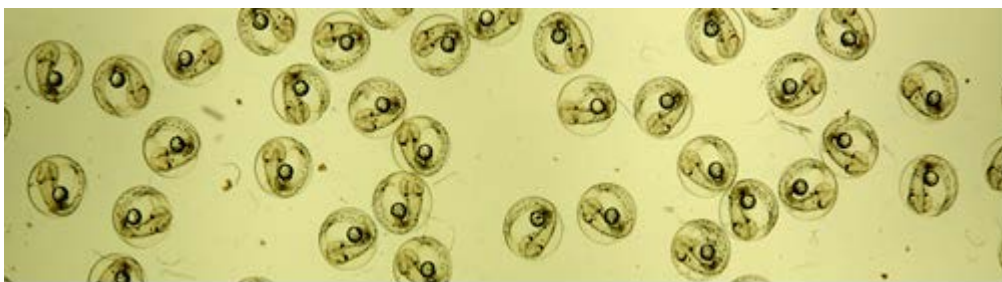


North Sea mackerel egg survey in May and June 2015

C.J.G. van Damme

Report number 15.010



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Summary

After technical problems prevented the North Sea mackerel egg survey to be carried out in 2014, a successful survey was carried out in May-June 2015. The survey was carried out on board 'RV Tridens'. The expected mackerel spawning area was covered in each of four periods in east-west transects, separated by 1 degree. In total 260 valid plankton hauls with a Gulf VII plankton sampler were performed, as well as 3 fish hauls and 4 sets of flowmeter calibrations hauls.

The distribution maps seem to suggest that most of the mackerel spawning is covered, but only on a few stations no eggs were caught, showing that the borders of the mackerel spawning area were not reached. However most of the stations with highest spawning concentrations were spread over the area and not on the edge of the sampled area, except in period 2 where some spawning may have been missed in the southwest part of the spawning area.

Not all plankton could be analysed on board thus a proper comparison with the previous survey is not yet possible. However, the highest number of mackerel stage 1 eggs found in a sample was lower compared to 2011.

Highest spawning occurred in a line southwest to northeast over the spawning area with highest spawning occurring in the southwest. This pattern is comparable to previous surveys.

Macroscopic maturity staging of the collected ovary samples implies that both samples for potential fecundity and atresia estimation were collected, allowing for an estimation of total fecundity of North Sea mackerel.

The first period numbers of mackerel eggs were low, numbers increased in the second period and decreased again in periods 3 and 4. Mackerel adults caught in the first trawl haul in the second period did not show signs of spawning. Both observations indicate that the 2015 survey started at the beginning of the spawning season of North Sea mackerel. The higher number of mackerel stage 1 eggs found in period 2 compared to period 1, 3 and 4 suggests that the peak of mackerel spawning was also covered this survey.

Water temperature increased over the four periods, but temperature was lower compared to the 2011 survey. However, despite being lower than the preferred 13-14°C in the first three periods, water temperature was within the range for mackerel spawning. In period 4 water temperature increased to 13°C. Highest temperatures were found in the southeast part of the survey area while highest spawning occurred in the southwest part.

Salinity pattern was stable over the four periods. In the southwest and northeast influence of less saline coastal water is seen. In the northwest part of the spawning area inflow of high saline Atlantic water can be seen.

The North Sea mackerel egg survey is coordinated by the ICES working group for mackerel and horse mackerel egg surveys (WGMEGS). The results of this survey will be finalised at the next WGMEGS meeting in 2017.

1. Introduction

Every three years an international egg survey is carried out, to monitor the spatial and seasonal distribution of North Sea mackerel. Till 2011 this survey was carried out by the Netherlands and Norway, but in March 2014 Norway decided to withdraw from the 2014 survey. IMARES was the only institute to carry out the North Sea mackerel egg survey in 2014. However, after one survey week in 2014, technical problems with RV Tridens meant the survey had to be terminated (Damme & Bakker, 2014). It was decided to carry out the survey in 2015. Norway did not reconsider its participation in the egg survey and no other country has stepped forward to participate. Hence in 2015 Netherland was again the sole participant in the North Sea mackerel egg survey.

During this survey (1) mackerel eggs are sampled using a Gulf VII plankton sampler and (2) adult mackerel are sampled to estimate fecundity and atresia. The survey is designed to cover the whole mackerel spawning area and season in the central and northern North Sea. The North Sea 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.

The method used to estimate mackerel spawning stock biomass is the so-called Annual Egg Production Method (AEPM). The total number of eggs produced during the entire spawning season is estimated. Dividing the total egg production by the numbers of eggs produced by a single female gives an estimate of the female spawning stock biomass. The ratio between female and male mackerel gives an estimate of the total spawning stock biomass. This method is simple but requires an accurate estimate of the total fecundity (total number of eggs produced by a single female in one spawning period) of a female. Most of the survey time is often directed at the collection of egg samples. But during the survey enough time should be planned to also collect adult samples for the fecundity estimate.

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 four weekly periods, using a Gulf VII plankton sampler to sample fish eggs. Additionally, pelagic trawl hauls were carried out 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 by the ICES working group on widely distributed stocks (WGWIDE).

This report contains the cruise report and preliminary results of North Sea mackerel egg survey 2015. The results will be finalised at the next WGMEGS meeting in 2017.

3. Materials and Methods

3.1 Sampling gear

Mackerel egg sampling was performed with a "Gulf VII", a High Speed Plankton Sampler (Fig. 3.1; Nash *et al.* 1998) (referred to as 'plankton sampler' in the remainder of the report) with a plankton net with 500 µm mesh size. A small Scripps depressor (25 kg) was attached to the plankton sampler for stabilisation of the sampler in the water. The volume of water filtered during each haul was measured using an internal Valeport electronic flowmeter mounted inside the nosecone. An external Valeport flowmeter is also mounted on the sampler frame to check for blowing of the net due to large amounts of phyto- and microzooplankton in the water that can clog the net.

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

Adult fish samples were sampled using the pelagic 4200 trawl of the vessel or with fishing rods.



Figure 3.1. Gulf VII high speed plankton sampler.

3.2 Fishing method

This survey is carried out on board the 'RV Tridens'. The speed during fishing with the plankton sampler is 5 knots through the water. At each station a 'double oblique' haul (a V-shaped haul through the water column) is performed (Fig. 3.2). The Gulf VII sampler is lowered to 5 m above the sea floor or, at deeper stations, 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 shallow depth a double 'double oblique' is performed without the plankton sampler 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. Eggs cannot float through a thermocline, hence it is not necessary to sample below one.

In each period a set of calibration hauls should be carried out to calibrate the flowmeters. During the calibration the plankton sampler without the codend is lowered to 20m depth. The plankton sampler is hauled at constant depth for 30 minutes at a speed of 5 knots through the water. During this haul the flowmeter revolutions, water track and bottom track are registered. This is repeated in the exact opposite direction in order to rule out any influence of water and tidal currents on the calibration.

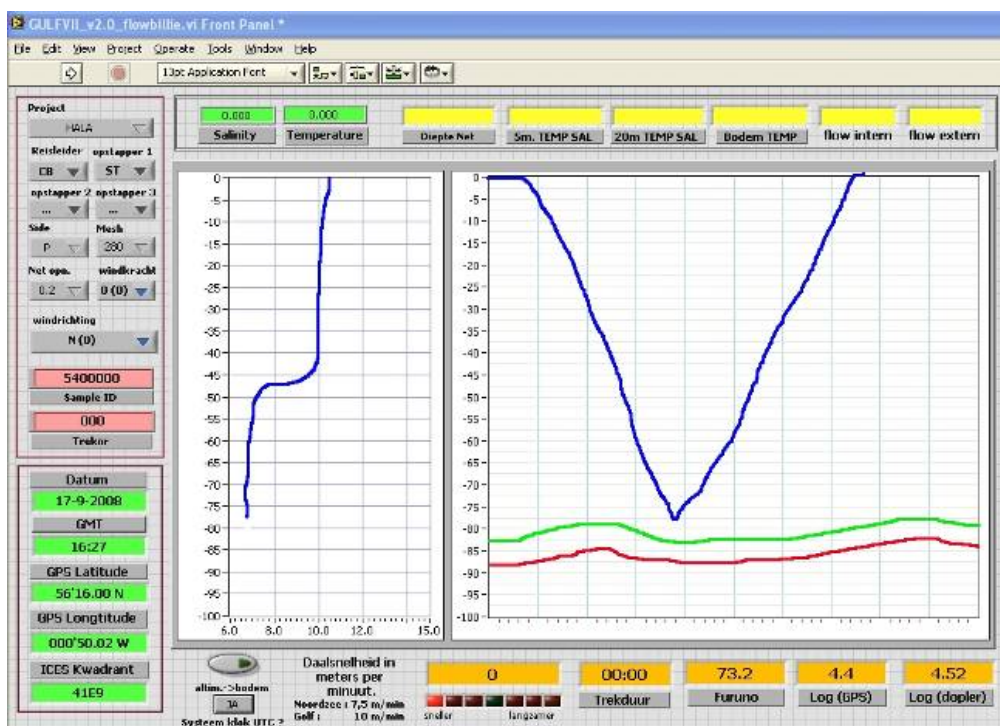


Figure 3.2. Illustration of an oblique haul in the Labview program.

When markings were visible on the echo sounder a trawl haul was carried out to try and catch adult mackerel. A total of 100 mackerel gonads were planned to be collected for oocyte development and fecundity analysis.

3.3 Sampling grid

Each sampling period the whole spawning area needed to be covered. In order to do this the North Sea was covered in east-west transects one degree apart. On each transect at each half ICES rectangle a plankton sample is taken (Annex A).

Each period one pelagic trawl haul was planned in the spawning area (Annex A). A pelagic haul is performed when fish are visible on the echo sounders.

3.4 Sample processing on board

3.4.1 Plankton samples

As soon as the plankton sampler 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 level using image analysis. All eggs are counted, measured and identified to species. For mackerel eggs at least one hundred eggs per sample 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.

For quality assurance sorting of the samples is checked. Of each period at least 3 samples from each 'sprayer' are checked for remaining eggs. If > 5% of the total number of eggs remains in the samples, all samples of this person were checked. Numbers of eggs in the sample are adjusted with the number of remaining eggs.

3.4.2 Adult fish samples

All the fish were put on the conveyor belt and the total catch weighed. All mackerel were sorted from the catch and weighed. If the catch was large 4 baskets of mackerel were randomly sorted from the catch. Total weight of all mackerel was estimated by randomly collecting 4 baskets of fish from the total catch and weighing both the mackerel subsample and the other fish. This subsample was raised to the total catch weight.

One hundred mackerel were taken randomly from the catch. If less than 100 mackerel were caught all individuals have been measured. Of each individual length, weight, sex, maturity and otoliths were taken.

From the mackerel, females in development stage 3 to 6 were collected for fecundity and atresia sampling. Over all periods fecundity and atresia samples of 100 females were collected. Of each female, length, weight, maturity, otoliths and ovary weight has been collected. Of the ovary one whole lobe was put in 3.6% formaldehyde for atresia sampling. From the other lobe 2 25 µl and 2 100 µl pipette samples were collected and put in 3.6% formaldehyde. Also a teaspoon full (2-3 g) of oocytes has been collected for histological confirmation of the maturity stage.

3.5 Fertilized eggs

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

At the start of development fertilized eggs needed to be 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 should be photographed on board and put into 4% formaldehyde solution.

Some fertilized eggs needed to be collected for energy content estimation of a single mackerel egg.

These eggs were put on 96% ethanol after collection.

3.6 Sample processing in the lab upon return from the survey

3.6.1 Plankton samples

Remaining samples from the 4th period need to be sorted and analysed. Some sampled of the 4th period also need to be checked for sorting. In total 19 samples from period 4 still needed to be sorted and eggs photographed, eggs of 37 samples still needed to be counted and identified to species upon return from the survey.

3.6.2 Adult fish samples

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

If all maturity stage 3 samples contain spawning markers potential fecundity estimation will not be possible and fecundity and atresia data from the last survey will need to be used.

3.7 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, time and harbours

From (harbour)	Date	Time (UTC)	To (harbour)	Date	Time (UTC)
Bergen (Norway)	26-05-2015	11:00	Den Helder	31-05-2015	15:00
Den Helder	01-06-2015	06:00	Stavanger (Norway)	06-06-2015	8:45
Stavanger (Norway)	08-06-2015	05:30	Scheveningen	17-06-2015	23:00

Scientific crew

- Cindy van Damme (cruise leader)
- Kees Bakker
- Ewout Blom (week 22)
- Ineke Pennock (week 23)
- Thomas Pasterkamp (week 23)
- Hanz Wiegerinck (week 24-25)

Volunteer Jacky Buijs (student)

Deviations from the planned sampling grid

The planned station grids for the four periods can be found in Annex A.

In period 1, week 22, we sampled 69 plankton stations and did one fish haul using rods (Fig. 4.1a). We did not sample the last planned plankton station (nr 170 Annex A). The weather circumstances and the water speed were excellent for a proper calibration of the flow meters. We therefore decided to leave the last planned station in favour of a flowmeter calibration.

In period 2, week 23, we sampled 60 plankton stations, did one pelagic trawl haul and a set of calibration tows (Fig. 4.1b). We experienced bad weather circumstances on Monday evening and Tuesday morning, forcing us to stop sampling and move to a calmer area. Due to this we lost 5 planned stations. Because of the weather we could not move fast and we lost survey time. In total 13 stations of the planned stations were not sampled.

In period 3, week 24, we sampled 72 plankton stations, did one pelagic trawl haul and a set of calibration tows (Fig 4.1c). Because stations were not plotted correctly in the ship's plotter, one planned plankton station was not sampled.

On request of the Rijkssrederij we did not go into port on 13-14 June but continued sampling. Due to this we could change the order of the plankton stations in periods 3 and 4 and reduce the total survey time needed.

In period 4, week 25, we sampled 62 plankton stations and did a set of calibration tows (Fig 4.1d). Because the last sampling week was shorter compared to the first three survey periods and all needed fecundity samples were already collected, no pelagic trawl haul was carried out in period 4. The sampling grid of this last period was altered from the planned one. The alterations were based on the results from the previous periods in order to cover the stations with expected mackerel eggs.

Survey: North Sea Mackerel Egg Survey 2015 Period 1 Tridens Week 22

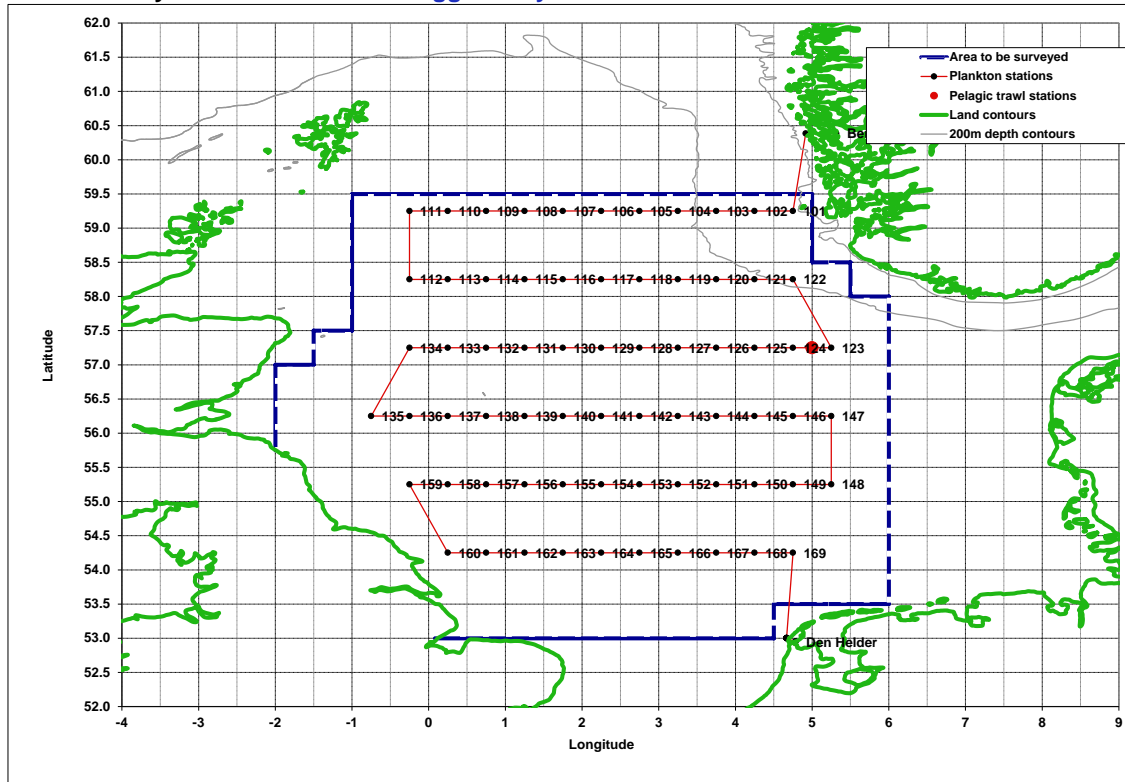


Figure 4.1a. Sampled station grid in period 1 (week 22).

Survey: North Sea Mackerel Egg Survey 2015 Period 2 Tridens Week 23

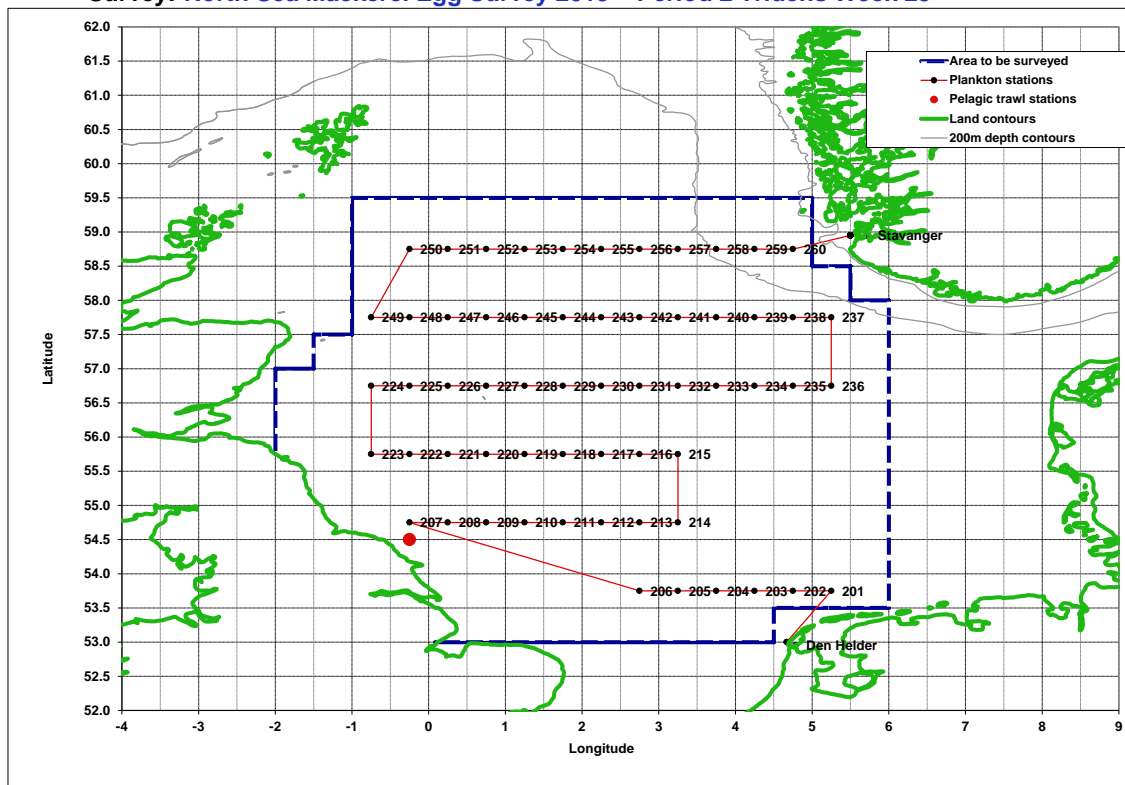


Figure 4.1b. Sampled station grid in period 2 (week 23).

Survey: North Sea Mackerel Egg Survey 2015 Period 3 Tridens Week 24

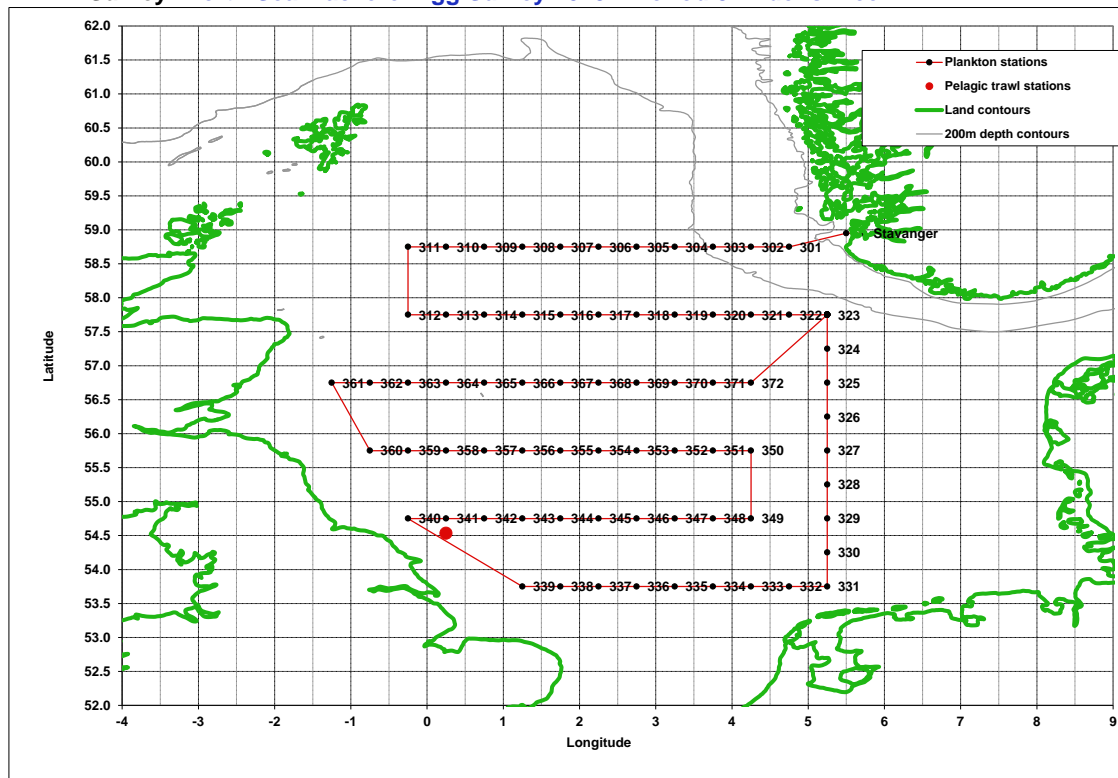


Figure 4.1c. Sampled station grid in period 3 (week 24).

Survey: North Sea Mackerel Egg Survey 2015 Period 4 Tridens Week 25

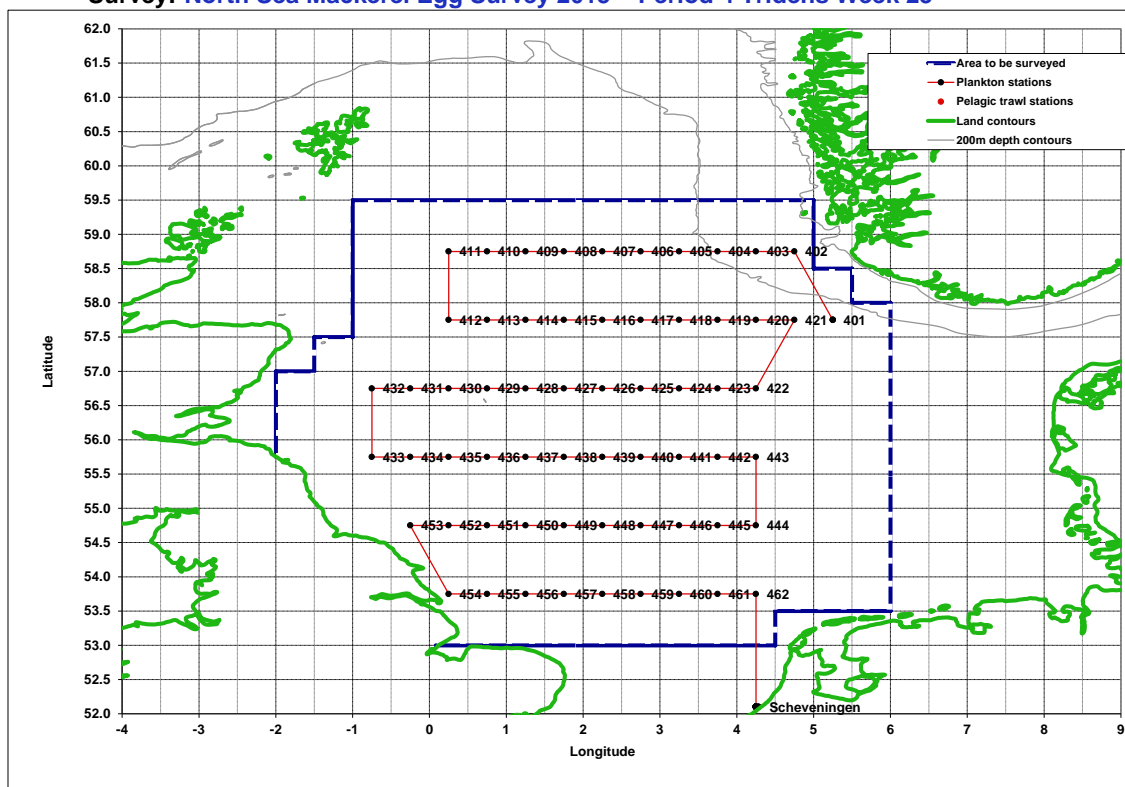


Figure 4.1d. Sampled station grid in period 4 (week 25).

Damage to sampling equipment

No damage to the sampling equipment occurred during this survey.

Survey

Period 1 (week 22)

We travelled from Schiphol to Bergen with the 5:50 (UTC) flight on Tuesday 26th May. We arrived on board the Tridens at 8:30 (UTC). We took on board the borrowed IMR temperature block to carry out egg development experiments during the 2016 Atlantic mackerel egg survey.

Because a pilot was not available, we left Bergen harbour one hour after the agreed time, at 11:00 (UTC). The weather was good and we arrived at the first plankton station ahead of schedule, at 16:46 (UTC). Plankton sampling went well and favourable weather conditions allowed for steady progress. On Thursday morning at 8:30 (UTC) we did a fishing haul. No fish was seen on the echosounder so we used the fishing rods. Besides two grey gurnards, no fish was caught. We did not have time to try another fish haul this period.

On Sunday morning at 5:05 (UTC) the weather conditions were good and water speed was excellent to calibrate the flowmeters. We decided to do a set of calibration hauls. It took one hour for the calibration and it was decided to leave the last planned station.

At 7:15 (UTC) on Sunday we sampled the last plankton station of this period. We arrived in Den Helder harbour on 31st May at 15:00 (UTC).

Period 2 (week 23)

We left Den Helder at 6:00 on 1st of June. With the wind we sailed to the first plankton station. We sampled the first stations at 10:34 (UTC). The first plankton stations were sampled without any problems. However during the day the wind speed increased and Monday evening at 19:00 (UTC) sampling had to be terminated because of the weather circumstances. Survey time was limited and we continued to move along the transect westwards until we could start sampling again. Of the first transect 5 plankton stations were not sampled.

On Tuesday morning we were in the shelter of the English coast. However, the forecast was still bad for that day. We decided to try a fishing haul with the pelagic trawl. It took considerable time to get things started for the haul. A new hard disk was installed in the catch trawl computer and it took one hour before it could be started. The crew also wanted to try another way of using the cables and fishing winches, which meant extra time was needed for setting and hauling the net. The fishing haul finally started at 8:04 (UTC). It was a successful haul with mackerel, sprat, whiting, herring and gurnards. We could sample 100 mackerels and managed to collect fecundity and atresia samples of 47 females. No spawning mackerel were caught. One huge mackerel was caught of 53 cm and 1440 g (Fig. 4.2).

We had lost survey time due to the lower speed because of the bad weather. It was agreed with the captain to therefore leave the two most easterly stations of the second and third transect. However, on Wednesday morning it turned out four stations on both transects were skipped, so eight stations in total. It was too late on Wednesday to undo this decision. According to the captain it was due to misunderstanding between him and the IMARES crew. During future surveys the cruise leader should check each day at a regular timeslot if station positions are entered correctly.

We continued plankton sampling for the remainder of the week. Though on Friday evening the weather circumstances decreased again. We could continue plankton sampling but sorting and identification of the fish eggs had to be ceased. On Saturday morning we did a set of calibration hauls. The last plankton station was sampled on Saturday at 4:36 (UTC). This meant that we had four hours of sampling time left within the agreed survey time, the time needed for the four extra stations which were unannounced skipped Tuesday night.

We arrived in Stavanger harbour at 8:45 (UTC).



Figure 4.2. A 'huge' female mackerel caught in the first pelagic fishing haul.

In period 2 Kees and Thomas reprogrammed the Labview plankton sampling program in order to create a Billie exchange 7 file with the survey data. This was successful and from the end of period 2 onwards Billie exchange 7 files were created. Data entering instructions for Billie 8 (exchange file 7) can be found in Annex B.

Period 3 (week 24)

A pilot was asked to come on board on at 4:00 (UTC) on Monday morning 8th of June. On Sunday evening the captain announced that because of the arrival of a ferry we could only leave Stavanger at 5:00 (UTC). Finally, we left Stavanger at 5:30 (UTC).

On Sunday the wind was strong and on Monday the waves were still high. However we could sample plankton and analyse samples without problems. We sampled the first plankton station at 8:36 (UTC). The weather improved and we continued plankton sampling without problems.

On Wednesday we were requested by the Rijksrederij if we could continue sampling during the weekend and not go into port. This was not a problem for the survey and we agreed to this. It also gave the possibility to change the sampling grid and remove to long steams thus reducing the needed survey time.

Because the plankton samples were not correctly plotted on the ship's plotter one plankton station was not sampled on Wednesday night.

On Thursday early morning, at 3:54 (UTC) a fishing haul was carried out. Another good catch with sprat, herring, mackerel and whiting. We could again sample 100 mackerel and collect the remaining 53 fecundity and atresia samples. Again no spawning fish were caught, thus fertilisation of fish eggs could not be done this survey.

After the fishing haul we continued plankton sampling. On Thursday we wanted to do a calibration of the flowmeters. However, due to failing network connections we could not correctly measure the track and we ceased the calibration. At that time it was assumed that the temperature in the room with the network computers was too high and this caused the loss in connection. This was solved on Friday and we carried out another set of calibration hauls. However on Saturday the network connection problems re-occurred. We continued sampling but the loss of connection now and then meant it took longer to start the CTD and Labview plankton sampling programs.

We sampled the last plankton station of this period on 13th June at 7:25 (UTC).

Period 4 (week 25)

As agreed we continued to steam to the first plankton station of period 4. We arrived at this station on 13th June at 12:35 (UTC). Plankton sampling went smoothly, until Sunday evening when the network

connection was completely lost at station 411. This meant the CTD needed to be run stand-alone and we did not have information on the towing speed of the plankton sampler, as well as we needed to write down all haul information manually.

On Sunday we also ran low on sample jars. We discovered that we only had taken 360 jars on board while 480 were requested. We managed to find jars of different sizes and types on the vessel that we could use for the samples.

On Monday we discovered that the network problems were not caused by network connections but by a failing ship's GPS on the bridge. This meant position data could not be retrieved over the network. It was not possible to solve this problem during the survey. A specialist is needed to repair the GPS. This should be solved as soon as possible.

On Tuesday the connection of the external flowmeter failed. But as no clogging of the net seemed to occur this did not cause problems for the plankton sampling. We continued plankton sampling without the external flowmeter. The flowmeter gave out during the calibration hauls on Tuesday 16th June. Thus for period 4 the calibration factor has been calculated as the mean of all previous periods.

The last plankton station was sampled on Wednesday 17th June at 15:21 (UTC). We arrived in Scheveningen on 17th June at 23:00 (UTC).

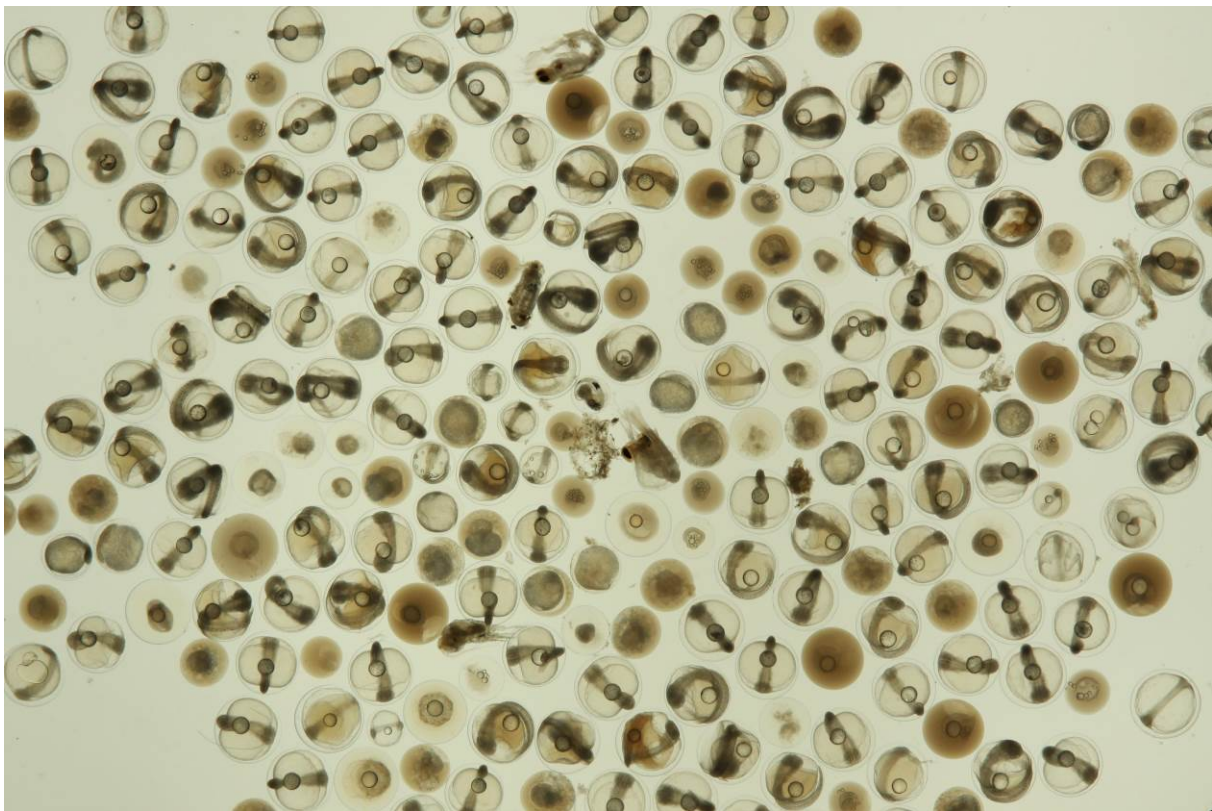


Figure 4.3. Mackerel and other fish eggs in a sample.

Sample-IDs

Plankton hauls 2015.5400120 - 2015.5400382

Fishing hauls 2015.5400421 – 2015.5400422

Samples and data

During the survey a total of 262 (including 2 invalid hauls due to loss haul information or of part of the sample) plankton stations with CTD measurements, 3 fishing hauls and 8 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.

4.1 Remarks for the next plankton surveys

During this survey we encountered network problems due to a failing GPS. Due to this we could not get the needed haul information for the individual tows. This also meant that the Seabird CTD and Labview programs did not function anymore. The GPS needs to be repaired as soon as possible as it affects all surveys.

In both the wet and the dry lab on the fish processing deck in total eight network connections are available, but only two in each lab are actually connected. During the mackerel egg surveys we used three computers in the dry lab and all of these needed to be connected to the network. The remaining connection ports should be connected to the network as well. This is apparently a technical issue.

During the survey the first mate and boatswain mentioned that on the deep hauls down to 200 m only little length of cable was left on the winch drum. During the 2016 mackerel egg survey in the Atlantic most of the stations are down to 200 m. It should be checked if enough cable is on the plankton winches and if not a new (1200m) cable should be put on the winch drums before the Atlantic survey, which will start in April 2016.

In the way we collected samples this survey was a success. Both the crew on the deck and on the bridge were very helpful and friendly and did a good job.

4.2 Internal remarks

Due to the repairs that needed to be done to the vessel and acoustic testing in Norway prior to the survey it was not feasible to thoroughly check in the Netherlands whether all material needed for the mackerel egg survey was on board and in working order or not. It turned out that some major gear was not complete, or spare parts were missing. We only had one proper separator funnel to sort the samples. Also 480 plankton sample jars were requested but only 360 were on board. Fortunately, spare jars were available on board.

Ultimately, the survey was not influenced by these potential problems; however, lessons can be learned from the complex logistic setting prior to the survey.

For future surveys, the following procedure should be applied, especially when the material has to be put on board well before the survey, and especially when the ship won't return in the Netherlands in between:

- Sufficient time should be planned by IMARES for loading the material on board. This should be communicated with the Rijksrederij (office, crew or watchman) to ensure entrance to the ship.
- The person responsible for preparation of survey gear makes sure everything on the materials list is prepared by ticking off the list supplied by the project leader
- In case the materials on the list cannot be made available prior to the survey, the project leader as well as the cruise leader is informed about this.
- The people loading the material on board check if everything from the list is really on board, by ticking off the boxes on the materials list.

5. Preliminary results

5.1 Mackerel eggs

It is difficult to compare the numbers of eggs found to previous surveys, since this is the first time the survey is carried out by one nation and with a lower resolution than previous surveys. Once the total egg production is estimated a reliable comparison to previous surveys can be done. However, highest numbers of mackerel eggs on one station found in this survey (383) was lower compared to the last survey in 2011 (434).

Mackerel eggs were found in all four periods (Fig. 5.1 - 5.2). Highest egg numbers were found in the south-western part of the spawning area in all periods. Numbers in period 1 were low, increased in period 2 and decreased again in periods 3 and 4.

Most of the mackerel spawning occurs from the southwest corner of the spawning area to the northeast corner, with highest spawning occurring the southwest. This pattern is comparable to previous surveys.

During the survey 243 plankton samples were sorted and eggs photographed. Eggs from 227 samples were identified on board. The remainder of the samples was sorted and analysed in the laboratory in IJmuiden.

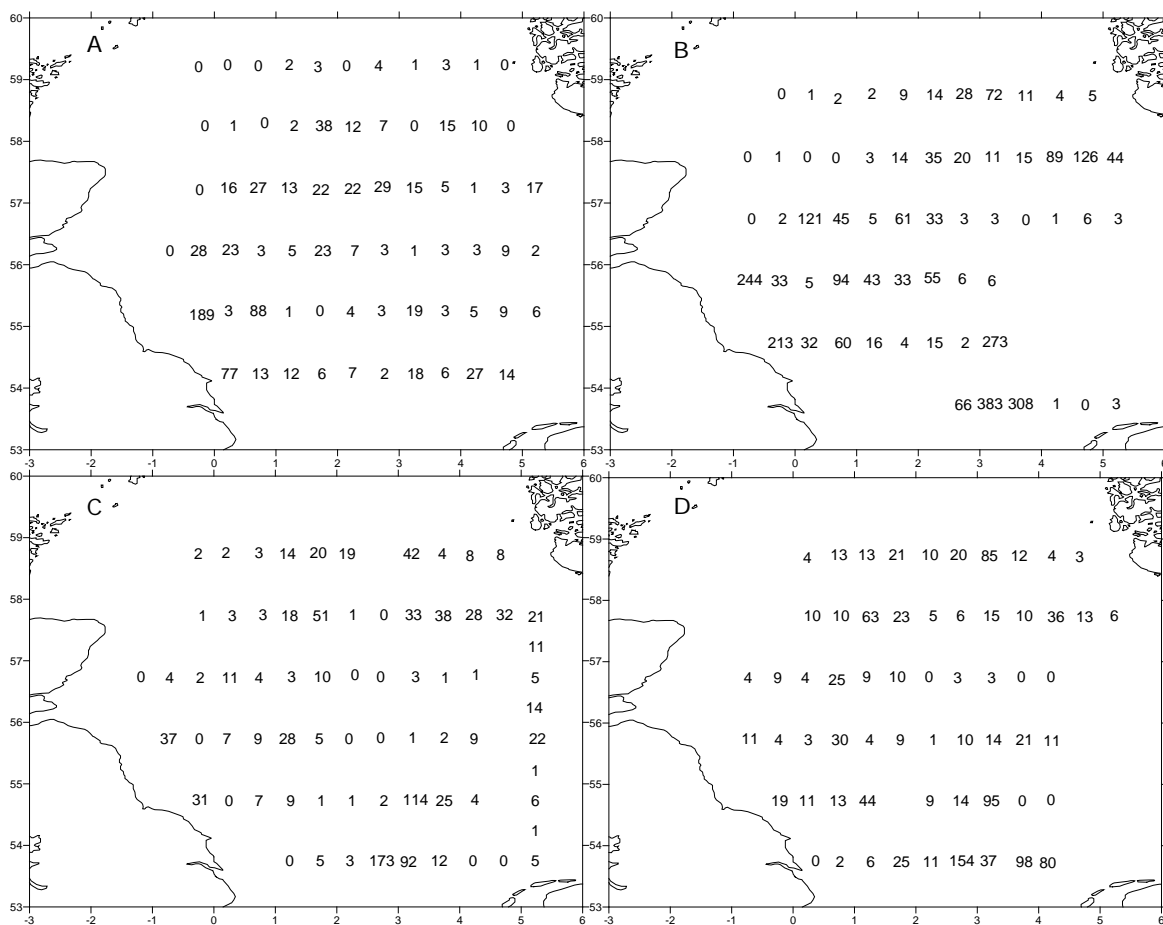


Figure 5.1. Total numbers of stage 1 mackerel eggs in period 1 (A), period 2 (B), period 3 (C) and period 4 (D).

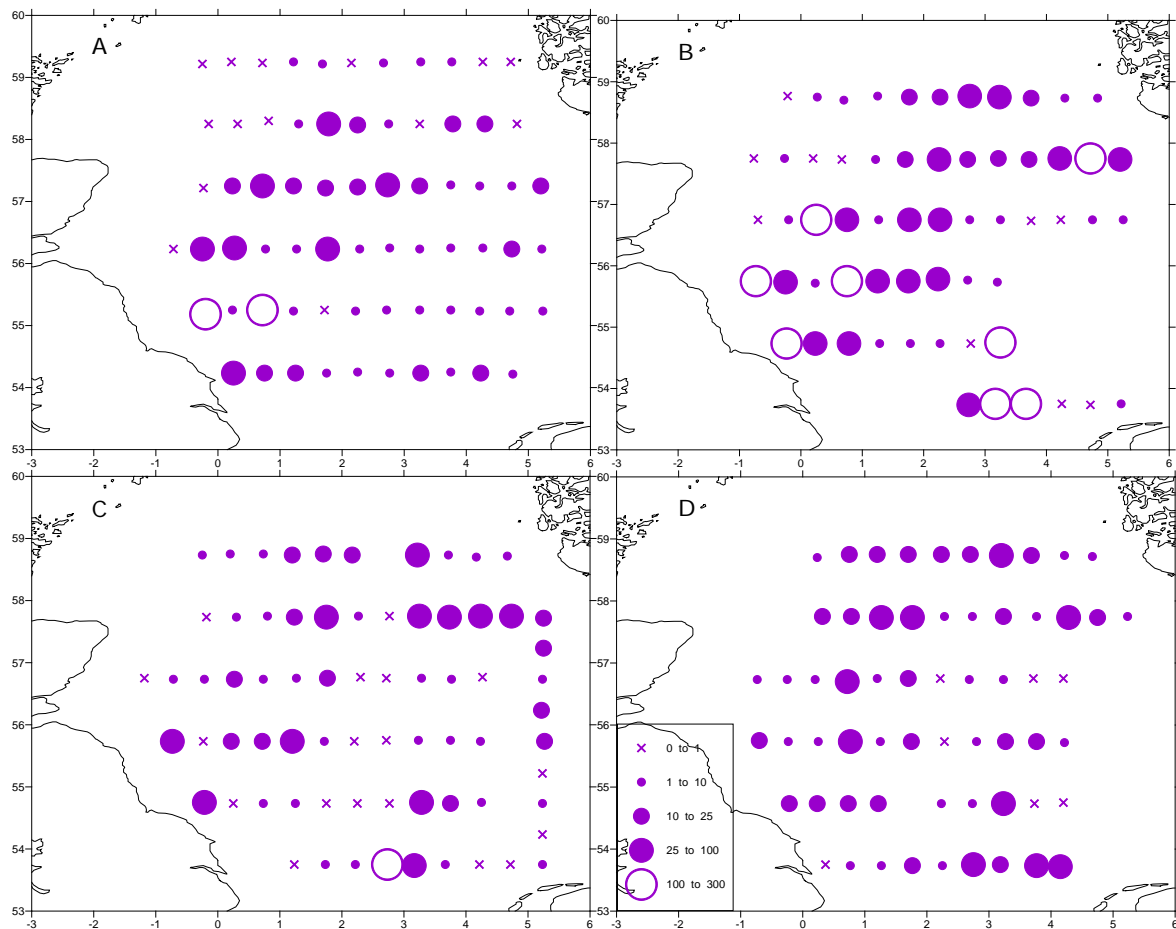


Figure 5.2d. Numbers of stage 1 mackerel eggs per m^2 in period 1 (A), period 2 (B), period 3 (C) and period 4 (D).

5.2 Adult fish samples

We carried out two successful pelagic trawl hauls. From each trawl haul we randomly sampled 100 mackerel. We collected fecundity and atresia samples from 100 females. From the first 150 mackerel sampled pictures were taken for the mackerel maturity staging workshop in September 2015.

The females and males from the first trawl haul in period 2 did not show macroscopic evidence of spawning.

5.3 Fertilized eggs

We did not catch running mackerel and therefore it was not possible to collect and fertilize eggs during this survey.

5.4 Hydrographical data

Temperature at the surface and 20m depth increased over the periods (Fig. 5.4-5.5). Warmest water was found in the southeast part of the spawning area. Although temperature at the surface was generally higher than at 20m depth, only few 'true' thermoclines (2.5°C difference over 10 m depth) were seen during the survey. In period 1 one station showed a thermocline and in period 4 two stations had a thermocline. All stations with a thermocline were found in the northeast part of the spawning area at stations with depths over 200m.

Mackerel can spawn in temperatures from 8 to 15°C, but usually mackerel shows a temperature preference for 13-14 °C for spawning. Maximum temperature in period 1 was 11.13 °C, increasing to 11.87°C in period 2, 12.95°C in period 3 and 13.38°C in period 4. These temperatures are within the range for mackerel spawning, but are below the preferred spawning temperature in periods 1 to 3. Temperatures found during the 2015 survey were lower compared to 2011.

Salinity was stable over the sampled periods (Fig. 5.6). Influences of fresh water from the English coast and the Norwegian fjords can be seen in the northeast and southwest part of the spawning area. Highest salinities are found in the northwest part of the spawning area, where there is inflow from the Atlantic Ocean.

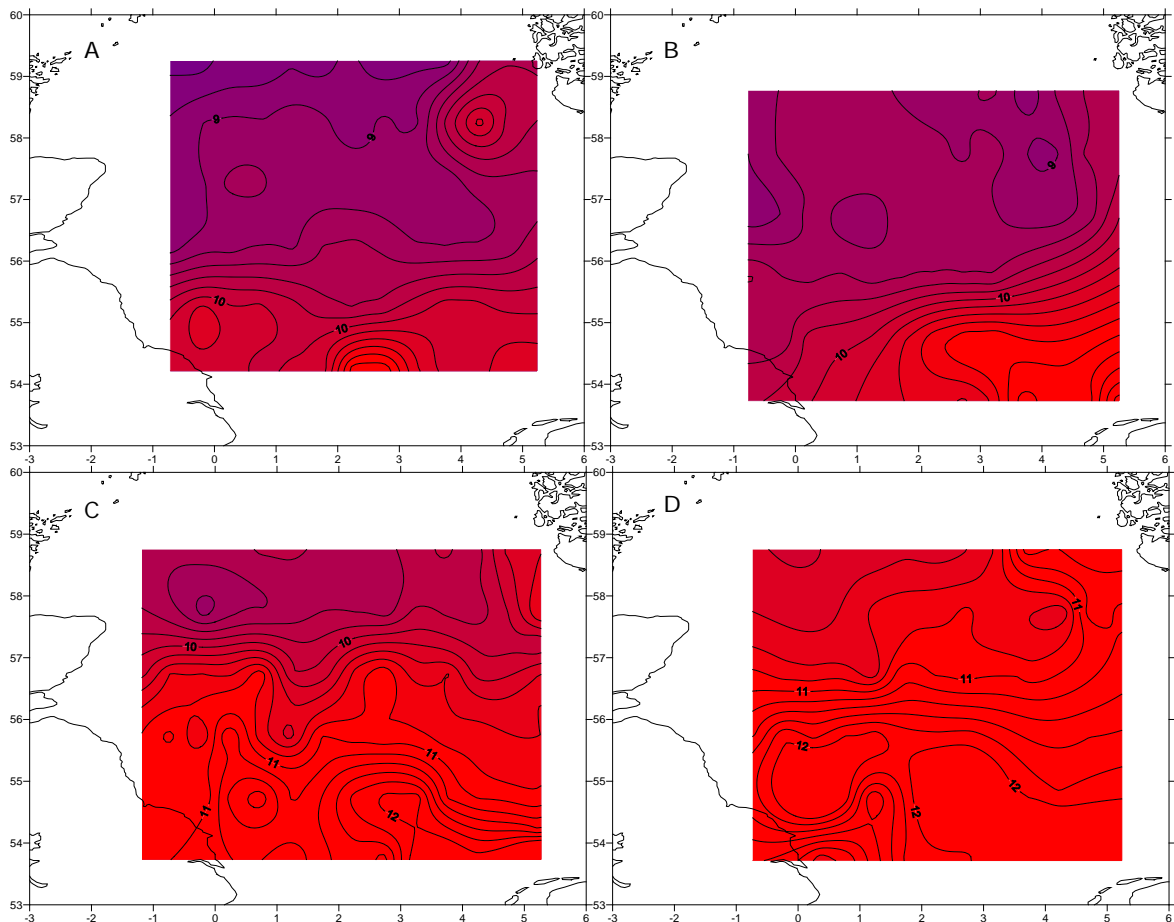


Figure 5.4. Temperature at the surface (5 m) during period 1 (A), period 2 (B), period 3 (C) and period 4 (D).

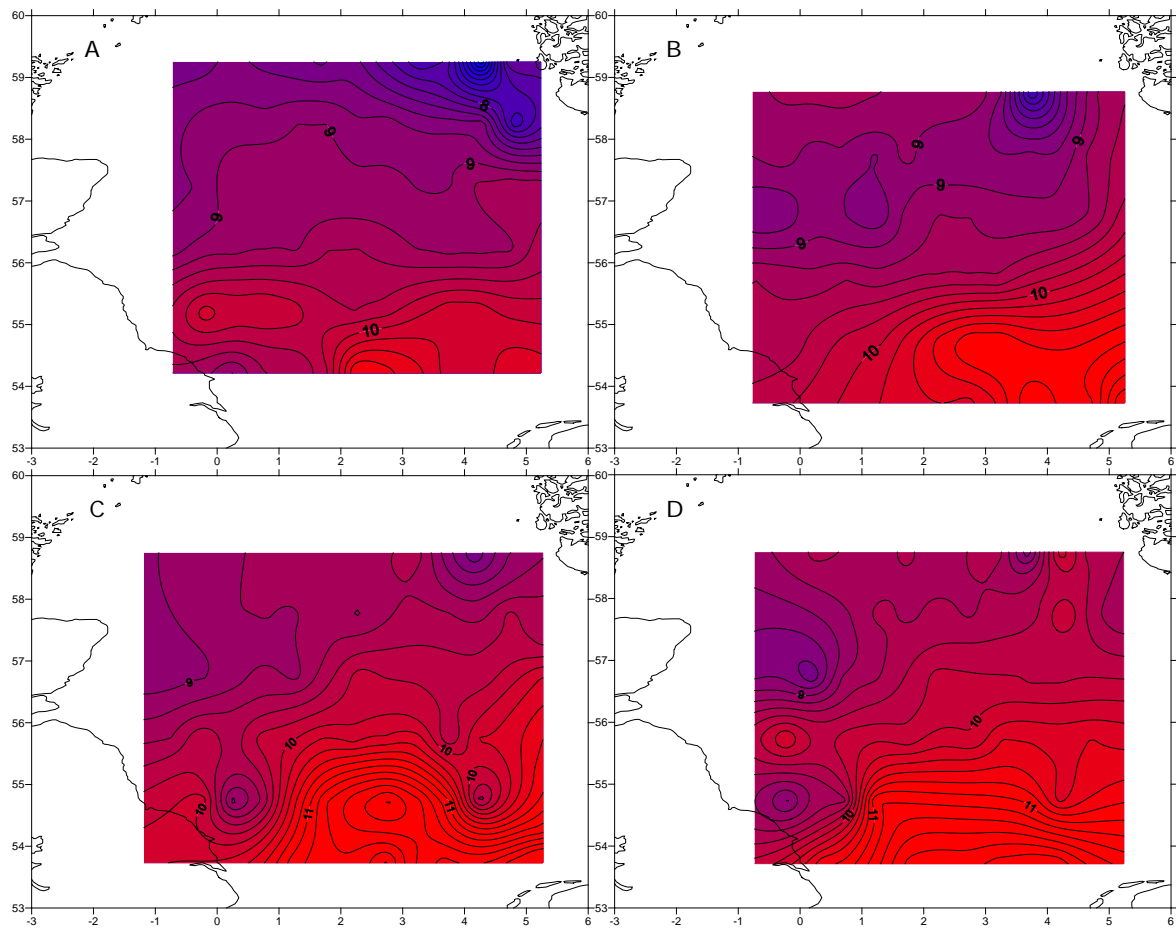


Figure 5.5. Temperature at 20 m depth during period 1 (A), period 2 (B), period 3 (C) and period 4 (D).

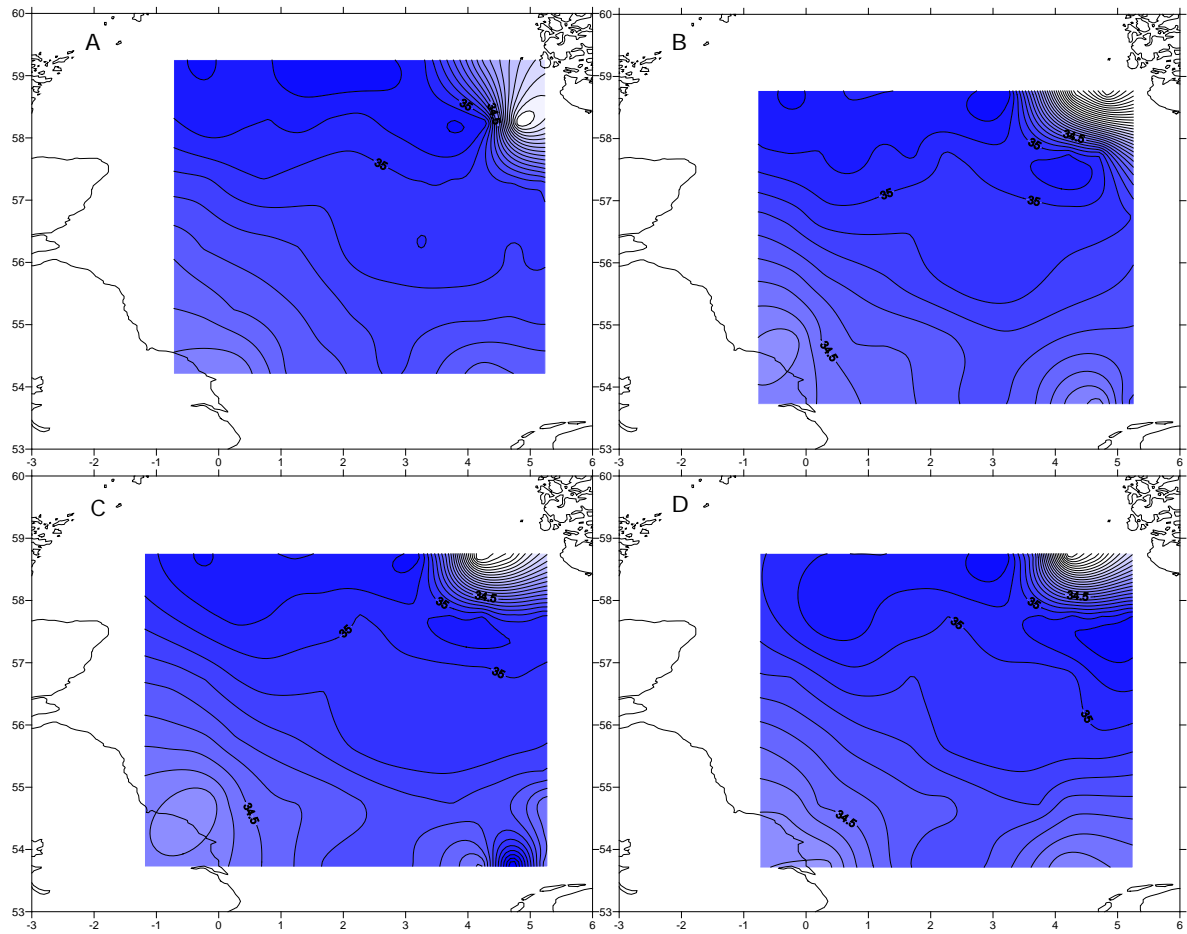


Figure 5.6. Salinity at 20 m depth during period 1 (A), period 2 (B), period 3 (C) and period 4 (D).

6. Conclusions

The 2015 North Sea mackerel egg survey was successful. It covered most of the original planned plankton stations. In each of the four periods the spawning area was covered with east-west transects spaced 1 degree apart. The distribution maps of mackerel stage 1 eggs indicate that most of the mackerel spawning is covered by the survey. As only few zero samples were caught, the borders of the mackerel spawning area were not reached in any of the periods. However most of the stations with highest spawning were found away from the border of the sampling grid, except in period 2 (Fig 5.2b) where some considerable spawning may have been missed in the southwest part of the spawning area. Therefore the eventual total egg production and SSB estimation will likely be an underestimation.

Macroscopic maturity staging implies that both samples for potential fecundity and atresia estimation were collected, allowing for an estimation of total fecundity of North Sea mackerel. It should be noted though that both pelagic trawl hauls were carried out in the southwest part of the spawning area. Within the limited time to cover the whole spawning area it was not possible to carry out more trawl hauls. Furthermore no evidence of mackerel was seen on the echosounder in the other parts of the spawning area.

As some plankton samples still need to be analysed it is not possible to do a reliable comparison with the previous survey. However, the highest number of mackerel stage 1 eggs found in a sample was lower in this survey compared to the last survey in 2011.

The first period numbers of mackerel eggs were low. Numbers increased in the second period and decreased again in periods 3 and 4. This, together with the mackerel adults in the first trawl haul in period 2 not showing signs of spawning, suggest that the survey started at the beginning of the spawning season of North Sea mackerel. The higher number of mackerel stage 1 eggs found in period 2 compared to period 1 and 3 suggests that the peak of mackerel spawning was also covered this survey.

Highest spawning occurred in a line southwest to northeast over the spawning area with highest spawning occurring in the southwest. This pattern is comparable to previous surveys.

Despite the increase of water temperature over the four periods, temperature was low during this survey, lower compared to the 2011 survey. In the first three periods water temperature was lower than the optimal 13-14°C for mackerel spawning, but it was within the range (8-15°C) for mackerel spawning. Highest temperatures were found in the southeast part of the spawning area while highest spawning occurred in the southwest part.

Salinity pattern was stable over the four periods and similar to the one found in the last North Sea survey in 2011. In the southwest and northeast influence of less saline coastal water is seen. In the northwest part of the spawning area inflow of more saline Atlantic water can be seen.

7. Quality Assurance

7.1 Check on the sorting of the plankton samples

For quality assurance the sorting of eggs from the plankton samples is checked. During the survey, of each plankton-‘sprayer’ at least 3 samples, with different total amounts of plankton, were checked if eggs were properly sorted (Table 1). Samples of sprayer one and two still contained over 5% of the total eggs or of the mackerel eggs after the original spray (Table 1). Samples of these sprayers need to be checked in the laboratory. It is unclear what is the reason for this as there is no relation with experience of the sprayer (e.g. both sprayer 2 and 4 were inexperienced, while 1 and 3 were experienced sprayers).

Remaining eggs which were collected in the control spray were also identified, counted and staged in case of mackerel eggs. The original results were corrected with the results of the control spraying for all the samples.

Samples of period will need to be checked in the laboratory.

Table 1. Eggs remaining in the sample after the original spraying (in brackets: standard deviation)

Sprayer	Average eggs remaining (%)	Average mackerel eggs remaining (%)
1	12.6 (18.8)	6.6 (13.2)
2	10.1 (13.6)	11.6 (14.5)
3	5.5 (6.1)	0.0 (0.0)
4	1.3 (1.6)	0.2 (0.5)
5	2.4 (3.7)	1.8 (3.1)
6	1.2 (2.1)	0.0 (0.0)

7.2 International calibration of egg identification and fecundity and atresia analyses

Before the Atlantic mackerel egg survey international workshops, Workshop on Egg staging, Fecundity and Atresia in Horse mackerel and Mackerel (WKFATHOM), are held to calibrate (1) egg species identification and egg staging and (2) to calibrate fecundity and atresia estimation. Four IMARES specialists participated in these workshops in 2012 and participated in the 2015 North Sea mackerel egg survey. Results of the 2012 workshop are described in the WKFATHOM (ICES, 2012) report.

7.3 ISO qualification

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

Acknowledgements

We would like to thank the crew of 'RV Tridens' for their help and commitment for the North Sea mackerel egg survey.

We would also like to thank the volunteer Jacky Buijs for his help, enthusiasm and dedication during the four weeks of the survey. He was dedicated in the collection of fish and plankton samples, sorted many of the plankton sampled and collected many thousands of eggs from all the samples.

References

- Nash RDM, Dickey-Collas M, Milligan SP (1998) Descriptions of the Gulf VII/PRO-NET and MAFF/Guildline unencased high-speed plankton samplers. J. Plankton Res. 20(10): 1915-1926.
- ICES (2012). Report of the Workshop on Egg staging, Fecundity and Atresia in Horse mackerel and Mackerel (WKFATHOM). ICES CM 2012/SSGESST:17, 209pp.
- Damme, CJG van, Bakker C (2014) North Sea mackerel egg survey 2014, IMARES report: C106/14, 25pp.

Justification

Rapport 15.010

Project Number: 4311211012

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

Approved: Ingeborg de Boois
Project leader WOT Surveys

A handwritten signature in black ink, reading 'I de Boois', with a horizontal line underneath.

Signature:

Date: October 2015

Approved: Luc van Hoof
Head of department Fish

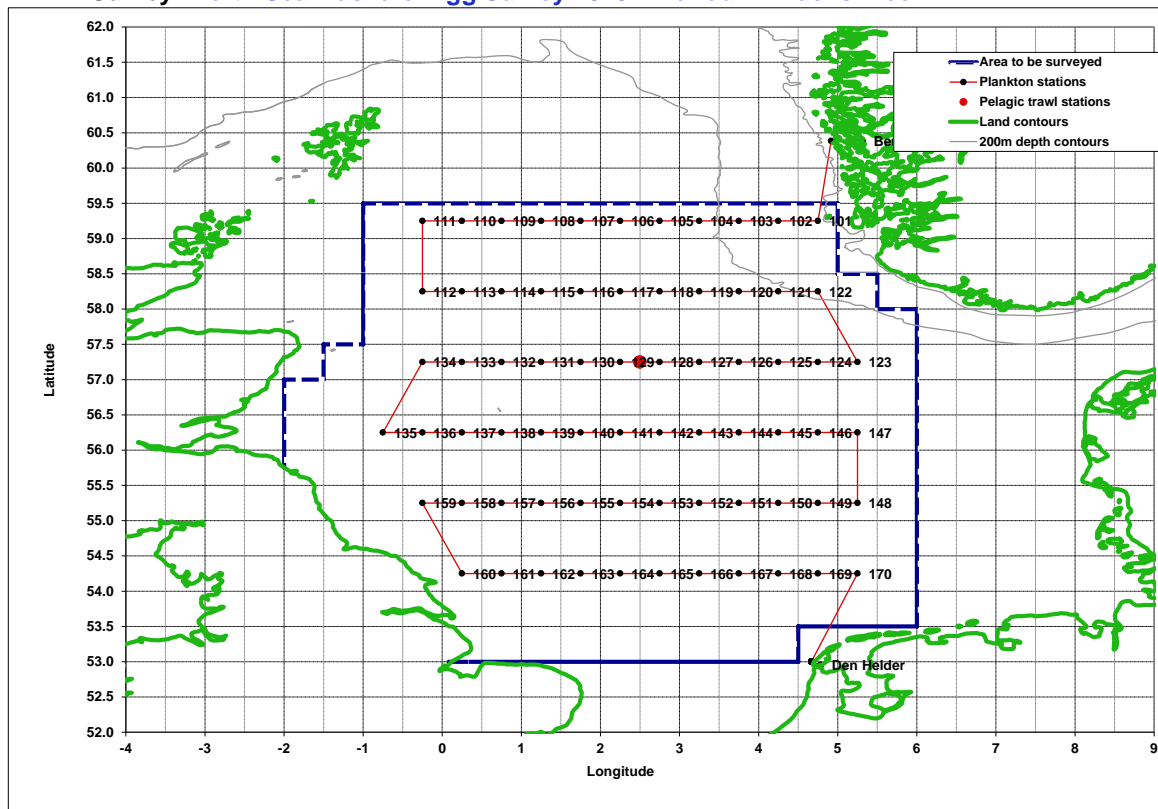
Signature:

A handwritten signature in blue ink, consisting of stylized, overlapping loops.

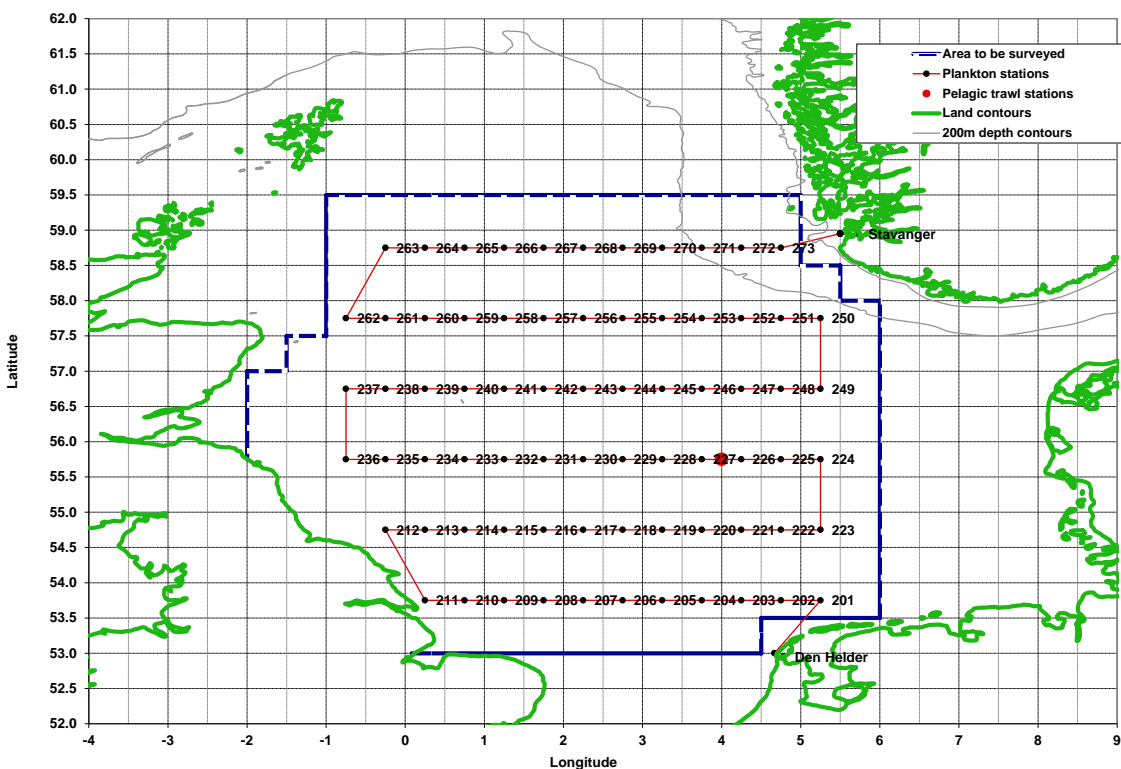
Date: October 2015

Appendix A. Proposed sampling grid

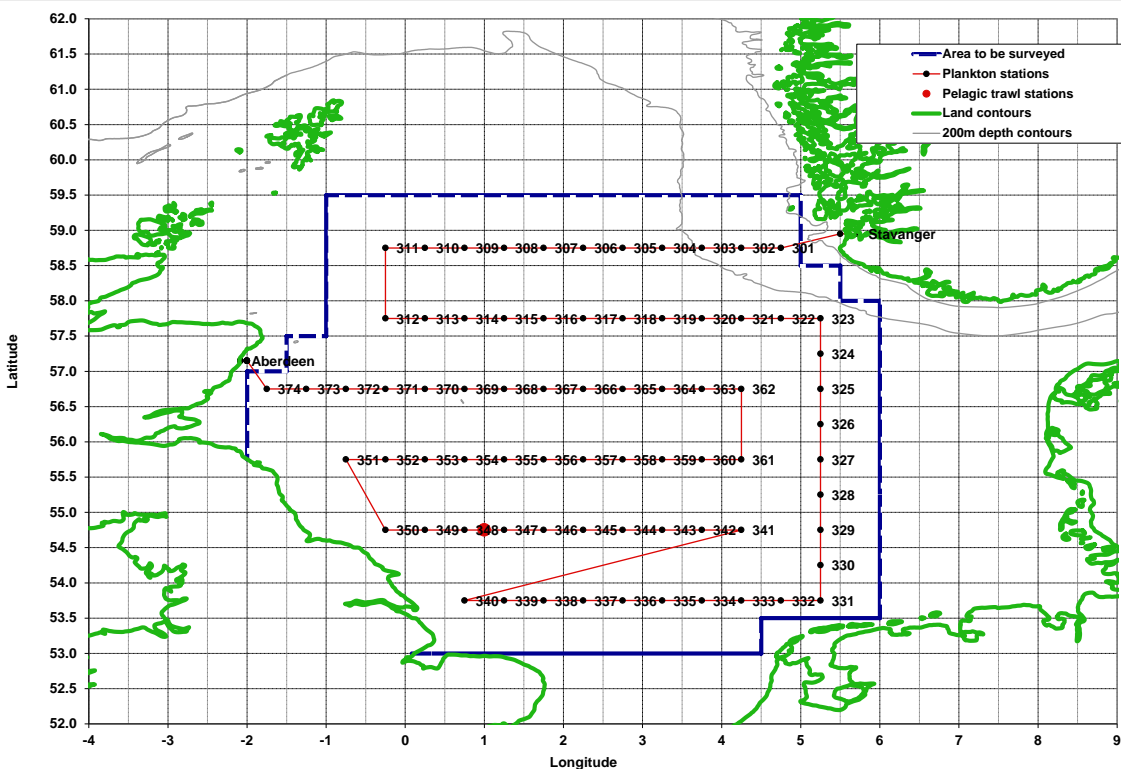
Survey: North Sea Mackerel Egg Survey 2015 Period 1 Tridens Week 22



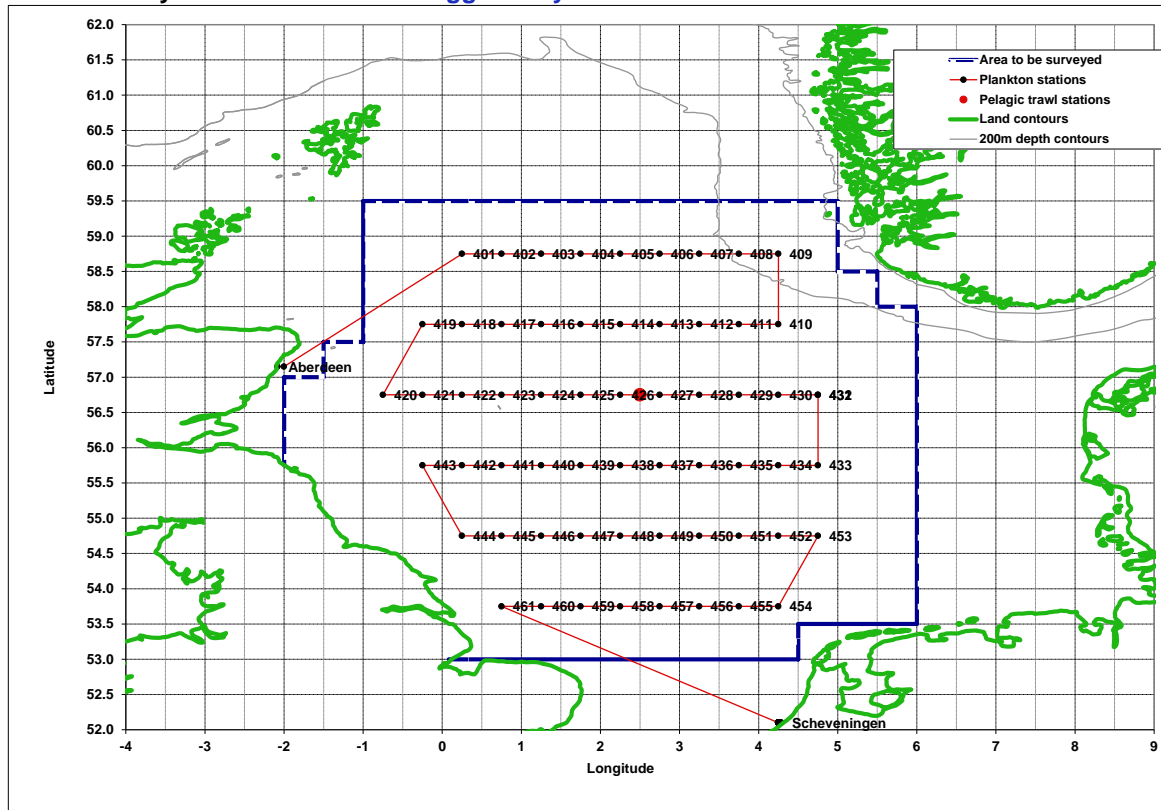
Survey: North Sea Mackerel Egg Survey 2015 Period 2 Tridens Week 23



Survey: North Sea Mackerel Egg Survey 2015 Period 3 Tridens Week 24



Survey: North Sea Mackerel Egg Survey 2015 Period 4 Tridens Week 25



Appendix B. Data entering instructions for Billie 8 (exchange file 7)

First page

The screenshot shows the Labview data entry interface for Billie 8. The interface is divided into several sections:

- Left Sidebar:** Contains icons for New, Next New, Open, Save, Save As, Length, Quantity, Age, CTD, and a green arrow icon.
- Main Data Entry Area:**
 - Program:** WGMEGS, Version: 1.0
 - Vessel:** Tridens II
 - Country:** NED, Harbour/stratum: [dropdown]
 - Station ID:** 427
 - Sample date:** 15/06/2015
 - Time:** 07:41, GMT, unknown
 - Time accuracy:** 1
 - Sample ID:** 5400347
 - Haul duration:** 1655:00
 - Missing Taxon:** c
 - Landing date:** [dropdown]
 - Area:** 42F1
 - Shoot:** Latitude 56.45, Longitude 1.42
 - Haul:** Latitude 56.45, Longitude 1.45
 - Pos. method:** gps
 - Pos. accuracy:** [dropdown]
 - Total catch:** 35.0 kg
- Crewmembers:**

Initials	Function
CvD	reisleider
CB	opstapper
Wie	opstapper
- Gear:**
 - Gear type:** Torpedo
 - Gear sub type:** G7
 - Gear count:** 1
 - Side:** S
 - Mesh size:** 0.005 m
 - Gear depth:** 85.0 m
- Bottom track:** 4371 m
- Water track:** 2114 m
- Towing direction:** 276 deg
- Conservation:** formol
- Handling:** [dropdown]

Program: WGMEGS

Station ID: Station number (see Appendix A)

Time: UTC

Haul duration: minutes:seconds, e.g. 17 minutes and 7 seconds is entered as 17:07 (Note: In the exchange file the seconds are recalculated to decimal seconds and rounded to 0.1)

Shoot position: position when plankton sampler starts sampling

Haul position: position where plankton sampler comes above the surface, Labview stops automatically at this position and save latitude and longitude.

Gear type: Torpedo

Gear sub type: G7

Mesh size: in m; either 0.0028 or 0.005

Gear depth: Deepest point of the plankton sampler

Bottom track: Labview estimates bottom track

Water track: Labview estimates water track

Conservation: formol

Handling: always 'whole'

Second page

Depth at shoot: Is depth at the deepest point of the sampler (is measured in Labview; see also remark in comment field)

Depth at haul: Leave empty for ichthyoplankton surveys

Salinity factor: Salinity at the bottom

Net opening: always 20 cm

ID int. flowmeter: Number of internal flowmeter

ID ext. flowmeter: Number of external flowmeter

Rotations: Number of rotations of the internal or external flowmeter

CTD measurements

Temperature and salinity at 5 meter depth.

Temperature and salinity at 20 meter depth.

(Notice that salinity is entered in the Conductivity field, this is due to the old Billie format, but in future ichthyoplankton surveys Salinity will be saved in the Salinity field)

Quantity field

Makreel x1.00f Catch [u0] *Quantity*

Quantity:	Weight:	MinLength:	MaxLength:
10	gram	cm	cm

☐ Ignore length limits

Results

- Makreel x1.00f Catch (10) [u0]
- Makreel x1.00f Catch (17) [u2]
- Makreel x1.00f Catch (18) [u3]
- Makreel x1.00f Catch (4) [u4]
- Makreel x1.00f Catch (2) [u5]
- Makreel ongespecificeerd x1.00f Catch (7) [u6]
- Makreel x1.00f Catch (5) [ue]
- Makreel x1.00f Catch (1) [ue]
- Makreel x1.00f Catch (3) [ue]
- Makreel x1.00f Catch (2) [ue]

Cancel Store

Quantity is number of eggs that have been counted and or staged.

Maturity stages:

- 0: Stage 1A
- 1: Stage 1B
- 2: Stage 2
- 3: Stage 3
- 4: Stage 4
- 5: Stage 5

Egg: if eggs have not been staged

No other stages should be used for entering data of egg samples.

Subsample factor

Units Used	Units Total	Method	Category	Subfactor
1	4.0	f	c	4.0
100.0	238.0	n	c	2.38

Catch
1.00
4.00
9.52

Factor: 9.52

+ - > + Empty OK

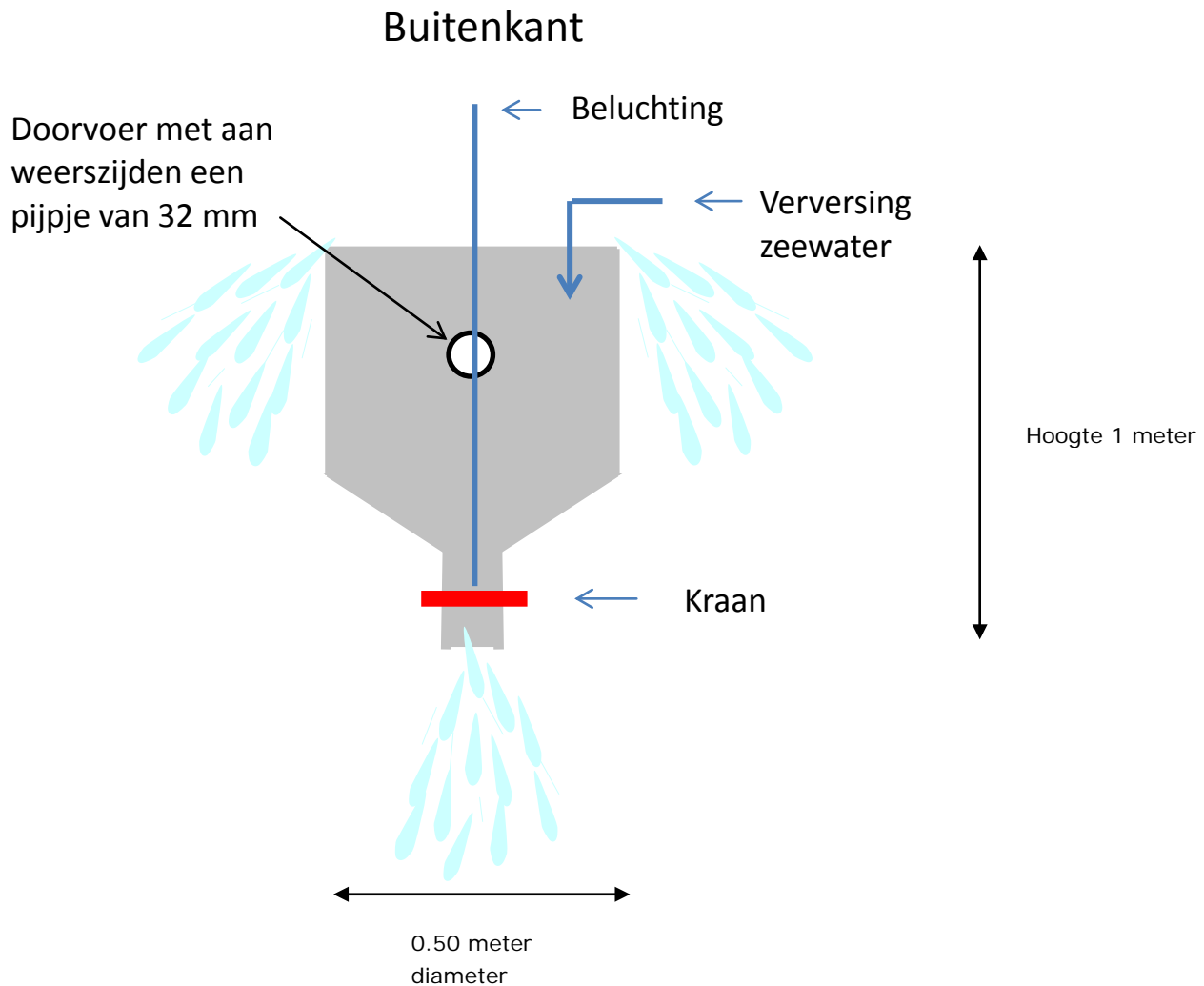
Subsampling can be done 1) using a folsom splitter or 2) when 100 eggs are staged and remaining eggs counted

Subsample by folsom splitter: Should always be the first line in the subsample field. In the example the whole egg sample is split in 4, using the folsom splitter, the method is 'f'.

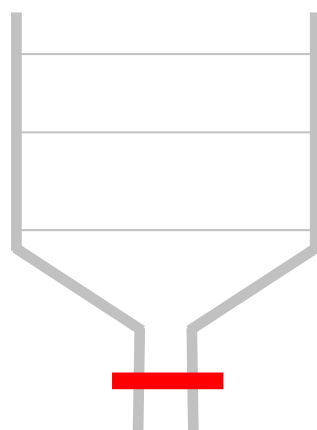
Subsample by staging and counting: Should always be entered after the folsom splitter subsample, but if the folsom splitter is not used only one line is entered in the subsampling field. In the example 100 eggs are staged and 138 eggs are counted. Thus units used is 100, units total is 238. The method is 'n'.

Appendix C. Requests for plankton surveys for the 2nd refit of Tridens

Trechter voor kweken van eieren en larven in de klimaatkamer aan boord van de Tridens



Binnenkant



Het doel van deze trechter is tweeledig:

1. Het bevruchten en opkweken van eieren tijdens (plankton)surveys in verschillende kleinere batches, voor het verzamelen van eieren in verschillende ontwikkelingsstadia als controle materiaal voor de determinatie van eieren en larven in de planktonmonsters
2. Bevruchten en opkweken van grote hoeveelheden eieren en larven in 1 batch, voor latere experimenten in het laboratorium bij terugkomst.

Een ronde conische trechter met 0.5 meter diameter gemaakt van zwarte of donkergrijs kunststof materiaal. Het materiaal moet zwart of donkergrijs zijn, omdat de eieren en larven dan beter zichtbaar zijn. Hoogte van de trechter moet ongeveer 1 meter zijn.

Zeewater en lucht toevoer kunnen door 2 slangen gedaan worden. Door een luchtslang tot aan de bodem van de trechter te hangen ontstaat er goede menging, verversing en stroming en blijven de eieren mooi in beweging en kunnen niet samenklonteren. Daarnaast kan aan de bovenkant het verversingswater worden gedoseerd. De slangen kunnen van bovenaf in de trechter ingebracht worden.

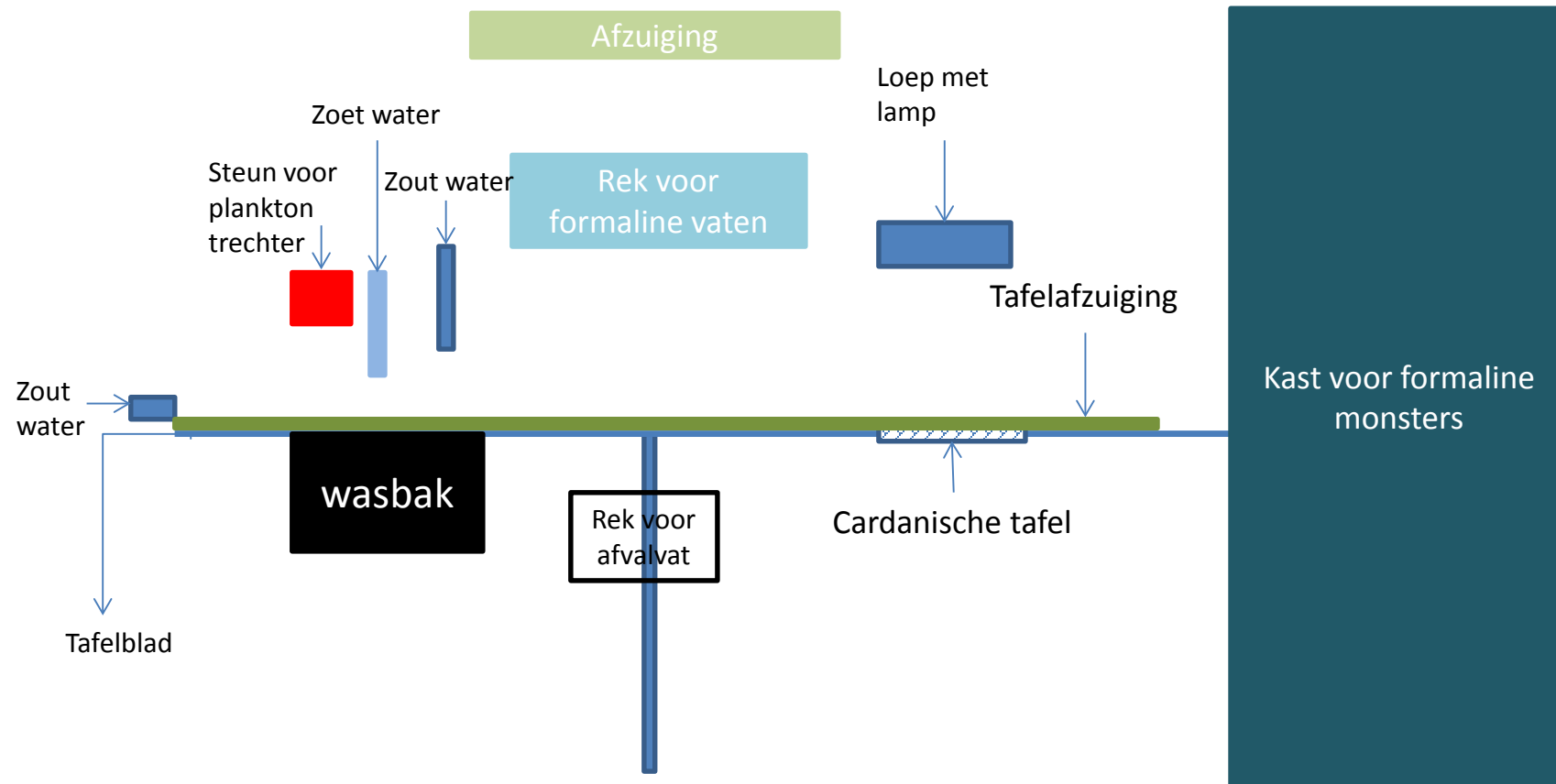
Een probleem van het bewegen van het schip is dat de watermassa in de trechter plotselinge bewegingen kan maken en kan uitstromen uit de trechter. Door deze plotselinge bewegingen ontstaat er een waterdruk op het filter waardoor eieren of larven mechanisch kunnen beschadigen. De trechter moet daarom op een zodanige manier (cardanisch of anders) neergezet of opgehangen worden dat plotselinge waterbewegingen voorkomen worden.

Er moet van bovenaf in de trechter gekeken kunnen worden. Er dient ook een deksel te zijn zodat de trechter bovenop afgesloten kan worden. Het deksel moet 250 μm gaas bevatten, zodat water eventueel langs boven kan uitstromen maar eieren en larven er niet uitkunnen. In het deksel moeten twee gaten gemaakt worden voor een slang voor de zeewater toevoer en een slang voor de beluchting.

Op 85 cm hoogte moet een doorvoer komen met aan beide kanten een PVC of PE pijp met een diameter van 32 mm. Korfjes met verschillende gaasdiameters kunnen dan gemakkelijk worden aangebracht in de trechter. De doorvoer moet ook afsluitbaar zijn.

Dode eieren zakken uit naar de bodem en de schuine bodem van een trechter helpt om de eieren onderin de trechter te verzamelen. De dode eieren kunnen dan makkelijk verwijderd worden door de kraan even open te zetten. Maar ook kan het water makkelijk afgevoerd worden en de trechter goed schoon gemaakt worden.

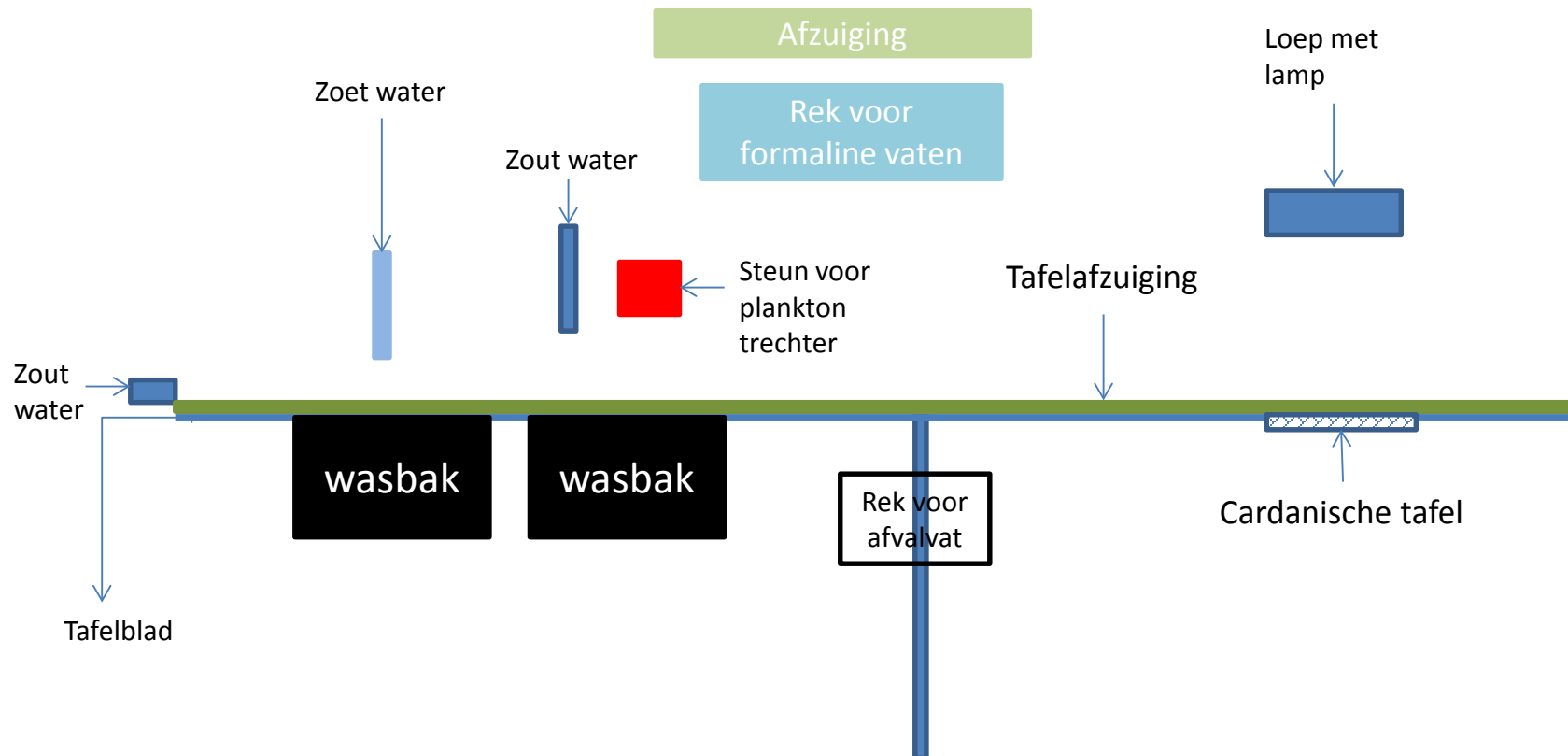
Binnen in de trechter moet op 3 hoogtes (20, 50 en 80 cm) de mogelijkheid gemaakt worden om gaas aan te brengen dat tijdens de reis makkelijk in en uit de trechter te halen is. Het gaas moet in de trechter vastgemaakt kunnen worden en niet bewegen met de beweging van het water.



Gewenste situatie

Kast voor formaline monsters verplaatsen naar het tussenstuk tussen het dek en het hydrografisch lab (waar nu de formaline voorraad opgeslagen wordt). Daar goede afzuiging maken zodat de voorraad formaline en de formaline monsters daar opgeslagen kunnen worden. Het huidige tafelblad verlengen en een tweede wasbak aanbrenge.

Het tafelblad wordt verlengd met de ruimte die ontstaat door het verplaatsen van de kast. Een tweede wasbak wordt aangebracht. Bij de tweede wasbak wordt de steun voor de plankontrechter geplaatst en een zout water kraan met de mogelijkheid voor een tuinslangaansluiting.



Plaatsen van een rek voor formaline vaten in het natte lab op het visverwerkingsdek

In het natte lab op het visverwerkingsdek kan onder de afzuiging ook een rek voor 3 formalinevaten geplaatst worden, mits de lucht en gas aansluiting verplaatst worden. Het rek moet dezelfde afmetingen hebben als in het hydrografisch lab.

