years 1991 to 1994. An additional disease-induced natural mortality of 0.1 was assumed. However, interim studies (Patterson, WD 1997; Tjelmeland WD 1997) directed at estimating disease-induced mortality have failed to provide compelling evidence for values above zero. Attempts to estimate natural mortality from tagging information (Hamre, WD 1997; Patterson, WD 1997a; Tjelmeland, WD 1997) were highly consistent with values in the range 0.13 to 0.16, but the Working Group did not consider that this parameter could be estimated with sufficient precision to justify a discrimination between levels of 0.13 and 0.16. Consequently it was decided to predicate the assessment model estimates on an arbitrarily-chosen M=0.15 for ages 3 and older, and no attempt was made to include additional disease-induced mortality in the maximum likelihood assessment model."

This value M=0.15 has been used for ages 3 and older since the assessment in 1997 (for all years) until the assessment made in 2005 (ICES 2005). Then a value of 0.5 was used for the plus group (16+) and was used until 2007. This increase of M was done in order to get the SSB at low values in the collapsed phase in the 1970s. It caused only a slight decrease of the SSB in the recent years (ICES 2005).

From 2008 onwards age 15 is used in the assessment as a plus group and a value of M=0.15 is used.

In the Working Group report from 1992 (ICES 1992) a comparison of acoustic estimates for year classes 1983-1985 and 1988, and the same year classes as 3 year old (VPA) gave an average annual M=0.88, so M=0.9 was used for ages 0-2.

For ages 0-2 then the following is stated in the report from 1997 (ICES 1997): "Values of natural mortality for juvenile fish (ages 0-2) used by the Working Group in 1996 were 0.9 for all years in historic VPA, but for forecasting purposes values of 1.56 for age 1 and 0.54 for age 2 were used for the 199-1995 year classes. These values were based on an unpublished Ph.D. Thesis by de Barros (1995); this work was not available for evaluation by the Working Group, and hence it was decided to retain the assumption of M=0.9 for ages 0 to 2 in all years. This value is consistent with the mean of de Barros' estimates." This value of M=0.9 is still used in the present assessments for ages 0-2.

B.2.3.1. M used in the present assessments

In the benchmark assessment, the natural mortality M=0.15 was used for ages 3 and older and M=0.9 was used for ages 0–2 in all years from 1988 onwards.

B.2.4. Maturity at age

In 2010 WKHERMAT evaluated the information on maturity for this stock. This work was planned to be carried out in the benchmark assessment in 2008 but at that time this information was not available. WKHERMAT proposed to used maturity o-gives based on back calculation of rings on the scale. This information provided a long time series which is reproducible. WGWIDE introduced this times series in the 2010 assessment.

B.2.4.1. Maturity data used in the assessments prior to 2010

The text in italics in the following paragraphs in this section is old text and no longer valid

Except for the year class 2002, the proportion mature at age used in assessment has generally been the same during the last ten years (Table B.2.4.1).

The growth rate of the 2002 year class has been higher than usually seen in large year classes of this stock. One reason for this is that a large part of the juveniles stayed in the Norwegian Sea as juveniles, favouring quicker growth than in the Barents Sea, which is the area where juveniles normally are distributed.

The proportion mature of this year class was calculated from samples collected during the surveys in the wintering area in November (before spawning) and in the Norwegian Sea in May (after spawning). The proportion of fishes in maturation stage 3 or larger (fish to spawn) in November 2005 was used as a first proxy to the proportion maturing. The proportion maturing according to these data was 0.85. The proportion in stages >5 (spent) in May was used as a proxy for the proportion having spawned. The proportion having spawned according to these data was 0.92. Based on these observations and calculations 0.9 was adopted as proportion mature of the 2002 year class at age 4. Based on this 1.0 instead of 0.9 was adopted as proportion mature of the 2002 year class at age 5. All other year classes in the later years were set at the standard 0.3 at age 4, 0.9 at age 5 and 1.0 at age 6 both in the assessment and predictions.

The Working Group has accepted the present values for the use in the assessment but considers that there is a need to validate the presently assumed values in particular for the most recent years. The proportion mature at age used in assessment is based on various surveys carried out *many years ago and is not always well documented. The Working Group acknowledged the potential problem of obtaining random samples of proportion mature at age from survey for this stock due to the different catchability of mature and immature fish of the same age groups caused by spatial segregation. An alternative method for estimating proportion mature at age was proposed to the Working Group. This method involves back-calculation of proportion mature at age from fully matured year classes and is based on work done by Engelhard et al. (2003) and Engelhard and Heino (2004). The Working Group found this approach interesting, but decided to explore it further before any decision should be taken regarding using it in assessment. The Working Group recommends that effort should be put into updating estimates on proportion mature at age from recent years with this method and compare it with data on direct measurements on proportion mature at age from the May survey during the period since 1997 when this survey was assumed to cover the entire stock. This work will be done by IMR but has not completed yet. Based on this, an evaluation will be done and may lead to revisions of the maturity 0-gives in the past.*

The surveys in the wintering area in November (reference) have stopped in 2008. From 2008 onwards only information is available from the May survey (reference). In 2009, WGWIDE has recommended to adjust (increase) the sampling for maturity in this survey in the May survey to ensure sufficient coverage (spatial and by age) of the data.

The old time series is not longer used and is presented in the stock annex.

B.2.4.2. Maturity data used in the assessments from 2010 onwards (inserted in 2011)

In 2010 a Workshop (WKHERMAT)[1] was held to evaluate existing maturity at age data. The Workshop was held because data on maturation were not available and considered in the benchmark assessment in 2008. The work of the Workshop therefore concludes the benchmark process. Three sources of maturity information were considered. The three different data sources were: a) maturity ogive used in assessment, b) survey data on maturity staging collected during surveys 4 and 5 and c) back-calculated maturity ogive using Gulland's method. In addition, data on maturity cycle in Norwegian spring spawning herring were presented and guidelines for sampling of maturity data were discussed in accordance with PGCCDBS.

The maturity matrix used in the ICES assessment goes back to 1907. Documentation on the source of information and the justification of changes is almost absent and the lack of documentation is a general problem in this data set. The data cannot be reproduced because the sources are unknown and most changes which have been made in the past cannot be explained.

The May surveys may potentially provide data to construct updated maturity ogives for the most recent years. The surveys indicate that most (but not all) herring in the Norwegian Sea are mature and most (but not all) herring in the Barents Sea are immature. However, the time series is short and there are some problems. For the age groups which occur both in the Norwegian Sea and Barents Sea, quantitative information on annual abundance is required for a the calculated weighted average maturity representative for the stock in both areas combined. The available information on the distribution of these age groups in not very reliable because there appear to be differences

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[1] Report of the Workshop on estimation of maturity ogive in Norwegian spring spawning herring (WKHERMAT). 1-3 March 2010 Bergen, Norway. ICES CM 2010/ACOM:51 REF. PGCCDBS

in the catchability in the survey between the Norwegian Sea and the Barents Sea. This needs to be addressed further before data from the survey can be used for maturity ogive estimations.

The back calculation data set indicates that maturation of ages 3, 4 and 5 has varied considerable over time and that maturation of large year classes is slower than for others. This applies to a lesser extend to the 2002 year class. However, the estimates for this year class are suggesting that at least a correction needs to be considered in the maturation assumed for this year class in previous assessments by ICES. WKHERMAT considered the data set derived by back calculation as a suitable potential candidate for use in the assessment because it is conceived in a consistent way over the whole time period and can meet standards required in a quality controlled process. However, the back calculation estimates cannot be used for recent years. Since the surveys do not provide suitable data at the moment, assumptions have to be made for recent year classes.

WGWIDE considered the results of WKHERMAT in 2010 and adopted the maturity o-gives derived from back calculation of scales for the historical time period (years 1950-2007) in the assessment. WGWIDE recommends that this data set remains updated in future years. For the years after 2007 for which no data are available from this method (including the years considered in the forecast) the following default maturity o-gives will be assumed. For 'normal' classes (average, median and weak year classes), an average maturity at age will be assumed from the periods 1983-2007 from the back calculation data set excluding the strong year classes 1983, 1991, 1992, 1998, 1999, 2002. For year classes which are considered strong, preliminary estimates will be assumed to be the average of the recent strong year classes 1983, 1991, 1992, 1998, 1999, 2002 in the data set.

The default maturity o-gives used for 'normal' and strong year classes are given in the text table below.

age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
normal yc	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
strong yc	0	0	0	0	0.1	0.6	0.9	1	1	1	1	1	1	1	1	1

A comparison of the old and new time series in given in the WKHERMAT report. The maturity ogives used in previous assessments are given in Table B.2.4.1. The maturity ogives used in the present assessment are presented in the WGWIDE report.

Except for those periods where strong year classes enter the stock, the revision of the maturity at age matrix affects has little effect on the estimates of SSB in the historical time series. Because strong year classes show slower maturation, the SSB estimates in periods where strong year classes recruit in the stock have been revised downwards compared to previous ICES assessments.

B.2.4.3 Terminal F calculation (added 2013)

The preliminary assessment in 2013 following the 2008 benchmark revealed the same strong retrospective patterns as have been observed since assessment year 2010. However, adding the latest catch statistics and survey information lead to unexpectedly large changes in the perception of the stock, particularly in the earlier period of the assessment time series (see WD Skagen 2013 and WGWIDE 2013 report) that were considered to be out of proportion. As a result of the data exploration WGWIDE 2013 implemented an updated algorithm for calculating the terminal F-values for last age classes where no data supporting the estimate of terminal stock numbers was available.

Because some of the year classes are very small, there are no data to estimate the terminal stock numbers in the VPA (before 1982, 1984 – 1988, 1995 and 2000 – 2001). In the 2008 benchmark the derivation of the terminal fishing mortalities for those of these year classes that had reached oldest true age, was defined as derived from the terminal F the year before and fishing mortalities at younger ages, with the standard procedure in TASACS. However, because of the sensitivity of this method to noise particularly in the estimates of older age groups, Skagen (WD to WGWIDE 2013) suggested a new algorithm for this derivation. The new algorithm for deriving the terminal stock numbers for these year classes assumes a fixed ratio between F at oldest age and average F in the year, which is equivalent to assuming a fixed selection at oldest age. Similar method is used in the assessment model ICA, and in the separable option in TASACS. The ratio is taken from the selection parameters, as the selection at oldest age relative to the mean over the ages 5 - 13. There is no standard way to estimate that ratio. However, a sensitivity analysis showed that the the exact ratio used has only a minor influence on the estimated numbers in the earlier time period and none on the latest part of the times series. Values between 1.1 and 1.7 give comparable results. The ratio between the terminal F and the average F over ages 5-13 calculated for all the years where terminal F is estimated is 1.3 (excluding all F = 0), and this was applied in the 2013 assessment. B.3. Surveys

A number of surveys on this stock have been carried out in the Norwegian Sea and Barents Sea to estimate the size of the stock, its age composition or the recruitment to the stock. Some of the surveys have stopped but data are still used in the assessment The surveys and its potential use are described in the sections below.

B.3.1. Survey 1. Norwegian acoustic survey on spawning grounds in February/March

<u>Background and status</u>

The survey has been carried out since 1988 but not in every year. The survey will not be carried out after 2008.

<u>Use of this survey in stock assessment</u>

The age groups 5–15+ have been used in the assessment for the years 1994 to 2005. After this year the survey has not been used in the assessment. The reason for this being that the survey was carried out very earlier and before the herring had reached the spawning grounds, with the possibilities of herring emerging the spawning grounds also through other routes than those covered in the survey.

<u>Results</u>

Results can be found in Table B.3.1.1 and Figure B.3.1.1.

B.3.2. Survey 2. Norwegian acoustic survey in November/December

<u>Background and status</u>

The survey has been carried out by Norway since 1992 in the Norwegian fjords where the adult herring winter. Since 2003 also the oceanic areas north of Lofoten/Vesterålen has been included in the survey to take account of changes in the wintering area. The fjordic coverage was ceased during the winter 2007/2008 because the herring had totally left the fjords.

<u>Results</u>

In 2007 the RV Johan Hjort carried out an acoustic survey in the oceanic wintering area in northern Norway (Figure B.3.2.1). The results of this survey are shown in Table B.3.2.1. This survey covers the known wintering area of the mature part of the stock. The survey gave a very low biomass estimate due to unknown reasons. One possible explanation is that a new wintering area is building up somewhere else. This has so far not been confirmed and remains an open question.

<u>Use of this survey in stock assessment</u>

Given the large changes in the wintering pattern of herring and the possibility of a third and undescribed wintering area, it was decided not to use this survey for the period following the new wintering pattern of the herring in the assessment. The survey will not be continued by Norway and will not be carried from 2008 onwards.

B.3.3. Survey 3. Norwegian acoustic survey in January

<u>Background and status</u>

This survey was carried out by Norway in the fjords in the period 1991–1999.

<u>Results</u>

The results of the survey in the wintering area in January can be found in Table B.3.3.1.

<u>Use of this survey in stock assessment</u>

Although the survey series has ended, the data are still used in the assessment. The age groups 5–15+ from 1991 to 1999 are currently used.

B.3.4. Survey 4 and 5. International ecosystem survey in the Nordic Seas

<u>Background and status</u>

The international ecosystem survey in the Nordic Seas is aimed at observing the pelagic ecosystem, focusing herring, blue whiting, zooplankton and hydrography. The survey, carried out since 1995, is coordinated by the ICES PGNAPES (ICES CM 2009/RMC:06) and is a cooperative effort by Faroes, Iceland, Norway, Russia, and the EU (Denmark, Germany, Ireland, The Netherlands, Sweden and UK). This trawl-acoustic survey supplies the most important time series for the assessment of NSSH and also a time series for young blue whiting in the juvenile areas.

<u>Results</u>

The age-disaggregated time-series of abundance for the Barents Sea and Norwegian Sea are presented in Table B.3.4.1. and Table B.3.4.2.

Survey covering the entire stock during its migration on the feeding grounds. An example of the coverage of the survey (2009) is given in Figure B.3.4.1.

<u>Use of this survey in stock assessment</u>

From the area west of 20°E the full time series of age groups 4 and older in survey 5 are used for the assessment. Survey 4 in the area east of 20°E covering the Barents Sea has been used in the final assessment from 2005 onwards. The survey supplies the recruitment for age groups 1 and 2 in the assessment. No data exist for 2003 and 2004 in this survey. The data for 2008 are not used. The data for survey 4 are also used for estimating recruitment in RCT3.

B.3.5. Survey 6 and 7. Joined Russian–Norwegian ecosystem autumn survey in the Barents Sea

Background and status

The survey consists of a trawl survey catching 0–group herring amongst other species and an acoustic survey estimating one and two year old herring. In 2001, the Working Group decided to include data on immature herring obtained during the Russian-Norwegian survey in August-October in estimating the younger year classes in the Barents Sea.

Results

The results from these surveys on 0–group herring are given in Table B.3.5.1. The results for the 1 to 3 age groups are given in Table B.3.5.2. The youngest age groups (0+ to 3+) of the Norwegian spring spawning herring stock are found in the Barents Sea at irregular intervals. It is difficult to access the stock size during autumn, due to various reasons. The age groups 1 to 3 are found mixed with 0–group herring and are difficult to catch in the sampling trawl used in this survey. The stock size estimates of herring are therefore considered less reliable than those for capelin and polar cod. An example of the distribution of young herring is shown in Figure B.3.5.1. An example of the distribution of 0–group herring is presented in Figure B.3.5.2.

Use of this survey in stock assessment

The indices of age groups 1 and 2 of survey 6 are used in the assessment with the exception of 2002.. The index of survey 7 is used for the estimation of recruitment by RCT3.

B.3.6 Survey 8 Norwegian herring larvae survey on the Norwegian shelf

Background and status

A Norwegian herring larvae survey has been carried out on the Norwegian shelf since 1981 during March-April. The objectives of the survey are to map the distribution of herring larvae and other fish larvae on the spawning grounds on the Norwegian shelf and to collect data on hydrography, nutrients, chlorophyll and zooplankton. The larval indices are used as indicator of the size of the spawning stock. Two indices are available from this survey.

Results

Two larvae indices are available from this survey and presented in Table B.3.6.1. Index 1 represents the total number of herring larvae found during the survey. Index 2 represents the back-calculated number of newly hatched larvae assuming 10% daily mortality. Examples of the distribution of the herring larvae are given in Figure B.3.6.1.

Use of this survey in stock assessment

The "Index 1" is used in the assessment as representative for the size of the spawning stock except for the years 2003 and 2009 (Table B.3.6.1).

B.3.7 Survey 9 International ecosystem summer survey in Nordic Sea

Background and status

This ecosystem survey initiated in 2004 by Norway and have since then been gradually expanded in geographical coverage and scientific complexity (e.g. Nøttestad and Jacobsen 2009). In 2009, and 2010, the survey coverage was expanded further with participations of vessels from Iceland and the Faroese in addition to two vessels from

Norway. The main objective of the survey is to study abundance, spatiotemporal distribution, aggregation and feeding ecology of Northeast Atlantic mackerel, Norwegian spring-spawning herring, blue whiting and other pelagic species in relation to oceanographic conditions, prey communities and marine mammals. Two different types and independent abundance estimates for herring can de derived from the survey, an acoustic estimate, and swept area estimate from pre-defined surface trawl stations.

Results

The survey was extended very much in 2009, so the acoustic estimates for herring since then (Table B.3.7.1) are not comparable to the previous estimates. An example of the coverage of the survey (2010) is given in Figure B.3.7.1.

Use of this survey in stock assessment

The time series where the herring stock has been covered adequately goes only back to 2009. Thus, the survey has not been used directly in the assessment of NSSH.

B.4. Commercial CPUE

No commercial CPUE data are used in the assessment.

B.5. Other relevant data

With the exception of 1999, 2001 and 2005, tagging has been carried out annually between 1975 and 2007. In 2007 Norway has decided to discontinue the tagging program in 2008 and in future years.

The use of the tagging data in the assessment was discontinued since 2006 due to a low number of recaptures. This comes as a result of too low tag density in the stock given the high stock size and amount of fish screened for tags.

C. Historical Stock Development

Model used: VPA

Software used: TASACS, version

Model Options chosen:

Analyses are restricted to the years 1988-present

Age range for the analyses is 0-15+

Natural mortality is assumed at 0.9 for ages 0, 1 and 2 and 0.15 for all older ages.

Assumed fraction of fishing mortality and natural mortality for each of the age-structured surveys

FLEET 1	FLEET 2	FLEET 3	FLEET 4	FLEET 5	FLEET 6	FLEET 7
0.17	0.91	0.17	0.41	0.41	0.70	0.70

Catchability for the age structured surveys independent of age for ages >4

Exploration of the survey data is carried out in order to investigate whether the survey contributes information to the assessment or whether there is no or little in-formation in the survey data. In the case where the survey contributes mostly noise to the assessment it is not included in further exploration and in the final assessment. In addition, when conflicting information appears between different surveys, it is attempted, as far as possible, to use expert knowledge about the performance and known problems of the different surveys, to resolve conflicts by excluding the data that were considered the least reliable.

Rather than excluding information from the survey on a subjective basis, criteria are set for exclusion. These are set based on the general observations and the analysis of comparisons of the consistency within and between the surveys. The following criteria are used for exclusion of data:

1) Data outside the range of years and age windows selected by previous WG have also been excluded in the present assessment. Such as incomplete survey coverage of the stock of survey not completed due to other reasons.
2) Survey data of poor year classes with mostly noise are excluded. This is for instance the case for year class 1995 in all surveys.
3) Reject ages where the analysis of consistency between and within surveys indicate severe problems. For instance for survey 1, the conclusion from the correlation analyses is not to use information at ages older than age 11.
4) If there is a conflict between data from different surveys, discard the data where known problems with the survey indicates that these are the least reliable. This applied in particular to conflicts between survey 2 and survey 5, where survey 2 indicated a rapid decline in the stock and survey 5 a more gentle decline. Since representative sampling of old fish in survey 2 is a known problem, caused by vertical segregation in the wintering areas in the Lofoten fjord, the survey 2 data are ignored and the survey 5 data used. at ages above 10 years.
5) If there are internal inconsistencies in the old ages in a survey (mismatch between abundance at young and old age), the old ages are ignored.
6) No zero values are used.

All observations still included were given equal weight, except for the catches at the youngest ages, where the following weightings, relative to the standard weighting of 1.0 are used:

Age 0	0.001
Age 1	0.001
Age 2	0.01
Age 3	0.1

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1988-last data year	0-15+	Yes
Canum	Catch at age in numbers	1988-last data year	0-15+	Yes
Weca	Weight at age in the commercial catch	1988-last data year	0-15+	Yes
West	Weight at age of the spawning stock at spawning time.	1988-last data year	0-15+	Yes
Mprop	Proportion of natural mortality before spawning	1988-last data year	0-15+	Yes
Fprop	Proportion of fishing mortality before spawning	1988-last data year	0-15+	Yes
Matprop	Proportion mature at age	1988-last data year	0-15+	Fixed in later years
Natmor	Natural mortality	1988-last data year	0-15+	Yes

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Norwegian acoustic survey on spawning grounds in February/Match	1995-2005	5-15+
Tuning fleet 2	Norwegian acoustic survey in Nov/Dec	1992-2001	4-14+
Tuning fleet 3	Norwegian acoustic survey in January	1991-1999	5-15+
Tuning fleet 4	International Ecosystem survey in the Nordic Seas and	1991-last data year	1-2
Tuning fleet 5	International Ecosystem survey in the Nordic Seas	1991-last data year	4-15+
Tuning fleet 6	Joined Russian-Norwegian ecosystem autumn survey in the Barents Sea	2000-last data year	1-2
Tuning fleet 7	Joined Russian-Norwegian ecosystem autumn survey in the Barents Sea	2000-last data year	0

Tuning fleet 8	Norwegian herring larvae survey	1981-last data year

The stock summary from the 2009 assessment is included in table 9.4.5.3. The TASACS assessment covers the period 1988 to the present. The data prior to 1988 originate from the Sea Star assessment carried out in 2007?D. Short-Term Projection

Model used: Deterministic short-term projection, with management option table presenting average F-values for age 5-14 weighted over population numbers at the start of the year.

Software used*:* Excel spread sheet. No approved and formal tested software exists. A spreadsheet was developed because available software programmes cannot provide management option tables with annual F-factors which take account for weighted F.

Initial stock size: Input to the short-term projection are the stock number at age 4-15+ (survivors) at the 1st of January taken from the final assessment. For instance, if the last data year is 2008, the assessment provides the surviving stock numbers at the 1st of January 2009. Stock numbers at age 0-3 are estimated separately from independent data sources (for instance using RCT3).

Maturity: As a default a standard fixed maturity o-give is applied. In the case biological information is available indicating a change in proportions maturation at age, the values may be adjusted

age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1

F and M before spawning: The SSB is calculated at the 1st of January. Consequently the proportion of F and M before spawning is 0.

Weight at age in the stock: for the intermediate year are the observed weights obtained from the winter survey (reference). For the other years the average of the last 3 years are used. Since 2008 the winter survey has stopped and weight at age data from commercial sampling in the same period and are used

Weight at age in the catch: is the average of the observed catch weights over the last three years.

Exploitation pattern: is the average over the last 3 years. In 2010 and 2011 the average over the last 5 years was used.

Natural mortality: fixed values, the same as used in the assessment

Intermediate year assumptions: catch constraint

Stock recruitment model used: not applicable

Procedures used for splitting projected catches: not applicable

E. Medium-Term Projections not defined

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

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. Long-Term Projections not defined

Model used:

Software used:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

G.1. Precautionary and limit reference points:

The reference points for herring were considered by the Workshop on Limit and Target Reference Points (WKREF) held in Gdynia in 2007. Although it was the intention to review and update the biological basis of limit reference point taking into account the possible effects of species interactions and regime shifts, this has not been done because of lack of data. Instead, the breakpoint of a segmented regression applied to the stock recruitment plot was investigated. This breakpoint gives an indication at which SSB recruitment starts to decline and is a candidate for Blim. The breakpoint in the stock recruit data varied between 2 to 4 million tonnes and seemed to be very sensitive to small changes in the estimates of the poor year classes (points near the origin of the S/R plot) in assessments carried out in different years. WKREF could not explain the sensitivity and considered this behaviour of the model highly undesirable. WKREF decided to ask the Methods Working Group to investigate this observation further. Given this, the use of segmented regression technique to establish a limit biomass reference point for Norwegian spring spawning herring was not considered appropriate until the observed methodological issue has been resolved.

The presently used values originate from an analysis carried out in 1998.

	ICES CONSIDERS THAT:	ICES PROPOSED THAT:
Precautionary Approach reference points	Blim is 2.5 million t	Bpa be set at 5.0 million t
	Flim is not considered relevant for this stock	Fpa be set at F = 0.15
Technical basis:		
Blim: MBAL		Bpa=Blim*exp(0.4*1.645) (ICES Study Group 1998)
Flim: not relevant for this stock		Fpa: based on medium term simulations (ICES Study Group 1998)

The new assessment did not give different perceptions of the dynamics and levels of SSB and Fishing Mortality compared to the assessment which was the basis for establishing the reference points. Therefore there was no need to reconsider the reference points because of the new assessment method.

MSY reference points (included in 2010)

HCS Simulation model analysis

HCS is a stochastic simulation model for studying different management scenarios. The parameterization of HCS for NSSH is described in a working document sent for WGWIDE in 2010 (WD, Skagen; the values for weights, natural mortality and initial N-values can be found in ICES 2009, WGWIDE Table 7.10.1.3, input to short term prediction; see also Skagen 2010, WD WKFRAME). Two stock-recruitment relationships, Beverton-Holt and hockey stick, are explored:

Beverton-Holt: $R = a*SSB/(SSB+b)$

Hockey stick: $S>b$: $R = a$

$S<b$: $R = a*SSB/b$

The stock-recruitment parameters are shown in Table 7.8.2. params, and a plot of these together with the data is shown in Figure 7.8.2.srstoch. A plot of the data together with model output for Beverton-Holt function is show in Figure 7.8.2 srmodeldata, and the cumulative distribution of recruitment in data and model output is shown in Figure 7.8.2.cumdist. The long term sustained yields with Beverton-Holt recruitment function are shown in Figure 7.8.2.catch. A similar figure for hockey stick recruitment function can be found in Skagen 2010 (WD, Skagen).

In WKHERMAT in 2010 a new maturity ogive matrix for NSSH based on a back calculation methods was estimated (ICES 2010, WKHERMAT). This is used in the assessment in 2010. There appears to be a difference in the maturation ogive between strong and weak year classes such that strong year classes tend to mature at later age compared to weak year classes (Engelhart & Heino 2004, ICES 2010, WKFRAME). However, the model used here currently allows only static maturity ogive, and in order to take into account the effect of variation in maturation of strong and weak year classes for MSY and F_{MSY} we have run the analysis using the standard maturity ogive used in assessment the latest years, an ogive estimated for weak year classes and an ogive estimated for strong year classes (Table 7.8.2.modelparams). Furthermore, in year 2009 the selection pattern is different to the historical period, appearing more dome-shaped than the historical sigmoidal selection pattern (Table 7.8.2.modelparams). We have not been able to identify any reason why the selection pattern would have changed, as there have been no changes in gear or fishery in general. Nevertheless, we also studied the effect of possible change in selection pattern by using alternatively the historical (old) or the selection curve from 2009 (Table 7.8.2.modelparams).

The results of the simulation analysis suggest that the MSY, for all the scenarios and with both stock-recruitment functions, is within the same range: between 1 and 1.2 million tonnes (Figure 7.8.2.msyBH, 7.8.2.msyHS, and Table 7.8.2.results). Even though the different scenarios result in MSY within the same range, the F_{MSY} has more variation (Figure 7.8.2.fmsy and Table 7.8.2.results). When Beverton-Holt recruitment function is used, the risk of stock going below B_{lim} (2.5 million t.) and $B_{trigger}$ (4 million t.) at F_{MSY} are both very low, whereas with the Hockey stick recruitment function the risk of the stock falling below $B_{trigger}$ at F_{MSY} is relatively high (Table 7.8.2.results). Hockey stick recruitment function appears not to be very useful in modelling population dynamics, as the spawning stock size where MSY is reached is the same point where stock reproductive capacity starts decreasing (see also the discussion in the equilibrium analysis below). When Beverton-Holt recruitment function is used, unweighted F_{MSY} using the historical fishery selection pattern is 0.16 (for all maturity ogive scenarios), and adopting the 2009 selection pattern suggests of F_{MSY} 0.12 (for all maturity ogive scenarios). In NSSH management weighted F values are used, and the weighted values tend to be somewhat lower than unweighted values (Figure 7.8.2.fvalues). As we have no reason to believe that the selection pattern has really changed, we consider unweighted F_{MSY} to be 0.16. This unweighted F value is in close agreement with the reference values originating from an analysis carried out in 1998 (ICES 2008/ACOM 13), where a weighted F_{pa} is defined as 0.150.

<u>Equilibrium and YPR analyses</u>

Deterministic and stochastic equilibrium analyses were carried out using the 'plotMSY' software (ICES 2010, WKFRAME) to determine candidate F_{MSY} values for the Norwegian spring spawning herring stock. Stock-recruitment pairs from the period 1988-2009, as outputted from the most recent assessment of the stock, were used together with 5-year averages of selectivity, weight and maturity at age (back-calculated ogive). Two stock recruit relationships were examined, Beverton and Holt and the ('smooth hockey stick' (segmented regression), and yield-per-recruit (YPR) analyses were also done. For the stochastic analyses, uncertainty (CVs) in the biological and fishery parameters at age were used to create alternative fits to two stock-recruit relationships (N=1000).

While the Beverton and Holt fit is reasonable under using the old maturity ogive to estimate SSB (results not shown), the majority of stochastic stock-recruit model fits fell out of the range of the deterministic fit to the data, and thus it can be concluded that the stock-recruit form is unclear and not suitable for the data and the level of uncertainty associated with the parameters. Using the new back-calculated maturity ogive, as has been decided by the working group for the assessment of this stock, results in an very poor Beverton and Holt fit (Figure 7.8.2.XXXsr), with an extremely steep slope at the origin and an asymptote at the geometric mean recruitment level. Given the lack of any clear patterns in the stock-recruit data, a hockey stick model fit, while uncertain around the origin, probably provides the most cautious fit to the data. For the hockey stick, the slope at the origin is the descending limb of the stock-recruit curve, which for this stock is relatively shallow, hence F_{crash} is low. The value for B_{msy} is at the breakpoint in the hockey stick, hence F_{msy} is estimated to be the same as F_{crash} (Table 7.8.2.XXXmsy). The uncertainty with regards to the slope at the origin makes this stock-recruitment function unsuitable as a basis for advice on F_{msy}. In such cases the slope is more useful as an indication of F_{pa} or F_{lim}.

Given the poor fits to stock recruitment functions, a yield-per-recruit analysis was conducted (Figure 7.8.2.XXXypr). The stochastic analysis shows a high degree of uncertainty and a very poorly defined F_{max}. That both the hockey stick and per-recruit analysis suggests a high degree of uncertainty with regards to F_{max} could be down to the assumptions made about the uncertainties input into the analyses, though these assumptions are believed to be realistic given the information on the stock. This would preclude the use of F_{max} as an F_{msy} proxy, although $F_{0.1}$ may remain a viable, safer alternative. The YPR curve shows that F values in the range 0.125-0.15 are likely to result in high long term yields.

<u>Conclusions</u>

In the equilibrium analysis, the structure of the stock and recruitment pairs as estimated from the most recent assessment does not lead to any clear definition of an optimum yield equilibrium fishing mortality level. Given this uncertainty it is more appropriate to select an F_{msy} proxy tested by a stochastic simulation model that takes into account the long term trends in the stock biomass. The simulation model results presented in this report and in the stock annex provide a more appropriate method for the determining a viable long term target, and the values from this analysis could be put forward as potential F_{msy} targets. However, it should be noted that it is clear that the estimation of MSY reference points is very sensitive to the choice of stock-recruitment function and the approach chosen to estimate the reference points. This is in accordance with previous analyses by Skagen (WD 2010) and by WKFRAME (ICES 2010, WKFRAME).

The stochastic model uses unweighted F values, which have historically been found to be slightly lower than the unweighted values (Figure 7.8.2.fvalues). Therefore, a weighted F_{msy} of 0.15 corresponding to the unweighted 0.16 F_{msy} proxy from the simulation analyses is proposed for this stock. This is in agreement with the current simulation-tested management plan F_{pa} level and should ensure high long term yield with a low risk to the stock.

Table 7.8.2.params. Norwegian spring spawning herring. Stock recruitment parameters used in the simulation model and their fit to the data (Skagen 2010).

	a-parameter	b-parameter	SSQ
Beverton-Holt	180805	6986	81.85
Hockey stick	88803	3957	81.47

Table 7.8.2.modelparams. Norwegian spring spawning herring. Age-specific maturation probabilities, exploitation patterns and weight at age in stock and in catches used in the different stochastic simulation scenarios.

	Maturity ogive			Exploitation pattern		Weight at age	
Age	historic	weak year class	Strong year class	Old	2009	stock	catch
0	0	0	0	0.00	0.00	0.001	0
1	0	0	0	0.05	0.00	0.01	0.052
2	0	0	0	0.04	0.87	0.033	0.115
3	0	0	0	0.05	0.26	0.077	0.159
4	0.3	0.4	0.1	0.18	0.29	0.141	0.225
5	0.9	0.8	0.6	0.41	0.47	0.215	0.264
6	1	1	0.9	0.67	0.84	0.27	0.301
7	1	1	1	1.03	0.93	0.306	0.32
8	1	1	1	1.10	1.01	0.336	0.338
9	1	1	1	0.81	1.65	0.346	0.359
10	1	1	1	1.03	1.10	0.364	0.366
11	1	1	1	0.77	0.73	0.369	0.375
12	1	1	1	1.42	1.14	0.411	0.391
13	1	1	1	1.36	0.59	0.353	0.397
14	1	1	1	1.39	0.56	0.389	0.396
15	1	1	1	1.39	0.56	0.393	0.406

Table 7.8.2.results. Norwegian spring spawning herring. MSY and FMSY values provided by HCS model for different scenario combinations. Risk B_{lim} refers to the probability that SSB < B_{lim} in the last year (2.5 million tonnes), and Risk $B_{trigger}$ refers to the probability that SSB < $B_{trigger}$ ($B_{trigger}$ = 5 million tonnes, risk calculated as risk B_{lim}).

		Beverton–Holt				Hockey stick			
Ogive	selection pattern	FMSY	MSY	Risk Blim	Risk Btrigger	FMSY	MSY	Risk Blim	Risk Btrigger
Historical	old	0.16	1120.1	0	0.026	0.32	1180.1	0.067	0.354
	2009	0.12	1071.5	0.006	0.064	0.2	1135.7	0.088	0.431
Weak year class	old	0.16	1132.8	0	0.022	0.32	1193.4	0.058	0.321
	2009	0.12	1083.4	0.006	0.051	0.2	1149.4	0.075	0.401
Strong year class	old	0.16	1093.3	0.002	0.045	0.26	1157.9	0.04	0.232
	2009	0.12	1046.4	0.007	0.086	0.16	1117.9	0.017	0.203

Table 7.8.2.msy. Deterministic and stochastic estimates of *F* and biomass reference points form two stock recruit relationships and yield-per-recruit analysis for the Norwegian spring spawning herring stock (*=poorly defined).

Beverton-Holt

	Fcrash	Fmsy	Bmsy	MSY
Deterministic	*	*	0.25	1.06
50%ile	0.52	0.15	3.11	0.61
CV	1.09	0.60	0.72	0.61

Hockey Stick

	Fcrash	Fmsy	Bmsy	MSY
Deterministic	0.18	0.18	4.25	0.70
50%ile	0.20	0.20	3.88	0.90
CV	0.71	0.69	0.39	0.49

Per recruit

	F01	Fmax
Deterministic	0.23	*
50%ile	0.19	0.77
CV	0.39	0.58

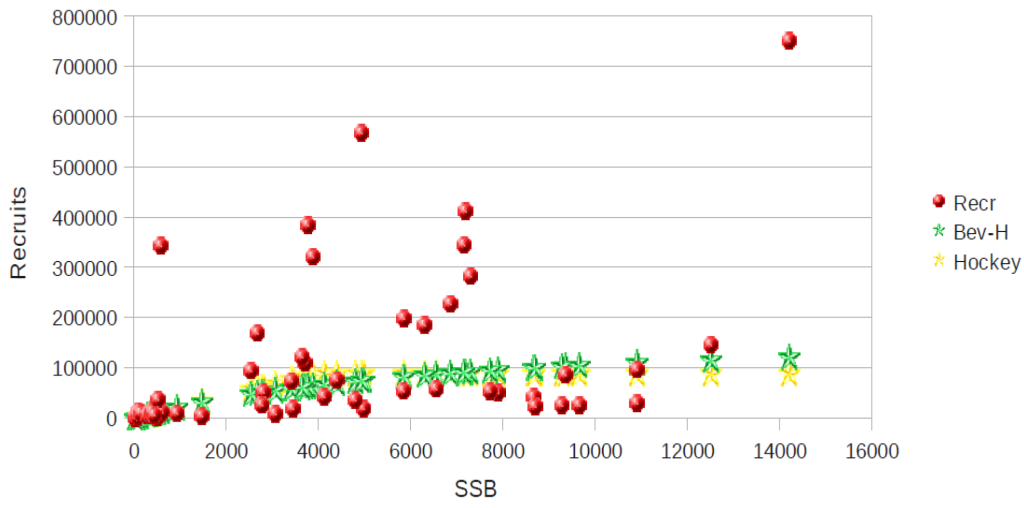

Figure 7.8.2. srstoch. Stock recruitment relationship used in the simulation model. Red dots show the recruitment from data, green stars the fitted Beverton-Holt function and yellow stars the fitted hockey stick function. Figure show also in Skagen 2010 (WD, Skagen).

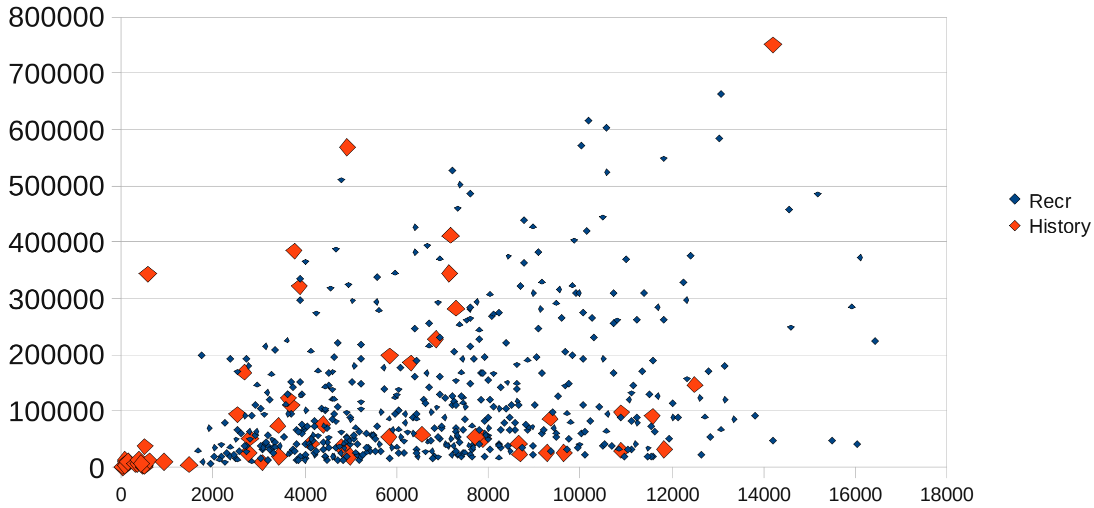

Figure 7.8.2.srmodeldata. Norwegian spring spawning herring. Stock-recruitment of NSSH from data (big red diamonds) and produced by the model (blue small diamonds) using Beverton-Holt recruitment function.

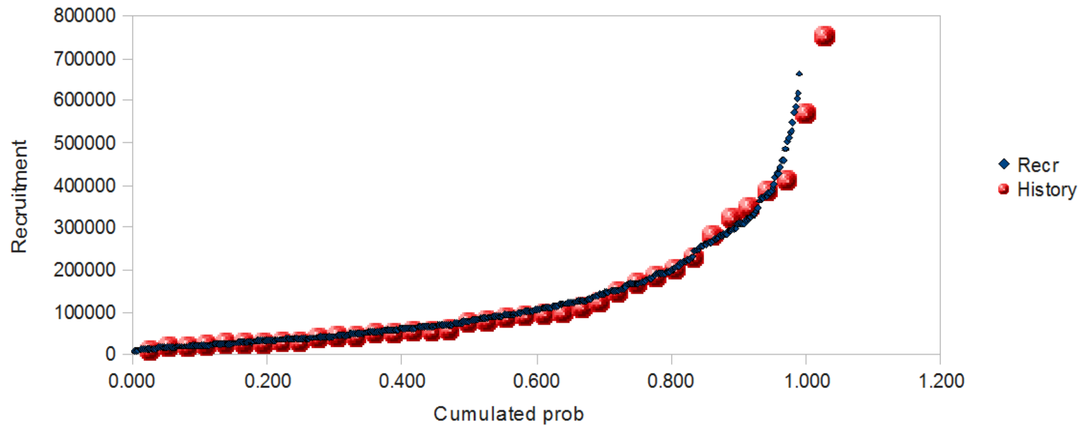

Figure 7.8.2.cumdist. Norwegian spring spawning herring. Cumulative probability of recruitment values of NSSH from the data (red dots) and produced by the model (small blue diamonds) using Beverton-Holt recruitment function.

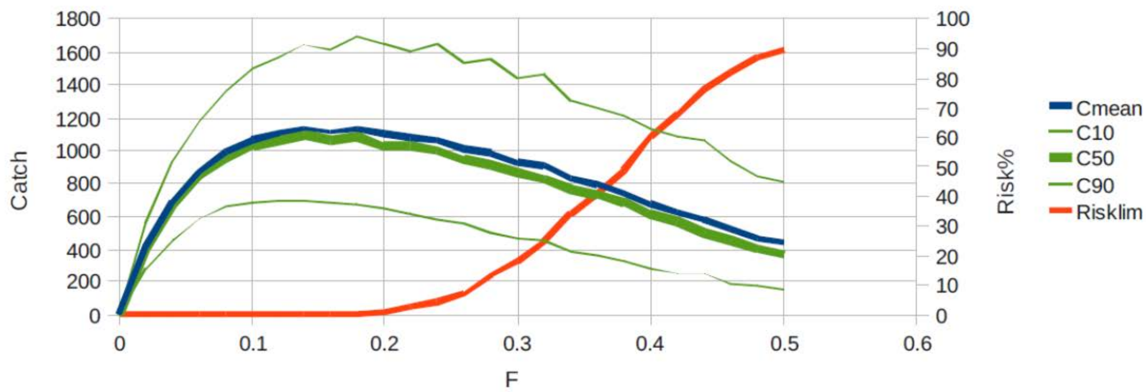

Figure 7.8.2.catch. Norwegian spring spawning herring. Yield (catch) and the probability of the stock being below Blim (2.5. million tonnes) after 50 years at target F for NSSH using Beverton-Holt recruitment function. C10, C50 and C90 show the 10, 50 and 90 percentiles of catch. Risklim shows the probability of stock falling below B_{lim} as a percentage of the model runs. For similar figure for hockey stick recruitment function see WD Skagen 2010.

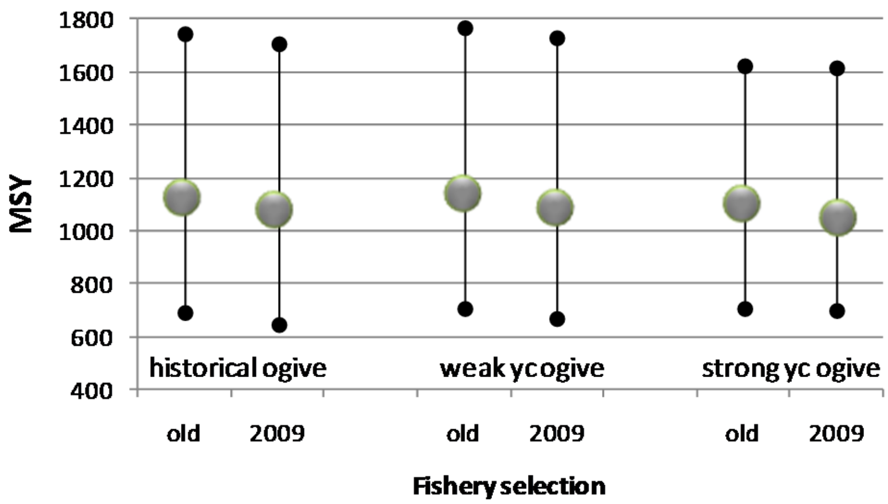

Figure 7.8.2.msyBH. Norwegian spring spawning herring. The MSY for three different maturity ogives and two different fishery selection patterns with 10 and 90 percentiles using Beverton-Holt recruitment function. See text for further details.

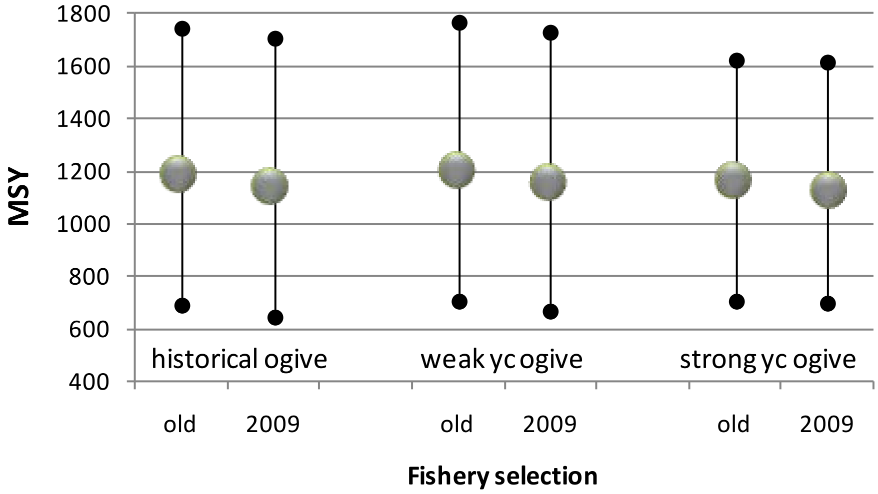

Figure 7.8.2.msyHS. Norwegian spring spawning herring. The MSY for three different maturity ogives and two different fishery selection patterns with 10 and 90 percentiles using hockey stick recruitment function. See text for further details.

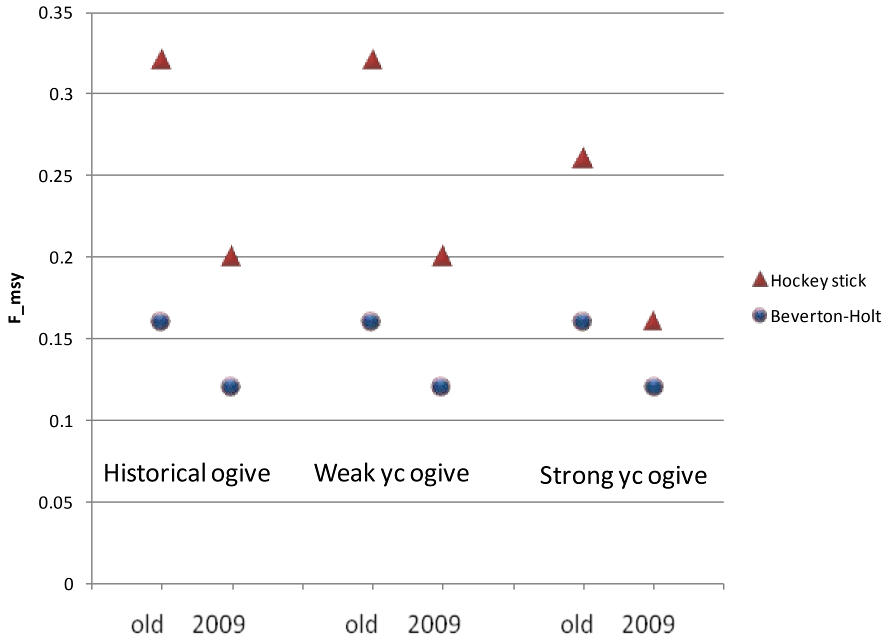

Figure 7.8.2.fmsy. Norwegian spring spawning herring. F_{MSY} for three different maturity ogives and two different fishery selection patterns with Beverton-Holt and hockey stick recruitment function. See text for further details.

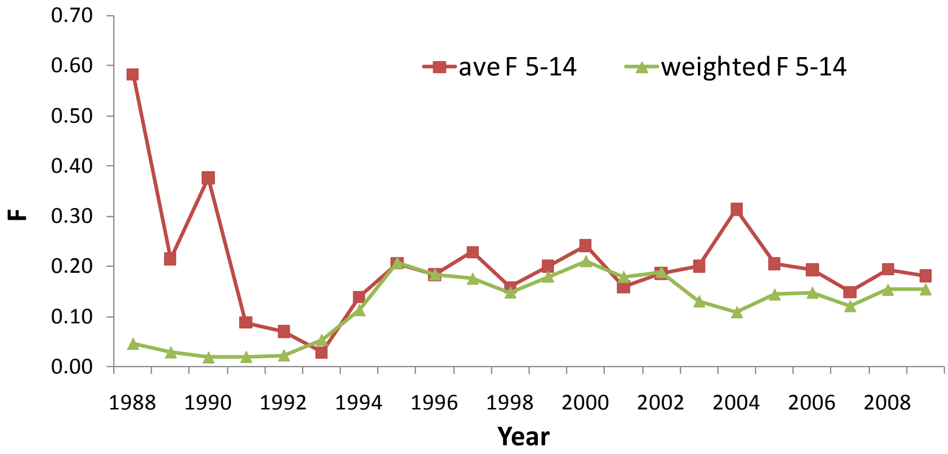

Figure 7.8.2.fvalues. Norwegian spring spawning herring. Unweighted (red squares) and weighted (green triangles) average F values from the current assessment.

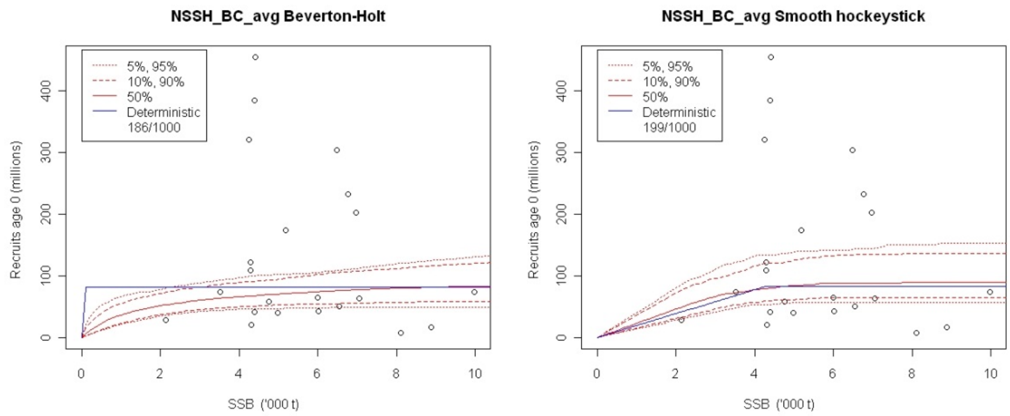

Figure 7.8.2.sr. Deterministic and stochastic (taking into account uncertainty in weights, selectivity and maturity at age) stock recruit relationship fits for the Norwegian spring spawning herring stock. Stock-recruit pairs are from the period 1988-2009.

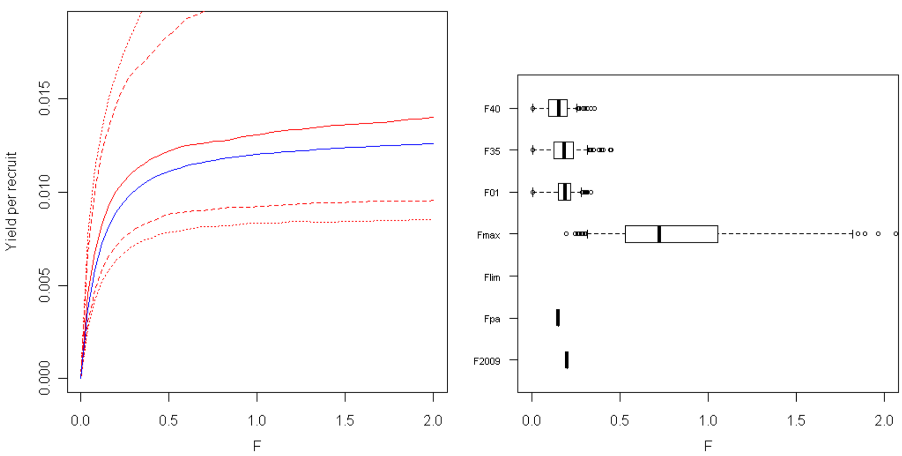

Figure 7.8.2 ypr. The yield-per-recruit (YPR) curve for the Norwegian spring spawning herring stock (left) and resulting stochastic estimates of *F* reference points (right).

G.3. Target reference points

The Coastal States have agreed a target reference point defined at F=0.125. (Note that the average fishing mortality is calculated as a weighted mean over the age groups 5–14 (weighted over abundance).

H. Other Issues not defined

Table B.2.4.1. Norwegian spring spawning herring. Maturity at age information used in the assessments before the 2010 assessments.

	age																
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1950	0	0	0	0	0.1	0.3	0.6	0.9	1	1	1	1	1	1	1	1	1
1951	0	0	0	0	0.1	0.3	0.6	0.9	1	1	1	1	1	1	1	1	1
1952	0	0	0	0	0.1	0.3	0.6	0.9	1	1	1	1	1	1	1	1	1
1953	0	0	0	0	0.1	0.3	0.6	0.9	1	1	1	1	1	1	1	1	1
1954	0	0	0	0	0.1	0.3	0.6	0.9	1	1	1	1	1	1	1	1	1
1955	0	0	0	0.08	0.22	0.37	0.85	1	1	1	1	1	1	1	1	1	1
1956	0	0	0	0.08	0.22	0.37	0.85	1	1	1	1	1	1	1	1	1	1
1957	0	0	0	0	0	0.5	0.6	1	1	1	1	1	1	1	1	1	1
1958	0	0	0	0.08	0.22	0.37	0.85	1	1	1	1	1	1	1	1	1	1
1959	0	0	0	0.08	0.22	0.37	0.85	1	1	1	1	1	1	1	1	1	1
1960	0	0	0	0.08	0.22	0.37	0.85	1	1	1	1	1	1	1	1	1	1
1961	0	0	0	0.04	0.35	0.68	0.94	1	1	1	1	1	1	1	1	1	1
1962	0	0	0	0	0.11	0.67	1	1	1	1	1	1	1	1	1	1	1
1963	0	0	0	0.04	0.03	0.32	0.9	1	1	1	1	1	1	1	1	1	1
1964	0	0	0	0.02	0.06	0.28	0.32	1	1	1	1	1	1	1	1	1	1
1965	0	0	0	0	0.34	0.35	0.76	1	1	1	1	1	1	1	1	1	1
1966	0	0	0	0.01	0.15	1	0.96	1	1	1	1	1	1	1	1	1	1
1967	0	0	0	0	0.01	0.23	1	1	1	1	1	1	1	1	1	1	1
1968	0	0	0	0	0	0.01	0.76	1	1	1	1	1	1	1	1	1	1
1969	0	0	0	0.62	0.89	0.95	1	1	1	1	1	1	1	1	1	1	1
1970	0	0	0	0.06	0.13	0.31	0.17	1	1	1	1	1	1	1	1	1	1
1971	0	0	0	0.1	0.25	0.6	0.9	1	1	1	1	1	1	1	1	1	1
1972	0	0	0	0	0.1	0.25	0.6	0.9	1	1	1	1	1	1	1	1	1
1973	0	0	0	0.5	0.9	1	1	1	1	1	1	1	1	1	1	1	1
1974	0	0	0	0.5	0.9	1	1	1	1	1	1	1	1	1	1	1	1
1975	0	0	0	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1
1976	0	0	0	0.5	0.9	1	1	1	1	1	1	1	1	1	1	1	1
1977	0	0	0	0.73	0.89	1	1	1	1	1	1	1	1	1	1	1	1
1978	0	0	0	0.13	0.9	1	1	1	1	1	1	1	1	1	1	1	1
1979	0	0	0	0.1	0.62	0.95	1	1	1	1	1	1	1	1	1	1	1
1980	0	0	0	0.25	0.5	0.97	1	1	1	1	1	1	1	1	1	1	1
1981	0	0	0	0.3	0.5	0.9	1	1	1	1	1	1	1	1	1	1	1
1982	0	0	0	0.1	0.48	0.7	1	1	1	1	1	1	1	1	1	1	1
1983	0	0	0	0.1	0.5	0.69	0.71	1	1	1	1	1	1	1	1	1	1
1984	0	0	0	0.1	0.5	0.9	0.95	1	1	1	1	1	1	1	1	1	1

1985	0	0	0	0.1	0.5	0.9	1	1	1	1	1	1	1	1	1	1	1
1986	0	0	0	0.1	0.2	0.9	1	1	1	1	1	1	1	1	1	1	1

Table B.2.4.1, cont. Norwegian spring spawning herring. Maturity at age information used in the assessments before the 2010 assessments.

	age																
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1987	0	0	0	0.1	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
1988	0	0	0	0.1	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
1989	0	0	0	0.1	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
1990	0	0	0	0.4	0.8	0.9	0.9	0.9	1	1	1	1	1	1	1	1	1
1991	0	0	0	0.1	0.7	1	1	1	1	1	1	1	1	1	1	1	1
1992	0	0	0	0.1	0.2	0.8	1	1	1	1	1	1	1	1	1	1	1
1993	0	0	0	0.01	0.3	0.8	1	1	1	1	1	1	1	1	1	1	1
1994	0	0	0	0.01	0.3	0.8	1	1	1	1	1	1	1	1	1	1	1
1995	0	0	0	0	0.3	0.8	1	1	1	1	1	1	1	1	1	1	1
1996	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
1997	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
1998	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
1999	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2000	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2001	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2002	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2003	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2004	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2005	0	0	0	0.1	0.3	0.9	1	1	1	1	1	1	1	1	1	1	1
2006	0	0	0	0	0.9	0.9	1	1	1	1	1	1	1	1	1	1	1
2007	0	0	0	0	0.3	1	1	1	1	1	1	1	1	1	1	1	1

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Table B.3.1.1. Norwegian Spring-spawning herring. Estimates from the acoustic surveys on the spawning stock in February-March. Numbers in millions. Biomass in thousands. Data in black box are used in assessment. There have been corrections due to age readings. ***Survey 1.***

	SURVEY 1						age								Total
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
1988		255	146	6805	202										7408	
1989	101	5	373	103	5402	182									6166	
1990	183	187	0	345	112	4489	146								5462	
1991	44	59	54	12	354	122	4148	102							4895	
1992*																
1993*																
1994	16	128	676	1375	476	63	13	140	35	1820					4742	
1995		1792	7621	3807	2151	322	20	1	124	63	2573				18474	3514
1996	407	231	7638	11243	2586	957	471	0	0	165	0	2024			25722	4824
1997*																
1998			381	1905	10640	6708	1280	434	130	39	0	64	0	915	22496	5360
1999	106	1366	337	1286	2979	11791	7534	1912	568	132	0	0	392	437	28840	7213
2000	1516	690	1996	164	592	1997	7714	4240	553	71	3	0	6	24	19566	4913
2001**																
2002**																
2003**																
2004**																
2005	103	281	811	3310	7545	10453	887	563	159	122	610	1100	686		26649	6501

2006	13	75	10167	684	1103	4540	4407	133	47	11	113	120	323	135	21871	4858
2007	109	534	2097	14575	952	592	3270	3092	263	276	20	285	189	628	26882	6004
2008	10	145	3517	3749	15066	972	612	2410	2374	426	136	121	90	171	29798	7244

*** No estimate due to poor weather conditions.**

**** No surveys.**

Table B.3.2.1 Norwegian Spring-spawning herring. Estimates obtained on the acoustic surveys in the wintering areas in November-December. Numbers in millions. Data in black box are used in assessment. There have been corrections due to age readings. ***Survey 2.***

	SURVEY 2								age					Total	
year	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	total	biomass
1992		36	1247	1317	173	16	208	139	3742	69					6947	
1993	72	1518	2389	3287	1267	13	13	158	26	4435					13178	
1994		16	3708	4124	2593	1096	34	25	196	29	3239				15209	
1995	380	183	5133	5274	1839	1040	308	19	13	111	39	907			15246	
1996		1465	3008	13180	5637	994	552	92	0	7	41	15	393		25384	
1997	9	73	661	1480	6110	4458	1843	743	66	0	0	64	0	904	16411	
1998	65	1207	441	1833	3869	12052	8242	2068	629	111	14	0	40	573	31144	
1999	74	159	2425	296	837	2066	6601	4168	755	212	0	15	0	146	17754	
2000	56	322	1522	5260	165	497	1869	4785	3635	668	205	0	0	11	18995	
2001	362	522	3916	1528	2615	82	338	864	3160	2216	384	127	0	1	16115	
2002*	7	50	276	1659	624	1029	32	188	516	1831	911	184	0	0	7307	
2003**	586	406	2167	10670	13237	1047	678	41	134	301	1214	502	10	37	31030	
2004**	257	6814	1123	1596	5334	6731	363	280	37	42	187	761	392	83	24000	
2005	61	352	7173	465	685	2030	3101	177	190	57	46	184	476	327	15325	
2006	940	7785	3712	21320	1153	340	2879	4851	4	23	713	4	150	58	43778	
2007	1233	343	4161	2407	6213	226	288	695	694	0	43	0	126	188	16617	3660

*** Much of the youngest yearclasses (-98,-99) wintered outside the fjords this winter and are not included in the estimate**

**** In 2003-2004 a combined estimate from the Tysfjord, Ofotfjord and oceanic areas off Vesterålen/Troms.**

Table B.3.3.1 Norwegian spring spawning herring. Estimates obtained on the acoustic surveys in the wintering areas in January. Numbers in millions. Data in the black box are used in the assessment. There have been corrections due to age readings. ***Survey 3.***

SURVEY 3													age		
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1991	90	220	70	20	180	150	5500	440							6670
1992		410	820	260	60	510	120	4690	30						6900
1993		61	1905	2048	256	27	269	182	5691	128					10567
1994	73	642	3431	4847	1503	102	29	161	131	3679					14598
1995		47	3781	4013	2445	1215	42	24	267	29	4326				16189
1996		315	10442	13557	4312	1271	290	22	25	200	58	1146			31638
1997*															-
1998	214	267	1938	4162	9647	6974	1518	743	16	4	0	33	7	462	25985
1999**	0	1358	199	1455	4452	12971	7226	1876	499	16	16	0	156	220	30444

*** No estimate due to poor weather conditions.**

**** No surveys since 1999.**

Table B.3.4.1. Norwegian spring-spawning herring. Acoustic estimates (billion individuals) of immature herring in the Barents Sea in May/June. No survey in 2003, 1990-2002. See footnotes. Data in black box used in the assessment except the yellow highlighted cell. ***Survey 4.***

	survey 4	age			
Year	1	2	3	4	5
1991	24.3	5.2			
1992	32.6	14	5.7		
1993	102.7	25.8	1.5		
1994	6.6	59.2	18	1.7	
1995	0.5	7.7	8	1.1	
1996[1]	0.1	0.25	1.8	0.6	0.03
1997[2]	2.6	0.04	0.4	0.35	0.05
1998	9.5	4.7	0.01	0.01	0
1999	49.5	4.9	0	0	0
2000	105.4	27.9	0	0	0
2001	0.3	7.6	8.8	0	0
2002	0.5	3.9	0	0	0
2003[3]					
2004[3]					

2005	23.3	4.5	2.5	0.4	0.3
2006	3.7	35.0	5.3	0.87	0
2007	2.1	3.7	12.5	1.9	0
2008[4]	0.043	0.38	0.2	0.28	0
2009	0.191	0.845	2.180	2.643	1.213

[1] Average of Norwegian and Russian estimates

[2] Combination of Norwegian and Russian estimates as described in 1998 WG report, since then only Russian estimates

[3] No surveys

[4] Not a full survey

Table B.3.4.2. Norwegian spring spawning herring. Estimates from the international acoustic surveys on the feeding areas in the Norwegian Sea in May. Numbers in millions. Biomass in thousands. Data in black box are used in assessment. There have been corrections due to age readings. *Survey 5.*

	survey 5									Age						Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
1996	0	0	4114	22461	13244	4916	2045	424	14	7	155	0	3134			50514	8532
1997	0	0	1169	3599	18867	13546	2473	1771	178	77	288	190	60	2697		44915	9435
1998	24	1404	367	1099	4410	16378	10160	2059	804	183	0	0	35	0	492	37415	8004
1999	0	215	2191	322	965	3067	11763	6077	853	258	5	14	0	158	128	26016	6299
2000	0	157	1353	2783	92	384	1302	7194	5344	1689	271	0	114	0	75	20758	6001
2001	0	1540	8312	1430	1463	179	204	3215	5433	1220	94	178	0	0	6	23274	3937
2002	0	677	6343	9619	1418	779	375	847	1941	2500	1423	61	78	28	0	26089	4628
2003	32073	8115	6561	9985	9961	1499	732	146	228	1865	2359	1769		287	0	75580	6653
2004	0	13735	1543	5227	12571	10710	1075	580	76	313	362	1294	1120	10	88	48704	7687
2005	0	1293	19679	1353	1765	6205	5371	651	388	139	262	526	1003	364	115	39114	5109
2006	0	19	306	14560	1396	2011	6521	6978	679	713	173	407	921	618	243	35545	9100
2007	0	411	2889	5877	20292	1260	1992	6780	5582	647	488	372	403	1048	1010	49051	12161
2008	0	1193	587	8332	8270	16345	1381	1920	3958	2500	416	242	159	217	408	45928	9996
2009	202	906	2980	2754	14292	9487	11629	1472	1253	2587	1357	267	183	60	258	49687	10700

Table B.3.5.1. Norwegian spring-spawning herring. Abundance indices for 0-group herring 1980-2008 in the Barents Sea, August-October. ***This index has been recalculated since 2006, these are the new values. Survey 7.***

survey 7	
Year	Abundance index
1980	4
1981	3
1982	202
1983	40557
1984	6313
1985	7237
1986	7
1987	2
1988	8686
1989	4196
1990	9508
1991	81175
1992	37183
1993	61508
1994	14884
1995	1308
1996	57169
1997	45808
1998	79492
1999	15931
2000	49614
2001	844
2002	23354
2003	28579
2004	133350
2005	26332
2006	66819
2007	22481
2008	15727

Table B.3.5.2. Norwegian spring-spawning herring. Acoustic estimates (billion individuals) of immature herring in the Barents Sea in August-October. Data in black boxes used in the assessment. ***Survey 6.***

survey 6			
	Age		
Year	1	2	3
2000	14.7	11.5	0
2001	0.5	10.5	1.7
2002	1.3	0	0
2003	99.9	4.3	2.5
2004	14.3	36.5	0.9
2005	46.4	16.1	7.0
2006	1.6	5.5	1.3
2007	3.9	2.6	6.3
2008	0.03	1.6	4.0

Table B.3.6.1.. Norwegian Spring-spawning herring. The indices for herring larvae on the Norwegian shelf for the period 1981-2009 ($N*10^{-12}$). Data in black box are used in the assessment. ***Survey 8.***

survey 8		
Year	Index1	Index 2
1981	0.3	
1982	0.7	
1983	2.5	
1984	1.4	
1985	2.3	
1986	1	
1987	1.3	4
1988	9.2	25.5
1989	13.4	28.7
1990	18.3	29.2
1991	8.6	23.5
1992	6.3	27.8
1993	24.7	78
1994	19.5	48.6
1995	18.2	36.3
1996	27.7	81.7
1997	66.6	147.5
1998	42.4	138.6
1999	19.9	73
2000	19.8	89.4
2001	40.7	135.9
2002	27.1	138.6
2003*	3.7	18.8
2004	56.4	215.1
2005	73.91	196.7
2006	98.9	389.0
2007**	90.6	
2008	107.9	393.3
2009***	8.4	53.8

Index 1. The total number of herring larvae found during the cruise.

Index 2. Back-calculated number of newly hatched larvae with 10% daily mortality. The larval age is estimated from the duration of the yolksac stages and the size of the larvae.

*** Poor weather conditions and survey was late in April**

**** only representative for the area 62-66°N**

*****Likely that spawning was particularly early in 2009**

Table B.3.7.1. Norwegian spring spawning herring. Acoustic estimates from the coordinated ecosystem survey in Norwegian Sea and adjoining waters in July-August. Numbers in millions. Biomass in thousands. ***Survey 9.***

survey 9							Age								Total	
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
2009	0	415	4136	3522	12448	7479	12362	1223	2144	1761	410	0	157	75	756	46888	13603
2010	543	327	1309	2631	2500	10141	6619	6471	1163	2310	804	422	166	87	144	35637	10717

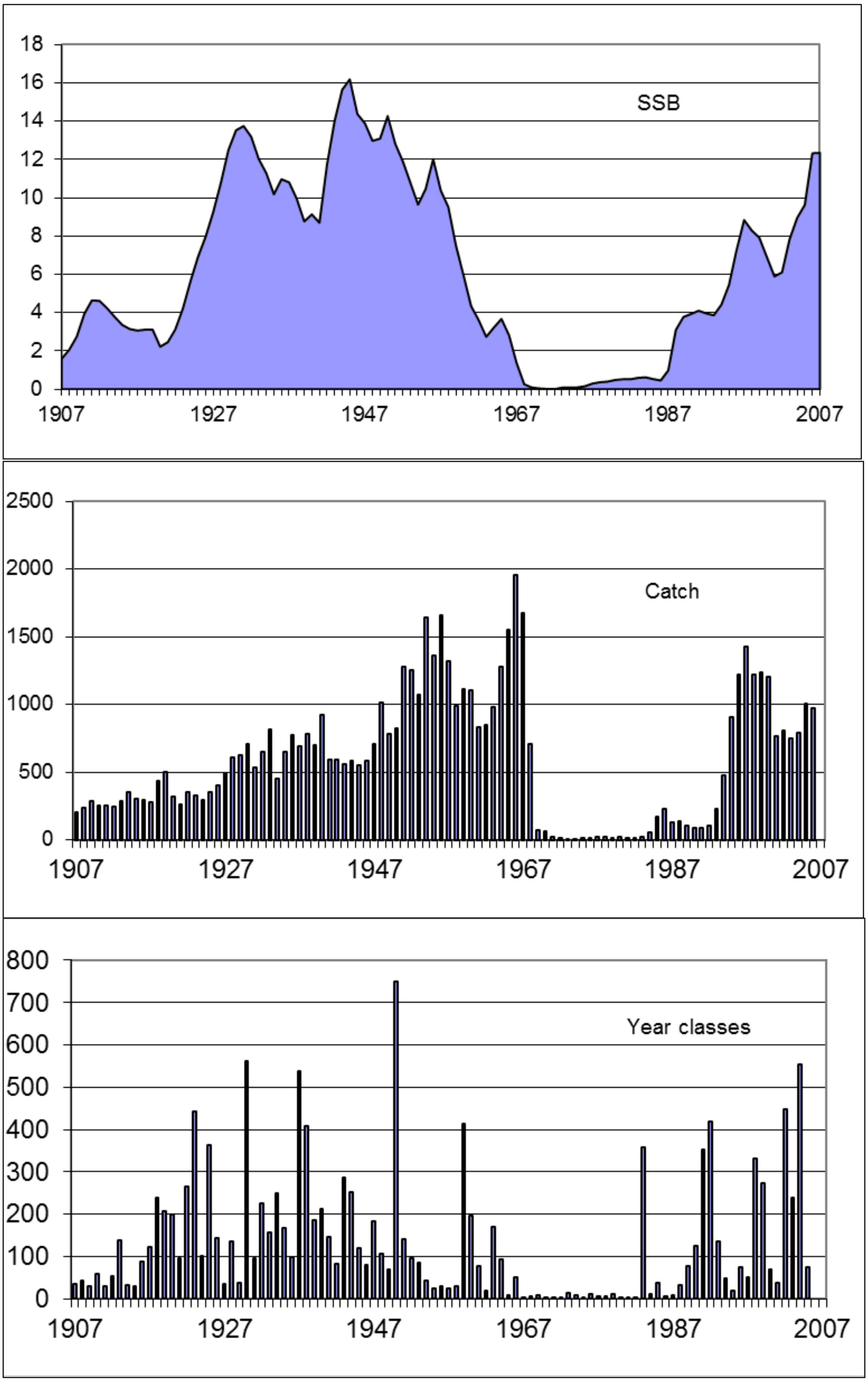

Figure A.1.1.1. Norwegian spring spawning herring. Long term trends in spawning stock, catches and recruits (1907-1988 from Toresen and Østvedt; 1989-2007 from WGNPBW 2007).

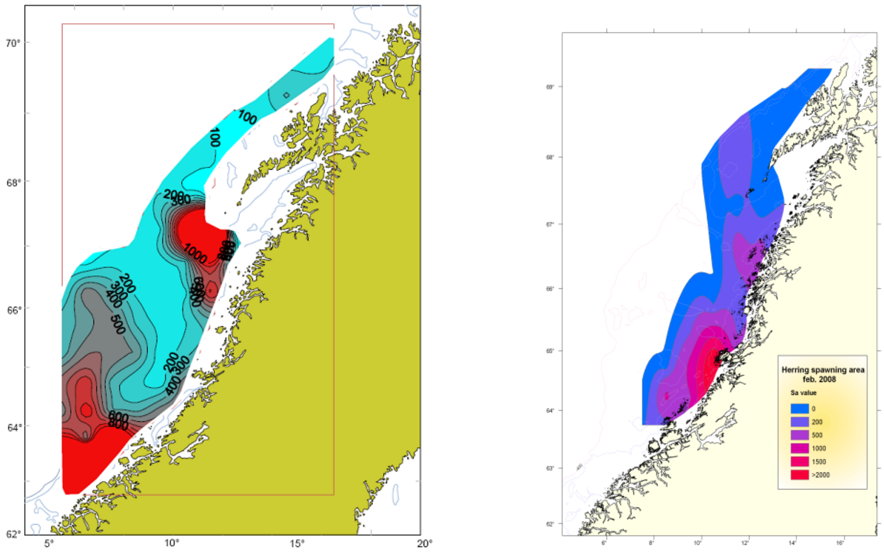

Figure B.3.1.1. NSSH Acoustic survey on spawning grounds in February March, 2007 (left) and 2008 (right).

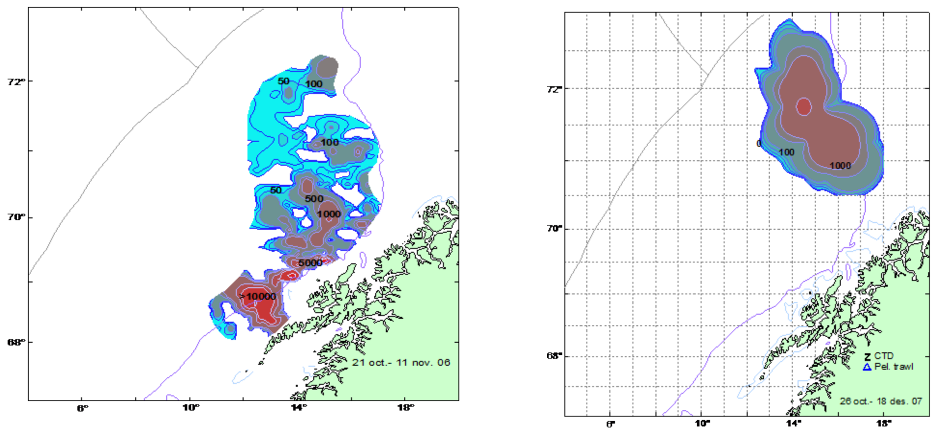

Figure B.3.2.1. NSSH Acoustic survey in November/December 2006 (left panel here) and 2007 (right panel).

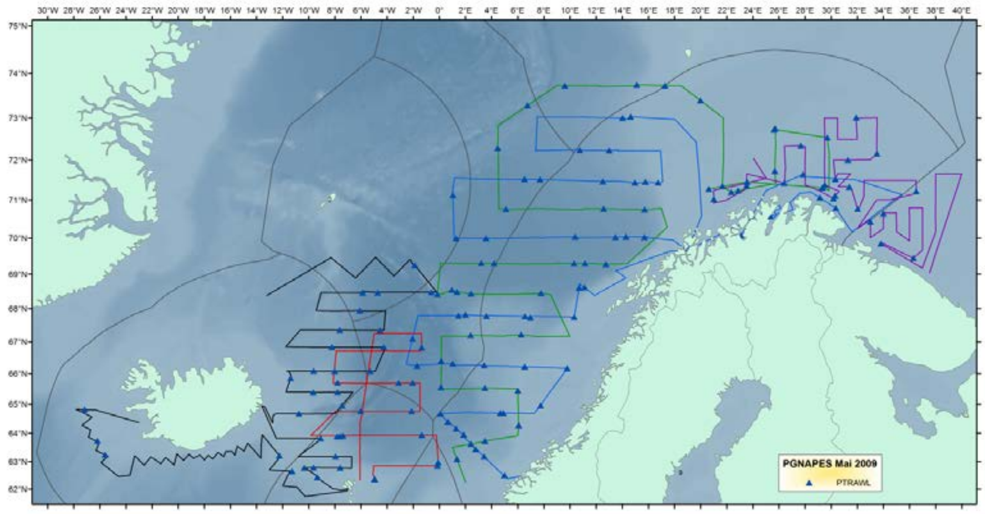

Figure B.3.4.1. Cruise tracks during the International North East Atlantic Ecosystem Survey in April-May 2009 and location of trawl stations.

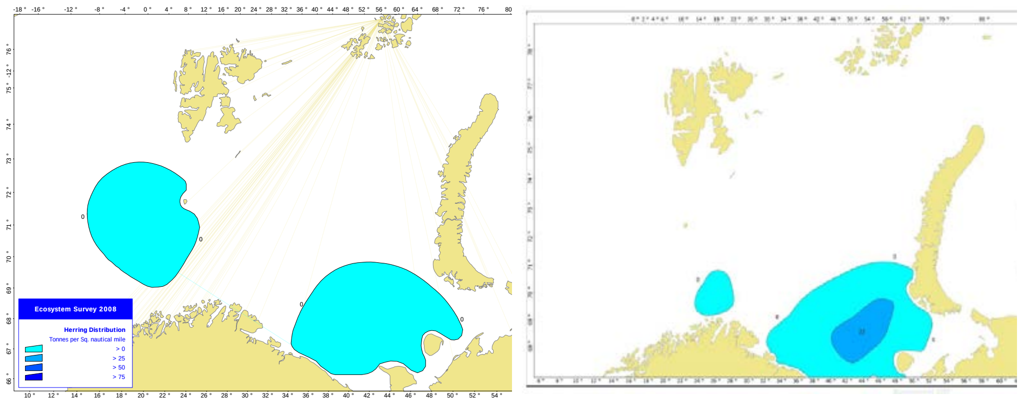

Figure B.3.5.1. Estimated total density of herring (tonnes/nautical mile²) in August-September 2008 (left panel) and 2007 (right panel).

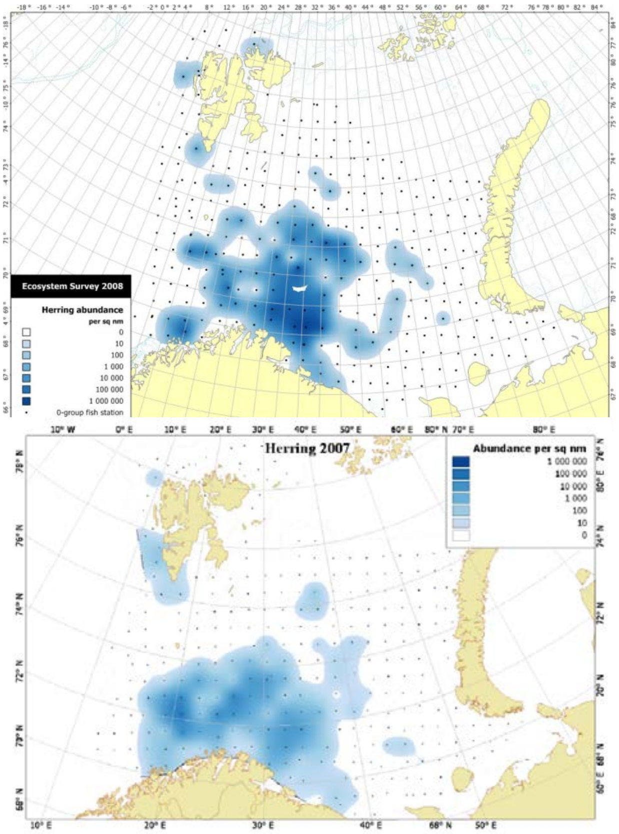

Figure B.3.5.2. NSSH O–group surveys in August/September in the Barents Sea in 2008 (left panel) and 2007 (right panel).

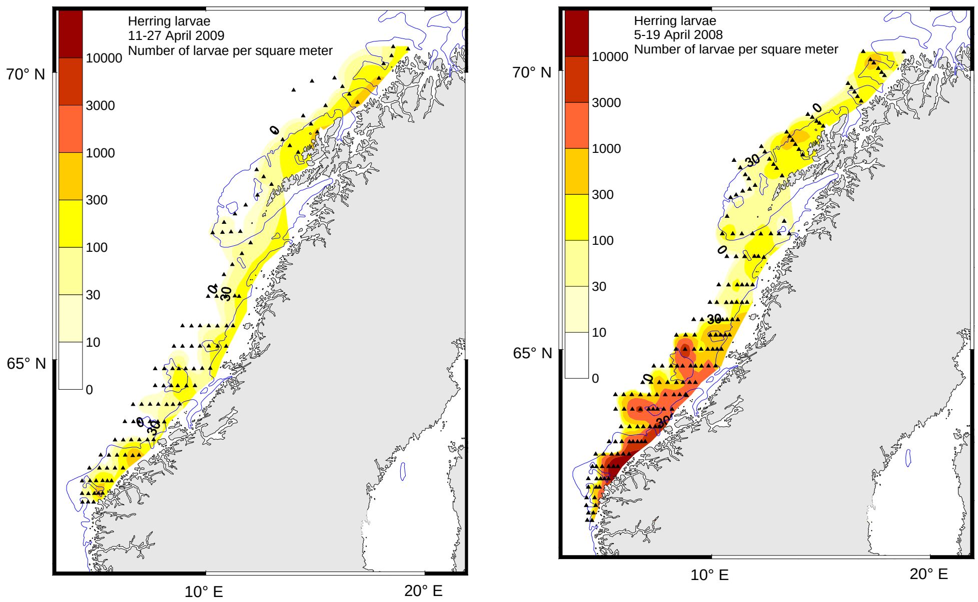

Figure B.3.6.1. NSSH. Distribution of herring larvae on the Norwegian shelf in 2009 (left panel) and 2008 (right panel). The 200 m depth line is also shown.

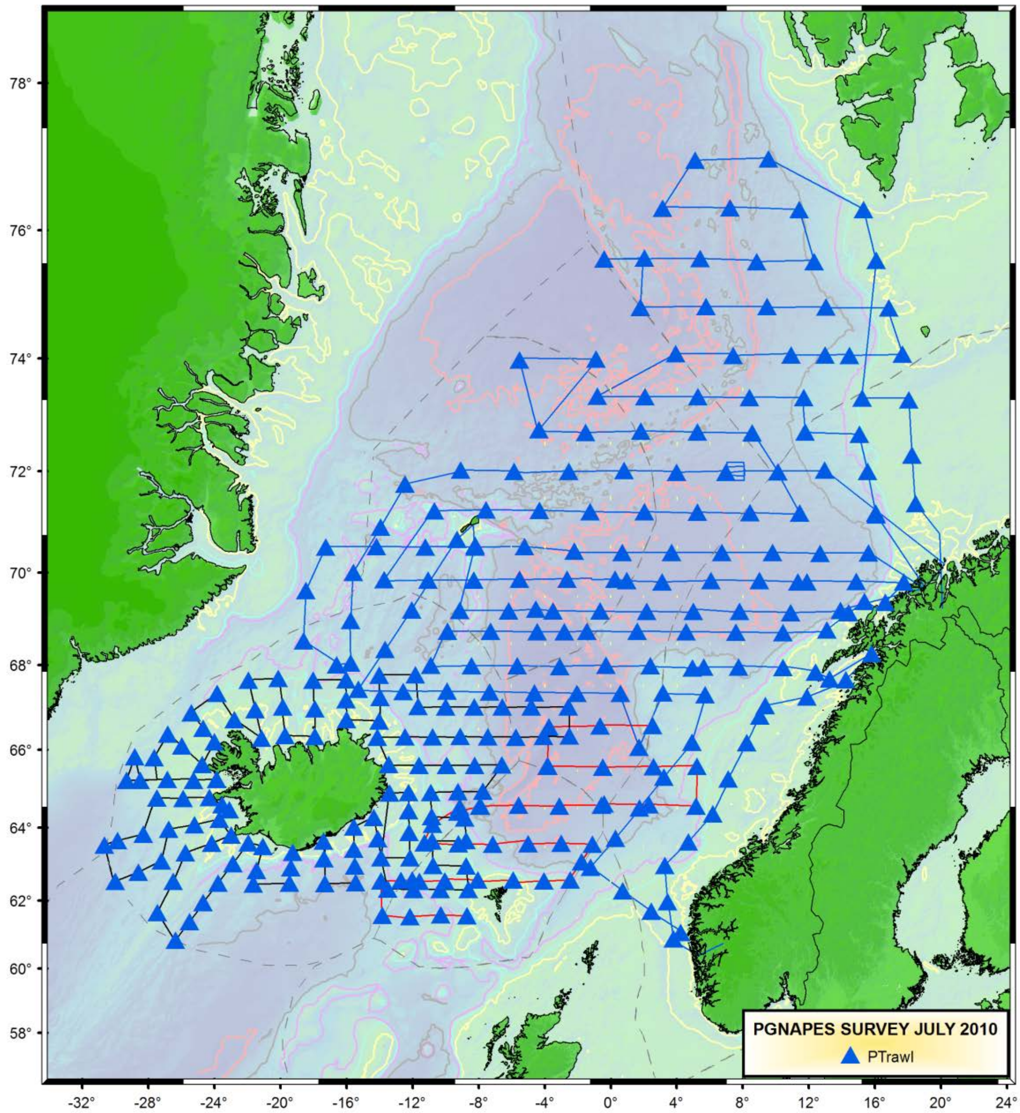

Figure B.3.7.1. Cruise tracks during the coordinated ecosystem survey in Norwegian Sea and adjoining waters in July-August 2010 and location of trawl stations.

Table 9.4.5.3 Herring in the Northeast Atlantic (Norwegian spring-spawning herring). Summary of the stock assessment. Data prior to 1988 are from the 2006 assessment year.

Year	Recruitment	SSB	Landings	F weighted
	Age 0			Ages 5-14
	thousands	tonnes	tonnes	
1950	751000000	14200000	826000	0.0584
1951	146000000	12500000	1280000	0.0697
1952	96600000	10900000	1250000	0.0728
1953	86100000	9350000	1070000	0.0663
1954	42100000	8660000	1640000	0.1130
1955	25000000	9270000	1360000	0.0783
1956	29900000	10900000	1660000	0.1100

Year	Recruitment	SSB	Landings	F weighted
	Age 0			Ages 5-14
	thousands	tonnes	tonnes	
1957	25400000	9650000	1320000	0.1030
1958	23100000	8690000	986000	0.0787
1959	412000000	7180000	1110000	0.1130
1960	198000000	5850000	1100000	0.1360
1961	76100000	4390000	830000	0.1040
1962	19000000	3440000	849000	0.1460
1963	169000000	2670000	985000	0.2530
1964	93900000	2530000	1280000	0.2260
1965	8490000	3060000	1550000	0.2780
1966	51400000	2800000	1960000	0.6960
1967	3950000	1470000	1680000	1.5200
1968	5190000	344000	712000	3.4900
1969	9780000	145000	67800	0.5900
1970	661000	71000	62300	1.3200
1971	236000	32000	21100	1.5300
1972	957000	16000	13200	1.5000
1973	12900000	85000	7020	1.1700
1974	8630000	91000	7620	0.1140
1975	2970000	79000	13700	0.1900
1976	10100000	138000	10400	0.1060
1977	5100000	286000	22700	0.1110
1978	6200000	358000	19800	0.0434
1979	12500000	388000	12900	0.0238
1980	1470000	471000	18600	0.0341
1981	1100000	504000	13700	0.0215
1982	2340000	503000	16700	0.0200
1983	343000000	575000	23100	0.0291
1984	11500000	602000	53500	0.0903
1985	36600000	515000	170000	0.3790
1986	6040000	437000	225000	1.0700
1987	9090000	926000	127000	0.4040
1988	25724000	2768000	135301	0.045
1989	73988400	3409000	103830	0.029
1990	109705800	3702000	86411	0.022
1991	320875600	3877000	84683	0.023
1992	383921700	3767000	104448	0.027
1993	121890400	3641000	232457	0.064
1994	42242100	4122000	479228	0.129
1995	18643900	4976000	905501	0.229
1996	57789400	6545000	1220283	0.192
1997	50575900	7887000	1426507	0.180
1998	282407700	7290000	1223131	0.153
1999	227356600	6852000	1235433	0.186

Year	Recruitment	SSB	Landings	F weighted
	Age 0			Ages 5-14
	thousands	tonnes	tonnes	
2000	54030800	5837000	1207201	0.213
2001	35695300	4794000	766136	0.180
2002	568142000	4928000	807795	0.184
2003	185261300	6298000	789510	0.114
2004	344513300	7149000	794066	0.094
2005	53536700	7715000	1003243	0.128
2006*	90770000	11580000	968958	0.131
2007*	30990000	11836000	1266993	0.098
2008**	103000000	12437000	1545656	0.125
2009**	103000000	13300000		
Average	100457748	4646433	690524	0.3220

*** Recruitment value has been replaced in the forecast by RCT estimate.**

**** GM mean 1989-2005**

Annex 02D - Stock Annex: Blue Whiting (Subareas I–IX, XII and XIV)

Quality Handbook	**Blue whiting (Subareas I– IX, XII and XIV)**

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	**Blue Whiting**
Working Group:	**Working Group for Widely distributed stocks**
Date:	**Updated in February 2012.**
Revised By:	**Afra Egan *et al.* (1st version 2010), WKPELA 2012**

A. General

A.1. Stock definition

Blue whiting (*Micromesistius poutassou*) is a pelagic gadoid that is widely distributed in the eastern part of the North Atlantic. The highest concentrations are found during spawning along the edge of the continental shelf in areas west of the British Isles and on the Rockall Bank plateau where it occurs in large schools at depths ranging between 300 and 600 meters but is also present in almost all other management areas between the Barents Sea and the Strait of Gibraltar and west to the Irminger Sea. Adults reach maturation at 2-7 years old and undertake long annual migrations from the feeding grounds to the spawning grounds (Bailey, 1982). Most of the spawning takes place between March and April, along the shelf edge and the banks west of the British Isles. Juveniles are abundant in many areas, with an important nursery area believed to be the Norwegian Sea, at least in times of high abundance. Morphological, physiological, and genetic research has suggested that there may be several components of the stock which mix in the spawning area west of the British Isles. Due to the large population size, its considerable migratory capabilities and wide spatial distribution, the stock composition and dynamics require continued monitoring. The migration routes of blue whiting in the north Atlantic are shown in Figure D1.

Blue Whiting Stock Identity

Prior to 1993, for the purposes of assessment, it was assumed that blue whiting had two components, a northern and a southern component. The Northern stock was known to feed in the Norwegian Sea and spawn to the west of the British Isles. The Southern stock was found along the continental shelf off the coast of Spain and Portugal with the main spawning areas towards the Porcupine Bank. The Porcupine Bank was considered a transitional area between the two main stocks (ICES, 1990). In 1993 it was argued that there was no strong evidence to maintain this division between the two stocks. Results from an otolith age reading workshop at that time showed no significant difference in mean annual ring diameter between northern and southern stocks. It was agreed by ACFM in 1993 that the two stocks should be combined for assessment purposes (ICES, 1995). Since then this stock has been assessed as one unit.

Several approaches have been employed to investigate the stock structure of blue whiting. The details of studies relating to genetics, larval otolith growth patterns and the movements of eggs and larvae have been published in recent years.

Blue Whiting have a wide geographic distribution and large population size, which is generally advantageous for the accumulation and preservation of genetic variability (Mork and Giaever, 1995). The first genetic work was carried out in the early 1990s. A study was carried out by Mork and Giaever, 1995 included samples from most of the eastern Atlantic but the amount of samples from the southern part of this area was generally low. Further work revealed significant geographic heterogeneity with reproductive units found at the fringes of the distribution range. A genetically distinct population was found in the Barents Sea and potential populations identified in the Mediterranean and Romsdalsfjord area of Norway. Samples taken from the area west of the British Isles and from the Norwegian Sea were genetically similar, which suggests a single blue whiting stock throughout the area (Giaever and Stein, 1998). Genetically distinct populations were also found in the Barents Sea and Mediterranean by Ryan *et al* 2005 by using one minisatellite and five microsatellite loci. Temporal variation was also seen between samples collected on the main spawning area. In this case there was insufficient data to identify explicitly the geographic range of these possible stocks. The most recent study conducted by Was *et al*, 2008 used a landscape genetics approach which combines spatial and genetic information to detect barriers to gene flow. This microsatellite analysis found that samples collected and analysed from along the south flowing current from the Porcupine Bank i.e. the Celtic Sea and Bay of Biscay were genetically different from those in the northward flowing current. Temporal variation was seen in samples collected in the Rockall Bank area and the reasons for this are inconclusive.

Oceanographic modelling has been used to examine movements of blue whiting eggs and larvae. Larval drift is an important factor in recruitment. A hypothesis put forward by Skogen *et al*, 1999, was that the southern stock will spawn in an area where the eggs and larvae are likely to drift southwards and the northern stock where the eggs and larvae will drift northwards. Based on modelled drift patterns they found that a possible separation line was located at 54.5ºN but this was subject to significant interannual variability over the twenty years studied. Work conducted by Bartsch and Coombs (1997) used a three dimensional baroclinic model suggests that particles released on the Porcupine Bank drifted southwards with a separation at about 53-54ºN. This work gave some additional information about stock separation but suggested that the division might be more southerly. Additional testing of the use of this type of model was recommended.

An investigation of larval growth histories was carried out in 2007 (Brophy and King, 2007). Groups that are spatially or temporally distinct after hatching show measurable differences in the larval portion of the otolith. This study has shown that larvae from the Bay of Biscay grow faster than those from more northerly spawning areas. It also confirmed that fish spawning to the west of Ireland and Scotland, do not form a randomly mixing unit and that subunits within this aggregation have experienced differences during the larval phase. It was hypothesised that the dispersal of larvae could influence the subsequent dispersal of spawning adults. The fish that are found in the feeding assemblages throughout the distribution may not contribute equally to the spawning assemblages in the north and south of the spawning grounds.

In 2009 the stock identification methods working group (SIMWG) stated that the perception of blue whiting in the NE Atlantic as a single unit stock is not consistent with recently observed differences in genetics and growth and should be revised; based on current available data. They recommended that a precautionary approach should initially treat blue whiting populations in areas VIIk and VIIj and further south as a separate unit from all other NE populations. SIMWG is in support of an initial, precautionary delineation of "two main stocks" but also vigorously suggests that a large, interdisciplinary project on this species is needed in order to comprehensively understand blue whiting stock structure in the NE Atlantic so that SIMWG may provide more robust advice (ICES, 2009a).

Recent results from length-at-age and otholith shape analysis presented in at WKPELA in 2012 (ICES, 2012?) did not provide evidence two separate stocks but rather substantial mixing of individuals on the common spawning grounds. At this meeting following a full review of available studies on blue whiting stock structure in the northeast Atlantic. The working group came to the conclusion that there is no scientific evidence in support of multiple stocks with distinct spawning locations or timings. The emerging picture is one of a single stock whose large scale spatial distriution varies as a function of hydrographic conditions and total abundance; this is commonly described as an abundance-occupancy relationship. Further, there seem to be a number of core nursery and feeding areas with marginal areas being occupied at times of high stock abundance. As a result, the working group decided to recommend treating blue whiting in ICES subareas I–IX, XII and XIV as a single stock for assessment purposes.

A.2. Fishery

Since 1988, 18 national fleets have been involved in the blue whiting fisheries. The highest landings have been reported by Norway, followed by the USSR/Russia, Iceland and the Faroes. Over the last decade, 13 or 14 national fleets land parts of the blue whiting quota each year. The highest concentrations of catches are generally found along the edge of the continental shelf in the area west of the British Isles, on the Rockall and Hatton Banks and around the Faroe Islands in quarter 1. In the following quarters catches are generally taken further north in the Norwegian Sea and also in the North Sea with lesser quantities of blue whiting caught in the southern area off Spain and Portugal.

Most of the catches are taken in the directed pelagic trawl fishery in the spawning and post spawning areas (Divisions Vb, VIa, b, and VIIb, c). Catches are also taken in the directed and mixed fishery in Subarea IV and Division IIIa, and in the pelagic trawl fishery in the Subareas I and II and in Divisions Va and XIVb. These fisheries in the northern areas have taken between 360,000–2,300,000 t per year in the last decade, while catches in the southern areas (Subarea VIII, IX, Divisions VIId, e and g–k) have been in the range of 20,000–85,000 t. The proportion of landings originating from the Norwegian Sea fluctuates greatly, having increased from 5% of the total in the mid-1990s to around 30% in 2003–2004, after which the proportion decreased again to below 10%. These fluctuations are thought to be linked to fluctuations in recruitment. In Division IXa blue whiting is mainly taken as bycatch in mixed trawl fisheries (ICES, 2008a). The proportions of landings originating in each area are mapped and presented in the annual working group reports.

The procedure of the working group is to split length frequency data into three areas, although it is recognised that the northern area comprises both spawning size fish and juveniles. The three areas are as follows:

1) The southern area around Spain and Portugal
2) The northern area which includes the spawning grounds and the Norwegian Sea
3) The North Sea and the Skagerrak.

A.3. Ecosystem aspects

The blue whiting stock has seen an almost threefold increase in spawning stock biomass since the mid 1990's. In recent years the stocks has declined in terms of spawning stock biomass and the year classes from 2005 and onwards are all poor. However, some signs of improved recruitment were observed from the two surveys in 2011 where young blue whiting were caught in the northern areas of the spawning stock survey in April (IBWSS) as well as in the May Ecosystem survey in the Nordic Seas (IESNS). Throughout this low period, recruitment strength in the Bay of Biscay and Celtic Sea seemed to have been high for the regions, indicating a anti-cyclic pattern. The early life stages have a significant influence on the reproductive success of this stock. The main blue whiting spawning areas are located along the shelf edge and banks west of the British Isles and Ireland. The eggs and larvae spawned on the Porcupine Bank area (west of Ireland) can drift both towards the south and towards the north, depending on the spawning location, oceanographic conditions and the effects from wind force, while the spawning products from the northern spawning area west of the Hebrides always drift northwards. The northward drift spreads the major part of the juvenile blue whiting to the Norwegian Sea and adjacent areas from Iceland, Faroes and North Sea to the Barents Sea. The larvae usually settle on the deeper areas of the various shelf-edges in the autumn and stay more or less associated with bottom the first winter or more, gradually becoming part of the mature stock after 2 or 3 years. Adult blue whiting carry out active feeding and spawning migrations in the same area as herring. Blue whiting has consequently an important role in the pelagic ecosystems of the area, both by consuming zooplankton and small fish, and by providing a food resource for larger fish and marine mammals (ICES, 2009b). However, a study by Utne *et al*. (in press 2012) suggest that the vertical overlap between blue whiting and herring/mackerel in the Norwegian Sea during the summer feeding period is limited as blue whiting prefer to stay in deeper waters than the other two species. These indicate that the food competition might be limited between blue whiting and mackerel/herring during the summer months in certain areas.

During the spawning stock survey on blue whiting in 2009, large amounts of mackerel were observed throughout the spawning grounds. The mackerel was distributed from 60-300 meters and fed heavily on pearlsides (*Maurolicus mülleri*) (PGNAPES, ICES RMC/06, 2009). The overlapping distribution of feeding mackerel within the blue whiting spawning grounds suggests a possible ecologic interaction between the two stocks, and predation from mackerel on blue whiting egg and larvae could be a contributing factor to the collapse in blue whiting recruitment observed. This interaction may have increased significantly both with the growth in the mackerel stock and with the changes observed in mackerel distribution in recent years. It is strongly suggested that investigations are carried out on this relationship in order to evaluate possible effects of mackerel on blue whiting recruitment.

Environmental conditions in the main spawning areas have undergone significant changes during this time. Changes in temperature, salinity and circulation have been recorded in long term trend data. Blue whiting are sensitive to temperature and salinity and will only spawn in waters with suitable ranges. Hatun *et al.* (2009a) suggests a temperature range of 9°-10°C and salinity ranges of between 35.35 and 35.45 psu.

The ICES report on ocean climate (ICES, 2008b) provides a summary of long term trends in environmental conditions until the end of 2007. Increases in temperature and salinity have been recorded over the blue whiting distribution area. An increase in sea surface temperature (SST) was shown at several of the monitoring stations in the NE

Atlantic with temperatures up 3°C since the early 1980s (ICES, 2008c). Salinity has shown some fluctuations throughout the time series. In the Rockall trough salinity reached a peak in 2003 and has declined slightly since then. The same trend can be seen in the Faroes Shetland Channel. In the Norwegian Sea increases in both temperature and salinity have occurred since the mid 1990s (ICES, 2008b).

The circulation of the North Atlantic is characterized by two large gyres: the subpolar and subtropical gyre. Some of the water in the subtropical gyre is re-circulated to the west of the Mid Atlantic Ridge (MAR) and some water continues east and crosses the MAR in the Azores Current and the remainder forms the North Atlantic Current (NAC) (ICES 2008f). The subpolar gyre controls the flow trajectory of the NAC in the Northeastern Atlantic. When the gyre is strong, it extends eastwards, branches off and carries cold less saline water to the Rockall Trough and over the Rockall plateau (Figure D2a). When the gyre is weak it moves west and allows subtropical water to spread north and west and this results in warmer more saline conditions (Figure D2b) (Hatun, *et al.* 2009a).

Work carried out by Hatun, *et al.* 2007 used a gyre index value which is obtained from the simulated sea surface height over the entire North Atlantic Ocean and it reflects the shape and strength of the subpolar gyre. Since blue whiting are known to spawn in water masses with a relatively narrow temperature and salinity range the variability in the strength of the gyre index influences their spawning distribution. A strong gyre index is associated with cold and fresh conditions in the North East Atlantic and this seems to coincide with spawning to the east, along the continental slope and the Porcupine Bank area. The post spawning migration takes place in the Faroe Shetland channel and is possibly associated with a smaller total fish stock. When the gyre index is weak spawning takes place on the western slope of the Faroe plateau and over the Rockall plateau. The post spawning migration is also on the west through the Faroe Bank channel and is possibly leads to a larger stock size. The estimated threefold increase in blue whiting biomass coincided with major changes in the marine climate and this shift between east and west during the mid 1990s indicates a possible connection.

Hatun, *et al.* 2009a explored the hypothesis that the spawning distribution is predominantly controlled by the marine climate conditions west of Ireland, along the continental slope and west of Rockall when the subpolar gyre is weak and towards the Porcupine bank when the subpolar gyre is strong. This study used hydrographic, acoustic biomass and larval data as well as catch statistics and data from the regional gyre index. This study showed that the spawning distribution of blue whiting is determined by oceanographic conditions to the west of Great Britain and Ireland which in turn are regulated by the North Atlantic subpolar gyre.

Further work was carried out to examine large scale bio-geographical shifts in the northeast Atlantic from the subpolar gyre which used an ocean circulation model and data from four trophic levels including phytoplankton, zooplankton, blue whiting and pilot whales (Hatun, *et al.* 2009b). This study found that changes in the distribution of blue whiting are caused by variable stock size and by shifts in the migration pattern. The subpolar gyre influences this process either by:

1. Directly regulating the currents and or hydrographic conditions that will influence the migration routes

or

2. Indirectly via trophodynamics.

This work suggests that recent advances in simulating the dynamics of the subpolar gyre may provide a potential for predicting the distribution of the main faunal zones in the north-eastern Atlantic a few years into the future. This in turn would facilitate more rational management of commercially important fish species.

Recruitment

A workshop was held in 2009 that examined blue whiting recruitment. The group reviewed and updated existing work on both the oceanography in the region and the distribution dynamics of blue whiting, particularly focusing on the most recent observations. A broad selection of hypothesizes were examined that may explain the recruitment dynamics of this stock. The group focused on two potential mechanisms that may account for the hypothesized links between the oceanographic climate and the recruitment dynamics.

1. The predation hypothesis

This hypothesis examines the role of mackerel predation and changes in the spawning distribution of blue whiting. Changes in the spawning distribution lead to changes in the mackerel-blue whiting larvae overlap, and therefore the degree of predation.

2. The food hypothesis

This hypothesis is based on the amount and availability of food to the larvae and juveniles. Changes in the oceanographic conditions may change the food availability and ultimately impact larval/juvenile growth, survival and recruitment. More research if required to examine these topics (ICES, 2009c, RMC:09)

Finally, the workshop examined potential schemes that could be used for generating recruitment forecasts. A high-degree of autocorrelation is present in the time-series, and indeed the assumption that recruitment in the following year is the same as the recruitment in the previous year was found to give relatively good predictions (r2=0.57). However, in the absence of a detailed process understanding, it was not possible to move beyond such basic schemes towards making genuine, knowledge-based, forecasts though qualitatively forecasts (high or low) might be feasible. Further research is required.

B. Data

B.1. Commercial catch

SALLOCL

Commercial catch data is obtained from national laboratories of nations exploiting blue whiting. Data exchange spreadsheets are submitted to the stock coordinator. Prior to 2009 the data in the exchange spreadsheets were allocated samples to catch using the SALLOCL-application (Patterson, 1998). This programme produced the standard outputs on sampling status and biological parameters. It also clearly documented any decisions made by the stock co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set.

InterCatch

InterCatch which is a web-based system for handling fish stock assessment data was first used in 2009. Blue Whiting data are submitted using the 'Data Submission Work-book' spreadsheet and converted into the InterCatch format by the program "InterCatchFilemaker", developed by Andrew Campbell from Marine Institute, Galway, Ireland. The total International Catch-at-Age was available through the InterCatch web program. The allocations for those countries reporting catches without samples, were generally made using all available data for the same ICES Division and the same quarter. In cases where this was not possible, data from the nearest Divisions and the same quarter were used.

B.2. Biological Data

Sampling Protocol

In recent years all of the main countries participating in this fishery have provided sampling data to the working group. The European Commission Regulation 1639/2001 sets out the minimum and extended programmes for the collection of data in the fisheries sector and includes guidelines for blue whiting. This regulation requires EU Member States to take a minimum of one sample to be taken for every 1000 t landed in their country. Detailed information on the number of samples collected, number of fish aged and measured by year and by country is presented in the working group report (ICES, 2008a). This regulation applies to EU member states and there are currently no guidelines in place for other countries. Current precision levels of the sampling intensity are unknown and the group recommends reviewing the sampling frequency and intensity on a scientific basis and providing guidelines for sampling intensity.

Age Reading

The most recent age reading workshop took place in Hirtshals Denmark in June 2005. Guidelines for ageing blue whiting are outlined in this report and all of the workshop participants agreed to follow these guidelines. The workshop found that overall there was a high level of agreement between age readers. The two main reasons for disagreement between age readers were firstly the position of the first ring when the Bowers ring is clear and secondly true rings not counted by less experienced readers. Younger fish achieved better precision than older fish. This illustrates the problems associated with ageing older fish and is a common problem among many fish species (Worsøe Clausen, *et al* 2005).

An otolith exchange was carried out in 2009/2010 for a workshop in 2011. Age reading problems of 1 and 2 group blue whiting became evident during the 2011 May survey where small blue whiting was aged as 1, 2 or a combination of 1 an 2 years, pending on which country read the otoliths. This clearly demonstrates the need to calibrate the age-readings by each institute participating in the surveys.

Age composition in the catch

The catch numbers at age were mean standardised by year and are presented in Figure D3. Strong year classes can be seen in the past as they moved through the fishery. In recent years the numbers of fish at younger year classes are not as abundant and there are no signs of incoming strong recruitment.

Weight at age in the catch and Weight at age in the stock

Mean weight at age in the catch data are calculated on an annual basis from data supplied by Denmark, the Faroes, Iceland, Ireland, the Netherlands, Norway, Portugal, Russia, Scotland and Spain. Figure D4 shows the mean weight at age for the total catch from 1981–2009 which is used in the stock assessment in 2010.

Maturity

Maturity at age used in the assessment was obtained by combining maturity ogives from the southern and northern areas, weighted by catch in numbers at age (ICES, 1995). These values have been used since 1994. Although the values of maturity at age may be too low, sufficient information for estimating new ogives is not available.

Natural Mortality

It is known that blue whiting is a common prey amongst many different fish, cetacean and mammal predators. Defining how this impact varies over time is not a trivial issue for such a widely distributed stock that also exhibits notable changes in stock productivity over time. The current M of 0.2 was derived from investigations undertaken in the 1980s that examined the age distribution of the stock before the industrial fishery started. The possible need for revising the current estimate of instantaneous natural mortality rate *M* for blue whiting was discussed in detail by the 2002 WG (ICES, 2002). The value of M estimated from different methods was in the range of 0.38 to 0.60. Although it was acknowledged that the current estimate M =0.2 yr might be too low, there is not a strong basis for revision. At the WKPELA pelagic benchmark meeting, in 2012, various methods to attempt to estimate how M may vary over ages were explored. The relationship between natural mortality and body weight was applied to the blue whiting data to determine a variable M by age. The values ranged from around 1.1 at age 0 to 0.7 at age 10, which is considerably higher than the value used so far. Methodological work by WGMG (ICES, 2003a) emphasizes that natural mortality rate cannot be estimated reliably with information normally available for stock assessment models, so it is considered that further examination would be necessary in order to incorporate such values into the assessment. The effect a change in the assumed natural mortality in the assessment would have on assessment results would also need to be explored. At present it is considered that there is no new information to support a revision of the current estimate of M.

F and M before spawning

Both are set at 0, equivalent to spawning on the 1st January.

Discards

Discards of blue whiting are thought to be small. Most of the blue whiting caught in directed fisheries are used for reduction to fish meal and fish oil. However, some discarding occurs in the fisheries for human consumption and as bycatch in fisheries directed towards other species. Estimates of discarding are not included in the assessment. Reports on discarding from fisheries which catch blue whiting were available from the Netherlands for the years 2002–2007. A study carried out to examine discarding in the Dutch fleet found that blue whiting made a minor contribution to the total pelagic discards when compared with the main species mackerel, horse mackerel and herring (Figure D5). The length frequencies of landed and discarded fish caught were compared and from this data it is clear that herring and blue whiting are not selected and discarded for length reasons (Figure D6). It is more likely that in sorting and processing of mackerel small fish are commonly discarded (Borges, *et al* 2008).

Information on discards was available for Spanish fleets in 2006. Blue whiting is a bycatch in several bottom trawl mixed fisheries. The estimates of discards in these mixed fisheries in 2006 ranged between 23% and 99% (in weight) as most of the catch is discarded and only last day catch may be retained for marketing fresh. The catch rates of blue whiting in these fisheries are however low. In the directed fishery for blue whiting for human consumption with pair trawls, discards were estimated to be 13% (in weight) in 2006.

Since 2004, was available the blue whiting discards data produced by Portuguese vessels operating with bottom otter trawl within the Portuguese reaches of ICES Division IXa. The discards data are from two fisheries: the crustacean fishery and the demersal fish fishery. The blue whiting estimates of discards in the crustacean fishery for the period of 2004-2011 ranged between 23% and 40% (in metric tonnes). For the same period the frequency of occurrence in the demersal fish fishery was around zero for the most of the years, in the years were it was significant (2004, 2006, 2010) was ranged between 43% and 38% (in metric tonnes).

In general, discards are assumed to be minor in the blue whiting directed fishery. Discard data are provided by the Netherlands to the working group. Blue whiting is also by catch in several Spanish bottom trawl mixed fisheries. However, the catch rates of blue whiting in these fisheries are low (ICES, 2008a). French bottom trawl fisheries also catch blue whiting; discard estimates should become available in 2012.

B.3. Surveys

A number of surveys are (or have been) carried out which provide data on blue whiting abundance in different areas of their distribution. One survey is used to tune the assessment. The remaining surveys are not used in the assessment but data are updated on an annual basis and could be incorporated at a later stage should further work suggest their inclusion would lead to an improvement in the assessment.

Surveys Used in the assessment

1. International Blue Whiting spawning stock survey (IBWSS)

The IBWSS is carried out in March-April on the spawning grounds to the west of the British Isles and was established in its current form in 2004. Five countries participate annually in the survey; the Russian Federation, Norway, Faroes, the Netherlands and Ireland. The survey is internationally coordinated through the Working Group of International Pelagic Surveys (WGIPS).

The design of the IBWSS has traditionally been aimed at reducing the effects of double counting of the northward migrating spawning aggregation. Consideration is also given to the start and end times of the survey window to assure a synoptic coverage while taking into account vessel availability in the different countries and temporal occurrence of spawning aggregations. The spatial confines of the survey, although not fixed, are defined as core spawning areas and secondary target areas as suggested in 2005. The overall design uses stratified transects with a random start (random latitude) to ensure transect coverage is not replicated but randomised between years. The survey procedures are described in the "Manual for Acoustic Surveys on Norwegian Spring-spawning Herring in the Norwegian Sea and Acoustic Surveys on Blue whiting in the Eastern Atlantic" (ICES, 2008). The main problem affecting the outcome of the survey relates to adverse weather conditions encountered in the Northeast Atlantic at the time of the survey. This survey was first used as a tuning series in the assessment in 2007 with ages 3-8.

During the 2011 WGWIDE working group meeting it was decided to exclude the 2010 values from the IBWSSS time series on the basis of a recommendation from WGNAPES. During the 2010 survey, poor weather and a mismatch between vessels led to a gap in coverage in north Porcupine and south Hebrides (ICES

CM2010/SSGESST:20). It was agreed within WGNAPES in 2010 that the gap in area coverage occurred in an area of concentrated fishing effort and thus contained a high but un-quantified biomass. Mean acoustic density for the un-surveyed rectangles within the core spawning area was determined by means of interpolation from surrounding surveyed rectangles following established methods. It was also agreed that the gap in coverage had no doubt resulted in an underestimate of the stock. However, the revised estimate was recommended to be accepted by WGWIDE in 2010 as the best available. In WGNAPES 2011(ICES CM2011/SSGESST:16) the time series was reviewed and the problems in the 2010 IBWSS was considered. The updated survey time series, including the 2011 survey, show a decline in the observed stock but the rate of decline is not as abrupt if the 2010 estimate is excluded. Due to the large uncertainties in the estimate from 2010, WGNAPES recommended to exclude the 2010 data from the time series in the assessment.

The original TS-length relationship applied for blue whiting was considered too low and tended to overestimate the abundance of fish. This original relationship was based on measurements taken from a juvenile cod in the 1970s and was applied as the best estimate available at the time. Acoustic abundance estimates of blue whiting have so far tended to be considerably higher than those based on the assessment. The Workshop on implementing a new TS relationship for blue whiting abundance estimates (WKTSBLUES) met in 2012. The objectives of the workshop were to implement a new TS-Length relationship proposed by Pedersen *et al*. (2011). This latest research used in-situ acoustic measurements and was taken over several years, utilizing several different observation platforms. As the measurements were taken during the spawning stock survey they are not only species-specific but also time and area specific, something which was not achieved with the old TS-length relationship. Recalculating the survey index resulted in an expected downward shift to around 32% of the original TSB. When recalculating the survey index all previous settings were retained to ensure continuity and comparability across the index. During the review of survey data an error was observed in the presented 2009 blue whiting estimate relating to abundance at age data. This error was corrected in the data in 2012.

2. International ecosystem survey in the Nordic Seas (IESNS)

An international ecosystem survey is carried out annually in the Nordic Seas from late April to early June aimed at observing the pelagic ecosystem in this area. This survey focuses on Norwegian spring spawning herring, blue whiting, zooplankton and hydrography.

The survey area was split into three subareas which are as follows:

Area I - Barents Sea

Area II - northern and central Norwegian Sea

Area III - Southwestern area, i.e. Faroese and Icelandic zones and Southwestern part of the Norwegian Sea

The survey is coordinated by WGIPS. Ages 1-2 from this survey were used as recruitment indices, but WKPELA2012 decided not to use any recruitment series in the assessment.

3. Norwegian survey on the spawning grounds

The Norwegian survey on the spawning grounds for blue whiting, west of the British Isles, provides the longest time series covering a significant part of the blue whiting stock, and is an important time series for tuning the assessment. This survey was carried out from 1991-2006. The time series from 1991 – 2003, ages 3-8 is currently used to tune the assessment. This survey was replaced by the International spawning stock survey.

Surveys not used in the assessment but provide information

4. Norwegian bottom trawl survey in the Barents Sea

Norway has conducted bottom trawl surveys targeting cod and other demersal fish in the Barents Sea since late 1970s. From 1981 onwards there have been systematically designed surveys carried out during the winter months (usually late January-early March) by at least two Norwegian vessels; in some years the survey has been conducted in co-operation with Russia. Blue whiting is a regular bycatch species in these surveys, and has in some years been among the numerically dominant species (Heino *et al*, 2003). This survey is presently giving the first reliable indication of year class strength of blue whiting. The survey is not used in the assessment because of it coverage at the edge of the distribution area, but it is used for recruitment predictions. The indices of 1 group blue whiting are presented in Table D1.

5. Spanish bottom trawl survey

Bottom trawl surveys have been conducted off the Galician (NW Spain) coast since 1980, following a stratified random sampling design and covering depths down to 500 m. The survey is directed to a mixture of species. Since 1983, the area covered in the Spanish survey was extended to completely cover Spanish waters in Division VIIIc. A new stratification has been established since 1997. The survey is not used in the assessments as it is only representative for a small part of the stock area. The mean catch and standard error of these bottom trawl surveys are presented in Table D2 and Figures E7. The stratified mean catch is presented in Figure D8.

6. Portuguese bottom trawl survey

Bottom trawl surveys have been conducted off the Portuguese coast since 1979, following a stratified random sampling design and covering depths down to 500 m. The area covered in the Portuguese survey was extended in 1989 to the 750 m contour. The survey is not used in the assessments as it is only representative for a small part of the stock area. The mean catch and standard error of these surveys is presented in Table D3.

7. French bottom trawl survey

Bottom trawl surveys have been carried out since 1987 in the Bay of Biscay and 1997 in the Celtic Sea following a random stratified sampling design and covering depths down to 700 m; both areas are covered in October-November. Estimates of aged 0 blue whiting using a cut off of 18 cm and raised to the total survey areas are presented in Table D5.

8. Irish bottom trawl survey

The current bottom trawl survey has been carried out since 2003 in October-November around Ireland using a stratified design (the design changed in 2005). Estimates of age 0 using a 18 cm cut off point are shown in Table D6.

7. Other Surveys

Several other surveys have in the past provided data to the Working Group. In recent years however these data have not been updated. Historical results from the following surveys are presented in WGNPBW working group reports.

- Norwegian Sea summer survey carried out in 1981 – 2001, 2005 – 2007. The stock estimates in numbers at age are given in the 2007 report.
- Faroes plateau spring bottom trawl survey carried out in March 1996–2008. The survey is aimed at cod, haddock and saithe, but varying amounts of blue whiting are caught as bycatch each year.
- Faroes plateau autumn bottom trawl survey carried out in August- September 1994–2008. The survey is aimed at cod, haddock and saithe, but varying amounts of blue whiting are caught as bycatch each year.

B.4. Commercial CPUE

Spanish pair trawl CPUE

The Spanish pair trawls CPUE series was used for several years as a tuning fleet in the blue whiting assessment. Following a recommendation of the methods working group (ICES, 2003) the use of this CPUE data was discontinued because this fleet represents only a small part of the landings caught in a small part of the distribution area. This data series runs from 1983-2003 and has not been updated since then. The age stratified CPUE data are shown in Table 4 and Figure 9 and show a slight declining trend in CPUE.

Norwegian CPUE

CPUE data in the spawning area was collected from the Norwegian commercial fleet 1982–2003. The time series has not been updated in recent years. The data are not considered to be representative for the development of the stock and are not used in the assessment.

B.5. Other relevant data

None.

C. Assessment Method and Data

Model used:

The State-space Assessment Model (SAM), analytical assessment.

At the Benchmark (WKPELA, 2012) the state-space models SAM model was chosen as the assessment model for blue whiting. SAM offers a flexible way of describing the entire system, with relative few model parameters. Compared to the previously used SMS model, SAM models fishing mortality from random walk, whereas SMS assumes a separable model for fishing mortality and thereby a rather stable exploitation pattern. Model diagnostics from both models for are similar; however SAM gives a slightly better fit to catch data as it allows variations in exploitation pattern from year to year. The assessment output from the two models is almost identical, such that the perception of the stock remains unchanged using SAM.

Software used:

Source code for the SAM model and all scripts are freely available at http://130.226.135.24/bluewhiting [Username: guest; Password: guest]. This web-page does also provide the latest assessment, including input and output.

Model Options chosen:

The blue whiting assessment makes use of one survey index (International Spawning Ground survey, IBWSSS) is used, and the total catch-at-age data. Fishing mortality random walks are allowed to be correlated.

The table below present the SAM configuration options (file model.cfg). In the file text following a hash-mark ("#") is a comment

```
# Min, max age represented internally in model
 1 10
# Max age considered a plus group? (0 = No, 1= Yes)

# Coupling of fishing mortality STATES
# 1 2 3 4 5 6 7 8 9 10 # Age
  1 2 3 4 5 6 7 8 9 9 # catch
  0 0 0 0 0 0 0 0 0 0 # IBWSSS

# Use correlated random walks for the fishing mortalities
# ( 0 = independent, 1 = correlation estimated)

# Coupling of catchability PARAMETERS
# 1 2 3 4 5  6  7  8 9 10 # Age
  0 0 0 0 0  0  0  0 0  0 # catch
  0 0 1 2 3  3  3  3 0  0 # IBWSSS
```

Coupling of power law model EXPONENTS

1 2 3 4 5 6 7 8 9 10

0 0 0 0 0 0 0 0 0 0 # catch

0 0 0 0 0 0 0 0 0 0 # IBWSSS

Coupling of fishing mortality RW VARIANCES

1 2 3 4 5 6 7 8 9 10

1 1 1 1 1 1 1 1 1 1 # catch

0 0 0 0 0 0 0 0 0 0 # IBWSSS

Coupling of log N RW VARIANCES

1 2 3 4 5 6 7 8 9 10

1 2 2 2 2 2 2 2 2 2

Coupling of OBSERVATION VARIANCES

1 2 3 4 5 6 7 8 9 10

1 2 3 3 3 3 3 3 4 4 # catch

0 0 5 6 6 6 7 7 0 0 # IBWSSS

Stock recruitment model code (0=RW, 1=Ricker, 2=BH)

0

Years in which catch data are to be scaled by an estimated parameter (mainly cod related)

0

Fbar range

3 7

so called checksum

123 123

The options for “Coupling of fishing mortality STATES” show that random walk for F is independent by age for the ages 1-8, and combined for age 9 and 10.

It is assumed that F at age is correlated to some degree estimated by the models. Therefore the option for “Use correlated random walks for the fishing mortalities” is set to 1.

The “Coupling of catchability PARAMETERS” specifies the grouping of ages with respect to survey catchability. For the IBWSSS survey there is assumed an age dependent catchability for age 3 and 4, and a combined (the same) catchability ages 5-8.

In the IBWSSS a linear relation between CPUE and stock size is assumed, such that the options for “Coupling of power law model EXPONENTS” are all set to 0.

The variance for the random walk for F (“Coupling of fishing mortality RW VARIANCES “) is assumed the same for all ages.

The “Coupling of OBSERVATION VARIANCES” specifies the options for observation noise for both catches and survey indices. For catches the observation variance is age dependent for age 1 and 2. For ages 4-8 the variance is assumed the same, and different from the variance for ages 9-10. For the IBWSSS survey the variance is the the same within the groups of age 3, 4-6, and 7-8.

There is no obvious relation between SSB and recruitment, but recruitment seems to be correlated between years. To reflect this, the “Stock recruitment model code” is set to 0=Random Walk.

SAM is a new model which has not been applied to blue whiting before. Small changes in model structure may be applied following the first WGWIDE assessment of the stock using this model. In particular, to be able to effectively handled large changes in F in the terminal year (as may happen with the low 2011 TAC) an alternative variance distribution may be required for the random walk on F (e.g. t-distribution).

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1981 –	1-10	Yes
Canum	Catch at age in numbers	1981 –	1-10	Yes
Weca	Weight at age in the commercial catch	1981 –	1-10	Yes
West	Weight at age of the spawning stock at spawning time.	1981 –	1-10	Yes
Mprop	Proportion of natural mortality before spawning	1981 –	NA	No
Fprop	Proportion of fishing mortality before spawning	1981 –	NA	No
Matprop	Proportion mature at age	1981 –	1-10	No
Natmor	Natural mortality	1981 –	NA	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	International Spawning Stock Survey	2004 – assessment year + 1	3-8

Models used for exploratory assessments

Previous WGWIDE working groups have conducted alternative assessments (e.g. TISVPA and XSA) in addition to the accepted assessment as a check on model assumptions and how the different model platforms handle the data. At future meetings exploratory analyses, potentially also including recruitment indices, will be encouraged. Advice will be based on the outputs of the SAM model.

D. Short-Term Projection

Model used:

Due to the uncertainty in the final year estimates of fishing mortality and stock numbers, the standard (deterministic) short-term forecast is considered inappropriate for this stock. Therefore, stochastic projections are performed, from which short-term projections are extracted. The stochastic projections are carried out by starting at the final year's estimates, using the variance-covariance matrix of those estimates. To run the short term forecast 1000 samples are generated from the estimated distribution of the final years estimates. Those 1000 replicates are then simulated forward according to the model and subject to different scenarios.

Software used:

Source code for the SAM model and all scripts including forecast script are freely available at http://130.226.135.24/bluewhiting [Username: guest; Password: guest].

Initial stock size: Final year's estimates, using the variance-covariance matrix of those estimates to generate replicates within the confidence bounds.

Maturity: The proportion mature for this stock is assumed constant over the years. The maturity ogive used in the short term forecast is the same as the ogive used in the assessment.

F and M before spawning: These values are both 0, spawning is assumed to take place the 1st January.

Weight at age in the stock and weight at age in the catch: Weight at age in the catch and weight at age in the stock are the same and for the short term forecast are calculated as three year averages.

Exploitation pattern: This is based on F in the year where the final three years of data calculated from the most recent assessment.

Natural Mortality: Natural mortality is assumed to be 0.2 across all ages. Maturity:

Intermediate year assumptions: TAC is landed fully.

Stock recruitment model used: None. Due to potential additional information affecting recruitment (qualitative use of recruitment indices, environmental impacts), the terminal stock estimate for age 1 and age 2 could optionally be raised by an input factor (the precise method by which this could be implemented has not been decided on.

E. Medium-Term Projection

Medium term projections were carried out as part of the management plan evaluation simulations at a meeting in May 2008 (Anon, 2008). These simulations were updated at WGWIDE in September 2008. HCS (Skagen, 2008) with some minor modifications were made to cover the needs of the blue whiting simulations. As a control, some simulations were repeated with the SMS software which is also used to assess the stock of blue whiting and was used for evaluation of the management plan presently in use (ICES, 2008a).

A new management plan evaluation will be conducted in 2012, scheduled for completion prior to WGWIDE 2012.

F. Long-Term Projections

Long term projections are not carried out for this stock.

G. Biological Reference Points

	Type	Value	Technical basis
Management	SSBMP	2.25 million t	Bpa
plan	FMP	0.18	Management strategy evaluation conducted in 2008 (Anon, 2008; ICES, 2008)
MSY	MSY Btrigger	2.25 million t	Bpa
Approach	FMSY	0.18	Management strategy evaluation conducted in 2008 (Anon, 2008; ICES, 2008)
	Blim	1.50 million t	Bloss
Precautionary	Bpa	2.25 million t	Blim exp(1.645*σ), with σ = 0.25.
Approach	Flim	Not defined	
	Fpa	Not defined	

The Workshop on Limit and Target Reference Points (WKREF) considered the biological reference points for Blue Whiting at a meeting in Gdynia, Poland in January in 2007 (ICES, 2007b). The original reference points for this stock were set in 1998, before the era of high productivity became apparent. The group examined the consequences of these new observations on the reference points by first splitting the time-series into two productivity regimes (low productivity from 1981–1994, and high productivity from 1995–2005). Standard methods (i.e. using the guidelines from the Study Group on Precautionary Reference points, SGPRP (ICES, 2003b) were then used to re-estimate the reference points, which were found to be comparable to the current values. A new probabilistic approach for estimating B_{lim} was also employed, but again, the result was found to be comparable with the current values. The group concluded that there was no basis for revising the current reference points. WKREF also noted that there may be no need for different B_{lim} values in different productivity regimes.

A stochastic equilibrium analysis made during the Working Group established by the Blue Whiting Coastal States on Blue Whiting management strategies (Anon, 2008) indicates a high risk of stock collapse with an F from approximately 0.3 and upwards given the "low recruitment" regime as observed in 1981–1996. F_{max} is poorly defined and a very limited increase in yield is obtained for F in the range 0.18 to 0.30. $F_{0.1}$ was estimated at 0.18. Sensitivity analysis of a change in exploitation pattern showed that these conclusions are robust with respect to the choice of exploitation pattern. A yield per recruit analysis was conducted using MFYPR which also calculated $F_{0.1}$ as 0.18.

At the WKPELA 2012 meeting the precautionary approach fishing mortality reference points for this stock were removed. A major problem was that fishing at F_{pa} implied a high probability of bringing the stock below B_{pa}, in other words the present combination of F_{pa} and B_{pa} is inconsistent, likewise for F_{lim} and B_{lim}.

Reference points for this stock may be revised in 2012 following the results of the long/medium term simulations of the blue whiting stock from the management strategy evaluation.

H. Other Issues

Changes in Blue Whiting Mean Weights over time

Possible causal relations for the visible reductions in mean weight at age were investigated by WGWIDE in 2008. Several aspects relating to the biology of fish stocks such as recruitment, growth or natural mortality, are influenced by ecosystem conditions. Some of these conditions were suggested as possible reasons for the change in mean weight at age. These include the following:

Density dependant competition– too many fish competing for the same food resource.

Changes in plankton abundance would impact on the amount of food available for blue whiting.

External environmental factors, such as temperature and salinity. Spawning is effected by both of these environmental variables.

An in depth analysis of the causes of these changes in mean weights, which would be needed for any kind of forecast is outside the scope of this working group (ICES, 2008a)

Possible effects of protecting juvenile Blue Whiting

The modern blue whiting fishery developed during the second half of the 1970s when the landings increased from around 100 000 tonnes to above 1 million tonnes. The majority of the catches have since been taken on the spawning grounds west of the British Isles. A small but fairly constant fraction of the catches are taken in the southern areas and in the North Sea (Norwegian trench) and a variable fraction in the Norwegian Sea (Figure D10). The proportion of landings taken in the Norwegian Sea increased after the strong year classes from 1995 onwards led to increased densities of (young) blue whiting in this area, but is now decreasing and was in 2007 around the pre-2000 level.

Landings from the Norwegian Sea and the North Sea are generally comprised of a higher proportion of juvenile fish compared to landings from the spawning area, though this proportion varies between years. A measure to reduce the exploitation of juveniles could therefore, in theory, be to close the fishery in these areas (or a temporal closure of the fishery outside the spawning season). However, it is impossible to estimate the resulting reduction in juvenile fishing mortality of such measures since juveniles are also exploited in the spawning ground fishery.

The effects on the yield per recruit curve of applying three different exploitation patterns on ages 1–2 were explored using the standard ICES software MFYPR; (1) zero exploitation, (2) "high" exploitation and (3) the constant F selection pattern used in SMS from 1999 onwards. The "high" exploitation pattern which gave the highest relative fishing mortality on ages 1–2 during the last 15 years was derived from the XSA assessment. The SMS exploitation pattern was used on ages older than 2 years. Figure D11 shows the three F selection patterns used and the resulting yield per recruit curves. The difference between the curves is marginal with similar values for $F_{0.1}$ derived. The conclusion is that the effect on yield of protecting juveniles is likely to be very small. A separate clause for the protection of juveniles in the management plan is not needed (ICES, 2008a).

H.1 Management and ICES advice

Management plans

A management plan was agreed for this stock between the four coastal states (Norway, Faroe Islands, Iceland, and EU) in December 2005. The text for the agreed plan is given below. This management agreement aims to maintain the SSB of the blue whiting stock at levels above 1.5 million tonnes (Blim) and the fishing mortality rates at levels of no more than 0.32 (Fpa). To achieve this, the TAC is reduced by at least 100 000 t a year until the fishing mortality is reduced to 0.32 (Fpa). The plan states that if the spawning stock falls below 2.25 million t unspecified actions to obtain a safe and rapid recovery to this level should be taken. ICES has evaluated this management plan in 2006 and found it not to be in accordance with the precautionary approach in a period of low recruitment.

<u>Text for the 2005 management plan for Blue Whiting</u>

1) *The Parties agree to implement a multi-annual management arrangement for the fisheries on the blue whiting stock which is consistent with the precautionary approach, aiming at constraining harvest within safe biological limits, protecting juveniles, and designed to provide for sustainable fisheries and a greater potential yield, in accordance with advice from ICES.*

2) *The management targets are to maintain the Spawning Stock Biomass (SSB) of the blue whiting stock at levels above 1.5 million tonnes (Blim) and the fishing mortality rates at levels of no more than 0.32 (Fpa) for appropriate age groups as defined by ICES.*

3) *For 2006, the Parties agree to limit their fisheries of blue whiting to a total allowable catch of no more than 2 million tonnes.*

4) *The Parties recognise that a total outtake by the Parties of 2 million tonnes in 2006 will result in a fishing mortality rate above the target level as defined in Paragraph 2. Until the fishing mortality has reached a level of no more than 0.32, the Parties agree to reduce their total allowable catch of blue whiting by at least 100 000 tonnes annually.*

5) *When the target fishing mortality rate has been reached, the Parties shall limit their allowable catches to levels consistent with a fishing mortality rate of no more than 0.32 for appropriate age groups as defined by ICES.*

6) *Should the SSB fall below a reference point of 2.25 million tonnes (Bpa), either the fishing mortality rate referred to in Paragraph 5 or the tonnage referred to in Paragraph 4 shall be adapted in the light of scientific estimates of the conditions then prevailing. Such adaptation shall ensure a safe and rapid recovery of the SSB to a level in excess of 2.25 million tonnes.*

7) *This multi-annual management arrangement shall be reviewed by the Parties on the basis of ICES advice*

The stock is currently in a period of low recruitment. In July 2008 a new draft management plan was proposed by the Coastal States. ICES has evaluated the draft management plan and considers it precautionary if fishing mortality in the first year is immediately reduced to the fishing mortality that is implied by the HCR. The text of this plan is also presented below.

<u>Text for the 2008 management plan for Blue Whiting</u>

1) The Parties agree to implement a long term management plan for the fisheries on the Blue Whiting stock, which is consistent with the precautionary approach, aiming at ensuring harvest within safe biological limits and designed to provide for fisheries consistent with maximum sustainable yield, in accordance with advice from ICES.
2) For the purpose of this long term management plan, in the following text, "TAC" means the sum of the coastal State TAC and the NEAFC allowable catches.
3) As a priority, the long term plan shall ensure with high probability that the size of the stock is maintained above 1.5 million tonnes (Blim).
4) The Parties shall aim to exploit the stock with a fishing mortality of 0.18 on relevant age groups as defined by ICES.
5) While fishing mortality exceeds that specified in paragraph 4 and 6, the Parties agree to establish the TAC consistent with reductions in fishing mortality of 35% each year until the fishing mortality established in paragraph 4 and 6 has been reached. This paragraph shall apply only during 2009 and 2010.
6) For the purposes of this calculation, the fishing percentage mortality reduction should be calculated with respect to the year before the year in which the TAC is to be established. For this year, it shall be assumed that the relevant TAC constrains catches.
7) When the fishing mortality in paragraph 4 has been reached, the Parties agree to establish the TAC in each year in accordance with the following rules:

In the case that the spawning biomass is forecast to reach or exceed 2.25 million tonnes (SSB trigger level) on 1 January of the year for which the TAC is to be set, the TAC shall be fixed at the level consistent with the specified fishing mortality.

In the case that the spawning biomass is forecast to be less than 2.25 million tonnes on 1 January of the year for which the TAC is to be set (B), the TAC shall be fixed that is consistent with a fishing mortality given by:

$F = 0.05 + [(B - 1.5)(0.18 - 0.05) / (2.25 - 1.5)]$

In the case that spawning biomass is forecast to be less than 1.5 million tonnes on 1 January of the year for which the TAC is to be set, the TAC will be fixed that is consistent with a fishing mortality given by $F = 0.05$.

8) When the fishing mortality rate on the stock is consistent with that established in paragraph 4 and the spawning stock size on 1 January of the year for which the TAC is to be set is forecast to exceed 2.25 million tonnes, the Parties agree to discuss the appropriateness of adopting constraints on TAC changes within the plan.
9) The Parties, on the basis of ICES advice, shall review this long term management plan at intervals not exceeding five years and when the condition specified in paragraph 4 is reached

In 2012 options for a new management plan will be explored.

ICES advice

In 2003, ICES stated that both estimates of SSB and fishing mortality were high but uncertain. Nevertheless, the spawning stock biomass in 2003 was likely to be above Bpa. Therefore, based on the most recent estimates of fishing mortality and SSB, ICES classified the stock as likely to be harvested outside safe biological limits (F>Flim). The incoming year classes seemed to be strong. ICES recommended that catches should be less than 925 000 tonnes in 2004 in order to achieve a 50% probability that the fishing mortality in 2004 is less than Fpa (=0.32). This would also assure a high probability that the spawning stock biomass in 2005 to be above Bpa (ICES, 2005).

In 2004 ICES concluded from the most recent estimates of fishing mortality and SSB, that the stock had full reproductive capacity, but was harvested unsustainably. Although the estimates of SSB and fishing mortality were not considered precise, it was certain that SSB was above Bpa and the estimated fishing mortality well above Flim. Recruitments in the last decade appeared to be at a much higher level than earlier. The unimplemented management plan implied catches of less than 1.075 million t in 2005 which was expected to keep fishing mortality less than 0.32 with 50% probability. This would also have assured a high probability that the spawning stock biomass in 2006 would be above Bpa. ICES recommended that measures be taken to protect juveniles (ICES, 2005).

In 2005 ICES advised that fishing within the limits of the management plan (F=0.32) implied catches of less than 1.5 million t in 2006. This would result in a high probability that the spawning stock biomass in 2007 would be above B_{pa}. The present fishing level was well above levels defined by the management plan and should be reduced. The primarily approach to reduce catch of juveniles is to reduce overall fishing mortality. Catches of juveniles in the last 4 years were much greater than in earlier periods. If an overall reduction of fishing mortality cannot be achieved then specific measures should be taken to protect juveniles (ICES, 2006a).

In 2006 ICES stated that the maximum catch in 2007 corresponding to a new agreed management plan is 1.9 million tonnes, which is expected to leave the spawning stock biomass at 2.86 million t, i.e. above B_{pa} in 2008, but would lead to an F above F_{lim} in 2007. Fishing mortality is estimated at 0.48 and was above the fishing mortalities expected to lead to high long-term yields and low risk of depletion of production potential. Fishing at Fpa implies catches of less than 980 thousand t in 2007. This was expected to result in a spawning stock biomass in 2008 well above B_{pa}. The newly agreed management plan was evaluated by ICES and was not considered in accordance with the precautionary approach. ICES concluded that the exploitation boundaries for this stock should be based on the precautionary limits (ICES, 2007a).

In 2007 ICES classified the stock as having full reproductive capacity, but being harvested at increased risk. SSB increased to a historical high in 2003, but has decreased since then. The estimated fishing mortality was well above F_{pa}. Recruitment in the last decade appears to be at a much higher level than prior to 1996. The 2005 and 2006 year classes were estimated at the pre 1996 level. ICES has evaluated the present management plan in 2006 and found it not to be in accordance with the precautionary approach. ICES concluded that the exploitation boundaries for this stock should be based on the precautionary limits. The advice for 2008 is a maximum TAC at 835 000 t based on an F at F_{pa} (ICES, 2008a).

The 2008 advice for Blue whiting states that based on the most recent estimates of fishing mortality and SSB, ICES classifies the stock as having full reproductive capacity, but being harvested at increased risk. SSB increased to a historical high in 2003, but has decreased since then and is expected to be just above Bpa in 2009. The estimated fishing mortality is well above Fpa. Recruitment of the 2005 and 2006 year classes are estimated to be in the very low end of the historical time-series. Surveys indicate that the 2007 year class could also be low.

In 2009 ICES advised that based on the most recent estimates of SSB (in 2009) and, fishing mortality (in 2008), ICES classifies the stock as having full reproductive capacity and being harvested sustainably (F=0.29). Year classes 2005-2008 are among the lowest observed. Due to recent low recruitment, SSB has declined from its historical peak in 2003-2004 of more than 7 million tonnes to 3.6 million tonnes at the beginning of 2009, and the decline is expected to continue in the short-term.

In 2010, following a sharp downward revision in the perceived abundance of the stock in the assessment, the TAC for blue whiting in 2011 was significantly lower than in 2010. This downward revision in the assessment estimates of abundance was driven predominantly by the low values of the 2010 IBWSSS acoustic survey. In 2011 these values were removed from the assessment of the stock (see Section B.3) resulting in an upward revision of abundance estimates. This lead in turn to a sharp increase in the TAC for 2012 compared with the low 2011 TAC.

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Table D1: 1-group indices of blue whiting from the Norwegian winter survey (late January-early March) in the Barents Sea. (Blue whiting <19cm in total body length which most likely belong to 1-group.)

	Catch Rate	
Year	All	<19cm
1981	0.13	0
1982	0.17	0.01
1983	4.46	0.46
1984	6.97	2.47
1985	32.51	0.77
1986	17.51	0.89
1987	8.32	0.02
1988	6.38	0.97
1989	1.65	0.18
1990	17.81	16.37
1991	48.87	2.11
1992	30.05	0.06
1993	5.8	0.01
1994	3.02	0
1995	1.65	0.10
1996	9.88	5.81
1997	187.24	175.26
1998	7.14	0.21
1999	5.98	0.71
2000	129.23	120.90
2001	329.04	233.76
2002	102.63	9.69
2003	75.25	15.15
2004	124.01	36.74
2005	206.18	90.23
2006	269.2	3.52
2007	80.38	0.16
2008	16.72	0.01
2009	3.74	0
2010	3.19	0.10

Table D2: Stratified mean catch (Kg/haul and Number/haul) and standard error of Blue Whiting in bottom trawl surveys in Spanish waters (Divisions VIIIc and IXa north). All surveys in September-October.

Kg/haul	30-100 m		101-200 m		201-500 m		TOTAL 30-500 m	
Year	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1985	9.50	5.87	119.75	45.99	68.18	13.79	92.83	28.24
1986	9.74	7.13	45.41	12.37	29.54	8.70	36.93	7.95
1987	-	-	-	-	-	-	-	-
1988	2.90	2.59	154.12	38.69	183.07	141.94	143.30	45.84
1989	14.17	12.03	76.92	17.08	18.79	6.23	59.00	11.68
1990	6.25	3.29	52.54	9.00	18.80	4.99	43.60	6.60
1991	64.59	34.65	126.41	26.06	46.07	18.99	97.10	17.16
1992	6.37	2.59	44.12	6.64	29.50	6.16	34.60	4.23
1993	1.06	0.63	14.07	3.73	51.08	22.02	22.59	6.44
1994	8.04	5.28	37.18	8.45	25.42	5.27	29.70	5.19
1995	19.97	13.87	36.43	4.82	15.97	4.10	28.52	3.66
1996	7.27	3.95	49.23	7.19	92.54	17.76	54.52	6.36
Kg/haul	70-120 m		121-200 m		201-500 m		TOTAL 70-500 m	
Year	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1997	17.87	7.35	44.68	10.52	57.14	16.60	42.62	7.29
1998	14.13	4.17	42.78	8.13	78.88	22.01	47.14	7.58
1999	93.01	14.60	112.39	19.92	169.21	50.26	124.66	17.85
2000	62.39	12.00	91.99	14.75	58.72	24.94	76.19	10.61
2001	8.35	3.31	50.18	10.09	52.41	16.71	42.02	7.02
2002	31.40	5.02	69.00	13.41	36.75	12.07	51.80	7.64
2003	42.52	12.22	71.40	11.01	46.43	11.42	58.13	6.92
2004	2.80	2.11	14.05	7.79	59.51	21.41	24.76	7.31
2005	50.63	16.15	95.17	19.28	40.06	8.88	69.94	10.57
2006	14.28	7.01	70.79	12.60	115.08	39.88	71.64	13.18
2007	4.76	3.75	39.10	23.21	21.69	4.41	26.86	11.74

Table D3 Stratified mean catch (Kg/haul) and standard error of bottom trawl surveys in Portuguese waters (Division IXa).

		20-100 m		100-200 m		200-500 m		500-750 m		TOTAL	
Year	Month	y	sy	y	sy	y	sy	y	sy	y	sy
1990	July	**2**	2	**153**	103	**242**	42	**50**	5	**96**	35
	October	**11**	5	**90**	28	**762**	234	**42**	10	**153**	35
1991	July	**1**	1	**140**	40	**268**	38	**64**	18	**98**	15
	October	**8**	5	**83**	18	**259**	53	**121**	27	**91**	11
1992	February	**7**	7	**43**	35	**249**	21	**73**	3	**68**	12
	July	**1**	1	**29**	18	**216**	43	**27**	5	**47**	9
	October	**1**	1	**22**	7	**208**	44	**80**	3	**54**	7
1993	February	**0**	0	**19**	14	**105**	31	**36**	0	**42**	10
	July	**0**	0	**3**	3	**151**	28	**55**	5	**34**	4
	November	**0**	0	**90**	0	**189**	43	**6**	1	**86**	9
1994	October	**0**	0	**374**	30	**283**	32	**49**	7	**174**	11
1995	July	**0**	0	**18**	14	**130**	20	**52**	3	**35**	5
	October	**18**	15	**103**	21	**328**	91	**31**	12	**94**	16
1996	October	**25**	24	**12**	2	**36**	6	**25**	7	**22**	8
1997	June	**0**	0	**3**	3	**116**	42	**45**	12	**27**	7
	October	**2**	1	**54**	20	**77**	13	**7**	2	**32**	8
1998	July	**0**	0	**8**	5	**105**	17	**38**	3	**25**	3
	October	**1**	1	**384**	87	**427**	101	**20**	2	**212**	36
1999	July	**1**	0	**60**	21	**66**	19	**25**	2	**37**	9
	October	**0**	0	**69**	16	**80**	20	**18**	8	**41**	7
2000	July	**23**	13	**109**	34	**116**	10	**63**	6	**75**	13
	October	**11**	4	**155**	53	**196**	22	**54**	4	**99**	19
2001	July	**18**	7	**238**	37	**305**	116	**57**	14	**152**	23
	October	**106**	6	**474**	224	**294**	66		0	**295**	97
2002	October	**19**	12	**176**	81	**180**	24		0	**116**	34
2003	October	**24**	10	**114**	14	**119**	30	**34**	6	**76**	8
2004	October	**0**	0	**44**	10	**380**	27			**84**	15
2005	October	**0**	0	**25**	7	**407**	239			**81**	42
2006	October	**1**	1	**154**	59	**196**	32			**95**	26
2007	October	**1**	1	**136**	66	**141**	25			**91**	32

Table D4: Age stratified CPUE from the Spanish surveys

Numbers	age							
	1	2	3	4	5	6	7	total
1982								
1983		7196	16392	9311	7476	6326	1718	48419
1984		13710	27286	14845	4836	1755	1750	64182
1985		14573	23823	14126	6256	1232	217	60227
1986		3721	14131	14745	7113	1278	505	41493
1987		25328	13153	6664	2938	1029	166	49278
1988		7778	21473	18436	6391	1300	781	56159
1989		15272	18486	17160	8374	3760	1003	64055
1990		21444	19407	5194	1803	1357	451	49656
1991		15924	15370	4989	2329	1045	440	40097
1992		10007	24235	9671	4316	1194	462	49885
1993		4036	13991	22493	7979	1354	658	50511
1994		543	6066	15917	7474	2990	1055	34045
1995		9090	14409	6833	4551	1990	623	37496
1996		3905	14557	14449	3931	3639	1834	42315
1997		8742	15875	11134	3698	1046	450	40945
1998		5884	13236	9803	10844	5229	1153	46149
1999		2048	10268	20242	9833	6287	3047	51725
2000		6207	15518	13987	5375	1264	1414	43765
2001		16223	16488	6830	1620	1148	162	42471
2002		10520	13725	10265	3385	336	69	38300
2003		9069	10461	6517	3983	1932	737	32699

Table D5. Stratified total numbers of blue whiting in French bottom trawl survey. NA no survey.

Year	Bay of Biscay	Celtic Sea	Variance (Biscay)	Variance (Celtic Sea)
1987	1313935981.7	NA	36528215960600000	NA
1988	1232403510.386	NA	104181056815335824	NA
1989	386898631.53	NA	10803455685233600	NA
1990	939550666.3	NA	28702880627300000	NA
1991	252039532.47	NA	3035806271405160	NA
1992	588546250.7	NA	9508732598060000	NA
1994	5518146422	NA	4.069619255e+17	NA
1995	2198718815.9	NA	87909759110826000	NA
1997	2085015191.84	7563919067.5	223112995134135808	326964129692377024
1998	2429940410	847781802.11	2.69773734417e+17	10432317514100000
1999	5332275585.6	4400073060	583976280075900032	8.491756792e+17
2000	3961897973	2945777150	2.8070907774e+17	1.0197334661e+17
2001	1315527385.4	1057830493.98	26628615465300000	30077478942323000
2002	3047994204.6	3656904157.62	208792419841729984	171254737153962912
2003	1308226336.15	1420863842.72	45621762165804800	13006693795190300
2004	1745829772.682	1120840204.85	187350873468851904	285938881215680000
2005	751195629.6	708676111.01	21756850596703000	15983137256765540
2006	7653085198.4	2768183161.2	1027720375481849984	465222574238270016
2007	2921175740.7	1235860328	62665823860790000	71468526200790000
2008	30957020.3	774364861.67	158326076200000	221764902757548992
2009	8332657852.96	9042511712.72	857103189073946496	2457647244348636160

2010	3323790245.4	2078662996.81	160121742822700000	134645834507700000

Table D6. Stratified mean numbers per haul of blue whiting in Irish bottom trawl survey (18 cm cutoff to determine age 0).

Year	Mean number per haul	SE_
2005	1653	659
2006	3143.8	1463.3
2007	941.5	225.4
2008	1225.7	269.5
2009	5698.2	976.6
2010	1415	394.7

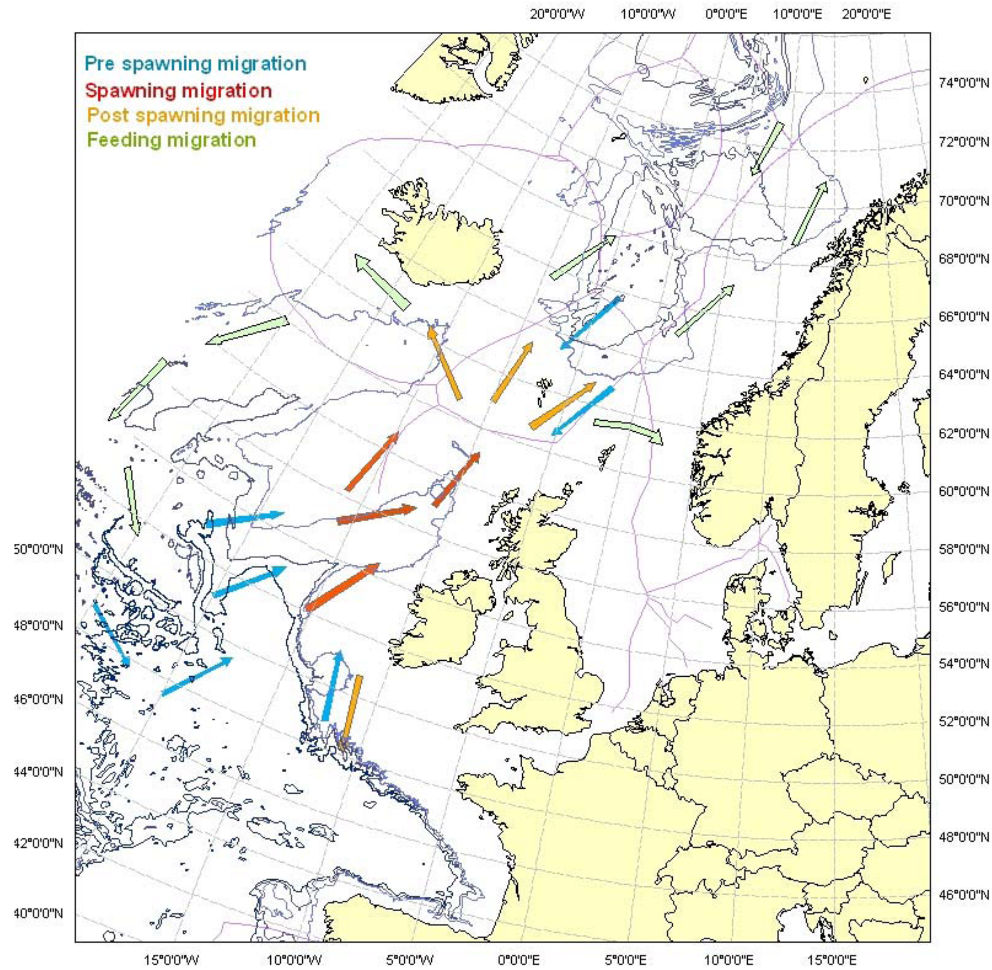

Figure D1. Migration routes for the blue whiting in the Northern Atlantic. Tangen and Sveinbjörnsson (Source: Worsoe Clausen, *et al* 2005)

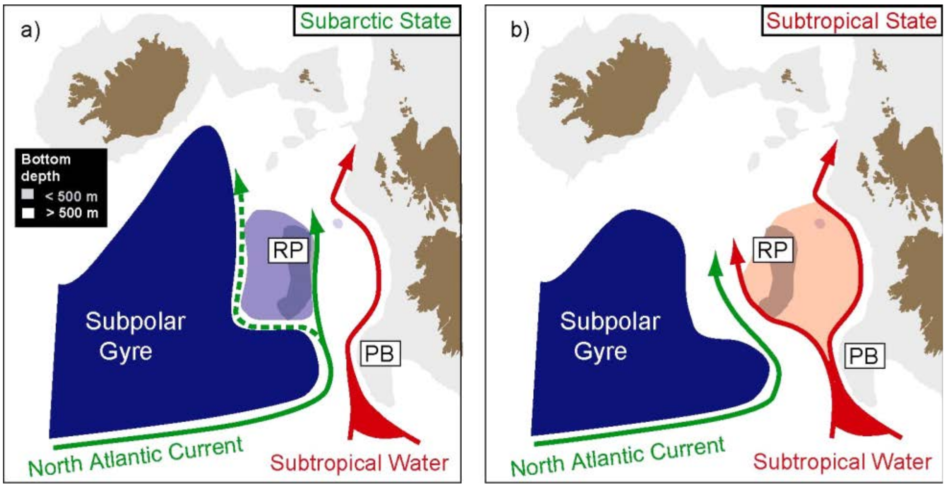

Figure D2: Outline of the source flows to the blue whiting spawning grounds in the Rockall Region. (a) A strong subpolar gyre (SPG) results in strong influence of cold subarctic water near the Rockall Plateau. (b) A weak gyre results in warm subtropical dominance near the plateau (based on Hátún *et al.* 2005). Abbreviations - RP: Rockall Plateau and PB: Porcupine Bank (Source: Hatun *et al.* 2009a).

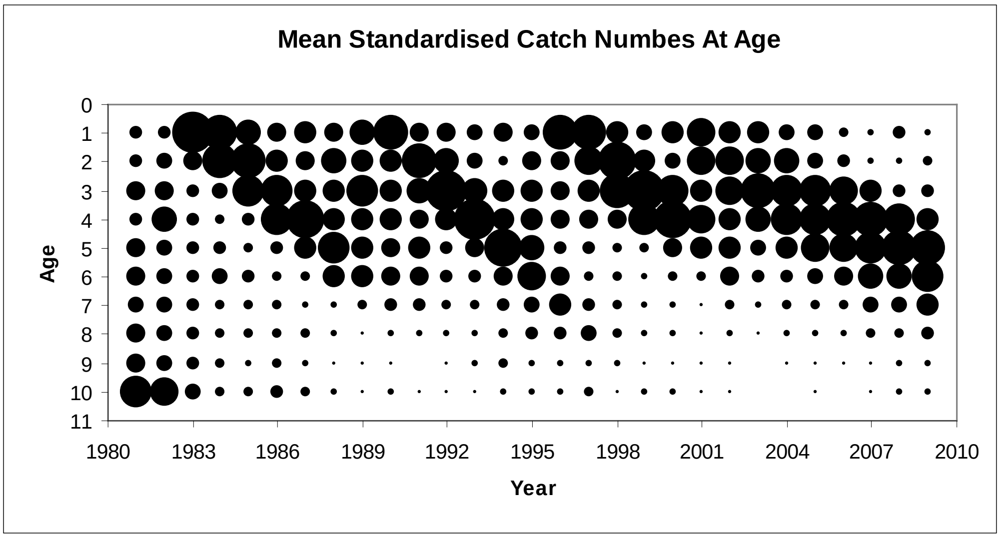

Figure D3: Catch numbers at age mean standardised by year 1981 - 2009

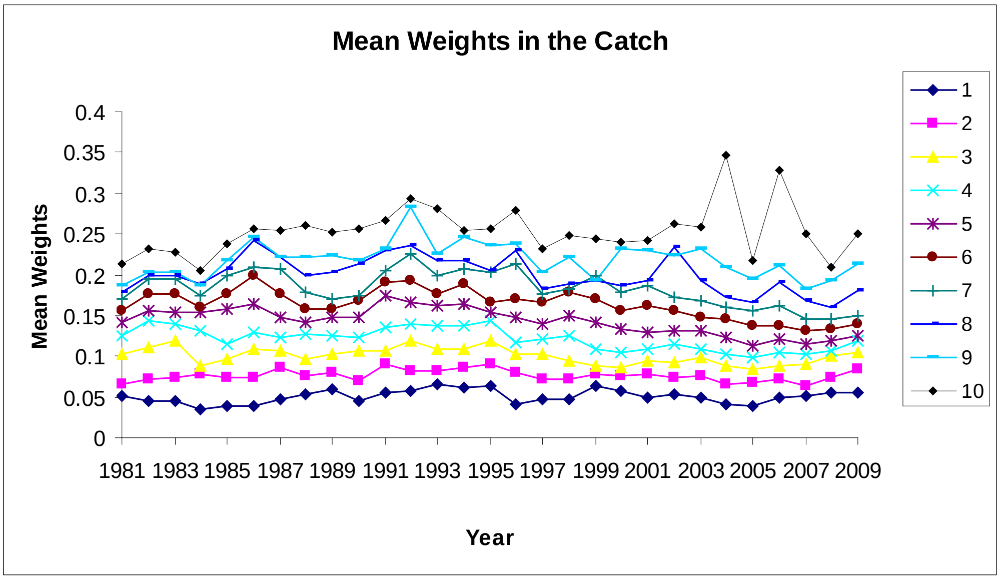

Figure D4: Mean weight in the catch 1981-2009

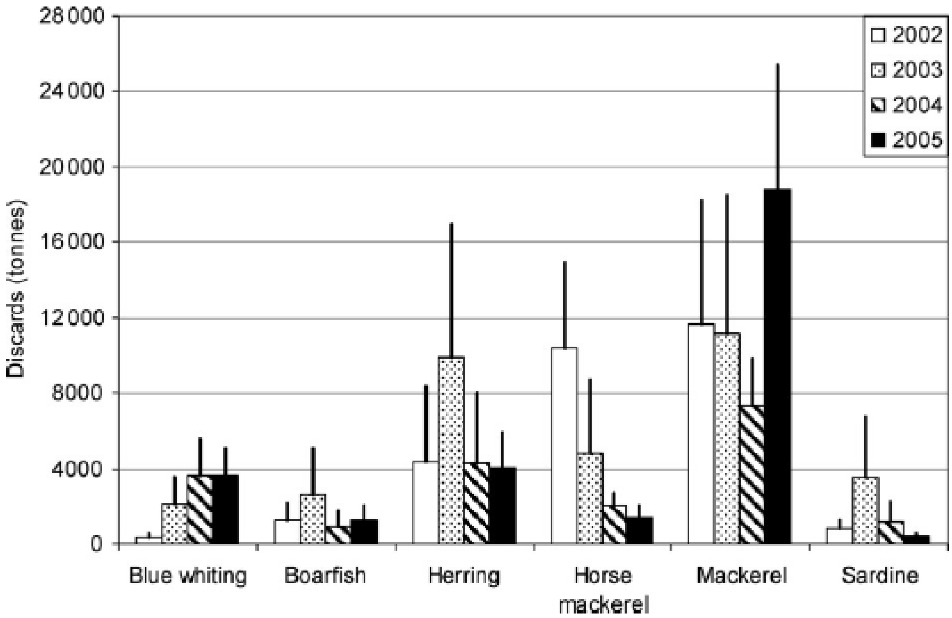

Figure D5: Biomass discarded by the Dutch freezer trawler fleet annually (raised using total number of trips) for the six most discarded species. The vertical lines represent the standard error on the estimates. (From Borges *et al* 2008)

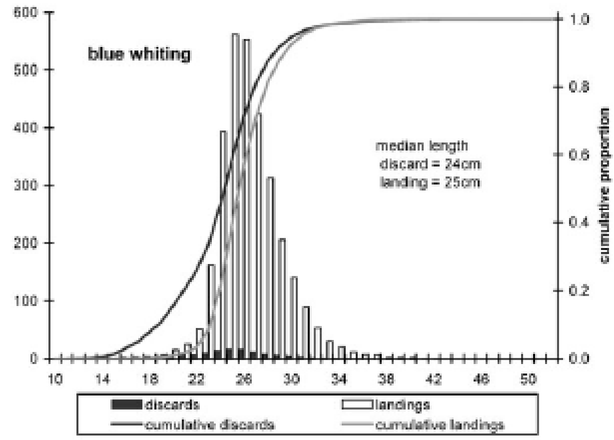

Figure D6: Length frequencies of discarded (filled histograms) and landed blue whiting (white histograms) by the Dutch fleet between 2002 and 2005. (From Borges, *et al* 2008)

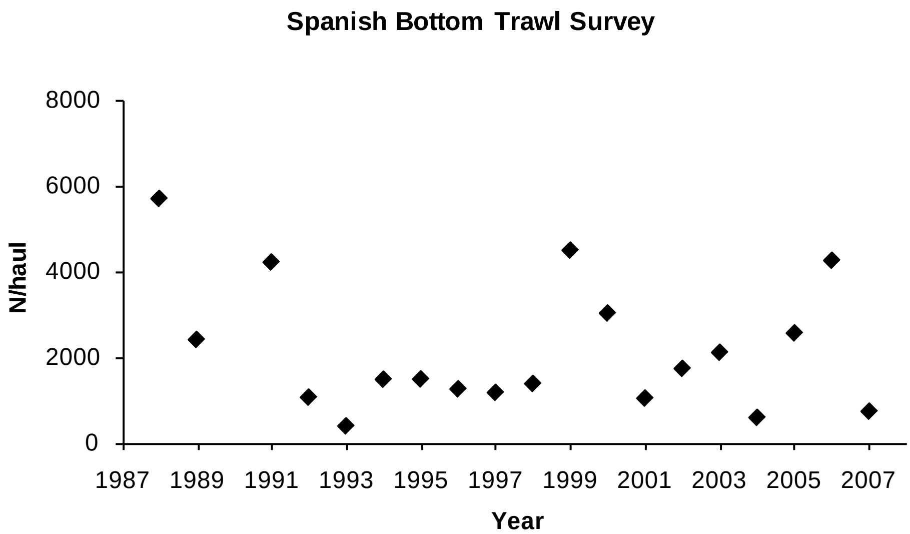

Figure D7. Mean catch rates (Kg/haul and Number/haul) of blue whiting in Spanish bottom trawl survey.

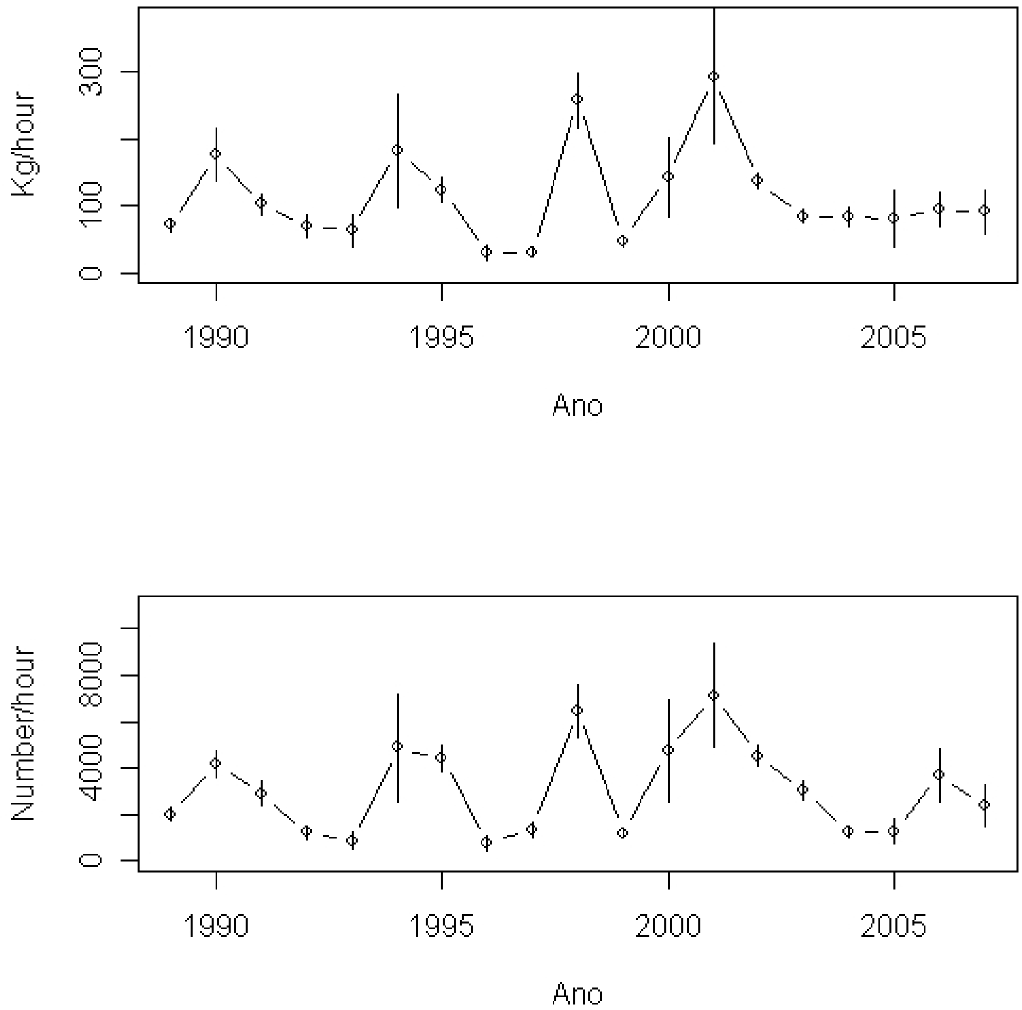

Figure D8: Stratified mean catch (Kg/haul and Number/haul) and standard error of blue whiting in bottom trawl surveys in Spanish waters (Divisions VIIIc and IXa north). All surveys in September –October

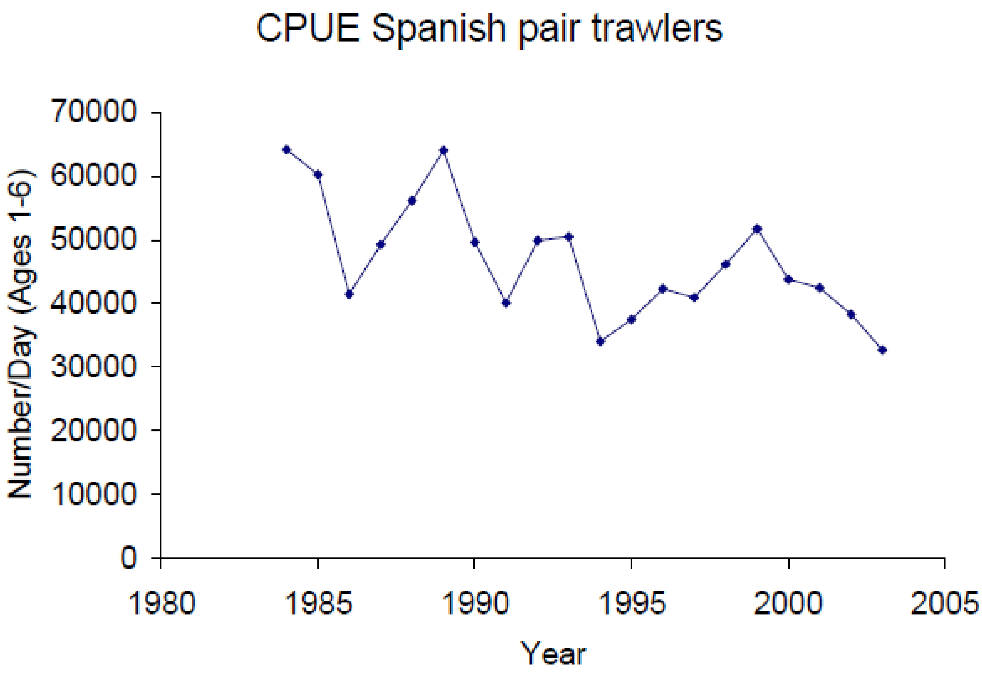

Figure D9: Blue Whiting CPUE from Spanish Pair Trawlers in ICES Div VIIIc and IXa (North)

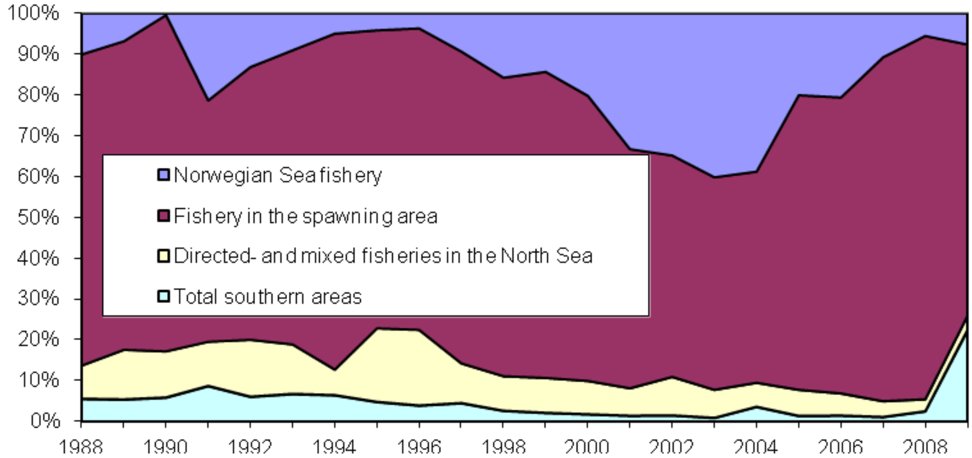

Figure D10: Development of Blue Whiting fisheries in different areas

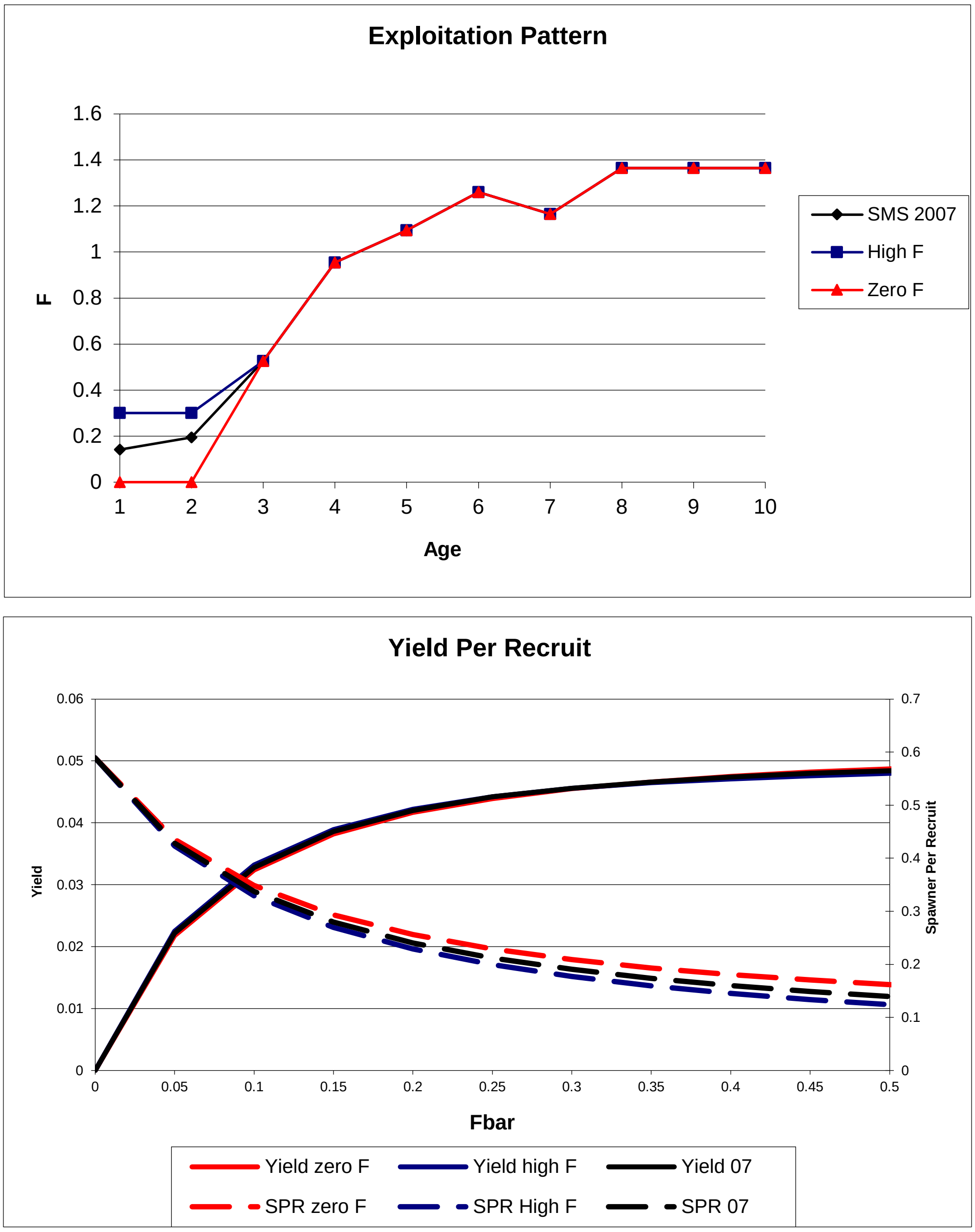

Figure D11: Blue Whiting exploitation pattern (upper) and yield per recruit curves (lower)

Annex 02E – Stock Annex: Northeast Atlantic Boarfish

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	**Boarfish in Sub areas V, IV, VI, VII, VII**
Working Group:	**WGWIDE 2014**
Date:	**02 September 2014**
Revised by:	**WGWIDE/Cormac Nolan**

A. General

A.1. Stock definition

The boarfish (*Capros aper*, Linnaeus) is a deep bodied, laterally compressed, pelagic shoaling species distributed from Norway to Senegal, including the Mediterranean, Azores, Canaries, Madeira and Great Meteor Seamount (Blanchard and Vandermeirsch, 2005). An analysis of IBTS data suggests a continuity of distribution spanning Subareas IV, VI, VII and VIII (Figure A.1.1). Isolated small occurrences appear in the North Sea in some years and an isolated landing in area Vb2 indicates spill-over into these areas (Figure A.1.2). A hiatus in distribution is apparent between Divisions VIIIc and IXa south. Boarfish are considered very rare in northern Portuguese waters but are abundant further south (Cardador and Chaves, 2010). Based on these results, a single stock is considered to exist in Subareas IV, V, VI, VII and VIII. This distribution is broader than the current EC TAC area: VI, VII, and VIII.

An analysis of bottom trawl survey data suggests a continuity of distribution spanning ICES Subareas IV, VI, VII, VIII and IX (Figure A.1.3). Isolated small occurrences appear in the North Sea (ICES Subarea IV) in some years indicating spill-over into this region. A hiatus in distribution was suggested between ICES Divisions VIIIc and IXa as boarfish were considered very rare in northern Portuguese waters but abundant further south (Cardador and Chaves, 2010), however it is unclear if this suggested hiatus represents a true stock separation. Based on these data, a single stock is considered to exist in ICES Subareas IV, VI, VII, VIII and IXa. This distribution is broader than the current EC TAC area: VI, VII and VIII and for the purposes of assessment in 2014 only data from these areas were utilised. A dedicated study on the stock structure of boarfish within the Northeast Atlantic and Mediterranean Sea commenced in October 2013, the results of which will feed into future assessments.

A.2. Fishery

Previous to the development of the fishery, boarfish was a discarded bycatch in pelagic fisheries for mackerel in Subareas VII and VIII. A study by Borges *et al*. (2008) found that boarfish may account for as much as 5% of the total catch of Dutch pelagic freezer trawlers.

The first targeting of boarfish began in 2001. Landings fluctuated between 100 and 700 t per year (Table A.2.1). In 2006 the landings began to increase considerably, and cumulative landings since 2001 are now in excess of 295 000 t. The expansion of the fishery in the mid 2000s was associated with developments in the pumping technology for boarfish catches. These changes made it easier to pump boarfish ashore. The fishery targets dense shoals of boarfish. Catches are generally free from bycatch from September to February. From March onwards a bycatch of mackerel is found in the catches. Information on the bycatch of other species in the boarfish fishery is sparse, though thought to be minimal. The fishery uses typical pelagic trawl nets with mesh sizes ranging from of 32 to 54 mm. Preliminary information suggests that only the smallest boarfish escape this gear. To date only RSW trawlers have participated in the fishery. From 2001 to 2006 only Ireland participated in the fishery. In 2007 UK-Scotland also participated, landing less than 1 000 t. In all years the vast majority of catches have come from SubareaVIIj (Figure A.1.2 and Table A.2.2). In 2010, 137 503 t were caught. Ireland continued to be the main participant (88 456 t), with Denmark taking 39 805 t and Scotland, 9 241 t.

A notional TAC was set for this species for the first time in 2011, covering ICES Subareas VI, VII and VIII. This TAC was set at 33 000 t. Before 2010, the fishery was unregulated. In October 2010, the European Commission notified national authorities that under the terms of Annex 1 of Regulation 850/1998, industrial fisheries for this species should not proceed with mesh sizes of less than 100 mm. In 2011, the European Parliament voted to change Regulation 850/1998 to allow fishing using mesh sizes ranging from 32 to 54 mm.

In 2011, 31 295 t were caught. Ireland continued to be the main participant (20 685 t), with Denmark taking 7 797 t and Scotland 2 813 t. Due to the 2010 net regulation and extended negotiations over quota allocations the Irish target fishery commenced in late Q3 and as such landings in Q1 and Q2 may be considered as bycatch. Twenty-nine Irish registered fishing vessels reported landings of boarfish. Only 2 Scottish vessels reported landings of boarfish, which were in Q3 and Q4. The number of Danish vessels participating in the fishery is unknown.

For 2012, ICES advised that catches of boarfish should not increase, based on precautionary considerations. As supporting information, ICES noted that it would be cautious that landings did not increase above 82 000 t, the average over the period 2008-2010, during which the stock did not appear to be overexploited. In 2012 the TAC was set at 82 000 t by the Council of the European Union.

In August 2012 the executive committee of the Pelagic RAC approved a long term management plan for boarfish. The management plan has not yet been evaluated by ICES. However, in 2013, ICES advised that Tier 1 of the plan can be considered precautionary if a Category 1 assessment is available.

For 2013, ICES advised that catches of boarfish should not be more than 82,000 t. This was based on applying a harvest ratio of 12.2% ($F_{0.1}$, as an F_{msy} proxy). For 2013, the TAC was set at 82 000 t by the Council of the European Union.

For 2014, ICES advised that, based on F_{MSY} (0.23), catches of boarfish should not be more than 133 957t, or 127 509t when the average discard rate of the previous ten years (6 448t) is taken into account. For 2014 the TAC was set at 127 509t by the Council of the European Union.

Since 2011, there has been a provision for by-catch of boarfish (also whiting, haddock and mackerel) to be taken from the western and North Sea horse mackerel EC quotas. These provisions are shown in the text table below. The effect of this is that a quantity not exceeding the value indicated of these 4 species combined may be landed legally and subtracted from quotas for horse mackerel.

Year	North Sea (t)	Western (t)
2011	2031	7779
2012	2148	7829
2013	1702	7799
2014	1392	5736

A.3. Ecosystem aspects

The ecological role and significance of boarfish in the NE Atlantic is largely unknown. However, in the south-east North Atlantic, in Portuguese waters, they are considered to have an important position in the marine food web (Lopes *et al.*, 2006). The diet has been investigated in the eastern Mediterranean, Portuguese waters and at Great Meteor Seamount and consists primarily of copepods, specifically *Calanus helgolandicus*, with some mysid shrimp and euphausiids (MacPherson, 1979; Fock *et al.*, 2002; Lopes *et al.*, 2006). This contrasted with the morphologically similar species, the slender snipefish, *Macroramphosus gracilis* and the longspine snipefish, *M. scolopax*, whose diet comprised *Temora* spp., copepods and mysid shrimps, respectively (Lopes *et al.*, 2006). Despite the obvious potential for these species to feed on fish eggs and larvae, there was no evidence to support this conclusion in Portuguese waters and they were not considered predators of commercial fishes and thus their increase in abundance was unlikely to affect recruitment of commercial fish species (Lopes *et al.*, 2006). If the NE Atlantic population of boarfish is sufficiently large then there exists the possibility of competition for food with other widely distributed planktivorous species.

Both seasonal and diurnal variations were observed in the diet of boarfish in all three regions. In the eastern Mediterranean and Portuguese waters, mysids become an important component of the diet in autumn, which correlates with their increased abundance in these regions at this time (MacPherson, 1979; Lopes *et al.*, 2006). Fock *et al.* (2002) found that boarfish at Great Meteor Seamount fed mainly on copepods and euphausiids diurnally and on decapods nocturnally, indicating habitat dependent resource utilisation.

Boarfish appear an unlikely target of predation given their array of strong dorsal and anal fin spines and covering of ctenoid scales. However, there is evidence to suggest that they may be an important component of some species' diets. Most studies have focused in the Azores and few have mentioned the NE Atlantic, probably due to the relatively low abundance in the region until recent years. In the Azores, boarfish was found to be one of the most important prey items for tope (*Galeorhinus galeus*), thornback ray (*Raja clavata*), conger eel (*Conger conger*), forkbeard (*Phycis phycis*), bigeye tuna (*Thunnus obesus*), yellowmouth barracuda (*Sphyraena viridensis*), swordfish (*Xiphias gladius*), blackspot seabream (*Pagellus bogaraveo)*, axillary seabream (*Pagellus acarne*) and blacktail comber (*Serranus atricauda*) (Clarke *et al.*, 1995; Morato *et al.*, 1999; Morato *et al.*, 2000; Morato *et al.*, 2001; Barreiros *et al.*, 2002; Morato *et al.*, 2003; Arrizabalaga *et al.*, 2008). Many of these species also occur in the NE Atlantic shelf waters although it is unknown whether boarfish represent a significant component of the diet in this region.

In the NE Atlantic boarfish have not previously been recorded in the diets of tope or thornback ray (Holden and Tucker, 1974; Ellis *et al.*, 1996,). However, this does not prove that they are currently not a prey item. A study of conger eel diet in Irish waters from 1998-1999 failed to find boarfish in the diet (O'Sullivan *et al.*, 2004). However, in Portuguese waters a recent study has found boarfish to be the most numerous species in the diet of conger eels (Xavier *et al.*, 2010). It has been suggested that boarfish are an important component of the diet of hake (*Merluccius merluccius*), as they are sometimes caught together. However, a recent study of the diet of hake in the Celtic Sea and Bay of Biscay did not report any boarfish in the stomachs of hake caught during the 2001 EVHOE survey (Mahe *et al.*, 2007).

The conspicuous presence of boarfish in the diet of so many fish species in the Azores is perhaps more related to the lack of other available food sources than to the palatability of boarfish themselves. Given the large abundance in NE Atlantic shelf waters it is likely that they would have been recorded more frequently if they were a significant and important prey item.

Boarfish are also an important component of the diet a number of sea birds in the Azores, most notably the common tern (*Sterna hirundo*) and Cory's shearwater (*Calonectris diomedea*) (Granadeiro *et al*., 1998; Granadeiro *et al*., 2002). This is surprising given that in the Mediterranean discarded boarfish were rejected by seabirds whereas in the Azores they were actively preyed on (Oro and Ruiz, 1997). Cory's shearwaters are capable of diving up to 15 m whilst the common tern is a plunge-diver and may only reach 2-3 m. It is therefore surprising that boarfish are such a significant component of their diet given that it is generally considered a deeper water fish. In the Azores boarfish shoals are sometimes driven to the surface by horse mackerel and barracuda where they are also attacked by diving sea birds (J. Hart, CW Azores, pers. comm.). Anecdotal reports from the Irish fishery indicate that boarfish are rarely found in waters shallower than 40 m. This may suggest that they are outside the range of shearwaters and gannets, the latter having a mean diving depth of 19.7±7.5 m (Brierley and Fernandes, 2001). However, the upper depth range of boarfish is within maximum diving depth recorded for auks (50 m) as recorded by Barrett and Furness (1990). Given their frequency in the diets of marine and bird life in the Azores, boarfish appear to be an important component of the marine ecosystem in that region. There is currently insufficient evidence to draw similar conclusions in the NE Atlantic.

The length-frequency distribution of boarfish may be important to consider. IBTS data shows an increase in mean total length with latitude (Table A.3.1) and perhaps the smaller boarfish in the southern regions are more easily preyed upon. Length-frequency data of boarfish from stomach contents studies of both fish and sea birds in the Azores indicate that the boarfish found are generally < 10 cm (Granadeiro *et al*., 1998; Granadeiro *et al*., 2002).

B. Data

B.1. Historical

In the Northeast Atlantic region boarfish have historically been characterised by apparent fluctuations in abundance. A literature review of historical sources suggests peaks in abundance in the following periods:

- 1840s to 1880s
- 1950s
- Mid 1980s to 1990s

From the 1840s to 1880s large abundances were periodically observed in the western English Channel (Day, 1880-1884; Couch, 1844; Cunningham, 1888). Gatcombe, writing in 1879, stated that they had become an extreme nuisance in trawl fisheries. In the early 1900s boarfish were noted for their sporadic occurrence in the English Channel and were scarce or absent for many years in the area around Plymouth where they had previously been abundant (Cooper, 1952). In the mid 1900s there was another apparent increase in abundance, which Cooper (1952) hypothesised was caused by a 'submarine eagre' that swept shoals of boarfish from submarine canyons in the southern edge of the Celtic Sea onto the continental shelf. It should be noted that these apparent peaks in abundance occurred during periods when fisheries and sampling were less widespread that the present day. The primary distribution area of boarfish, along the shelf edge, was rarely, if ever sampled during this time. Therefore, the observations of peaks in abundance are only related to inshore areas. There is no evidence that boarfish were not also abundant offshore throughout these periods.

Increases in abundance were observed in the Bay of Biscay, Galician continental shelf waters and the Celtic Sea between the 1980s and 2000 (Farina *et al.*, 1997; Pinnegar *et al.*, 2002; Blanchard and Vandermeirsch, 2005). The relative abundance in the Bay of Biscay increased from 0.3% in 1973 to 16% in 2000 resulting in boarfish becoming one of the dominant species in the fish community in this region (Blanchard and Vandermeirsch, 2005).

Based on the above information the external reviewers in 2012 noted the possibility that boarfish was a deep-water species that had undergone a shoreward range extension onto the shelf in the late 1980's. They suggested that this was consistent with the large proportion of older fish in the stock and stated "If the increased abundance during the early 1990s was due to increasing recruitment on the continental shelf, then it seems unlikely that so many old fish would be observed". On this basis the reviewers made two recommendations: one was to extend the acoustic survey tracks into deeper water off shelf waters. This is already part of the standard protocol of the acoustic survey and since 2011 all westward transects extend until no boarfish shoals have been recorded for 15 nm (O'Donnell *et al.*, 2013). No boarfish shoals have been detected off the shelf from 2011 to 2013 and anecdotal evidence from the fishing industry also suggests that boarfish is a shelf species and does not occur off the shelf. The second recommendation was to use an integrated analysis model capable of simultaneously examining the age composition data, the catch time series, and the survey index time series to compare the movement hypothesis to the increased recruitment on the shelf hypothesis. Whilst it would be an interesting exercise this second point is deemed unnecessary as there is no evidence for boarfish being a deep water off-shelf species. It is also unclear why the reviewers considered that the increasing abundance during the early 1990's could not be due to increased recruitment on the shelf as these fish would now be in the 20+ age group and thus increased recruitment on the shelf could be the source of these fish.

Preliminary GAM modelling of the IBTS data also lends supports to the fact that boarfish are a shelf species (see main text Section 6.6.2). There is no evidence of a spread of boarfish from oceanic waters onto the shelf. Furthermore the GAM models highlight where the theories such as this likely arose. The periodic increases in abundance in the western English Channel may simply have been an incursion of boarfish from shelf waters. Such incursions are evident from the GAM model in 1999 and 2002 (Figure B.4.3). The reasons for these incursions are unknown but may be related to annual hydrographic conditions. They do not occur in all years and as such likely result in a perceived local increase in abundance.

B.2. Commercial catch

For 2013 catch number-at-age see main text.

For 2012 catch number-at-age were prepared for Irish, Danish and Scottish landings using the ALK in table B.2.1. This general ALK was constructed based on 814 aged fish from Irish, Danish and Scottish caught samples. There were a number of data quality issues (see main text Section 6.2.2) and unsampled métiers. Allocations were made according to table B.2.2. Only Irish collected samples were deemed reliable enough for length frequency and length weight analyses. In total 68 Irish samples were collected and 8565 fish were measured for length frequency.

For 2011, catch number-at-age were prepared for Irish, Danish and Scottish landings using the ALKs in table B.2.1. There were a number of unsampled metiers and allocations were made appropriately. In total 27 samples were collected (16 by Denmark and 11 by Ireland), 4 066 fish were measured for length frequency and 704 fish were aged for construction of the ALKs (Table B.2.3).

For years prior to 2011, a proxy catch-at-age matrix was constructed using the age-length key from a combination of fisheries-independent and dependent data (Table B.2.4). Length-frequencies of commercial catches are available from 2007 onwards (Table B.2.5). Ageing is based on the method that has been validated for ages 0-7 by Hüssy *et al*. (2012; in press). These age samples were collected mainly during 2010. The age range is similar to the published growth information presented by White *et al*. (2011).

ALKs were applied to commercial length-frequency data available for the years 2007-2011 to produce a proxy catch numbers-at-age (Figure B2.1 and Table B.2.6). It can be seen that many older fish are still present in catches, though there appears to be a reduction of older ages since 2007. The modal age in all four years is 6. Other dominant age classes ranged from 4 to 8.

B.3. Biological data

The boarfish are classified in the order Perciformes. They are a small (max 23cm TL), thin, laterally compressed pelagic shoaling species. They have a red to orange colour and are sexually dimorphic. They are widely distributed at depths from the surface to 600m.

Kaya and Özaydin (1995) conducted a study on boarfish in the Mediterranean (Turkish waters) and estimated a maximum age of 4 years and age at maturity 2 years. These results conflicted with the results of White et *al*., (2011) who attained a maximum age of 26 years and age at maturity of 5.25 and 4.6 years for males and females respectively, based on samples from the NE Atlantic. Neither study included a validation of the ageing method used or information on methods used for maturity determination.

In 2010, a biological study of boarfish commenced based on both fishery dependent and independent samples (n=3376). Samples were collected from ICES Divisions VIa, VIIb, VIIh, VIIj and VIIIa from September 2009 to December 2010 (excluding August). TL ranged from 26 to 180 mm, with one additional fish reaching 233mm. Based on 232 of these samples Hüssy *et al*. (2012) carried out an age validation study. Subsequently an ALK was produced and used for preliminary growth investigations. Farrell *et al*. (2012) also investigated the reproductive biology of the species based on 2015 of these samples. From these 2 studies the following biological background information has been gathered:

Boarfish reach a maximum age of 31 years. An ALK based on 407 age readings, from 0 to 28 years, of males and females combined was applied to a combination of length-only fishery independent and dependant data (n=1633). The von Bertalanffy growth curve was constructed based on the typical parameterisation of the von Bertalanffy growth equation (Table B.3.1 and Figure B.3.1):

$TL_{age} = L_{inf}*(1-exp(-K*(age-t0)))$

The growth curve and ALK were used to investigate length-at-age, age distribution and maturity at age/length. Growth is fastest in the first 2-3 years then levels off and energy is allocated to other processes such as reproduction. The age distribution (Figure B.3.2) is uni-modal with a peak at 7 years (corresponding to approx. 12cm). Length classes were continuous up to 18cm after which only one individual fish was present in the 23cm length class. The abundance of females peaked in the 12cm length class, while the highest number of males was observed in the 11cm length class.

The length and age at 50 % maturity were 9.7 cm TL and 3.5 years, respectively (Figure B.3.3). The reproductive cycle commenced between February and April and finished between October and December, when fish entered the resting phase. Oocyte development was asynchronous and all oocytes stages were present concurrently in spawning fish. There was no hiatus between pre-vitellogenic and vitellogenic oocytes. Spawning occurred in June and July with a notable peak in July (Figure B.3.4). No samples were available from August. The boarfish is a batch spawner. In September there was a generalised atresia and remaining oocytes were observed to be resorbed. Aquarium observations of spawning fish indicated that males spawned daily whilst females spawned every 2-3 days. In the controlled aquarium environment spawning lasted approximately 9 months. All indications are that the boarfish has indeterminate fecundity.

B.4. Surveys

B.4.1. IBTS

The following data was used in the 2013 assessment model (see Section C). For 2014 assessment input see main text.

The western IBTS data and CEFAS English Celtic Sea Groundfish Survey were investigated for their utility as abundance indices. An index of abundance was constructed from the following surveys:

- EVHOE, French Celtic Sea and Biscay Survey, (Q4) 1997 to 2012
- IGFS, Irish Groundfish Survey, (Q4) 2003 to 2012
- WCSGFS, West of Scotland, (Q1 and Q4) 1986 to 2012 (no Q4 survey in 2010)
- SPPGFS, Spanish Porcupine Bank Survey, (Q3) 2001 to 2012
- SPNGFS, Spanish North Coast Survey, (Q3/Q4) 1991 to 2012
- ECSGFS, CEFAS English Celtic Sea Groundfish Survey, (Q4) 1982 to 2003

From the IBTS data CPUE was computed as the number of boarfish per 30 minute haul. The abundance of boarfish per year per ICES Rectangle was then calculated by summing the boarfish in a given rectangle and dividing by the total number of hauls in that rectangle. Length frequencies are presented in Table B.4.1 for each survey. The complete area was sampled from 2003-2011.

The shoaling nature of the species results in occasional large hauls. This is evidenced in the 2008 data which appears to indicate a peak in abundance. Therefore, the number of rectangles sampled was compared with the number of rectangles in which boarfish were caught (Figure B.4.1). The occurrence of boarfish increased from 2003 to 2007 despite a decrease in the number of rectangles sampled from 2004 to 2010. From 2007 to

2010 there was a slight decrease in the occurrence of boarfish but this appears to have levelled off in 2011.

The IBTS appears to give a relative index of abundance, with good resolution between periods of high and low abundance. The main centres of abundance in the survey (Figure A.1) correspond to the main fishing grounds (Figure A.2). Figure B.4.2 shows the signal in abundance, increasing in the 1990s, declining again in the early 2000s, before increasing again. These trends have been reported by (Farina *et al.*, 1997; Pinnegar *et al.*, 2002; Blanchard and Vandermeirsch, 2005). These authors used IBTS and other trawl survey data to show the increased abundance of the species in this area.

Anecdotal evidence from the fisheries indicates that from September to March boarfish are found on the shelf in dense shoals often in close proximity to the bottom. These shoals are particularly abundant around the banks in ICES Division VIIj in the Celtic Sea. Therefore boarfish are likely effectively sampled by the demersal gear of the IBTS despite being a pelagic species. However the shoaling nature of the species results in occasional large hauls.

The preliminary results of a GAM modelling project of the IBTS data up to 2011, including the Portuguese data, are presented to illustrate the temporal and spatial distribution of boarfish in the ICES Area. A GAM based on the probability of occurrence of boarfish in a surveyed area was developed based on presence absence data from over 13,000 individual fishing hauls in 7 groundfish surveys over a 30 year period (Figures B4.3 and B4.4). The GAM models clearly illustrate that boarfish are distributed on the shelf and have a wide area of distribution. In recent years (2003 onwards) there has been an increase in the northerly distribution of boarfish. The depth distribution profile of boarfish within these hauls was also calculated, which shows that boarfish have a depth distribution preference of approximately 100-300m and the probability of occurrence in deeper water decreases sharply (Figure B.4.5). The proportion of each region over which boarfish were distributed per year was also investigated and shows an increasing trend over time (Figure B.4.6). This indicates that the area of spread of boarfish within the surveyed area has increased during the period.

For subsequent surplus production modelling, biomass indices were extracted from each of the IBTS surveys using a delta-lognormal model (Stefánsson, 1996). Many of the surveys exhibited a large proportion of zero tows (Figure B.4.7) with occasionally very large tows, hence the decision to explicitly model the probability of a non-zero tow and the mean of the positive tows. A delta-lognormal fit comprises fitting two generalized linear models (GLMs). The first model (binomial GLM) is used to obtain the proportion of non-zero tows and is fit to the data coded as 1 or 0 if the tow contained a positive or zero CPUE, respectively. The second model is fit to the positive only CPUE data using a lognormal GLM. Both GLMs were fit using ICES rectangle and year as explanatory factor variables. Where the number of tows per rectangle was less than 5 over the entire series, they are grouped into an "others" rectangle. An index per rectangle and year is constructed, according to Stefánsson (1996), by the product of the estimated probability of a positive tow times the mean of the positive tows. The station indices are aggregated by taking estimated average across all rectangles within a year. To propagate the uncertainty, all survey index analyses were conducted in a Bayesian framework using MCMC sampling in WinBUGS (Spiegelhalter *et al.*, 2004).

B.4.2. Acoustic Survey

The Boarfish Acoustic Survey (BFAS) series was initiated in July 2011 and is now in its fourth year. The 2011 survey, the first in the series, was conducted by Marine Institute scientists aboard the Irish pelagic RSW vessel FV ''Felucca'' with a towed body system with a calibrated 38 kHz split beam transducer (O'Donnell *et al.*, 2012a). The survey was designed to extend the Malin Shelf Herring Acoustic Survey (MSHAS) conducted aboard the RV "Celtic Explorer" to the south, which increased the range of continuous coverage from approximately 58.5°N to 47.5°N (Figure B.4.2.1). The 2011 BFAS operated on a 24 hour basis as it was an exploratory survey and the distribution and behaviour of boarfish during this time of year were unknown prior to the survey. The combined surveys resulted in a continuous coverage over 33 days, 90 000 nmi^2 and transect coverage over 4 500 nmi. 24 trawls were sampled and lengths, weights, maturity data, and otoliths of boarfish were collected. In 2011 the total biomass of boarfish in the survey area was estimated at 456 115 t. Estimates of boarfish biomass by category are presented in Table B.4.4 and the spatial distribution of the echotraces attributed to boarfish in each year can be seen in Figure B.4.2.1.

The text table below explains the categories used to report estimated biomass from all BFASs. Following standard acoustic survey protocols the Total Biomass estimate includes the '*Definitely*', '*Probably*' and '*Mixture*' categories but excludes the '*Possibly*' category.

Category	Definition
Definite	"Definitely" echotraces were identified on the basis of captures of boarfish from the fishing trawls which were sampled directly. Based on the directly sampled schools echotraces were also characterised as definitely boarfish which appeared very similar on the echogram i.e. large marks which showed as very high intensity (red), located high in the water column(day) and as strong circular schools.
Probably	"Probably" was attributed to smaller echotraces that had not been fished but which had similar characteristics to "definite" boarfish traces.
Mixture	"Mixture" was attributed to NASC values arising from all fish traces in which boarfish were contained, based on the presence of a proportion of boarfish in the catch or within the nearest trawl haul. Boarfish were often taken during trawling in mixed species layers during the hours of darkness.
Possibly	"Possibly" was attributed to small echotraces outside areas where fishing was carried out, but which had the characteristics of definite boarfish traces.

In 2012 the survey methodology was refined by switching to daylight only (04:00-00:00) surveying. This change in protocol was a result of the observation during the 2011 BFAS that boarfish shoals were observed to break up during the night (00:00-04:00) and could not be acoustically detected or quantified. The 2012 total biomass estimate was 863 446 t (O' Donnell *et al*., 2012b; Table B.4.4), with the increase partially attributable to the protocol change.

In July 2013 the BFAS series was continued, with the survey being conducted again aboard the FV "Felucca" (O'Donnell *et al.*, 2013). The survey used the same equipment and followed the same protocol as the 2012 survey and the survey track was broadly similar (Figure B.4.2.1). In total 4,295nmi (nautical miles) of cruise track was undertaken by both vessels over 53 transects relating to a total area coverage of 57,020nmi^2. Transect spacing was set at 15nmi for the *Felucca* and 15 and 7.5nmi for the *Explorer* component. Coverage extended in coastal areas from the c.50m contour to the shelf slope (250m). The survey was carried out from 04:00–00:00 each day. In 2013 thirty three hauls were carried out during the survey, 19 of which contained boarfish. A total of 1,074 boarfish echotraces were identified during the survey. Of this 98% were categorised as '*Definitely*' boarfish, 1.6% as '*Probably*' and 0.3% '*Boarfish in a mixture*'. The total estimated biomass of the survey area was 423 158 t (Table B.4.4).

As no species-specific target strength (TS) previously existed for boarfish, an industry funded project was conducted to model boarfish TS. Samples were collected during the 2011 survey and MRI scans were taken of the swim bladders from the observed size range of boarfish. 3D swimbladder dimensions of each fish sample were used as input to a KRM model. An estimated TS-L relationship of -65.98dB was derived based on model calculations. This TS was used in 2012 to produce biomass estimates for the 2012 and 2011 survey. In 2013 this TS was reviewed and revised to -66.2dB (Fässler *et al.*, 2013; O'Donnell, 2013). This new TS (-66.2dB) was applied to the 2013 survey data and retrospectively to the 2012 and 2011 BFAS survey data for use in the boarfish assessment.

The large change in biomass observed between the surveys cannot be easily explained and is no doubt the result of multiple factors (O'Donnell *et al.*, 2013). Expected inter-annual variation between successive acoustic estimates is in part responsible. However, factors outside survey effects should also be considered including hydrographic conditions and prey availability. As boarfish continue to feed during spawning the availability of prey will also determine spatial distribution of schools locally and clusters of schools at larger scales. If conditions for spawning are not optimum then the prey availability will drive distribution. As the survey covered the same area using the same survey design and good trawl sampling was achieved it is methodologically a replicate of that performed in 2012. However, factors outside of the survey have no doubt influenced the distribution of the stock both in the large scale (how it was distributed over the greater survey area) and at the smaller scale (in terms of schooling behaviour). The latter being directly related to how available boarfish were to the acoustic recording equipment. As no bottom trawl was available during the survey it was not possible to target the seabed within the acoustic dead zone (ADZ) for presence/absence of boarfish. Unquantified sonar observations and off track investigations indicated that echosounder observations were indeed representative of aggregations present in the wider area. This raises the possibility that boarfish could have also been distributed within the ADZ and out of the range of echosounder and midwater trawl sampling.

It should be noted that the survey does not contain the stock fully, given that concentrations of boarfish are likely to be found southward of the survey area as evidenced by both IBTS data and information from the PELACUS survey on the northern Spanish Shelf (Carrera *et al.*, 2013).

C. Assessment: data and method

Assessments, projections and reference points (Sections C to H) from 2013 are presented here. For 2014 assessment see main text.

A number of exploratory assessment runs for boarfish were carried out in 2013.

Model used: Bayesian Schaefer state space surplus production model (BSP) (Meyer and Millar 1999)

Model Options chosen:

- Run priors:
- r ~ U(0.001,2)
- ln K ~ U(ln max(C), ln 10xsum C) = U(ln 144,047t, ln 4,450,407t)
- a ~ U(0.001, 1.0)

- ln q_i ~ U(-16,0) (for IBTS)
- $1/\sigma_\eta^2$ ~ Gamma(0.001,0.001)

Model Outputs:

Full run estimates:

- *r* (intrinsic rate of population growth)
- *K* (carrying capacity)
- *a* (proportion of *K* in 1982)
- q_i (catchabilities, 6 IBTS and 1 acoustic survey)
- B_t (biomass states, 33 years)

Errors:

- Single biomass process error encompassing recruitment and growth variability
- Measurement errors come directly from variance of delta-lognormal indices

Prior assumptions on the parameter distributions were:

- Intrinsic rate of population growth: r ~ U(0.001,2)
- Natural logarithm of the carrying capacity ln K ~ U(ln max(C), ln 10xsum C)=U(ln 144,047t, ln 4,450,407t)
- Proportion of carrying capacity in first year of assessment: a ~ U(0.001, 1.0)
- Natural logarithm of the survey-specific catchabilities ln qi ~ U(-16,0) (for IBTS only). Acoustic survey is discussed below when separate runs are described.
- Process error precision ~Gamma(0.001,0.001)

Eight initial runs were performed. The four base runs are explained in the table below:

Run	$q_{acoustic}$	$I_{acoustic,2012}$ (t)	$I_{acoustic,2013}$ (t)
1	Fixed at 1	Total (863,446)	Total (439,897)
2	Free (strong prior)	Total	Total
3	Fixed at 1	Definitely (708,019)	Definitely (431,571)
4	Free (strong prior)	Definitely	Definitely

$q_{acoustic}$ is the catchability of the acoustic survey, $I_{acoustic}$ is the acoustic index value used for the specified years.

Runs 1 and 3 assume that the acoustic survey surveys the entire stock and is an absolute index of abundance. Runs 2 and 4 assumes a strong prior ln $q_{acoustic}$ ~ N(1,1/4) (standard deviation of 1/4), which has 95% of the density between 0.5 and 2. Given the short acoustic series (2 years) it is not possible to estimate this parameter freely (using an uninformative prior) but assuming a strong prior removes the assumption of an absolute index from the acoustic survey and will be continually updated as data accrue.

Following concerns regarding the quality of the recording of boarfish from the early part of the ECSGFS survey and the fact that the WCSGFS survey is distant from the center of abundance and unlikely to provide an index for the complete stock, sensitivity runs were performed on Runs 1-4 that completely omitted the ECSGFS and WCSGFS surveys. These are referred to as runs 1.1, 2.1, 3.1, and 4.1 with the same settings as the corresponding runs 1 through 4 respectively with the omission of these two surveys.

Following plenary discussion of the sensitivity runs, it was decided that the final run be based on a run that includes all surveys with the omission of the first 5 years of the WCSGFS and first 9 years of the ECSGFS. The reasons for this decision was

- -It is unclear whether boarfish were consistently recorded in the early part of the ECSGFS
- -The WCSGFS is thought to be at the northern extreme of the distribution and may not be an appropriate index for the whole stock.
- -The SPNGFS commences in 1991 such that running the assessment from 1991 onwards includes at least three surveys without relying solely on the ECSGFS and WCSGFS.
- -Surveys are internally weighted such that highly uncertain values receive lower weight.

Run 2.2. is therefore the final run. The specifications are that for run 2 with the omission of the early parts of the WCSGFS and ECSGFS, as detailed above.

Run convergence

Parameters for runs 1-4, sensitivity runs 1.1, 2.1, 3.1, 4.1 and final run 2.2 converged with good mixing of the chains and R_{hat} values lower than 1.1 indicating convergence (Figures C.1, C.2 C.3). MCMC chain autocorrelation was also low indicating good sampling of the parameter posteriors (Figures C.4 and C.5).

Diagnostic plots for these runs are provided in Figures C.6 and C.7, showing residuals about the model fit. There is relatively little difference between any of the runs in the fitting of the trawl surveys, and a fairly balanced residual pattern is in evidence. In some cases outliers are apparent, for instance in the English survey in the final year (2003). However, these points are down-weighted according to the inverse of their variance and hence to not contribute much to the model fit. For this reason, no indices were removed from the analyses. The west of Scotland IBTS survey, located at the northern extreme of the stock distribution underestimates the stock in the early period (years) and overestimates it in the recent period from all fits. This could be indicative of stock expansion into this area at higher stock sizes and suggests that this index is not representative of the whole stock. Figures C.8, C.9 and C.10 show the prior and posterior distributions of the parameters of the biomass dynamic model. The estimate of q in runs 2, 2.1, 4 and 4.1 is less than 1.0, leading to higher estimates of final stock biomass than the acoustic survey.

Trajectories of observed and expected indices are shown in Figures C.11, C.12 and C.13, along with the stock size over time and a harvest ratio (total catch divided by estimated biomass). It can be seen that runs 2, 2.1, 2.2, 4 and 4.1 lead to larger stock sizes given the non-absolute assumption on the acoustic survey catchability. Parameter estimates from the four preliminary runs (1-4), four sensitivity runs (1.1, 2.1, 3.1, 4.1) and the final run (run 2.2) are summarized in Table C.1.2. It can be seen that the precision of the estimates of stock size are higher (more certain) for the runs where q is set at 1.0 for the acoustic surveys (Runs 1, 3, 1.1, 3.1). As the acoustic survey does not span the entire range of the stock, assuming the catchability of the acoustic survey is likely incorrect, hence the decision to use a strong prior on the acoustic survey catchability. Consequently the group considers run 2.2 as the final run for the purposes of stock assessment and forecasting catch options for 2013.

D. Short-Term Projection

A short term forecast was performed by projecting run 2.2 forward by one year. However, as there is no recruitment estimate it is not possible to construct a traditional style catch forecast for management purposes. Instead, short term projections over a range of fishing mortality and catch options are provided on a risk based approach. An intermediate year catch constraint was applied (2013 TAC, 82 000 t + average discards of 6 448 t). The population is then projected forward within the assessment under a range of management objectives that included the yield at:

- F_{MSY}=0.23 based on *r*/2 from run 2.2
- $F_{0.1}$=0.13 based on yield-per-recruit analysis
- F_{lim}=0.367 based on the F associated with a long-term biomass of *K*/5 (0.2 carrying capacity used for B_{lim})
- F_{pa}=exp(-1.645*CV(TSB_{2013}))*F_{lim} = exp(-1.645*0.436)* 0.367 = 0.179
- C_{2014}=C_{2013}
- C_{2014}=0 (zero catch option)
- C_{2014}=1.2*C_{2013} (20% increase in catch)
- C_{2014}=0.8*C_{2013} (20% decrease in catch)

A forward projection on the risk of the stock falling below B_{msy} ($B_{trigger}$), B_{lim} and fishing mortality exceeding F_{lim} are estimated. Fishing mortality for the fixed catch projections is calculated as -ln(1-C_{2014}/TSB_{2014}).

E. Medium-Term Projections

A yield per recruit analysis was conducted in 2011 (Minto *et al.* WD 2011) and $F_{0.1}$ was estimated to be 0.13 whilst F_{max} was estimated as in the range 0.23 to 0.33. (Figure E.1 and E.2). The estimation of $F_{0.1}$ was considered to be quite good.

F. Long-Term Projections

No long term projections were carried out.

G. Biological Reference Points

The following reference points were applicable to the 2013 assessment. Some have since been updated in 2014. See main text section 6.9 for more details.

ICES (1997) considered that precautionary F targets (F_{pa}) should be consistent with F<M for prey species. This approach would ensure that fishing does not out-compete natural predators for their prey. This would suggest that a good candidate precautionary F_{pa} can be defined as exp(-1.645*CV(TSB_{2013}))*F_{lim}=0.179. B_{lim} may be defined from the stock size estimates available from the stock assessment. It is proposed that B_{lim} be set at 0.2* *K*, (0.2 * 911 209 t = 182 241 t), based on the results of Run 2.2.

Yield per recruit analysis, following the method of Beverton and Holt (1957) found $F_{0.1}$ to be robustly estimated at 0.13 (ICES WGWIDE, 2011; Minto *et al.*, WD 2011).

An estimate of F_{msy} is available from the stock assessment as 0.23, which is in close agreement with the lower range of F_{max} from yield per recruit analyses (0.23 to 0.33; Minto *et al*., WD 2011).

An estimate of B_{msy} is available from stock assessment Run 2.2 (455 605 t). This is proposed as a conservative basis for MSY $B_{trigger}$.

H. Other Issues

H.1 Management and ICES advice

In 2010, an interim management plan was proposed by Ireland for boarfish in ICES Divisions VI, VII and VIII. The plan was as follows:

1) Until a long term management plan has been developed, and evaluated, the following interim TAC setting rule shall apply.

2) The TAC for 2011 (hereinafter referred to as the Reference TAC) shall be set in the range 22,000-33,000 t, 50%-75% of the Recent Average Yield 2007-2009.

3) The TAC for 2012 shall be based on the Reference TAC, adapted by the rule, below, based on the Exploitation Indicator (E) and Reproductive Capacity Indicator (R)*:

a) If the average of either E or R in the past two years is 20% or more lower than in the preceding three years, a 15% TAC decrease applies.

b) If the average of either E or R in the past two years is 20% or more higher than in the preceding three years, a 15% TAC increase applies.

c) If the average of either E or R in the past two years is less than 20% different than in the preceding three years, no TAC change applies.

d) Notwithstanding 3.b above, in no case shall the TAC for a given year exceed the Reference TAC.

1) A precautionary closed season shall operate between the 15th March and the 31st August. This is because it is known that mackerel and boarfish are caught in mixed aggregations at these times.

2) A closed area shall be implemented in VIIg from 1st September to 31st October, in order to prevent catches of Celtic Sea herring, known to form feeding aggregations in this region at these times.

3) If catches of species covered by TAC, other than boarfish amount to more than 5% of the total catch by day by ICES statistical rectangle, then fishing must cease in that rectangle.

4) Vessels participating in the fishery for boarfish shall only land in designated ports.

5) Participating vessels already facilitate scientific studies, and observer coverage, and this cooperation shall be further developed.

***Indicator Definitions**

Exploitation Indicator E is defined as follows:

The mean length of fish of size greater than length at maturity as estimated in 2007 in the ICES western IBTS.

Reproductive Indicator R is defined as follows:

The total abundance of mature boarfish as estimated per year by the ICES western IBTS survey.

In 2011, ICES was asked by the European Commission to provide advice for boarfish in 2012 for the Celtic Sea and in the Bay of Biscay and the Iberian Coast. Data analysis suggests that a single management area exists in Subareas IV, V, VI, VII and VIII. This differs from the request made by the EC to ICES and also differs to the TAC area (VI, VII and VIII).

In 2012 a management plan was proposed by the Pelagic RAC. This management plan has not yet been fully evaluated by ICES. However, ICES identifies that Tier 1 of the proposed plan coincides with the ICES generic approach to giving advice for data-rich situations. Given that a Category 1 assessment is now being used for advice, ICES recommends that Tier 1.1 of the plan be considered consistent with the PA and MSY approaches for as long as a Category 1 assessment is available (ICES, 2013). This plan is presented below.

1) The TAC setting rules 1.1-1.6 shall apply. Precedence is in decreasing order from Rule 1.1. These are shown in the table below. The decision year for TAC setting is the last year in the assessment, and not the TAC year.

Rule	Assessment	Uncertainty	Condition	Procedure
1.1.a	SSB and F	Low	SSB > Btrigger	Ftarget
1.1.b			SSB < Btrigger	SSB * (Ftarget / Btrigger)
1.2.a	SSB and F	Higher	SSB > Btrigger	Ftarget
1.2.b			SSB < Btrigger	SSB * (Ftarget / Btrigger) * G
1.3.a	F	Any	F < Ftarget	Reference TAC * G
1.3.b			F > Ftarget,	RTAC + (-RTAC / Flim-Fpa)*(F-Fpa) * G
1.4.a	U	Any	U > Upa, TAC =	Reference TAC * G
1.4.b			U < Upa, TAC =	U * (Reference TAC / Upa) * G
1.5.	Survey biomass	Any	TAC y,q3,4 = TACy+1, q1 =	ASB * 1-exp-F0.1_ * G * 0.62 ASB * 1-exp-F0.1_ * G * 0.38
1.6	None		No information on stock status and no risk of recruitment impairment	TAC = 33,000 t (interim management plan TAC)

2) Notwithstanding Paragraph 1, if in the opinion of ICES, the stock is at risk of recruitment impairment, a TAC shall be based on advice given by ICES, and at a lower level than provided for in Paragraph 1, rules 1.1 to 1.6.

3) Closed seasons, closed areas and moving on procedures shall apply to all directed boarfish fisheries as follows:

i A closed season shall operate from 15th March to the 31st August. This is because it is known that herring and mackerel are present in these areas and may be caught with boarfish.

ii A closed area shall be implemented inside the Irish 12 mile limit south of 52°30 from 12th February to 31st October, in order to prevent catches of Celtic Sea herring, known to form aggregations at these times.

iii If catches of other species covered by TAC, amount to more than 5% of the total catch by day by ICES statistical rectangle, then all fishing must cease in that rectangle for 5 consecutive days.

H.2 Review

This assessment was peer-reviewed by two independent experts on behalf of ICES in 2012. . In 2013, a new assessment was provided, that was based on last previous year's work and took into account the reviewers' comments, which are detailed below.

The reviewers suggested that an age based model would be most appropriate. An age based model, however, is not attainable in the short term because:

- Insufficient age samples are available per year to derive representative CNAA.
- The age range of the species is wide and the year range of the fishery is narrow, making it impossible to populate the age-matrices of any such model in the short term.

The impediments to having an age based assessment can be overcome with time. The reviewers recommend the development of an age-based assessment in a 3-year timeframe. A cost-benefit analysis is required on whether to pursue an age based approach. At present there are insufficient resources for a full ageing programme. The reviewers suggested that more samples with fewer fish per sample and to refine the age length relationship for older fish. Perhaps the most expedient approach is to collect a large amount of samples, but only age a sub-set of these to maintain the indicator pseudo-cohort F estimates. If better resources are considered to be warranted, then the backlog of samples could be aged to produce CNAA over several years.

Given the problems with an age-based assessment, it was necessary to develop the biomass dynamic model further, whilst paying attention to the reviews conducted in 2012. The main points of the reviews on the biomass dynamic model are presented in the text table below, along with notes on how they were addressed.

Reviewer comment	How addressed
Provide indication of steepness of stock recruitment relationship	The model does not provide modelled recruitment, so this is not relevant to current model specification.
Better description of weighting of individual surveys	Surveys are weighted based on the survey index variability. A highly uncertain survey is therefore down-weighted within the assessment as detailed below. Apart from the index uncertainties, no a-priori weights are given to the indices although sensitivities to the exclusion of certain surveys were conducted and described below.
Clarification of rationale for model(run) selection	We now include a full clarification on final run selection.

Provide sensityivity analysis of prior assumptions	We include a sensitivity analysis to prior assumptions based on a "low resilience" assumption of WKLIFE (ICES, 2012) based on the maximum age for the species.
Need to describe process error to observation error	The process error and observation errors are described in full below.
Better description of Monte Carlo Markov Chain simulations	We now include traceplots of MCMC chains for the all runs to illustrate convergence accompanied by the Rhat statistic (ratio of between-chain to within-chain variance) with Rhat =1 indicating perfect convergence and Rhat < 1.1 indicative of acceptable convergence (Kéry, 2010). We also present autocorrelation functions of the final run to indicate MCMC sample independence.
Better description of catch used as inputs, including discards	Discards are described in Section 6.1.6.
Sensitivity analysis required on model results to assumptions on error variances	Measurement error variances come directly from the survey index analyses. The estimated process error variance is very strongly updated from a gamma prior on the precision so we don't think a sensitivity analysis is warranted for the error variances.
Show correlation among abundance indices	Now presented in Figures 6.6.2.5 and 6.6.2.6.
Include sensitivity analysis for including indices with zero or negative correlations with other indices	Again, the survey indices are internally weighted by their measurement error uncertainty and we do not a priori exclude series. Our sensitivity analyses remove the WCSGFS and ECGFS. The ECGFS survey displays negative correlation with the EVHOE and SPNGFS.

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Table A.2.1. Boarfish in Subareas V, VI, VII, VIII. Landings by year (t), 2001–2012. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	Ireland	Denmark	Scotland	Total landings	Estimated Discards	Total Catch inc discards
2001	120	0	0	120	NA	120
2002	91	0	0	91	NA	91
2003	458	0	0	458	10929	11387
2004	675	0	0	675	4476	5151
2005	165	0	0	165	5795	5959
2006	2772	0	0	2772	4365	7137
2007	17615	0	772	18387	3189	21576
2008	21585	3098	0.45	24683	10068	34751
2009	68629	15059	0	83688	6682	90370
2010	88457	39805	9241	137503	6544	144047
2011	20685	7797	2813	31295	5802	37096
2012	55949	19888	4884	80720	6634	87355

Table A.2.2 Boarfish in ICES Subareas V, VI, VII, VIII. Landings by year (t), 2001–2012 and area where available. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

	Denmark	Ireland	Scotland	Total
2001	0	120	0	120
2002	0	91	0	91
2003	0	458	0	458
VI		65		65
VII		393		393
2004	0	675	0	675
VI		292		292
VII		345		345
VIII		38		38
2005	0	165	0	165
VI		10		10
VII		117		117
VIII		38		38
2006	0	2772	0	2772
VI		21		21
VII		2750		2750
VIII		1		1
2007	0	17615	772	18386
V		6		6
VI		93		93
VII		17510	772	18282
VIII		5		5
2008	3098	21584	0	24683
VI		28	0	28
VII		21557		21557
2009	15059	68629	0	83688
VI		45		45
VII		68584		68584
2010	39805	88457	9241	137503
VI		1355	10	1365
VII	39805	87101	9231	136138
2011	7797	20685	2813	31295
VI		26		26
VII	7779	20659	2813	31251
VIII	18			
2012	19888	55949	4884	80720
VI		125		125
VII	18283	55731	4884	78898
VIII	1604	93		1697
Total	**85647**	**277199**	**17710**	**380556**

Table A.3.1 Boarfish in ICES Subareas VI, VII, VIII. IBTS length-frequency data.

		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
IRL	8	1																		
Q4	8.5																			
VIIh	9																			
	9.5	1	5																	
	10		7	3																
	10.5		6	2		2														
	11		1	3	1	4	2	2												
	11.5				2	9	2	2												
	12					5	4	4	2											
	12.5					2	3	2	2	1	3									
	13					3	3		3	2					1			2		1
	13.5						1	1	1	1	2	3	1			1	1	2		1
	14										1	2	2	1	1	1				1
	14.5									1					1			2		1
	15															1		2		1

		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
IRL	9		1																	
Q4	9.5		1																	
VIIj	10		1		2															
	10.5		1				1													
	11			2	2	2	1	1												
	11.5			1	4	15	8	4	2											
	12				1	12	10	8	7	5		1								
	12.5				1	8	12	6	7	6	4	2								
	13					1	4	8	5	6	5	8	2	2	1	1		1	1	
	13.5						2	1	3	5	2	5	5	5	2	1	4	2	1	6
	14								1	2	1	4	6	2	4	3	1	2	2	12
	14.5									1		2	3	5		5	2	2		14
	15										1	1	1	1		5	4	2	1	19
	15.5															2	1	2	1	19
	16																			8
	16.5																			2
	17																			1

IRL & DNK		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
Q4	7	1																		
VIIh	8	1																		
	9	1	5	1																
	10		18	10	5	4														
	11		1	6	12	20	6	5												
	12				1	13	20	13	6	3	4									
	13					4	9	5	6	8	5	3	2	1	5	1	1	4		3
	14								1	1	3	4	4	2	3	2		4	3	9
	15												1	1	1	4	2	3	2	9
	16																			1

IRL & DNK		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
Q4	7	1																		
VIIJ	8		1																	
	9		1																	
	10		2	2	2		1													
	11			3	6	21	14	5	2											
	12				2	25	25	18	16	12	4	3								
	13					2	9	10	11	12	10	13	7	9	3	3	4	3	2	6
	14								1	5	3	8	9	7	5	9	6	6	2	28
	15										1	1	1	2	1	7	5	4	2	38
	16													1	1					11
	17																			1

Table B.2.1. Boarfish age length key produced from 2011 commercial samples. Figures highlighted in grey are estimated.

		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
IRL	8	1																		
Q4	8.5																			
VIIh	9																			
	9.5	1	5																	
	10		7	3																
	10.5		6	2		2														
	11		1	3	1	4	2	2												
	11.5				2	9	2	2												
	12					5	4	4	2											
	12.5					2	3	2	2	1	3									
	13					3	3		3	2					1			2		1
	13.5						1	1	1	1	2	3	1			1	1	2		1
	14										1	2	2	1	1	1				1
	14.5									1					1			2		1
	15															1		2		1

		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
IRL	9		1																	
Q4	9.5		1																	
VIIj	10		1		2															
	10.5		1				1													
	11			2	2	2	1	1												
	11.5			1	4	15	8	4	2											
	12				1	12	10	8	7	5		1								
	12.5				1	8	12	6	7	6	4	2								
	13					1	4	8	5	6	5	8	2	2	1	1		1	1	
	13.5						2	1	3	5	2	5	5	5	2	1	4	2	1	6
	14								1	2	1	4	6	2	4	3	1	2	2	12
	14.5									1		2	3	5		5	2	2		14
	15										1	1	1	1		5	4	2	1	19
	15.5															2	1	2	1	19
	16																			8
	16.5																			2
	17																			1

IRL & DNK		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
Q4	7	1																		
VIIh	8	1																		
	9	1	5	1																
	10		18	10	5	4														
	11		1	6	12	20	6	5												
	12				1	13	20	13	6	3	4									
	13					4	9	5	6	8	5	3	2	1	5	1	1	4		3
	14								1	1	3	4	4	2	3	2		4	3	9
	15												1	1	1	4	2	3	2	9
	16																			1

IRL & DNK		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
Q4	7	1																		
VIIJ	8		1																	
	9		1																	
	10		2	2	2		1													
	11			3	6	21	14	5	2											
	12				2	25	25	18	16	12	4	3								
	13					2	9	10	11	12	10	13	7	9	3	3	4	3	2	6
	14								1	5	3	8	9	7	5	9	6	6	2	28
	15										1	1	1	2	1	7	5	4	2	38
	16													1	1					11
	17																			1

Table B.2.2. Age length key allocations made to unsampled metiers in 2011.

Country	Area	Quarter	Landed (t)	ALK
IRL	VIIb	1	39	IRL_VIIj_Q4
IRL	VIIj	1	38	IRL_VIIj_Q4
IRL	VIIb	2	1	IRL_VIIj_Q4
IRL	VIIh	3	820	IRL_VIIh_Q4
IRL	VIIj	3	1092	IRL_VIIj_Q4
IRL	VIa	4	26	IRL_VIIj_Q4
IRL	VIIb	4	235	IRL_VIIj_Q4
IRL	VIIc	4	9	IRL_VIIj_Q4
IRL	VIIg	4	811	IRL_VIIj_Q4
IRL	VIIh	4	7720	IRL_VIIh_Q4
IRL	VIIj	4	9894	IRL_VIIj_Q4
DNK	VIIh	1	32	Combined IRL&DNK (1.0cm)_VIIh_Q4
DNK	VIIIa	1	18	Combined IRL&DNK (1.0cm)_VIIh_Q4
DNK	VIIj	1	1	Combined IRL&DNK (1.0cm)_VIIj_Q4
DNK	VIIh	4	4123	Combined IRL&DNK (1.0cm)_VIIh_Q4
DNK	VIIj	4	3623	Combined IRL&DNK (1.0cm)_VIIj_Q4
SCT	VIIh	3	434	IRL_VIIh_Q4
SCT	VIIh	4	2379	IRL_VIIh_Q4

Table B.2.3. Boarfish in ICES Subareas V, VI, VII, VIII. Sampling intensity by country of commercial catches.

			DK				IRL				SCT			
Year	Q	Area	Landings	Samples	Measured	Allocated	Landings	Samples	Measured	Allocated	Landings	Samples	Measured	Allocated
2007	1	VIa					12	0	0	VIIj_Q2 and VIa_Q4				
	1	VIIIa					5	0	0	VIIj_Q2 and VIa_Q4				
	1	VIIj					5253	0	0	VIIj_Q2 and VIa_Q4	772	0	0	Irish 2007 combined
	2	VIIg					120	0	0	VIIj_Q2 and VIa_Q4				
	2	VIIj					4130	2	197	VIIj_Q2 and VIa_Q4				
	3	VIIb					0	0	0	VIIj_Q2 and VIa_Q4				
	4	Vb2					6	0	0	VIIj_Q2 and VIa_Q4				
	4	VIa					82	1	20	VIIj_Q2 and VIa_Q4				
	4	VIIb					1259	0	0	VIIj_Q2 and VIa_Q4				
	4	VIIj					6748	0	0	VIIj_Q2 and VIa_Q4				
	Total		0	0	0		17615	3	217		772	0	0	
2008	1	VIa					5	0	0	VIIj_Q4				
	1	VIIg					184	0	0	VIIj_Q4				
	1	VIIj					5041	0	0	VIIj_Q4				
	2	VIIj					46	0	0	VIIj_Q4				
	3	VIIj					4067	0	0	VIIj_Q4				
	4	VIa					23	0	0	VIIj_Q4	0.5	0	0	Irish 2008 combined
	4	VIIb					3	0	0	VIIj_Q4				
	4	VIIj					12216	1	152	VIIj_Q4				
	Total		3098	0	0		21584	1	152		0.5	0	0	
2009	1	VIIb					55	0	0	VIIj_Q3				
	1	VIIg					2979	0	0	VIIj_Q3				
	1	VIIh					1971	0	0	VIIj_Q3				
	1	VIIj					10901	2	359	VIIj_Q3				
	2	VIIg					1933	0	0	VIIj_Q3				
	2	VIIh					3169	0	0	VIIj_Q3				
	2	VIIj					2727	0	0	VIIj_Q3				
	3	VIIh					10378	0	0	VIIj_Q3				
	3	VIIj					11423	1	175					
	4	VIa					45	0	0	VIIj_Q4				
	4	VIIb					18	0	0	VIIj_Q4				
	4	VIIh					2707	0	0	VIIj_Q4				
	4	VIIj					20321	6	941					
	Total		15059	0	0		68629	9	1475		0	0	0	
2010	1	VIa									10	0	0	Irish 2010 VIIb_Q1
	1	VIIb					1069	1	102					
	1	VIIg	577	1	77		2392	0	0	VIIj_Q1				
	1	VIIh	1079	0	0	VIIg+VIIj_Q1	326	1	94					
	1	VIIj	32422	2	193		34466	12	1447		2504	0	0	Irish 2010 VIIj_Q1
	2	VIIh					102	0	0	VIIh_Q3				
	2	VIIj	344	0	0	VIIj_Q1								
	3	VIIg					338	0	0	VIIh_Q3				
	3	VIIh	377	0	0	VIIh_Q4	5540	8	1316		548	0	0	Irish 2010 VIIh_Q3
	3	VIIj	2660	0	0	VIIj_Q4	11531	31	3275		2171	0	0	Irish 2010 VIIj_Q3
	4	VIa					1355	1	117					
	4	VIIb					1189	0	0	VIIj_Q4				
	4	VIIc					35	0	0	VIIj_Q4	4	0	0	Irish 2010 VIIj_Q4
	4	VIIe	2	0	0	VIIh_Q4								
	4	VIIg	94	0	0	VIIh+VIIj_Q4	920	0	0	VIIh_Q4				
	4	VIIh	9	3	384		2484	6	715		1165	0	0	Irish 2010 VIIh_Q4
	4	VIIj	2241	2	217		26710	27	2738		2840	0	0	Irish 2010 VIIj_Q4
	Total		39805	8	871		88457	87	9804		9241	0	0	
2011	1	VIIb					39	0	0	VIIj_Q4				
	1	VIIh	32	0	0	VIIh_Q4								
	1	VIIIa	18	0	0	VIIh_Q4								
	1	VIIj	1	0	0	VIIj_Q4	38	0	0	VIIj_Q4				
	2	VIIb					1	0	0	VIIj_Q4				
	3	VIIh					820	0	0	VIIh_Q4	434	0	0	Irish 2011 VIIh_Q4
	3	VIIj					1092	0	0	VIIj_Q4				
	4	VIa					26	0	0	VIIj_Q4				
	4	VIIb					235	0	0	VIIj_Q4				
	4	VIIc					9	0	0	VIIj_Q4				
	4	VIIg					811	0	0	VIIj_Q4				
	4	VIIh	4123	11	1347		7720	3	319		2379	0	0	Irish 2011 VIIh_Q4
	4	VIIj	3623	5	611		9894	8	1789					
	Total		7797	16	1958		20685	11	2108		2813	0	0	
2012	1	VIIb					4365	3	339					
	1	VIIg					616	0	0	IRL_Q3_VIIh				
	1	VIIh	3789	1	150	IRL_Q3_VIIh	1005	0	0	IRL_Q3_VIIh				
	1	VIIj	11403	3	102	IRL_Q1_VIIj	27812	42	4987					
	1	VIIIa	1330	2	214	IRL_Q3_VIIh								
	2	VIIh	208	0	0	IRL_Q3_VIIh								
	3	VIIb					49	0	0	IRL_Q1_VIIb				
	3	VIIh					3176	5	682		1537	0	0	IRL_Q3_VIIh
	3	VIIj					834	2	341					
	4	VIa					125	1	96					
	4	VIIb	80	0	0	IRL_Q1_VIIb	87	0	0	IRL_Q1_VIIb	838	0	0	IRL_Q1_VIIb
	4	VIIc					108	0	0	IRL_Q1_VIIb	907	0	0	IRL_Q1_VIIb
	4	VIIh	1840	4	445	IRL_Q4_VIIh	6398	7	945		1602	0	0	IRL_Q4_VIIh
	4	VIIIa	274	0	0	IRL_Q4_VIIj	93	0	0	IRL_Q4_VIIh				
	4	VIIj	963	2	180	IRL_Q4_VIIj	11281	8	1175					
Total			19888	12	1091		55949	68	8565		4884	0	0	

Table B.2.4. Boarfish in ICES Subareas V, VI, VII, VIII. Age length key produced from combined commercial and survey samples. Shaded portion indicates commercial fishery size and age range.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	28	29
2.5	3																												
3	10																												
3.5	2																												
4	1																												
5		2																											
5.5		7																											
6		5																											
6.5		6	2																										
7		5	3																										
7.5		4	3																										
8			5	1																									
8.5			17	6																									
9		1	7	9	1																								
9.5			3	11	6																								
10			1	6	17	7	1																						
10.5			1	1	14	10	1																						
11					13	15	7	2																					
11.5				2	2	8	7	4	1																				
12						3	14	3	5																				
12.5					1	2	5	8		4	3	1																	
13							3	3	4	4	2	1	1	1			1												
13.5								3	3	2	3	1	1	2		1	1			1	1								1
14										4	3	1	3		1		1							1	1				
14.5								1		2	2		2	2	3				2		1	2							
15											1				1	1		1	1		1	1	1		1			1	
15.5											1	1	3		1		1			1		1			1		1	1	
16																				1			1	1					
16.5																1			1		1			1		2			
17																		1	1			2	3		2				
17.5																							1						
18																											1		
23																													

Table B.2.5. Boarfish in ICES Subareas V, VI, VII, VIII. Length-frequency distributions of the international catches (raised numbers in '000s) for the years 2007-2012.

TL (cm)	2007	2008	2009	2010	2011	2012	Total
6	0	0	0	156	0	0	156
6.5	0	0	0	439	0	0	439
7	0	0	0	1090	522	56	1667
7.5	0	0	1354	1574	0	0	2928
8	0	0	677	375	1345	185	2581
8.5	0	0	0	1082	0	555	1637
9	0	0	677	5382	851	555	7464
9.5	0	7473	17367	7883	7012	641	40375
10	9609	11209	54130	29410	33243	2791	140392
10.5	0	52308	174796	130889	15848	6132	379974
11	84555	63517	343283	361774	70615	24571	948316
11.5	0	59781	321637	655875	93487	81928	1212708
12	44199	119561	297737	739025	189434	264888	1654845
12.5	0	70990	207739	564347	114904	398772	1356751
13	82633	52308	147965	353484	133539	419060	1188989
13.5	0	29890	149314	246146	51235	307533	784119
14	117224	22418	105782	224611	50857	176710	697602
14.5	0	14945	71273	127711	25309	89726	328964
15	65338	33627	47816	125463	25569	52791	350603
15.5	0	11209	13082	81386	5473	25065	136215
16	13452	11209	19397	24256	4181	13149	85644
16.5	0	3736	4061	6209	2280	2738	19024
17	0	3736	677	1913	456	827	7609
17.5	0	0	0	0	0	0	0
18	0	0	0	283	0	0	283

Table B.2.6. Boarfish in ICES Subareas V, VI, VII, VIII. Proxy catch numbers-at-age of the international catches (raised numbers in '000s) for the years 2007-2012.

	2007	2008	2009	2010	2011	2012
1	0	0	1575	2415	0	28
2	352	5488	15043	11229	2894	893
3	2114	21140	65744	72709	41913	5467
4	40851	105575	338931	294382	28148	41278
5	48915	141300	475619	567689	30116	110272
6	62713	195339	543707	878363	175696	146582
7	26132	104031	307333	522703	143967	492078
8	29766	66570	172783	293719	107126	365840
9	56075	53159	155477	276672	77861	271916
10	44875	46893	130148	232122	60022	173486
11	14019	15289	42521	78588	46079	69396
12	32359	21178	61350	114600	40468	40968
13	4848	11854	39609	59932	24352	58888
14	16837	13570	31569	59060	19724	30277
15+	109481	112947	196967	349320	157707	217260

Table B.3.1 Parameter estimates of the von Bertalanffy growth equation

	Estimate	Std. error	t value	Pr(>|t|)
Linf	15.563073	0.134828	115.43	<2e-16 ***
K	0.190592	0.006698	28.45	<2e-16 ***
t0	-1.662997	0.109091	-15.24	<2e-16 ***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				
Residual standard error: 0.8982 on 404 degrees of freedom				

Table B.3.2. Boarfish in area VI, VII and VIII. IBTS length-frequency data converted to age-structured index by application of the common ALK.

All	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1997	9186	11460	5356	4603	4209	7331	6050	4331	4970	4375	1498	2491	1741	1248	635	1242	161	676	635	3814
1998	17475	19641	6886	6423	5693	7515	5791	3814	4860	4439	1481	2883	1654	1644	685	1240	236	917	685	4965
1999	11838	33029	20031	8826	3580	3421	2837	1990	2911	2552	804	1716	1045	1010	320	705	80	539	320	2435
2000	19340	29071	12974	18627	16220	19669	14950	10117	11553	9928	3345	5427	3955	2717	1310	2709	265	1470	1310	7757
2001	20344	44451	20694	25753	22184	16593	9665	4839	5137	4484	1492	2471	1545	1362	643	1109	175	824	643	4482
2002	10040	33131	18597	13158	9120	9171	6846	4380	6006	5313	1699	3476	2053	2046	696	1430	202	1115	696	5313
2003	840	4714	8356	20850	19443	18478	13092	7863	10801	10051	3279	7063	3662	4270	1598	2792	629	2439	1598	12890
2004	5958	5660	2092	2537	3567	8255	7560	5288	8479	8618	2871	6954	2968	4378	1924	2576	866	2794	1924	16191
2005	4201	4323	2012	2784	3836	9869	9393	6931	10296	9875	3269	7332	3684	4419	1814	2913	759	2642	1814	14728
2006	44120	35631	8054	7238	6703	8802	9417	6528	14774	15648	4994	14441	5398	9659	3847	4781	1967	6478	3847	37015
2007	24531	128029	67188	19124	7326	8707	7376	4824	8405	8454	2739	7014	2967	4520	1748	2495	799	2784	1748	15325
2008	43985	262478	172674	148047	91323	53729	31280	15702	23250	22959	7433	17778	7213	11602	5022	6177	2310	7992	5022	45589
2009	18107	42788	14748	10829	12257	14366	9760	5252	7847	7656	2476	5816	2443	3766	1259	2049	642	2128	1259	11324
2010	58552	98227	37475	25665	30828	52503	37174	21833	27440	24593	8035	15093	8215	8983	3253	6110	1257	4997	3253	25820
2011	8615	17617	17110	34003	34910	52378	39952	26259	31789	27728	9181	16113	10503	8764	3850	7350	1012	5048	3850	26631
2012	32050	40410	12771	13406	14205	27201	28554	21680	36693	35756	11588	28599	13608	17833	7714	10766	2944	11650	7714	64807
EVHOE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20+**
1997	1876	6003	3741	3911	3938	7065	5867	4218	4832	4259	1461	2428	1699	1214	623	1215	159	659	623	3737
1998	12977	15997	6248	6247	5591	7435	5732	3777	4806	4386	1463	2843	1635	1619	676	1224	232	904	676	4888
1999	7576	31223	19915	8732	3499	3308	2715	1905	2720	2357	743	1540	975	893	285	647	62	474	285	2102
2000	17676	27730	12586	17986	15525	18740	14297	9737	11041	9490	3208	5160	3797	2556	1266	2604	253	1384	1266	7385
2001	14389	41313	20357	25467	21921	16211	9247	4525	4543	3951	1332	2057	1322	1098	578	959	153	684	578	3884
2002	6719	31728	18455	12784	8389	7115	4767	2851	3429	3018	994	1806	1123	1009	421	796	117	573	421	2964
2003	509	3993	7348	18371	17276	16113	10798	6270	7620	6852	2267	4294	2501	2456	1009	1838	326	1387	1009	7340
2004	1265	1976	1261	1722	2227	4124	3228	2061	2871	3058	1066	2426	939	1509	901	917	382	1142	901	7311
2005	2102	2603	1497	2098	3015	7160	5992	4177	5301	4873	1642	3144	1796	1776	833	1368	285	1065	833	6107
2006	35834	26593	4803	2199	1386	1489	1332	947	1521	1484	485	1170	557	725	311	445	125	464	311	2596
2007	16818	122140	65369	16986	4919	4316	2967	1715	2452	2392	788	1802	820	1124	484	678	204	715	484	4049
2008	41611	258758	168378	134061	77106	37738	18750	8277	9132	8183	2660	4868	2458	2992	1226	1876	492	1919	1226	10417
2009	13338	36829	12194	5626	5982	7788	5443	3054	4443	4230	1364	3079	1382	1965	618	1114	309	1064	618	5485
2010	33601	83903	35048	21678	23503	34210	23037	12643	16303	14519	4647	9008	4716	5551	1689	3457	690	2957	1689	14298
2011	2212	12471	14982	28729	26114	31844	23915	15535	19473	16964	5542	10176	6534	5663	2262	4513	597	3197	2262	16235
2012	20089	34348	11535	11098	10795	14979	13308	9004	15662	14714	4598	11467	5540	7325	2325	4142	920	4164	2325	20439
IGFS+WCSGFS+EVHOE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20+**
2003	636	4552	8306	20803	19406	18414	13013	7804	10668	9916	3237	6942	3612	4190	1573	2752	617	2393	1573	12654
2004	1685	3414	1912	2444	3481	8017	7255	5037	8031	8189	2735	6610	2796	4164	1860	2446	838	2683	1860	15644
2005	2930	3604	1895	2694	3773	9738	9200	6777	9949	9514	3154	7004	3553	4203	1731	2801	721	2505	1731	13978
2006	36687	28176	6830	7100	6633	8714	9277	6421	14479	15337	4898	14144	5288	9457	3779	4686	1933	6356	3779	36365
2007	17873	124020	66810	18929	7205	8648	7322	4790	8309	8353	2708	6917	2932	4453	1729	2464	788	2746	1729	15126
2008	42240	260577	172031	147113	90691	53328	31023	15587	22918	22641	7344	17496	7113	11395	4967	6101	2285	7861	4967	44972
2009	13607	37705	13658	10616	12063	14060	9426	5030	7283	7072	2296	5275	2243	3396	1141	1878	582	1909	1141	10185
2010	33976	84649	35967	24858	30441	52245	36921	21671	26982	23992	7828	14456	8055	8546	3060	5910	1145	4712	3060	24053
2011	2884	13954	16666	33742	34724	52174	39716	26089	31387	27290	9039	15699	10356	8486	3752	7213	958	4882	3752	25707
2012	20395	35049	12386	13340	14140	26984	28191	21406	35924	34955	11342	27840	13323	17314	7548	10525	2861	11338	7548	63197
SPNGFS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20+**
1997	7306	5446	1609	681	249	203	121	67	69	56	18	22	18	11	4	11	0	6	4	23
1998	4493	3640	638	175	101	79	58	37	54	53	17	40	19	25	9	15	4	14	9	77
1999	4258	1802	116	93	80	112	121	85	191	195	61	175	70	117	35	58	18	65	35	333
2000	1661	1325	347	518	553	750	537	315	443	379	116	237	139	146	37	91	10	78	37	325
2001	5952	3099	308	205	161	197	190	148	199	175	58	114	77	62	25	53	6	34	25	169
2002	3315	1395	104	54	43	55	63	47	98	88	26	71	37	46	10	25	3	24	10	97
2003	203	155	38	26	16	14	10	5	9	9	3	7	3	4	2	2	1	3	2	15
2004	4267	2243	177	82	68	171	219	186	303	279	89	209	118	124	37	85	14	63	37	294
2005	1253	701	108	78	46	50	60	51	84	78	25	59	33	35	15	24	4	22	15	116
2006	7297	7378	1191	85	34	36	56	44	116	112	33	100	43	68	14	32	8	35	14	154
2007	6646	3990	367	180	106	37	30	18	55	54	16	50	20	35	8	15	4	20	8	92
2008	1736	1886	629	908	597	329	178	62	202	183	47	158	53	122	28	36	10	81	28	352
2009	4487	5077	1085	168	104	79	71	26	174	155	37	147	56	113	9	34	6	58	9	194
2010	24558	13572	1504	792	346	101	85	41	222	365	132	436	76	306	146	130	91	206	146	1347
2011	5730	3656	432	244	163	94	77	38	140	182	61	198	48	140	50	59	33	84	50	493
2012	11653	5359	383	62	55	160	276	202	620	657	201	638	228	441	140	198	73	266	140	1382

Table B4.4 Boarfish in ICES Subareas V, VI, VII, VIII. Boarfish acoustic survey results.

2011 *MFV Felucca* - 24 hour operations

	Abun (mil)	Biomass (t)	%
Total estimate			
Definitely	7,049	393,893	86.4
Probably	1,134	62,222	13.6
Mixture	-	-	-
Total estimate	**8,183**	**456,115**	**100**
Possibly			
CV TSB	17.5	17.6	
SSB Estimate			
Definelty	7,019	393,312	86.4
Probably	1,126	62,063	13.6
Mixture	0	0	0.0
SSB estimate	**8,145**	**455,375**	**100**
Possibly	-	-	

2012 *MFV Father McKee* - daylight only (04:00 - 24:00) operations

	Abun (mil)	Biomass (t)	%
Total estimate			
Definitely	11,684	708,019	82.0
Probably	2,072	123,723	14.3
Mixture	501	31,704	3.7
Total estimate	**14,257**	**863,446**	**100**
Possibly	16	1,017	
CV TSB	10.6	10.7	
SSB Estimate			
Definelty	11,615	706,582	82.0
Probably	2,050	123,286	14.3
Mixture	500	31,676	3.7
SSB estimate	**14,165**	**861,544**	**100**
Possibly	16	1,017	

2013 *MFV Felucca* - daylight only (04:00 - 24:00) operations

	Abun (mil)	Biomass (t)	%
Total estimate			
Definitely	8,834	431,571	98.1
Probably	240	7,187	1.6
Mixture	17	1,139	0.3
Total estimate	**9,091**	**439,897**	**100**
Possibly	-	-	
CV TSB	17.5	16.7	
SSB Estimate			
Definelty	8,120	416,124	98.3
Probably	179	5,895	1.4
Mixture	17	1,139	0.3
SSB estimate	**8,316**	**423,158**	**100**
Possibly	-	-	

Biomass derived using a modelled boarfish TS-Length relationship (-66.2dB).

Table B4.5. Boarfish in ICES Subareas V, VI, VII, VIII. Pseudo-cohort derived estimates of fishing mortality (F) and total mortality (Z), in comparison with total landings per year. Pearson correlation coefficient of F vs. landings (tonnes) indicated.

Age	2007	2008	2009	2010	2011	2012	2007	2008	2009	2010	2011	2012
	Raised numbers						ln (raised numbers)					
1	0	0	1575	2415	0	28	0	0	7	8	0	3
2	352	5488	15043	11229	2894	893	6	9	10	9	8	7
3	2114	21140	65744	72709	41913	5467	8	10	11	11	11	9
4	40851	105575	338931	294382	28148	41278	11	12	13	13	10	11
5	48915	141300	475619	567689	30116	110272	11	12	13	13	10	12
6	62713	195339	543707	878363	175696	146582	11	12	13	14	12	12
7	26132	104031	307333	522703	143967	492078	10	12	13	13	12	13
8	29766	66570	172783	293719	107126	365840	10	11	12	13	12	13
9	56075	53159	155477	276672	77861	271916	11	11	12	13	11	13
10	44875	46893	130148	232122	60022	173486	11	11	12	12	11	12
11	14019	15289	42521	78588	46079	69396	10	10	11	11	11	11
12	32359	21178	61350	114600	40468	40968	10	10	11	12	11	11
13	4848	11854	39609	59932	24352	58888	8	9	11	11	10	11
14	16837	13570	31569	59060	19724	30277	10	10	10	11	10	10
15+	109481	112947	196967	349320	157707	217260	12	12	12	13	12	12
Z							0.19	0.35	0.35	0.34	0.28	0.31
F (Z-M), where M = 0.16							0.03	0.19	0.19	0.18	0.12	0.15
Catches (t)							21576	34751	90370	144047	36937	86414
Correllation coefficient landings vs. F							0.61					

Table C 1.1. Boarfish in ICES Subareas V, VI, VII, VIII. Results of VIT pseudo-cohort analysis based on 2010 mortality estimates.

Catch mean age	8.66
Catch mean length	12.81
Mean F	0.14
Mean Z	0.3
Number of recruits, R	52 752
Spawning Stock Biomass, SSB	2 053 583 t
Total Stock Biomass, SSB	2 814 472 t

Table C 1.2. Boarfish in ICES Subareas VI, VII, VIII. Key parameter estimates from all runs. CV(TSB_{2013}) is the coefficient of variation of the estimated total stock biomass in 2013.

Run	r	K	F_{MSY}	B_{MSY}	TSB_{2013}	CV(TSB_{2013})
1	0.481	731549	0.241	365775	500945	0.156
2	0.493	835581	0.247	417791	633617	0.44
3	0.467	634469	0.233	317234	472169	0.153
4	0.466	865294	0.233	432647	665705	0.555
1.1	0.552	768400	0.276	384200	493886	0.161
2.1	0.551	898583	0.275	449292	604780	0.444
3.1	0.528	660356	0.264	330178	470985	0.157
4.1	0.517	828299	0.259	414150	607527	0.434
2.2	0.459	911209	0.229	455605	653668	0.436

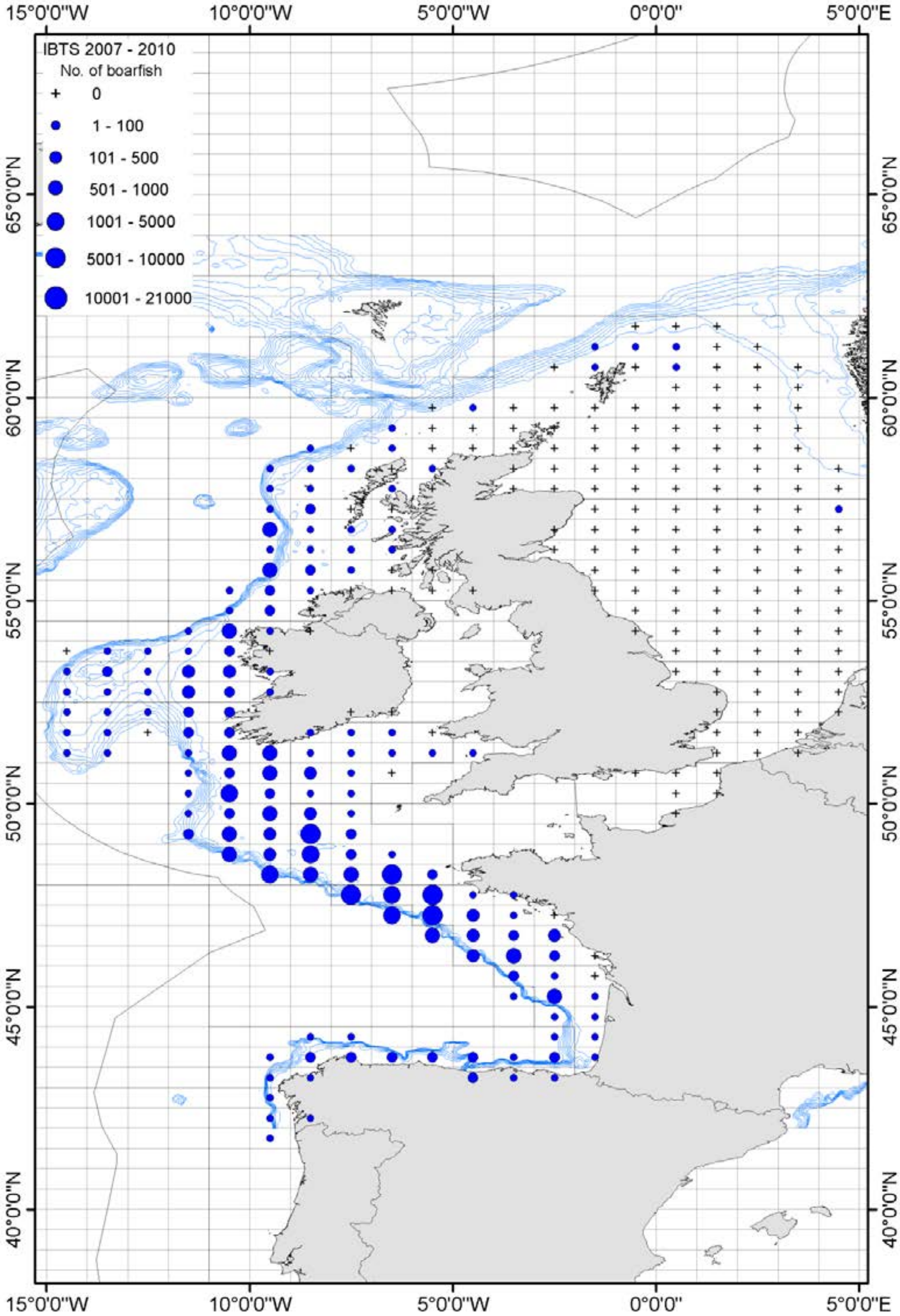


Figure A.1.1 Boarfish in ICES Subareas V, VI, VII, VIII. Distribution of boarfish in the NE Atlantic showing proposed management area.

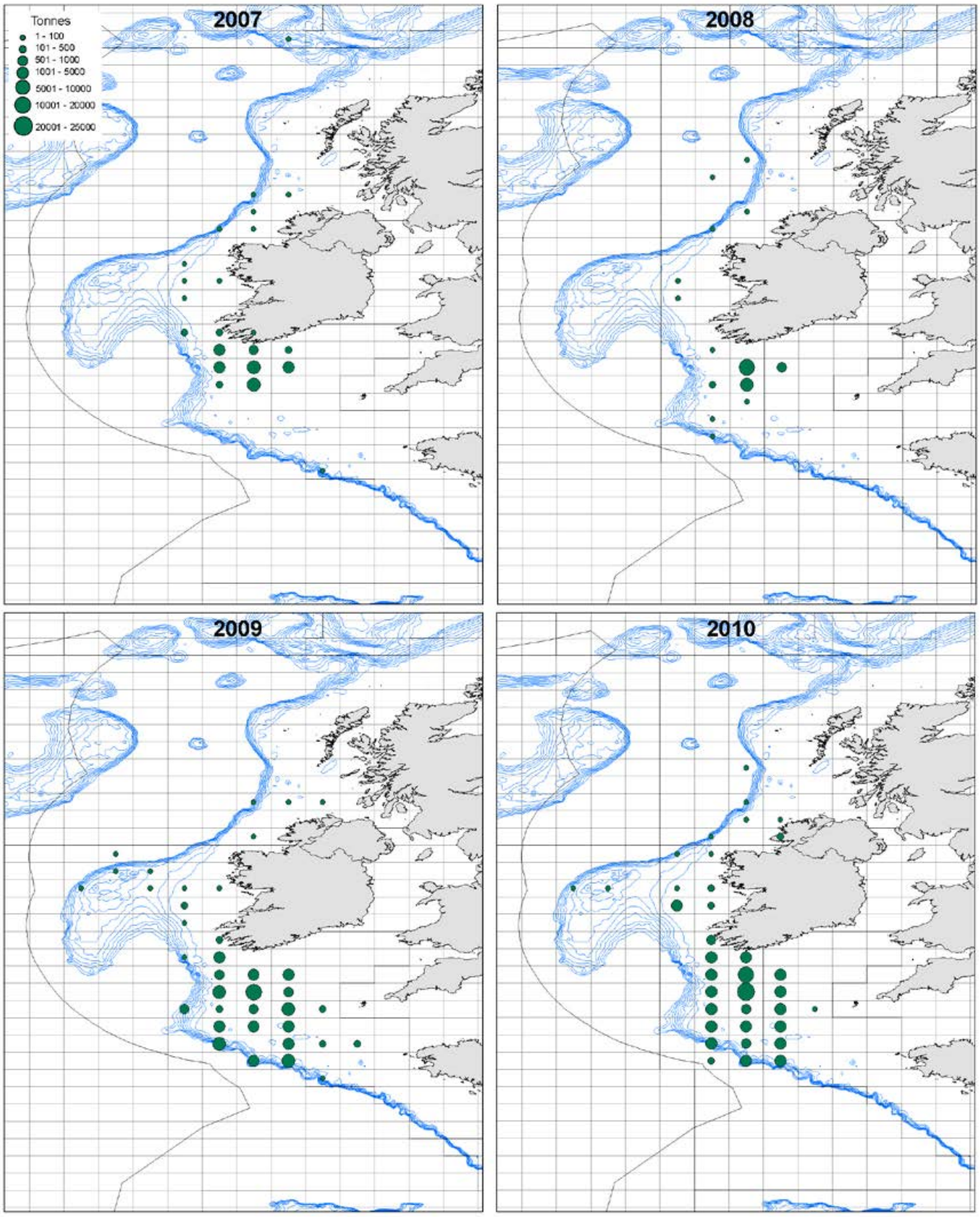


Figure A.1.2. Boarfish in ICES Subareas V, VI, VII, VIII. Irish catches by rectangle and year .

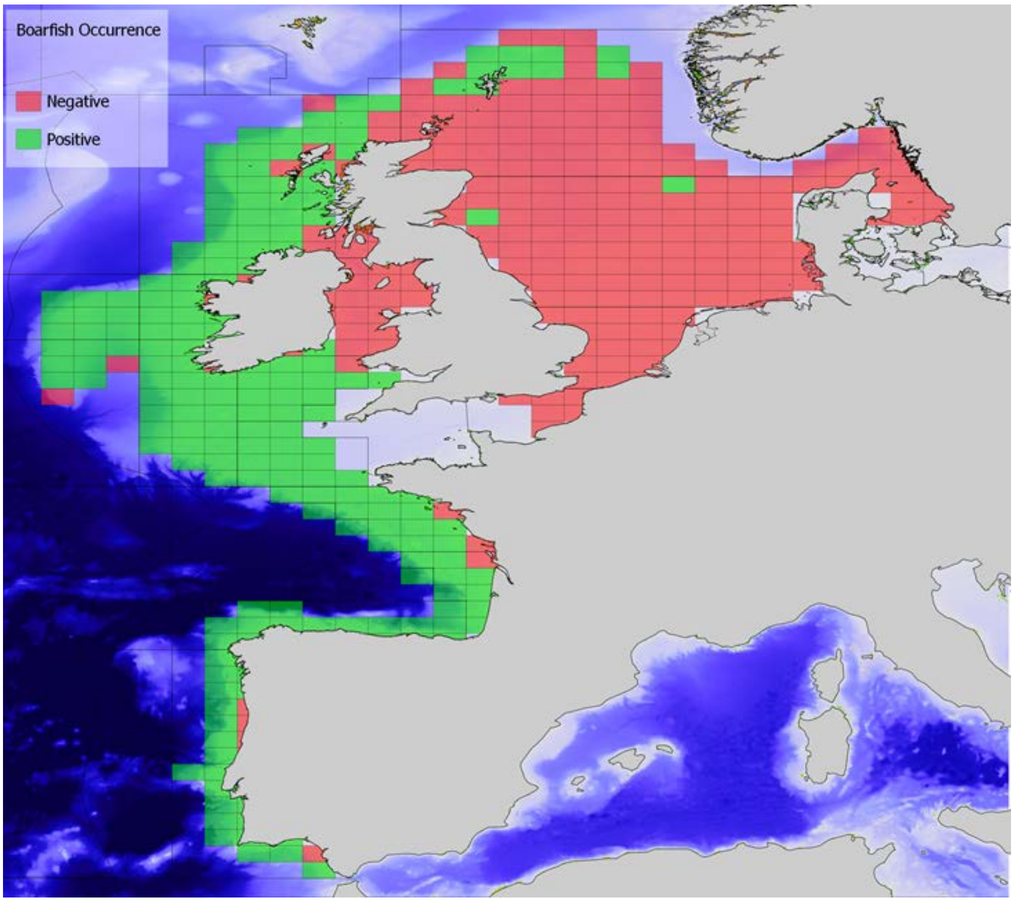


Figure A.1.3. Boarfish in ICES Subareas VI, VII, VIII. Distribution of boarfish in the NE Atlantic area based on presence and absence in IBTS surveys.

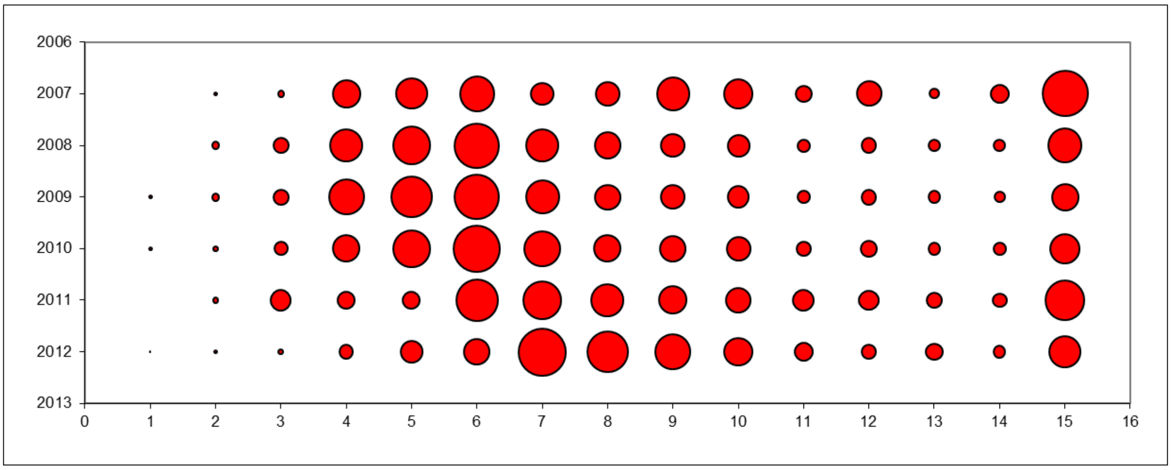


Figure B.2.1. Boarfish in ICES Subareas V, VI, VII, VIII. Catch numbers-at-age standardised by early mean. 20+ is the plus group.

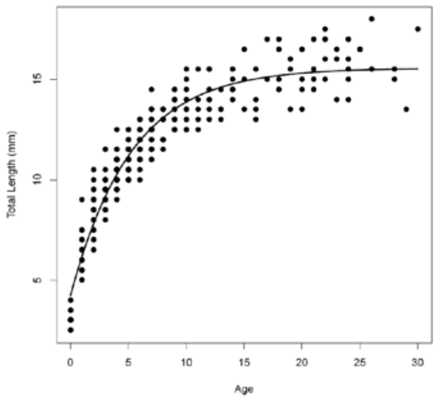


Figure B.3.1 von Bertalanffy growth curve; see Table B.3.1 for parameter estimates

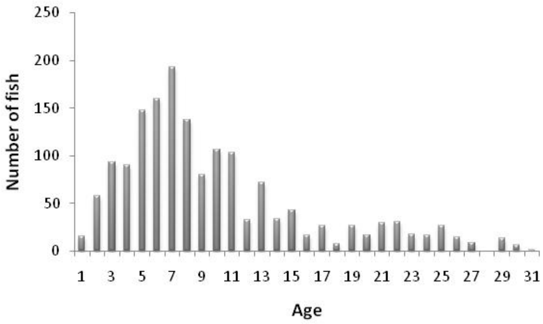


Figure B.3.2 Age distribution for n=1633 fish sampled

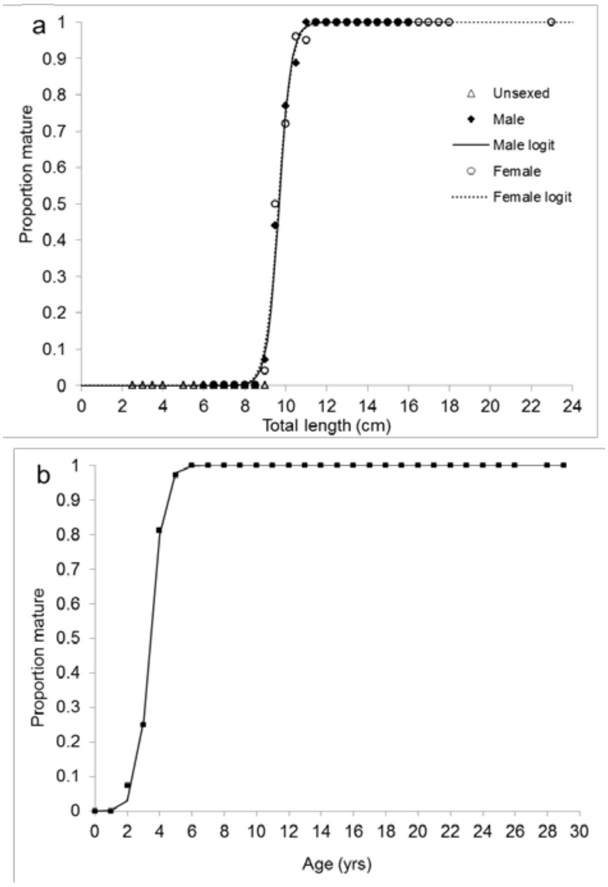


Figure B.3.3 Maturity ogives for (a) total length and (b) age for boarfish

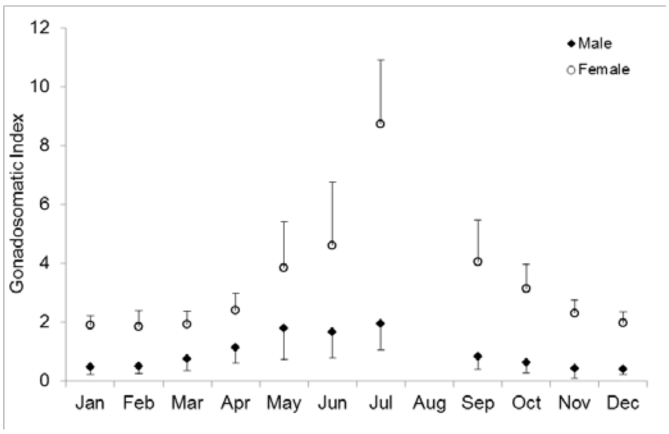


Figure B.3.4 Gonadosomatic index for male and female boarfish

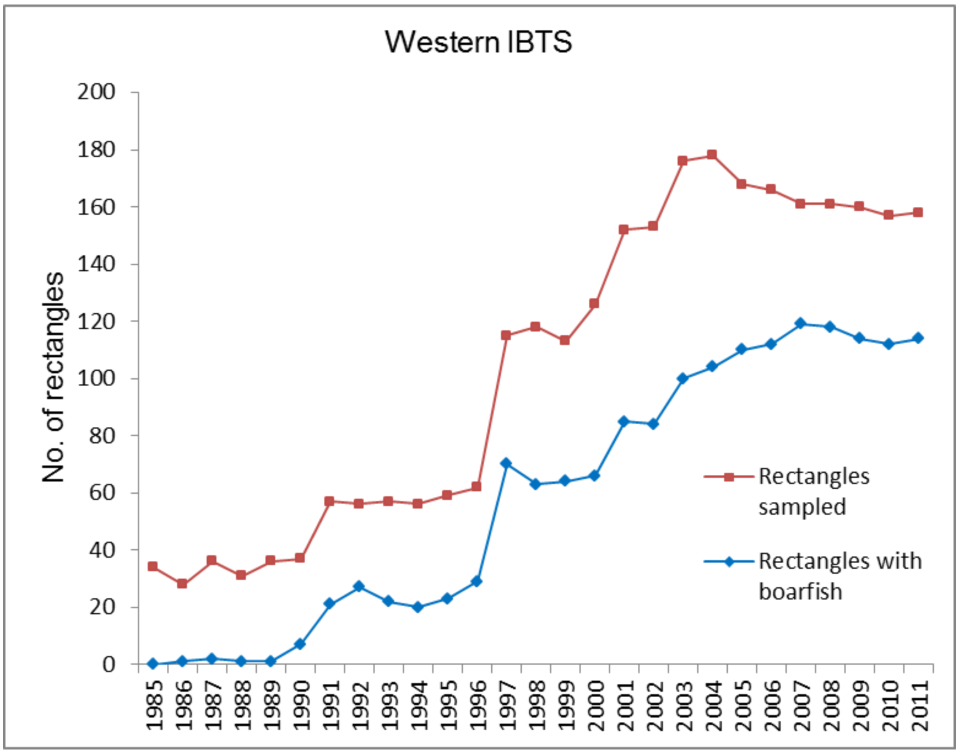


Figure B.4.1 Occurrence of boarfish in ICES Rectangles sampled during the western IBTS 1985 – 2011.

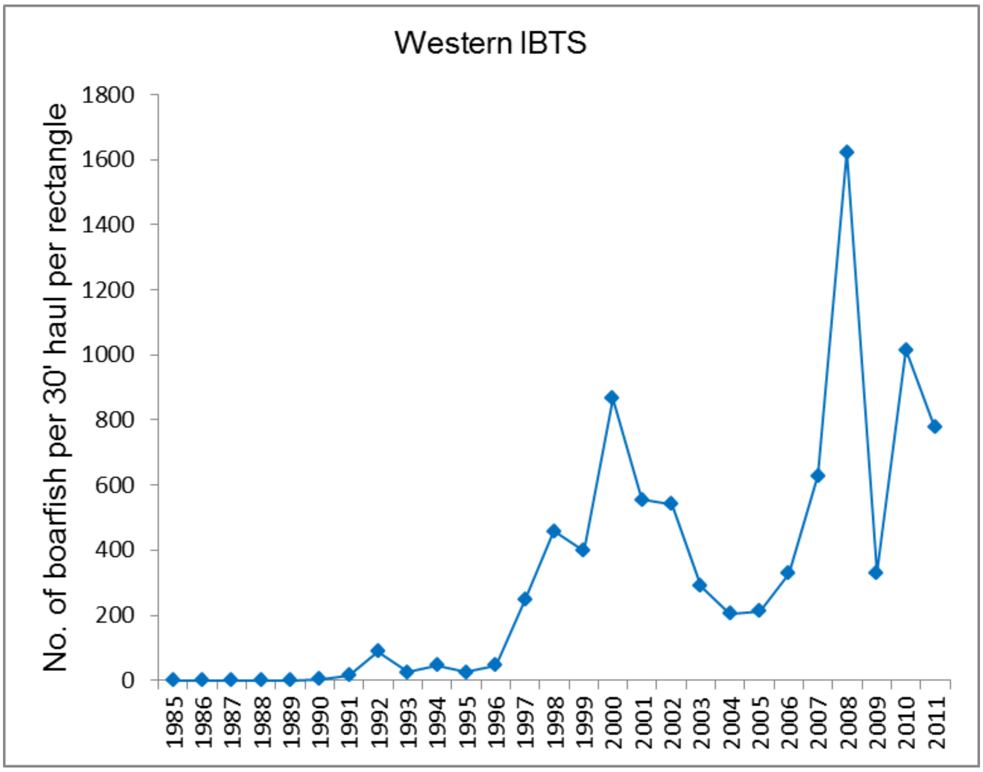
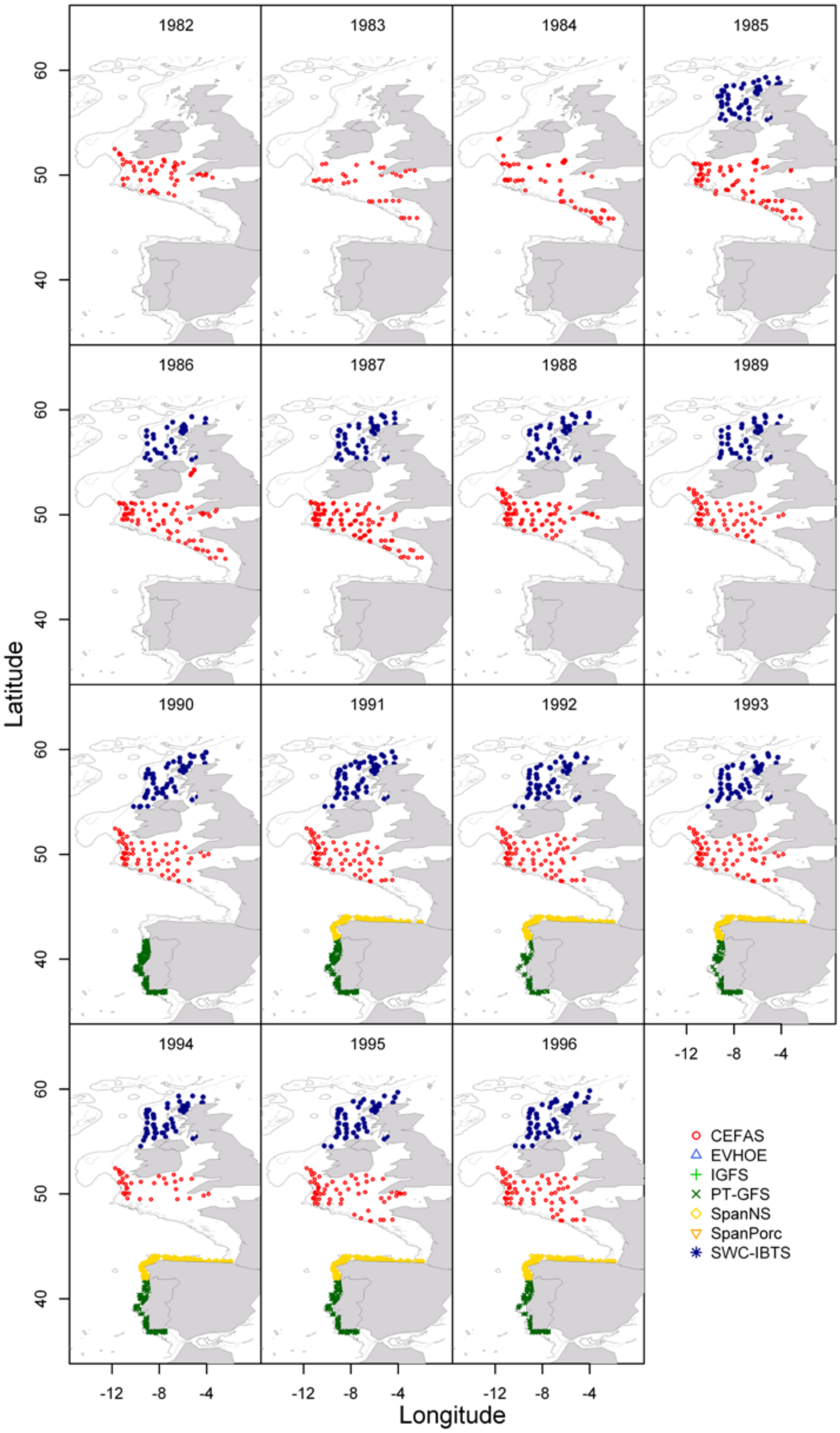


Figure B.4.2 Boarfish in ICES Subareas VI, VII, VIII. CPUE in number per 30 minute haul of boarfish per rectangle in the western IBTS survey 1985 to 2011.


1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
Latitude
60
50
40
-12
-8
-4
Longitude
CEFAS
EVHOE
IGFS
PT-GFS
SpanNS
SpanPorc
SWC-IBTS

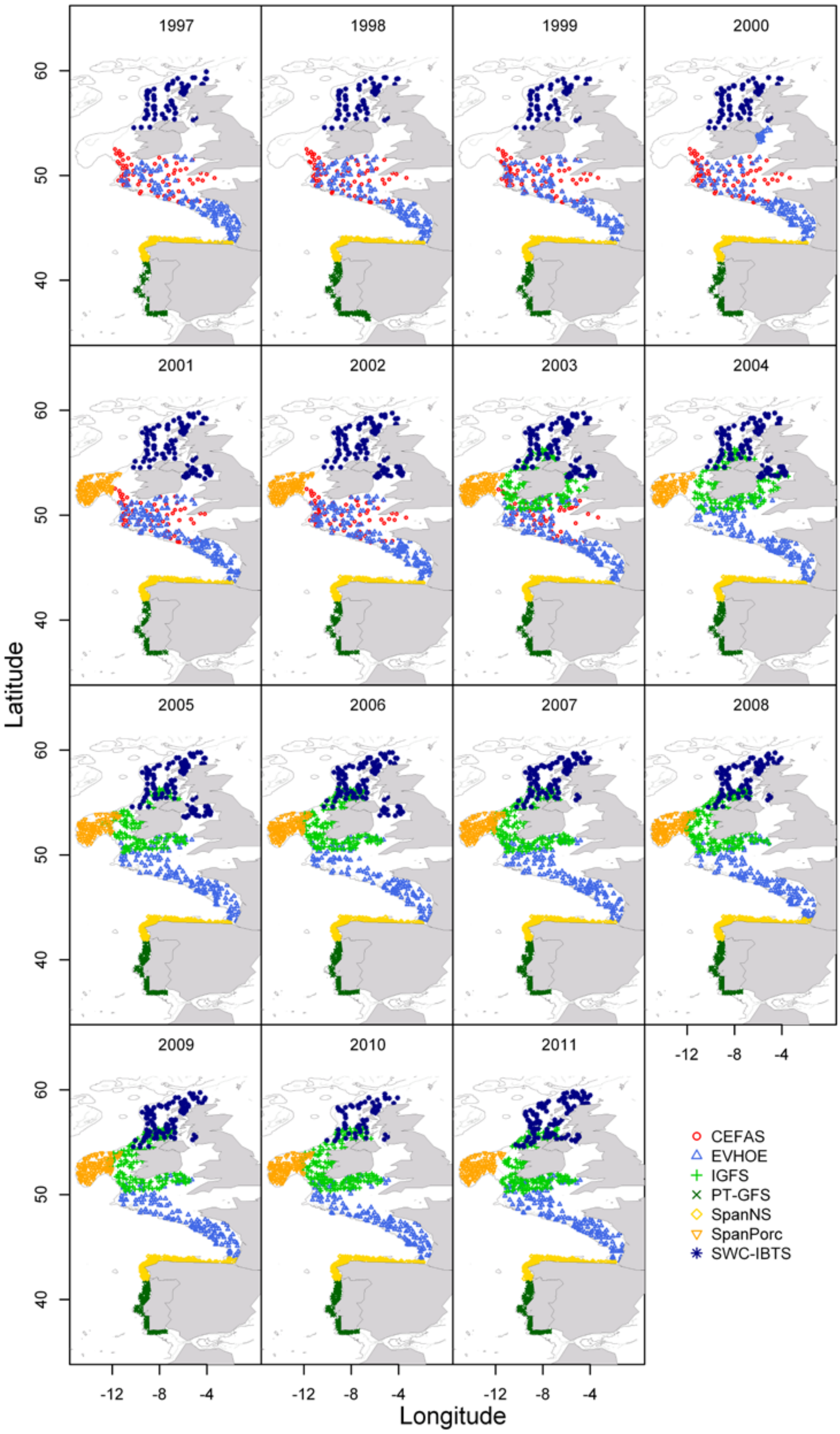
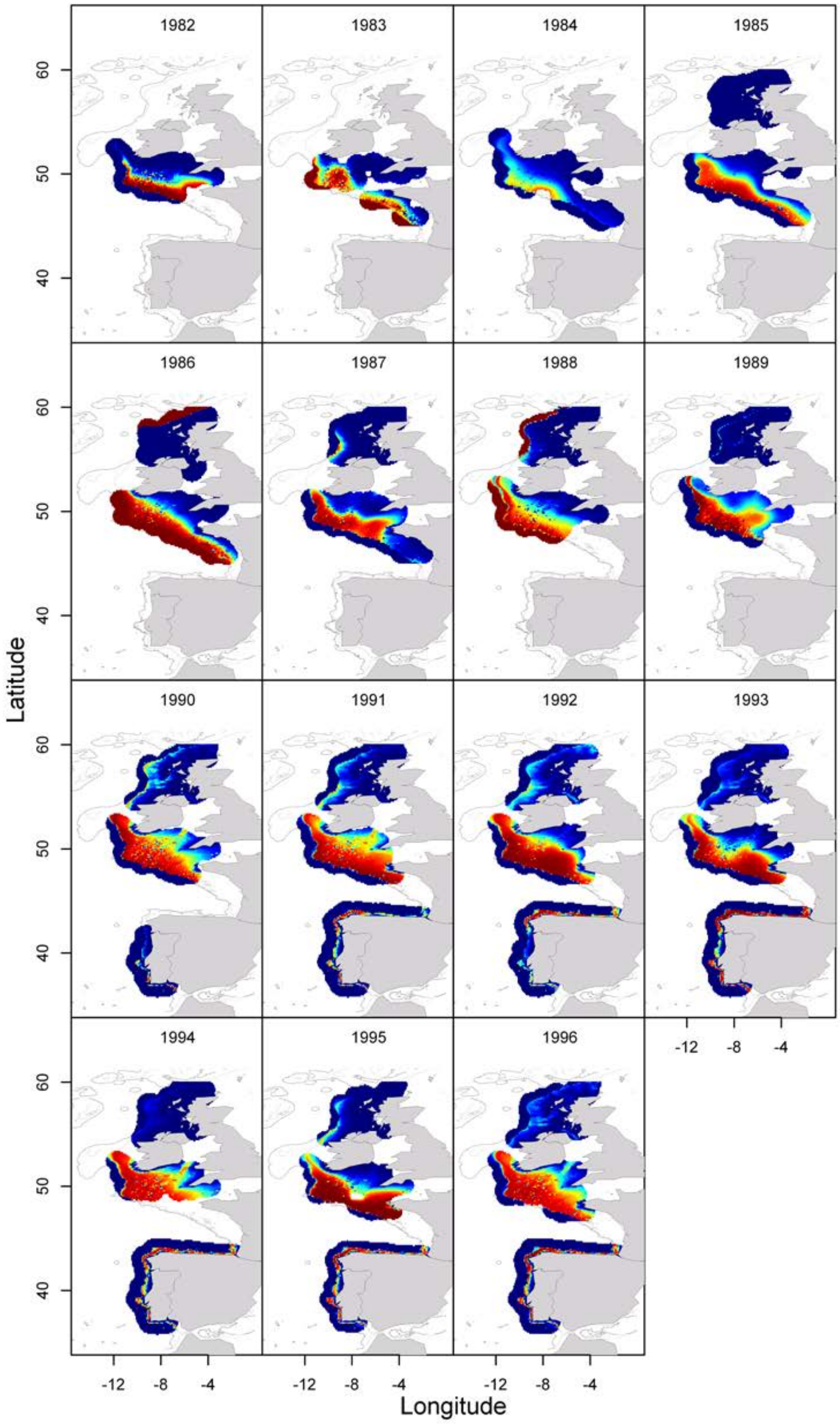


Figure B.4.3 Boarfish in ICES Subareas VI, VII, VIII. The haul positions of bottom trawl surveys by year analysed as part of the GAM modelling.


1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
Latitude
Longitude
60
50
40
-12
-8
-4

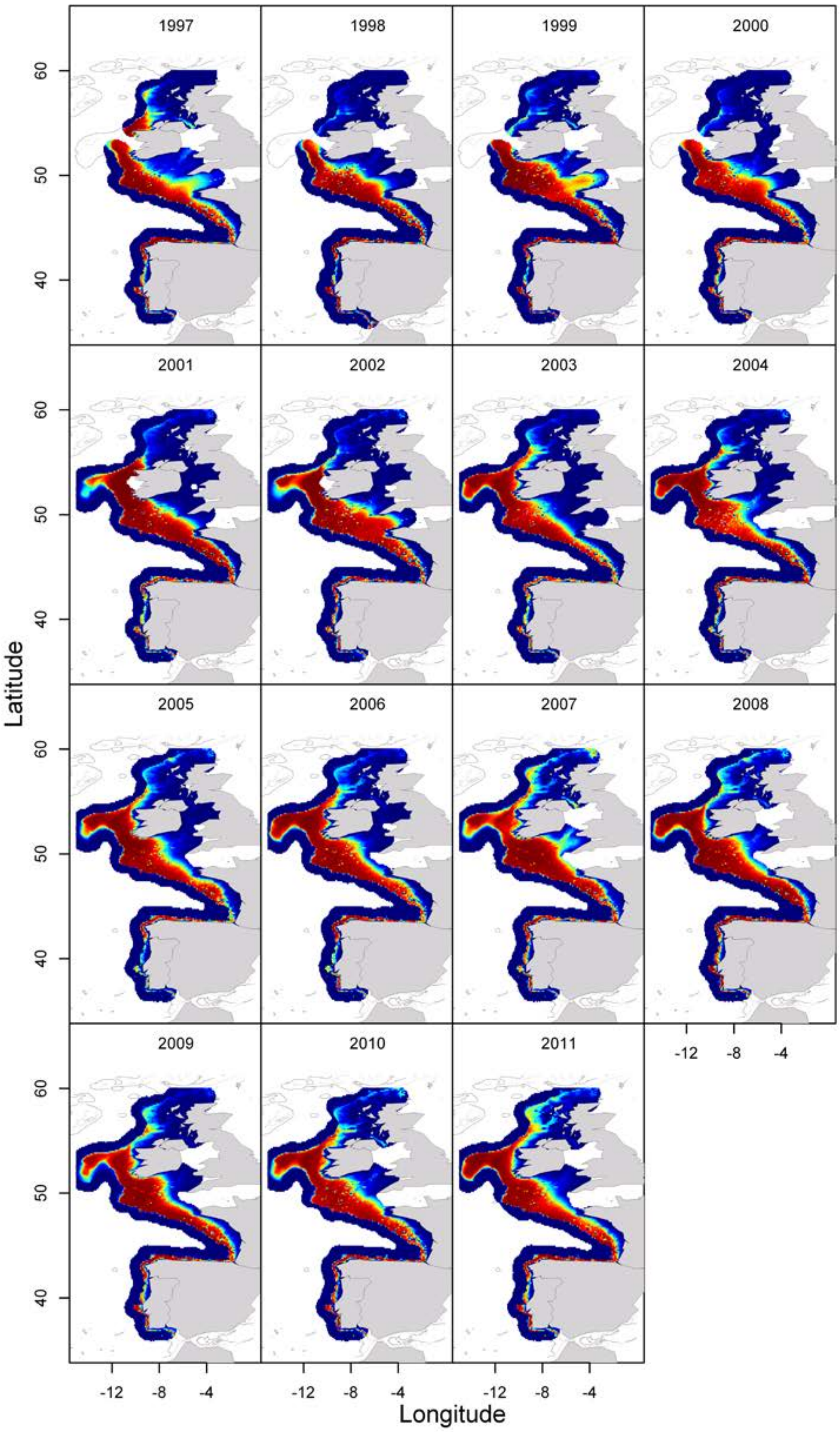


Figure B.4.3. Boarfish in ICES Subareas VI, VII, VIII. The occurrence GAM of the probability of occurrence of boarfish in a survey area 1997 – 2011. Red indicates definite occurrence and blue indicates absence.

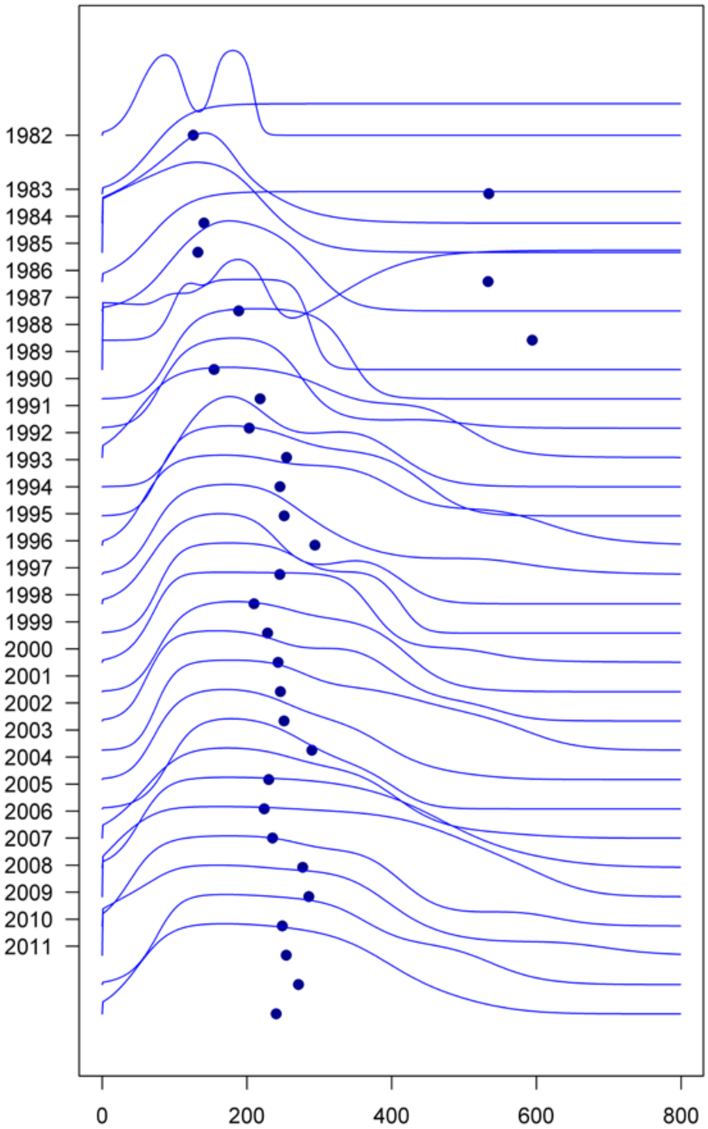


Figure B.4.5. Boarfish in ICES Subareas VI, VII, VIII. The depth distribution profile of boarfish within the IBTS surveys.

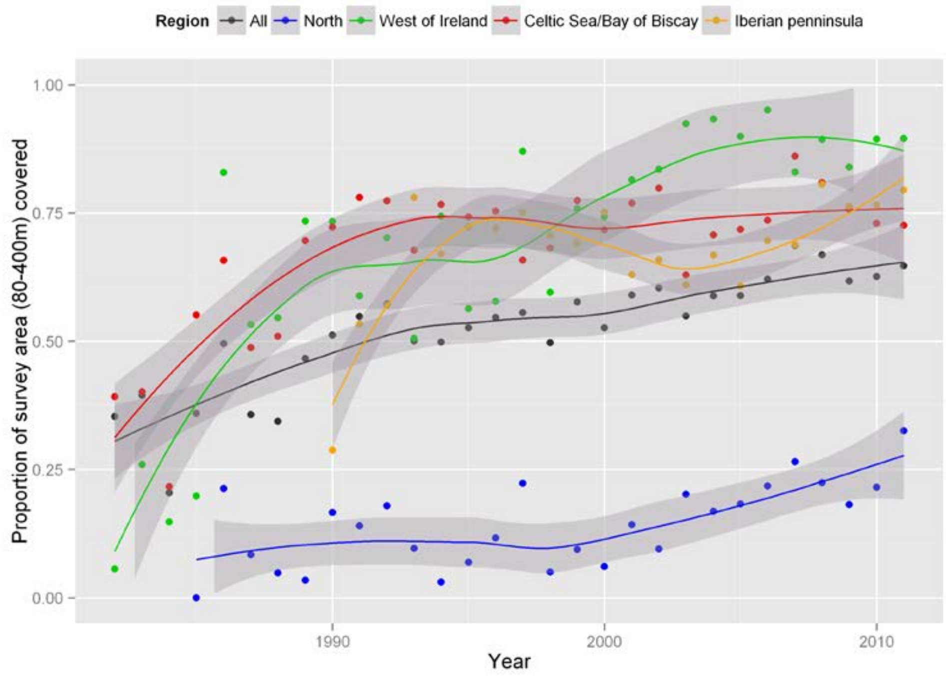


Figure B.4.6. Boarfish in ICES Subareas VI, VII, VIII. The proportion of survey area covered by boarfish per region and per year.

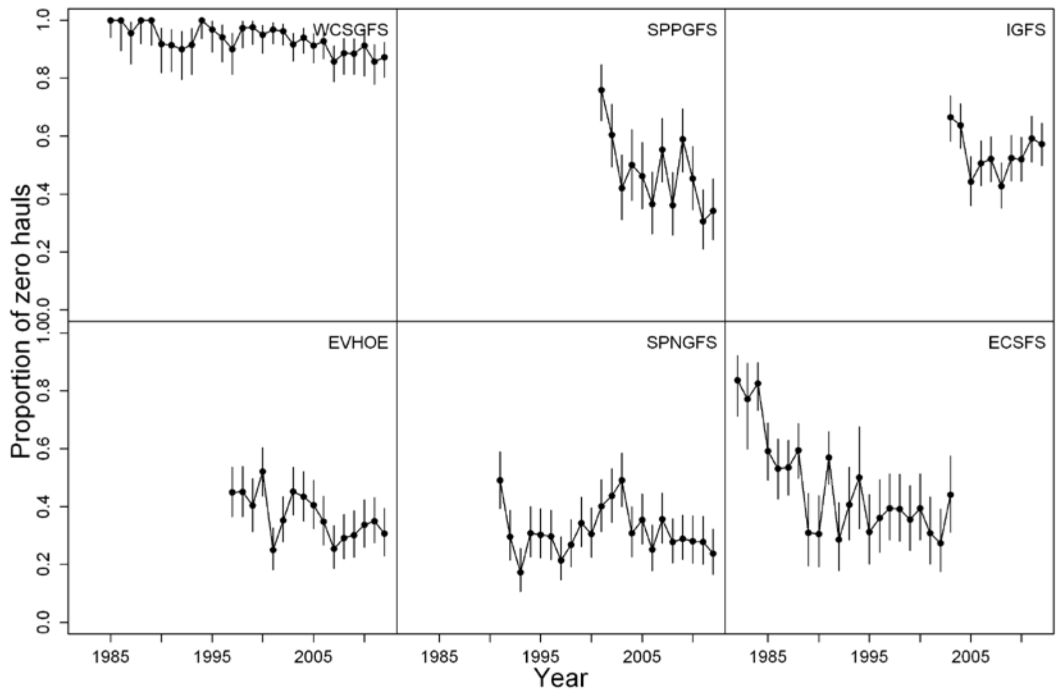


Figure B.4.7. Boarfish in ICES Subareas VI, VII, VIII. The proportion of zero hauls per IBTS survey.

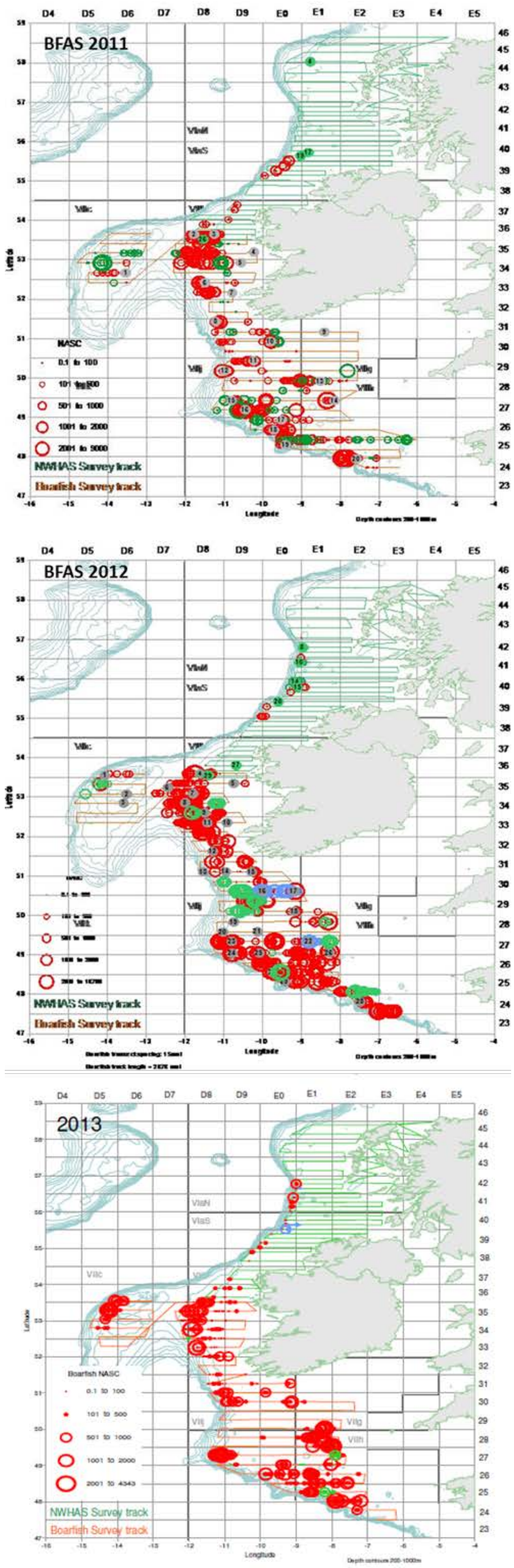


Figure B.4.2.1. Boarfish acoustic survey track and haul positions from acoustic surveys 2011 to 2013.

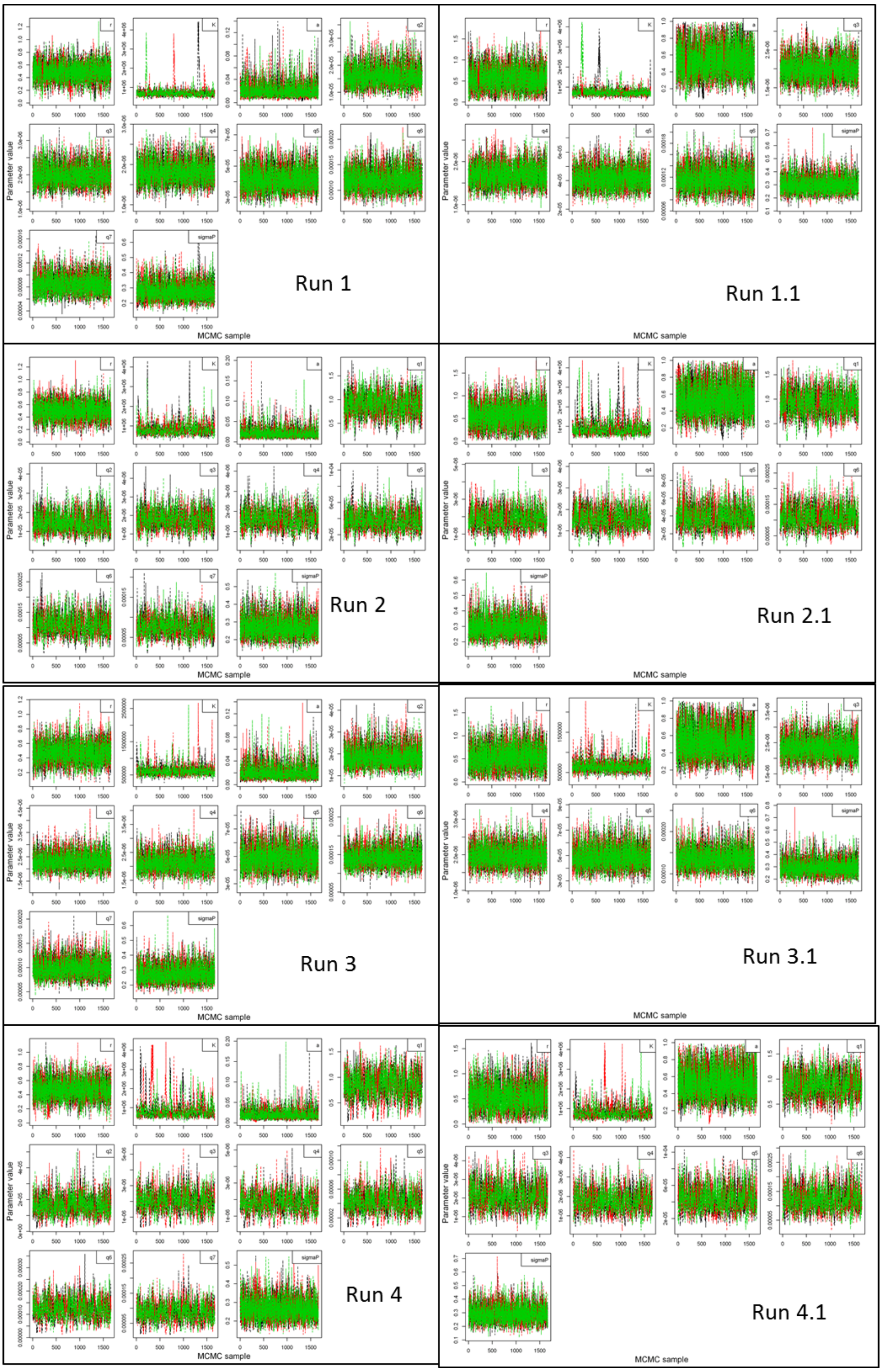


Figure C.1. Boarfish in ICES Subareas VI, VII, VIII. Parameters for runs 1-4 and sensitivity runs 1.1, 2.1, 3.1, 4.1 converged with good mixing of the chains.

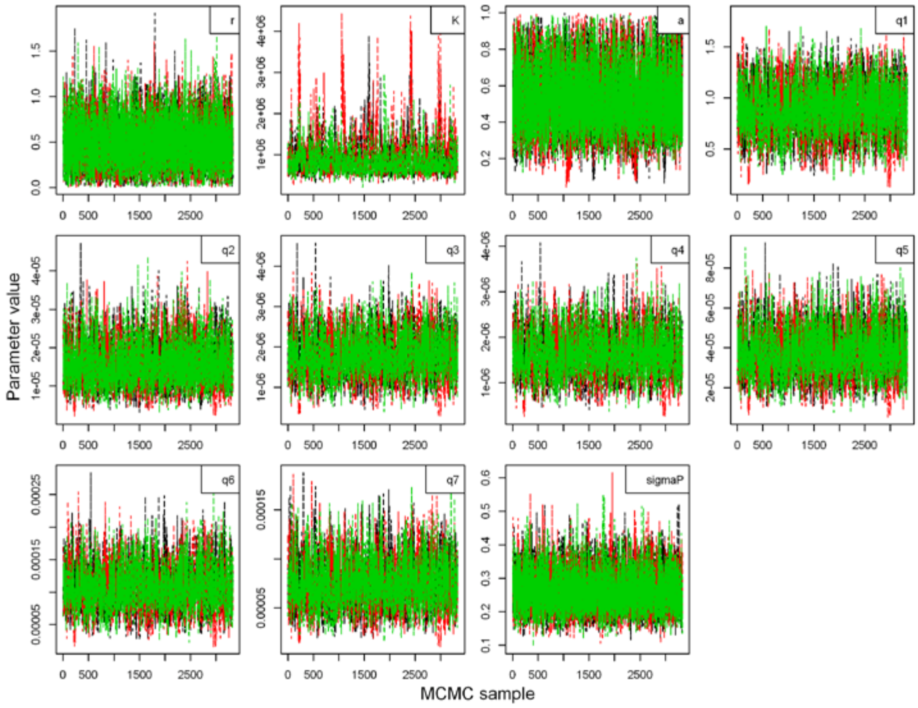


Figure C.2. Boarfish in ICES Subareas VI, VII, VIII. Parameters for run 2.2 converged with good mixing of the chains.

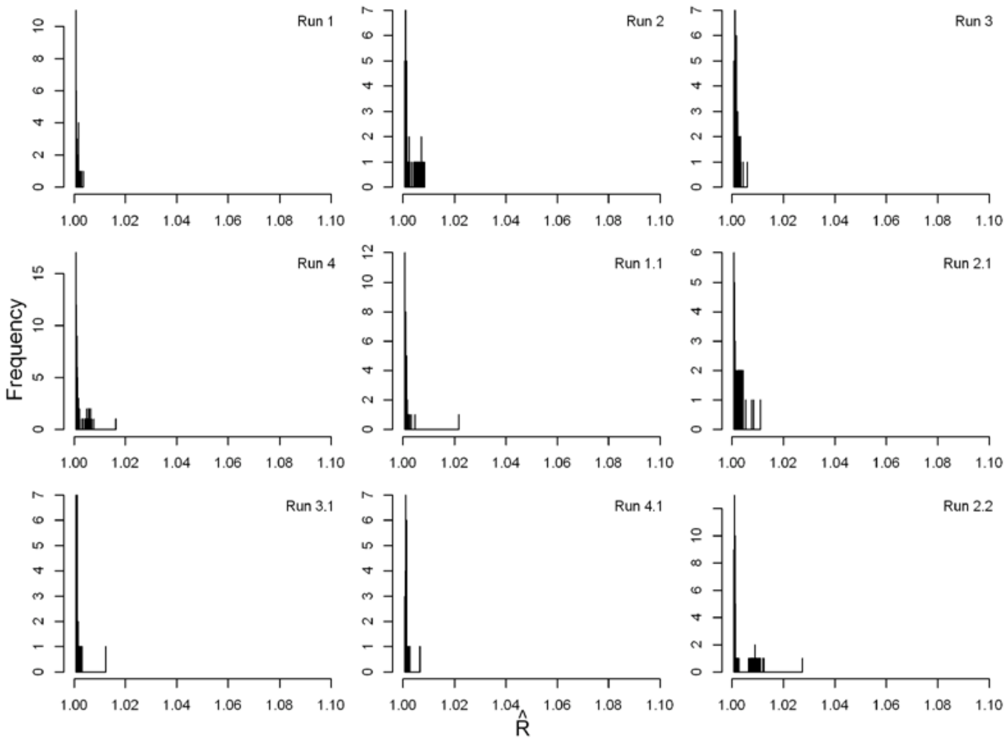


Figure C.3. Boarfish in ICES Subareas VI, VII, VIII. Rhat values lower than 1.1 indicating convergence.

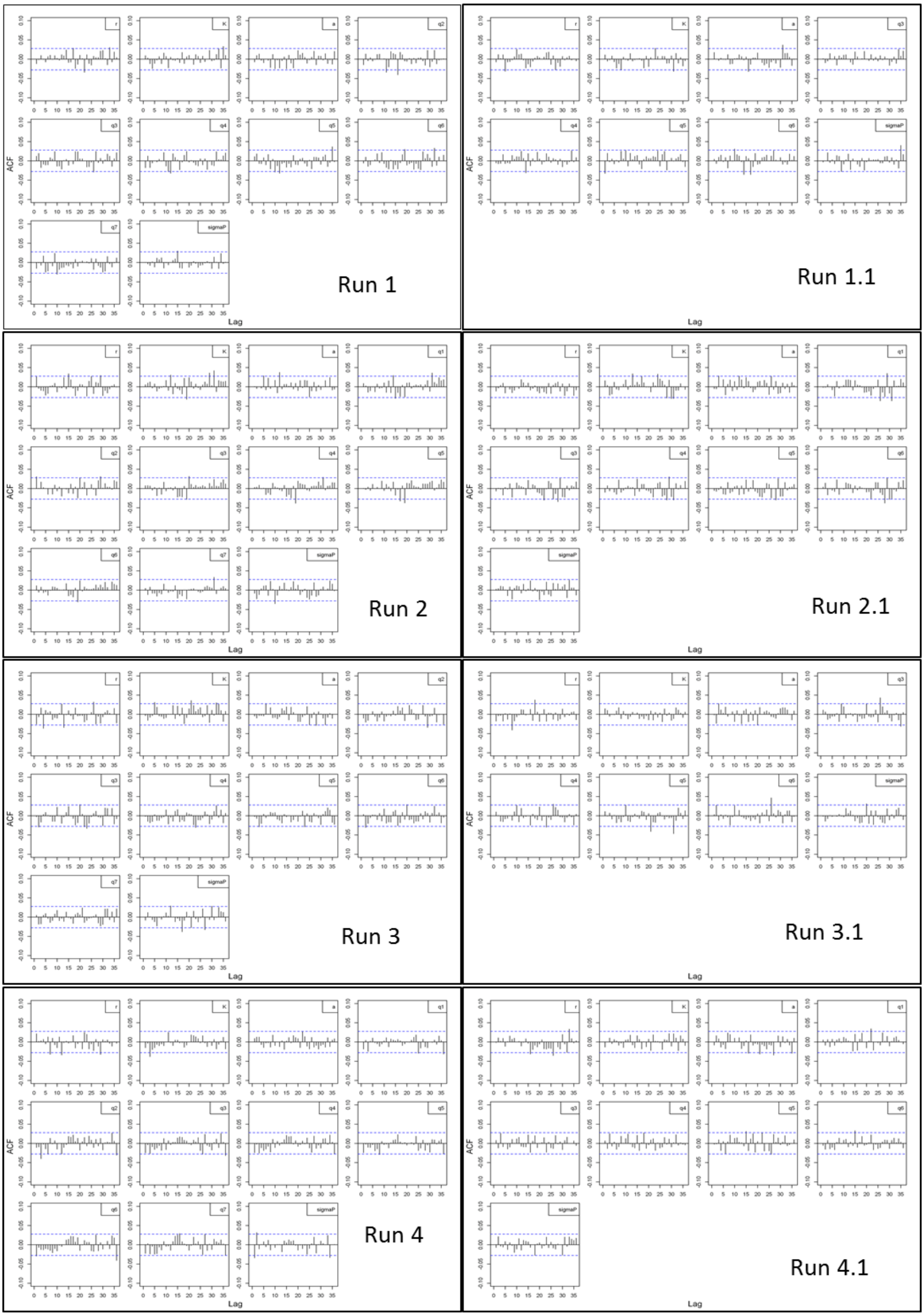


Figure C.4. Boarfish in ICES Subareas VI, VII, VIII. MCMC chain autocorrelation for runs 1-4, sensitivity runs 1.1, 2.1, 3.1, 4.1.

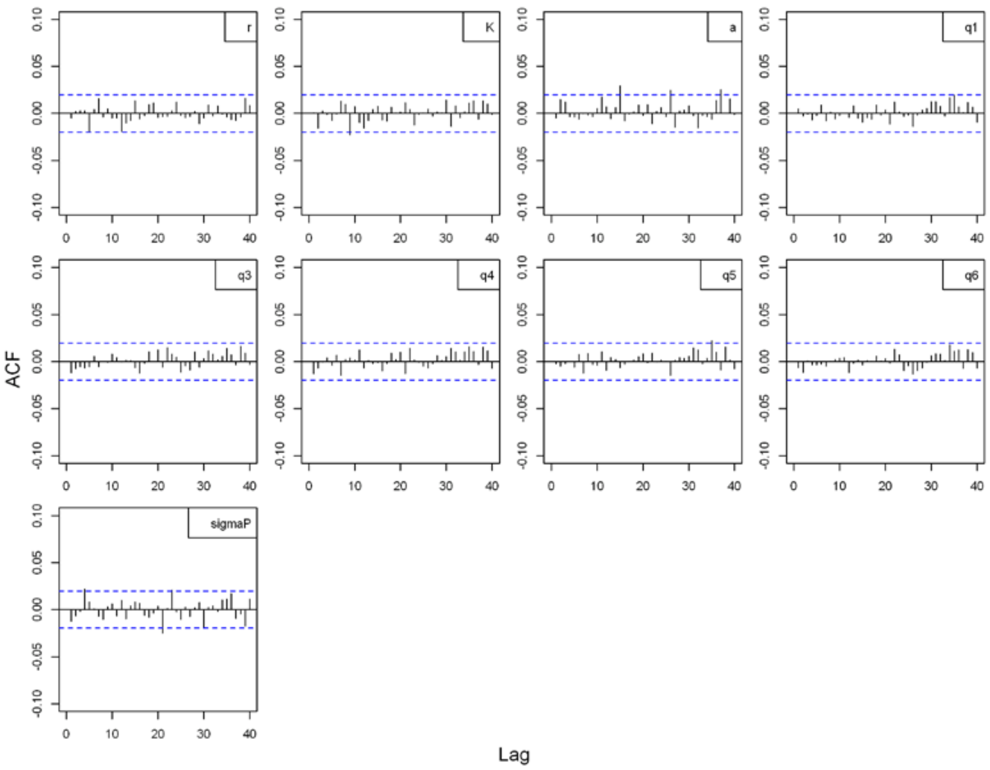


Figure C.5. Boarfish in ICES Subareas VI, VII, VIII. MCMC chain autocorrelation for run 2.2.

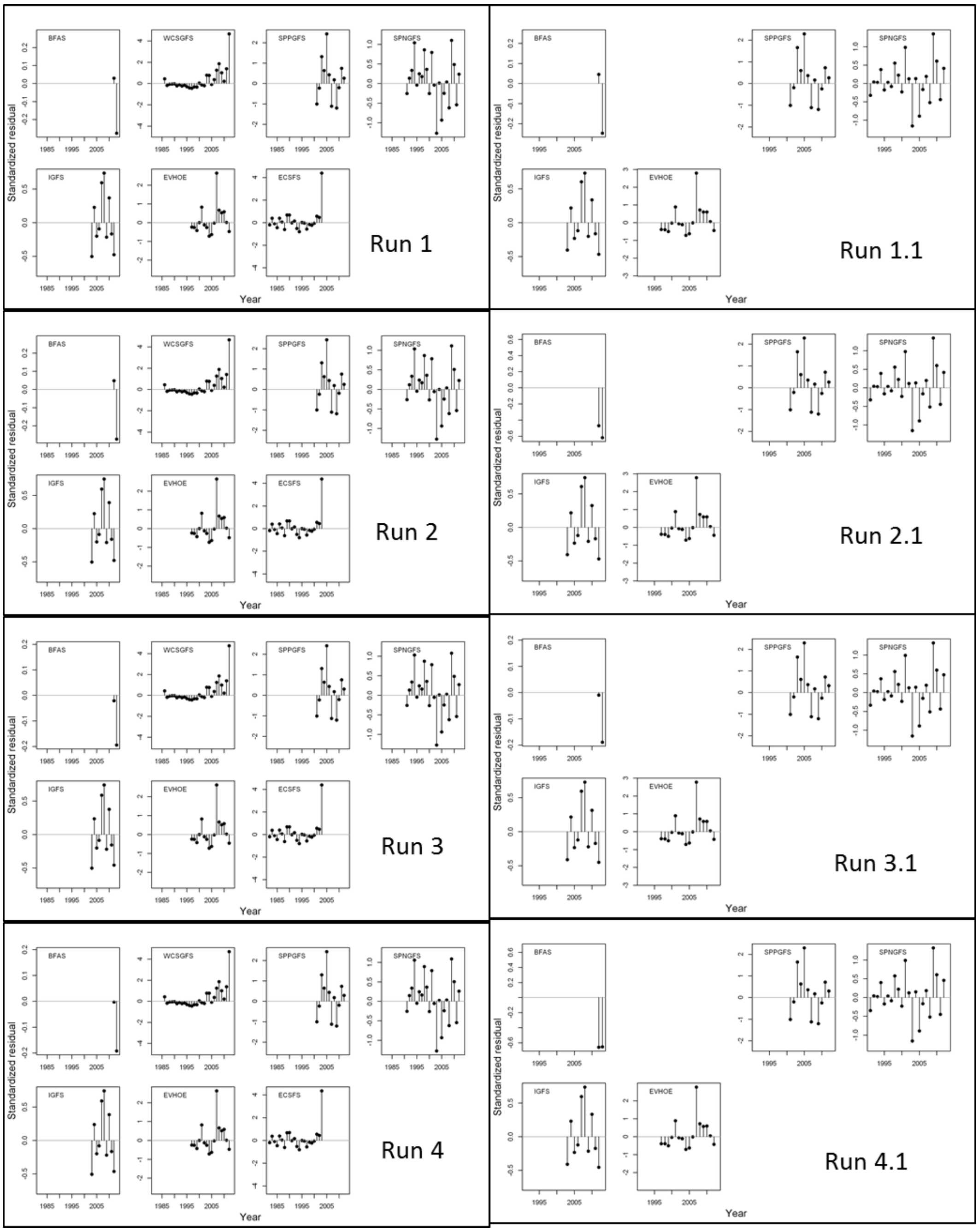


Figure C.6. Boarfish in ICES Subareas VI, VII, VIII. Residuals around the model fits for runs 1-4, sensitivity runs 1.1, 2.1, 3.1, 4.1.

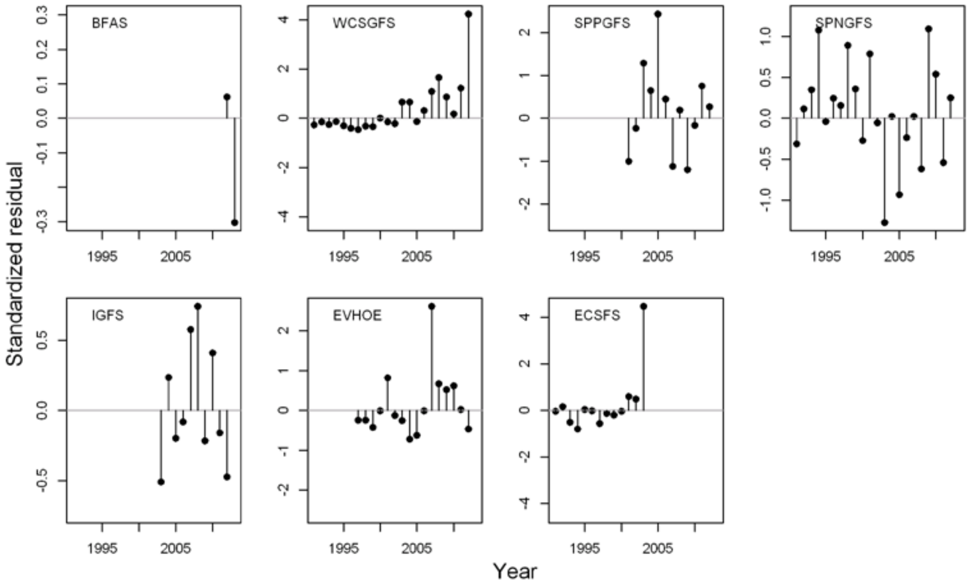


Figure C.7. Boarfish in ICES Subareas VI, VII, VIII. Residuals around the model fit for run 2.2.

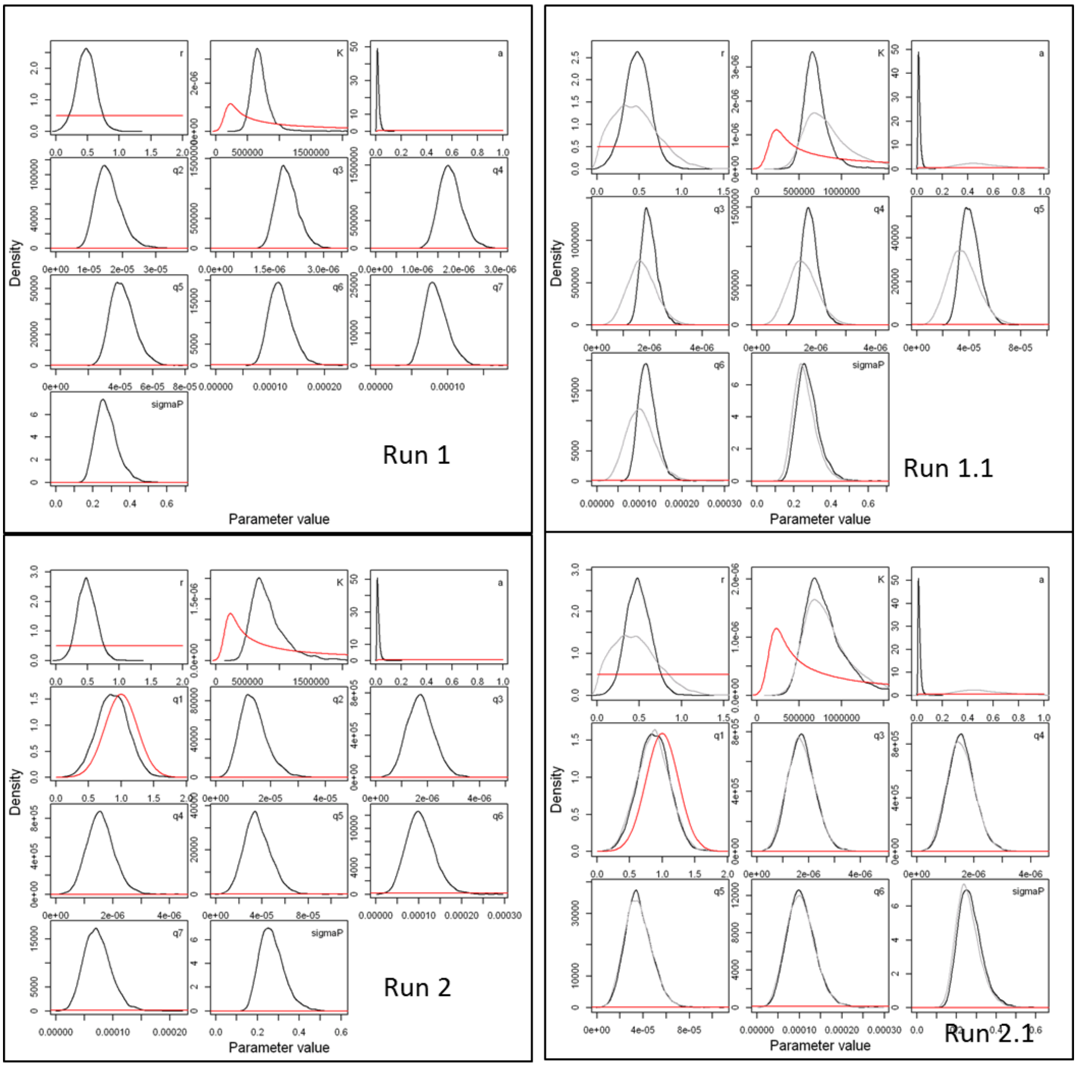


Figure C.8. Boarfish in ICES Subareas VI, VII, VIII. prior and posterior distributions of the parameters of the biomass dynamic model. Runs 1, 1.1, 2 and 2.1.

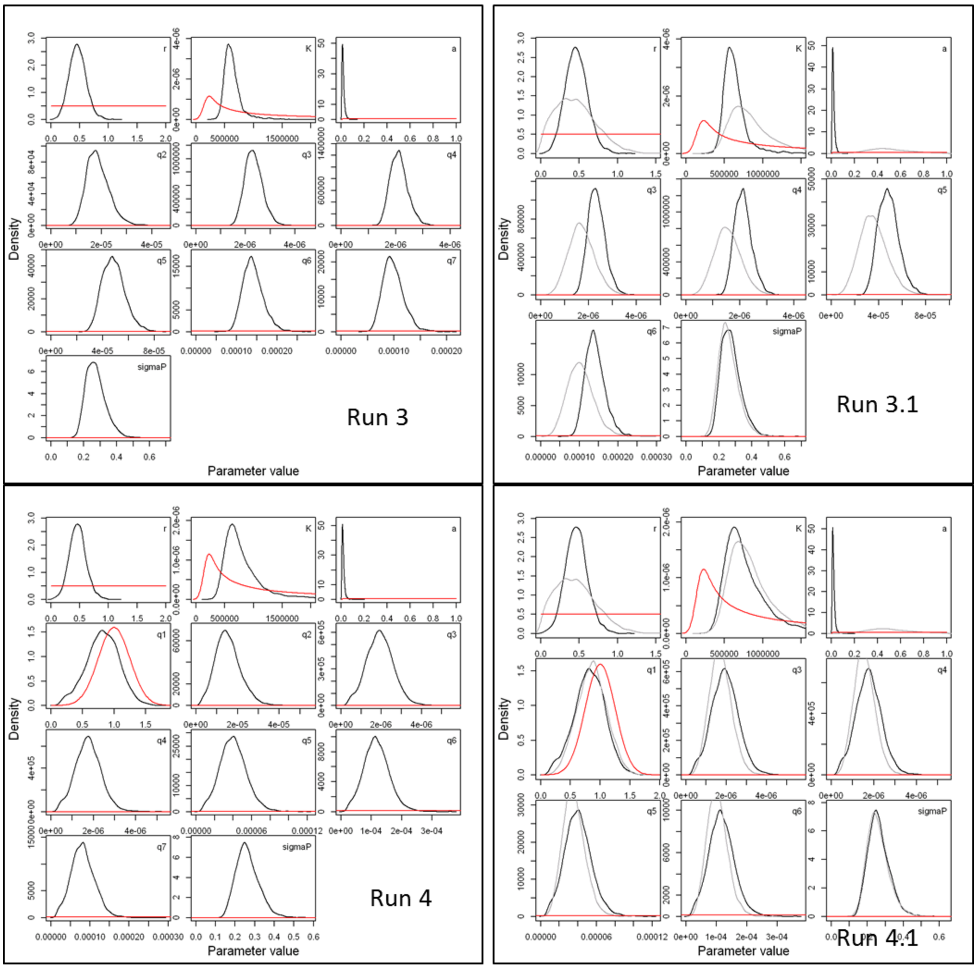


Figure C.9. Boarfish in ICES Subareas VI, VII, VIII. prior and posterior distributions of the parameters of the biomass dynamic model. Runs 3, 3.1, 4 and 4.1.

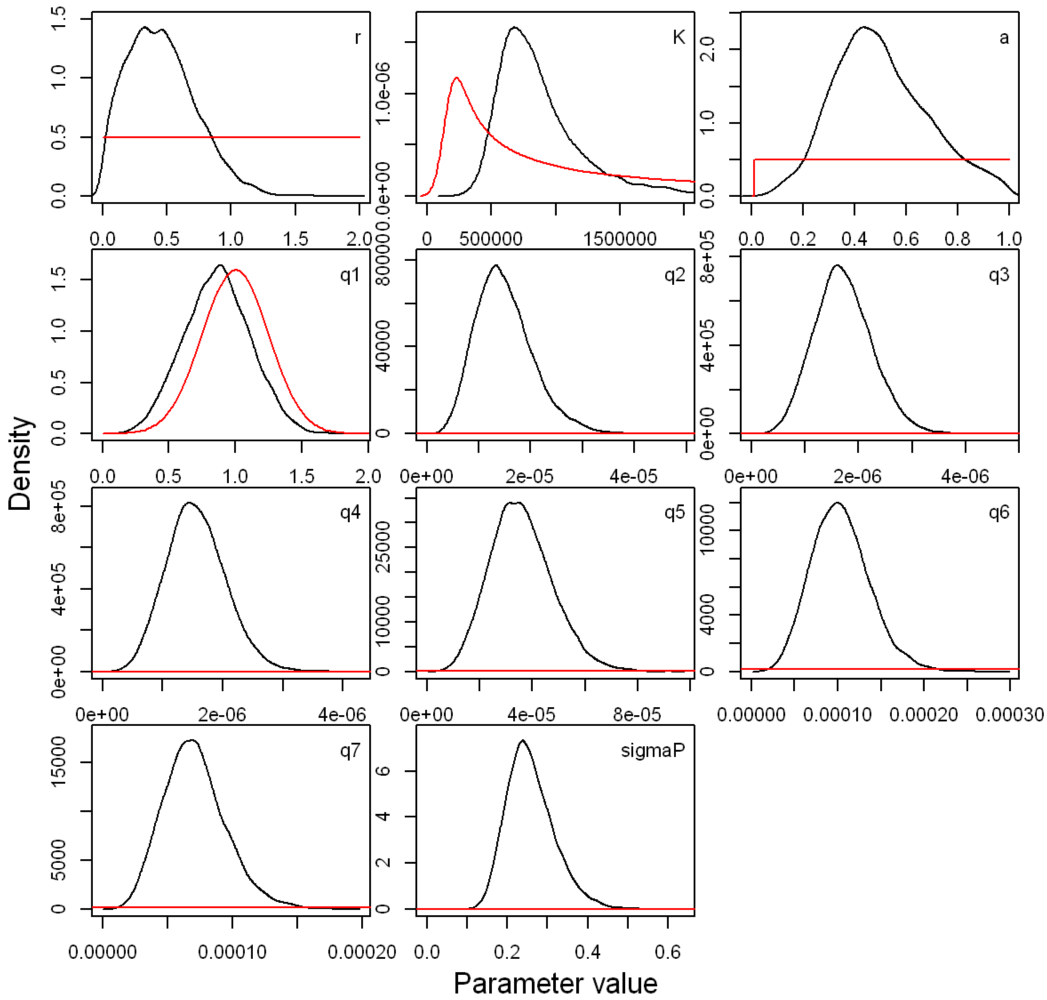


Figure C.10. Boarfish in ICES Subareas VI, VII, VIII. prior and posterior distributions of the parameters of the biomass dynamic model. Run 2.2.

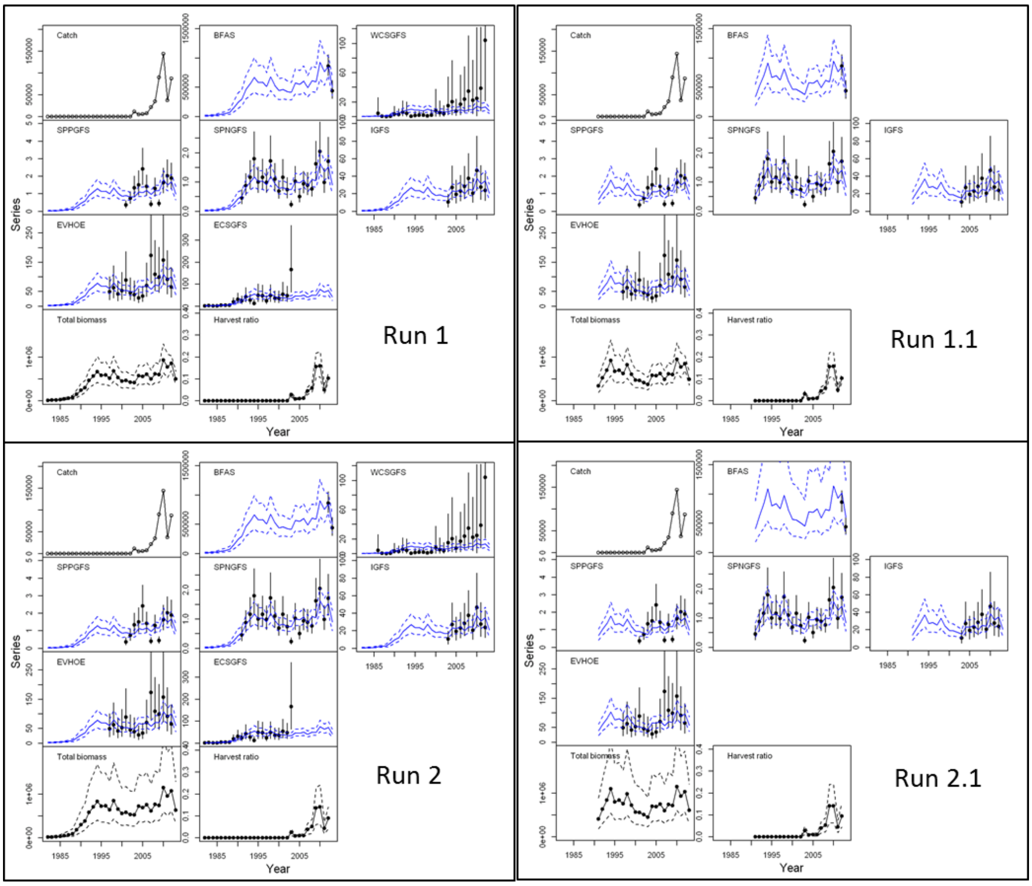


Figure C.11. Boarfish in ICES Subareas VI, VII, VIII. Trajectories of observed and expected indices for runs 1, 1.1, 2 and 2.1. The stock size over time and a harvest ratio (total catch divided by estimated biomass) are also shown.

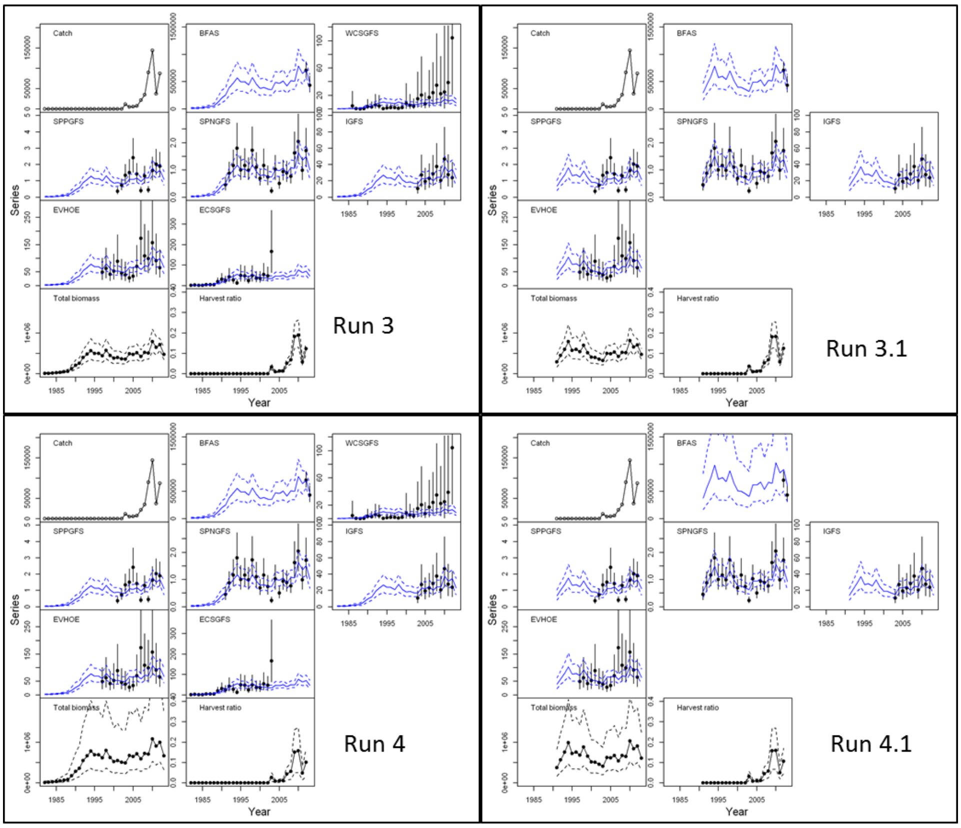


Figure C.12. Boarfish in ICES Subareas VI, VII, VIII. Trajectories of observed and expected indices for runs 3, 3.1, 4 and 4.1. The stock size over time and a harvest ratio (total catch divided by estimated biomass) are also shown.

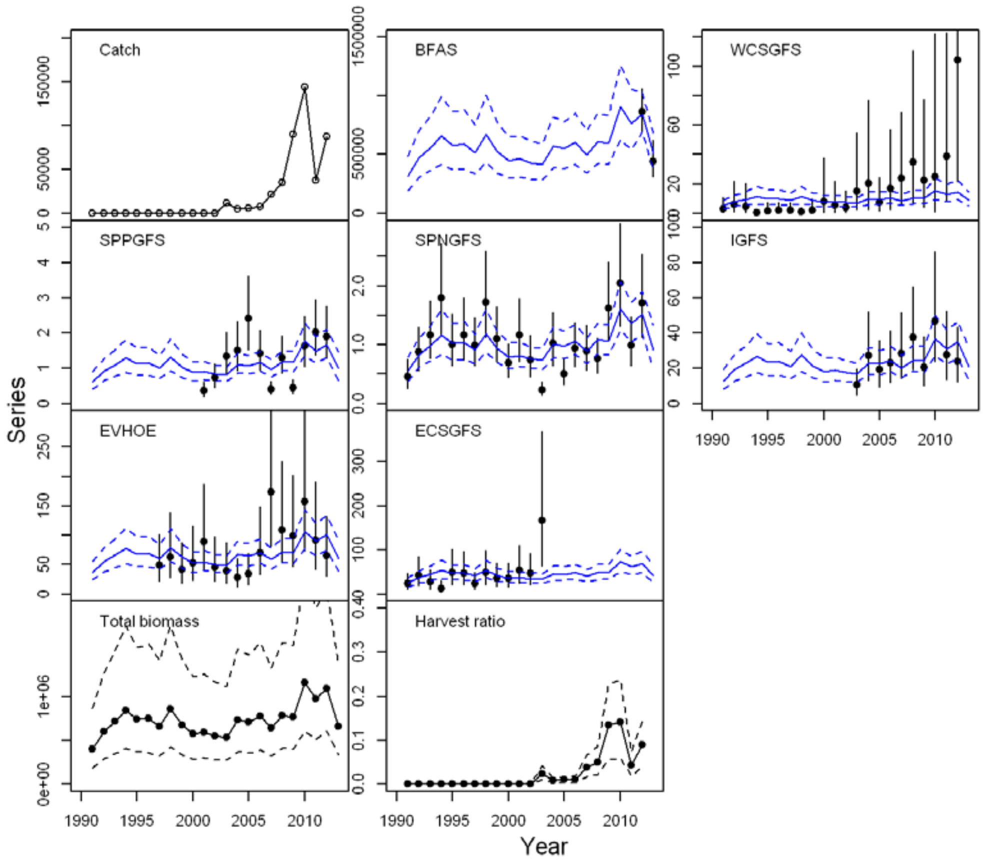


Figure C.13. Boarfish in ICES Subareas VI, VII, VIII. Trajectories of observed and expected indices for run 2.2. The stock size over time and a harvest ratio (total catch divided by estimated biomass) are also shown.

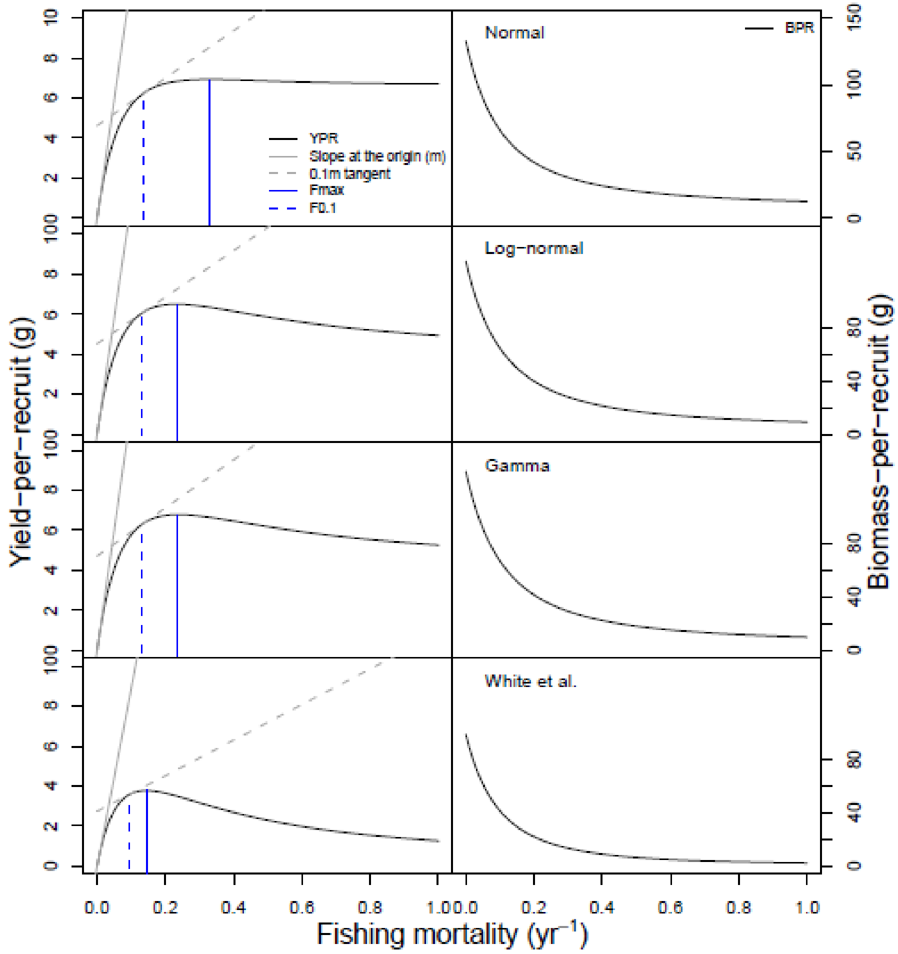


Figure E.1 Boarfish in ICES Subareas V, VI, VII, VIII. Results of exploratory yield per recruit analysis. Beverton and Holt model applied to various fits of the VBGF and for comparison with the VBGF parameters provided by White et al. 2011.

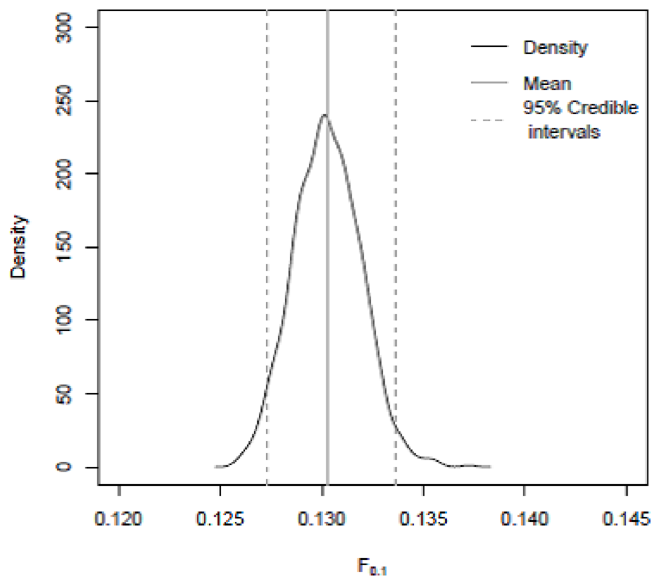


Figure E.2 Boarfish in ICES Subareas V, VI, VII, VIII. Sensitivity of estimation of $F_{0.1}$.

Annex 03 - Special Requests

NEAFC Request for advice regarding blue whiting

Morten Vinter, Asta Gudmundsdottir, Dankert Skagen

WGWIDE Aug-Sep 2014

The Request

The North-East Atlantic Fisheries Commission (NEAFC) has noted that ICES in its blue whiting forecast for 2014, assumed the level of recruitment in 2013 to be the same as that in 2012 rather than the geometric mean of the years 1981-2010, which means the spawning biomass in 2015 might be overestimated.

Furthermore, NEAFC noted that the distribution of spawning biomass estimates using the stochastic forecast model is both wide and skewed, which in its view could lead to an overestimation of the F values that are deemed precautionary.

ICES is requested to review the assumptions and performance of the stochastic forecast model. ICES is also requested to assess whether or not there are any implications with respect to the reliability of its previous evaluations of the various options to revise the management plan, as outlined in special requests 9.3.3.1 and 9.3.3.7 of June and October 2013 respectively.

Background

In the forecast derived with the stochastic model, the distribution of the spawning stock is both wide and skewed and the lower quantiles of the distribution are tight. This leads to the concern that the spawning stock biomass values corresponding to probability levels in the lower tail of the distribution may be overestimated and thus resulting in too high F values being erroneously found to be precautionary.

Results and conclusions

The SAM model provides uncertainty of fishing mortality and stock numbers in the final year estimates that can only be fully applied in a stochastic short-term forecast. The default stochastic projections applied for SAM assessments are carried out by projecting the final year's SAM estimates of stock numbers (log(N)) and fishing mortality (log(F)). Using the variance-covariance matrix of those estimates, a high number (1000) of replicates of the initial stock numbers and fishing mortalities are randomly drawn, such that the variance and co-variance between stock N and F are maintained. Due to additional information affecting recruitment (qualitative use of recruitment indices from surveys not used by SAM), the initial stock estimate for age 1 and age 2, and future recruitment can optionally be raised by an input factor. The 1000 replicates are then simulated forward according to the management options. The forecast result presented in the option table is finally derived from the median of the 1000 replicates.

Compared to a deterministic forecast the stochastic forecast gives slightly higher estimates of TAC and SSB. For this year's advice the TAC for 2015 is estimated 4-5% higher and SSB in 2016 is 8-9% higher. The difference is due to the assumed log-normal distributed stock number. The median of the projected stock N is unbiased compared to the stock N from a deterministic forecast, but the median of quantities like yield and SSB, which is the sum of several age groups N weighted by e.g. F, mean weight and proportion mature, will be higher. The difference between the stochastic and deterministic values increases by when there is more uncertainty around the stock numbers and fishing mortalities used for the forecast.

In the evaluations carried out to answer special requests 9.3.3.1 and 9.3.3.7 the HCS software was used (ICES 2013). These simulations did not directly run a SAM model for each year. Instead, assessment errors were generated matching the level observed in the most recent (at the time) SAM assessment for the stock. This was done by taking the true stock numbers according to the population model and using an autoregressive model with a combination of a year factor and an age factor noise terms to generate errors in the terminal stock numbers. This is to mimic not only year to year uncertainty in the 'assessed' stock numbers, but also some retrospective error.

As is done in practice, the 'assessed' stock numbers are projected forward to the TAC year to get the TAC. This projection is deterministic, based on the point estimates, with specified assumptions for catches or fishing mortalities, according to the harvest rule under study.

At WGWIDE, the default SAM stochastic forecast has been applied for the last three years. For this year however, a deterministic version was applied for advice to match that used in the MSE evaluation (ICES advice 2013). The conclusion that a HCR with target F=0.30 is precautionary, is sensitive to the choice of forecast model. This conclusion is dependent on the use of a deterministic forecast, and may no longer be valid should a stochastic forecast, with a TAC estimated 4-5% higher than in the MSE, is applied in reality. Due to time constraints it is not possible to correct the evaluation and re-estimate a precautionary target F. Therefore ICES uses a deterministic forecast this year which is consistent with the assumptions in the management strategy evaluation.

Annex 04 – Stock Data Problems Relevant to Data Collection WGWIDE

Stock	Data Problem	How to be addressed in	By who
Northeast Atlantic Mackerel	Submission of data	Data submissions must be submitted by the deadline, submitted on the exchange format sheet and be submitted directky to the stock coordinator or, if uploaded to Sharepoint, the stock coordinator muct be notified In addition, should the data submitter change the stock cordinator MUST be notified of this. Also, should the data submitter be unavailable after the data has been submitted (e.g. vacation) an alternative contact should be avaialble who can be contacted in the event of any queries.	National laboratories
Northeast Atlantic Mackerel	Discardand slippage information	Discardand slippage information is incomplete. All fleets should be monitored and sampled for discard and slipping. Data should be supplied to the coordinator by the submission deadline, accompanied by documentation describing the sampling protocol.	National laboratories, RCMNA, RCMNS&EA
Northeast Atlantic Mackerel	Sampling deficiencies– general	All countries involved should provide sampling information. Increased cooperation between countries would help reduce redundancy and increase coverage. There is a particular lack of sampling coverage of the freezer trawler fleet in quarter 4.	National laboratories, RCMNA, RCMNS&EA
Northeast Atlantic Mackerel	Sampling of foreign vessels	Any information available from the sampling of foreign vessels should be forwarded to the appropriate person in the national laboratory in order that they may use this information when compiling the data submission.	National laboratories; RCMNA, RCMNS&EA

Stock	Data Problem	How to be addressed in	By who
Boarfish	Lack of sampling and age data.	Following the MoU between ICES and EU boarfish (Capros aper) was included into WGWIDE. Sampling data are still only very limited accessible. Therefore boarfish should be included in the list of DCF species.	WGCATCH, WGBIOP. RCMs, EU
Boarfish	Boarfish only measured to the 1 cm on the IBTS.	Following the MoU between ICES and EU boarfish (Capros aper) was included into WGWIDE. Boarfish should be measured to the 0.5 cm on the IBTS due to the small length range and the relatively high ages observed.	ICES IBTSWG
Boarfish	Third year of the acoustic survey funded by levy on the Irish and Danish industry.	Following the MoU between ICES and EU boarfish (Capros aper) was included into WGWIDE. The Acoustic survey needs to be continued annually and should be considered under the DCF.	WGBIOP, EU, ICES SSGESST
Horse Mackerel – Western Stock	Uncertainties in the use of the current egg production method for the assessment	Evaluation of the assessment model based on egg production and fecundity	Future Benchmark
Horse Mackerel – Western Stock	Lack of fishery independent information	Exploration of additional fishery independent time-series to base an abundance index on	Future Benchmark
Horse Mackerel – Western Stock	Discard Information	Discard information is incomplete. All fleets where discarding is thought to be occurring should be sampled for discard. Data should be supplied to the coordinator accompanied by documentation describing the sampling protocol.	National Institutes, RCM NA
Horse Mackerel – North Sea Stock	Low level of sampling and survey data. Currently only IBTS data are available which are not entirely suitable for pelagic species	Collection of information from other working groups. Possible implementation of an acoustic survey for horse mackerel in 3rd or 4th Quarter.	WGBIOP, WGCATCH, RCM NS&EA
Norwegian Spring Spawning Herring	Contrasting age distributions between laboratories in the May survey	It is recommended that a workshop on age reading is required for NSS herring to address discrepancies across nations, encountered during the recent May surveys.	WGBIOP

Stock	Data Problem	How to be addressed in	By who
Norwegian Spring Spawning Herring	Low sampling effort on some nations (considerably lower than the 1 sample/1000 tonnes recommended for this stock by EU)	Sampling effort should be increased by nations with little or no samples.	National laboratories; RCM NS&EA

Annex 05 – Assessment Audits

Audit of (NEA mackerel)

Date: 1/9/2014 (15h30)

Auditor: Beatriz Roel (Cefas)

General

This assessment was discussed thoroughly during the WGWIDE meeting.

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: SAM, tuning by 3 survey indices and tagging data
5) **Data issues:** the SSB time-series was revised during the meeting.
6) **Consistency**: last year no assessment was presented. Consistency was evaluated in relation to the May 2014 update assessment. Comparison show consistency in stock trends. The small differences in the estimates of catch, F and SSB for 2012 and 2013 can be explained to a large extent by the revision of the Egg time-series.
7) **Stock status**: B and F estimates are within safe biological limits. There is high uncertainty about 2013 recruitment and has been estimated on the basis of the recruitment index and GM using RCT3. Some strong year classes were estimated in recent years.
8) **Man. Plan.**: The MP in place, although precautionary, needs to be updated and tuned with with the new State Space model assessment.

General comments

This was a thorough assessment of the state of NEA mackerel which was well presented during the meeting. The report was not finalized at the time of writing this Audit so, possible typos and small inconsistencies are not reported.

Technical comments

This assessment has been characterized by substantial underestimation of the catch. Catch estimates for 2013 and 2014 are likely to be under estimated because of limited discards information and no information on slippage.

The Egg production time-series revision was carried out at this meeting and addressed issues raised by WKPELA. The process was well documented in the Report.

Estimates of SSB and F in the final year were reasonably precise however, it was noted that the distribution of the uncertainty about point estimates had a suggestion of bimodality particularly for SSB.

Retrospective patterns. Moderately strong retrospective patterns were noted for F. Although those were interpreted as the result of the late introduction of the IESSNS survey (ages 6+) it did appear peculiar the fact that it did not reflect in the SSB retrospective.

Short-term forecast. The method used to estimate age 0 in 2013 deviated slightly from the one described in the Annex in that the tapered GM was computed over a longer period. The decision made by WGWIDE was justified and was appropriate in my view.

Short-term predictions were done deterministically according to the Annex. Stochastic forecast would be feasible given that the assessment is considered to provide reliable estimates of uncertainty on which to base the predictions.

Conclusions

The assessment has been performed correctly and according to the Stock Annex. Some changes were made to the methods for short-term predictions.

Some suggestions for future consideration/benchmark follow:

Assumptions about stock components need to be revised in light of recent findings.

The observed declining trend in weights at age in the stocks needs to be investigated.

The data used to compute the recruitment index does not fully cover all nursery areas of mackerel. Some modifications of the recruitment index have been suggested and those will need to be evaluated.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  - Yes
- Is the assessment according to the stock annex description?
  - Yes
- Is general ecosystem information provided and is it used in the individual stock sections.
  - Yes, as much as it can be used.
- If a management plan has been agreed, has the plan been evaluated?
  - Yes, but a new plan is being evaluated to address new perceptions resulting from the most recent Benchmark.

For update assessments

- Have the data been used as specified in the stock annex?
  - Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  - Yes, an exception is commented in a previous section of this audit.
- Is there any **major** reason to deviate from the standard procedure for this stock?
  - No

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  - The update assessment gives a valid basis for advice.

Audit of Northeast Atlantic Mackerel

Date 2014.09.05

Auditor: Eydna í Homrum

General

The stock assessment for NEA mackerel in 2014 has been done according to the stock annex. The assessment for NEA mackerel was last benchmarked in February 2014. All inputs to the assessment were as described in the stock annex.

For single stock summary sheet advice:

1) **Assessment type: update –** was benchmarked February 2014
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: state-space assessment model (SAM). Tuning: 3 surveys (SSB from Triennial Egg Survey, IBTS recruitment abundance index (log transformed) and IESSNS abundance index) and Tagging/Recapture data from Norwegian tagging program
5) **Data issues:** all data described in the stock annex were available for this year's assessment of NEA mackerel.
6) **Consistency**: Last year, NEA mackerel was assessed as a data limited stock. The assessment was benchmarked February 2014.
7) **Stock status**: SSB in 2013 was 4.3 mio tonnes, which is above Bpa – SSB has been stable the most recent years, $F_{4\text{-}8}$ (0.22) is below Fpa . Recruitment has shown an increasing trend since the late 1990s.
8) **Man. Plan.**: A management plan, agreed upon in 2008, is in place. The benchmark workshop recommended that the management plan should be revised before advice is released for 2015.

General comments

The NEA mackerel section is well structured and easy to follow. The assessment procedure has been described in sufficient detail.

Technical comments

The assessment and forecast are done according to the stock annex.

References – missing from reference list

Simmonds et al 2010.

Carrera and Riviero – reference incomplete

Tables – No reference to:

Table 2.1.2.1,

Table 2.5.5.2.3

Audit of North Sea Horse Mackerel: Divisions Iva (1st and 2nd quarter), IIIa (excluding Western Skagerrak in 3rd and 4th quarter), IVb, IVc and VIId

Date: September 2014

Auditor: **Nicola Walker**

For the attention of: Advisory drafting group, ACOM and WGWIDE

General

The assessment and suggested advice is based on the ICES data-limited approach (Category 3); adjusting the landings (last three years average) by the ratio of the most recent index values (2 or 3) with the preceding values (3 or 5). The index was derived from the IBTS Q3 survey using a GLM approach.

For single stock summary sheet advice:

1) **Assessment type:** SALY
2) **Assessment**: Trends
3) **Forecast**: Not presented
4) **Assessment model**: Category 3 of the ICES data-limited approach (DLS). Input data: IBTS indices of fishable biomass (2006-2013) and total landings data (2011-2013).
5) **Data issues:** The available survey data do not cover the main fishing grounds for the stock. Cohort signals in the catch are weak.
6) **Consistency:** The 2012 and 2013 advice was also based on the DLS approach using IBTS Q3 survey indices. The advice from 2012 remains valid.
7) **Stock status**: Currently at a low biomass. There may be a potential increase in the most recent years but this is highly uncertain.
8) **Man. Plan.:** Currently there is no agreed management plan.

General comments

This was a well documented, well ordered and considered section. The derivation of the survey indices and the explanation of the exploratory assessment model were clear and easy to follow. The DLS approach seems appropriate given the issues with the data. The advice seems appropriate given the high uncertainty around the survey index.

Technical comments

- The age compositions in Figures 4.3.1 and 4.3.2 are for the period 1987-2013, but are stated as 1987-1995 in the text.
- Year numbering 'jumps around' on the x-axis of Figure 4.3.2.
- Typo in the first paragraph of 4.4.3 'int he'.
- Section 4.4.3.1 refers to a dispersion parameter *k* which is not shown in the GLM equations.
- Reference to ADMB missing in 4.5.1.

- Repeat of the word 'index' in 4.5.1.
- Figure number missing in first sentence of 4.5.2.

Conclusions

The DLS assessment is a good basis for advice.

Audit of North Sea Horse Mackerel: Divisions Iva (1st and 2nd quarter), IIIa (excluding Western Skagerrak in 3rd and 4th quarter), IVb, IVc and VIId

Date September 6, 2014

Auditor: **Anna H Olafsdottir**

Audience: ACOM, Advisory drafting group and WGWIDE

This is a data poor stock and currently there is no approved stock assessment model.

Annual catch limits calculated using data limited approach (Category 5), in 2012, are recommended for 2015.

No forecast is provided.

There is no stock annex for this stock.

General

Date exploration included: calculations of two stock indexes (GLM index and DLN index) from IBTS survey data. Futhermore, four different runs of the JAXass model were executed.

The GLM index preformed best: it was robust to inclusion of new data, it provided appropriate treatment of IBTS survey data, and confidence boundaries of final estimate can be calculated.

Recommend exploring methos of using information from data-rich stocks to help developing stock assessment methods for data-poor stock like the NSHM mackerel stock.

For single stock summary sheet advice:

Advice for this stock provided by WGWIDE, in 2012, according to data limited approact (category 5), adviced an annual catch of 25,500 metric tonnes for the next three years unless there was a clear signal of changes in stock size. The different exploratory analyses executed in 2014 gave highly uncertain stock estimates, hence, the advice from 2012, of an annual catch of 25,500 t remains unchanged.

1) **Assessment type:** Data exploration.

2) **Assessment**: Input data in the DLS approach: IBTS Q3 indices of fishable biomass (2008-2012), total landings data (2010-2012).

3) **Forecast**: not presented

4) **Assessment model**: Data limited approach (Category 5) was preformed in 2012 and remains valid for 2015.

5) **Data issues:**

There is no information neither on maturity-at-age nor mortality.

Cohort structure is not clearly detectable in the catch data, speculations this could be caused by age reading issues, geographical shifts in fishing, or mixing of North Sea and Western stocks in the catch samples.

Highly uncertain Z due to weak cohort signal in catch data.

IBTS surveys do not cover the main fishing area.

6) **Consistency:** Advice from 2012 remains valid for the third year.

7) **Stock status**: Results from data exploration indicate low stock status but there is high uncertainty associated with estimates.

8) **Man. Plan**.: There is none.

General comments

This was a well documented, well ordered and considered section.

Technical comments

Reference form a midel missing in section 4.5.1

Figure number missing in section 4.5.2

Conclusions

Different methods to estimate stock size using available data were explored and rejected for various reasons, hence, the DLS annual catch advice from 2012 was recommmened for the third year. The assessment has been performed correctly.

Audit of Norwegian Spring Spawning Herring

Date September 2014

Reviewer: **Patrícia Gonçalves, Gersom Costas**

For the attention of: Advisory drafting group, ACOM and WGWIDE

General

The assessment and short term forecast of **Norwegian Spring Spawning Herring** in the NE Atlantic was based on data handling procedures and assessment modeling as described in the last benchmark assessment carried out in 2008 with some exception described below.

- Since 2010 a new maturity-at-age data was used for the whole time-series, following a recommendation from Workshop on estimation of maturity ogive in Norwegian spring spawning herring (WKHERMAT).
- In 2013, an updated algorithm was used to calculating the terminal F-values for last age classes where no data supporting the estimate of terminal stock numbers was available. The same procedure was used this year.
- In 2013 Intercatch was used for the first time to calculate age and size distributions
- Minor discards are known to take place, but cannot be quantified accurately; the proportion of discards in the total catches is considered negligible.
- MSY and PA reference points have been reviewed by ICES in 2013.

The information used in the assessment is catch data and survey data from eight surveys. The analysis was restricted to the years 1988 – 2014, which is regarded as the period representative of the present production and exploitation regimes, and is presumed to be of main interest for the management.

Historically, the size of the stock has shown large variations and dependency on the irregular occurrence of very strong year classes. But it is assumed that future recruitment patterns are similar as observed in the past.

A deterministic short term projection is used.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: Analytical
3) **Forecast**: short term forecast presented
4) **Assessment model**: VPA (TASACS toolbox) tuning by 8 surveys series (Norwegian acoustic survey on spawning grounds in Feb./Mar. (NASF), Norwegian acoustic survey in Nov./Dec. (NASN), Norwegian acoustic survey in Jan. (NASJ), 2 International ecosystem surveys in the Nordic Seas (IESNS), 2 Ecosystem surveys in the Barents Sea (Eco-NoRu-Q3 (Aco)), Norwegian herring larvae survey on the Norwegian shelf (NHLS))
5) **Data issues:** Assessment period 1988–2014: Commercial catches (international catches, ages, and weight-at-age from catch sampling). Eight survey indices: one larval survey (NHLS), two recruitment surveys (indices from Eco-NoRu-Q3 (Ace), and for surveys covering the adult stock, including one survey which

provides an index of the abundance of young herring in the Barents Sea (including IESNS). No commercial indices. Maturity ogive variable by year-class strength. Natural mortalities are fixed values from historical analyses.

6) **Consistency**: the assessment of 2013 is consistent with last year's assessment.

7) **Stock status**: The stock is declining and estimated at B_{pa} in 2013. In the last 15 years, five large year classes have been produced (1998, 1999, 2002, 2003, and 2004). However, the available information indicates that year classes born after 2004 have been small. Fishing mortality in 2013 was slightly below F_{pa} and F_{MSY}, but above the management plan target F. The precautionary approach states that should the SSB fall below B_{pa} the fishing mortality should be reduced to ensure a safe and rapid recovery of the B_{pa}. Even zero catches in 2015 is expected to lead to a reduction in SSB in 2016 to 3.4 million tonnes

8) **Man. Plan.**: EU, Faroe Islands, Iceland, Norway, and Russia agreed in 1999 to implement a long-term management plan for Norwegian spring-spawning herring. The management plan aims to constrain harvesting within safe biological limits and is designed to provide sustainable fisheries in the long term. ICES has evaluated the plan and concluded that it is consistent with the precautionary approach.

General comments

Change in maturity-at-age contributes to the change in perception of estimated SSB in the 2010 and later assessments compared to previous assessments.

The new updated algorithm implemented to derive the terminal fishing mortalities on the oldest age groups in the assessment for cohorts where there is insufficient information to estimate these, has increased the stability in the assessment.

There are indications that there are changes in the catchability of herring in tuning survey (feeding area survey in the Norwegian Sea in May). These changes would produce bias in the results of the assessment. Studies on change of catchability of herring in the survey are required.

For the fishing seasons 2013 and 2014, a lack of agreement by the Coastal States on their share in the TAC has led to unilaterally set quotas which together are higher than the TAC indicated by the management plan. In addition, increased unilateral catches in 2013 taken by Greenland were reported to WGWIDE. If this situation continues, the high catches will accelerate the present decline of the stock and increase the risk of the stock going below B_{lim}.

The discards of this stock are considered to be low, slippage occurs. The amount of slippage is unquantified and thus cannot be accounted for in the assessment.

Technical comments

In Section "7.3.1.2 Germany" The reported landings in 2013 were 4242 tonnes taken in IIa and IIb. However, the total landings reported in Table 7.5.1.1 are 4244 tonnes.

In Section "7.3.1.4 Faroe Islands" instead of "The majority of the landings was…" must be "The majority of the landings were …"

Figure 7.7.3.2.6 referenced from section 7.7.3.2 is missing.

Figure 7.7.3.2.5 and Figure 7.7.3.2.6 should be named as Figure 7.7.3.2.1 and Figure 7.7.3.2.2 because don't appear Figure 7.7.3.2.1. to Figure 7.7.3.2.4

Table 2 referenced in section 7.5.7.4 is missing.

Table 7.5.7.6.1: there isn't any value Index 2 in 2014. They don't explain why

In section 7.7.1 , 2nd paragraph say "For survey 5 Figure 7.7.1.3 shows the disaggregated catches in numbers plotted on a log scale" but this figure is about "Age disaggregated abundance indices from the acoustic survey on the feeding area in the Norwegian Sea"

In section 7.7.3.1 shoud be cited Figure 7.7.3.1. And this figure should be named Figure 7.7.3.1.1 both in text and figures files

Table 7.7.2.1 (The stock summary of the exploratory TISVPA run) is not referenced in the text.

There is not reference ICES 2013c

There is not reference ICES 2014b

Figure 7.7 3.3 is not referenced in the text

Conclusions

The assessment has been performed correctly.

Audit of Boarfish in the Northeast Atlantic

Date 05-Sep-2014

Auditor: **D. C. M. Miller and M. Payne**

General

The fishery for boarfish in the northeast atlantic is relatively new. Time series of catches are short and the time series of the main survey (the acoustic survey) is shorter. The assessment is supplemented with a number of IBTS indices, though these are noisy and have some conflicting signals since they come from distinct areas of the stock distribution. This year the acoustic survey showed a large drop in estimated biomass compared to last year. This has changed our perception of the stock condition, scaling the biomass 30-40% lower over the whole time series.

For single stock summary sheet advice:

1) **Assessment type**: update

2) **Assessment:** analytical

3) **Forecast**: presented (short term) under Fmsy

4) **Assessment model**: Bayesian state-space surplus production, tuning by acoustic and bottom trawl survey series (SPPGFS, SPINGFS, IGFS, EVHOE and BFAS)

5) **Data issues:** assessment highly influenced by the acoustic surveys for which there are only three data points

6) **Consistency:** same procedures applied as last year, with a fairly large retrospective adjustment down in biomass

7) **Stock status:** SSB is above Blim and F is below Fmsy. There is large uncertainty around current estimate of biomass.

8) **Man. Plan.**: There is currently no agreed management plan

General comments

This is a well written, detailed report. It is a good reflection of all the work that has gone into this stock in recent years. All procedures seem to have been followed as they were in 2013 (the first year with an accepted Category 1 assessment).

Data

Sampling level of catches is OK.

The catch at age data show no strong year classes since the 2005 year class (the 2010 year class looks strong at age 3, but too early to say now). This can almost be seen in the IBTS data too. It seems the increase around 2010 may have come on the back of a period of strong year classes, and the subsequent reduction in biomass has resulted from the poorer recruitment since 2005.

It is difficult to explain the observations of sharp increases and decreases in abundance of this long-lived fish. Perhaps is can be explained by patterns in historic recruitment or changes in the distribution of the stock relative to the survey and fishery. It is argued that the latter is unlikely.

Because the acoustic survey is still new, we are not sure what level of interannual variation to expect. This variation resulting from changes in the availability of the stock to the acoustic survey could be caused by survey effects, hydrographic conditions, prey availability etc. The model results are sensitive to this survey since it provides an anchor for the assessment, which would be very difficult to fit otherwise.

The noisy IBTS indices are inverse-variance weighted and hence to not contribute much to the model fit.

Assessment

This year's model had lower K and r parameter estimates than last year, and a very slightly higher q estimate for the acoustic survey. This leads to lower biomass estimated over the time series that allows the model to reconcile the sharp reduction in the acoustic survey with the levels of catches that have been taken.

Forecast

SPALY.

Intermediate year TAC assumption may be an over estimate. 2014 TAC, 127 509 t + average discards of 6 371 t. The 2013 TAC of 82000t was not caught completely, and early indications are that the fishery will not be easy this year.

A wide range of forecasts were done.

FMSY has been recalculated by the model (r/2) as 0.17, down from 0.23 in 2013. This ensures consistency between the model outputs and the calculated reference point. It is not standard procedure in ICES to change reference points from year to year. However, it would be inappropriate to remain using the Fmsy value calculated last year which also assumed a higher K and higher r values than the current forecast assumes.

Technical comments

- The "**Advice and management applicable to 2011, 2012 and 2013"** section is usually only for the previous year, but given that this is a new fishery I think it is useful that some more detail on the recent past is provided.
- Overall there are quite a few sections that describe the fish and the fishery that do not change much from year to year (e.g. historical literature sources, fishing technology, details about the surveys. These could be moved to the stock annex and replaced in the report by refernces to the stock annex to make it briefer. But again, given that this is a new fishery it is OK to leave it in there for now.
- Some minor tracked changes and comments made in the draft report.

Conclusions

The assessment and forecast has been performed correctly. The stock assessment method makes use of all available fisheries independent data, as well as landings and discard data.

The short time series of the acoustic survey is of concern, along with whether or not the target F should be fixed or change annually to ensure compatibility with the most recent assessment results.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  - o **YES**
- Is the assessment according to the stock annex description?
  - o **YES**
- Is general ecosystem information provided and is it used in the individual stock sections.
  - o **YES**
- If a management plan has been agreed, has the plan been evaluated?
  - o **SORT OF**. The management plan, proposed by the Pelagic RAC in 2012, has not been fully evaluated by ICES. However ICES advised in 2013 that the HCR in tier 1 of the plan can be considered in accordance with the precautionary approach if a Category 1 assessment is available.

For update assessments

- Have the data been used as specified in the stock annex?
  - o **YES**
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  - o **YES**
- Is there any **major** reason to deviate from the standard procedure for this stock?
  - o **NO**. The sharp decline in the acoustic survey over two years causes some concern, but not enough to deviate form the agreed method. The survey indicates a decreasing stock, and so too does the assessment method, with appropriate reductions in advised catch.
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  - o **YES**. The assessment make the best use of all available data.

Audit of Western Horse Mackerel in IIa, IVa, Vb, VIa, VIIa-c, e-k, and Sub-area VIII (Western stock)

Date 04.09.2014

Auditor: Are Salthaug

For the attention of: Advisory drafting group, ACOM and WGWIDE

General

The assessment and short term forecast of **Western Horse Mackerel** in **IIa, IVa, Vb, VIa, VIIa-c, e-k, and Subarea VIII (Western stock)** is based on data handling procedures and assessment modeling as described in 2008 when the assessment was accepted by WGWIDE (separable window was increased to 6 years in 2009). The assessment has not been benchmarked.

For single stock summary sheet advice:

1) **Assessment type: SALY**
2) **Assessment**: analytical
3) **Forecast**: presented (short term)
4) **Assessment model**: SAD (linked Separable-ADAPT VPA), tuning by 1 survey index (triennial egg survey)
5) **Data issues:** lack of discard information. Lack of age-disaggregated survey data. Lack of annual survey data.
6) **Consistency**: The assessment seems to be consistent with the 2012 assessment.
7) **Stock status**: SSB is estimated to be at 0.61 Mt in 2014, which is the lowest in the time series. F has been increasing since 2007. Recruitment has been low since 2010.
8) **Man. Plan.**: There is currently no agreed management plan.

General comments

The procedure is conducted according to the stock annex. Only available tuning data are based on a triennial survey which is designed for deriving the annual egg production of mackerel but is also used for estimating an egg production index for horse mackerel. Discard data are only available for parts of the fishing fleet, so the total amount cannot be calculated.

Technical comments

Section 5.2.5 and Table 5.2.5.3: mean weights at age in stock were assigned as 0.085kg. A basis for this choice should be given.

The table numberes referred to in section 5.1.1 and 5.1.2 are wrong.

Weight units should be given on the y-axis or in the figure text in figure 5.2.5.1 and 5.2.5.2

Conclusions

Procedures have been carried out in accordance with the stock annex. However, the assessment suffers from the lack of age information in the single available fishery-independent index. This results in a rescaling of the assessment every three years, when a new survey point becomes available and a revision of the reference points.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?

  YES

- Is the assessment according to the stock annex description?

  YES

- Is general ecosystem information provided and is it used in the individual stock sections.

  YES

- If a management plan has been agreed, has the plan been evaluated?

The management plan proposed by the Pelagic RAC in 2007 was used to set the EU TAC for 2008-2010. The plan was evaluated by ICES in 2013 and found to **not** to be consistent with the precautionary approach.

For update assessments

- Have the data been used as specified in the stock annex?

  YES

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

  YES

- Is there any **major** reason to deviate from the standard procedure for this stock?

  NO

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

  YES

Audit of Blue Whiting - Subareas I–IX, XII and XIV

Date 04/09/2014

Auditor: **Andrew Campbell, Jens Ulleweit**

General

The assessment and short term forecast of **Blue Whiting - Subareas I–IX, XII and XIV** is based on data handling procedures and assessment modeling following the benchmark of 2012. Re-evaluation of the reference points took place in May and October 2013.

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented.
4) **Assessment model**: SAM model (with comparative runs in SMS and XSA, all giving similar results)
5) **Data issues:** There is a lack of juvenile indices leading to a poor estimation of incoming recruitment.

   The population structure of blue whiting in the NE Atlantic appears to be more complex than the current single-stock structure used for management purposes. The assessment model and survey data are assumed to mainly reflect the northern component: there is no recent information available regarding the relative size of the southern component. According to the catch statistic the majority of the stock seems however to be covered.

   Blue whiting otoliths have proven to be quite difficult to age and a evaluation at the latest workshop shows that the experience of the reader determines the interpretation of the otolith structure. This strongly indicates that biased readings might have been present in many cases for the historical data used in the assessment, even for experienced age-readers. Here is a need for more regular exchanges.

   Discards are not included but are considered negligible.

6) **Consistency**: After benchmark in 2012 this is the third year that the SAM model has been applied for this stock. Comparison of the final assessment results from the last 6 years show stable and consistent output, except for the 2010 assessment which was flawed by low survey coverage in this year. However, the 2014 new advice is based on a deterministic forecast while a stochastic forecast has been applied in the previous two years. This change is made to match the assumption made by the management strategy evaluation of an alternative management plan. The deterministic forecast gives a 5-6 % lower TAC than the stochastic forecast previously applied.
7) **Stock status:** SSB has almost doubled from 2010 (2.9 million tonnes) to 2014 (5.5 million tonnes) and is clearly above Bpa (2.25 million tonnes). This increase is due to historical low F since 2011 in combination with a higher recruitment (age 1) since 2010. The uncertainty around the recruitment in the most recent year is high.

8) **Man. Plan.**: Agreed by Norway, the EU, the Faroe Islands, and Iceland in 2008. The plan uses i) a target fishing mortality (F = 0.18) if SSB is above SSBMP (= Bpa), ii) a linear reduction to F = 0.05 if SSB is between Bpa and Blim, and iii) F = 0.05 if SSB is below Blim. ICES evaluated the plan in 2008 and concluded that it is in accordance with the precautionary approach.

   ICES evaluated a NEAFC request concerning an alternative management plan in May 2013 and further in October 2013. No agreement on the application of a new management plan has been obtained.

General comments

Procedures have been carried out in accordance with the stock annex with the exception of the forecast which is based on determistic projections instead of stochastic projections.

Technical comments

Annex Issues

Stock weights – there is no discussion on the stock weights (in section titled 'Weight at age in the catch and Weight at age in the stock). For the assessment these are assumed the same but there is no explanation as to why this is a valid assumption. Additionally, the table of input data in the annex implies that the two are different.

Surveys used in the assessment – the annex implies 3 surveys are used in the assessment whereas only the IBWSS is used quantitatively.

Link to stockassessment.org in annex out of date

Some information is missing on model options in annex (from model.cfg file). The flags for 'max age a plus group?' and 'use correlated random walks' are not printed.

Annex considers deterministic forecast inappropriate, yet this was used in 2014. Needs to be updated to reflect this.

Reference points table requires updating

Tables need updating with most recent information

Draft Report Issues

<u>Tables</u>

Table 8.3.1.1 – no footnote provided for **** label

Table 8.3.3.1 – there are two tables with this number (Catch weight at age and Natural Mortality & Proportion Mature at Age)

Tables 8.3.4.1.1 and 8.4.1 both contain IBWSS data. The data for 2008 differs. That shown in 8.4.1 matches that used in the assessment

Table 8.8.2.1.1 Input to short term projections – the footnotes are incorrectly annotated (second one needs additional * and spelling corrected). These notes indicated that stock numbers for ages 1 and 2 were updated using alternative values. However, there alternatives are not the numbers in the table.

Table 8.8.2.2.2 – Stochastic forecast. The numbers in this table do not match those on stockassessment.org

<u>Figures</u>

Figure 8.2.2-3 referenced from section 8.2 but could not find them

Text

Section 8.3.1.2 states that 977 samples were collected. Table 8.3.1.2.2 indicates the total was 915.

Section 8.3.1.3 references table 8.3.1.3.4 as the catch numbers at age. This data is in table 8.3.1.4.1

Section 8.3.1.4 refers to table 8.3.1.4.1 as showing the mean weight at age in the catch. This table contains the number at age.

Section 8.3.3 refers to table 8.3.3.1. There are two tables with this number. A reference should be included for the cited working document.

Section 8.3.4.1 refers to tanle 8.3.4.1.1 as containing the spawning stock estimates whereas the table quotes total stock biomass.

Need to use superscripts when quoting numbers in scientific format (paragraph 2 of 'Results' subsection)

The third paragraph in the Results subsection is unclear and subsequently difficult to understand.

Section 8.3.4.2. Final paragraph should refer to six years of data, not five.

Section 8.4. Paragraph 2 should indicated which year the 'year effects' refer to. Paragraph 3 contains several typos.

Conclusions

The assessment has been performed correctly

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice? **Yes**
- Is the assessment according to the stock annex description? **Yes, but annex requires updating**
- Is general ecosystem information provided and is it used in the individual stock sections.**In general: yes. Clarifying need in terms of the population structure of blue whiting**
- If a management plan has been agreed, has the plan been evaluated? **Yes.**

For update assessments

- Have the data been used as specified in the stock annex? **Yes, but annex requires updating with the most recent information**
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **Yes, with the exception of the forecast. The annex requires updating in this respect**
- Is there any **major** reason to deviate from the standard procedure for this stock? **No major reason**

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **yes**