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.

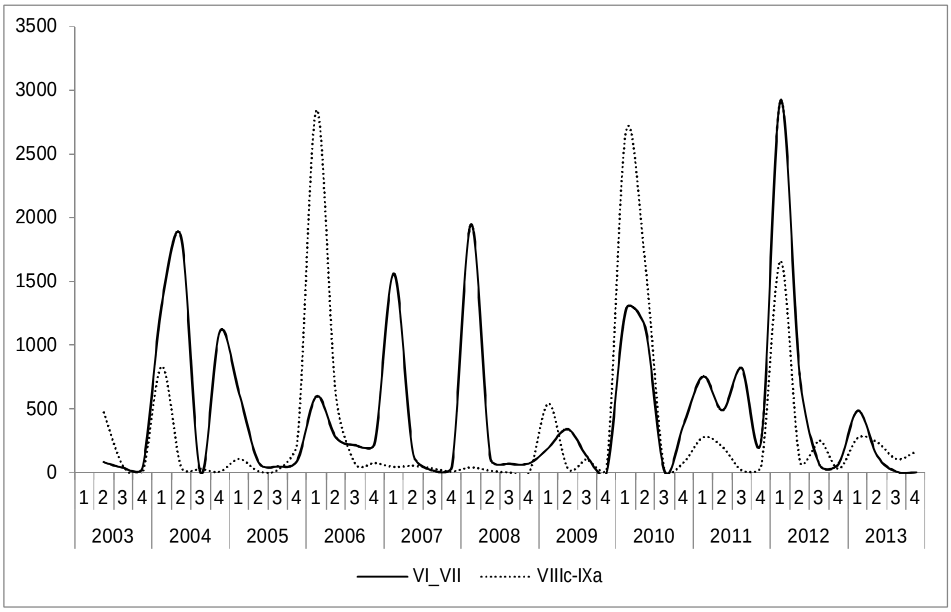


Figure 2. Atlantic mackerel quarterly discard estimates in number (thousands) for the Spanish trawl fishery in ICES Sub-areas.

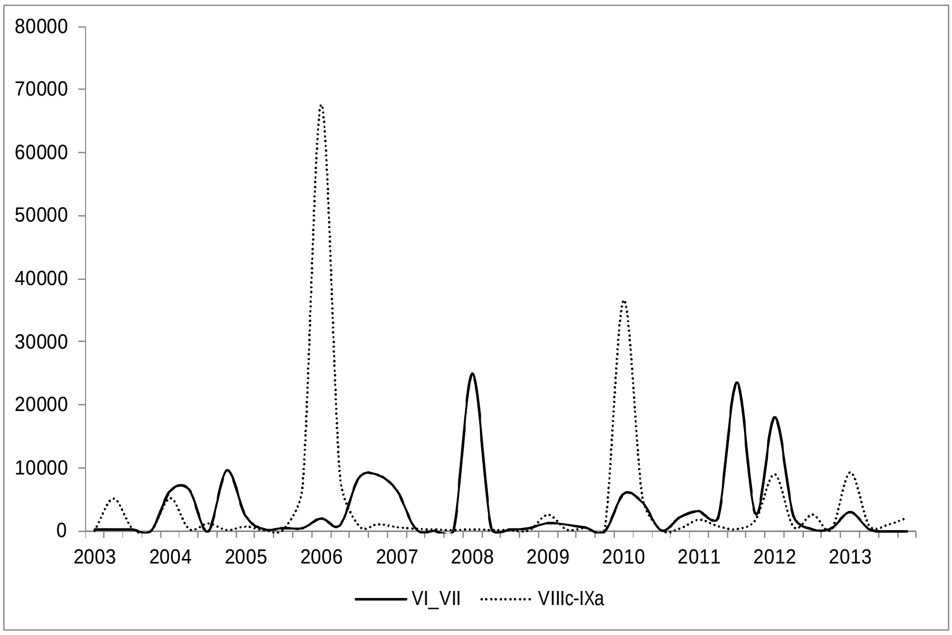


Figure 3. Atlantic mackerel yearly discard estimates in weight (tonnes) for the Spanish trawl fishery in ICES Sub-areas

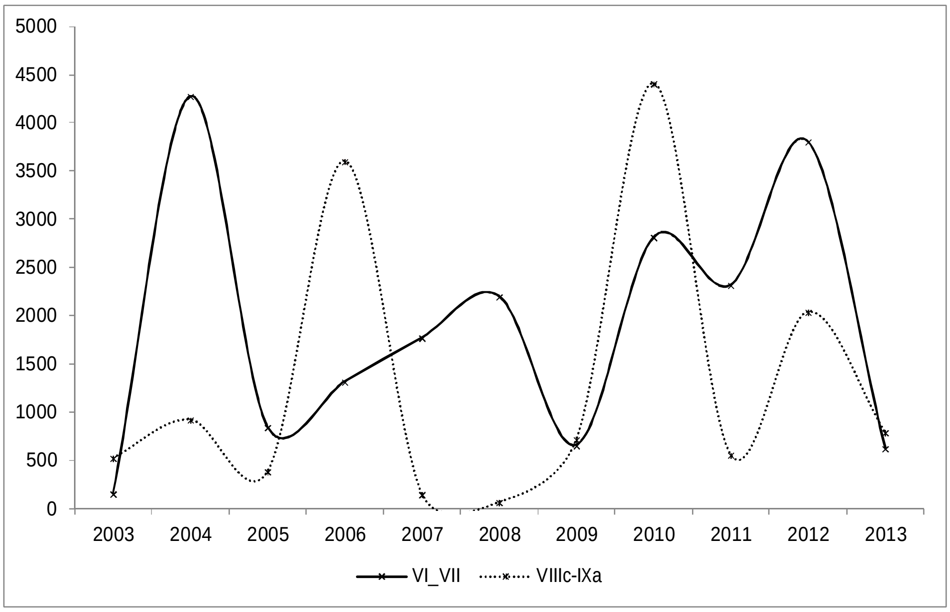


Figure 4. Observer on board indices (kg caught per haul) from métiers operated in Sub-areas VI_VII

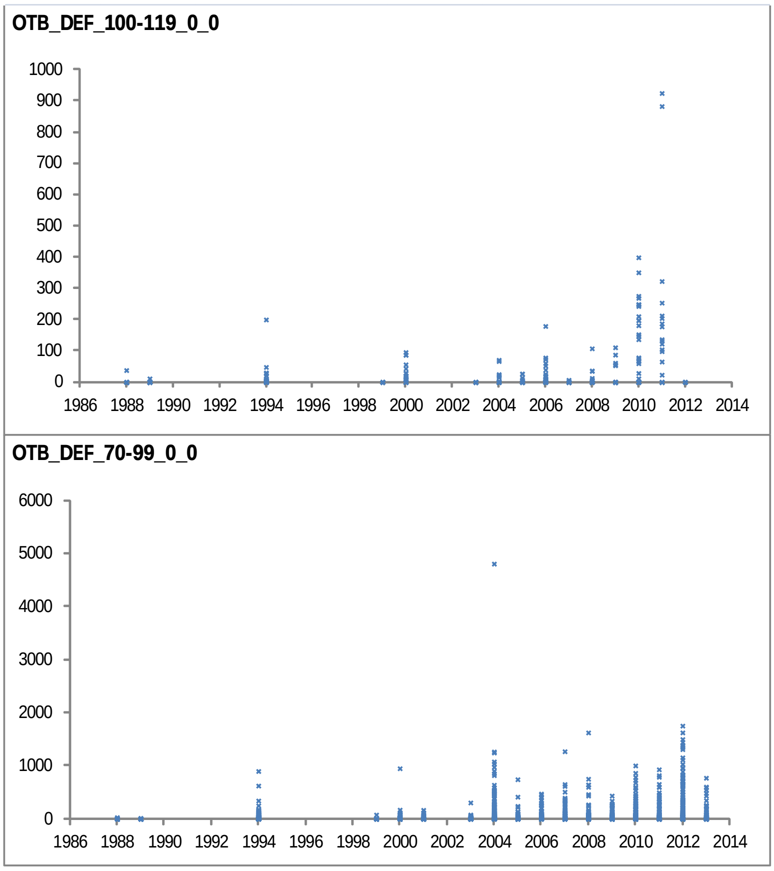


Figure 5. Effort in number of trips in Sub-areas VI_VII

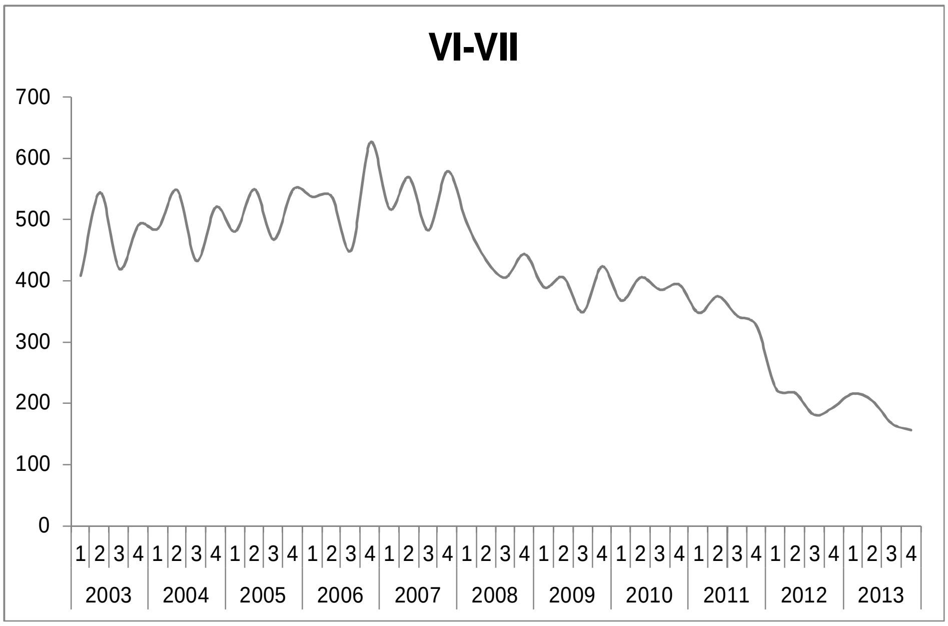


Figure 6. Catch indices, Total Catch per Haul (kg) in observed trips of OTB_DEF_>=55_0_0, OTB_MPD_>=55_0_0 and PTB_MPD_>=55_0_0

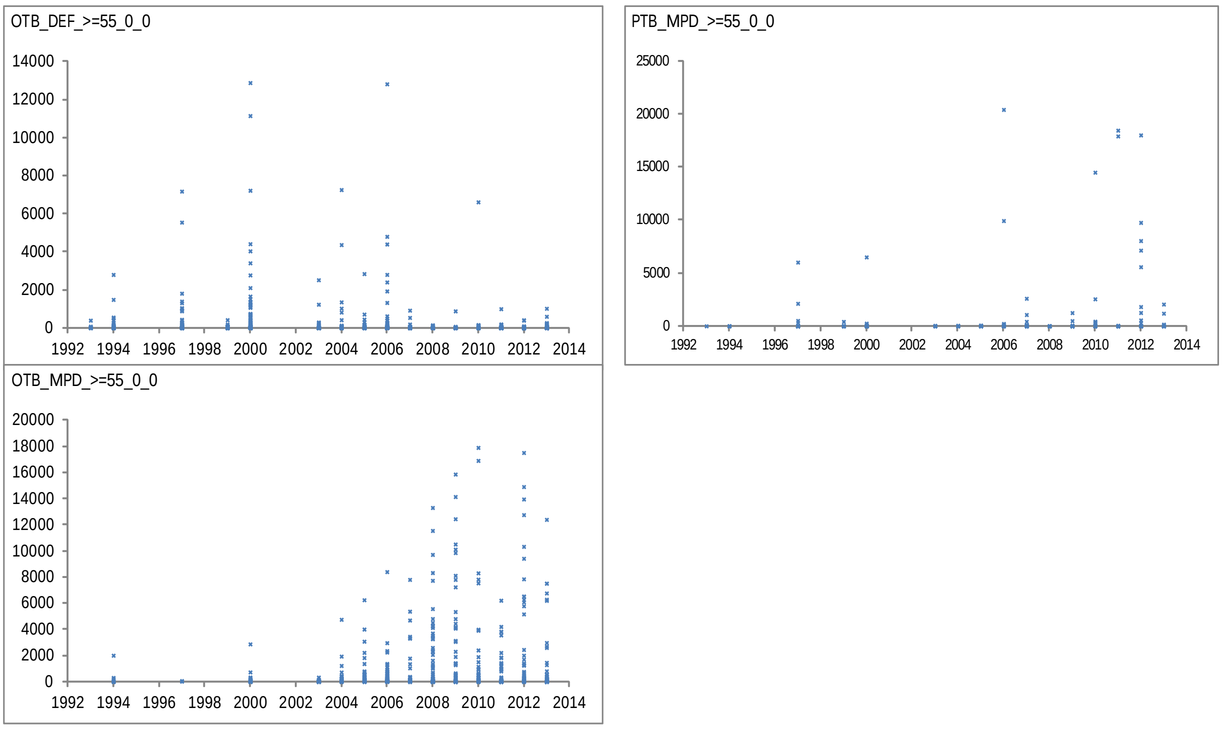


Figure 7. Discard rate (discard weight/catch weight) by métier in Divisions VIIIc and IXa. 1994-2013

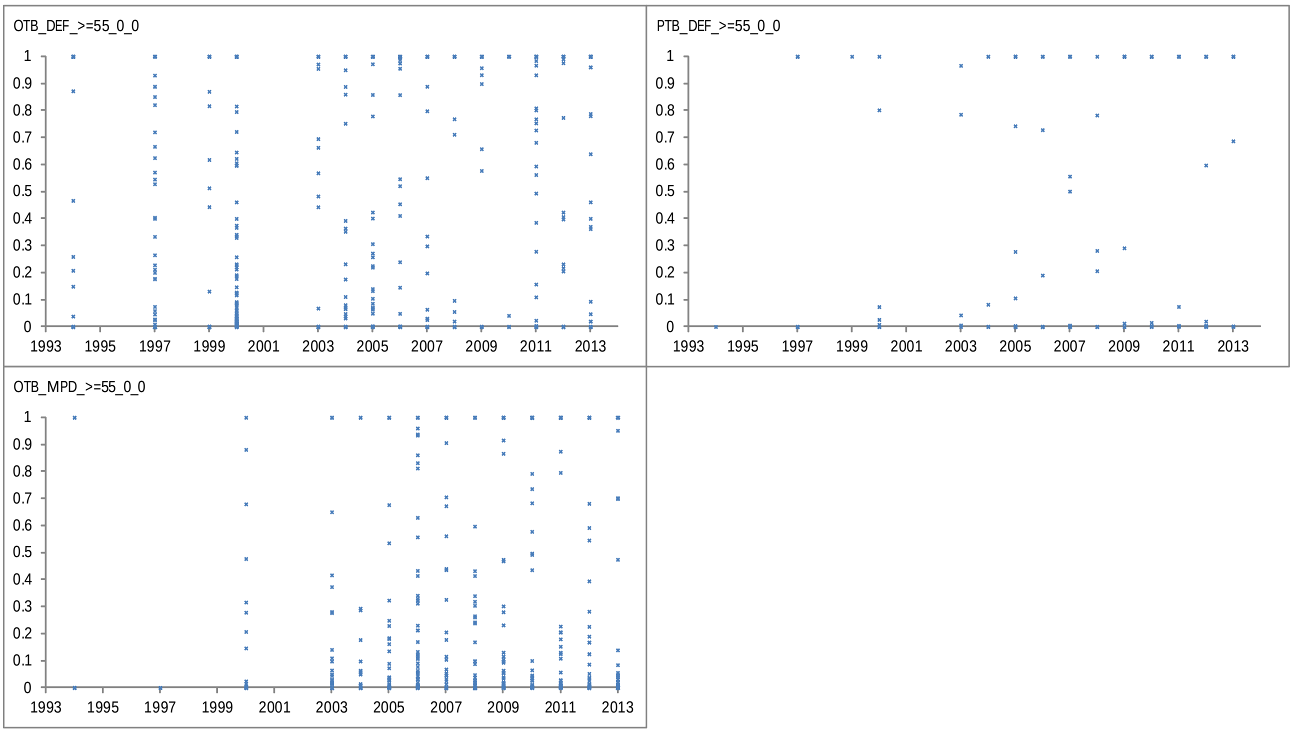


Figure 8. Effort in number of trips in Divisions VIIIc, IXaN

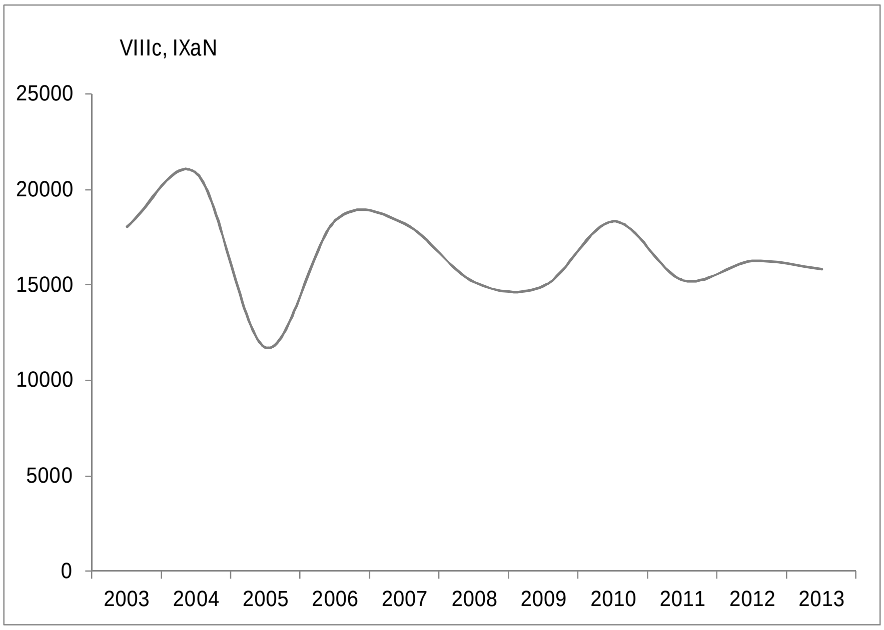


Figure 9. Observer on board indices; kg caught/haul (points, on the left axis) and mean kg caught/haul (line, on the right axis) from all métiers, upper figure and discard indices in lower.

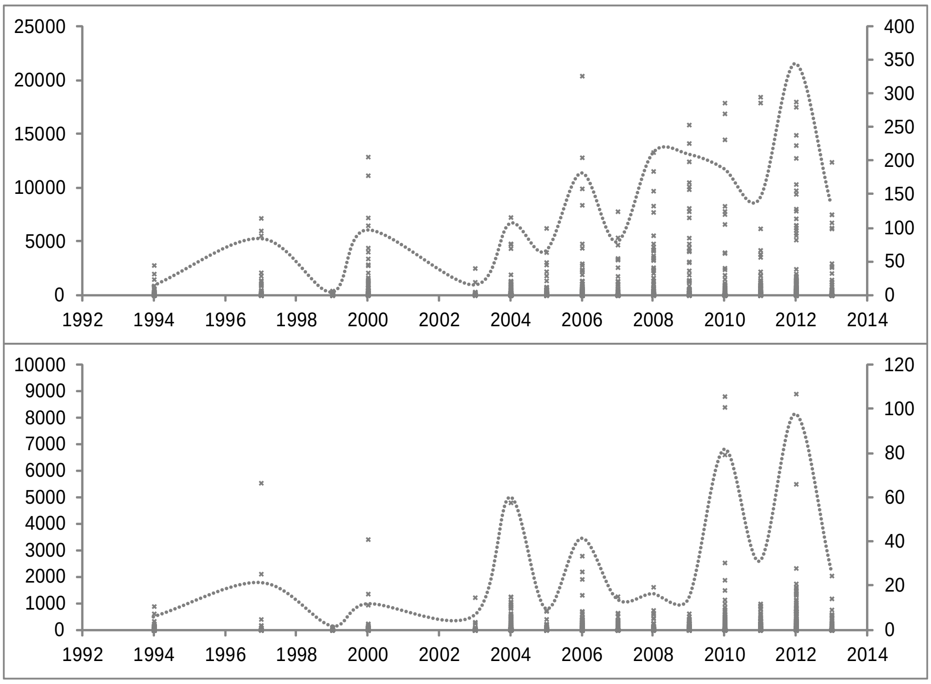


Figure 10. Quarterly age composition of Spanish trawl discards of Atlantic mackerel in ICES Sub-areas VI and VII.

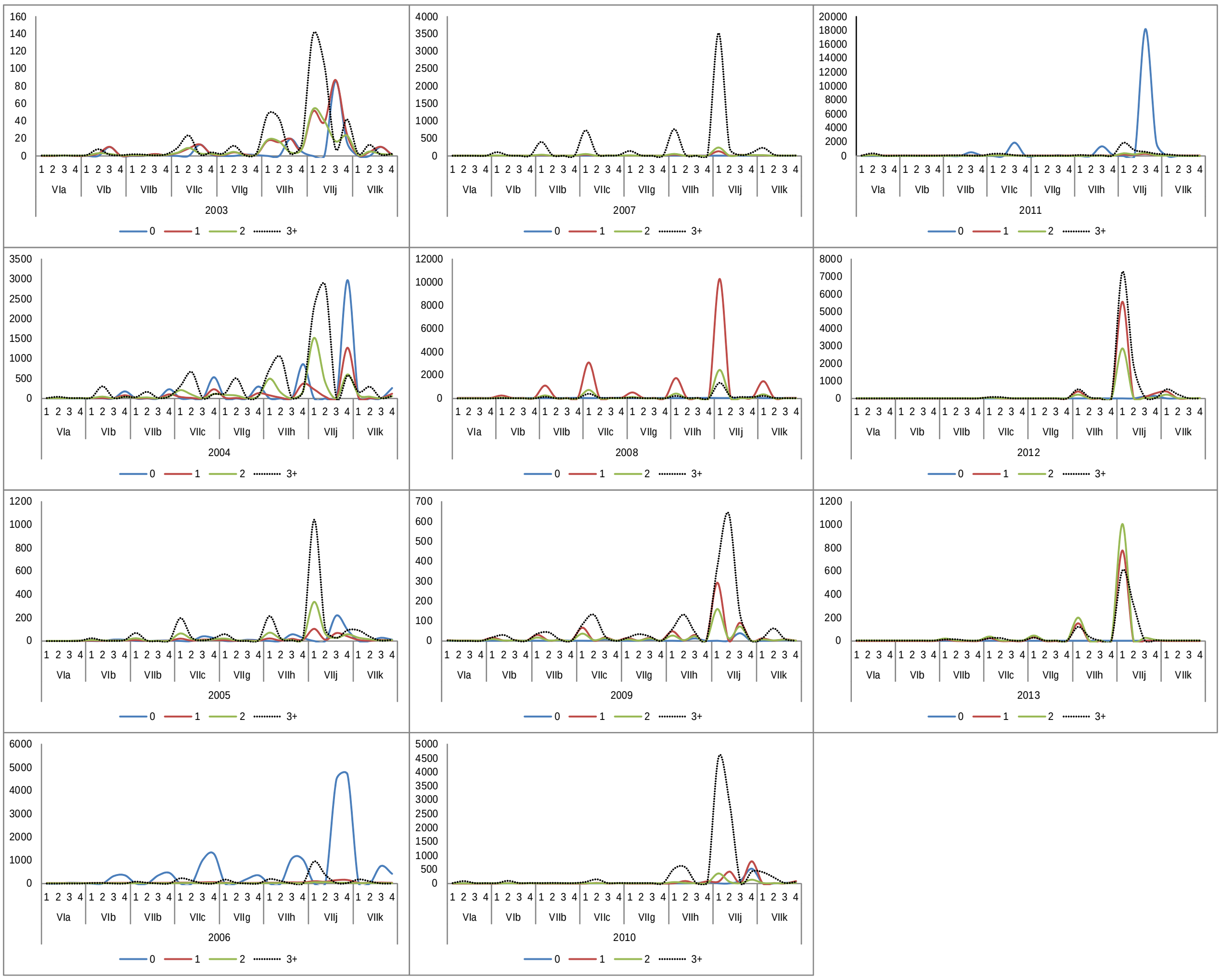
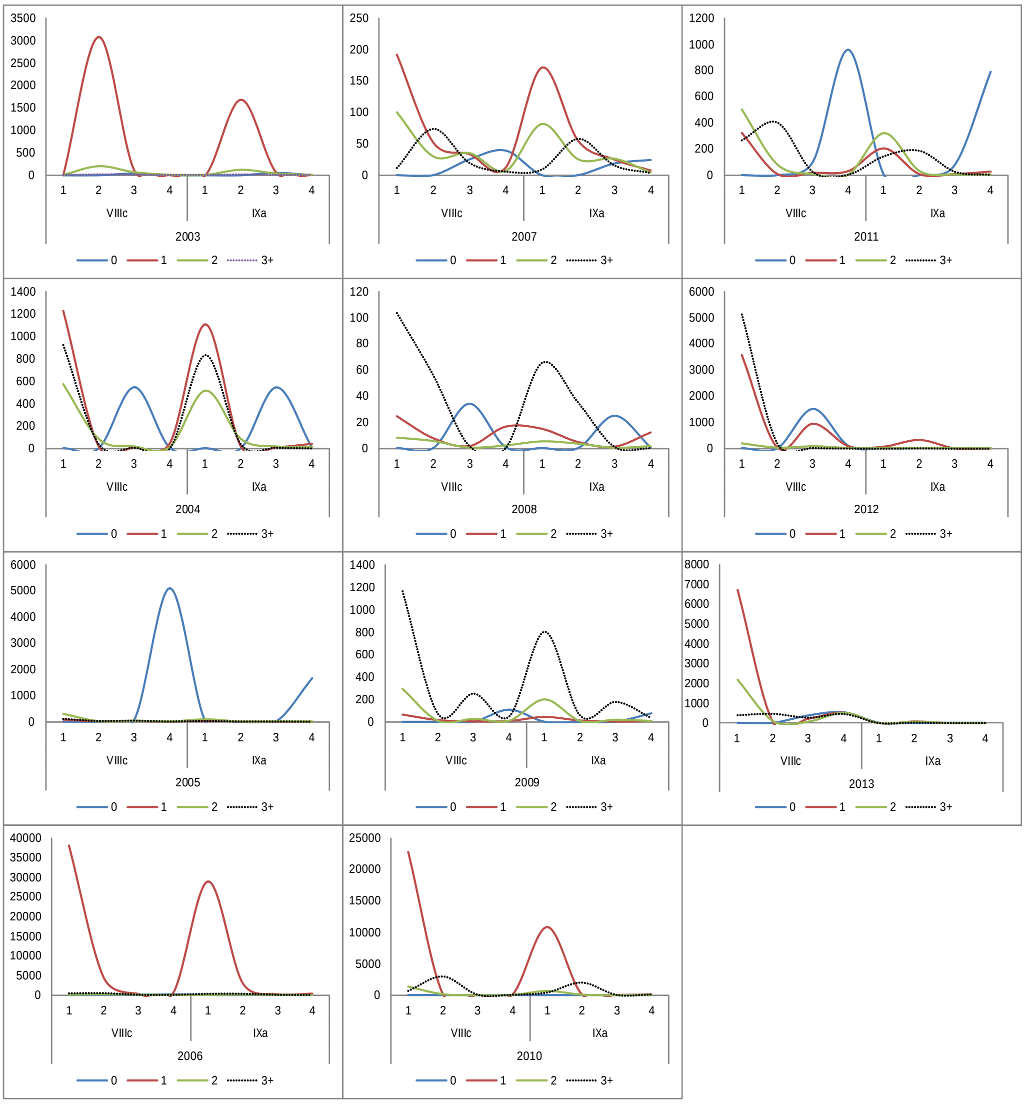


Figure 11. Quarterly age composition of Spanish trawl discards of Atlantic mackerel in ICES Divisions VIIIc-IXaN.



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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.

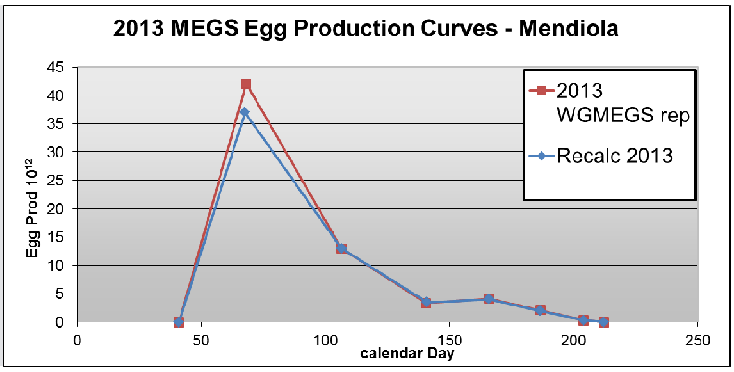

Figure 1.-. Comparison of the originally reported and revised mackerel egg production curve for the Western area.

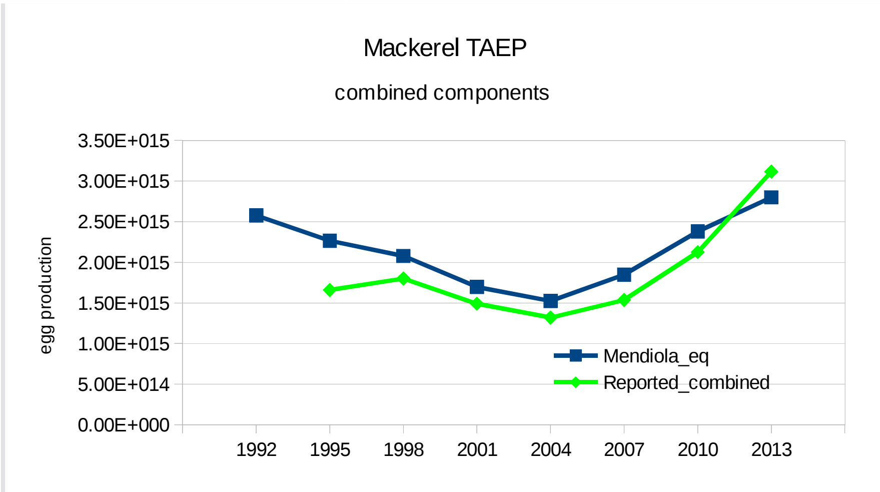

Figure 2.-. Mackerel TAEP estimates derived from the mackerel egg surveys. The green line represents the Annual egg Production for the mackerel reported by WGMEGS. The blue line represents the recalculated egg production using Mendiola equation. It should be noted that reported egg production in 2013 was estimated using Mendiola equation.

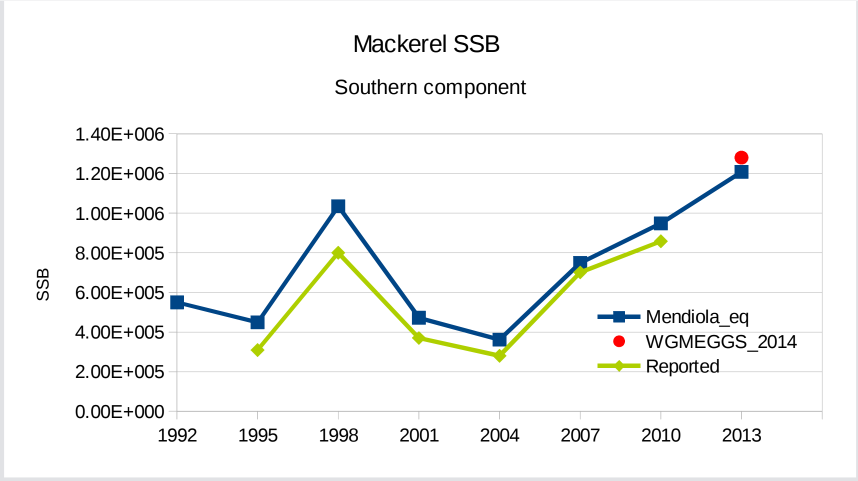

Figure 3.-.. Mackerel SSB estimates derived from annual egg production for the southern area only. The green line represents the reported estimates by WGMEGS until 2012. The red spot is the estimate given by WGMEGS for the updated advice. The blue line represents the recalculate SSB using Mendiola egg development equation.

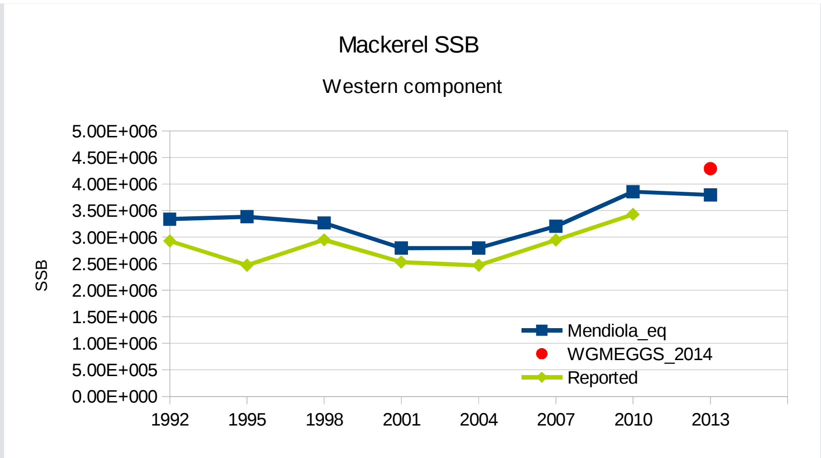

Figure 4.-.. Mackerel SSB estimates derived from annual egg production for the western area only. The green line represents the reported estimates by WGMEGS until 2012. The red spot is the estimate given by WGMEGS for the updated advice. The blue line represents the recalculate SSB using Mendiola egg development equation

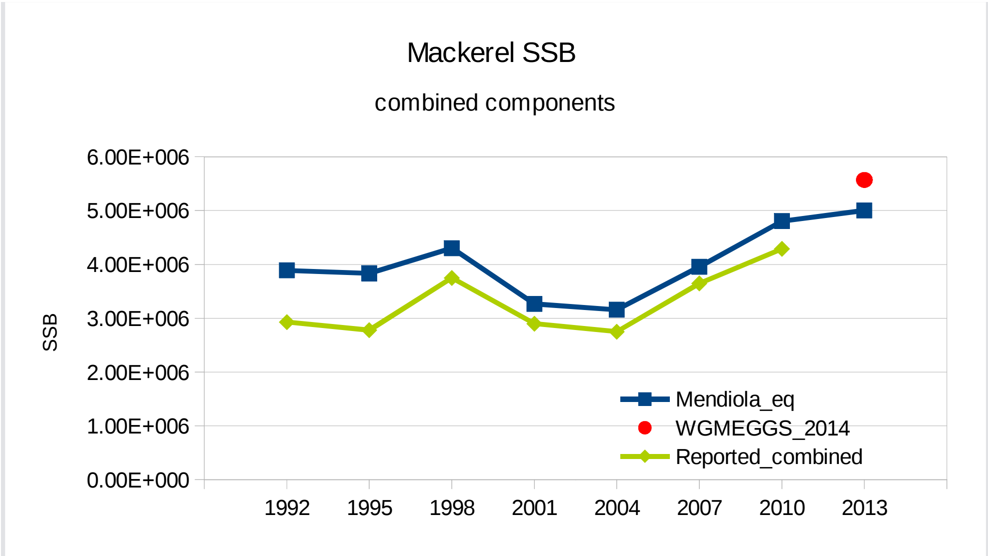

Figure 5.-. Mackerel SSB estimates derived from the mackerel egg surveys for the combined survey area. The green line represents the reported estimates by WGMEGS until 2012. The red spot is the estimate given by WGMEGS for the updated advice. The blue line represents the recalculate SSB using Mendiola 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

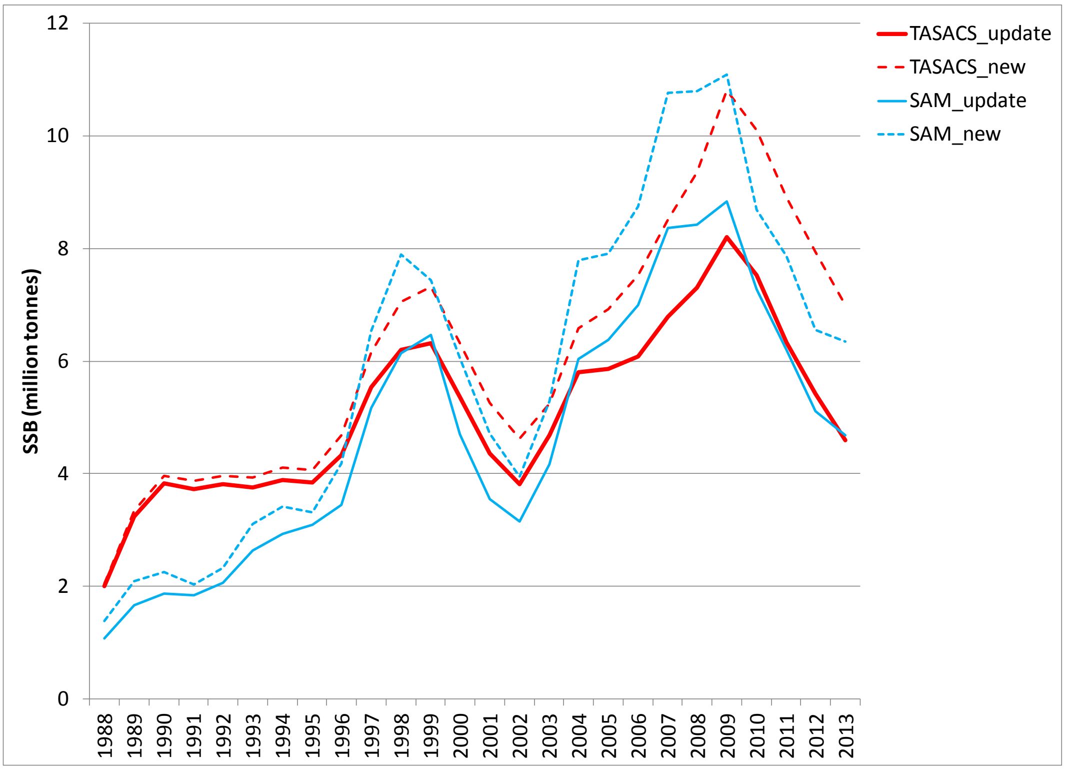

Figure 1. Comparison of SSB from TASACS and SAM using approximately the same survey data as in the final ICES assessment from 2013 (*TASACS_update* and *SAM_update*) and using the survey data recommended by Salthaug and Johnsen (2014) (*TASACS_new* and *SAM_new*).

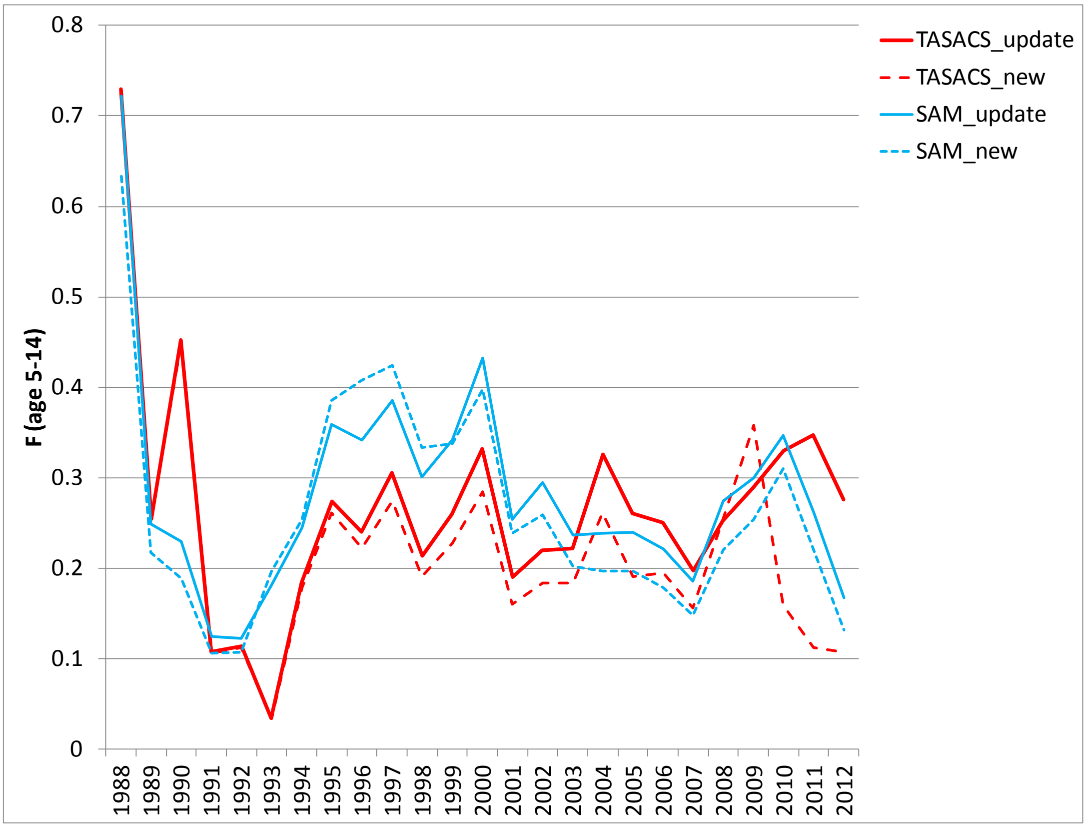

Figure 2. Comparison of mean F from TASACS and SAM using approximately the same survey data as in the final ICES assessment from 2013 (*TASACS_update* and *SAM_update*) and using the survey data recommended by Salthaug and Johnsen (2014) (*TASACS_new* and *SAM_new*).

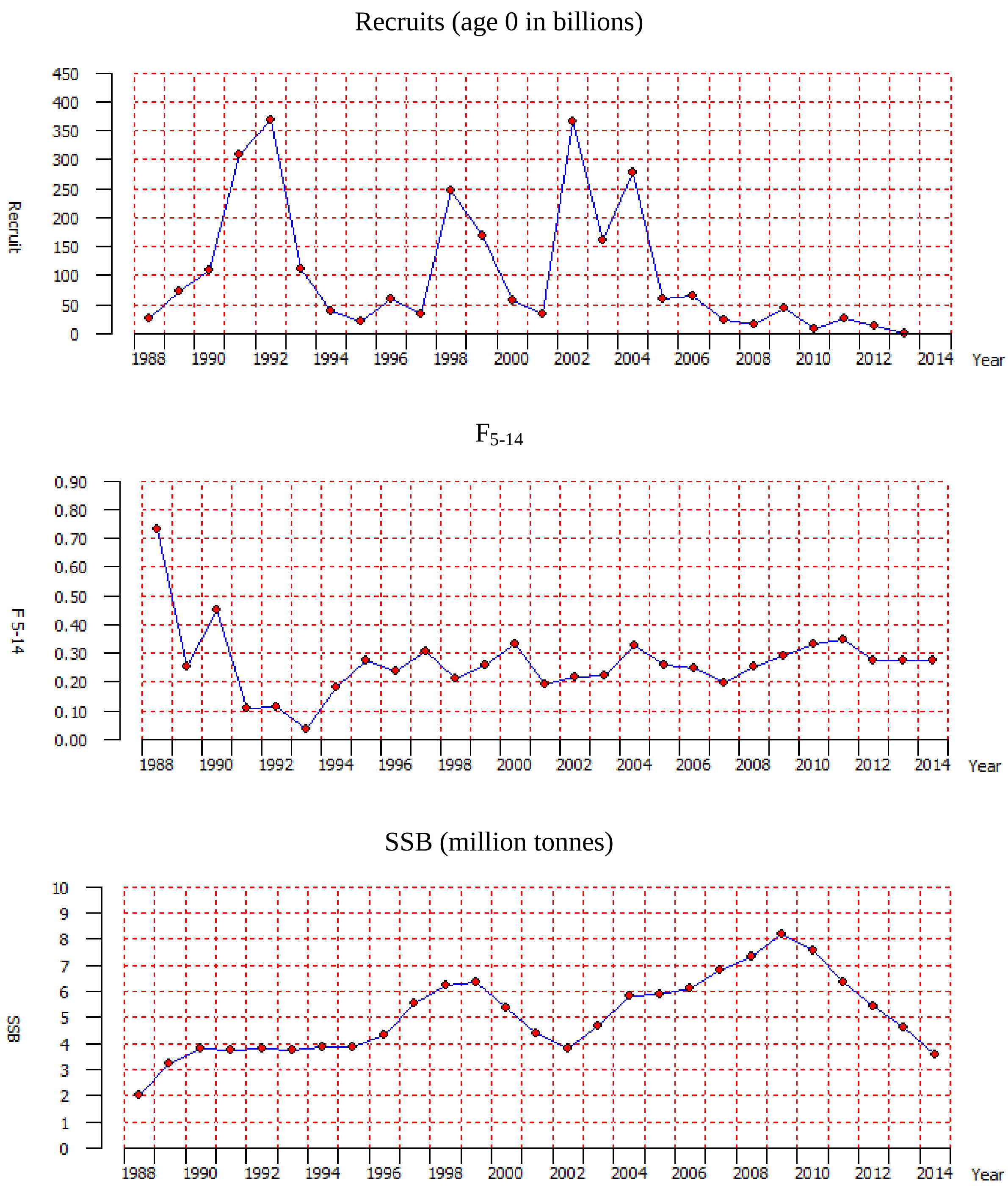

Figure 3. Stock summary of *TASACS_update*.

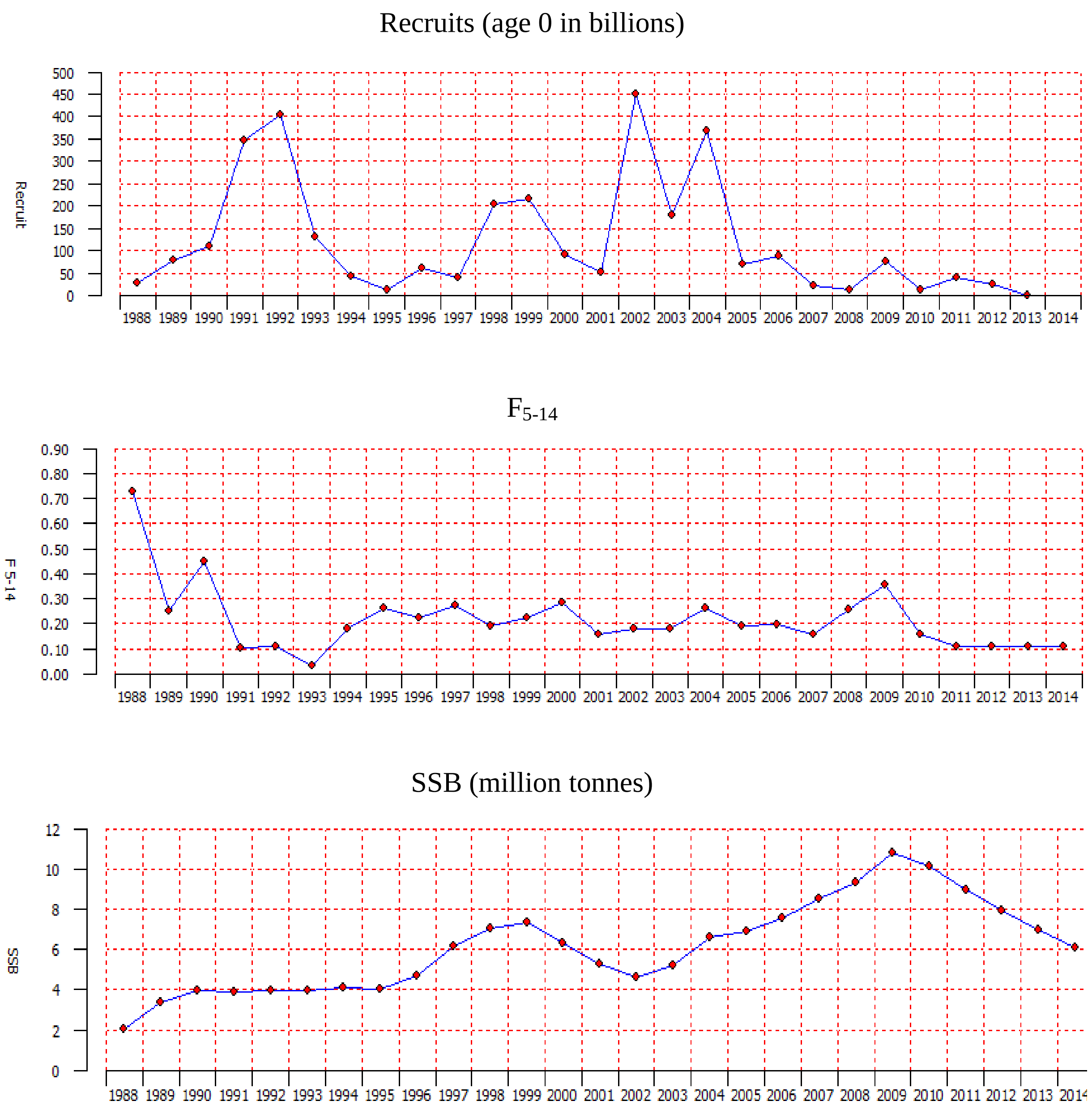

Figure 4. Stock summary of *TASACS_new*.

SAM_update ***SAM_new***

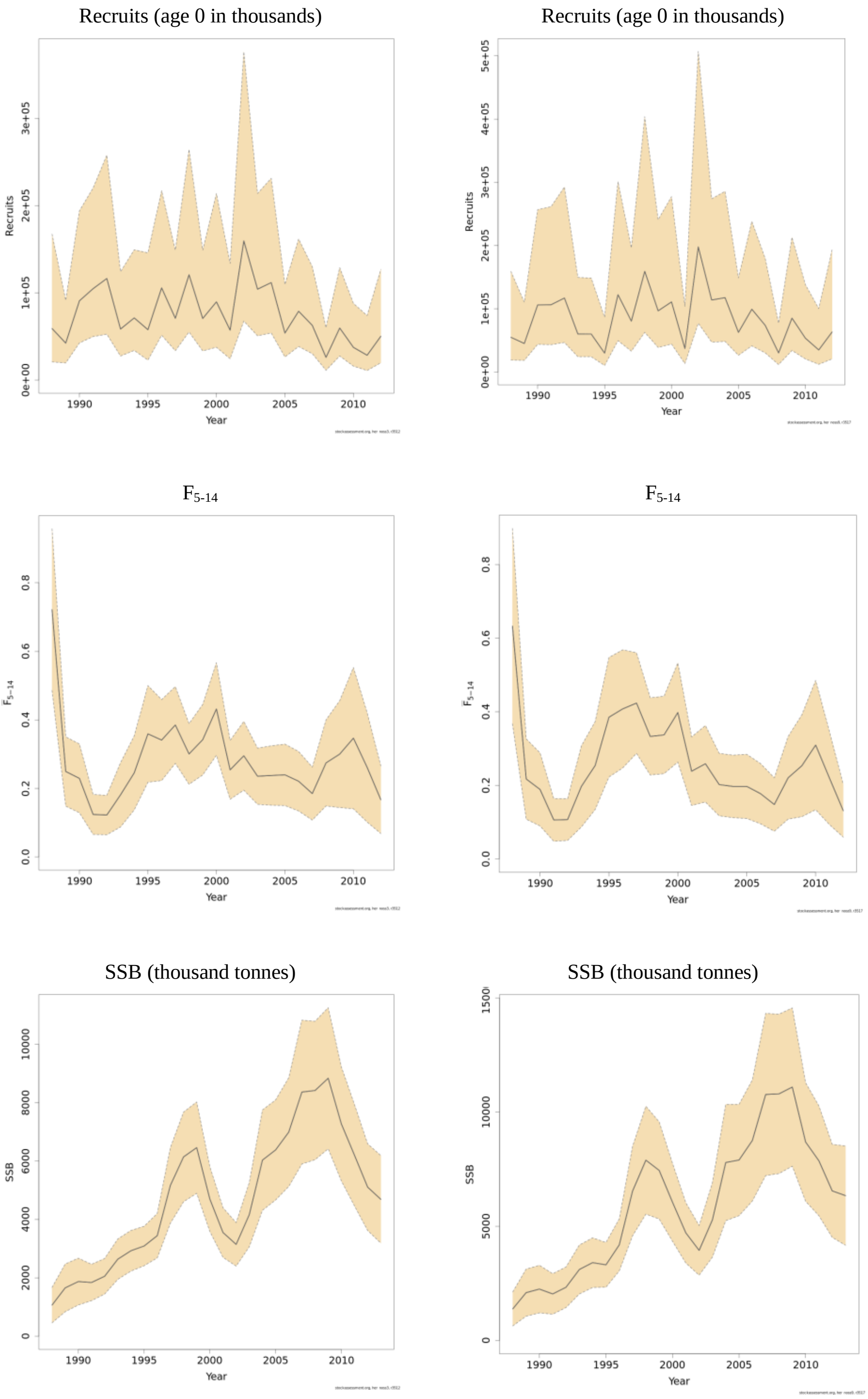

Figure 5. Stock summary of *SAM_update* (left) and *SAM_new* (right).

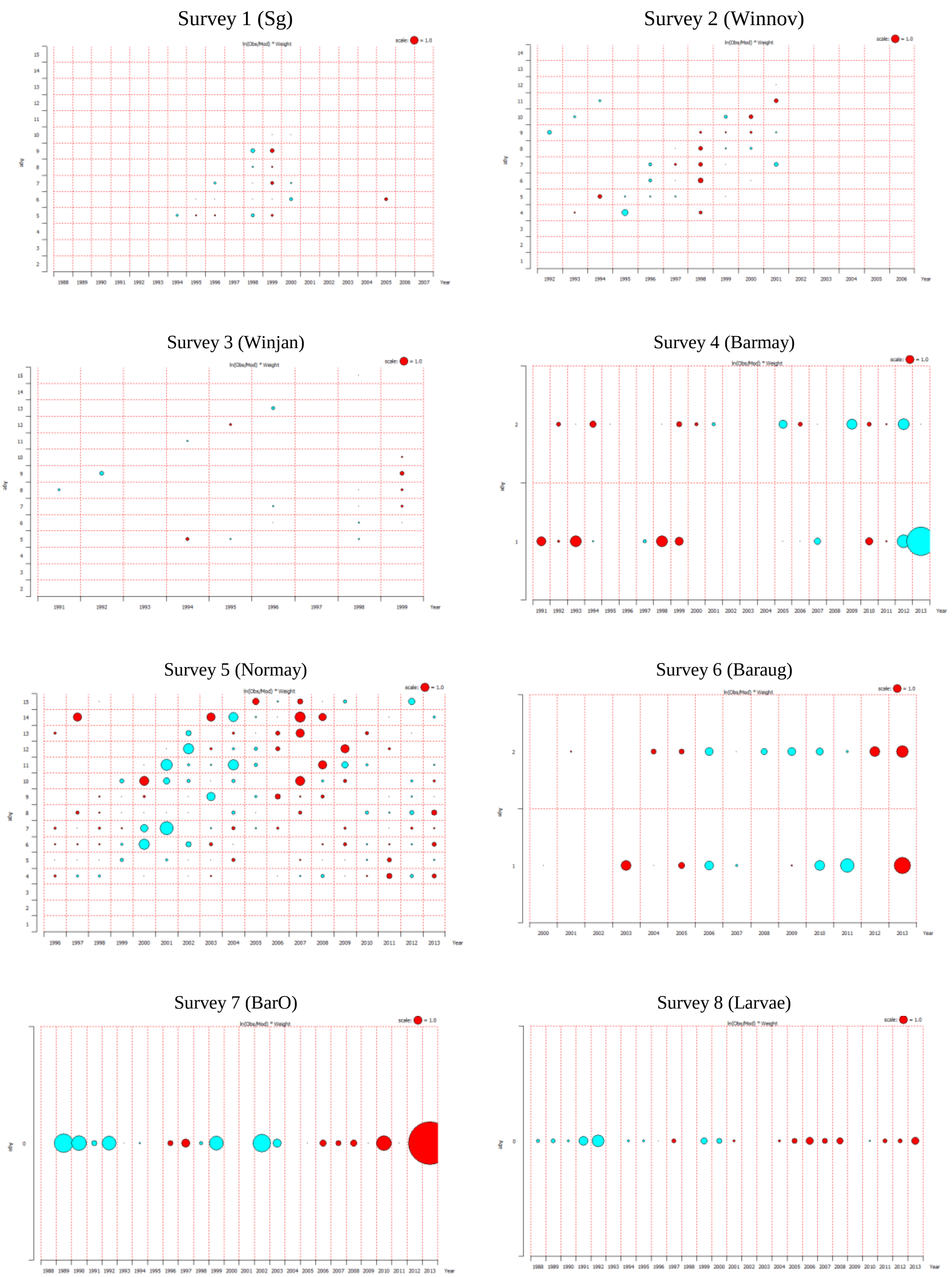

Figure 6. Residuals for the surveys in *TASACS_update*. A red bubble shows that the observed value is higher than the expected value.

Figure 7. Residuals for the surveys in *TASACS_new*. A red bubble shows that the observed value is higher than the expected value.

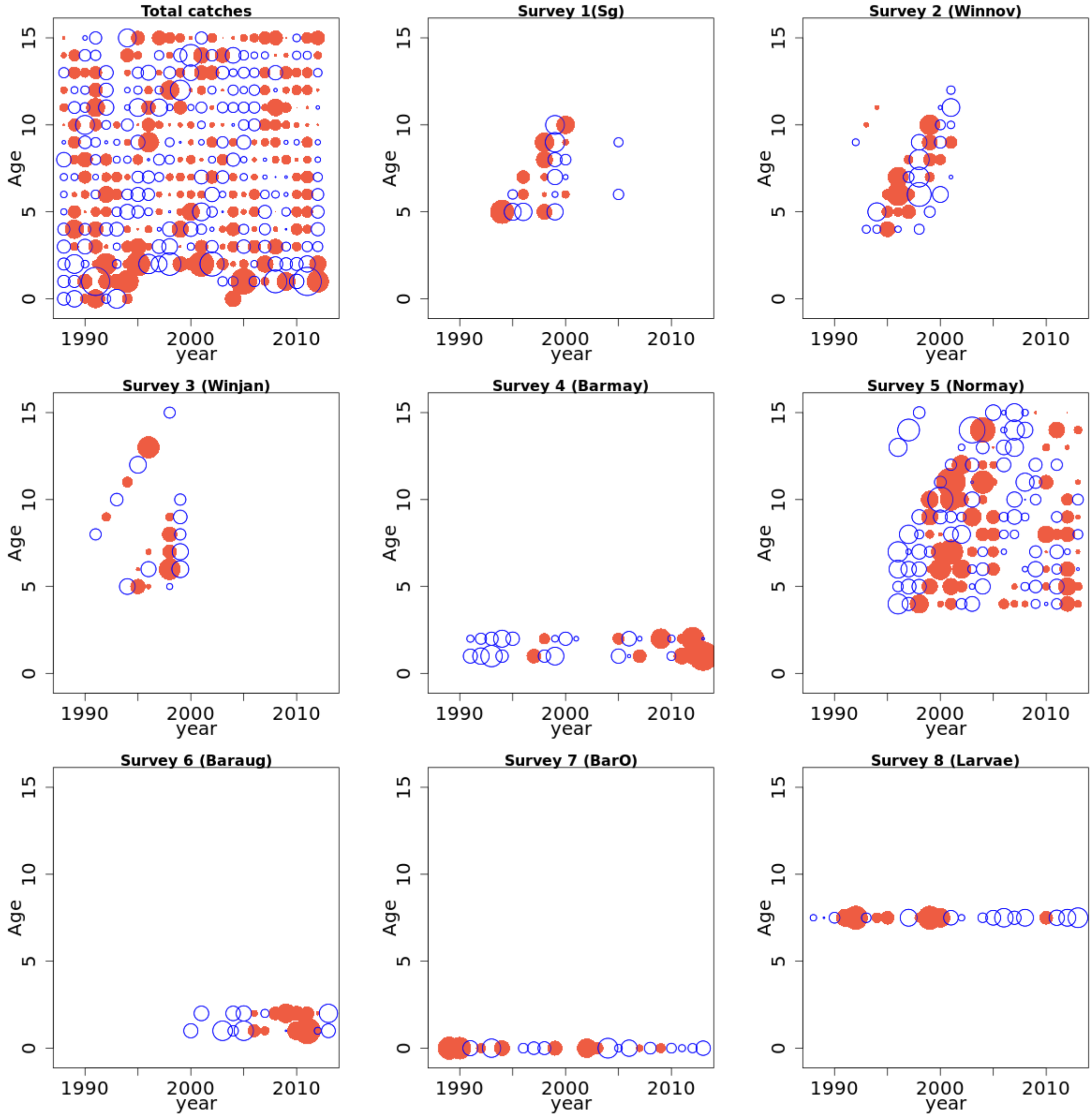

Figure 8. Residuals for the surveys in *SAM_update*. A red (filled) bubble shows that the observed value is less than the expected value.

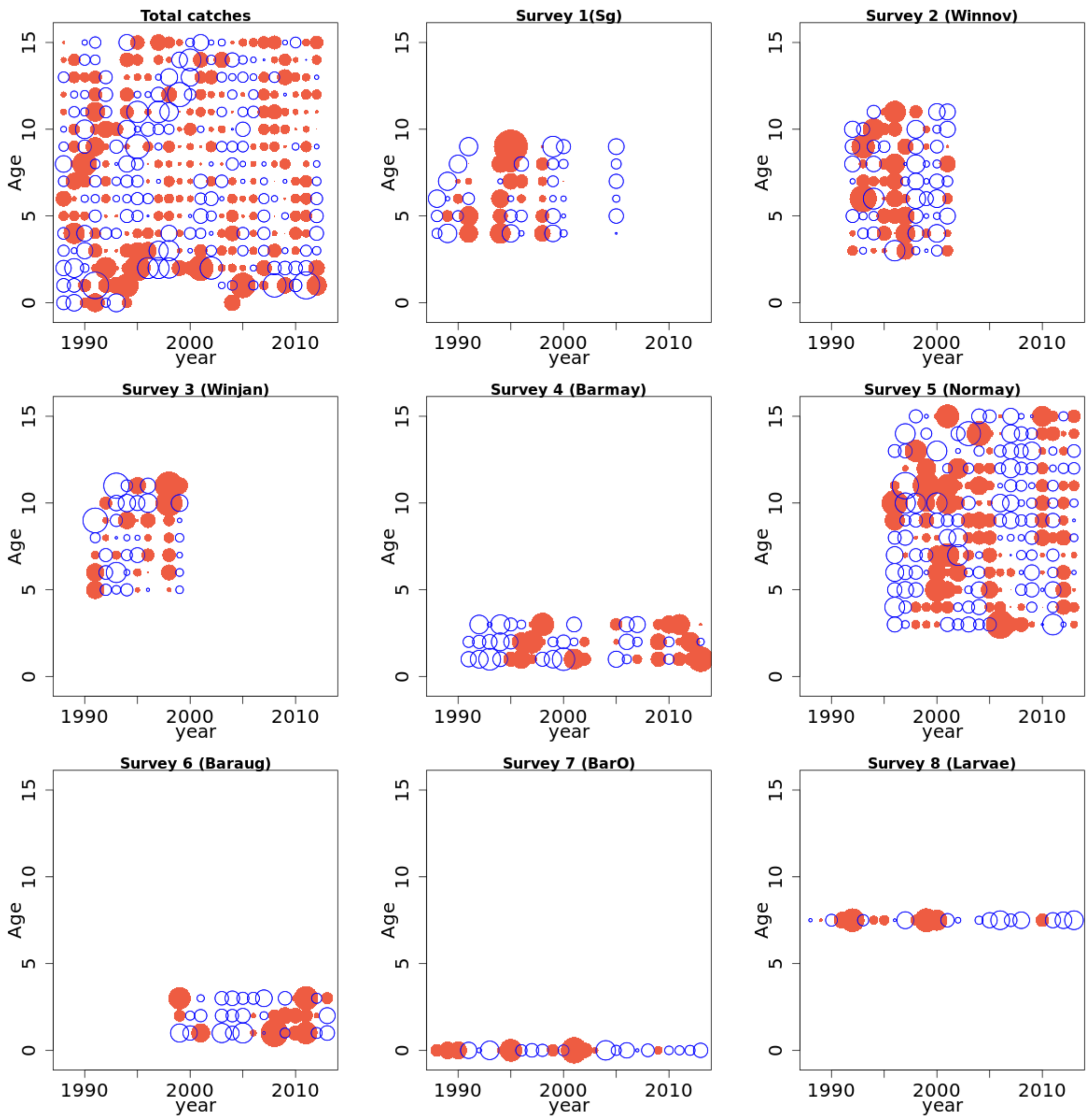

Figure 9. Residuals for the surveys in *SAM_new*. A red (filled) bubble shows that the observed value is less than the expected value.

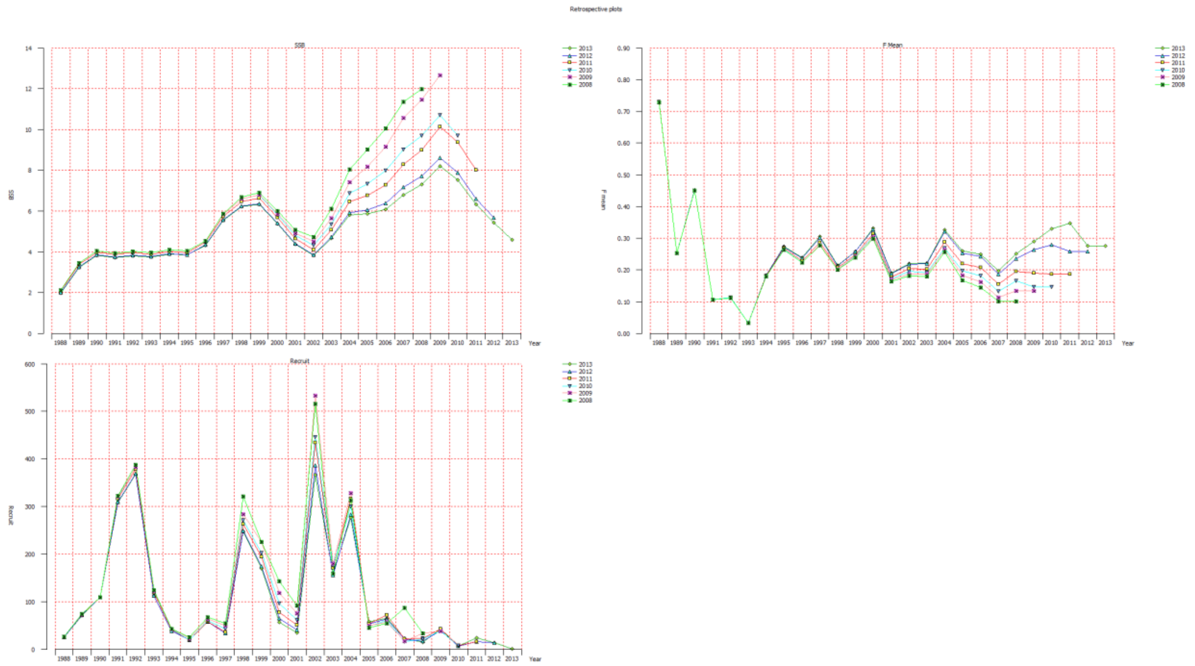

Figure 10. Retrospective analysis of SSB, F and recruits using *TASACS_update*. SSB is in million tonnes and recruits in billions.

Figure 11. Retrospective analysis of SSB, F and recruits using *TASACS_new*. SSB is in million tonnes and recruits in billions.

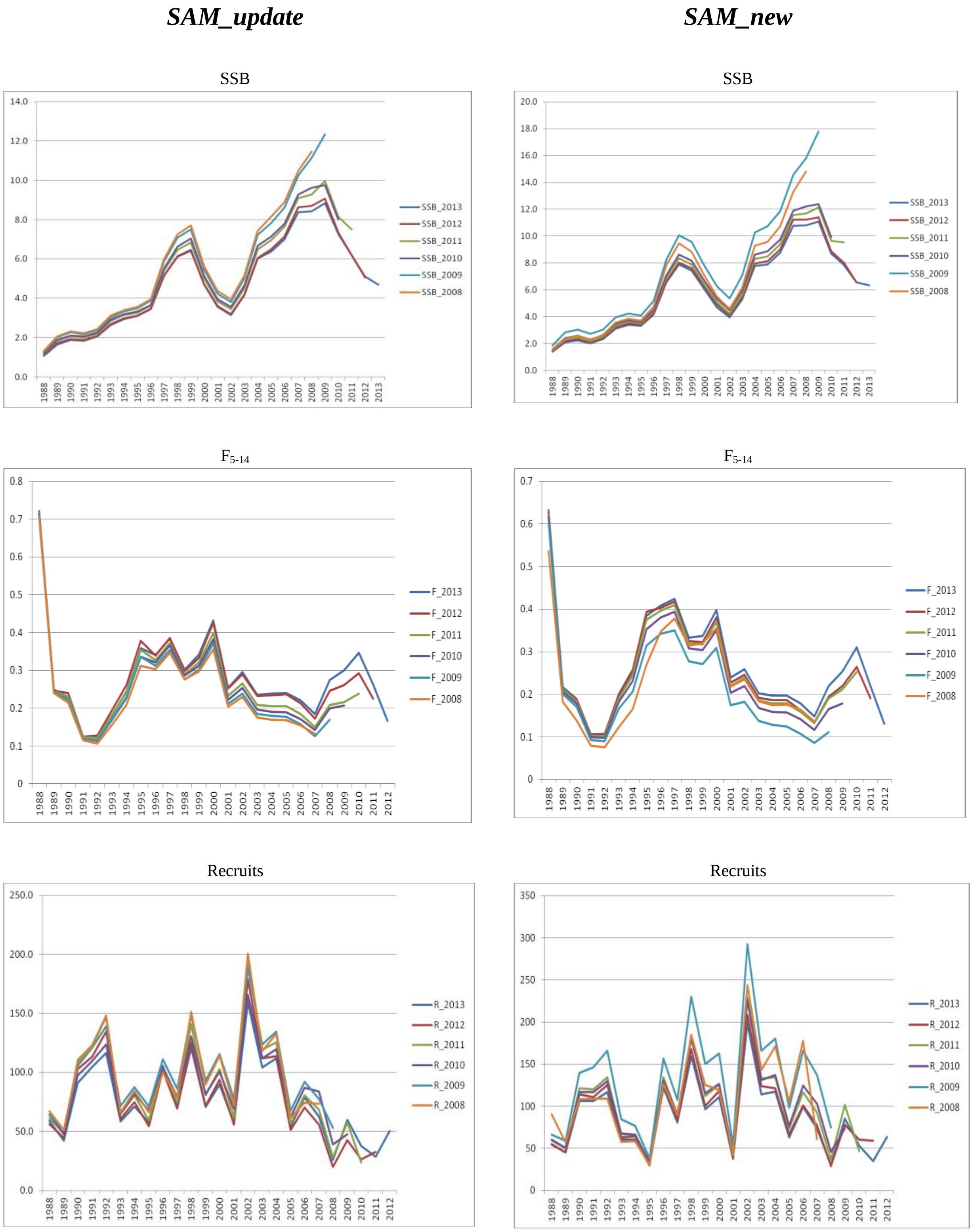

Figure 12. Retrospective analysis of SSB, F and recruits using *SAM_update* (left) and *SAM_new* (right). SSB is in million tonnes and recruits in billions.

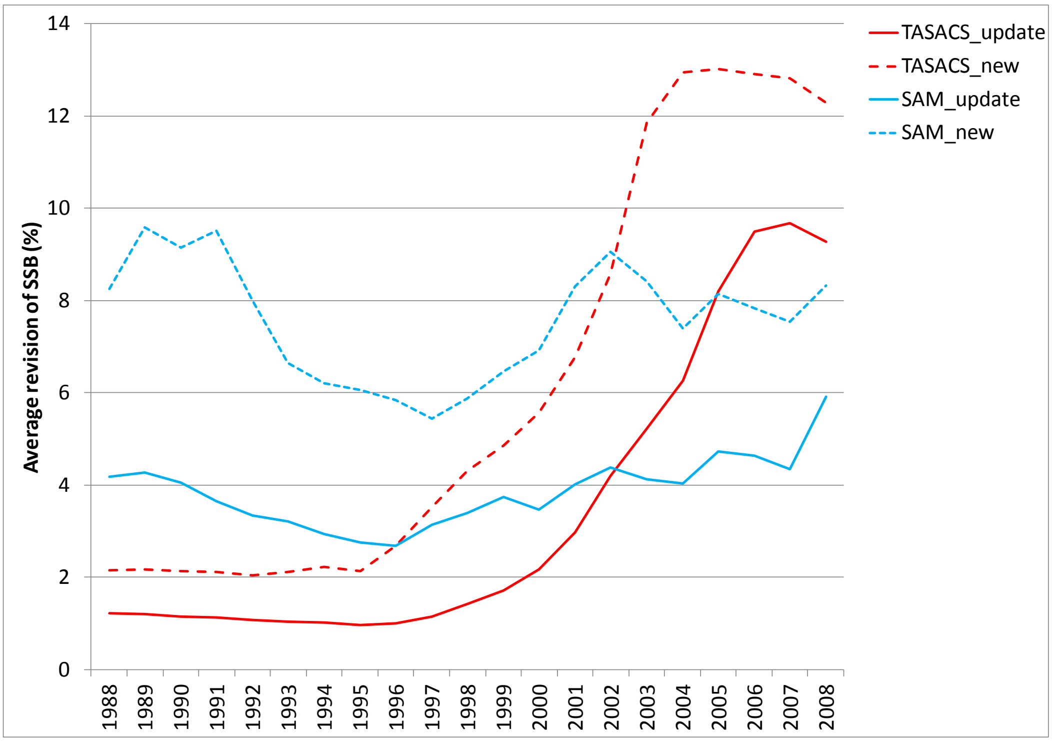

Figure 13. Average yearly revision of SSB in the retrospective analyses.

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

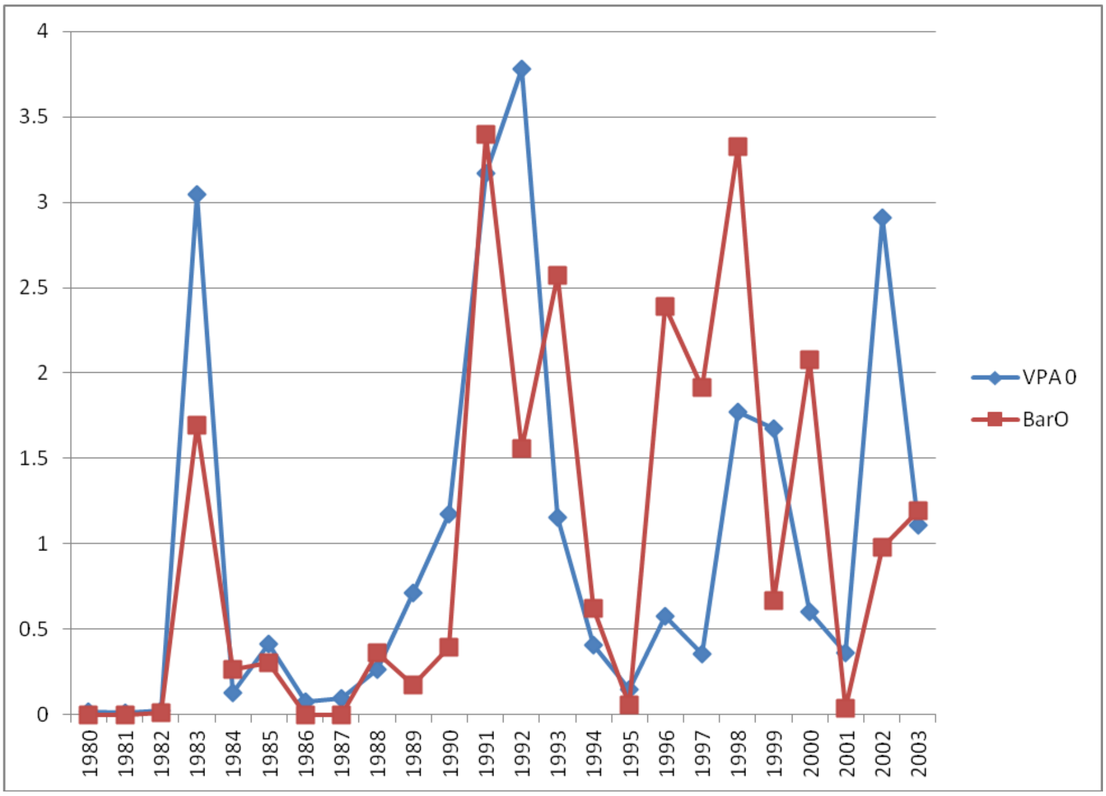

Figure 1. Mean standardised time series with abundance estimates of age 0.

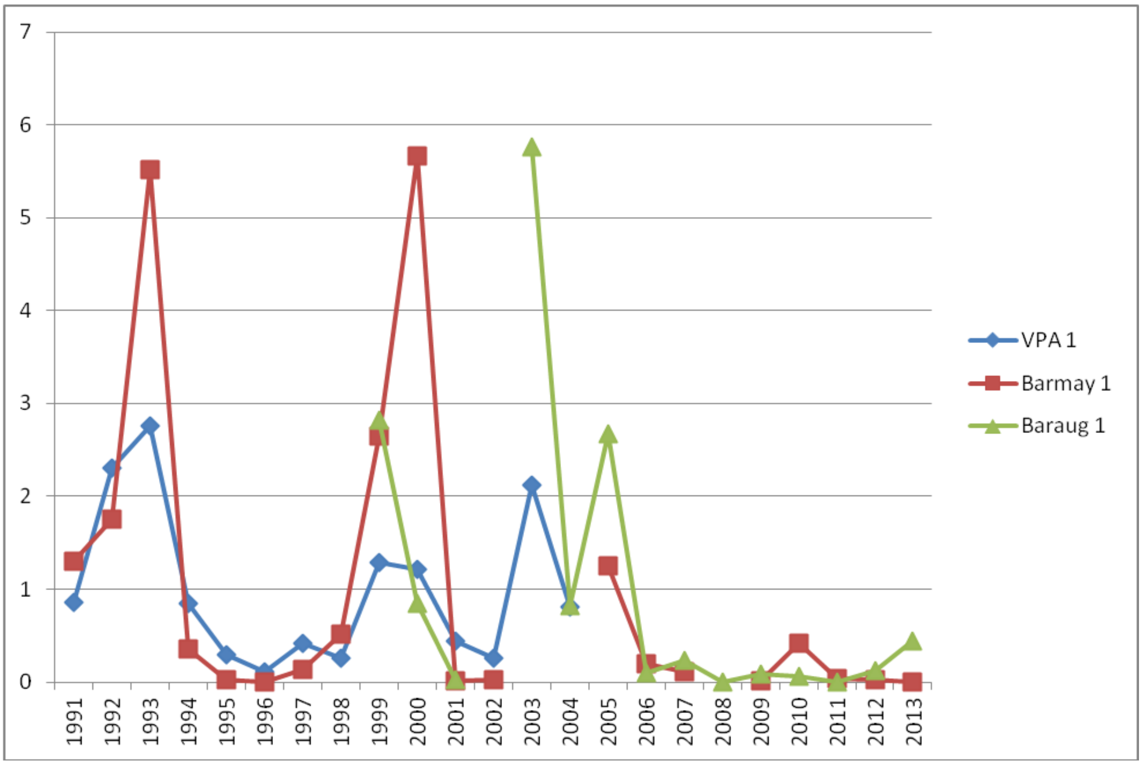

Figure 2. Mean standardised time series with abundance estimates of age 1. Only the survey time series with both internal and external consistency are shown.

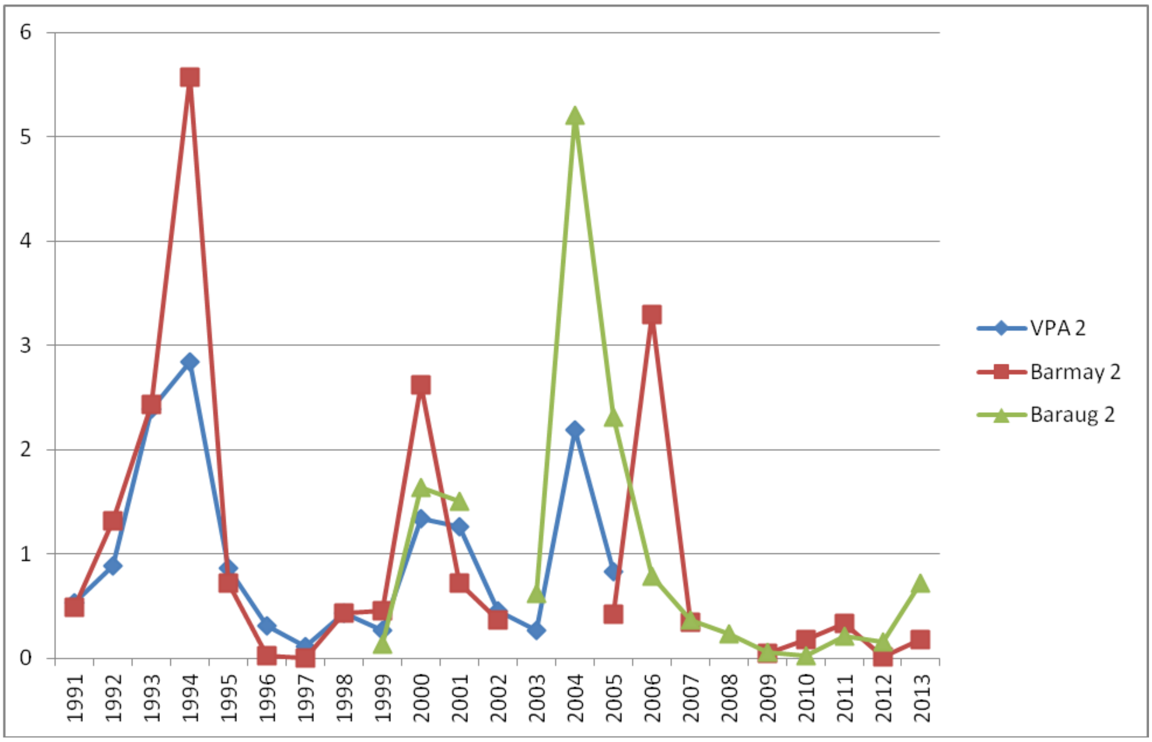

Figure 3. Mean standardised time series with abundance estimates of age 2. Only the survey time series with both internal and external consistency are shown.

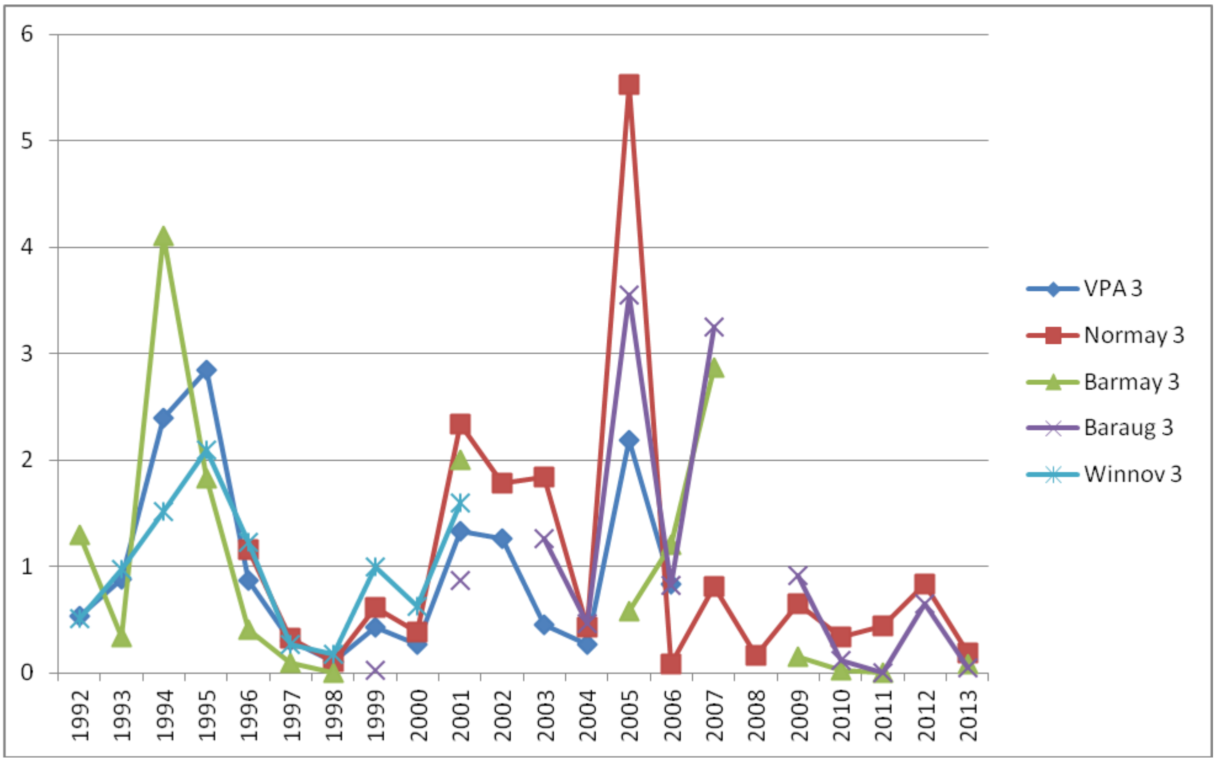

Figure 4. Mean standardised time series with abundance estimates of age 3. Only the survey time series with both internal and external consistency are shown.

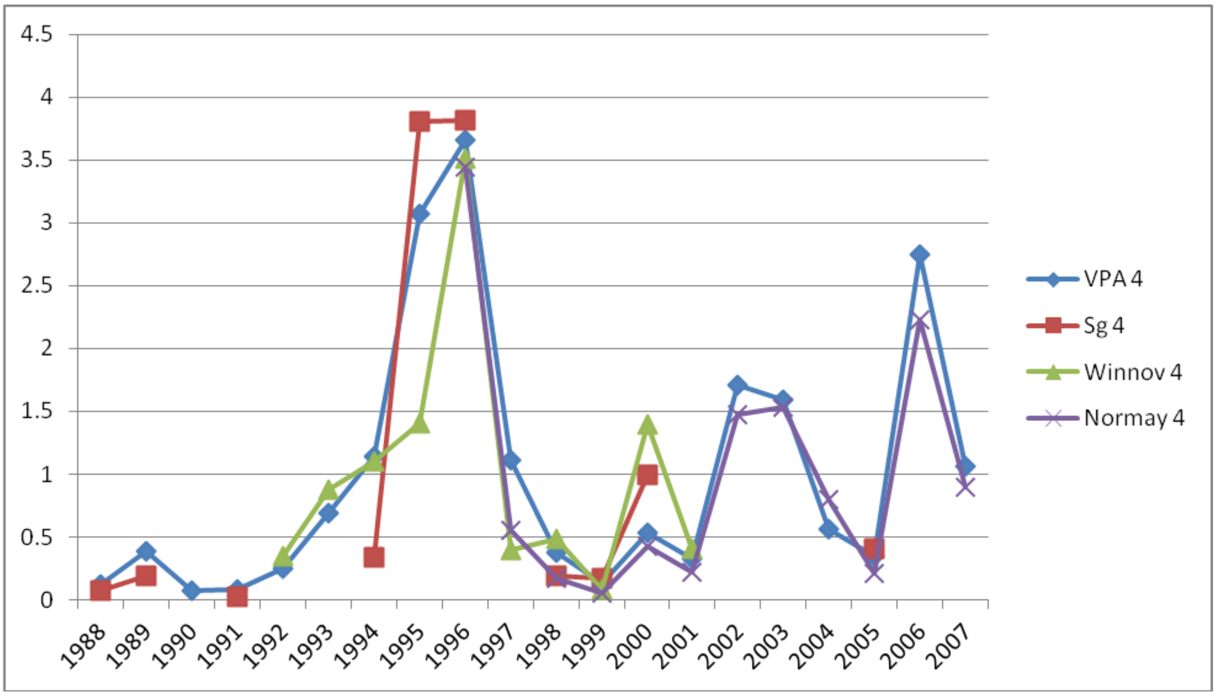

Figure 5. Mean standardised time series with abundance estimates of age 4. Only the survey time series with both internal and external consistency are shown.

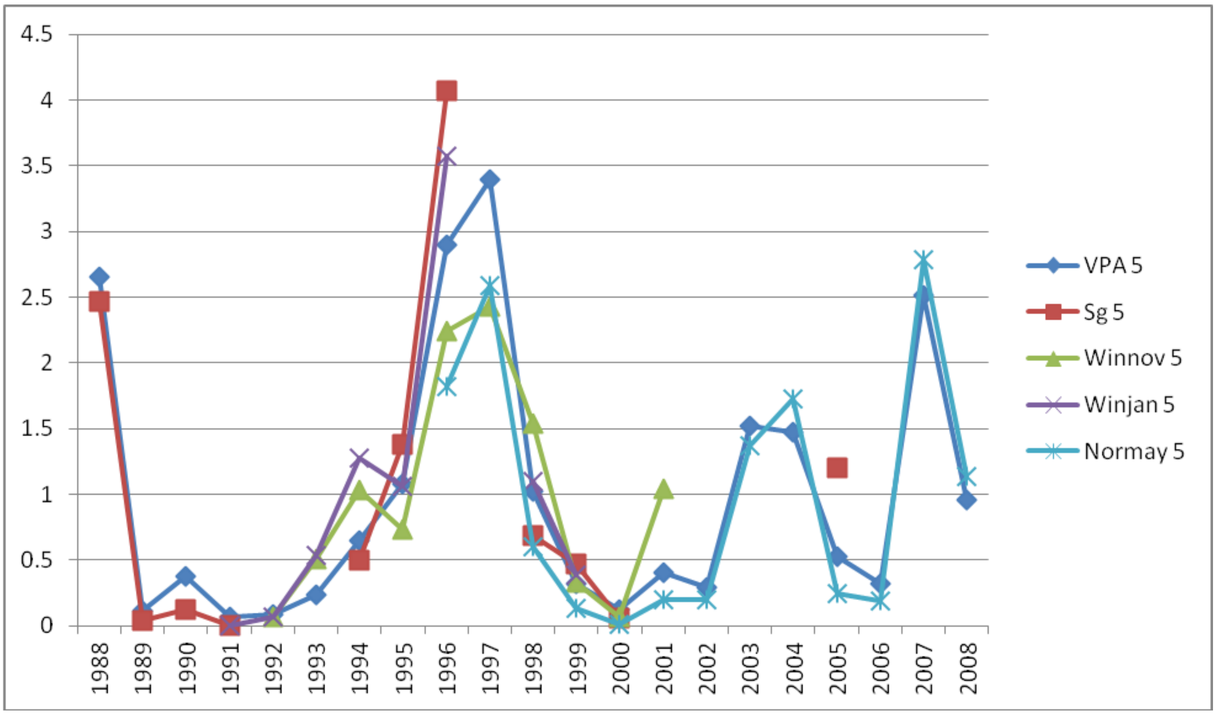

Figure 6. Mean standardised time series with abundance estimates of age 5. Only the survey time series with both internal and external consistency are shown.

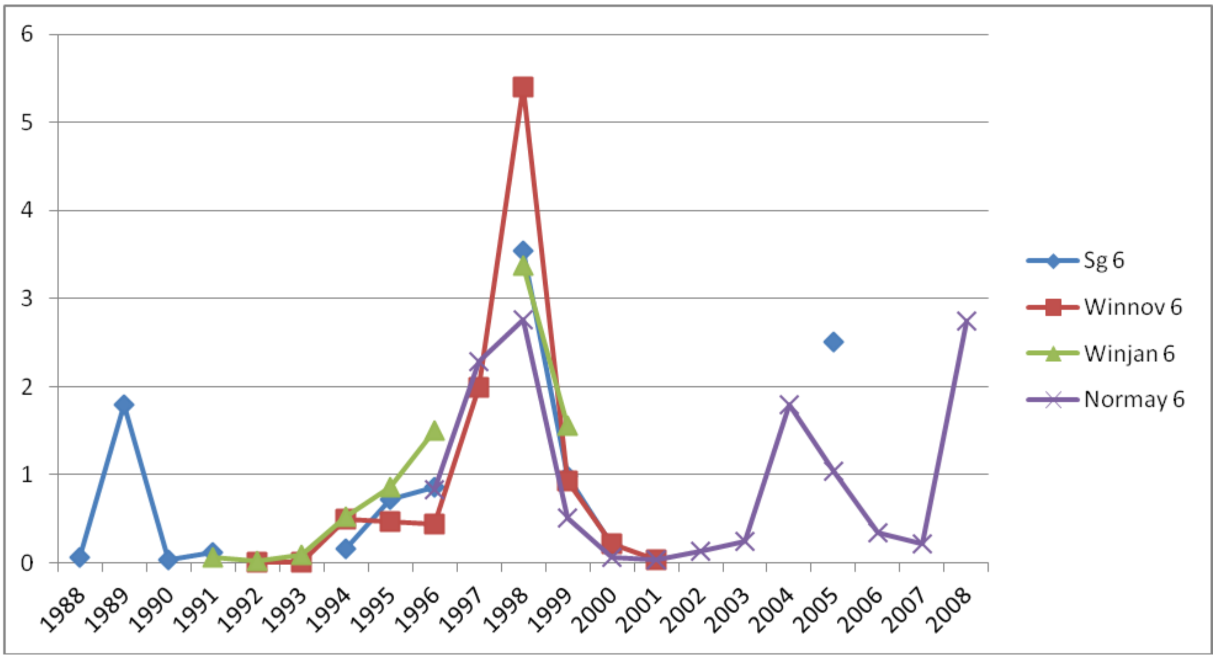

Figure 7. Mean standardised time series with abundance estimates of age 6. Only the survey time series with both internal and external consistency are shown.

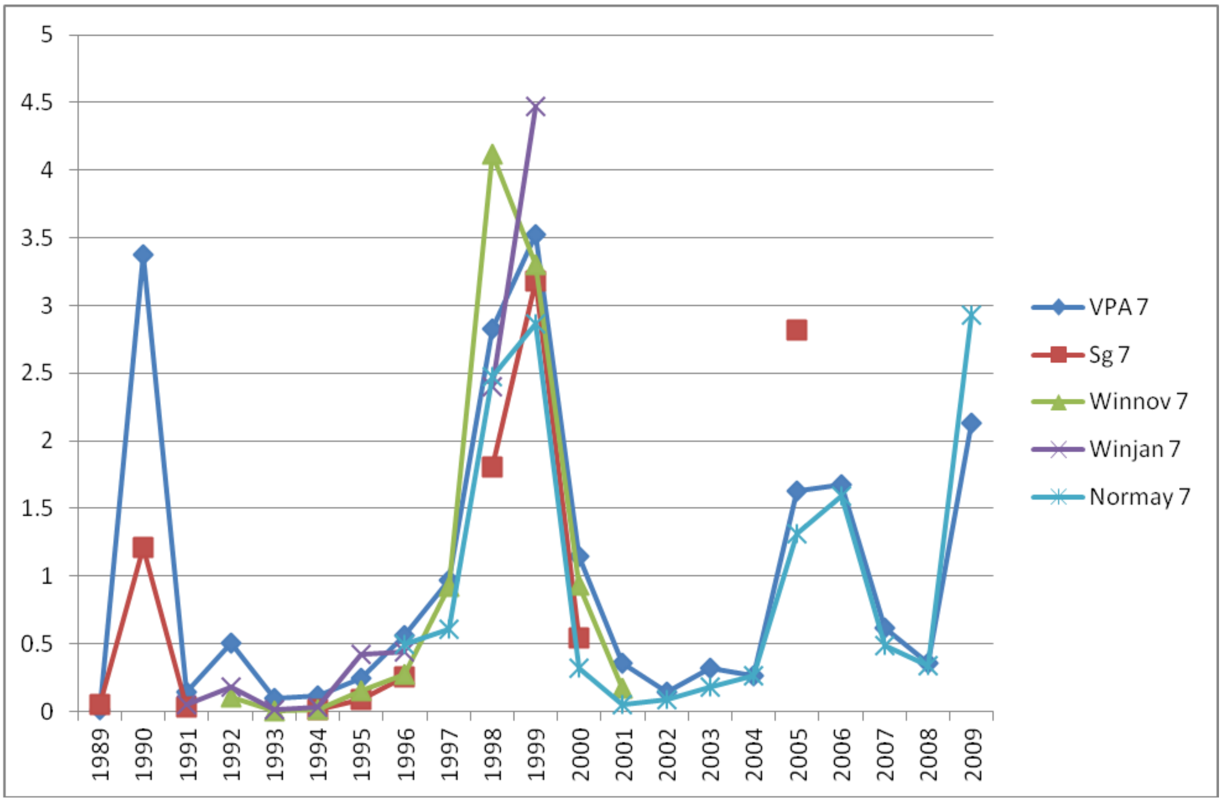

Figure 8. Mean standardised time series with abundance estimates of age 7. Only the survey time series with both internal and external consistency are shown.

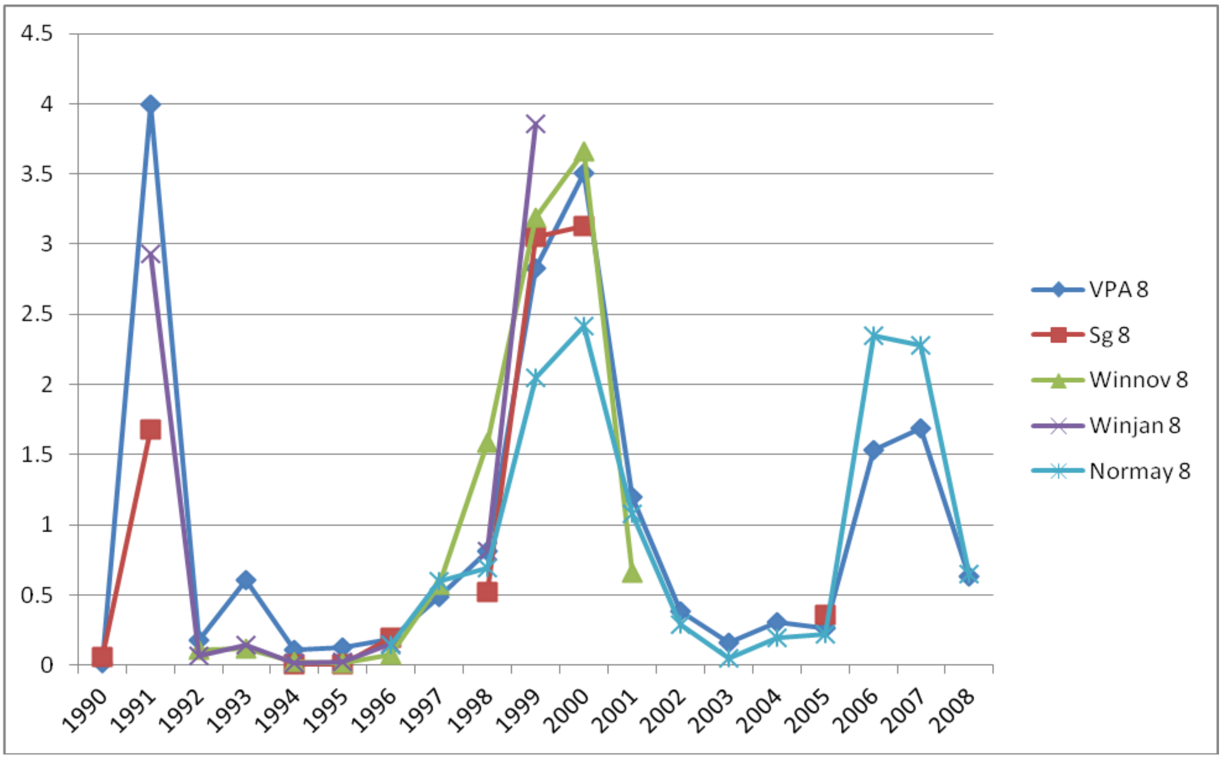

Figure 9. Mean standardised time series with abundance estimates of age 8. Only the survey time series with both internal and external consistency are shown.

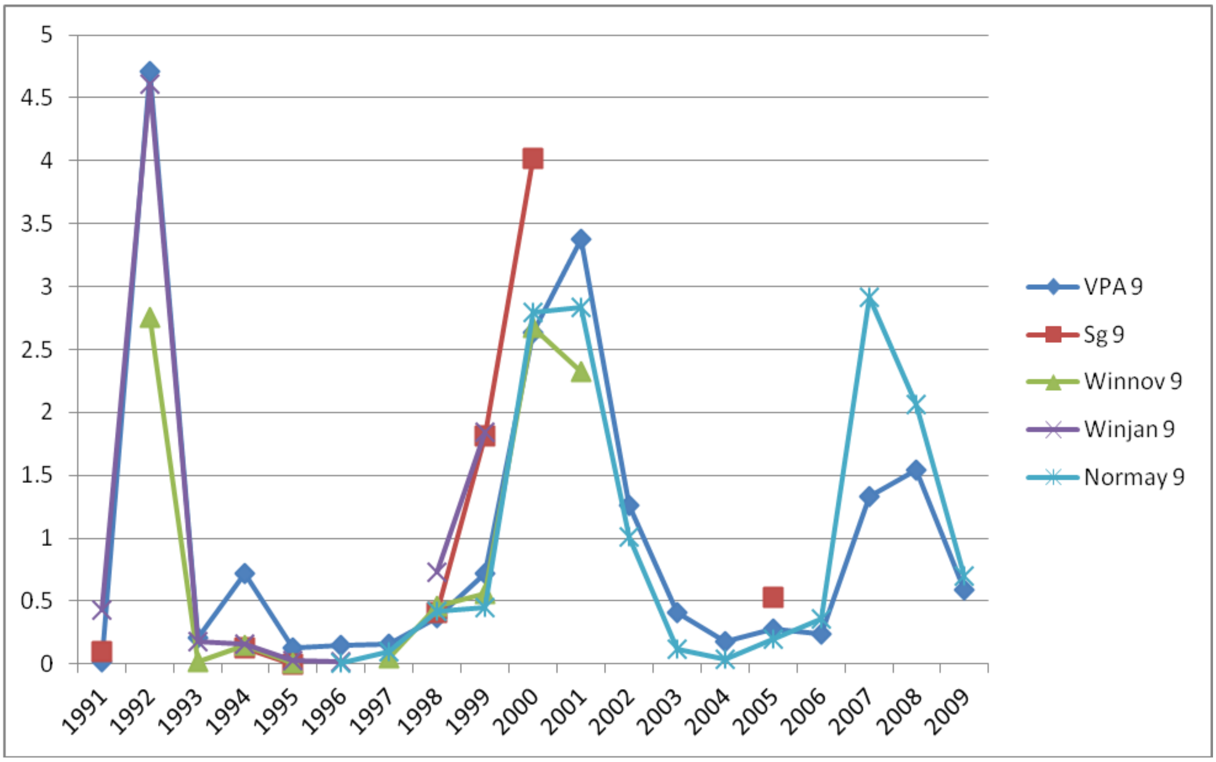

Figure 10. Mean standardised time series with abundance estimates of age 9. Only the survey time series with both internal and external consistency are shown.

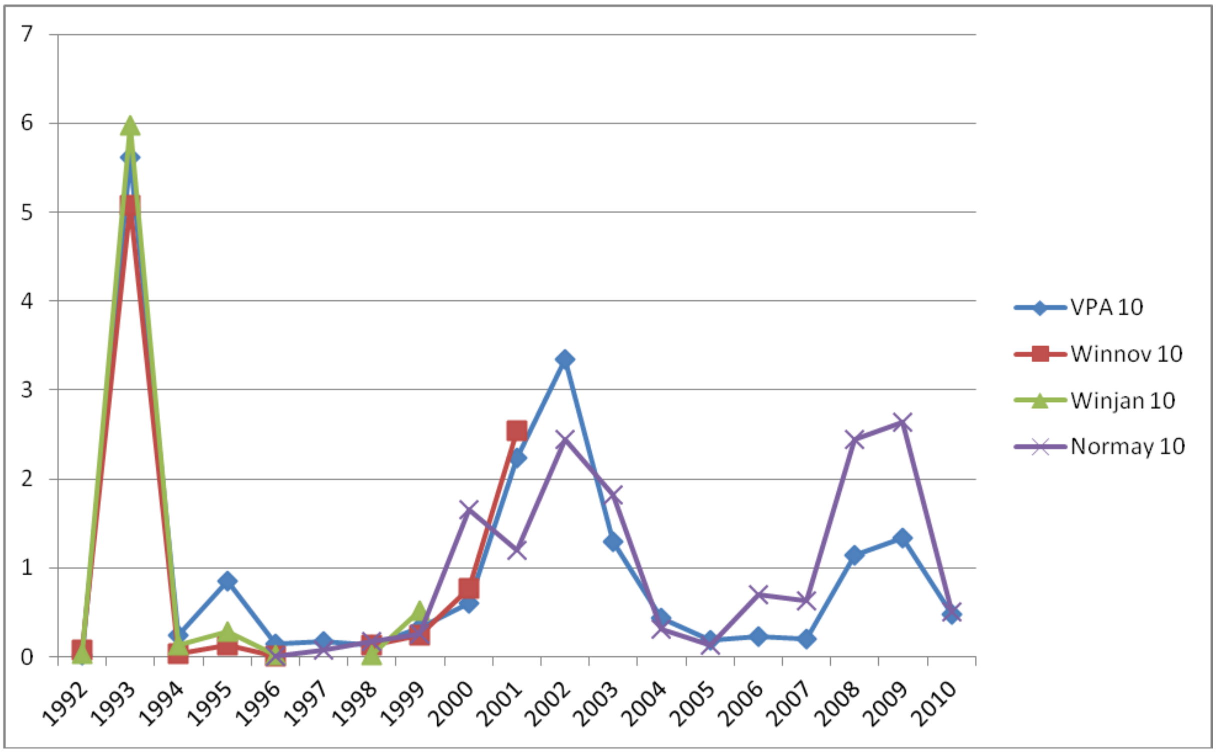

Figure 11. Mean standardised time series with abundance estimates of age 10. Only the survey time series with both internal and external consistency are shown.

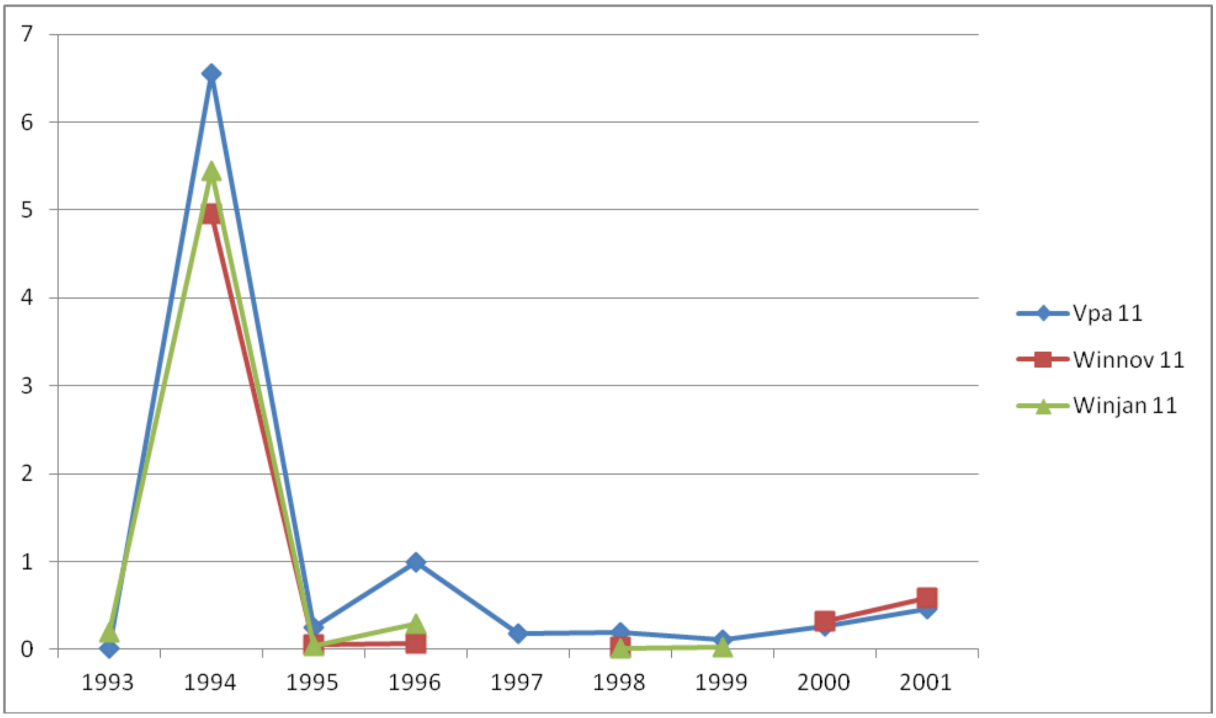

Figure 12. Mean standardised time series with abundance estimates of age 11. Only the survey time series with both internal and external consistency are shown.

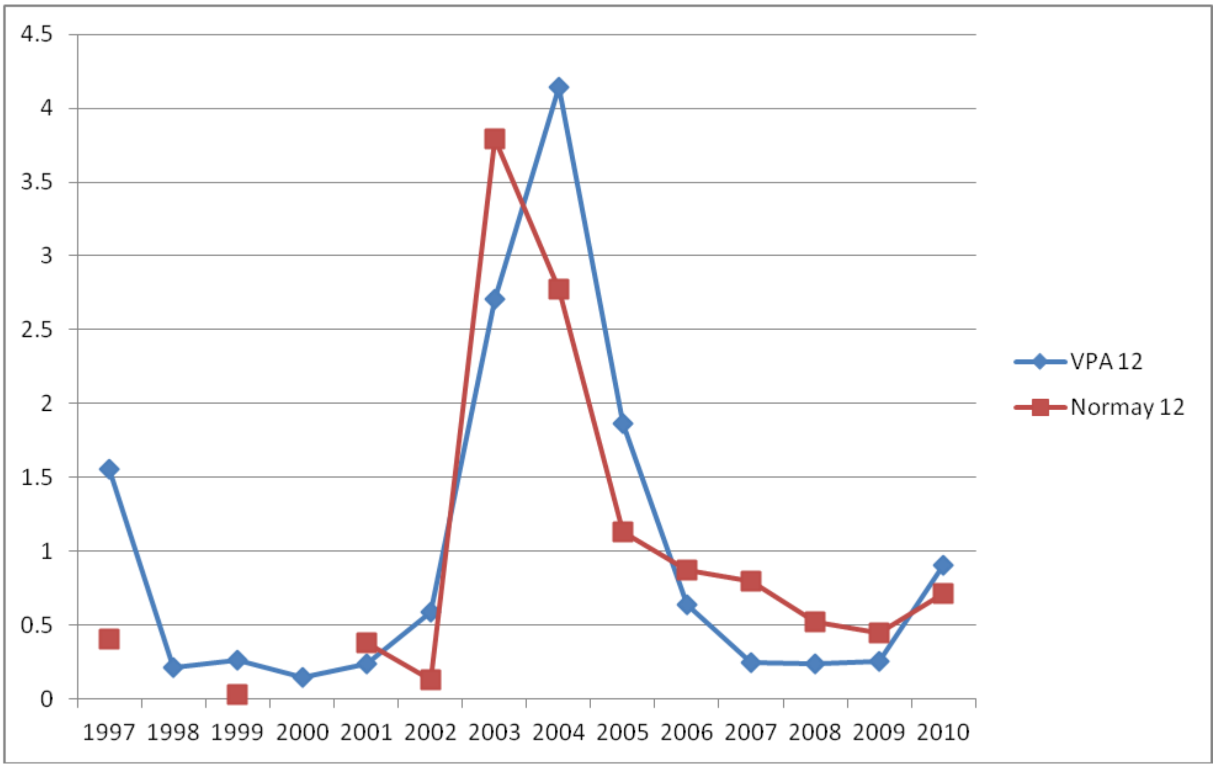

Figure 13. Mean standardised time series with abundance estimates of age 12. Only the survey time series with both internal and external consistency are shown.

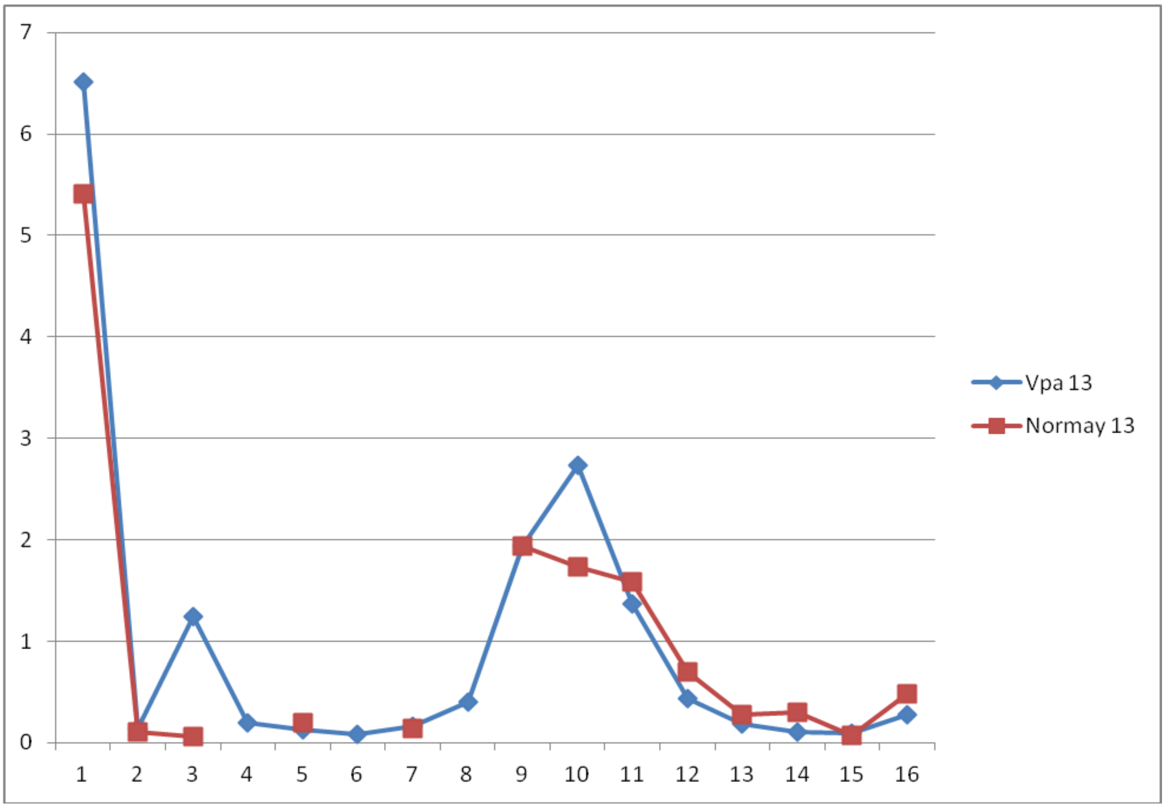

Figure 14. Mean standardised time series with abundance estimates of age 13. Only the survey time series with both internal and external consistency are shown.

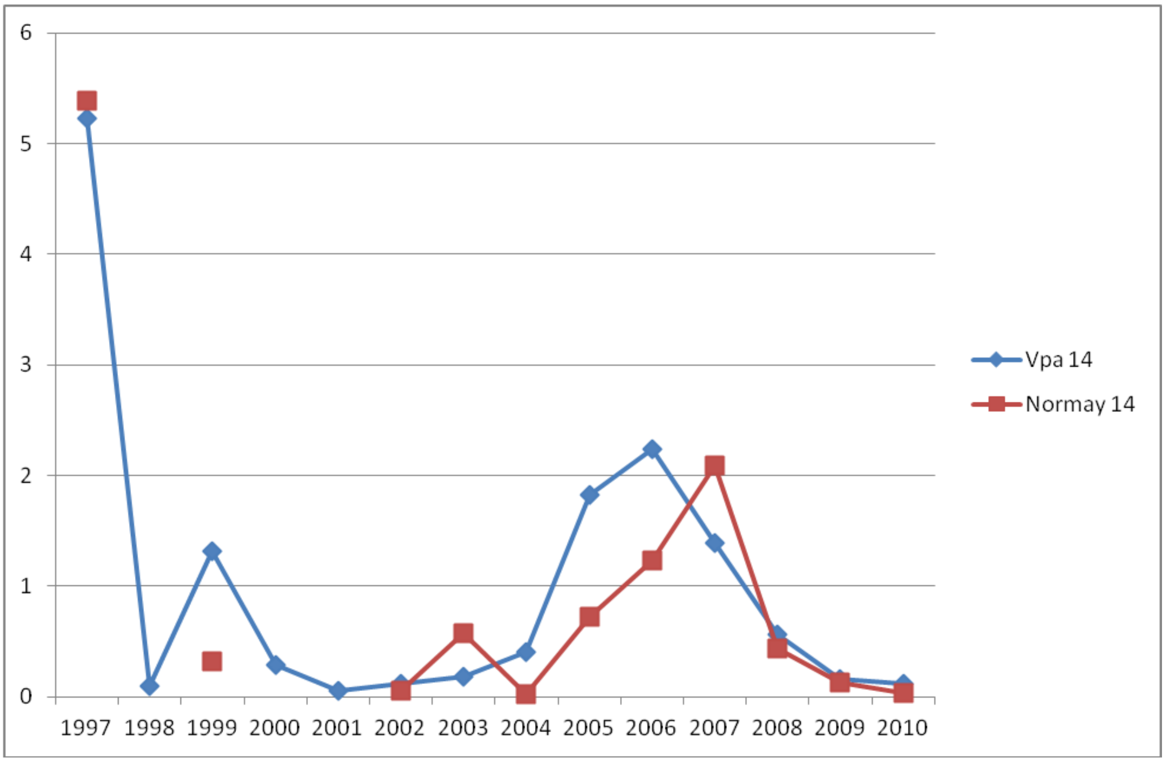

Figure 15. Mean standardised time series with abundance estimates of age 14. Only the survey time series with both internal and external consistency are shown.

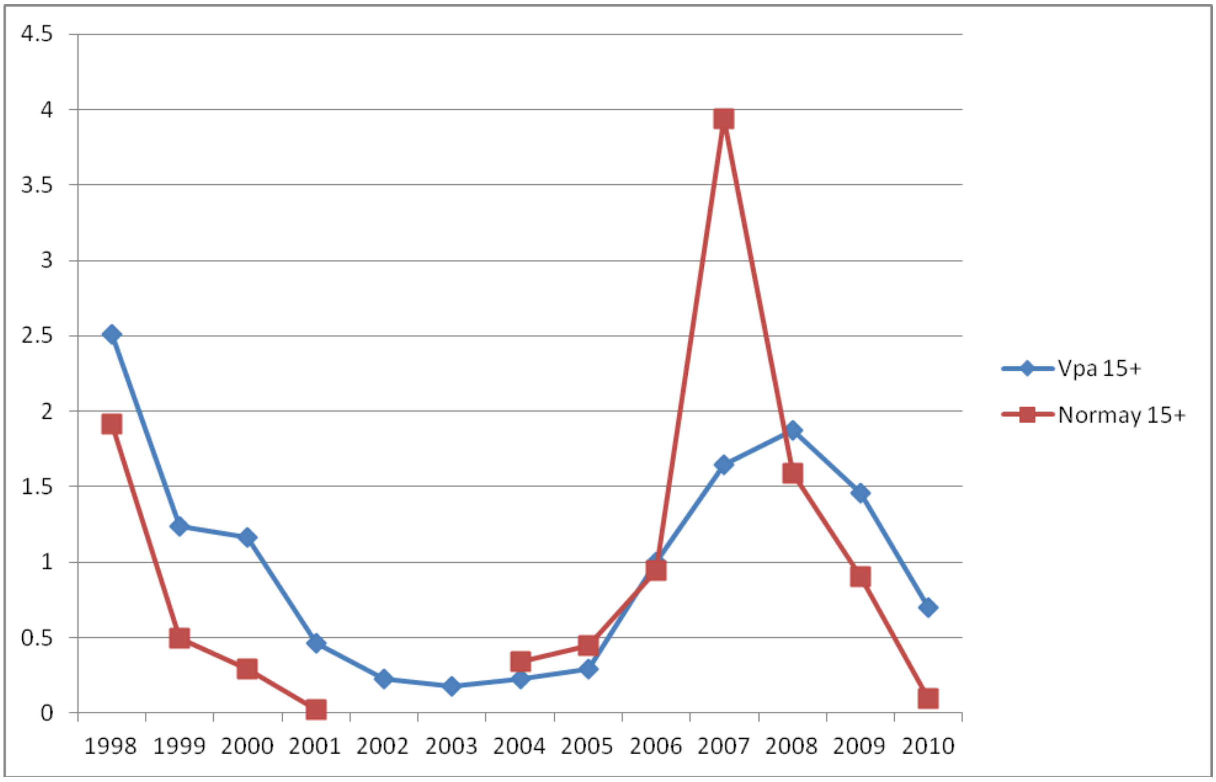

Figure 16. Mean standardised time series with abundance estimates of age 15+. Only the survey time series with external consistency are shown.

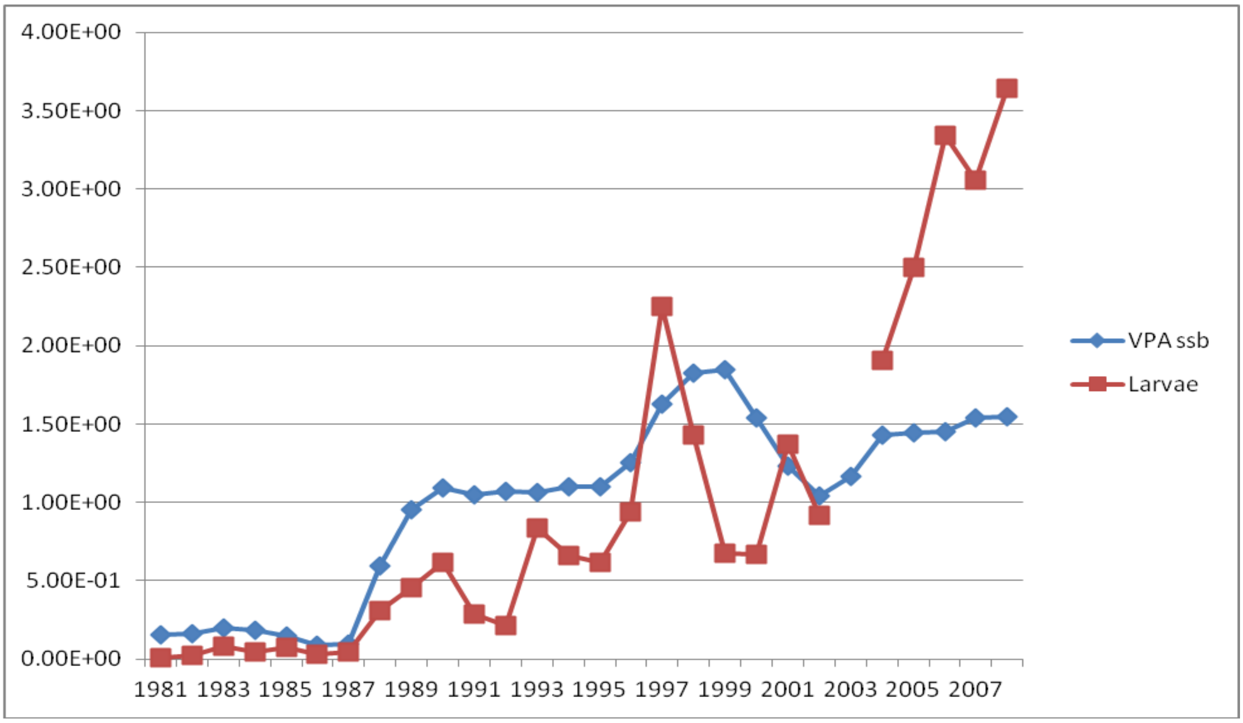

Figure 17. Mean standardised time series with SSB estimates.

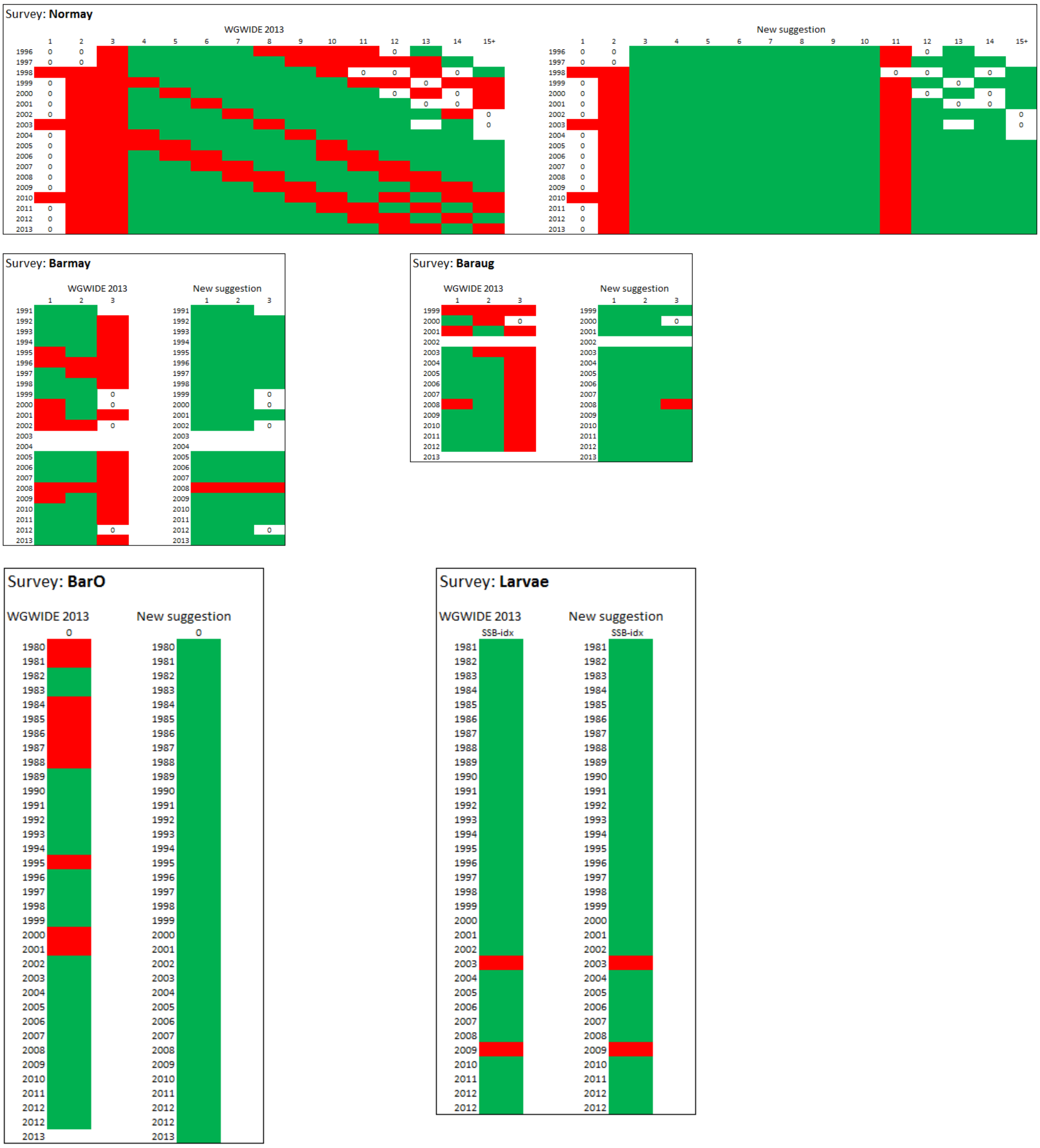

Figure 18. Comparison of excluded and included survey indices in the latest ICES stock assessment (‘WGWIDE 2013’) and the suggestion based on the present work (‘New suggestion’). Green: included, red: excluded, white: no observation (blank) or zero-value (0). The top rows with numbers in each survey 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 × fishery × 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 × 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

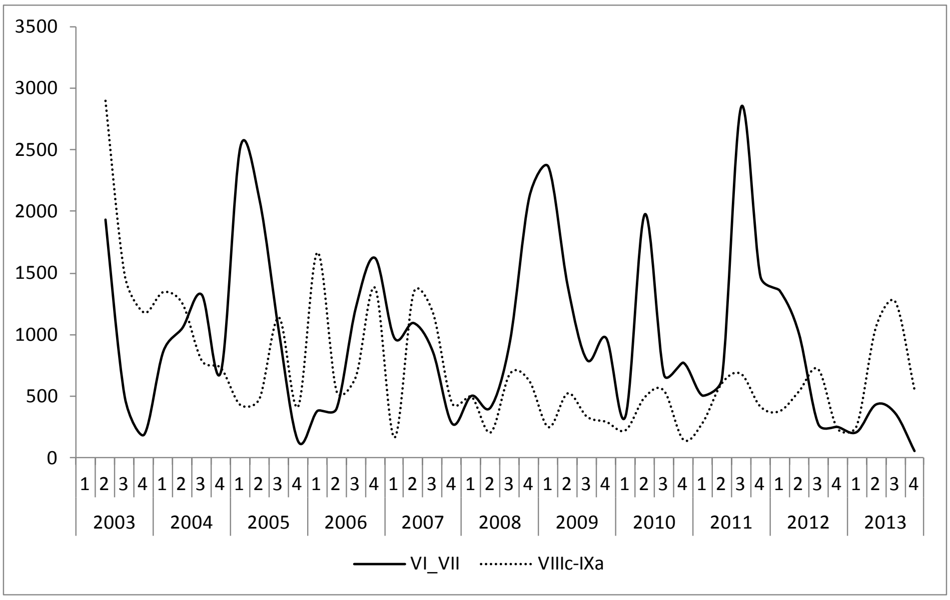


Figure 2. Blue whiting quarterly discard estimates in number (thousands) for the Spanish trawl fishery in ICES Sub-areas

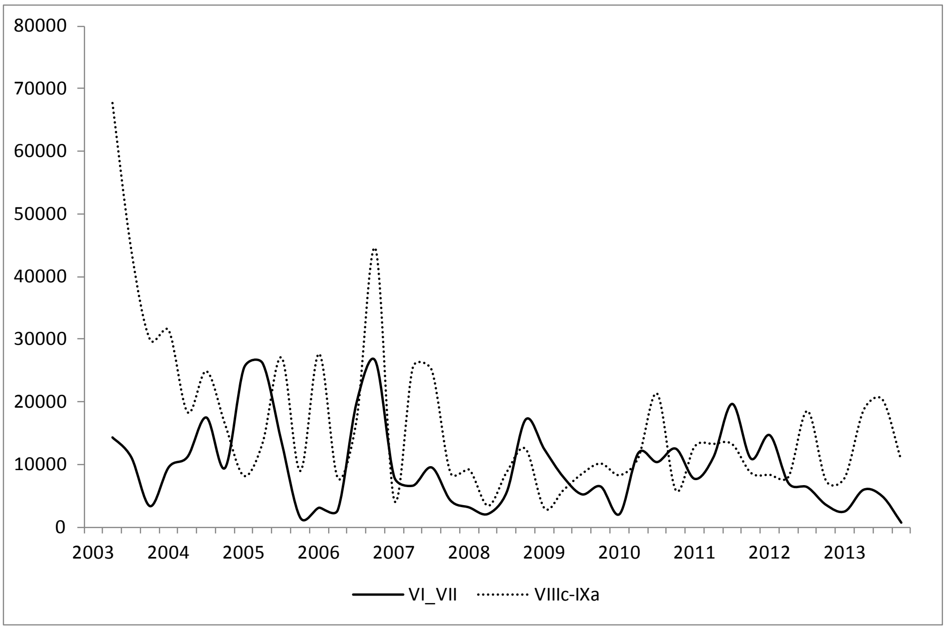


Figure 3. Blue whiting yearly discard estimates in weight (tonnes) for the Spanish trawl fishery in ICES Sub-areas

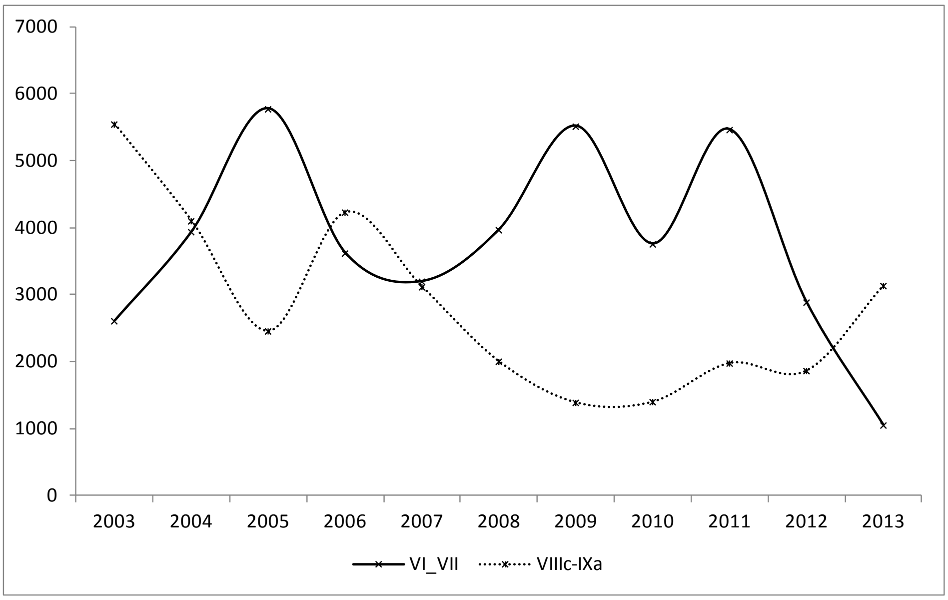


Figure 4. Observer on board indices (kg caught per haul) from métiers operated in Sub-areas VI_VII

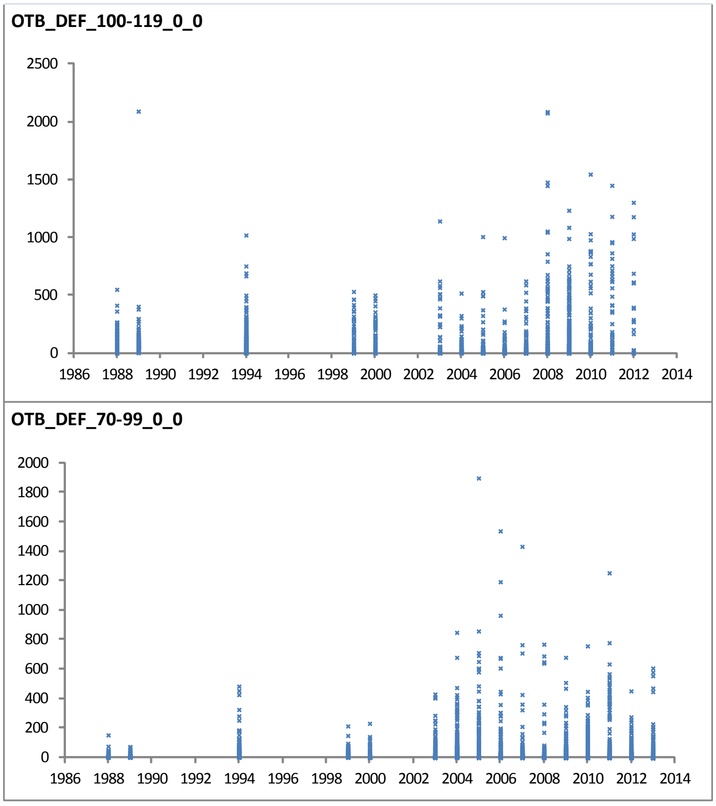


Figure 5. Effort in number of trips in Sub-areas VI_VII

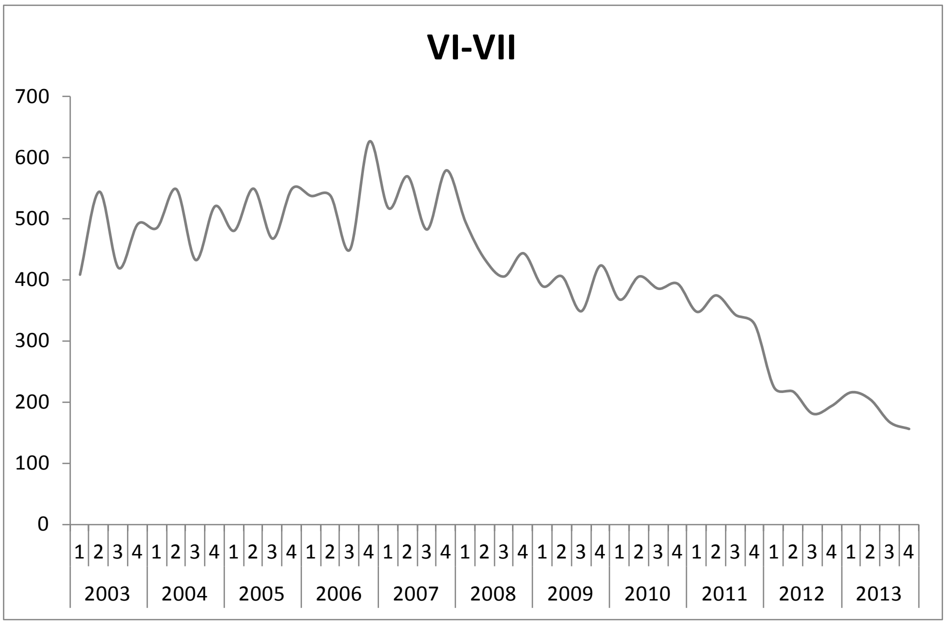


Figure 6. Discard rate (discard weight/catch weight) by métier in Divisions VIIIc and IXa. 1994-2013

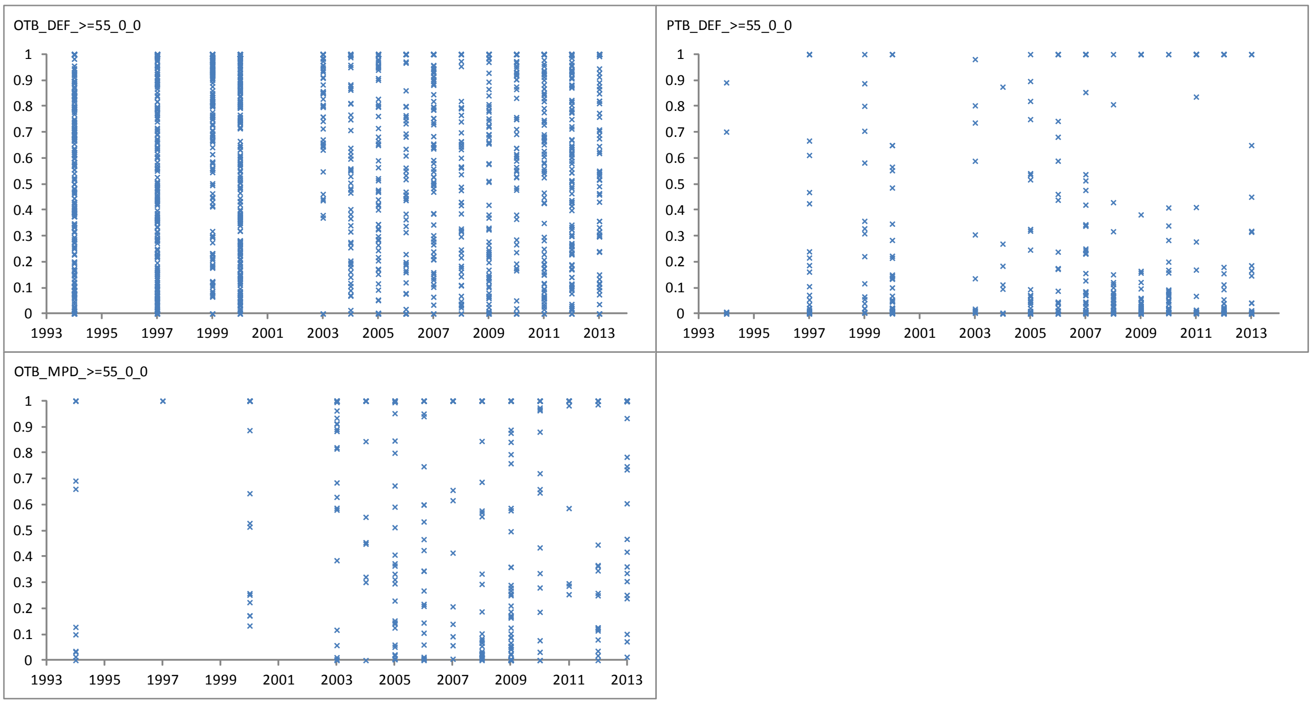


Figure 7. Total catch per haul (kg) in observed trips of OTB_DEF_>=55_0_0, OTB_MPD_>=55_0_0 and PTB_MPD_>=55_0_0

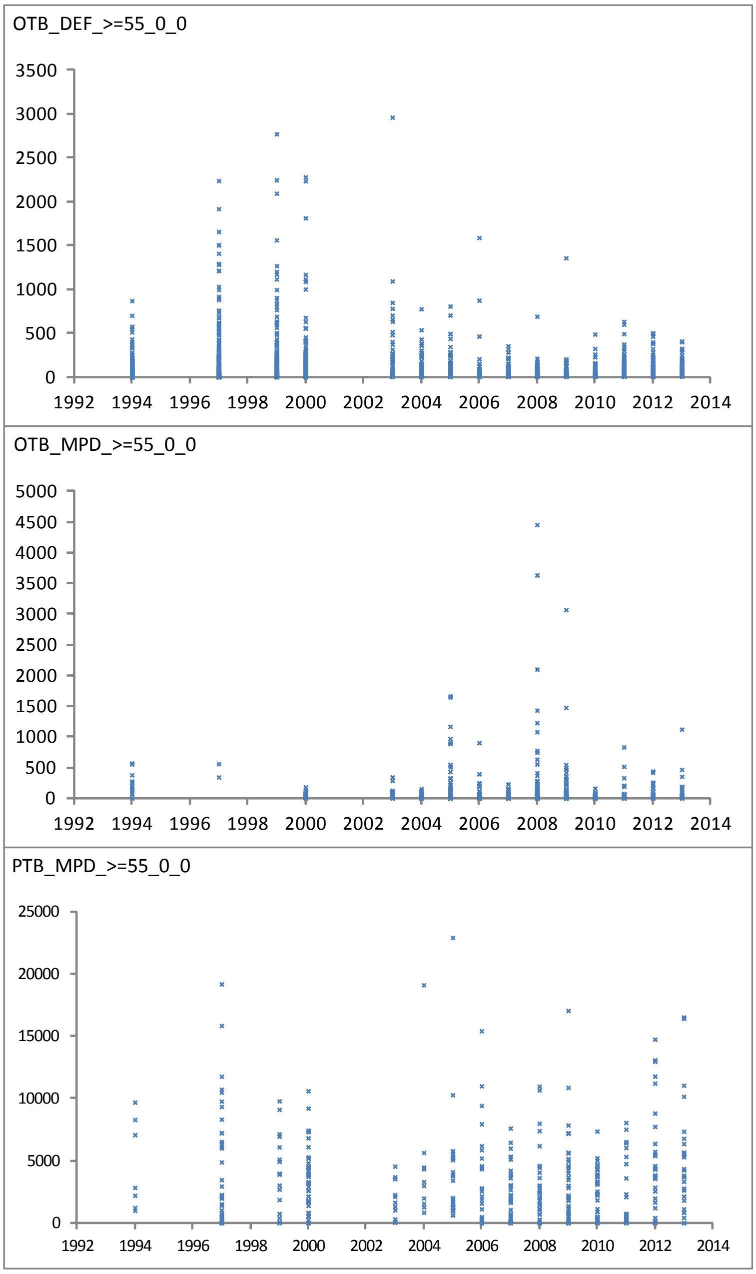


Figure 8. Effort in number of trips in Divisions VIIIc, IXaN

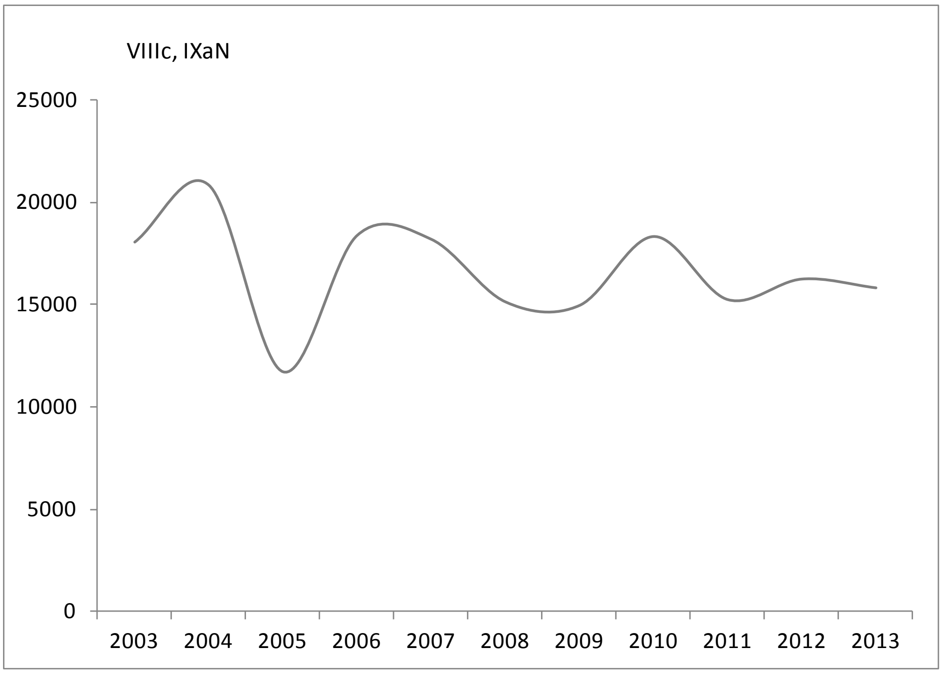


Figure 9. Observer on board indices; kg caught/ haul (points, on the left axis) and mean kg caught/haul (line, on the right axis) from all métiers.

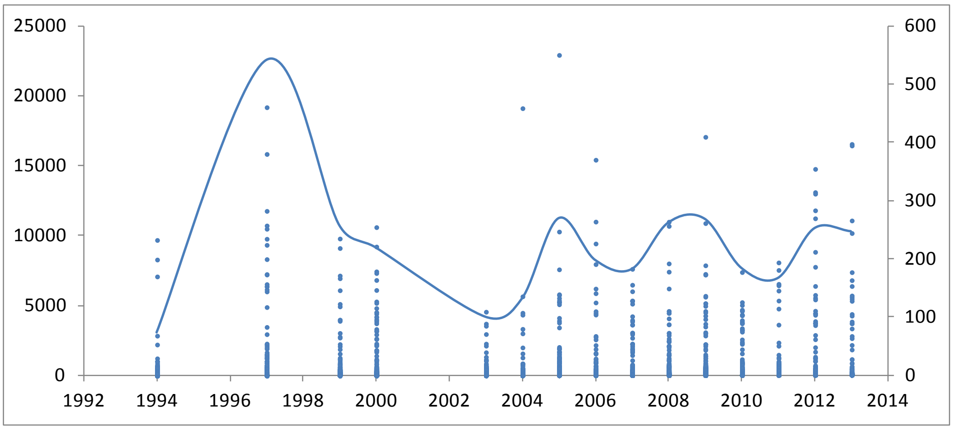


Figure 10. Quarterly age composition of Spanish trawl discards of blue whiting in ICES Sub-areas VI and VII.

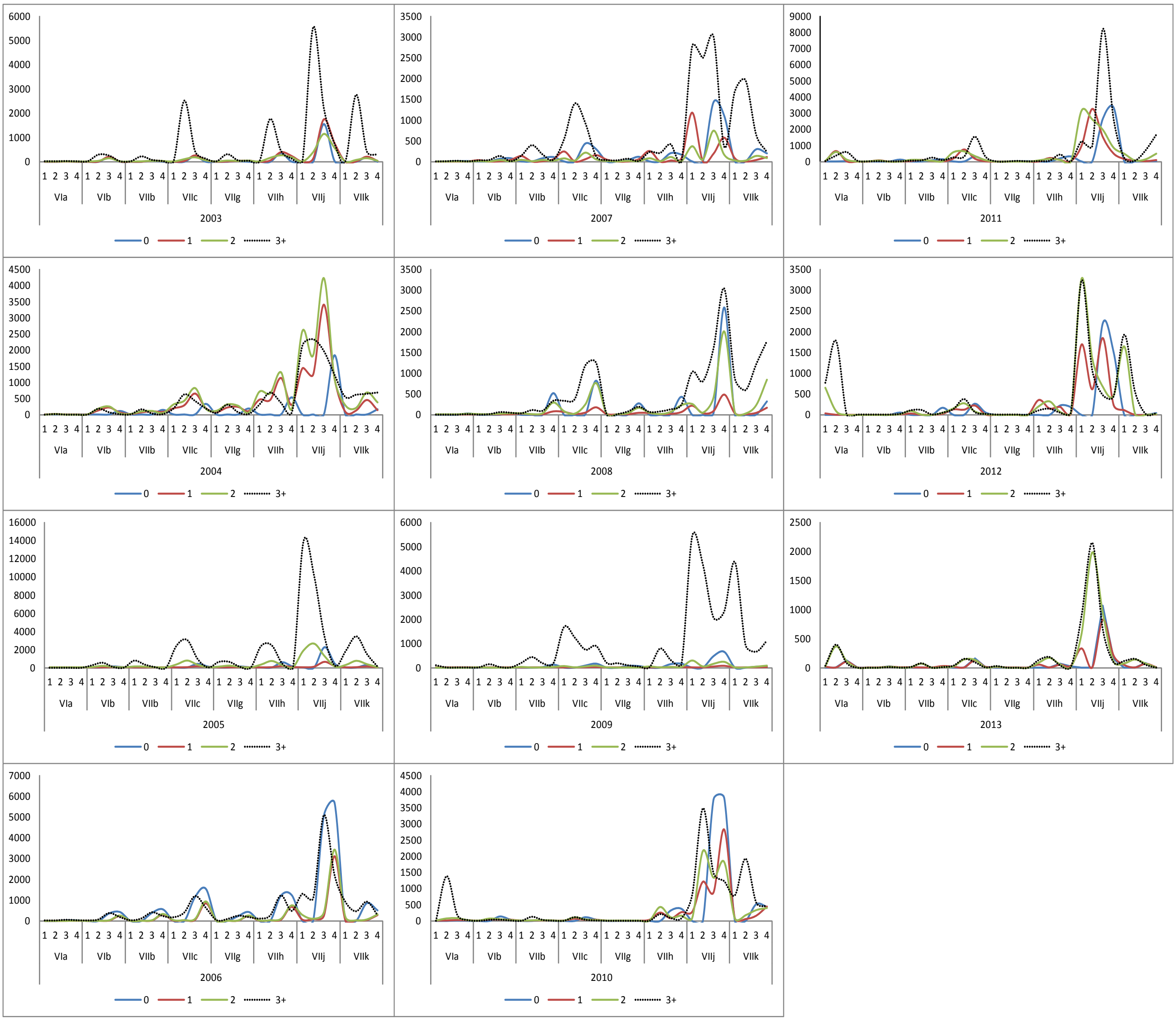
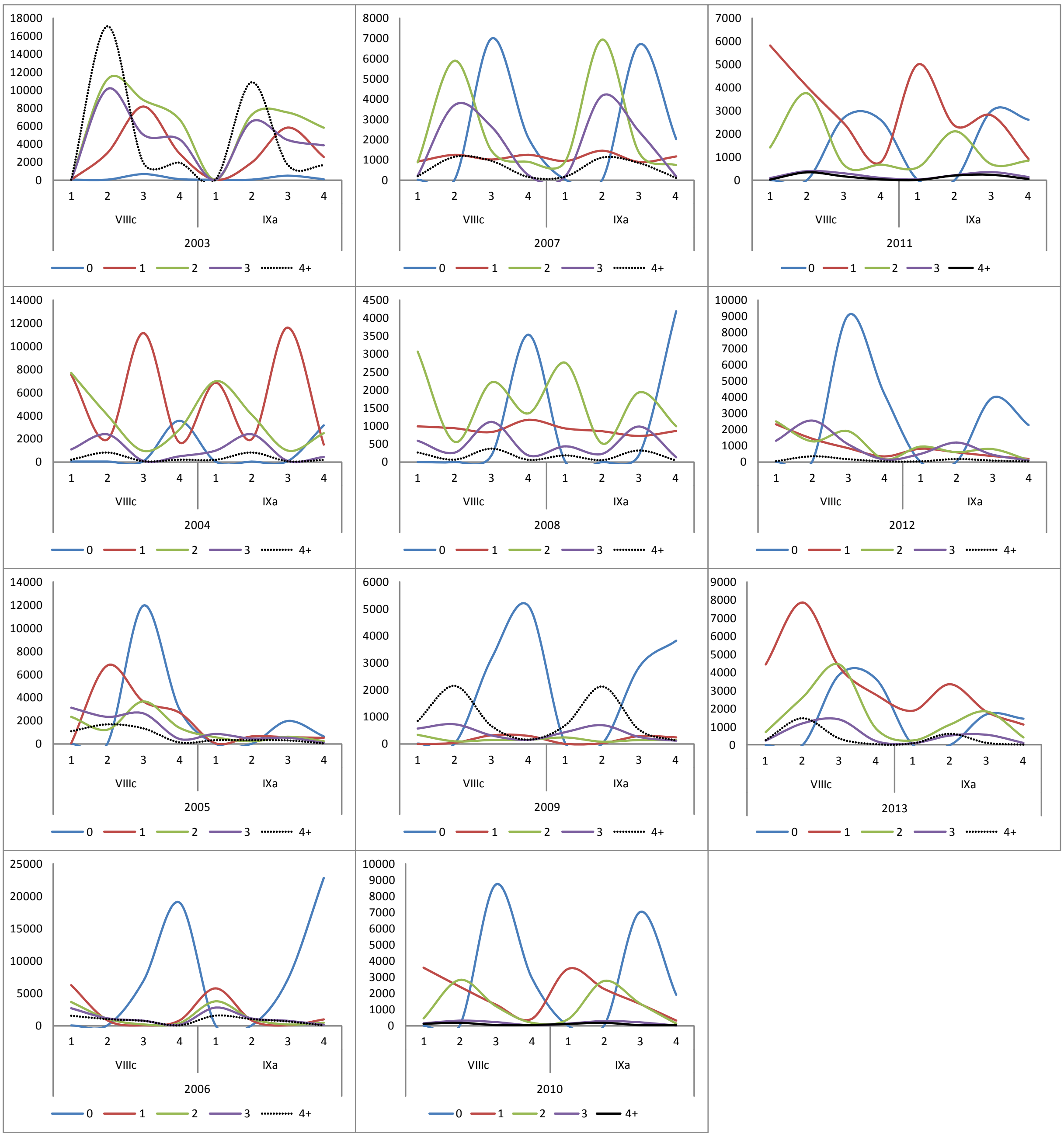


Figure 11. Quarterly age composition of Spanish trawl discards of blue whiting in ICES Divisions VIIIc-IXaN.



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)

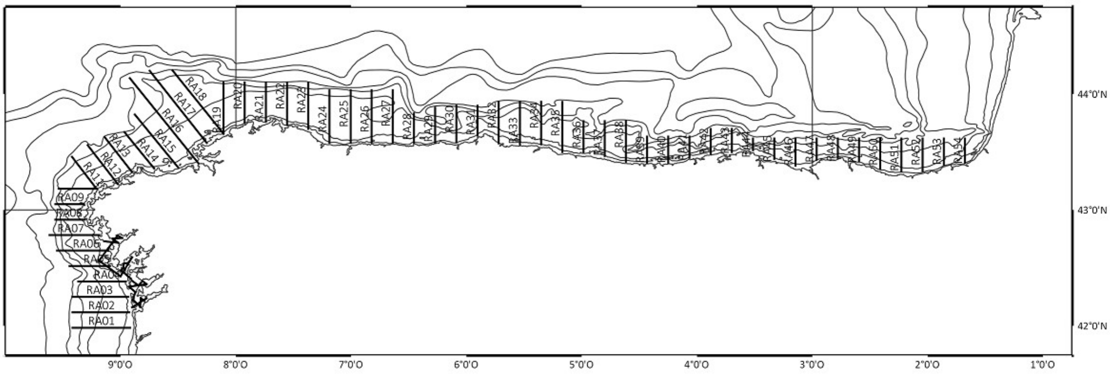


Figure 1 Survey track

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 $((\text{I.Lat}-43.18333)^2+(\textit{I.Lon}*(\cos(\text{I.Lat}*\text{pi}()/180))-6.714441)^2)^{0.5})*60+(43.1833-41.5)*60$, 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.

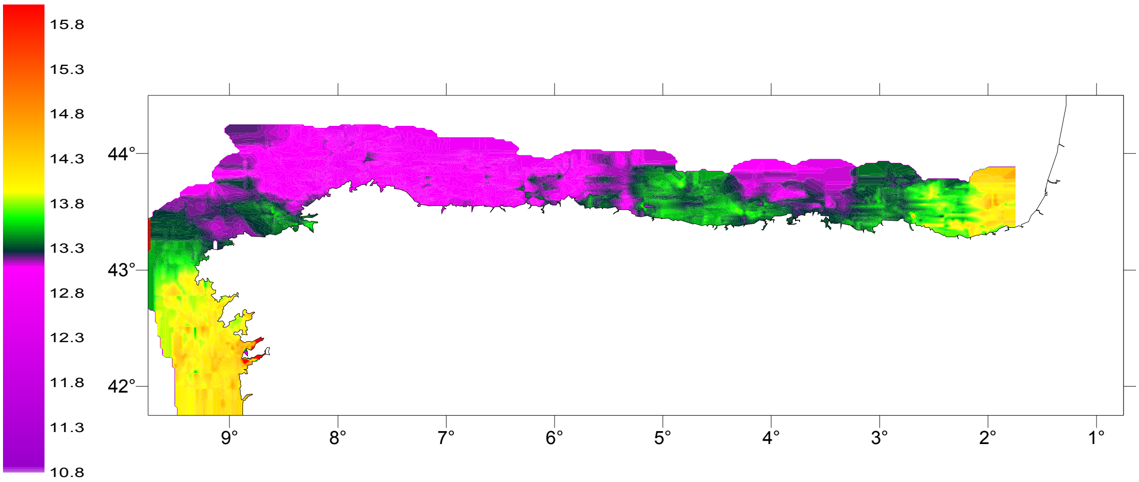


Figure 2a: Sea Surface Temperature during PELACUS 0314 survey

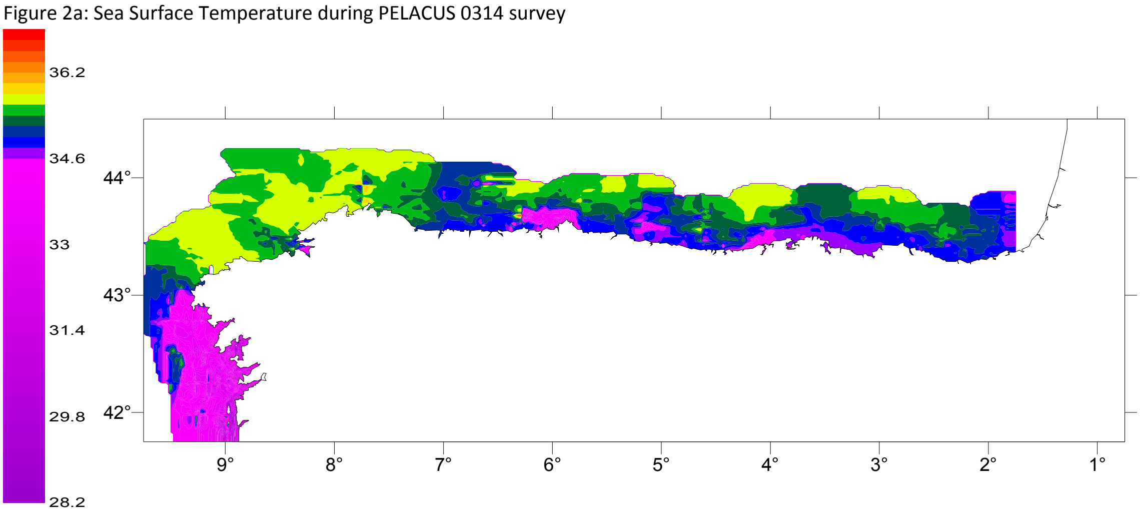


Figure 2b: Sea Surface Salinity during PELACUS 0314 survey

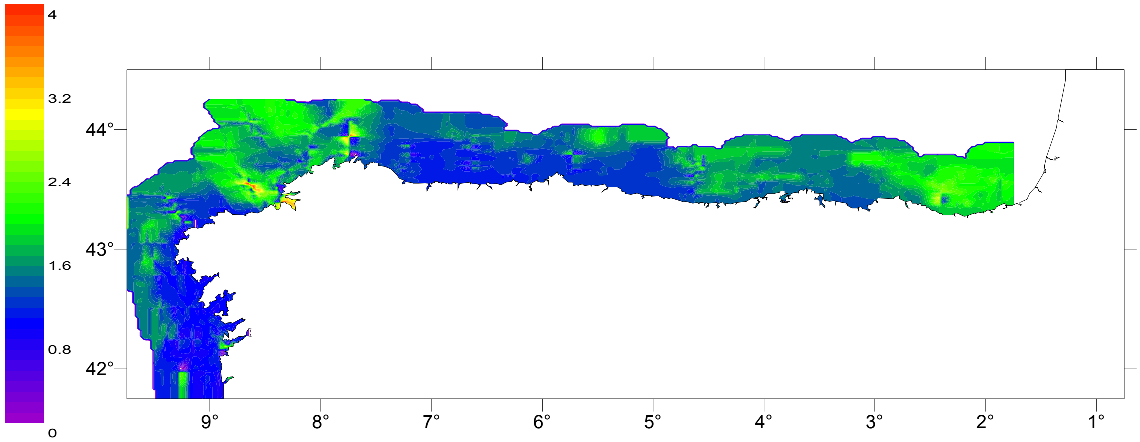


Figure 2c: Sea Surface Fluorescence during PELACUS 0314 survey

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).

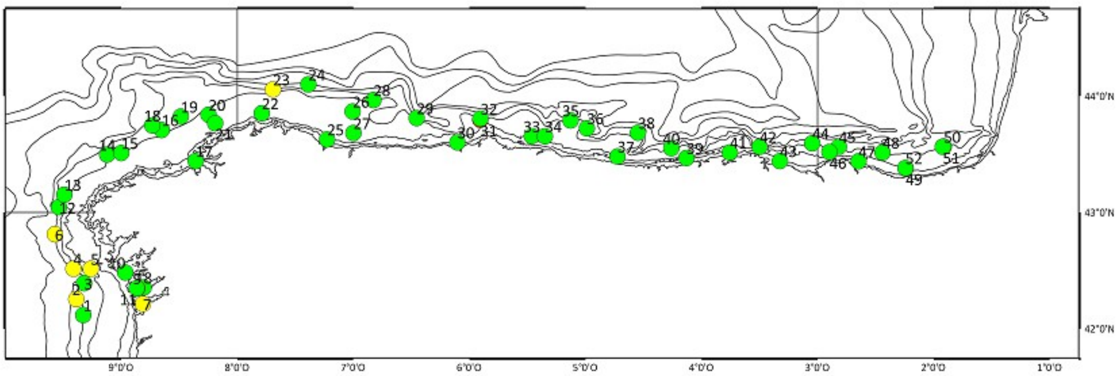


Figure 3: Fishing station and colour system according to ground-truth criteria (red bad; yellow, acceptable; and green good)

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.

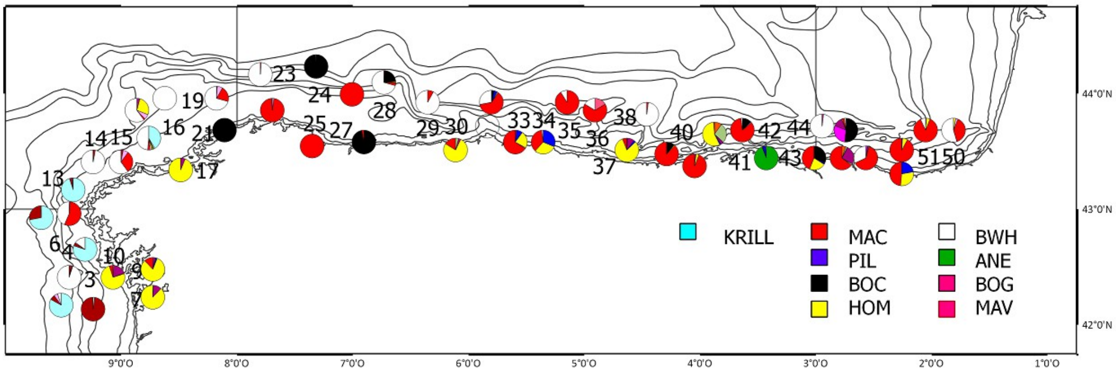


Figure 4: Fish proportion (% in number) at each fishing station. (KRILL -M. norvegica; MAC-mackerel; PIL-sardine; BOC-boarfish; HOM- horse mackerel; WHB-blue whiting; ANE- anchovy; BOG-bogue; and MAV-M. muelleri)

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.

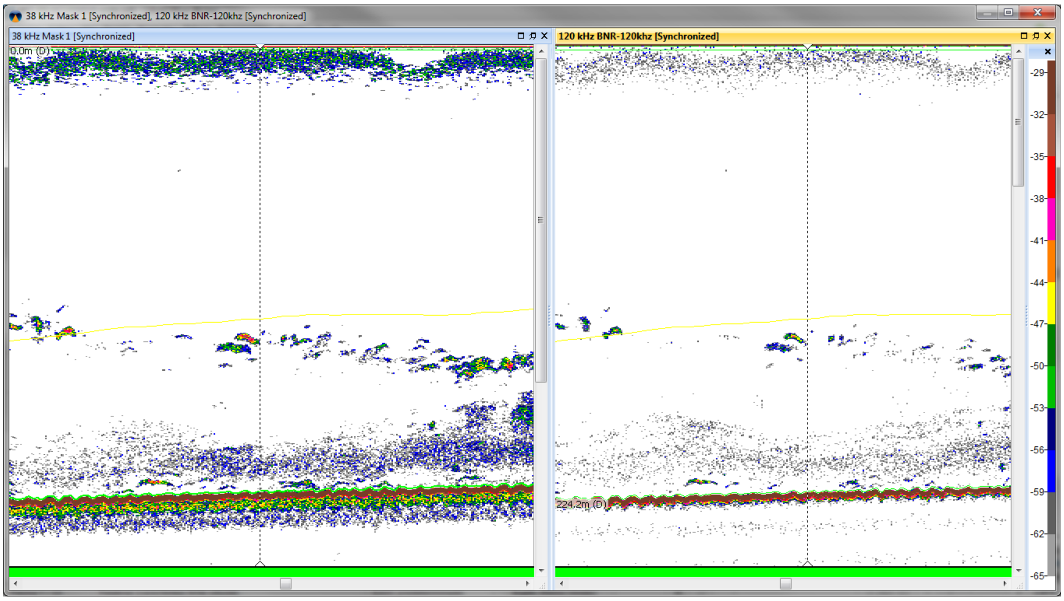


Figure 5: M. muelleri schools located at 140 m depth (total depth is 200). The yellow line is the depth sensor of the trawl door. M. muelleri represented 98% of the catch and 2% was krill (Meganyctiphanes norvegica).The fishing station was performed on 12th March at 13:30 GMT.

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

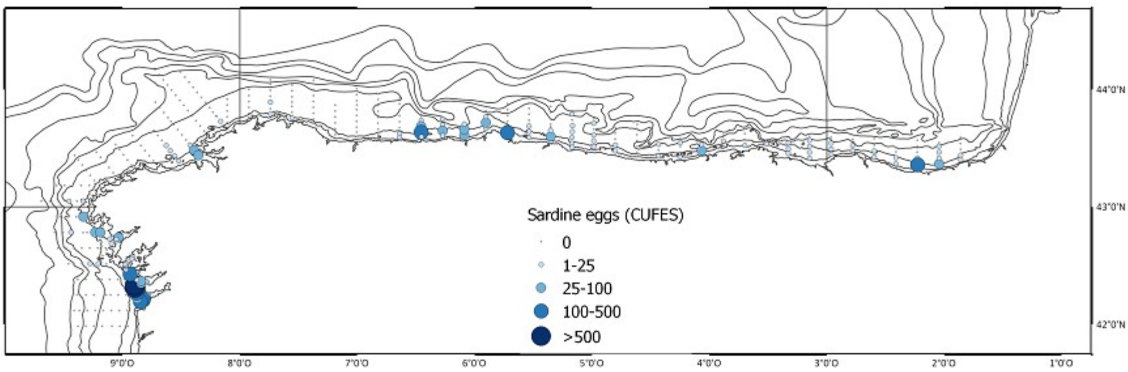


Figure 6. Number of sardine egg collected at the CUFES stations

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

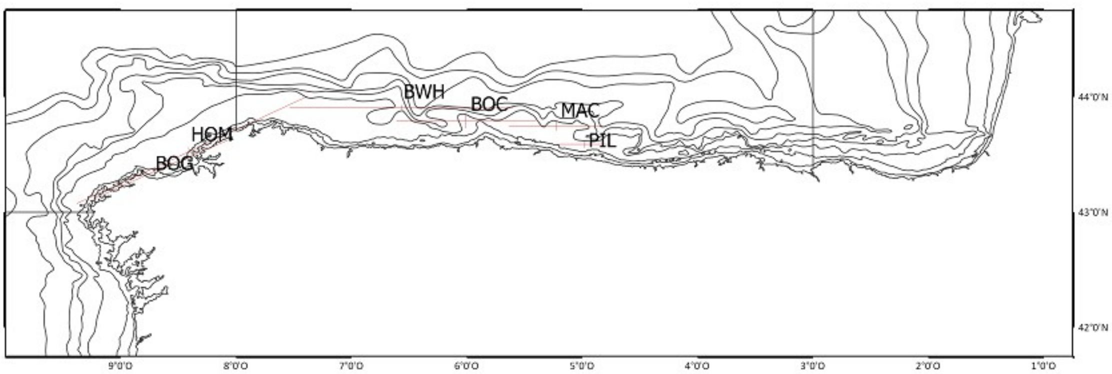


Figure 7 Centre of gravity of NASC distribution for the main fish species. Lines are proportional to the confidence intervals for both variables, Distance to the Origin (D.O.) and Depth

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.

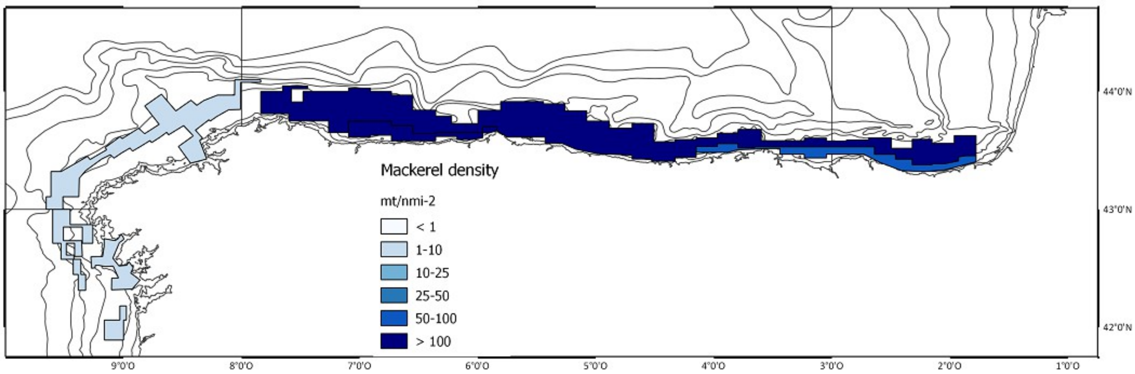


Figure 8. Mackerel: spatial distribution PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >500)

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***

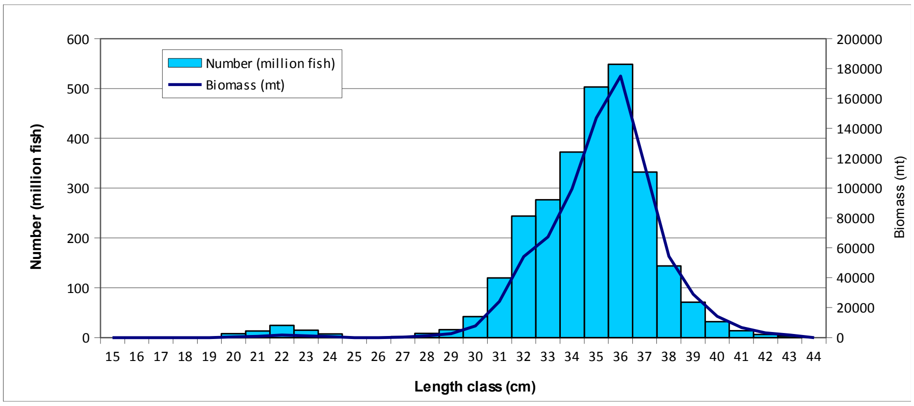
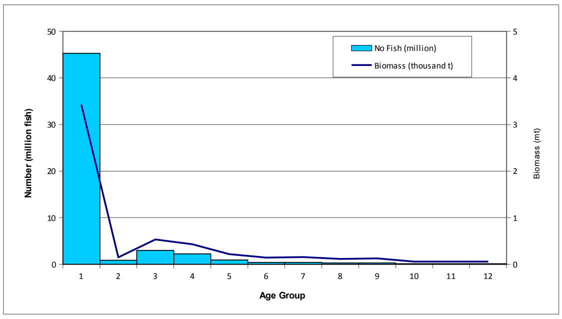
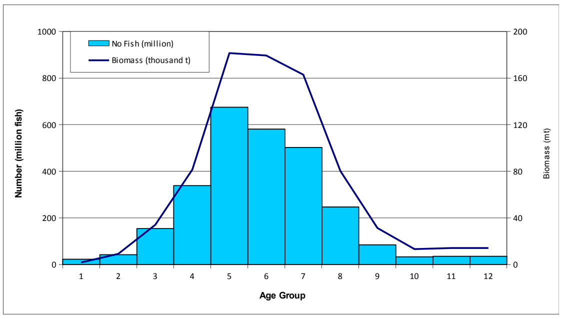


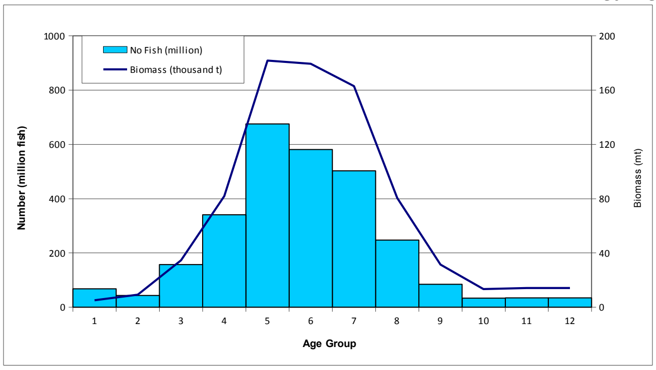
Figure 9. Mackerel length distribution in both number and biomass during PELACUS0314 survey.



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	1	2	3	4	5	6	7	8	9	10	11	12	Total	No fish (milli
						AGE GROUPS								
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).

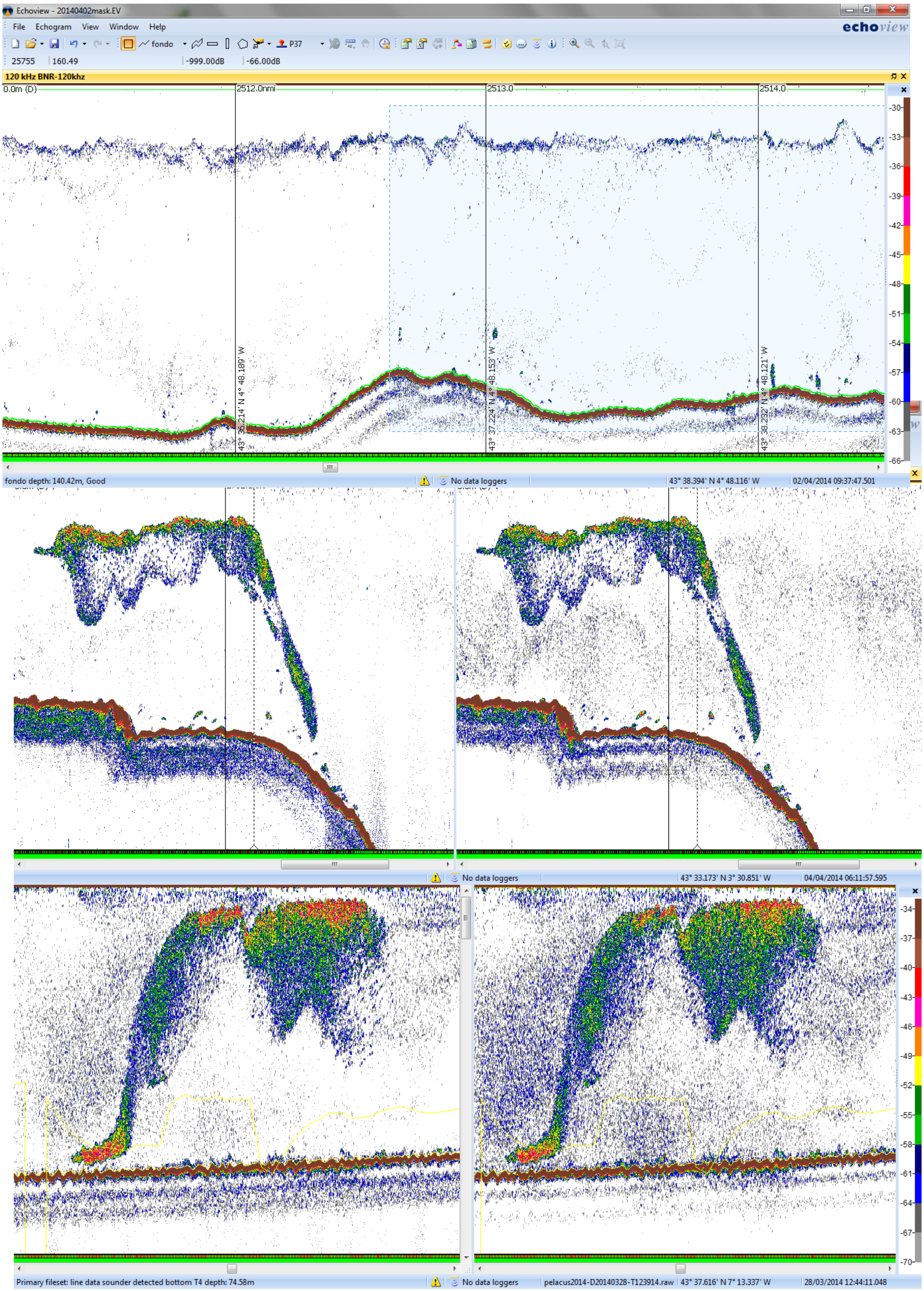


Figure 10. Mackerel occurrence during PELACUS 0314. Top panel subsurface layer (120 kHz echogram; threshold set at -70dB); Mid panel, diving reactions close to the self-edge(200 kHz left and, 120 kHz, right). Bottom panel, raising reaction.

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.

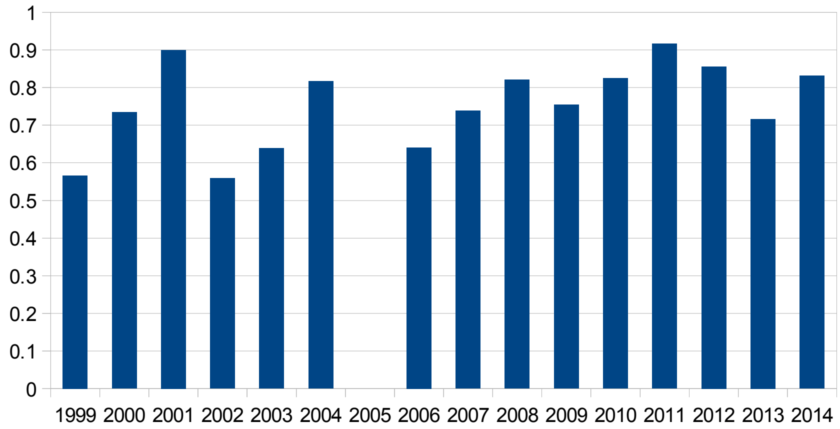
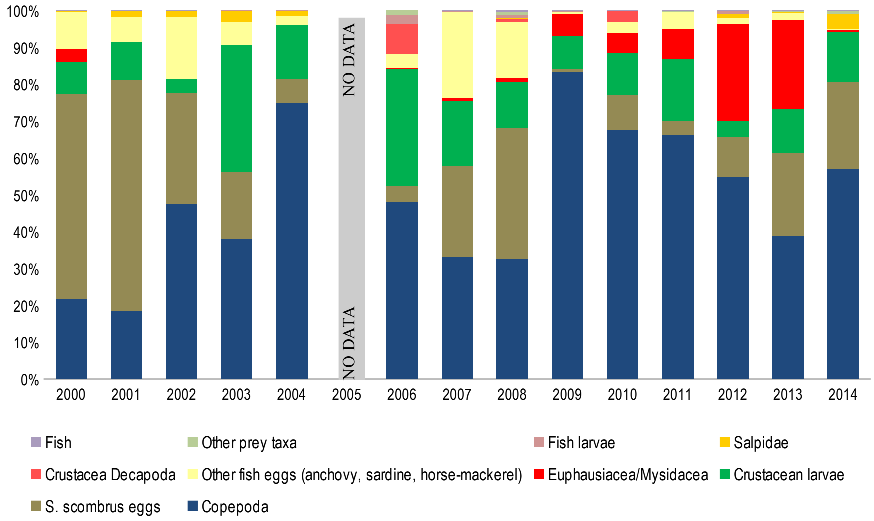


Figure 13:Percentage of non-empty mackerel stomachs taken during PELACUS time series (1999-2014)



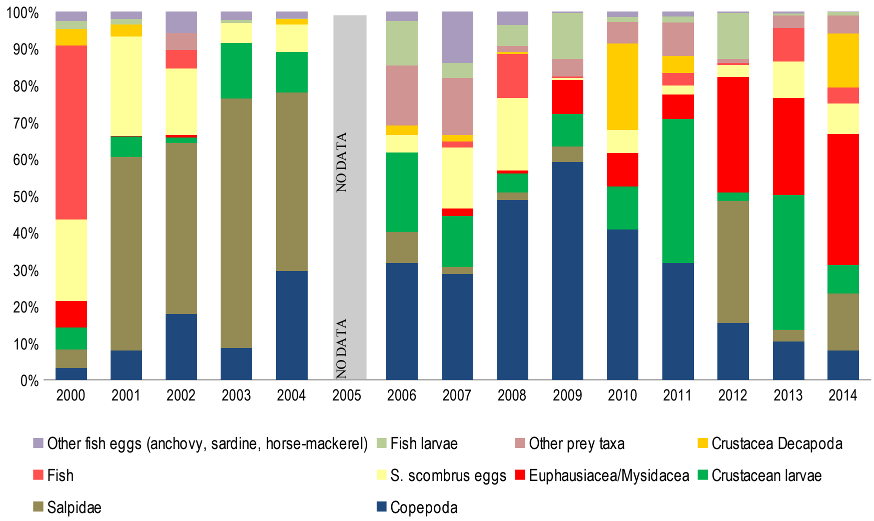


Figure 14: Mackerel diet in number (top panel) and in volume (bottom panel). All figures are in percentage.

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.

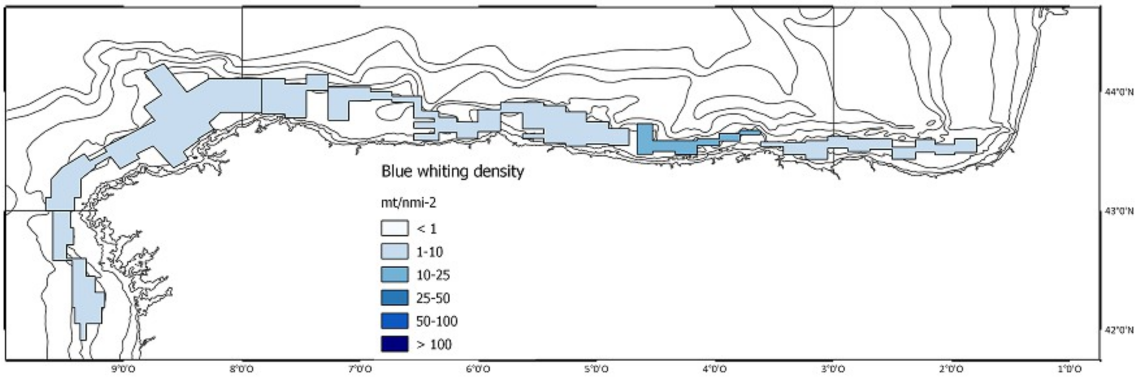


Figure 15. Blue whiting spatial distribution PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100)

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***

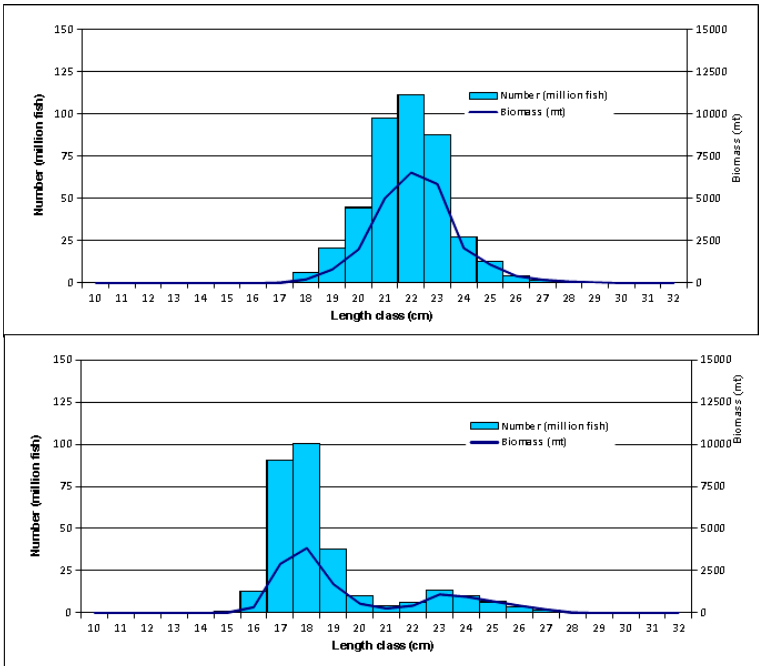


Figure 16. Blue whiting length distribution in both number and biomass during the PELACUS0314 (above) and PELACUS 0313 (below) surveys.

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).

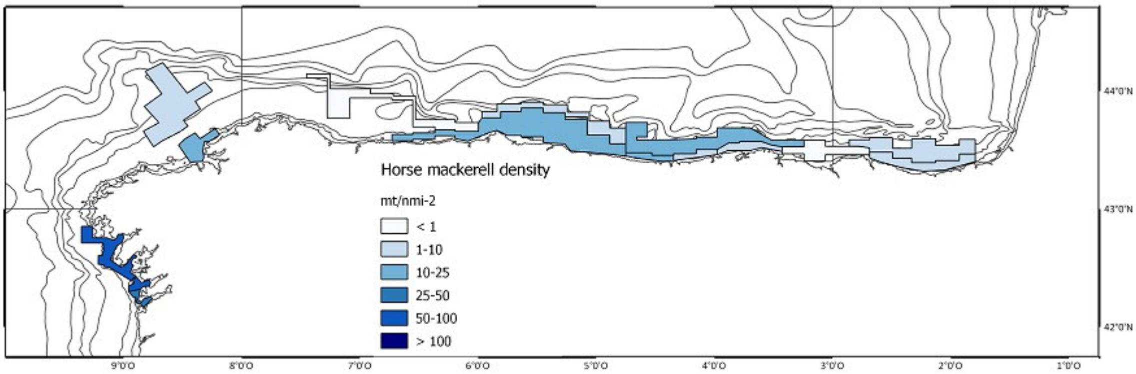


Figure 17. Horse mackerel spatial distribution PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100

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	ŏ^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.

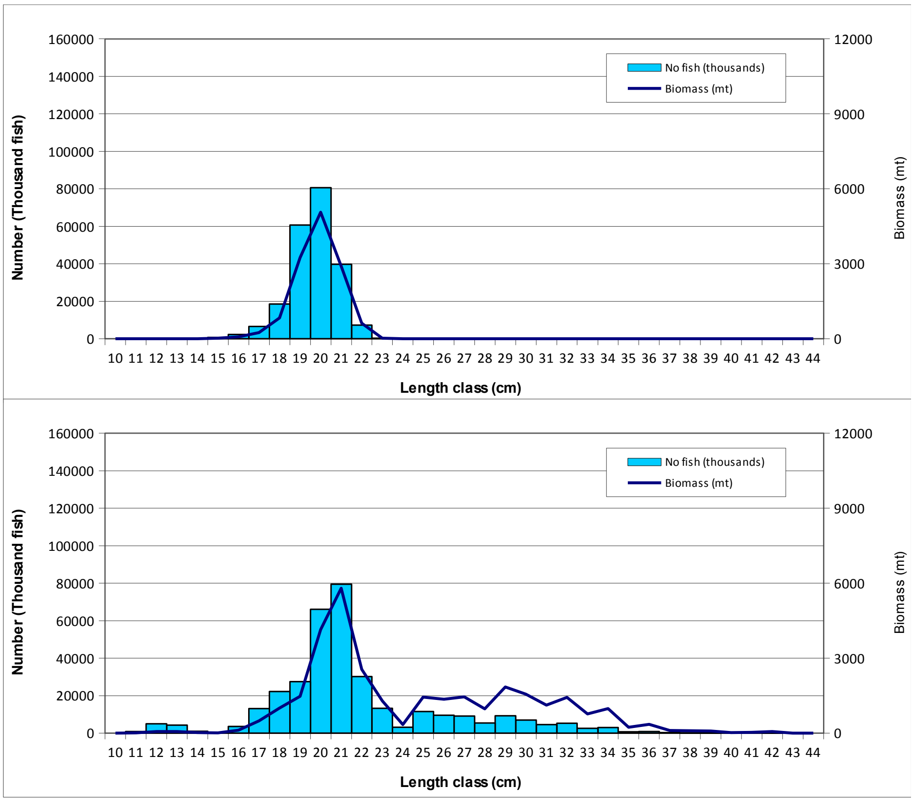


Figure 18. Horse mackerel length distribution in both number and biomass during the PELACUS0314 in IXaN (above) and VIIIc (below).

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.

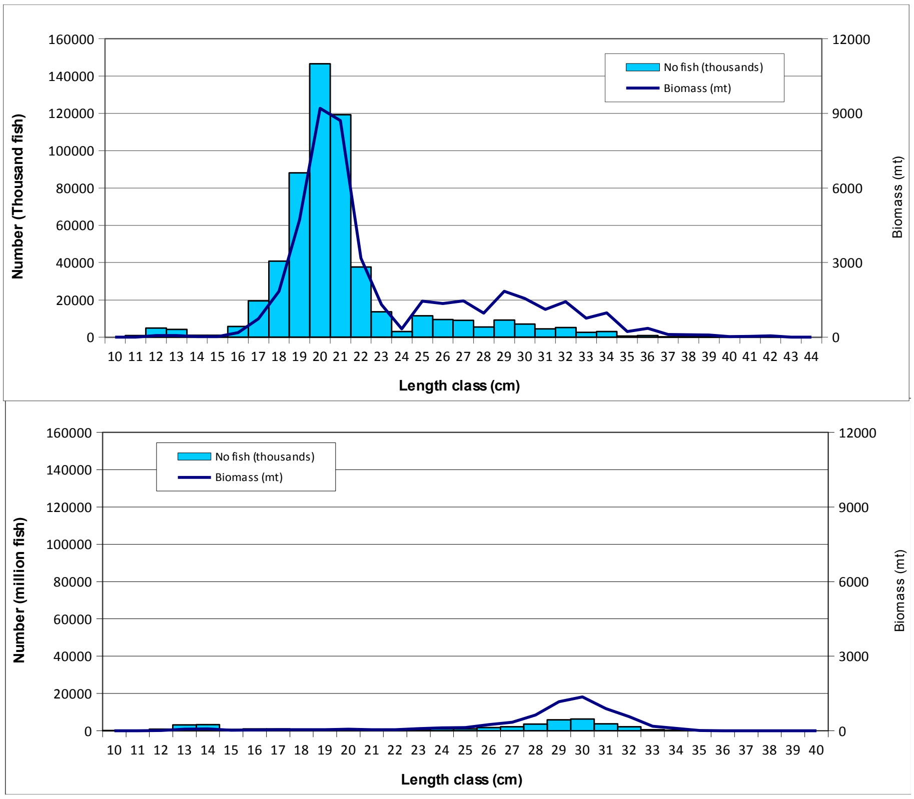


Figure 19: Horse mackerel length distribution in both number and biomass during the PELACUS0314 (above) and PELACUS 0313 (below) surveys.

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%)

<u>Boarfish distribution and assessment</u>

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.

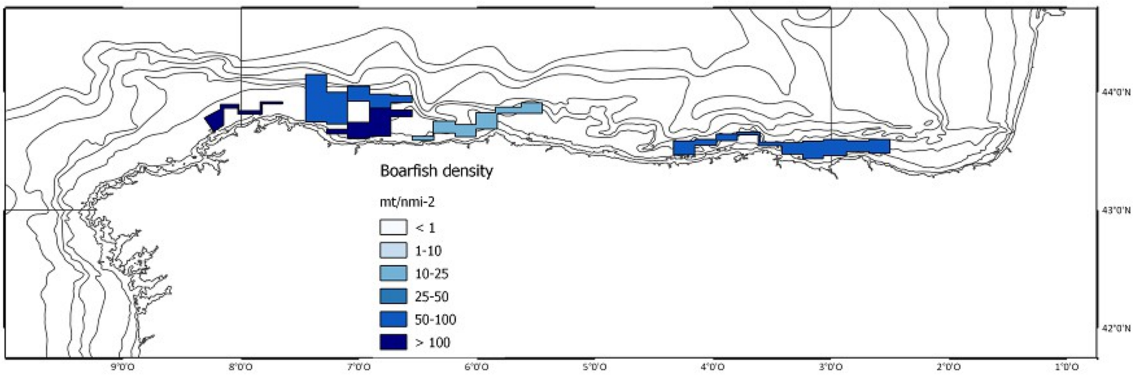


Figure 20. Board fish spatial distribution PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1,; 1-10; 10-25; 25-50; 50-100; and >100)

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***

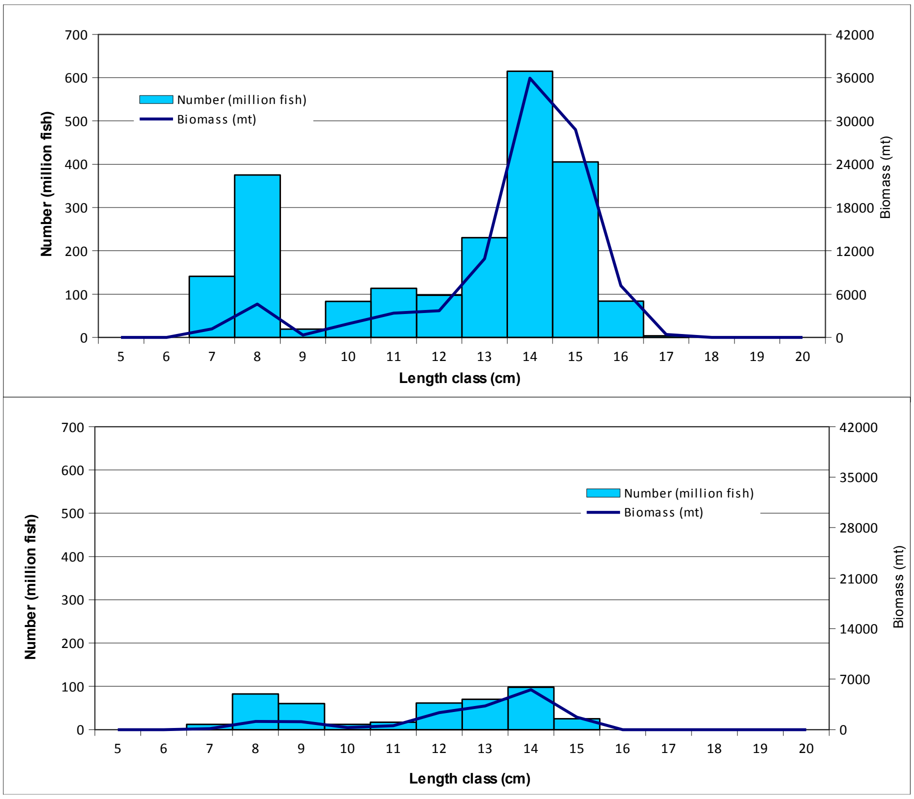


Figure 21. Boarfish length distribution in both number and biomass during the PELACUS0314 (above) and PELACUS 0313 (below) surveys.

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.

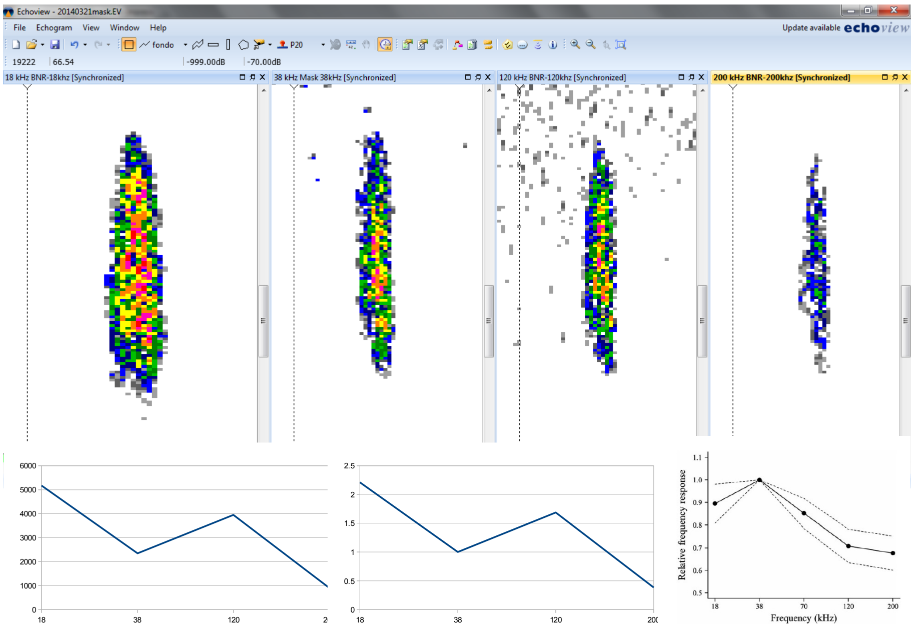


Figure 22a. Boarfish school as observed at 18, 38, 120 and 200 kHz and its absolute frequency response (left plot), relative one (middle plot) and the observed relative frequency response as found in Fässler et al (2003) (right plot).

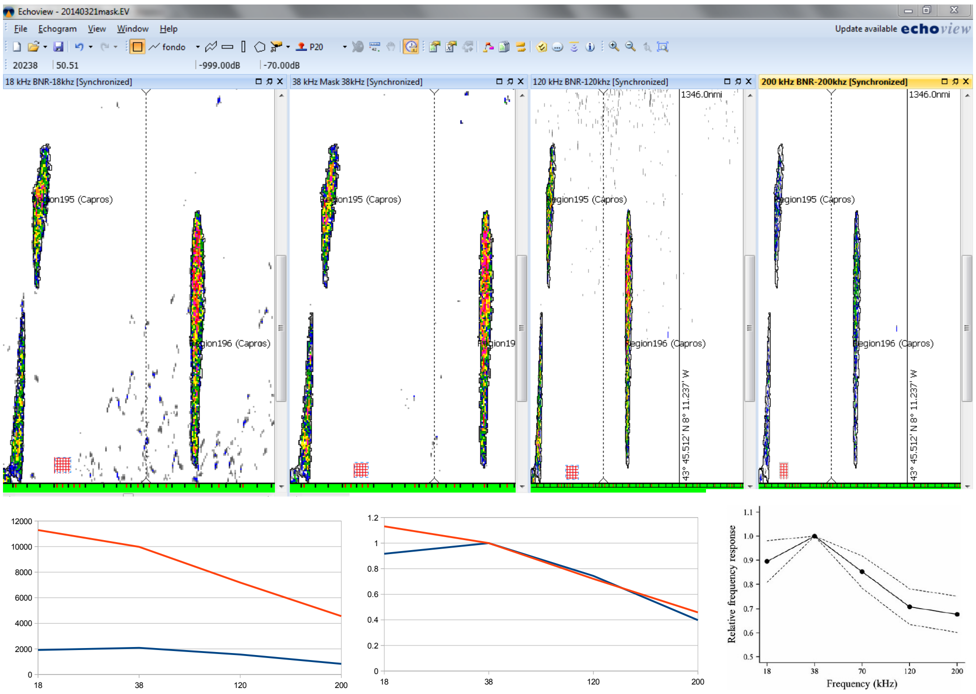


Figure 22b. Ib. Boarfish schools as observed at 18, 38, 120 and 200 kHz and its absolute frequency response (left plot), relative one (middle plot) and the observed relative frequency response as found in Fässler et al (2003) (right plot).

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.

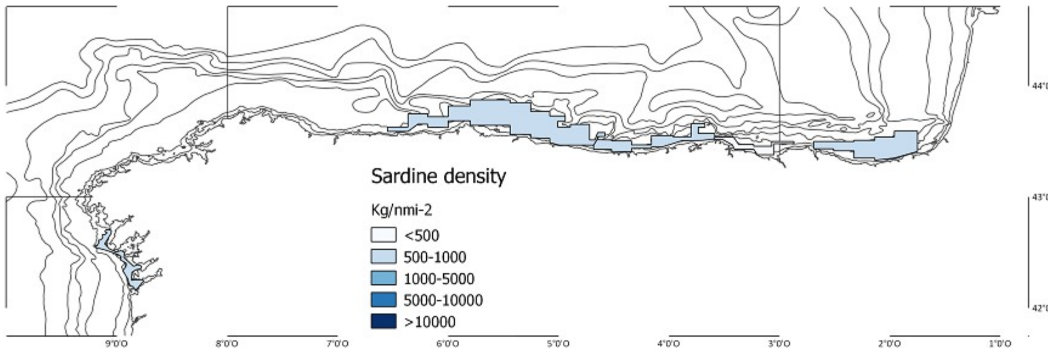


Figure 23. Sardine spatial distribution in PELACUS0314 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates the mean density expressed as kilograms per squared nautical mile (<500,; 500-1000; 1000-5000; 5000-10000; and >10000)

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.

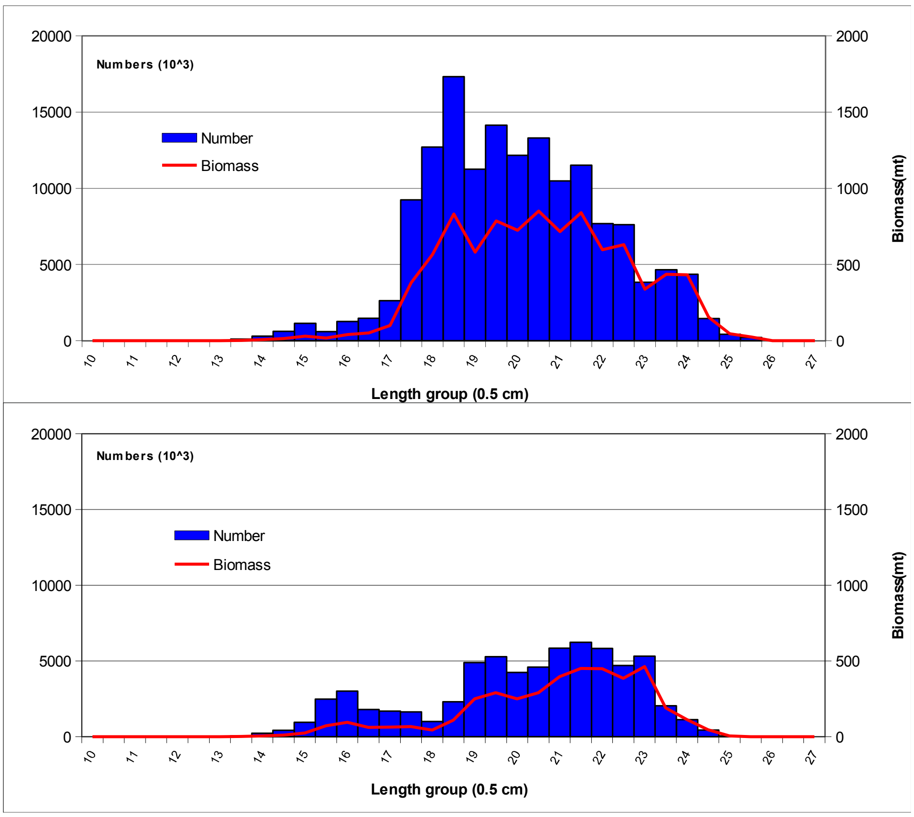


Figure 24. Sardine length distribution in both number and biomass during the PELACUS0314 (above) and PELACUS 0313 (below) surveys.

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.

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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.

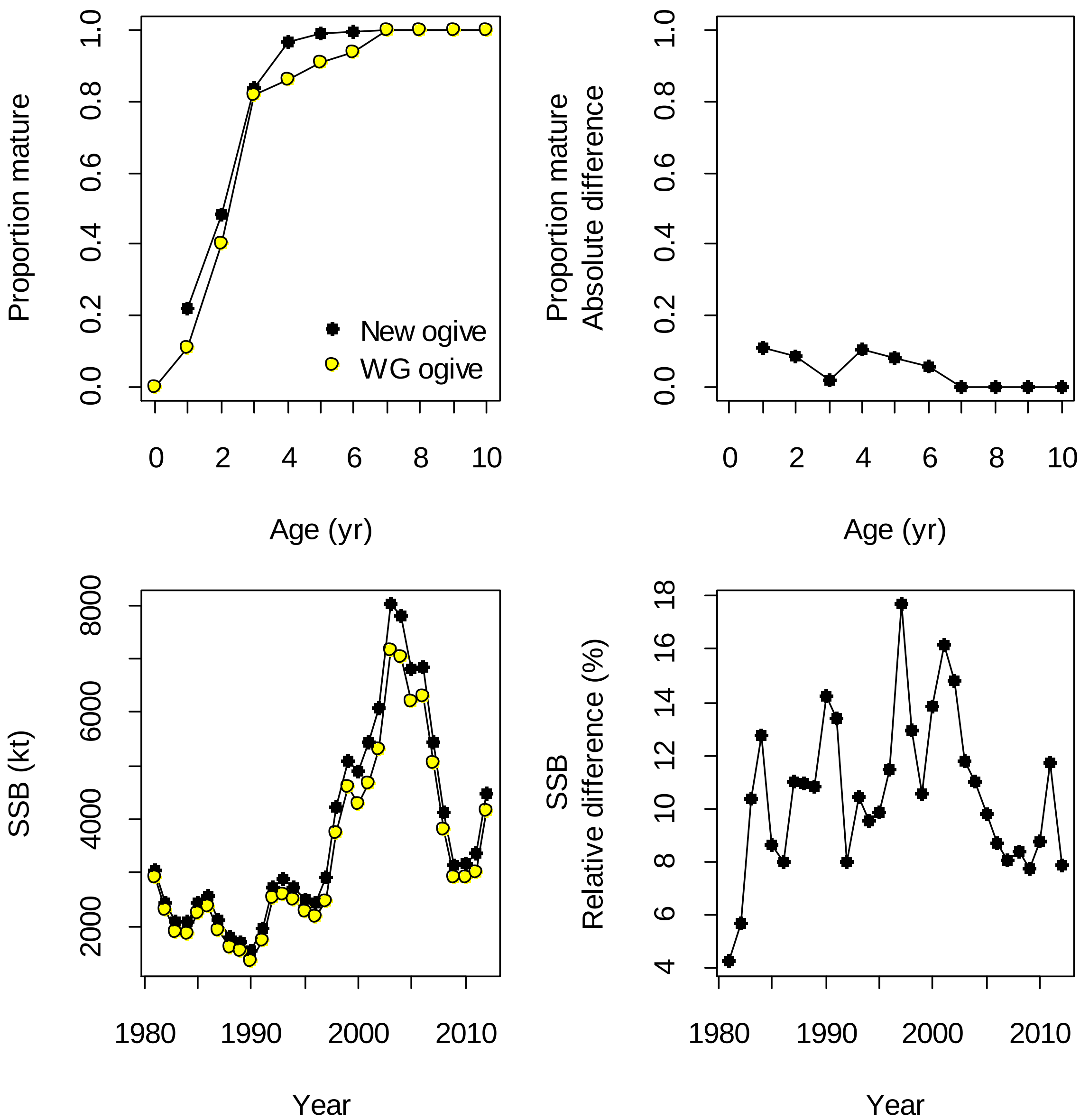

Figure 1. The provisional revised maturity ogive and its consequence for SSB.

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.

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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).

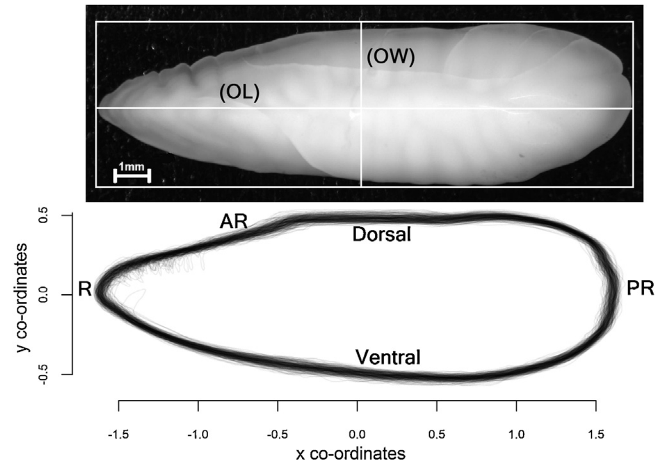

Fig. 1. (Above) otolith is digitized against a black background to emphasize the outline. A rectangle is placed around the otolith, from which otolith width (OW) and otolith length (OL) are measured. (Below) the 249 combined otolith outlines are centred, scaled and aligned. The notation R, AR and PR 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 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).

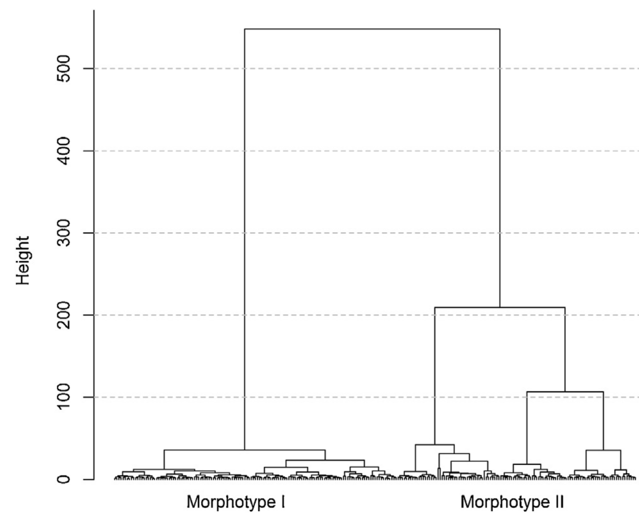

Fig. 2. K-means clustering based on the euclidean distance (height) of the elliptic fourier descriptors. The tree is split into two clusters according to morphotype.

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).

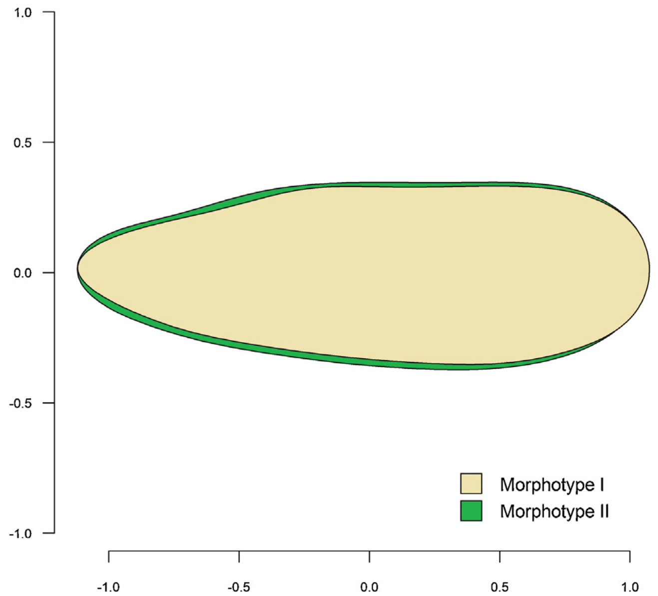

Fig. 3. The recreated average outline of the two otolith morphotypes, overlaid to demonstrate shape differences.

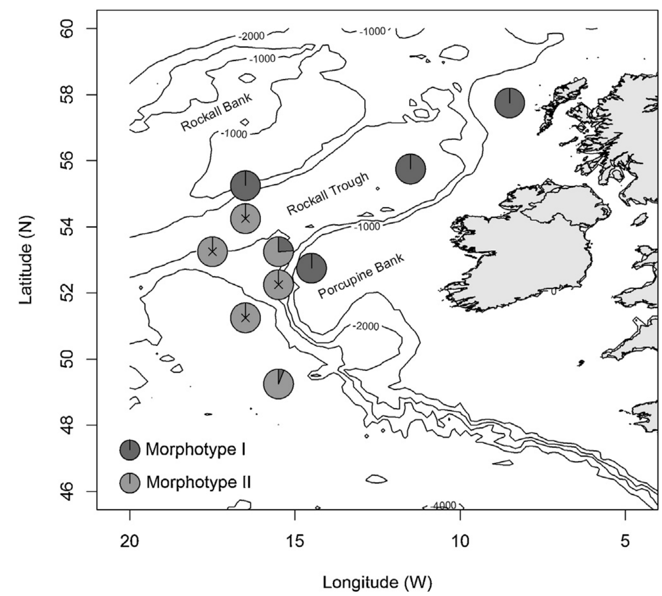

Fig. 5. The distribution of otolith morphotypes across the spawning area. Pie charts represent proportions of morphotype I and II found in each sample. 2003 samples are represented by an "x" in the centre of the pie chart.

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).

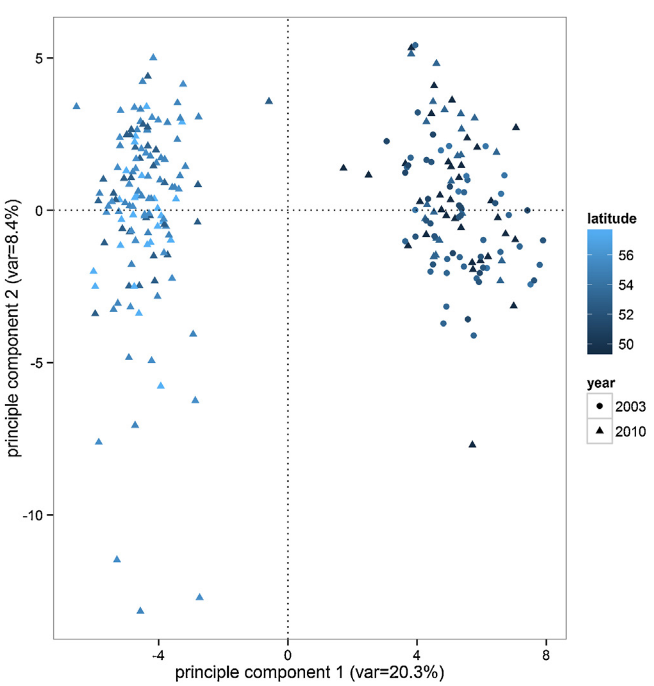

Fig. 4. Scores from Principle Component Analysis. The colour of the points reflect a latitudinal gradient, whereby points from Southern latitudes are dark blue, becoming a lighter shade of blue from more Northern latitudes. The percentage variance described by each component is listed on the axes.

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

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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.

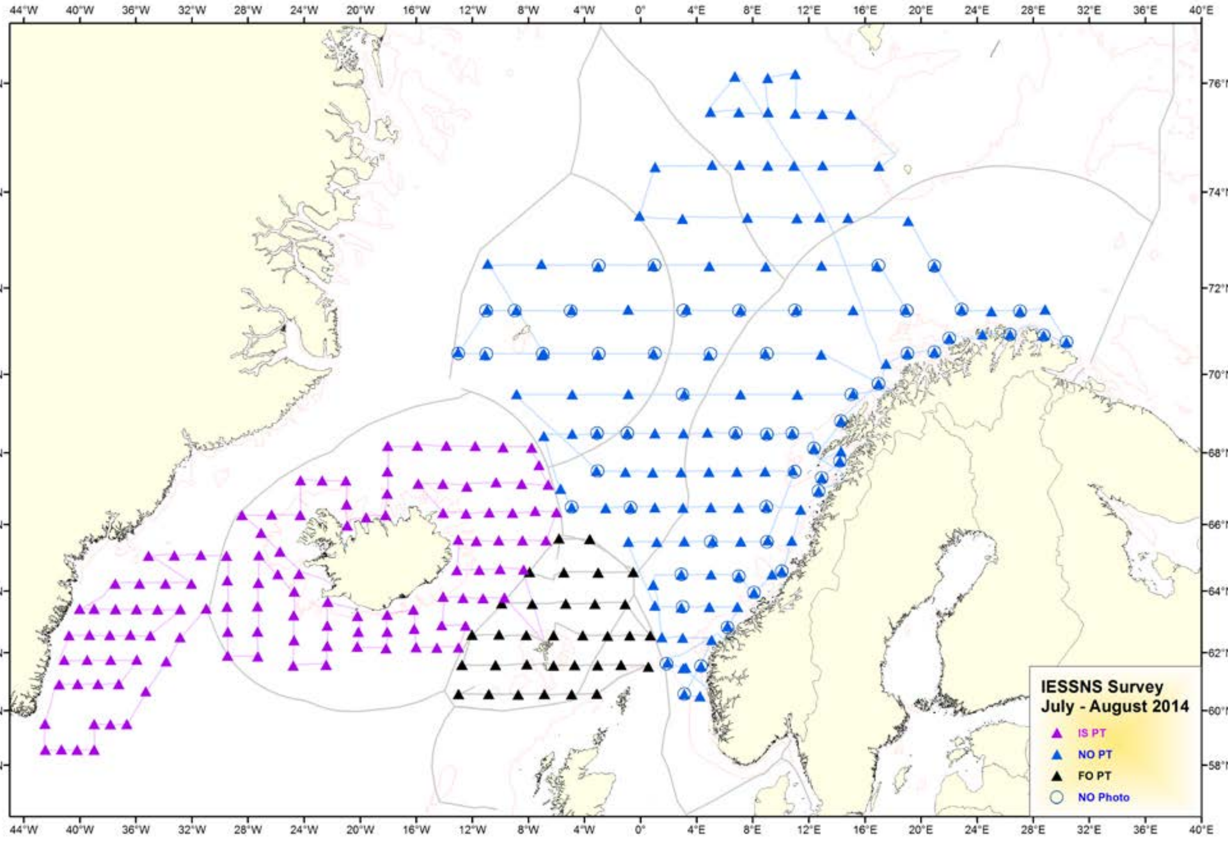


Figure 1. Cruise tracks and pelagic trawl stations shown for M/V "Brennholm" and "Vendla" (Norway) in blue, M/V "Finnur Friði" (Faroe Islands) in black and R/V "Arni Fridriksson" (Iceland/Greenland) in purple within the covered areas of the Norwegian Sea and surrounding waters from 2nd of July to 11th of August 2014.

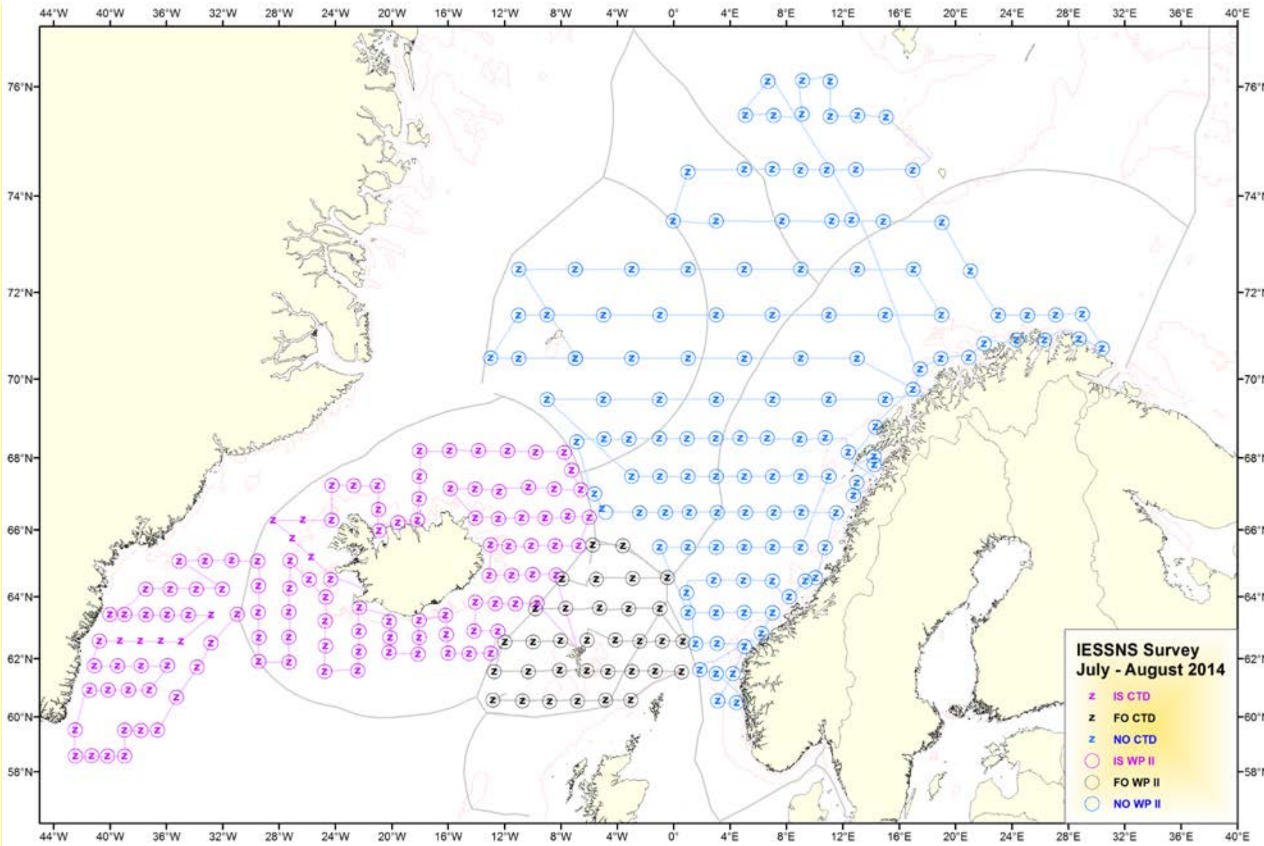


Figure 2. CTD stations (0-500 m) using SEABIRD SBE 37 (Arni Fridriksson) SEABIRD SB 25+ (Finnur Friði) and SAIV SD200 (Brennholm and Vendla) CTD sensors and WP2 plankton net samples (0-200 m depth). These were taken systematically on every pelagic trawl station on all four vessels

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).

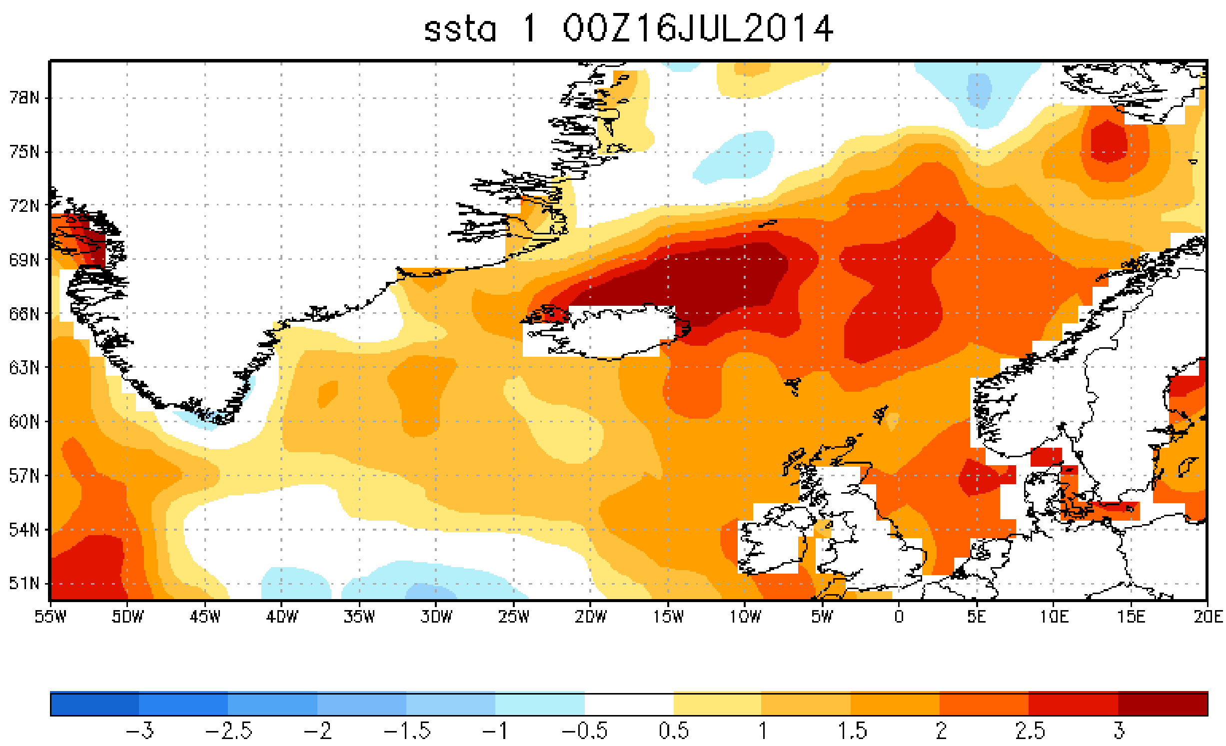


Figure 3. Sea surface temperature anomaly in July (°C; centered for mid July 2014) showing warm and cold conditions in comparison to a 20 year average.

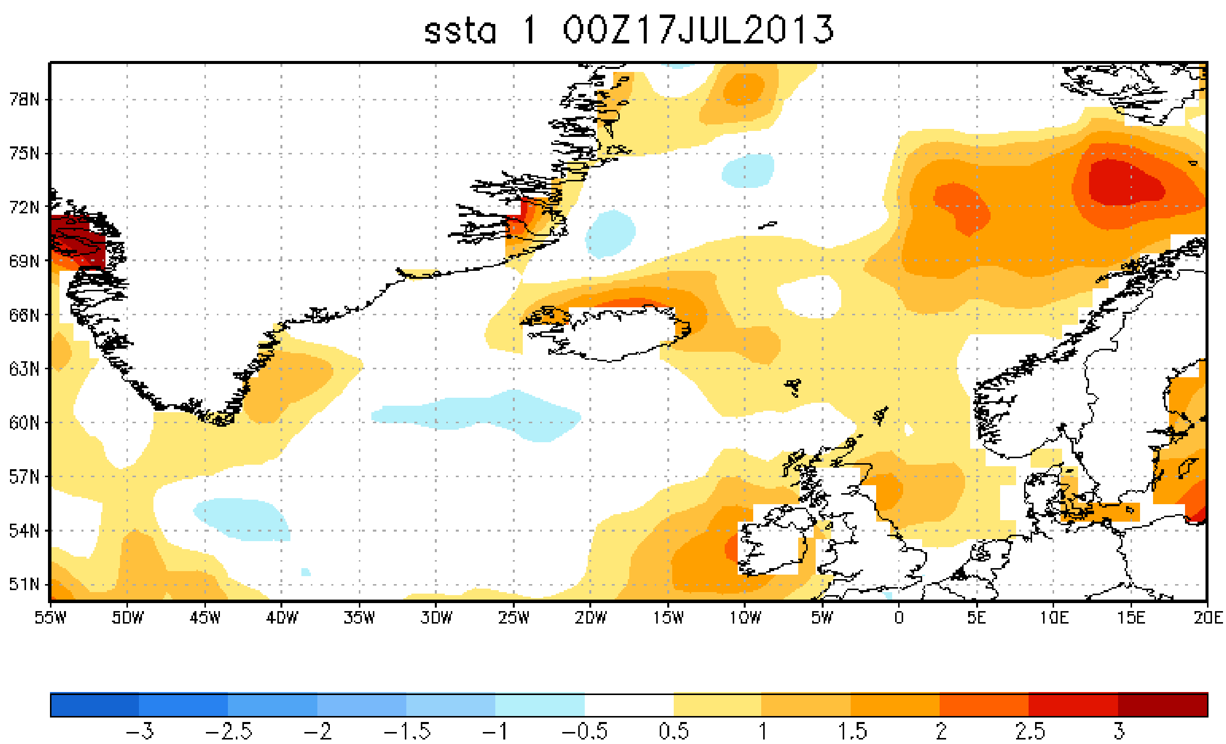


Figure 4. Sea surface temperature anomaly in July (°C; centered for mid July 2013) showing warm and cold conditions in comparison to a 20 year average.

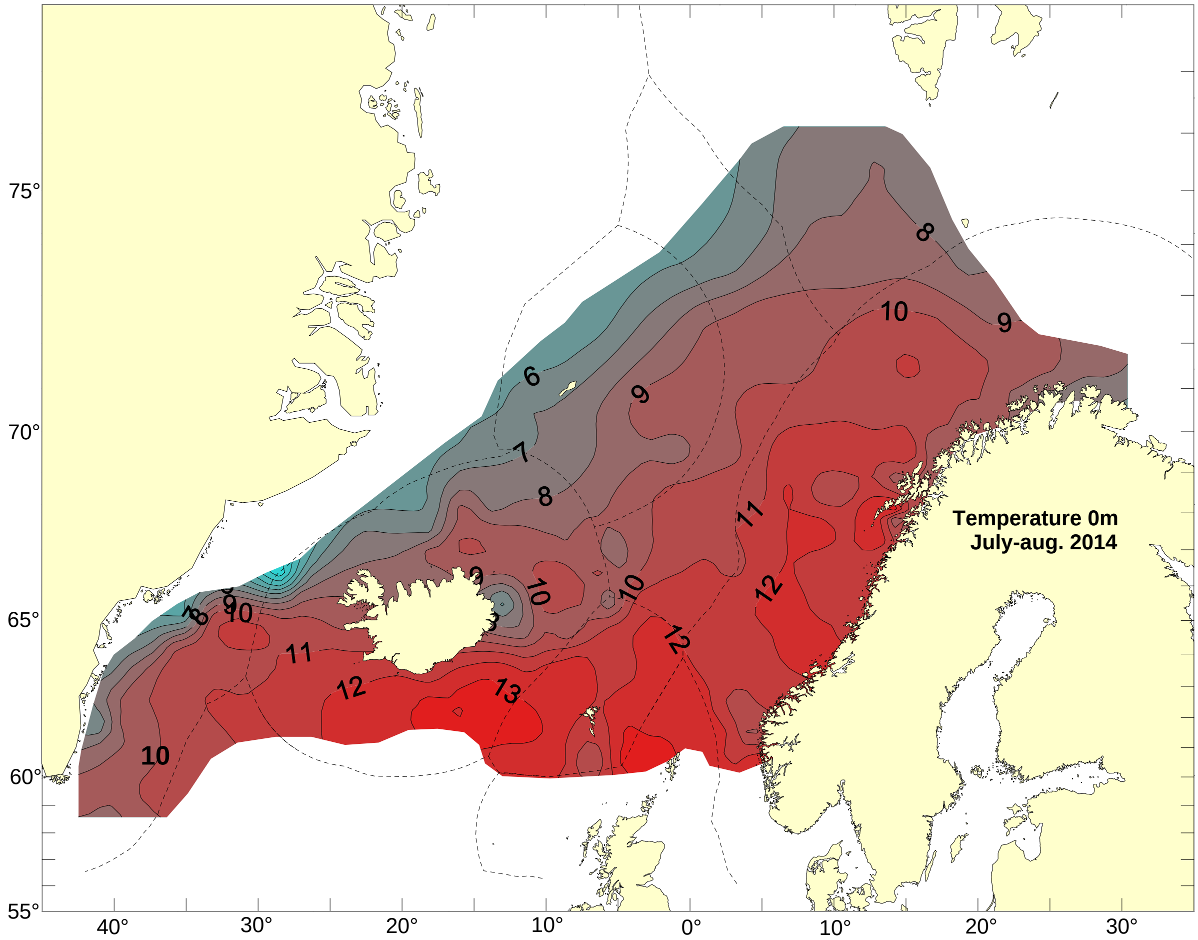


Figure 5. Temperature (°C) at 10 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

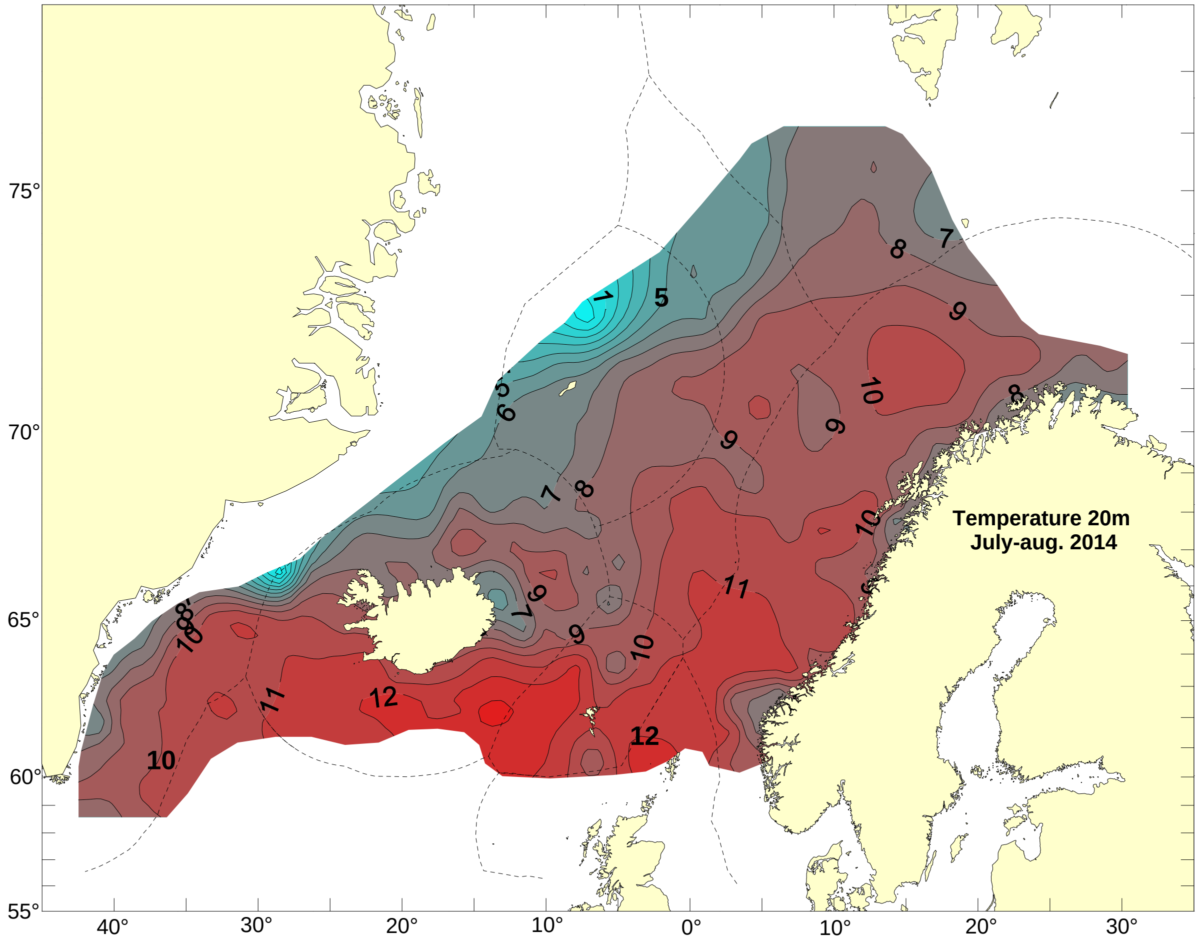


Figure 6. Temperature (°C) at 20 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

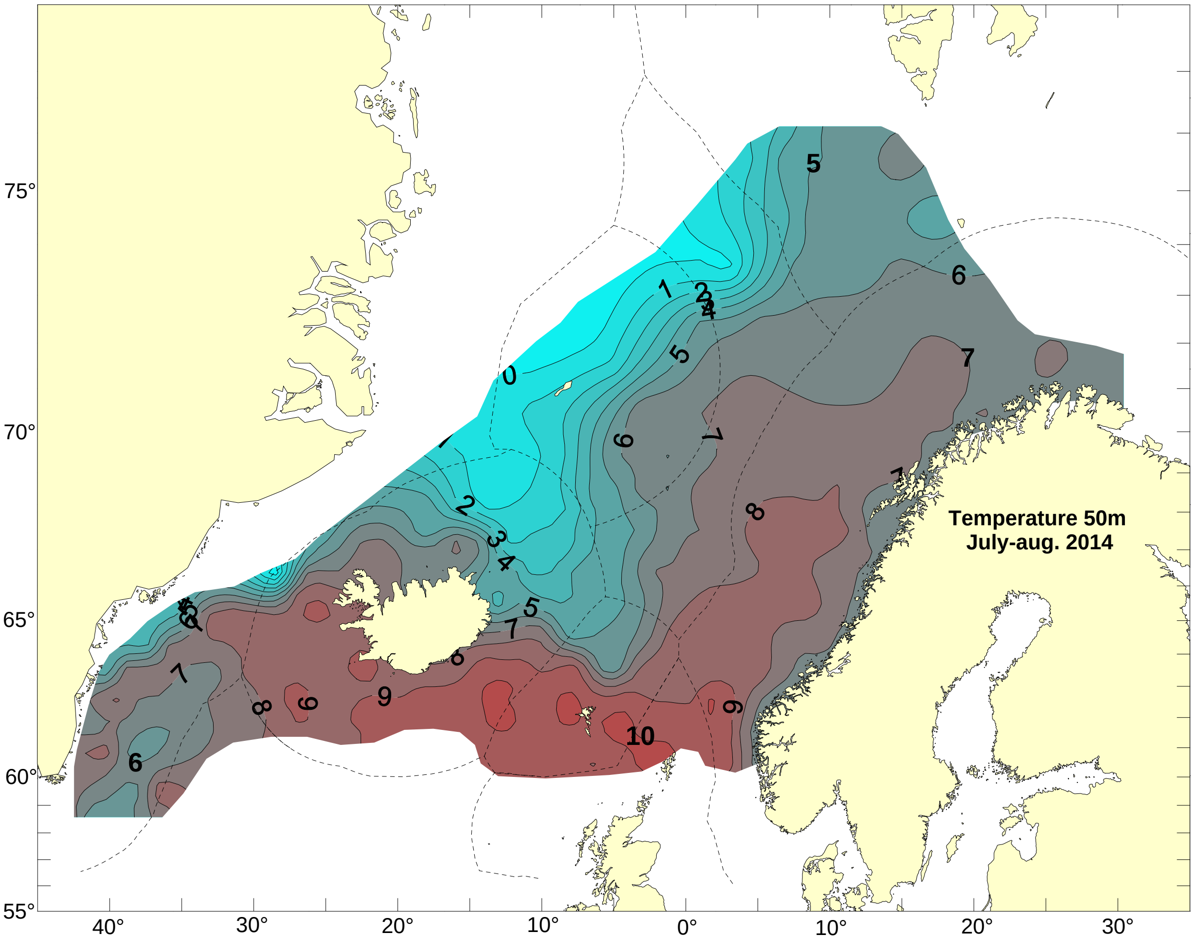


Figure 7. Temperature (°C) at 50 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

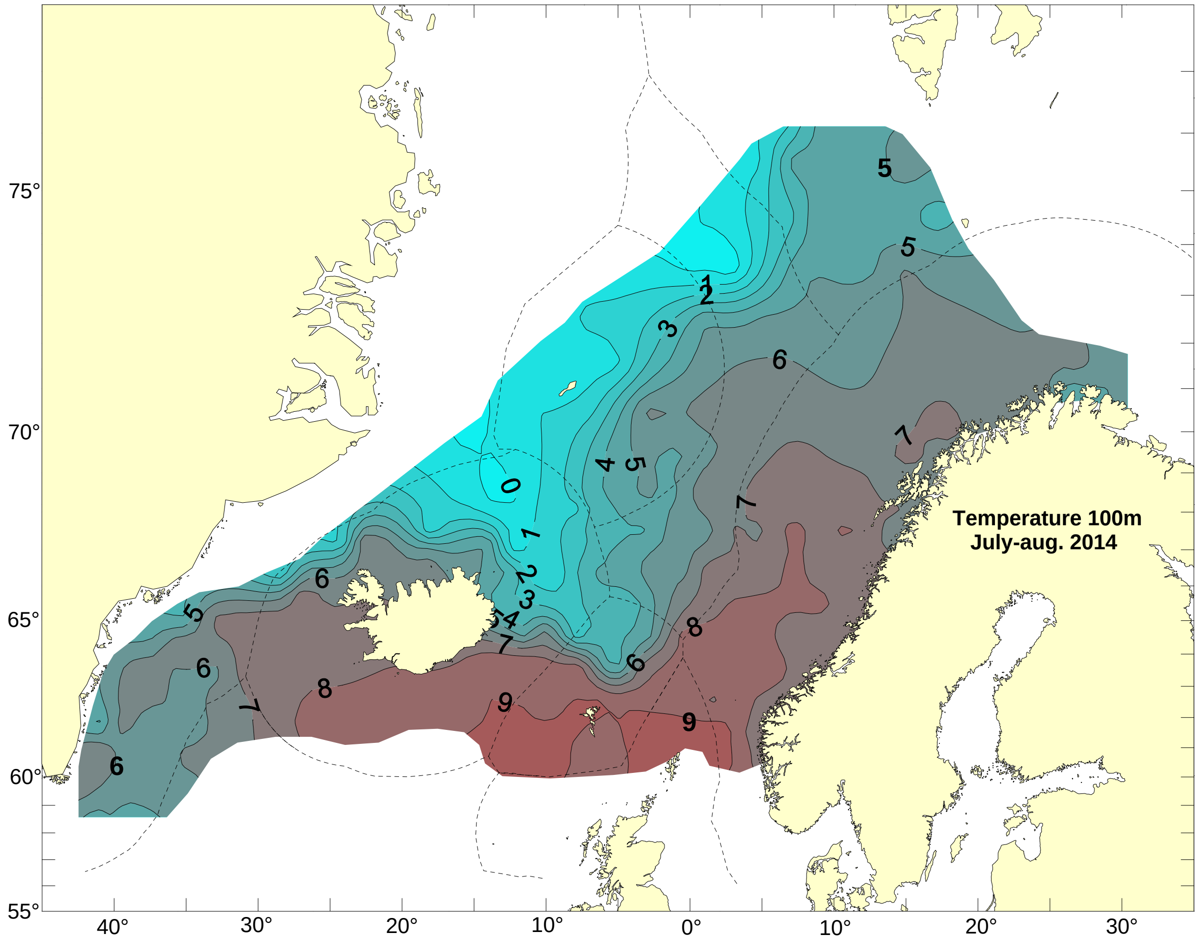


Figure 8. Temperature (°C) at 100 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

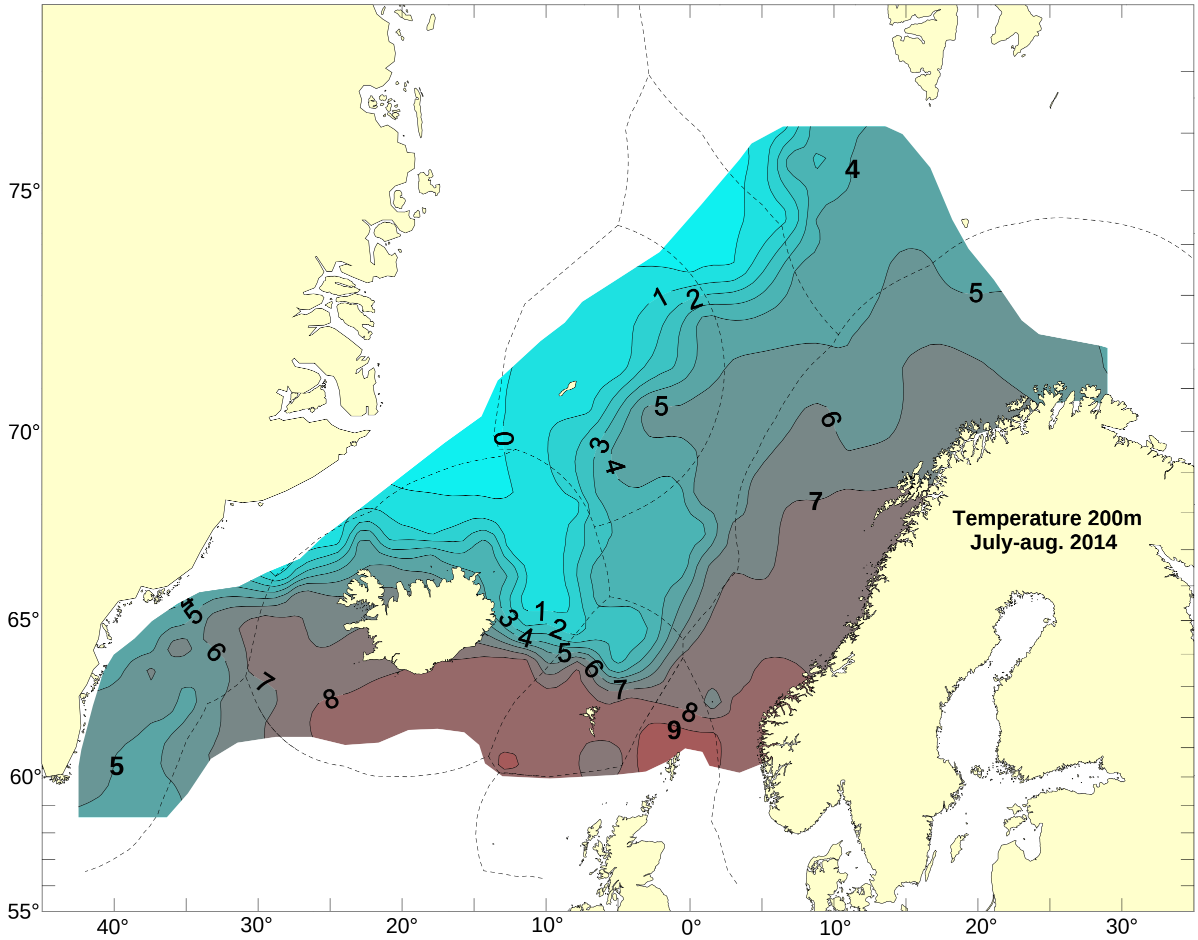


Figure 9. Temperature (°C) at 200 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

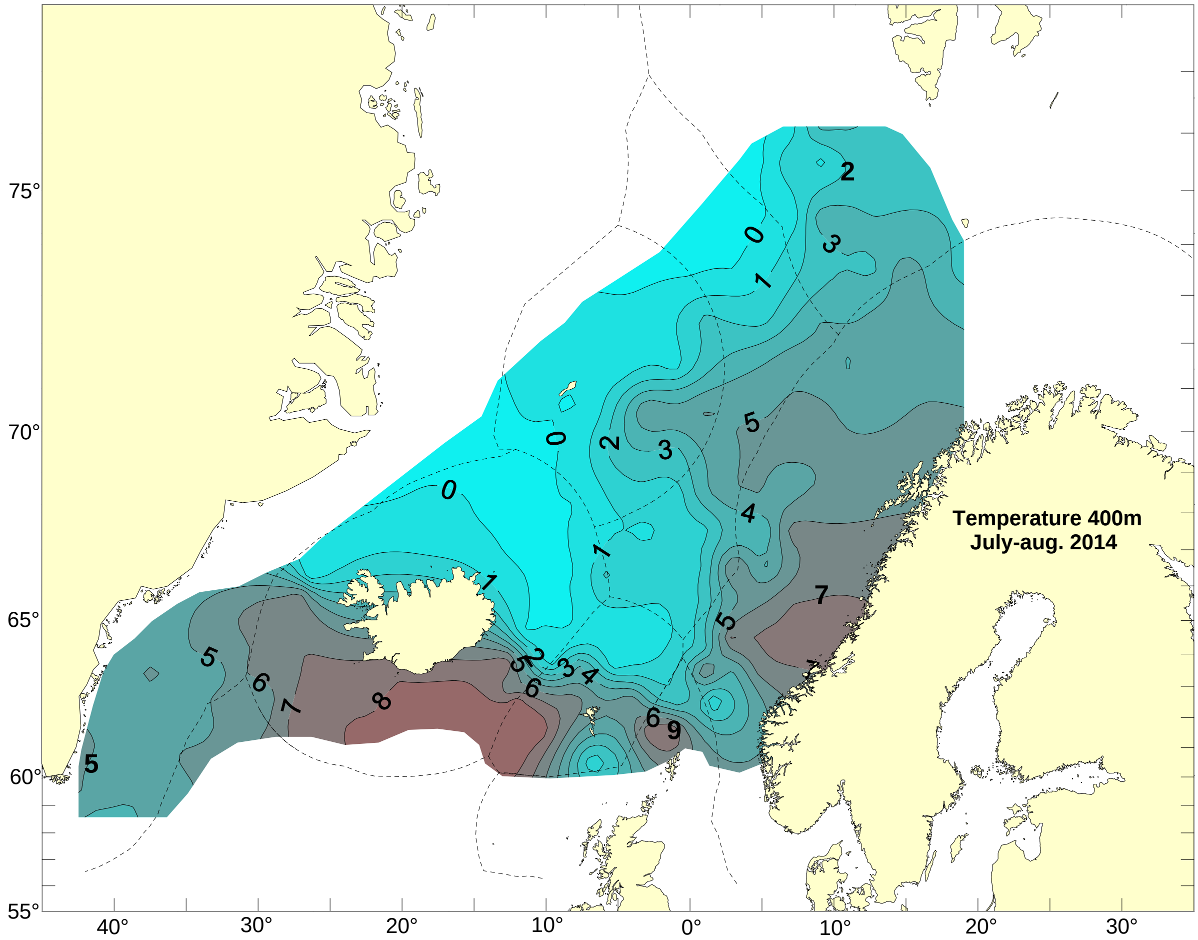


Figure 10. Temperature (°C) at 400 m depth in the Norwegian Sea and surrounding waters in July/August 2014.

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.

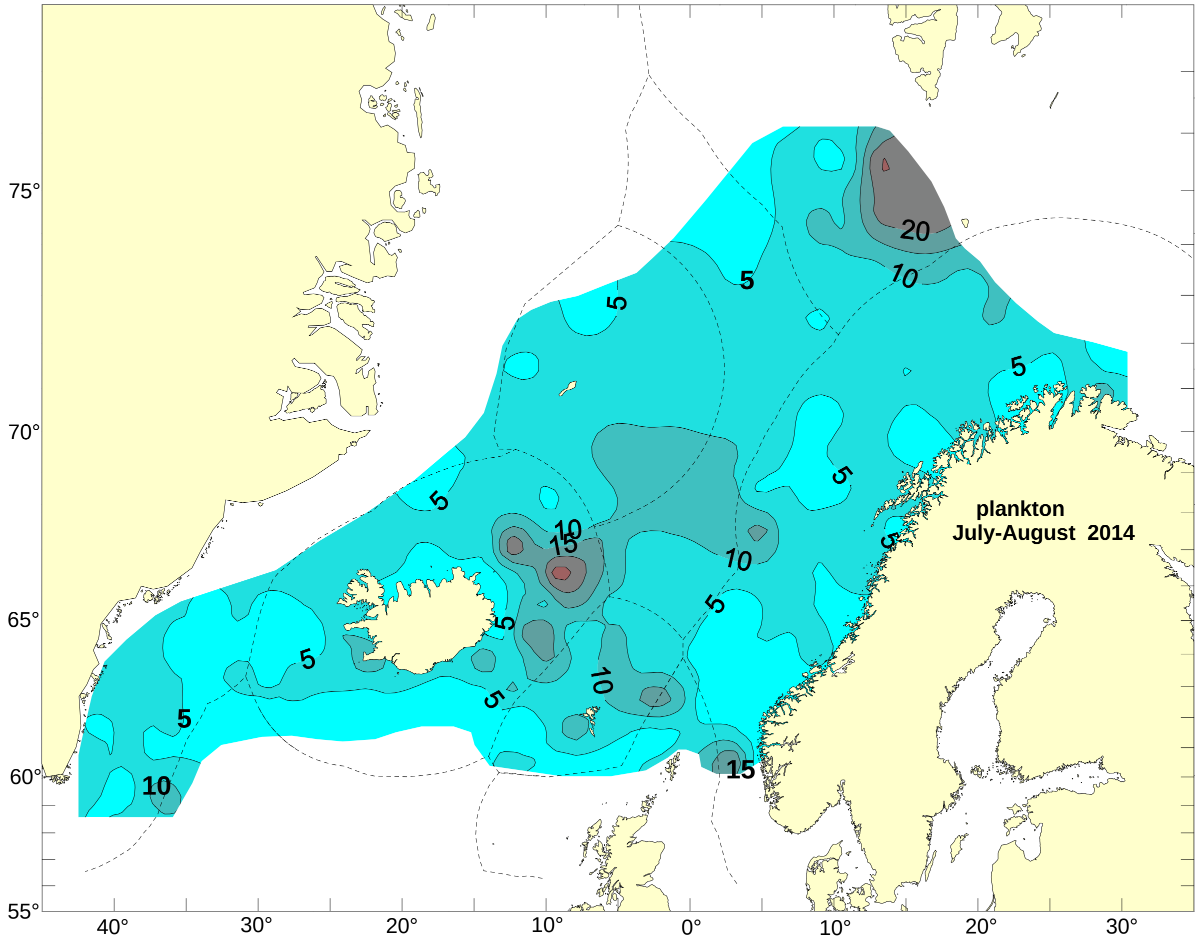


Figure 11. Zooplankton biomass (g dw/m^2, 0-200 m) in the Norwegian Sea and surrounding waters, 2nd of July -9th of August 2014.

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/m^2)		
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.

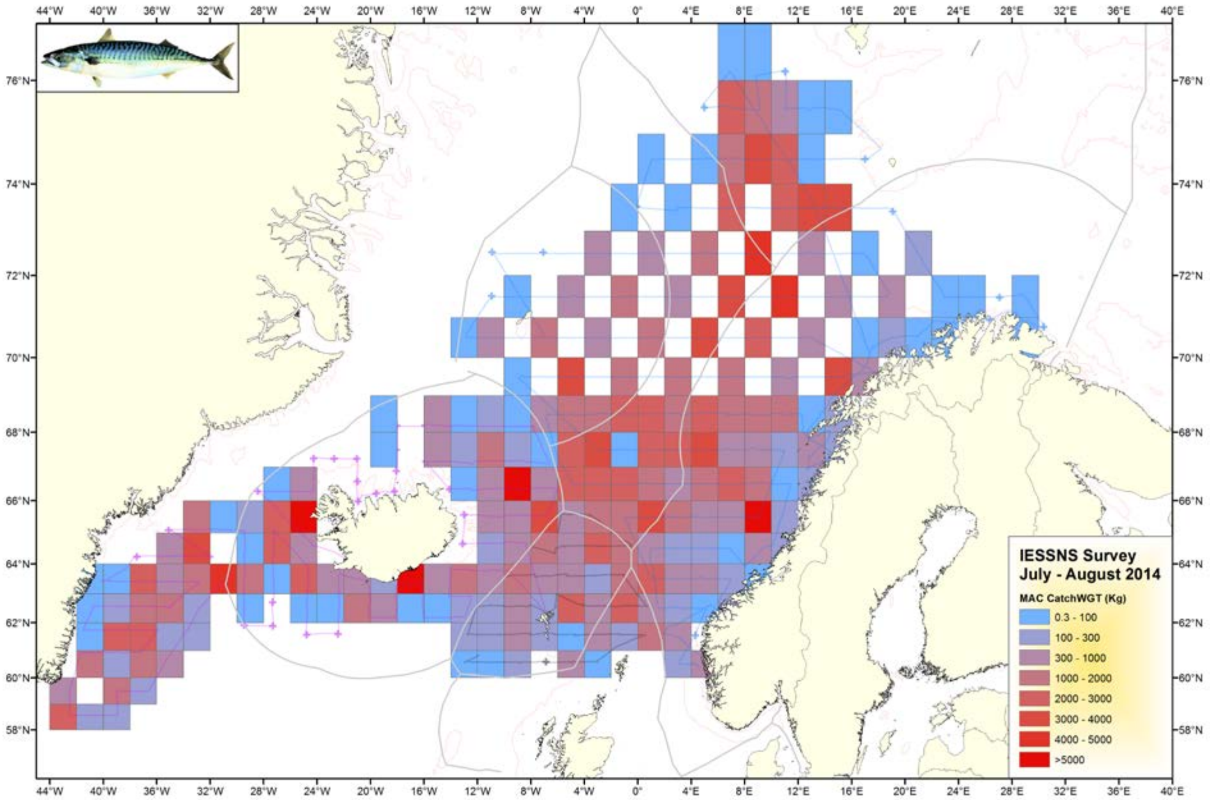


Figure 12. Catches of mackerel in kg represented in standardized rectangles. Light blue represents small catches (0.3-100 kg), while dark red represents catches of more than 5000 kg mackerel after 30 min standardized towing with the Multpelt 832 pelagic trawl. Vessel tracks are shown as continuous lines. 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).

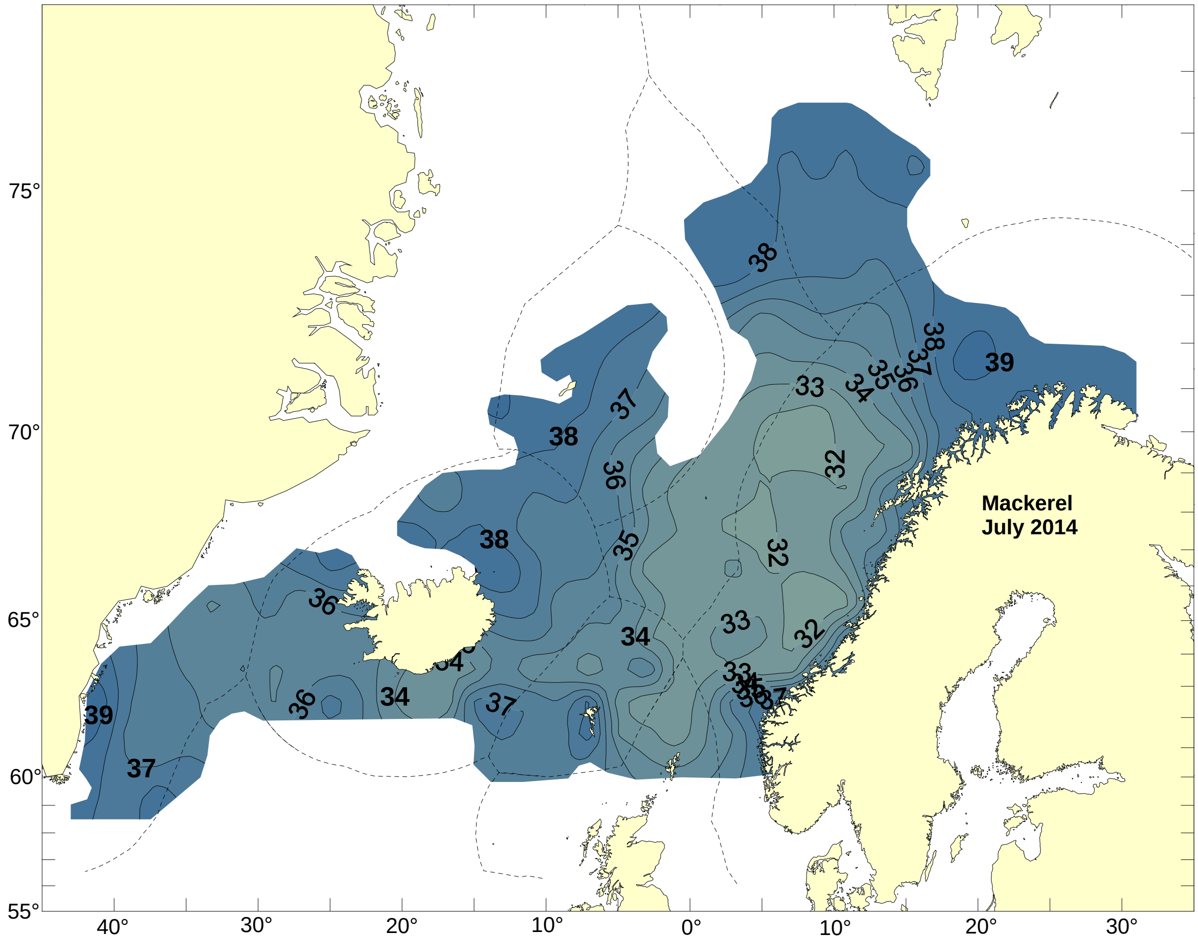


Figure 13. Average length distribution of NEA mackerel from the joint ecosystem survey with M/V "Brennholm", M/V "Vendla", M/V "Finnur Friði" and R/V "Arni Fridriksson" in the Norwegian Sea and surrounding waters between 2nd of July and 12th of August 2014.

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.

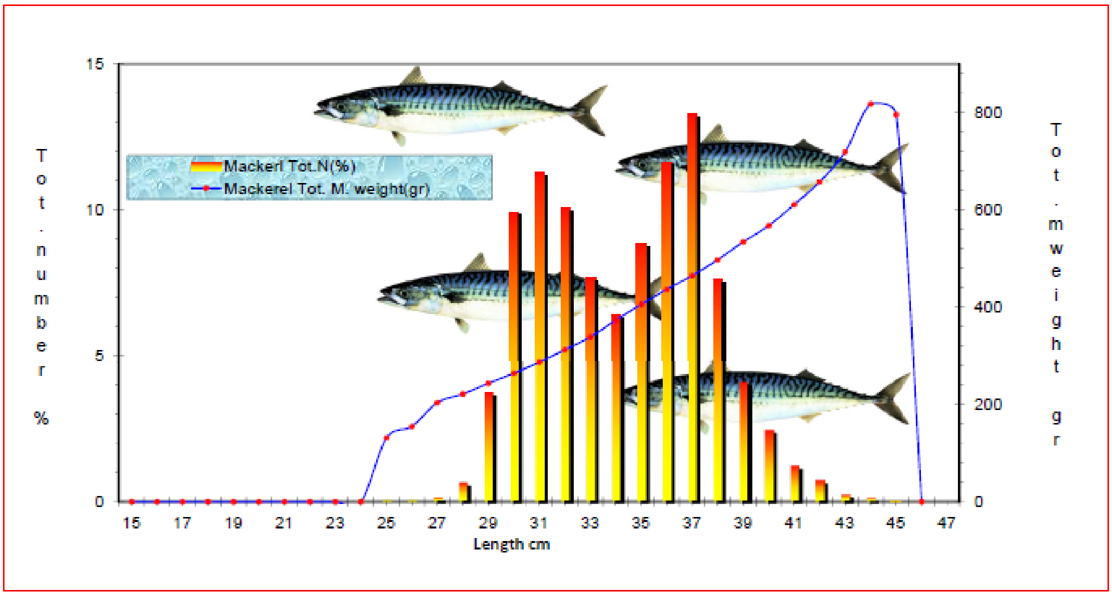


Figure 14. Length (cm) and weight (g) distribution in percent (%) for mackerel sampled in the trawl catches. Note that these values are not weighed with catch or area size and can therefore divide from the estimation of length distribution in the stock (not provided).

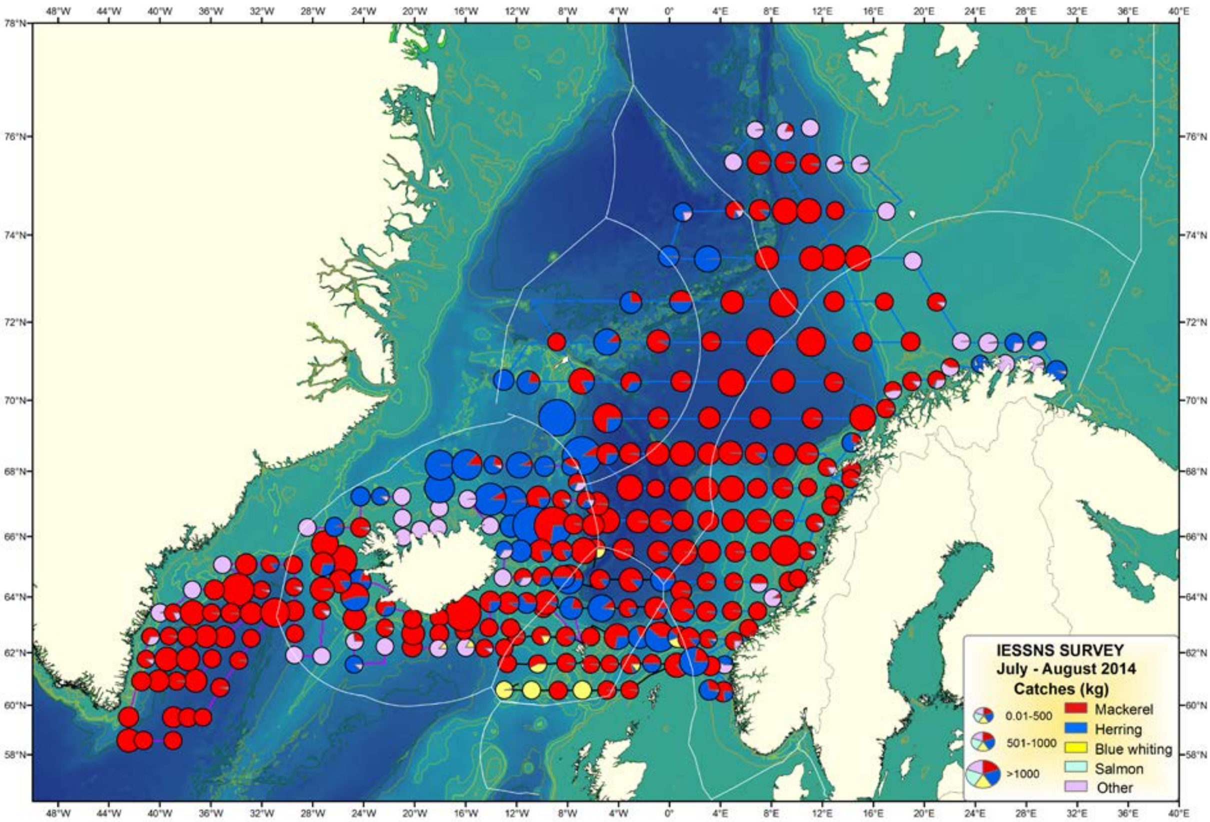


Figure 15. Distribution and spatial overlap between mackerel (red), herring (blue), blue whiting (yellow) and salmon (violet) from joint ecosystem surveys conducted onboard M/V "Brennholm" and M/V "Vendla" (Norway), M/V "Finnur Friði" (Faroe Islands) and R/V "Arni Fridriksson" (Iceland) in the Norwegian 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.

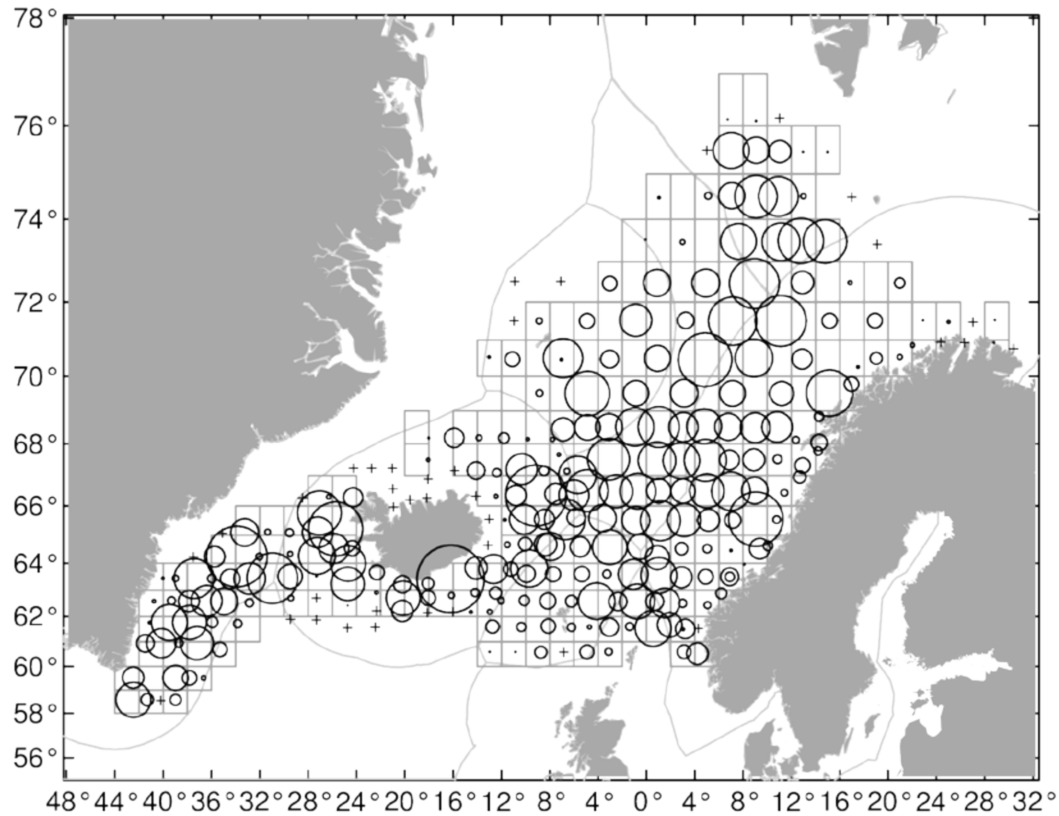


Figure 16. Stations and catches of mackerel in July/August 2014 where the circles size is proportional to square root of catch (kg/km^2) and stations with zero catches are denoted with +.

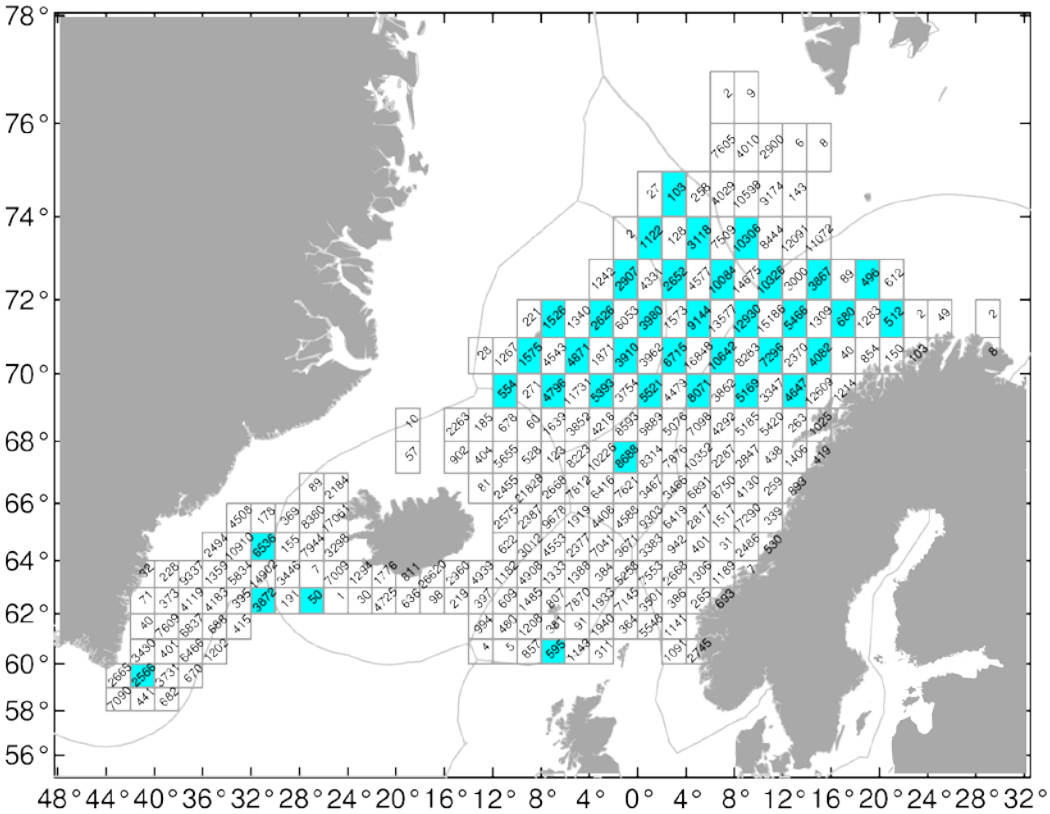


Figure 17. Standardized mackerel catch rates (kg/km²) in 1° lat. by 2° lon. rectangles from swept area estimates in July/August 2014 where interpolated rectangles are denoted with blue shading.

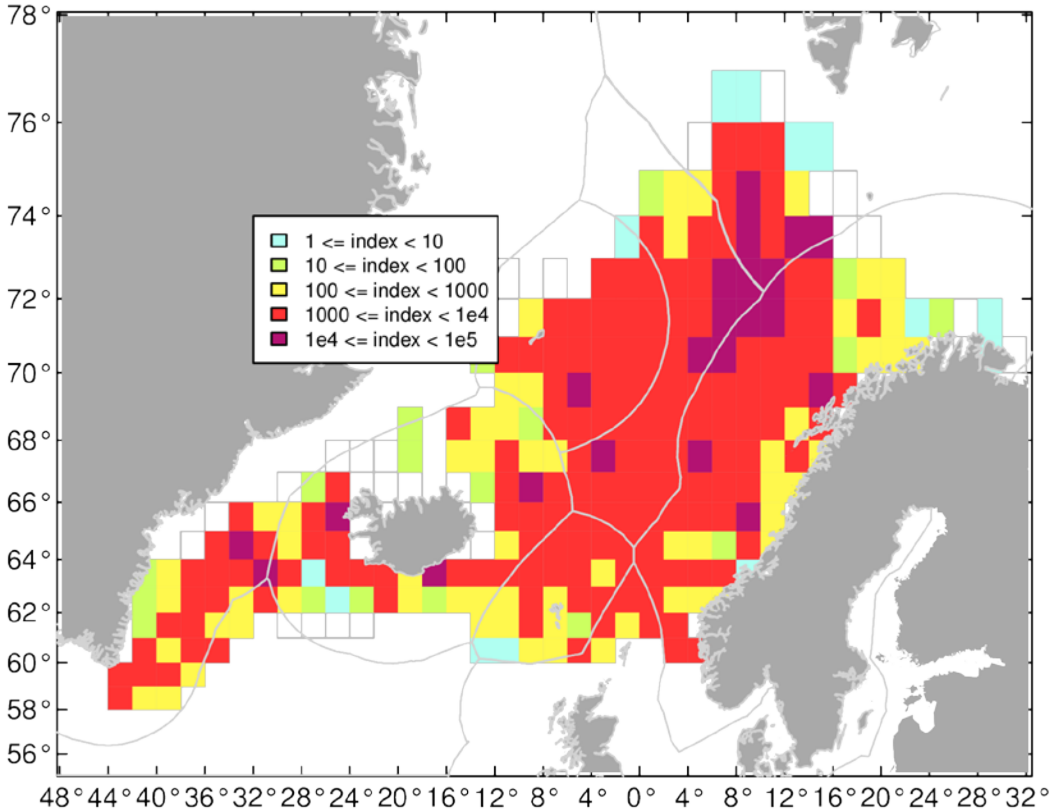


Figure 18. Standardized mackerel catch rates (kg/km²) for mackerel in the July/August 2014 survey represented graphically. Colouring of levels is the same as in the 2013 IESSNS survey report (Nøttestad et al. 2013).

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.

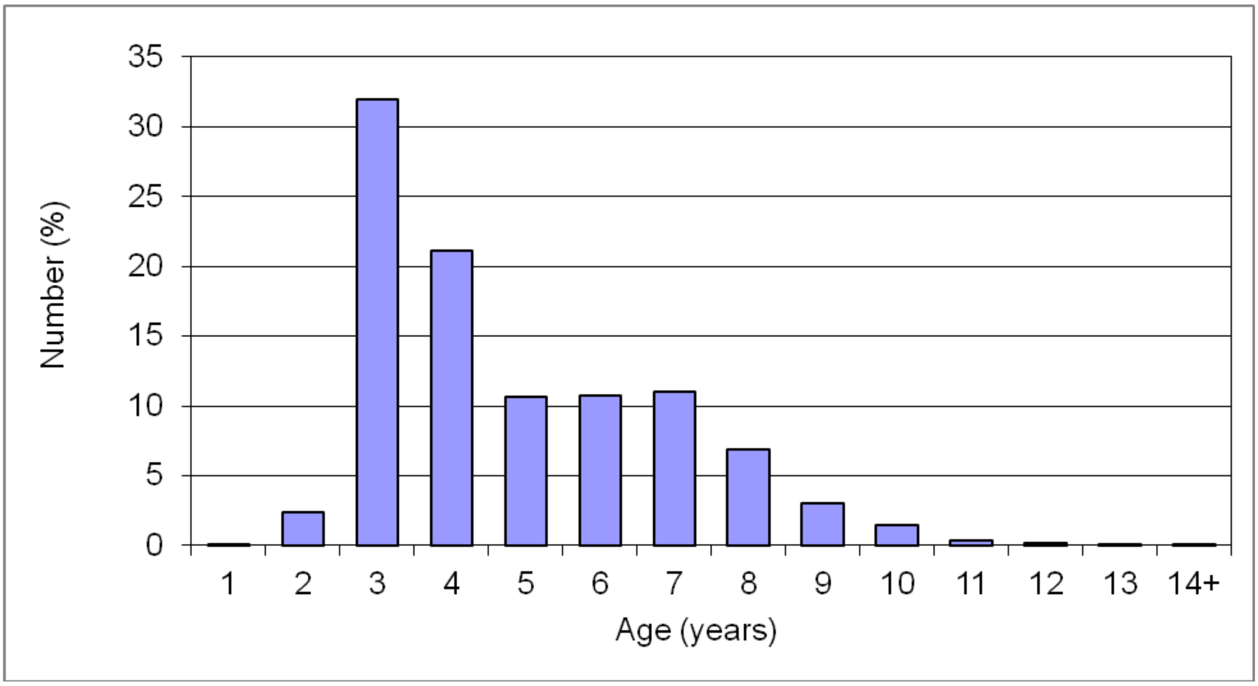


Figure 19. Age distribution in percent (%) of Atlantic mackerel scaled to the total catches, in the Norwegian Sea and surrounding waters from 2nd of July to 12th of August 2014.

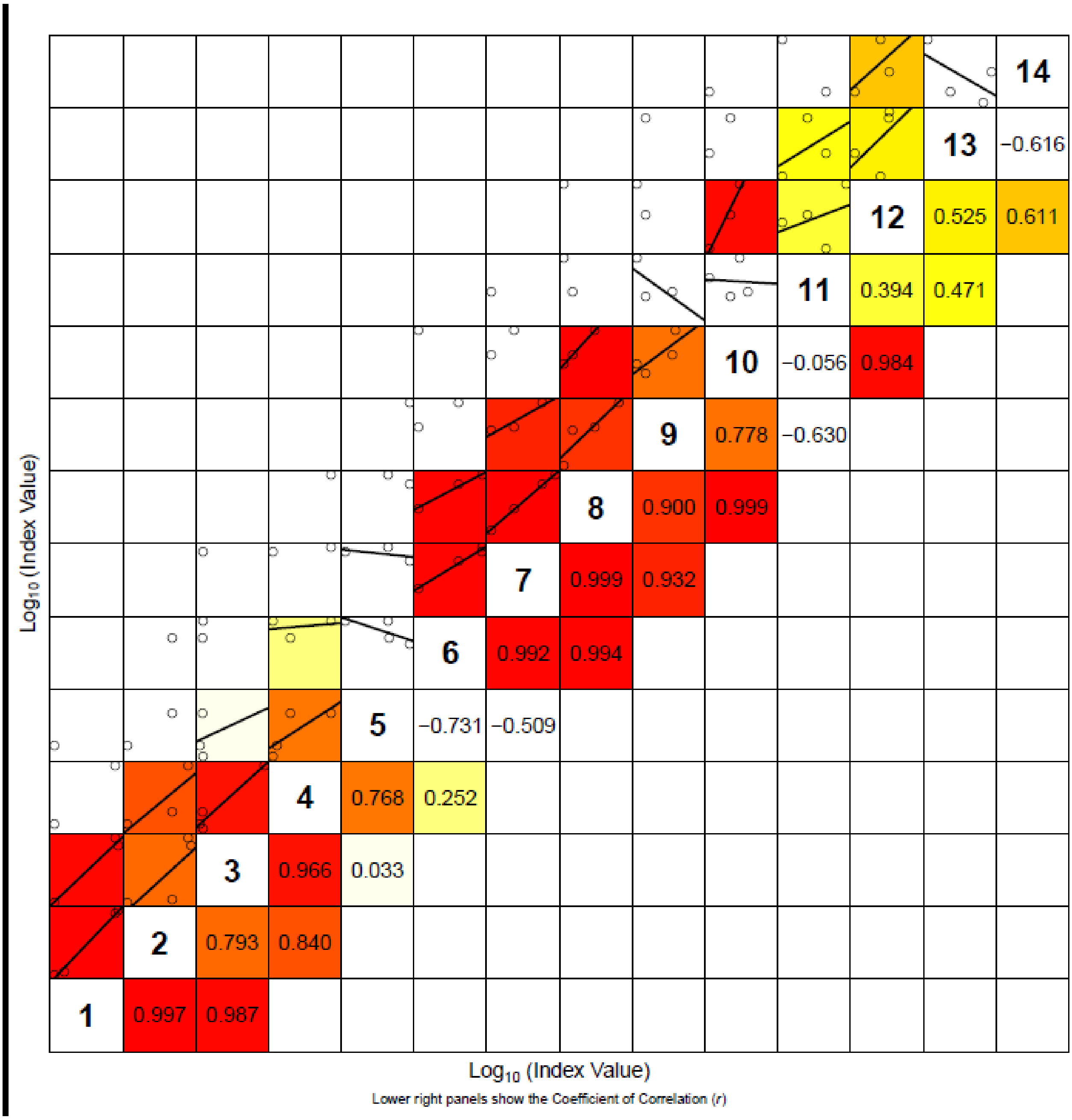


Figure 20a. Consistency plot of mackerel from the July/August 2014 survey (IESSNS).

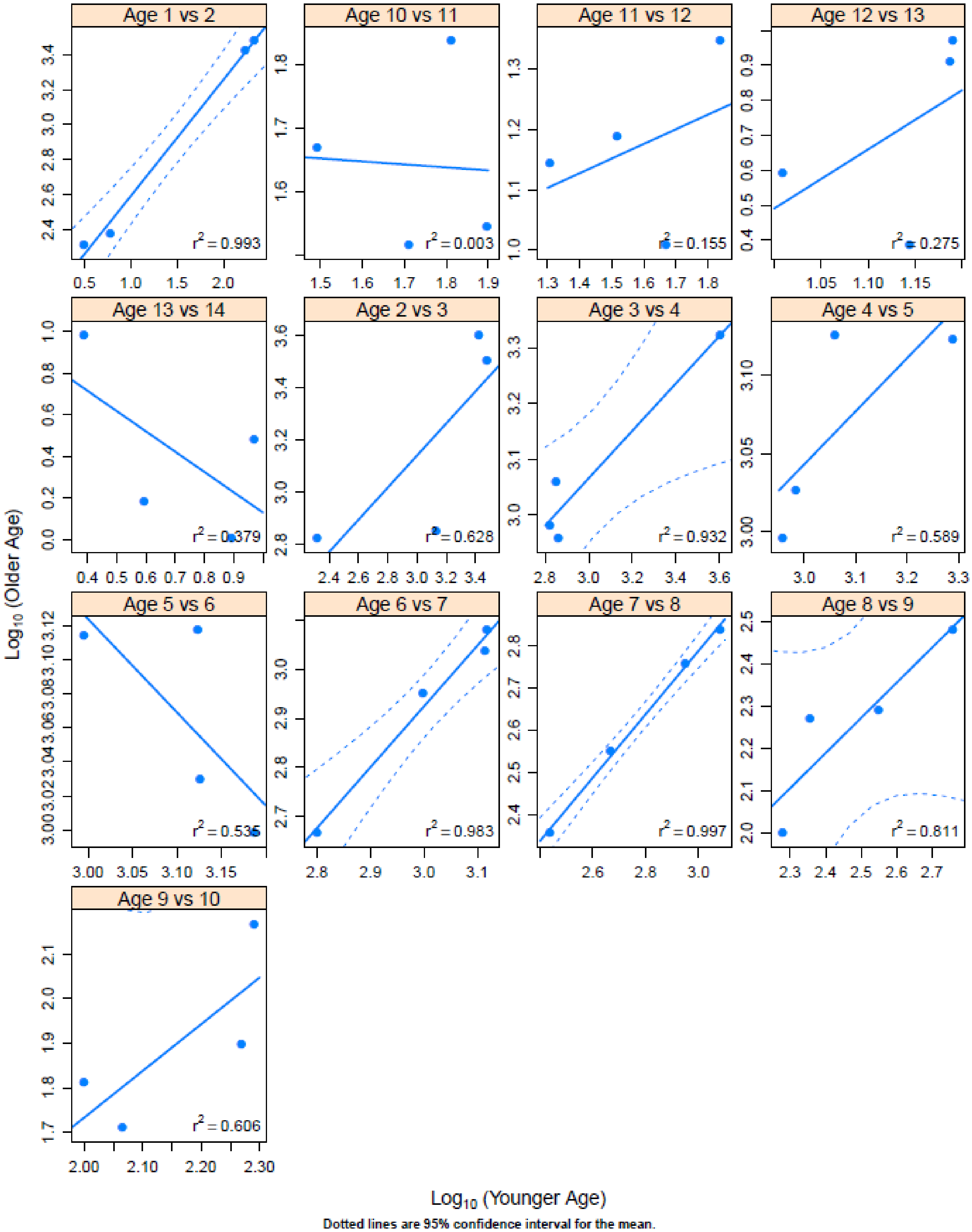


Figure 20b. Consistancy plot (Log10 transformed on the x- and y axis) for each year class 1-14+. The correlation is given as r² for each year class. Dotted lines are 95% confidence interval for the mean.

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+).

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14(+)	Habitat range (mill. km^2)
(a) Number of individuals (billions)															
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

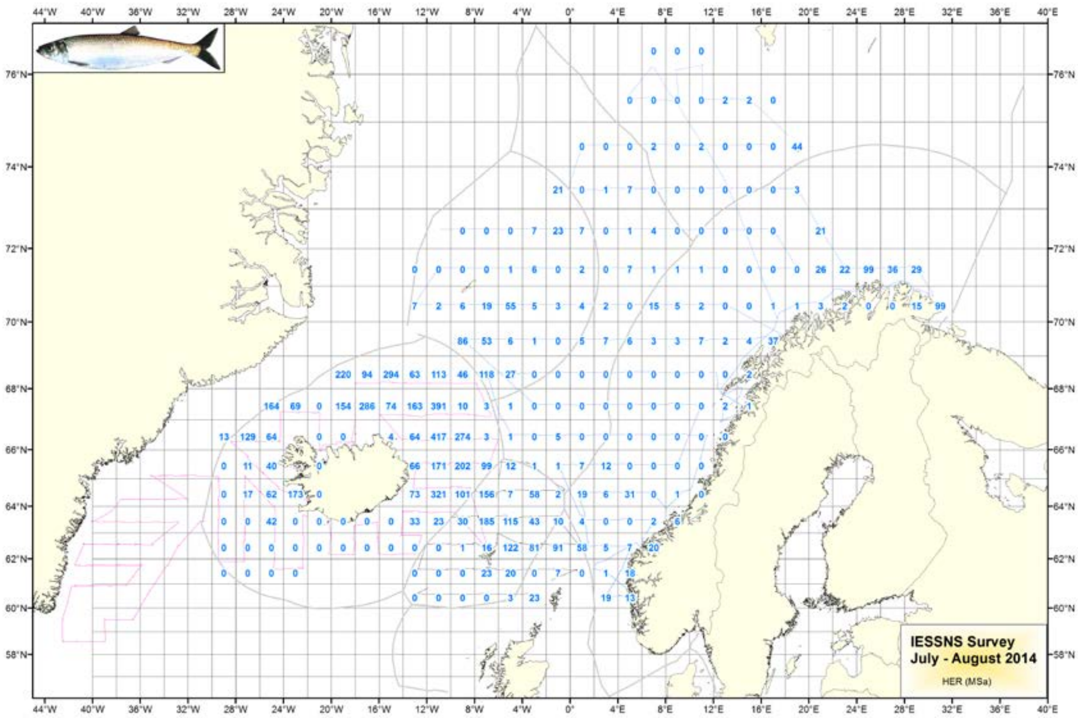
The mackerel schools detected were of small size, predominantly with low density and appeared in the upper 20-30 m of the water column throughout the day, on Simrad SH80 and Simrad SX90 operated within large geographical areas. Only small and loose mackerel schools were recorded on the multibeam sonars 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)

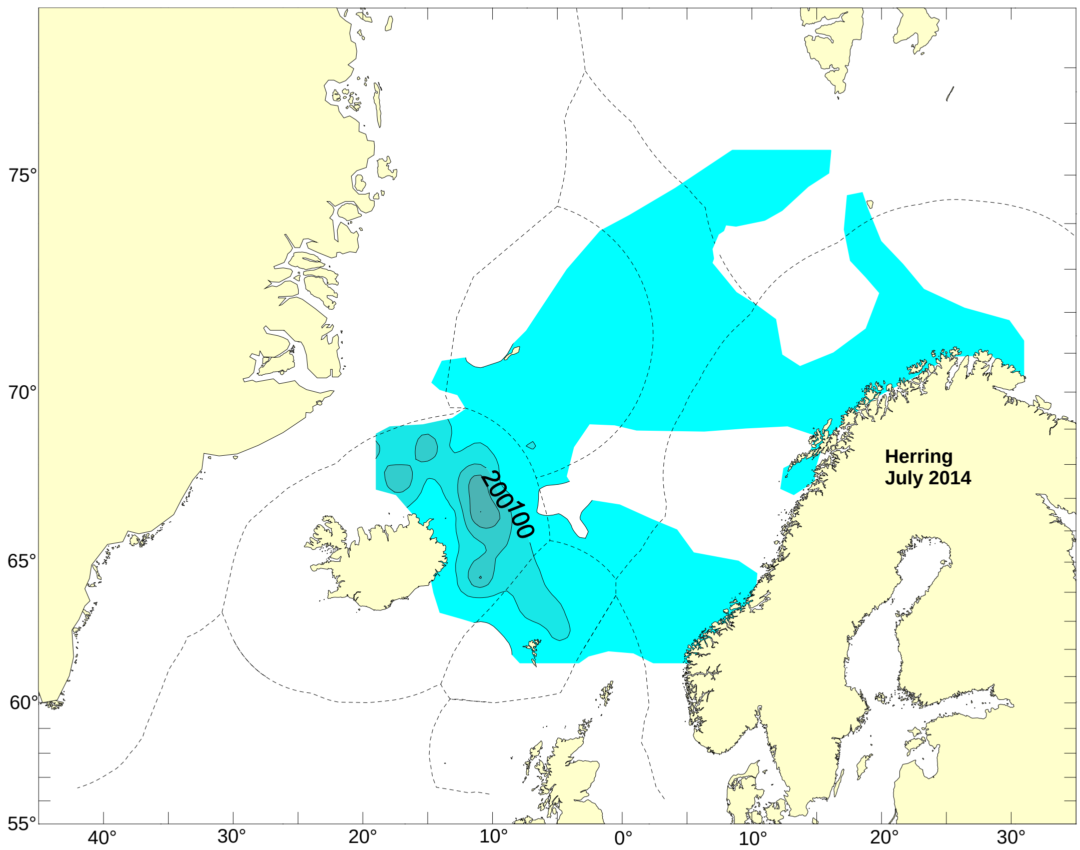


Figure 21. The sA/Nautical Area Scattering Coefficient (NASC) values of herring along the cruise track, 2nd of July to 12th of August 2014 (a) within a rectangles and (b) shown on a contour plot.

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).

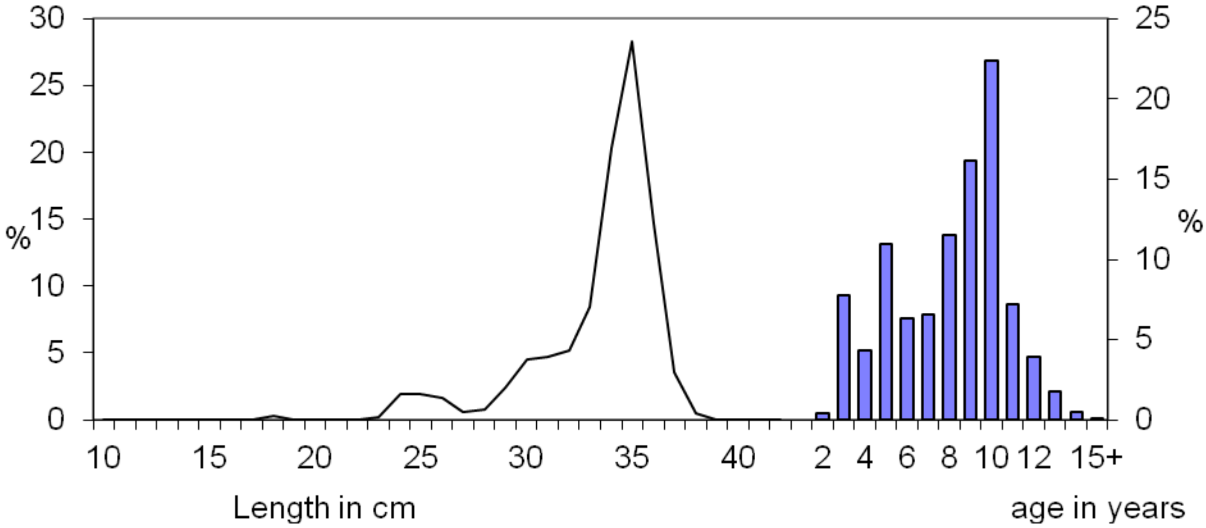


Figure 22. Age and length distribution of Norwegian spring-spawning herring from 2nd to July 11th August 2014.

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.

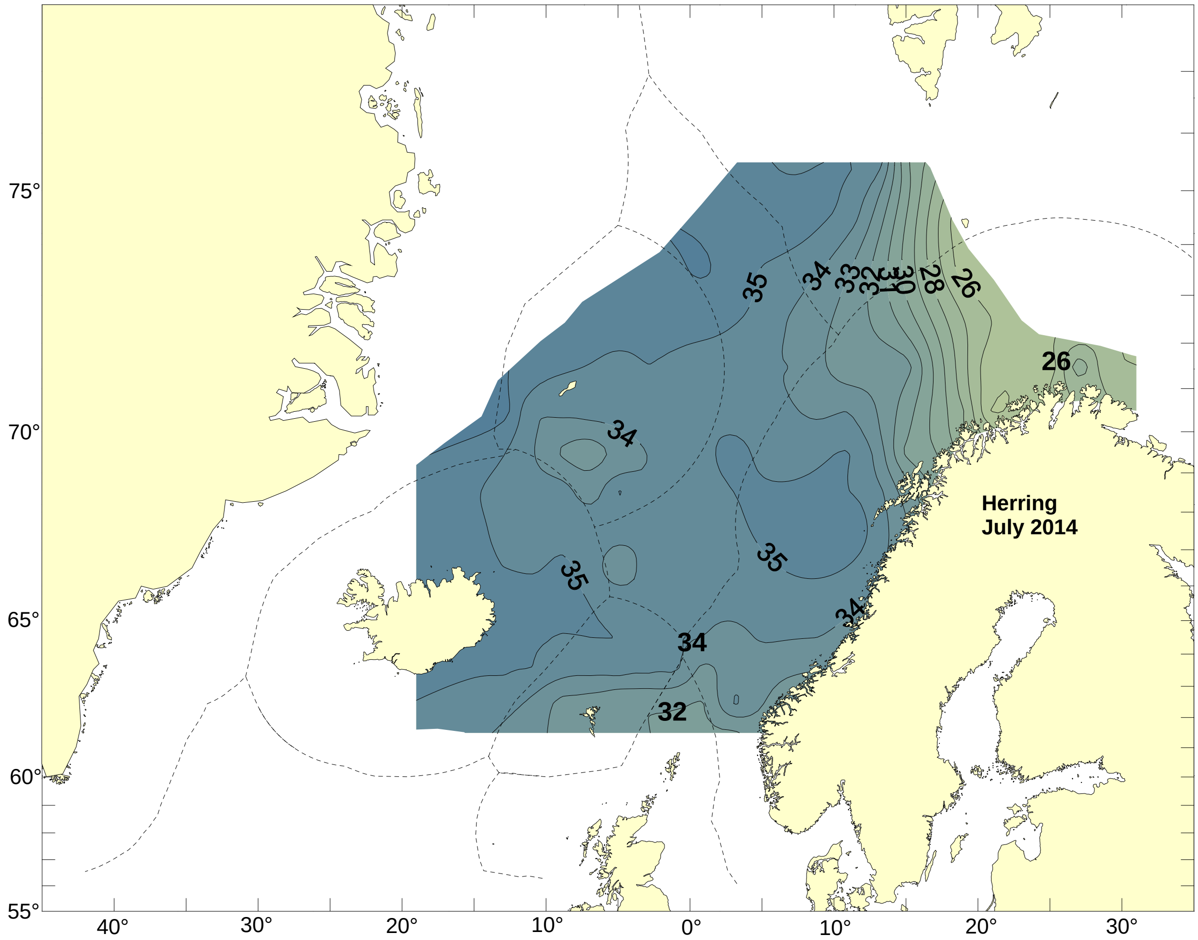


Figure 23. Length distribution of Norwegian spring-spawning herring during the coordinated ecosystem survey 2nd of July to 12th of August 2014.

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.

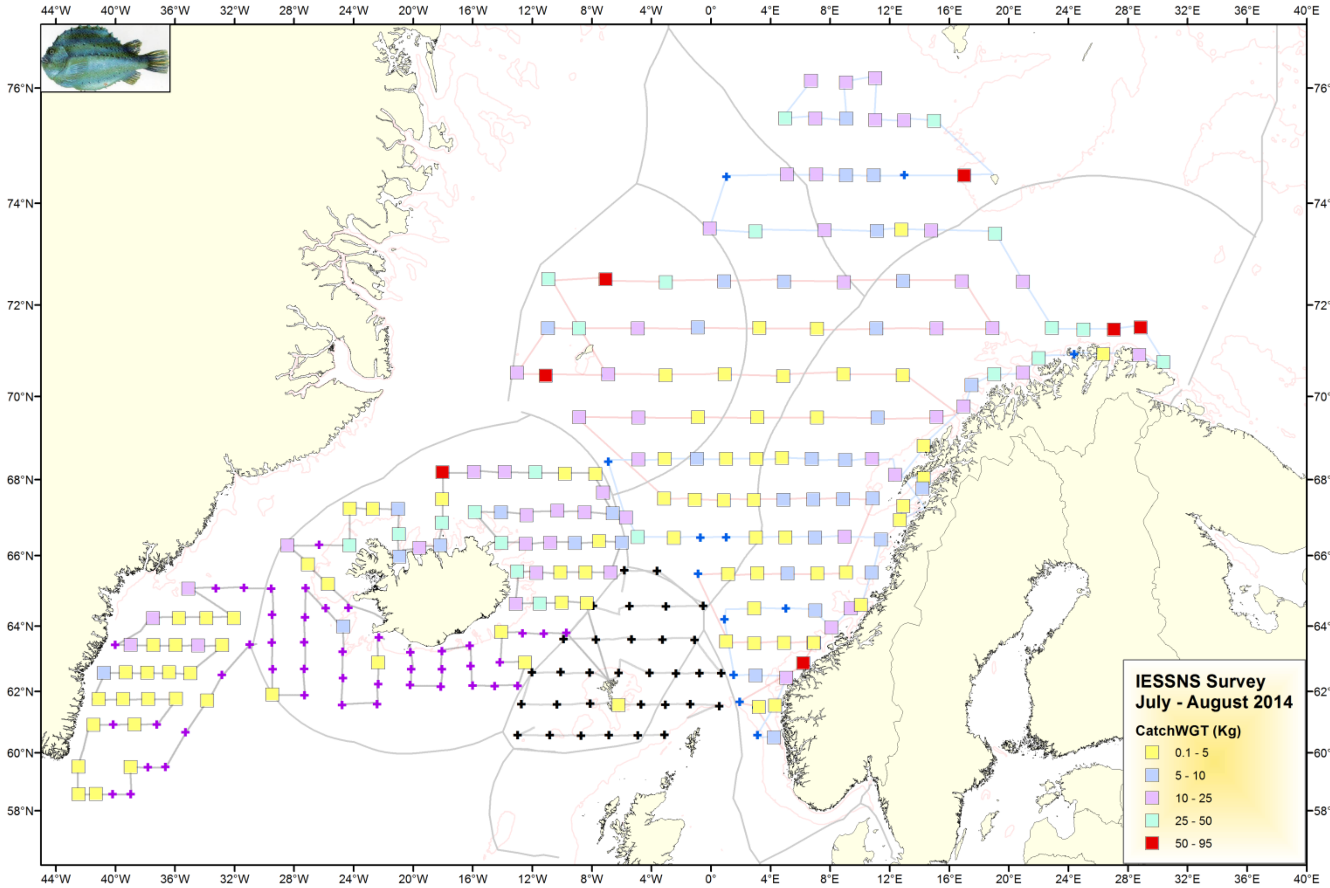


Figure 24. Lumpfish catches at surface trawl stations during the IESSNS survey in July and August 2014.

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).

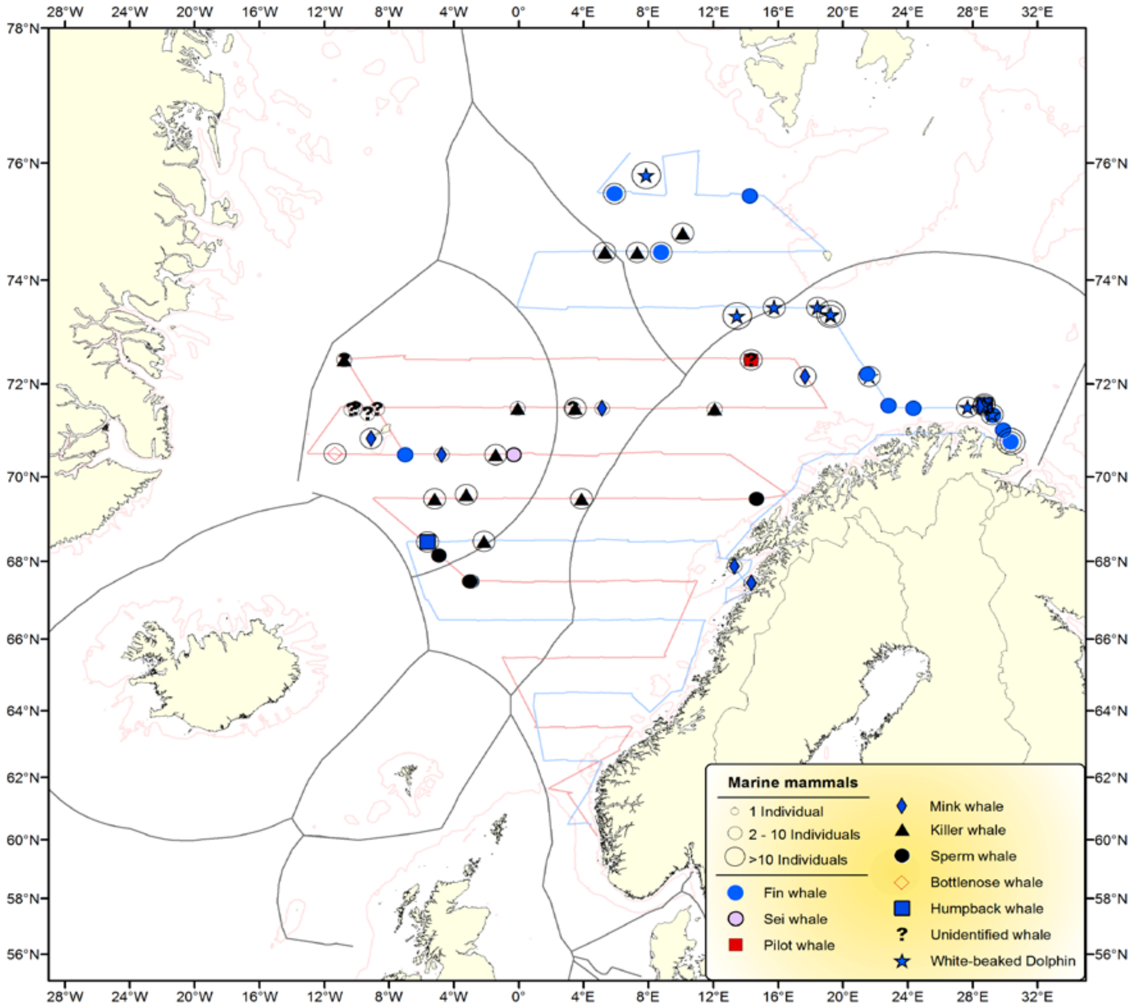


Figure 25. Overview of all marine mammals sighted onboard M/V "Brennholm" and M/V "Vendla" in the Norwegian Sea and surrounding waters from 2nd to 28th of July 2014. No marine mammal sightings were done onboard the Icelandic and Faroese vessels.

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. 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

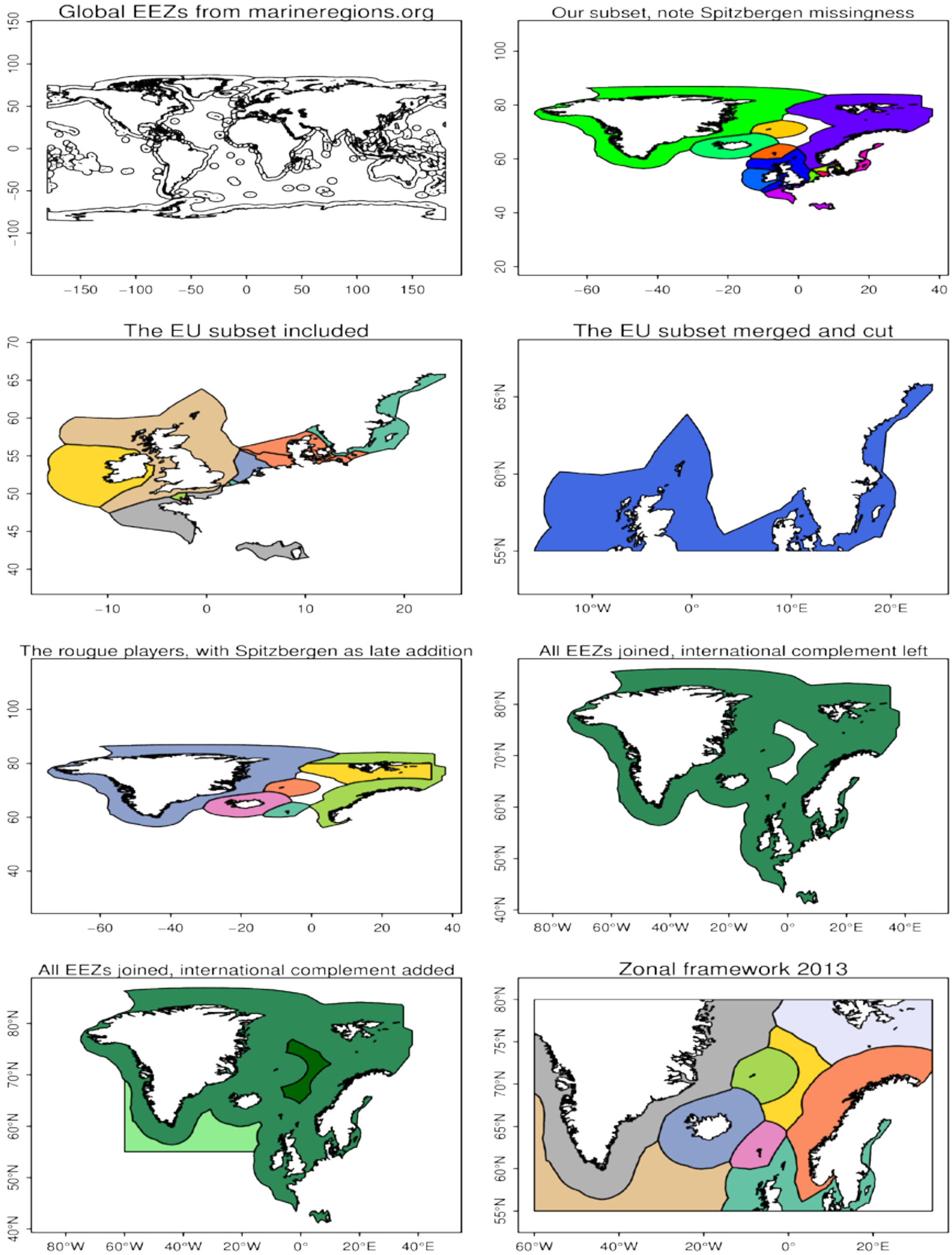


Figure A1. Zonal framework developed and used in 2013, extended and used again in 2014.

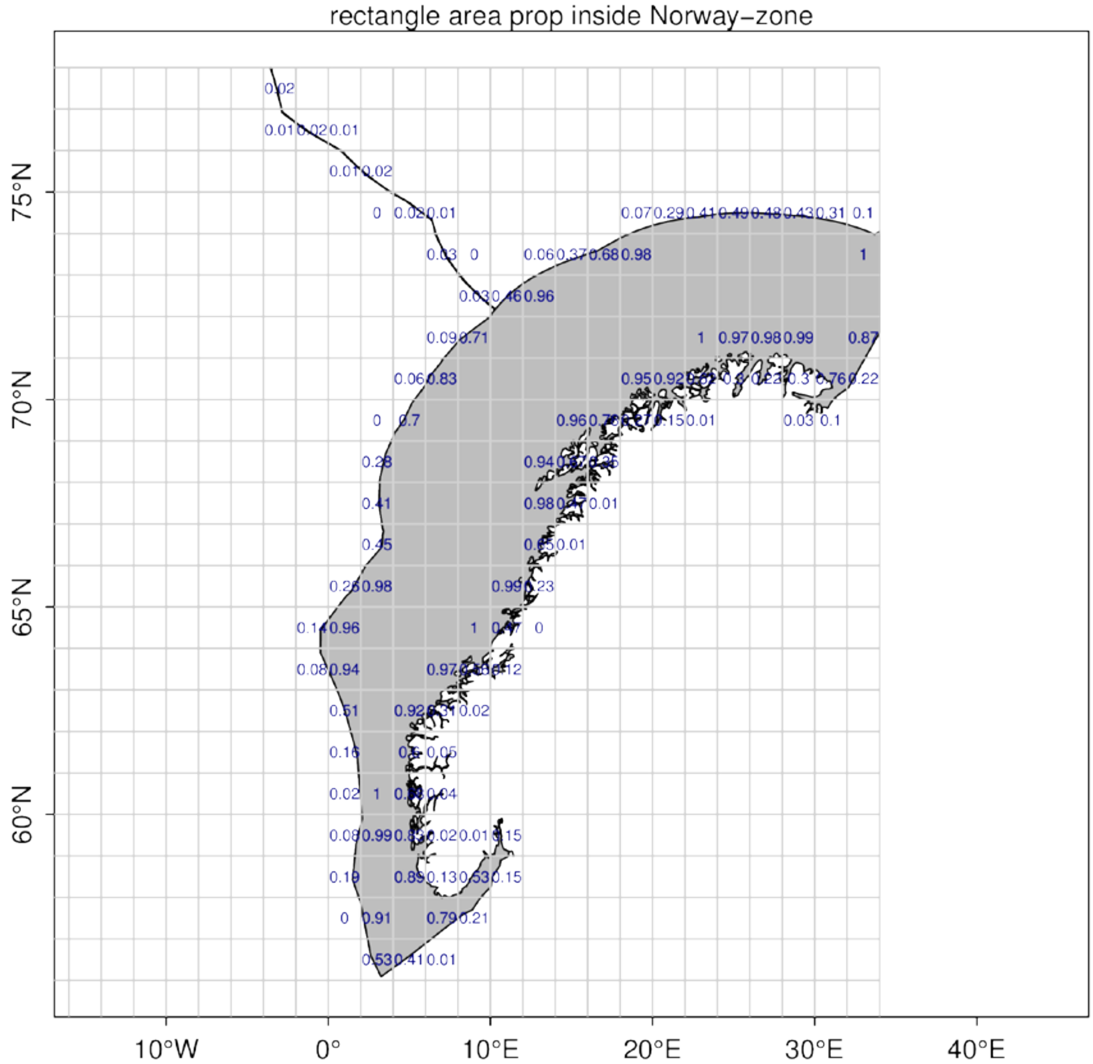


Figure A2. Sea area rectangle (1° latitude by 2° longitude) proportions within the Norway EEZ. The 'outgrowth' is due to discrepancy between the text file used for the Spitzbergen EEZ (pers. comm. Þ. Sigurðsson, MRI, from NEAFC work) and the Norway EEZ according to low-resolution shapefile on htpp://marineregions.org.

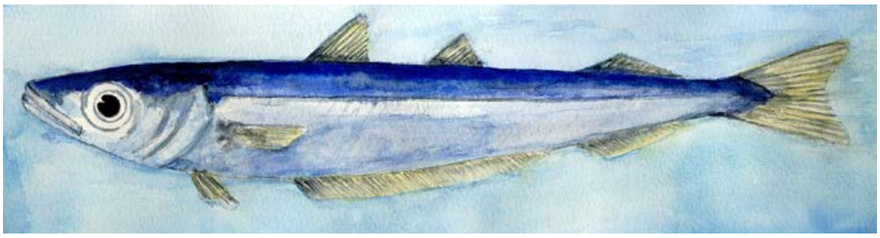
Working Document

Working Group on International Pelagic Surveys

Copenhagen, Denmark, 19-23 January 2015

Working Group on Widely Distributed Stocks

Copenhagen, Denmark, 26 August-1 September 2014



INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY (IBWSS) SPRING 2014

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* Participated in post cruise meeting, × via correspondence
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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 m^2/mile^2 with a vertical extension of up to 50-100 m over depths more than 1500 m (near the shelf edge), and 59221 m^2/mile^2 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 m^2/mile^2 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 31.1x10^9 individuals (Figure 6, Tables 3 & 4). Spawning stock was estimated at 3.2 million tonnes and 24.4x10^9 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 (nm^2)		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	Prop.
	1	2	3	4	5	6	7	8	9	10+			weight	mature*
(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

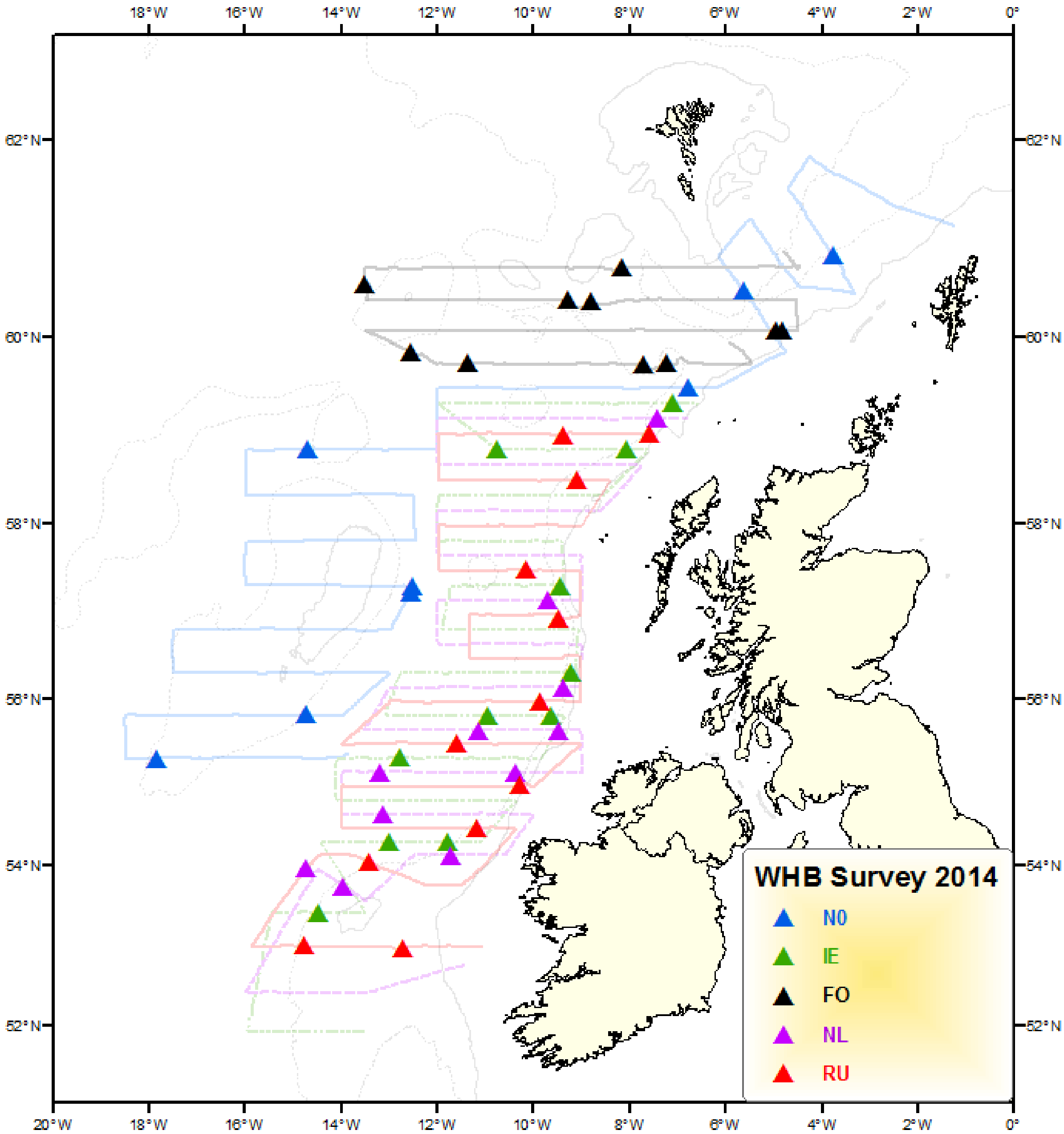


Figure 1. Vessel cruise tracks and trawl stations of the International Blue Whiting Spawning stock Survey (IBWSS) from March-April 2014. IE: Ireland (Celtic Explorer); FO: Faroe Islands (Magnus Heinason); NL: Netherlands (Tridens); RU: Russia (Fritjof Nansen); NO: Norway (G.O. Sars).

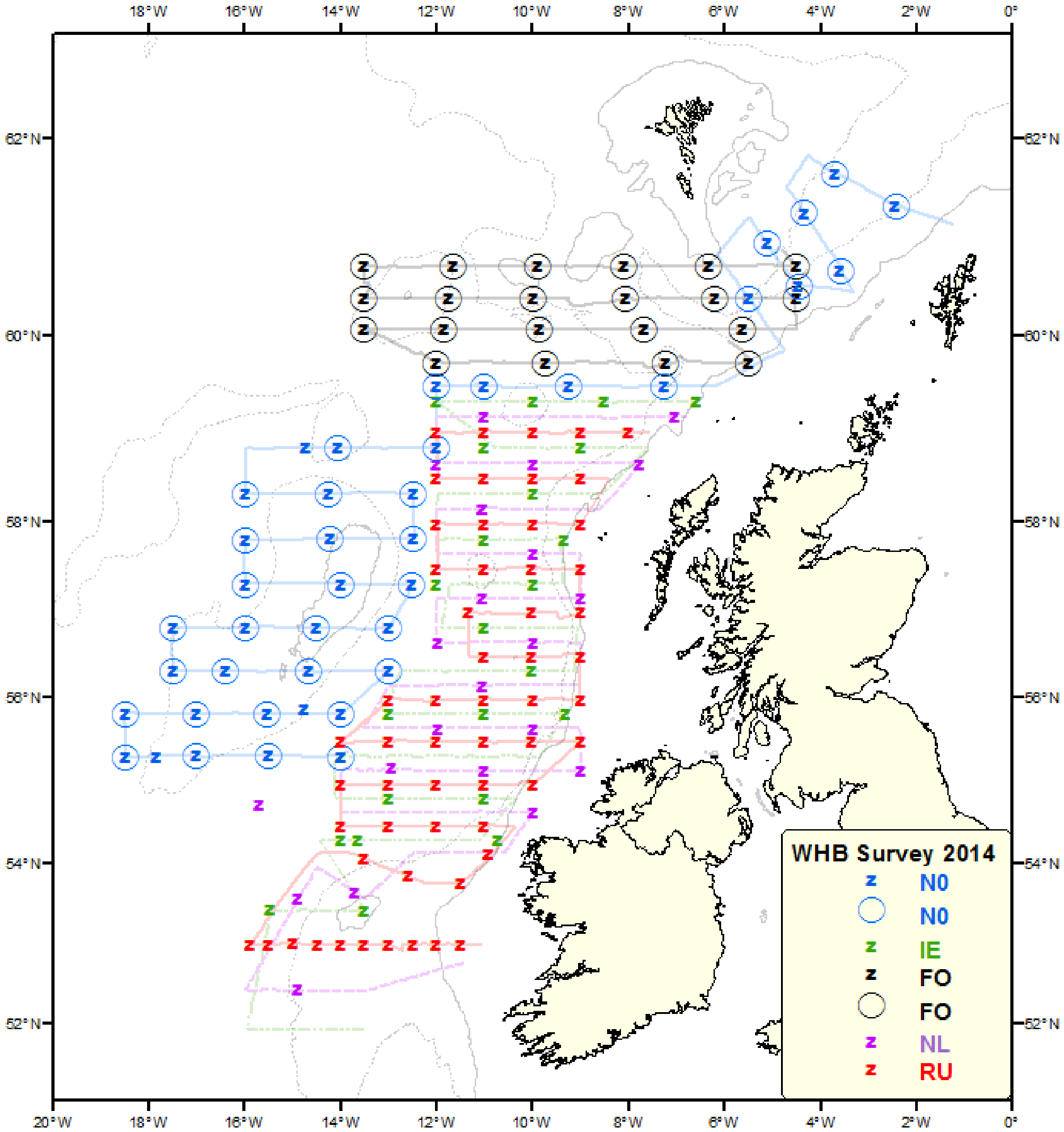


Figure 2. CTD stations overlaid onto vessel cruise tracks for the combined survey ('z'). Circles represent plankton trawls. green: Celtic Explorer; black: Magnus Heinason; purple: Tridens; red: Fritjof Nansen; blue: G.O. Sars. March-April 2014.

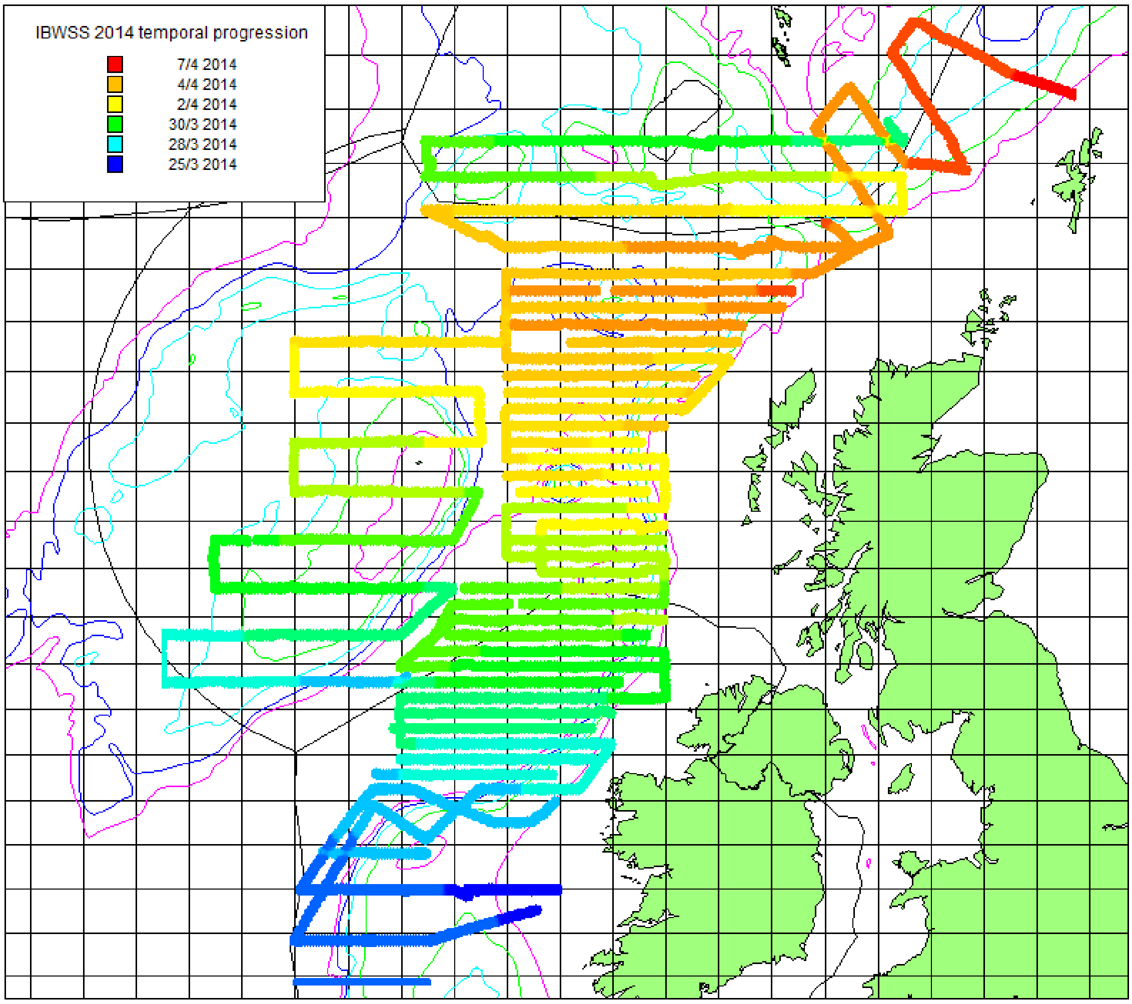


Figure 3. Temporal progression for the International Blue Whiting Spawning stock Survey (IBWSS), 25. March – 7. April 2014.

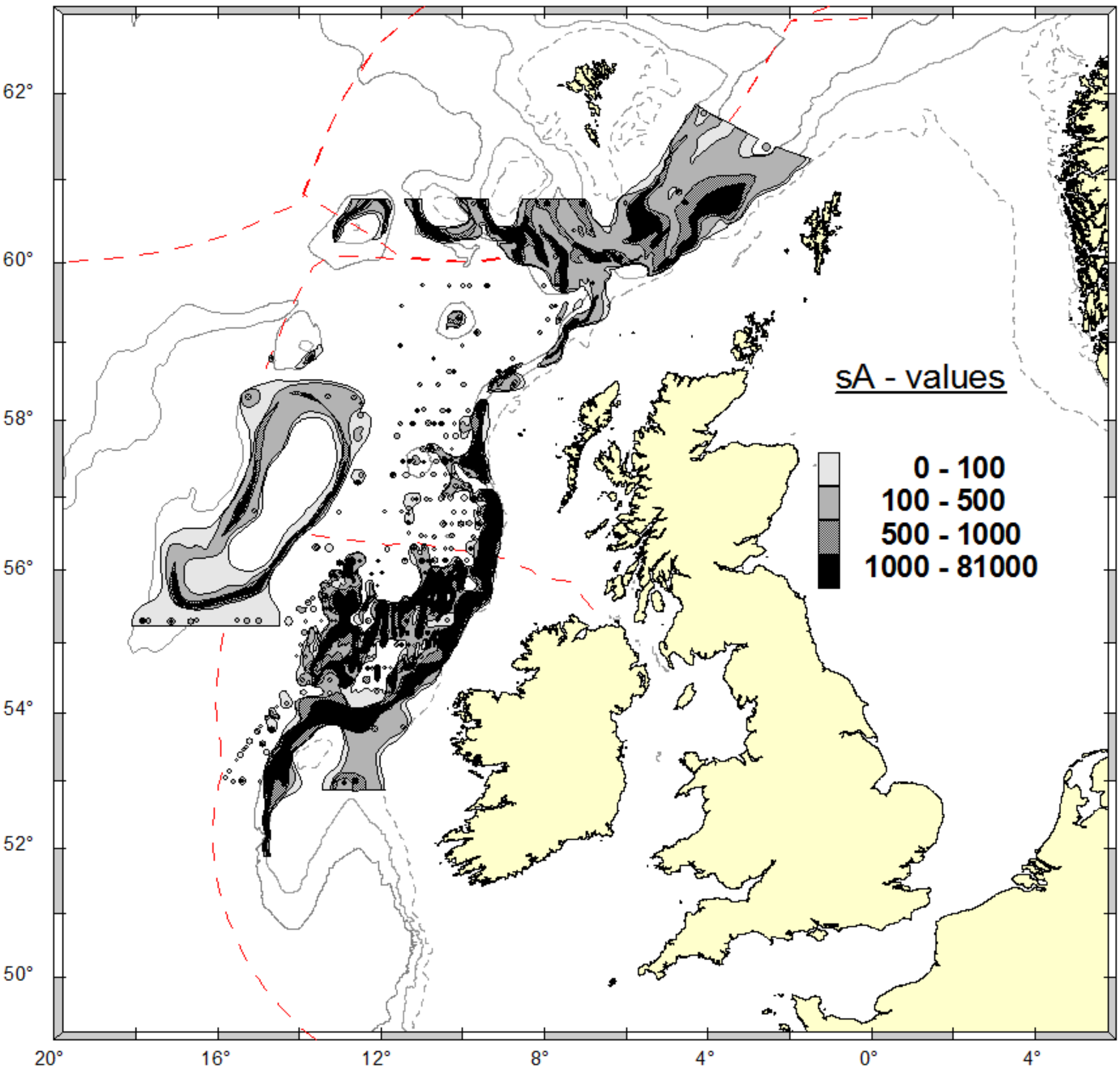


Figure 4. Map of blue whiting acoustic density (s_A, m^2/n.m.^{2}) , 24. March – 07. April 2014.

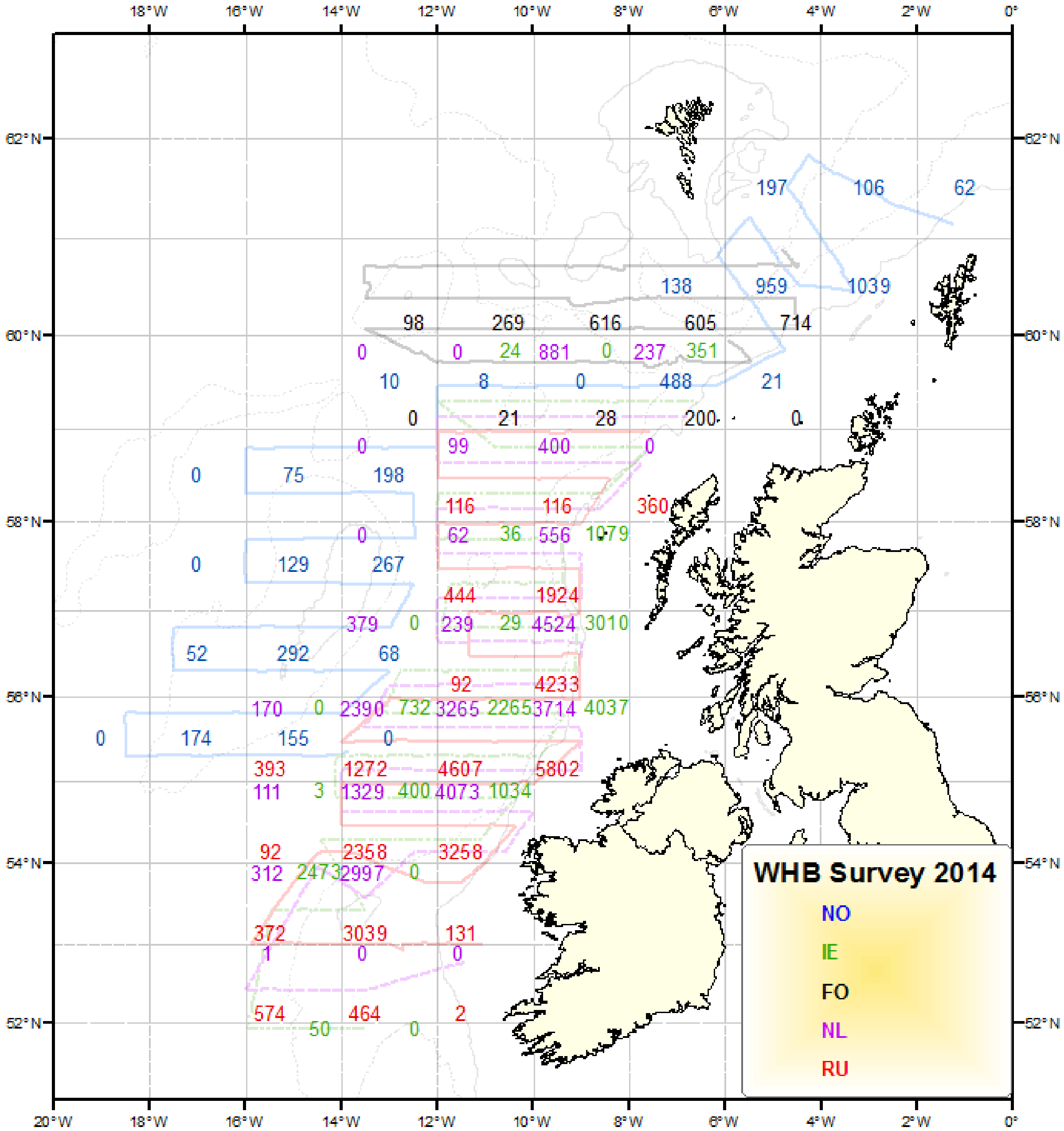


Figure 5. Mean blue whiting acoustic density (s_A, $m^2/n.m.^2$) for IBWSS 2013 by individual vessel: Celtic Explorer: green, Magnus Heinason: black, Tridens: grey, Fritjof Nansen: red, G.O. Sars: blue. March-April 2014.

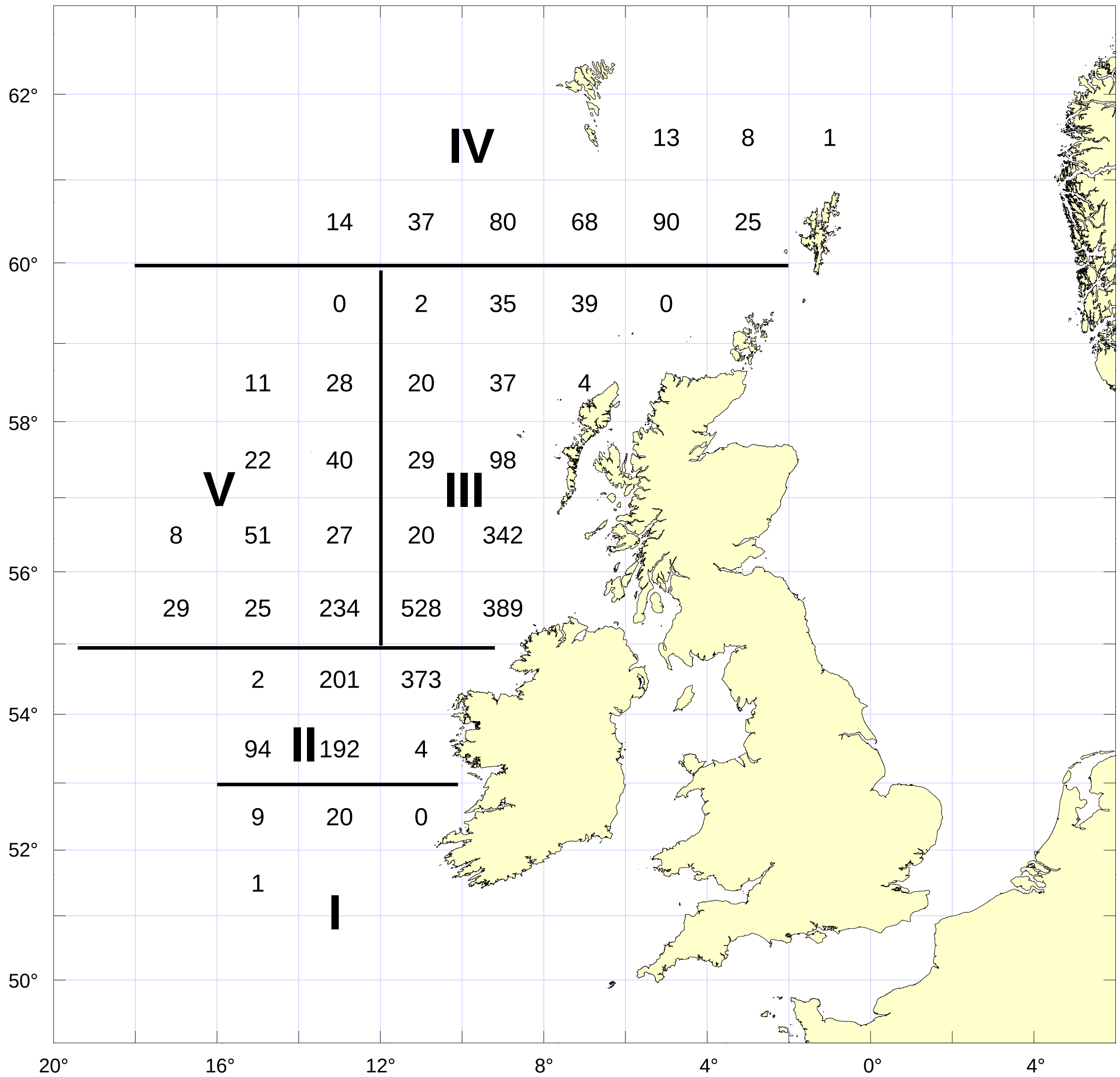


Figure 6. Blue whiting biomass (x1000t) from IBWSS 2014 by sub-area as used in the assessment.

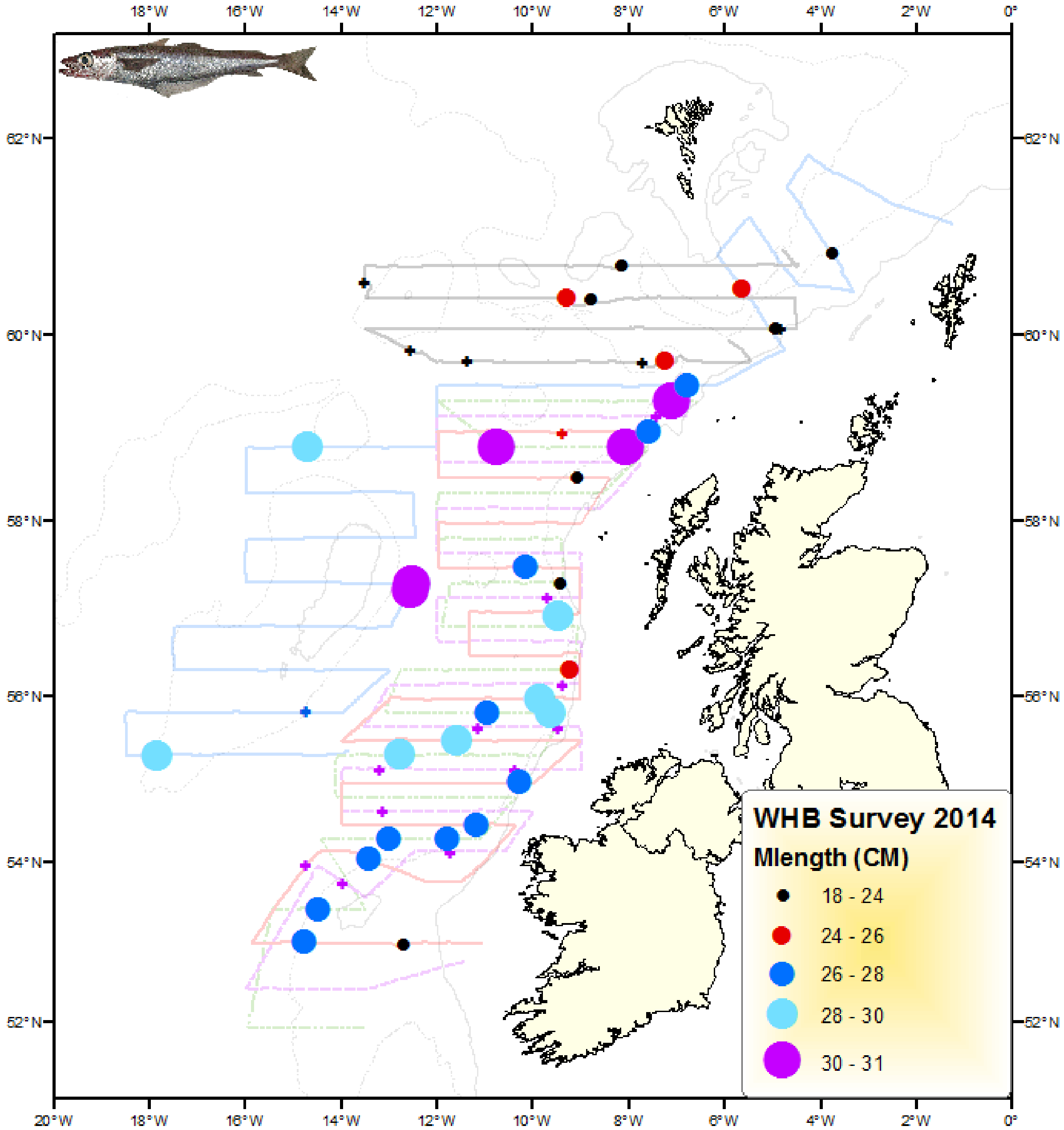


Figure 7. Mean length of blue whiting caught in trawl catches during IBWSS 2014 by individual vessels in March-April 2014. Crosses indicate trawls without any blue whiting catches.

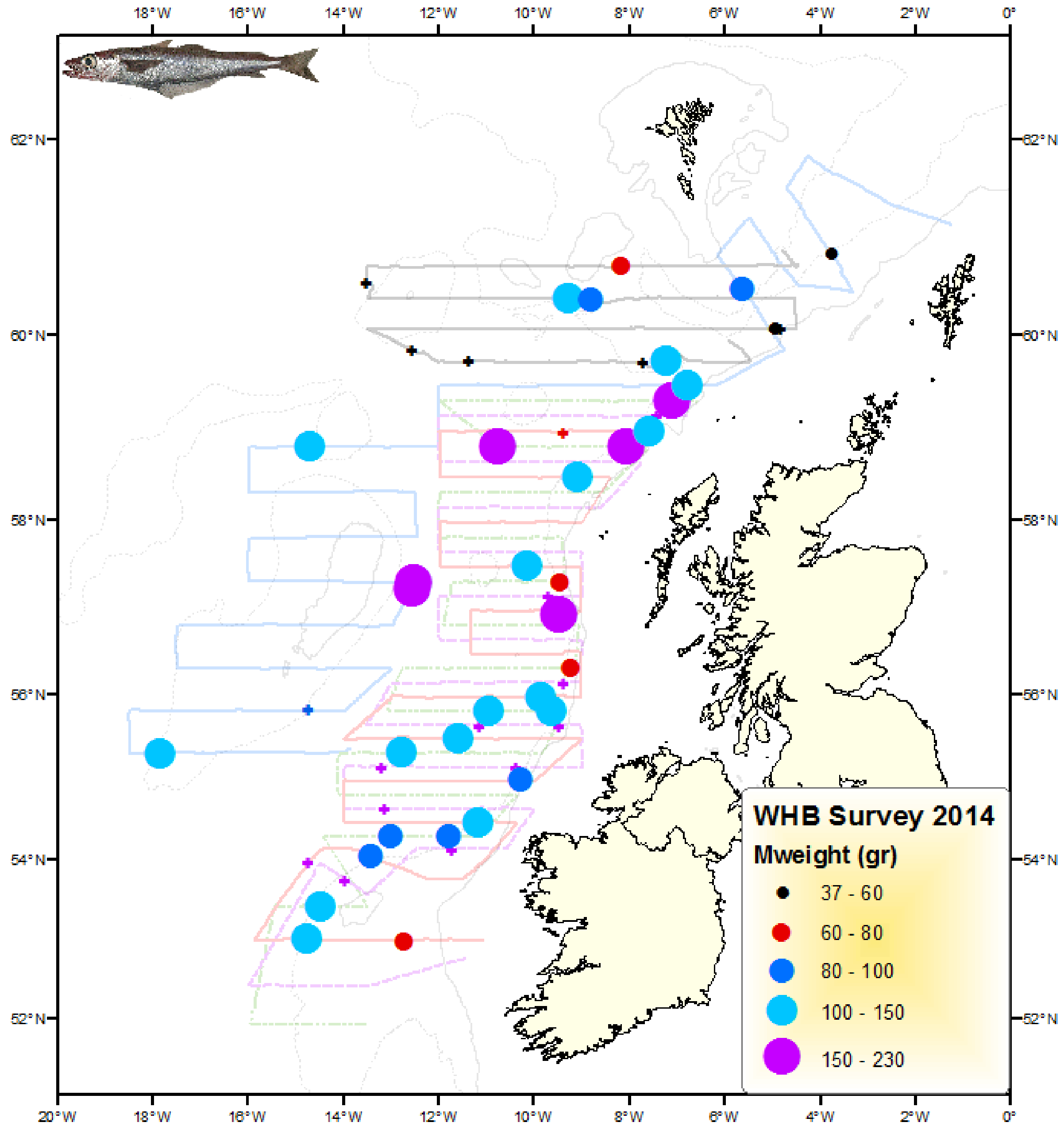
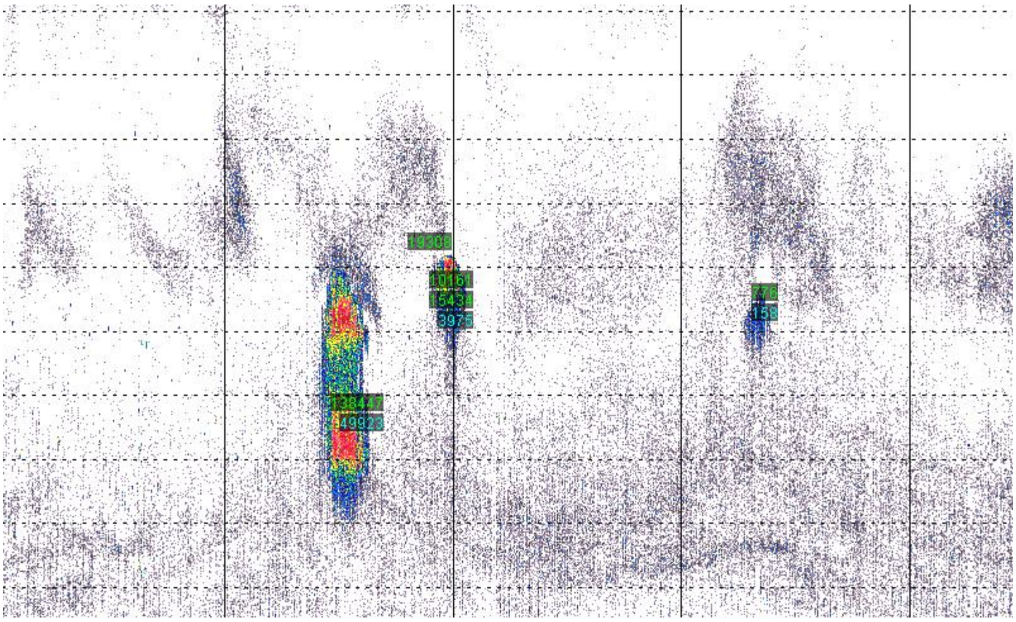
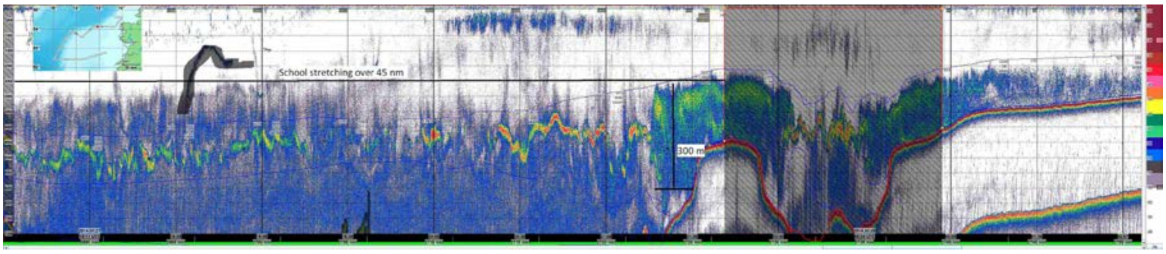


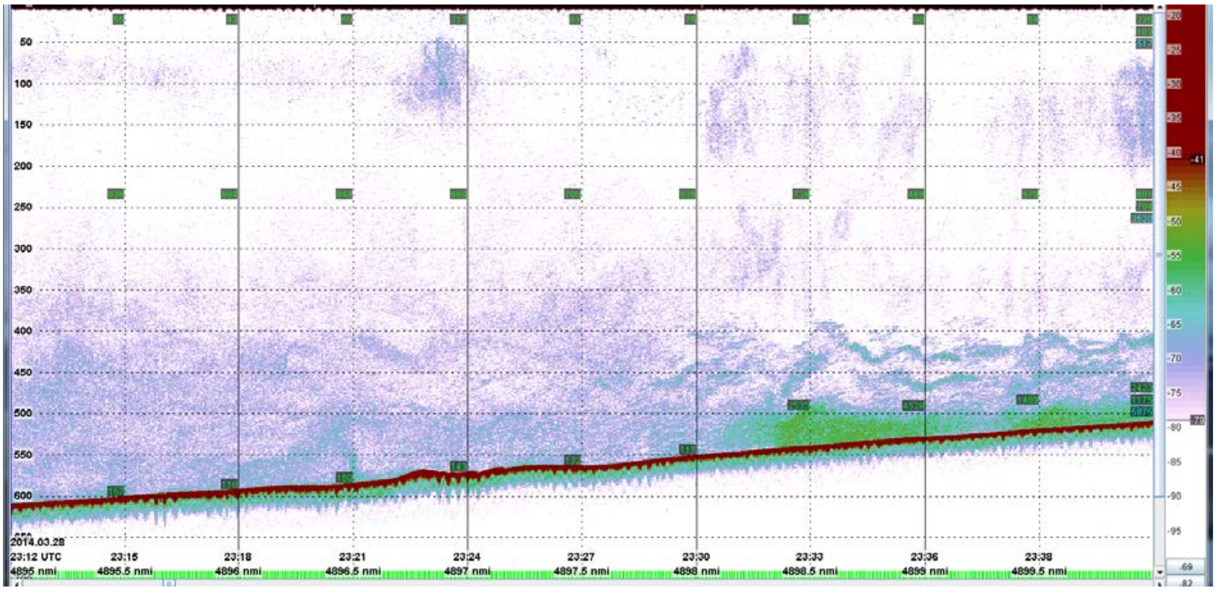
Figure 8. Mean weight of blue whiting caught in trawl catches during IBWSS 2014 by individual vessels in March-April 2014. Crosses indicate trawls without any blue whiting catches.



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.

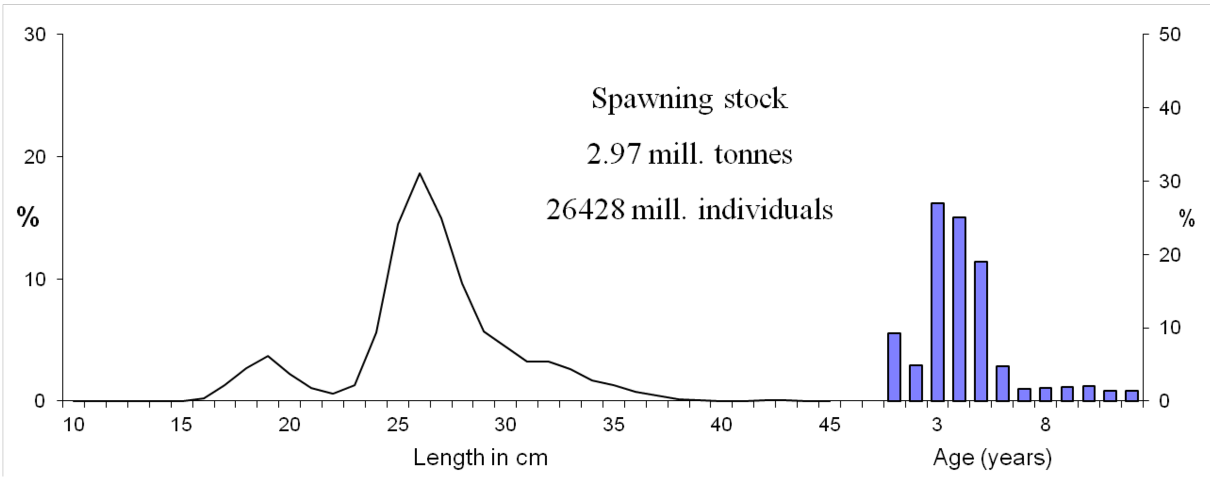


Figure 10. Length and age distributions (numbers) of total stock of blue whiting. Spawning stock biomass is given. March-April 2014.

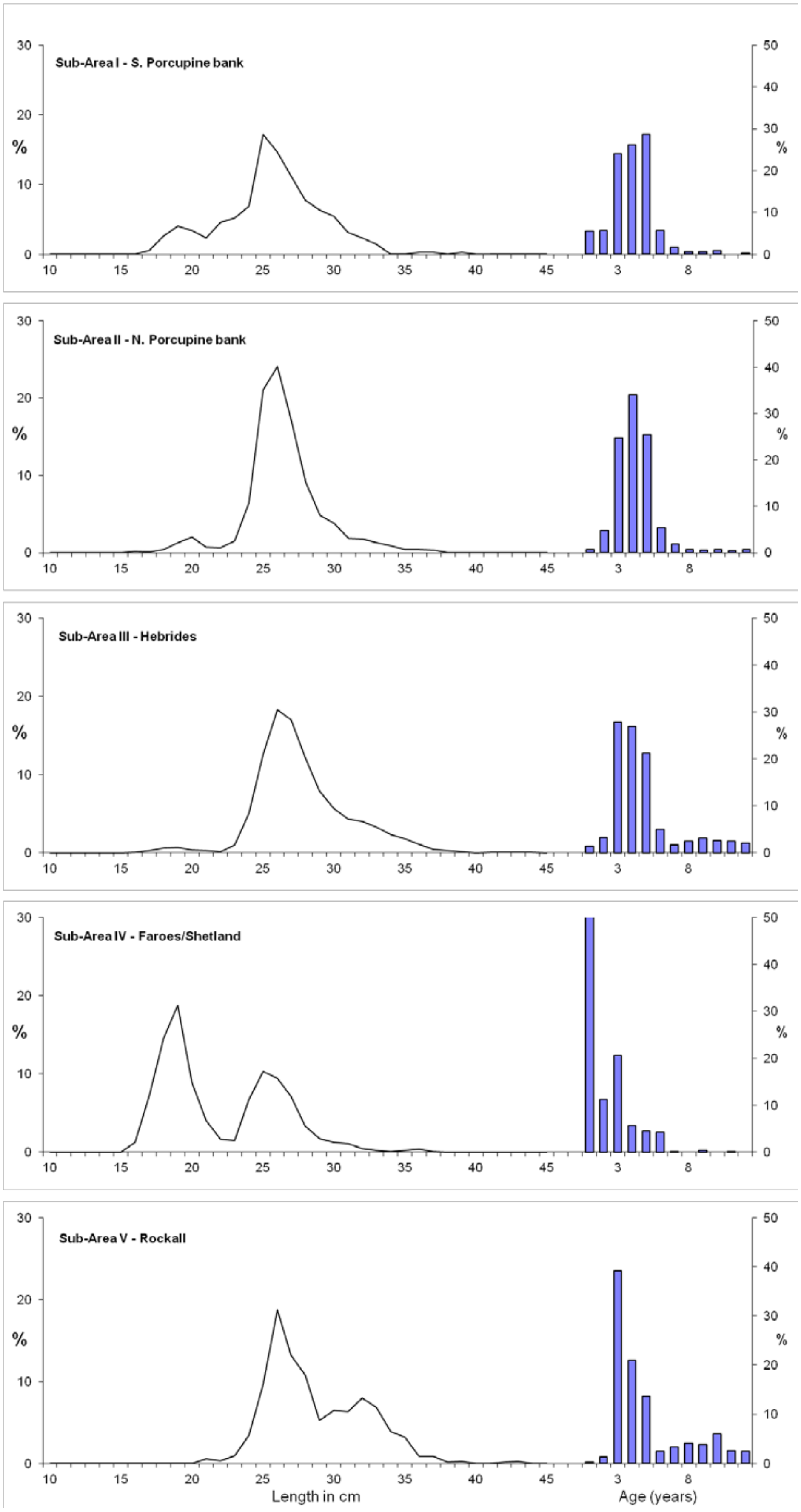


Figure 11. Length and age distribution (numbers) of blue whiting by covered sub-area (I–V). March-April 2014.

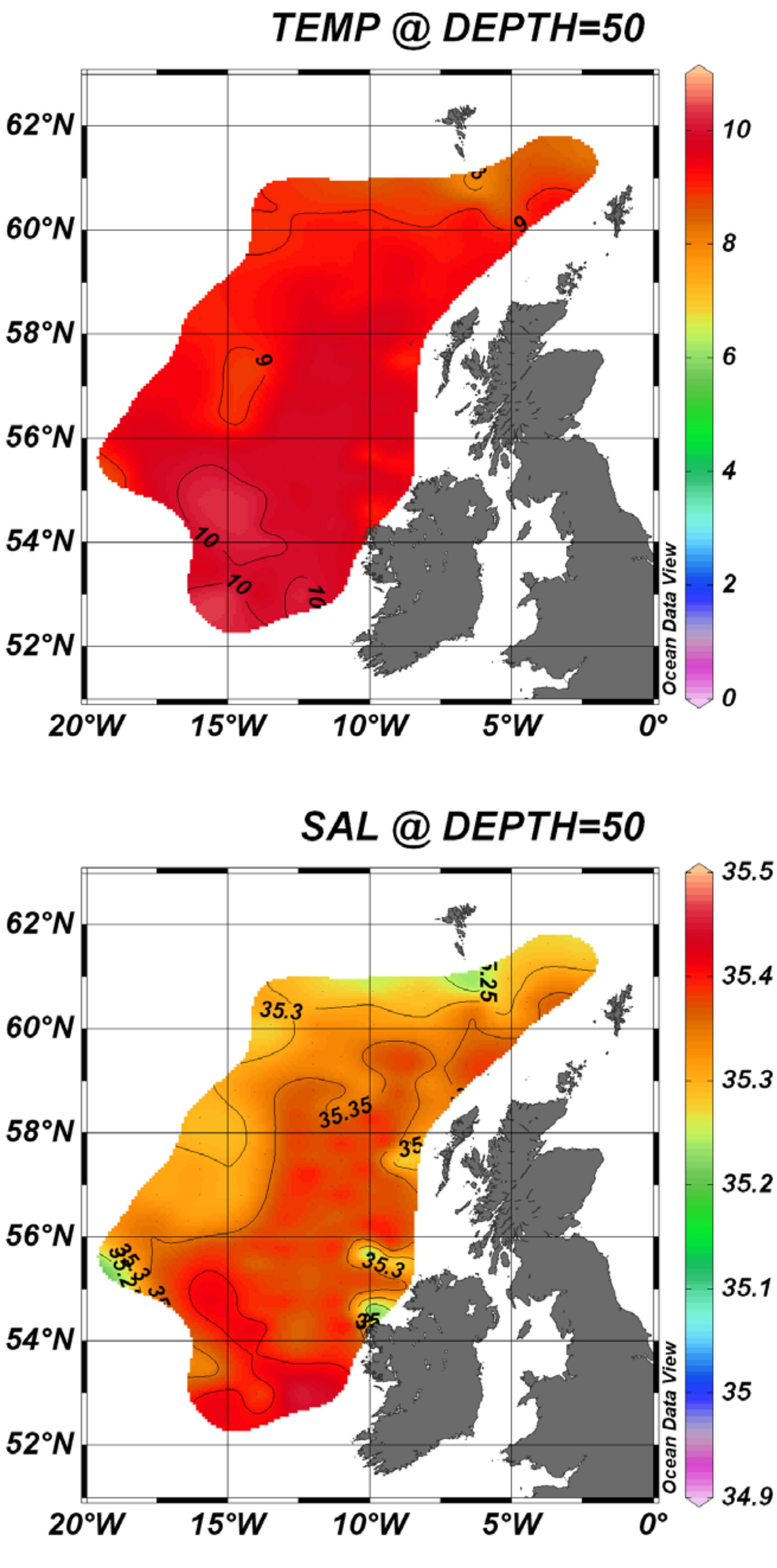


Figure 12. Horizontal temperature (top panel) and salinity (bottom panel) at 50m subsurface as derived from vertical CTD casts. March-April 2014.

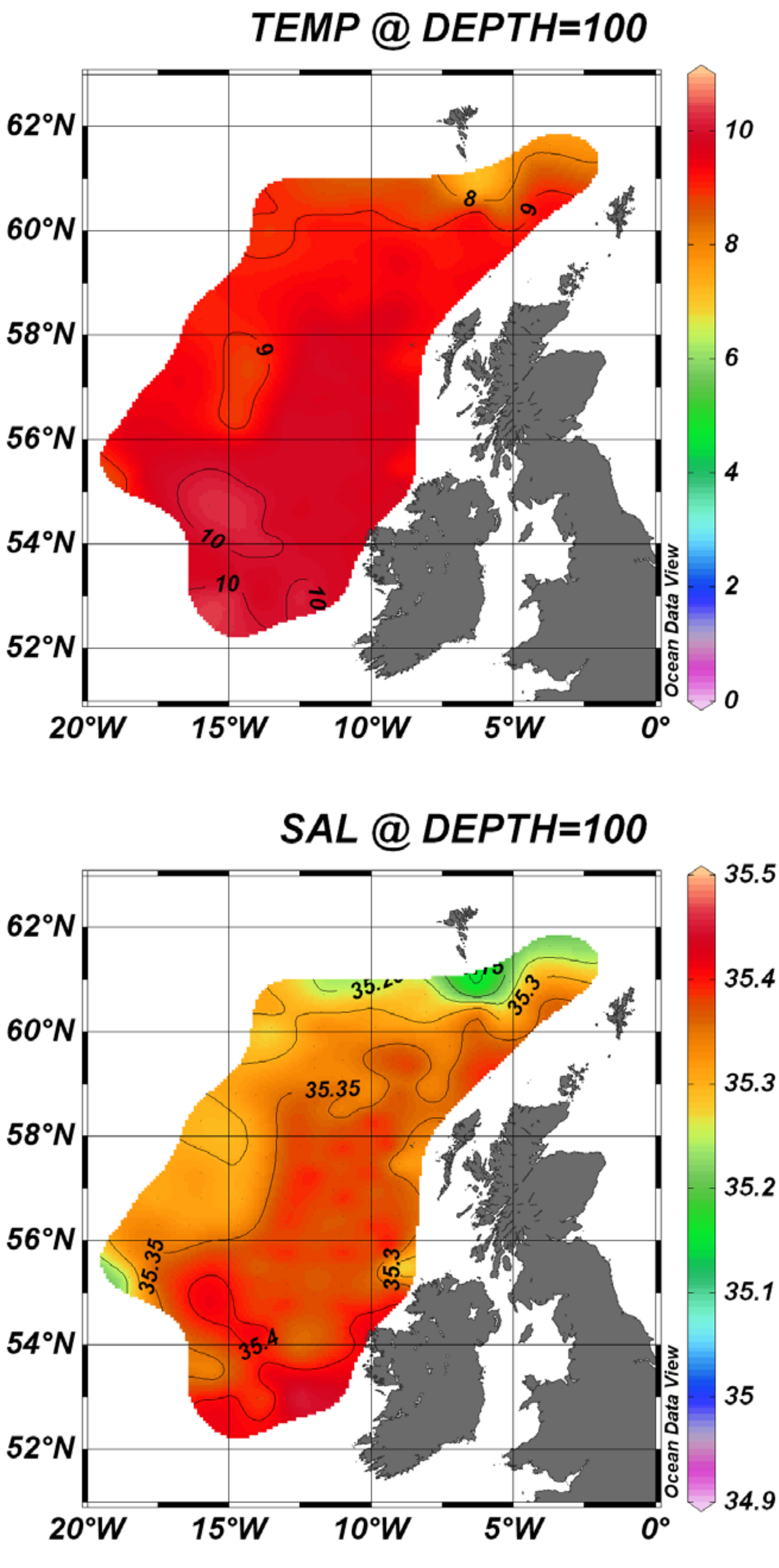


Figure 13. Horizontal temperature (top panel) and salinity (bottom panel) at 100m subsurface as derived from vertical CTD casts. March-April 2014.

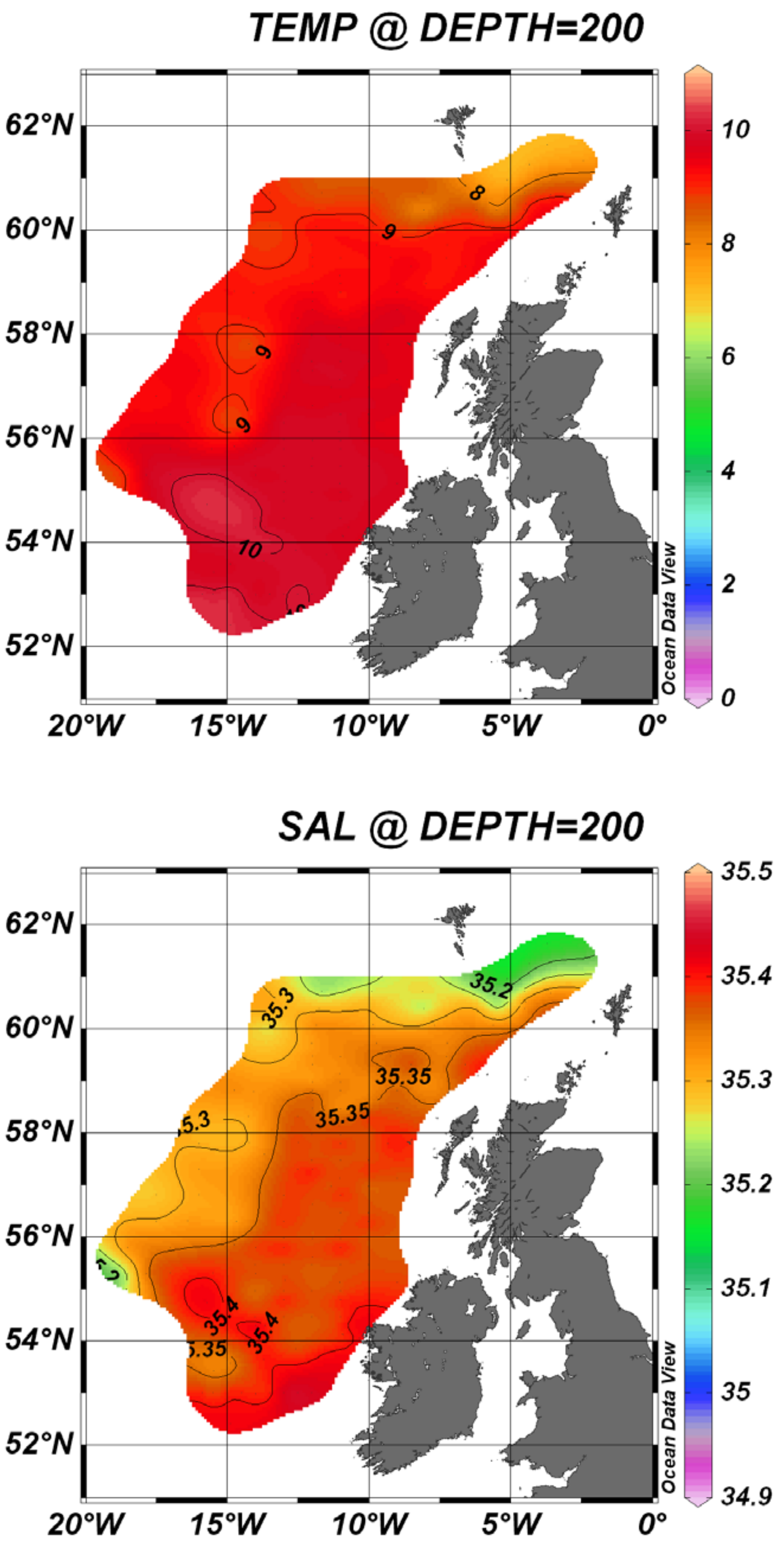


Figure 14. Horizontal temperature (top panel) and salinity (bottom panel) at 200m subsurface as derived from vertical CTD casts. March-April 2014.

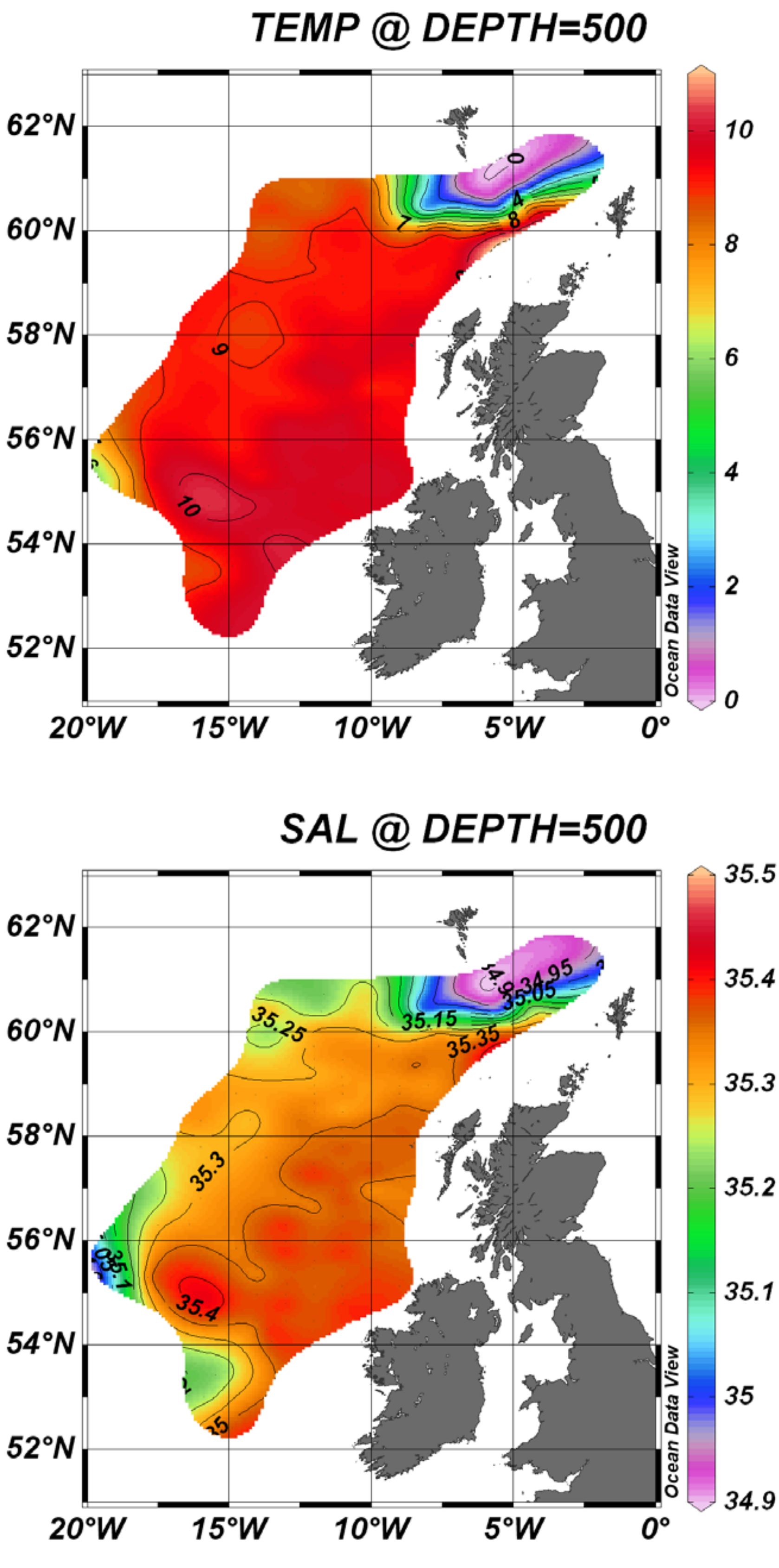


Figure 15. Horizontal temperature (top panel) and salinity (bottom panel) at 500m subsurface as derived from vertical CTD casts. March-April 2014.

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.

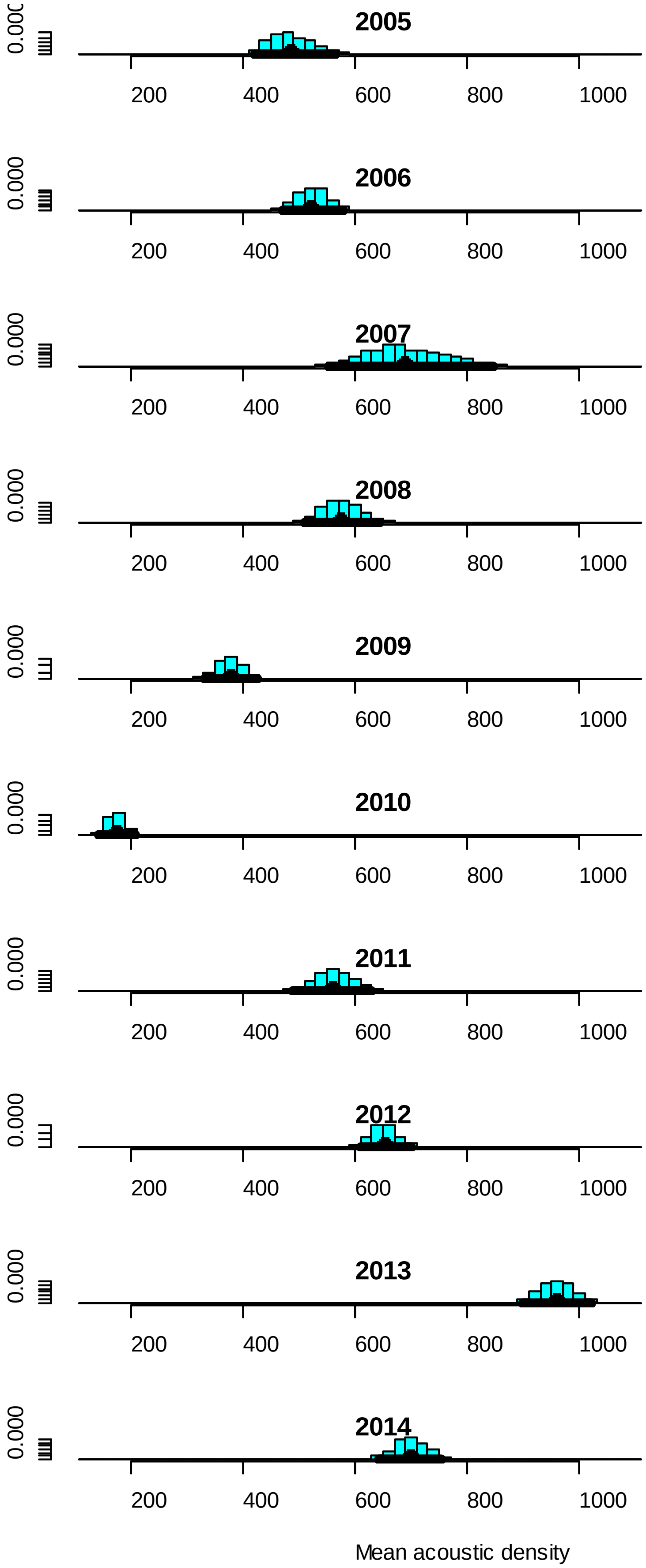


Figure 1. Distribution of mean acoustic density (in $m^2/n.m.^2$) by year based on 1000 bootstrap replicates of acoustic data from blue whiting surveys. Mean acoustic density is indicated with a black dot on the x-axis, while the horizontal bar shows 95% confidence limits.

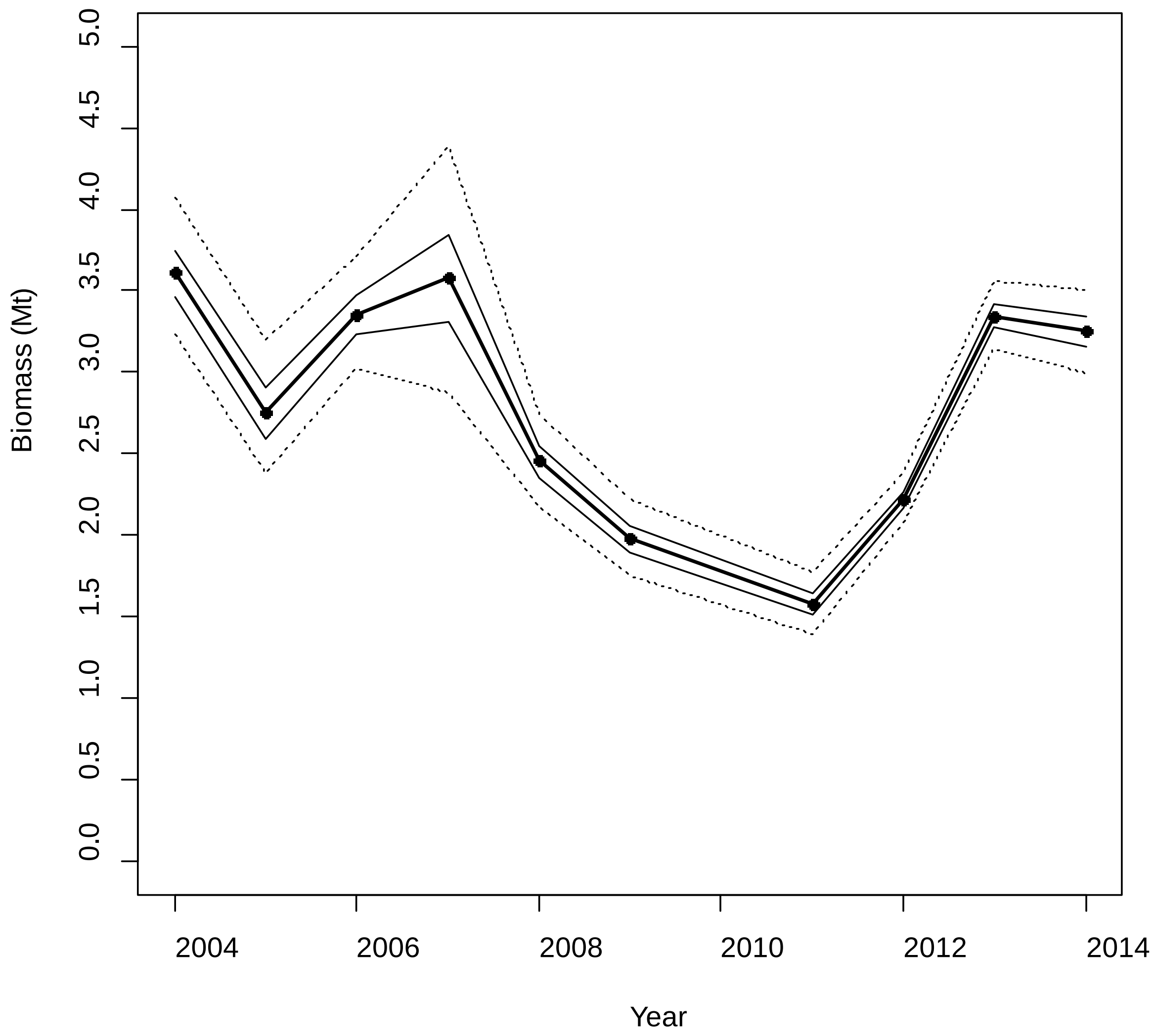


Figure 2. Approximate 50% and 95% confidence limits for blue whiting biomass estimates. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations 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).

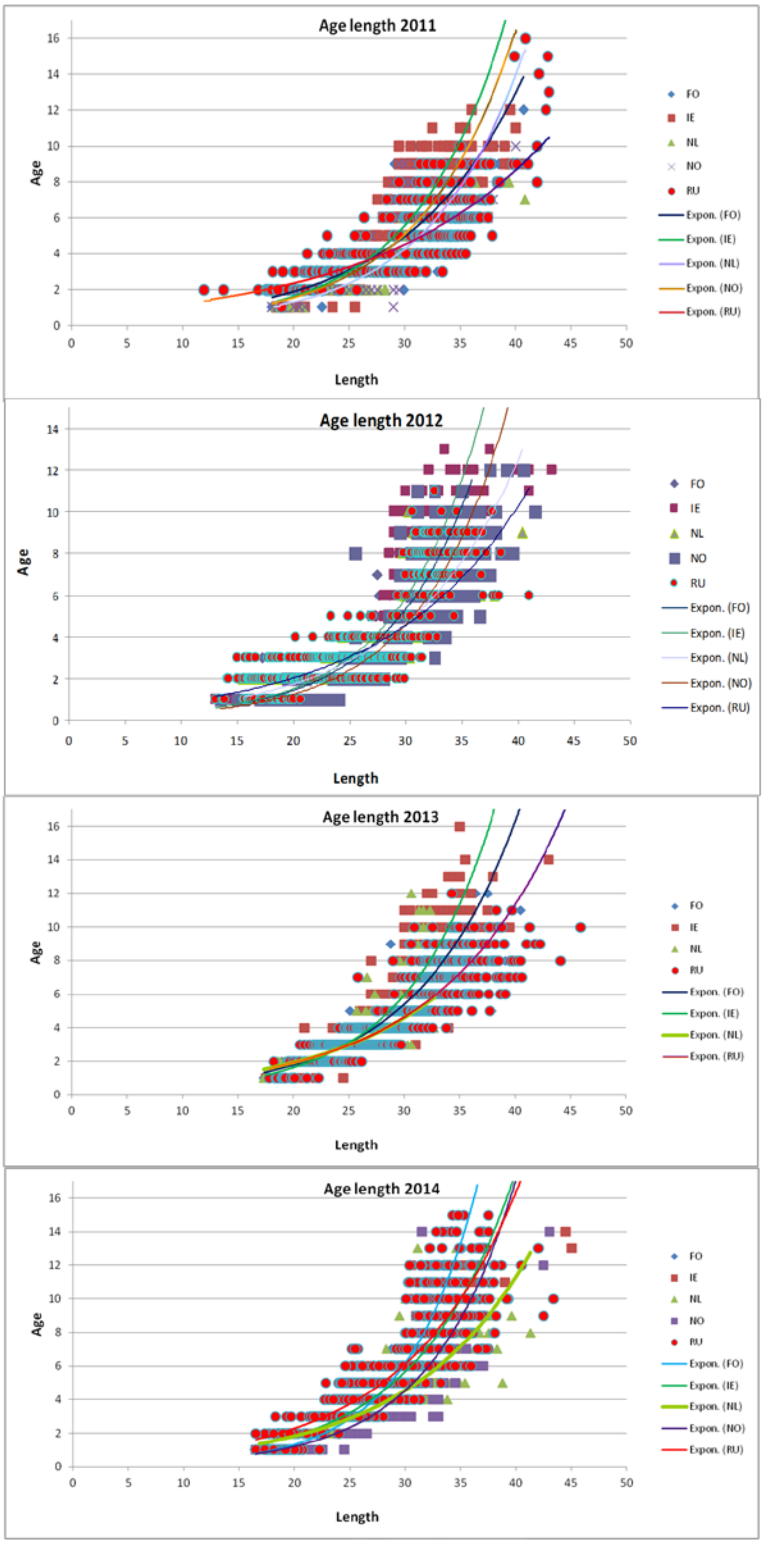


Figure 2. Profile of length at age by nation of blue whiting collected during individual surveys from 2011-2014 (FO; Faroes, IE; Ireland, NL: Netherlands, NO; Norway* and RU; Russia).* No participation from Norway in 2013.

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).

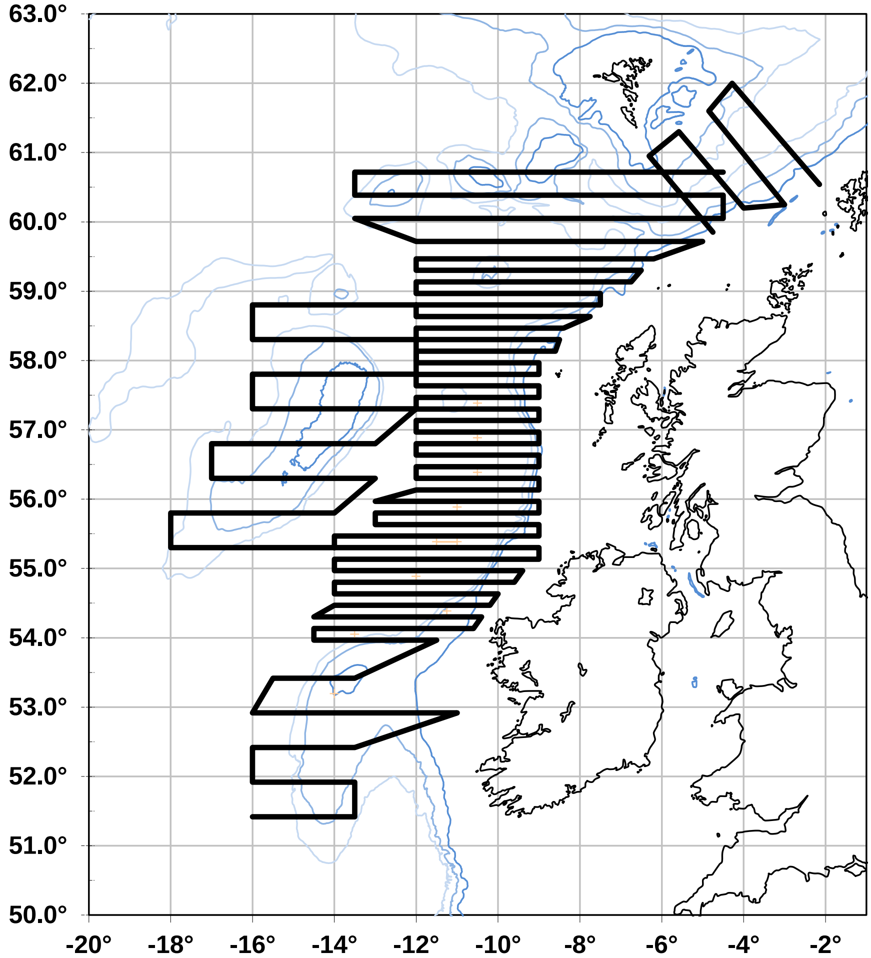


Figure 1. Preliminary survey tracks for the combined 2015 International Blue Whiting Spawning stock Survey (IBWSS).

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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Øyvind Tangen[2], Valentine Anthonypillai[2], Kjell Utne[2], [2], Åge Høines[2], Kjell Arne Mork[2], Webjørn Melle[2], Erling Kaare Stenevik[2]

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

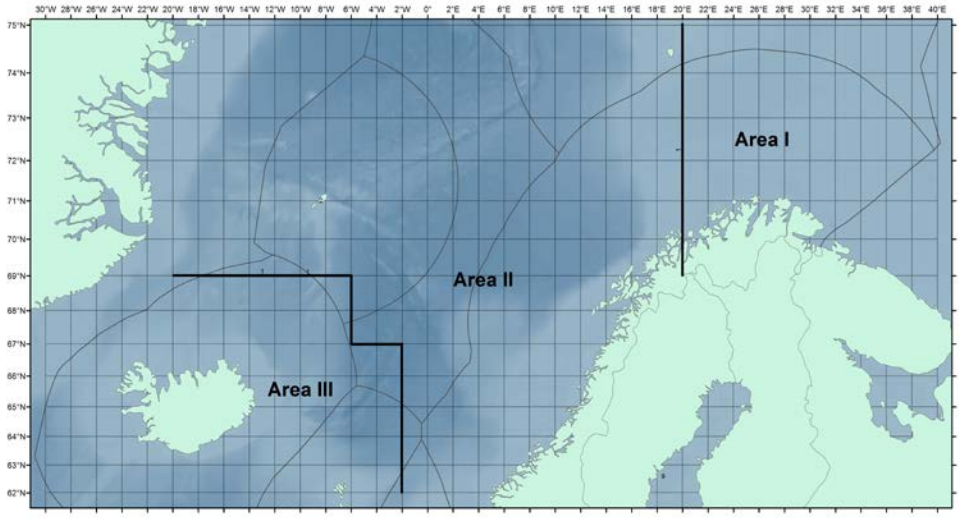

Figure 1. Areas defined for acoustic estimation of blue whiting and Norwegian spring-spawning herring in the Nordic Seas.

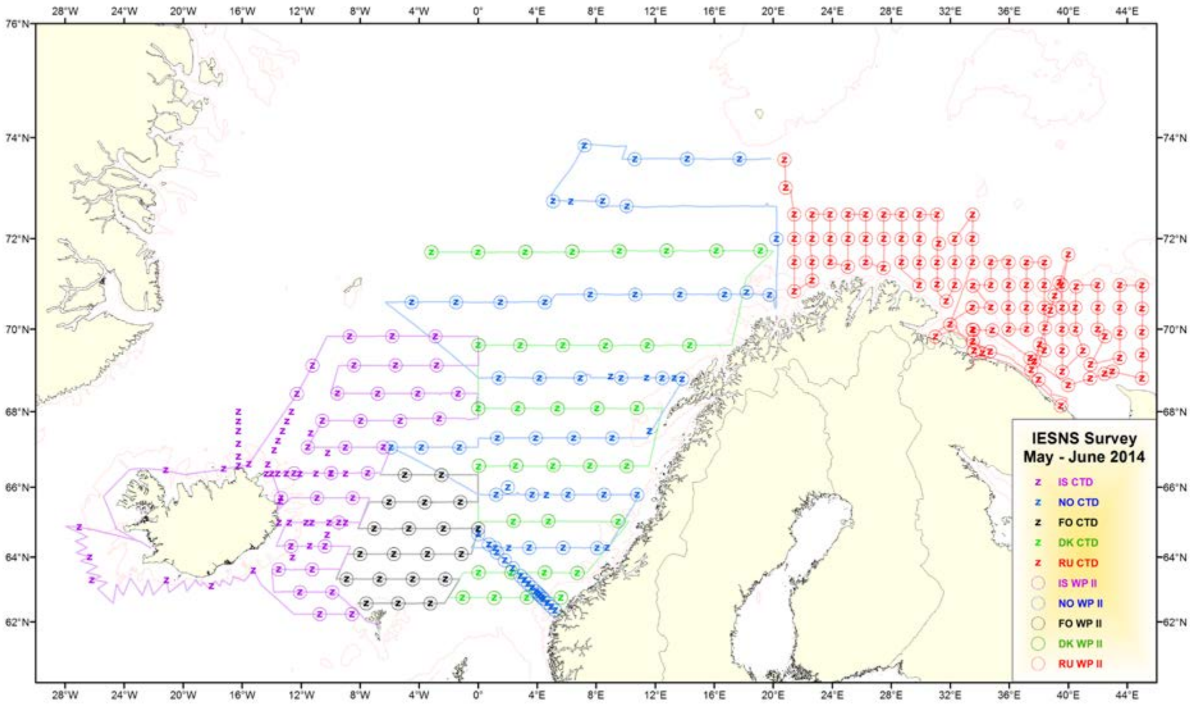

Figure 2. Cruise track, CTD and WP II stations by country for the International ecosystem survey in the Nordic Seas in April-June 2014.

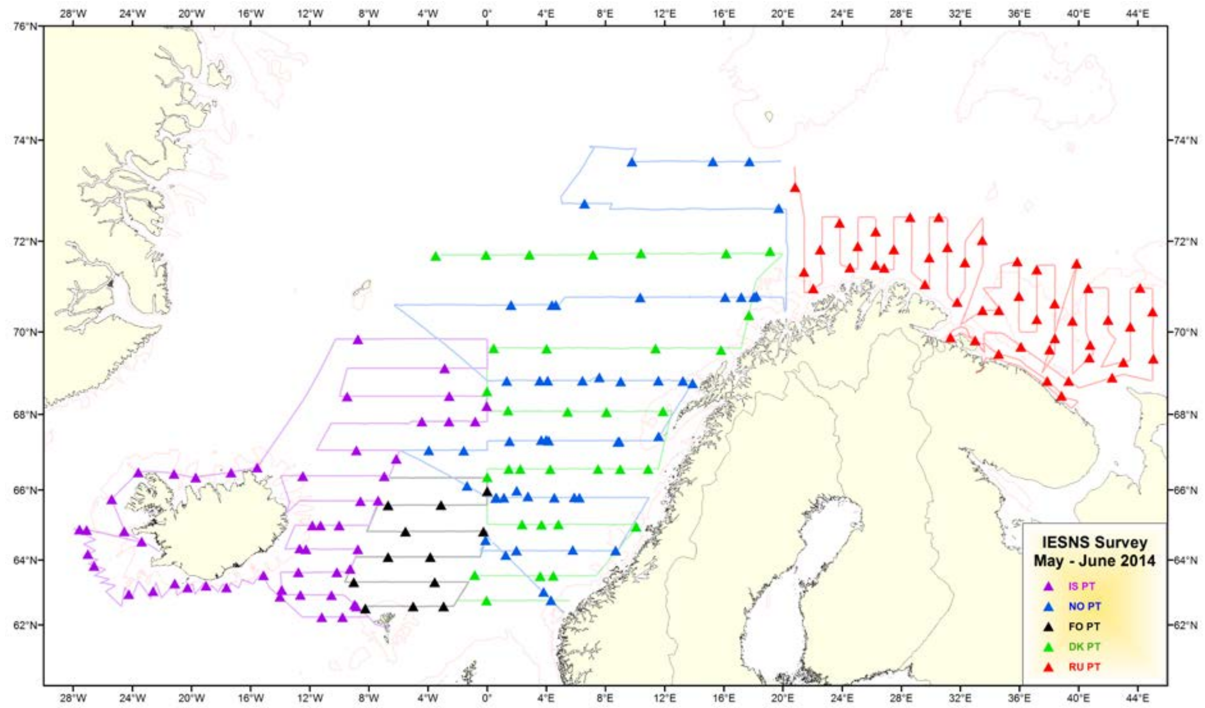

Figure 3. Cruise tracks during the International North East Atlantic Ecosystem Survey in April-May 2014 and location of trawl stations.

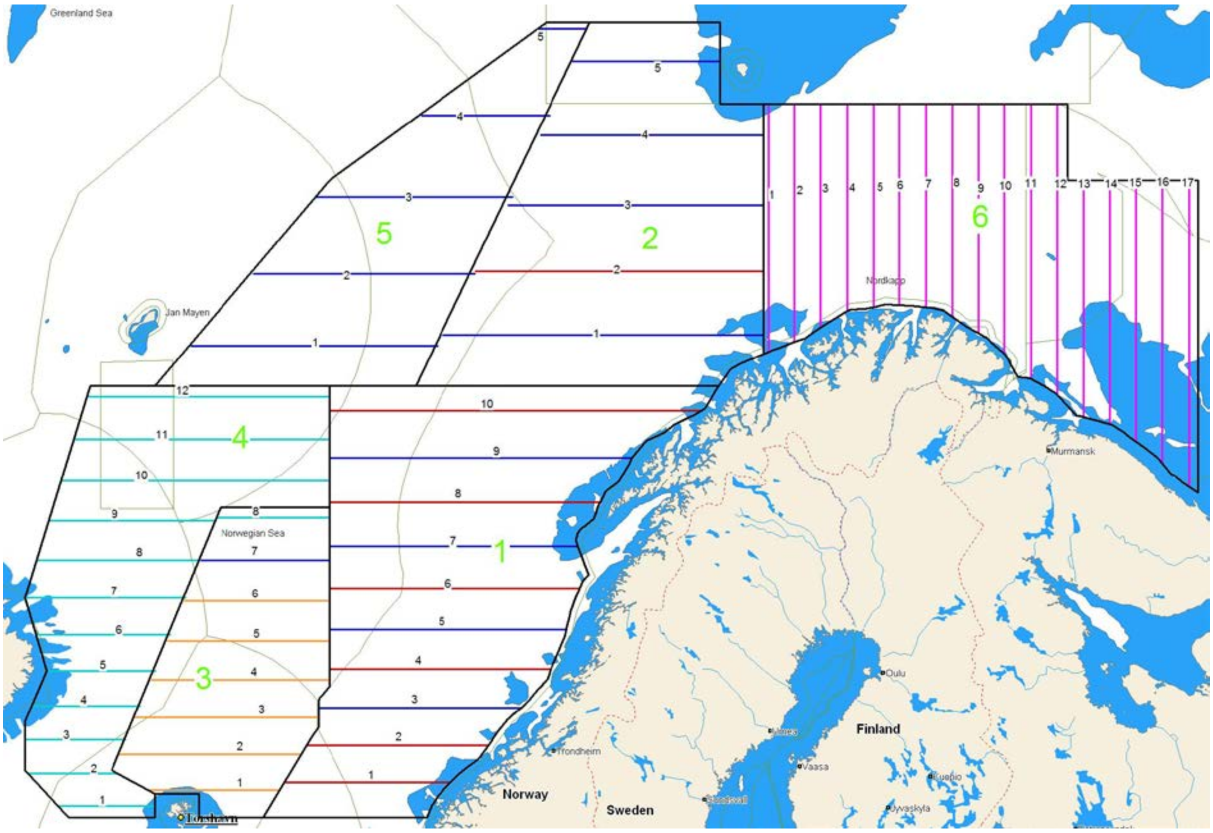

Figure 4. The planed cruise tracks and division of the five stratum used in the IESNS survey 2014.

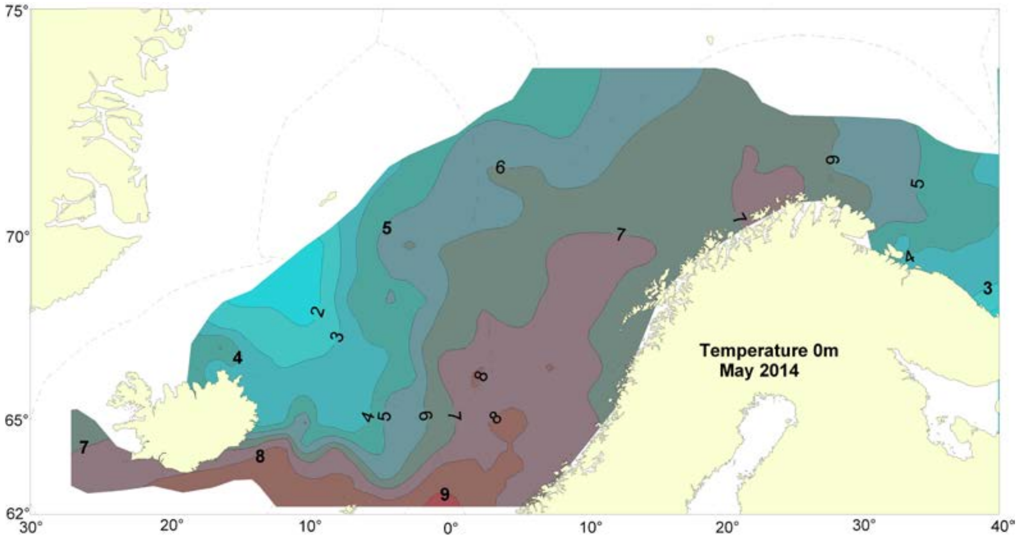

Figure 5. The horizontal sea surface temperature distribution in April-June 2014.

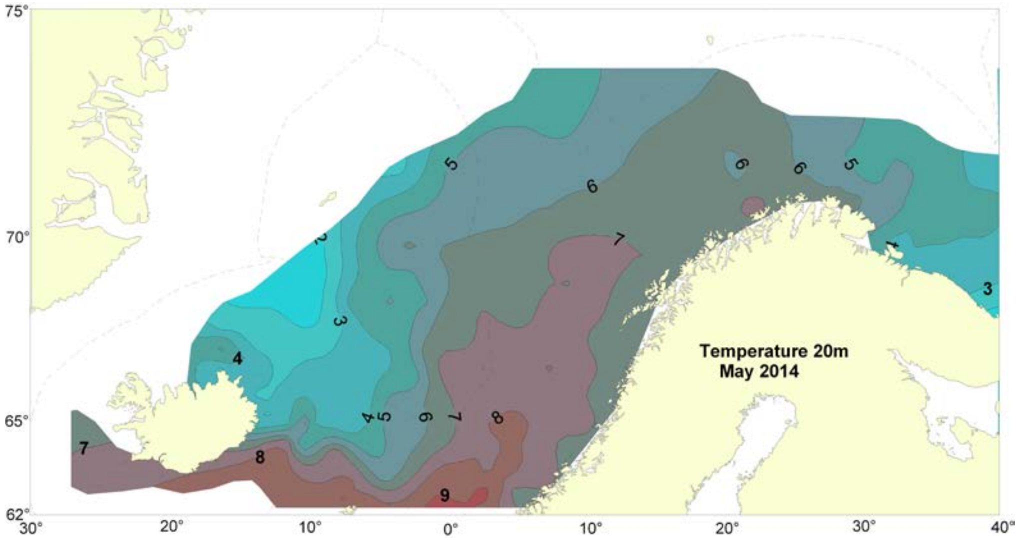

Figure 6. The horizontal distribution of temperatures at 20 m depth in April-June 2014.

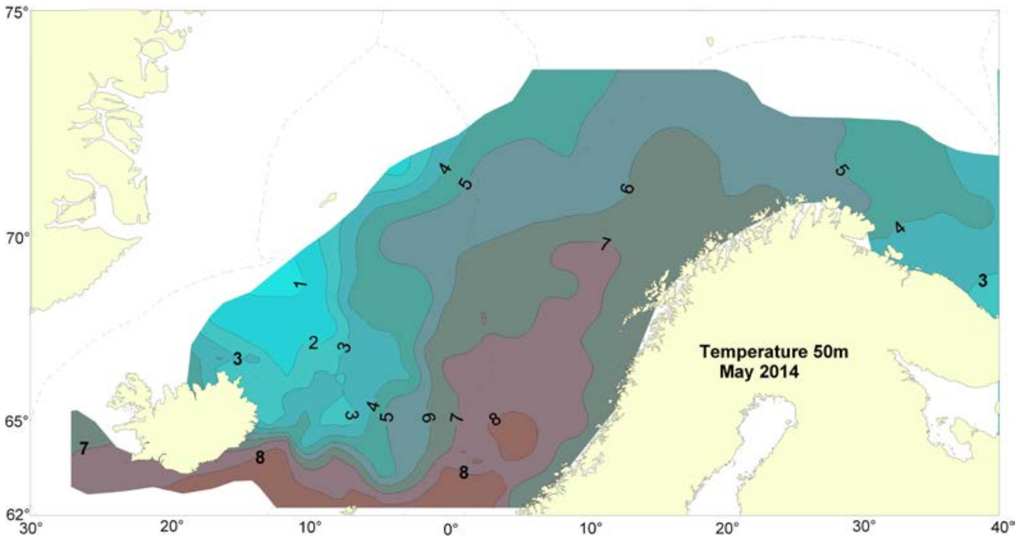

Figure 7. The horizontal distribution of temperatures at 50 m depth in April-June 2014.

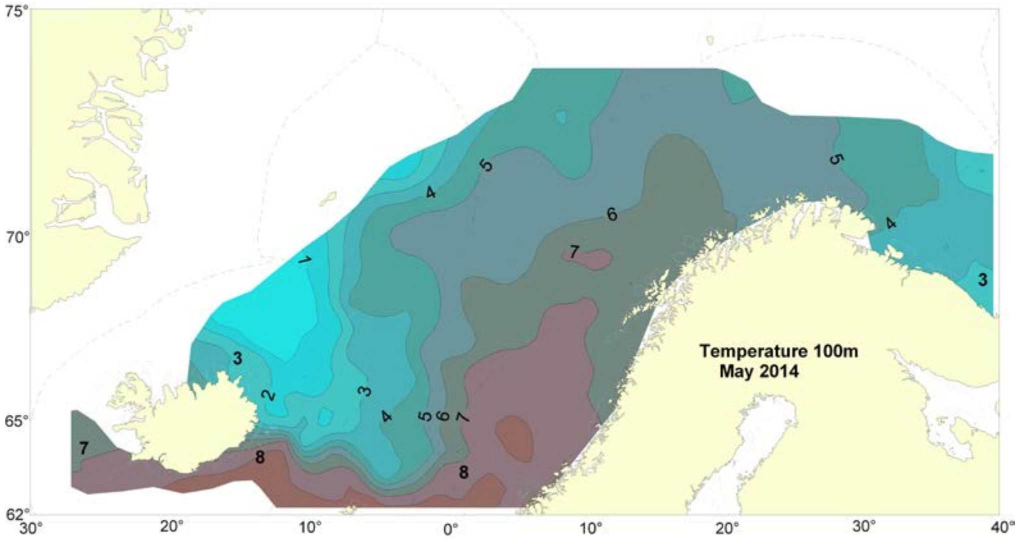

Figure 8. The horizontal distribution of temperatures at 100 m depth in April-June 2014.

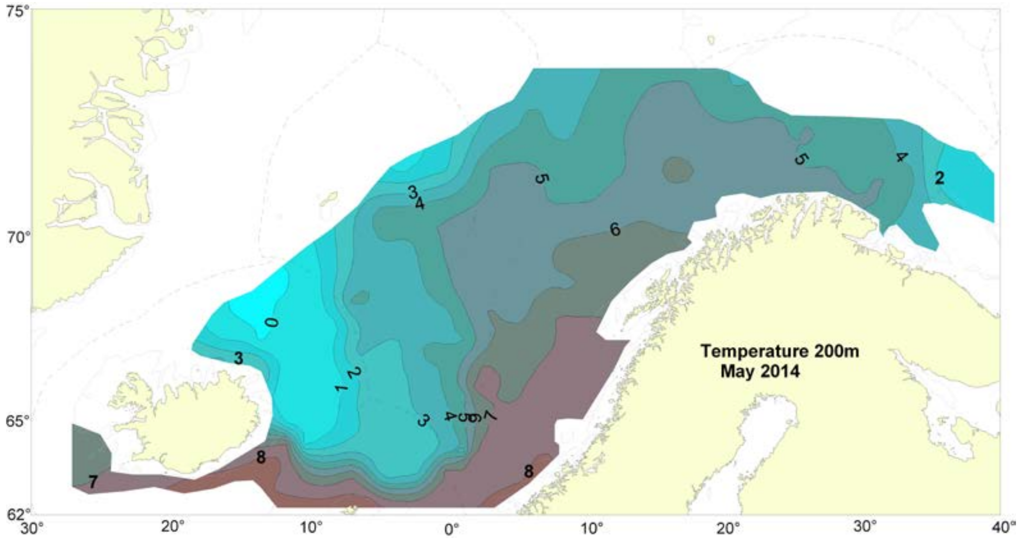

Figure 9. The horizontal distribution of temperatures at 200 m depth in April-June 2014.

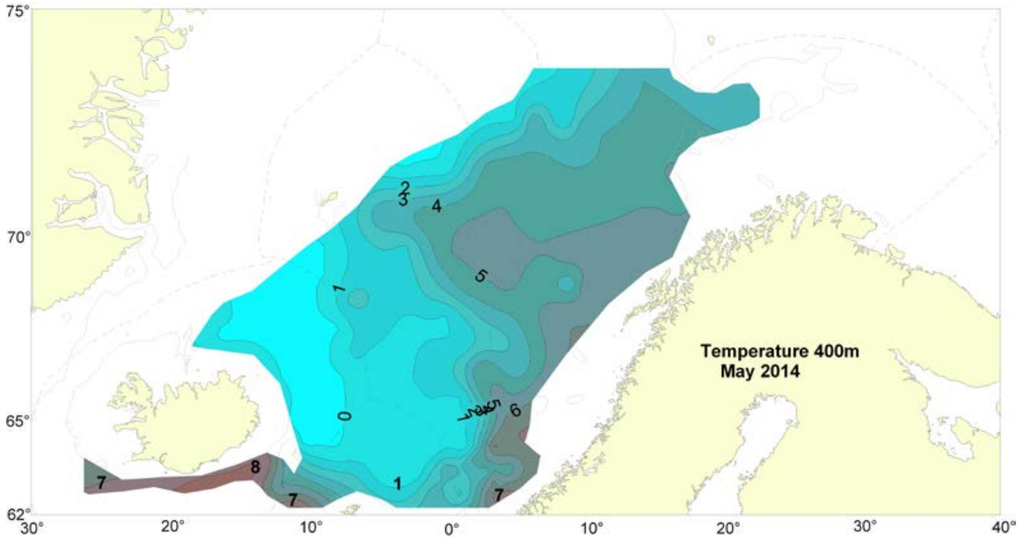

Figure 10. The horizontal distribution of temperatures at 400 m depth in April-June 2014.

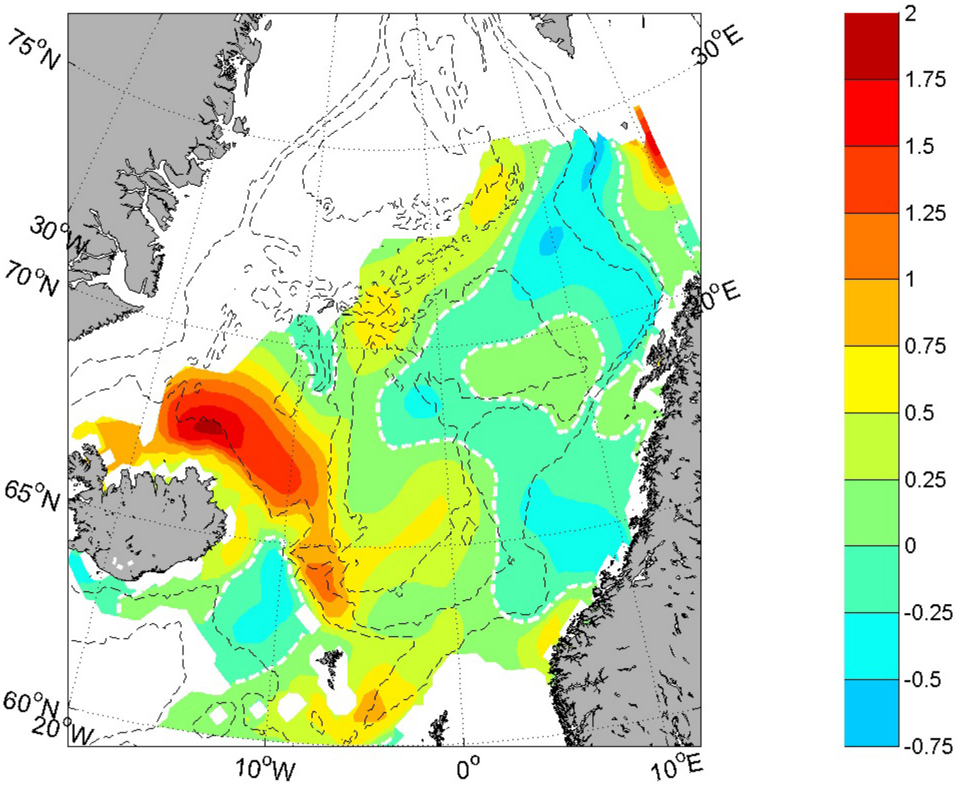

Figure 11. Temperature anomaly at 20 m depth for May 2014. Reference period: 1995-2013.

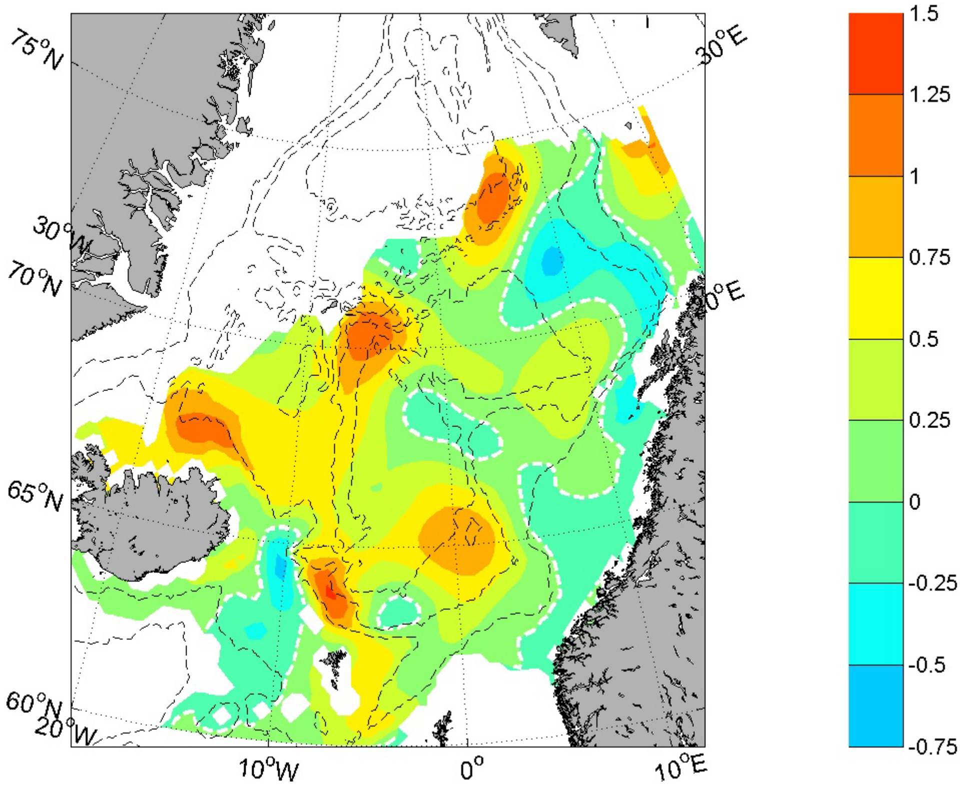

Figure 12. Temperature anomaly at 100 m depth in May 2014. Reference period: 1995-2013.

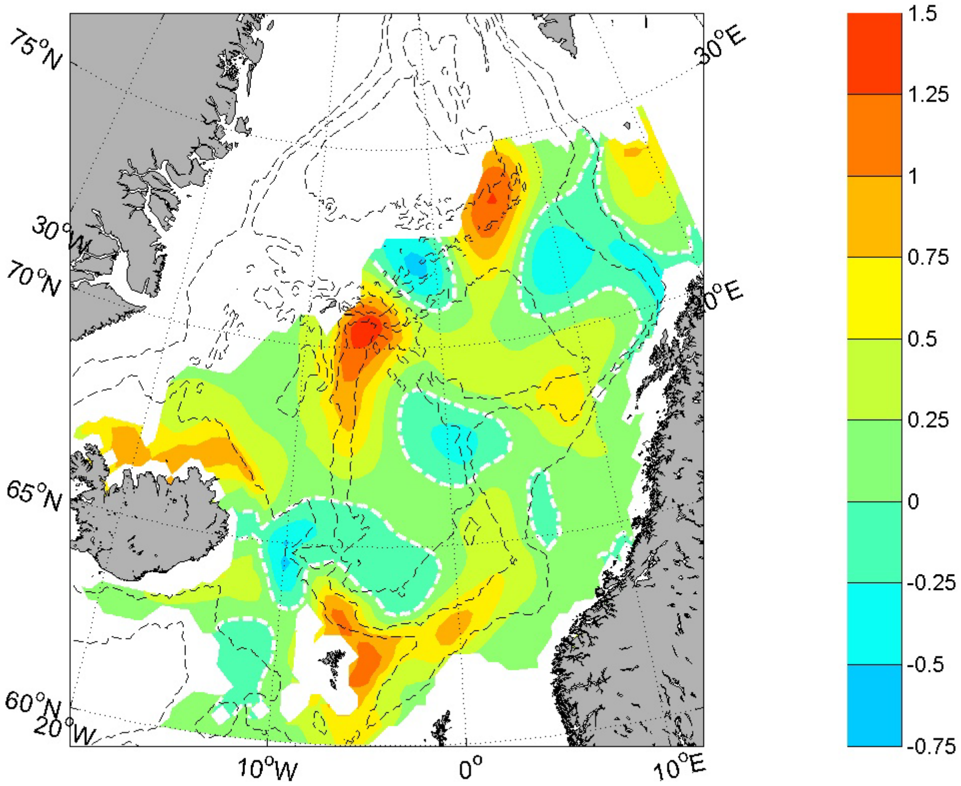

Figure 13. Temperature anomaly at 200 m depth in May 2014. Reference period: 1995-2013.

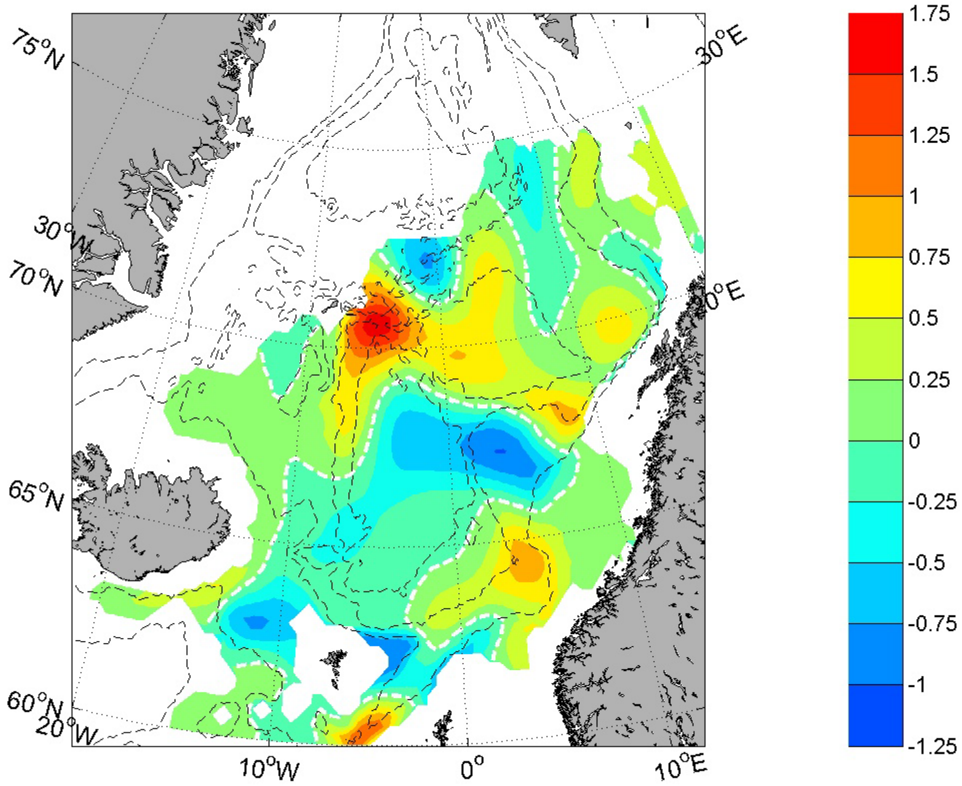

Figure 14. Temperature anomaly at 400 m depth in May 2014. Reference period: 1995-2013.

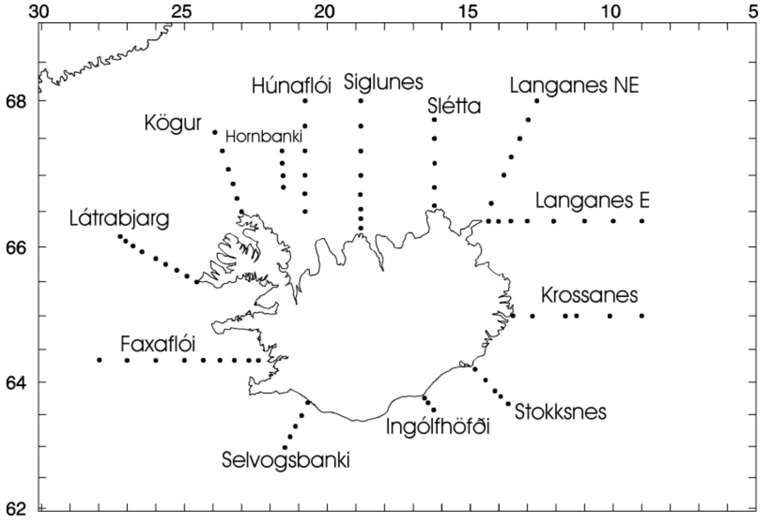

Figure 15. Location of the fixed Icelandic hydrographic sections referred to in the text and Figures 16-18.

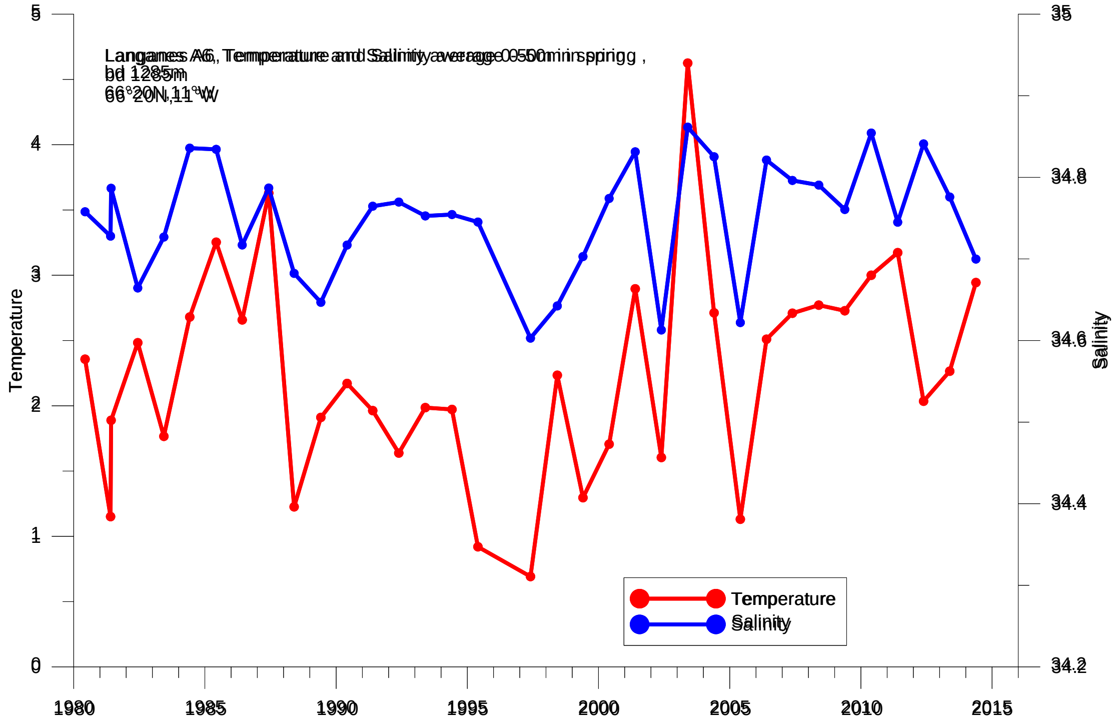

Figure 16. Temperature and salinity in May 2014 east of Iceland, at station Langanes A6 (66°22'N, 11°00'W). Depth averaged 0-50m.

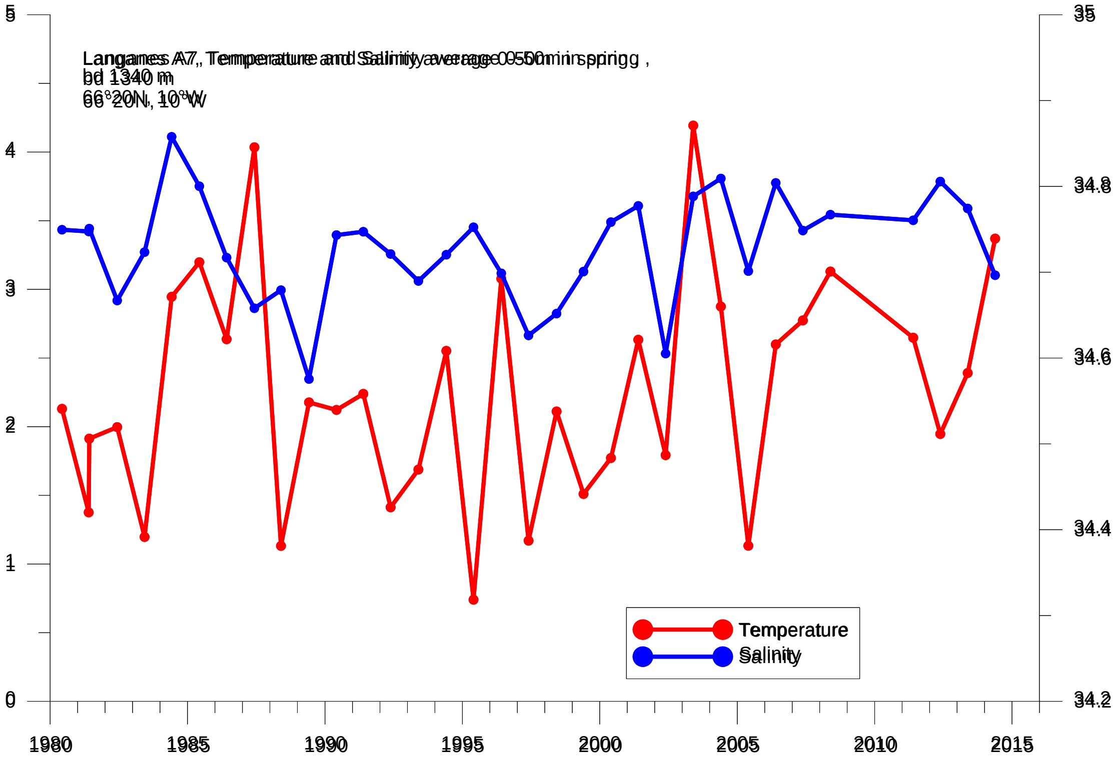

Figure 17. Temperature and salinity in May 2014 east of Iceland, at station Langanes A7 (66°22'N, 10°00'W). Depth average 0-50m.

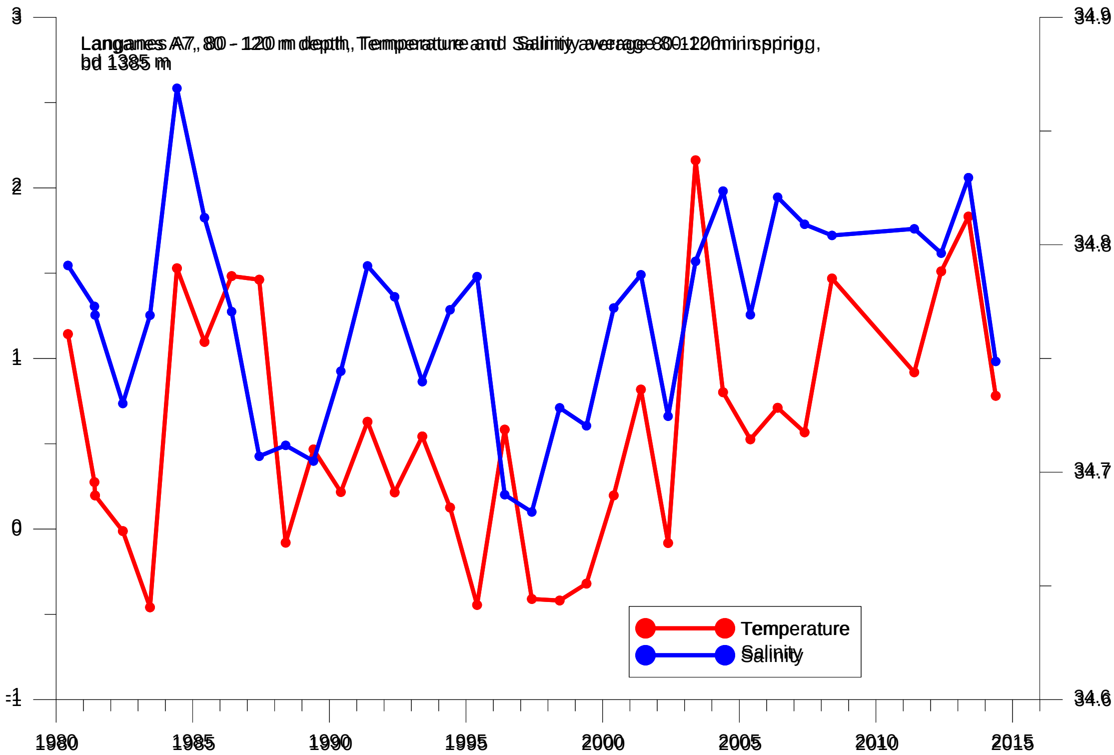

Figure 18. Temperature and salinity in May 2014 east of Iceland at station Langanes A7 (66°22'N, 10°00'W). Depth average 80-120m.

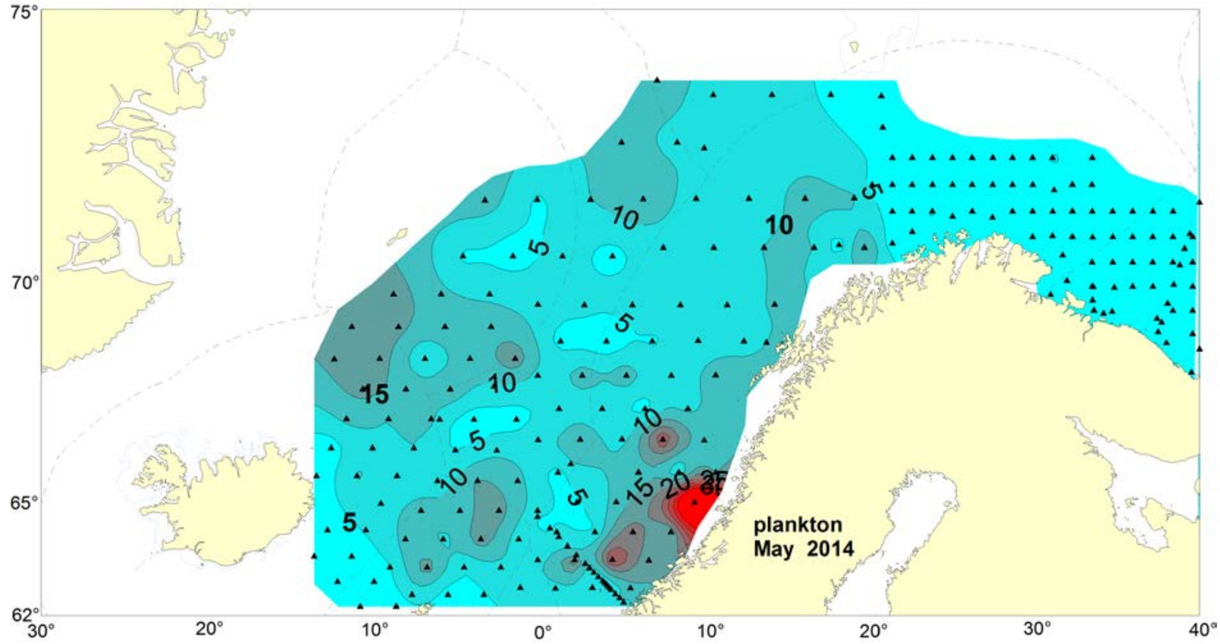

Figure 19. Zooplankton biomass (g dw m-2; 200–0 m in April-June 2014.

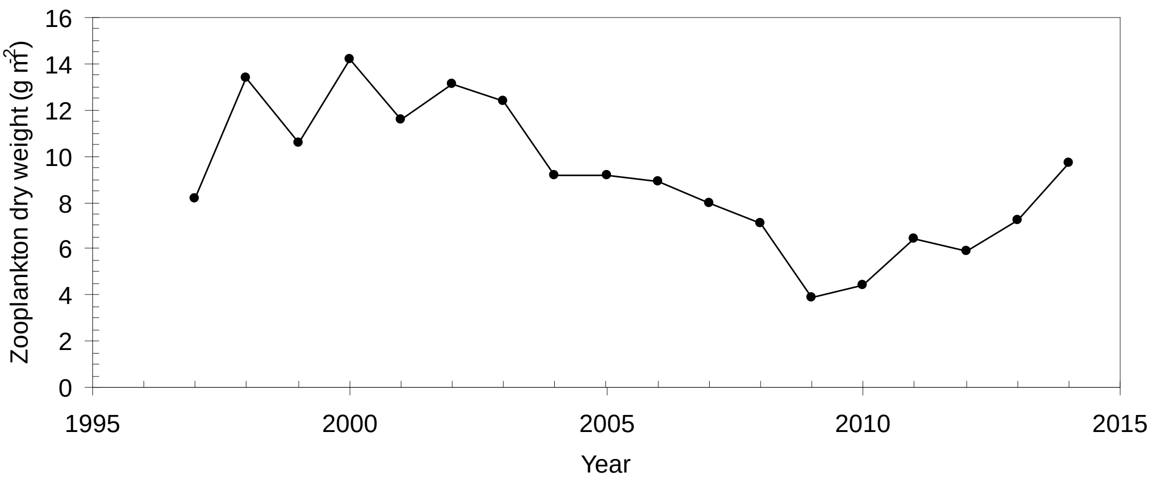

Figure 20. The annual mean dry weight of zooplankton across the whole coverage area in the May surveys in the Norwegian Sea and adjacent waters from 1997 to 2014.

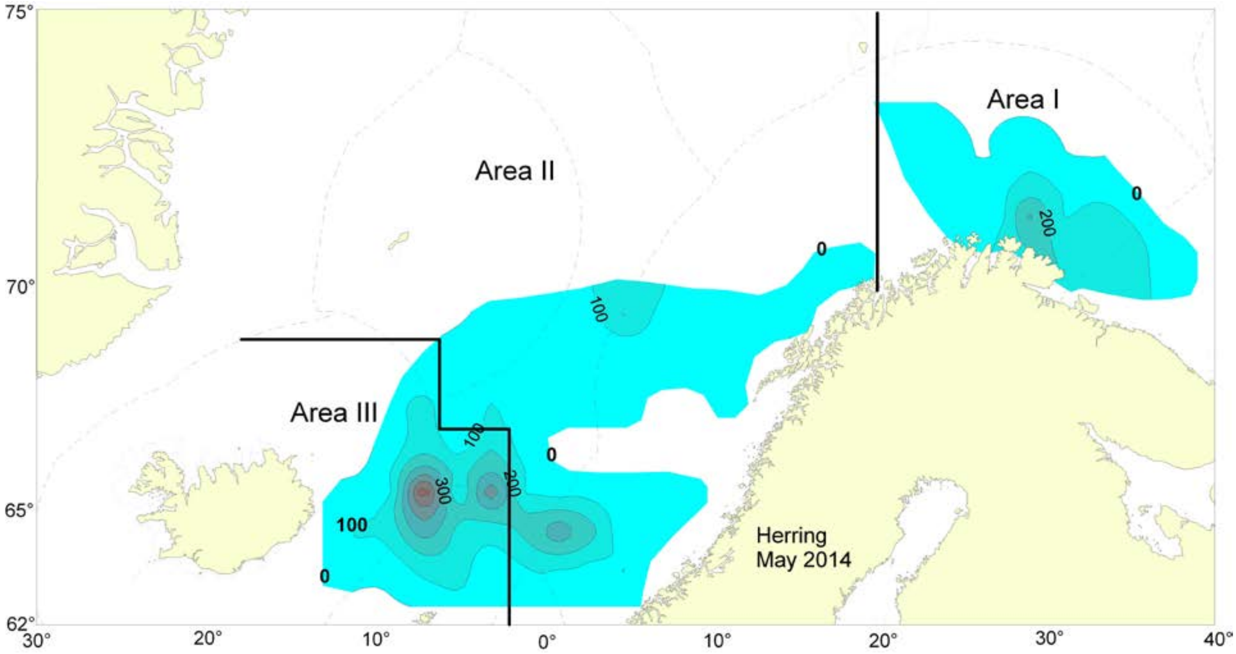

Figure 21. Distribution of Norwegian spring-spawning herring as measured during the International survey in April-June 2014 in terms of s_A-values (m^2/nm^2) based on combined 5 nm values.

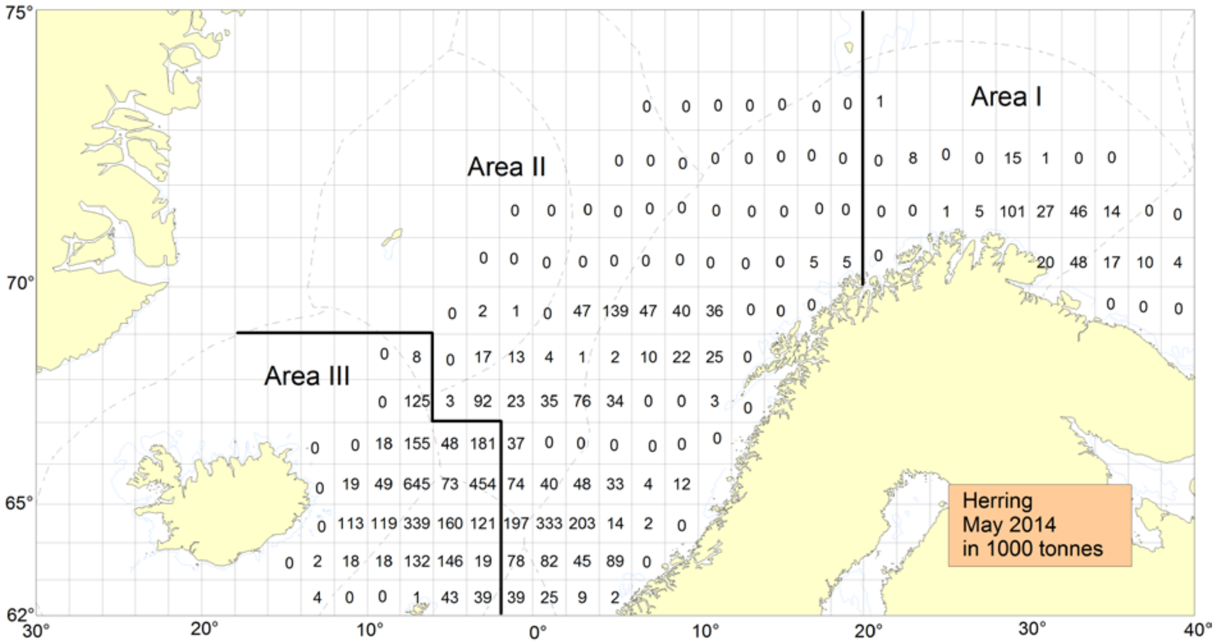

Figure 22. Norwegian spring-spawning herring biomass from IESNS 2014 by sub-area.

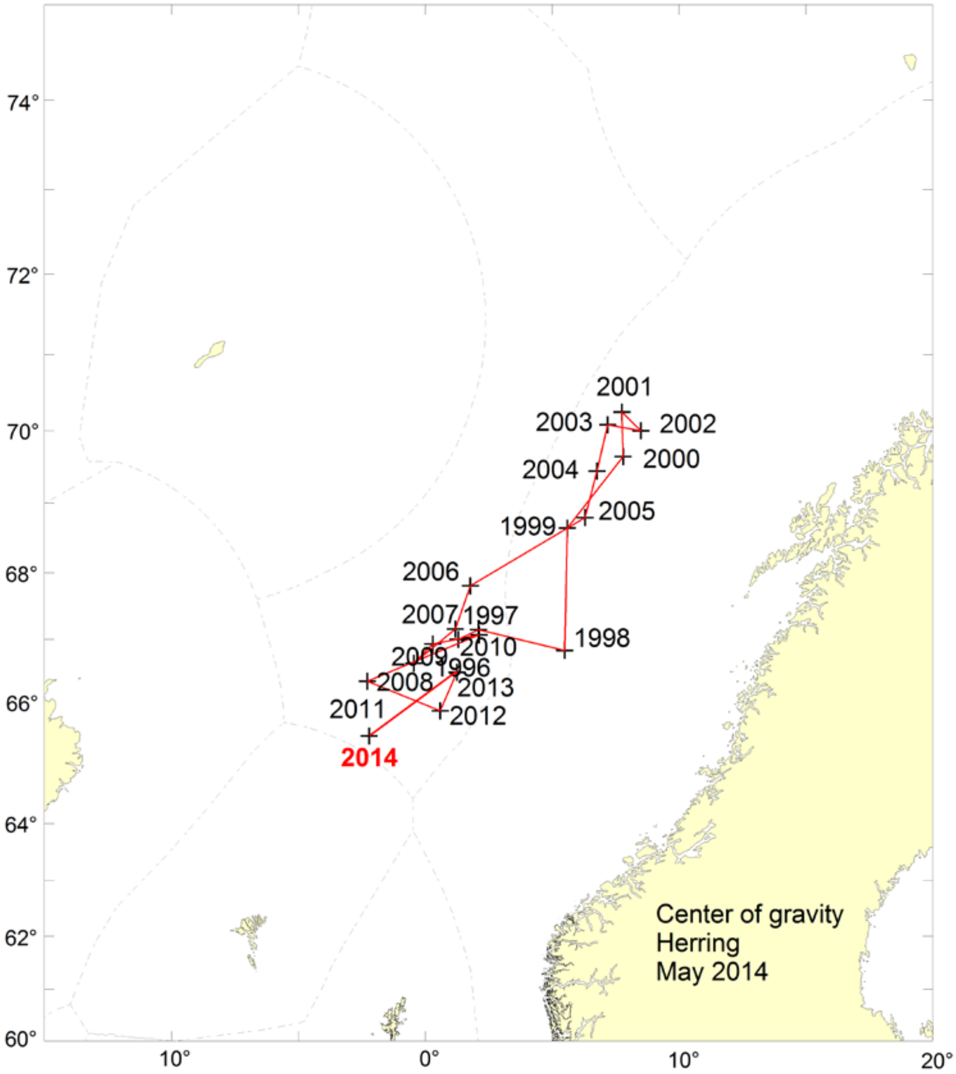

Figure 23. Centre of gravity of herring during the period 1996-2014 derived from acoustic. Acoustic data from area II and III only, i.e. west of 20º E

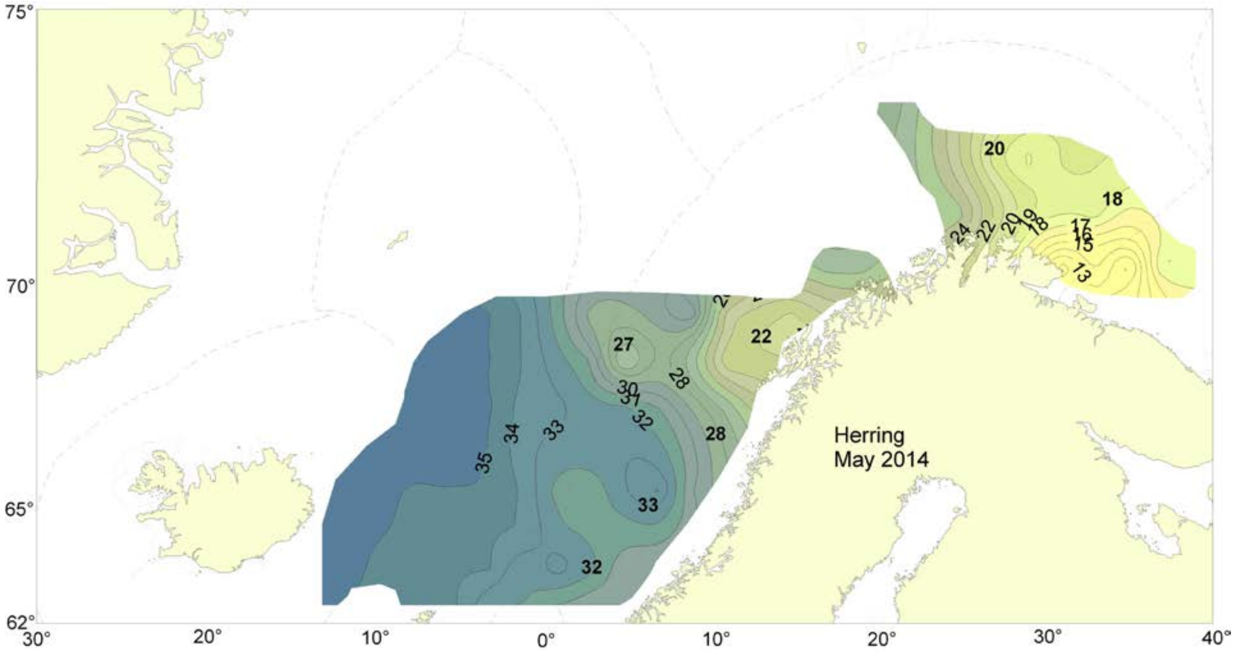

Figure 24. Mean lemgth of Norwegian spring-spawning herring as measured during the International survey in April-June 2014.

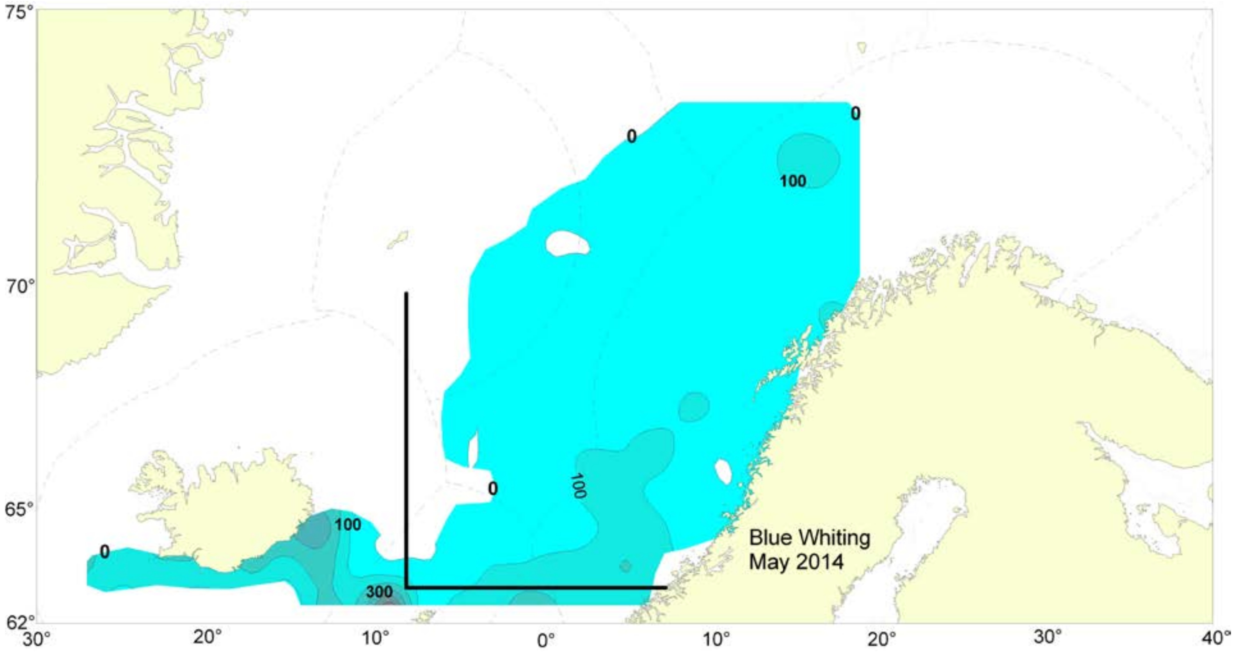

Figure 25. Distribution of blue whiting as measured during the International survey in April-June 2014 in terms of sA-values (m²/nm²) based on combined 5 nm values. The standard area is shown on the map.

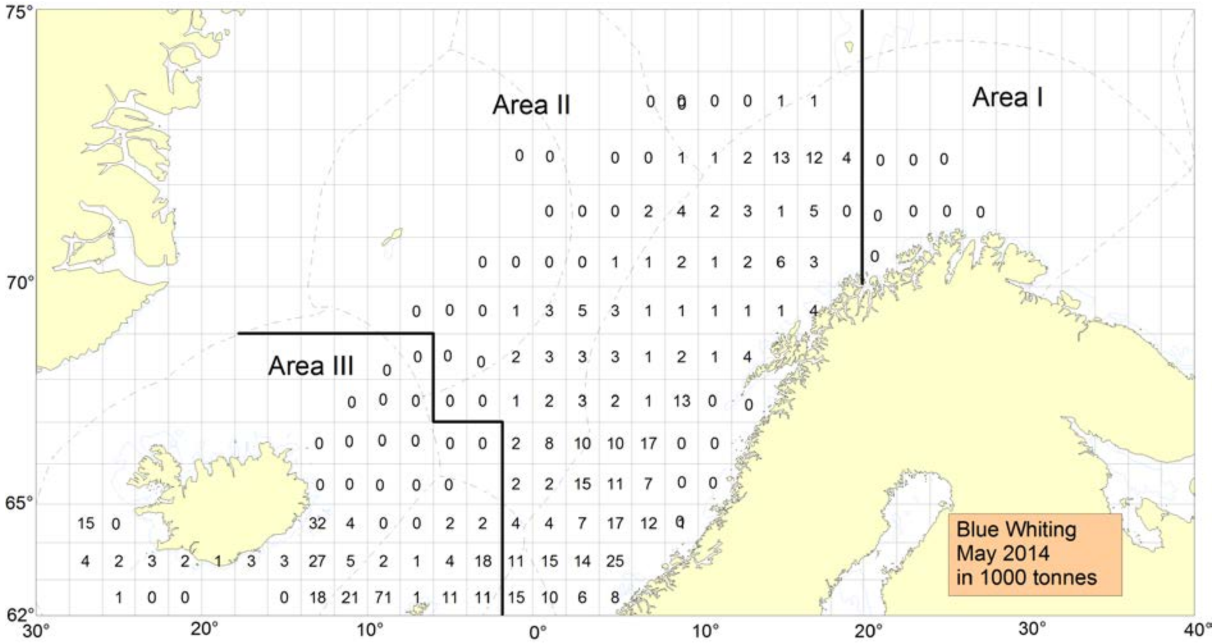

Figure 26. Blue whiting biomass from IESNS 2014 by sub-area.

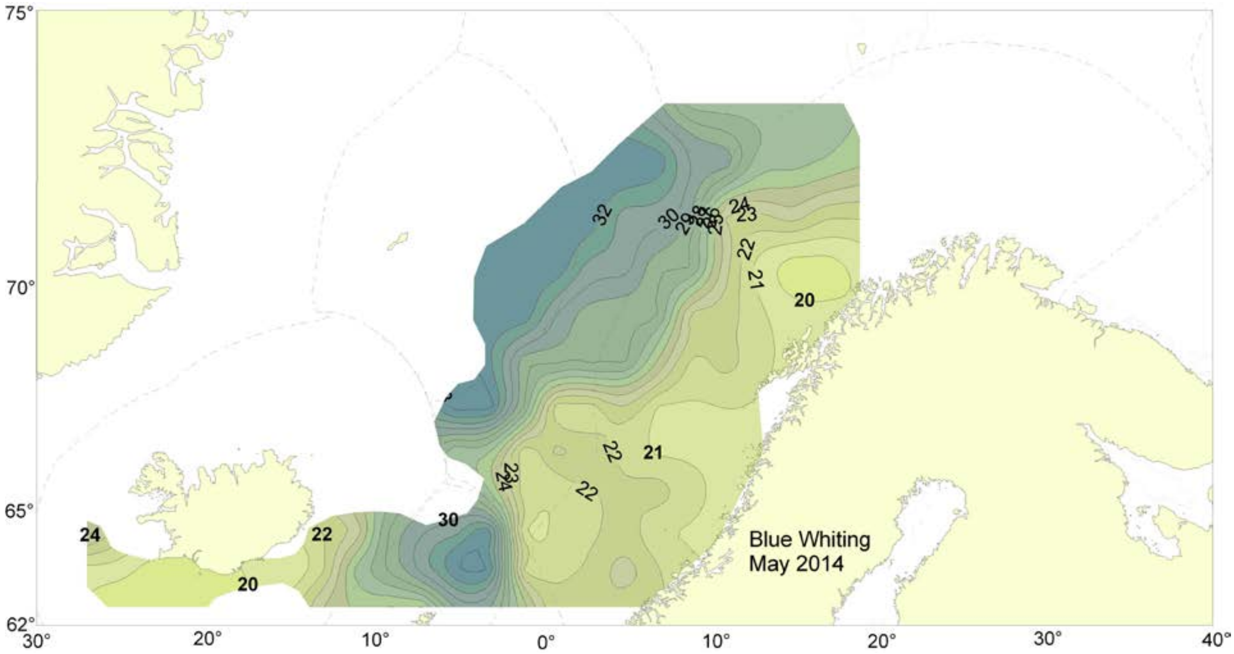

Figure 27. Mean length (cm) of blue whiting recorded in the North-east Atlantic Ecosystem Survey in April–June 2014.

WD to WGWIDE 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

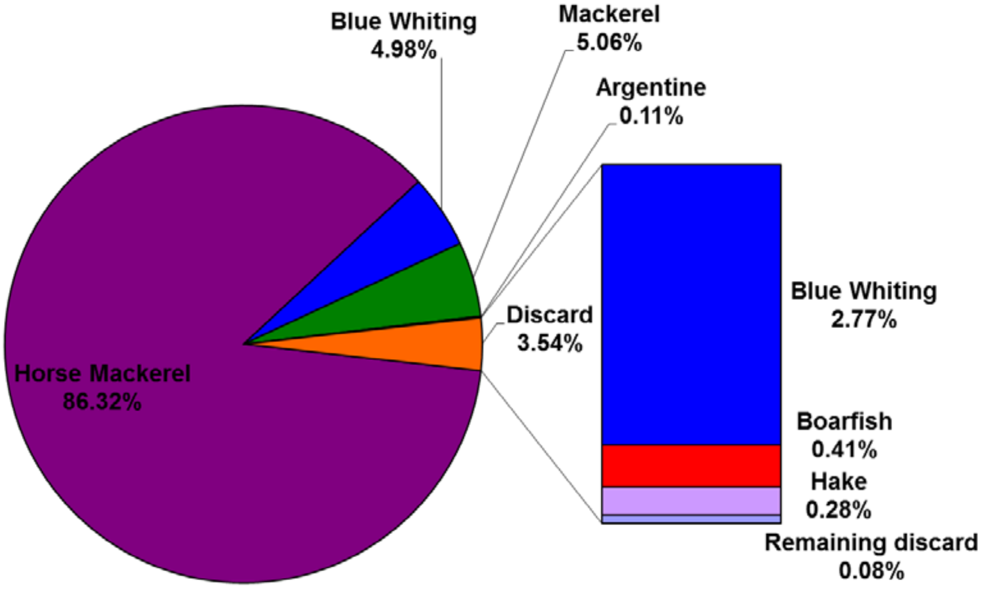

Fig. 1: Catch composition of the observed trip

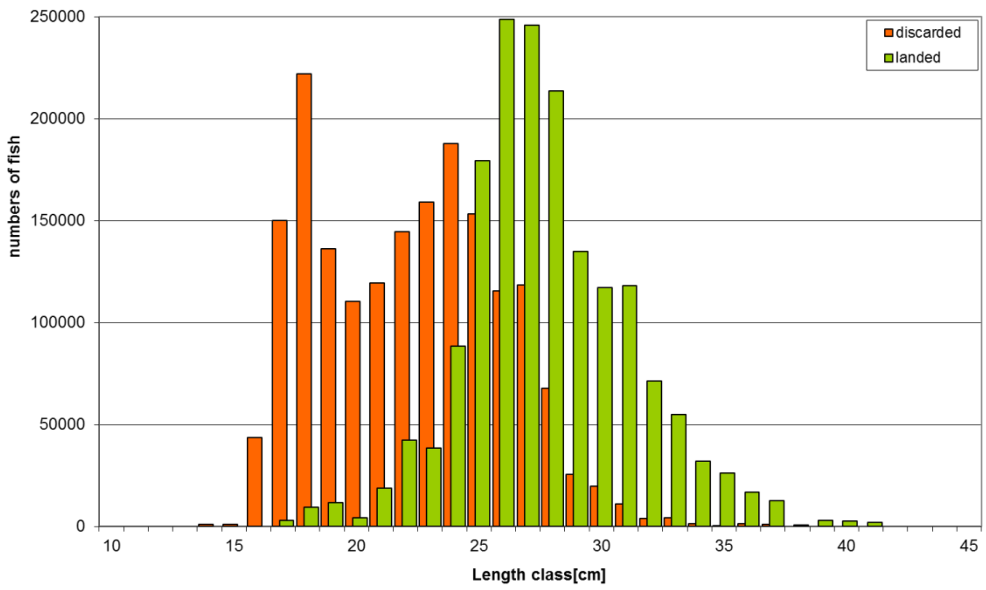

Fig. 2: Length distribution of blue whiting by landings and discards

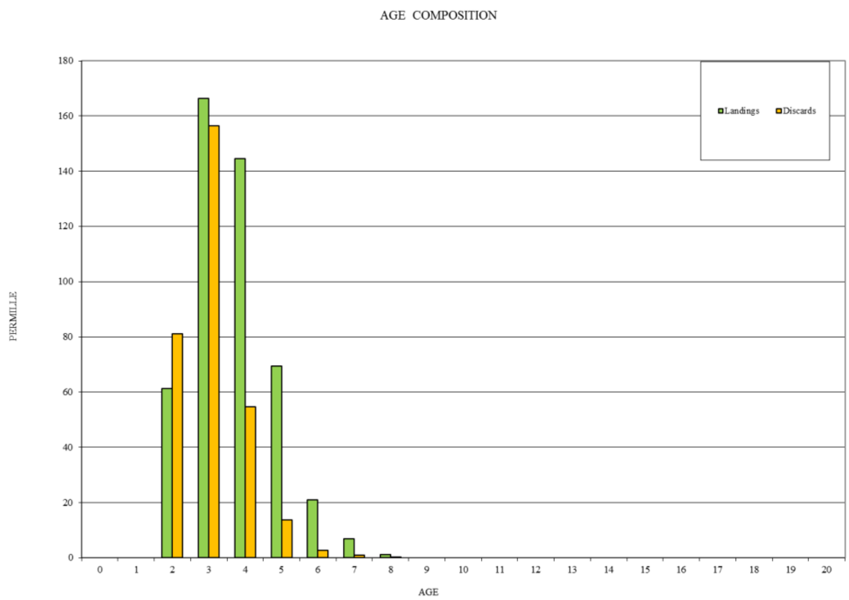

Fig. 3: Age composition of blue whiting by landings and discards