WORKING GROUP ON MACKEREL AND HORSE MACKEREL EGG SURVEYS (WGMEGS)

VOLUME 1 | ISSUE 66

ICES SCIENTIFIC REPORTS

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ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
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ISSN number: 2618-1371 I

ICES Scientific Reports

Volume 1 | Issue 66

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Recommended format for purpose of citation:

ICES. 2019. Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS).

ICES Scientific Reports. 1:66. 233 pp. http://doi.org/10.17895/ices.pub.18618143

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Contents

i Executive summary

The Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS) is responsible for the planning, data collection, and data analysis of the ICES triennial mackerel and horse mackerel egg surveys. This report focuses on the Terms of Reference that are directly involved with the execution of the mackerel and horse mackerel egg survey (MEGS) in 2019.

The results of the two Workshops on Egg staging, Fecundity and Atresia in Horse mackerel and Mackerel (WKFATHOM) (12–16 October 2018, Bremerhaven, Germany and 9–12 November 2018, IJmuiden, The Netherlands) were discussed, with the subsequent enhancements and recommendations proposed during these workshops outlined in the workshop report (ICES, 2018a) incorporated into both of the WGMEGS manuals (ICES, 2019a), (ICES, 2019b).

Planning for the 2019 survey was fine-tuned. Although the broad planning of the 2019 survey was undertaken during the 2018-planning meeting and reported in the 2018 WGMEGS report, amendments to the provisionally agreed plan required additional intersessional refinements. The settled plan for the 2019 survey has been included as an annex in the latest version of the WGMEGS Manual for the Mackerel and Horse Mackerel Egg Surveys (ICES SISP 6, 2019a). In 2019, the survey once again faced significant challenges with regards to its ability to provide adequate geographical and temporal coverage given the limited vessel resources at our disposal.

After their withdrawal from the MEGS survey in 2016, Norway re-joined the survey in 2019, however Iceland withdrew its participation in early 2019. Also, contrary to the first survey plan, which was published with the 2018 WGMEGS report (ICES 2018b), Denmark was not able to participate. The resulting gaps in the survey plan were mitigated by the inclusion of additional surveys undertaken on commercial vessels. In 2019, Portugal, Spain (IEO and AZTI), Ireland, UK/Scotland, the Netherlands, Germany, the Faroe Islands, and Norway participated in the egg survey.

In 2019, the survey was split into six sampling periods. Due to a delay in starting the Portuguese survey it was decided to move the start date of period 2 in the southern area earlier into January and to incorporate the 9a survey into period 2. The final, sixth period ended in late July. Waters west and southwest of the Iberian Peninsula were surveyed in period 2 only. The Cantabrian Sea was sampled in periods 3 – 5 while Biscay was sampled in periods 2 to 6. The Celtic Sea and waters west of the British Isles were sampled in periods 2 to 7, and the vast oceanic waters north and northwest of Britain towards Iceland and into the Norwegian Sea were sampled in periods 5 and 6.

Mackerel daily egg production was highest in period 4, (April), for the western component, while for the southern component the maximum was observed in period 3. Total mackerel egg production (provisional, southern and western component combined) was 1.64×10^{15}. Provisional fecundity estimate was 1142 egg per gram female, resulting in an SSB index of 3.1×10^{6} tonnes.

For the Western stock of horse mackerel, highest mean daily egg production was estimated during the final sampling period 7. For almost all sampling periods, egg production in this species was much lower than observed during previous egg surveys. Total annual egg production for western Horse mackerel was 1.78×10^{14}.

ii Expert group information

Expert group name	Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS)
Expert group cycle	Multiannual fixed-term
Year cycle started	2018
Reporting year in cycle	2/3
Chair(s)	Gersom Costas, Spain
	Matthias Kloppmann, Germany
Meeting venue(s) and dates	9 – 13 April 2018, Dublin, Republic of Ireland, (18 participants)
	26 – 27 August 2019, Sta Cruz de Tenerife, Spain, (8 participants)

1 The timing and planning of the 2019 Mackerel/Horse Mackerel Egg Survey in the ICES Subareas 5 to 9 – amendments to the original plan (ToR a)

1.1 Countries and Ships Participating

Originally, as laid out in the published December 2018 survey plan (ICES 2019a), Germany, Ireland, Netherlands, Scotland, Portugal, Spain (IEO), Spain (AZTI), Iceland, Faroe Islands, and Norway intended to participate in the mackerel and horse mackerel egg surveys in the western and southern area in 2019. However, due to financial restrictions, Iceland was not able to provide ship's time to the survey. Also, due to prevailing engine problems, Germany had to replace its originally planned vessel by the Danish RV Dana, which also necessitated a shortening and slight postponement of the intended cruise. Survey dates, as well as vessel details, for cruises can be found below in table 1.1.1. The return of Norway to the survey provided additional coverage in the northern area compared to 2016.

The survey coordinator for the 2019 survey was Brendan O' Hea, Marine Institute, Galway, Ireland.

Table 1.1.1 Countries, vessels, areas assigned, dates and sampling periods for the 2019 surveys.

Country	Vessel	Area	Dates	Period
Portugal	Noruega	Portugal	Jan 23rd – Feb 26th	2
Ireland	Celtic Explorer	West of Ireland, Celtic sea, Biscay,	February 8th – 28th	2
	Corystes	West of Ireland, west of Scotland	June 9th – 29th	6
Scotland	Scotia	West of Scotland	February 24th – Mar 1st	2
	Altaire	West of Scotland, west of Ireland	March 19th – Apr 1st	3
	Altaire	West of Scotland	April 16th – 29th	4
	Scotia	West of Scotland, west of Ireland	May 8th – 30th	5
	Altaire	West of Scotland, west of Ireland, Celtic sea, Biscay	July 1st – 23rd	7
Spain (IEO)	Vizconde de Eza	Cantabrian sea, Galicia, southern Biscay	March 14th – April 5th	3
	Vizconde de Eza	Cantabrian sea, Galicia, Biscay	April 9th – May 4th	4
Spain (AZTI)	Ramon Margalef	Northern Biscay	March 19th – April 6th	3
	Ramon Margalef	Biscay, Cantabrian sea	May 4rd - 24th	5
Germany	Dana	Celtic sea, west of Ireland	March 29th – April 12th	3
	Dana	Celtic sea, west of Ireland, west of Scotland	April 15th – 30th	4
Netherlands	Tridens	Northern Biscay, Celtic sea	May 4th – 24th	5
	Tridens	Biscay, Celtic sea	June 5th – 23rd	6
Norway	Brennholm	Faroes & Norway	June 9th – 29th	6
Faroes	Magnus Heinason	Faroes, Iceland	May 23rd – June 5th	5

1.2 Survey Design

The AEPM survey design for mackerel and horse mackerel (Western and Southern stocks) for 2019 was not changed, however another attempt was made to estimate DEPM adult parameters for both species. This required additional sampling during the perceived peak spawning periods for these stocks, as identified from the 2010 surveys during WKMSPA 2012 (ICES 2012a). For the 2019 survey, this sampling was planned to take place during periods 3 and 4 for mackerel, during periods 6 and 7 for western horse mackerel, and during period 2 for southern horse mackerel.

In 2019 the survey was split into six sampling periods, and the design and survey deployment plan were very similar to those employed in 2016. Once again, the Faroe Islands participated in the survey during May, which expanded the geographic range of the survey in the North during that period. Norway participated in the survey, during period 6, also expanding the survey area north-eastwards into the Norwegian Sea.

Due to a delay in starting the Portuguese survey it was decided to move the start date of period 2 in the southern area earlier into January and to incorporate the division 9a survey into period 2. In 2019 the survey effort in division 9.a again targeted at a single extended DEPM survey. No sampling in division 9.a took place after the end of period 2.

Sampling in the western area commenced in period 2. During period 2 the survey concentrated on the Bay of Biscay, the Celtic Sea, West of Ireland and West of Scotland. In Periods 3 and 4 sampling started in the Cantabrian Sea and continuing north to the northwest of Scotland. No sampling took place in the Cantabrian Sea, or southern Biscay, after period 5. In Periods 5 and 6 the survey area was extended into Faroese and Icelandic waters. In periods 6 and 7 the surveys were designed to identify a southern boundary of spawning and to survey all areas north of this. The deployment of vessels to all areas and periods is summarized in Table 1.2.1.

While in 2013 the peak of mackerel spawning occurred in period 2 in the Bay of Biscay, in 2016 it occurred in May, to the west of Scotland. Therefore, and due to the expansion of the spawning area that has been taking place since 2007, the emphasis in 2019 was once again focused on maximizing area coverage. Cruise leaders were asked to cover their **entire** assigned area using alternate transects and then use any remaining time to fill in the missed transects. If time was short this should be concentrated in those areas identified as having the highest densities of egg abundance.

Table 1.2.1 Periods and area assignments for vessels by week for the 2019 survey.

		Area							
week	**Starts**	**Portugal, Cadiz & Galicia**	**Cantabrian Sea**	**Biscay**	**Celtic Sea**	**North west Ireland**	**West of Scotland**	**Northern Area**	**Period**
4	20-Jan-19	PO1 (DEPM)							2
5	27-Jan-19	PO1 (DEPM)							2
6	3-Feb-19	PO1 (DEPM)		IRL1	IRL1				2
7	10-Feb-19	PO1 (DEPM)		IRL1	IRL1				2
8	17-Feb-19	PO1 (DEPM)		IRL1	IRL1				2
9	24-Feb -19	PO1 (DEPM)		IRL1	IRL1	SCO(IBTS)	SCO(IBTS)		2
10	3-Mar-19								3
11	10-Mar-19		IEO1						3
12	17-Mar-19		IEO1	AZTI1		SCO2	SCO2		3
13	24-Mar-19		IEO1	AZTI1		SCO2	SCO2		3
14	31-Mar-19		IEO1		GER1	GER1			3
15	07-Apr-19		IEO2	IEO2	GER1	GER1			4
16	14-Apr-19		IEO2	IEO2	GER2	GER2	GER2/SCO3	SCO3	4
17	21-Apr-19		IEO2	IEO2	GER2	GER2	GER2/SCO3	SCO3	4
18	28-Apr -19		IEO2	IEO2					4
19	5-May-19		AZTI2 (DEPM)	AZTI2 (DEPM)	NED1	SCO4	SCO4		5
20	12-May-19		AZTI2 (DEPM)	AZTI2 (DEPM)	NED1	SCO4	SCO4		5
21	19-May-19		AZTI2 (DEPM)	AZTI2 (DEPM)	NED1	SCO4	SCO4	FAR	5
22	26-May-19					SCO4	SCO4	FAR	5
23	2-Jun-19			NED2	NED2				6
24	9-Jun-19			NED2	NED2	IRL2	IRL2	NOR	6
25	16-Jun-19			NED2	NED2	IRL2	IRL2	NOR	6
26	23-Jun-19					IRL2	IRL2	NOR	6
27	30-Jun-19			SCO5	SCO5	SCO5	SCO5		6
28	7-Jul-19			SCO5	SCO5	SCO5	SCO5		7
29	14–Jul-19			SCO5	SCO5	SCO5	SCO5		7
30	21-Jul-19			SCO5	SCO5	SCO5	SCO5		7
31	28-Jul-19								7

2 The timing and planning of the 2019 Mackerel/Horse Mackerel Adult Sampling Programme in the ICES Subareas 5 to 9– amendments to the original plan (ToR b)

2.1 Sampling for mackerel AEPM/DEPM in the Western and Southern areas.

Samples for estimation of mackerel potential fecundity and atresia (AEPM), and batch fecundity and spawning fraction (DEPM) should be mostly taken on vessels participating in the egg survey or from commercial fishing vessels by observers. Recognizing the constraints of the egg survey, which has to prioritize its sampling to the correct estimation of either annual or daily egg production, cruise leaders were asked to try to distribute trawl stations for the above-mentioned estimations across the survey area aiming at a widespread sampling regime for adults. Maturity of fish should be determined according to the Walsh Scale and the WKMATCH 2012 (ICES 2012b) revised maturity scale.

On each transect, trawl hauls were attempted close to stations with high stage 1 mackerel egg production. Trawling should be carried out preferably at dusk or during the night in the western area, and during the afternoon in the southern area.

Detailed survey procedures are laid out in the respective appendices of the WGMEGS survey and fecundity manuals (ICES 2019a, b).

2.2 Sampling for horse mackerel DEPM in the Western and Southern stocks.

Adult samples for horse mackerel DEPM parameters should be collected during period 6 & 7 from trawl hauls on the Western horse mackerel stock and during period 2 from trawl hauls on the Southern horse mackerel stock. All procedures for sampling adult horse mackerel are laid out in detail in the WGMEGS survey and fecundity manuals (ICES 2019 a, b).

3 Results of mackerel and horse mackerel egg staging and identification and fecundity and atresia workshops (WKFATHOM2) (ToRs c, d, e, g)

The Workshop on egg staging, fecundity and atresia in horse mackerel and mackerel (WKFATHOM) met twice in 2018. One meeting, held 8 to 12 October in Bremerhaven, Germany, was dedicated to calibrate egg sorting, staging and identification. The second, from 19 until 23 November in IJmuiden, The Netherlands, to calibrate fecundity and atresia estimation and standardize analysis for the DEPM methods.

The 'spray technique' for the removal of fish eggs from preserved plankton samples was again tested and shown to inexperienced participants. It was also tested for its proposed suitability to separate hake eggs from other eggs in the samples, because hake eggs appear to remain buoyant with the other plankton and do not sink.

The majority of the time at the Bremerhaven workshop was spent identifying and staging mackerel, horse mackerel and similar eggs. The results promoted discussion and highlighted specific problem areas. These discussions led to the further development of standard protocols, and enhancements to the species and stage descriptions. The results of the identification and staging exercises were very reassuring and with respect to the staging even better than those obtained at the 2015 workshop. While the experienced readers showed that they at least kept or even improved their capabilities in identifying and staging fish egg, the workshop also provided an excellent basis for training the new and unexperienced readers in their primary survey tasks

The survey manual SISP 6 (ICES 2019a) was updated and published through ICES during the first half of 2019.

The screening, fecundity and atresia calibration at the IJmuiden workshop proved beneficial to all participants. Particularly when the percentage of non-agreement in exercises is high. For screening clarification in the differentiation between the hydration and egg stages was necessary as well as classification of spent ovaries and massive atresia. For atresia estimation problems occurred basically when the methodological routine was not correctly applied. After discussions the manual has been improved. There was agreement on identification of vitellogenic and early alpha atretic oocytes. Few key features were agreed to define the transition of POF stages. POF staging remains difficult and further POF Staging ring test among participant is required.

The fecundity manual SISP 5 (ICES 2019b) was updated and published through ICES during the first half of 2019.

4 2019 Mackerel AEPM/DEPM Survey execution and preliminary results (ToR h)

4.1 The 2019 survey execution

As already described in section 1.1, the 2019 MEGS was split into 6 survey periods, the start and end dates of which can be found in table 4.1.1. For each of the 6 sampling periods, particular points to note are:

Period 2 – Portugal started the 2019 survey series on January 23rd. This DEPM survey is mainly targeting the southern horse mackerel stock and is designed for this purpose, but it provides mackerel egg samples as well. The survey is usually undertaken between Cadiz and the Galicia and is confined to ICES division 9.a. Period 2 also marks the commencement of the western area surveys. In the west MEGS once again started sampling earlier in February than would have been the case prior to the 2010 and 2013 surveys. Sampling was undertaken by Ireland (West of Scotland, west of Ireland, Celtic Sea, Biscay), and Scotland (West of Ireland and West of Scotland) (Figure 4.1.1). This year the mackerel migration appears to have been similar to that noted in 2016 and as a consequence only very low levels of spawning were found. The eggs that were recorded were close to the 200m contour line. Despite some very poor weather at the start of February survey coverage was good with 101 stations sampled, only 20 interpolations, and 14 replicate samples.

150 and 100 adult samples were collected for the southern and western Atlantic mackerel respectively through 56 fishing trawls, with only 12 being positive for Atlantic mackerel. No Atlantic mackerel samples were obtained during period 2 within the western area (Figure 4.1.2).

Period 3 – In period 3 the German vessel was operating to the West of Ireland, Celtic Sea and northern Biscay with Northwest Ireland and the West of Scotland being covered by Scotland. The Bay of Biscay, Cantabrian Sea and Galicia were covered by Spain (IEO and AZTI). Egg numbers were quite low to the west of Scotland, however further south large numbers of eggs were found close to the 200m contour line and the Porcupine bank (Figure 4.1.3). In Biscay and the Cantabrian Sea IEO and AZTI recorded a number of stations with large egg numbers. This was much higher than that recorded in 2016 for this area and time period. 362 stations were sampled and there were only 16 interpolations. There were 68 replicate samples with the majority being completed in the Cantabrian Sea.

1926 adults were collected during period 3, most of which were located south 48ºN (Figure 4.1.4) along the Cantabrian shelf and the Bay of Biscay (91%). More northern trawls were located southwest of Ireland, where less individuals were collected. In total 38 fishing trawls were performed, 12 of which were negative in Atlantic mackerel individuals.

Period 4 – This period was covered by three surveys. Denmark had intended to survey West of Scotland but were forced to withdraw. Scotland was subsequently able to mobilize an additional survey to cover this area. Germany surveyed west of Ireland, Celtic sea and northern Biscay while IEO completed the survey coverage in southern Biscay and the Cantabrian Sea (Figure 4.1.5). Once again moderate levels of eggs were recorded throughout the area, with the highest concentrations still being found close to the 200m contour line. The exception this year was a number of stations with exceptionally high counts recorded by Scotland along the 200m contour between the Butt of Lewis and Shetland. 319 stations were sampled and there were 55 interpolations. 50 replicate samples were taken, and these were collected from the Cantabrian Sea.

Individuals were collected both north of 48ºN, along the Irish and Scottish coasts, and the Cantabrian Sea (Figure 4.1.6). In total 723 samples were collected, split into 218 and 505 for the northern and southern

part of the surveyed area respectively. 5 of the 8 fishing trawl operations carried out were positive for Atlantic mackerel. Issues associated with the autotrawl system on the Scottish vessel restricted trawling operations to 1 deployment during this period.

Period 5 – In period 5, the entire spawning area from the Cantabrian sea to the West of Scotland, and up to Faroese waters at around 61°N was planned to be surveyed by AZTI, the Netherlands, Scotland, Faroes and Iceland. Due to the withdrawal of Iceland, Faroes agreed to cover the whole of the northern area on alternate transects. Extra stations were also added to the east of Faroes where very high mackerel counts had been recorded by Scotland in period 4. Several stations with significant numbers of stage 1 eggs were recorded in the Cantabrian Sea but throughout Biscay and into the southern Celtic sea numbers were generally low to moderate (Figure 4.1.7). This pattern continued west of Ireland to around 54°N, with spawning remaining on and around the Shelf edge. North of this however the pattern was similar to 2016, albeit the overall spawning density was significantly reduced compared to 3 years ago. Spawning activity fanned out greatly both westwards and northwards. Due to the large area Scotland had to survey their vessel was forced to restrict exploration of the western boundary to the SW of Rockall Bank. In this area significant numbers of eggs were recorded and consequently it was not possible to fully delineate the boundary in this region. North of this the Faroese survey completed stations North of Hatton Bank and up towards the Icelandic coast before bad weather curtailed sampling and ended the survey. In total 409 stations were sampled and there were 184 interpolations. 22 replicate samples taken.

The fishing trawls in this period were widespread distributed from Cantabrian Sea in the south to Faroes in the north. A total of 687 individuals were collected in 14 positive trawling operations, i.e. 17 fishing trawls were done in total (Figure. 4.1.8). Issues associated with the trawl winch deployment system on the Scottish vessel curtailed trawling operations during this period resulting in only 1 successful deployment.

Period 6 – During period 6 northern Biscay, from 46°N and also the Celtic sea were covered by the Netherlands while Ireland covered west of Ireland and also west of Scotland. Norway surveyed the area north of 59°N from the south of Iceland to the Norwegian coast. Low levels of spawning were observed all along the survey area from Biscay in the south to the West of Ireland and Porcupine bank (Figure 4.1.9). In contrast to the period 5 survey very few mackerel eggs were found between 54°N and 58°N, apart from close to the 200m line. West of the Faroes Norway secured the northern boundary at 63°N, while to the east of the Faroes small numbers of eggs were observed right up to survey boundary at 64°N. 422 stations were sampled with 210 interpolations. Six replicate station was completed.

889 individuals were obtained from 14 fishing trawl operations, 10 of them being positive in Atlantic mackerel. These individuals were distributed from Celtic Sea to Norwegian Coast. The most northly and westerly located trawls were obtained within this period (Figure 4.1.10).

Period 7 – This period was covered entirely by Scotland sampling on alternate transects in the area from 47°15N in the South (Figure 4.1.11). Due to the lack of eggs encountered the Scottish survey adhered very closely to the 200m contour. As a result, the survey followed this contour line as far as Shetland before heading north to reach 63.15°N. 145 stations were sampled with 60 interpolations. Only 1 replicate station was completed. Only very low levels of spawning were observed, and these were confined to the continental shelf and shelf edge with all spawning boundaries being delineated successfully.

137 mackerel were obtained during 6 fishing trawls were performed during this period although, 2 of which contained mackerel. These individuals were distributed between NW Ireland and Porcupine Bank Figure 4.1.12).

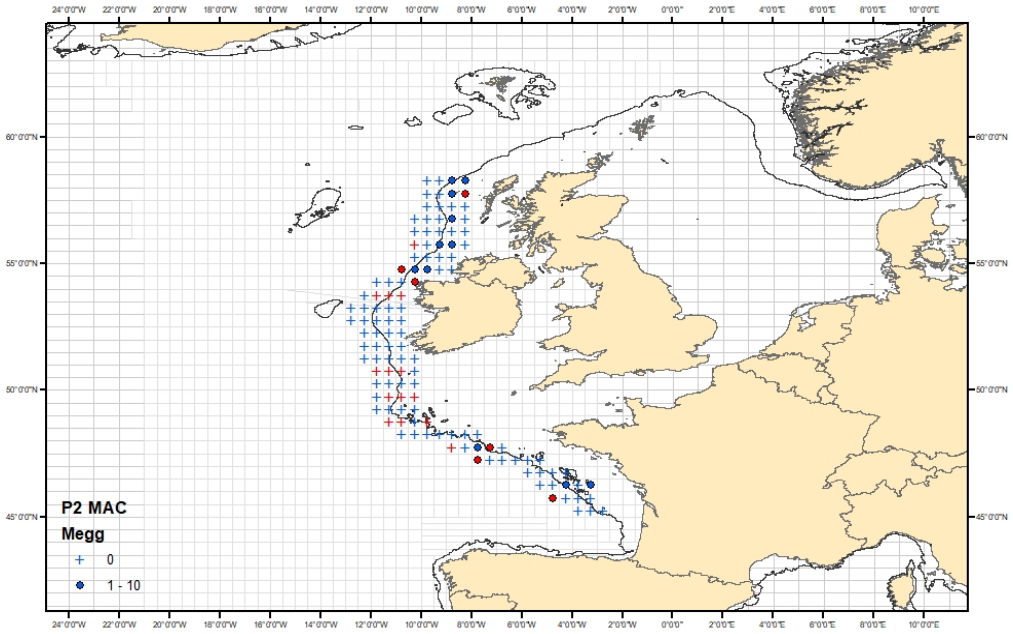

Figure 4.1.1: Mackerel egg production (stage 1 eggs/m2/day) by half rectangle for period 2 within the western area (Feb 11th – Mar 1st). Filled blue circles represent observed values, filled red circles represent interpolated values, blue crosses represent observed zeroes, red crosses denote interpolated zeroes.

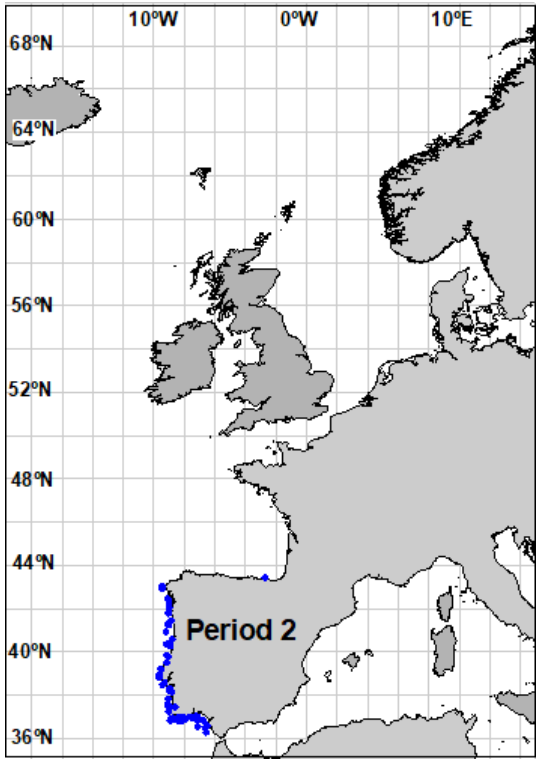

Figure 4.1.2 Fishing hauls (both, positive or negative for Atlantic mackerel) for period 2.

No egg production results are currently available for the southern area within period 2 (Jan 23rd – Feb 26th).

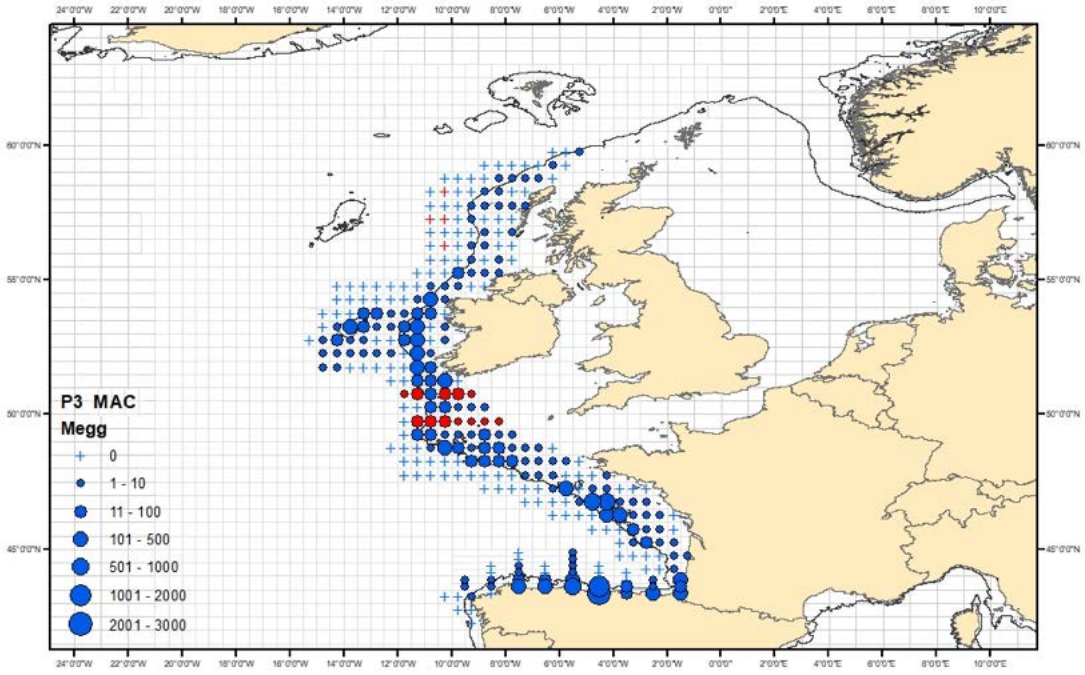

Figure 4.1.3: Mackerel egg production (stage 1 eggs/m2/day) by half rectangle for period 3 within the western (Mar 19th – Apr 12th) and southern areas (Mar 14th – Apr 5th). Filled blue circles represent observed values, filled red circles represent interpolated values, blue crosses represent observed zeroes, red crosses denote interpolated zeroes.

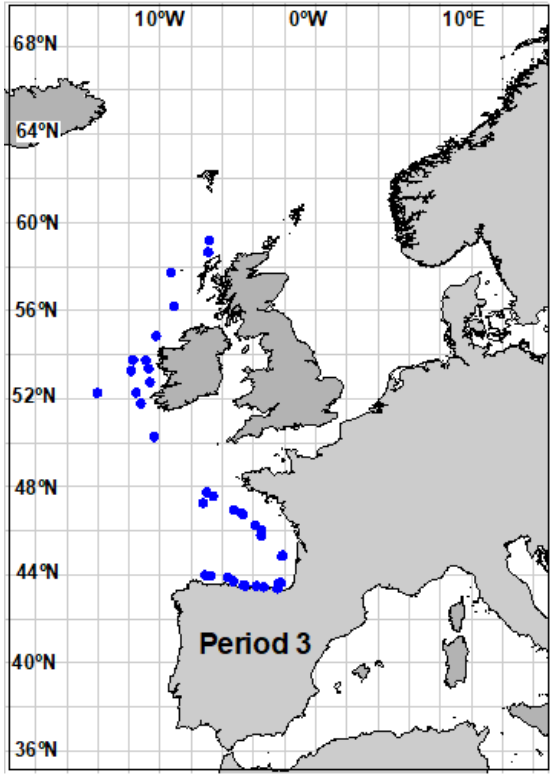

Figure 4.1.4: Fishing hauls (both, positive or negative for Atlantic mackerel) for period 3.

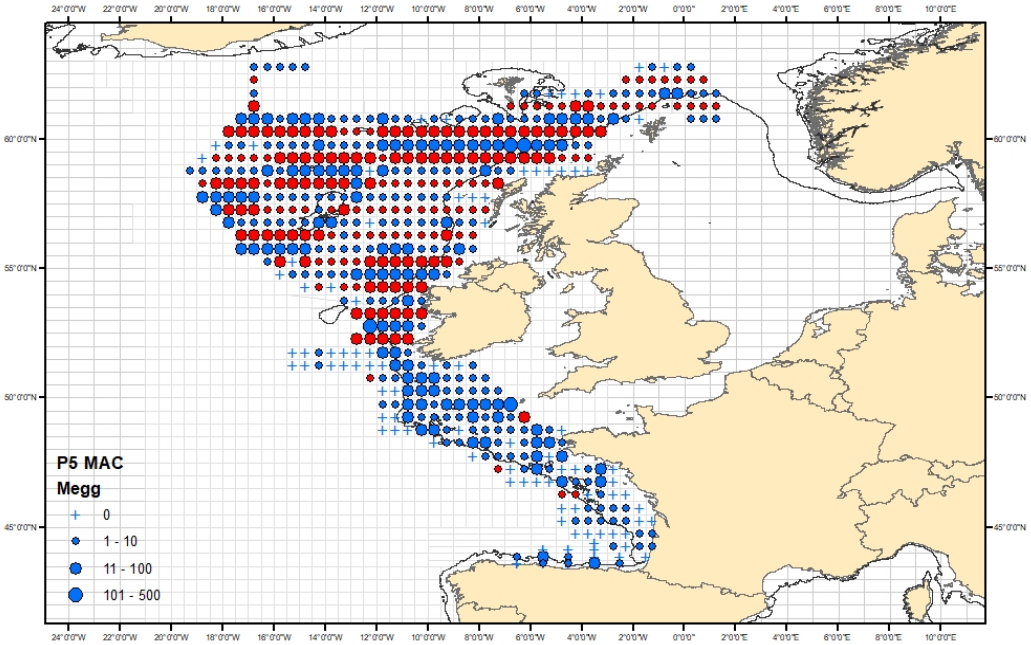

Figure 4.1.7: Mackerel egg production (stage 1 eggs/m2/day) by half rectangle for period 5 within the western (May 4th – May 31st) and southern areas (May 4th – May 8th). Filled blue circles represent observed values, filled red circles represent interpolated values, blue crosses represent observed zeroes, red crosses denote interpolated zeroes.

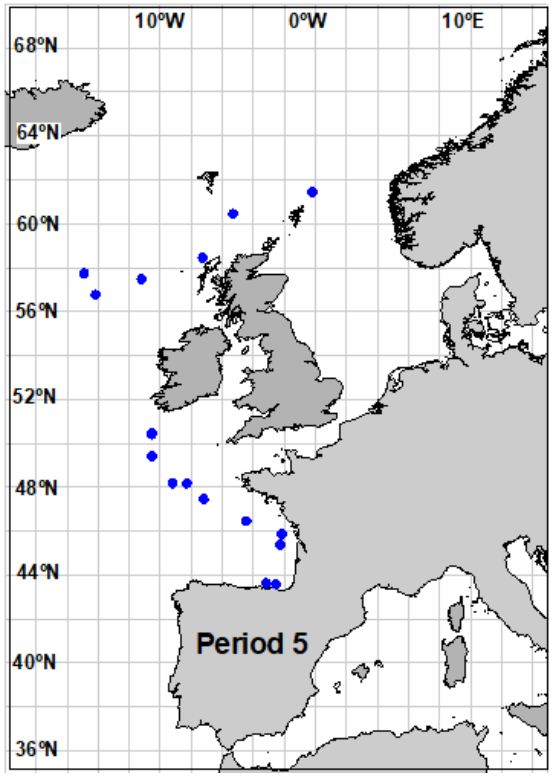

Figure 4.1.8: Fishing operations, trawl and rod & line (both, positive or negative for Atlantic mackerel) for period 5.

mackerel) for period 5.

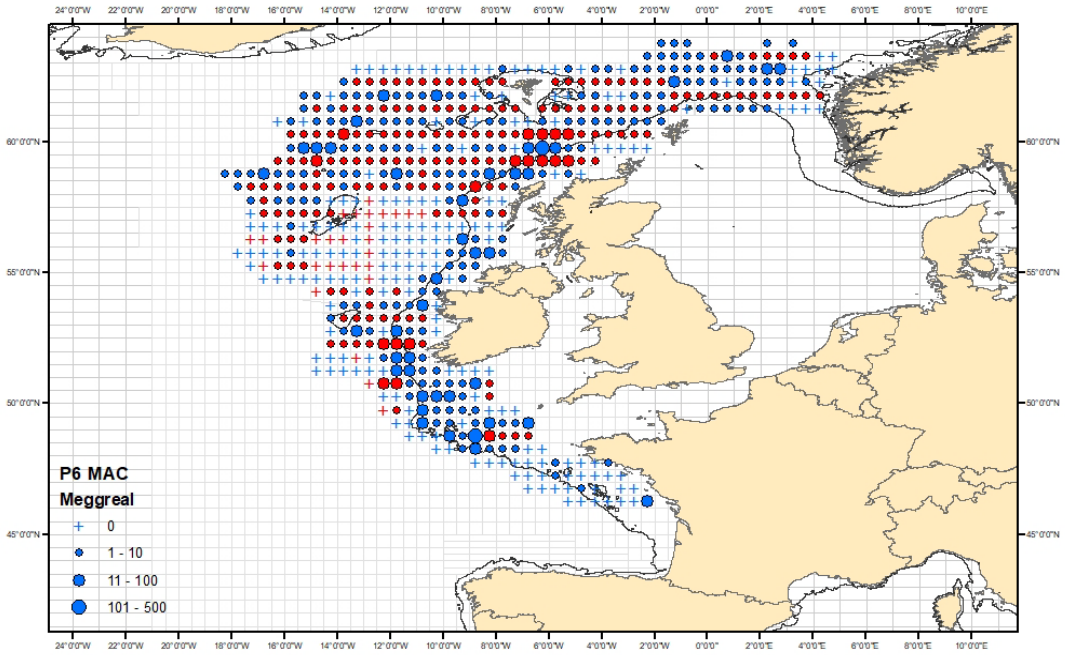

Figure 4.1.9: Mackerel egg production (stage 1 eggs/m2/day) by half rectangle for period 6 within the western area (Jun 6th – Jun 28th). Filled blue circles represent observed values, filled red circles represent interpolated values, blue crosses represent observed zeroes, red crosses denote interpolated zeroes.

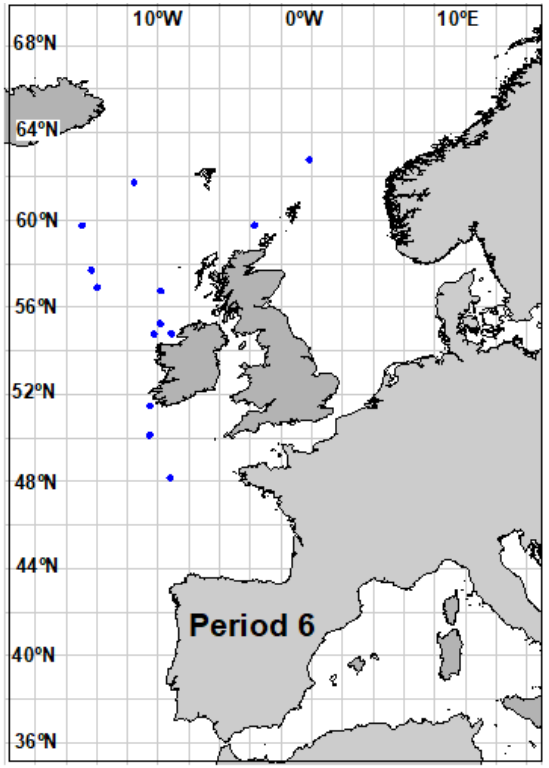

Figure 4.1.10: Fishing operations, trawl and rod & line (both, positive or negative for Atlantic mackerel) for period 6.

line
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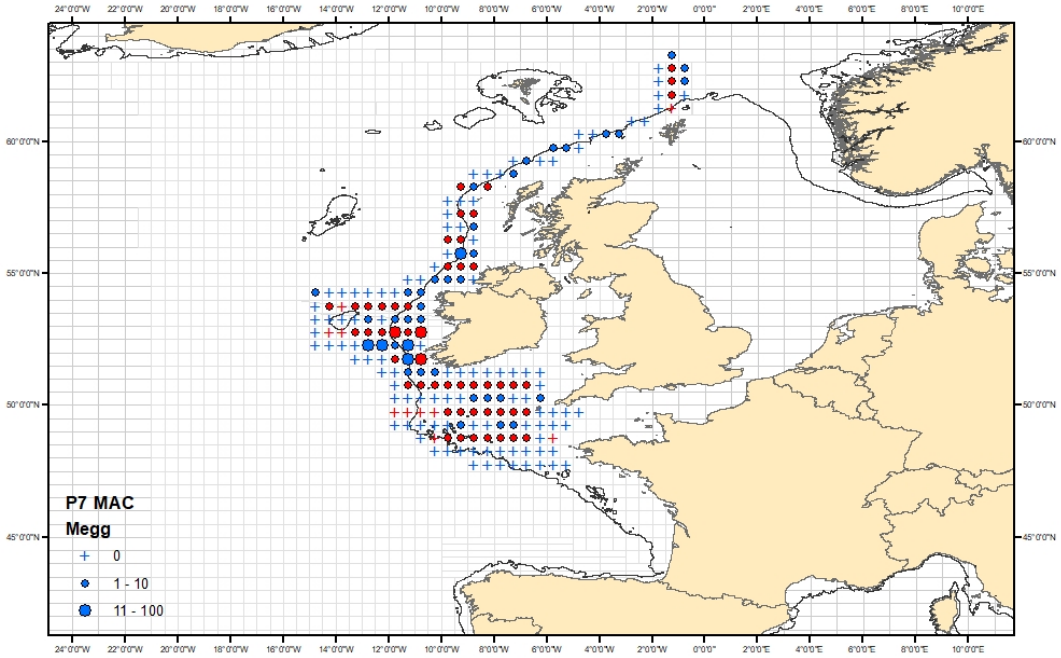

Figure 4.1.11: Mackerel egg production (stage 1 eggs/m2/day) by half rectangle for period 7 within the western area (July 2 – June 22). Filled blue circles represent observed values, filled red circles represent interpolated values, blue crosses represent observed zeroes, red crosses denote interpolated zeroes.

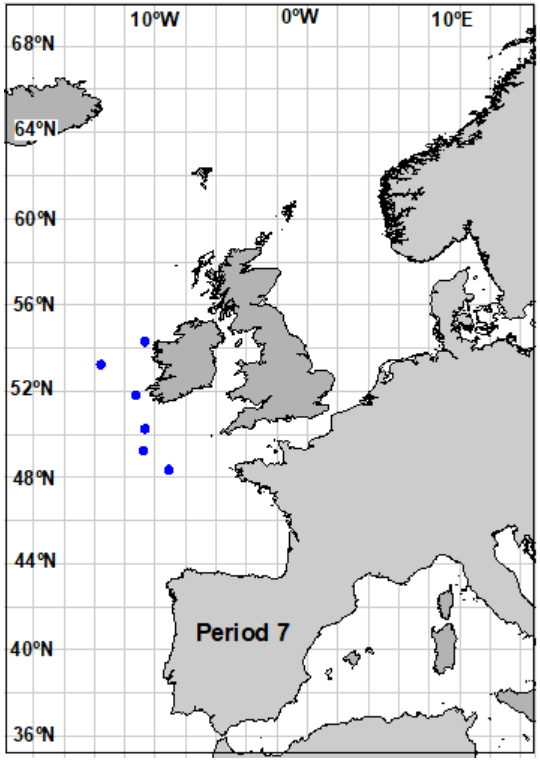

Figure 4.1.12: Fishing hauls (both, positive or negative for Atlantic mackerel) for period 7.

Figure 4.1.12: Fishing hauls (both, positive or negative for Atlantic mackerel) for period 7.

4.2 Hydrography – Temperatures at 20 m depth

The temperature values at 20 depth are used in the calculation of the daily egg production for mackerel and horse mackerel. Horizontal distribution of those temperatures during all sampling periods are displayed in figure 4.2.1. Overall, temperatures at 20 m depth ranged from values < 8 °C to >17.5 °C and were very similar in their distribution to those observed during the 2016 MEGS. Lowest temperatures were always observed in the North increasing towards the South and also with progression of the sampling periods. Temperatures were almost everywhere and all the time higher than the supposed threshold minimum value of 8 °C associated to an increased probability of mackerel egg occurrence.

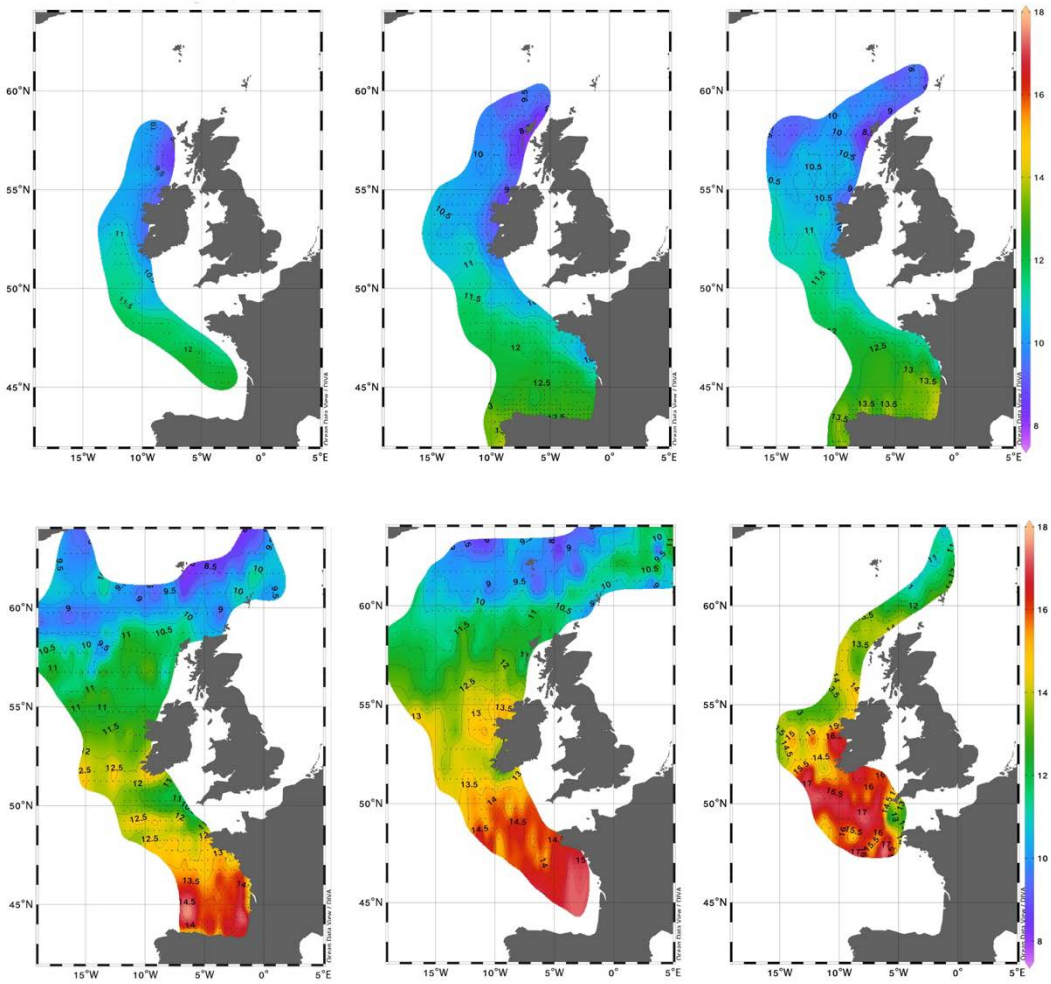

Figure 4.2.1 The 20 m depth temperature distribution for periods 2 – 4 (top row, left to right) and periods 5 – 7 (bottom row, left to right).

4.3 Mackerel AEPM Preliminary Results

4.3.1 Stage 1 Egg production in the Western Areas

2010 provided an unusually large spawning event early in the spawning season, while 2013 yielded an even larger spawning event indicating that spawning was probably taking place well before the nominal start date of 10th February (day 42). In 2016 the first survey commenced on February 5th which is five days prior to the nominal start date. That year however mackerel migration was later and slower than that recorded in the previous two surveys. The pattern in 2019 followed that of 2016 with no early peak spawning being recorded (Figure 4.3.1.1 & Table 4.3.1.1). This year however peak spawning was found to have taken place in period 4, rather than period 5 as was the case in 2016. Unlike 2016 when concern was expressed that survey coverage may have underestimated the total egg production estimate, area coverage in 2019 was much better. The expansion observed in western and northwestern areas during periods 5 and 6 in 2016 was once again reported during 2019, however egg numbers were not as large as in 2016. During period 5 the northern and northwestern boundaries were once again not delineated, however the exploratory egg surveys carried out in this region during both 2017 and 2018 provide significant evidence that while some spawning has been missed the loss of egg abundance is not sufficiently large to significantly impact the SSB estimate.

The nominal end of spawning date of the 31st July is the same as was used during previous survey years and the shape of the egg production curve for 2019 does not suggest that the chosen end date needs to be altered. The provisional total annual egg production (TAEP) for the western area in 2019 was calculated as $1.22 * 10^{15}$ (Table 4.3.1.1). This is a 20% reduction on the 2016 TAEP estimate which was $1.55 * 10^{15}$.

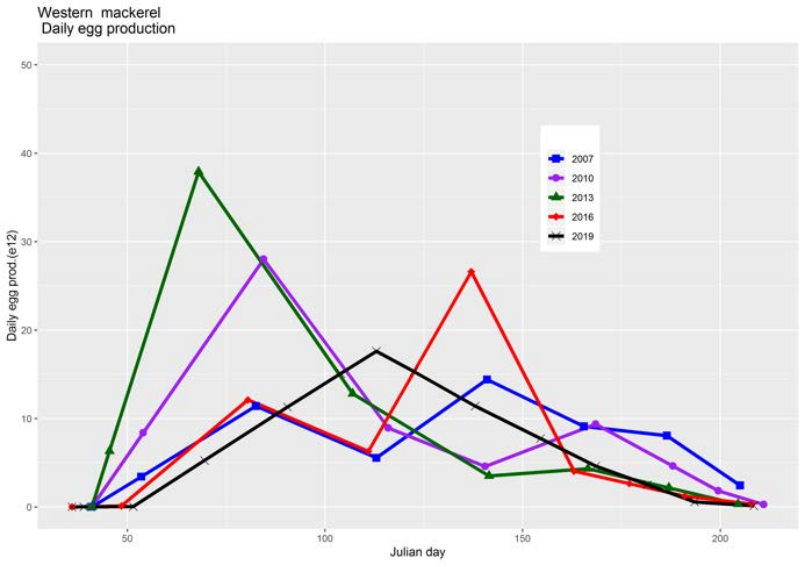

Figure 4.3.1.1: Provisional annual egg production curve for mackerel in the western spawning component. The curves for 2007, 2010 2013 and 2016 are included for comparison.

Table 4.3.1.1 Western estimate of mackerel total stage I egg production by period using the histogram method for 2019.

Dates	Period	Days	Annual stage I egg production * 10^{15}
	Pre 2		0
Feb 11th – Mar 1st	2	25	0.0007
Mar 2nd – 18th	2 - 3	17	.09
Mar 19st – April 12th	3	25	0.28
Apr 13th – 14th	3 - 4	2	.03
Apr 15th – April 30th	4	16	0.28
May 1st – 3rd	4 - 5	3	.05
May 4th – May 31st	5	28	0.32
Jun 1st – 5th	5 - 6	5	0.04
Jun 6th – June 28th	6	23	0.11
June 29th – July 1st	6 – 7	3	0.008
June 2nd – July 22nd	7	21	0.01
July 20th – July 31st	Post 7	12	0.004
Total			1.22
CV			20%

4.3.2 Stage 1 Egg production in the Southern Areas

The start date for spawning in the southern area was the 23rd January (Table 4.3.2.1). The start date of the Portuguese period 1 survey in division 9.a was delayed by around 1 week. As a result, the survey dates aligned more closely to period 2. It was subsequently reclassified within period 2 and survey period 1 was removed. Sampling in the Cantabrian Sea where most of the spawning occurs within the Southern area commenced 6 days later than in 2016 on the 14th March. The same end of spawning date of the 17th July was used again this year and the spawning curve suggests that there is no reason for this to change (Figure 4.3.2.1). As in 2013 the survey periods were not completely contiguous, and this has been accounted for (Table 4.3.2.1). The provisional total annual egg production (TAEP) for the southern area in 2019 was calculated as **$4.19 * 10^{14}$**(Table 4.3.2.1). This is a 54% increase on the 2016 TAEP estimate which was $2.25 * 10^{14}$ (Figure 4.3.1.2).

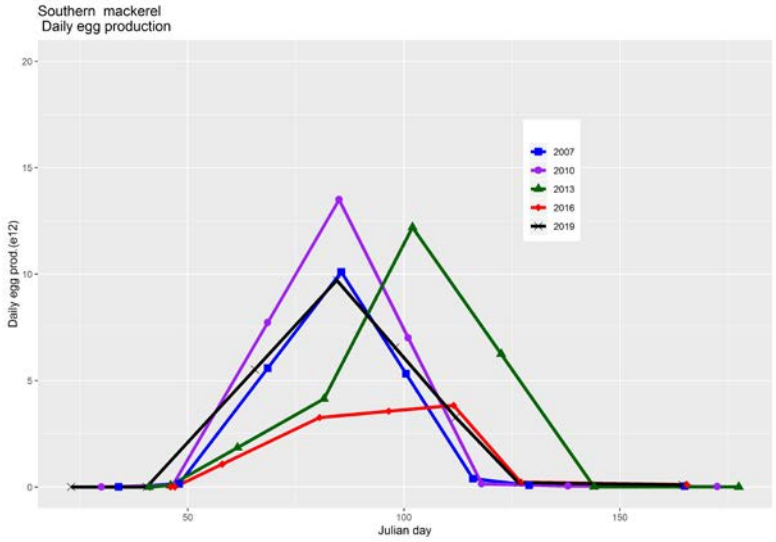

Figure 4.3.2.1: Provisional annual egg production curve for mackerel in the southern spawning component. The curves for 2007, 2010, 2013 and 2016 are included for comparison.

Table 4.3.2.1: Southern estimate of mackerel total stage I egg production by period using the histogram method for 2019.

Dates	Period	Days	Annual stage I egg production x 10^{14}
	1	No sampling	
Jan 23rd – Feb 26th	2	35	0
Feb 27th –Mar 13th	2 - 3	15	0.83
March 14th – April 5th	3	23	2.23
April 6th – April 9th	3 - 4	4	0.26
April 10th – May 3rd	4	24	0.79
May 4th – May 8th	5	5	0.01
May 9th –July 17th	Post 5	71	0.07
Total			4.19
CV			99%

4.3.3 Total Egg production

Total annual eggs production (TAEP) for both the western and southern components combined in 2019 is **$1.63*10^{15.}$** (Figure4.3.3.1). This is a decrease in production of **9%** compared to 2016.

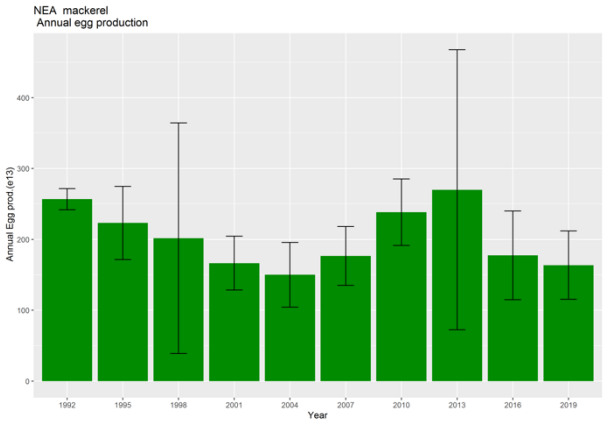

Figure 4.3.3.1: Combined mackerel TAEP estimates ($*10^{15}$) - 1992 – 2019.

4.3.4 Adult sampling

Adult Parameters

Atlantic mackerel fecundity samples were collected during periods 2-7, spread over an area within a bounding box of 62.77N 14.94W – 36.55N 0.16W. Eight institutes participated in the collection. The biological sampling was carried out in 4612 individuals and 1335 of which were retained for further fecundity analysis (Table 4.3.4.1). Unfortunately, only the 45% of the adult sampling objective was achieved (see ICES WGMEGS 2018).

Table 4.3.4.1. Total number of Atlantic mackerel individuals collected in the biological sampling and number of ovaries retained for further fecundity analysis.

Period	Biological sampling	Fecundity sampling
2	250	75
3	1926	695
4	723	237
5	687	167
6	889	161
7	137	0
Total	4612	**1335**

Screening

The histological screening of samples was performed by four institutes while fecundity was analysed by six institutes. As for earlier years, this preliminary fecundity estimate is based on samples from period 2 and 3 only. Not all samples from the periods 4-5 arrived at the participating screening laboratories with enough time to process them before the ICES WGWIDE 2019 meeting. Results of those samples will, however, be included in the finalized results in April 2020.

Of the total 1335 individuals obtained for fecundity, 904 samples were screened, of which 707 were from periods 2 and 3 (Table.4.3.4.2). Of those, 565 samples showed spawning markers, i.e. migratory nucleus stage (MIG), hydrated oocytes, eggs, and post ovulatory follicles (POFs). Both MIG and POF presence /absence are difficult to detect on whole mount samples and therefore they are looked for only in the histological screening.

Table 4.3.4.2. Number of samples collected and analysed by period. The column *Fecundity Histology* shows the number of samples that were qualified by histological screening for fecundity analysis. *Fecundity Whole Mount* shows the number of samples that qualified for fecundity analysis after the whole mount screening that came afterwards. *Atresia presence* means the number of samples in which early alpha atresia was found.

Period	Screened	Spawning Markers	POFs	Fecundity Histology	Fecundity Whole mount	Atresia Presence
2	32	24	21	2	2	3
3	675	541	494	38	33	156
4	191	173	165	2	1	32
5	6	4	4	1	1	0
Total	904	565	684	43	37	191

Results from previous surveys showed that POF scoring could vary considerably between periods. At WKFATHOM2 (ICES 2018) this issue was discussed and more detailed criteria for POF staging were elaborated. Looking at screening results from 2019, POFs were identified more frequently than in 2016 for periods 2 and 3, i.e. 74 %vs.59% (Table **4.3.4.2**).

A total of 159 samples from periods 2-3 showed presence of atresia without considering those that were classified as "spent" or having "massive atresia" (Table **4.3.4.2**).

Considering that most of the samples in periods 2-3 were at MIG or hydrated oocyte stage (n = 596) and that only 66 were in vitellogenic oocyte stage, potential fecundity samples were reduced to 39 individuals. The whole mount evaluation allows identifying whether there is any mismatch between the histological and whole mount reading of the samples selected for fecundity analysis. In general, both readings agreed. However, five samples classified as fecundity samples in histology were reclassified in whole mount screening due to presence of hydrated oocytes (n = 2), eggs (n = 1) or being early vitellogenic (n=1) or spent (n = 1). These samples were dropped from the first pull of potential samples and the final number of fecundity samples reduced to 34.

Nonetheless, more samples will be screened during the following months, in fact, 63 samples belonging to period 2 and 3 are potentially used for fecundity analysis (Table **4.3.4.1**).

Related to this, a screening ring test was performed before the beginning of the survey among the analysing laboratories. 10 people from 5 institutes participated on a screening exercise consisted on 11 histological pictures of ovaries at different stages. Preliminary results (Figure 4.3.4.1) provided a high screening agreement among participants, although results will be further analysed and together with the other ring tests as agreed during WKFATHOM2 meeting (2018) for the final report of WGMEGS in 2020.

Figure 4.3.4.1: Screening ring test carried out before the beginning of Mackerel egg survey as agreed during WKFATHOM2.

Biological data of fish samples to fecundity

Mean length, weight and ovary weight of fish analysed for fecundity were higher in 2019 than in previous survey (Figure 4.3.4.2).

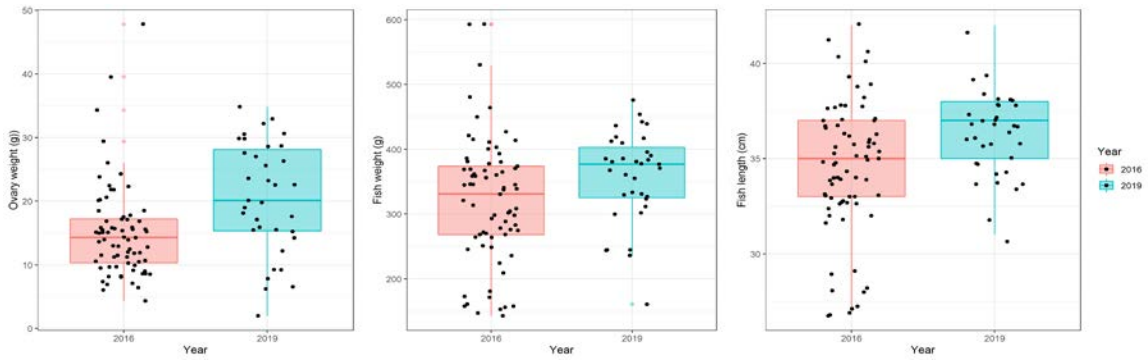

Figure 4.3.4.2: Fish length ad weight, and ovary weight of individuals analysed for fecundity.

Fish condition (Fulton K) and gonadosomatic index (GSI) were analysed to see if there were any change in the distribution pattern compared to 2016 (Figure 4.3.4.3). Comparing the same periods, we found that the condition factor was slightly lower while the GSI was higher in 2019 than in 2016

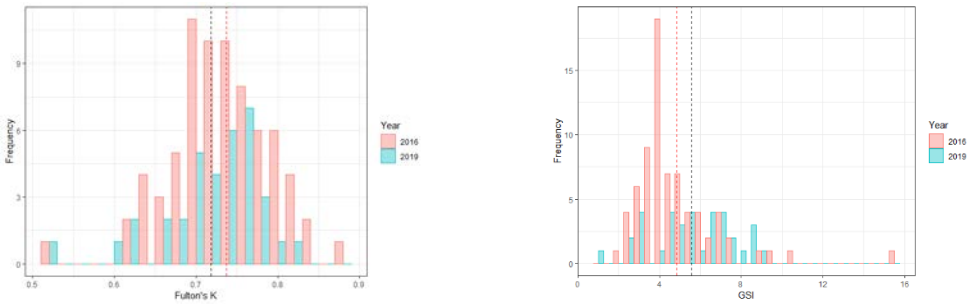

Figure 4.3.4.3: Fulton's K and GSI of individuals analysed for fecundity in 2016 and 2019. Dashed lines are the means in 2016 (red) and 2019 (black) for each factor and index respectively.

4.3.5 Potential Fecundity

For the 2019 preliminary estimate of potential fecundity, 34 samples were available, which represents 5% of all samples screened for periods 2 and 3. This number was lower than in 2016, when 66 samples were available for the preliminary report. However, as mentioned before 63 samples more will be screened soon, some of which will be added to the pull of samples for fecundity estimation analysis.

For the 2013 and 2016 surveys, the median was used for relative fecundity estimation while the mean was used previously. The reason for the change is related to the fact that that unlike the mean, the median is not influenced by extreme values. A posterior analysis showed that the median for relative potential fecundity was close to the arithmetic mean in most years. The largest difference was in 2013, but even then, the median was within the confidence interval of the potential fecundity arithmetic mean. During WGMEGS 2018 (ICES 2018b) we discussed whether we should use the trimmed mean instead of the median for the potential fecundity estimate. A trimmed mean is preferred for calculation of confidence intervals. However, until the time-series data are reanalysed in the near future, it was decided that the relative fecundity estimate should still be based on the median rather than the mean, as for 2013 and 2016. (Figure 4.3.5.1).

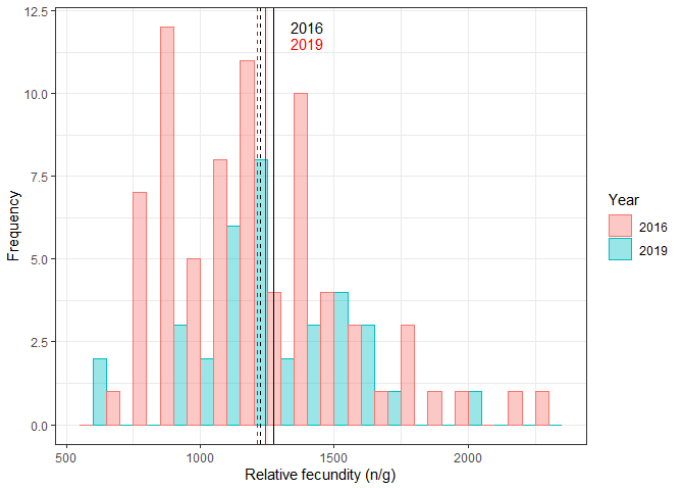

Figure 4.3.5.1: Relative fecundity preliminary estimation in 2016 and 2019. Median: dashed line, Mean: solid line.

The preliminary relative potential fecundity in 2019 was slightly higher than in 2016 (1215 and-1159, respectively) (Figure 4.3.5.2 and Table 4.3.5.1). This difference was however not significant (Kruskal–Wallis U-test, test statistics missing, $p > 0.05$).

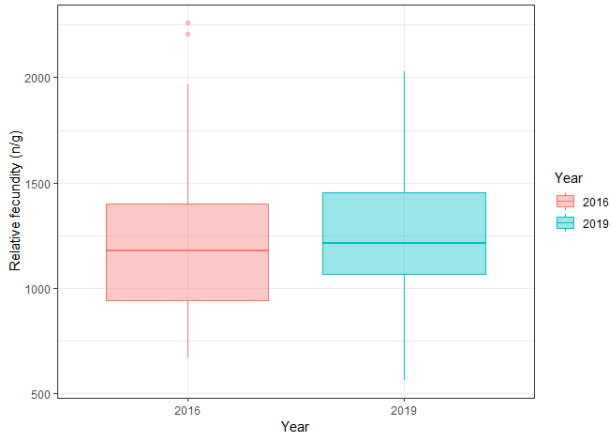

Figure 4.3.5.2: Relative fecundity preliminary estimation in 2016 and 2019.

Table 4.3.5.1. Estimate of relative fecundity (n/g fish) and statistics.

N	Median	Mean	sd	Max	Min	95%CI
34	1215	1263	285	2029	564	1163-1362

Atresia

Atresia is the loss of oocytes by reabsorption before spawning and must be subtracted from the potential fecundity (whole mount fecundity counting) to estimate the realized fecundity. In this preliminary report, intensity of atresia will not be presented due to the time consumed for the histology screening.

The prevalence of atresia estimated by histological screening may however be a good indicator of the level of atresia. Prevalence of atresia is defined as the percentage of spawning fish which have early stage atresia (early alpha-atresia). Among the 507 samples considered (Table **4.3.4.1**) the prevalence of atresia estimated was 31 % (fish from period 2-3, excluding spent fish and fish with massive atresia).

A fecundity ring test was carried out among participants before the beginning of the survey in January (Figure 4.3.5.3). 7 samples were analysed by 10 people from 6 institutes. Preliminary results showed that there were not significant differences among participants ($p > 0.05$) but they will be further analysed for the next WGMEGS report in 2020.

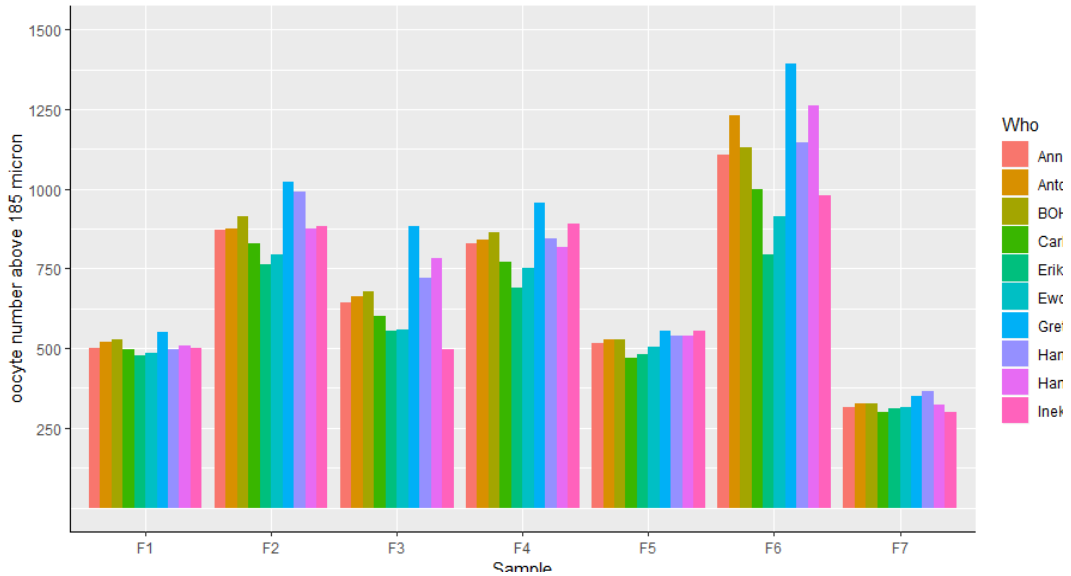

Figure 4.3.5.3: Fecundity ring test carried out before the beginning of Mackerel egg survey as agreed during WKFATHOM2.

An atresia ring test will be carried out among survey participants during the current autumn-winter in order to calibrate the survey readings, which results will be provided during WGMEGS 2020 meeting.

4.3.6 Realized Fecundity

Realized fecundity is defined as the potential fecundity minus the loss by atresia. The loss by atresia is a function of both intensity of atresia and prevalence of atresia. The intensity of atresia for 2019 is still unavailable, therefore the loss was calculated from the average loss from the surveys since 2001 (Table 4.3.6.1). The relative loss by atresia from this period (2001-2016) ranged from 6-9% (average 6%).

Based on this, the preliminary realized fecundity-estimate for 2019 was 1142 oocytes/gram female. The working group acknowledges that the number of analysed samples for preliminary potential fecundity this year is lower (n = 34) than previous years. The realized fecundity estimate is, however, well within the observed range of realized fecundity (1002-1209, average 1066 egg per gram female) from all previous surveys back to 1998 (Table 4.3.6.1). For the three most recent surveys, realized fecundity varied between 1070 and 1209 eggs per gram female (average 1122).

Table 1.3.6.1 Summary table of mackerel fecundity and atresia by survey year.

	Assessment year							
	1998	**2001**	**2004**	**2007**	**2010**	**2013**	**2016**	**2019**
								Prel.
Fecundity samples (n)	96	187	205	176	74	132	97	34
Prevalence of atresia (n)	112	290	348	416	511	735	713	507
Intensity of atresia (n)	112	290	348	416	511	56	66	
Relative potential fecundity (n/g)	1206	1097	1127	1098	1140	1257*	1159*	1215*
Prevalence of atresia	0.55	0.2	0.28	0.38	0.33	0.22	0.3	0.31
Geometric mean intensity of atresia (n/g)	46	40	33	30	26	27	30	
Potential fecundity lost per day (n/g)	3.37	1.07	1.25	1.48	1.16	0.8	1.2	
Potential fecundity lost (n/g)	202	64	75	89	70	48	72	
Relative potential fecundity lost (%)	17	6	7	9	6	4	6	
Realized fecundity (n/g)*	1002	1033	1052	1009	1070	1209	1087	1142

*Median not mean relative potential fecundity

4.3.7 Biomass estimation

Based on the total annual egg production (TAEP) for the western and southern component, a preliminary realized fecundity estimate of 1142 oocytes/gr female, a sex ratio of 1:1 and a raising factor of 1.08 (ICES, 1987), the preliminary total spawning-stock biomass (SSB) was estimated as shown below:

$$SSB = \frac{TAEP}{F'} * s * cf$$

Where

F′ = realized fecundity,

s = 2 for a given sex ratio of 1:1,

cf = 1.08 (fixed raising factor to convert prespawning to spawning fish)

Giving

- 2.301 million tonnes for western component (2016: 3.077).
- 0.792 million tonnes for southern component (2016: 0.447).
- 3.092 million tonnes for western and southern components combined (2016: 3.524)

4.4 Mackerel DEPM Preliminary Results

4.4.1 Egg Production

Egg production data are provided by periods 3 and 4 surveys (see Table 4.2.1.1 and Table 4.2.1.2). Detailed analysis and corresponding results for daily egg production will be presented with the final WGMEGS report in 2020.

4.4.2 Adult sampling

The number of adults collected was 2649, corresponding to individuals in the peak of spawning (see Table 4.4.1, previous section). This number is 57% of the samples collected in all periods. 932 ovaries were stored for fecundity analysis. Thus, the DEPM sampling objective was achieved in a 48%.

Screening

By the time of reporting preliminary results, 866 out of 932 individuals were screened (Table 4.4.1) for batch fecundity and POFs. 62 samples were candidate for batch fecundity estimation according to screening results for the moment. More samples will be screened soon that may be potentially used for batch fecundity estimation. Regarding POFs, during the screening only POFs presence/absence is recorded; POFs staging, which is used for spawning fraction estimation, will be done in a second step analysis. This requires quite enough morphophysiological experience and it is time consuming. In fact, results from previous surveys showed that POF scoring could vary considerably between periods. At WKFATHOM2 (ICES 2018) this issue was discussed and more detailed criteria for POF staging were elaborated.

Table 4.4.1. Number of samples qualified by histological screening for POFs staging and batch fecundity analysis.

Period	Screened	POFs	Batch Fecundity Histology
3	675	494	49
4	191	165	13

4.4.3 Batch fecundity

As mentioned before, there is no data available yet due to time schedule.

Spawning-fraction-POFs will be staged during the current autumn-winter along with a POF ring test that will be carried out among survey participants in order to calibrate the readings, which results will be provided during WGMEGS 2020 meeting.

Summary table for mackerel AEPM/DEPM adult sampling

Period	Number of fishing trawls		Number of measured individuals	Objective number of ovaries to collect	Number of collected ovaries	Number of screened ovaries	AEPM		DEPM	
	(+)	(-)					Fecundity*	Atresia	Batch fecundity	POFs
2	12	44	250	200	75	32	2	3	0	0
3	26	12	1926	990	695	675	32	156	49	494
4	8	3	723	1260	237	191	0	32	13	165
5	14	3	687	225	167	6	0	0	0	0
6	10	4	889	175	161	0	0	0	0	0
7	2	4	137	100	0	0	0	0	0	0
Total	72	70	4612	2950	1335	904	34	191	62	659

4.5 The 2019 Horse Mackerel AEPM/DEPM Survey execution and preliminary results (ToR h)

4.5.1 Western Horse Mackerel AEPM Survey execution

Period 2 – No horse mackerel eggs were found in this period (to see the extent of the sampling area, see Figure 4.1).

Period 3 – In period 3 horse mackerel spawning starts in the Cantabrian Sea, but numbers of eggs found are very low. Some spawning also took place west of Ireland (Figure 4.5.1.1).

Period 4 – Horse mackerel was spawning continues in the Cantabrian Sea, extending into southern Biscay. Small numbers of eggs were found in the Celtic Sea (Fig. 4.5.1.2).

Period 5 – Horse mackerel spawning continues in the Cantabrian Sea, Celtic Sea and northern Bay of Biscay, but in low numbers around the 200m depth contour. Some eggs were also found south and west of Ireland (Figure4. 5.1.3).

Period 6 – Spawning was confined to the Celtic sea with very few eggs being found outside this area, apart from some stations close to the French coast (Figure 4.5.1.4). 10 fishing trawls, four of which containing horse mackerel, caught 404 individuals from an area between the Celtic Sea and north of Ireland/West coast of Scotland. (Figure 4.5.1.5)

Period 7 – Eggs are found from the Celtic Sea to west of Scotland. In general egg numbers were low but occasional stations with high counts were found. Peak spawning took place in this period. High egg numbers are found in the Celtic Sea and Rockall (Figure 4.5.1.6). 220 specimens of horse mackerel individuals were collected by 4 positive fishing trawls (6 trawls in total) from the area between southwest of the coast of Ireland and the Celtic Sea (Figure 4.5.1.7)

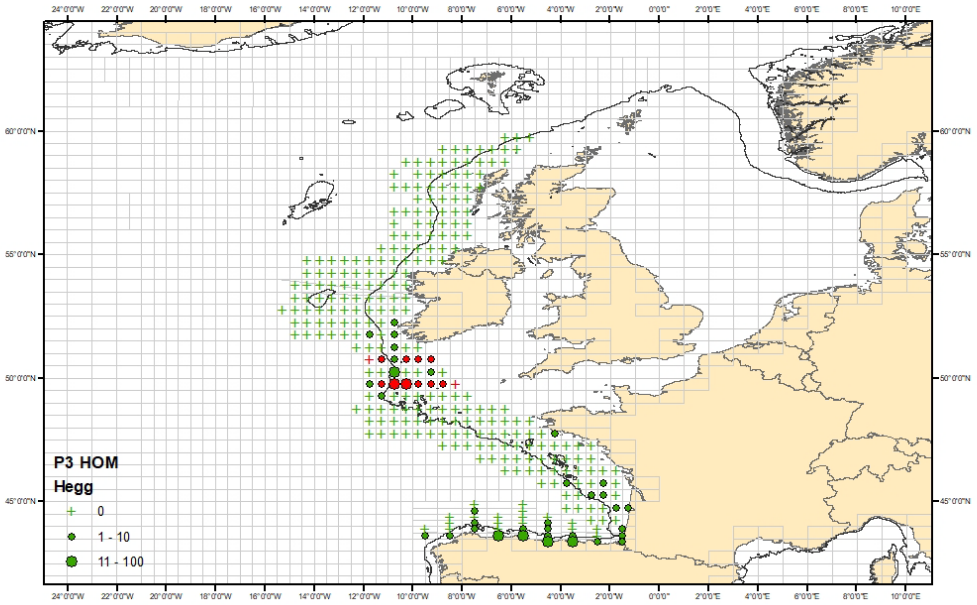

Figure 4.5.1.1: Western horse mackerel egg production (stage 1 eggs/m2/day) by half rectangle for period 3 (Mar 15th – Apr 14th). Filled green circles represent observed values, filled red circles represent interpolated values, green crosses represent observed zeroes, red crosses denote interpolated zeroes.

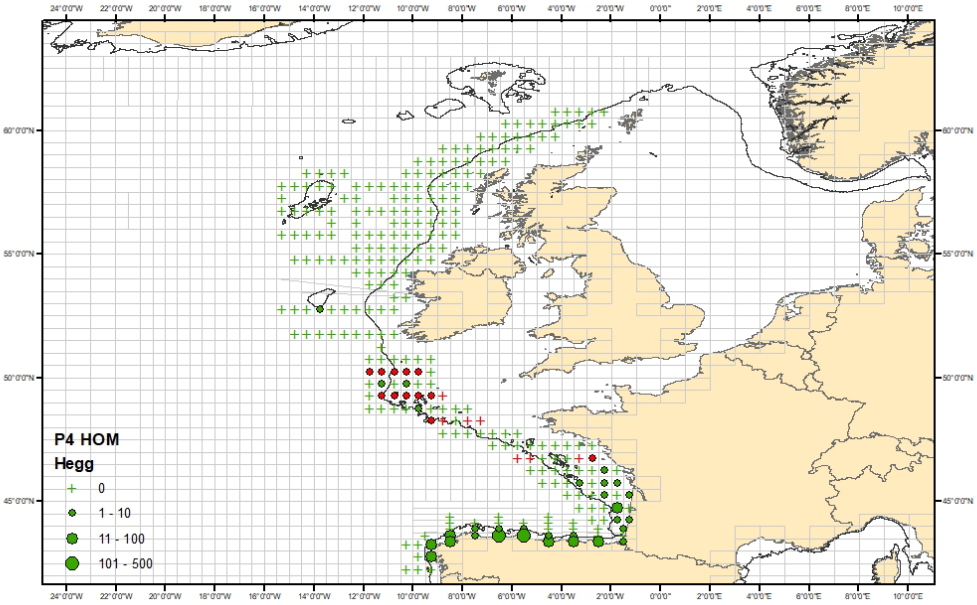

Figure 4.5.1.2: Western horse mackerel egg production (stage 1 eggs/m2/day) by half rectangle for period 4 (Apr 15th – May 2nd). Filled green circles represent observed values, filled red circles represent interpolated values, green crosses represent observed zeroes, red crosses denote interpolated zeroes.

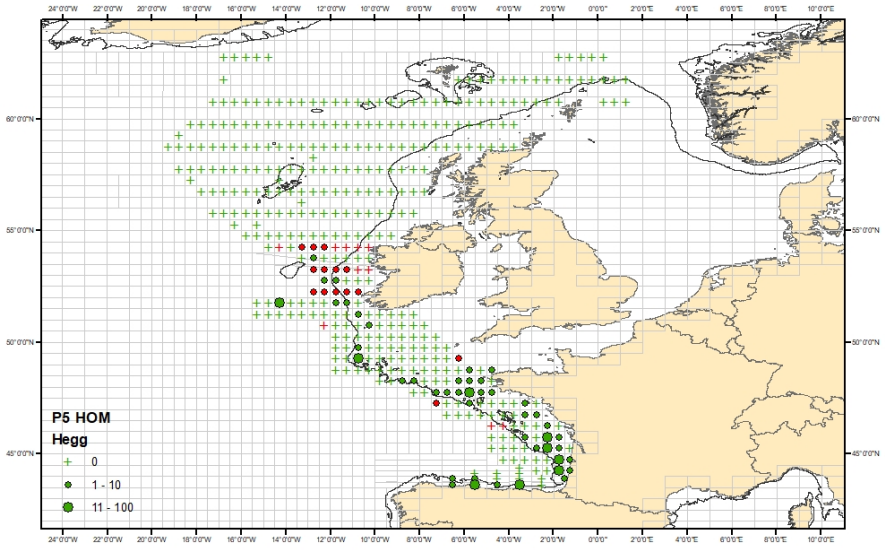

Figure 4.5.1.3: Western horse mackerel egg production (stage 1 eggs/m2/day) by half rectangle for period 5 (May 4th – May 31st). Filled green circles represent observed values, filled red circles represent interpolated values, green crosses represent observed zeroes, red crosses denote interpolated zeroes.

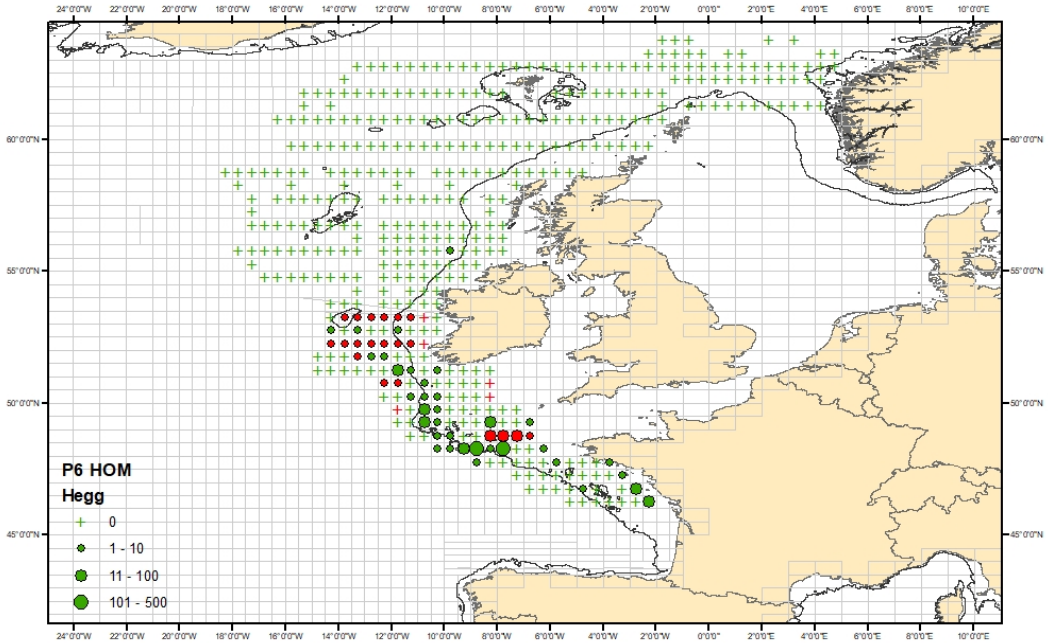

Figure 4.5.1.4: Western horse mackerel egg production (stage 1 eggs/m2/day) by half rectangle for period 6 (Jun 6th – Jun 28th). Filled green circles represent observed values, filled red circles represent interpolated values, green crosses represent observed zeroes, red crosses denote interpolated zeroes.

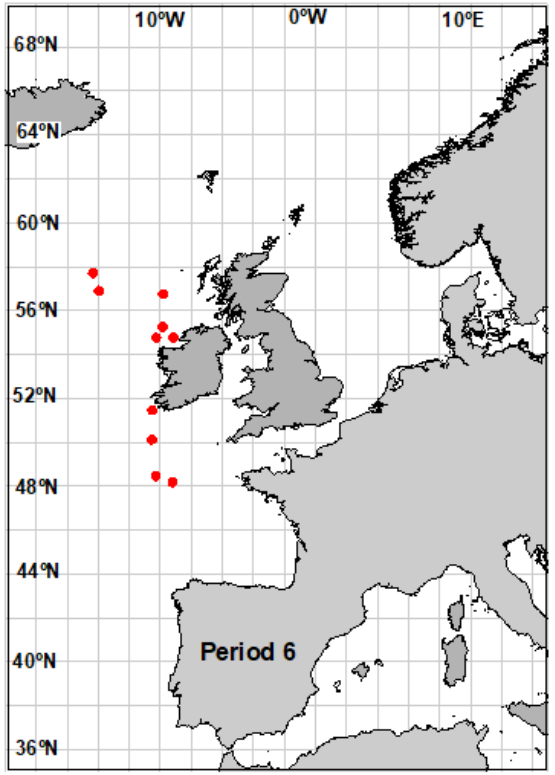

Figure 4.5.1.5: Fishing operations, trawl and rod & line (both, positive or negative for Atlantic horse mackerel) for period 6.

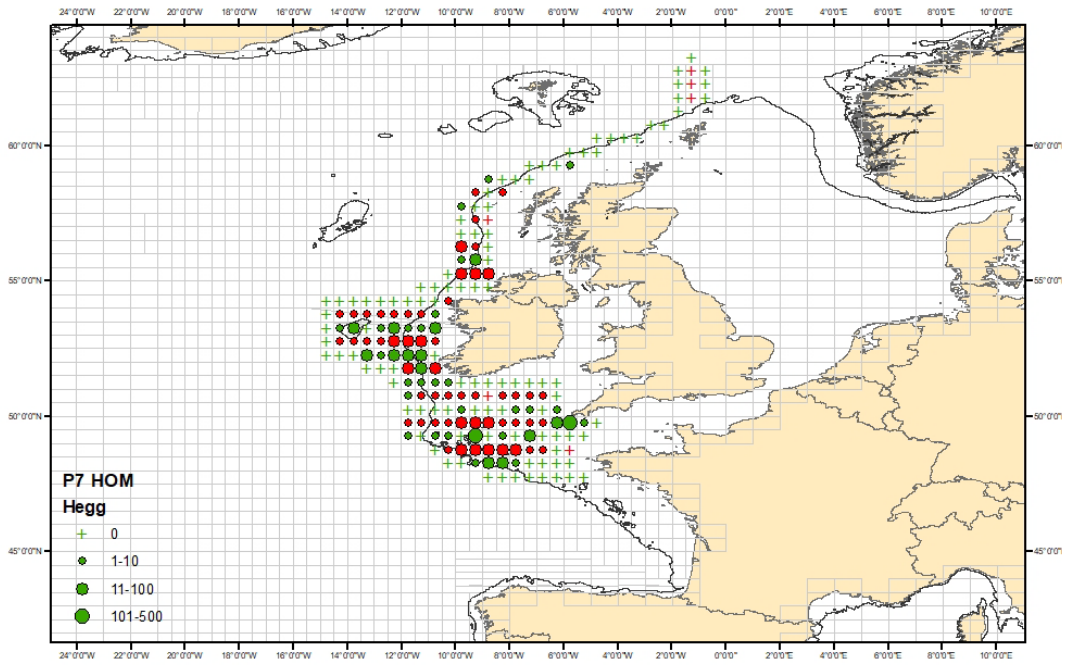

Figure 4.5.1.5: Western horse mackerel egg production (stage 1 eggs/m2/day) by half rectangle for period 7 (Jul 2nd – Jul 22nd). Filled green circles represent observed values, filled red circles represent interpolated values, green crosses represent observed zeroes, red crosses denote interpolated zeroes.

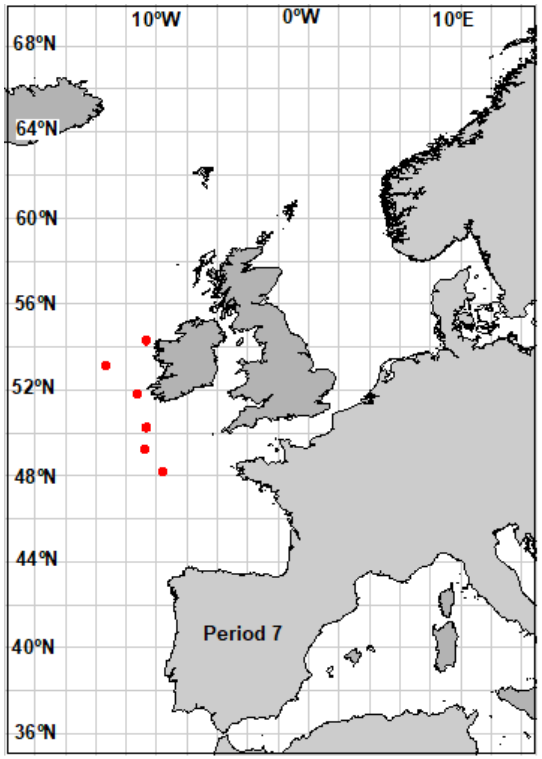

Figure 4.5.1.7: Fishing trawls (both, positive or negative for Atlantic horse mackerel) for period 7.

4.5.2 Western Horse Mackerel AEPM Preliminary Results.

Total Egg production

Period number and duration are the same as those used to estimate the western mackerel stock, as are the dates defining the start and end of spawning (Table 4.4.2.1). The shape of the egg production curve does not suggest that those dates should be altered for 2019 (Fig 4.4.2.1). The total annual egg production was estimated at 1.78 x 10^{14}. This is a decrease of almost 53% on 2016 which was 3.31 × 10^{14} and is the lowest estimate of annual egg production ever recorded for this species.

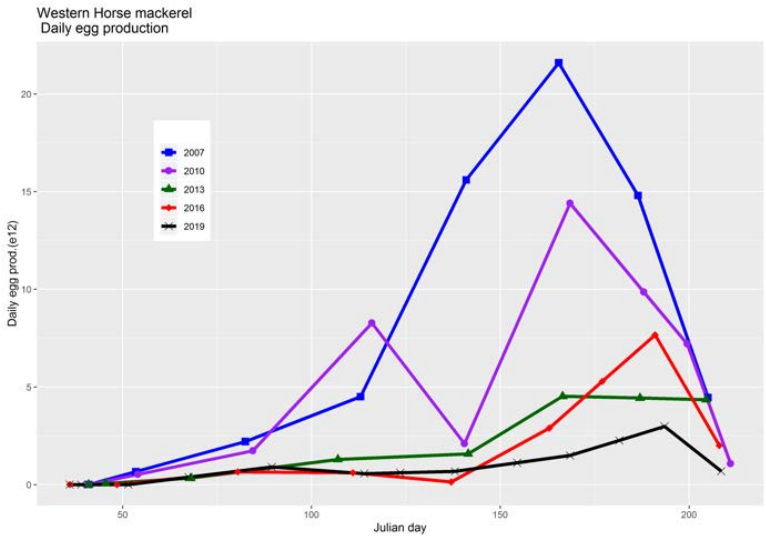

Figure 4.5.2.1: Provisional annual egg production curve for western horse mackerel. The curves for 2007, 2010, 2013 and 2016 are included for comparison.

Table 4.5.2.1: Western estimate of horse mackerel total stage I egg production by period using the histogram method for 2019

Dates	Period	Days	Annual stage I egg production * 10^{15}
	Pre 2		0
Feb 11th – Mar 1st	2	25	0
Mar 2nd – 14th	2 - 3	13	.005
Mar 15th – April 14th	3	31	0.03
Apr 15th – May 2nd	4	18	0.01
May 3rd	4 - 5	1	.0006
May 4th – May 31st	5	28	0.02
Jun 1st – 5th	5 - 6	5	0.006
Jun 6th – June 28th	6	23	0.034
June 29th – July 1st	6 – 7	3	0.007
June 2nd – July 22nd	7	21	0.06
July 20th – July 31st	Post 7	12	0.004
July 23rd – 31st	Post 7	9	0.007
Total			0.178
CV			57%

4.5.3 Western Horse Mackerel DEPM Preliminary Results

4.5.3.1 Egg production in the peak spawning period.

Expected peak spawning for western horse mackerel is in period June to July. This year, peak spawning for western horse mackerel was found to have taken place in period 7 (July), same period that in 2016. The Stage I egg production for period 7was 6.26 * 10^{13} and .for period 6 was 3.42 * 10^{13} (Table 4.5.2.1) .

4.5.3.2 Adult parameters

This year for horse mackerel only DEPM ovary samples were collected in periods 6 and 7, during peak of spawning. Since horse mackerel fecundity is at this moment not used for estimating the spawning-stock biomass the focus of the fecundity analysis has been on mackerel.

624 individuals were sampled during periods 6 and 7; 182 female samples ranging from 3-6 maturity Walsh scale were collected for fecundity analysis. No screening was done due to time constrains as last survey ended on July. Thus, it is uncertain the number of samples directed to batch fecundity analysis and spawning fraction. All samples will be analysed and results presented at the 2020 WGMEGS meeting.

4.5.3.3 DEPM results –Western Horse Mackerel

The horse-mackerel egg data of the DEPM survey are still under revision. Data are expected to be analysed and results will be presented at the 2020 WGMEGS meeting.

Summary table for horse mackerel DEPM adult sampling

Period	Number of fishing trawls		Number of measured individuals	Objective number of ovaries to collect	Number of collected ovaries	Number of screened ovaries	DEPM	
	(+)	(-)					Batch fecundity	POFs
6	4	6	404	510	122	0	0	0
7	4	2	220	510	60	0	0	0
Total	8	8	624	1020	182	0	0	0

4.5.4 Southern Horse Mackerel DEPM. Survey execution and preliminary results

The Portuguese survey takes place and covers the southern and western Atlantic-Iberian waters (ICES division 9a). The DEPM methodology involves surveying during the peak spawning time in spawning area. Concurrently adult samples are obtained for adult parameter estimation (female mean weight, sex-ratio, batch fecundity and spawning fraction).

In 2019 the DEPM for southern horse mackerel survey was carried out in the period 23 January - 28 February in division 9.a by Portugal. A total of 550 stations were located along the 48 transects of the regular grid.

4.5.4.1 Hydrography

In 2019, and according to schedule, surveying during the PT-DEPM19-HOM started at its southern limit, off Cape Trafalgar, in the Bay of Cadiz, on the 25th of January and ended at its northern border, close to Cape Finisterre, on the 25th of February, with a 2 days break in Lisbon for vessel replenishment and team replacements.

The oceanographic conditions encountered during the period of late January – end of February were the typical for a winter situation (Figure 1). The sea surface temperature ranged from 12.5ºC, in the northern coast (Aveiro to Cape Finisterre), where an extended water mass of lower temperature were observed, to close to 17ºC in the more offshore area of the Cadiz Bay (Figure 4.5.4.1, left panel). The distribution of surface salinity also showed well the wintry patterns with clear plumes of less saline water due to river run-off. This pattern was particularly marked in the NW region (Figure 4.5.4.1, middle panel). Associated to the regions of fresh water influence (but also linked to some signs of upwelling in specific spots) patches of high fluorescence (higher chlorophyll density) were very conspicuous (Figure 4.5.1.1, right panel), indicating the characteristic onset of the late winter primary production activity.

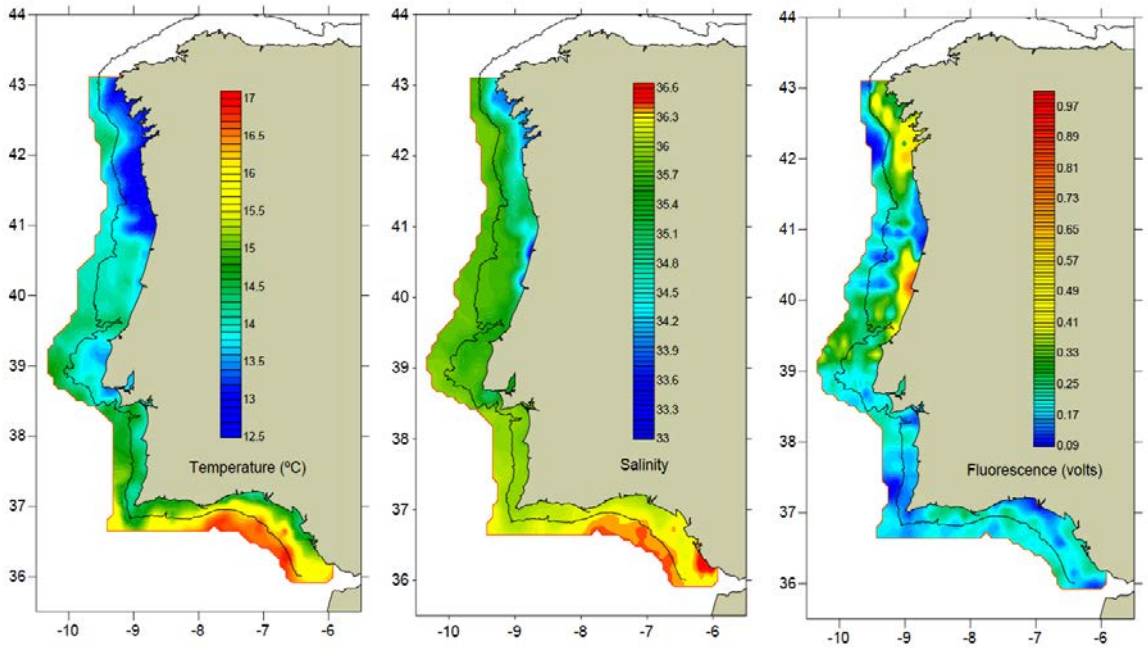

Figure 4.5.4.1.1 Sea surface distributions of temperature (left panel), salinity (middle panel) and fluorescence (right panel). The data were obtained by the sensors associated to the CUFES system.

4.5.4.2 Results from egg and adult sampling

Egg sampling

Currently the analysis of the samples is in progress. So far, identification and stageing for horse-mackerel is complete for around one third of the samples.

In the 194 samples analysed (Figure 4.5.4.2.1 right panel), horse-mackerel eggs represented 9% of the total eggs collected in this region. Hardly any horse-mackerel eggs were observed in the Gulf of Cadiz and higher densities of horse-mackerel were observed to the west of Cape Sta Maria and in the west coast between Cape Sines and river Sado (Portugal coast).

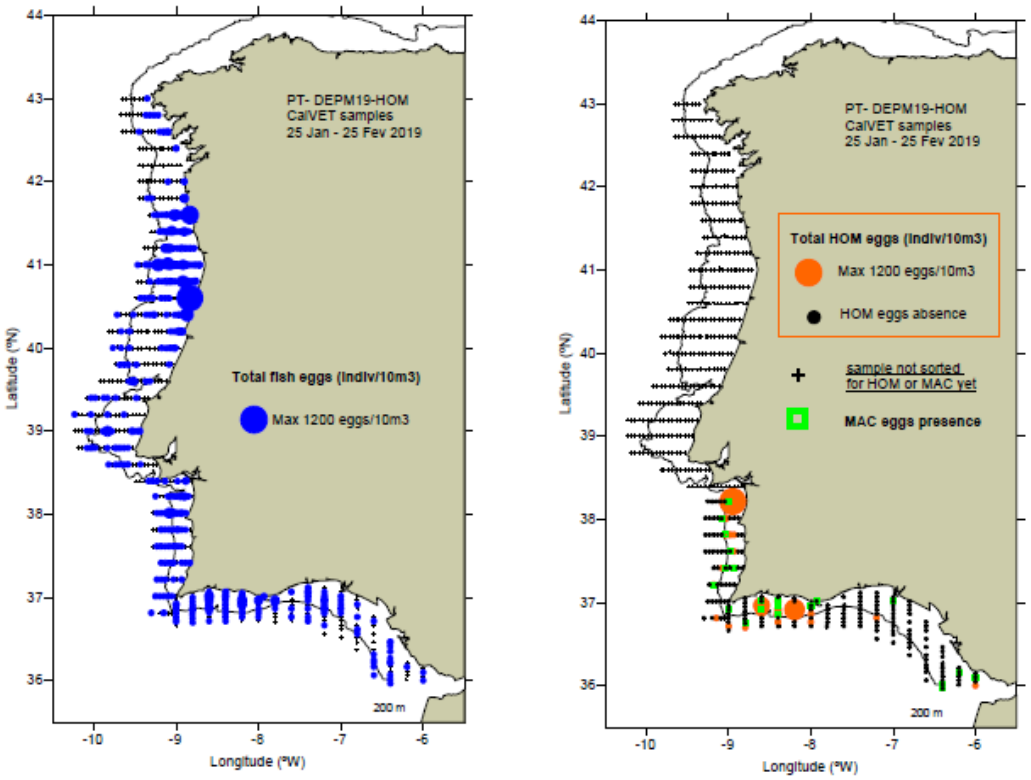

Figure 4.5.4.2.1 Survey coverage, sampling stations occupied and fish egg abundance distributions. Left panel, total egg abundance distribution (in blue) and right panel, horse-mackerel (HOM) total egg abundance distribution (in orange). Green squares indicate mackerel (MAC) egg presence. The analyses for HOM and MAC eggs are still incomplete.

Adult parameters

Biological data from 2215 fish were obtained from 71 fishing trawls, being 35 of them positive in horse mackerel (Figure 4.5.4.2.2), 1051 ovaries were preserved for histological processing. The horse mackerel sampled ranged in size from 13 to 42 cm.. Smaller fish were caught significantly in the South and most of the female fish sampled were mature (~5% of macroscopically scored fish as immature); less than 1% of the females were in a post-spawning phase whereas ~1/4 were in a developing one.

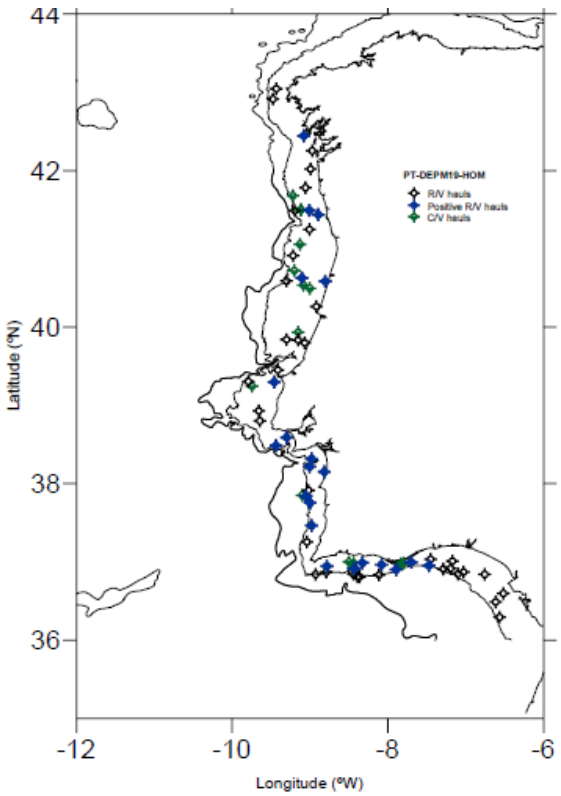

Figure 4.5.4.2.2 Position of the fishing hauls carried out during the survey onboard the research vessel or from the commercial fleet which horse mackerel samples were obtained for the estimation of the DEPM parameters.

5 References

ICES 2012a. Report of the Workshop on Survey Design and Mackerel and Horse Mackerel Spawning Strategy (WKMSPA), 16-17 April 2012, Galway, Ireland. ICES CM 2012/SSGESST:05. 28 pp.

ICES 2012b. Report of the workshop for maturity staging chairs (WKMATCH). ICES CM 2012\ACOM:58, 57 pp.

ICES 2018a. Report of the Workshop on egg staging, fecundity, and atresia in horse mackerel and mackerel (WKFATHOM2). 8-12 October and 19-23 November. Bremerhaven, Germany and IJmuiden, Netherlands. ICES CM 2018/EOSG:22. 74pp.

ICES 2018b. Report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS), 9 - 13 April 2018, Marine Institute, Dublin, Ireland. ICES CM 2018/EOSG:17 70 pp.

ICES 2019a. Manual for mackerel and horse mackerel egg surveys, sampling at sea. Series of ICES Survey Protocols SISP 6. 82 pp. http://doi.org/10.17895/ices.pub.5140

ICES 2019b. Manual for the AEPM and DEPM estimation of fecundity in mackerel and horse mackerel. Series of ICES Survey Protocols SISP 5. 89 pp. http://doi.org/10.17895/ices.pub.5139

Annex 1: List of participants

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Annex 2: Agenda

Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS)

26-27 August 2019, Sta Cruz de Tenerife, Spain – post survey meeting

Relevant ToR's (years 2 & 3)

g) Examine the results of the, workshops on mackerel and horse mackerel egg staging and identification (Bremerhaven, Germany, 8 – 12 October 2018), and fecundity and histology (IJmuiden, The Netherlands, 19 – 23 November 2018), and incorporate these into the Survey Manual for the 2019 survey;

h) Fine-tune survey execution in 2019;

i) Analyse and evaluate the results of the 2019 mackerel and horse mackerel egg surveys in the western and southern areas;

1. calculate the total seasonal stage 1 egg production estimates for mackerel separately for the western and southern areas;
2. calculate the total seasonal stage 1 egg production estimates for the western horse mackerel stock (AEPM);
3. analyse and evaluate the results of the mackerel and horse mackerel fecundity and mackerel atresia sampling in the western and southern areas;
4. provide estimates of the spawning-stock biomass of mackerel, using stage 1 egg production estimates and the estimates of fecundity and atresia, separately for the western and southern areas;
5. evaluate the quality and reliability of the 2019 survey in the light of the previous surveys and to evaluate the reliability of the preliminary estimates calculated in 2019 against the final estimates.

Provisional estimates of mackerel SSB, and egg production of horse mackerel are delivered in the year of the survey. The estimates however are finalized during the WGMEGS meeting in the year after the Atlantic survey.

j) Plan and coordinate the 2020 North Sea mackerel egg survey.

k) Review and reformat the historic time-series of North Sea mackerel egg surveys and upload data to the ICES egg and larvae database

Agenda

Monday 26 August 2019

10:00 Start; General announcements; Introduction; etc
10:30 Presentation of survey reports by country
11:15 Coffee Break
11:30 Continuation of survey report presentations
12:30 Lunch break
13:15 Continuation of morning presentations (if necessary).Discussion of morning presentations
14:00 Presentation of survey results (egg production) by the survey coordinator
14:30 Presentation of the survey results (fecundity)

15:00 Discussion of the results with respect to coverage, timing, adult parameter sampling, gaps and their consequences for the estimation of the TAEP/SSB
15:30 Coffee break
16:00 Start preparing and writing the interim WGMEGS report for presentation to WGWIDE
17:30 End of the day

Tuesday 27 August 2019

09:00 Presentation of the results of the IBPNeaMAC and WKRRMAC workshops by Jens Ulleweit
09:30 Discussion of those results and their implications for future work of WGMEGS
10:30 Presentation of MEGS time series data analysis by Gersom Costas
11:00 Coffee break
11:30 Plans for the final year of this term, delegation of tasks.

12:30 Lunch
13:15 Report writing, recommendations, action plan
17:30 end of meeting

Annex 3: Working Documents presented to WGMEGS

Results of the 2018 Exploratory Mackerel Egg Survey

By Finlay Burns, Brendan O' Hea, Bjorn Gunnarsson

During May/June of 2018 a second exploratory survey was carried out on board a chartered Scottish fishing vessel (Altaire) with the objective of exploring the North-western boundary region and survey as far west as required until a zero spawning boundary was established. The survey deployed the Gulf 7 plankton sampler on a series of transects commencing on Rockall Bank and tracking East to West and vice versa heading steadily North up towards the Icelandic Shelf and also surveyed the West side of Iceland. In addition, there was support of the Nordic countries collecting extra plankton samples within this period during the International Ecosystem survey in the Norwegian Sea (IESNS) and Icelandic Spring Capelin surveys.

The results from this survey demonstrated that during May/June the spawning mackerel are avoiding crossing the cooler waters of the South Iceland Basin and instead are favouring the conditions on the Eastern side of the basin as they migrate North and certainly this is a widely held view. The total absence of mackerel eggs within the analyzed IESNS samples is consistent with the results that were presented in 2017 and reaffirm the assessment that for the region stretching from the East coast of Iceland across to the Faroe/Shetland channel the existing Northern boundary surveyed by MEGS should be relatively secure with very little if any mackerel spawning taking place at that time of year at latitudes North of the Faroe Islands. No mackerel eggs were found in samples from any of the surveys where the recorded temperature at 20 m was less than 8 degrees Celsius.

Annex 4: Individual survey reports

1. Portugal/IPMA
2. Ireland/ Marine Institute, Period 2
3. Scotland/Marine Scotland, Periods 2, 3, 4, 5 & 7
4. Spain/IEO, Period 3
5. Spain/AZTI, Period 3
6. Germany/TISF, Periods 3 & 4
7. Spain/IEO, Period 4
8. Spain/AZTI, Period 5
9. Faroes/HAVSTOVAN, Period 5
10. The Netherlands/WMR, Periods 5 & 6
11. Ireland/Marine Institute, Period 6
12. Norway/HI, Period 6

1. Individual survey report: Portugal/IPMA

Please find the individual survey report below

Working Document presented to WGMEGS meeting, 26-27 August 2019, Sta Cruz de Tenerife, Spain

Southern horse-mackerel 2019 DEPM survey summary

PT-DEPM19-HOM

Maria Manuel Angélico, Elisabete Henriques and Cristina Nunes

IPMA - Portuguese Institute for the Ocean and Atmosphere Lisbon, Portugal

BACKGROUND

The egg production survey undertaken by IPMA within the framework of the EU-DCF/PNAB programme and coordinated with other surveys/countries by ICES-WGMEGS is, since 2007, specifically dedicated to the southern horse-mackerel stock, using the DEPM approach, but it also provides information for the AEPM international effort directed at the mackerel stock. The Portuguese survey takes place during the horse-mackerel peak spawning period and covers the southern and western Atlantic-Iberian waters (ICES area 9a). The methodology involves surveying of the whole region (following a regular grid of stations along transects perpendicular to the coast) collecting plankton samples for egg density estimation and spawning area delimitation. Contemporarily adult fishes are obtained by bottom trawling for estimation of female mean weight, sex-ratio, batch fecundity and spawning fraction. Complementary samples for adult parameter estimation are obtained from the commercial fleet.

In 2019 the survey was carried out in the period 23 January - 28 February onboard RV Noruega. The initial results reported in this document include the sampling effort undertaken for the different parameters under estimation and preliminary information on egg density spatial distribution and fish length frequency distribution.

The complete results will be available for the WGMEGS meeting in April 2020.

METHODOLOGY

Egg sampling and analyses

Plankton sampling for obtaining egg density estimation and spawning area delimitation, is conducted over the whole region following a regular grid of stations along transects perpendicular to the coast (12 nmiles apart). The sampler used is a modified CalVET structure (double rings of 40 cm diameter, 150 µm mesh nets and a CTDF probe) performing vertical hauls from bottom or 150m depth to the surface. Concurrently CUFES (fitted with a 335 µm mesh size net) samples are collected (every 3 nmiles) along the path between the CalVET stations and surface temperature, salinity and fluorescence are recorded. In the laboratory horse-mackerel, mackerel and chub-mackerel eggs are identified and staged according to an eleven stages scale (IPMAs scale) and then converted to the WGMEGS stages scale (4 stages for HOM, 5 stages for MAC).

Adult sampling and analyses

Surveying for horse mackerel takes place simultaneously with the ichthyoplankton sampling, an average of two fishing hauls per day were performed opportunistically using bottom trawl gear. For each trawl, complete biological sampling of a random sample of 60 fish is undertaken, individual biological information is recorded, a minimum of 30 ovaries per trawl are preserved for histology and fecundity estimation, and otoliths are collected for ageing. Extra effort is taken to obtain females with hydrated ovaries for the fecundity estimation (F), as well as to also collect fish of smaller sizes to obtain a maturity ogive. Sampling is complemented with fish from commercial vessels, obtained at several harbours along the coast during the period of the survey.

Mackerel sampling is also carried out whenever possible to support the estimations undertaken by WGMEGS, sub-samples of the preserved ovaries being sent to all partner institutes for the screening analysis and the fecundity calculations.

In laboratory, the preserved ovaries are weighed, processed histologically, and the histological slides analysed according to the criteria described in the ICES SISP 5. The estimation of the sex ratio (R), the mean female weight (W) and the mean female expected batch fecundity (F) are based on the biological data recorded from the fish samples. The gonads preserved and histological slides are used to measure the individual batch fecundity (Fobs), to assess the mature/immature condition of females, and to estimate the daily spawning fraction (S).

RESULTS

Environmental setting

In 2019, and according to schedule, surveying during the PT-DEPM19-HOM started at its southern limit, off Cape Trafalgar, in the Bay of Cadiz, on the 25th of January and ended at its northern border, close to Cape Finisterre, on the 25th of February, with a 2 days break in Lisbon for vessel replenishement and team replacements.

The oceanographic conditions encoutered during the period of late January – end of February were the typical for a winter situation (Figure 1). The sea surface temperature ranged from 12.5ºC, in the northern coast (Aveiro to Cape Finiterre), where an extended water mass of lower temperature were observed, to close to 17ºC in the more offshore area of the Cadiz Bay (Figure 1, left panel). The distribution of surface salinity also showed well the wintry patterns with clear plumes of less saline water due to river runoff. This pattern was particullary marked in the NW region (Figure 1, middle panel). Associated to the regions of fresh water influence (but also linked to some signs of upwelling in specific spots) patches of high fluorescence (higher chlorophyll density) were very conspicuous (Figure 1, right panel), indicating the characteristic onset of the late winter primary production activity.

Egg distribution

The plankton sampling took place according to the survey plan. A total of 550 CalVET stations (paired nets, therefore 550 samples in ethanol and 550 in formaldeihed solution) were occupied along the 48 transects of the regular grid (Figure 2). Profiles of temperature, salinity and fluorescence were obtained concurrently to the plankton hauls (510 in total due to logistic problems). During the navigation between the CalVET stations 723 CUFES samples were collected.

The analysis of the samples is underway and so far one of the paired nets from each haul has been sorted for all the ichthyoplankton individuals but taxonomic, and egg stageing, analyses are in progress. So far, identification and stageing for horse-mackerel and mackerel, is complete for around one third of the samples (from one of the paired nets). Geographically the data on horse-mackerel and mackerel is available from Cape Trafalgar, in the Cadiz Bay, to just south of Lisbon, in the west coast (Figure 2, right panel).

Fish eggs were collected over the entire surveyed area but were not evenly distributed spatially. The pattern of distribution in the southern region up until Lisbon, was more uniform in space but the egg density was lower whereas in the NW shores the egg abundances were higher but the

distribution patchier (Figure 2, left panel). Overall, eggs were collected in 53% of the plankton hauls, and sardine eggs were observed in 40% of those samples. Sardine eggs represented 47% of the total eggs observed (results not shown here).

In the 194 samples analysed so far for horse-mackerel and mackerel (Figure 2, right panel), the former were observed in 15% while the latter were identified in 11% (sardine eggs were present in 26% of these samples). Horse-mackerel eggs represented 9% of the total eggs collected in this region whereas only 1% were identified as mackerel (not very surprising as the species is not abundant in this southern limit of its distribution). Hardly any horse-mackerel eggs were observed in the Cadiz Bay region and this result is in agreement with the absence the species in the fishing trawls despiste the effort undertaken for its capture (see figure 3). The higher densities of horse-mackerel were observed in the portuguese waters to the west of Cape Sta Maria and in the west coast between Cape Sines and river Sado. Mackerel eggs were scattered across the area surveyed but were collected in very low numbers.

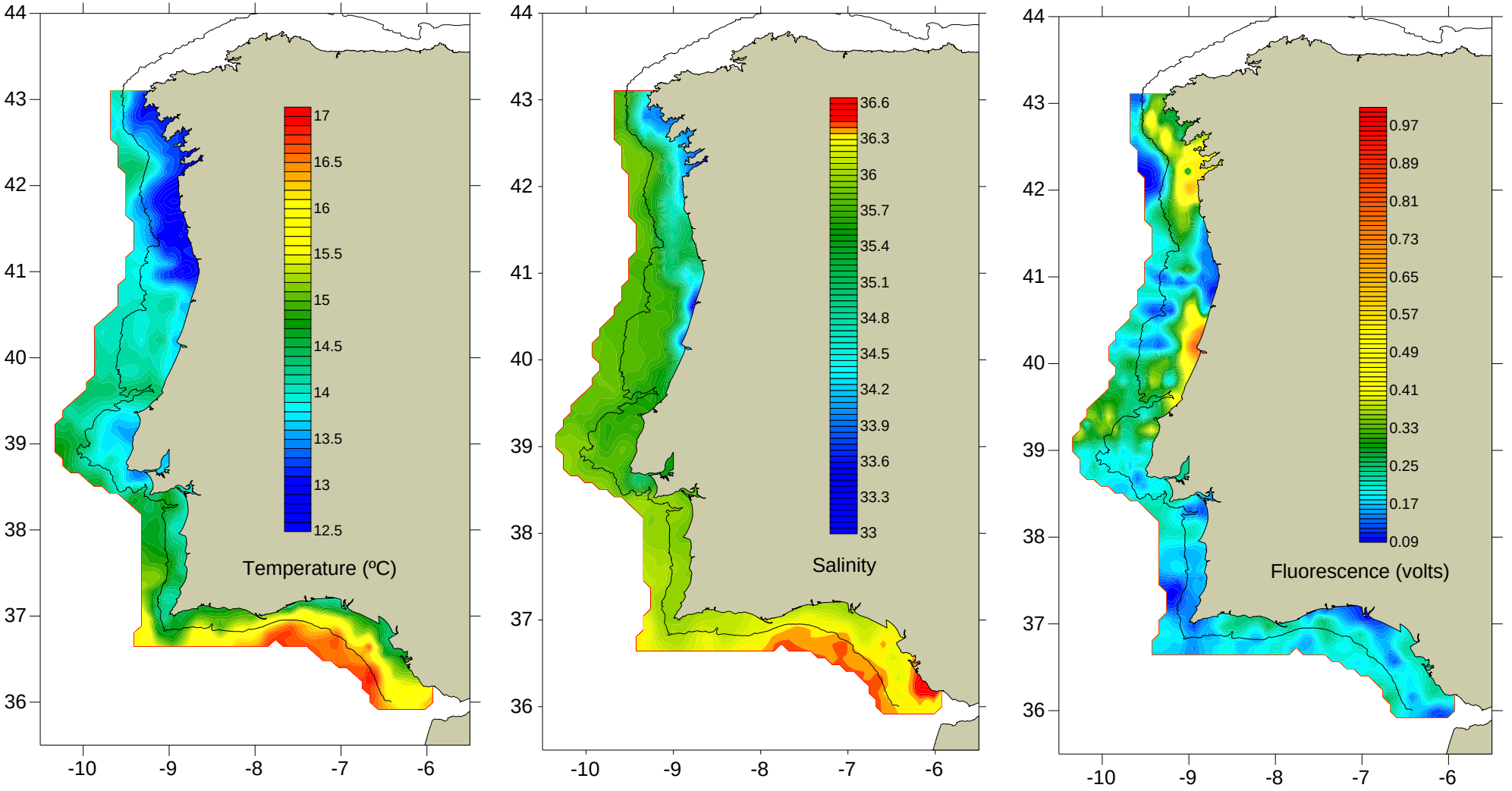

Figure 1. Sea surface distributions of temperature (lef panel), salinity (middle panel) and fluorescence (rigth panel). The data was obtained by the sensores associated to the CUFES system.

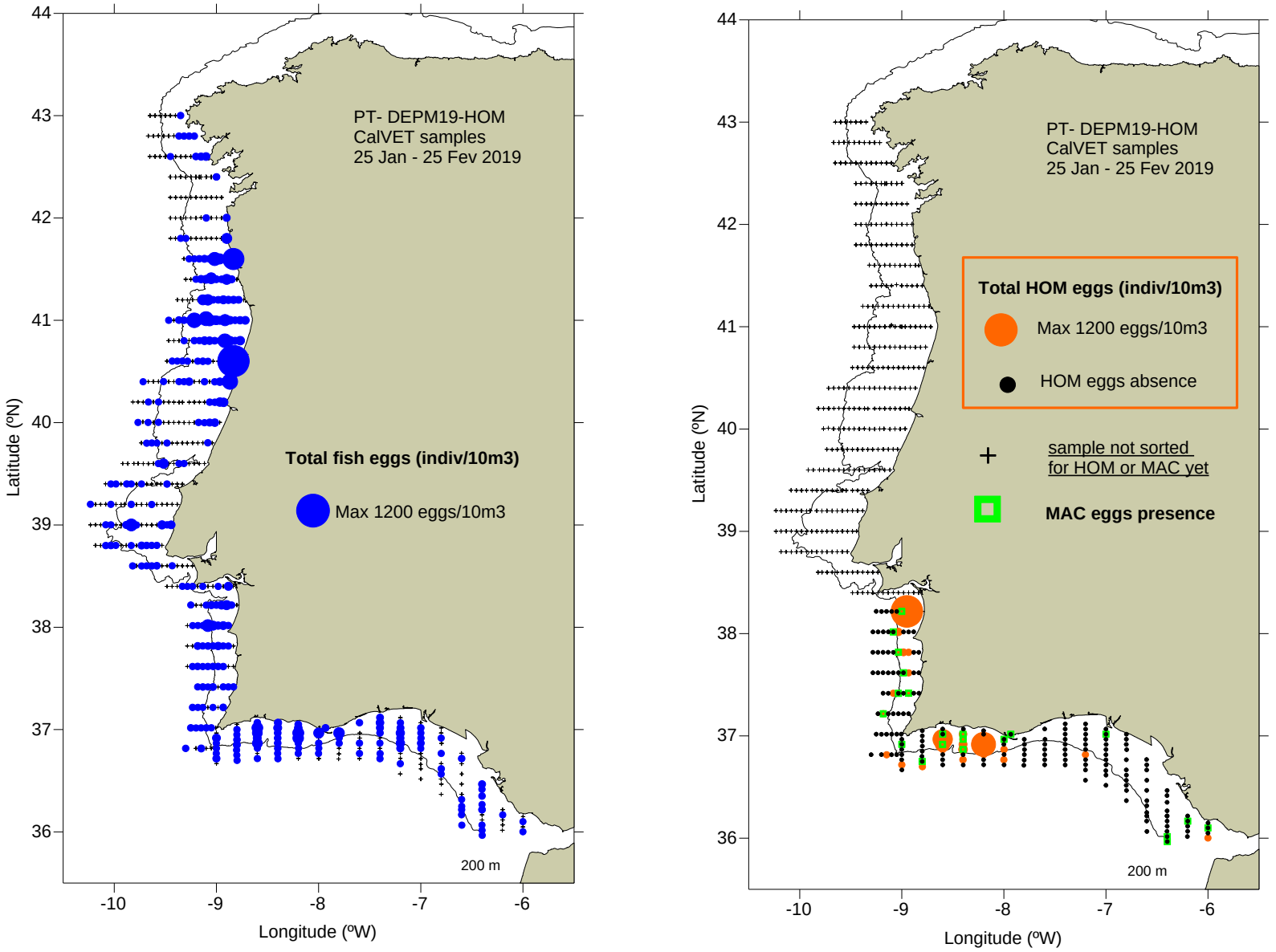

Figure 2. Survey coverage, CalVET sampling stations occupied and fish egg abundance distributions. Left panel, total egg abundance distribution (in blue) and right panel, horse-mackerel (HOM) total egg abundance distribution (in orange). Green squares indicate mackerel (MAC) egg presence. The analyses for HOM and MAC eggs is still incomplete, the results refer to the first 194 station of a total of 550. At present final results are only available for the area from Cape Trafalgar to river Sado.

Fishing trawls distribution and fish length composition

On the whole, 56 fishing hauls were obtained on board the research vessel, 20 hauls (37.5%) being positive for horse mackerel (Figure 3). These horse mackerel fish samples were complemented with 15 samples collected by the bottom trawl and purse seine fleets and landed at 7 Portuguese harbours (Matosinhos, Aveiro, Figueira da Foz, Peniche, Sesimbra, Portimão/Olhão) from the same period when the research vessel was surveying each area. Despite a large effort in fishing (9 trawls) in the Cadiz Spanish waters, no horse mackerel were caught in this area (result corroborated also by the absence of eggs of the species as depicted in the map of figure 2).

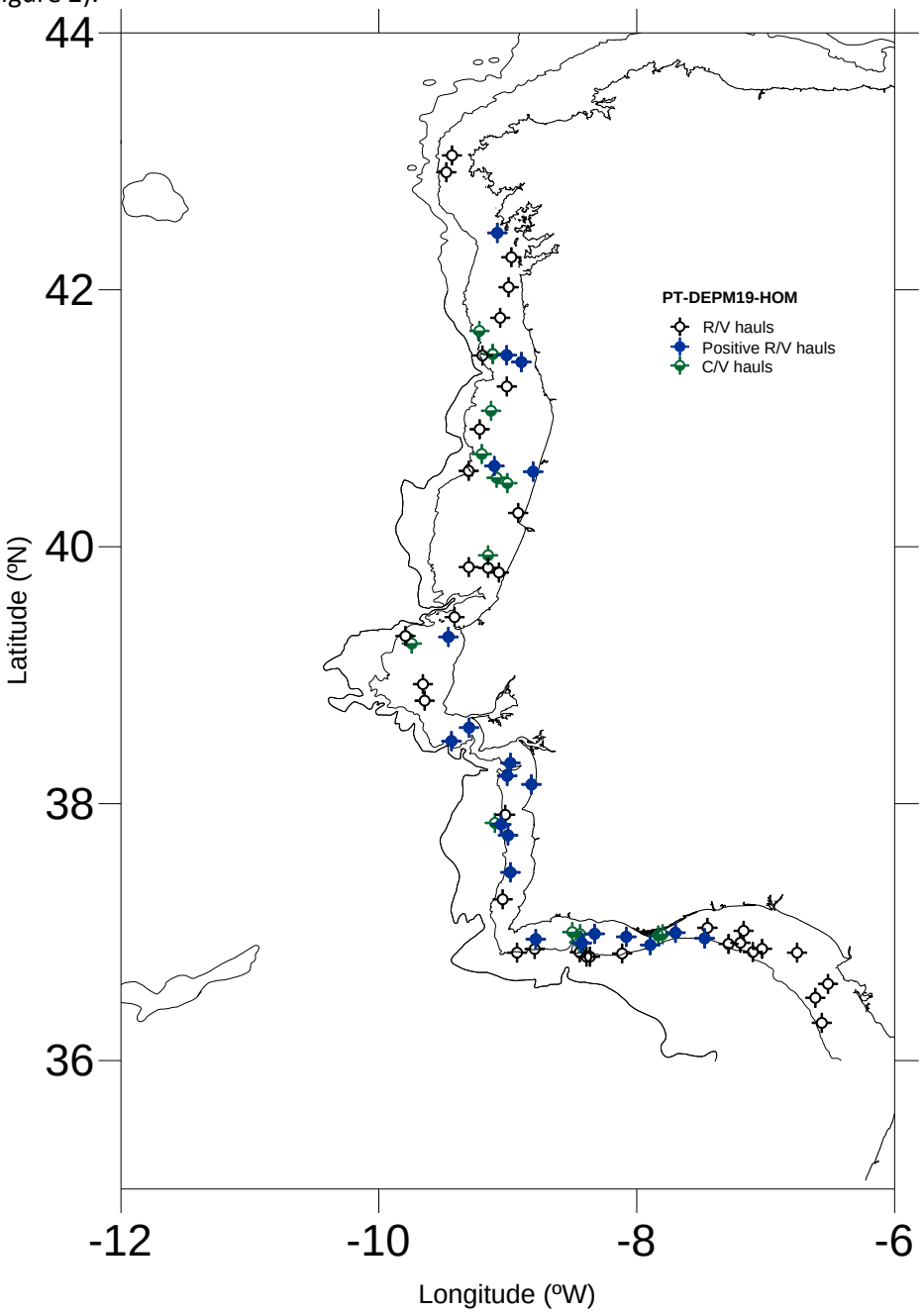

Figure 3. Position of the fishing hauls carried out during the survey onboard the research vessel or from the commercial fleet (R/V hauls: by Noruega), C/V hauls: by the commercial vessels) and identification of those from which horse mackerel samples were obtained for the estimation of the DEPM parameters (Positive R/V e C/V hauls).

On the whole, biological data from 2215 fish were obtained from these 35 samples, 1051 ovaries were preserved and stored in 4% buffered formaldehyde for histological processing (among which 102 hydrated ovaries for batch fecundity estimation), and 1483 otoliths collected for age determination. Three of these samples, one for each of the 3 areas (South, Southwest, Northwest Portugal) were collected for the specific purpose of estimating a maturity ogive, as most of the fish caught were of smaller size (lengths from 13 to 22 cm).

The horse mackerel sampled ranged in size from 13 to 42 cm, a similar range compared to 2016 (except a few even smaller fish caught in the South in 2016). Smaller fish were caught significantly in the South (where the size frequency distribution appears clearly bimodal) but also in the West coast (Figure 4). Apart from the three samples referred above for the maturity ogive, the large majority of the female fish sampled were mature (~5% of macroscopically scored fish as immature); less than 1% of the females were in a post-spawning phase whereas ~1/4 were in a developing one.

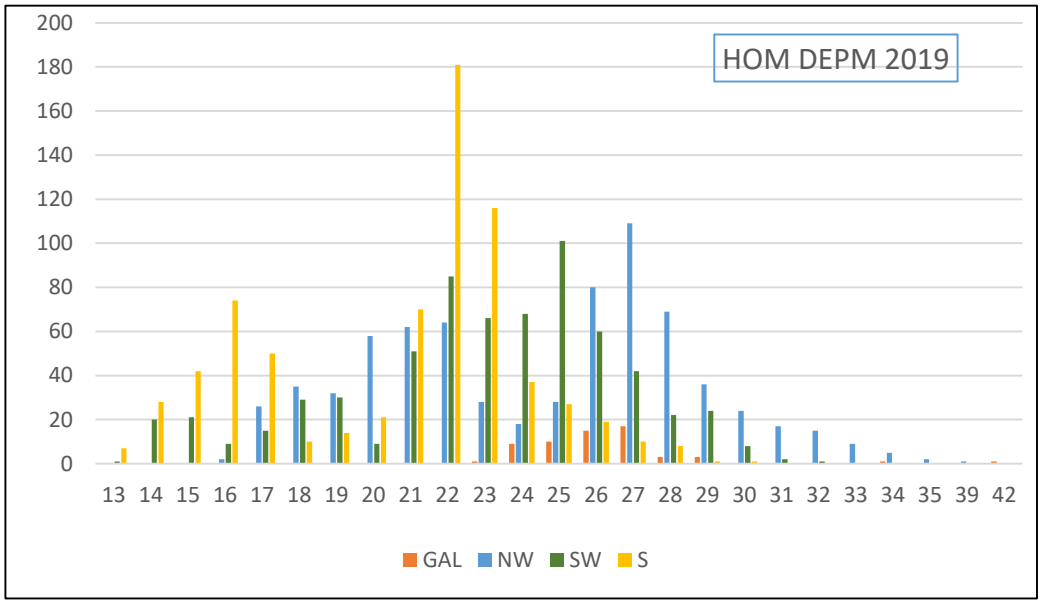

Figure 4. Length frequency distribution of the horse mackerel sampled in 2019 (both R/V and C/V samples) by area (GAL: Galicia; NW: Northwest Portugal; SW: Southwest Portugal; S: South Portugal).

Concerning the mackerel samples, the species was scarce in the fishing hauls, being present in 14 out of the 56 hauls (25%), for some of which only a few individuals were caught. A total of 45 ovaries were preserved and the corresponding micropipette sub-samples collected, in both South and West Atlantic Iberian coasts (6 and 39 ovaries, respectively), from the 28th Jan. to the 21st Feb. (period 2) and in the 18th March (period 3). These ovaries are from females of 27 to 40 cm length (Figure 5) and from 121 to 565 g total weight. The samples were shipped to the different institutes to be processed and analysed.

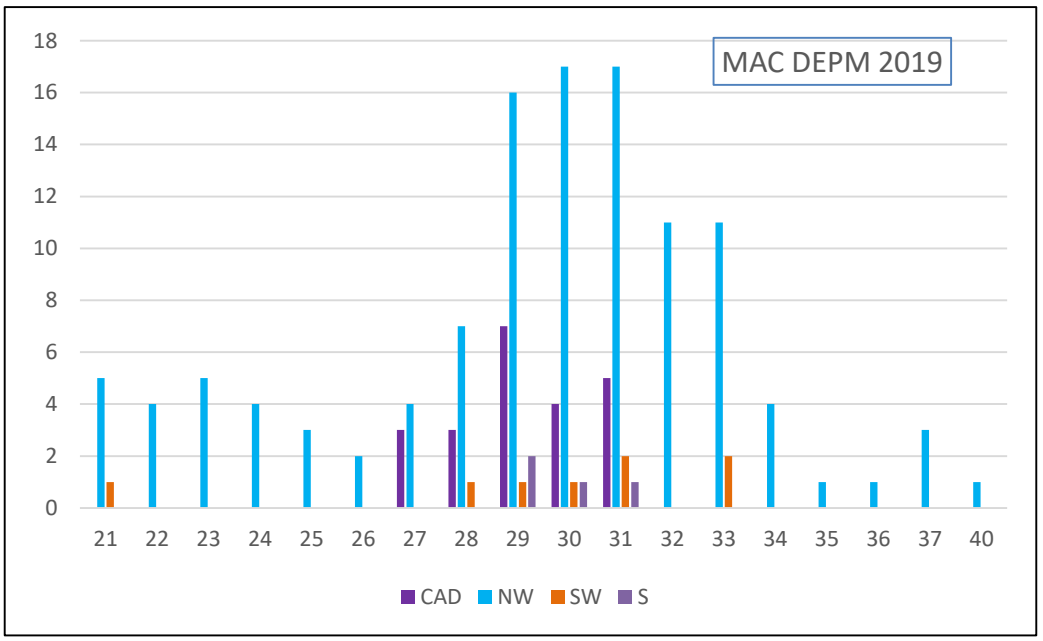

Figure 5. Length frequency distribution of the mackerel sampled in 2019 (both R/V and C/V samples) by area (NW: Northwest Portugal; SW: Southwest Portugal; S: South Portugal; CAD: Cadiz Spanish waters).

Acknowledgements

Acknowledges are due to all IPMA staff that participated in the survey and in the laboratorial analyses and also to the RV Noruega crew for their valuable collaboration.

2. Individual survey report: Ireland/ Marine Institute, Period 2

Please find the individual survey report below

Mackerel Egg survey, February 8th – 28th, 2019

by

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Keywords: Mackerel, Horse mackerel, eggs, surveys, plankton.

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Abstract

Every three years the International Council for the Exploration of the Sea (ICES) coordinates a series of mackerel and horse mackerel egg surveys covering the north-eastern Atlantic from Gibraltar to the Faroe Islands between January and July. The aim of this survey programme is to assess the north eastern Atlantic mackerel and horse mackerel stock. The Marine Institute participates in this programme and on this survey covered stations to the west of Scotland, west of Ireland, the Celtic Sea, and the Bay of Biscay. Plankton samples were collected at 94 stations, and the eggs they contained were preserved in 4% buffered formaldehyde. Only five mackerel eggs were found, four stage 1a and one stage 2, and no horse mackerel eggs were found. No fishing hauls were made to collect adult mackerel samples for fecundity analysis.

1 Introduction

Every three years the International Council for the Exploration of the Sea (ICES) coordinates a series of mackerel, *Scomber scombrus,* and horse mackerel, *Trachurus trachurus*, egg surveys covering the eastern Atlantic from Gibraltar to the south coast of Iceland between January and July. The aim of this survey programme is to estimate the spawning stock biomass of the north-eastern Atlantic mackerel and provide an estimate of egg abundance for horse mackerel stocks. The Marine Institute participates in this programme and in this survey covered stations to the west of Scotland, west of Ireland, the Celtic Sea, and the Bay of Biscay.

This was one of sixteen surveys that will monitor the spawning area of the fish in the coming months. Preliminary results from on-board sample analysis of egg numbers are presented, but full laboratory analysis will be carried out in the coming months. The data will be submitted to the Working Group on Mackerel and Horse Mackerel Egg Surveys, WGMEGS, in April 2020. Preliminary data will be used by the Working Group on Widely Distributed stocks, WGWIDE, at their assessment meeting in August 2019.

2 Materials and Methods

2.1 Scientific Personnel

Name	Service area / Affiliation	Role
Brendan O' Hea	MI- FEAS	Scientist in charge
Dermot Fee	MI- FEAS	Scientist
Dave Tully	MI- FEAS	Scientist
Ian Murphy	MI- FEAS	Scientist
John Enright	MI- FEAS	Scientist
Sean O' Connor	MI- FEAS	Scientist

2.2 Survey Plan

2.2.1 Area of operation

The survey was carried out to the west of Scotland, west of Ireland, the Celtic Sea, and the Bay of Biscay, from 45.25N to 57.25N, and from 2.75W to 12.75W. This covered stations in ICES areas VIa, VIIb, c, h, j, k, VIIIa, b and d (Figure 1). Survey stations were at 0.5 degrees spacing, both latitudinally and longitudinally, every ICES half statistical rectangle. The survey was adaptive, and while theoretical eastern and western limits were set, in practice the presence or absence of eggs dictated moving to the next transect. The chief scientist would decide when to terminate each transect, depending on the numbers of eggs of the target species in the samples. Survey protocols called for the survey area to be sampled on alternate transects initially. The intervening transect should be sampled on the return leg, if time permitted. For stations that can't be sampled it is possible to interpolate an egg count using data from neighbouring stations.

2.2.2 Specific operations

Plankton Hauls

At each station the GULF VII plankton sampler was towed at four knots on a V-shaped profile. The GULF was deployed over the stern, using a winch with 11mm co-axial cable, capable of providing real-time data, in an armoured sheath. The water column was sampled to between five and ten metres of the bottom, depending on weather conditions, or

a maximum depth of 200m. Attached to the sampler was a real-time CTD and flowmeter system which collected temperature and salinity data, and measured the volume of water filtered during the tow. It also provided real-time depth positions which made it possible to control the rate of descent and ascent of the GULF sampler.

Note was taken of the volume of water sampled by the GULF during each haul. Salinity at 5m, 20m and bottom of the tow, and the water temperature at 5m, 20m, 50m, 100m, and deepest temperature were calculated for each tow. All survey protocols can be found in SISP 6 (ICES 2014).

Once back aboard the net was washed down, the cod-end was removed, and a fresh cod-end was attached before the net was washed down again. The cod-ends were then brought to the lab, and the plankton sample was washed out. The sample was preserved in 4% buffered formalin. It was examined under a microscope after two hours and any eggs and fish larvae were removed. A second examination of each sample took place after 36 hours. A count was kept of mackerel, hake and horse mackerel stage 1 eggs, mackerel, hake and horse mackerel eggs of later stages, and other fish eggs.

Fishing Hauls

As part of the survey samples of mature mackerel are collected at various latitudes. Fishing sites are normally selected close to the 200m contour line. Hauls are made using a herring pelagic net. For 2019 the Irish survey had a sampling target of 130 mackerel gonads with maturity stages between 3 and 6 on the Walsh scale, over four weight categories (ICES 2018). Survey protocols can be found in SISP 5 (ICES 2016).

From one ovary, cut a small (0.5cm) section with a scalpel, and immediately put this sample into an individually coded histology cassette. For atresia cut off both ends (1–2 cm, depending on the size of the ovary) off the ovary used for the screening sample, and place the remaining part in a bottle. From the other, intact, ovary (not used for the screening sample) take two samples of 25 μl (a, b) and two samples of 100 μl (c, d) with a pipette and put each sample in its own individually coded Eppendorf tube. All these samples should be stored in 3.6% buffered formalin. The sampling protocols are attached in the appendix of this document.

After the survey the histological screening samples should be distributed to the various laboratories carrying out the histology work. These screening samples would be analysed under a microscope before a decision was made whether the rest of each sample should be analysed for fecundity, batch fecundity, or atresia. The Eppendorf samples should also be sent out at the same time.

AEPM / DEPM

WKMPSA 2012 (ICES 2012) advised that during the 2013 survey potential fecundity and atresia samples for mackerel would be collected during the whole survey period, as was done on previous surveys. During the peak spawning period, March, enhanced sampling

effort would be directed at collecting mackerel samples to estimate DEPM adult parameters. For 2019 WGMEGS decided that this DEPM sampling should be conducted in March, as well continuing into April.

For western horse mackerel WGWIDE have not incorporated the fecundity sampling results into the SSB estimate since 2001. WKMPSA recommended that for 2013 horse mackerel sampling effort should be directed at collecting and analysing fecundity samples to estimate DEPM adult parameters during the peak spawning period, in this case June. Sampling of adult horse mackerel would not take place during the other survey periods. This protocol is in place again for 2019, however this year DEPM sampling will also be carried out in July, (ICES 2018b).

2.3 Equipment and system details and specifications

GULF VII plankton sampler

11mm armoured co-axial cable

Hydro-Bios CTD and flow sensor

Pelagic Herring net

Simrad ER-60

2.4 Protocols used

The protocols for the plankton sampling were updated during the 2018 WGMEGS meeting and are listed in the 2018 WGMEGS, (ICES 2018a) and WKFATHOM2, (ICES 2018b) reports. The fecundity protocols for mackerel and horse mackerel were also updated in 2018 and are also listed in both 2018 reports, and in the appendix of this report. Survey and fecundity sampling protocol manuals were produced in 2013. Both of these were updated prior to the 2019 surveys and are awaiting publication by ICES.

3 Results

Plankton Hauls

In 2019 the survey took place at a similar time to the 2016 survey. The original plan had been to start the survey off the west coast of Mayo. Just prior to the start of the survey it was decided to add some additional transects to the north of this, as the mackerel migration was later than had been expected. A total of 94 plankton hauls were carried out, over eighteen transects, (Figure 1, Table 1). The most notable feature of the survey this year was a distinct lack of eggs throughout the entire survey area. The distribution of the eggs was quite narrow and it proved possible to sample transects quite quickly. As the weather was quite poor for much of the survey this helped in covering a large area. Due to the narrow transects it was possible to sample nearly all transects on the survey.

All eggs and larvae were extracted from the plankton samples while at sea. Many of these were identified and staged at sea, with the later samples being analysed in the laboratory, once ashore.

In total 655 eggs were collected. Only five of these were mackerel, four Stage 1a and one Stage 2, all of which were collected in Biscay (Figure 2, Table 1). Of the remaining eggs Hake made up 47% with other species, not targeted by the survey, accounting for 53%.

224 Stage 1 Hake eggs were collected (Figure 3, Table 1). The majority of these were collected west of Ireland and in Biscay, with very few being found off Scotland or in the Celtic sea. Stage 1 hake eggs were recorded at 48% of stations, very similar to the 2016 result. No Horse mackerel eggs were found.

The GULF sampler was initially run off a small winch which allowed live CTD data to be streamed back to the vessel. After two weeks this winch broke down and the GULF was moved to a standby winch. Initially this winch was unable to provide a live data feedback from the GULF, so the position of the sampler in the water column was monitored using a Marport depth sensor, with the CTD logging the data. This data was downloaded after every tow to ensure everything had progressed correctly. After a couple of days modifications were made to this alternate winch and live data streaming resumed.

Fish Hauls

No fishing tows were carried out. This was partly due to the poor weather experienced during much of the survey, and also as a result of the fish staying very close to the seabed and therefore being very difficult to see on the sounder. This behaviour was also remarked on by commercial vessels who were targeting the mackerel at the same time.

4 Discussion and Conclusions

In 2010 peak spawning of mackerel was found to have occurred during the first survey sampling period. In an attempt to rectify this sampling was mover earlier in the year in 2013, however once again peak spawning was found in the first sampling period. At its 2015 meeting, (ICES 2015), WGMEGS decided to move the start of the survey forward to early February, in an attempt to catch the start of spawning. This proved to be a success that year. The low numbers of eggs found and low numbers of adults caught show that the survey commenced before any major spawning has taken place. WGMEGS decided to repeat this early survey timing again in 2019, (ICES 2018a).

From a plankton sampling viewpoint the survey was quite successful. Despite a lot of poor weather 94 samples were collected. As a result of the survey taking place early in the spawning season the eggs weren't spread too widely. It was possible to sample stations on 75% of the transects, thereby reducing the number of transects which would require interpolation.

It proved extremely difficult to catch adult fish. None were seen on the fishing sounders and as a result no fishing tows took place.

Acknowledgements

Much appreciation is expressed to the skipper, Anthony Hoban, and crew of the *Celtic Explorer.* Their many skills kept the survey functioning, especially during the challenging weather conditions encountered during much of the survey. Thanks are also expressed to the scientists for their perseverance and good humour during the trip.

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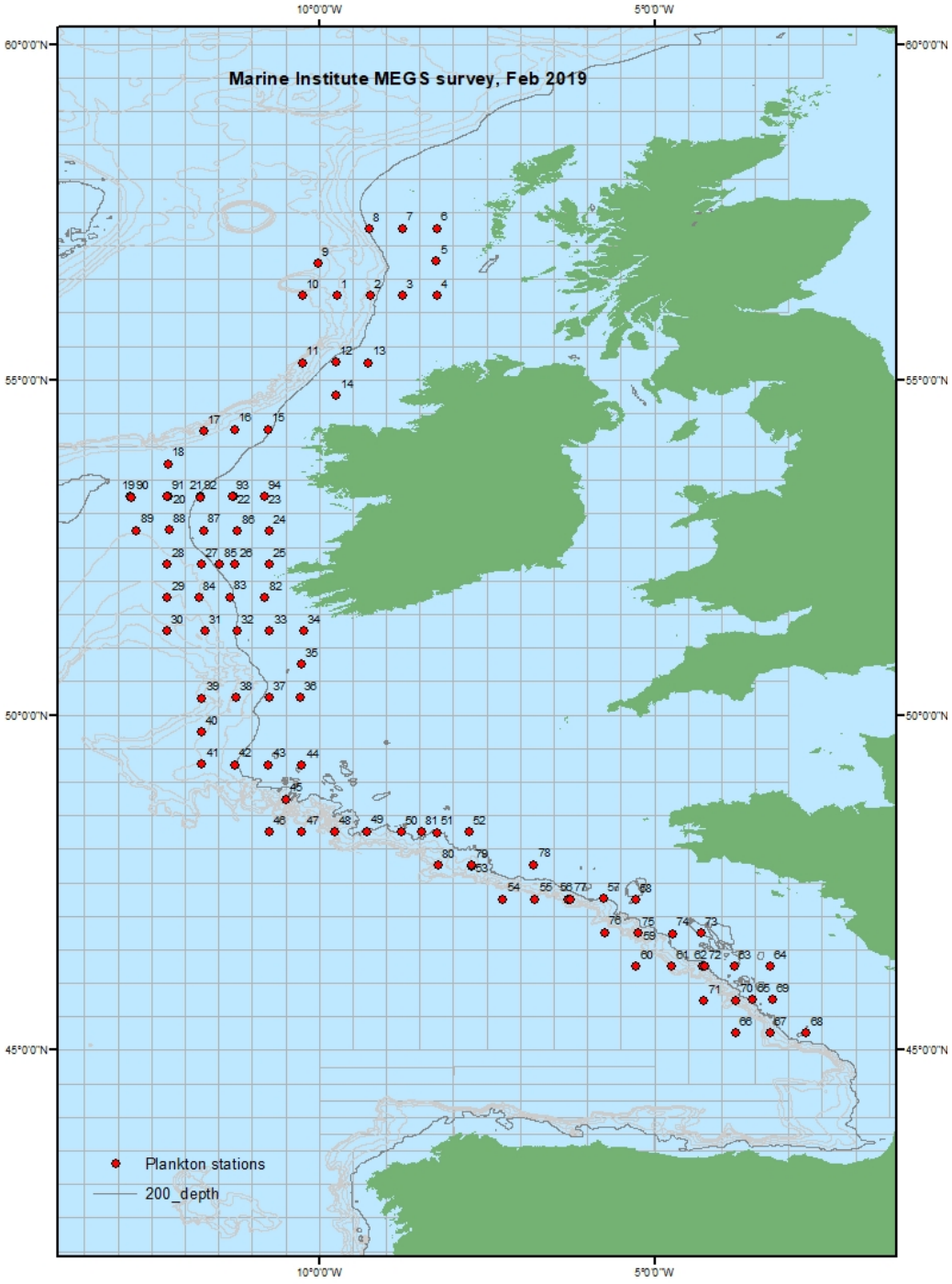

Figure 1: GULF plankton stations, February 2019.

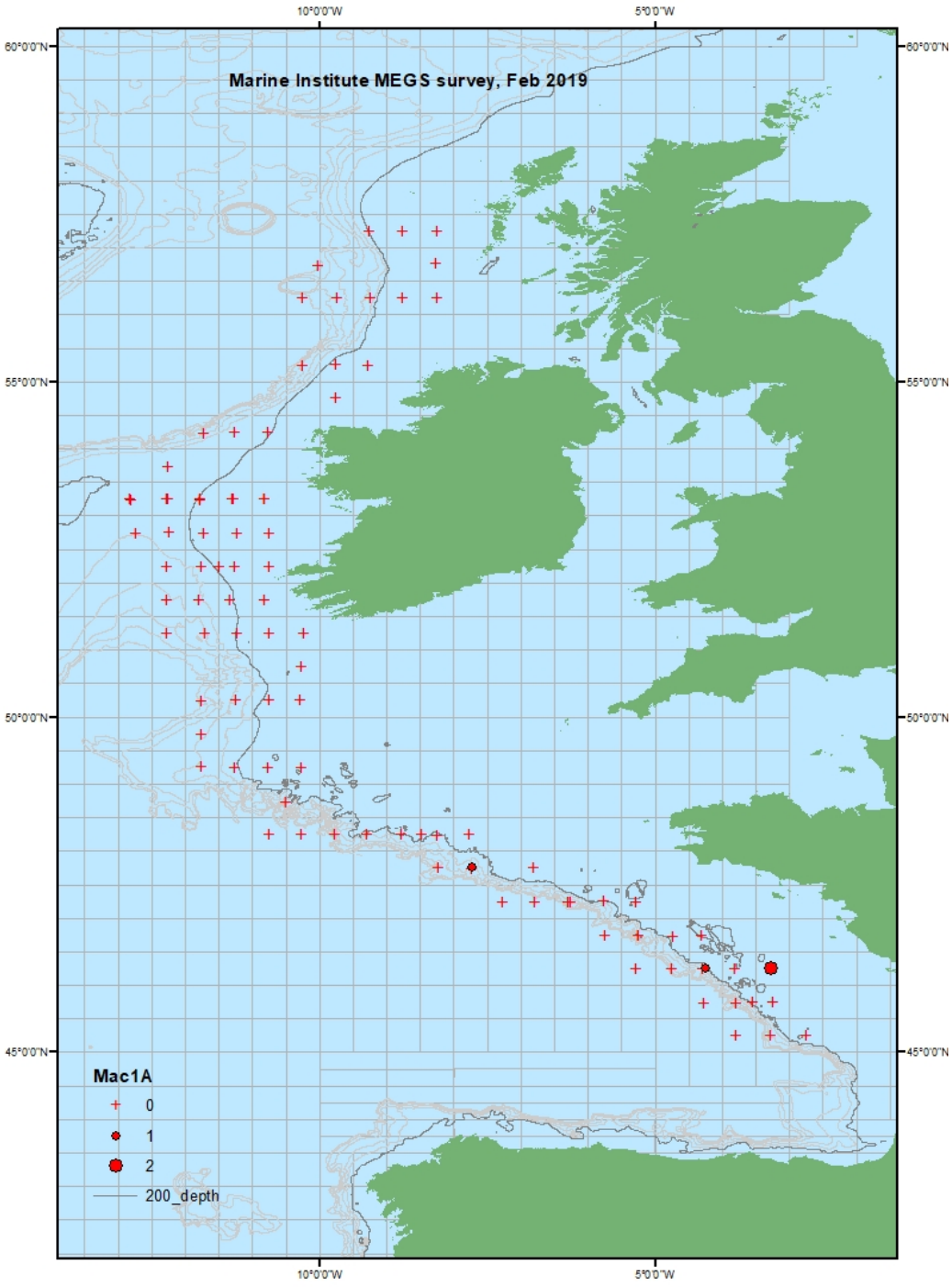

Figure 2 Numbers of Stage 1 Mackerel eggs, February 2019.

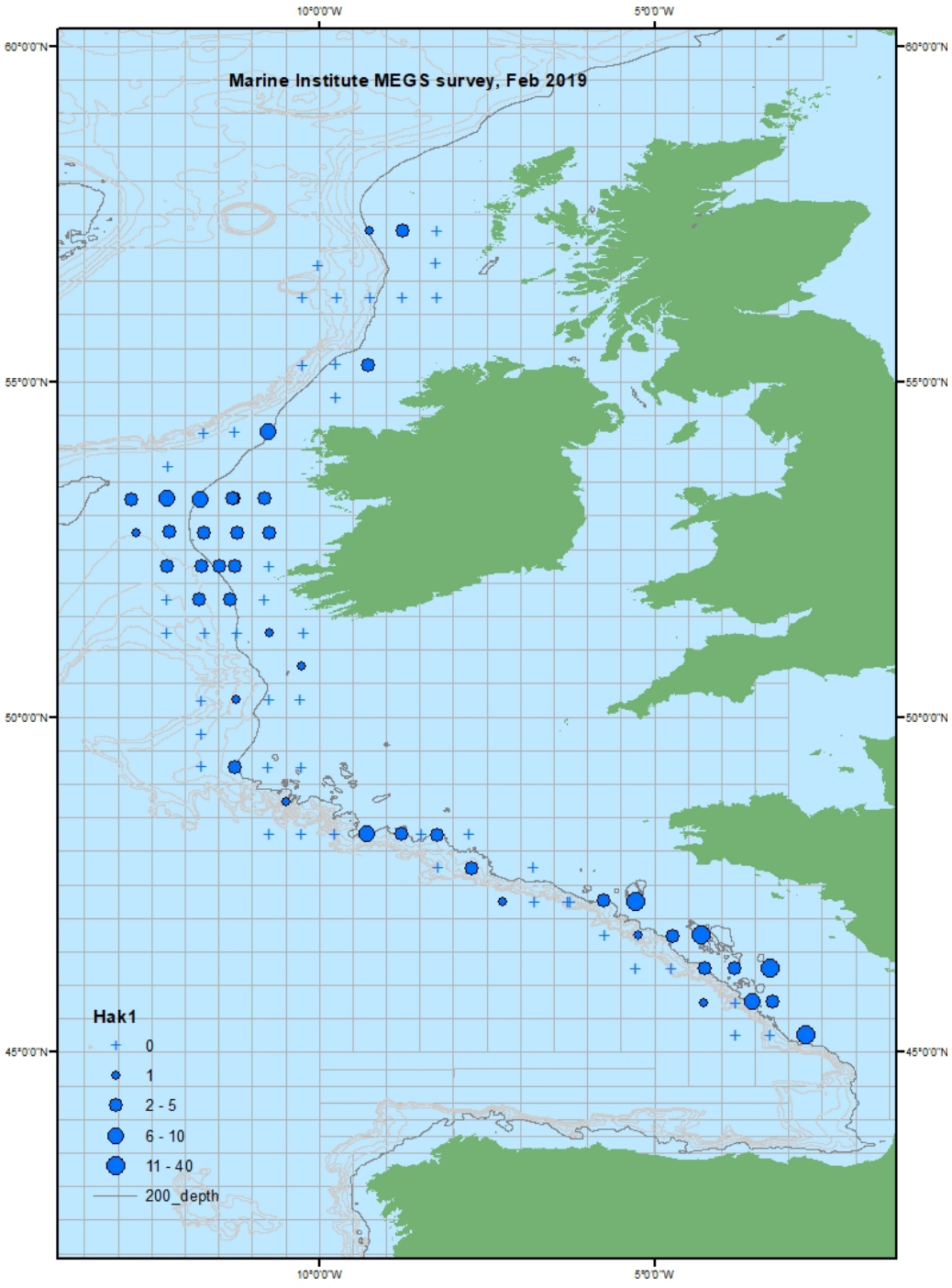

Figure 3 Numbers of Stage 1 Hake eggs, February 2019.

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Table 1 Plankton stations and associated Stage 1 egg numbers, February 2019.

StationNumber	Date	Time	DecLat	DecLong	Mac1A	Hom1A	Hak1	Others
1	11/02/2019	07:10	56.25	-9.77	0	0	0	4
2	11/02/2019	09:14	56.25	-9.27	0	0	0	0
3	11/02/2019	11:24	56.25	-8.78	0	0	0	6
4	11/02/2019	13:22	56.25	-8.28	0	0	0	15
5	11/02/2019	16:44	56.76	-8.26	0	0	0	2
6	11/02/2019	09:50	57.24	-8.25	0	0	0	5
7	11/02/2019	22:49	57.25	-8.72	0	0	3	12
8	12/02/2019	11:03	57.25	-9.23	0	0	1	1
9	12/02/2019	21:08	56.75	-10.00	0	0	0	0
10	13/02/2019	02:54	56.26	-10.25	0	0	0	0
11	14/02/2019	01:59	55.27	-10.25	0	0	0	0
12	14/02/2019	04:45	55.25	-9.77	0	0	0	0
13	14/02/2019	06:46	55.25	-9.28	0	0	3	4
14	14/02/2019	12:16	54.76	-9.73	0	0	0	4
15	14/02/2019	19:59	54.25	-10.72	0	0	6	2
16	14/02/2019	22:42	54.25	-11.23	0	0	0	0
17	15/02/2019	01:19	54.25	-11.72	0	0	0	0
18	15/02/2019	10:55	53.76	-12.25	0	0	0	0
19	15/02/2019	17:04	53.26	-12.78	0	0	0	1
20	15/02/2019	19:58	53.25	-12.28	0	0	0	0
21	15/02/2019	22:11	53.25	-11.80	0	0	1	0
22	16/02/2019	02:28	53.25	-11.30	0	0	2	9
23	16/02/2019	02:46	53.25	-10.84	0	0	2	29
24	16/02/2019	07:51	52.75	-10.75	0	0	2	4
25	16/02/2019	14:16	52.26	-10.75	0	0	0	2
26	16/02/2019	17:21	52.25	-11.23	0	0	2	2
27	16/02/2019	20:14	52.26	-11.72	0	0	2	2
28	17/02/2019	23:01	52.26	-12.23	0	0	2	0
29	17/02/2019	05:00	51.77	-12.27	0	0	0	0
30	17/02/2019	11:46	51.24	-12.31	0	0	0	0
31	17/02/2019	14:37	51.25	-11.74	0	0	0	0
32	17/02/2019	17:03	51.25	-11.26	0	0	0	2
33	17/02/2019	19:16	51.25	-10.77	0	0	1	1
34	17/02/2019	21:42	51.25	-10.25	0	0	0	0
35	18/02/2019	02:09	50.77	-10.27	0	0	1	0
36	18/02/2019	06:15	50.27	-10.27	0	0	0	0
37	18/02/2019	09:07	50.25	-10.71	0	0	0	0
38	18/02/2019	12:17	50.25	-11.20	0	0	1	0

39	18/02/2019	15:46	50.25	-11.71	0	0	0	2
40	18/02/2019	19:38	49.77	-11.75	0	0	0	0
41	18/02/2019	23:19	49.26	-11.78	0	0	0	0
42	19/02/2019	01:36	49.25	-11.29	0	0	2	0
43	19/02/2019	04:05	49.25	-10.78	0	0	0	0
44	19/02/2019	06:18	49.25	-10.28	0	0	0	0
45	19/02/2019	11:22	48.76	-10.48	0	0	1	0
46	19/02/2019	18:17	48.27	-10.74	0	0	0	1
47	19/02/2019	20:51	48.25	-10.29	0	0	0	2
48	19/02/2019	23:22	48.25	-9.81	0	0	0	0
49	20/02/2019	02:00	48.25	-9.33	0	0	6	1
50	20/02/2019	04:48	48.25	-8.81	0	0	2	0
51	20/02/2019	07:19	48.25	-8.28	0	0	2	0
52	20/02/2019	09:31	48.25	-7.80	0	0	0	0
53	20/02/2019	14:33	47.76	-7.73	0	0	4	7
54	20/02/2019	19:02	47.27	-7.28	0	0	1	0
55	20/02/2019	21:28	47.25	-6.81	0	0	0	1
56	21/02/2019	00:00	47.25	-6.32	0	0	0	1
57	21/02/2019	02:56	47.25	-5.79	0	0	2	1
58	21/02/2019	05:16	47.25	-5.30	0	0	33	12
59	21/02/2019	08:31	46.77	-5.24	0	0	1	1
60	21/02/2019	12:03	46.27	-5.27	0	0	0	3
61	21/02/2019	14:57	46.25	-4.77	0	0	0	0
62	21/02/2019	17:17	46.25	-4.32	0	0	0	0
63	21/02/2019	19:45	46.25	-3.83	0	0	2	27
64	21/02/2019	22:22	46.25	-3.30	2	0	27	43
65	22/02/2019	02:02	45.77	-3.52	0	0	9	2
66	22/02/2019	05:31	45.27	-3.78	0	0	0	0
67	22/02/2019	08:18	45.24	-3.31	0	0	0	14
68	22/02/2019	11:06	45.25	-2.75	0	0	18	17
69	22/02/2019	15:02	45.74	-3.23	0	0	2	12
70	22/02/2019	17:39	45.74	-3.75	0	0	0	2
71	22/02/2019	20:08	45.74	-4.22	0	0	1	1
72	22/02/2019	23:42	46.22	-4.25	1	0	2	0
73	23/02/2019	03:06	46.73	-4.31	0	0	34	41
74	23/02/2019	05:24	46.73	-4.71	0	0	5	2
75	23/02/2019	07:54	46.74	-5.21	0	0	0	0
76	23/02/2019	10:25	46.75	-5.71	0	0	0	0
77	23/02/2019	14:32	47.23	-6.24	0	0	0	0
78	23/02/2019	18:42	47.74	-6.78	0	0	0	0
79	24/02/2019	00:17	47.75	-7.70	1	0	0	0
80	24/02/2019	02:46	47.75	-8.19	0	0	0	0

81	24/02/2019	06:16	48.24	-8.47	0	0	0	1
82	26/02/2019	04:10	51.73	-10.81	0	0	0	0
83	26/02/2019	06:20	51.75	-11.32	0	0	3	0
84	26/02/2019	08:32	51.75	-11.79	0	0	2	1
85	26/02/2019	12:10	52.23	-11.49	0	0	3	24
86	26/02/2019	15:38	52.73	-11.22	0	0	2	7
87	26/02/2019	18:00	52.75	-11.70	0	0	2	5
88	26/02/2019	20:16	52.75	-12.20	0	0	4	0
89	26/02/2019	22:36	52.75	-12.69	0	0	1	0
90	27/02/2019	02:11	53.23	-12.79	0	0	2	0
91	27/02/2019	04:39	53.25	-12.30	0	0	6	0
92	27/02/2019	06:49	53.24	-11.80	0	0	9	0
93	27/02/2019	08:54	53.25	-11.32	0	0	3	1
94	27/02/2019	11:15	53.25	-10.84	0	0	4	7

Mackerel sampling procedure at sea

Before the cruise:

Fill the labelled 2.5 ml eppendorf tubes with 1.2 ml of 3.6% buffered (sodium phosphate) formaldehyde. Also fill the 20ml scintillation tubes with 15ml of buffered formalin.

During the cruise:

Measure the weight of the whole catch and select a subsample of 100 fish and measure the total weight of the subsample.

Measure total length, weight, maturity (Walsh scale) and sex of each fish in the subsample.

Select females in maturity stages 3-6 from the subsample of 100, (if there are less than 100 fish take them all), for fecundity and atresia analysis. Be sure to divide the females equally into the 4 weight categories: < 250g, 251-400g, 401-550g and >551g. If the size range of fish is restricted in the catch the remaining sample quota should be taken from the more abundant classes to fill the weight classes.

Measure:

- Total length
- Total weight
- Maturity
- Otoliths
- Weight of gut, ovary and liver. (If it is not possible to take these weights at sea, take the pipette and atresia samples, and fix the remainder of the ovary. Subsequently weigh the ovary in the lab. Gut and liver should also be frozen and weighed in the lab. The fixed and frozen weights should be corrected to fresh weights.)

Fecundity sampling:

- From one ovary, cut a small (0.5cm) section with a scalpel, and immediately put this sample into an individually coded histology cassette. Then place this cassette into a coded 250 ml vial, making sure the sample is covered with 3.6% buffered formaldehyde solution (one part ovary and nine parts formaldehyde), (Figure 4).
- From the other ovary (not used for the screening sample) take two samples of 25 μl (a, b) and two samples of 100 μl (c, d) with a pipette and immediately put each sample in its own individually coded Nunc tube. Take in a bit more sample than you need and press the plunger until it reaches the line (25 or 50 μl) and blot off any oocyte that is outside the tip, using your hand or a piece of paper. Ensure all oocytes are immersed in 3.6% buffered formaldehyde solution. For the 100 μl samples, take two times 50 μl with the pipette. Rinse the pipette with water and dry it with a paper towel prior to sampling another fish. The reason to obtain two samples of 25 μl and 100 μl respectively is to guarantee samples, in case a sample is lost during the processing. Send out the samples coded as (a, b) and (c, d) to the analysing institutes, following the colour sending code as indicated by the label.

Atresia sampling:

- For atresia: Cut off both ends (1–2 cm, depending on the size of the ovary) of the ovary used for the screening sample, and place the remaining part in a bottle (100–250 ml with wide opening), and fill it with 3.6% buffered formaldehyde (Figure 4). Label (f) the bottle with coded label with the sample

reference number. Make sure that the bottle is filled with formaldehyde and ensure that the ratio of tissue to formaldehyde is not less than 1:3.

After the cruise:

Immediately after the cruise:

- Screening samples in the 250 ml vials should be sent to the analysing institutes (AZTI, IEO, Wageningen Marine Research, and IMR, Table 2).
- Also send out Nunc tubes for the fecundity and batch fecundity samples along with the ring test tubes (AZTI, IEO, Wageningen Marine Research, IMR, MI, and MSS).

Pack the consignments for each country with a maximum volume of 1000 ml solution in each package. On the outer cover of the package, indicate the type (e.g. ethanol or formaldehyde), volume, and concentration of fixative (3.6% formaldehyde) and that it is within the limits for unclassified transport. Add safety sheets. Consignments should be sent to home addresses (given in Table 2) not Post box addresses.

Once results of the screening are obtained, the adult sampling coordinators will divide the samples between the analysing institutes.

All the ovary samples should remain fixed in 3.6% formaldehyde for at least two weeks, before whole mount analysis or the sections for the atresia analysis are taken. From the fixed ovary lobe, cut two 5 mm thick slices and put them in a coded histology cassette. Write the code with a wooden pencil on the outside of the cassette. If the ovary is very big, you may have to use two cassettes. Separate the cassettes into four colour-coded, leak proof bottles, filled with 70% ethanol. First place the cassettes inside individual mini-grip bags or fabric teabags before putting them into the leak proof bottles to avoid cross contamination between cassettes. Send the cassettes for analysis to the different institutes, based on the list provided by the sampling coordinators.

Table 2

RLABO	ALABO	Sample type	Country	Institute and address	Responsible person
E, F	E, F	a,b,c,d,e	Norway	IMR, Nordnesgaten 50, 5005 Bergen, Norway	Merete Fonn / Anders Thorsen
A, B	A, B	a,b,c,d	Ireland	MI, Rinville, Oranmore, Co. Galway, Ireland	Brendan O`Hea

C, D	C, D	a,b,c,d	Scotland	Marine Scotland Science, Marine Laboratory, Victoria Road, Torry, Aberdeen, AB11 9DB, Scotland	Finlay Burns / Hannah Holah
M, N	M, NM	a,b,c,d,e	Spain	IEO, Subida A Radio Faro 50-52, 36390 Vigo, Spain	Antonio Solla
K, L	K, L	a,b,c,d,e	Spain	AZTI, Herrera Kaia, Portualde z/g 20110 Pasaia, Basque Country, Spain	Paula Alvarez / Maria Korta
I, J	I, J	a,b,c,d,e	Netherlands	IMARES, Haringkade 1, 1976 CP IJmuiden, Netherlands	Cindy van Damme / Hanz Wiegerinck
G, H	-	-	Germany		
O, P	-	-	Portugal		
Q, R	-	-	Faroe		
S, T	-	-	Iceland		
U, V	-	-	Denmark		
W, X	-	-	England		

Horse mackerel sampling procedure at sea

Before the cruise:

Fill the labelled 2.5 ml Eppendorf tubes with 1.2 ml of 3.6% buffered (sodium phosphate) formaldehyde

During the cruise:

Measure the weight of the whole catch and select a subsample of 100 fish and measure the total weight of the subsample.

Measure the total length, weight, maturity (Walsh scale) and sex of each fish in the sub-sample and take otoliths for age reading.

DEPM sampling

The objective of the sampling is to get 30 females in stage 2-6 and 15 hydrated females (HF) per **HAUL**. For the first 100 fish in the subsample select the first 30 females in maturity stages 3 – 6. For these females do full biological sampling and take Screening, Atresia, 2X25µl Fecundity and 2X100µl Batch Fecundity Samples.

If 30 females (including 15 HF) are obtained in the 100 individuals of subsample 1, the sampling of the haul is finished. If the number of females is less than 30, we need to collect additional females from another subsample2 of 100 individuals until the quota of 30 females is met. It is important to keep in mind that in this second sub-sample it is not necessary to sample the 100 individuals, but it is completed when the objective of 30 females (including 15HF) is fulfilled. In this subsample2 we just collect females while the males are discarded without taking any biological data. However, if in the sample of 30 females from the second subsample we did not obtain 15 HF, we should look for them in the rest subsample2. From these HF it is only necessary to take a sample of ovary for Batch fecundity. If no more HF are found in this subsample2, the sampling of the haul is OVER.

If there are less than 30 females in the subsample then randomly select another 100 fish. Continue with the full biological sampling until you have sampled 30 hydrated females. If after 200 fish you still haven't reached 30 hydrated females finish sampling.

Select females in maturity stages 3-5 from the subsample for fecundity analysis. Be sure to divide the females equally into the 4 weight categories: < 150g, 151-250g, 251-350g and >351g. If the size range of fish is restricted in the catch the remaining sample quota should be taken from the more abundant classes to fill the weight classes.

Measurements:

- Total length
- Total weight
- Maturity
- Otoliths for age reading
- Weight of ovary. (If it is not possible to take the ovary weight at sea, take out the ovary and weigh the fish without the ovary. Then take the pipette and atresia samples and fix the remainder of the ovary, and weigh the ovary in the lab. The fixed and frozen weights should be corrected to fresh weights.)

Fecundity sampling:

- From one ovary, cut a small (0.5cm) section with a scalpel, and immediately put this sample into an individually coded histology cassette. Then place this cassette into a coded 250 ml vial, making sure the sample is covered with 3.6% buffered formaldehyde solution (one part ovary and nine parts formaldehyde), (Figure 4).
- From the other ovary (not used for the screening sample) take two samples of 25 μl (a, b) and two samples of 100 μl (c, d) with a pipette and immediately put each sample in its own individually coded Nunc tube, (Figure 4). Take in a bit more sample than you need and press the plunger until it reaches the line (25 or 50 μl) and blot off any oocyte that is outside the tip, using your hand or a piece of paper. Ensure all oocytes are immersed in 3.6% buffered formaldehyde solution. For the 100 μl samples, take two times 50 μl with the pipette. Rinse the pipette with water and dry it with a paper towel prior to sampling another fish. The reason to obtain two samples of 25 μl and 100 μl respectively is to guarantee samples, in case a sample is lost during the processing. Send out the samples coded as (a, b) and (c, d) to the analysing institutes, following the colour sending code as indicated by the label (Table 2).

Atresia sampling:

- For atresia: Cut off both ends (1–2 cm, depending on the size of the ovary) of the ovary used for the screening sample, and place the remaining part in a bottle (100–250 ml with wide opening), and fill it with 3.6% buffered formaldehyde (Figure 4). Label (f) the bottle with coded label with the sample reference number. Make sure that the bottle is filled with formaldehyde and ensure that the ratio of tissue to formaldehyde is not less than 1:3.

After the cruise :

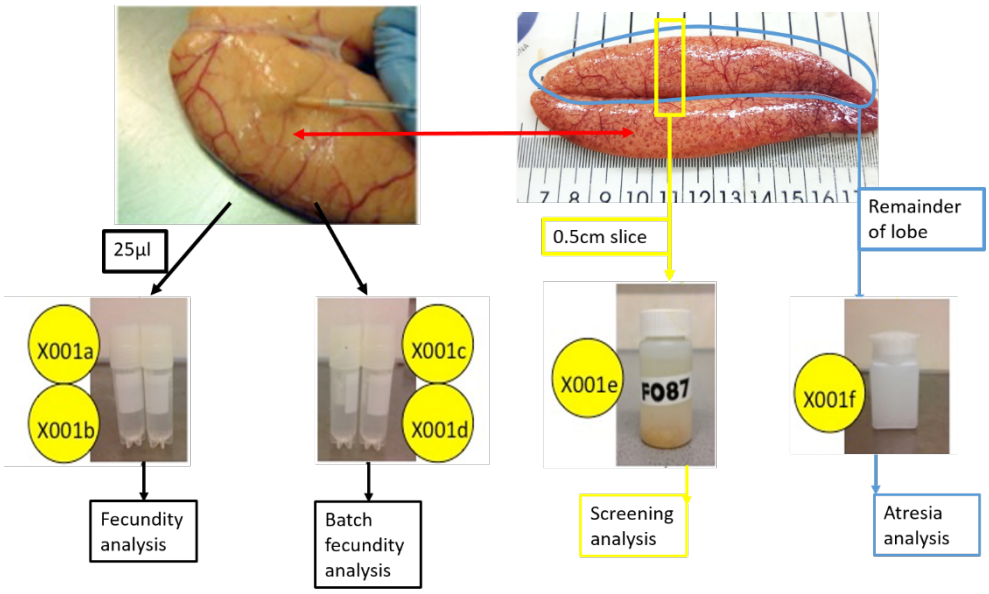
Immediately after the cruise, the screening samples in the histology cassettes should be sent to the analysing institutes (Table 2).

All the ovary samples should remain fixed in 3.6% formaldehyde for at least two weeks, before whole mount analysis or the sections for the atresia analysis are taken. From the fixed ovary lobe, cut two 5 mm thick slices and put them in a coded histology cassette. Write the code with a wooden pencil on the outside of the cassette. If the ovary is very big, you may have to use two cassettes. Separate the cassettes into four colour-coded, leak proof bottles, filled with 70% ethanol. Pack the consignments for each country with a maximum volume of 1000 ml solution in each package. On the outer cover of the

package, indicate the volume of fixative and that it is within the limits for unclassified transport.

After the screening, the adult sampling coordinators will divide the samples between the analysing institutes. Send the cassettes and Nunc samples for analysis to the different institutes, based on the list provided by the sampling coordinators.

Figure. 4. Sampling at sea.



Survey narrative: *Celtic Explorer* February 2019

Date	Events
Friday February 8th:	The vessel was mobbed early in the morning. The ship was supposed to sail on the evening tide, however due to a poor weather forecast it was decided to delay departure by 24 hours
Saturday February 9th:	The scientific complement boarded the vessel in mid-afternoon and departed Galway on the evening tide. The ship headed north to begin sampling to the west of Tiree, one of the Hebrides.
Sunday February 10th:	Weather conditions began to deteriorate early in the morning and continued to worsen. The skipper eventually decided to knock out for a number of hours. Due to the size of the survey area to be completed it was decided to sample every second transect initially, with the intervening stations to be sampled on the return journey.
Monday February 11th:	The wind decreased overnight and we arrived at the first station at 04:00. When the GULF was deployed data transmission was problematic. The GULF was retrieved and checked. It was deployed a second time with the same result. A fault was diagnosed with the winch slip ring termination. It was decided to abandon the station and switch over to the back-up winch. We arrived at the next station, renamed as number 1, at 07:10, at position 56.25N 09.75W. Live data from the GULF came through correctly. Wind speed increased again throughout the day. Four stations were carried out on the transect before turning north. Transect two was started at 19:50 at position 57.25N 08.25W. Seven stations were carried out for the day.
Tuesday February 12th:	One further station was carried out on transect 2. It was decided to turn south to transect three. Weather conditions deteriorated on the passage to this transect and the ship hove to for a number of hours. Two stations were carried out for the day.
Wednesday February 13th:	The weather continued to be poor and only one station was carried out for the day.
Thursday February 14th:	Transect three was started at 02:00 at 55.25N 10.25W. Three stations were carried out and the transect was completed at 07:00 at 55.25N 9.25W. The vessel turned south again and reached transect four at 20:00 at position 54.25N 10.75W. The wind increased in strength during the day and some stations were sampled in extreme conditions. Six stations were carried out for the day.
Friday February 15th:	Transect 4 was completed at 02:00 at position 54.25N 11.75W. Transect 5 was started at 17:00 at position 53.25N 12.75W. Winds continued to remain strong. Five stations were completed for the day.
Saturday February 16th:	Transect 5 was completed at 03:00 at position 53.25N 11.75W. After steaming 60 miles south transect 6 was started at 14:00 at position 52.25N 10.75W. Winds continued strong. Six stations were carried out for the day.

Sunday February 17th:	Transect 6 was completed at 01:00 at position 53.25N 11.25W. Transect 7 was started at 51.25N 12.25W and completed at 22:00 at 51.25N 10.25W. Six stations were sampled for the day.
Monday February 18th:	Transect 8 was started at 06:00 at position 50.25N 10.25W and completed at 16:00 at 50.25N 11.75W. Transect 9 was started at 23:30 at position 49.25N 11.75W. Seven stations were carried out for the day.
Tuesday February 19th:	Weather is poor again, winds back up to 40 knots. Progress has slowed considerably. Transect 9 was finished at 07:00 at position 49.25N 10.25W. Transect 10 was started at 18:00 at position 48.24N 10.75W. Seven stations were carried out for the day.
Wednesday February 20th:	Transect 10 was finished at 10:00 at position48.25N 07.75W with transect 11 being started at 19:00 at position 47.25N 7.25W. The weather has continued to improve as we have sampled to the east and the speed of the vessel has increased. Eight stations were carried out for the day.
Thursday February 21st:	Transect 11 was completed at 06:00 at position 47.25N 05.25W. Transect 12 was started at 12:00 at 46.25N 05.25W and completed at 23:00 at position 46.25N 03.25W. The weather has improved greatly and the vessel can now steam at normal transit speed. Nine stations were carried out for the day.
Friday February 22nd:	Transect 13 was started at 05:30 at position 46.25N 03.75W, and was completed at 12:00 at position 45.25N 02.25W. This marked the most southerly transect of the survey and the vessel turned northwards. Transect 14 commenced at 15:00 at position 45.75N 03.25W, and was completed at 21:00 at position 45.75N 04.25W. Eight stations were carried out for the day.
Saturday February 23rd:	Transect 15 was started at 03:00 at position 46.75N 04.25W and completed at 11:00 at position 46.75N 05.75W. Transect 16 was started at 19:00 at position 47.75N 06.75W. During this tow the winch started experiencing difficulty and eventually broke down, however the GULF was successfully retrieved. The tow was declared invalid. While the vessel steamed to the next station on the transect the GULF was switched to the GP2 winch, originally used at the start of the survey. Repairs had been carried out to this winch during the survey. The live feed from the winch failed again. It was decided to run the CTD in log mode and attach a Marport depth sensor to the GULF frame to monitor the depth.
Sunday February 24th:	Transect 16 was completed at 03:30 at position 47.75N 08.25W. An intertransect station was carried out at 06:30 at position 48.25N 08.25W. Soon after this station was finished one of the crew was taken ill. A decision was made to return to Cork to seek hospital treatment. The vessel turned off transect, steamed to Cork at full speed, and arrived in port at 23:30. Three stations were carried out for the day. During the steam to Cork modifications were made to the GP2 winch which allowed live CTD data transmission to resume.
Monday February 25th:	A replacement crewman arrived on board at 12:00 and the vessel put to sea again at 15:00. The steam to resume transects is 120 miles.
Tuesday February 26th:	We restarted sampling to the west of Ireland on transect 17 at 04:00 at position 51.75N 10.75W. Transect 17 was completed at 09:00 at position 51.75N 11.75W. Transect 18 was started at 15:30

	at position 52.75N 11.25 W and finished at 23:30 at position 52.75N 12.75W. Eight stations were carried out for the day.
Wednesday February 27th:	Transect 18 was started at 02:00 at position 53.25N 12.75W and was completed at 11:30 at position 53.25N 10.75W. This was a repeat of transect 5 from earlier in the survey. This completed the survey. The vessel steamed for Galway and the sampling equipment was decommissioned.
Thursday February 28th:	Demobbed the survey and had the post cruise meeting

3. Individual survey report: Scotland/Marine Scotland, Periods 2, 3, 4, 5 & 7

Please find the individual survey report below

MSS Mackerel Egg Surveys – 2019 combined survey report

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Introduction

The triennial mackerel and horse mackerel egg survey (MEGS) aims to survey the entire spawning season in both space and time and through relating the numbers of freshly spawned mackerel eggs in the water column to the numbers of eggs present in the adult mackerel delivers an SSB estimate to the assessment working group for widely distributed species (WGWIDE). It also provides an annual egg production index for western horse mackerel. In 2019 the survey was divided into 6 temporal sampling periods that together span the entire spawning season for NEA mackerel within the southern and western areas and western horse mackerel. Within these periods individual surveys are allocated a geographic area to cover by the survey coordinator. Scotland (MSS) participated in 5 of the survey periods providing 4 dedicated egg surveys as well as completing additional egg sampling during trawling downtime on the spring Scottish West coast Groundfish Survey (SCOWCGFS-Q1).

Narrative

MSS contributed a total of 80 survey days spread across 5 different survey periods during the 2019 MEGS survey programme (see figure 1 for calendar view of MSS MEGS surveys by month). These were undertaken on both research and commercial charter vessels. During the 2019 MEGS programme an additional Scottish survey was undertaken by Scotland within survey period 4. This was to mitigate any impact to the overall MEGS survey schedule caused by Iceland's decision to withdraw from the egg survey late in 2018 and at relatively short notice. A combined total of 518 plankton deployments were completed by MSS during the 2019 survey programme with the Gulf 7 plankton sampler. Approximate depth during each deployment was provided using a SCANMAR sensor and in the case of the period 7 survey a temperature unit was also attached to the sampler to allow for thermocline detection. A CTD unit also attached to the sampler provided accurate depth, temperature and salinity data for all surveys. Calibrated valeport replica flowmeters were used throughout to calculate the volume filtered during each deployment. This is an essential component in calculating the density of eggs in the water column. All egg densities reported in all figures have been standardised to numbers recorded per metre squared (m^2). Sampling and processing of samples was undertaken in accordance with the protocols and procedures as described in the MEGS Sampling at Sea manual, SISP 6, V2.2. Table 1 provides a summary of survey vessel and deployment details for each of the MEGS surveys undertaken by MSS during 2019.

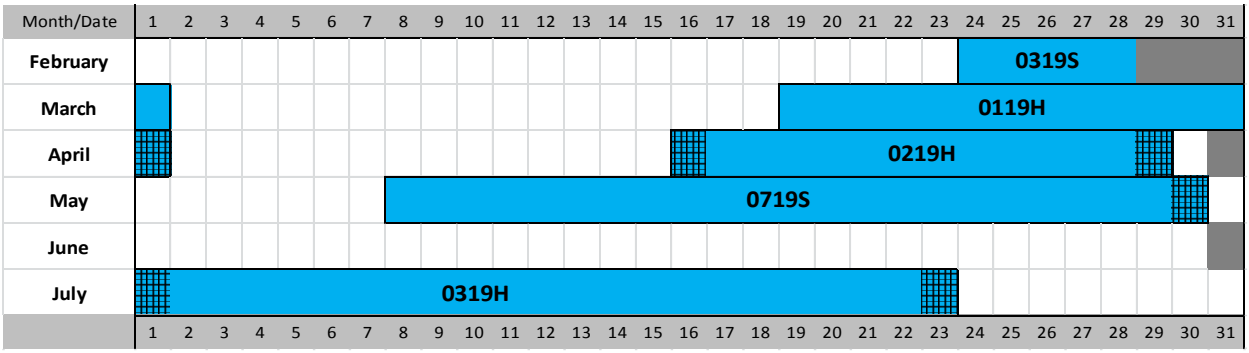

Figure 1. Calendar view of MEGS surveys completed by MSS during 2019. Cross-hatched cells denote survey transit days when no sampling was undertaken.

Table 1: 2019 MSS MEGS survey and vessel details and also summary of deployments

Survey Period	Survey	Survey dates	Days	Survey Type	Survey Area	Vessel	Vessel Type	Vessel Length(m)	G7 Stations	Repeat var stations	F/M calibration runs	Trawl Stations	fish rod deploy
2	0319S	24/2/19 - 1/3/19	6	IBTS	West of Scotland, NW Ireland	Scotia	Research	70	21	0	4	N/A	N/A
3	0119H	19/3/19 - 1/4/19	14	MEGS	West of Scotland, NW Ireland	Altaire	Commercial	76	86	2	8	5	0
4	0219H	16/4/19 - 29/4/19	14	MEGS	West of Scotland, NW Ireland, Rockall	Altaire	Commercial	76	102	2	4	1	2
5	0719S	8/5/19 - 30/5/19	23	MEGS	W Scotland , Ireland, Rockall and Hatton Banks	Scotia	Research	70	164	2	6	1	3
7	0319H	1/7/19 - 23/7/19	23	MEGS	Faroe/Shetland, W Scot, Ireland, Celtic Sea and Biscay	Altaire	Commercial	76	145	1	4	6	0

Results

General synopsis

No major issues were experienced and all surveys were successful in covering their allocated survey areas. Across all surveys there was around 1.5 days lost to weather, one day being lost during survey 0119H within period 3 and 12 hours were lost North of Rockall on 0719S and during period 5. Other issues causing minor disruption were an unplanned staff transfer journey ashore due to a minor injury and a military exercise west of the Hebrides that required Scotia to divert for several days during survey 0719S within period 5. During 0719S Scotia experienced significant trawling issues arising from problems associated with the transducer winch setup. Although not hampering the overall progress of the survey it severely restricted the ability of Scotia to conduct any successful pelagic trawling operations. Though these issues were eventually resolved, only one successful deployment of the trawl was made during the entire survey. Similarly, during survey 0219H Altaire encountered serious issues with its autotrawl system that were identified during the first trawl. This resulted in no subsequent trawls being completed during that survey. Clogging was encountered on 41 occasions and almost exclusively on the later surveys within periods 5(17) and 7(24). In the majority of the cases it was caused by high volumes of phytoplankton present in the watercolumn. Figures 2 – 6 provide survey specific plots

providing station position, temperature, clogging and also trawl positions. During the period 7 survey, thermoclines were encountered during survey 0319H and on 42 stations (also presented in figure 6).

Egg Sampling

During each survey all plankton samples were processed and sorted with all fish eggs being removed for analysis. All the mackerel, horse mackerel, hake and ling eggs were successfully staged and identified at sea. A total of 86531 eggs were sorted and analysed across the 5 surveys. From these 36516 mackerel eggs were staged and identified as well as 3404 horse mackerel eggs. Table 2 provides a breakdown of the total numbers of eggs removed by survey for both mackerel and horse mackerel as well as the total numbers of freshly spawned eggs for the same species. Total numbers of hake and ling eggs (all stages) recorded by survey are also provided.

Table 2: Total egg numbers reported by MSS survey for target species.

Survey Period	Survey	mackerel eggs recorded (all stages)	stage 1a + 1b mackerel (M1) eggs recorded	horse mackerel eggs recorded (all stages)	stage 1a + 1b h. mackerel (HMA1) eggs recorded	hake eggs recorded (all stages)	ling (spp) eggs recorded (all stages)
2	**0319S**	62	**36**	0	**0**	42	0
3	**0119H**	281	**181**	0	**0**	255	82
4	**0219H**	19122	**9682**	0	**0**	73	463
5	**0719S**	16542	**4972**	22	**17**	5	172
7	**0319H**	509	**233**	3382	**1308**	40	0
	Total	36516	**15104**	3404	**1325**	415	717

Taken in isolation the results from individual surveys provide very little by way of an indication of the overall stock situation for the target species. The full and final results from this as well as the other egg surveys will be collated and uploaded into the ICES egg and larval database. Egg production results from this and the other MEGS survey contribute to and will be incorporated into the spawning stock biomass (SSB) estimate for NEA mackerel and annual egg production (AEP) index for western horse mackerel.

Mackerel *(Scomber scombrus)*

Period 2 & 3 (feb – mar)
During the period 2 and period 3 surveys there mackerel spawning recorded was recorded only at very low densities within the shelf areas surveyed by 0319S and 0119H and This is entirely consistent with the expectations for west of Scotland during February and March

with spawning being confined to the continental shelf and boundaries very well defined. Figures 7 – 8 provide plots for all stage 1 (M1) eggs/m^2/station for both surveys.

Period 4 (april)
During period 4 survey 0219H was tasked with surveying Rockall Bank and also west of Scotland. Mackerel spawning was only recorded at very low levels over the top of Rockall bank, however North of the Barra Fan mackerel spawning started to increase significantly as the survey proceeded North with very high densities being recorded west and northwest of the Butt of Lewis. These levels of spawning are unprecedented at these latitudes and continued until almost level with Shetland. Most of the spawning was contained within the continental shelf and shelf break although low levels of mackerel spawning were still present on the boundary stations on the western and Northern edges. (fig 9).

Period 5 (may)
Survey 0719S was tasked with surveying Rockall and Hatton Bank as well as western Scotland and Ireland. Scotia encountered mackerel eggs over almost all of the surveyed area with the highest densities of freshly spawned eggs being recorded on and around the Faroe – Shetland channel area which was very close to the areas of very high spawning density recorded during period 4. In keeping with recent years mackerel spawning had moved offshore and low densities were recorded as far west as the west side of Hatton Bank at almost 20 degrees west. Despite this the boundaries were generally well defined although there were several boundary stations on the SW of Rockall bank recording moderate densities of mackerel spawning. (figs 10)

Period 7 (july)

Survey 0319H was tasked with mopping up the residual mackerel spawning during the last survey of the 2019 MEGS schedule. Mackerel eggs were only present in around 30% of all stations and only ever at very low densities. A few stations providing slightly elevated densities and these being located around the NW of Ireland, Porcupine Bank and on the shelf edge southwest of Ireland. Mackerel spawning was recorded right up to to 63^{o}15N, however this was only at very low densities. (figs 11)

Horse mackerel *(T. trachurus)*

Periods 2 – 4 (feb – april)

No horse mackerel eggs were recorded from MSS surveys during periods 2, 3 and 4. This is entirely consistent with the areas and temporal periods being sampled.

Period 5 (may)

Only 22 horse mackerel eggs were recorded, spread across 3 stations during the whole of survey 0719S. These were located on the Porcupine Bank.

Period 7 (july)

Horse mackerel eggs were similarly only present within around 35 percent of all the surveyed stations and at generally low to moderate densities with some notable spawning hotspots located around the Porcupine Seabight and also south of Land's End in the southern Celtic Sea area. Virtually no horse mackerel spawning was observed north of 56^{o}N. This is a significant decrease on the results reported from 2016 within the same period and

geographic area. See figure 12 for plot of period 7 stage 1 horse mackerel (HMA1) eggs/m^2/station.

Trawling

A total of 356 mackerel and 220 horse mackerel were sampled across the 5 MSS surveys. Within these 106 and 60 samples respectively were retained for fecundity analysis. Table 3 provides the breakdown of samples of adult fish analysed by survey and period. Horse mackerel are only sampled for DEPM sampling and this is undertaken during survey periods 6 & 7 therefore they were only sampled by MSS during period 7 and on survey 0319H.

Table 3: Adult samples collected by survey and period for mackerel and horse mackerel during MEGS 2019 MSS surveys.

Period	Survey	total mackerel sampled	mackerel fecundity samples	total horse mackerel sampled	horse mackerel fecundity samples
2	**0319S**	0	**0**	-	-
3	**0119H**	63	**7**	-	-
4	**0219H**	100	**30**	-	-
5	**0719S**	55	**22**	-	-
7	**0319H**	138	**47**	220	**60**
	Total	356	**106**	220	**60**

Miscellaneous

IMR – CLIMRATES, 35 mackerel ovary samples collected for Thassya during survey periods 3 & 4. These were collected along with the routine fecundity sampling.

Ti – GENETICS, 4 stations fresh picked from periods 5 and 7. 23 fresh sorted/inspected eggs were subsequently preserved in pure ethanol. Once removed fresh from sample, the eggs are measured, staged and also measured. They are then placed individually into labelled Eppendorf vials with 96% ethanol. Will aim to validate analysts results. Results will be forthcoming.

UCD – GENETICS, stock validation project aiming to genetically discriminate north sea from western horse mackerel. 97 horse mackerel tissue samples were collected for Ed Farrell during period 7 and within area 7. This project was targeting spawning fish and due to a lack of these encountered during the survey the samples were taken across several hauls instead of the preferred one.

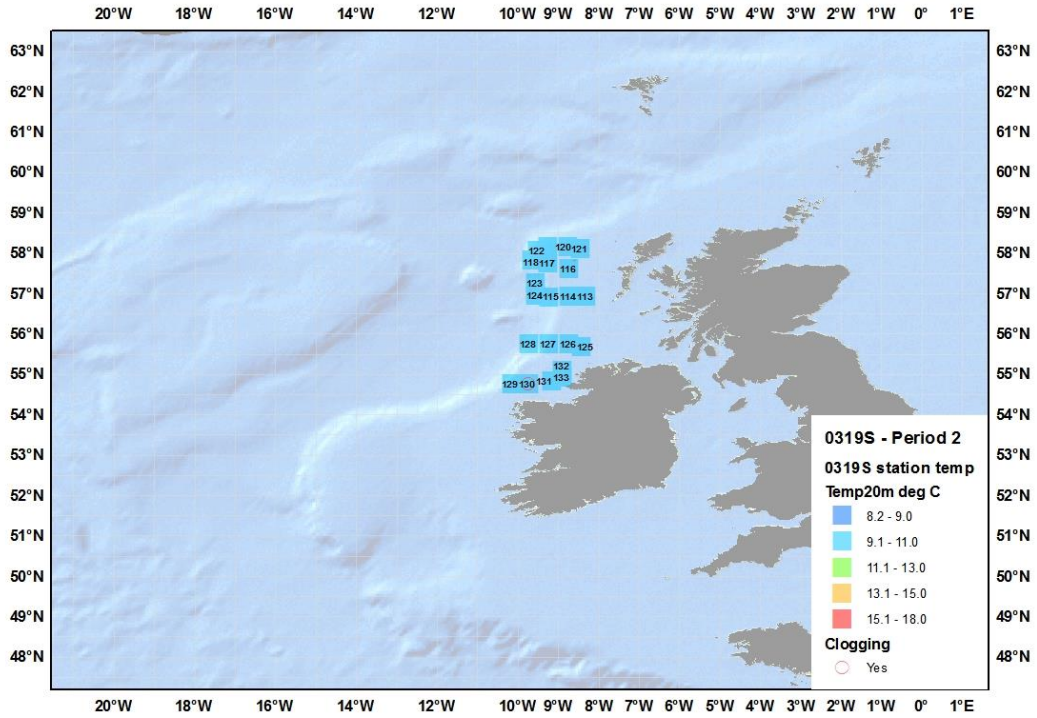

Figure 2: 0319S– P2 Map displaying plankton station, location as well as clogging locations. Also included is the temperature profile for all stations at 20m depth.

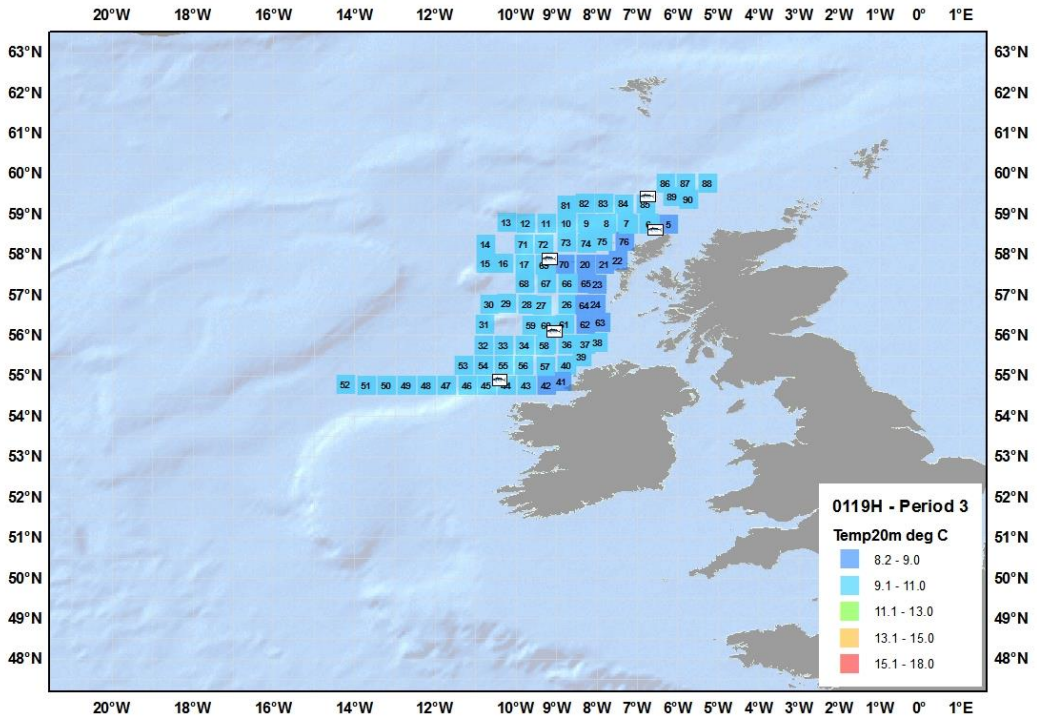

Figure 3: 0119H– P3 Map displaying plankton station and location. Trawling deployments are denoted using a fish icon. Temperature profile at 20m is also present.

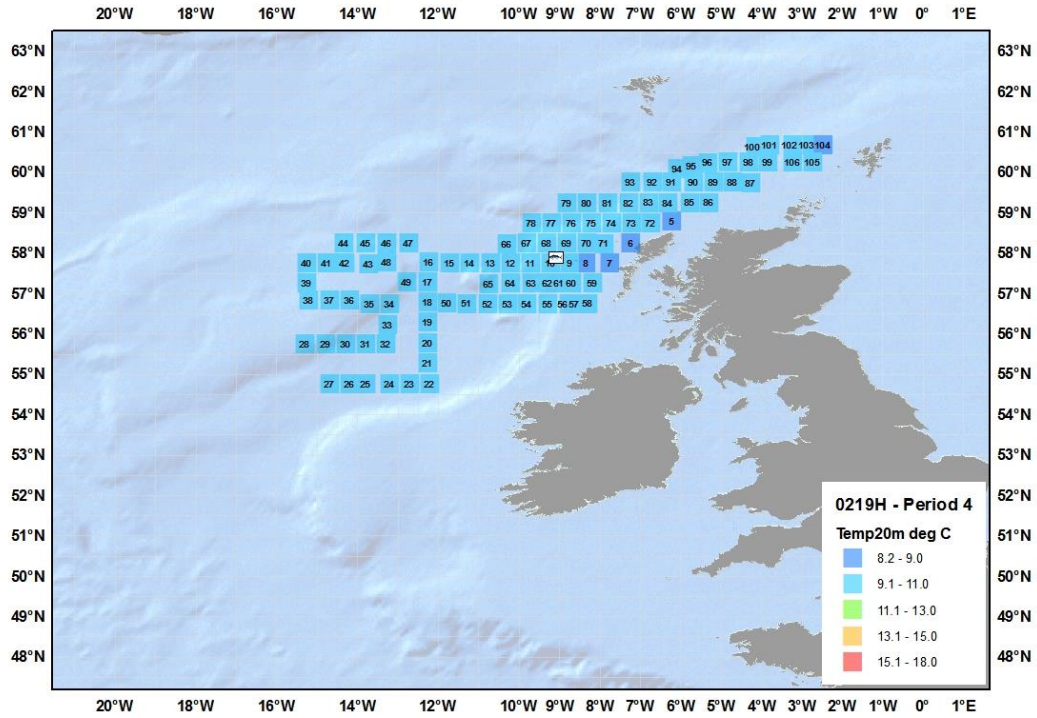

Figure 4: 0219H– P4 Map displaying plankton station and location. Trawling deployments are denoted using a fish icon. Temperature profile at 20m is also present.

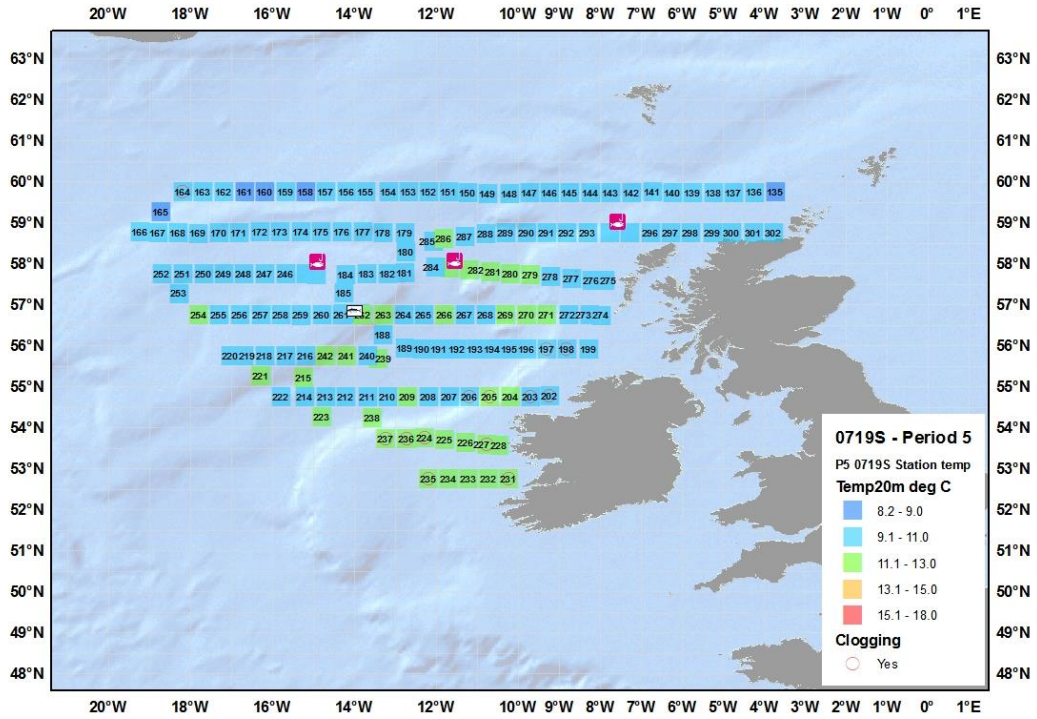

Figure 5: 0719S– P5 Map displaying plankton station, location as well as clogging locations. Also included is the temperature profile for all stations at 20m depth. Also displayed are trawl deployments (fish) and rod and line locations (purple fish and hook).

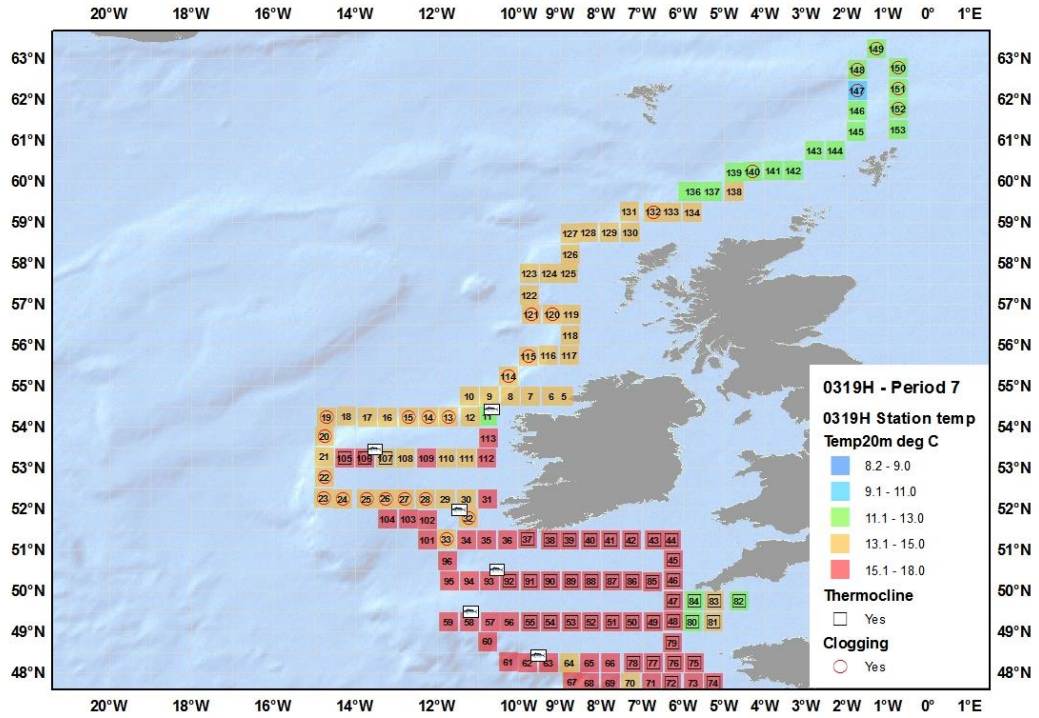

Figure 6: 0319H– P7 Map displaying plankton station, location as well as clogging locations. Also included is the temperature profile for all stations at 20m depth. Trawl deployments are also presented (fish) as well as stations where a thermocline was encountered.

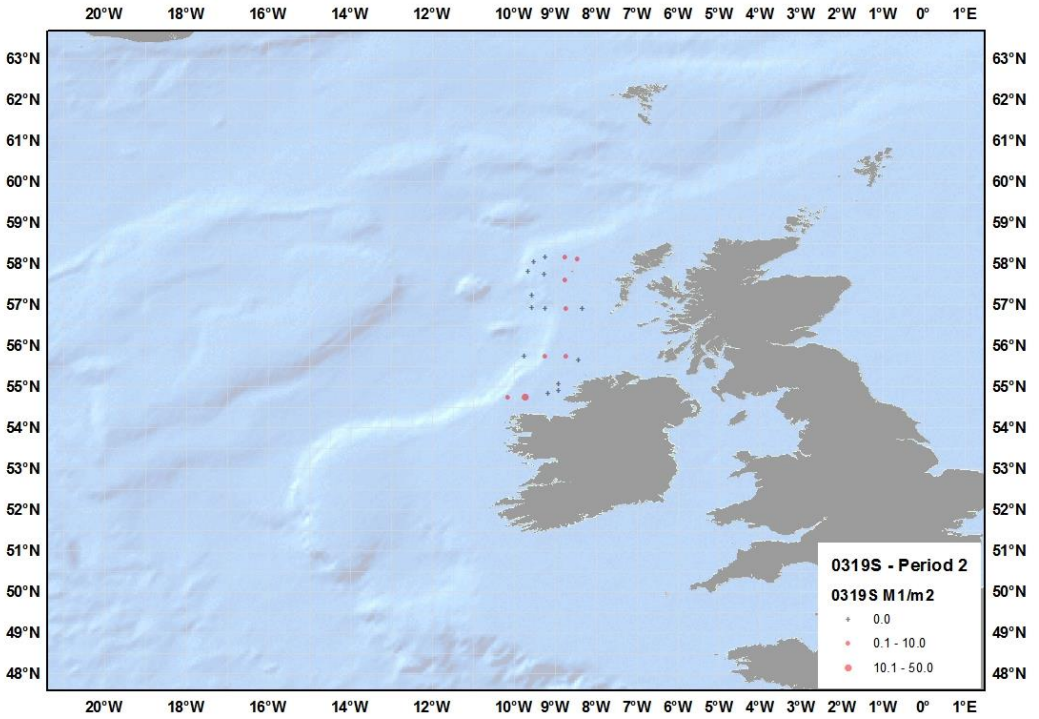

Figure 7: 0319S Map displaying bubble plot for stage 1 (M1) of mackerel egg per m^2 for each station**.**

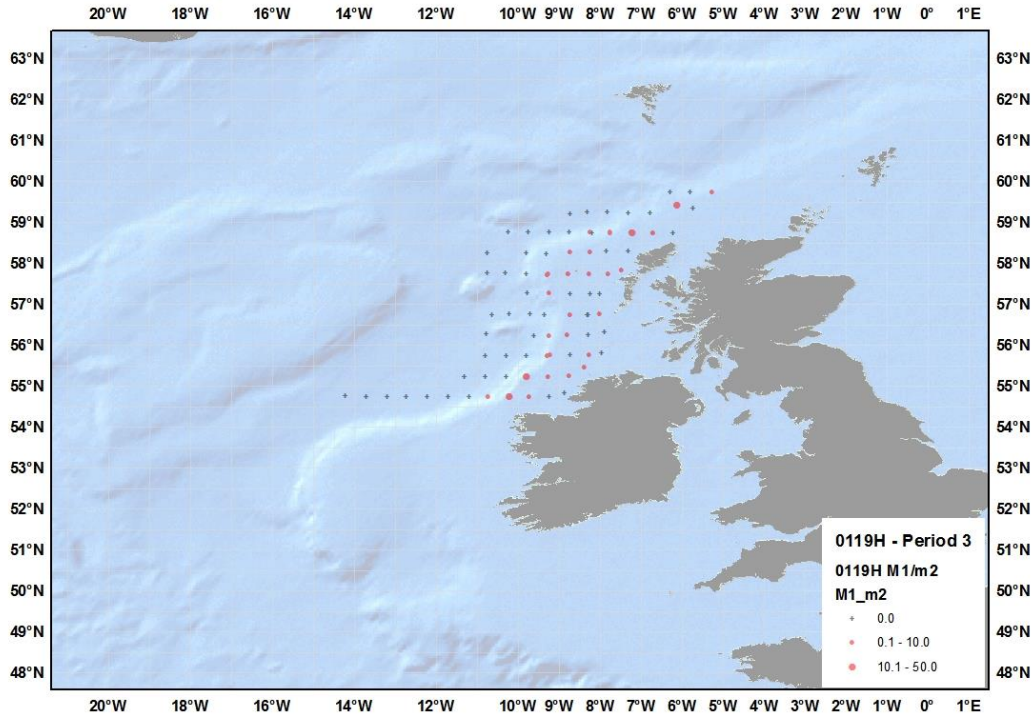

Figure 8: 0119H Map displaying bubble plot for stage 1 (M1) of mackerel egg per m^2 for each station**.**

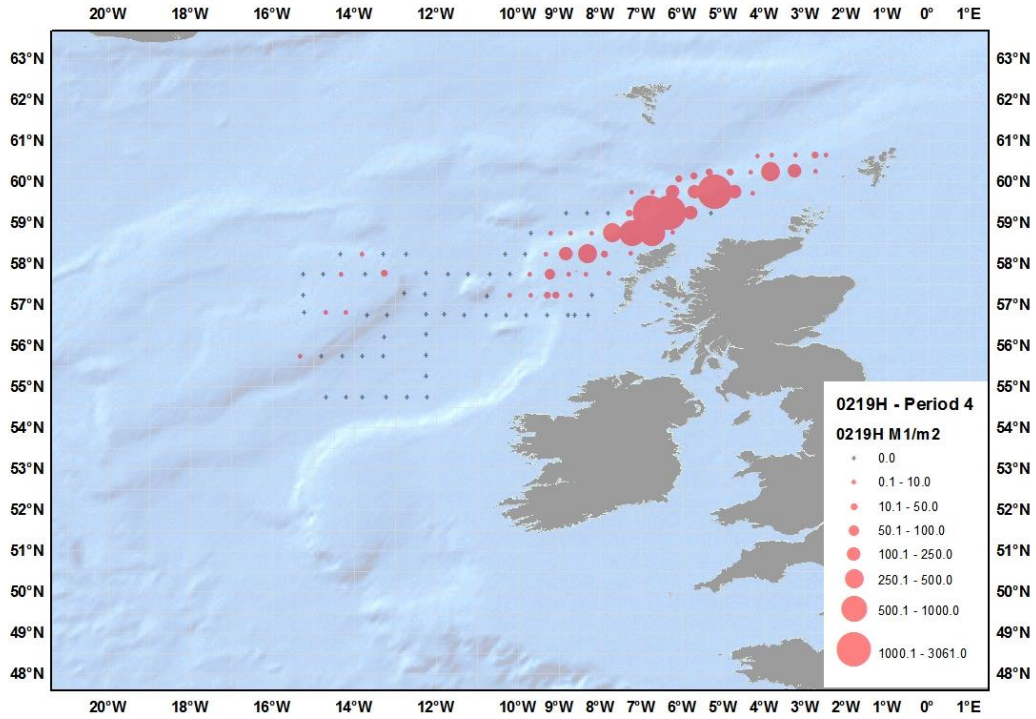

Figure 9: 0219H Map displaying bubble plot for stage 1 (M1) of mackerel egg per m^2 for each station**.**

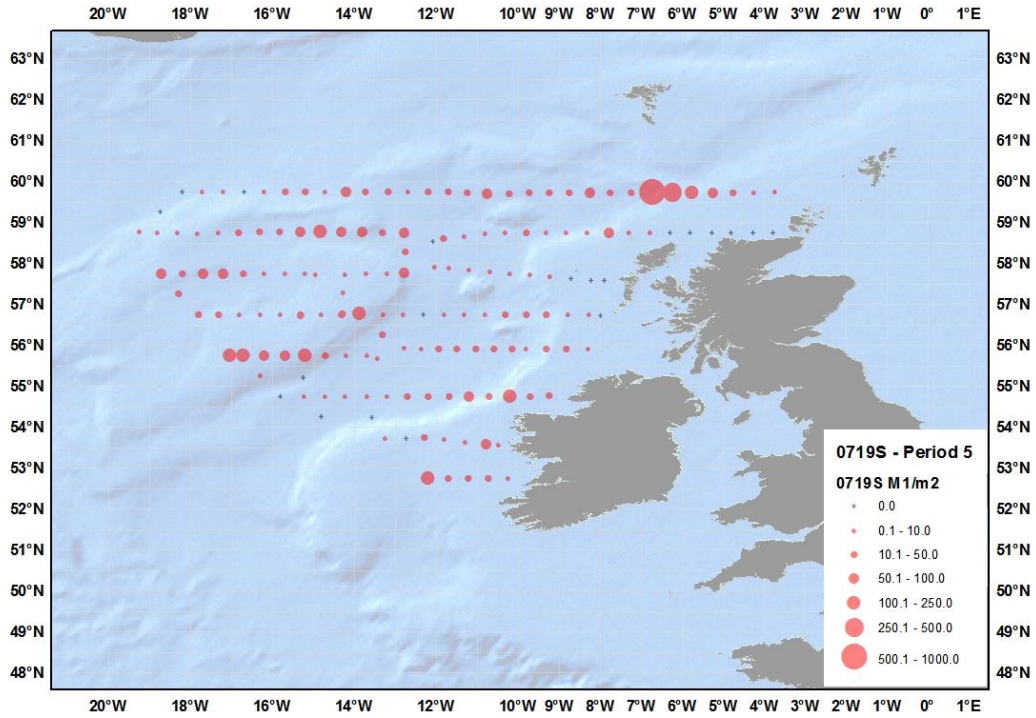

Figure 10: 0719S Map displaying bubble plot for stage 1 (M1) of mackerel egg per m^2 for each station**.**

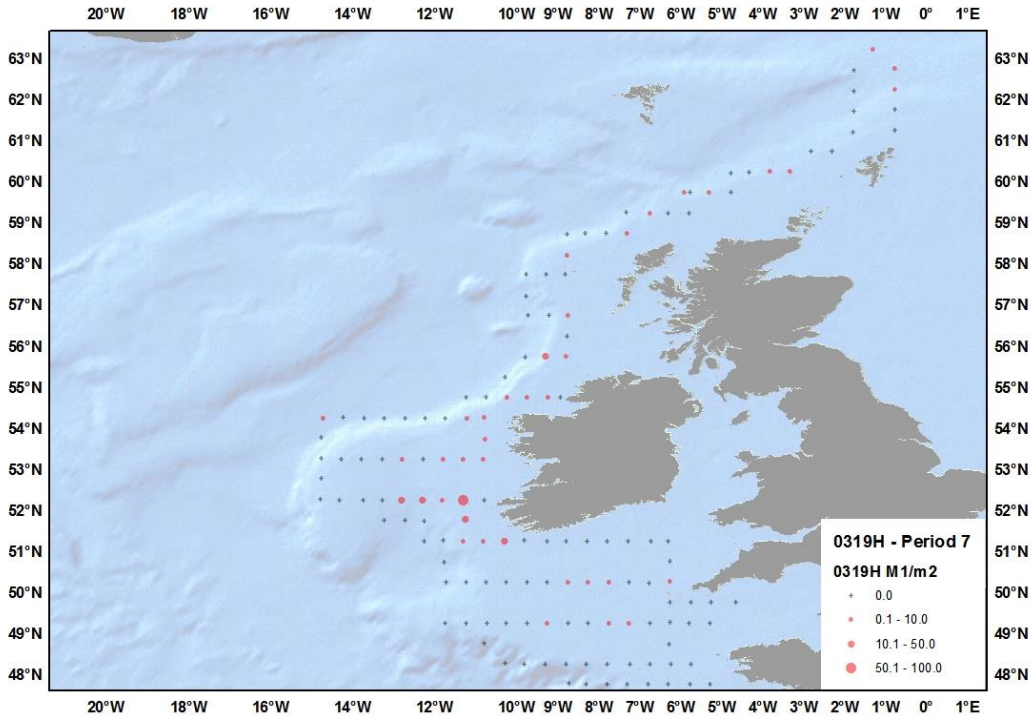

Figure 11: 0319H Map displaying bubble plot for stage 1 (M1) of mackerel egg per m^2 for each station**.**

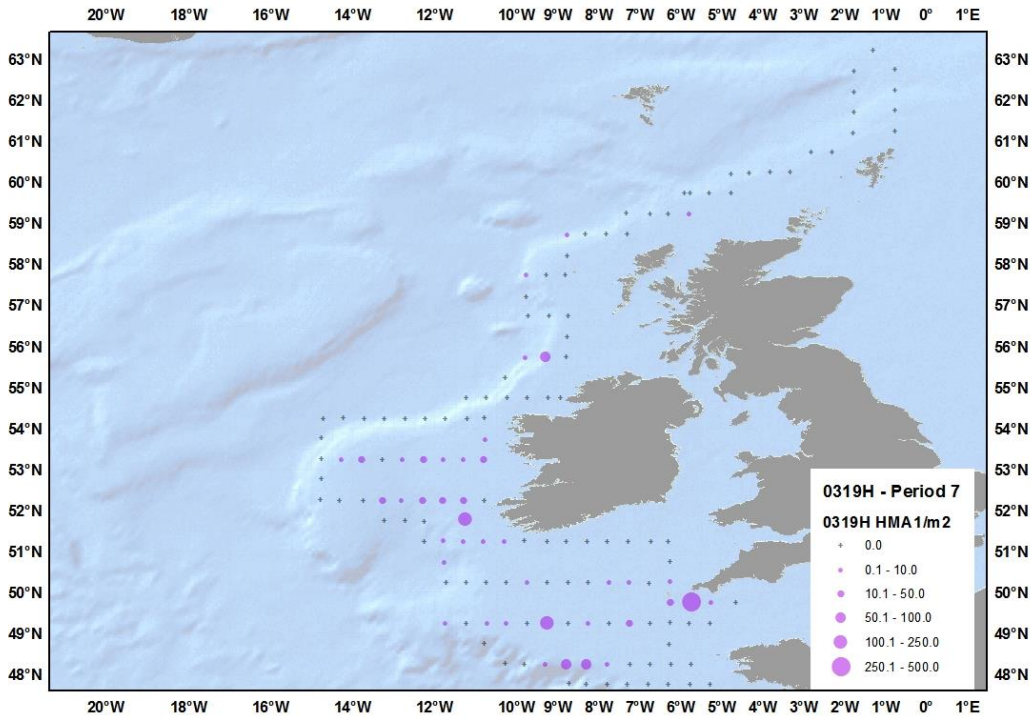

Figure 12: 0319H Map displaying bubble plot for stage 1 (HMA1) horse mackerel egg per m^2 for each station**.**

4. Individual survey report: Spain/IEO, Period 3

Please find the individual survey report below

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA **SECRETARIA GENERAL DE PESCA**

Cruise Report RV "Vizconde de Eza"

Survey MEGS19 – CAREVA 14/03-06/04

IEO Spanish Participation in the International Mackerel and Horse Mackerel Egg Survey 2O19 (PERIOD 3)

Isabel Riveiro, Gersom Costas, Dolores Garabana, Luisa Iglesias, Antonio Solla, Pablo Carrera

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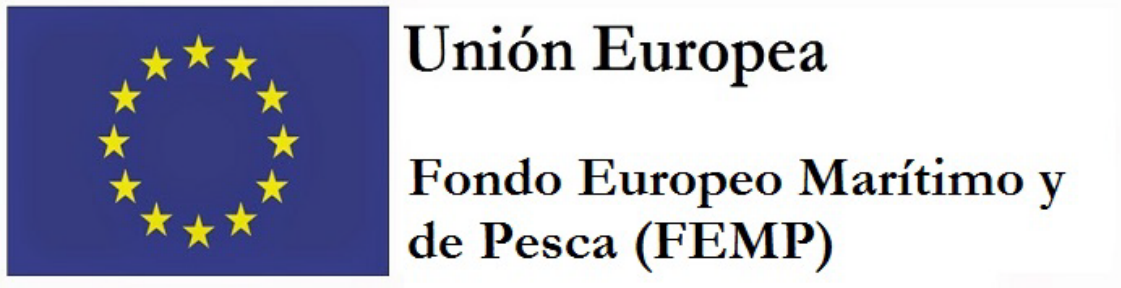
Acknowledgements

CAREVA survey has been funded by the European Union through the European Maritime and Fisheries Fund (EMFF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

We thank the crew of the R/V “Vizconde de Eza” and scientific staff onboard for their professional assistance, ensuring the success of the survey.



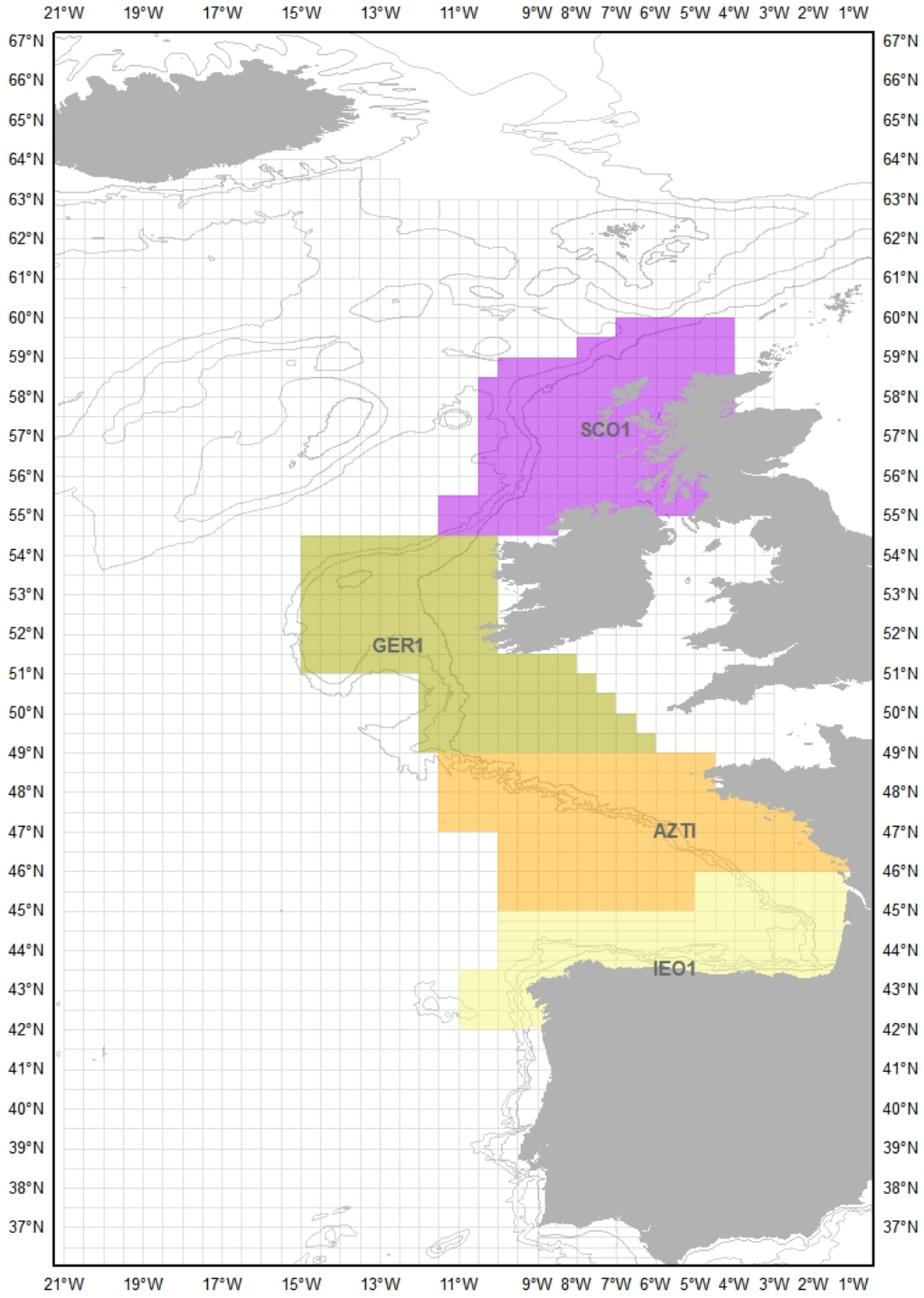
1. INTRODUCTION

CAREVA survey is part of the Spanish "Data Collection Framework" program and is coordinated within the framework of the ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (ICES WGMEGS).

The survey calendar is shown in the following table (in yellow the commitment of the IEO):

		Area							
Semana		Portugal, Cadiz & Galicia	Cantabrian Sea	Biscay	Celtic Sea	North west Ireland	West of Scotland	Northern Area	Period
3	13-Jan-19	PO1 (DEPM)							1
4	20-Jan-19	PO1 (DEPM)							1
5	27-Jan-19	PO1 (DEPM)		IRL1	IRL1				2
6	3-Feb-19	PO1 (DEPM)		IRL1	IRL1				2
7	10-Feb-19	PO1 (DEPM)		IRL1	IRL1				2
8	17-Feb-19	PO1 (DEPM)				SCO(IBTS)	SCO(IBTS)		2
9	24-Feb -19					SCO(IBTS)	SCO(IBTS)		2
10	3-Mar-19								3
11	10-Mar-19		IEO1						3
12	17-Mar-19		IEO1	AZTI1	GER1	SCO2	SCO2		3
13	24-Mar-19		IEO1	AZTI1	GER1	SCO2	SCO2		3
14	31-Mar -19		IEO1	AZTI1	GER1	GER1			3
15	07-Apr-19		IEO2	IEO2	GER2	GER2			4
16	14-Apr-19		IEO2	IEO2	GER2	GER2	GER2	IRL-EX	4
17	21-Apr-19		IEO2	IEO2	GER2	GER2	GER2	IRL-EX	4
18	28-Apr -19		IEO2	IEO2					4
19	5-May-19		AZTI2 (DEPM)	AZTI2 (DEPM)	NED1	SCO3	SCO3	ICE	5
20	12-May-19		AZTI2 (DEPM)	AZTI2 (DEPM)	NED1	SCO3	SCO3	ICE	5
21	19-May-19		AZTI2 (DEPM)	AZTI2 (DEPM)	NED1	SCO3	SCO3	FAR	5
22	26-May -19		AZTI2 (DEPM)	AZTI2 (DEPM)				FAR	5
23	2-Jun-19		AZTI2 (DEPM)	NED2	NED2			FAR	5
24	9-Jun-19			NED2	NED2	IRL2	IRL2	NOR	6
25	16-Jun-19			NED2	NED2	IRL2	IRL2	NOR	6
26	23-Jun -19					IRL2	IRL2	NOR	6
27	30-Jun -19								6
28	7-Jul-19			SCO4	SCO4	SCO4	SCO4		7
29	14 –Jul-19			SCO4	SCO4	SCO4	SCO4		7
30	21-Jul-19			SCO4	SCO4	SCO4	SCO4		7
31	28-Jul-19								7

The sampling scheme for the THIRD period, in which CAREVA (IEO1) will be carried out, is shown in the following map:



Ichthyoplankton samples, as well as hydrographic information, were collected during CAREVA survey on board R/V "Vizconde de Eza", while most of the adult's samples for AEPM/DEPM estimates were provided by PELACUS0319 acoustic survey, carried out in the same area at the same time, on board R/V "Miguel Oliver" (*Secretaria General de*

Pesca). Both surveys are coordinated by the PELASSES project (*Instituto Español de Oceanografía*).

Extra adult samples (in order to complete areas and periods) were obtained from commercial vessels operating in the area.

On the other hand, the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas 7, 8 and 9 (WGACEGG), has recommended the use of the CUFES to delimit the spawning area of the sardine during ichthyoplankton surveys directed to mackerel and horse mackerel, so that sampling with CUFES will be carried out during CAREVA.

2. PARTICIPANTS AND AFFILIATION

ISABEL RIVEIRO ALARCÓN	1
GERSOM COSTAS BASTIDA	1
JOSE LUIS VILLAVERDE ROSALES	1
LUISA IGLESIAS GARCÍA	1
MONTSERRAT PÉREZ RODRÍGUEZ	1
ARANCHA CARROCEDA	2
JOSE VARELA ROMAY	2
Mª JESÚS LLEVOT SÁNCHEZ	2
GABRIEL POMAR VERT	3
FRANCISCO FERNÁNDEZ CORREGIDOR	4
VENICIO PITA FREIRE	5
ALMA HERNANDEZ DE ROJAS	5
ROSARIO NAVARRO RODRÍGUEZ	6
PATRICIO AHUMADA	
MIGUEL ANGEL SANTORUM BELLO	

1: IEO C.O. Vigo, 2: IEO C.O. A Coruña, 3:IEO C.O. Baleares, 4: IEO C.O. Málaga, 5: IEO C.O. Gijón, 6:IEO C.O. Santander.

3. ITINERARY

Date (UTC)	
14/03/2019 8:00	Vigo Harbour. Security and administrative issues.
14/03/2019 17:30	Start of sampling in Galicia waters 42.25N 9.17W
14/03/2019-18/03/2019	Plankton stations in Galicia – Cantabrian waters of Asturias (st 1-st 26)
18/03/2019	Fishing hauls for incubation experiments
18/03/2019-19/03/2019	Plankton stations in Cantabrian waters of Asturias (st 27-st 26)
20/03/2019	Start of sampling in French waters (45.75N, 4.76W)
20/03/2019-24/03/2019	Plankton sampling in French waters – Cantabrian waters of Basque Country (st 28-69)
25/03/2019-26/03/2019	Break in Santander Harbour
27/03/2019 1:50	Start of sampling in Cantabrian waters (43.44N 1.84W)
27/03/2019-02/04/2019	Plankton stations in Cantabrian Sea (st 70-st 118)
03/04/2019	Sampling interruption due to bad weather conditions
04/04/2019-05/04/2019	Plankton stations in Galicia waters (st 119-st 123)
06/04/2019	End of CAREVA survey in Vigo Harbour

The first survey, CAREVA, began in the port of Vigo on March 14th. Plankton stations were performed in alternative transects from south to north (beginning in 42.25N 9.17W) until reaching the coast of Asturias, where the presence of mackerel eggs was more intense. In this area, fishing hauls were done in order to carry out fertilization and incubation experiments of mackerel eggs. Just after the beginning of the experiments, the R/V “Vizconde de Eza” moved to the northernmost sampling area on the French shelf (45.75N, 4.76W) and from there, the plankton stations continued southward to the Spanish coast in the Cantabrian Sea. The first leg of the survey was characterised by good weather conditions and ended with a scheduled personnel exchange on 25th/26th March in Santander.

During the second part of CAREVA, meteorological conditions were much worse, but the progress achieved in the first part allowed that the proposed plankton stations were carried out, and some extra work (plankton samples replicates and sequential sampling every hour in some fixed stations) was performed.

Figures 1a and 1b show fishing hauls and plankton stations performed before the survey (period 2) and during CAREVA survey (period 3).

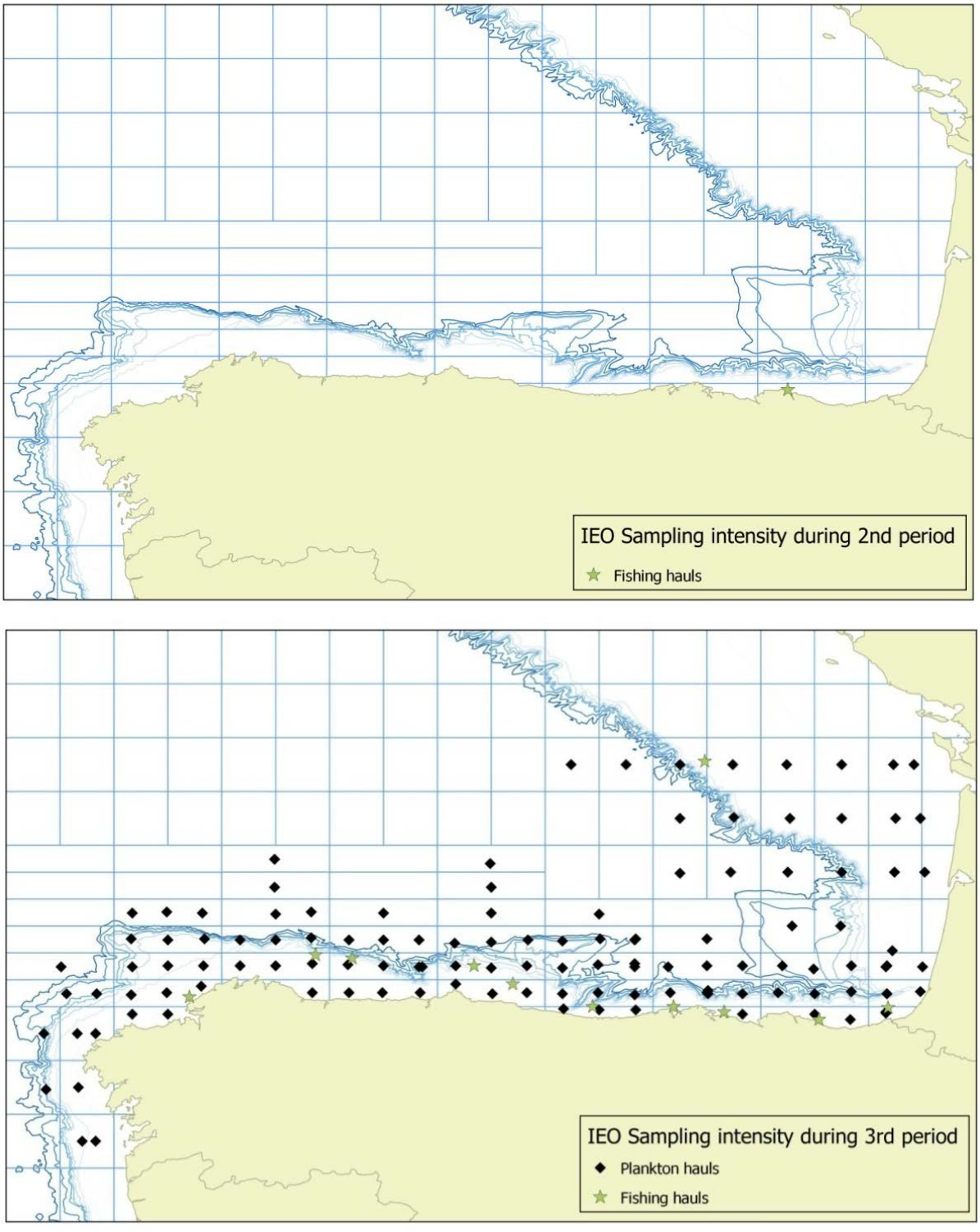


Figure 1. Sampling intensity. 1a)Fishing hauls during period 2. 1b) Fishing hauls and plankton stations during period 3.

4. METHODS

4.1. Plankton sampling

Sampling consisted of ichthyoplankton sampling on fixed (BONGO) and underway (CUFES) stations.

BONGO net consists in a double net structure of 40 cm mouth. The bongo hauls were performed using a net with 250 µm mesh size and plastic cod-ends, operating obliquely from 200 m depth to the surface. In shallower areas, the net was towed from 5 m above the bottom to the surface. General Oceanics Flowmeters were used to record the towing length and estimate the sampled water volume (assuming a filtration efficiency of 100%), while a CTD Seabird SB37 (coupled to BONGO net) was used to record maximum sampling depth and to register thermal structure of the water column.

CUFES (Fig. 6, Continuous Underway Fish Egg Sampler) sampled at the surface (3-5 m depth) with a mesh size of 335 µm. CUFES samples were used to delimit sardine spawning grounds, and was used only in the survey CAREVA (period 3).

Fish eggs in the samples were separated from the remaining plankton organisms onboard by performing the spray method recommended by the WGMEGS. Fish eggs were identified using morphological criteria (egg diameter, oil globule diameter, segmentation of yolk sac and pigmentation) and counted immediately after collection.

All samples were fixed in 4% buffered formaldehyde solution for subsequent verification of egg counts and staging in the laboratory. At least sub-samples of up to 100 individuals per target species (mackerel, horse mackerel) were staged.

Apart from the stations defined before the survey, some extra experiments were developed in order to better understand fish egg abundance variability with time, and changes in egg vertical distribution. For that purposes, some stations were replicated in different dates and one single station was re-sampled at different depths during a 12h cycle:

Number of replicates: 8

Original station- Date	**Replicate station- Date**		
56 23/03/2019	72	27/03/2019	
57 23/03/2019	71	27/03/2019	
58 23/03/2019	70	27/03/2019	
62 23/03/2019	69, 81	24/03/2019	28/03/2019
65 24/03/2019	85	28/03/2019	
66 24/03/2019	84	28/03/2019	
28 19/03/2019	107	31/03/2019	

Sequential sampling with BONGO at 8 maximum depths (25, 50, 100, 150, 200, 250, 300, 400m) combined with one CUFES sample, every hour from 9:00 to 20:00h. Positions:

Position	Date
43 92 45N 5 756 W	29/03/19
43 7421N 4 827 W	31/03/19
44 0166N 7 152 W	02/04/19

4.2. Fertilization and incubation experiments

During CAREVA, when a high density of mackerel eggs was found (Asturias coast), fishing hauls were performed, in order to collect adult mackerel for egg incubation experiments (figure BBB shows the position of the valid haul for the experiment).

Some running males and females were selected for the fertilization in two groups (two different containers with seawater). After fertilization, floating eggs were placed in filtered seawater at three temperatures: 11, 13 and 15ºC.

At the beginning of the experiment, we sampled 10 eggs (and preserved them in formalin) every hour during the first 24h, after that, every two hours until the end of the embryonic period, except for the lower temperature, where we sample every four hours after two days of incubation.

In every sampling, we used a plastic pipette for the water oxygenation and we removed the dead eggs from the bottom of the container. Twice a day, we changed the total volume of water (with filtered water, 0.45 microns, at the selected temperature of the experiment).

4.3. Hydrographic sampling

As mentioned before, a was incorporated to the BONGO structure, and allows collecting regularly conductivity (salinity)/temperature/depth profiles simultaneously to each ichthyoplankton haul.

In addition a CTD Seabird25 was deployed for a better resolution in the hydrographical description of the water column (until 200m depth or 5m above the bottom in shallower stations).

Due to a mechanical breakdown in the Seabird SBE37 CTD at station 44, from this station to the end of the survey, only CTD25 was deployed. In order to know the maximum depth of the sample, a Marport net monitoring sensor was then used coupled to the BONGO net.

4.4. Fecundity

Fecundity sampling was adapted as closely as possible to the sampling planning described in the ICES survey protocol 'Manual for the mackerel and horse mackerel egg surveys (MEGS): sampling at sea version 2.2' and fecundity samples were taken following the standardized sampling methods described in the same survey protocol.

Total and batch fecundity estimation are key for AEPM and DEPM egg production methods and has to match in time and space with plankton (egg) sampling. Due to IEO internal management purposes no samples were taken in CAREVA0319, but most of the IEO fecundity samples were planned to be taken during the PELACUS0319 survey, as both surveys match in time. The specific IEO fecundity sampling schedule and fecundity methods are described in the PELACUS 0319 survey plan. A complementary sampling from commercial fish was fixed at A Coruña and Santander IEO laboratories to full fill the IEO required number of samples.

4.5. Biochemical analysis

With the objective of performing biochemical analysis (genetics,...), one of the nets was preserved in absolute ethanol just after the sampling, and 72 hours after fixation the ethanol was renewed. These samples will be sorted and analysed in the lab.

5. RESULTS

5.1. Egg abundance and distribution

In total, 123 BONGO stations were carried out and 411 CUFES samples were collected during PERIOD 3 (CAREVA survey).

Only 16 of the 123 stations were negative for fish eggs (13%). A total of 84255 fish eggs were sampled, with an average abundance of 691 eggs (average density of 797 eggs m^{-2}).

- Mackerel egg abundance and distribution.

Figure 2 shows mackerel egg distribution during CAREVA.

Mackerel was the most abundant species in the area, with a total number of eggs in the samples of 74610.

This species was present in the 63% of the stations, with a higher abundance in the central part of the Spanish Cantabrian coast.

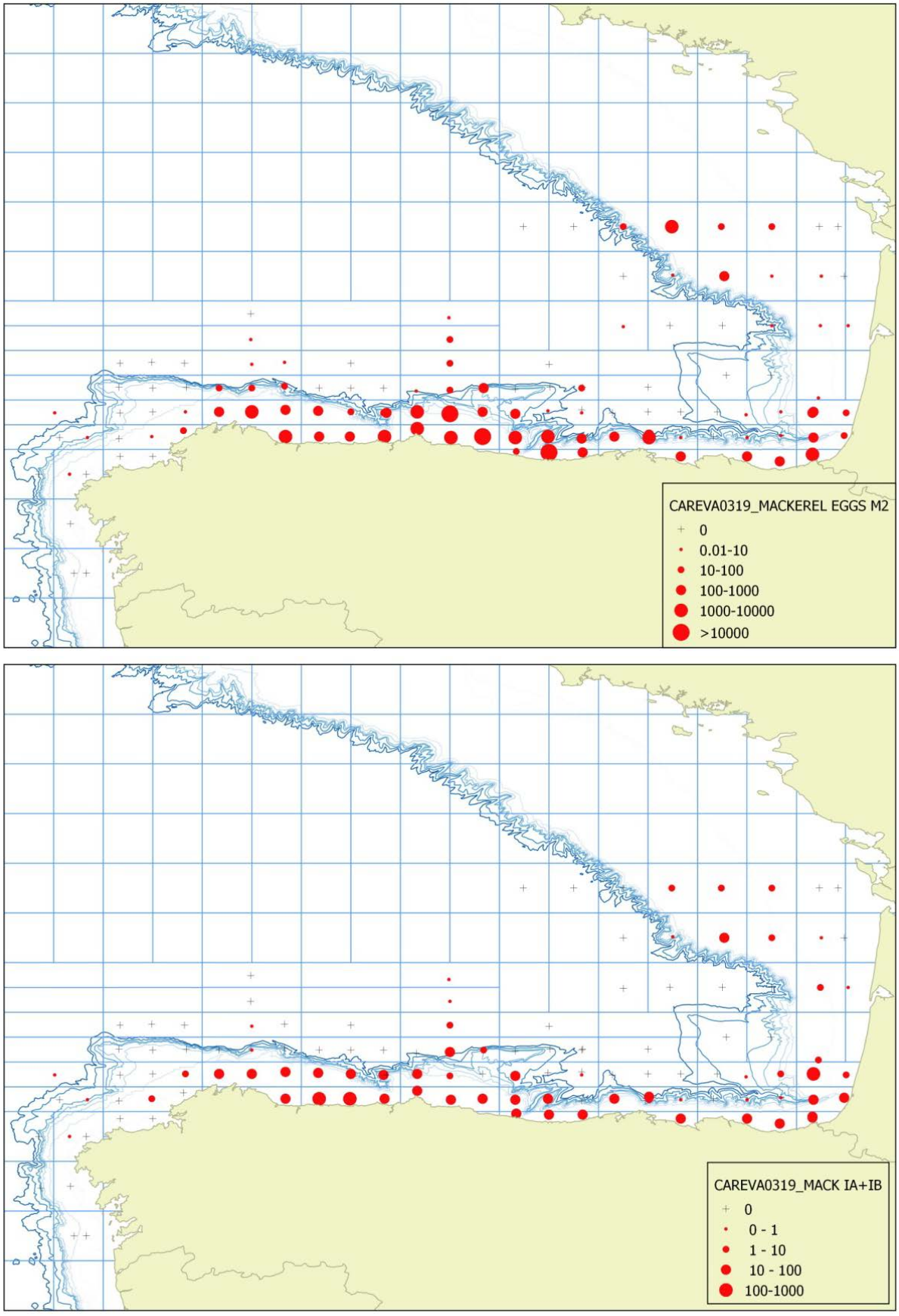


Figure 2. Mackerel abundance and distribution during CAREVA survey. 2a) Total egg distribution (eggs m-2) and figure 2b) Number of eggs in stage Ia and IB.

- Horse mackerel egg abundance and distribution.

Figure 3 shows horse mackerel egg distribution during CAREVA.

Horse mackerel was found in 48 of the 123 stations (40%) and has a scarce presence in the French platform.

This species was mainly located in the division 8.c with a total abundance in the samples of 1907 eggs and an average density of 16.27 eggs m^{-2}.

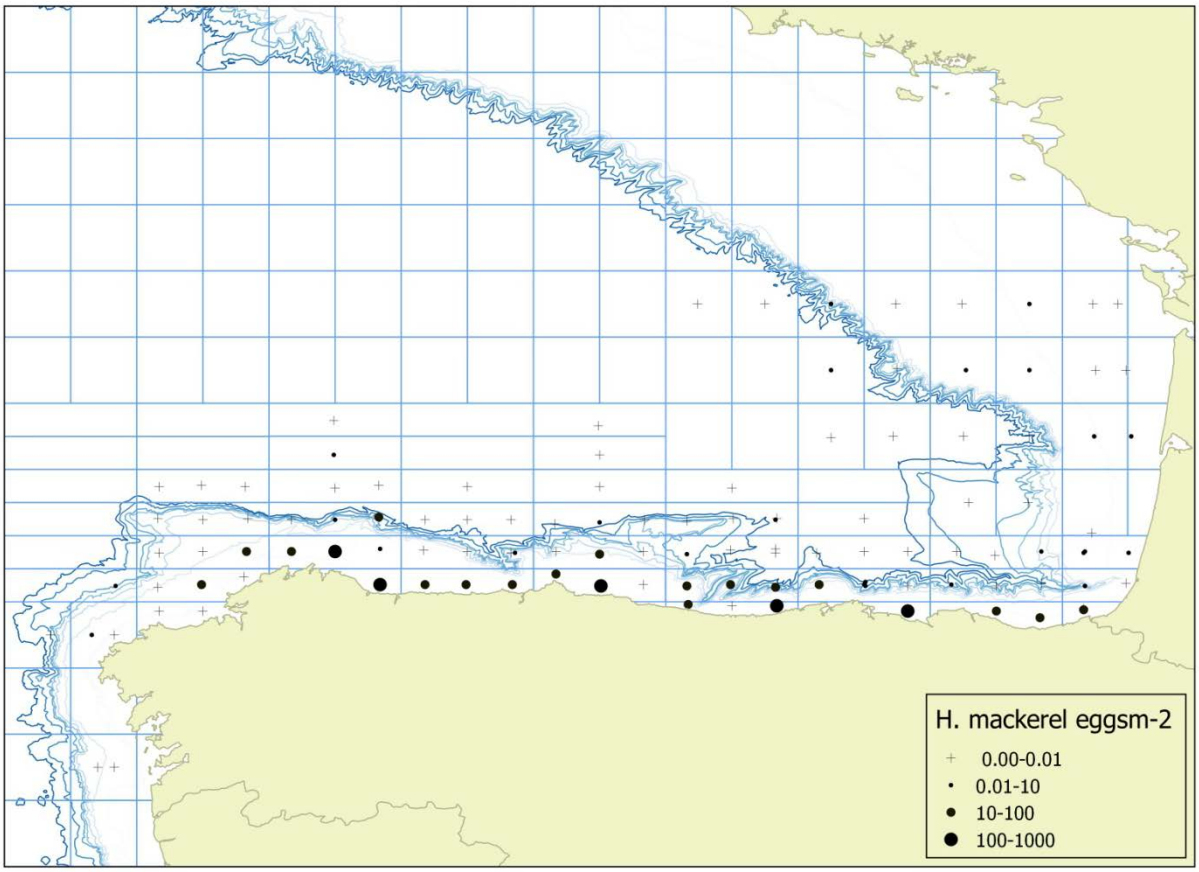


Figure 3. Horse mackerel abundance and distribution during CAREVA survey.

- Sardine egg abundance and distribution.

Figure 4 shows sardine egg distribution during CAREVA.

Sardine was located in the 24% of the stations, with 3749 eggs in total, corresponding to an average density of 42.09 eggs m^{-2}.

Higher abundances were registered in the area of Asturias, in the western part of the 8.c ICES division, and in the Basque Country waters. In Galicia waters (9.a.n ICES subdivision) sardine was absent.

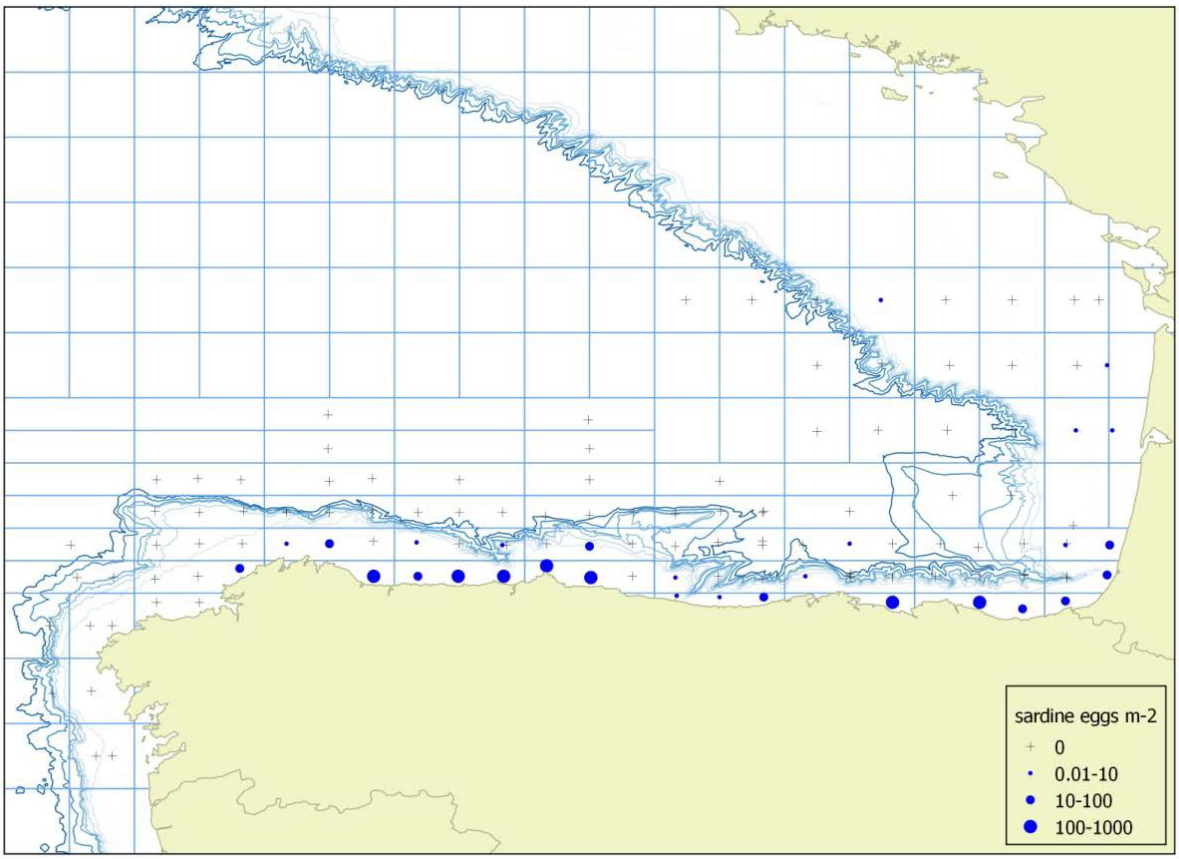


Figure 4. Sardine egg abundance and distribution during CAREVA survey.

- Anchovy egg abundance and distribution.

Figure 5 shows anchovy egg distribution during CAREVA.

Anchovy was scarce during CAREVA, because spawning time for anchovy in this area begins later in the year.

In total, only 307 eggs were found in the 22% of the stations, mainly in the inner part of the Bay of Biscay, with an average density of 2.64 eggs m^{-2}.

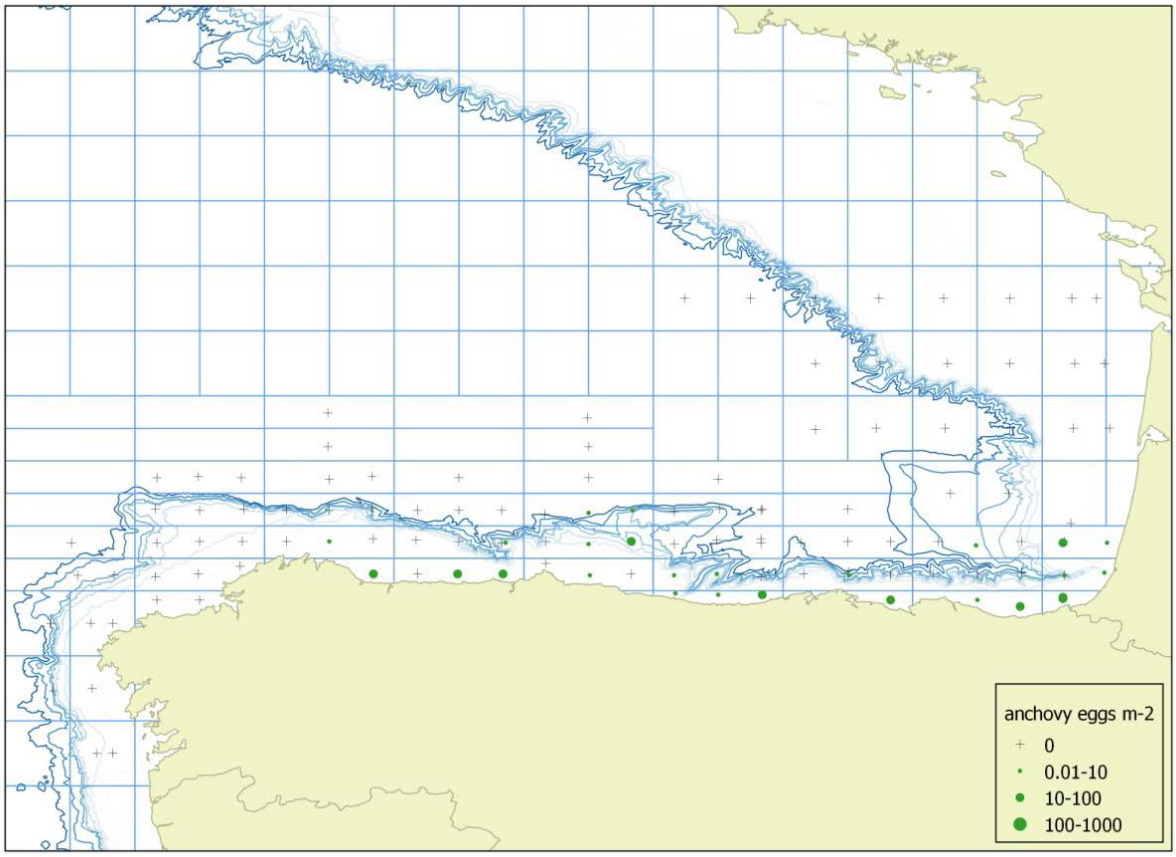


Figure 5. Anchovy egg abundance and distribution during CAREVA survey.

- Other species abundance and distribution.

Figure 6 shows egg distribution of other species during CAREVA.

-Eggs of many more species of fish were found, mainly of the mesopelagic species: *Maurolicus muelleri* (especially in the deeper stations) and of some other species with multiple oil drops and without oil drop in shallower waters.

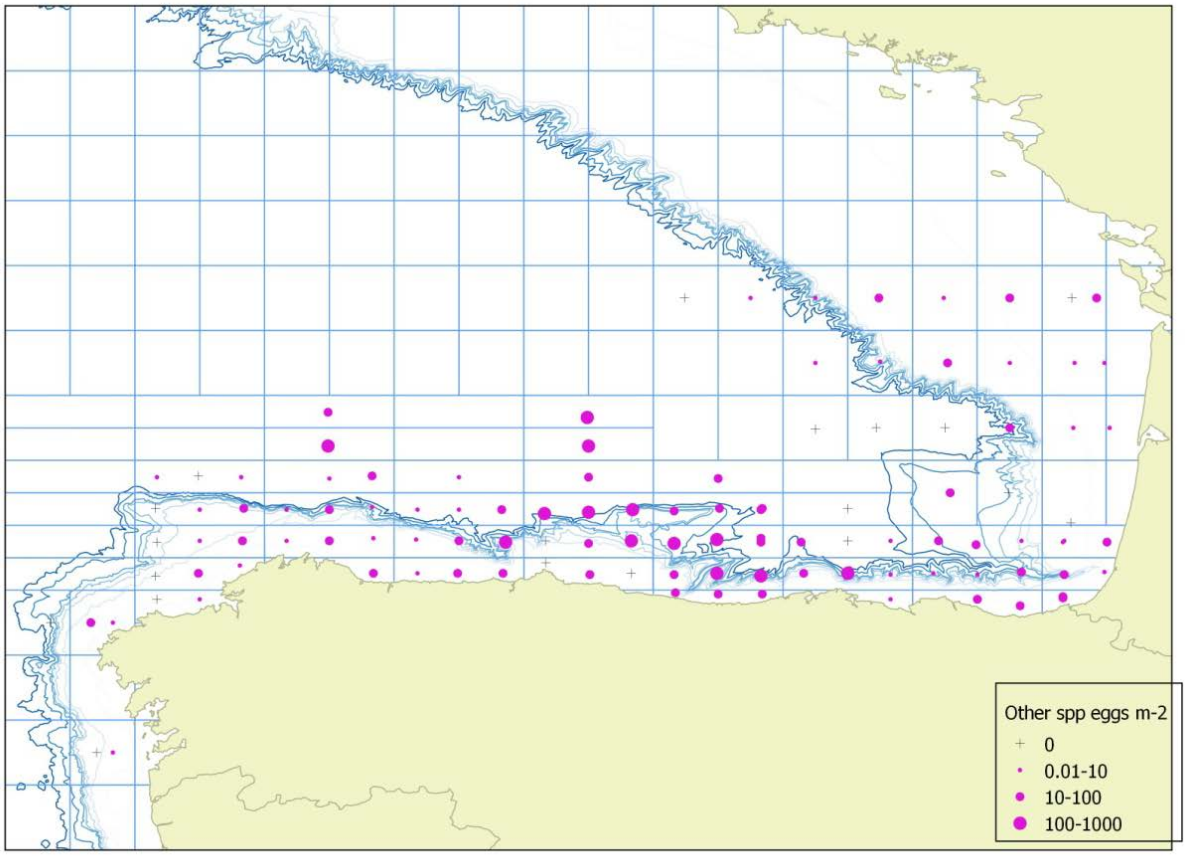


Figure 6. Egg abundance and distribution of other fish species during CAREVA survey.

5.2. Hydrography

Figure 7 shows surface temperature (SST) during CAREVA survey registered by the thermosalinometer of the R/V "Vizconde de Eza".

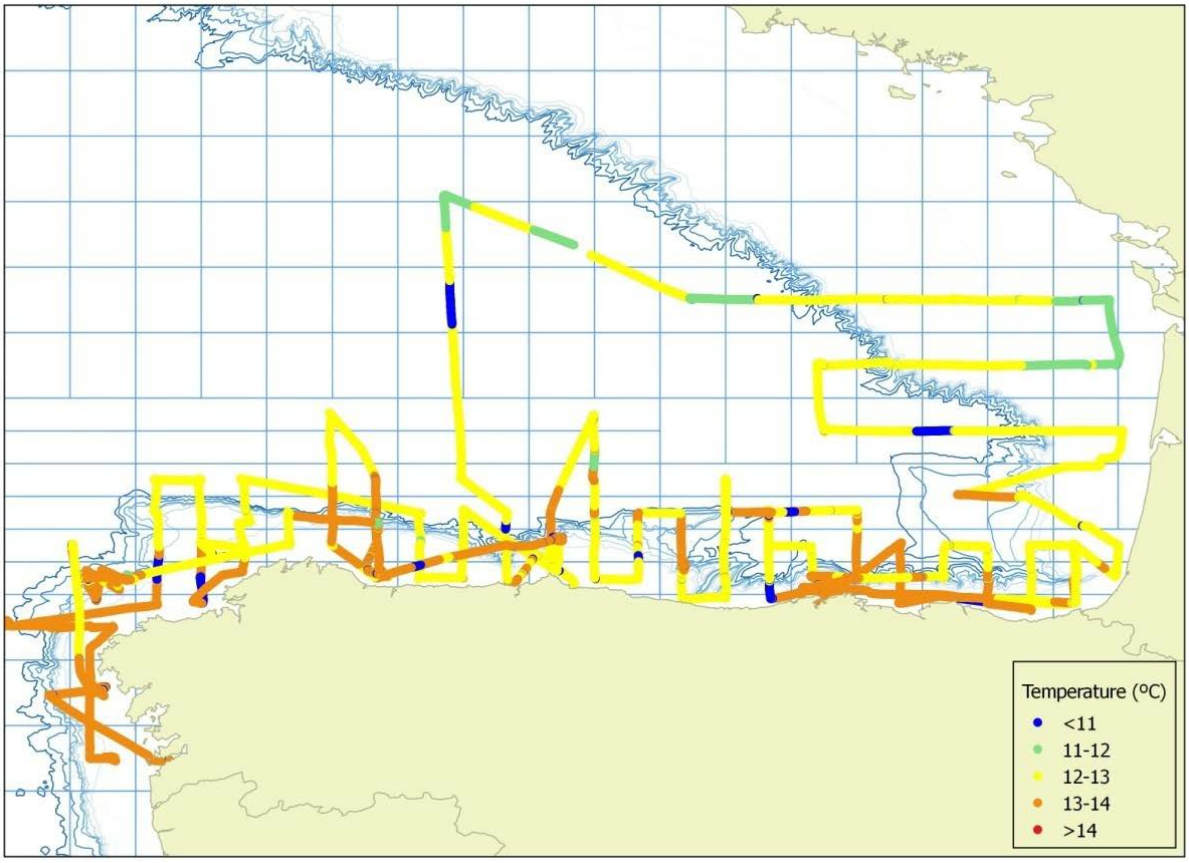


Figure 7. Sea surface temperature during CAREVA tracking.

Data from 123 CTD performed during the survey have been sent in the Excel spreadsheet to the group WGMEGS, and will be analysed in depth before the next meeting.

5.3. Fecundity

A total of 1720 fish were taken for AEPM and DEPM fecundity and sex ratio estimations (Table 1). Most of them were sampled in PELACUS0319 making the best use of the acoustic monitoring and the survey general sampling. Around 100 fish were sampled from each of the 17 hauls distributed during March and April. Biological data were taken for all sampled fish and additional fecundity sampling was made in 30 females per haul.

Table 1. IEO sampling for AEPM and DEPM estimations by date and survey.

		Commercial		Survey	
		Santander	A Coruña	PELACUS0319	
March	04	90			
	07		100		
	13	100			
	24			100	
	27			105	
	28			100	
	29			107	
	31			100	
April	01			101	
	02			100	
	04			107	
	05			105	
	08	100		100	
	09			100	
	10			105	
	11			100	
Total		290	100	1330	1720

5. Individual survey report: Spain/AZTI, Period 3

Please find the individual survey report below

SURVEY REPORT RV "Ramón Margalef".
Date: 19 March to 6 April
AZTI (BASQUE COUNTRY – SPAIN) PARTICIPATION IN THE INTERNATIONAL MACKEREL AND HORSE MACKEREL EGG SURVEY 2019
Cruise leader: Paula Alvarez

Background

The ICES triennial Mackerel and Horse Mackerel egg surveys are carried out since 1977. These surveys are aimed to produce both an index and a direct estimate of the biomass of the Northeast Atlantic mackerel stock and the southern and western horse mackerel stocks applying Egg Production Method. To estimate the Spawning Stock Biomass, using this method, it is necessary to obtain annual estimates of both the total egg production and the realised fecundity of the females. Mackerel and horse mackerel egg survey is the only source providing fishery independent information for these stocks.

The planning and coordination of the surveys is agreed within the ICES Working Group for Mackerel and Horse Mackerel Egg Surveys (WGMEGS). The planning of the 2019 Egg Surveys was coordinated at the meeting carried out in Dublin, in April of 2018 and tuned during the year of the cruise.

Since 2013 both methods, annual and daily egg production methods are applied to estimate the stocks Biomass.

This report describes the actions developed by AZTI Foundation (Technological Institute for Fisheries and Food) in relation to the international survey 2019, following the recommendations given during that meeting and provides some preliminary results and comments.

The survey carried out by AZTI will provide egg and fecundity data corresponding to the Bay of Biscay during two cruises, specifically in 46º 30' N- 48º 45' N /1º15'-10º 00' W (first cruise Period 3) and 43ºN-46º 00´N, /1º15'- 7º 00' W second cruise (period 5). As usual, AZTI provides data of mackerel and horse mackerel eggs abundance in May from the annual Anchovy DEPM survey. Bearing in mind that (1) the main goal of this survey is anchovy and (2) this specie shows a spatial distribution of their spawning grounds quite different from mackerel and horse mackerel, the sampling of lasts ones is highly constrained by the former (for example the extension of the area to covert). Since 2013, AZTI has added 5 extra days ships in May to complete the areas which are

not uncovered by anchovy DEPM or that their coverage could significantly alter the anchovy sampling.

The first cruise took place during the period 19th March to 6th April. The second cruise carried out from 4th -25th of May.

The surveys were carried out on board of R/V Ramon Margalef (plankton and adults) for the first cruise, and R/V Margalef (plankton) and R/V Emma Bardan (adults) for the second cruise. These surveys are part of the European data collection established in 2002 and in part, financially supported by the EU.

ITINERARY

FIRST LEG (19 MARCH TO 6 APRIL) summary of activities

(R/V Ramon Margalef)

18 March	R/V Ramon Margalef arrives port at 8:00. AZTI staffs start to load gears, material so on and arrange the laboratory.
19 March	Depart Pasaia at 8:30 h, tested of devices. At 10:00 arrive "Variaciones" D3 station and deploy an CTD and a Bongo. At 12:00 head north. At 22:50 we deploy a buoy 4 at the position 5º 29´N y 2º 11' W.
20 March	Arrive first transect at 4:30 am and we start working in transect. **First adult haul and positive**. Starting incubation experiment with the running mackerel. Second buoy is deployed at 4ºW.
21 March	Work in Transect 1 until finish it (B10) and w move to transect 2. **Second adult haul and positive** 2
2 March	Finished transect 2 (B20) we moved to transect 3 (46º 45´N). All day work in this area.
23 March	Continuing on transect 3 which was completed at 15:00 (B33), then head north (Transect 4). Start the transect at 8º 45' N
24 March	Working on transect 4 toward west until 11º 45'N (B40) and move to Transect 5. Work in this transet until station B45. No incidents.
25 March	Continuing on transect 5 until station 53. **Third adult haul and negative.** Move to transect 4 to complete the this transect.
26 March	Arrived at transect 4 a 8:00 and start sampling eastern until station 57. In between **Fourth adult haul**. Just 4 mackerel. The rest are ochavos. Head to Lorient
28 March	Arrive Lorient at 8:00 and we stay there until 19:30. We resume transect 4 at 23:15 and move to north. Complete a station in transect 5 and achieve transect 6 at 12:30. First station B64.
29 March	Work in transect 6 until station B76. Finish transect at 16:30. Heading to transect 3 looking for mackerels.
30 March	Arrive at fishing area around 13:00 h. **Fifth adult haul**. It was positive but just 12.5 kg of mackerel. The remain was capres aper. Move to transect 2.
31 March	Arrive to transect at 07:00 am and started searching mackerel signal. Order next haul at 8:30 (**sixth adult haul**). Positive results (350 kg of mackerel). Head north for next haul (14:00). Positive signal of mackerel and deploy the net (**seventh adult haul**). Positive results (500 kg of mackerel). Move to south (6 hours trip) to resume plankton hauls at 23:00h.

1 April	Working in the area without incidences. Not signal of adults. It is late and decided to postpone the adult haul for next day. Bad weather forecast for 3th of April
2 April	We complete the last transect and the last plankton station at 12:00. Not presence of adults, so we go on in your search. Finally we detect fish in the echo-sounder, but due to the existence of fishing net in the area we had to abort the fishing manoeovre. At the end of the day, we decide to attempt the last **adult haul (eighth haul).** Nothing in. Mid-night and the weather condition are worse that expected.
3 April	Heading SE, to Pasaia. Gale warning to the evening. . Finally we arrived Pasaia port at 13:00 a.m.
5 April	Resume the survey at 14:00 hours to fish adults. We move around the area using the echo-soundar to detect the shools. Nothing found.
6 April	Returned the searching at 8:00. Finally we deploy the pelagic net and we obtained a positive response. Back to Pasaia's Port where we arrived at 14:00. SURVEY IS FINISHED.

Survey desing

The sampling area located in the Bay of Biscay consisted of a grid with a series of E-W transects spaced of 0.5° longitude and 0.5° latitude (see Fig 1). Sampling was carried out in an east–west and west-east direction covering the potential spawning area for mackerel and horse-mackerel according to a preliminary plan (ICES, 2015). A transect was completed when a station had zero or near zero values or when two consecutive stations had low values.

Adult samples were collected using pelagic trawls in those areas where eggs presence was observed or pelagic shoals were detected in the sonar. The collection of adults followed a scheme designed previously (ICES 2015).

Sampling procedures

Hydrographical measurements

Vertical profiles of temperature and salinity were obtained using a RBR CTD. Temperature at 5m,20m,50m, 100m and bottom depth and surface and 20m depth salinity were noted at each station.

Sampling of ichthyoplankton

Plankton samples were taken with a Bongo sampler equipped with a net of 250 um mesh size and a nose cone diameter of 40 cm. It was deployed on double oblique hauls (45º approximately), to a maximum depth of 200m or to within 5m of the bottom in shallower water. It was retrieved to the surface at a rate of 20m/mn and towed at a ship speed of 2-2.5 knots. Calibrated flow-meters were used to calculate the volume of water filtered. Bongo net was equipped with a CTD sensor (RBR model) to record depth, temperature, salinity and chlorophyll profiles for each deployment and a transponder (HIPAP) to measure real time in-situ sampler depth. Haul performance was automatically carried out at constant lowered (50m/min) and retrieved (20m/min) cable speed. During the haul the parameters starting

position, date, time, total cable length, haul duration, sampler depth and weather conditions were monitored and noted.

During the cruise the content of the two nets of the Bongo frame was separately stored in two jars and preserved in buffered 4% formaldehyde, to be analysed later on. Just one of the net collectors was analysed. The pH of the plankton samples were checked every 12 hours during the first 2 days after preserving.

The plankton sample was washed from the end bags into a jar and preserved with 4% solution of buffered (sodium acetate trihydrate buffer) formaldehyde. Following the recommendation suggested by the WGMEGS AZTI changed the buffer usually employed (sodium tretraborate) for sodium acetate tri-hydrate (420g of sodium acetate trihydrate dissolved in 10 litres of 4% formaldehyde) and sea water for fresh water. Samples were filtered from the formaldehyde at least 12 hours after preservation, washed with seawater and placed into jars. On board, the eggs were sorted out using "spray method" when it was considered necessary (high number of eggs in the sample) . This method was tested and recommended during the Workshop on Mackerel and horse mackerel egg staging and identification held in CEFAS, Lowestoft 20-25 October 2003 (ICES CM 2004/G:13). The method was repeated three times and the number of eggs removed after each spraying were placed into small formaldehyde filled tubes. Only the plankton from one of the net collectors was selected for eggs sorting and identification.

Once in the lab., some selected sorted plankton samples were checked to confirm the absence of fish eggs in them.

The identification and staging of mackerel and horse mackerel was carry out at laboratory.

Results

Meteorology and Hydrography

During Period 3 meteorological conditions were unusually stable. Wind speed ranged from 1 to 23 knots and the wind direction moved from NE winds during the first half of the survey to SE during the second half. Wind speed increased, gradually until the day 24th (Figure xx) and then progressively decreased until the end of the survey. The height of waves rarely exceeded 2 m, being the most usual condition between 0.5-1.5 m height. Under these conditions, the sampling was carried out faster as expected, and the area assigned to AZTI was successfully completed and the spawning western limit totally established.

Sea temperature and salinity were collected at each station. Temperature at 20 m depth ranged from 10.3 to 12.5ºC and increases from east to west (**Figure 2**). The coldest temperatures were associated to river mouths. Salinity varied between 33.5-35.8%. Minimum values of salinity related to river's outlet were observed (**Figure 2**). There was no thermal stratification throughout the area.

Plankton samples

A total of 76 Bongo catches were conducted during the P3 cruise containing a total of 15 376 fish eggs. Only one sample did not contain any fish eggs and the highest egg densities were encountered above the shelf edge in the two southern transects (**Figure 3**).

Of all fish eggs, 81% (= 12 431) were of mackerel and some 0.1 % (= 13) of horse mackerel. Other eggs caught were those of hake (*Merluccius merluccius, 117 eggs*), sardine (*Sardine pilchardus, 249 eggs), whiting (Lepidorombus sp, 13 egg) and pearlside (Maurolicus muilleri, 1087). A total of 1466 eggs were not identified (10%).* Noticeable is the low abundance of horse mackerel eggs but due to the low number of stations in 2010 (37 stations) is difficult to compare. The eggs of pearlside were the second specie most abundant (8.7% of total) in the ichtioplankton samples.

Mackerel eggs were found in all but one of the plankton samples with the highest abundance above the shelf break and water depths between 100 and 200 m (81% of total mac abundance). The highest mackerel egg densities were encountered south-westerly of the French shelf (Fig 5.2.2b). 29 % of all mackerel eggs were of stages IA and IB, 24% of stage II, 23% of stage III, 16% of stage IV and finally 8% of stage V. Figure 4 shows the geographical distribution. The number of mackerel eggs per station range from 1 to 4327 eggs (all stages). Highest mackerel egg numbers were found at 46°45'N and 04°15'-04°45'W.

Horse mackerel eggs were much less abundant than mackerel eggs. Figure 5 shows the horse mackerel distribution in the area. All together only 13 horse mackerel eggs (5 in stages 1A and 1B) were found on 5 stations. The number of horse mackerel eggs per station range from 1 to 7 eggs (all stages).

Fecundity samples

In period 3, 8 out 12 hauls were positives for mackerel (target specie). Spatial distribution of adult stations is shown in Figure 6. The most important captures of mackerel were located over the shelf-break in the inner part. Total catch consisted of 2 different fish species, being the most abundant *S scombrus* (90%) and *C. aper* (0.10%). Other species like *T. tachurus*, *M. merluccius* were barely presented in the hauls. The maximum capture of mackerel (about 3000 kg) occurred at 46º 45'N 4º 45´W coinciding with a high mackerel eggs abundance. **Figure 6** illustrates the length distribution of mean length of mackerel by haul. The mean length of fish varied barely from 34 to 37 cm total length. Individuals smaller were captured at the north of the area, however the number of specimens in the hauls was very small, so their representativity is limited.

577 mackerels were measured, weighted, sexed and 232 females were selected. For those females, total carcass weight, gonad weight, otolith, and subsamples of ovary for fecundity studies were taken. As regards the proportion of male and female, the last ones represent 40.2% and males 60.8%.

By age, females ranged from 2 to 13 years old, being the 5 years old group the most frequent (22%) followed by the groups of 7 (19%) and 8 (17%) years old. Age of males ranged from 2 to 12. The group of age 3 was the most abundant (30%) followed by the age groups 5 and 8 years old, both representing some 25% of total.

Distribution of mackerel by weight range (**Table 1**) is clearly centred on intermediate range, (73% of the total mackerel in 250-400 gr range). Large individuals were few abundant, mainly for males (less of 3% of mackerels) while for females this proportion was the double. In consequence it was not possible to obtain an equitable distribution of sample weights.

Table 2 shows the distribution of maturity stages of mackerel (male and female) collected during the survey. According to macro-maturity scale (Walsh scale), some differences was observed between sex. For example, the 92% of males collected during the survey were categorized as actively spawning (Stage 4) whereas only the 34% of females reached this stage. The most usual spawning stage for females was that defined as late ripening (stage 3), which it corresponds to a phase previous to spawning. The number of females observed in this stage was 176 (63%). No individual found in stage 6 (spend).

Length frequency histogram for male and female mackerel is shown in **figure 7**. Little differences are observed between sex. The mode of the distribution is at 36.6 cm for males and at 36.4 cm for females.

Mackerel eggs fertilization

Two running females and two running males to provide material for the incubation were caught the 20th of March. Eggs and sperm were stripped from the fish to a bowl with ½ liter of sea mar filtrated. We waited for about 40 minutes for fertilization. The temperature in the bowl was about 10ºC (similar to sea water temperature). Once we confirmed that the fertilization occurred, we started to transfer the eggs to the incubator (**Figure 8**). About batches of 150 eggs were placed in 60 ml glass jar containing 50 ml of filtered sea water.

Every day dead eggs were remove and count and replaced half of the water with fresh sea water at appropriated temperature. The temperatures selected for the eggs' incubation were 8,12,14, 16 and 18ºC. Temperatures were automatically controlled by sensors and recorded every 2 minutes.

Preliminary results

The variability of temperature during the experiment is shown in **Figure 9**. Intermediates temperatures were lesser homogeneous than the rest.

The time taken from fertilization to the total hatching ranged from 93 hours at 17.7ºC to 318 hours at 8.7ºC.

The curves shown the development time in relation to temperature is illustrated in **Figure 10**.

ACKNOWLEGMENTS

The cruise was partly funded by the European Commission (DG-Fish) under the EU directive 199/2008.

I am grateful to the crews of the R/V Ramon Margalef and also to all the staffs of the scientific team, because without the collaboration of all of them this work could not have been done. Thanks friends!!!!

Figures

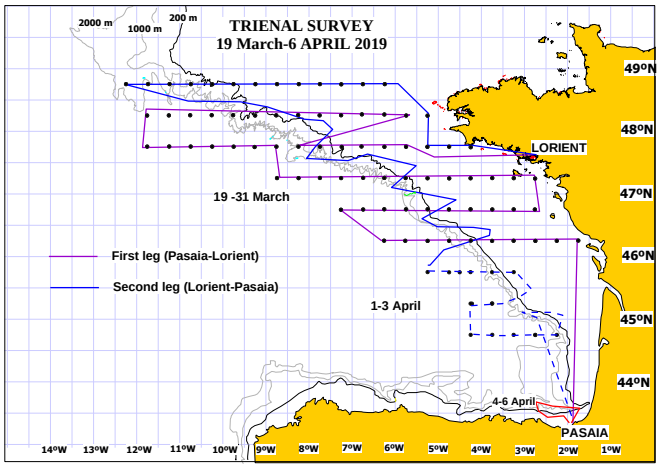


Figure 1: Map showing the tracks carried out during the P3 survey from 19th March to 6th April.

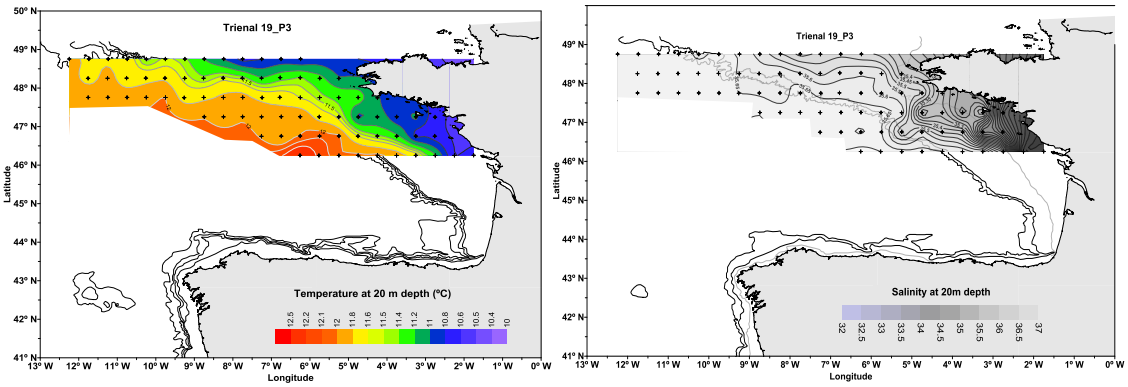


Figure 2 : Spatial distribution of Temperature (ºC) (left map) and salinity (‰o) at 20m depth (right map).

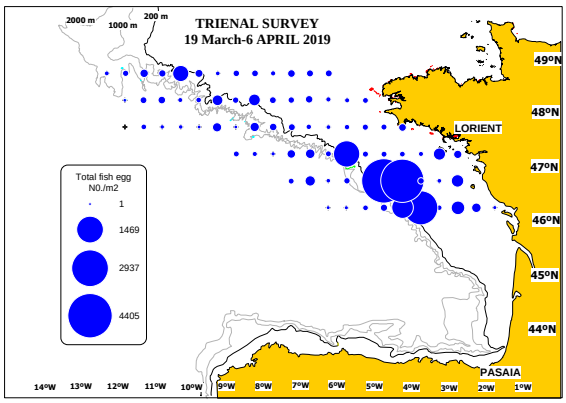


Figure 3 : Spatial distribution of Temperature (ºC) (on the left) and salinity (‰o) at 20m depth (on the right).

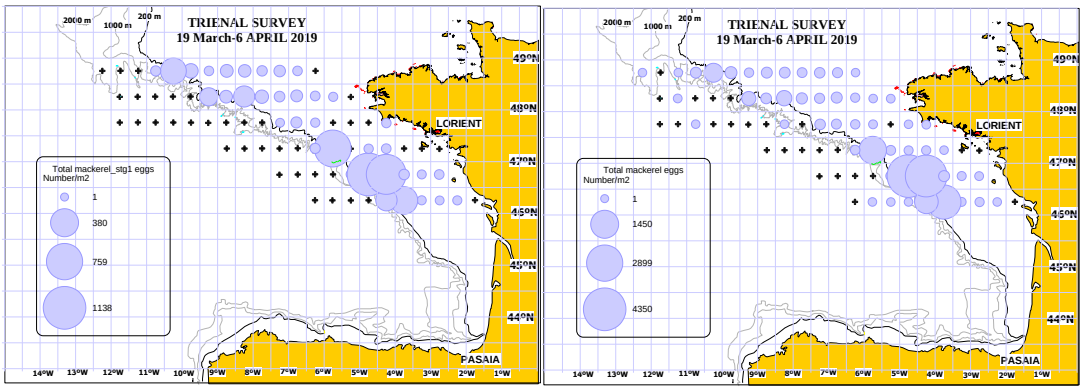


Figure 4: Spatial distribution and abundance (number/m^2) of mackerel eggs in **stage 1** (1A+1B) (on the left) and total mackerel eggs for period 3 survey (on the right). Crosses indicate not eggs presence.

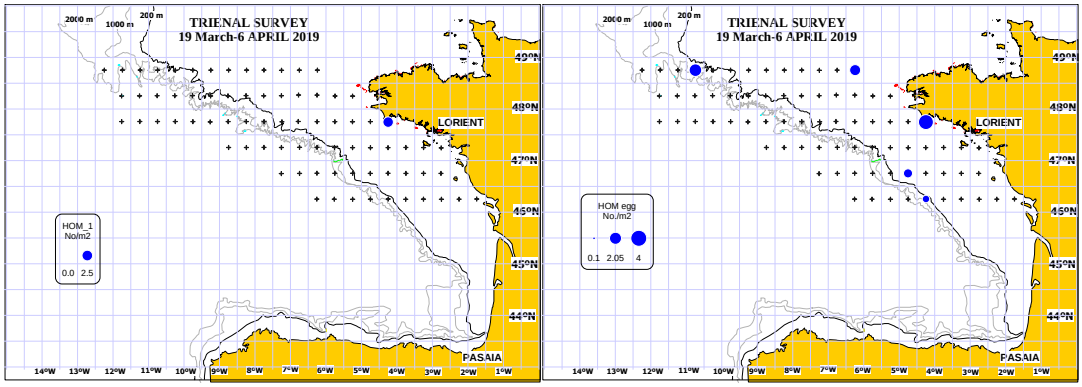


Figure 5: Spatial distribution and abundance (number/m^2) of horse mackerel eggs in **stage 1** (1A+1B) (on the left) and total horse mackerel eggs for period 3 survey (on the right). Crosses indicate not eggs presence.

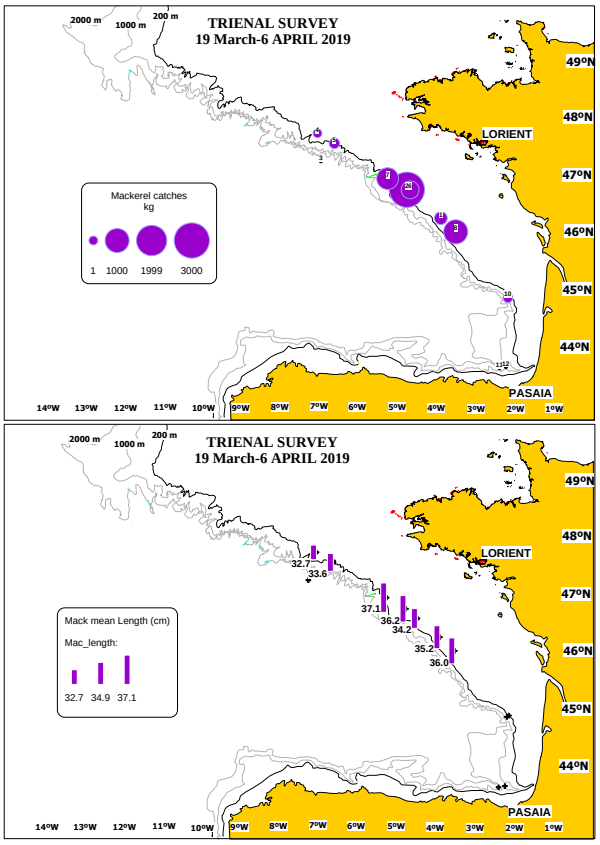


Figure 6: Spatial distribution of mackerel captures (on the top) and mean length per haul (on the bottom) for mackerel of captures during P3.

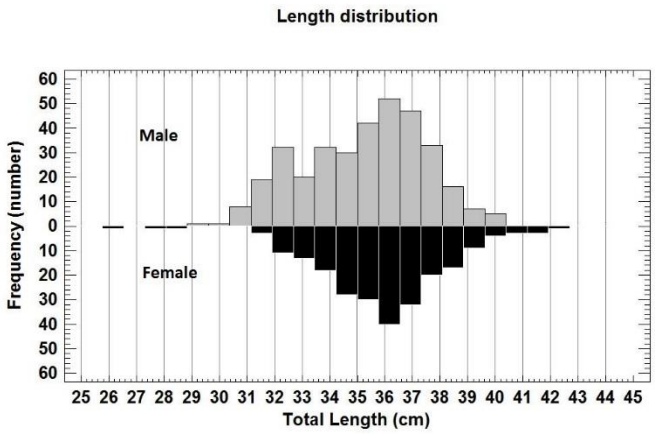


Figure 7: Plot of length frequency distribution for mackerel by sex for period 3.

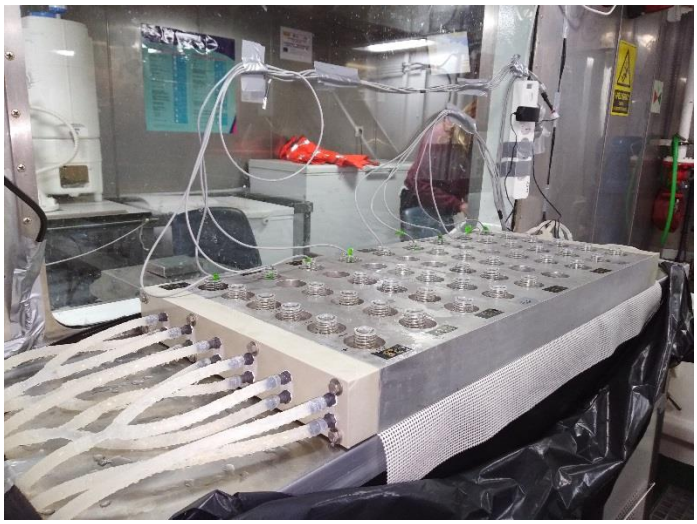


Figure 8: Temperature-gradient used during the mackerel eggs development experiments.

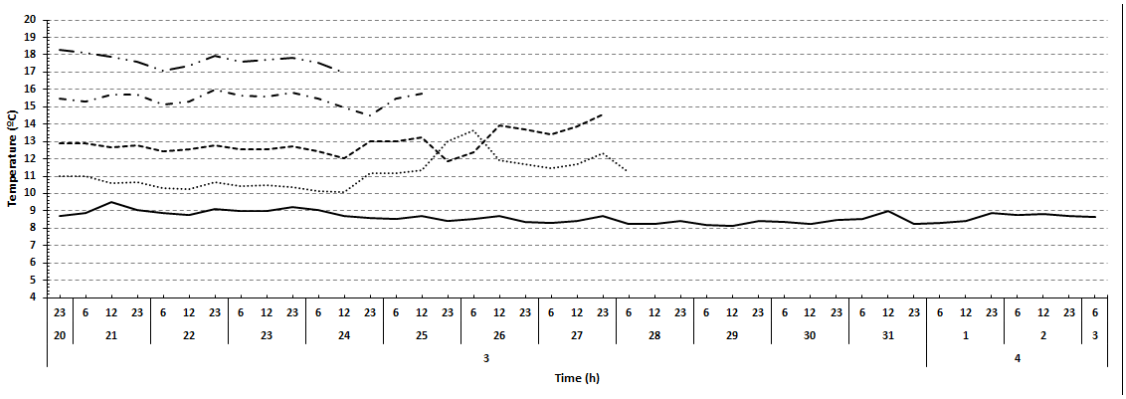


Figure 9: Plot of temperature variability during the experiment. Each data represents six hours average temperature. The experiment started the 20th of March and finished the 4rd of April.

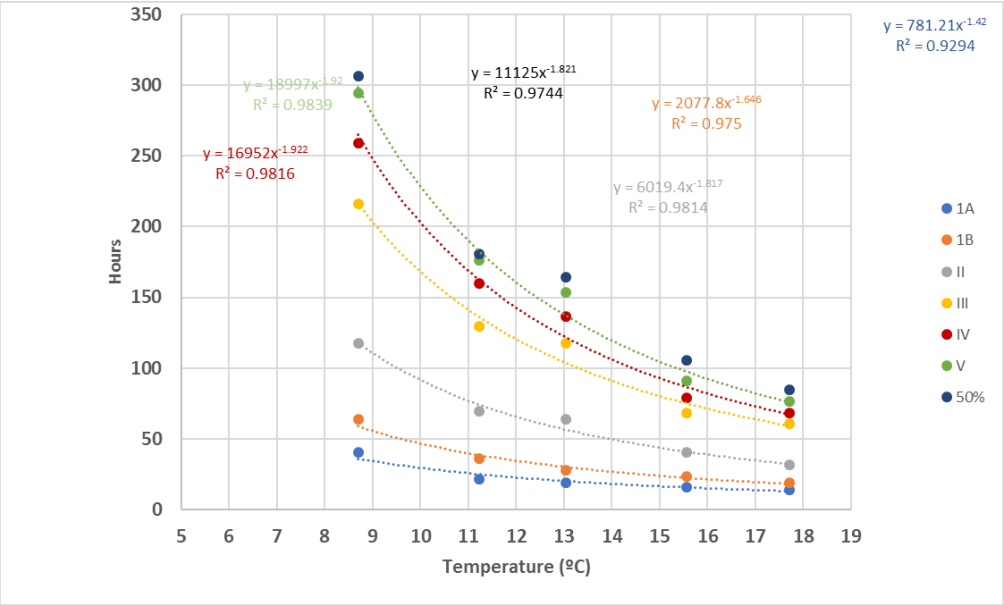


Figure 10: Raw data of development time (hours) at the end of each stage versus temperature (ºC). The regression curves for each stage are incorporated in the panel.

TABLES

Table 1: Mackerel weight distribution by sex for period 3.

Weight	MALE	%	FEMALE	%	Total	%
<250	83	24.1%	24	10.2%	107	18.4%
250-400	248	71.9%	176	74.9%	424	73.1%
>400	14	4.0%	35	14.9%	49	8.5%
TOTAL	**345**		**235**		**580**	

Table 2: Mackerel maturity stage distribution (Walsh scale) by sex for period 3.

Maturity	MALE	%	FEMALE	%	TOTAL	%
1	0	0%	4	1.70%	4	1%
2	1	0%	0	0%	1	0%
3	19	6%	148	63%	167	29%
4	319	93%	81	35%	400	69%
5	6	2%	2	1%	8	1%
6	0	0%	0	0%	0	0%
TOTAL	**345**		**235**		**580**	

6. Individual survey report: Germany/TISF, Periods 3 & 4

Please find the individual survey report below

Federal Research Institute for Rural Areas, Forestry and Fisheries

Thünen-Institute of Sea Fisheries

Herwigstraße 31, 27572 Bremerhaven Telephone +49471 94460-117 Telefax +49471 94460-199 Datum: 09.05.19 Az.: Ulle/Grie/4312

Cruise Report RV "Dana"
Survey MEGS19 - 28.03. – 30.04.2019
German Participation in the International Mackerel and Horse Mackerel Egg Survey 2019

Cruise Leader: Jens Ulleweit

INTRODUCTION

The mackerel and horse mackerel egg survey forms a part of an ICES-coordinated international study in the Eastern North Atlantic conducted during the first half of 2019. This investigation takes place triennially since the late 1970s and is coordinated by the ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS).

The main objective of this series of individual cruises from January until August is to produce both an index and a direct estimate of the biomass of the Northeast-Atlantic mackerel stock and the southern and western horse mackerel stocks. The mackerel and horse mackerel egg survey is the main source providing fishery independent information for these stocks.

The general method is to quantify the freshly spawned eggs in the water column on the spawning grounds. To be able to establish a relationship between eggs and spawning stock biomass, the fecundity of the females must also be determined. This is done by sampling sufficient numbers of gonads before, during and after spawning. These samples are then histologically analysed. In combination, the realised fecundity (potential fecundity minus atresia) of the females and the actual number of freshly spawned eggs in the water render an estimate of the spawning stock biomass.

As a consequence of the long spawning period and the large area involved, the mackerel and horse mackerel eggs surveys have been highly international from the very beginning. In 2019 a total of 18 individual cruises with research vessels and chartered fishing vessels is carried out, with the contribution of UK (Scotland), Spain, Ireland, Portugal, Germany, the Netherlands, Faroese Islands and Norway.

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DFFU

The cruise of RV "Dana" is a contribution to these international efforts assessing and managing the mackerel and horse mackerel stocks. This cruise was a replacement of the 426th cruise of FFS "Walther Herwig III" which had to be cancelled due to urgent repairs of the German research ship. The survey itself is part of the European data sampling directive established in 2002 and financially supported by the EU.

PARTICIPANTS

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Mr Jens Ulleweit	TI SF, Chief Scientist
Ms Vivien Wiedbrauk	TI SF, Hochschule Bremerhaven
Mr Simon Wieser	TI SF

CRUISE ITINERARY

Date/UTC

28/03, 07:30 – 16:00 hrs	Safety course for scientific crew in Esbjerg/Denmark
29/03, 10:30 hrs	Boarding Esbjerg/Denmark
29/03, 13:00 hrs	Departure Esbjerg/Denmark
01/04, 05:00 hrs	Arrival in standard sampling area, start of sampling
12/04, 15:00 hrs	End of sampling 1st leg
13/04, 16:00 hrs to 15/04, 10:00 hrs	Break in Brest, France (personnel exchange, extended stay due to weather conditions)
15/04, 16:30 hrs	Arrival in standard sampling area, start of sampling
26/04, 18:00 hrs	End of sampling and departure from survey area
29/04, 17:00 hrs	Arrival in Hirtshals/Denmark
30/04, 10:00 hrs	Disembarkment of scientific crew and equipment

Narrative

In 2019 the entire spawning period of mackerel and horse mackerel is divided into seven sampling periods. According to the survey proposal of the responsible ICES working group it is planned to obtain a full coverage of the entire spawning area throughout all sampling periods. RV "Dana" was advised to contribute to the sampling during the 3rd period from the 29th of March to the 12th of April and during the 4th period from the 13th to the 30th of April. For period 3 RV "Dana" was supposed to cover the survey area in the West of Ireland and the Celtic Sea between 54°15`N and 49°15`N and in period 4 in the area West of Scotland, West of Ireland and the Celtic Sea between 56°45`N and 47°45`N, respectively. The proposal was to conduct, if possible, alternate transects during the first part of every leg of the survey and then fill in the missing transects on the way back.

RV "Dana" started at ICES statistical rectangle 27E2 at 49°15`N 007°45`W continuing sampling westwards on the same latitude thereafter. The survey area was then covered by plankton hauls on every other row of statistical ICES rectangles on alternate transects northwards towards 53°45'N being the most northern transect to be covered during the 1st leg. On the way southwards RV "Dana" sampled the remaining transects until 54°15`N. Due to heavy weather conditions in the first week the sampling was disrupted

several times for intervals of 2 to 8 hours. 87 plankton hauls and ten fishing hauls for fecundity sampling were conducted during this leg all together.

The first leg ended with a scheduled personnel exchange on 13th / 14th April in Brest, France. Because of a passing storm front the stay had to be extended until noon of April, 15th.

The remaining survey time was then used to cover the investigation area in northerly direction from ICES rectangle 24E4 at 47°45`N 005°45`W first on alternate transects until the transect on 52°45`N. Wave heights on Porcupine Bank made it impossible to cover the area of the Northern part of Porcupine Bank. Therefore the Irish Shelf was partly covered only by short transects. However, from 52°45`N northwards the area was then covered on all transects in order to make the best use of the remaining survey time with the given weather conditions. Sampling for RV "Dana" ended with the 180th plankton haul at 56°15`N 8°15`W. Due to an upcoming storm front RV "Dana" left then the survey area in northerly direction. Four fishing hauls were conducted during this part of the survey.

Results of the survey were intermittently communicated to the survey-coordinator. Figure 1 provides an overview over all positions and activities carried out during the cruise.

METHODS

Plankton

Plankton samples were taken with a Hydrobios "Nackthai" (a modified Gulf sampler) equipped with a CTD probe to measure real time in-situ depth, temperature and salinity as well as the permanent water flow through the mouth opening and outside the net to determine the volume of filtered water.

The "Nackthai" net mesh size was 280 µm. The plankton sampler was towed at a nominal speed of 4 knots through the water at a towing cable lowering as well as retrieval speed of 0.5 ms^{-1} allowing for a uniform sampling of the water column. Maximum sampling depth was 200 m or 5 m above the sea bed. Ship's and towing cable lowering and retrieval speed were monitored continuously and noted along with data on starting position, date, time (both UTC), weather condition, total cable length, temperature and salinity at pre-defined depths as well as the haul duration.

After completion of each plankton haul the contents of the net was gently washed down into the cod-end bucket that was detached thereafter and the plankton sample was preserved and stored according to the standard WGMEGS operation procedure. The samples were then allowed to stand for at least 12 h before they were further processed to make sure that all organisms were well fixed and soaked with formaldehyde.

Fish eggs in the samples were separated from the remaining plankton organisms by performing the spray method recommended by the WGMEGS report. All fish eggs were sorted into eggs with and without oil globule and counted. Fish eggs with oil globules were then identified by species and staged.

At the end of the cruise all egg samples had been sorted once for mackerel and horse mackerel eggs in total or, as representative sub-samples of up to 200 eggs per sample. At least sub-samples of up to 150 individuals per target species were staged.

Fecundity

For trawling the pelagic nets Turbo Trawl and Fotø Trawl of RV "Dana" were used. The trawling stations were placed on the shelf edge and on the Porcupine Bank between 120

and 320m depth, since concentrations of mackerel and horse mackerel were expected here. No trawling was conducted in Irish Coral Reef Special Areas of Conservations.

The whole catch was sorted by fish species. Either all mackerel or a subsample of mackerel was selected, of which length and weigh, sex and maturity were determined and otoliths were taken. Furthermore, for mature female mackerel the following parameters were also determined: Length, weight (total, ovary), sex and maturity. Four parallel micropipette samples were then taken of the ovaries. Then the ovaries were removed, sliced into halves and put into different formalin jars.

Micropipette samples and ovaries will be sent to different laboratories for the histological fecundity analysis.

Additional work

Additional gonad samples of adult female mackerel were collected for the Norwegian projekt „CLIMRATES" and additional egg samples were collected for molecular genetic investigations in collaboration with biome-id in order to verify species identification.

RESULTS

Meteorology and Hydrography

The first leg was hampered by heavy weather conditions within the first sampling days due to the passing of severe low pressure systems with strong south-westerly winds. On the second leg passing low pressure systems hampered the coverage on the Porcupine Bank and forced RV "Dana" to leave the survey area earlier than anticipated.

During both legs sea temperature in 5m depth was between < 9.5°C in the North and East and >12.1 °C in the South and West of the sampled area. Temperatures on the shelf were always distinctly cooler than over the shelf edge and beyond it. Due to still wintry conditions the water body was well mixed.

Egg distribution (preliminary results)

A total of 180 Nackthai catches (2016 and 2013: 96; 2010: 218) were conducted containing a total of 36053 fish eggs. Only a small proportion of samples contained no fish eggs at all and highest egg densities were encountered above the shelf edge as well as above Porcupine Bank.

Preliminary results show that of all fish eggs, 91% (n=32814; 2016: 21809) were of mackerel and only 1 % (n=352; 2016: 288) of horse mackerel, respectively. Other eggs caught in significant numbers were those of hake (*Merluccius merluccius*), blue whiting (*Micromesistius poutassou*), pearlside (*Maurolicus muelleri)*, *Soleidae and* macrourids (Macrouridae). Noticeable is again the very low abundance of found horse mackerel eggs (in average 2 eggs per haul, 2016: 1 per haul, 2013: 3 eggs per haul, 2010: 46 eggs per haul).

Mackerel eggs were found in 68% of the plankton samples with the highest abundance above the shelf break and water depths between 124 and 200 m. Highest mackerel egg densities were encountered on the Irish shelf and around the Great Sole Bank (Fig.2). 37% off all mackerel eggs were freshly spawned (stages 1A and 1B), in period 3 7043 eggs of 24924 (28%), in period 4 3588 of 7889 eggs in total (45%). Figure 3 shows the geographical distribution of these eggs. Mean egg number per station were 182 eggs (all stages; 2016: 197, 2013: 311). Highest mackerel egg numbers could be found at 51°45'N 010°45'W with a maximum value of 6340.

Horse mackerel eggs were much less abundant than mackerel eggs (only in 11% of all hauls). All together 352 horse mackerel eggs (all stages) of which 183 horse mackerel eggs in stages 1A and 1B) were found.

Fecundity sampling

14 fishing stations were conducted during the survey, 10 in sampling period 3 and four in period 4.

In period 3 mackerel were only caught in three out of the ten hauls. Only one mixed mackerel and horse mackerel aggregation could be detected. This haul consisted of 1500kg horse mackerel and 450kg mackerel. Other species caught were boarfish, blue whiting, hake, megrim, lanternfish and pearlsides. No fish aggregations could be detected during the entire survey period 4. Only two hauls were yielding mackerel, one with 100kg, the other with 6kg. Other species (boarfish, blue whiting, hake, John Dory, argentines, silvery pout, pearlsides) were only caught in very small amounts.

All together 155 fecundity samples of mackerel were taken as well as length, sex, maturity and otoliths of a bigger subsample of mackerel.

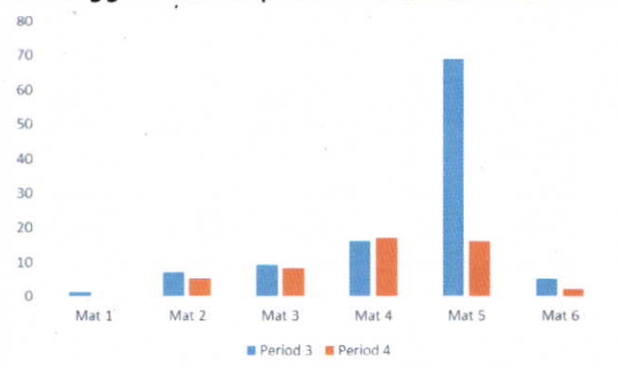

Fig.5: Maturity stages distribution of female mackerel, MEGS 2019

Like 2016 but in contrast to earlier survey years most of the mackerel (male and female) had already spawned (Maturity stage >=4) but due to the low number of samples this alone cannot be taken as an indicator for the spawning time. Fig. 5 shows the maturity stage distribution of female mackerel analysed during the egg survey.

ACKNOWLEDGEMENT

The cruise was partly funded by the European Commission (DG-Fish) under the EU directive 199/2008.

I wish to thank Captains Jesper Sandager (Leg 1) and Hildur Friis (Leg 2) and their crews onboard RV "Dana" for their great support and co-operation. It was a very friendly forward coming working atmosphere! Also, I would like to thank all members of the scientific team for their hard work especially in very bad weather conditions.

Bremerhaven, 07/05/2019

Jens Ulleweit
(Cruise Leader German MEGS 2019)

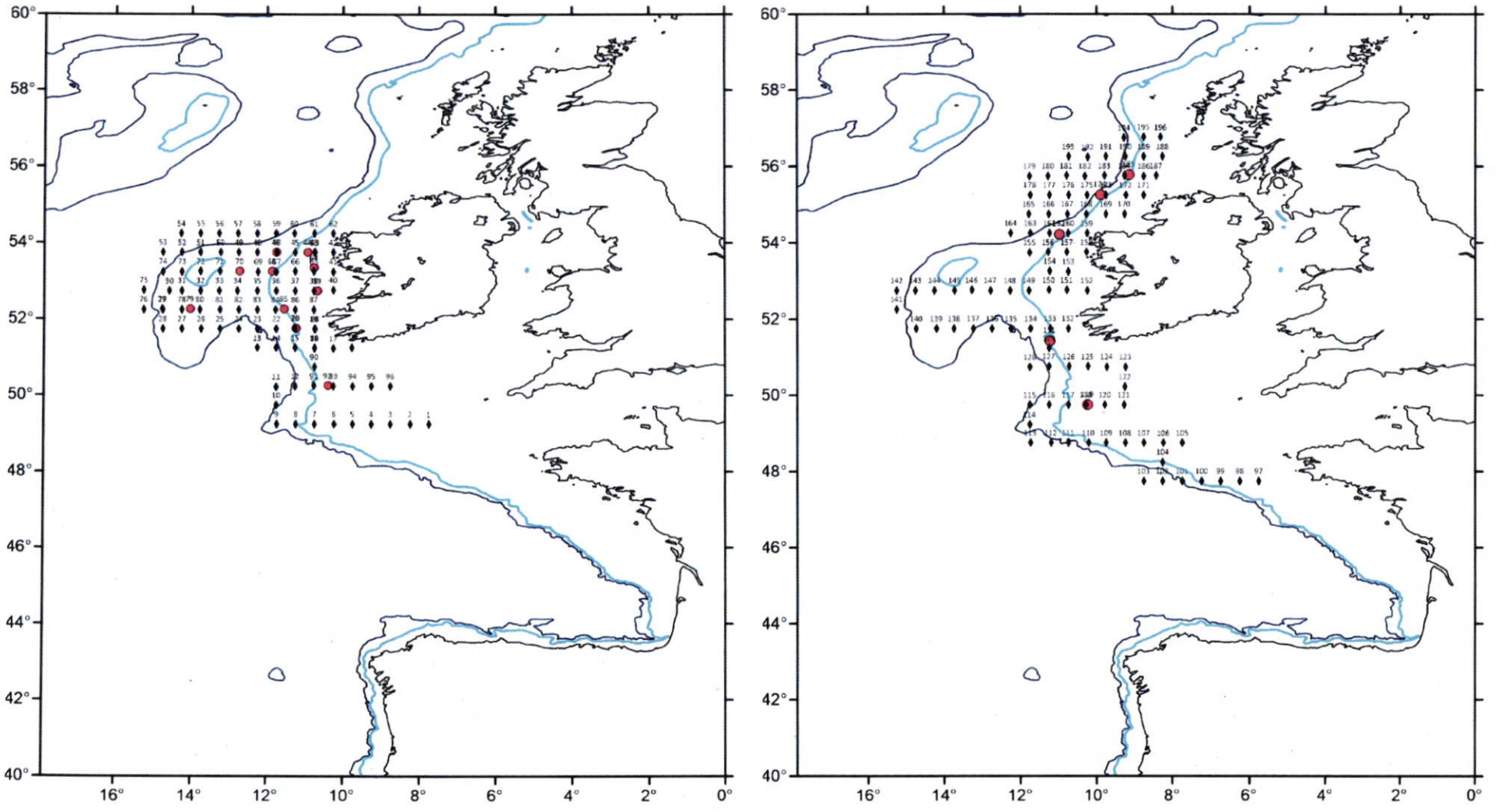

Fig.1: RV "Dana" MEGS19, station grid in the 3rd (left panel) and 4th sampling period (right panel); black diamonds = positions of plankton hauls; red circles = positions of fishing hauls

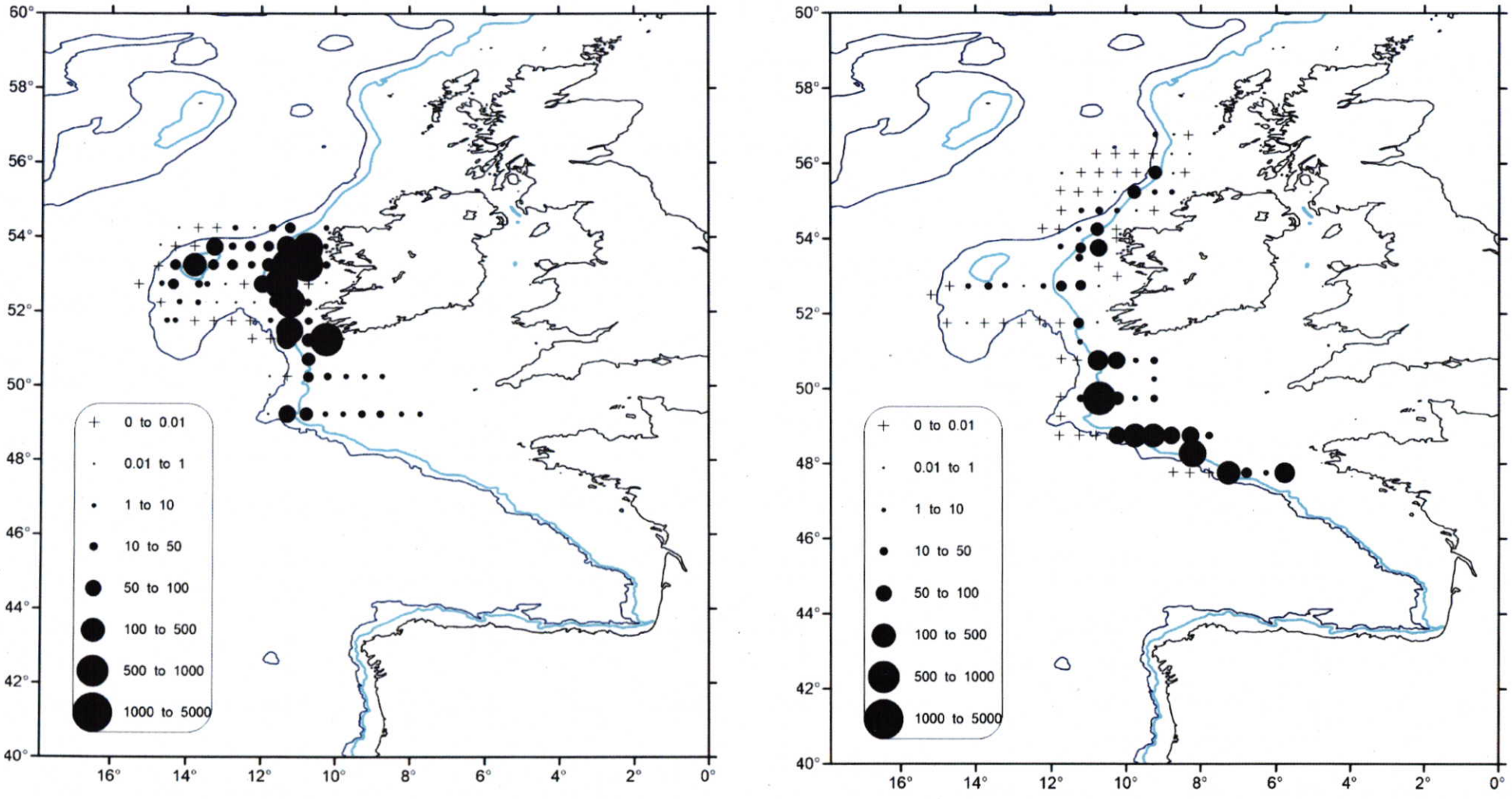

Fig.2: RV "Dana" MEGS19, distribution of mackerel eggs (all stages) in the 3rd (left panel) and 4th sampling period (right panel) in absolute numbers

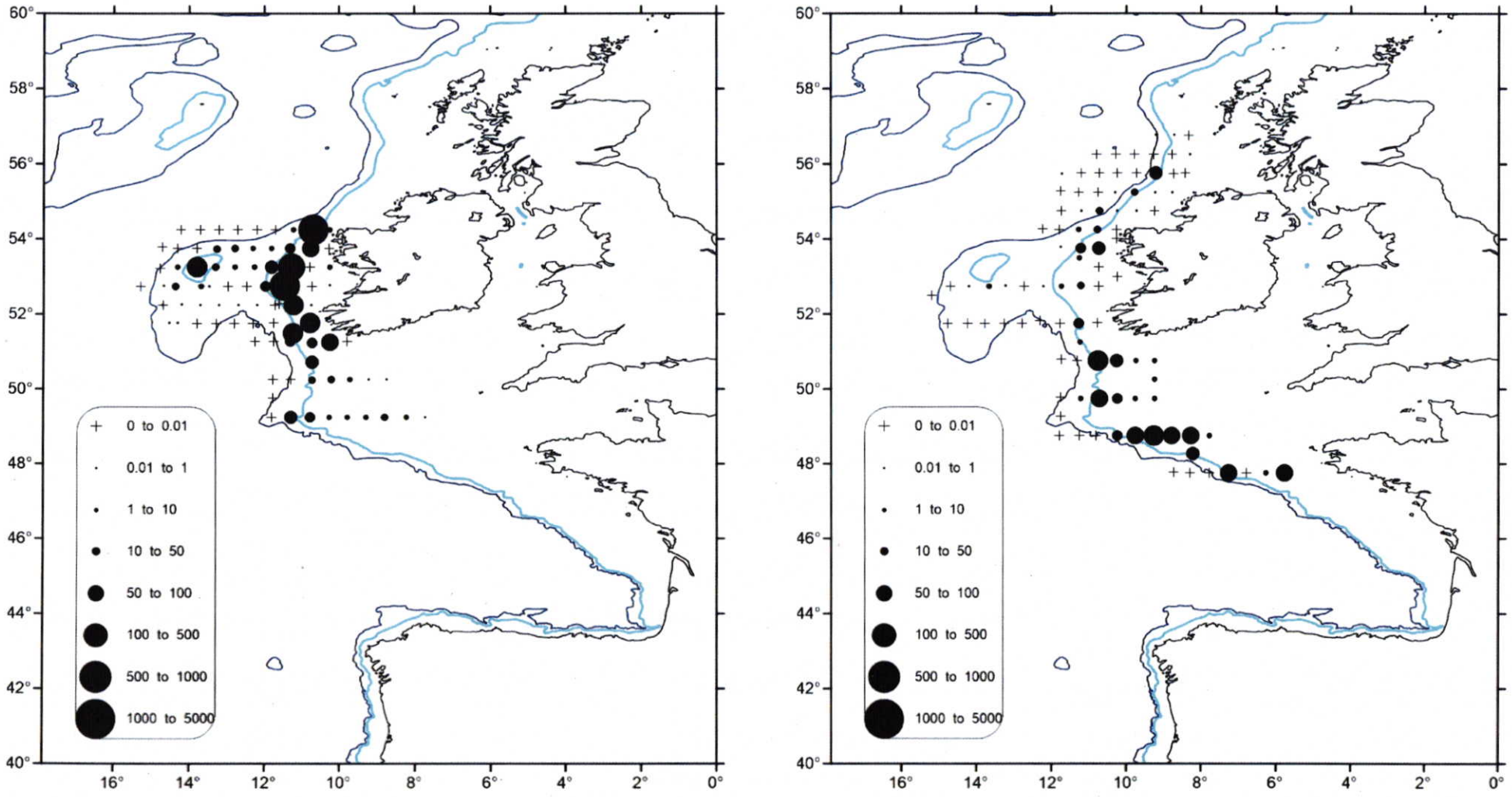

Fig.3: RV "Dana" MEGS19, distribution of all freshly spawned mackerel eggs (stages 1A, 1B) in the 3rd (left panel) and 4th sampling period (right panel) in absolute numbers

7. Individual survey report: Spain/IEO, Period 4

Please find the individual survey report below

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA **SECRETARIA GENERAL DE PESCA**

Cruise Report RV "Vizconde de Eza"

MEGS19 Survey – JUREVA 10/04-03/05

IEO Spanish Participation in the International Mackerel and Horse Mackerel Egg Survey 2O19 (PERIOD 4)

Isabel Riveiro, Gersom Costas, Dolores Garabana, Luisa Iglesias, Antonio Solla, Pablo Carrera

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Acknowledgements

JUREVA 0419 survey has been funded by the European Union through the European Maritime and Fisheries Fund (EMFF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

We thank the crew of the Vizconde de Eza and scientific staff onboard for their professional assistance, ensuring the success of the survey.

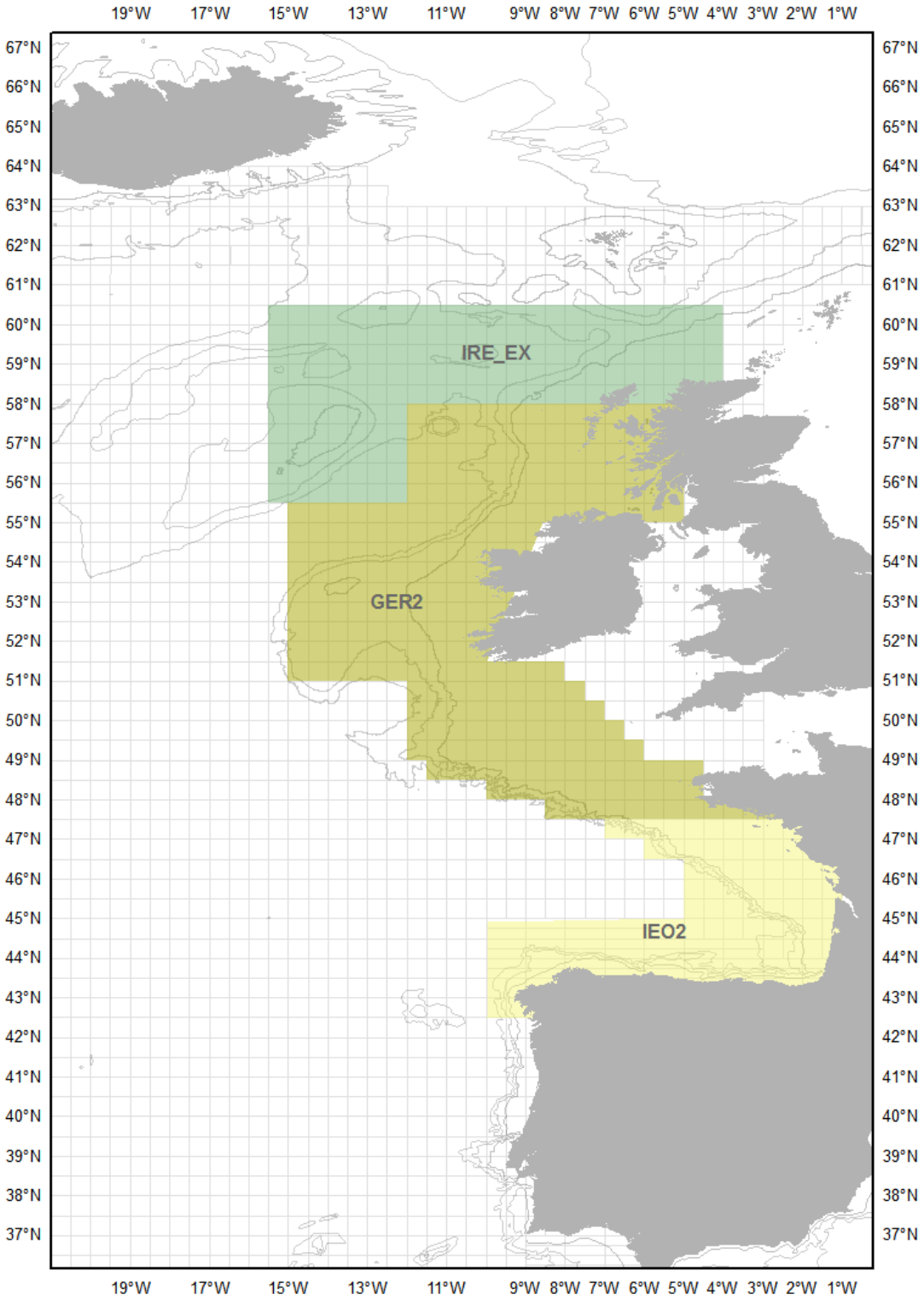
1. INTRODUCTION

JUREVA survey is part of the Spanish "Data Collection Framework" program and is coordinated within the framework of the ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (ICES WGMEGS).

The survey calendar is shown in the following table (in yellow, the commitment of the IEO for 2019):

		Area							
Semana		Portugal, Cadiz & Galicia	Cantabrian Sea	Biscay	Celtic Sea	North west Ireland	West of Scotland	Northern Area	Period
3	13-Jan-19	PO1 (DEPM)							1
4	20-Jan-19	PO1 (DEPM)							1
5	27-Jan-19	PO1 (DEPM)		IRL1	IRL1				2
6	3-Feb-19	PO1 (DEPM)		IRL1	IRL1				2
7	10-Feb-19	PO1 (DEPM)		IRL1	IRL1				2
8	17-Feb-19	PO1 (DEPM)				SCO(IBTS)	SCO(IBTS)		2
9	24-Feb -19					SCO(IBTS)	SCO(IBTS)		2
10	3-Mar-19								3
11	10-Mar-19		IEO1						3
12	17-Mar-19		IEO1	AZTI1	GER1	SCO2	SCO2		3
13	24-Mar-19		IEO1	AZTI1	GER1	SCO2	SCO2		3
14	31-Mar -19		IEO1	AZTI1	GER1	GER1			3
15	07-Apr-19		IEO2	IEO2	GER2	GER2			4
16	14-Apr-19		IEO2	IEO2	GER2	GER2	GER2	IRL-EX	4
17	21-Apr-19		IEO2	IEO2	GER2	GER2	GER2	IRL-EX	4
18	28-Apr -19		IEO2	IEO2					4
19	5-May-19		AZTI2 (DEPM)	AZTI2 (DEPM)	NED1	SCO3	SCO3	ICE	5
20	12-May-19		AZTI2 (DEPM)	AZTI2 (DEPM)	NED1	SCO3	SCO3	ICE	5
21	19-May-19		AZTI2 (DEPM)	AZTI2 (DEPM)	NED1	SCO3	SCO3	FAR	5
22	26-May -19		AZTI2 (DEPM)	AZTI2 (DEPM)				FAR	5
23	2-Jun-19		AZTI2 (DEPM)	NED2	NED2			FAR	5
24	9-Jun-19			NED2	NED2	IRL2	IRL2	NOR	6
25	16-Jun-19			NED2	NED2	IRL2	IRL2	NOR	6
26	23-Jun -19					IRL2	IRL2	NOR	6
27	30-Jun -19								6
28	7-Jul-19			SCO4	SCO4	SCO4	SCO4		7
29	14 –Jul-19			SCO4	SCO4	SCO4	SCO4		7
30	21-Jul-19			SCO4	SCO4	SCO4	SCO4		7
31	28-Jul-19								7

The sampling scheme for the period 4, in which JUREVA 0419 (IEO2) will be carried out, is shown in the following map:


19°W
17°W
15°W
13°W
11°W
9°W
8°W
7°W
6°W
5°W
4°W
3°W
2°W
1°W
67°N
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IRE_EX
GER2
IEO2

Ichthyoplankton samples, as well as hydrographical information, were collected during JUREVA 0419 survey on board R/V “Vizconde de Eza”, while most of the adult’s samples for AEPM/DEPM estimates were provided by PELACUS0319 acoustic survey, carried out in the same area at the same time, on board R/V “Miguel Oliver” (*Secretaria General de Pesca*). Both surveys are coordinated by the PELASSES project (*Instituto Español de Oceanografía*).

2. PARTICIPANTS AND AFFILIATION

GERSOM COSTAS BASTIDA	1
JOSE LUIS VILLAVERDE ROSALES	1
JOSE MANUEL ALONSO CAMPELOS	1
JOSE CEBRIAN DOMINGUEZ	1
DOLORES GARABANA BARRO	2
GABRIEL POMAR VERT	3
RAUL LAIZ CARRION	4
JOSE Mª QUINTANILLA HERVAS	4
FRANCISCO FERNÁNDEZ CORREGIDOR	4
JOSE M RODRIGUEZ	5
VENICIO PITA FREIRE	5
CARMEN HERNANDEZ PARRAS	6
PATRICIA CORTEGOSO XABIER	7
PATRICIO AHUMADA	
MIGUEL ANGEL SANTORUM BELLO	

1:IEO C.O. Vigo, 2: IEO C.O. A Coruña, 3:IEO C.O. Baleares, 4: IEO C.O. Málaga, 5: IEO C.O. Gijón, 6:IEO C.O. Santander, 7: Vigo University

3. ITINERARY

Date (UTC)	
10/04/2019 8:00	Vigo harbour. Security and administrative issues
10/04/2019 14:50	Navigation to the 1st station
10/04/2019 15:31	Start of sampling work at 42.25ºN, 9.15ºW
17/04/2019 10:30	Navigation to Santander harbour (fo evacuation of an ill crew member)
17/04/2019 16:46	Santander harbour
17/04/2019 21:00	Navigation to restart work
18/04/2019 16:15	Start of sampling work (at 47.20ºN, 2.82ºW)
20/04/2019 18:30	End of plankton stations for the 1st half of the survey
20/04/2019 18:30	Navigation to Santander harbour.
21/04/2019 14:10	Santander harbour. Change of part of the scientific staff.
22/04/2019 a 13:30	Start of the 2nd leg (Beginning of work at 46.58ºN, 3.77ºW)
24/04/2019 -27/04/2019	Stop work due to poor weather conditions
27/04/2019-29/04/2019	Plankton stations in French waters
29/04/2019	Short stop work (5.5 h) due to military exercises in French waters
30/04/2019	End of work in French waters
30/04/2019-03/05/2019	Plankton stations in Cantabrian waters
03/05/2019	End of the survey in Vigo Harbour.

4. METHODS

4.1. Plankton sampling

Sampling consisted of ichthyoplankton sampling on fixed (BONGO) stations.

BONGO net consists in a double net structure of 40 cm mouth. The bongo hauls were performed using a net with 250 µm mesh size and plastic cod-ends, operating obliquely from 200 m depth to the surface. In shallower areas, the net was towed from 5 m above the bottom to the surface. General Oceanics Flowmeters were used to record the towing length and estimate the sampled water volume (assuming a filtration efficiency of 100%), while a Marport net monitoring sensor was used coupled to the BONGO net to record maximum sampling depth.

Fish eggs in the samples were separated from the remaining plankton organisms onboard by performing the spray method recommended by the WGMEGS. Fish eggs were identified using morphological criteria (egg diameter, oil globule diameter, segmentation of yolk sac and pigmentation) and counted on board immediately after collection.

All samples were fixed in 4% buffered formaldehyde solution for subsequent verification of egg counts and staging in the laboratory. At least sub-samples of up to 100 individuals per target species (mackerel, horse mackerel) were staged.

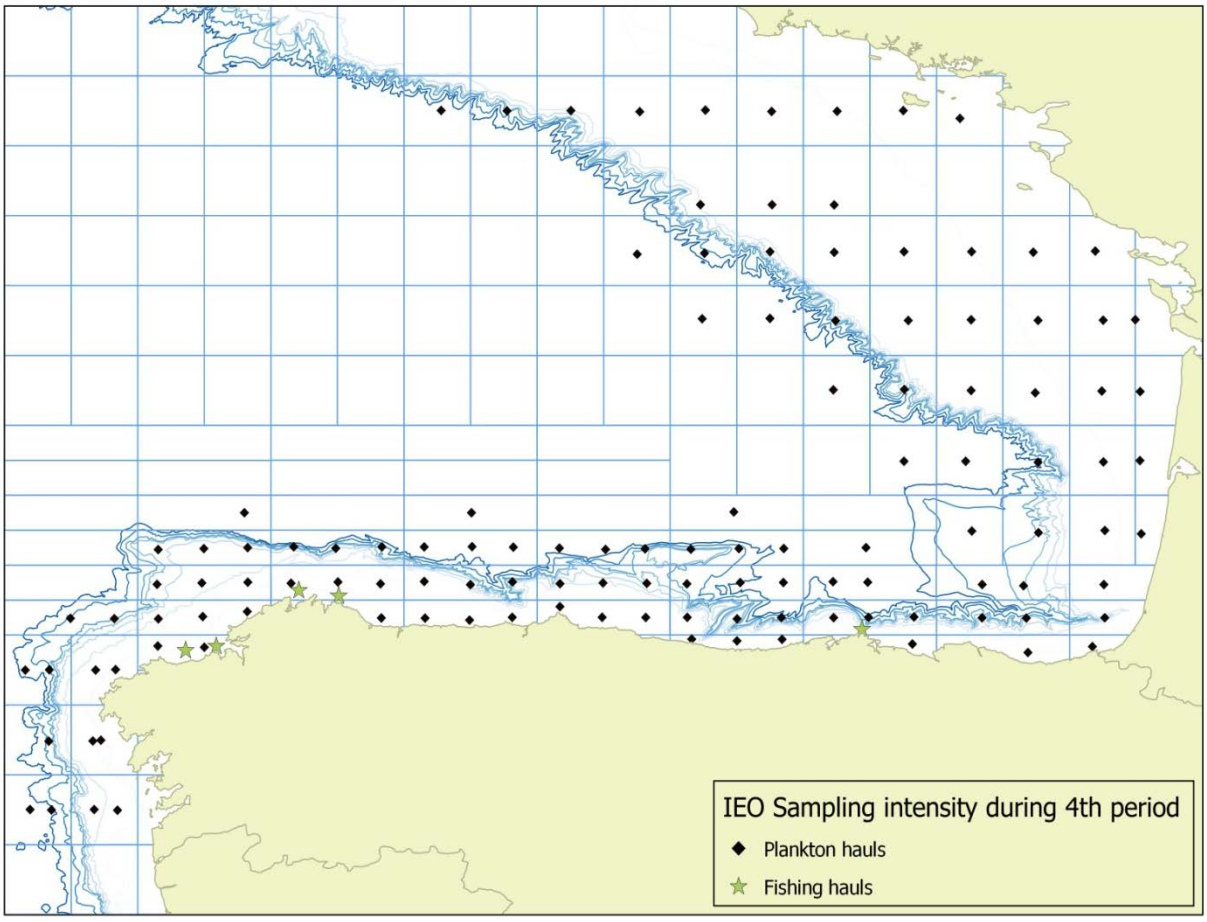

Figure 1. Sampling intensity. Fishing hauls and plankton stations during period 4.

4.2. Hydrographic sampling

A CTD Seabird25 was deployed for the hydrographic description of the water column (until 200m depth or 5m above the bottom in shallower stations).

4.3. Fecundity

Fecundity sampling was adapted as closely as possible to the sampling schedule planning described in the ICES survey protocol 'Manual for mackerel and horse mackerel egg surveys , sampling at sea" version 2.2 (SISP 6) and fecundity samples were taken following the standardized sampling methods described in the same survey protocol.

Total and batch fecundity estimation are key for AEPM and DEPM egg production methods and has to match in time and space with plankton (egg) sampling. Due to IEO internal management purposes no samples were taken in JUREVA0419, but most of the IEO fecundity samples were planned to be taken during the PELACUS0319 survey, as both surveys match in time. The specific IEO fecundity sampling schedule and fecundity methods are described in the PELACUS 0319 survey plan. A complementary sampling from commercial fish was fixed at A Coruña and Santander IEO laboratories to full fill the IEO required number of samples.

5. RESULTS

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5.1. Egg abundance and distribution

For period 4 survey (JUREVA 0419) a total of 124 BONGO stations, distributed in 19 transects, were performed. During JUREVA0419, only 15 of the stations were negative, 88% of the stations included fish eggs.

Total egg abundance was lower than in the previous survey (CAREVA0319), with 50934 eggs (84255 eggs in CAREVA, which means a 60% reduction). The average density was 442 eggs m^{-2}.

- Mackerel egg abundance and distribution.

Figure 2 shows mackerel egg distribution during JUREVA0419.

Mackerel was the most abundant species in the area, as in the previous survey, with a total number of eggs in the samples of 24145. Abundance in JUREVA0419 represents approximately one third of the recorded in CAREVA0319 survey. This lower egg abundance, in the samples indicates that the spawning peak is already exceeded.

This species was present in the 57% of the stations, with an average density of 206 eggs m^{-2} with a continuous distribution along the Cantabrian Sea and was scarcer on the shallower waters of the French platform.

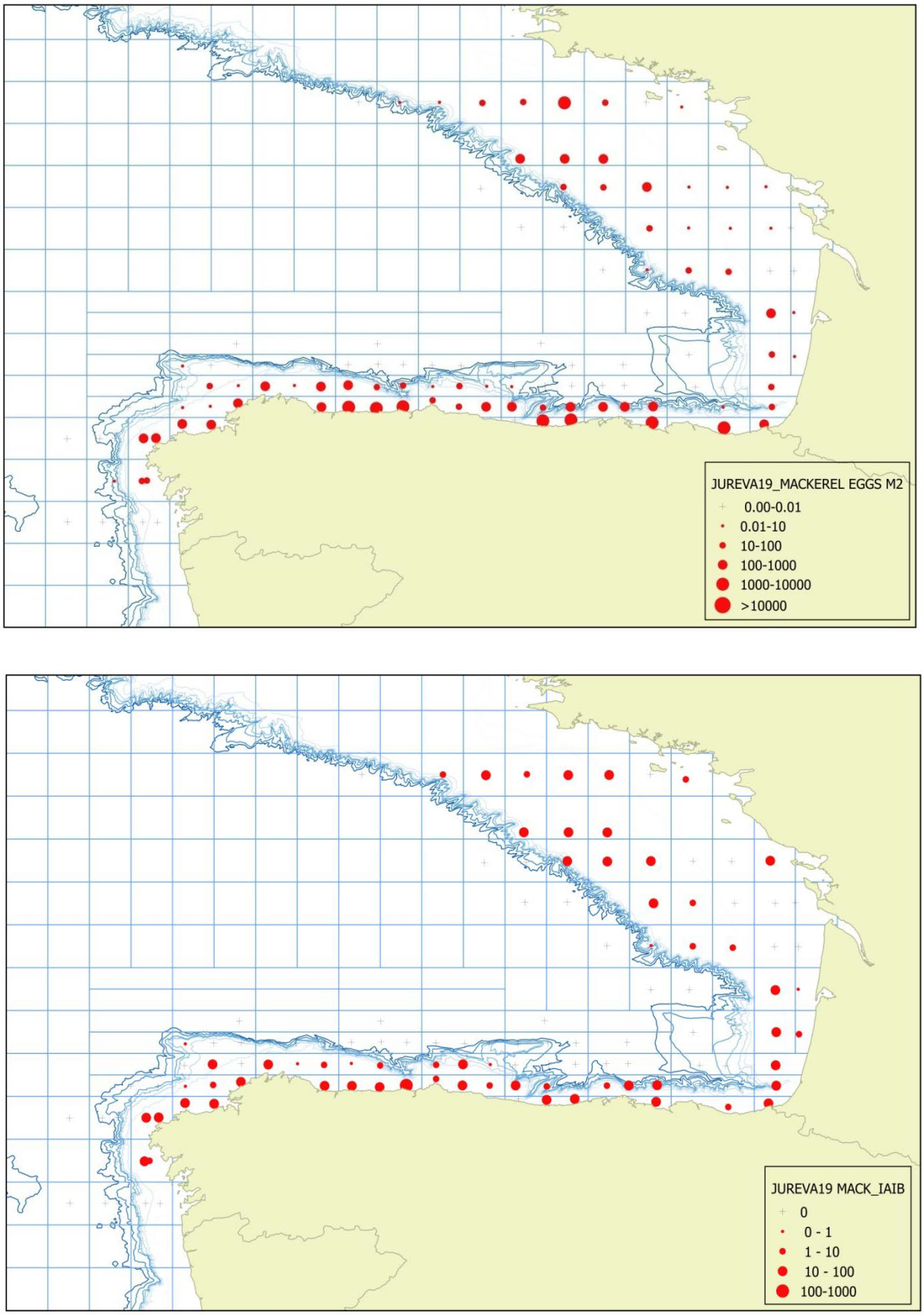

Figure 2. Mackerel abundance and distribution during JUREVA survey. 2a) Total egg distribution (eggs m-2) and figure 2b) Number of eggs in stage IA and IB.

- Horse mackerel egg abundance and distribution.

Figure 3 shows horse mackerel egg distribution during JUREVA 0419.

Horse mackerel was found in 50 of the 124 stations in survey (40%).

This species was mainly located in the ICES division 8.c with a total abundance in the samples of 4970 eggs and an average density of 40 eggs m^{-2}. The abundance of horse mackerel in JUREVA 0419 was much higher than the one registered in the March survey CAREVA 0319, since this species has a delayed spawning in the area. Also, the distribution area was much wider.

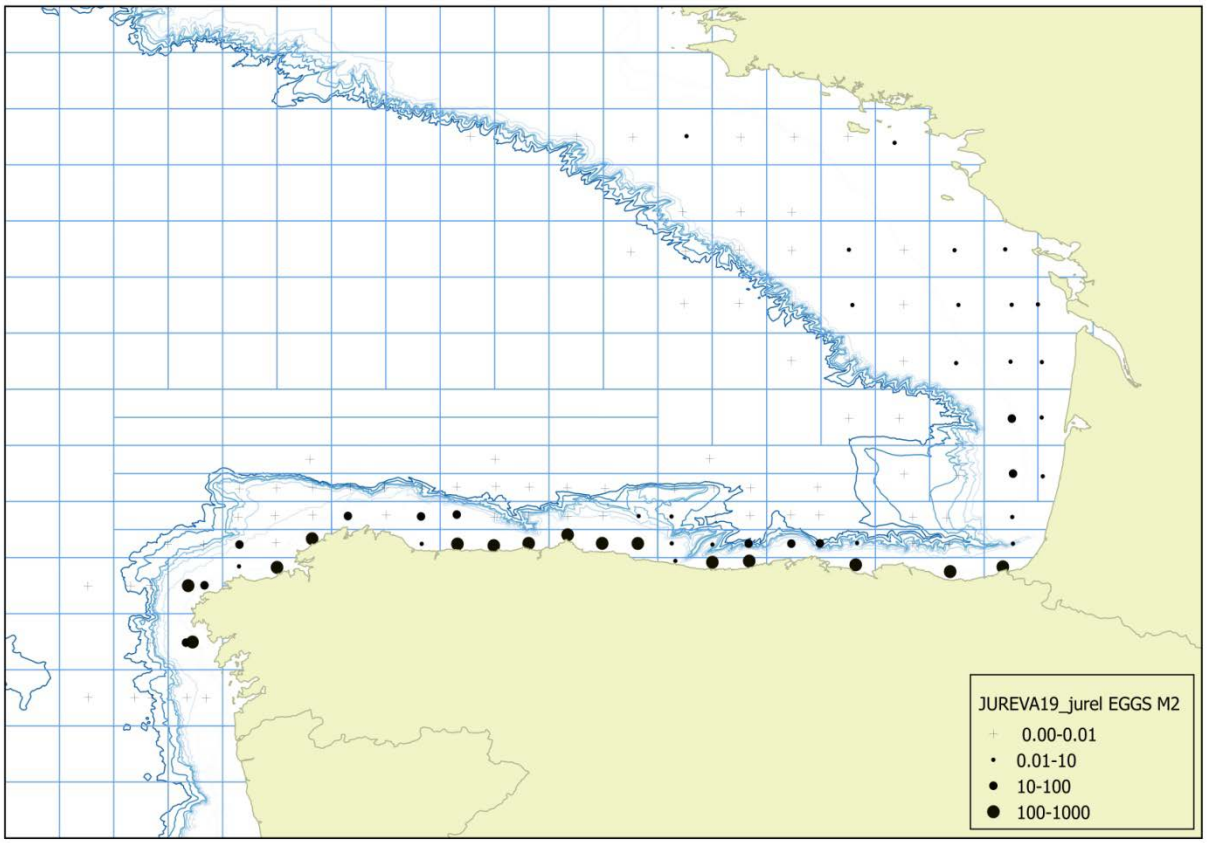

Figure 3. Horse mackerel abundance and distribution during JUREVA 0419 survey.

- Sardine egg abundance and distribution.

Figure 4 shows sardine egg distribution during JUREVA 0419.

Sardine was located in the 29% of the stations (only 36 positive stations), with 2451 eggs in total, corresponding to an average density of 21.1 eggs m^{-2}, lower than in the previous survey (CAREVA 0319) this year.

Higher abundances were registered in shallower stations in French waters, Cantabrian Sea and northern waters of Galicia. In southern Galicia waters (9.a.n ICES subdivision), sardine eggs were scarce.

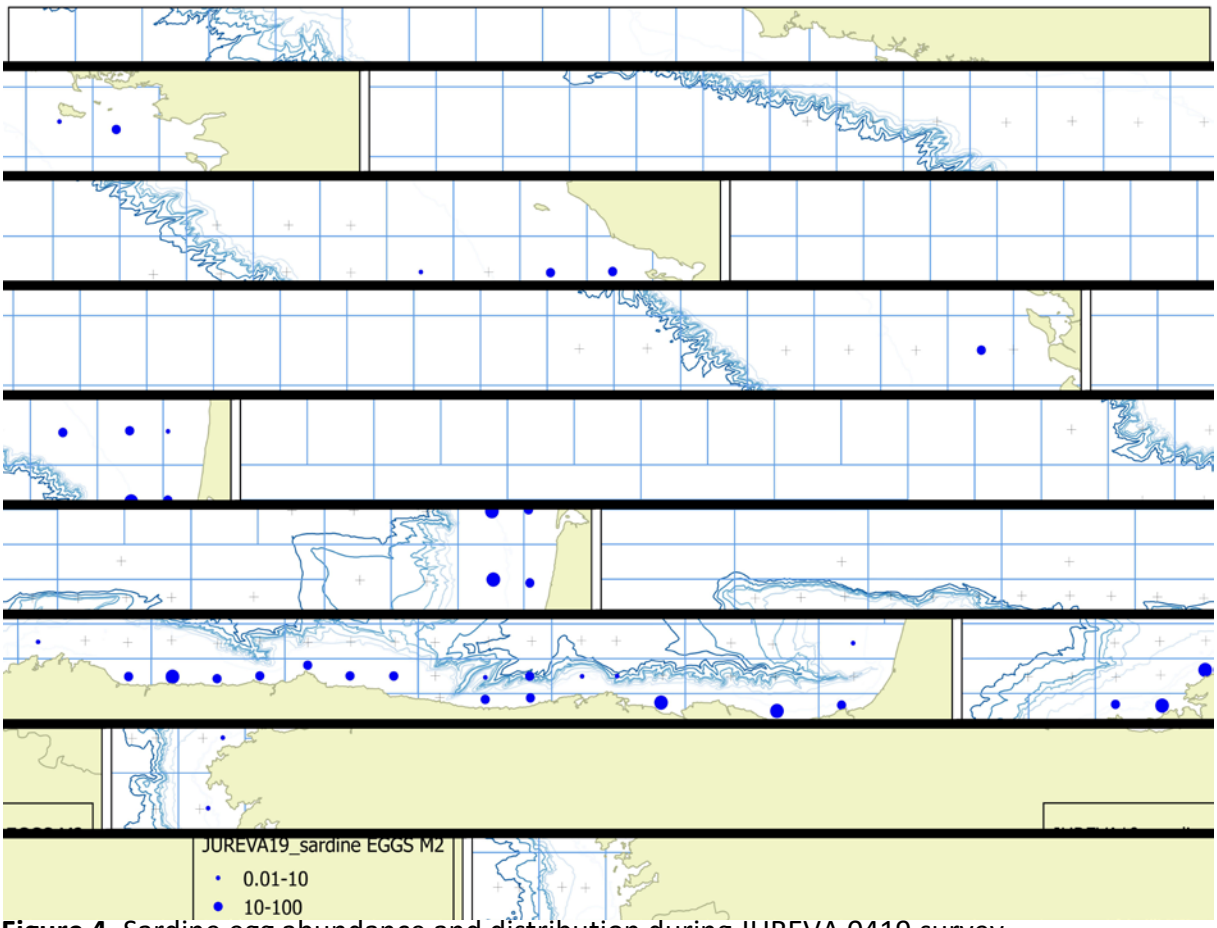

Figure 4. Sardine egg abundance and distribution during JUREVA 0419 survey.

- Anchovy egg abundance and distribution.

Figure 5 shows anchovy egg distribution during JUREVA 0419.

Anchovy eggs were much more abundant during JUREVA 0419, because this survey was carried out near the peak of spawning of this species in the area.

In total, 16571 anchovy eggs were found in the 41% of the stations, mainly in the inner part of the Bay of Biscay, with an average density of 151 eggs m^{-2}, being the second species in abundance during the survey.

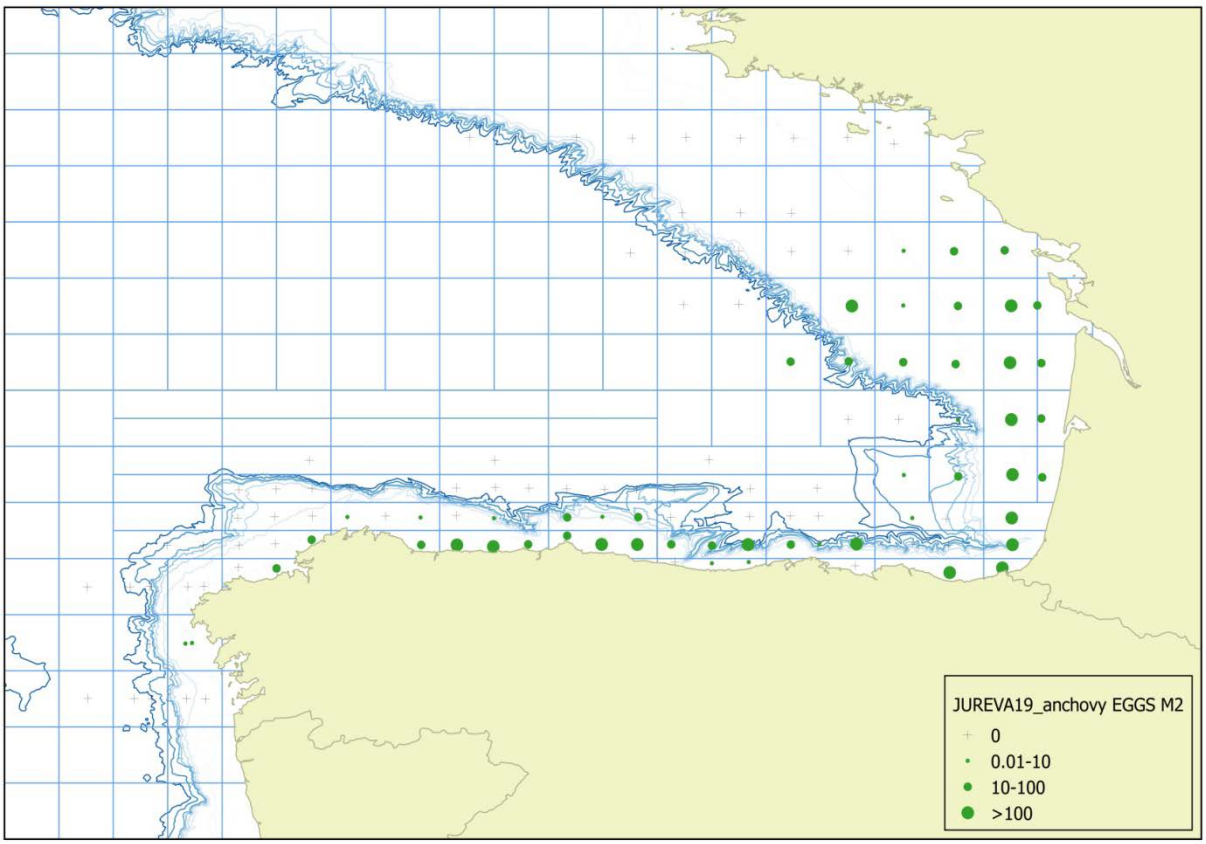

Figure 5. Anchovy egg abundance and distribution during JUREVA 0419 survey.

- Other species abundance and distribution.

Figure 6 shows egg distribution of other species during JUREVA 0419.

2797 eggs of many more species of fish were found, mainly of the mesopelagic species: *Maurolicus muelleri* (especially in the deeper stations) and of some other species with multiple oil drops and without oil drop in shallower waters. These species were found in the 76% of the stations, with an average density of 24.2 egg m^{-2}.

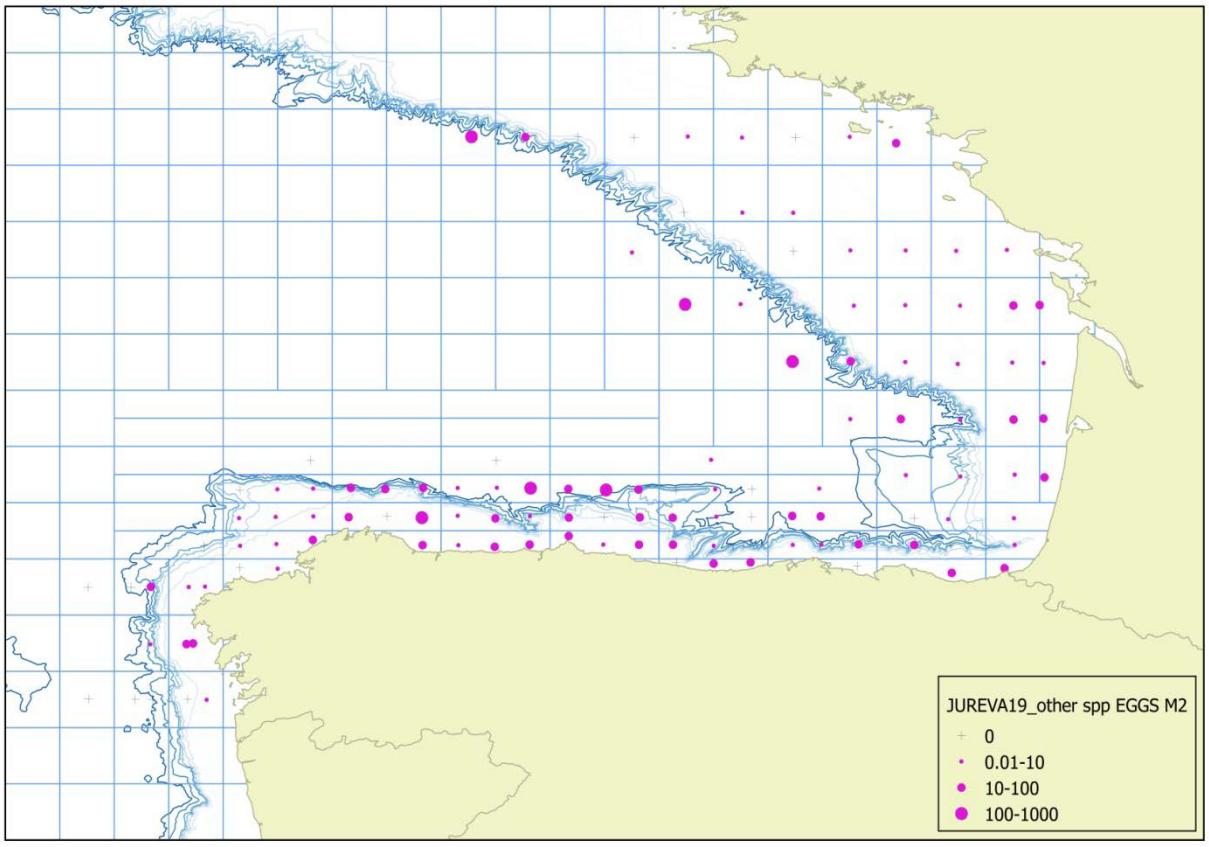

Figure 6. Egg abundance and distribution of other fish species during JUREVA survey.

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5.2. Hydrography

Figure 7 shows Sea Surface Temperature (SST) during JUREVA 0419 survey registered by the thermosalinometer of the R/V "Vizconde de Eza". In general, temperature was higher than in CAREVA 0319 survey, and warmer waters were observed in the inner part of the Cantabrian Sea.

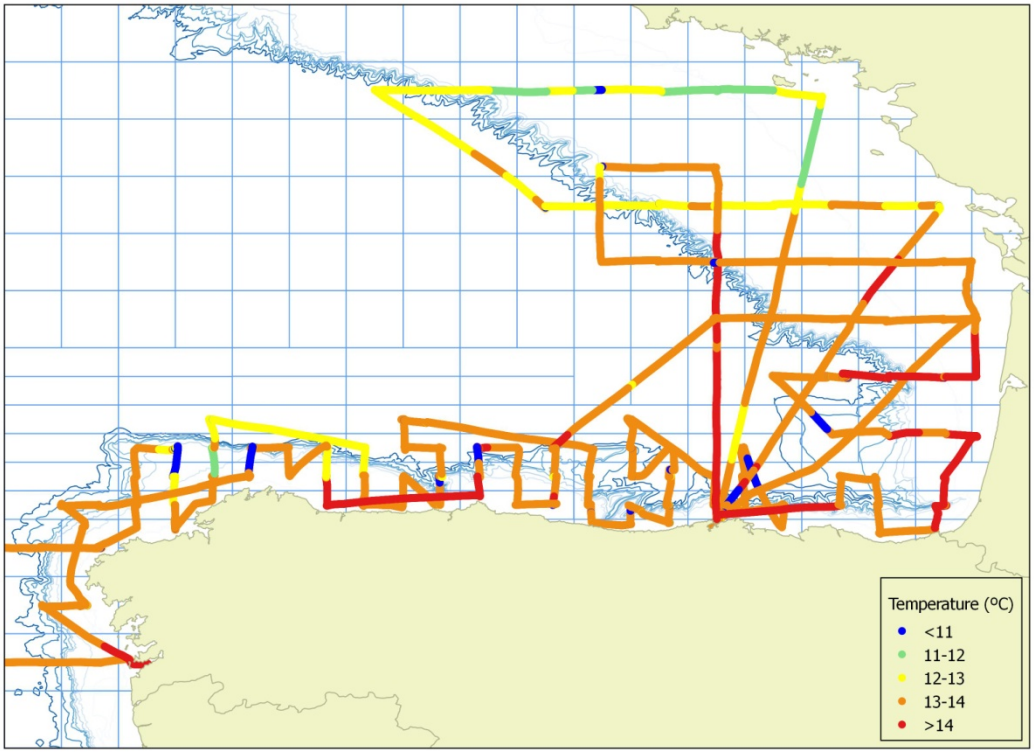


Figure 7. Sea surface temperature during JUREVA 0419 tracking.

Data from 124 CTD performed during the survey have been sent in the Excel spreadsheet to the group WGMEGS, and will be analysed in depth before the next WGMEGGS meeting.

5.3. Fecundity

A total of 1720 fish were taken for AEPM and DEPM fecundity and sex ratio estimations (Table 1). Most of them were sampled in the survey PELACUS0319 making the best use of the acoustic monitoring and the survey general biological sampling. Around 100 fish were sampled from each of the 17 hauls distributed during March and start of April. Biological data were taken for all sampled fish and additional fecundity sampling was made in 30 females per haul. Due to the PELACUS0319 survey strategy, fecundity sampling during period 3 was better distributed on time but most of the period 4 fecundity sampling was made in the start of April. Experience on mackerel distribution during its annual migration along the Cantabrian sea marked this mode of operation that guarantee the fulfillment of IEO assigned number of samples. That's why only two fecundity samples match with JUREVA0419 plankton survey that started in April the 10th. However fecundity is a quite stable parameter and thus significant differences between samples taken with a difference of 15 days are supposed to be absent.

Table 1. IEO sampling for AEPM and DEPM estimations by date and survey.

		Commercial		Survey	
		Santander	A Coruña	PELACUS0319	
March (Period 3)	04	90			
	07		100		
	13	100			
	24			100	
	27			105	
	28			100	
	29			107	
	31			100	
April (Period 4)	01			101	
	02			100	
	04			107	
	05			105	
	08	100		100	
	09			100	
	10			105	
	11			100	
Total		290	100	1330	1720

8. Individual survey report: Spain/AZTI, Period 5

Please find the individual survey report below

SURVEY REPORT RV "Ramón Margalef".
Date: 4-24 May
AZTI (BASQUE COUNTRY – SPAIN) PARTICIPATION IN THE INTERNATIONAL MACKEREL AND HORSE MACKEREL EGG SURVEY 2019
Cruise leader: Paula Alvarez and Maria Santos

Background

The ICES triennial Mackerel and Horse Mackerel egg surveys are carried out since 1977. These surveys are aimed to produce both an index and a direct estimate of the biomass of the Northeast Atlantic mackerel stock and the southern and western horse mackerel stocks applying Egg Production Method. To estimate the Spawning Stock Biomass, using this method, it is necessary to obtain annual estimates of both the total egg production and the realised fecundity of the females. Mackerel and horse mackerel egg survey is the only source providing fishery independent information for these stocks.

The planning and coordination of the surveys is agreed within the ICES Working Group for Mackerel and Horse Mackerel Egg Surveys (WGMEGS). The planning of the 2019 Egg Surveys was coordinated at the meeting carried out in Dublin, in April of 2018 and tuned during the year of the cruise.

Since 2013 both methods, annual and daily egg production methods are applied to estimate the stocks Biomass.

This report describes the actions developed by AZTI Foundation (Technological Institute for Fisheries and Food) in relation to the international survey 2019, following the recommendations given during that meeting and provides some preliminary results and comments.

The survey carried out by AZTI will provide egg and fecundity data corresponding to the Bay of Biscay during two cruises, specifically in 46º 30' N- 48º 45' N /1º15'-10º 00' W (first cruise Period 3) and 43ºN-46º 30´N, /1º15'- 7º 00' W second cruise (period 5). As usual, AZTI provides data of mackerel and horse mackerel eggs abundance in May from the annual Anchovy DEPM survey. Bearing in mind that (1) the main goal of this survey is anchovy and (2) this specie shows a spatial distribution of their spawning grounds quite different from mackerel and horse mackerel, the sampling of lasts ones is highly constrained by the former (for example the extension of the area to covert). Since 2013, AZTI has added 5 extra days ships in May to complete the areas which are

not uncovered by anchovy DEPM or that their coverage could significantly alter the anchovy sampling.

The second cruise carried out from 4th -24th of May on board of R/V Ramon Margalef (for plankton) and R/V Emma Bardan (adults). The survey is part of the European data collection established in 2002 and in part, financially supported by the EU.

ITINERARY

SECOND LEG (4- 24 May) summary of activities

(R/V Ramón Margalef-Emma Bardan)

4 May	Travel to Santander and depart at 14:00 hour heading North. First station, in front of Santander, started at 16:00. Wind conditions were getting worse along the day with maximum speed of 25 knots. Not stop working.
5-6 May	We continued sailing north completing the plankton grid without mishaps. We reached the northernmost radial the 5th in the afternoon and came all the way south until arriving at the Cantabria sea again. Wind speed still high.
7-8 May	Working without contretemps in the Cantabria sea but worried about bad weather forecasts. Finally, we were able to complete this first part successfully.
9 May	**Break in Pasaia port for personnel** exchange and to refuel, and depart again at 20:00 to complete the sampling
9-24 May	Working in French waters until finish the last plankton net planned.

The R/V Enma Bardan supported our survey collected adults samples over the time and all around the area.

Survey desing

The sampling area located in the Bay of Biscay consisted of a grid with a series of E-W transects spaced of 0.5° longitude and 0.5° latitude (see Fig 1). Sampling was carried out in an east–west and west-east direction covering the potential spawning area for mackerel and horse-mackerel according to a preliminary plan (ICES, 2015). A transect was completed when a station had zero or near zero values or when two consecutive stations had low values.

Adult samples were collected using pelagic trawls in those areas where eggs presence was observed, or pelagic shoals were detected in the sonar. The collection of adults followed a scheme designed previously (ICES 2015).

Sampling procedures

Hydrographical measurements

Vertical profiles of temperature and salinity were obtained using a RBR CTD. Temperature at 5m,20m,50m, 100m and bottom depth and surface and 20m depth salinity were noted at each station.

Sampling of ichthyoplankton

Plankton samples were taken with a Bongo sampler equipped with a net of 250 um mesh size and a nose cone diameter of 40 cm. It was deployed on double oblique hauls (45º approximately), to a maximum depth of 200m or to within 5m of the bottom in shallower water. It was retrieved to the surface at a rate of 20m/mn and towed at a ship speed of 2-2.5 knots. Calibrated flow-meters were used to calculate the volume of water filtered. Bongo net was equipped with a CTD sensor (RBR model) to record depth, temperature, salinity and chlorophyll profiles for each deployment and a transponder (HIPAP) to measure real time in-situ sampler depth. Haul performance was automatically carried out at constant lowered (50m/min) and retrieved (20m/min) cable speed. During the haul the parameters starting position, date, time, total cable length, haul duration, sampler depth and weather conditions were monitored and noted.

During the cruise the content of the two nets of the Bongo frame was separately stored in two jars and preserved in buffered 4% formaldehyde, to be analysed later on. Just one of the net collectors was analysed. The pH of the plankton samples were checked every 12 hours during the first 2 days after preserving.

The plankton sample was washed from the end bags into a jar and preserved with 4% solution of buffered (sodium acetate trihydrate buffer) formaldehyde. The jars were labelled and stored to be analysed in land.

Once in the lab., the “spray method” was applied only if the abundance of fish eggs is high, if not, the sorting out is carried out manually.

All eggs of target species were identified and staged.

Results

Meteorology and Hydrography

In general, meteorological conditions were characterized by low pressure systems.

Temperature ranged from 12.7 to 16.4 ºC and decreases from east to west and increases from south to north as the survey progresses (Figure 2). The coldest temperatures were recorded at the river mouths (both Cantabria sea and French rivers). Few differences in temperature were recorded among surface and 20 m depth (Figure 2) when it is compared with historical data. At that water depth temperature ranged from 12.4 to 14.7ºC. Weak thermal stratification at 20-30 m depth occurred for period 5. Salinity ranged from 33.2-35.8 ‰ at both surface and 20 m depth. Minimum values were recorded at rivers outlets.

Plankton samples

A total of 58 Bongo catches were conducted during the P5 cruise containing a total of 28308 fish eggs. Only two samples did not contain any fish eggs and the highest egg densities were encountered in the west part of the Cantabria sea on the French shelf (**Figure 3**).

Of all fish eggs, 2.9% (= 809) were of mackerel and some 4.5 % (= 1288) of horse mackerel. Other eggs caught were those of hake (*Merluccius merluccius, 14 eggs*), sardine (*Sardine*

pilchardus, 1244 eggs), whiting (Lepidorombus sp, 12 eggs) and pearlside (Maurolicus muilleri, 1608 eggs) and anchovy (Engraulis encrasichoulus, 20914 eggs). A total of 1955 eggs were not identified (6.9%). It was remarkable the high abundance of anchovy eggs (74% of the total eggs), which denoted that May was the peak of spawning for this specie. The eggs of pearlside were the second specie most abundant (5.7 % of total) in the ichtioplankton samples.

Mackerel eggs were found in 34 of the total plankton samples with the highest abundance located in the Cantabrian sea, on the shelf and between longitudes 3º-6ºW. The highest mackerel egg density (234 eggs/m2) was encountered at position 43.8ºN 5.25ºW (Fig 4). 34 % of all mackerel eggs were in stages I (A and B), 29% of stage II, 26% of stage III, 8% of stage IV and finally 3% of stage V. Figure 4 shows the geographical distribution. The number of mackerel eggs per station range from 1 to 234 eggs (all stages). The highest mackerel egg 1 numbers (105 eggs/m^2) were found at 43°6'N latitude and 03°75'W longitude.

Horse mackerel eggs were more abundant in this period than in period 3. Positive stations represented 50% of the total. Abundance ranged from 1 to 465 eggs/m^2, the later located in the Cantabrian sea in position 43°6'N - 03°75'W (Figure 5). 25 % of all mackerel eggs were in stages IA and IB, 25% of stage II, 37% of stage III and finally 13% of stage IV. Figure 5 shows the geographical distribution of horse mackerel egg stage 1. The number of horse mackerel eggs per station in stage 1 ranged from 1 to 58 eggs/m^2, with the highest abundance on the French shelf between 45-46ºN

Fecundity samples

Period 5: In this period, 4 hauls were positives for mackerel (it must be taken into account that in this period the target species was anchovy). Spatial distribution of adult stations is shown in Figure 5.3.1b. The most important captures of mackerel were located at the eastern part of the Cantabria sea. Total catch consisted of 5 different fish species, being the most abundant E. encrasicolus (61%), S. scombrus (35%), T. trachurus (3%) and M. poutassou (1%). During this period the mackerel catches were relatively low (about 118 kg total) and were mixed with other species mainly anchovy and horse-mackerel.

66 mackerels were measured, weighted and sexed. For females, total carcass weight, gonad weight, otolith, and subsamples of ovary for fecundity studies were taken.

By sex, the distribution was: 41 mackerels were females (62.1%), 25 were males (37.9%) (Table 1). Females were slightly heavy than males. For similar length of 34 cm, female was 4% heavier than male.

By age, females ranged from 1 to 12 years old, being the groups 7 and 8 years old group the most frequent (22% each of them) followed by the groups of age 6 (15%). Age of males ranged from 1 to 11. The group of age 1 was the most abundant (36%) followed by the age group 11 years old, which represented some 16% of total.

While for males it was possible to obtain almost equal number of specimens for each weight range (Table 1), that was not able for females, where the lightest range was poorly represented.

According to the macro-maturity scale (Table 2), the distribution of adults revealed that for females the population seemed to be equally separated into two different stages, pre-spawning (Stage 3) or post-spawning (stage 5); however, for males, the stage 5 was the most abundant.

ACKNOWLEGMENTS

The cruise was partly funded by the European Commission (DG-Fish) under the EU directive 199/2008.

I am grateful to the crews of the R/V Ramon Margalef and also to all the staffs of the scientific team, because without the collaboration of all of them this work could not have been done. Thanks folks!!!!

Figures

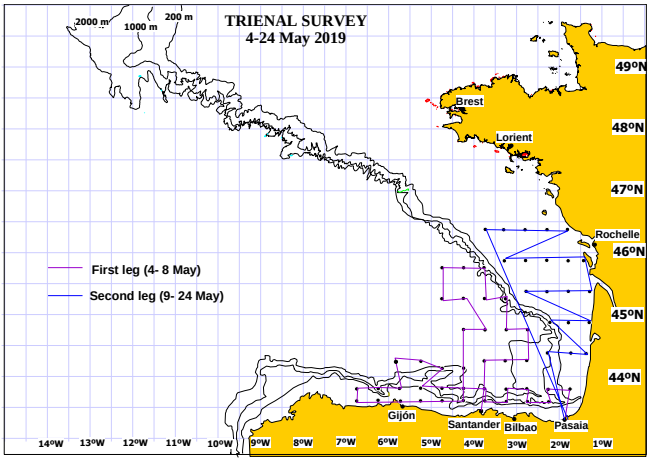


Figure 1: Map showing the tracks carried out during the P5 survey from 4th March to 24th April.

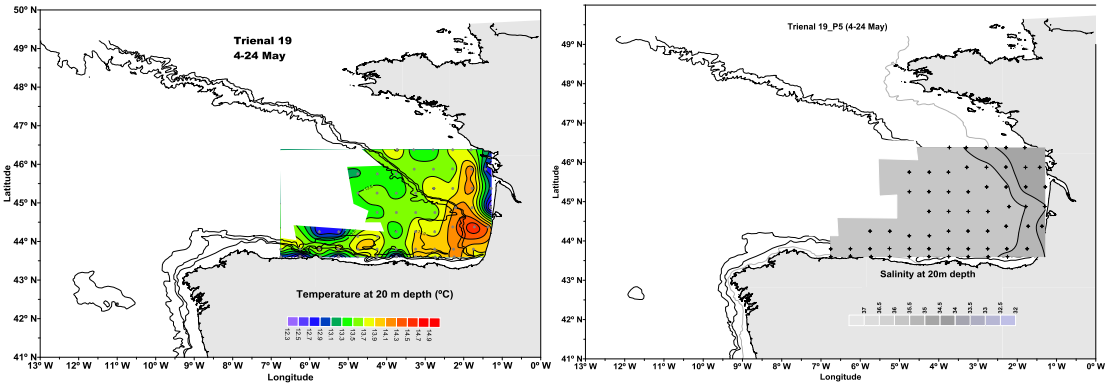


Figure 2 : Spatial distribution of Temperature (ºC) (left map) and salinity (‰) at 20m depth (right map).

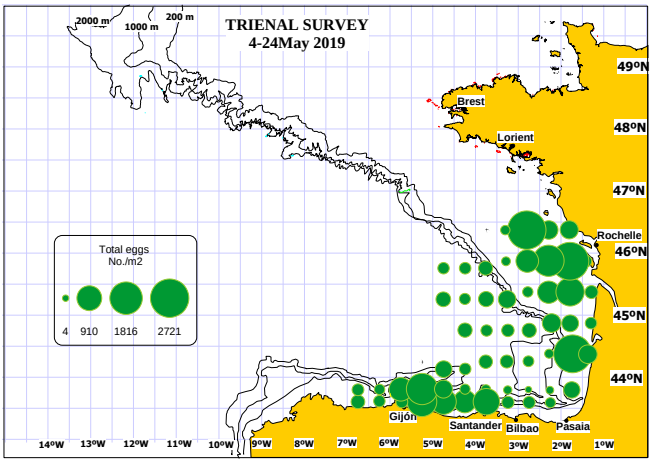


Figure 3: Spatial distribution and abundance (number/m²) of total fish eggs for P5. Crosses indicate not eggs presence.

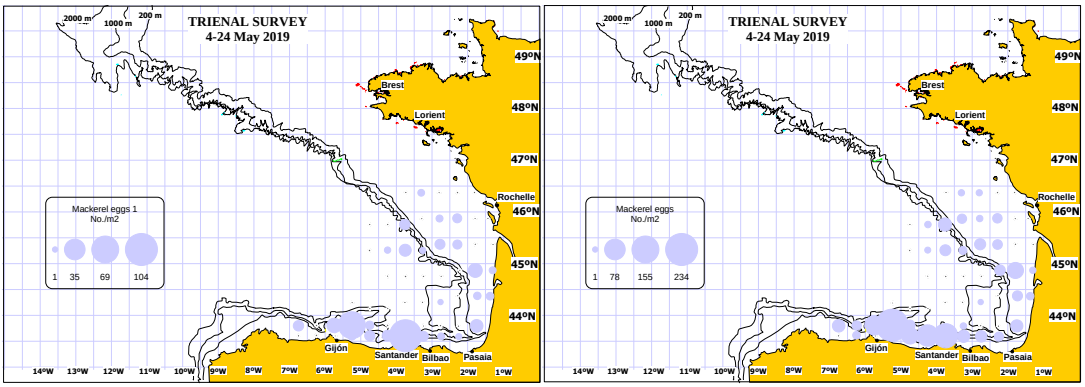


Figure 4: Spatial distribution and abundance (number/m^2) of mackerel eggs in **stage 1** (1A+1B) (on the left) and total mackerel eggs for period 5 survey (on the right). Crosses indicate not eggs presence.

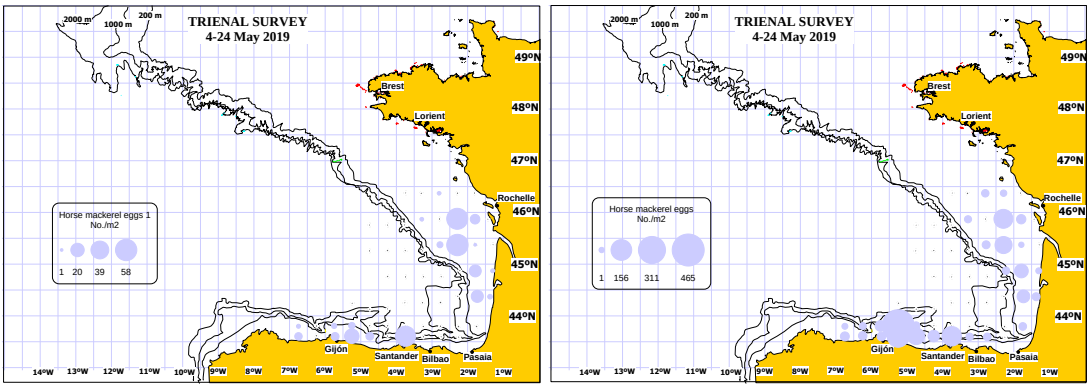


Figure 5: Spatial distribution and abundance (number/m^2) of horse mackerel eggs in **stage 1** (1A+1B) (on the left) and total horse mackerel eggs for period 5 survey (on the right). Crosses indicate not eggs presence.

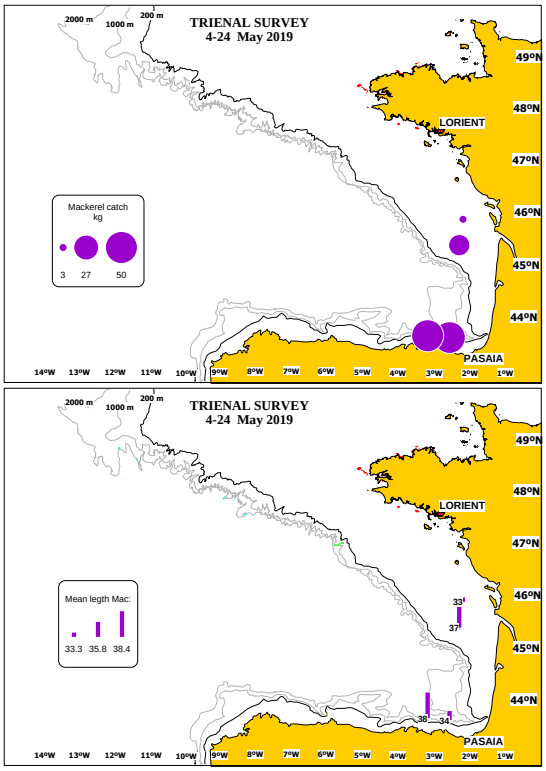


Figure 6: Spatial distribution of mackerel captures (on the top) and mean length per haul (on the bottom) for mackerel of captures during P5.

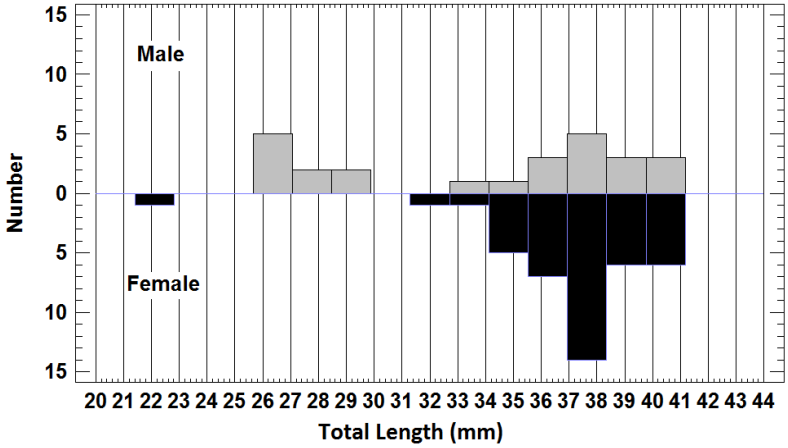


Figure 7: Plot of length frequency distribution for mackerel by sex for period 5.

TABLES

Table 1: Mackerel weight distribution by sex for period 5.

Weight	MALE	%	FEMALE	%	Total	%
<250	9	36%	1	10.2%	10	15%
250-400	8	32%	23	74.9%	31	47%
>400	8	32%	17	14.9%	25	38%
TOTAL	**25**		**41**		**66**	

Table 2: Mackerel maturity stages distribution by sex for period 5.

Maturity	MALE	%	FEMALE	%	TOTAL	%
1	0	0%	1	2%	1	2%
2	0	0%	0	0%	0	0%
3	3	12%	17	41%	20	30%
4	3	12%	3	7%	6	9%
5	17	68%	19	46%	36	54%
6	2	8%	1	2%	3	5%
TOTAL	**25**		**41**		**66**	

9. Individual survey report: Faroes/ HAVSTOVAN, Period 5

Please find the individual survey report below

CRUISE REPORT BY SÓLVÁ KÁRADÓTTIR ELIASEN

Cruise no. 1922

Faroese part of MEGS 2019

24 May – 4 June 2019

R/V Magnus Heinason OW2252

Participants:

Jákup Pæturssonur Dam

Durita Sørensen

Poul Vestergaard

Sólvá Káradóttir Eliasen

HAVSTOVAN
FAROE MARINE RESEARCH INSTITUTE

POBox 3051 - FO 110 Tórshavn, Faroe Islands

INTRODUCTION

The MEGS survey is carried out every three years. In 2019 there were eight participating countries. Each of the eight participating countries covered a certain area in a certain period. The Faroe Islands were out in the period 23.May – 4.June.

The main aim of the cruise is to investigate the number of mackerel eggs. The preliminary area is assigned in the SISP 2019 manual, but as the results from cruises prior to the Faroese are ready, the area is always a subject to changes. The initial cruise track of R/V *Magnus Heinason* is shown in Figure 1 with 91 planned plankton stations.

In general, the first eight days of the cruise went as planned. On day eight there was a change in weather, and the remaining part of the cruise it was not possible to sample due to bad weather. Thus, only 62 of 91 planned stations were taken. Two trawl stations were both planned and taken.

The present survey report is based on data from R/V *Magnus Heinason* only. Therefore no estimate of mackerel spawning in general is given due to incomplete coverage of the distribution area and varying survey area among years.

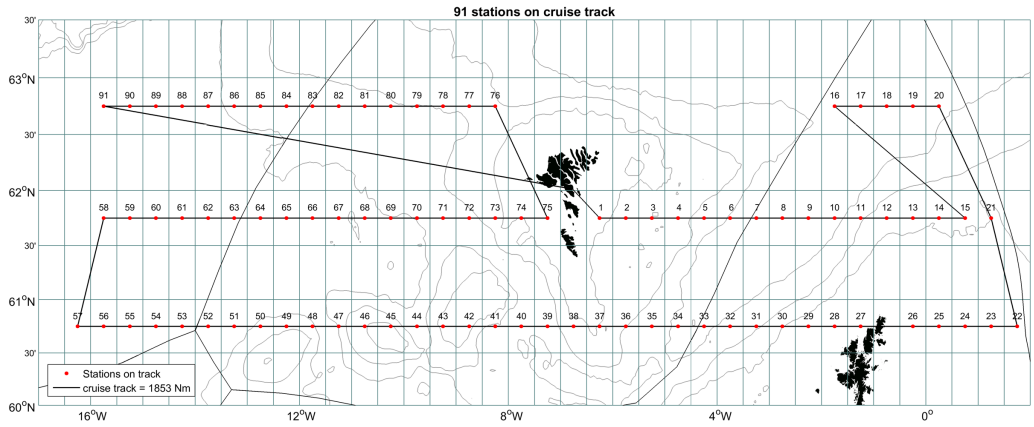


Figure 1 Original cruise plan of R/V *Magnus Heinason*.

MATERIAL AND METHODS

A Gulf VII plankton sampler with Hydro-Bios CTD and flowmeter was used to collect eggs, and pelagic trawl was used to collect biological data from adult mackerel. The sampling was carried out according to the SISP manual.

At the plankton stations, we were, in addition to the prescribed task in the SISP manual, asked to collect eggs to Matthias Kloppmann for genetic analysis.

For the adult sampling our task was to sample ovaries from 45 fish (a,b,c,d,e and f samples) and in addition to that, we aimed at sampling 100 ovaries to Thassya dos Santos Schmidt.

Trawl specifications for *Magnus Heinason*:

Circumference (m)	640
Vertical opening (m)	45–55
Mesh size in codend (mm)	40
Typical towing speed (kn)	3.0–3.5

RESULTS

EGG SAMPLING

The Gulf VII sampler worked well in good weather and 62 plankton stations were taken and 3002 eggs caught and analyzed, see Figure 2-4. At the western end of the 60 45N line, mackerel eggs were still seen in the samples and it was decided to sample two more stations to the west, before turning north. Due to this additional westward sailing, it was decided to sample the remaining two lines (61 45N and 62 45N) simultaneously by doing a zig-zag sailing from one line to the other. However, this was never carried out due to bad weather.

Eggs were sorted in two groups: "mackerel" and "other". In the staging, no distinction was made between stage Ia and Ib. An analysis of sizes of the eggs and the sea temperatures in which they were caught is shown in Figure 5-8.

The excel datasheet with egg counts has been submitted to this year's survey coordinator, Brendan O'Hea.

EGGS FOR GENETIC ANALYSIS

57 eggs were stored for genetic analysis and have been sent to Matthias Kloppmann. The first five of these were not included in the egg-counts, but the remaining 52 eggs were photographed before being stored in ethanol and have been included in the egg-counts.

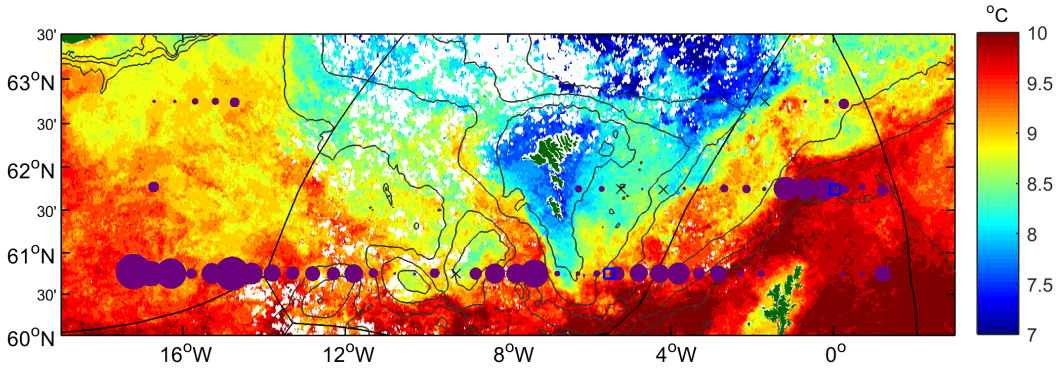


Figure 2 Abundance of mackerel eggs (all stages) shown as size of circles. The largest circle corresponds to 240 eggs m^{-3}. 0 egg is shown as an "x". SST from based on remote sensing in the period 24.May – 4.June 2019 is shown in colours. Trawl stations are indicated by blue squares.

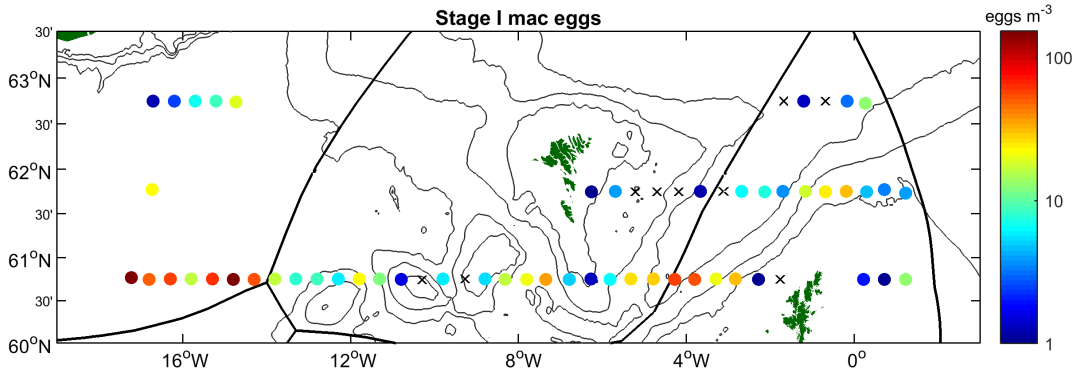


Figure 3 Abundance of stage I mackerel eggs shown as colored circles. 0 egg is shown as an "x".

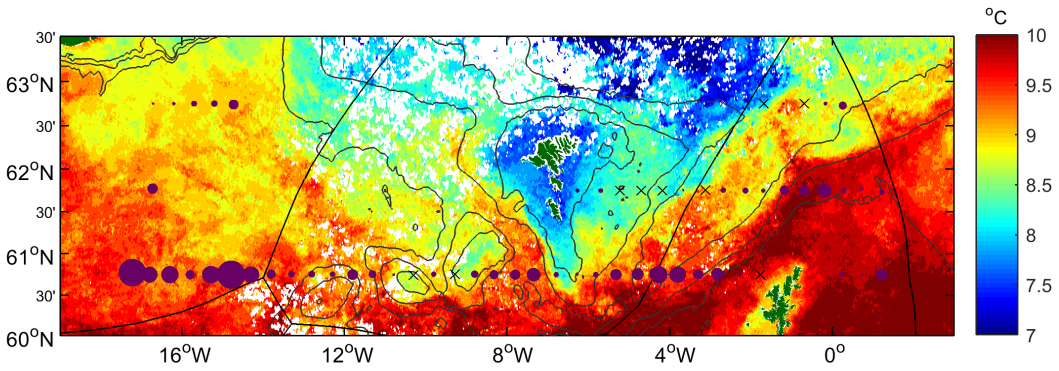


Figure 4 Abundance of other eggs shown as size of circles. The largest circle corresponds to 134 eggs m^{-3}. 0 egg is shown as an "x". SST from based on remote sensing in the period 24.May – 4.June 2019 is shown in colours.

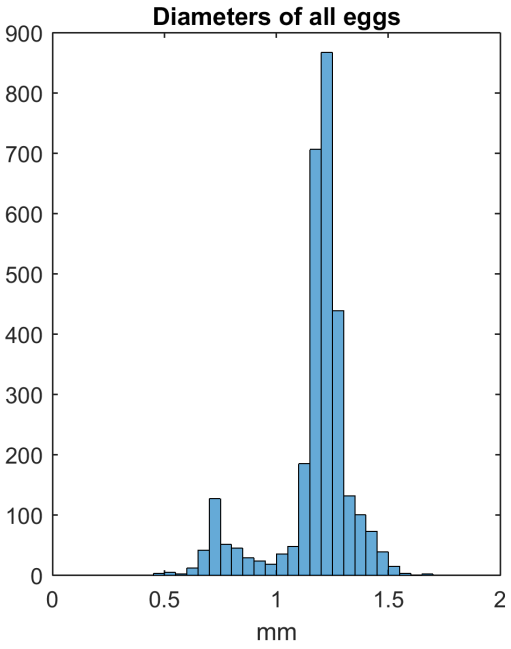


Figure 5 Diameters of all 3002 eggs sampled on the 62 plankton stations

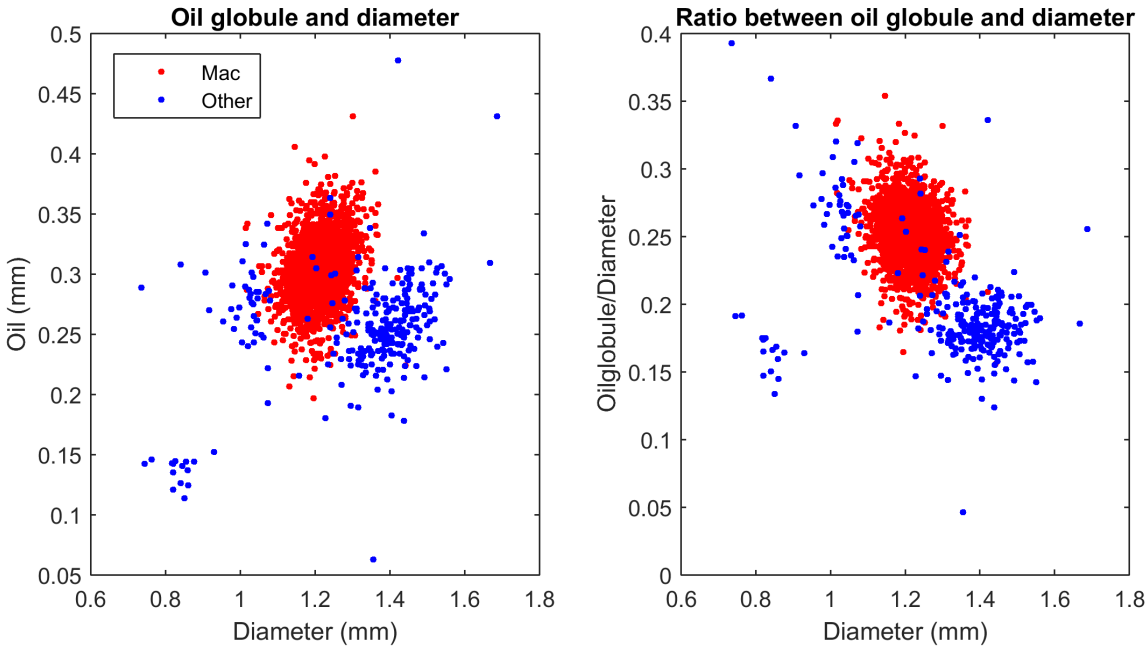


Figure 6 Of the 3002 eggs found, 2434 had an oil globule. Of these, 2159 have been classified as mac eggs.

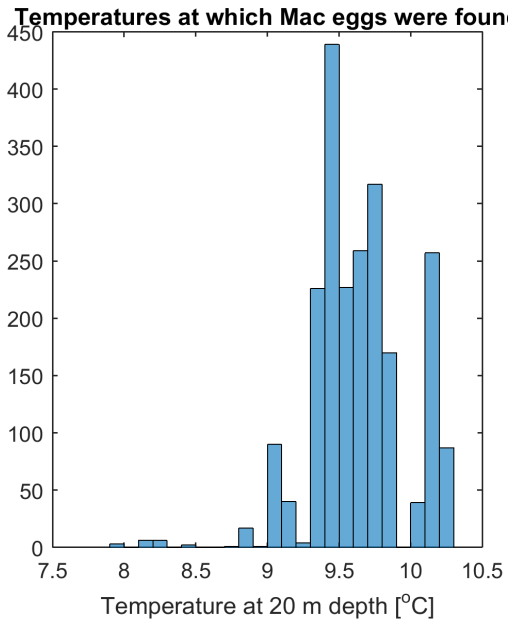


Figure 7 Temperature at 20 m depth (as observed by the CTD) at stations where mac eggs were found.

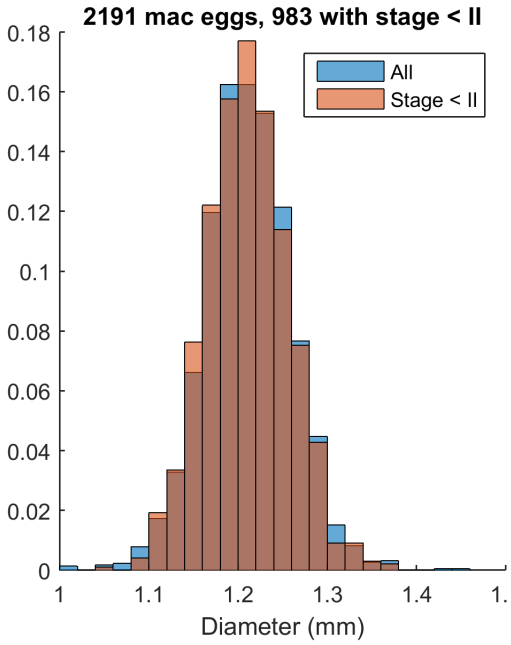


Figure 8 Size range of mackerel eggs.

ADULT SAMPLING

Two trawl stations were taken on the cruise.

While sampling, the ovaries were weighed on board with a weight with a 1g precision (and not 0.1 g precision as it should be according to the manual).

TRAWL STATION 19220016

The position of this station is shown in the top panel in Figure 9. At this station we aimed at collecting 25 of the prescribed 45 ovaries. The catch was a mix of mackerel and herring and the caught mackerel was young, with a large proportion of un-mature fish.

There were two mistakes in the handling of the catch on station 19220016:

1. While both collecting 100 random fish, at the same time as making sure that there were equally many from four different weight categories with maturity 3-6, we got confused. In the end, we found 50 females of different sizes and thus, the sample was not done randomly from the catch!

2. It was not clear to us that we were supposed to measure and weight males, and thus, this was not carried out.

   Thus, neither the age, length and weight distribution of the catch is known, nor how large a fraction of the catch was males at station 19220016.

We collected 25 (a,b,c,d,e,f) ovary samples, although the e- and f-samples were carried out according to the 2016 manual. 48 fish were sampled for Thassya dos Santos Schmidt.

TRAWL STATION 19220037

At this station we aimed at collecting 20 of the 45 prescribed ovaries. The catch was a mix of mackerel and herring and 100 mackerels were randomly selected for length, weight and age measurement. As far as we are aware of, all sampling was carried out according to the SISP manual. The ratio between males and females at this station was 61 to 39 and the length, weight and age distribution is shown in Figure 9.

In addition to the 20 a,b,c,d,e and f-samples taken, 39 ovary samples were collected for Thassya dos Santos and one fish was used for ring-test.

The excel datasheet for adult sampling from both trawl stations has been submitted to the biological sample coordinator Jens Ulleveit, and the samples have been sent to their respective recipients.

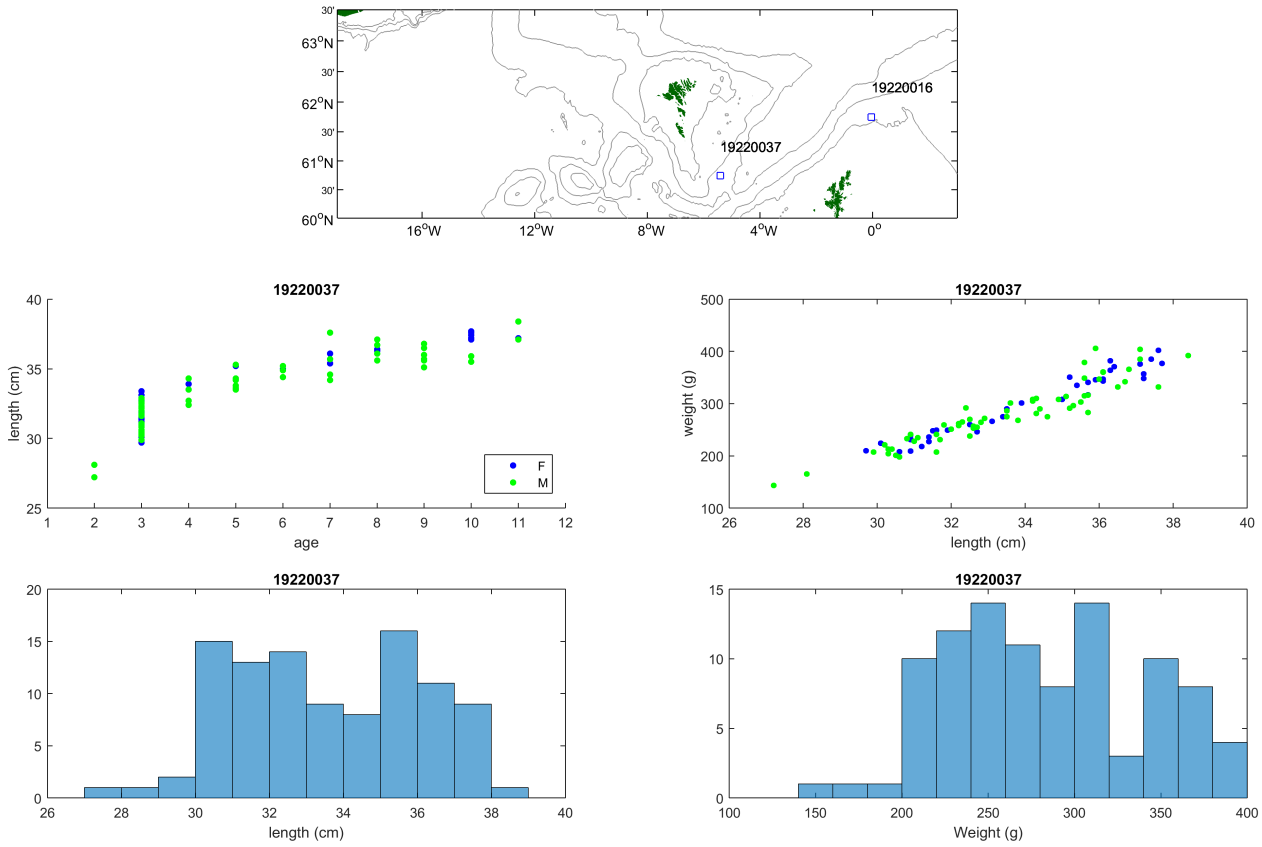


Figure 9 Overview of results from trawl station 19220037. 100 mackerels were measured. Top panel: positions of the two trawl stations. Middle panels: age-length and length-weight relationships. Bottom panels: length and weight distributions.

10. Individual survey report: The Netherlands/WMR, Period 5&6

Please find the individual survey report below

Results period 5 and period 6

9/8/2019, Ewout Blom

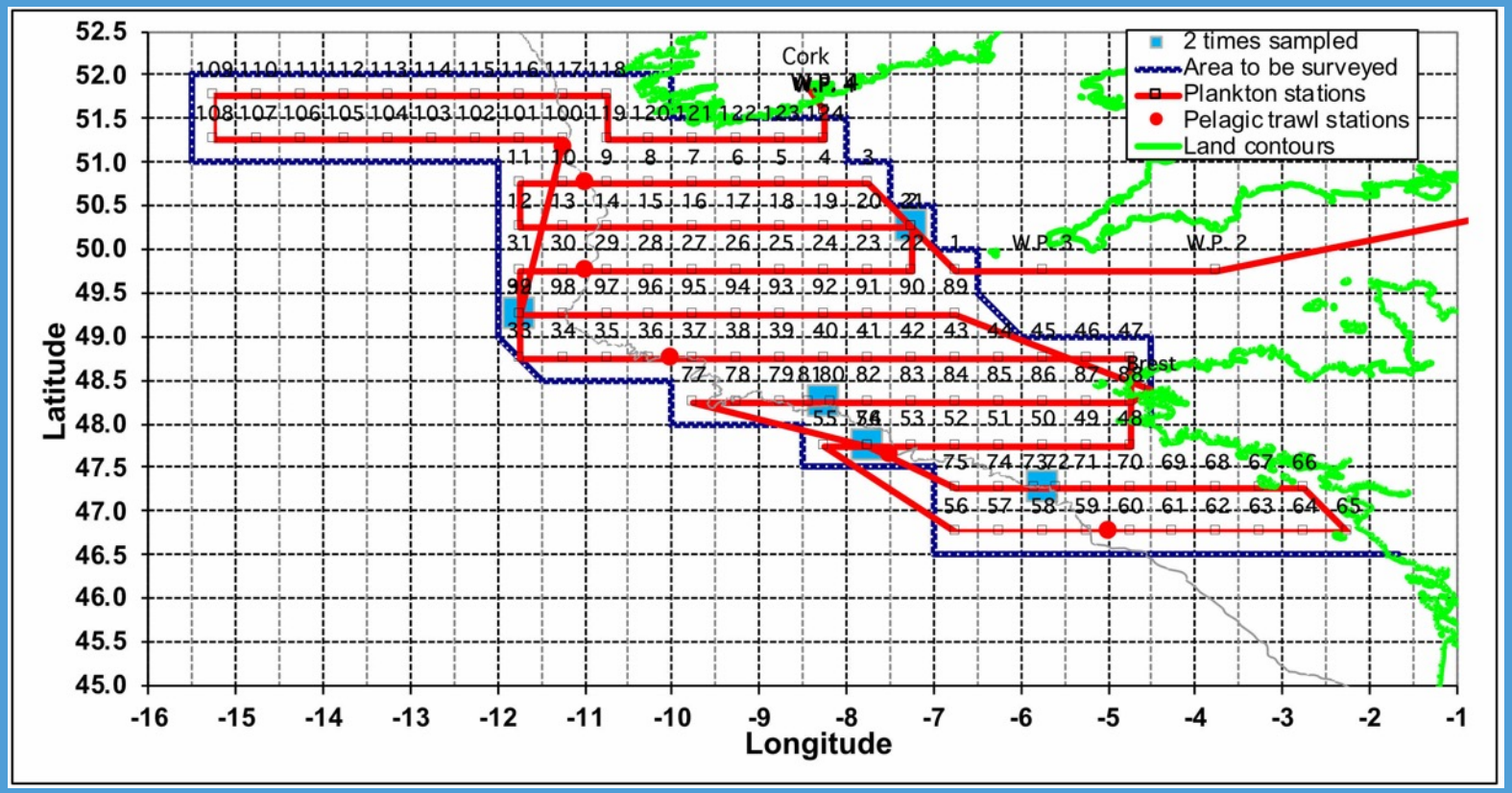
Index

- Boundaries and limitations
- Period 5
    - Planned plankton stations versus sampled plankton stations.
    - Results for Mackerel and Horse mackerel eggs period 4
- Period 6
    - Planned sampling grid versus sampled plankton stations.
    - Results for Mackerel and Horse mackerel eggs period 6
- Conclusion/ discussion

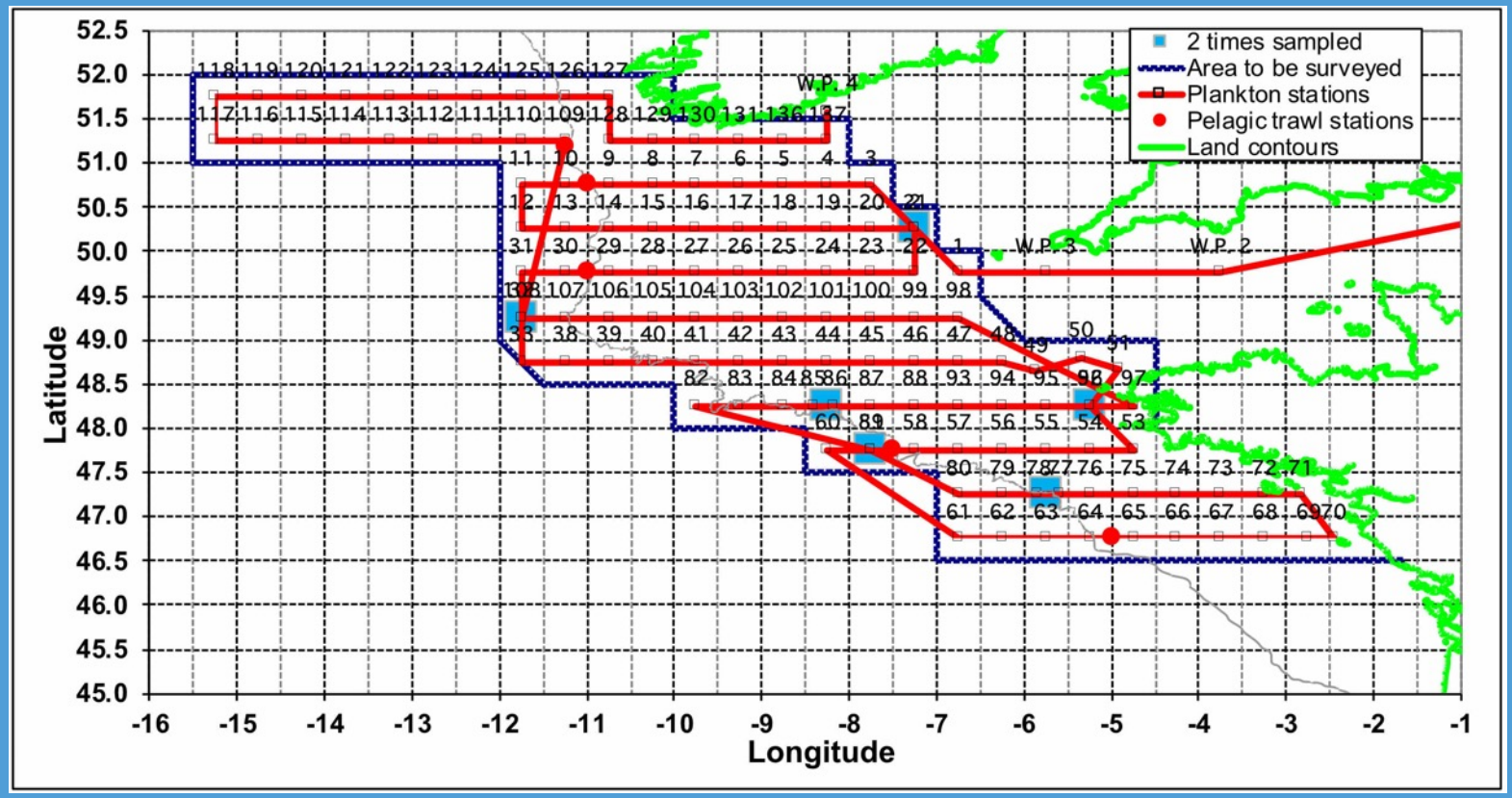
Boundaries and limitations

- The survey of the Netherlands for period 5 went completely as planned. Calm weather and no technical problems.
- The survey of the Netherlands for period 6 had two major setbacks: the cruise started 2,5 days later as planned and soon after its start, one of the crew had to be taken ashore.
- As a consequence, too much time was lost and stations had to be skipped for period 6.
- The spray results were not good, all samples needed to be re-checked.
- All samples have been checked and analysed twice and the results shared with WGMEGGS.
- Quantity of the eggs shown in the graph's are **not corrected** for flowmetercounts or other parameters!

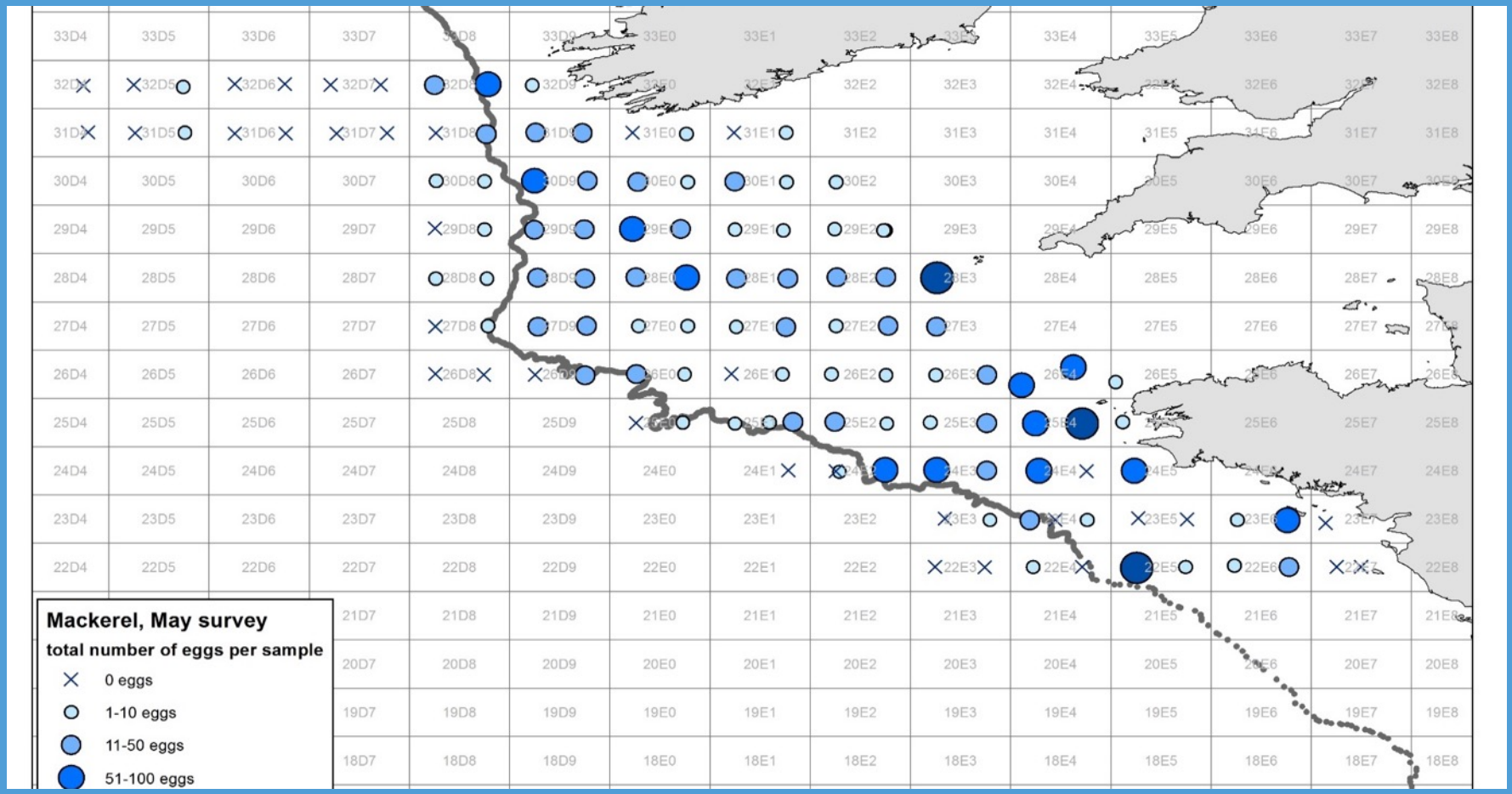
Planned stations period 5, the Netherlands



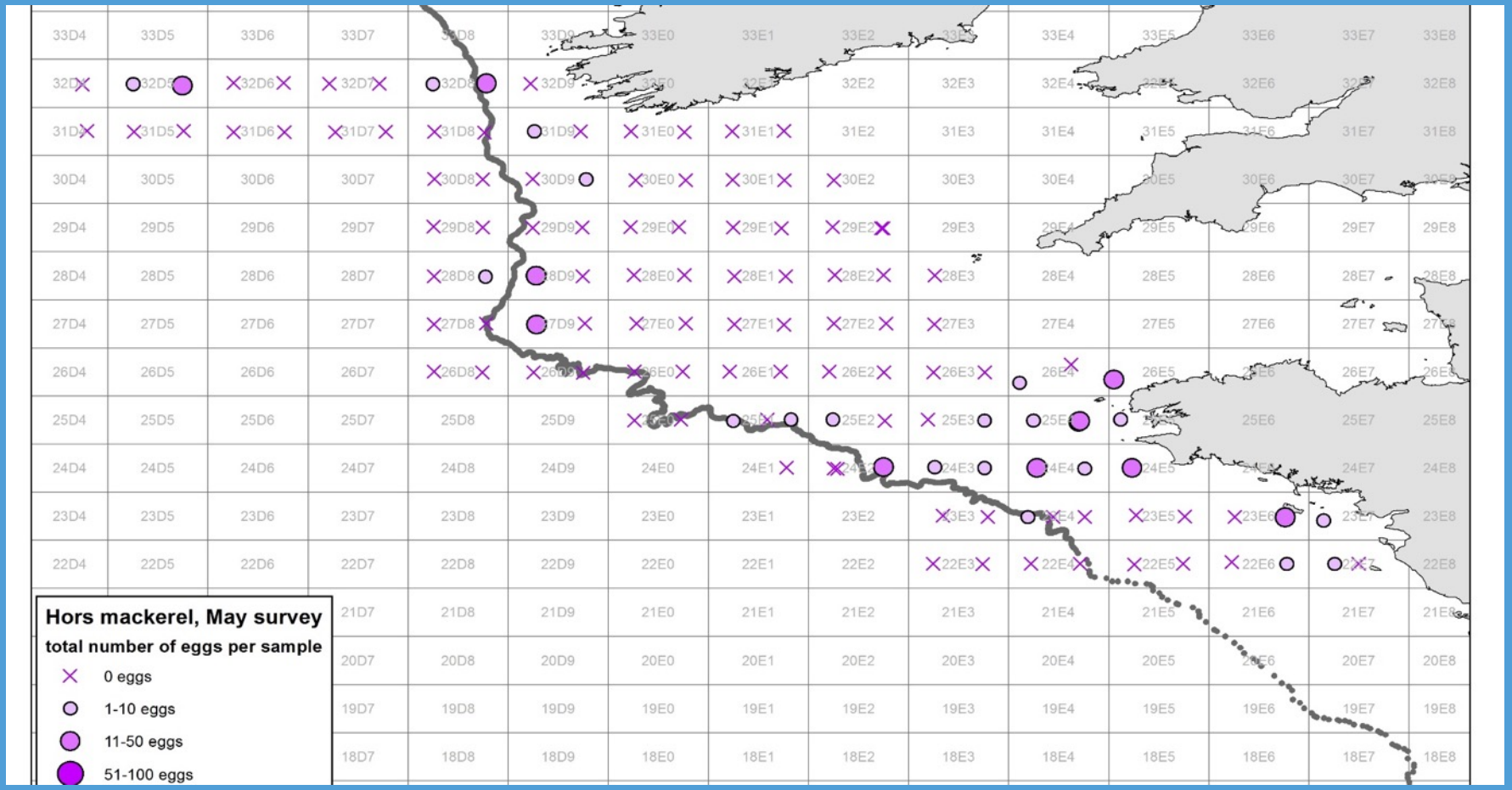
Sampled stations period 5, the Netherlands



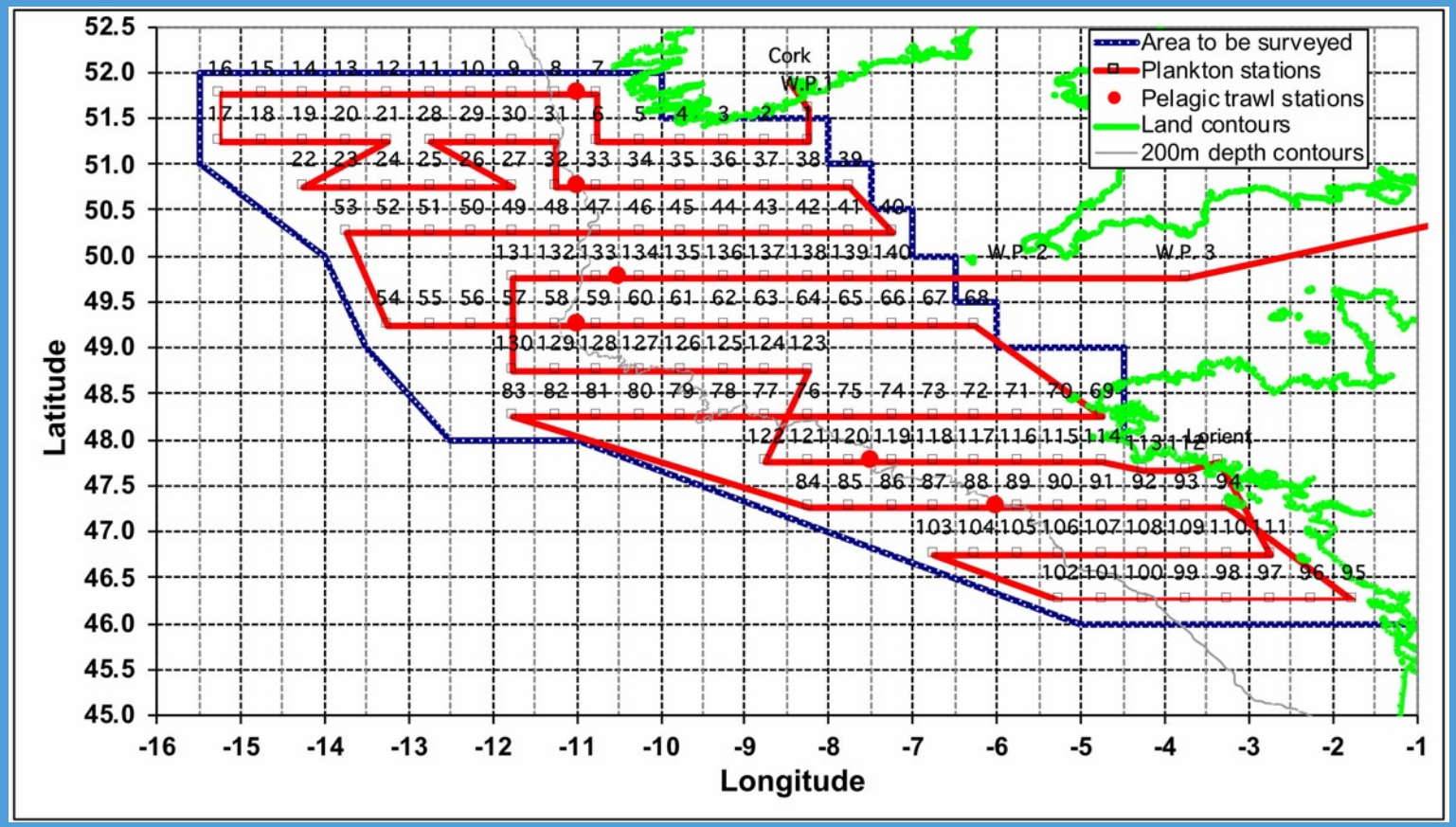
Results for mackerel eggs/station period 5 the Netherlands. No (!) correction for flowmeter counts.



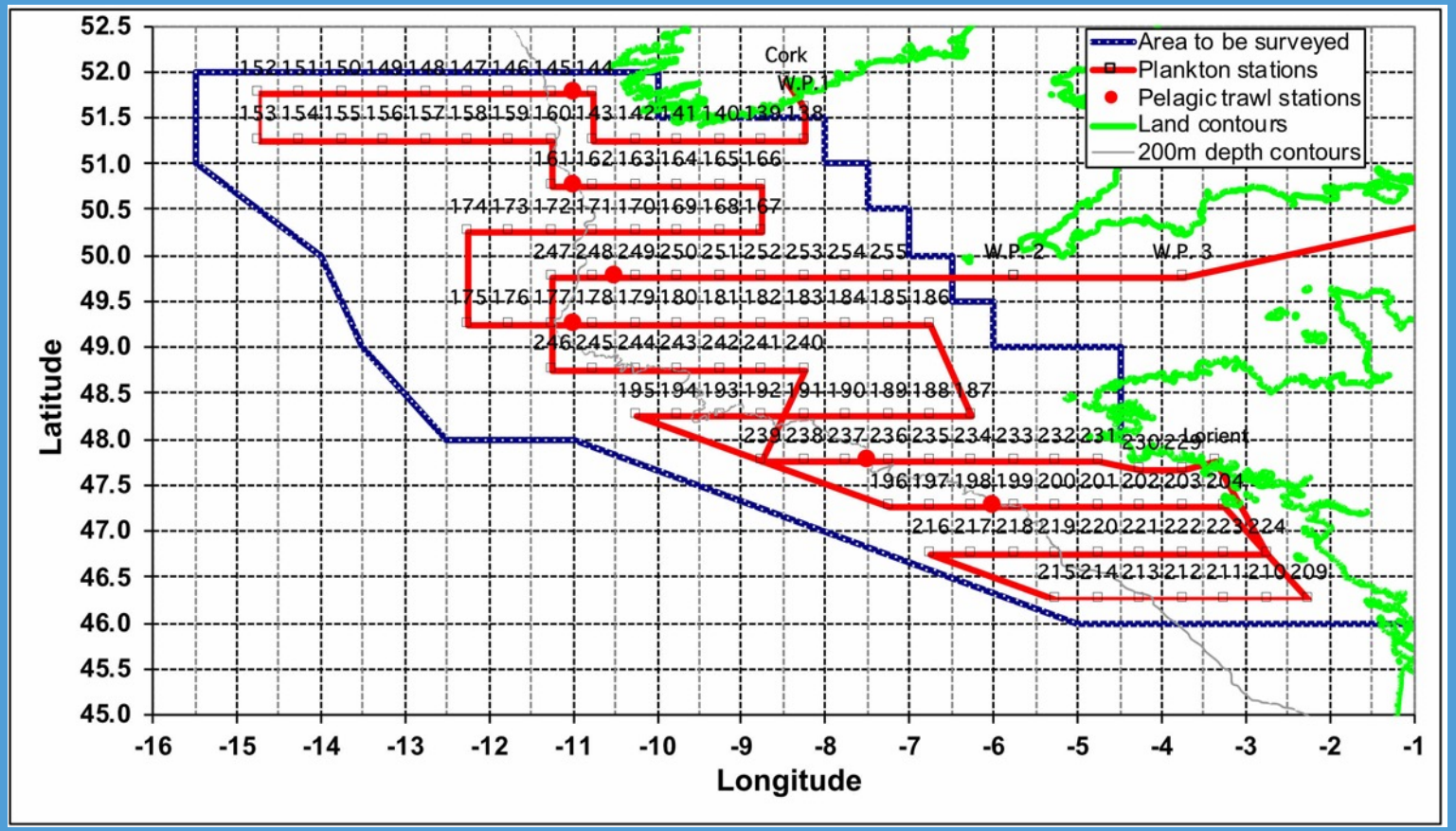
Results for horse mackerel eggs/ station period 5 the Netherlands. No (!) correction for flowmeter counts.



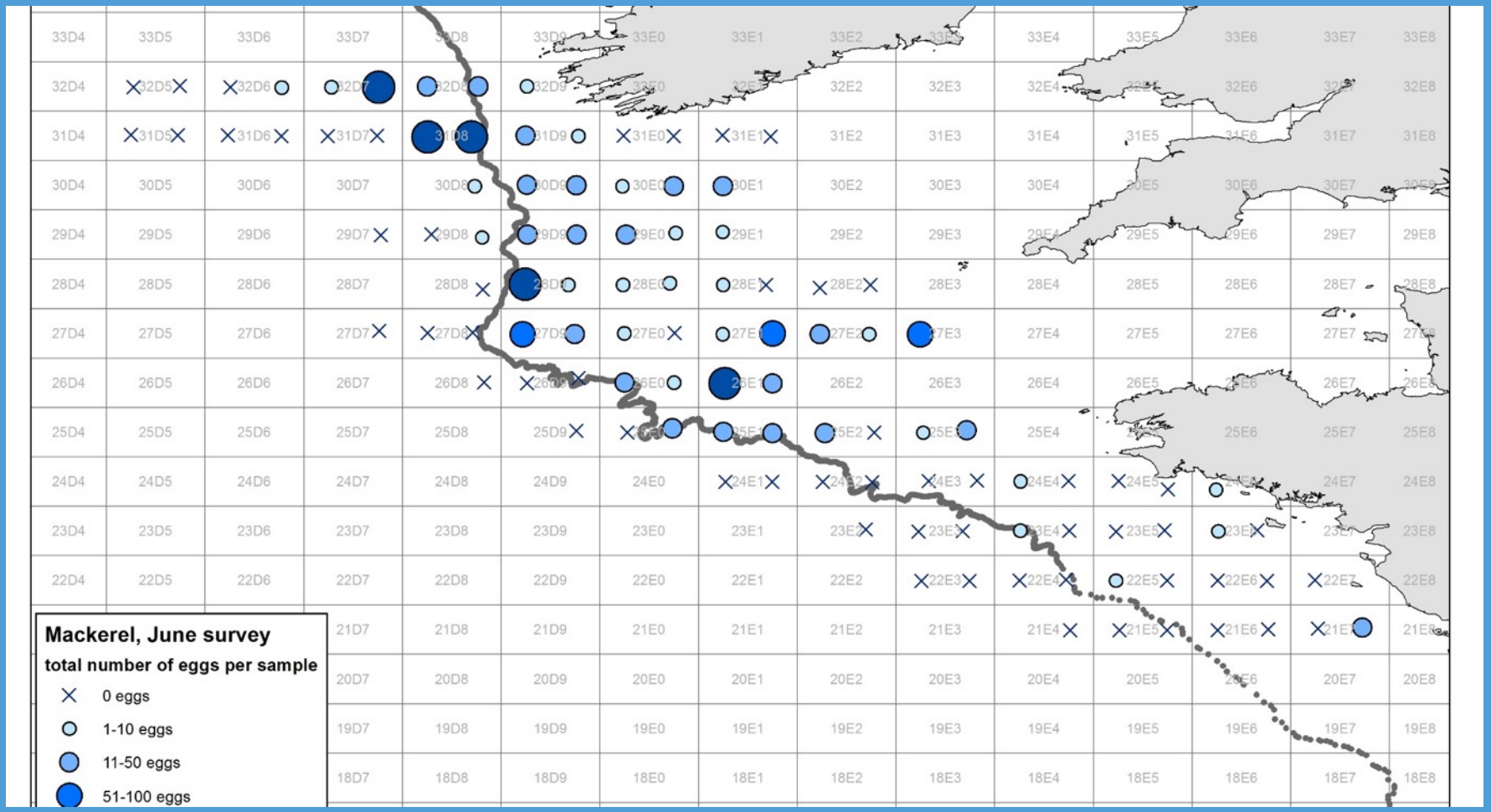
Planned stations period 6, the Netherlands



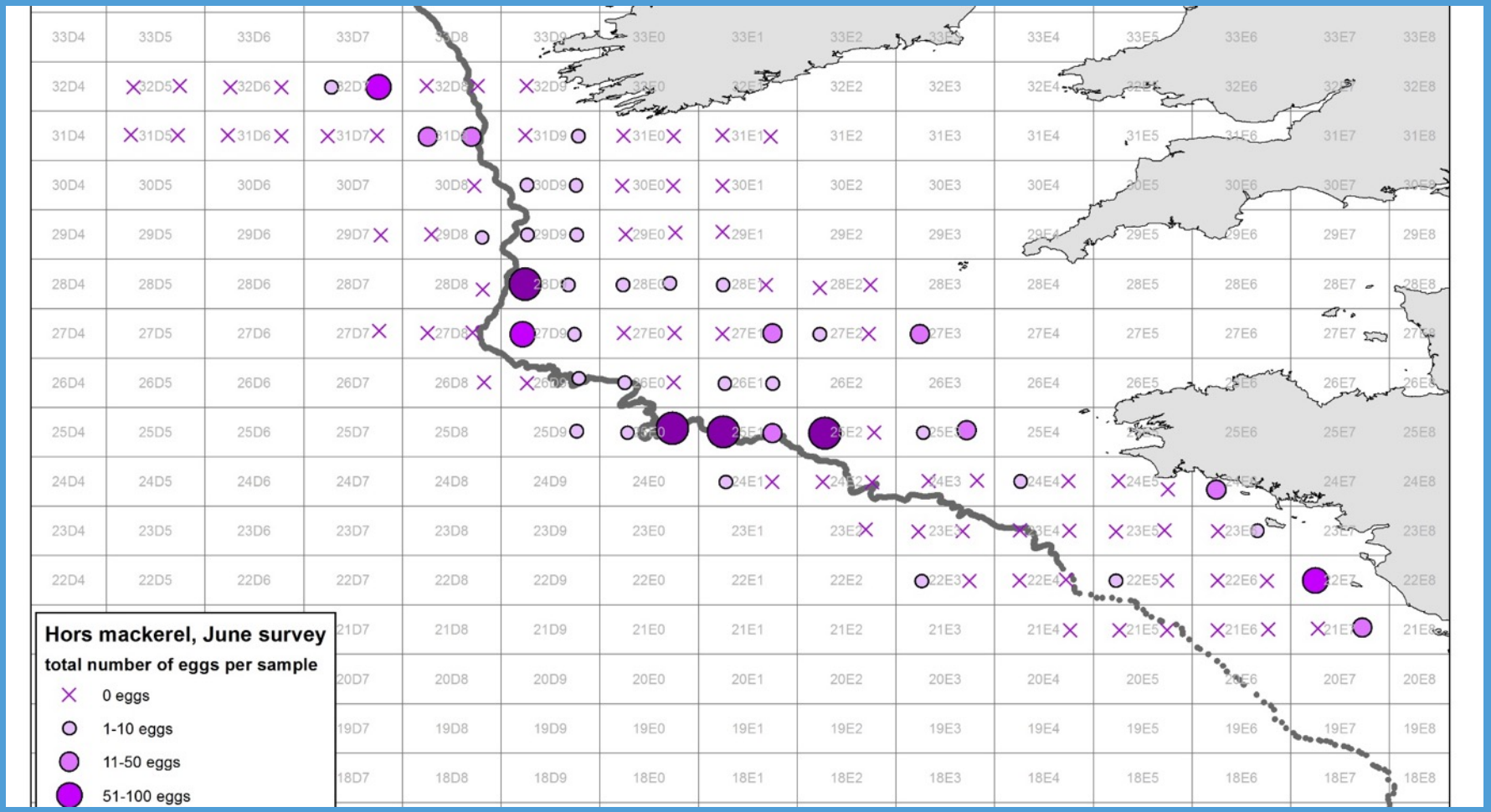
Sampled stations period 6, the Netherlands



Results for mackerel eggs/ station period 6 the Netherlands. No (!) correction for flowmeter counts.



Results for horse mackerel eggs period 6 the Netherlands. No (!) correction for flowmeter counts.



Conclusion

- Period 5 Mackerel: We found mackerel eggs in most stations. On the western boundary of our sampling area we found zero or low number of mackerel eggs. However on the eastern border of our sampling area, in the Celtic Sea and towards the English channel we found higher number of mackerel eggs on the border of our sampling area.

- Period 5 Horse mackerel: We found horse mackerel eggs only on a few locations in our sampling area during this period.

- Period 6 Mackerel: Due to technical problems we sampled a smaller area as planned. On the western boundary of our sampling area we mostly found zero mackerel eggs although we skipped several stations. On the Western boundary we also skipped several stations. During period 4 we sampled stations with (relatively) high numbers of mackerel eggs in this area and it is difficult to predict what we missed. For period 6, stations in 26E2, 26E3 and 26E4 were not planned and not sampled. Together with the stations in 25E4, which were skipped, creates an area we did not sample which would have been of interest also because we caught higher number of mackerel eggs in that area during period 4.

- Period 6 Horse mackerel: We found higher number of horse mackerel eggs around the stations close to the 200 m depth line. In most area's we found zero horse mackerel eggs on the borders. There were no stations planned below 25E0 which would have been better because we found higher number in the area. As for mackerel, stations in 26E2, 26E3, 26E4 and 25E4, would have been of interest for horse mackerel as well.

11. Individual survey report: Ireland/Marine Institute, Period 6

Please find the individual survey report below

Mackerel Egg survey, June 9th – 29th, 2019

by

Brendan O' Hea

Marine Institute, Fisheries Ecosystems Advisory Services,

Rinville, Oranmore, Co. Galway.

Keywords: Mackerel, Horse mackerel, eggs, surveys, plankton.

Table of Contents

Abstract

Every three years the International Council for the Exploration of the Sea (ICES) coordinates a series of mackerel and horse mackerel egg surveys covering the north-eastern Atlantic from Gibraltar to the Faroe Islands between January and July. The aim of this survey programme is to assess the north eastern Atlantic mackerel and horse mackerel stock. The Marine Institute participates in this programme and on this survey covered stations to the west of Scotland and west of Ireland. Plankton samples were collected at 149 stations, and the eggs they contained were preserved in 4% buffered formaldehyde. Stage 1 mackerel eggs were found in many of the stations however a large area of sea west of Ireland was found to be devoid of mackerel eggs. A number of fishing hauls using rod and line were made to collect adult mackerel and horse mackerel samples for fecundity analysis. Two of the hauls were successful for mackerel but no adult horse mackerel were caught.

1 Introduction

Every three years the International Council for the Exploration of the Sea (ICES) coordinates a series of mackerel, *Scomber scombrus,* and horse mackerel, *Trachurus trachurus*, egg surveys covering the eastern Atlantic from Gibraltar to the south coast of Iceland between January and July. The aim of this survey programme is to estimate the spawning stock biomass of the north-eastern Atlantic mackerel and provide an estimate of egg abundance for horse mackerel stocks. The Marine Institute participates in this programme and in this survey covered stations to the west of Scotland and west of Ireland.

This was one of sixteen surveys that monitored the spawning area of the fish during the first six months of the year. All eggs were extracted from the plankton stations, identified and staged before the end of the survey. These data will be analysed by the Working Group on Mackerel and Horse Mackerel Egg Surveys, WGMEGS, in April 2020. Preliminary data will be used by the Working Group on Widely Distributed stocks, WGWIDE, at their assessment meeting in August 2019.

2 Materials and Methods

2.1 Scientific Personnel

Name	Service area / Affiliation	Role
Brendan O' Hea	MI- FEAS	Scientist in charge
Robert Bunn	MI- FEAS	Scientist
Grainne Ryan	MI- FEAS	Scientist
Artur Opanowski	Contractor	Scientist
Aidan Long	Contractor	Scientist
Catherine O' Sullivan	Contractor	Marine mammal observer

2.2 Survey Plan

2.2.1 Area of operation

The survey was carried out to the west of Scotland and west of Ireland, from 52.75N to 58.75N, and from 4.75W to 18.25W. This covered stations in ICES areas VIa, VIb, VIIb, c, j and k (Figure 1). Survey stations were at 0.5 degrees spacing, both latitudinally and longitudinally, every ICES half statistical rectangle. The survey was adaptive, and while theoretical eastern and western limits were set, in practice the presence or absence of eggs dictated moving to the next transect. The chief scientist would decide when to terminate each transect, depending on the numbers of eggs of the target species in the samples. Survey protocols called for the survey area to be sampled on alternate transects initially. The intervening transect should be sampled on the return leg, if time permitted. For stations that can't be sampled it is possible to interpolate an egg count using data from neighbouring stations.

2.2.2 Specific operations

Plankton Hauls

At each station the GULF VII plankton sampler was towed at four knots on a V-shaped profile. The GULF was deployed over the stern, using a winch with 11mm co-axial cable,

capable of providing real-time data, in an armoured sheath. The water column was sampled to between five and ten metres of the bottom, depending on weather conditions, or a maximum depth of 200m. Attached to the sampler was a real-time CTD and flowmeter system which collected temperature and salinity data, and measured the volume of water filtered during the tow. It also provided real-time depth positions which made it possible to control the rate of descent and ascent of the GULF sampler.

Note was taken of the volume of water sampled by the GULF during each haul. Salinity at 5m, 20m and bottom of the tow, and the water temperature at 5m, 20m, 50m, 100m, and deepest temperature were calculated for each tow. All survey protocols can be found in SISP 6 (ICES 2019a).

Once back aboard the plankton net was washed down, the cod-end was removed, and a fresh cod-end was attached before the net was washed down again. The cod-ends were then brought to the lab, and the plankton sample was washed out. The sample was preserved in 4% buffered formalin. It was examined under a microscope after three hours and any eggs and fish larvae were removed. A second examination of each sample took place after 36 hours. A count was kept of mackerel, hake and horse mackerel stage 1 eggs, mackerel, hake and horse mackerel eggs of later stages, and other fish eggs.

Fishing Hauls

As part of the survey samples of mature mackerel are collected at various latitudes, with fishing sites normally being selected close to the 200m contour line. Hauls are made using a herring pelagic net, however during summer surveys rod and line can be more effective. For this survey Ireland had a sampling target of 65 mackerel ovaries with maturity stages between 2 and 6 on the Walsh scale, over four weight categories and 300 Horse mackerel ovaries. The survey protocols, below, can also be found in SISP 5 (ICES 2019b).

From one ovary, cut a small (0.5cm) section with a scalpel, and immediately put this sample into an individually coded histology cassette. For atresia cut off both ends (1–2 cm, depending on the size of the ovary) off the ovary used for the screening sample, and place the remaining part in a bottle. From the other, intact, ovary (not used for the screening sample) take two samples of 25 μl (a, b) and two samples of 100 μl (c, d) with a pipette and put each sample in its own individually coded Eppendorf tube. All these samples should be stored in 3.6% buffered formalin. For horse mackerel the 25μl samples were not collected. The sampling protocols are attached in the appendix.

After the survey the histological screening samples should be distributed to the various laboratories carrying out the histology work. These screening samples would be analysed under a microscope before a decision was made whether the rest of each sample should be analysed for fecundity, batch fecundity, or atresia. The Eppendorf samples should also be sent out at the same time.

AEPM / DEPM

WKMPSA 2012 (ICES 2012) advised that during the 2013 survey potential fecundity and atresia samples for mackerel would be collected during the whole survey period, as was done on previous surveys. During the peak spawning period, March, enhanced sampling effort would be directed at collecting mackerel samples to estimate DEPM adult parameters. For 2019 WGMEGS decided that this DEPM sampling should be conducted in March, as well continuing into April.

For western horse mackerel WGWIDE have not incorporated the fecundity sampling results into the SSB estimate since 2001. WKMPSA recommended that for 2013 horse mackerel sampling effort should be directed at collecting and analysing fecundity samples to estimate DEPM adult parameters during the peak spawning period, in this case June. Sampling of adult horse mackerel would not take place during the other survey periods. This protocol is in place again for 2019, however this year DEPM sampling will also be carried out in July, (ICES 2018b).

2.3 Equipment and system details and specifications

GULF VII plankton sampler

11mm armoured co-axial cable

Hydro-Bios CTD and flow sensor

Pelagic Herring net

Simrad ER-60

2.4 Protocols used

The protocols for the plankton sampling were updated during the 2018 WGMEGS meeting and are listed in the 2018 WGMEGS, (ICES 2018a) and WKFATHOM2, (ICES 2018b) reports. The fecundity protocols for mackerel and horse mackerel were also updated in 2018 and are also listed in both 2018 reports, and in the appendix of this report. Survey and fecundity sampling protocol manuals were initially produced in 2013. Both of these manuals were revised and updated prior to the 2019 surveys and were published by ICES early in 2019.

3 Results

Plankton Hauls

The 2019 survey took place at a similar time, and in a similar area, to the 2016 survey. It had been hoped to sample 130 stations during the trip, however due to the fine weather encountered throughout the trip the final number of stations was 149 (Figure 1, Table 1). The majority of stations in deeper waters to the west didn't contain any mackerel or horse mackerel eggs. Instead large numbers of *Maurolicus* species were found in most of these hauls. Horse mackerel eggs were found in very low numbers.

All eggs and larvae were extracted from the plankton samples, and were identified and staged while still at sea.

In total 15274 eggs were collected, the majority of which, 87%, were other eggs, species not targeted by the survey. Mackerel accounted for 12.3% of the eggs with the remainder being small numbers of Horse mackerel and Hake. The majority of the non-target eggs found were *Maurolicus* spp.

1880 mackerel eggs were collected, 572 of which were Stage 1 (Figure 2, Table 1). Mackerel eggs were found in 57% of stations with Stage 1 eggs being extracted from 46%. Mackerel eggs were mainly found close to the 200m contour line and also on the two most northerly transects.

Small numbers of Hake eggs, 116 were found, 61 of which were stage 1. Stage 1 hake eggs were recorded at 14% of stations.

Only 21 Horse mackerel eggs were found, 10 of which were stage 1.

Clogging of the GULF plankton mesh wasn't as big an issue as in 2016, however the offshore stations, in particular, contained large amounts of gelatinous material. The main culprits were salps, small jellyfish and tunicates.

Fish Hauls

No fishing hauls were carried out using the net, however a number of attempts were made to catch adult fish using rod and line. Two of these were successful and sufficient adult females were caught to fulfil the sampling requests.

4 Discussion and Conclusions

In 2010 and 2013 mackerel peak spawning was found to have occurred early in the year, and took place in February/March in those years. In an attempt to quantify this early spawning the start date of the 2016 surveys was moved to early February. In 2016 however peak spawning was found to have reverted to its "traditional" time of May/June. Data from 2019 would indicate that peak spawning took place towards the end of April, but was more evenly spread throughout the season than in 2016.

From a plankton sampling viewpoint the survey was very successful. Due to the fine weather encountered throughout the survey, while 130 stations were planned, 149 stations were eventually completed. Mackerel eggs were found primarily along the 200m contour and along the northern transects.

Horse mackerel eggs were found in very low numbers.

It proved extremely difficult to catch adult fish, however we managed to collect 60 mackerel fecundity samples out of our 65 sample target. Many of the female fish sampled appeared to be spent and seem to have finished spawning.

Acknowledgements

Much appreciation is expressed to the skipper and crew of the *RV Corystes.* Their many skills kept the survey functioning. Thanks are also expressed to the scientists for their perseverance and good humour during the trip.

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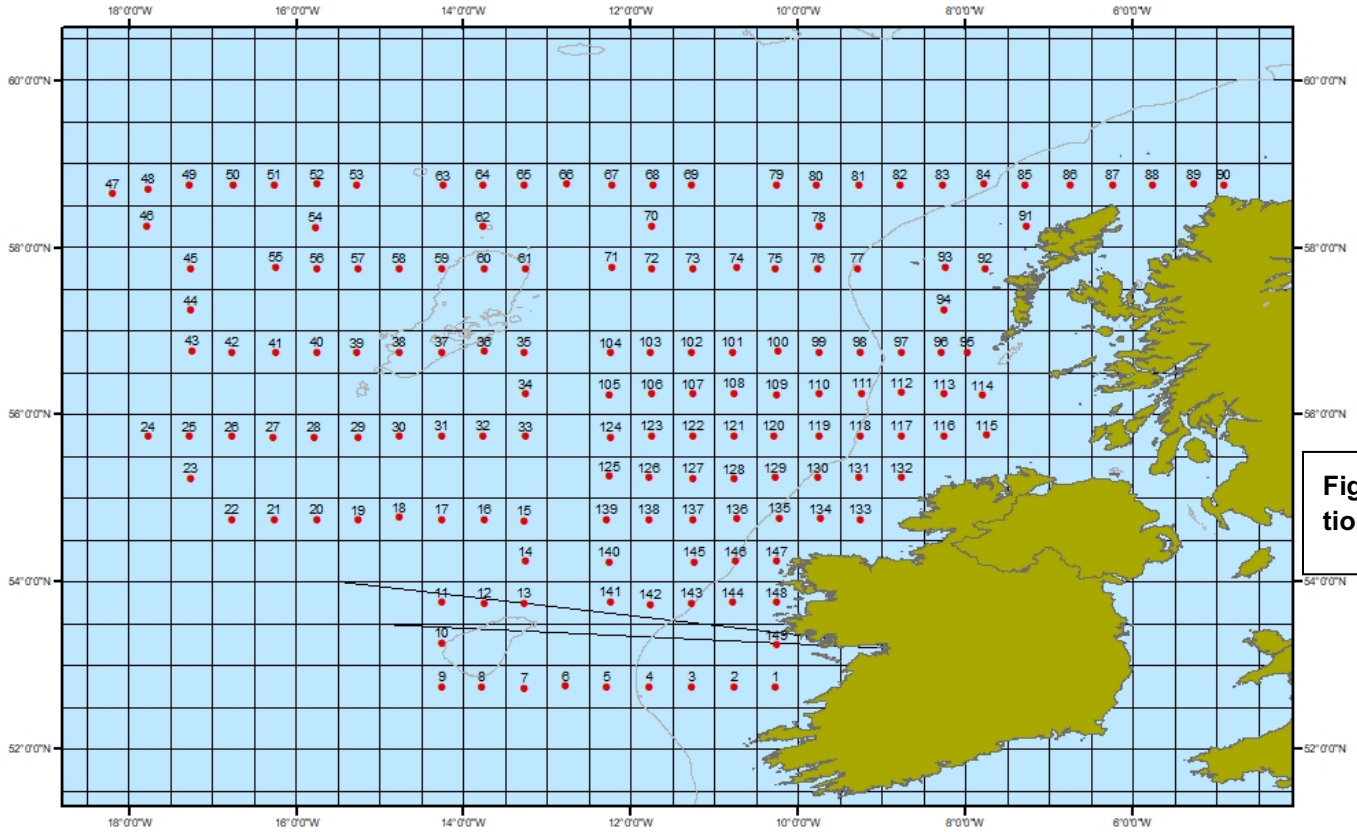


Figure 1: GULF plankton stations, June 2019

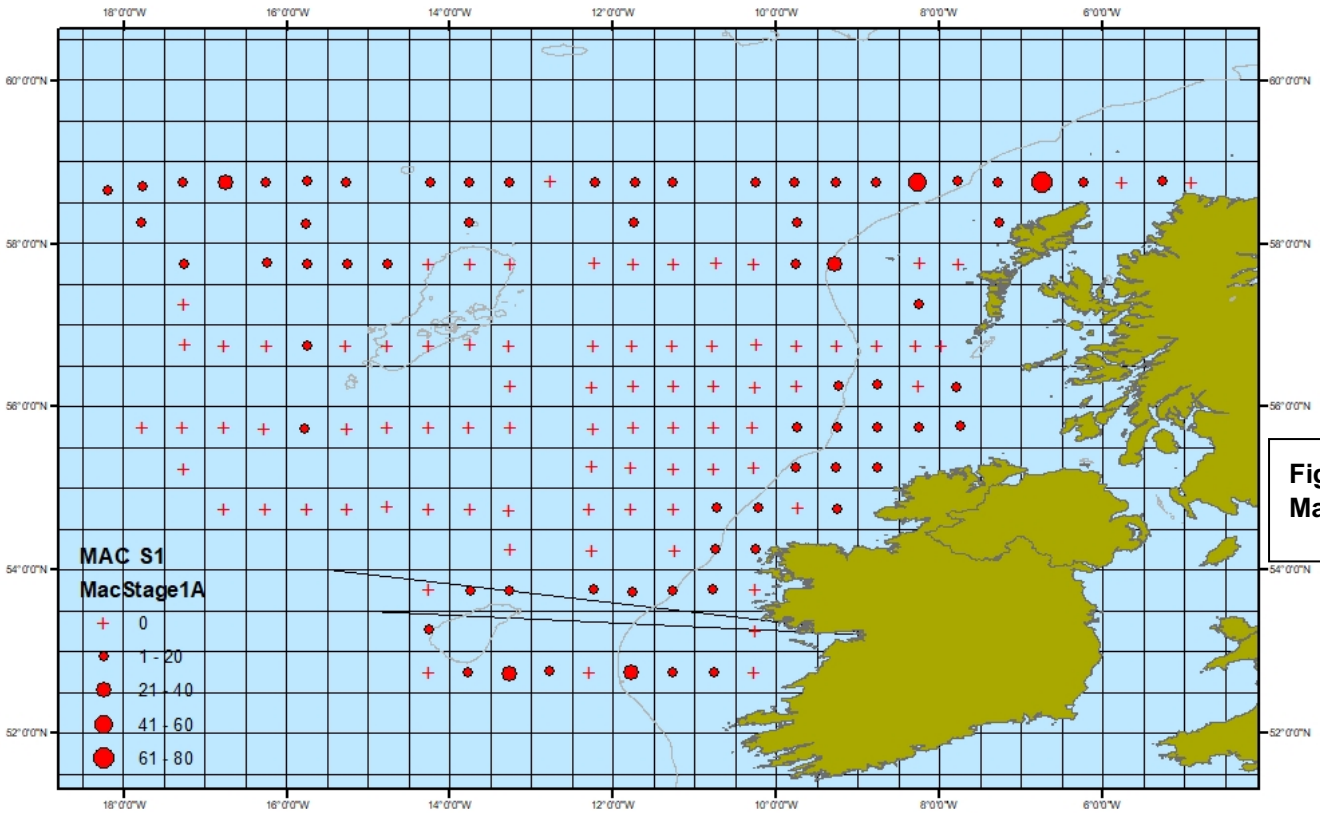


Figure 2 Numbers of Stage 1 Mackerel eggs, June 2019

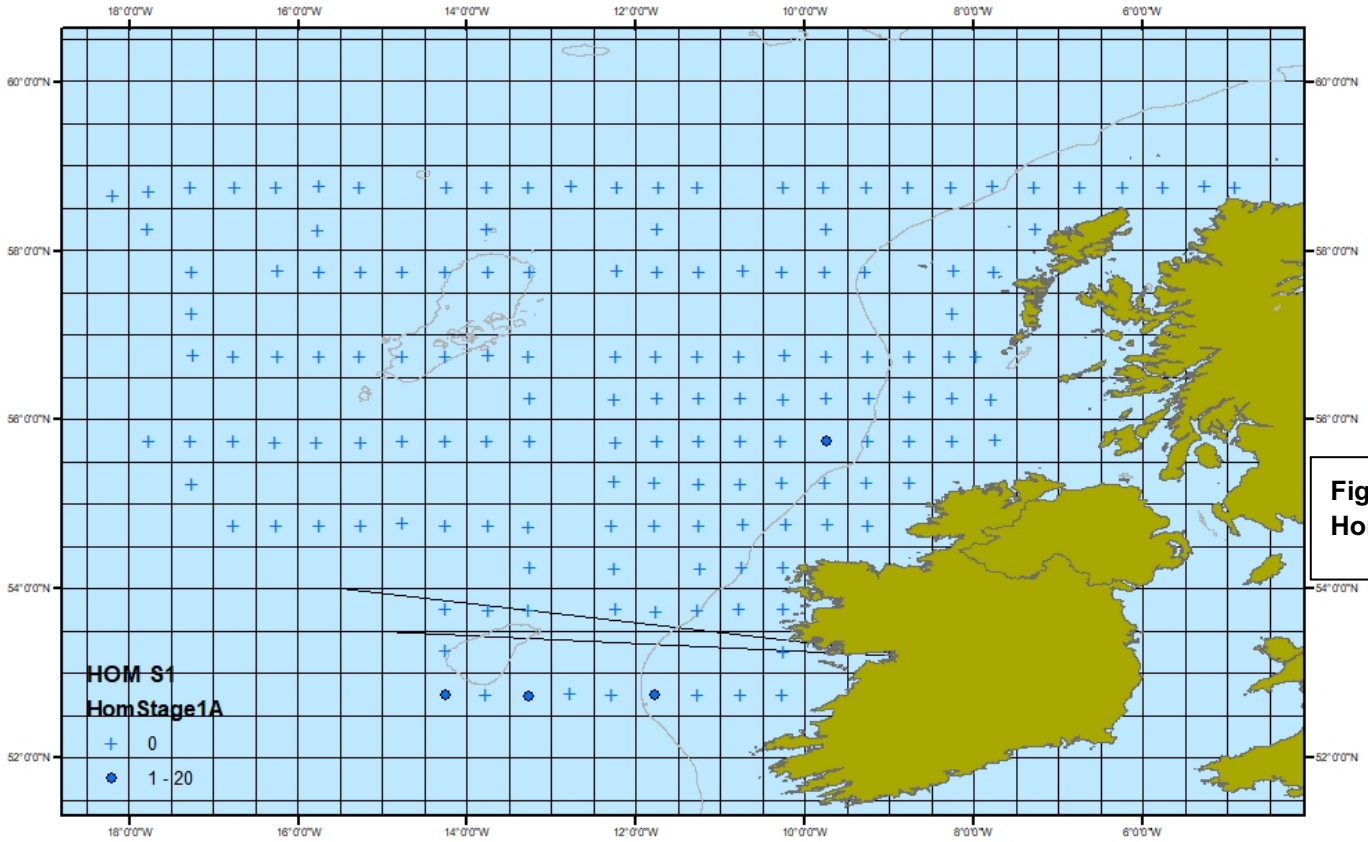


Figure 3 Numbers of Stage 1 Horse mackerel eggs, June 2019

Table 1 Plankton stations and associated Stage 1 egg numbers, June 2019.

Station Number	Date	Time	Long Dec	Lat Dec	Mac1A	Hom1A	Hak1	Others
1	10/06/2019	03:10	-10.25	52.75	0	0	0	0
2	10/06/2019	05:31	-10.73	52.75	9	0	0	6
3	10/06/2019	07:52	-11.24	52.75	7	0	1	6
4	10/06/2019	10:07	-11.74	52.75	33	8	1	37
5	10/06/2019	12:33	-12.24	52.75	0	0	0	15
6	10/06/2019	14:54	-12.73	52.75	10	0	0	5
7	10/06/2019	17:20	-13.25	52.75	26	1	0	77
8	10/06/2019	19:59	-13.74	52.75	2	0	0	5
9	10/06/2019	22:11	-14.21	52.75	0	1	0	75
10	11/06/2019	02:24	-14.25	53.26	9	0	0	77
11	11/06/2019	06:18	-14.25	53.73	0	0	0	34
12	11/06/2019	08:49	-13.79	53.75	1	0	0	16
13	11/06/2019	11:05	-13.30	53.75	4	0	0	0
14	11/06/2019	15:14	-13.25	54.23	0	0	0	39
15	11/06/2019	19:57	-13.25	54.75	0	0	0	140
16	11/06/2019	22:11	-13.70	54.75	0	0	0	90
17	12/06/2019	00:30	-14.21	54.76	0	0	0	106
18	12/06/2019	02:54	-14.72	54.81	0	0	0	12
19	12/06/2019	05:20	-15.23	54.76	0	0	0	61
20	12/06/2019	07:41	-15.71	54.75	0	0	0	55
21	12/06/2019	09:57	-16.21	54.75	0	0	0	76
22	12/06/2019	12:17	-16.72	54.76	0	0	0	90
23	12/06/2019	17:05	-17.22	55.25	0	0	0	22
24	12/06/2019	22:03	-17.74	55.77	0	0	0	301
25	13/06/2019	01:09	-17.24	55.76	0	0	0	116
26	13/06/2019	04:29	-16.74	55.76	0	0	0	85
27	13/06/2019	07:44	-16.25	55.75	0	0	0	166
28	13/06/2019	10:39	-15.77	55.75	7	0	0	93
29	13/06/2019	13:28	-15.25	55.75	0	0	0	55
30	13/06/2019	16:05	-14.77	55.76	0	0	0	65
31	13/06/2019	18:43	-14.28	55.75	0	0	0	88
32	13/06/2019	21:00	-13.80	55.75	0	0	0	38
33	13/06/2019	23:24	-13.28	55.75	0	0	0	57

34	14/06/2019	03:57	-13.25	56.23	0	0	0	71
35	14/06/2019	07:58	-13.25	56.72	0	0	0	118
36	14/06/2019	10:12	-13.70	56.76	0	0	0	52
37	14/06/2019	12:33	-14.22	56.76	0	0	0	4
38	14/06/2019	14:47	-14.73	56.76	0	0	0	2
39	14/06/2019	17:01	-15.22	56.75	0	0	0	50
40	14/06/2019	19:25	-15.71	56.75	1	0	0	43
41	14/06/2019	21:47	-16.20	56.75	0	0	0	5
42	15/06/2019	00:19	-16.72	56.76	0	0	0	17
43	15/06/2019	02:29	-17.20	56.78	0	0	0	33
44	15/06/2019	06:46	-17.25	57.23	0	0	0	27
45	15/06/2019	10:36	-17.25	57.73	3	0	0	93
46	15/06/2019	14:41	-17.74	58.24	2	0	0	189
47	15/06/2019	18:36	-18.20	58.63	2	0	0	53
48	15/06/2019	20:52	-17.79	58.69	11	0	0	113
49	15/06/2019	23:14	-17.29	58.73	13	0	0	28
50	16/06/2019	01:28	-16.78	58.75	39	0	0	41
51	16/06/2019	03:32	-16.29	58.75	10	0	0	112
52	16/06/2019	05:44	-15.79	58.75	4	0	0	504
53	16/06/2019	07:50	-15.30	58.75	7	0	0	118
54	16/06/2019	11:55	-15.75	58.26	11	0	0	96
55	16/06/2019	15:40	-16.22	57.78	1	0	0	84
56	16/06/2019	17:57	-15.79	57.75	2	0	0	59
57	16/06/2019	20:01	-15.30	57.75	1	0	0	64
58	16/06/2019	22:06	-14.80	57.75	1	0	0	57
59	17/06/2019	00:13	-14.29	57.75	0	0	0	4
60	17/06/2019	02:22	-13.78	57.75	0	0	0	30
61	17/06/2019	06:27	-13.28	57.73	0	0	0	5
62	17/06/2019	10:53	-13.72	58.23	1	0	0	67
63	17/06/2019	15:00	-14.22	58.72	5	0	0	438
64	17/06/2019	17:13	-13.80	58.75	7	0	0	832
65	17/06/2019	19:19	-13.30	58.75	8	0	0	497
66	17/06/2019	21:26	-12.80	58.75	0	0	0	273
67	17/06/2019	23:33	-12.27	58.75	10	0	0	673
68	18/06/2019	01:32	-11.77	58.75	18	0	0	654
69	18/06/2019	03:26	-11.30	58.75	1	0	0	627
70	18/06/2019	07:39	-11.72	58.27	5	0	0	333
71	18/06/2019	11:49	-12.22	57.78	0	0	0	184
72	18/06/2019	13:54	-11.78	57.75	0	0	0	572
73	18/06/2019	15:55	-11.29	57.74	0	0	0	470
74	18/06/2019	17:55	-10.79	57.75	0	0	0	404

75	18/06/2019	19:50	-10.30	57.75	0	0	0	294
76	18/06/2019	21:57	-9.80	57.75	3	0	0	131
77	19/06/2019	00:08	-9.30	57.75	34	0	0	76
78	19/06/2019	04:13	-9.77	58.23	2	0	0	141
79	19/06/2019	08:42	-10.28	58.73	1	0	0	401
80	19/06/2019	10:57	-9.80	58.72	3	0	0	57
81	19/06/2019	13:22	-9.29	58.73	2	0	0	12
82	19/06/2019	15:48	-8.79	58.73	3	0	0	11
83	19/06/2019	18:09	-8.29	58.74	42	0	1	37
84	19/06/2019	20:17	-7.81	58.74	11	0	0	3
85	19/06/2019	22:22	-7.29	58.74	16	0	1	12
86	20/06/2019	00:42	-6.76	58.75	61	0	12	25
87	20/06/2019	02:42	-6.26	58.75	3	0	1	17
88	20/06/2019	04:34	-5.78	58.75	0	0	0	5
89	20/06/2019	06:27	-5.28	58.75	1	0	0	2
90	20/06/2019	07:45	-4.93	58.75	0	0	0	6
91	21/06/2019	21:38	-7.24	58.26	2	0	0	4
92	22/06/2019	01:46	-7.74	57.75	0	0	0	18
93	22/06/2019	03:44	-8.23	57.78	0	0	1	3
94	22/06/2019	07:25	-8.25	57.27	1	0	0	2
95	22/06/2019	12:00	-7.95	56.75	0	0	0	25
96	22/06/2019	13:25	-8.25	56.75	0	0	0	11
97	22/06/2019	15:21	-8.73	56.75	0	0	0	7
98	22/06/2019	18:12	-9.22	56.75	0	0	0	10
99	22/06/2019	20:25	-9.71	56.75	0	0	0	14
100	22/06/2019	22:35	-10.20	56.77	0	0	0	75
101	23/06/2019	00:43	-10.73	56.75	0	0	0	64
102	23/06/2019	02:46	-11.23	56.75	0	0	0	55
103	23/06/2019	05:02	-11.73	56.75	0	0	0	30
104	23/06/2019	07:09	-12.21	56.75	0	0	0	90
105	23/06/2019	11:03	-12.24	56.26	0	0	0	17
106	23/06/2019	13:30	-11.78	56.25	0	0	0	11
107	23/06/2019	15:51	-11.27	56.23	0	0	0	30
108	23/06/2019	18:18	-10.79	56.23	0	0	0	24
109	23/06/2019	20:44	-10.27	56.23	0	0	0	119
110	23/06/2019	23:12	-9.78	56.24	0	0	0	68
111	24/06/2019	01:40	-9.26	56.24	15	0	0	23
112	24/06/2019	05:15	-8.78	56.27	1	0	0	6
113	24/06/2019	07:19	-8.28	56.25	0	0	0	60
114	24/06/2019	09:18	-7.82	56.24	2	0	0	11
115	24/06/2019	12:39	-7.72	55.76	2	0	0	10

116	24/06/2019	14:44	-8.24	55.75	16	0	12	16
117	24/06/2019	16:54	-8.73	55.75	15	0	6	69
118	24/06/2019	18:48	-9.22	55.75	3	0	2	94
119	24/06/2019	20:50	-9.71	55.75	3	1	1	0
120	24/06/2019	23:04	-10.24	55.75	0	0	0	54
121	25/06/2019	01:18	-10.72	55.75	0	0	0	24
122	25/06/2019	03:41	-11.24	55.77	0	0	0	31
123	25/06/2019	06:27	-11.73	55.77	0	0	0	12
124	25/06/2019	09:05	-12.23	55.76	0	0	0	82
125	25/06/2019	12:44	-12.24	55.29	0	0	0	48
126	25/06/2019	16:16	-11.75	55.26	0	0	0	108
127	25/06/2019	19:34	-11.28	55.25	0	0	0	38
128	25/06/2019	22:19	-10.78	55.24	0	0	0	20
129	26/06/2019	01:05	-10.28	55.27	0	0	0	0
130	26/06/2019	05:42	-9.74	55.26	2	0	1	19
131	26/06/2019	08:16	-9.28	55.26	5	0	2	6
132	26/06/2019	11:00	-8.74	55.26	1	0	0	3
133	26/06/2019	14:45	-9.24	54.76	1	0	0	3
134	26/06/2019	17:04	-9.72	54.77	0	0	1	1
135	26/06/2019	19:28	-10.19	54.77	16	0	1	3
136	26/06/2019	22:14	-10.69	54.76	2	0	0	26
137	27/06/2019	00:36	-11.22	54.76	0	0	0	25
138	27/06/2019	02:52	-11.74	54.75	0	0	0	2
139	27/06/2019	05:17	-12.25	54.77	0	0	0	61
140	27/06/2019	09:15	-12.22	54.26	0	0	0	14
141	27/06/2019	13:07	-12.20	53.78	2	0	3	0
142	27/06/2019	16:34	-11.74	53.73	3	0	5	67
143	27/06/2019	19:30	-11.29	53.76	1	0	1	33
144	27/06/2019	22:01	-10.78	53.74	15	0	5	30
145	28/06/2019	02:00	-11.22	54.22	0	0	2	8
146	28/06/2019	04:41	-10.78	54.25	10	0	0	63
147	28/06/2019	07:12	-10.27	54.25	1	0	0	27
148	28/06/2019	10:40	-10.25	53.77	0	0	1	39
149	28/06/2019	14:39	-10.25	53.26	0	0	0	4

Mackerel sampling procedure at sea

Before the cruise:

Fill the labelled 2.5 ml eppendorf tubes with 1.2 ml of 3.6% buffered (sodium phosphate) formaldehyde. Also fill the 20ml scintillation tubes with 15ml of buffered formalin.

During the cruise:

Measure the weight of the whole catch and select a subsample of 100 fish and measure the total weight of the subsample.

Measure total length, weight, maturity (Walsh scale) and sex of each fish in the subsample.

Select females in maturity stages 3-6 from the subsample of 100, (if there are less than 100 fish take them all), for fecundity and atresia analysis. Be sure to divide the females equally into the 4 weight categories: < 250g, 251-400g, 401-550g and >551g. If the size range of fish is restricted in the catch the remaining sample quota should be taken from the more abundant classes to fill the weight classes.

Measure:

- Total length
- Total weight
- Maturity
- Otoliths
- Weight of gut, ovary and liver. (If it is not possible to take these weights at sea, take the pipette and atresia samples, and fix the remainder of the ovary. Subsequently weigh the ovary in the lab. Gut and liver should also be frozen and weighed in the lab. The fixed and frozen weights should be corrected to fresh weights.)

Fecundity sampling:

- From one ovary, cut a small (0.5cm) section with a scalpel, and immediately put this sample into an individually coded histology cassette. Then place this cassette into a coded 250 ml vial, making sure the sample is covered with 3.6% buffered formaldehyde solution (one part ovary and nine parts formaldehyde), (Figure 4).
- From the other ovary (not used for the screening sample) take two samples of 25 μl (a, b) and two samples of 100 μl (c, d) with a pipette and immediately put each sample in its own individually coded Nunc tube. Take in a bit more sample than you need and press the plunger until it reaches the line (25 or 50 μl) and blot off any oocyte that is outside the tip, using your hand or a piece of paper. Ensure all oocytes are immersed in 3.6% buffered formaldehyde solution. For the 100 μl samples, take two times 50 μl with the pipette. Rinse the pipette with water and dry it with a paper towel prior to sampling another fish. The reason to

obtain two samples of 25 μl and 100 μl respectively is to guarantee samples, in case a sample is lost during the processing. Send out the samples coded as (a, b) and (c, d) to the analysing institutes, following the colour sending code as indicated by the label.

Atresia sampling:

- For atresia: Cut off both ends (1–2 cm, depending on the size of the ovary) of the ovary used for the screening sample, and place the remaining part in a bottle (100–250 ml with wide opening), and fill it with 3.6% buffered formaldehyde (Figure 4). Label (f) the bottle with coded label with the sample reference number. Make sure that the bottle is filled with formaldehyde and ensure that the ratio of tissue to formaldehyde is not less than 1:3.

After the cruise:

Immediately after the cruise:

- Screening samples in the 250 ml vials should be sent to the analysing institutes (AZTI, IEO, Wageningen Marine Research, and IMR).
- Also send out Nunc tubes for the fecundity and batch fecundity samples along with the ring test tubes (AZTI, IEO, Wageningen Marine Research, IMR, MI, and MSS).

Pack the consignments for each country with a maximum volume of 1000 ml solution in each package. On the outer cover of the package, indicate the type (e.g. ethanol or formaldehyde), volume, and concentration of fixative (3.6% formaldehyde) and that it is within the limits for unclassified transport. Add safety sheets. Consignments should be sent to home addresses, not Post box addresses.

Once results of the screening are obtained, the adult sampling coordinators will divide the samples between the analysing institutes.

All the ovary samples should remain fixed in 3.6% formaldehyde for at least two weeks, before whole mount analysis or the sections for the atresia analysis are taken. From the fixed ovary lobe, cut two 5 mm thick slices and put them in a coded histology cassette. Write the code with a wooden pencil on the outside of the cassette. If the ovary is very big, you may have to use two cassettes. Separate the cassettes into four colour-coded, leak proof bottles, filled with 70% ethanol. First place the cassettes inside individual mini-grip bags or fabric teabags before putting them into the leak proof bottles to avoid cross contamination between cassettes. Send the cassettes for analysis to the different institutes, based on the list provided by the sampling coordinators.

Horse mackerel sampling procedure at sea

Before the cruise:

Fill the labelled 2.5 ml Eppendorf tubes with 1.2 ml of 3.6% buffered (sodium phosphate) formaldehyde

During the cruise:

Measure the weight of the whole catch and select a subsample of 100 fish and measure the total weight of the subsample.

Measure the total length, weight, maturity (Walsh scale) and sex of each fish in the sub-sample and take otoliths for age reading.

DEPM sampling

The objective of the sampling is to get 30 females in stage 2-6 and 15 hydrated females (HF) per **HAUL**. For the first 100 fish in the subsample select the first 30 females in maturity stages 3 – 6. For these females do full biological sampling and take Screening, Atresia, 2X25µl Fecundity and 2X100µl Batch Fecundity Samples.

If 30 females (including 15 HF) are obtained in the 100 individuals of subsample 1, the sampling of the haul is finished. If the number of females is less than 30, we need to collect additional females from another subsample2 of 100 individuals until the quota of 30 females is met. It is important to keep in mind that in this second sub-sample it is not necessary to sample the 100 individuals, but it is completed when the objective of 30 females (including 15HF) is fulfilled. In this subsample2 we just collect females while the males are discarded without taking any biological data. However, if in the sample of 30 females from the second subsample we did not obtain 15 HF, we should look for them in the rest subsample2. From these HF it is only necessary to take a sample of ovary for Batch fecundity. If no more HF are found in this subsample2, the sampling of the haul is OVER.

If there are less than 30 females in the subsample then randomly select another 100 fish. Continue with the full biological sampling until you have sampled 30 hydrated females. If after 200 fish you still haven't reached 30 hydrated females finish sampling.

Select females in maturity stages 3-5 from the subsample for fecundity analysis. Be sure to divide the females equally into the 4 weight categories: < 150g, 151-250g, 251-350g and >351g. If the size range of fish is restricted in the catch the remaining sample quota should be taken from the more abundant classes to fill the weight classes.

Measurements:

- Total length
- Total weight
- Maturity
- Otoliths for age reading
- Weight of ovary. (If it is not possible to take the ovary weight at sea, take out the ovary and weigh the fish without the ovary. Then take the pipette and atresia samples and fix the remainder of the ovary, and weigh the ovary in the lab. The fixed and frozen weights should be corrected to fresh weights.)

Fecundity sampling:

- From one ovary, cut a small (0.5cm) section with a scalpel, and immediately put this sample into an individually coded histology cassette. Then place this cassette into a coded 250 ml vial, making sure the sample is covered with 3.6% buffered formaldehyde solution (one part ovary and nine parts formaldehyde), (Figure 4).
- From the other ovary (not used for the screening sample) take two samples of 25 µl (a, b) and two samples of 100 µl (c, d) with a pipette and immediately put each sample in its own individually coded Nunc tube, (Figure 4). Take in a bit more sample than you need and press the plunger until it reaches the line (25 or 50 µl) and blot off any oocyte that is outside the tip, using your hand or a piece of paper. Ensure all oocytes are immersed in 3.6% buffered formaldehyde solution. For the 100 µl samples, take two times 50 µl with the pipette. Rinse the pipette with water and dry it with a paper towel prior to sampling another fish. The reason to obtain two samples of 25 µl and 100 µl respectively is to guarantee samples, in case a sample is lost during the processing. Send out the samples coded as (a, b) and (c, d) to the analysing institutes, following the colour sending code as indicated by the label (Table 2).

Atresia sampling:

- For atresia: Cut off both ends (1–2 cm, depending on the size of the ovary) of the ovary used for the screening sample, and place the remaining part in a bottle (100–250 ml with wide opening), and fill it with 3.6% buffered formaldehyde (Figure 4). Label (f) the bottle with coded label with the sample reference number. Make sure that the bottle is filled with formaldehyde and ensure that the ratio of tissue to formaldehyde is not less than 1:3.

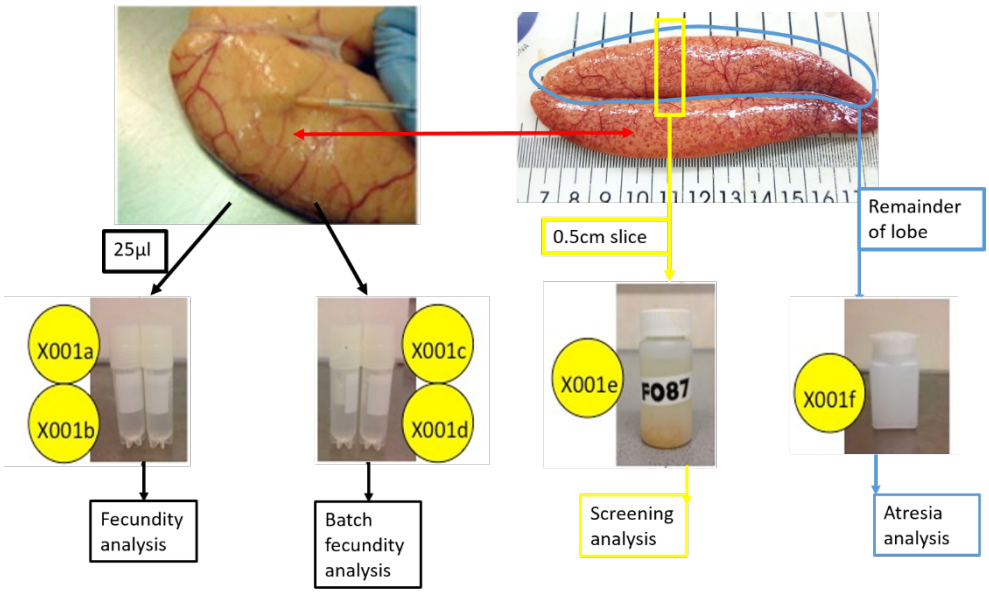
After the cruise :

Immediately after the cruise, the screening samples in the histology cassettes should be sent to the analysing institutes.

All the ovary samples should remain fixed in 3.6% formaldehyde for at least two weeks, before whole mount analysis or the sections for the atresia analysis are taken. From the fixed ovary lobe, cut two 5 mm thick slices and put them in a coded histology cassette. Write the code with a wooden pencil on the outside of the cassette. If the ovary is very big, you may have to use two cassettes. Separate the cassettes into four colour-coded, leak proof bottles, filled with 70% ethanol. Pack the consignments for each country with a maximum volume of 1000 ml solution in each package. On the outer cover of the package, indicate the volume of fixative and that it is within the limits for unclassified transport.

After the screening, the adult sampling coordinators will divide the samples between the analysing institutes. Send the cassettes and Nunc samples for analysis to the different institutes, based on the list provided by the sampling coordinators.

Figure. 4. Sampling at sea.



Date	Events
Sunday June 9th:	The vessel was mobbed early in the morning. The scientists boarded at 19:00, had the safety briefing, and the vessel sailed at 22:00
Monday June 10th:	The vessel arrived on station at 04:00 at position 52.75N 10.25W and commenced sampling. The weather was good and the ship maintained 10 knots between stations. Nine stations were carried out for the day. Due to the survey area to be sampled it was decided to sample every transect
Tuesday June 11th:	Transect 1 was completed at 23:50 at position 52.75N 14.25W. The vessel turned north for 60 miles before turning east along the north slope of the Porcupine Bank. This transect was only two stations before the ship turned north again. The wind strengthened during the day, slowing the vessel. Transect 2 was reached at 21:00 at position 54.75N 13.25W with the vessel turning westwards. Seven stations were completed for the day.
Wednesday June 12th:	Transect 2 was completed at 13:00 at position 54.75N 16.75W. As no mackerel eggs were encountered on the transect it was decided to terminate it early and instead steam to the northwest to transect 3. Transect 3 was started at 22:00 at position 55.75N 17.75W. Eight stations were carried out for the day.
Thursday June 13th:	Transect 3 was completed at 23:55 at position 55.75N 13.25W. Nine stations were sampled during the day.
Friday June 14th:	Transect 4 was started at 08:00 at position 56.75N 13.25W. Eight stations were carried out during the day.
Saturday June 15th:	As once again no mackerel eggs were found on this transect it was decided to terminate it early and move north. Transect 4 was ended at 03:00 at position 56.75N 17.25W. It was decided to combine transects 5 and 6 into one long transect and carry out sampling in a series of “dovetail joints”. The transect was started at 18:30 at position 58.75N 18.25W. This was the most northerly and westerly station sampled during the trip. Despite the steaming distances involved in travelling from transect 4 eight stations were carried out for the day.
Sunday June 16th:	We continued along transect 5. During the night an issue developed with the vessel’s A-frame. Due to a hydraulic ram failure it was no longer possible to move the frame when deploying and retrieving the GULF sampler. The crew managed to position the A-frame over the stern and locked it into position. This gave the GULF clearance over the stern. A rope attached to the Gilson winch was used to assist in bringing the sampler back on board. Nine stations were carried out for the day.
Monday June 17th:	Continued along transect 5. Two fishing attempts were made using rod and line close to Rockall, in shallow water, however nothing was caught. Nine plankton stations were carried out for the day.
Tuesday June 18th:	Nine stations were carried out for the day.

Wednesday June 19th:	Nine stations were carried out for the day. Another fishing attempt was made using rod and line, in water depth between 100 and 150m. Once again no fish were caught.
Thursday June 20th:	Transect 5 was completed at 09:00 at position 58.75N 04.84W. Five stations were carried out. The vessel then headed to Stornoway to take on fuel, water, stores and to replace one member of the crew. The vessel arrived in port at 16:00.
Friday June 21st:	In the morning the vessel took on fuel and stores and departed Stornoway at 14:00. The weather was quite windy and heavy seas slowed the passage. The vessel was back on station at 21:30 at position 58.25N 07.25W. One station was carried out.
Saturday June 22nd:	A number of stations were fished west of the Hebrides as the vessel travelled to the next transect. The ship started transect 6 at 12:00 at position 56.75N 07.85W, before turning westwards. Fishing, using rod and line, was carried out at 56.75N 09.75W, to collect a sample of adults for fecundity sampling. Fishing lasted 30 minutes and approximately 75kg of fish were collected. This was more than adequate to sample. Nine plankton stations were carried out for the day
Sunday June 23rd:	Transect 6 was completed at 08:00 at position 56.75N, 12.25W. As the weather was staying fine, and the vessel was able to steam at 10 knots, it was decided that there was sufficient time before the vessel returned to Galway to start sampling every transect, rather than every second transect as had been the case up to now. Transect 7 was started at 11:45 at position 56.25N 12.25W. Ten stations were carried out for the day.
Monday June 24th:	Transect 7 was finished at 10:00 at position 56.25N 07.75W with transect 8 being started at 12:45 at position 55.75N 07.75W. Ten stations were carried out for the day.
Tuesday June 25th:	Transect 8 was finished at 10:00 at position 55.75N 12.25W with transect 9 being started at 13:30 at position 55.25N 12.25W. Eight stations were carried out for the day.
Wednesday June 26th:	Transect 9 was finished at 11:30 at position 55.25N 08.75W with transect 10 being started at 15:00 at position 54.75N 09.25W. Three attempts were made to catch adults for sampling, using rod and line. The first two were unsuccessful but the third attempt, carried out at 54.75N 10.25W, produced approximately 50kg of fish. This was sufficient to carry out the necessary sampling. Eight stations were carried out for the day.
Thursday June 27th:	Transect 10 was finished at 06:00 at position 54.75N 12.25W with transect 11 being started at 09:00 at position 53.75N 12.25W. Transect 11 was completed at 22:30 at position 53.75N 10.75W. Eight stations were carried out for the day.
Friday June 28th:	Transect 12 was started at 02:00 at position 54.25N 11.25W and was a mix of stations to complete the survey tract. The transect was completed at 15:00 at position 53.25N 10.25W. this concluded the survey and the vessel headed towards Galway.
Saturday June 29th:	The vessel returned to Galway at 02:00 and later in the morning the survey was demobbed. The post cruise meeting was held on board at 10:0 before the vessel left port to return to Belfast.

MEGS Mini MMO Report 2019

Materials and Methods

One marine mammal observer (MMs) participated in the survey from 09/06/19-29/06/19.

Cetacean watches were conducted using a standard single platform line transect survey design. Visual watches were undertaken from the vessel's bridge wings, located 8.3m above sea level (when conditions allowed), during daylight hours. During periods of unfavourable weather, observations were carried out from the bridge (also 8.3m above sea level).

Cetacean survey effort commenced every day at 08:00 local time and concluded at 20:00 local time. To prevent MMO fatigue and to optimise the validity of the data, survey effort was carried out in two-hour shifts.

Survey effort was concentrated in periods of sea state 6 or less and in moderate or good visibility. Survey effort conducted outside of these parameters was recorded as auxiliary effort. Survey effort for cetaceans was concentrated within an arc of 60^{o} either side (i.e., to port and to starboard) of the vessel's track-line but all sightings to 90^{o} both side of the track-line and further aft was also recorded. Searching for cetaceans was predominantly done with the naked eye, however, Nikon Prostaff 7s 8x42 binoculars and a Canon EOS100 DSLR camera with a 70-300mm zoom lens was used to confirm parameters such as species identification, group size and behaviour. Survey effort was also carried out at stations where the GULF sampler was being towed and CTD data was collected. Survey effort was postponed during periods of poor weather.

The Cybertracker data collection software was used to record all positional, environmental and sightings (including position of sightings) data.

Using a portable GPS receiver with a USB connection, the Cybertacker software automatically recorded the ships position directly into a Microsoft Access database every 5 seconds.

Input of environmental data was recorded every 20 minutes and sooner if there was a change in environmental conditions. The MMO inputted data regarding wind speed, wind direction, sea state, swell, visibility, cloud cover and precipitation. All data entry was time stamped by Cybertracker and saved in the Cybertracker database. Ancillary data such as changes in survey activity (e.g. fishing/steaming), and auxiliary and incidental sightings were also recorded.

Sightings were recorded as primary sightings when the sightings were observed first by the MMO while the MMO was conducting a constant watch. Auxiliary sightings were defined as sightings which occurred while the MMO was 'on effort' with the sighting being first detected by another crew member. The species identity, distance and range of auxiliary sightings was confirmed by the MMO. All other sightings were recorded as incidental sightings, these included sightings occurring while the MMO was 'on effort' which were not detected by the MMO, and all sightings which were detected while the MMO was 'off effort'.

The distance of each sighting from the ship was estimated using a fixed interval range finder, while the bearing from the ship was estimated with an angle board. This data, along with data such as species identification, group size, composition, heading, sighting cues, surfacing interval, behaviour and any associations with birds or other cetaceans was also recorded on the time stamped Cybertracker sighting record page.

Where species identification could not be confirmed, sightings were recorded at an appropriate taxonomic/confidence level (i.e. probable, possible, unidentified whale, unidentified dolphin etc.). Recordings of sightings were aided with the use of a handheld audio voice recorder.

Results

In total, 133 hours and 28 minutes of survey effort was conducted over the entire survey. Environmental data was collected a total of 647 times during the survey.

In total, 64 marine mammal sightings, consisting of 204 individuals, were recorded throughout the survey. This accounts for sightings all primary, auxiliary and incidental sightings. The sightings included; 3 whale species, 6 dolphin species, 1 porpoise species, 2 seal species, unidentified large whale sightings, unidentified cetacean sightings, unidentified dolphin sightings and unidentified seal sightings. A list of the species encountered can be seen in Table 2.

Minke whales (*Balaenoptera acutorostrata*) were the most frequently encountered species observed making up 17% of all sightings, while only making up just 7% of all individuals counted. Altogether, there were 11 sightings of minke whales which consisted of 14 individuals. Large numbers of minke whales were recorded on 24/06/2019 on Stanton bank where 8 sightings were recorded.

The second most frequently observed species were unidentified dolphins species, accounting for 16% of all sightings, with 10 sightings consisting of 32 individuals.

The third most frequently observed species were pilot whales (*Globicephala melas*), accounting for 14% of all sightings, with 9 sightings. Pilot whales were also the most abundant species encountered, accounting for 31% of all individuals counted (64 individuals) during the 9 sightings.

The second most abundant species were common dolphins (*Delphinus delphis*). Common dolphins accounted for 27% of all individuals counted (56 individuals) during the 8 sightings of the species.

The third most abundant species were unidentified dolphin species which accounted for 16% of all individuals counted (32 individuals) during the 10 sightings of the species.

In addition to the above, 1 incidental sighting of other marine megafauna was reported by a crew member to the MMO which included; 1 probable basking shark sighting. In total, 1 individual was observed (see Table 3). Unfortunately the MMO did not get the opportunity to observe this sighting.

The distribution of the sightings and other marine megafauna can be seen in Figure 5.

Table 2. Summary of all marine mammal sightings during the survey

Species	Latin Name	No. of Sightings	No. Of Individuals	Range of Group Size
Atlantic white sided dolphin	*Lagenorhynchus acutus*	1	5	5
Bottlenose dolphin	*Tursiops truncatus*	1	1	1
Common dolphin	*Delphinus delphis*	8	56	1-30
Fin or sei whale	*Balaenoptera physalus/borealis*	1	1	1
Grey seal	*Halichoerus grypus*	6	6	1
Harbour porpoise	*Phocoena phocoena*	1	1	1
Killer whale	Orcinus orca	1	1	1
Minke whale	*Balaenoptera acutorostrata*	11	14	1-2
Pilot whale	*Globicephala melas*	9	64	1-20
UnID cetacean		3	4	1-2
UnID dolphin		10	32	1-10
UnID large whale		6	6	1
UnID seal		5	9	1-5
White beaked dolphin	*Lagenorhynchus albirostris*	1	4	4
	Total	64	204	

Table 3. Summary of all marine megafauna sightings during the survey

Species	Latin Name	No. of Sightings	No. Of Individuals	Range of Group Size
Probable basking shark	*Cetorhinus maximus*	1	1	1
	Total	1	1	

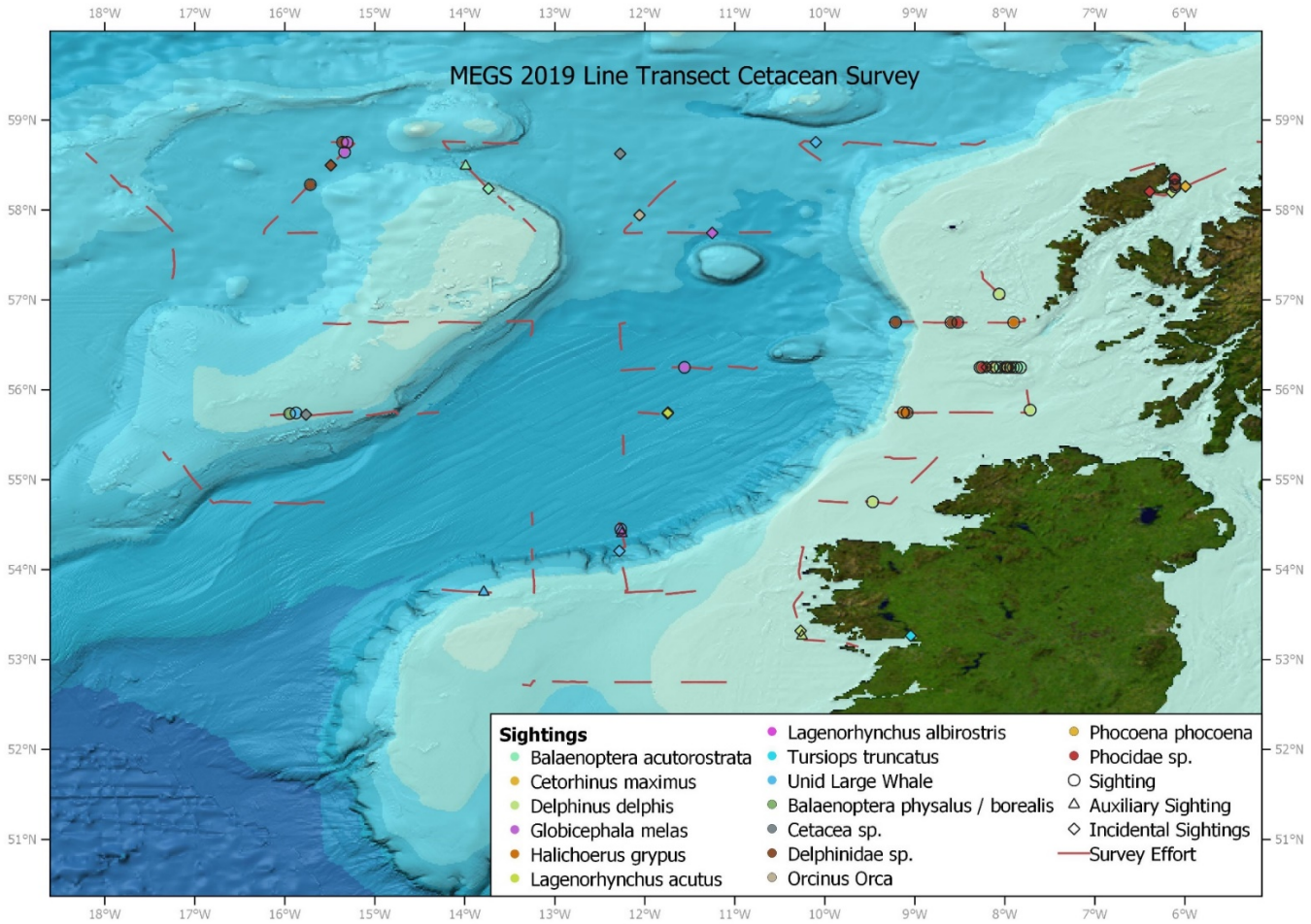


Figure 5. Distribution of all marine mammal sightings and other marine megafauna during the survey

12. Individual survey report: Norway/HI, Period 6

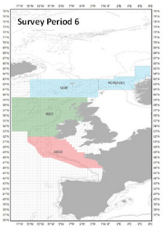
Please find the individual survey report below

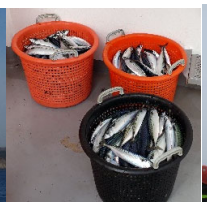
Triennial ICES coordinated Mackerel Egg Survey

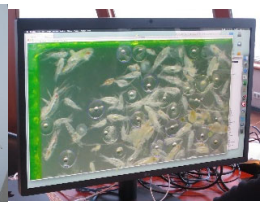
Cruise Report for Period 6, MS Brennholm (Norway), cruise 2019836 (Havforskninginstituttet)

9-29th June 2019

Institute of Marine
Research, P.O Box 1870
Nordnes, 5817 Bergen,
NORWAY





Background

The mackerel and horse mackerel egg survey is an integral part of the ICES-coordinated international study on pelagic fish stocks in the Eastern North Atlantic. The egg survey is conducted triennially during the first half of the year and has been undertaken since the late 1970s. This survey is coordinated by the ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS).

A series of cruises, covering the time and area where both mackerel and horse mackerel are expected to spawn, occurs between January and August. The main aim of the survey is to provide a fishery independent estimate of the spawning stock biomass (SSB) and its trends over time. The outcome is the production of both and index of, and a direct estimate of the biomass of the Northeast-Atlantic mackerel, and southern and western horse mackerel stocks. Due to the long spawning period and the large area involved, the mackerel and horse mackerel egg surveys have from the outset been conducted through international cooperation. In 2019 a total of 18 individual cruises, using a combination of research vessels and chartered fishing vessels, was undertaken with participation by UK (Scotland), Spain, Ireland, Portugal, Germany, the Netherlands, Faroe Islands and Norway.

The survey consists of two principal methods. The first to quantify the recently spawned eggs in the water column on the spawning grounds. The second is to determine the fecundity of the females through obtaining sufficient samples of ovaries before, during and after spawning. Sample processing consist of histological analyses for the estimation of realised fecundity (potential fecundity minus atresia) of the females. The combination of the egg abundances and female fecundity is used to establish a relationship between eggs in the water column or eggs spawned and spawning stock biomass.

The cruise was funded by Norway's FiskeriForsknigsAvgift (FFA) midler.

Cruise Plan

The survey was undertaken on the fishing vessel MS Brennholm, a pelagic trawler/purse seiner. This vessel provides both a multi-purpose laboratory (suitable for both adult fish (trawl) sample processing and microscope work on plankton samples for egg studies).

The area allocated to Norway for the survey was essentially bounded between 59-63°N and 2-14°W, an additional area to the east (to 8°E and 66°N) was requested by the Norwegian fishing industry (see ICES SISP 2019 Fig. 1.6, Fig. 1). The additional area toward the Norwegian coast had not previously been considered in any mackerel egg survey, however, the fishing industry had reported mackerel in spawning condition in this area in the past. The time allocated for the cruise was the 9th-29th June 2019. This time period was insufficient for a full coverage of the area so a preliminary, optimistic cruise track was allocated as in Figure 1. Due to the time constraints the area to the east of 5°E and north of 63°N was not considered for inclusion in this survey.

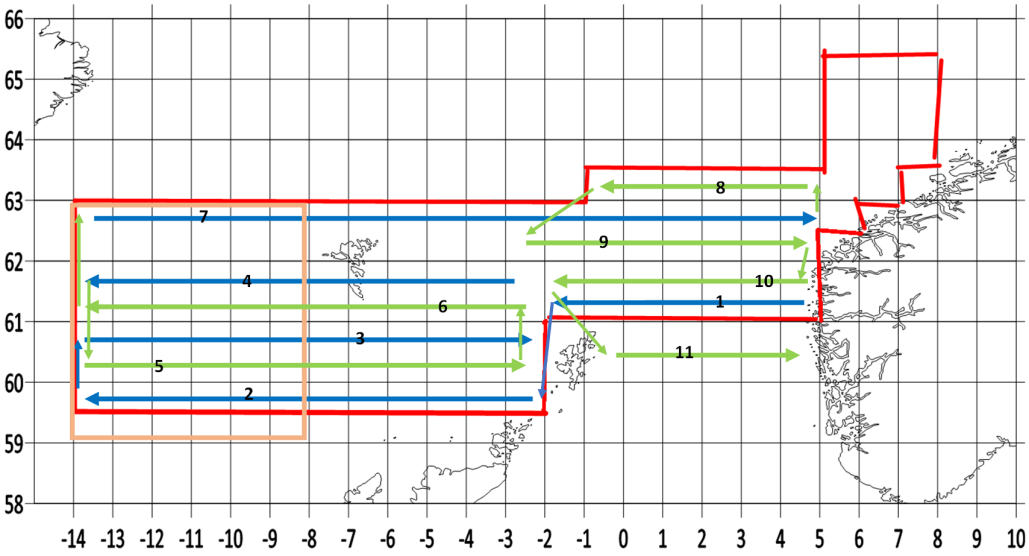


Figure 1. Designated area (bounded by red) and potential cruise tracks (blue and green) for the Period 6 survey allocated to Norway.

Cruise schedule and participants

Equipment was loaded in Bergen (Nykirkekaien) starting on Saturday 8th June 2019 (see Table 1). The vessel departed Bergen on Sunday the 9th June at 1620h UTC. Calibration of the Gulf VII flow meters was undertaken in Byfjorden.

Table 1. Timeline for cruise 2019836

Date (2019)	***Time***	***Activity***
8th June		Loading
9th June	1620	Departed Bergen, Nykirkekaien
	1652	Byfjorden, testing towing Gulf VII and flow meters
10th June	0142	Started sampling
18th June	1130	Arrived Torshavn, Faroes
19th June	1100	Departed Torshavn, Faroes
29th June	0000	Arrived Bergen, Nykirkekaien
	1000	Equipment fully unloaded

The scientific personnel on the cruise are given in Table 2. The original plan was for Anders Thorsen to be replaced by a colleague from the Netherlands at the mid-cruise break in the Faroes. Unfortunately, this colleague could not join our cruise so Anders Thorsen remained on for the duration of the cruise. In addition to the scientific personnel there were also the captain and 8 additional crew from the Brennholm.

Table 2. Science personnel on the MS Brennholm (2019836)

Personnel	**Activity/speciality**
Richard Nash	Cruise leader, fish eggs and larvae
Anders Thorsen	Fish eggs and larvae, image analyses
Thassya Christina dos Santos Schmidt	Adult fish sampling, fecundity sampling
Merete Fonn	Fish eggs and larvae, image analyses
Frøydis Tousgaard Rist Bogetveit	Adult fish sampling, fecundity sampling
Katerina Charitonidou	Fecundity sampling (guest scientist, Greece)

All personnel worked on all aspects of the sampling being undertaken.

The cruise track on the western edge of the survey area was changed since a late application for permission to sample in Icelandic waters had to be made. The Icelandic authorities were very prompt in granting a licence.

Methods

Field sampling

Plankton

Fish eggs and larvae were sampled using a Gulf VII (Nash et al. 1998) with a 280μm mesh net (manufactured by SPARTEL, Totnes, UK). The sampler was towed at 4 knots (2.1 $m.s^{-1}$) in a double oblique profile (surface to a maximum of 200m depth and back to the surface. The sampler was fitted with General Oceanics mechanical flow meters (internal in the nose cone, external in a small tube raised above the top frame). A SAIV (Saiv, Bergen) CTD was mounted on the top of the Gulf VII frame to provide profiles of temperature, salinity and depth during each haul. These data were downloaded off the CTD after each haul. In addition, a SCANMAR depth probe was also mounted on the Gulf VII, to give instantaneous depths to the bridge whilst towing, so that the maximum depth could be controlled.

At the completion of a tow, the net was gently hosed down and cod end immediately transferred to the shipboard laboratory.

The flow meters were calibrated using standard protocols (see ICES SISP 2019) with the reciprocal course technique.

Adult fish sampling

Adult fish were sampled in surface waters (30 min hauls) using a Multpelt 830m Pelagic Trawl (see ICES 2013, Nøttestad et al. 2016, for descriptions). The trawl was fitted with a kite on the headline and SCANMAR depth probe on the foot rope. The foot rope was at 30-36m depth.

Shipboard laboratory processing

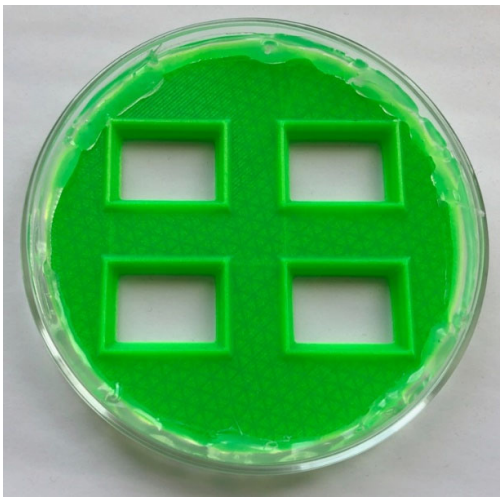
Plankton samples

Sample immediately split into a half and two quarters portions and placed on ice. All fluids and sample sorting trays were held on ice and used whilst cold. Starting with one quarter, two or three

personnel immediately worked through the samples picking out all eggs and fish larvae. At all times the samples were kept at a low temperature. Once the sample had been sorted all eggs were electronically photographed in a Petri dish with 4 photo frames (Picture 1) using an Olympus SZX-10 stereomicroscope (0.5X objective and a zoom factor of 1.25X) with a 12 Mpx SPOT Insight camera. The images had a resolution of 198.4 px/mm (see Appendix for detailed image protocols). After photography the eggs were preserved in ethanol. The ethanol preservation is to allow genetic analyses back ashore to confirm species identification where necessary.

After completion of imaging and preserving the eggs, the larvae were all imaged as well and preserved in 4% formalin.

The remainder of the plankton sample was preserved in 4% formalin. In a few cases where the quantities of zooplankton were large a quantified subsample was retained.

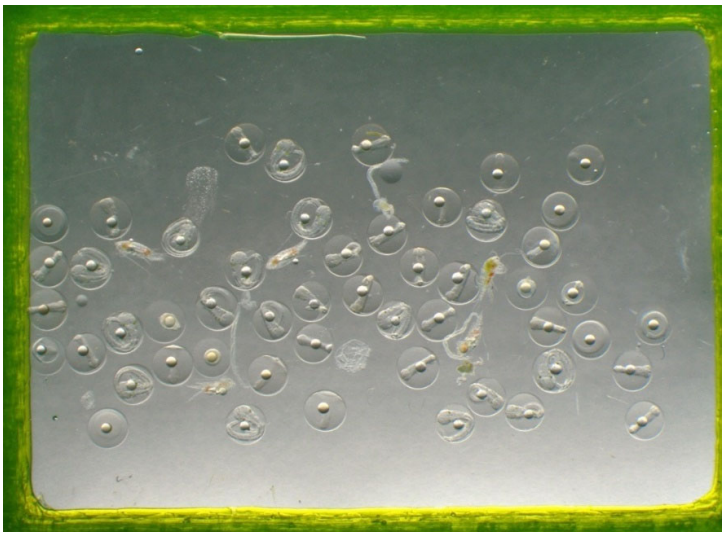


Picture 1. Petri dish with four photo frames adjusted to photo area. The frames were filled with 50 % sea water to allow eggs to sink to the bottom.

Image analyses

All egg images (Picture 2) were scrutinised for species identification and all eggs counted. In the case of mackerel eggs, the first 100 eggs on each station were measured for egg and oil globule diameters along with their stage (following the standard staging given in the Mackerel Egg Survey Manual (ICES SISP 2019). After mid cruise, these data were generally available within two hours of the completion of a haul, however, when not needed immediately a fully updated data set was available within 6 hours.

The egg analysis were performed using the open source image analysis program Image J (v. 1.52o, https://imagej.nih.gov/ij/index.html) with the ObjectJ plugin (v. 1.04n, https://sils.fnwi.uva.nl/bcb/objectj/) and the StampFishEgg project file (https://sils.fnwi.uva.nl/bcb/objectj/examples/stampfisheggs/md/stampfisheggs.html).



Picture 2. Example of egg picture prepared for egg identification.

Trawl samples

On retrieval of the trawl the total catch was estimated from the number of baskets needed to contain the catch. Four baskets of mixed fish (randomly collected) were retained for further analyses. In the case of relatively small catches all fish were sorted by species.

The Institute of Marine Research sampling protocol (see Mjanger et al. 2012) consists of measure (length and weight) 100 randomly selected specimens per haul. Additional information was recorded for the first 30 specimens, such as sex, maturity stage and gonad weight. Age was determined for the first 30 specimens. Extra females' samples were taken to achieve the number of samples needed. Maturity was classified based on eight macroscopic gonadal stages: 1–2: immature, 3–5; maturing and mature, 6: spawning, 7: spent, and 8: resting (Mjanger et al. 2012). Posteriorly, the Walsh scale (Walsh et al. 1990) and ICES scale (ICES WKMATCH 2012) were included in the data. Walsh scale has six stages: 1: virgin, 2: early ripening, 3: late ripening/partly spent, 4: ripe, 5: partly spent (late), 6: spent/recovering spent. ICES scale has also 6 stages: A: immature, Ba: developing but functionally immature, Bb: developing and functionally mature, Ca: actively spawning, Cb: spawning capable, D: regressing/regenerating. The results presented here are in the Walsh scale.

Results

General

A total of 163 Gulf VII hauls for eggs and four trawl hauls for adult fish were undertaken (Fig. 2). CTD data are available for 160 of the stations (data were not recorded for three stations (see Fig. 3 – white circles). Salinity data are not available for a further seven stations where an operational error with the CTD compromised the salinity data acquisition.

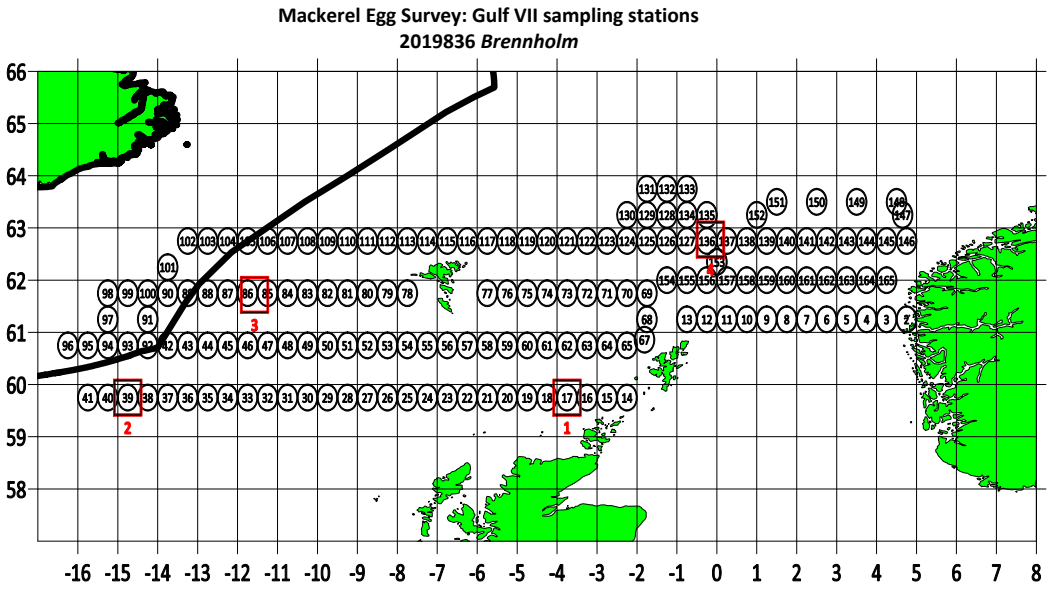


Figure 2. Stations realised. Gulf VII stations are shown with circles (station numbers are also given in the centre of the circle). Trawl stations (with station numbers) are given as red boxes and numbers.

For a period of time between the 15th and 16th July there was no communication between the cruise log computer and the ship's navigation. Automated station logging was not possible, however, handwritten station, start and finish, positions and times were undertaken. Unfortunately, the bottom depth was not recorded after the electronic link between the ship's navigation and the cruise logger was restored. The reasons for this are still unclear.

Distribution of temperature at 20m

Over the whole area surveyed, the temperature varied between 7.90 and 11.74°C. In the western area (west of 2°W) the general pattern was a decrease in temperature with increasing latitude. In the eastern area (east of 2°W) the warmest waters occurred in toward the Norwegian coastline off Møre. In addition, this eastern area was as warm as western waters 2 to 3 degrees latitude to the south.

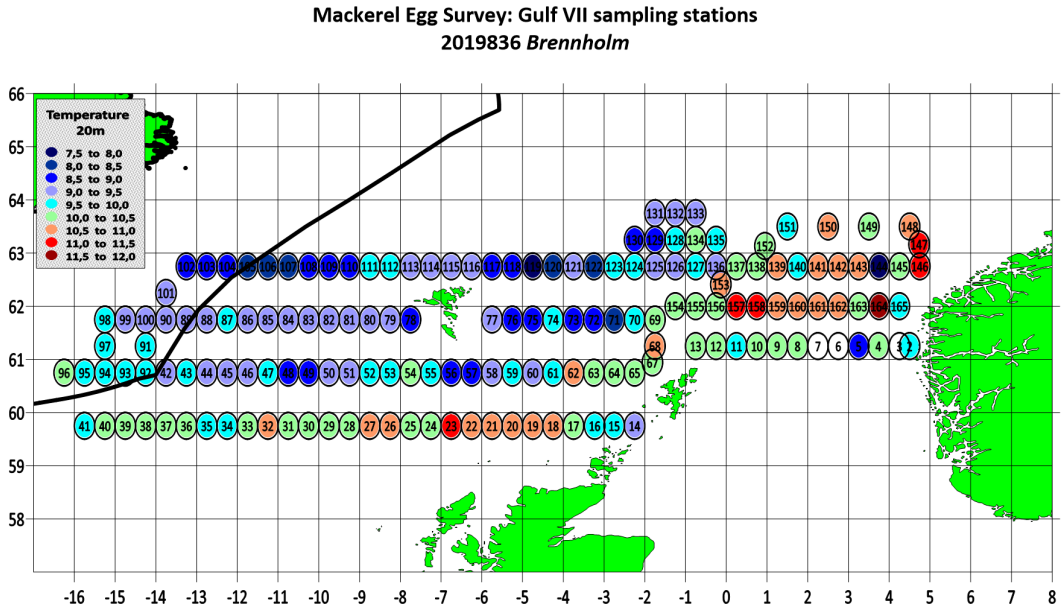


Figure 3. Distribution of temperature at 20m depth. Data from the SAIV CTD attached to the Gulf VII highspeed plankton sampler.

Plankton and egg analyses

The most abundant and frequently found eggs during the survey were mackerel (65%) with pearlside (*Maurolicus muelleri*) eggs being the second most abundant (32%) (see Table 3). The remaining eggs only constituted approximately 3% of the total eggs caught, of these the most notable were ling as these are similar to mackerel but smaller.

Table 3. Egg types found during the Norwegian triennial mackerel egg survey.

Egg type	Frequency	Percent	Cum. (%)
Hake	1	0.03	0.03
Triglidae	2	0.05	0.08
Callionymus	3	0.08	0.15
Cod	7	0.18	0.33
Codlike	16	0.40	0.73
Ling	18	0.45	1.18
Unidentified Fish	68	1.71	2.89
Pearlside	1285	32.29	35.18
Mackerel	2580	64.82	100.00

Mackerel egg distributions

Stage 1 (recently spawned) mackerel eggs occurred over most of the area sampled (Fig. 4). Eggs were notably absent from the area immediately to the south west of the Shetland islands (59^{o} 45'N), along the western part of the most northern long transect sampled (62^{o} 45'N), north and west of the Faroes, and close to the Norwegian coastline. Subjectively, there were three groupings of stage 1 eggs; in the south-western quadrant of the sampled area (toward the Iceland deeps), north and east

of Shetland and a relatively large concentration to the north-west of mainland Scotland. This latter concentration was on the southern limit (59° 45'N) of this survey.

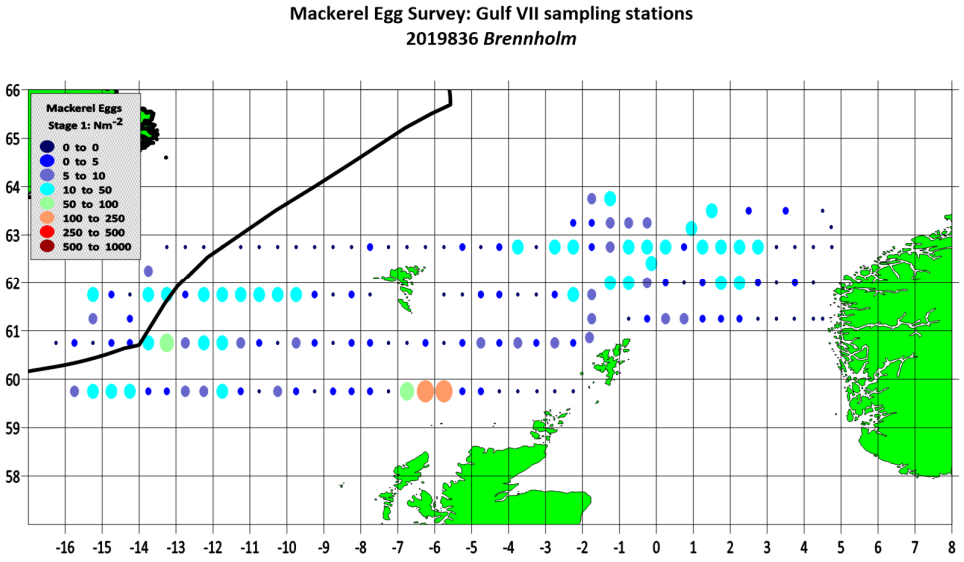


Figure 4. Distribution of mackerel stage 1 (stages 1A and 1B combined) during cruise 2019836 (June 2019).

There is a suggestion that spawning of mackerel tends to be within relatively narrow thermal windows and as such stage 1 eggs should likewise occur within a relatively narrow thermal range. Samples were taken in areas where the temperature ranged from 7.9 to 11.7°C. Stage 1 eggs occurred across the range 8-11°C, however, the majority of eggs occurred between 9 and 11°C. The occurrence tended to mirror the sampling effort.

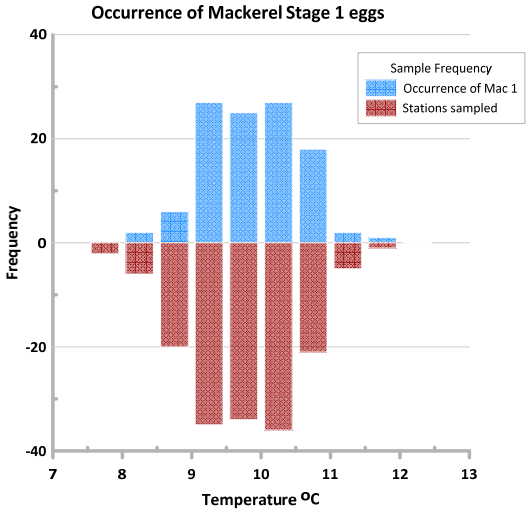


Figure 5. The occurrence of mackerel stage 1 eggs and the ambient water temperature at 20m depth.

The occurrence, in regard to the thermal environment, appears to also have a spatial aspect (see Fig. 6). There also appears to be quite a complex pattern, especially when considering egg abundance as well, which is probably related to other spatially explicit factors e.g. water depth, latitude and date relative to spawning time.

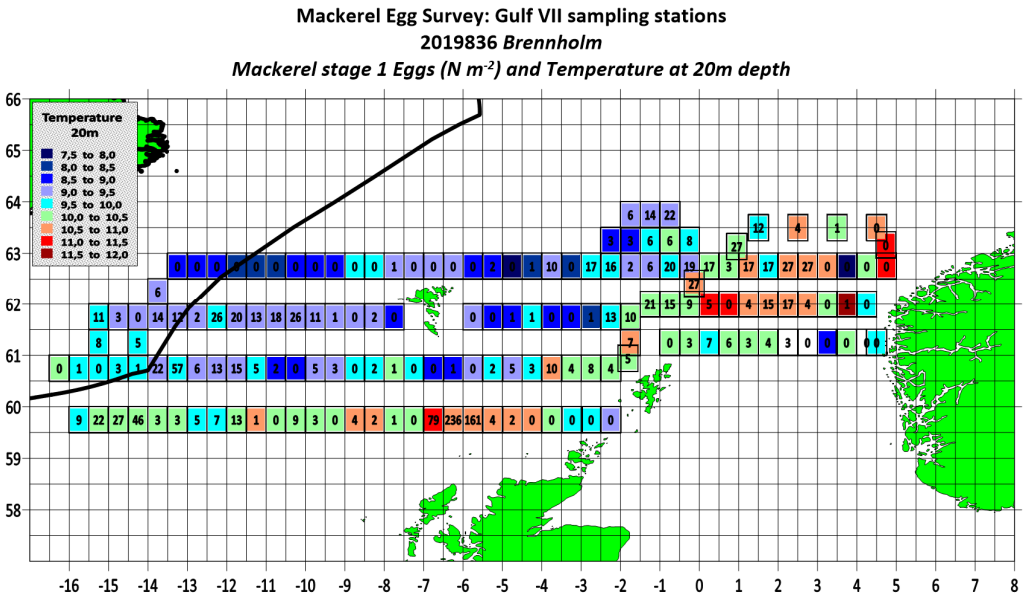


Figure 6. Distribution of mackerel stage 1 eggs (numbers m^{-2} are given inside the squares) relative to the ambient temperature at 20m depth.

The complexity of stage 1 egg abundance and just two physical parameters (in this case water depth and temperature at 20m depth) is illustrated in Fig. 7. Due to using the log of abundance with no transform the abundance only reflects positive values i.e. zero occurrences of egg are not shown in this graph.

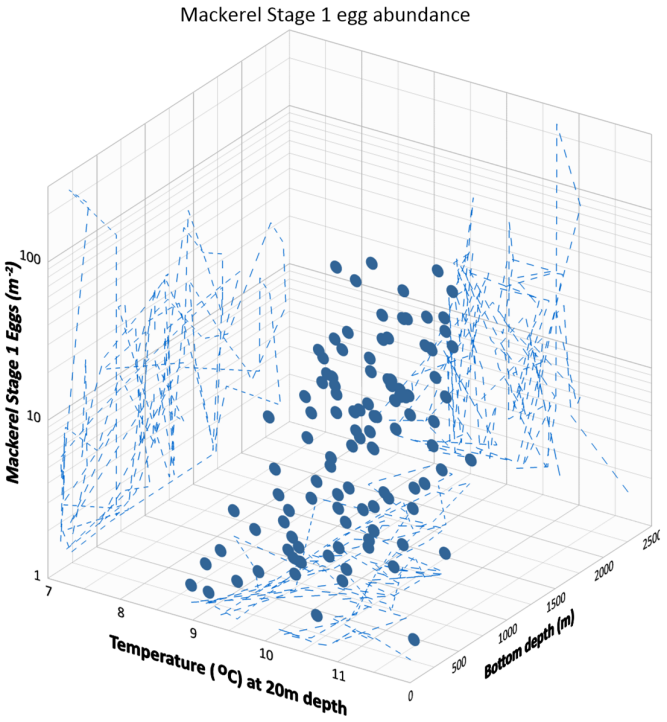


Figure 7. The positive abundances of mackerel stage 1 eggs (m^{-2}) with both temperature at 20m depth and the bottom depth.

Stage 2 and above mackerel egg abundances are not used for estimating mackerel egg production. However, allowing for drift the distribution can give indications of spawning locations prior to the current survey. Overall the distribution of the older aged eggs (Fig. 8) is broadly similar to the stage 1 eggs (see Fig. 4).

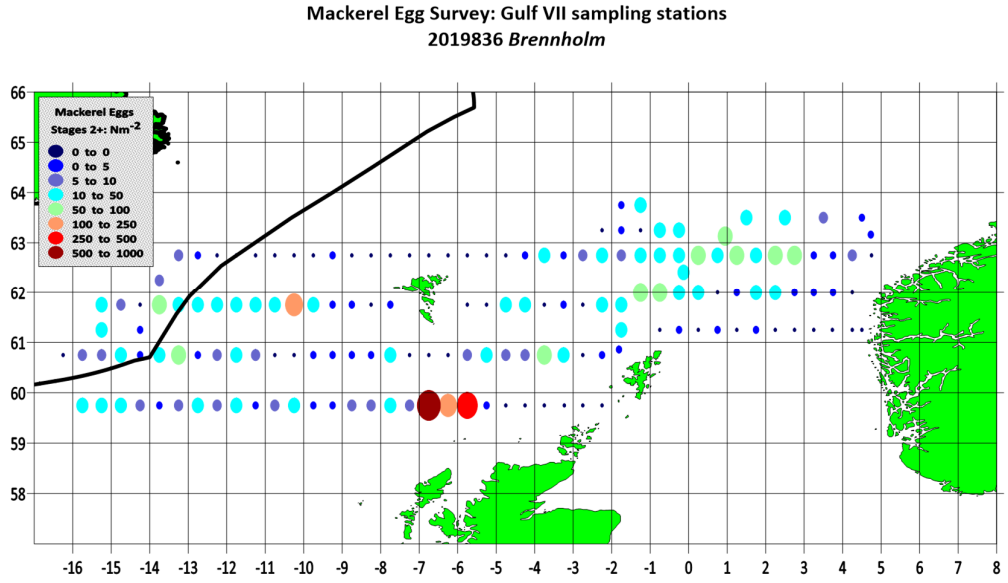


Figure 8. Distribution of stage 2+ mackerel eggs in June 2019. Brennholm 2019836.

Other eggs and larvae

The majority of eggs which were not classified as mackerel occurred in the south western quadrant of the survey area (Fig. 9). The majority of these eggs were pearlsides. The species or taxonomic group distribution is given in Table 3.

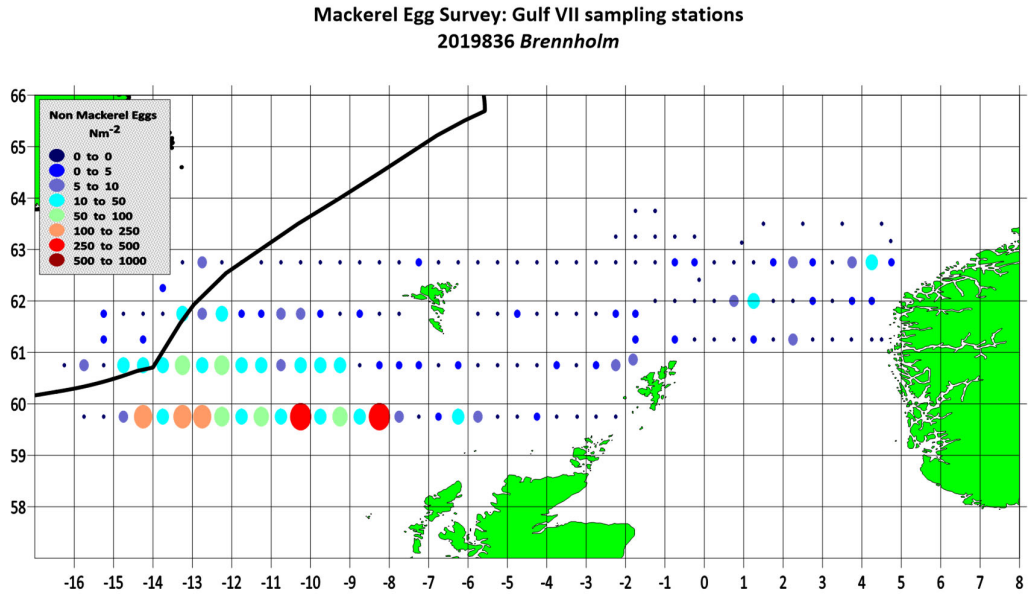


Figure 9. Distribution and abundance of other eggs in June 2019, Brennholm 2019836.

Fish larvae occurred in many of the samples, however, the highest densities occurred on the southern most transect (59° 45'N) (Fig. 10). The overall pattern was a reduction in abundance from southwest to northeast of the survey area.

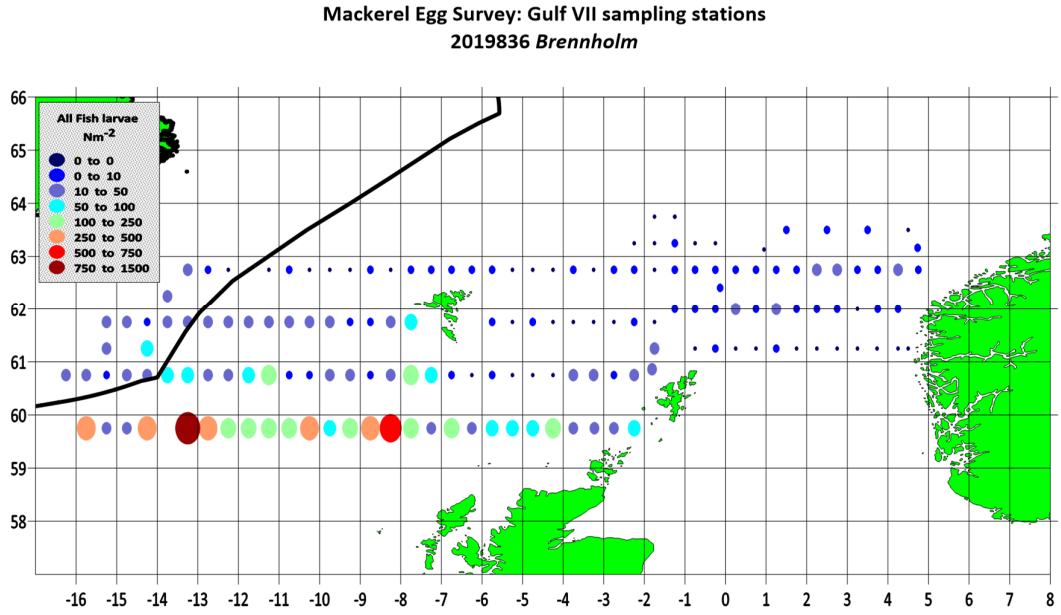


Figure 10. Distribution and abundance of fish larvae in June 2019, Brennholm 2019836.

Egg characteristics

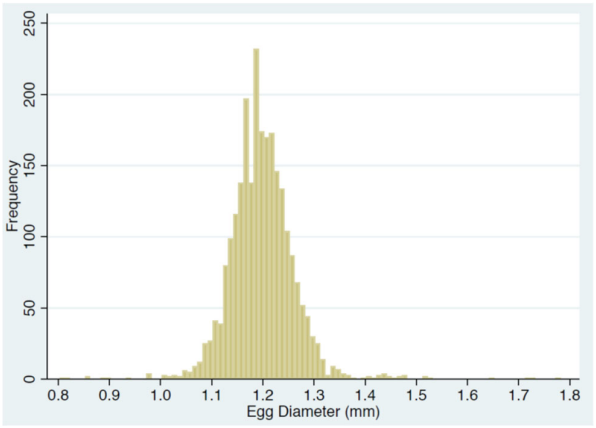


Figure 11. Diameter distribution of all measured eggs with oil droplet.

Among the measured eggs with one oil droplet diameters ranged from 0.8 – 1.8 mm (Fig. 11), but only a few of these eggs were outside the range typical for mackerel (1.05 – 1.35 mm, Fig. 12). Note however, that Pearlside, the most abundant egg with oil droplet except from Mackerel, was usually not measured. Pearlside eggs were easily identified by their sculptured chorion.

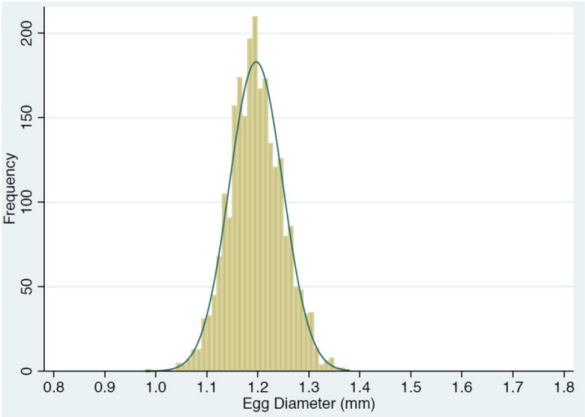


Figure 12. Diameter distribution of all measured eggs categorized as mackerel eggs. Green line shows the corresponding normal distribution.

Eggs identified as mackerel eggs had a median diameter of 1.20 mm and 5 and 95 percentiles of 1.11 and 1.29 mm respectively. The size histogram (Fig. 12) showed a close to perfect normal distribution. There was only a small difference between the size histogram for all measured eggs with oil droplet and the histogram with only eggs identified as mackerel.

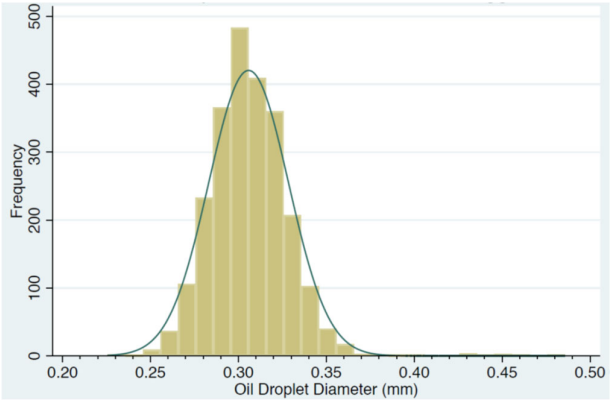


Figure 13. Oil droplet diameter distribution of Mackerel eggs.

For mackerel the oil droplet diameter distribution also had a normal distribution (Fig. 13). The median value was 0.30 mm and the 5 and 95 percentiles were 0.27 and 0.34 mm respectively.

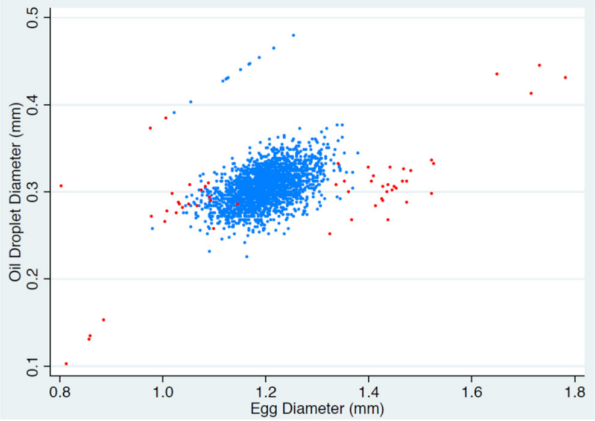


Figure 14. Oil droplet diameter versus egg diameter. Mackerel represented with blue dots, other species with red dots.

Plotting egg diameter versus oil droplet diameter (Fig. 14) revealed some overlap between mackerel and other species, but mostly mackerel eggs were clustered separately from the others. A few eggs, mostly mackerel, had a much higher oil droplet diameter compared to egg diameter than the others. We suspect some kind of error have caused this relationship, but measurements control on the original pictures has not revealed any error.

Trawl samples:

The total biomass varied from 70 kg to 811 kg of fish (Table 4). Most of the catch were represented by mackerel. Table 4 presents an overview of fish processed per trawl haul, and number of ovary samples collected. A total of 65 fecundity samples were collected, most of the females were partly spent and spent (Walsh scale). Extra late ripening and ripe females' samples (N = 14) were then collected to achieve this total number of ovary samples. Additionally, 86 ovary samples were collected to the Climrates project (Thassya dos Santos Schmidt), and 23 samples were provided to Katerina Charitonidou.

Table 4. Overview of total biomass per haul, the biomass of mackerel, number of individuals measured, otoliths removed, and number of ovary samples collected for 3 projects: the mackerel fecundity (WGMEGGS), Climrates and Katerina PhD project.

Serial number	Total catch (kg)	Total mackerel biomass (kg)	Morphometric parameters	Otoliths	Mackerel fecundity	CLIMRATES project	Katerina
37701	168.9	160	100	30	8		
37702	300	283.2	100	30	13		
37702 (batch 2)			36	36	0	30	7
37703	70	58.6	100	30	16		
37703 (batch 2)			28	28	6	22	
37704	811.3	780.8	100	30	10		
37704 (batch 2)			62	46	12	34	16

Overall, mackerel length ranged from 24 to 38 cm. Samples collected in the first and fourth trawl hauls showed a broader length distribution and smaller average length (31.2 and 32.5 cm, respectively) compared to the second and third hauls (average of 37.2 and 36.4 cm, respectively) (Fig. 15). The most abundant length classes in each haul were: 31 cm and 31-32 cm (Fig. 15a and d) and 37 cm (Fig. 15b and c).

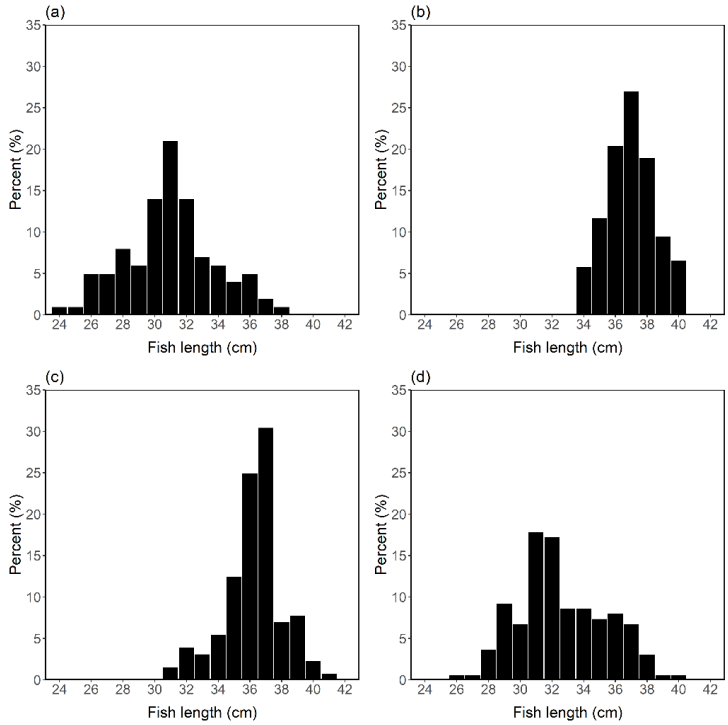


Figure 15. Length distribution of mackerel per trawl haul. (a) Serial number 37701, (b) 37702, (c) 37703, and (d) 37704.

Mackerel age, for both genders combined, ranged from 2 to 13 years old. Fish at age 3 were predominant in the first and fourth hauls (58.6% and 60.7%, respectively). The second and third hauls were more diverse, but predominant by ages 7 (23.3%) and 9 (23.3%), respectively (Fig. 16).

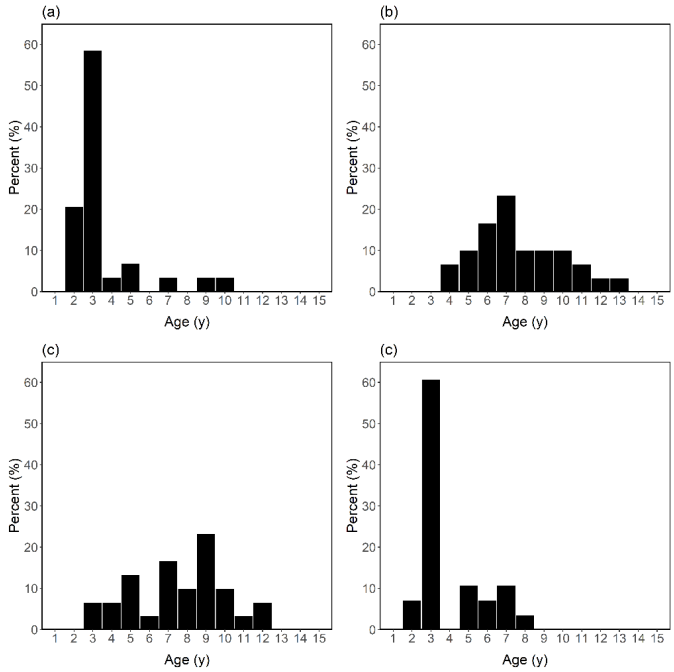


Figure 16. Age structure of mackerel per trawl haul. (a) Serial number 37701, (b) 37702, (c) 37703, and (d) 37704.

Weight-at-length relationship is presented (Fig. 17). The formula found was Weight = $0.014 \times \text{Length}^{2.851}$ ($R^2 = 0.925$).

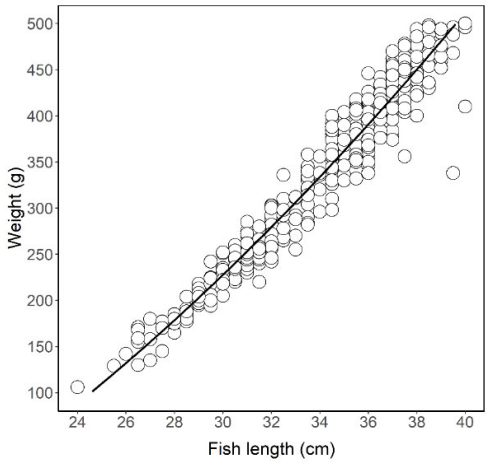


Figure 17. Weight-at-length relationship.

The total sex ratio were 53.3% males and 46.7% females (see Table 5). A ratio 1:1 was only recorded in the first haul. Males were slightly more abundant on the second and fourth hauls (Table 5).

Table 5. Total and per haul sex ratio recorded during the mackerel egg survey (only random samples).

	Female		Male	
	N	**%**	**N**	**%**
37701	15	50.0	15	50.0
37702	12	40.0	18	60.0
37703	16	53.3	14	46.7
37704	13	43.3	17	56.7
Total	**56**	**46.7**	**64**	**53.3**

Most of the mackerel (genders combined) were in spent and recovering spent stage, and partly spent stage. Mackerel samples collected on the first haul (serial number 37701) were mostly virgin and early ripening (Table 6).

Table 6. Maturity stage (Walsh scale) per trawl haul, both genders are combined. Only the first 30 random samples were considered here.

	37701		37702		37703		37704	
Maturity	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
1	9	30.0	0	0	1	3.3	1	3.3
2	10	33.3	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	1	3.3	0	0	1	3.3
5	3	10.0	11	36.7	10	33.3	10	33.3
6	8	26.7	18	60.0	19	63.3	18	60.0

Discussion

Egg identification and egg size distribution

Mackerel and ling eggs are very similar in appearance. According to the literature (Lockwood *et al*., 1977, Russell 1976) the main difference between these egg types are that ling eggs typically are slightly smaller (0.97-1.13 mm) than the mackerel eggs (1.0-1.38 mm), although overlap may occur. In our material this seems not to be a big issue since very few eggs were found in the size range that are typical for Ling eggs. Also, we consider the close to perfect normal size distribution of the eggs that we took as Mackerel as an indication that most of those identifications were correct.

Since other egg species that appeared in our survey area are significantly different in size or appearance compared to Mackerel, we consider that these are unlikely to have caused major problems for our Mackerel identification.

During our survey the sorted eggs were conserved in ethanol after photography. In contrast to what is the case for formalin fixated samples ethanol conserved samples can be used for species identification, post survey, using genetic techniques. Genetics based analyses of fish eggs can give an irrefutable species identification.

The contribution of egg production in the Norwegian Sea, east of 3°W and north of 61°N

The area north of 61°N and more specifically to the east of 3°W has not previously been included in the triannual mackerel egg survey. It is known that not only has there been an extension of the mackerel spawning in the northeast Atlantic to the west but also an extension northward. In addition, there have been suggestions by fishermen that spawning may extend substantially into the Norwegian Sea and possibly up the Norwegian coastline. This survey does undoubtably show that spawning is occurring to the north and east of the traditional survey area, at least during June. Even though, most of fish were spent by the end of the month (see Table 6). The presence of older staged eggs also suggests that there was spawning occurring in this area earlier.

The lack of survey coverage in period 5 (May) and then in period 7 (July onward) of this area means that there is no information of the seasonality of spawning in the area. In addition, the limited coverage in this survey canot fully delineate the full areal extent of any spawning. However, it would be of value to estimate the potential contribution this extra area could make to an estimate of SSB in period 5. The potential contribution and future inclusion of this northern area in the mackerel egg survey warrant discussion. Such a discussion may benefit from considering the North Sea survey as well and the contribution that these eastern portions of the stock make to the overall estimate of mackerel SSB.

As a preliminary investigation into the possibility that spawning is occurring northward in the Norwegian Sea it would be profitable to examine the maturity stages of mackerel caught during the July Norwegian Sea Ecosystem survey. During the first part of the survey the catches of one vessel (MS Vendla) in the eastern area were mainly spent or recovering stages (T.C. dos Santos Schmidt *pers. obs.*). Whether this is indicative of the rest of the area has not been investigated.

The significance of not surveying to the zero abundance of mackerel stage 1 eggs in the western limits of the survey

There are instances of survey lines being curtailed prior to a complete lack of stage 1 eggs (zero lines). Survey time is finite therefore there has to be some rule for stopping the westward progression of the survey so as to ensure sufficient coverage. This is a practical requirement for the survey. It would be useful to investigate the possible contribution of low levels of egg production potentially over large areas on the final estimate of SSB.

On a related issue, in this particular survey, the use of image analysis systems on fresh eggs allowed a fairly rapid decision-making process based on the numbers of stage 1 eggs caught in the most recently sampled stations. Unfortunately, westward extensions of the survey area had to be curtailed based on time constraints despite knowing there were stage 1 eggs present in the area.

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