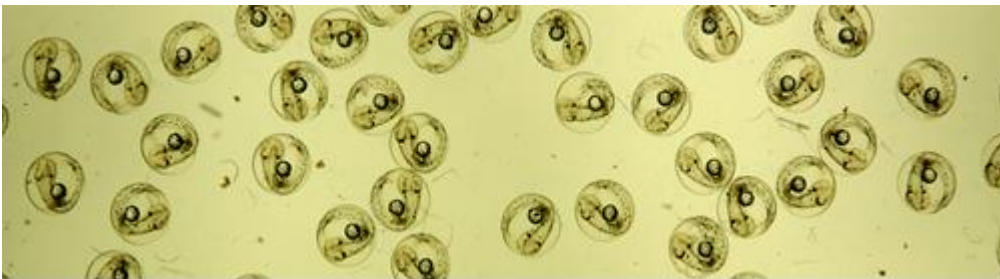


North Sea mackerel egg survey: Dutch participation May and June 2011

C.J.G. van Damme

Report number C026/12



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Contents

Contents.....	3
Summary	4
1. Introduction.....	5
2. Aim of the project.....	6
3. Methods	7
3.1 Gears.....	7
3.2 Fishing method	7
3.3 Sampling grid	8
3.4 Sample processing on board	10
3.4.1 Plankton samples.....	10
3.4.2 Adult fish samples	12
3.4.3 Hydrated oocytes and POF's	12
3.4.5 Fertilized eggs.....	12
3.5 Sample processing in the lab.....	12
3.5.1 Plankton samples.....	12
3.5.2 Adult fish samples	12
3.6 Calculation of the number of eggs.....	13
4. Survey	14
5. Results.....	20
5.1 Mackerel eggs.....	20
5.2 Adult fish samples	25
5.3 Hydrated oocytes and POF's	25
5.4 Fertilized eggs	25
5.5 Hydrographical data.....	25
6. Exchange with ICES colleagues	29
7. Acknowledgements	30
8. Quality Assurance	31
8.1 Check on the sorting of the samples.....	31
8.2 ISO.....	31
Justification.....	32

Summary

In 2011 the North Sea mackerel egg survey was performed. The entire spawning area was sampled by IMR, Norway and IMARES, The Netherlands. The whole spawning area was sampled three times. IMARES covered the complete sampling area in the first period, in the second period IMR covered the northern part and IMARES the southern part of the spawning area. The third period the whole spawning area was covered by IMR.

In total 190 ichthyoplankton samples were taken with a Gulf VII plankton torpedo with a Seabird CTD mounted on top. Additionally, adult fish samples for the estimation of fecundity and atresia were taken using a pelagic trawl.

The survey was successful and IMARES managed to sample all but 3 of the planned stations. Numbers of mackerel eggs found in the samples were comparable to 2008. Total mackerel egg production in 2011 was $116 \cdot 10^{12}$ (Fig. 5.9) and Spawning Stock Biomass (SSB) was estimated at $165 \cdot 10^3$ tons, which is slightly higher compared to 2008. Highest egg production was found in the first sampling week and it is possible that the beginning of mackerel spawning is missed.

1. Introduction

Every three years an international North Sea survey is carried out by two European institutes, Institute for Marine Research (IMR) from Norway and Institute for Marine Resources and Ecosystem Studies (IMARES) from the Netherlands, to monitor the spatial and seasonal distribution of North Sea mackerel. During this survey mackerel are sampled using a Gulf VII plankton torpedo. The survey is designed to try and cover the whole spawning area and season in the central and northern North Sea. The mackerel egg survey is coordinated by the ICES working group for mackerel and horse mackerel egg surveys (WGMEGS). The Netherlands participates in this survey since 1983.

2. Aim of the project

The purpose of this project is to monitor the spatial distribution and seasonal patterns in the appearance of mackerel eggs in the North Sea. IMARES, on board the 'RV Tridens' sampled the entire spawning area in period 1 and the southern part in period 2. In period 2 IMR sampled the northern part of the spawning area and covered the whole area in period 3. Both institutes used a Gulf VII plankton sampler. Also pelagic hauls were carried out on board 'RV Tridens' to collect adult mackerel to estimate fecundity. These data will be combined to provide a fisheries-independent estimate of the spawning stock biomass of North Sea mackerel.

3. Methods

3.1 Gears

The sampling of the fish eggs is carried out with a "High Speed Plankton Sampler Gulf VII" (Fig. 3.1) (referred to as 'torpedo' in the remainder of the report) with a plankton net with mesh size 500 μm . A small skrips-depressor of 35 kg is attached to the torpedo. The amount of water filtered during each haul is measured using an internal Valeport electronic flowmeter. On the frame an external flowmeter is also mounted, to check for blowing of the net due to large amounts of phyto- and microzooplankton in the water.

On top of the torpedo a Seabird 911plus CTD with a Benthos PSI 916 altimeter is mounted to monitor live view the depth of the torpedo in the water column and the bottom under the torpedo. The CTD also measures temperature and salinity.

Adult fish samples were taken using the pelagic 2000 trawl or with fishing rods.



Figure 3.1. Gulf VII plankton torpedo.

3.2 Fishing method

This survey is carried out on board the 'RV Tridens'. The speed during fishing with the plankton torpedo is 5 knots through the water. At each station a 'double oblique' haul is performed (Fig. 3.2). The Gulf VII sampler is lowered to 5 m above the sea floor or to 200 m depth maximum. To ensure enough water is filtered during the haul, haul duration should at least be 10 minutes. At stations with low depth a double 'double oblique' is performed without the torpedo breaking the surface of the water. In this way each 10 meters of the water column are sampled 1 minute going down and going up. In case of a thermocline stronger than 2.5°C over 10 meters the sampler is lowered to 20 meters below the thermocline.

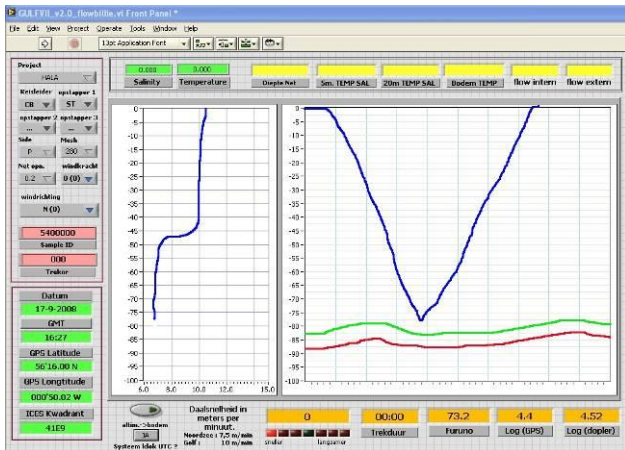


Figure 3.2. Illustration of a 'double oblique' haul in the Labview program.

3.3 Sampling grid

IMARES is asked by WGMEGS to sample the whole spawning area in period 1 (Fig. 3.3.1 & 3.3.2) and the southern part of the spawning area in period 2 (Fig. 3.3.3). Each half ICES rectangle a plankton sample is taken. Each week two pelagic trawl hauls were planned in the spawning area (Fig. 3.3.1 – 3.3.3). A pelagic haul is performed when fish are visible on the echo sounders.

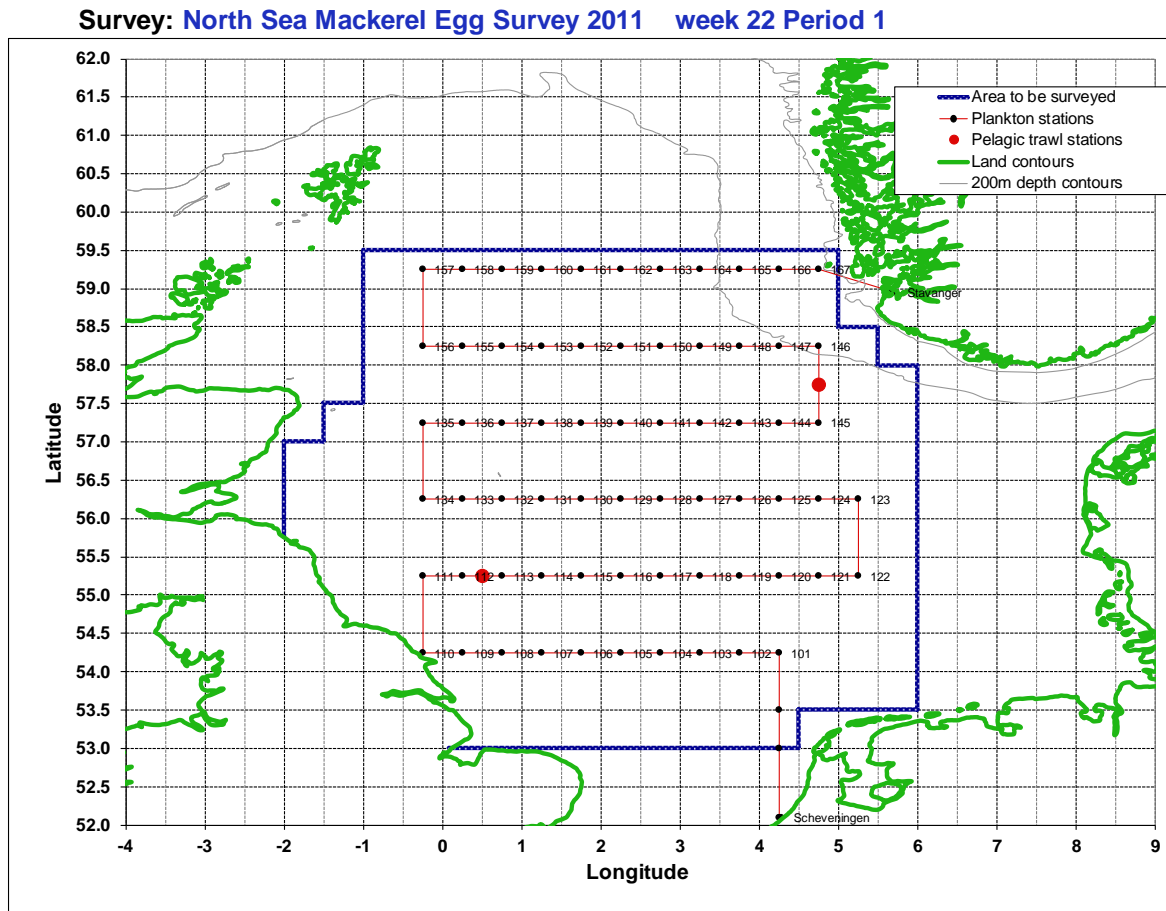


Figure 3.3.1. Planned sampling grid in week 22 (Period 1).

Survey: North Sea Mackerel Egg Survey 2011 week 23 Period 1

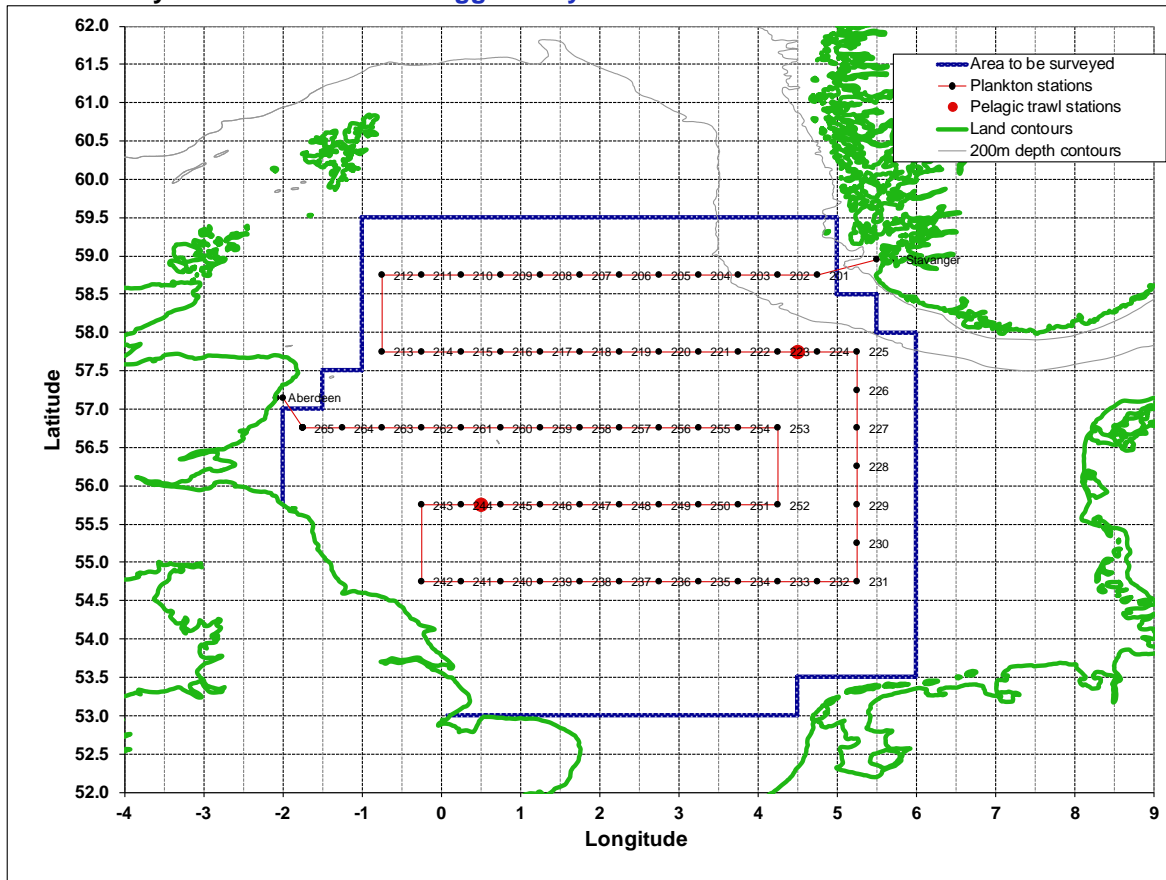


Figure 3.3.2. Planned sampling grid in week 23 (Period 1).

Survey: North Sea Mackerel Egg Survey 2011 week 24 Period 2

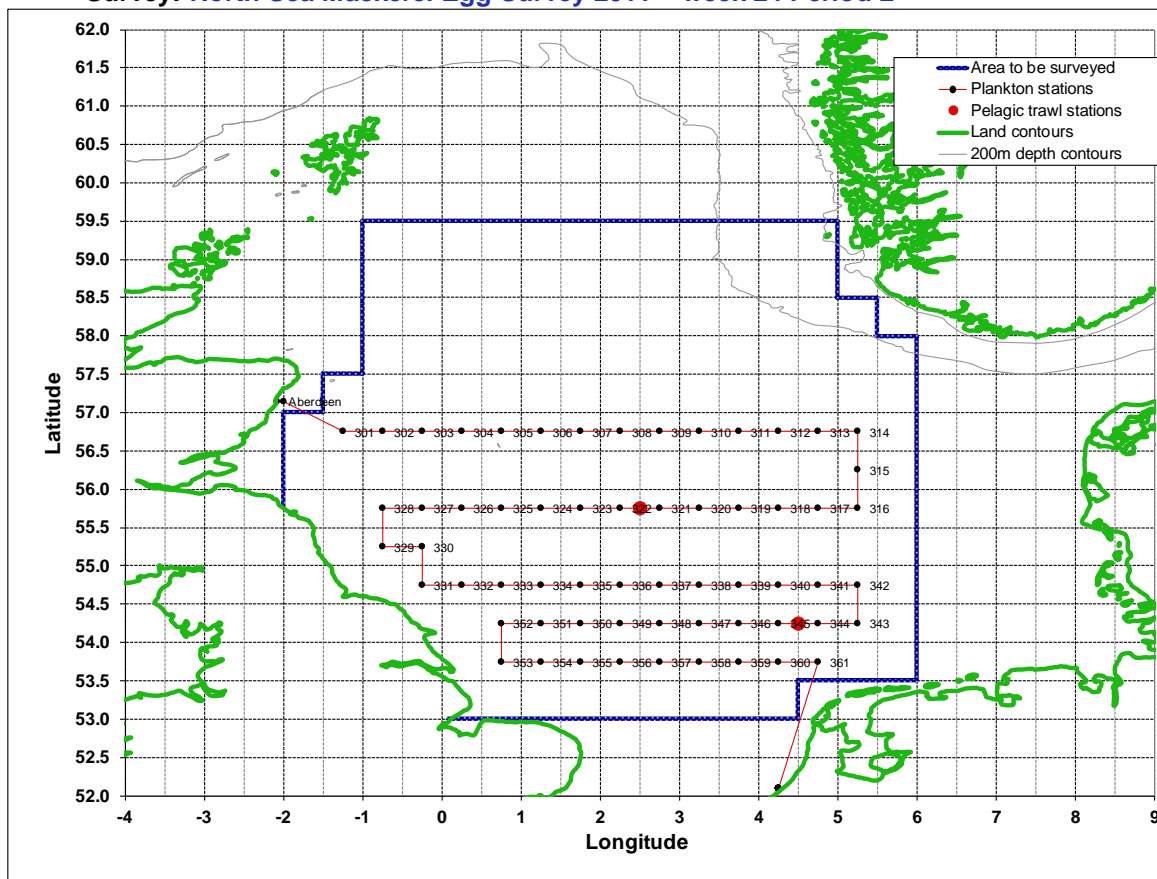


Figure 3.3.3. Planned sampling grid in week 24 (Period 2).

3.4 Sample processing on board

3.4.1 Plankton samples

As soon as the torpedo is back on board the vessel, the sample (Fig. 3.4) is brought to the hydrographic lab.



Figure 3.4. The codend with the plankton sample.

The fresh sample is immediately fixed in 4% buffered formaldehyde. After at least 24 hours of fixation, the fish eggs are separated from the other plankton using the 'spray method'. The sample is sprayed until few eggs remain in the last spray. Then the whole plankton sample is sorted to check for remaining eggs. Eggs are photographed and identified to species using image analysis (Fig. 3.5). All eggs are counted and identified to species. For mackerel eggs, per sample, at least one hundred eggs are measured and the development stage is determined. The remaining mackerel eggs are counted. If the sample contains a lot of eggs these are all sorted from the sample, and then subsampled using a 'Folsom'-splitter ensuring at least 100 mackerel eggs are staged.

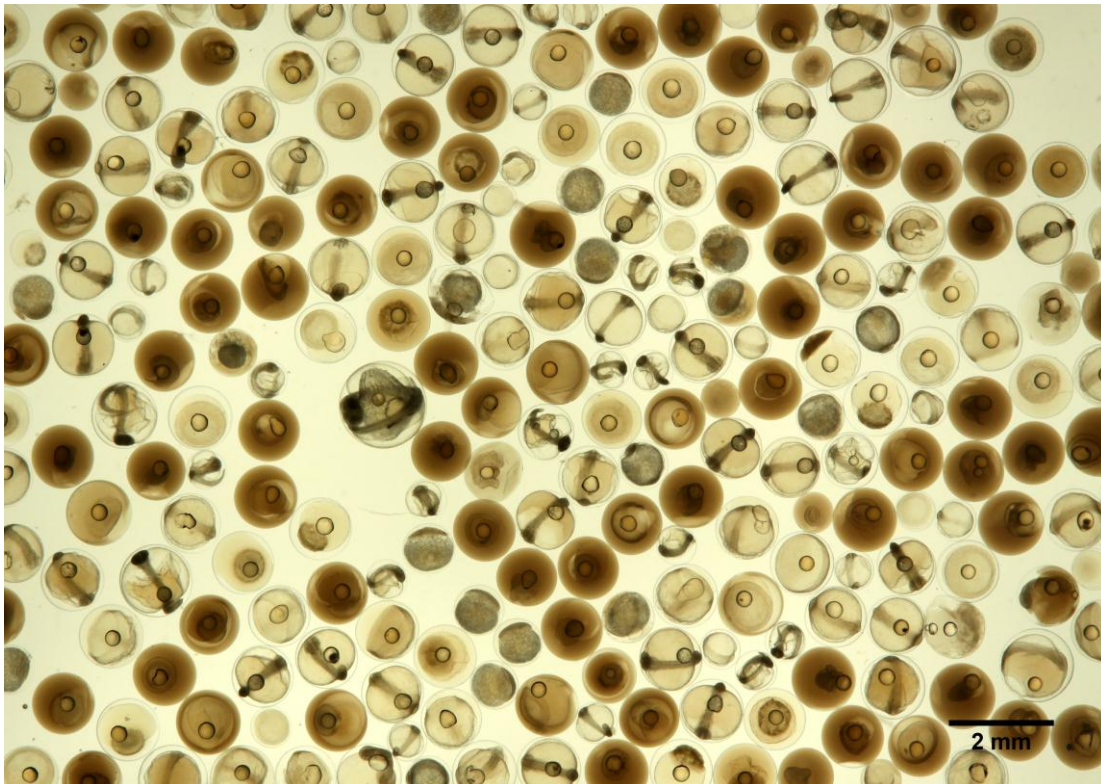


Figure 3.5. Mackerel and other fish eggs in a sample.

3.4.2 Adult fish samples

In principal all the fish are put on the conveyor belt and the total catch weighed. All mackerel are collected from the catch. Total weight of all mackerel is measured. One hundred mackerel are taken randomly from the catch. If less than 100 mackerel are caught all are measured. Of each individual length, weight, sex and maturity are taken.

From the 100 mackerel, females in development stage 3 to 6 are collected. In total 50 female mackerel are sampled divided over all the trawl hauls. Of each female, length, weight, maturity, age, ovary weight, liver weight, stomach weight and guts weight is collected. Of the ovary one whole lobe is put in 3.6% formaldehyde for atresia sampling. From the other lobe 2 25 µl pipette samples are collected and put in 3.6% formaldehyde. Also a teaspoon full of oocytes is collected for histological confirmation of the maturity stage. Of 10 mackerel 10 pipette samples are taken for a ring test between analyzing institutes.

3.4.3 Hydrated oocytes and POF's

Post-ovulatory follicles (POF's) are a sign that the female has already spawned during this spawning season. However it is unknown how long the POF's remain in the ovary before they are reabsorbed. This trial will allow for the collection of POF's at different time intervals after spawning and for histological examination of the different POF's degeneration stages.

Of 6 females with mature oocytes, some oocytes are collected. These oocytes will be treated with hormones and put in plastic vials in the constant temperature room to develop until ripe for spawning. During this trial the different development stages of the oocytes and POF's will be collected from the samples, and the time that POF's remain in the ovaries will be estimated.

All collected oocytes and POF's are photographed on board and fixed in 3.6% buffered formaldehyde solution for later histological analysis in the lab.

3.4.5 Fertilized eggs

While sorting out the catch, running mackerel are separated. The gonads from the running males and females are extracted as soon as possible. Using alcohol and seawater rinsed scalpels, the gonads are cut open and put in a sieve in clean sea water in order to fertilize hydrated eggs. After one hour the gonad remains are removed and the fertilized eggs are transferred to a clean sieve and put in the experimental tank with running seawater.

At the start of development fertilized eggs are sampled every few hours to ensure development stage 1B eggs are sampled. From development stage 2 sampling can be reduced but all stages should be collected up till hatching.

All eggs sampled are photographed on board and put into 4% formaldehyde solution.

3.5 Sample processing in the lab

3.5.1 Plankton samples

Remaining samples from the 2nd period need to be sorted and checked for sorting.

3.5.2 Adult fish samples

Upon return in the laboratory, fecundity samples are checked with histology for spawning markers. If no spawning markers are visible the samples are analysed for fecundity. If spawning markers do occur, this sample is analysed for atresia.

After fixation of at least 14 days in 3.6% formaldehyde the ovary lobes for atresia estimation are ready to be cut. From each lobe one or two whole sections (depending on the size of the ovary) of 0.5 cm thickness will be put in individual cassettes and sorted in 70% alcohol.

Half of the fecundity and atresia samples is sent to IMR for analysis. The remaining fecundity and atresia samples are analysed by IMARES.

If all maturity stage 3 samples contain spawning markers fecundity estimation is not possible and fecundity and atresia data from the last survey are used.

3.6 Calculation of the number of eggs

The total number of eggs in the water is calculated using the below formulas:

The volume filtered is obtained from the formula:

$$\text{Volume filtered} = \frac{\text{area of mouth opening (m}^2\text{)} * \text{efficiency factor} * \text{flowmeter revolutions}}{\text{flowmeter calibration constant}}$$

The numbers per square metre at each station can be calculated as:

$$n / m^2 = \frac{\text{eggs per sample (n)} * \text{sampler depth (m)}}{\text{volume filtered (m}^3\text{)}}$$

4. Survey

Date and time

From (harbour)	Date	Time (UTC)	To (harbour)	Date	Time (UTC)
Scheveningen	30-05-2011	11:15	Stavanger	04-06-2011	09:00
Stavanger	06-06-2011	08:30	Aberdeen	10-06-2011	21:00
Aberdeen	12-06-2011	11:30	IJmuiden	16-06-2011	05:00

Crew Cindy van Damme (cruise leader)
Kees Bakker
Hans Wiegerinck

Volunteers

Jeike van de Poel
Carmen Embregts

Guests

Carlos Pinto (ICES)

Deviations from the proposed sampling grid

In week 22 we did not sample the two most western stations on the Northerly transects due to time constraints (Fig. 4.1.1). In week 23 we did not sample one station in front of Aberdeen harbour due to time constraints (Fig. 4.1.2). Also stations at the end of the transects were moved from the centre of the half ICES rectangle to the borders in order to reduce steaming time. In order not to have to drop stations due to time constraints, in week 24 all stations at the end of the transects were moved from the centre of the half ICES rectangle to the borders (Fig 4.1.3). We managed to sample all stations in the last week. In total 5 fishing hauls were performed, three in week 22 and two in week 23 (Fig 4.1.1 & 4.1.2). Since all adults samples were collected from these 5 hauls no fishing was done in week 24.

Survey: North Sea Mackerel Egg Survey 2011 week 22 Period 1

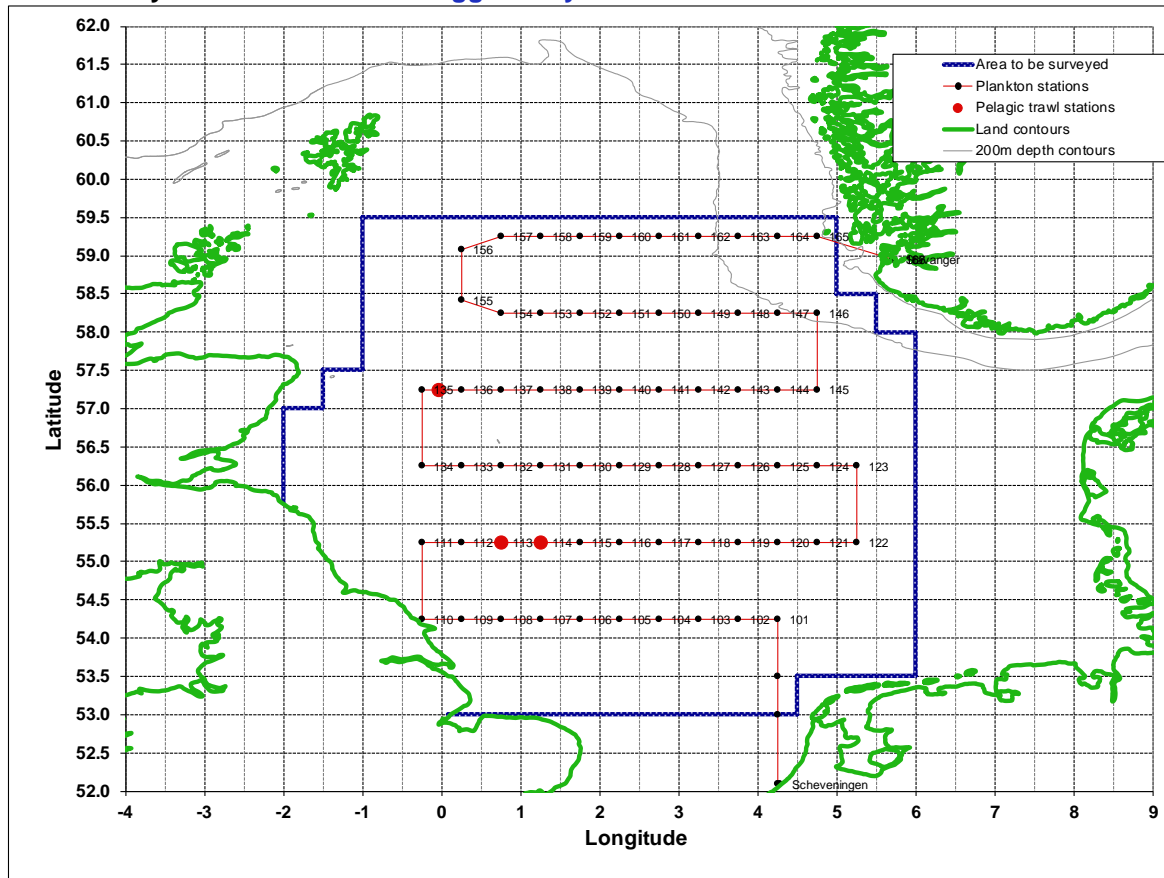


Figure 4.1.1. Sampled station grid in week 22 (Period 1).

Survey: North Sea Mackerel Egg Survey 2011 week 23 Period 1

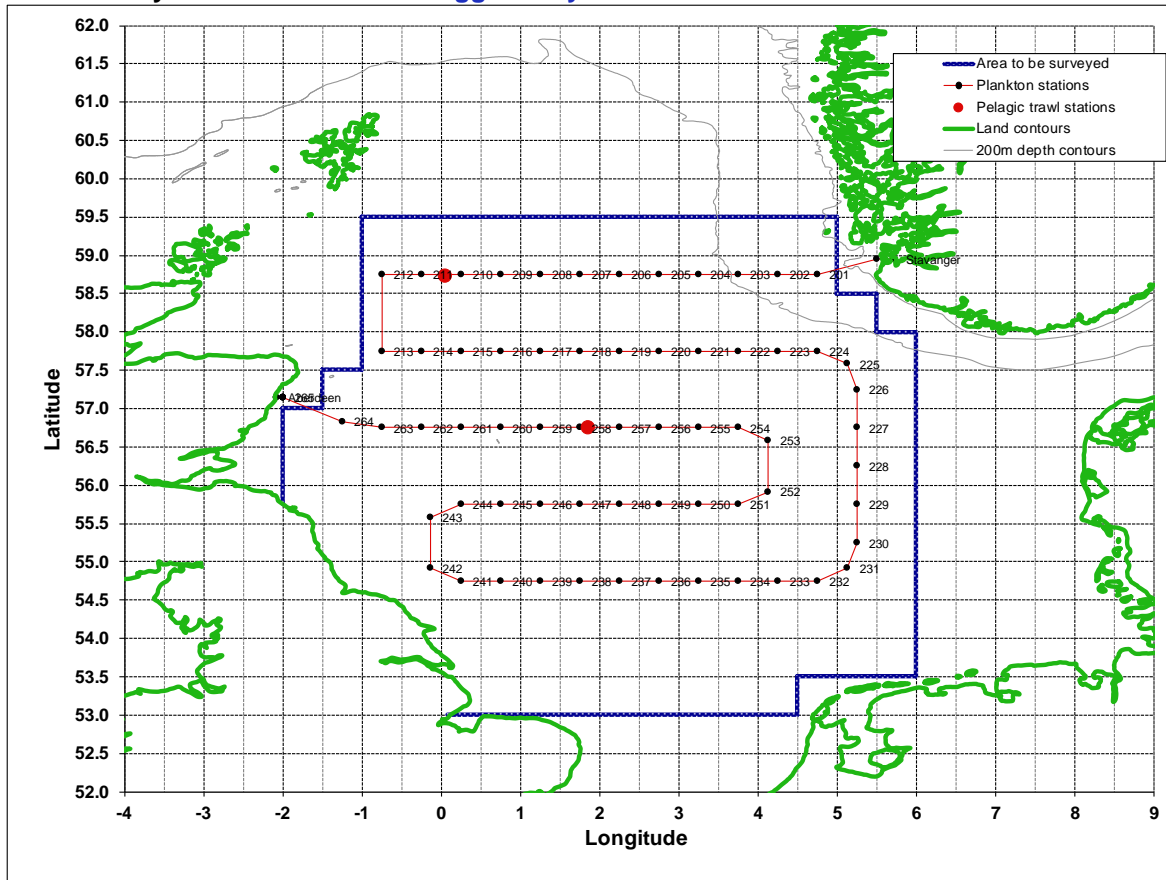


Figure 4.1.2. Sampled station grid in week 23 (Period 1).

Survey: North Sea Mackerel Egg Survey 2011 week 24 Period 2

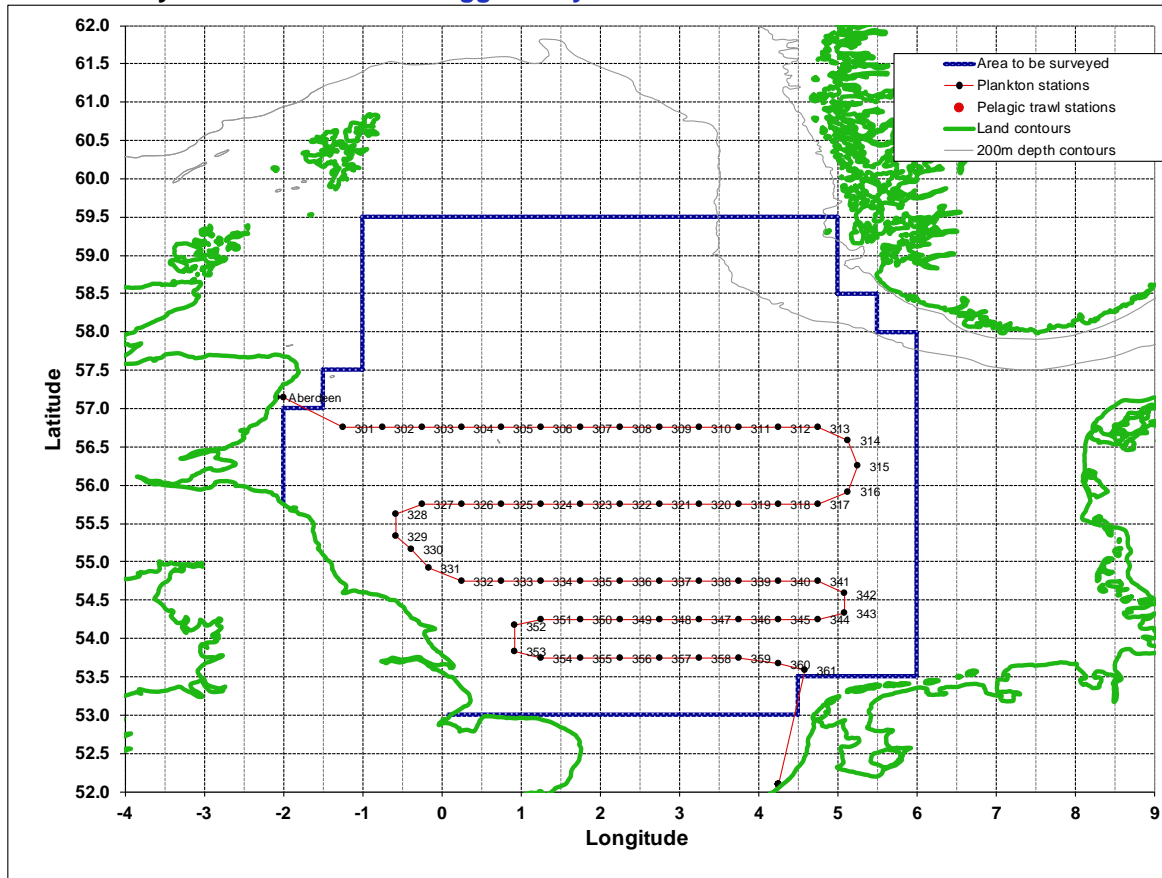


Figure 4.1.3. Sampled station grid in week 24 (Period 2).

Damage to sampling materials

No damage to the sampling gear occurred during this survey. Due to one rain shower problems occurred with the connections of the slip-rings of the starboard side winch. This was solved during the survey.

Survey

Week 22

Left Scheveningen harbour on Monday 30 May 2010 at 11:15 (UTC). Steaming north to the first station at 54.15N 4.15E. On our way to the first station we performed a trial and calibration haul with the Gulf 7 plankton torpedo to test if everything was working properly. The test and calibration showed that all was working properly. Two calibration hauls were performed.

We arrived at the first station on 30th May 21:15 (UTC). Fishing with the Gulf 7 torpedo was all right.

On Tuesday morning the pelagic net was prepared for fishing. At station 109 the codend was dropped on deck and the sample was lost. Tuesday evening we fished with fishing rods for mackerel. At 18:45 (UTC) we saw dolphins and gannets foraging around the vessel but we manage to catch only 4 mackerel, one female and three males. At dusk, 20:15 (UTC), we caught 28 kg mackerel in 15 minutes angling.

Sampling of the catch was finished at 23:00 (UTC).

The weather was good during this week and sampling with the plankton torpedo occurred without any problems for the remainder of this week. At station 151 the CTD data was recorded as station 150, thus no CTD file of station 150 (5400170) is available. However, temperature and salinity were saved in the Billie file for this tow.

On Thursday at 08:00 (UTC) we did a pelagic trawl haul. The trawl sonar did not work properly, but we managed to catch an almost clean mackerel haul. The haul consisted of 628 kg of mackerel and 2kg of other fish, mainly whiting and haddock. The catch contained running males and females and eggs were collected and fertilized. Eggs developed until stage 2 however, than development stopped, probably due to infection. Eggs were collected in the different development stages and fixed on 4% formaldehyde.

Eggs were also fixed in 96% alcohol for genetic analysis at the University of Hamburg.

On Friday evening at stations 156 (5400176), at 17:23 (UTC), labview failed while the torpedo was lowered in the water but could be restarted without having to hauls the torpedo up again. This problem probably occurred due to full memory of the computer. A large print task was send to the printer in the hydrographic lab thus causing memory failure of the labview computer.

The last station 165 (5400185) was sampled at 05:36 (UTC) on Saturday morning 4th June. We arrived in Stavanger at 9:00 (UTC).

We caught a lot of mackerel and sprat eggs this week.

Week 23

Left Stavanger harbour on Monday 6th June at 08:30 (UTC). Due to engine problems we could not leave Stavanger harbour until 08:30. We arrived at the first station at 11:41. A rain shower caused water to penetrate in the slip-ring connections of the starboard side winch and we switched to the portside plankton winch at station 203 (5400188). Due to a connection problem in the lab we did not receive any data from the vessel at station 206 and could not see the torpedo in the water column, so it was hauled back to the vessel (this is an invalid haul).

On Tuesday morning we performed a pelagic fishing haul. We only caught 20 norway pout and no mackerel.

We tried to switch back to the starboard side winch at station 216 (5400201), because we did not receive data from the external flowmeter from the port side winch, but half way the haul we lost communication with the CTD. The torpedo was hauled back on board and since the switch to the other winch takes considerable time we left this station to steam to the next one. After some repairs we again tested the starboard side winch at station 230 (5400215). We managed to do a full haul but with errors in the communication with the CTD so switched back again to the portside winch at station 231.

At station 239 another test with the starboard side winch was done and this time all worked properly and we continued sampling with this winch.

On Thursday afternoon and evening we angled for mackerel after every plankton haul but we only caught 3 mackerel. On Friday morning we performed another pelagic trawl haul and caught an almost clean mackerel haul (127 kg mackerel and 9 kg other fish (mostly haddock)). We again caught running female and male mackerel and eggs were fertilized.

The last station was sampled at 16:20 (UTC) on Friday 10th of June. We arrived in Aberdeen at 21:00 (UTC).

We caught lots of mackerel and other fish eggs this week.

Week 24

During the weekend a close watch was kept on the fertilized eggs by Tridens and IMARES crew and the eggs continued to develop. Mackerel eggs were sampled at different development stages.

We left Aberdeen harbour on Sunday 12th of June at 11:30 (UTC). We arrived at the first plankton station at 13:55 (UTC). Due to improper handling of the winch, with very different setting and hauling speeds during the haul, station 304 was an invalid haul and the sample lost.

After station 304 plankton sampling occurred without any problems.

Since all mackerel fecundity and atresia samples were collected in the first two weeks no pelagic fishing was done this week.

The last plankton station was sampled at 21:57 (UTC) on Wednesday 15th of June. We arrived in IJmuiden harbour on Thursday 16th of June at 07:00 (UTC).

Again a lot of mackerel eggs were caught.

In total 190 plankton hauls were performed, of which 4 were invalid. Eggs of 148 samples were counted, staged and identified to species.

Sample-id's

Plankton hauls 2011.5400121 - 2011. 5400310

Fishing hauls 2010.5400321 – 2010.5400325

Samples and data

During this period a total of 190 (including 4 invalid hauls) plankton stations with CTD measurements, 5 fishing hauls and 2 calibration tows were performed covering the whole of the proposed sampling area. At each plankton station a double oblique haul was performed and minimum sampling time was 10 minutes.

Remarks for the next surveys

The slip-ring connections of the plankton winches are vulnerable to water leakage and need to be replaced. This survey we only had few rain showers, but the one shower caused connection problems with the starboard winch. The slip-rings on both plankton winches need to be replaced for high-quality slip-rings before the herring larvae survey in September 2011.

The length of the cables of both plankton winches is too short to reach 200 meter depth stations. The cables need to be replaced for 1200 meter cables in 2012 in order to be able to carry out the plankton sampling for the Atlantic mackerel and horse mackerel egg survey in 2013.

5. Results

5.1 Mackerel eggs

Numbers of mackerel eggs found in the samples were comparable to the previous survey in 2008 (Fig. 5.1 - 5.8). Highest egg numbers were found in the south western part of the spawning area. Total mackerel egg production in 2011 was 116×10^{12} (Fig. 5.9) and Spawning Stock Biomass (SSB) was estimated at 165×10^3 tons (Table 5.1), which is slightly higher compared to 2008. However, the highest egg production was found in the first sampling week (Fig. 5.9) and it is possible that the beginning of mackerel spawning is missed. The egg production could be an underestimate of the total mackerel egg production.

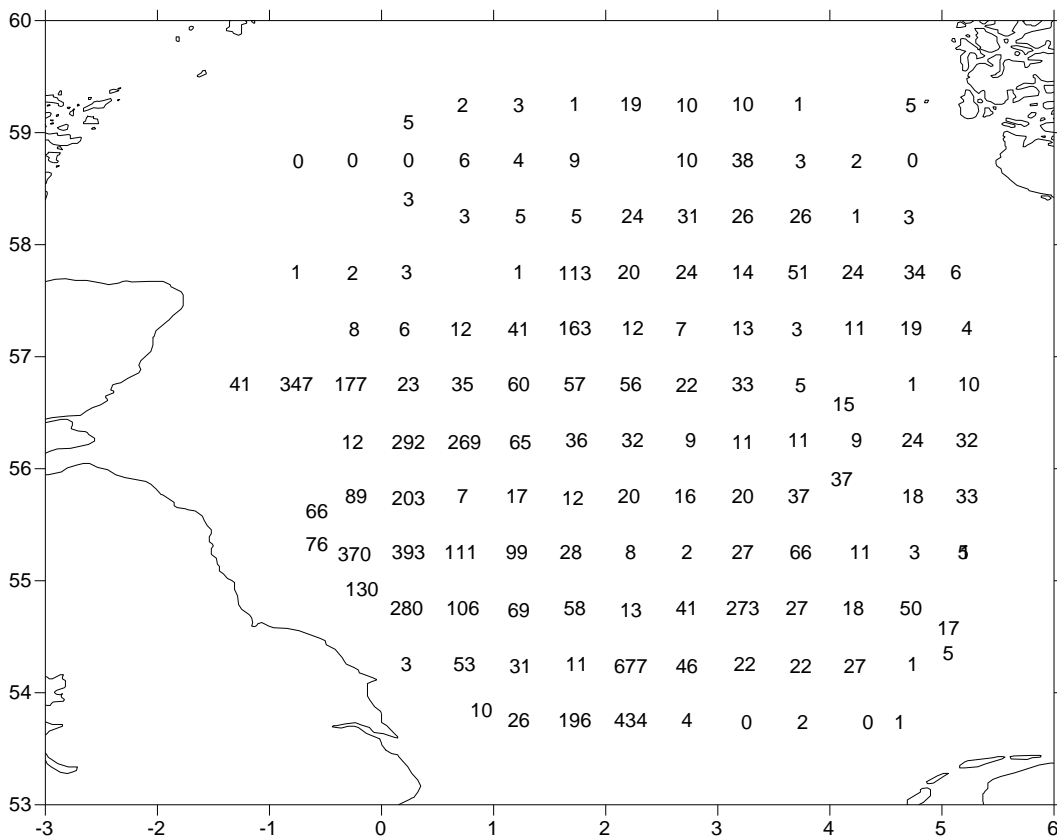


Figure 5.1. Total numbers of stage 1 mackerel eggs in all samples.

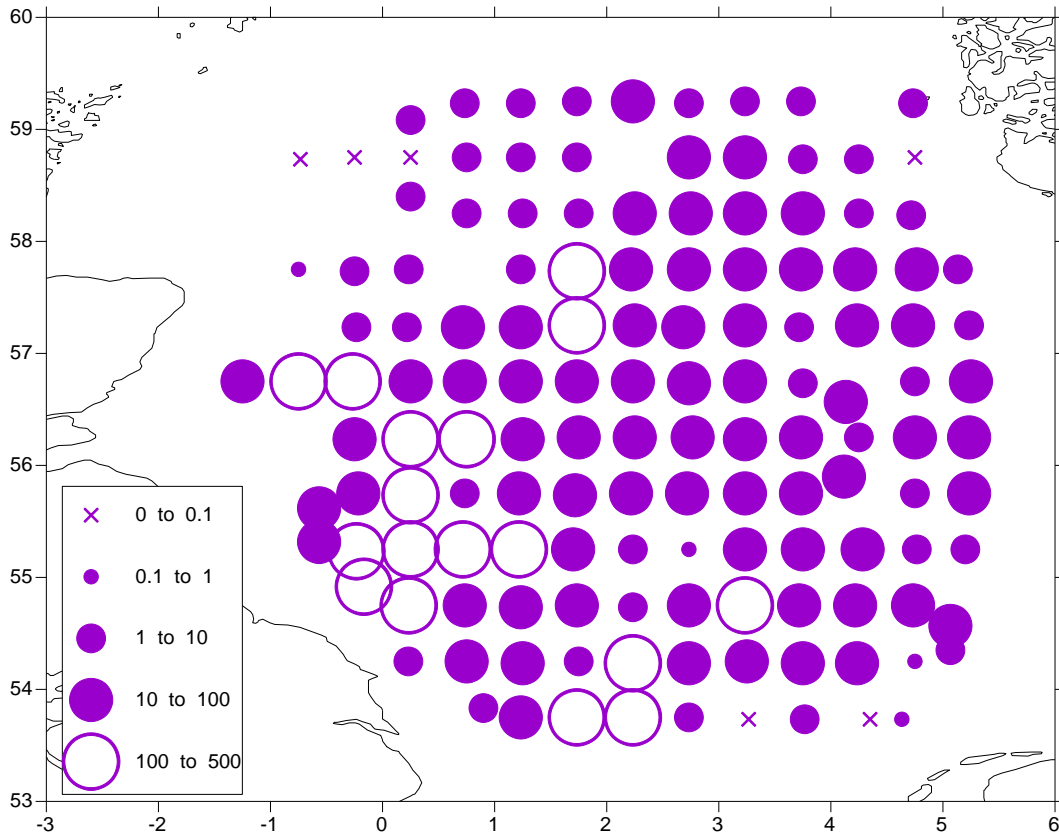


Figure 5.2. Numbers of stage 1 mackerel eggs per m^2 in all the samples.

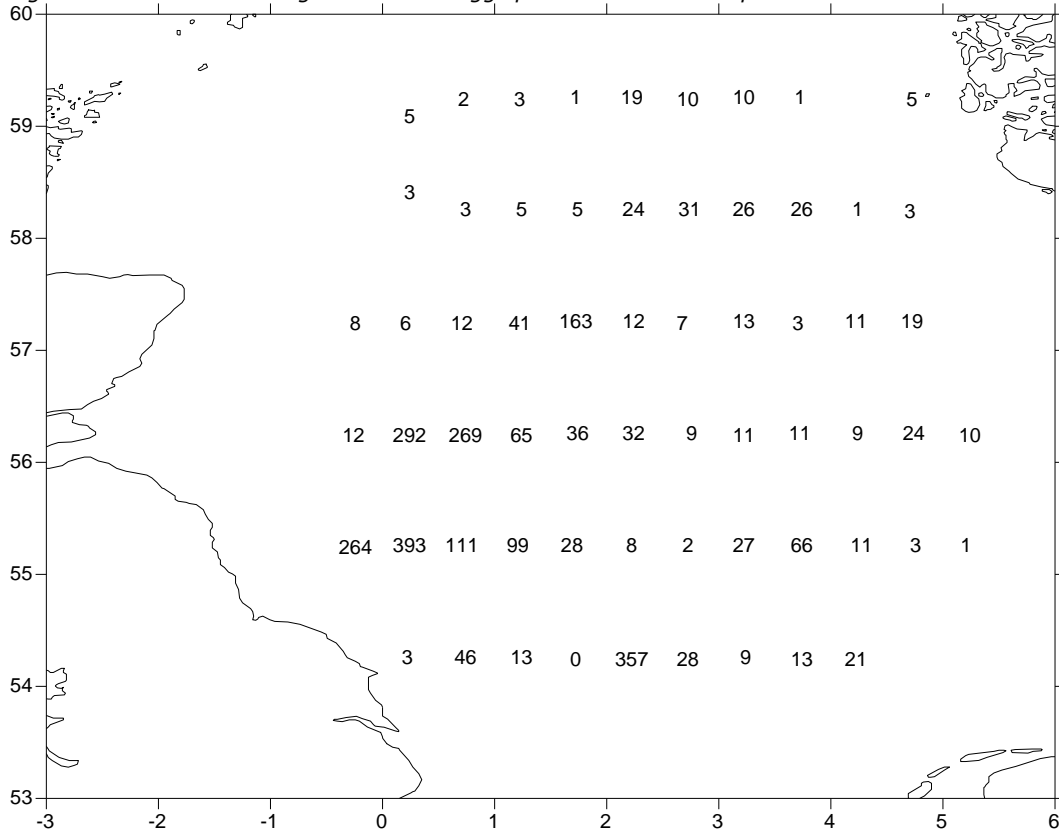


Figure 5.3. Total numbers of stage 1 mackerel eggs in week 22, in the samples.

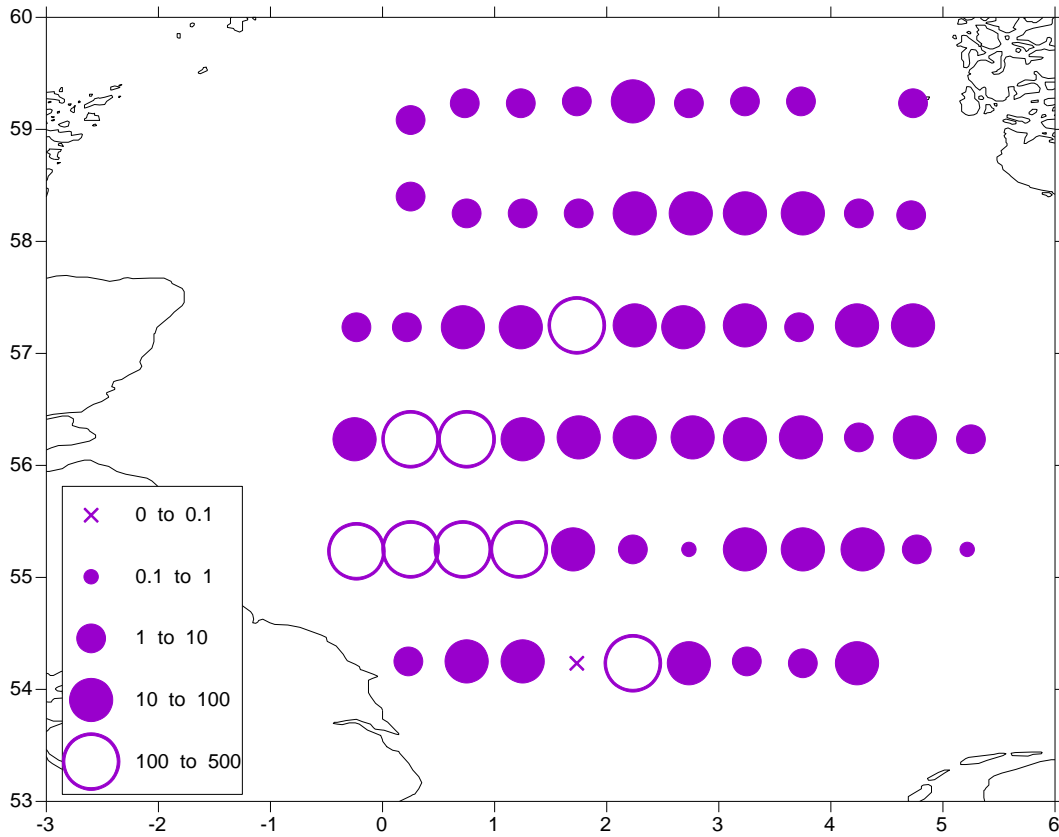


Figure 5.4. Numbers of stage 1 mackerel eggs per m^2 in week 22, in the samples.

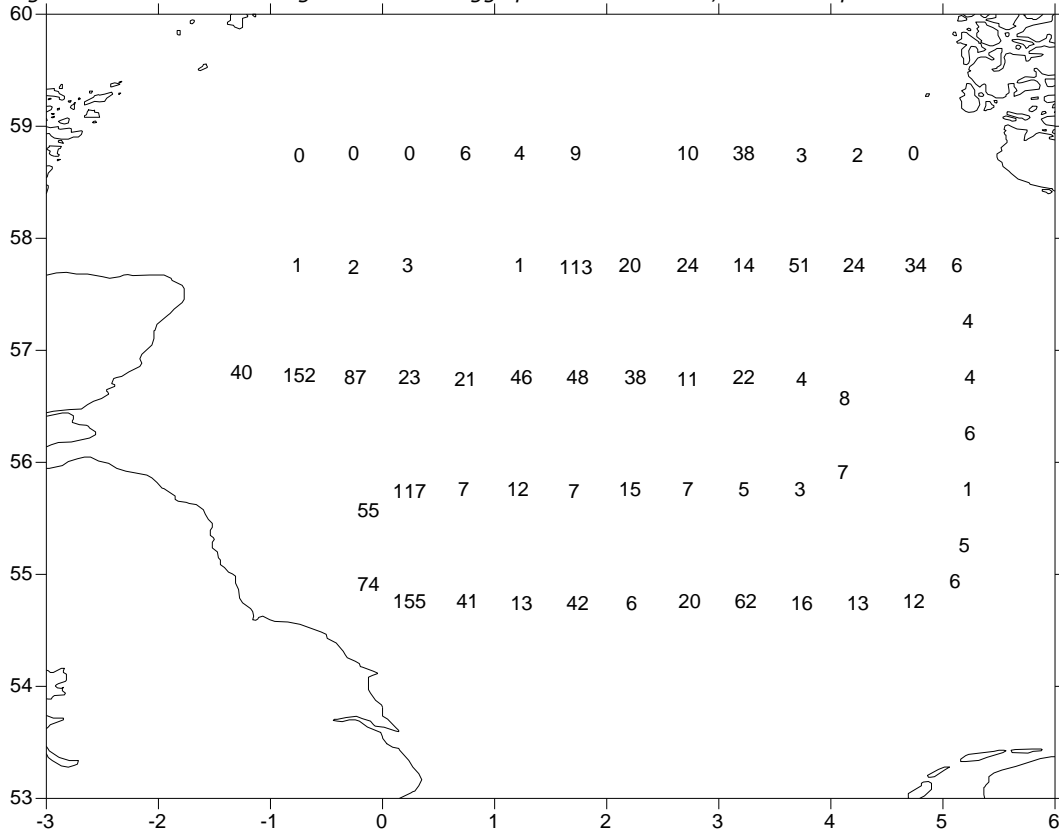


Figure 5.5. Total numbers of stage 1 mackerel eggs in week 23, in the samples.

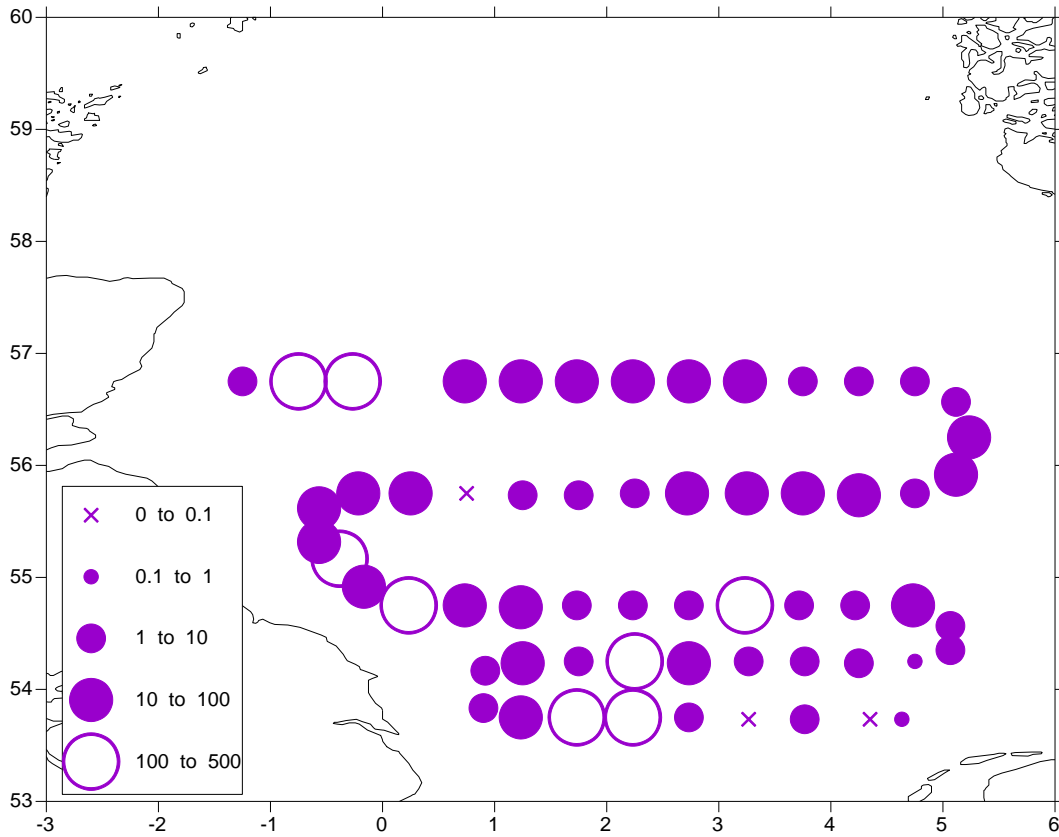


Figure 5.8. Numbers of stage 1 mackerel eggs per m^2 in week 24, in the samples.

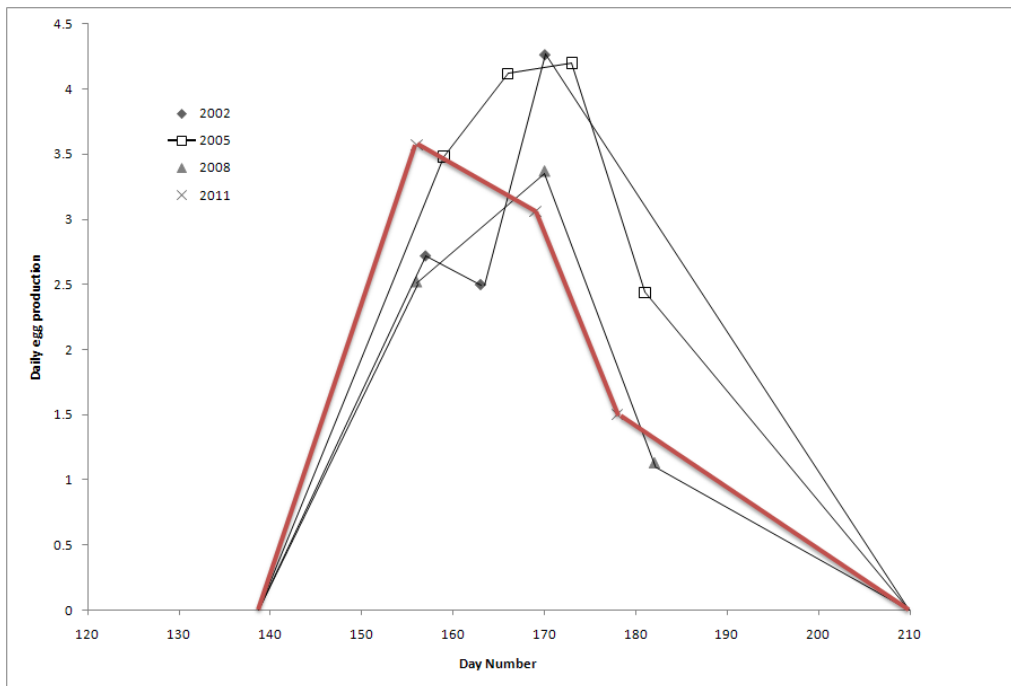


Figure 5.9. Egg production curve ($\times 10^{12}$) in 2002, 2005, 2008 and 2011.

Table 5.1 North Sea mackerel egg production and Spawning Stock biomass (SSB)

Year	Egg prod *10 ¹²	SSB*10 ³ tons	Observed peak of spawning (midpoint of the coverage giving the highest production)
1980	60	86	(25 June) ¹
1981	40	57	17 June
1982	126	180	23 June
1983	160	228	13 June
1984	78	111	12 June
1986	30	43	23 June
1988	25	36	20 June
1990 ²	53	76	24 June
1996	77	110	19 June
1999	48	68	-
2002	147 (118)	210 (168)	-
2005	155	223	22 June
2008	108	154	18 June
2011	116	165	-

5.2 Adult fish samples

We did a total of 5 fishing hauls, 3 in week 22 and 2 in week 23, of which 4 contained mackerel. We managed to collect all female ovary samples we were asked to take. The samples were divided over the different tows.

5.3 Hydrated oocytes and POF's

Since only very few maturity stage 3 females were found in the fish samples, all of these were sampled for fecundity and it was not possible to collect oocytes for in vitro development studies.

5.4 Fertilized eggs

We managed to fertilize eggs in week 22, which did not develop beyond stage 2. Eggs in different development stages were collected for reference. In week 23 we again fertilized mackerel eggs. These survived and continued to develop until hatching. We were able to collect mackerel eggs in all the development stages. Of both batches eggs were collected and fixed on alcohol for genetic analysis at the University of Hamburg.

5.5 Hydrographical data

Salinity at 20m was stable over the sampled period and the sampling area (Fig. 5.10 – 5.12). Only in the north-eastern part of the spawning area close to the Norwegian coast seawater salinity dropped (Fig. 5.10 – 5.11).

Seawater temperature at 20m depth increased from North to South, with lowest temperatures found close to the Norwegian coast (Fig. 5.13 – 5.15). Temperature also increased over time (Fig. 5.13 – 5.15).

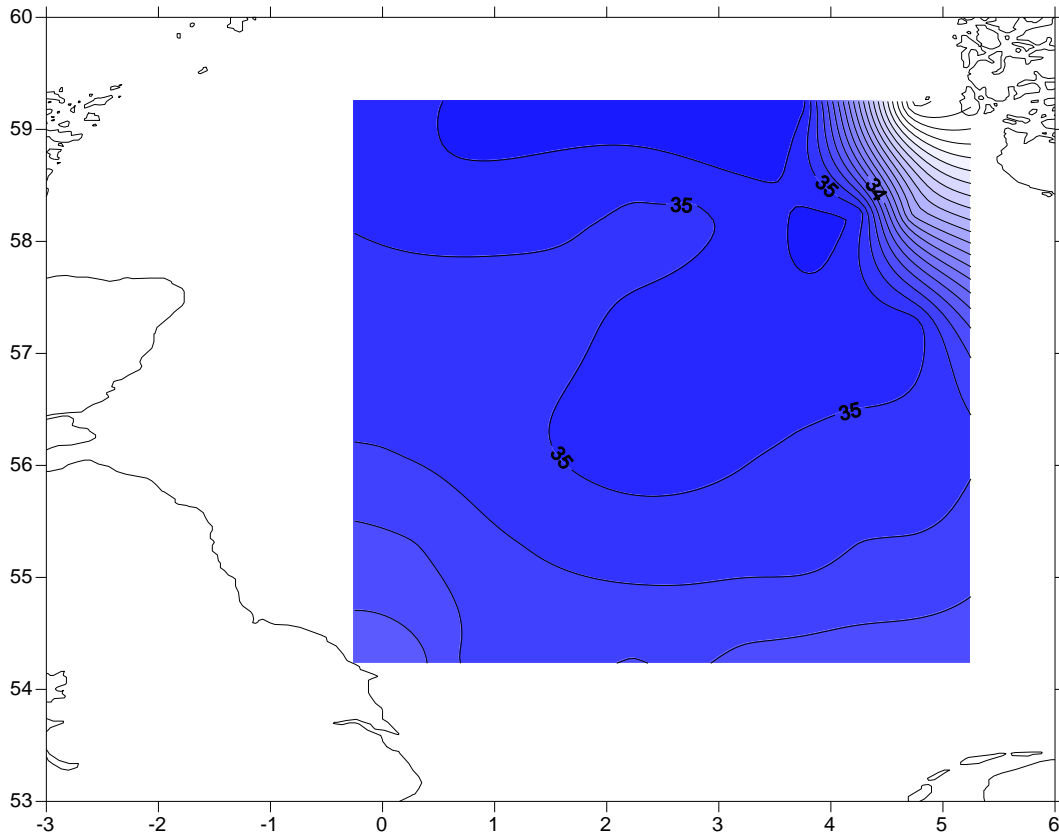


Figure 5.10. Salinity at 20m depth in the sampled area in week 22.

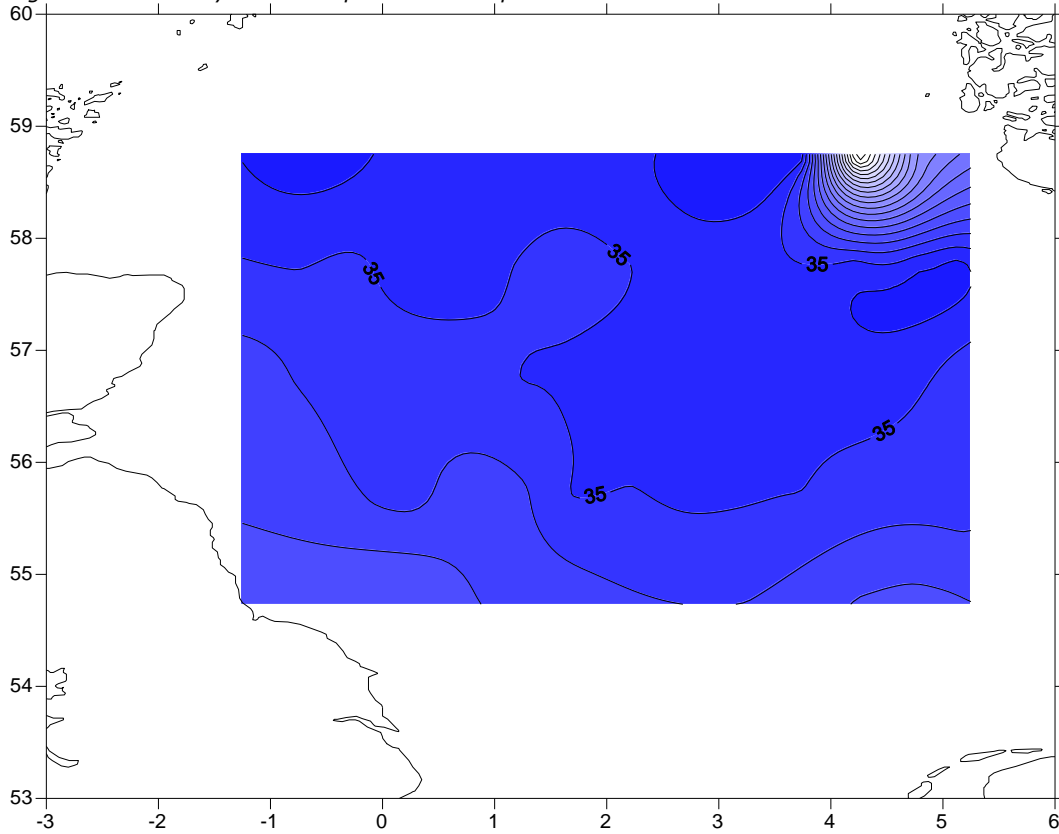


Figure 5.11. Salinity at 20m depth in the sampled area in week 23.

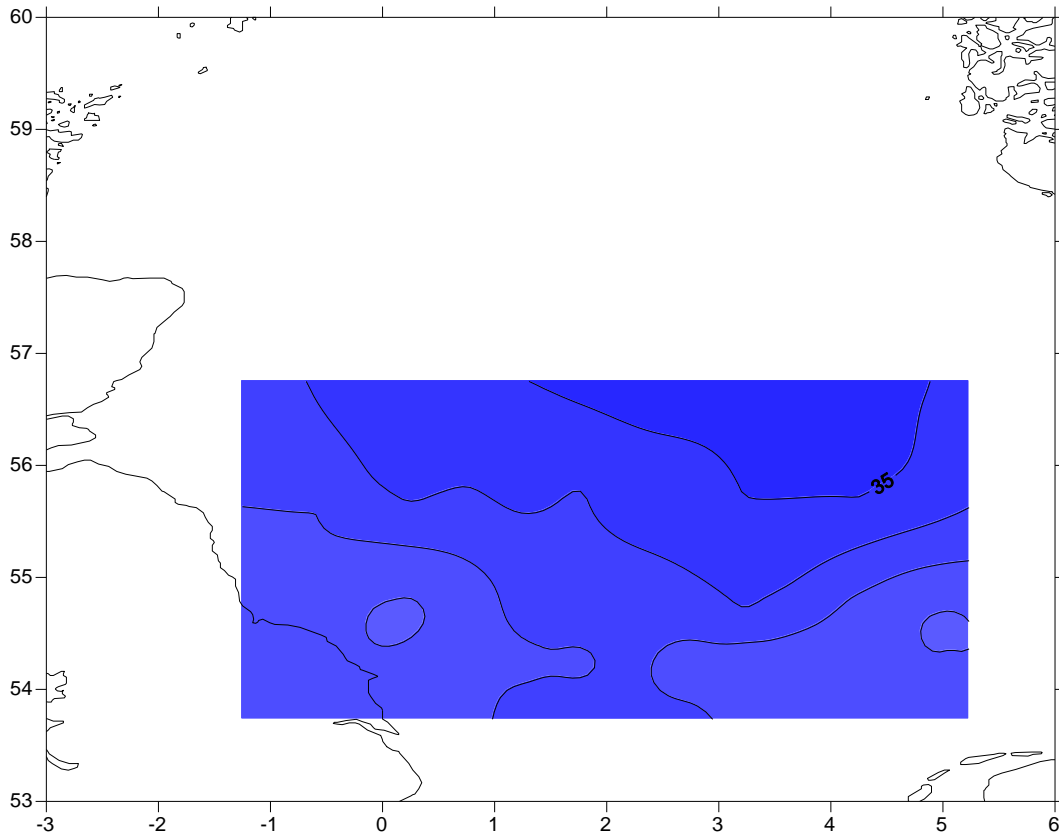


Figure 5.12. Salinity at 20m depth in the sampled area in week 24.

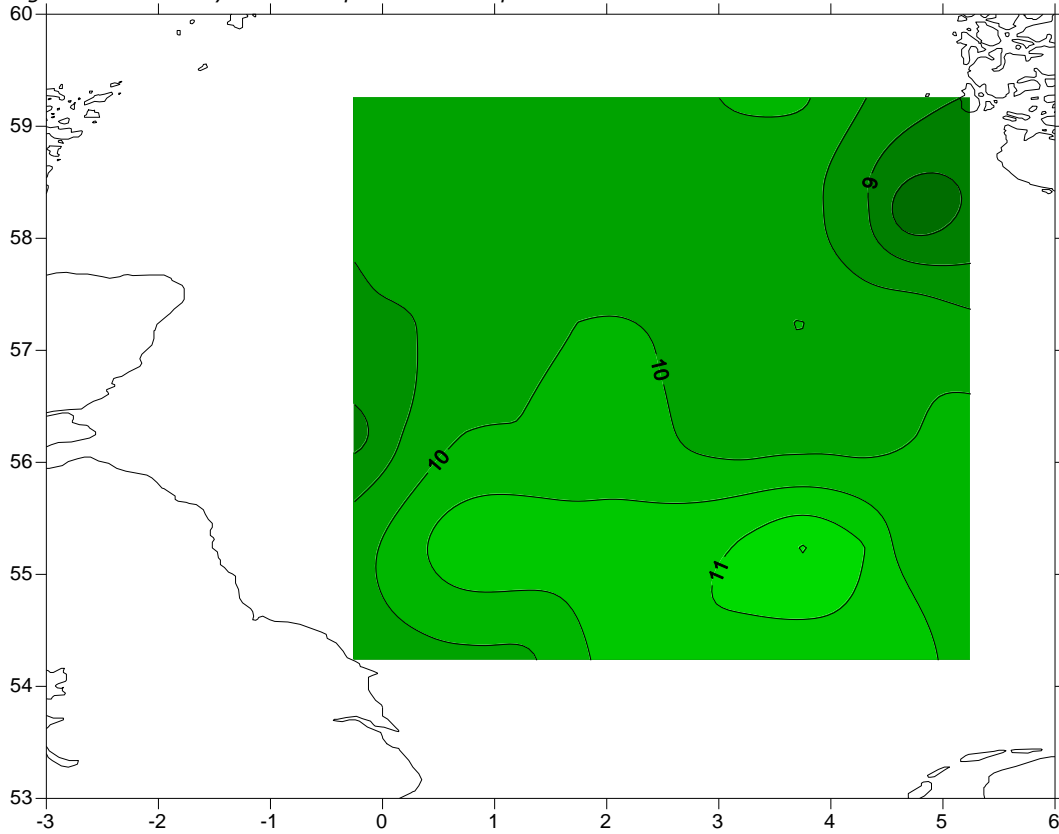


Figure 5.13. Temperature at 20m depth in the sampled area in week 22.

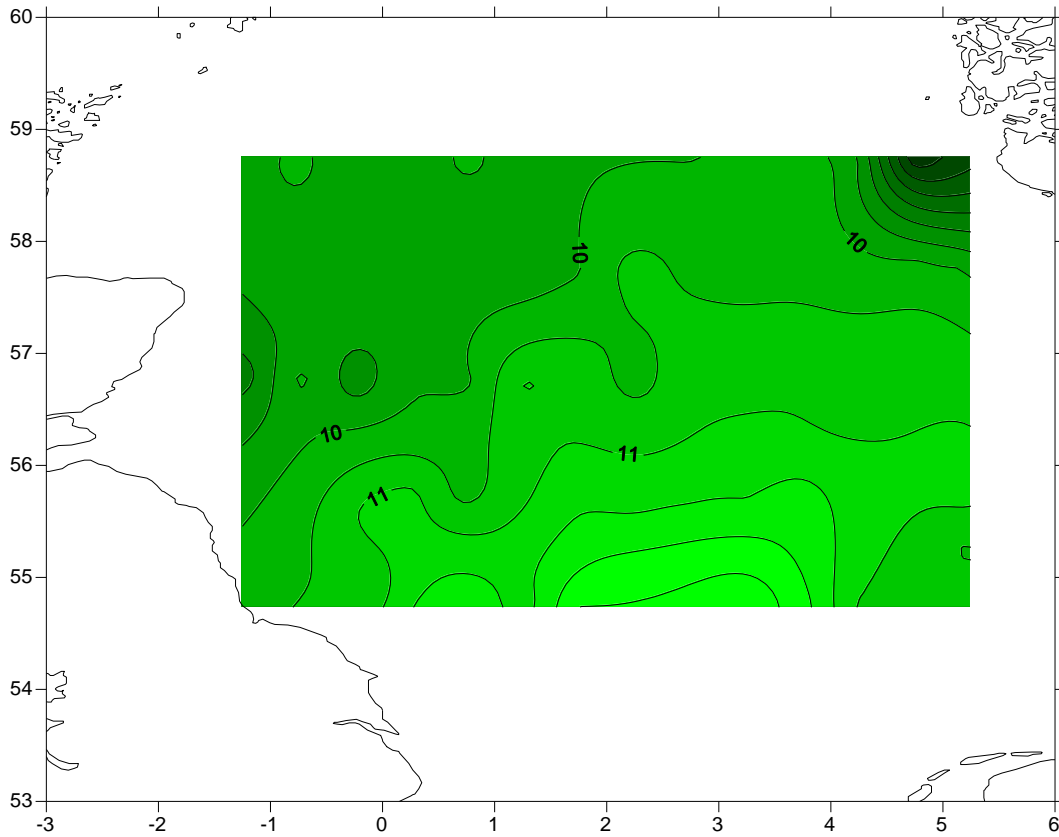


Figure 5.14. Temperature at 20m depth in the sampled area in week 23.

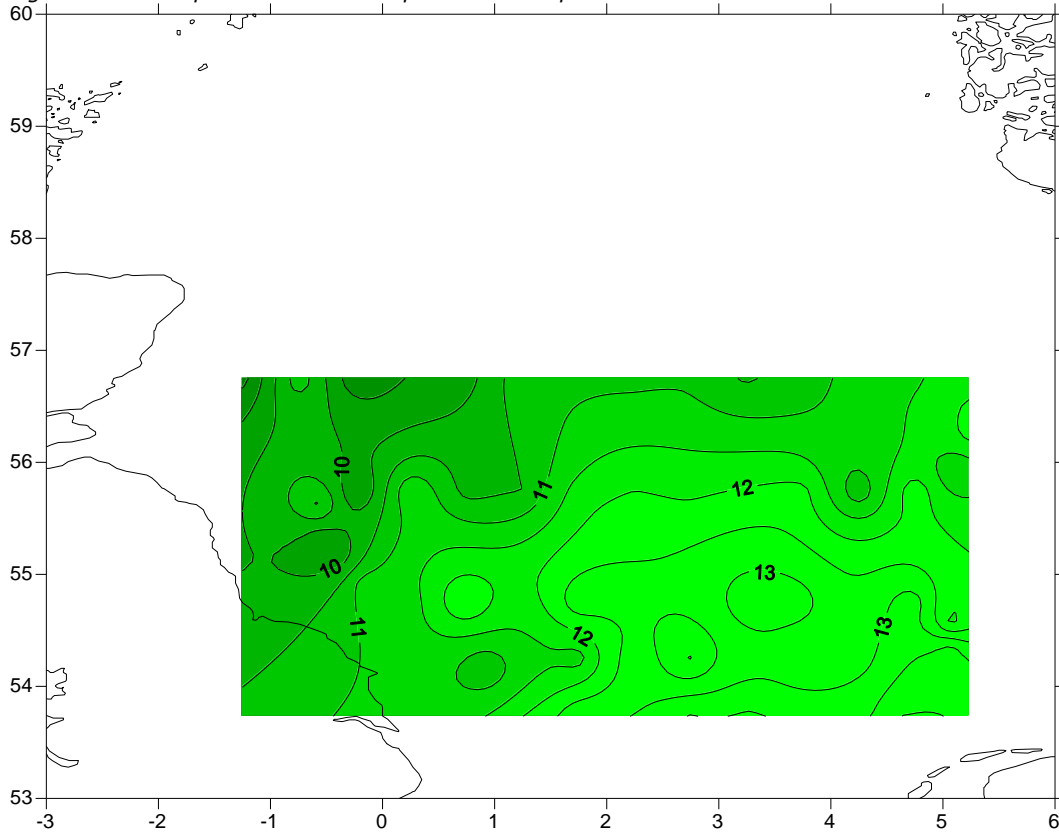


Figure 5.15. Temperature at 20m depth in the sampled area in week 24.

6. Exchange with ICES colleagues

During the 2011 mackerel egg survey, Carlos Pinto from the ICES data centre joined the survey on board 'RV Tridens' during week 23. Carlos is currently in charge of developing the ICES database for the storing of ichthyoplankton data collected during the ICES coordinated ichthyoplankton surveys. Field experience helps to understand how ichthyoplankton data are collected and will give a better insight in how to best store these data in an ICES database.

These exchanges of staff between vessels are highly educational and should be encouraged in future surveys.

7. Acknowledgements

We would like to thank the crew of 'RV Tridens' for a pleasant stay on board and their cooperation with the plankton and adult fish sampling. We would also like to thank all the volunteers, Jeike van de Poel and Carmen Embregts, and our ICES colleague, Carlos Pinto, for their much appreciated support and help during the survey.

8. Quality Assurance

8.1 Check on the sorting of the samples

For quality assurance sorting of the samples is checked. During and after the survey, of each plankton-`sprayer' at least 3 samples, with different total amounts of plankton, are checked if eggs are properly sorted. If > 5% of the total number of eggs remain in the samples, all samples of this person are checked and numbers adjusted.

8.2 ISO

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 57846-2009-AQ-NLD-RvA). This certificate is valid until 15 December 2012. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Environmental Division has NEN-AND-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2013 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.


Justification

Report number : C026/12

Project number : WOT-05-406-110-IMARES-11

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: Ingeborg de Boois
Project leader WOT Surveys

Signature: 

Date: 23 February 2012

Approved: John Schobben
Head of department fish

Signature: 

Date: 23 February 2012