

Towards monitoring zooplankton and small pelagic fish in the Wadden Sea

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Summary

This report presents the activities and results from the ZKO Wadden Sea study “839.08.242 Acoustic surveys and plankton sampling” funded by NWO.

This pilot study consisted of two parts: (1) testing the possibility to mount a scientific echosounder on the TESO ferry between Den Helder and Texel to monitor the abundance of pelagic fish in the Marsdiep area and (2) testing the possibility to sample plankton by means of an Autonomous Plankton Sampler on board the ferry MS Vlieland between Harlingen and Vlieland. The tests with the installation of these systems are described. The study included also four reference hydro acoustic surveys, targeted on pelagic fish, in the Marsdiep in May and October 2010 and 2011.

Hydro acoustic data collection with an echosounder on the TESO ferry was not possible due to air bubbles causing noise and transmission loss. We expect that this can be solved in the future, by making special adjustments on the hull where the equipment is mounted.

The hydro acoustic surveys revealed the presence of high concentrations of clupeids in the Marsdiep, dominated by sprat (*Sprattus sprattus*). The summed biomass of Clupeids in the Marsdiep was estimated to be 613/369 tonnes in May 2010/2011 and 67/69 tonnes in October 2010/2011. The biomass of pelagic fish per water volume in October is approximately 20 times as high as the biomass of demersal fish per water volume as estimated from the DFS survey in autumn. The majority of the pelagic fish schools are found in the upper layers of the water column. Almost 50% of the fish is distributed in the upper 6 m. As the depth of the hull mounted transducer on the TESO ferry is 5 meter, it is to be expected that most fish will be missed. For future monitoring of pelagic fish it is therefore recommended to install a fixed installation at the bottom heading towards the surface.

An Autonomous Plankton Sampler (APS), based on the widely applied Continuous Plankton Recorder, was installed at the MS Vlieland, the ferry sailing from Harlingen to the isle of Terschelling. The efficiency of zooplankton collecting appeared to be sensitive to the water inlet system for which the necessary adjustments could not (for safety reasons) be implemented on the ferry. Different vessels were therefore used to further improve the APS, in particular the inlet system by using a gauze funnel of different sizes and sampling directions. An improved design was tested for robustness under offshore conditions, and a final design was used to collect samples in the Wadden Sea. The final design was able to collect different taxonomical groups of (meso)zooplankton, including copepods and larvae of zoobenthic species, in relevant quantities. In case the system would be implemented in monitoring, it is recommended to install the APS on board of a monitoring vessel. Further research should be dedicated to the catch efficiency of different species and groups of zooplankton.

1 Introduction

This pelagic ZKO monitoring, was an experimental study carried out as part of the ZKO monitoring program on the monitoring of pelagic fish and zooplankton. The ZKO program (Dutch National Ocean and Coastal Research Program or Zee en Kust Onderzoek, ZKO; www.nwo.nl/en/research-and-results/programmes/The+National+Ocean+and+Coastal+Research+Programme%E2%80%AC) has been launched in order to integrate fill gaps in current marine research, carried out by different Dutch scientific institutes. More specifically, the objective of the pelagic fish and zooplankton programme was to complement the existing but incomplete monitoring programme in the Wadden Sea (NIOZ fyke net catches) by providing information on the seasonal patterns in fish biomass, size structure and species composition of the pelagic fish assemblages as well as the seasonal fluctuations in abundance and species composition of zooplankton. As there is currently no experience with monitoring of zooplankton and pelagic fish in the Wadden Sea, the program is designed as a pilot.

The only existing monitoring on fish in the Wadden Sea area are the daily catches of the NIOZ fyke in the Marsdiep (Van der Veer et al., 2011). The value of this program for knowledge on pelagic fish is limited since the fyke catches for mainly large, straddling fish rather than school of small pelagic fish.

1.1 Pelagic fish assemblages

Coastal areas are presumed to be important nursery and feeding areas, not only for bottom-dwelling species, but also for pelagic fish. Although the influence of coastal habitats on survival, growth, and reproduction of marine species has been demonstrated, the absolute value of these habitats to their population dynamics have rarely been quantified (Vasconcelos et al., 2014). Coastal areas provide the habitat used by fish during a particularly vulnerable life stage. At the same time these areas are often intensively exploited by diverse human activities and have been degraded in recent times (Airoldi and Beck, 2007; Beck et al., 2001).

Small pelagic fish are usually only studied in areas with a bottom depth over 20 m. A main reason for this lack of studies in shallow coastal waters is the difficulty to apply traditional acoustic methods during acoustic surveys in these often turbid waters.

The Dutch Wadden Sea is Europe's largest estuarine area. The Wadden Sea and adjoining coastal area, both Natura 2000 sites, are used by juvenile fish that later in life recruit to commercially exploited adult populations (herring *Clupea harengus*, pilchard *Sardina pilchardus*, anchovy *Engraulis encrasicolus*, sandeel *Ammodytes* sp.). Older life stages of some of these species stay in the shallow waters for feeding. Still, in the past decennia main research focus was put on demersal fish, caught with bottom trawls (Bolle et al., 1994; Tulp et al., 2008; van der Veer et al., 2011).

Besides its commercial importance, pelagic fish also play an important role in the coastal ecosystem as a main prey species for large, local concentrations of waterbirds, both in the breeding and overwintering period. Several tern species (Sternidae) that form large colonies on the Wadden Sea islands feed on pelagic fish during their breeding period to provide for their chicks and for self-maintenance (Daenhardt and Becker, 2011; Daenhardt et al., 2011). They catch small fish striking the water in shallow dives or skimming the surface. During wintertime grebes (*Podiceps cristatus*) and auks (Alcidae) spend several weeks up to months along the Dutch coast, where they feed on small pelagics (Couperus and Tulp, 2005). In contrast to terns, grebes and auks catch their prey while diving. The fraction of small pelagics available to both diving and non-diving birds is hence strongly dependent on the vertical distribution of fish schools and their behaviour.

1.2 Zooplankton

Zooplankton composition has proven to be a clear environmental indicator, e.g. in changing nutrient levels in the Wadden Sea (Fransz et al., 1992). Even though zooplankton is likely a key factor determining the quality of estuarine areas for juvenile fish, zooplankton studies in coastal or estuarine areas are rare. As a result zooplankton has been ignored in ecosystem wide studies (e.g. Philippart et al. 2007). Changes in regional sea temperatures and the zooplankton composition has shown to be correlated to and affect plankton eating fish (Beaugrand et al. 2003). At present there is no zooplankton monitoring programme in the Dutch Wadden Sea in the Netherlands. In order to fill this gap we tested a cost-effective sampling method using the Continuous Plankton Recorder (CPR) approach of the Sir Alister Hardy Foundation for Ocean Science (SAHFOS).

Zooplankton is characterised by strong seasonal variations in abundance and species composition and requires high-frequency sampling. The advantage of the CPR approach is that it is less laborious and time consuming, when compared to net sampling and allows recordings at a high frequency. As there is no experience in applying the CPR methodology in shallow coastal waters such as the Wadden Sea, the current study is considered to be a pilot study. If successful, it would offer a new methodology for continuous recordings of zooplankton that can be applied in numerous habitats difficult to access with commonly used sampling techniques. In this report the installation of the plankton recorder, the collection and analysis of zooplankton samples are described.

1.3 Hydro-acoustics

Hydro-acoustic surveys are an efficient tool in describing spatial distribution and biomass estimates of pelagic fish over large areas. An area is covered by a vessel by means of transects. The vessel uses an echosounder: which is a device which transmits sound pulses and receives their echo's. The time interval between the emission and return is a measure for depth. In the same way, schools of fish can be detected: the strength of the echo is a measure for the density of the school or the quantity of fish. However, additional trawl hauls are required to validate the acoustic observations on fish density and distribution. In addition, catching fish enables collecting biological data (length, age, sex and maturity). When an undefined school of fish is detected by means of echolocation, a haul is made to investigate species composition and length distribution. The net is shot within 15 to 20 minutes after detection of the school. Hauls for species identification can therefore never be planned in advance and are not randomly spread (Figure 1).

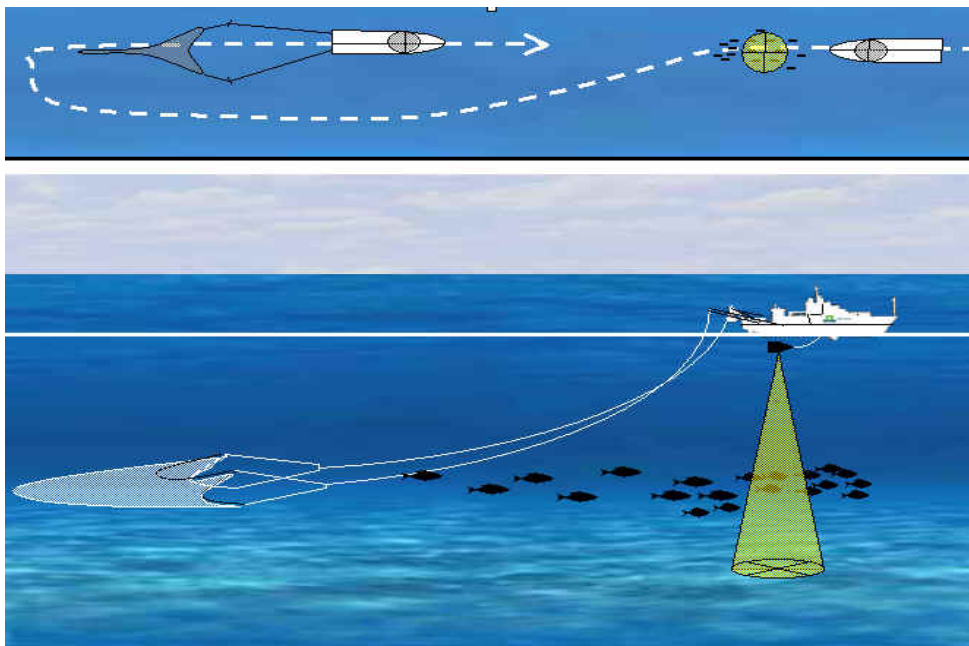


Figure 1. Scheme of the sampling method for pelagic fish. When an undefined school of fish is detected on the echo-sounder (B), the vessel turns and shoots a pelagic trawl within 15 to 20 minutes.

In order to explore the possibilities for a cost effective standardised method to monitor pelagic fish, an echosounder was installed on the TESO ferry, which operates between Den Helder and the Texel to test the feasibility of on-going routine monitoring. Additionally four hydro acoustic surveys were carried out in the Marsdiep – the water channel between Den Helder and Texel - tidal basin, in spring and autumn 2009 and 2010. In order to test the possibility to monitor plankton, an Autonomous Plankton Recorder (APS) was installed on the ferry between Harlingen and Vlieland. The APS collects (zoo)plankton from water that is pumped up from the water column during cruising. Several transects can be stored automatically in a box with a fixative, allowing operation on commercial vessels.

1.4 Objectives

The objectives of the research described in this report are to conduct a number of tests runs of two monitoring techniques new to the Wadden Sea area:

- 1 echosounders to detect pelagic fish schools and
- 2 an Autonomous Plankton Sampler (APS) to detect plankton

These tests are conducted within the context of setting up cost effective standardised methods for monitoring pelagic fish and zooplankton for the next years/decades in the Wadden Sea area. The aims of the monitoring program are to:

- Monitor the trends in biomass, size structure, species composition and biological parameters of pelagic fish
- Monitor the trends in abundance and species composition of the zooplankton (APS)
- Develop a cost-effective acoustic monitoring programme for pelagic fish

This report describes the installation of the acoustic (chapter 2.1) – and plankton recording equipment (chapter 2.2) and the results of the tests carried out with these devices (chapter 3.1 and 3.2, respectively).

The objective within the test runs are

- to calculate the biomass is of pelagic fish in the Marsdiep area by means of echo integration (Simmonds and Maclellon, 2005)
- to describe approximate dimensions of schools as well as their vertical and horizontal movements in relation of the tide
- to describe catch composition and length frequency distribution
- to evaluate the use of an echosounder on board the TESO ferry

2 Materials and Methods

Figure 2 presents the survey area. An overview of the days of data collection, hauls and samples collected in this project for the acoustic – and the plankton sampling part can be found in **Fout! Verwijzingsbron niet gevonden..** An overview of platforms used during this study is provided in Figure 3.



Figure 2 The Marsdiep area between Den Helder and Texel. The polygon gives the boundary of the area for abundance estimation.

Table 1 Overview of surveyed days during this study. Survey days during the acoustic surveys include the time spent for the calibration of the equipment and the steaming up to the Marsdiep area from IJmuiden

Date (start)	Acoustic		Zooplankton sampling	
	trial TESO (days)	survey (hauls)	ship/ platform	samples/ analyses
April 2009			NIOZ quay	Initial testing
April 2009			MS Vlieland	Plankton sampling (analysed)
17 May 2010		5/19		
14 September 2010	2			
August 2010			Zilvervisje	Plankton sampling (no analyses)
November 2010			FRV Tridens	Plankton sampling (no analyses)
11 October 2010		5/19		
26 October 2010	5			
2 May 2011		5/18	GO58	Plankton sampling (analysed)
4 May 2011	1			
17 October 2011		5/9		



Figure 3. Platforms used during this study - Upper left: aluminium flat bottomed research vessel "Zilvervisje". Middle left: chartered fishing vessel GO58, which was used for the acoustic surveys in

May and October 2010 and 2011. Middle right Ferry MS Vlieland. Below: Fisheries Research Vessel *Tridens*.

2.1 Hydro acoustics

2.1.1 Installation of an echosounder on board the TESO Ferry

The 200 kHz transducer and transceiver was installed in the moon pool of the TESO ferry in September 2010. Technically the equipment worked fine. The depth of the transducer in the moon pool was at 5 m below the water surface: any fish swimming higher in the water column would be missed.

During the third quarter of 2010 two days data were collected. The echograms showed a lot of transmission loss, probably due to air bubbles.

2.1.2 Surveys

Four hydro acoustic surveys were carried out: 17 – 21 May 2010, 11 – 15 October 2010, 2 – 5 May 2011 and 17 – 21 October 2011 (see Table 1). The acoustic equipment used, was a 38 kHz SIMRAD EK60 splitbeam echosounder, mounted on a towed body (Figure 4). The towed body was towed at approximately 2m depth alongside a chartered fish cutter, the GO58, “Jakoriwi”. The Marsdiep area was randomly surveyed between the sand bank “De Razende Bol” at the North Sea side and the Wadden Sea side up to depth of 5m.

In total 132, 164, 160 and 61 – total 517 - nautical miles (nm) were covered in the respective years during the surveys.

In October 2010 and May 2011 in the Marsdiep area, data were recorded on board the TESO ferry; in October 2010 one week later than the survey; in May 2011 on one day during the survey.

Prior to each survey the equipment was calibrated using standard methodology described by the manufacturer (<http://www.simrad.com>) and can be found in Foote et al. (1982). Calibrations of the two surveys in 2010 took place in the entrance of the port of Rotterdam (Figure 5). For the surveys in 2011, we relied on the calibrations carried out during surveys in the offshore windfarm off Egmond, in April and October, 2011 respectively (calibration reports: Annex I).

Data were analysed with Myriad Echoview software. Within this application an algorithm was applied to distinguish between swimbladdered and non-swimbladdered fish species (see paragraph 2.1.3), where catch data is used to groundtruth acoustic findings. The acoustic target strength (TS) of fishes with swimbladder - in the Marsdiep dominated by clupeids - is several orders of magnitude larger than the TS of non-swimbladdered fishes, in the Marsdiep area consisting mainly of sandeel (*Ammodytes tobianus*) (Simmonds and Maclellan, 2005), for low frequency echosounders such as the 38 kHz used during this study. As a result a mix of acoustic indications of the latter with echo's from swimbladdered fishes would create a large overestimation if echo's from clupeids are wrongly assigned to sandeel. On the other hand is echo's from sandeel are wrongly assigned to clupeids this will have a negligible effect on the abundance estimation. Therefore echo integration was only applied to clupeids.



Figure 4 Towed body, hoisted on board.



Figure 5 Calibration of the EK60 echosounder was carried out in the entrance of the port of Rotterdam.

2.1.3 Analysis

2.1.3.1 Identification of clupeids and school dimensions

The acoustic data were analysed with post processing software *Myriax Echoview* (<http://www.echoview.com>). Echoview uses algorithms to create so called synthetic echogram, transformed echograms or filtered echograms. The algorithm used in the present study was designed to exclude everything but clupeid schools. The algorithm cleaned the data from background noise and excluded data below 0.5 m of the bottom or above 0.5 m below the surface. The data were blurred and a median filter was applied to make schools more visible, before the school detection algorithm, included in *Myriax Echoview*, was run. The mean TS of each school was computed and a threshold of -45 dB was applied as this is the frequency that has shown to distinguish Clupeid schools in the uppers 50m of the water column in fisheries hydro acoustics (i.e. Fassler et al, 2011) . Thus each school with a strong mean TS was kept as a clupeid school. Results were exported based on the selected schools, masked with the raw data. Export in Echoview was carried out by region and by cell, so that values for each school with depth information were generated. The resulting files contained information about the position of the data points (GPS information, latitude, longitude and time), the depth of the detected schools, the *Nautical Area Scattering Coefficient* (NASC, e.g. the reflected surface of acoustic energy in m^2/nmi^2), school height and length (m), maximum circumference (m) and area of the slice at the circumference (m^2), school surface (m^2) and volume (m^3) (Figure 6).

After applying the Echoview algorithm, additional filtering of the dataset was carried out by removing extreme values. This was necessary because the threshold for school detection was set very broadly (not restrictive), to be able to include a large range of school sizes and shapes, especially very small schools. This resulted in detections of schools of extreme size, which were removed after expert judgement. The following records were removed : school length < 550m; school height(m) < length/1000, height < 0.01m; slice-area < 0.01m^2 , circumference < 0.01m^2 , slice-area/circumference1 < 0.01, length < 0.3m, school volume < 0.001m^3 , NASC > $2.10^5 \text{ m}^2/\text{nmi}^2$.

2.1.3.2 Vertical fish distribution in relation to tide

The resulting vertical distribution was tested against the predicted tide. Tidal information – water level per ten minutes - was taken from http://live.getij.nl/getij_locaties.cfm?taal=nl for the location of Den Helder. The water level was compared to the presence of fish (NASC) per 1 m vertical layers and 20 minute intervals.

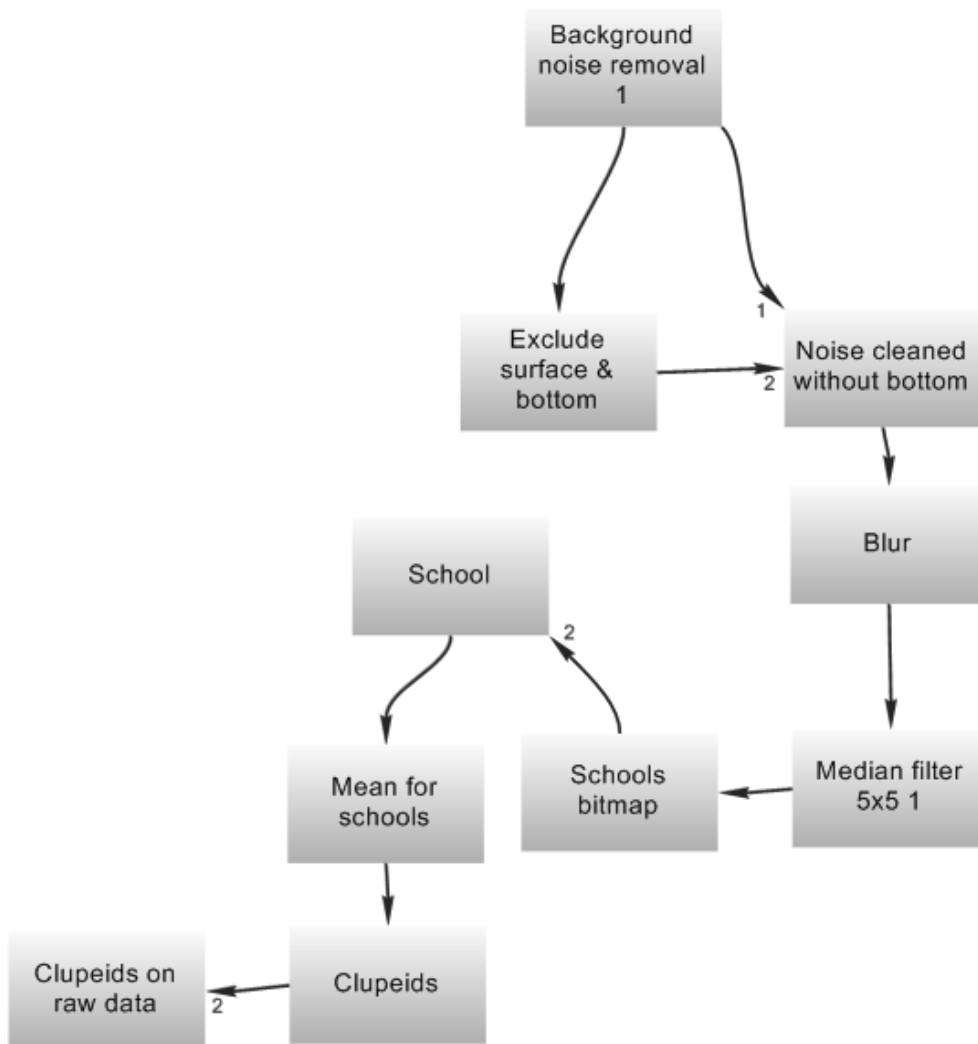


Figure 6 Schematic presentation of the algorithm applied to detect clupeid school with the post processing software Myriax Echoview (Figure taken from Myriax Echoview manual).

2.1.3.3 Fish catches

The acoustic recordings were verified by fishing with a semi pelagic trawl “Zwever” with a 6 mm meshes codend lining, an effective trawl opening of approximately 12 meter horizontal and 5m vertical (Annex II). The fishing speed was 3.3 knots through the water. Fishing was carried out to identify species-composition of recordings observed on the echo sounder and to obtain length frequency samples of herring and sprat. In general, after we decided to make a tow with a pelagic trawl (based on the echo information), the vessel turned and fished back on its track line. All hauls were executed in midwater, mostly close to the surface.

The catch was subsampled and divided in species fractions. The weight of the subsample was estimated or measured with a scale (± 10 g), length estimates were obtained through measuring up to 150 specimens rounded down to the nearest cm, i.e.: 10.7 cm is recorded as size class 10 cm.

2.1.3.4 Abundance estimation

For an arbitrary polygon area (Annex III), established for each survey, length distribution of clupeids and sandeel were determined as the un-weighted mean of all trawl results. Within the polygon, the number of surveyed nautical miles were 97, 116, 68 and 28 nm for each survey respectively. From these

distributions the mean acoustic backscattering cross-section “sigma” (σ_{bs}) was calculated according to the target strength-length relationships (TS) recommended by the ICES Working Group on International Pelagic Surveys (PGIPS; <http://www.ices.dk/community/groups/Pages/default.aspx#k=wgips>): $TS = \log(\text{length}) - 71.2$. The numbers of herring and sprat were calculated by dividing the NASC by the overall σ_{bs} in the Marsdiep area. The mean weight of all clupeids (Herring, Sprat, Pilchard, Anchovy) in the catches was calculated by applying the standard length weight relationship ($W = aL^b$) found by Grift et al (2004) for sprat off the Dutch coast: $a = 0.004$ and $b = 0.23$ during the second quarter; $a = 0.0058$ and $b = 2.85$ during the fourth quarter.

The abundance of sandeel was calculated based on the number of fish caught per area fished in the trawl hauls, assuming that fish did not escape the net. The distance fished was calculated by multiplying the trawl speed with the trawl time. The area fished was calculated by multiplying the distance with the effective horizontal opening of the net. The total area within the polygon was divided by the area fished. Multiplication of this quotient with the actual weight caught, gives the total fish abundance.

2.2 Zooplankton

Five cruises were carried out to test the set-up of a zooplankton sampling system by means of an on-board Autonomous Plankton Sampler (APS) based on the Continuous Plankton Recorder system (Figure 4, Table 1). Based on its performance, the set-up of the sampling system was changed from one cruise to another, to improve the sampling of zooplankton. Carrying out standardised sampling was not the purpose of this study at this stage.

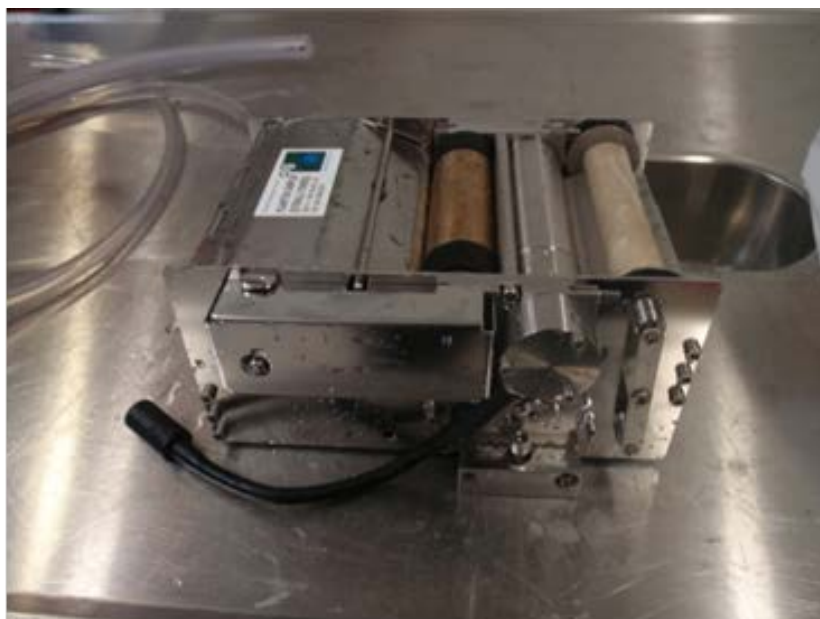


Figure 7 The plankton sampling unit (“plankton recorder”) of the APS.

2.2.1 Description of the APS and sample treatment

A CPR system (Continuous Plankton Recorder) was adapted in cooperation with Chelsea Technologies (CTG) in order to enable the on-board application of sampling. The CPR system is towed behind a ship, sampling the water *in situ*. With the Autonomous Plankton Sampler (APS), water is pumped from the sea through a programmable and thus autonomous plankton recorder. Zooplankton is captured between two

layers of gauze inside the plankton recorder and subsequently wrapped on a gauze roll soaked in preservation fluid. Samples were taken during sailing.

This system has the advantage that no gear is set overboard, thus excluding the risk of mechanical damage to the recorder, the ship or other obstacles. In addition, maintenance can be reduced to a minimum, because the APS can be programmed for a sequence of sampling events in advance, and all parts are readily accessible from inside the ship. Digital data logging and a computer interface in principle allow coupling of the flow data with concurrent measurements of temperature/salinity and GPS position.

After initial testing it appeared that technical adjustments to the sampling system were necessary, involving changes to the intake of water. Unfortunately, it was not allowed by the ship owner to make changes to the inflow system in the hull of the ship. Therefore, the APS system was tested at different platforms of opportunity (e.g. research vessels).

Sampling and sample treatment

Zooplankton was collected on gauze with a mesh size of 150 μm (as provided with the CPR) for the duration of 10 to 25 minutes per sample, representing a water volume ranging from 0.5 to 1.5 m^3 . After one sampling phase, the gauze was rolled into preservation fluid (borax buffered formaldehyde-seawater solution). During sailing, multiple samples were collected (Figure 8), and the gauze was recovered in the laboratory. Sections of the gauze representing one sample were cut and stored in a small bottle on buffered formaldehyde-seawater solution (3.7%). The gauze was rinsed with seawater to extract the plankton from the net. The net was further inspected to assure that all zooplankton was removed. A sample was rinsed into a Bogorov plankton counting chamber, and plankton was identified on the level of higher taxonomic groups (order, family and genera).

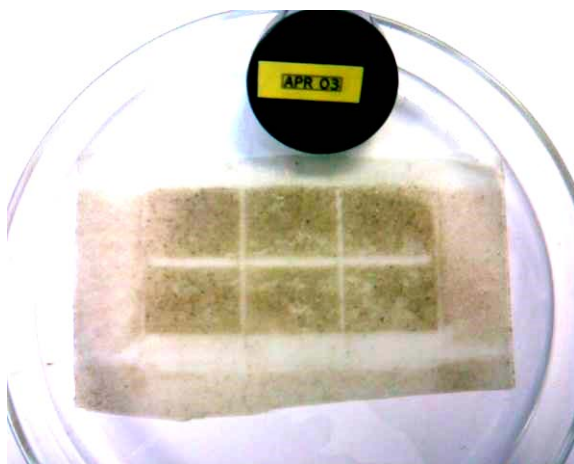


Figure 8 A typical sample of the APS after 20 minutes of sampling.

2.2.2 Applications of the APS

A first trial was carried out on board of the Ferry “MS Vlieland” sailing from the city of Harlingen at the main land to the isle of Terschelling in the Wadden Sea. The MS Vlieland’s compartment where the ship’s seawater system intake is situated was found suitable for the installation of the APS. A separate access to seawater could be used to provide the APS with seawater from outside the ship’s hull using 1” piping (see also Annex VI). The seawater inflow was approximately 1.5 m below the waterline, with an opening of 12 cm^2 (outer diameter approx. 2.5 cm) directed perpendicular to the ship hull (see Annex VI). A self-priming centrifugal pump was installed downstream of the APS to establish a constant flow of water through the APS during sampling. The piping system that connects the sea water inflow with the APS and

the pump was installed during the MS Vlieland's docking period in March 2009. The APS itself and the pump were installed shortly after delivery on June 3rd, 2009. Samples were taken during sailing with a speed of about 12 knots.

Since the preliminary installation of the APS on MS Vlieland in 2009 had yielded too low numbers of zooplankton, the aim in 2010 was to investigate possible improvements of the sampling efficiency of the Autonomous Plankton Sampler (APS). The poor performance could have been due to the small opening and direction of the collecting pipe and/or the high speed of the vessel. In August 2010, a mobile system was developed to test sampling with a larger opening by means of a gauze funnel (10x20 cm) directed in the sailing direction, and at lower sailing speed. A mobile APS system was installed on board of the small vessel *Zilvervisje* (Figure 9). Samples were taken in the Wadden Sea close to isle of Texel in August 2010. Zooplankton samples were collected and analysed to assess the performance of the sampling set-up. The results of this test indicated that the adapted mobile APS system using a gauze funnel at the inflow opening yielded zooplankton abundances in an order of magnitude realistic for the Wadden Sea (see results section).



Figure 9 Testing of mobile APS on board of the small research vessel *Zilvervisje*.

After further improvement of the system, the mobile system was tested again during an zooplankton survey on board of RV *Tridens* in November 2010. The gauze funnel was installed aside the ship at about 1.5 m depth (Figure 10) in order to test a more robust system (funnel) at higher sailing speed. Different funnel sizes were tested; 10x10 cm, and 10x20 cm openings, with the opening directed in the sailing direction, and at various angles for comparison. The system operated well during offshore conditions and zooplankton samples were collected at sailing speeds of up to 13 kn. However, no priority was given to analyse the samples for species and counts, since they were taken outside of the Wadden Sea. The main result was the demonstration of the robustness of the system.

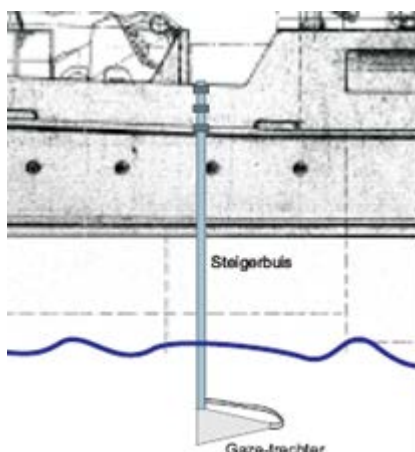


Figure 10 Drawing of inflow pipe on the RV Tridens.

In 2-4 May 2011, the system as applied on the RV Tridens was implemented on board of a commercial fishing vessel (GO58). A survey was carried out in a concerted action with the acoustic work, with the aim to collect relevant data for the Wadden Sea. Zooplankton samples were taken and analysed.

A summary of surveys is presented in Table 2.

Table 2 Summary table of zooplankton surveys to test the on-board APS system

Code	Sampling vessel	Sampling location	Sampling date	Description of set-up and adaptations
V 2009*	Ferry Vlieland	Harlingen-Vlieland transect	April 2009	Water pumped from sea water system of Ferry; opening 2cm ² , direction at right angle of ship hull
V2009a	Ferry Vlieland	Harlingen-Vlieland transect	June 2009	No changes
V2009b	Ferry Vlieland	Harlingen-Vlieland transect	July 2009	No changes
M 2010	Zilvervisje	Wadden Sea near Texel	August 2010	Water pumped through gauze funnel opening (200 cm ²), directed in sailing direction of ship (similar to Figure 10)
N 2010	RV Tridens	North Sea	November 2010	More robust gauze funnel systems (100 and 200 cm ²), offshore conditions, high sailing speed
W 2011	GO58 fishing ship	Wadden Sea	May 2011	Gauze funnel system 200 cm ² , Wadden Sea sampling

Selected samples were analysed from the monitoring of zooplankton, since the focus was on the technical implementation of the Autonomous Plankton Sampler (APS). Samples from the trial runs were analysed for surveys in 2009 taken on board of a Ferry, for 2010 from a small research vessel and in 2011 taken from a commercial ship. The efficiency of the catch is reflected by the composition of taxonomic groups in the samples, and the density of zooplankton, calculated from the numbers caught and the volume of water sampled by the APS.

3 Results

3.1 Hydro acoustics

3.1.1 Recordings from the TESO ferry

The quality of the data from the echosounder installed in the TESO ferry were too poor to base an accurate species identification and biomass estimation on, as illustrated in Figure 11.

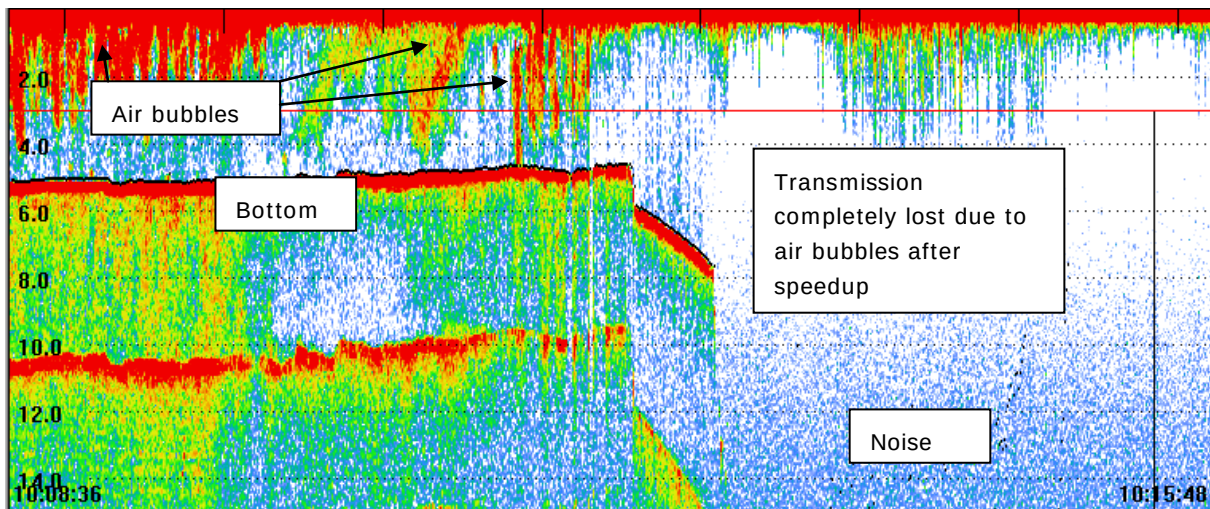


Figure 11 Echogram (200 kHz) from 26 October in the Marsdiep from the echosounder mounted in the TESO line. After the ferry leaves the dock, blobs of air bubbles are visible. After speedup, the echosounder suffers from transmission loss, indicated by the disappearance of the bottom and the noise in the water column. (the red line is a boundary line for echo integration in the interface of the echosounder).

3.1.2 Hydro acoustic surveys

The hauls carried out during the acoustic surveys in May and October, 2010-2011 and the polygon for the calculation of the abundance of pelagic fish are presented in Figure 12. Annex IV provides the survey tracks across the area for each survey.

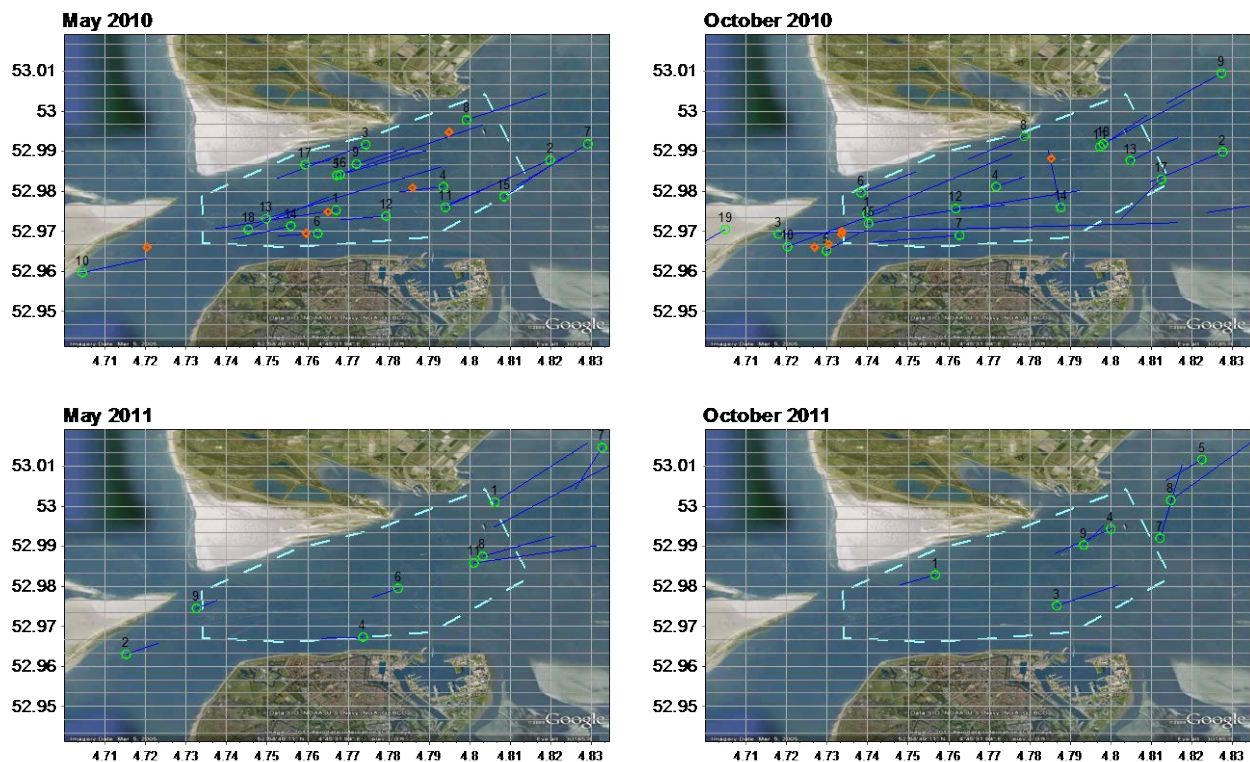


Figure 12 Pelagic hauls carried out during the acoustic surveys in May and October, 2010-2011. The starting positions are presented as green circles, the fished track is represented by blue lines. The orange dots in the May surveys are CTD downcasts (not in this report).

Figure 13 gives an example of a typical 38 kHz echogram in the Marsdiep area.

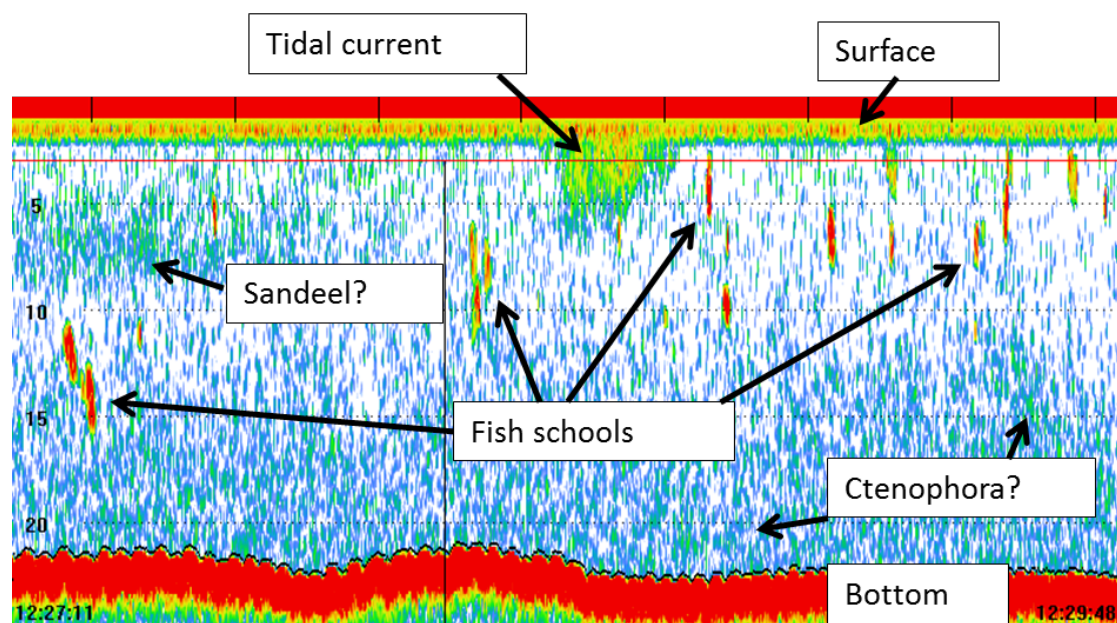


Figure 13 Typical 38 kHz echogram in the Marsdiep area. Tidal current and the wake of vessels (not in this echogram) as well as swimbladdered fish congregations can be recognized easily. The recognition of nonswimbladdered fish, plankton and Ctenophora(Comb jellies) is equivocal.

3.1.2.1 Biomass in the Marsdiep area

Table 3 provides the abundance and biomass of clupeids in the Marsdiep area based on acoustic estimates and biological measurements. The mean length of clupeids (8.2 cm) in May 2010 was large compared to the mean length in October (7.3 cm), whereas the mean length in October 2010 (5.9 cm) was smaller than in October 2011 (7.9 cm). The biomass in the Marsdiep area, based on the mean weight and the NASC is in May higher (612 tonnes in 2010 and 369 tonnes in 2011) than in October, where the estimates are remarkably similar for both years (67 tonnes and 69 tonnes).

The biomass of clupeids in the area is much higher, by a factor of 20 in October, when compared to demersal fish biomass estimates raised to the same water volume in the Demersal Fish Survey (DFS). A rough estimate for sandeel, based on trawled area, is more than 20 tonnes in May and 0 tonnes in October. If the trawl catch rates of clupeids are raised to the area, the biomass is in the range of (low) hundreds of tonnes (Table 4).

Table 3 Abundance and biomass by survey, based on Nautical Area Scattering Coefficient's (NASC), acoustic Target Strength (TS) calculated from the mean length from all hauls, acoustic cross section (σ_{bs}) and the mean fish weight calculated from the length according to the standard length weight relationship ($W=aL^b$) as found for sprat by Grift et al (2004).

survey	mean length (cm)	TS (Db)	σ_{bs}	NASC	surface nm2	abundance	mean weight (g)	biomass (kg)
May 2010	8.2	-52.9237	0.000064	1551.987	7.225	174939643	3.5038	612955.3
October 2010	5.9	-55.783	0.000033	339.3784	7.225	73893830.3	0.9128	67447.27
May 2011	7.3	-53.9335	0.000051	1077.486	7.225	153247724	2.4097	369278.2
October 2011	7.9	-53.2475	0.000059	269.606	7.225	32741865.7	2.0973	68670.25

Table 4 Estimates of biomass and densities in the Marsdiep area. The first column gives the abundance of swimbladdered fish (dominated by Clupeids) calculated by means of echo integration. The third gives the estimates abundance of demersal fish in the DFS to illustrate that pelagic fish outnumbers demersal fish by a factor of 20. The third and fourth column gives the biomass estimate of sandeel, based on trawled surface.

(tonnes)	transects surveyed inside/outside polygon - nmi	survey - ZKO Pelagic fish Marsdiep (clupeids) -tonnes(kg/ha)	Demersal Fish Survey (DFS) Western Waddensea -tonnes(kg/ha)	length of trawl track in + outside polygon - nmi	Rough estimate based on fished surface ZKO Marsdiep survey (sandeel) -tonnes(kg/ha)	Rough estimate based on fished surface ZKO Marsdiep survey (clupeids) tonnes(kg/ha)
May 2010	97/132	613(247.3)		14.6	21.9(8.9)	207(83.5)
Oct 2010	116/164	67.4(27.2)	3.1(1.3)	15.7	0(0)	277(111.8)
May 2011	68/160	369.3(149)		8.1	22.2(9)	504.2(203.5)
Oct 2011	28/61	68.7(27.7)	2.7(1.1)	7.4	0(0)	157.6(63.6)

3.1.2.2 Fish behaviour in relation to tide

The distribution of fish in the water column is presented in Figure 14. Almost 50% of the fish is found in the upper 6m. Results for fish concentrations in relation to tide (minutes after low tide) are presented in Figure 15 and Figure 16. There is a slight indication of higher fish concentrations in May 2010 during high tide and no indication of any relation to tide in October 2010 and May 2011 (Figure 15). In October 2011 the data collected are too patchy to draw any conclusion.

Figure 16 indicates that in May 2010 the relative fish distribution is higher in the upper layers during high tide, while in October 2011 the relative distribution is higher in lower layers. In May and October 2011 no pattern is visible.

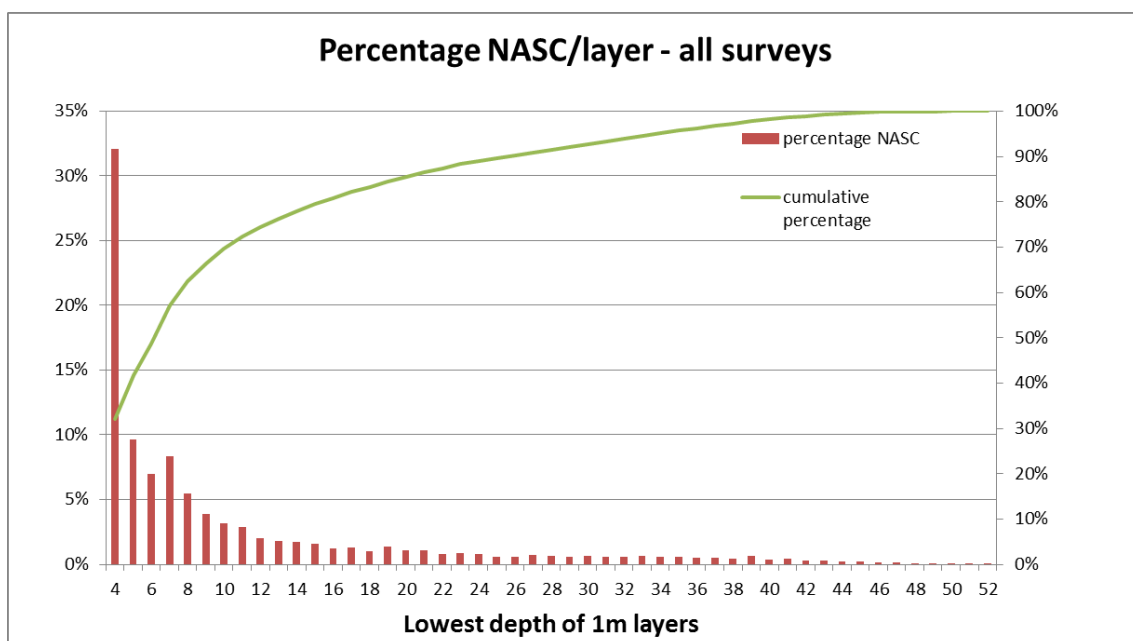


Figure 14 Distribution of fish in the water column by layers of 1m as percentage NASC (% Nautical Area Scattering Coefficient).

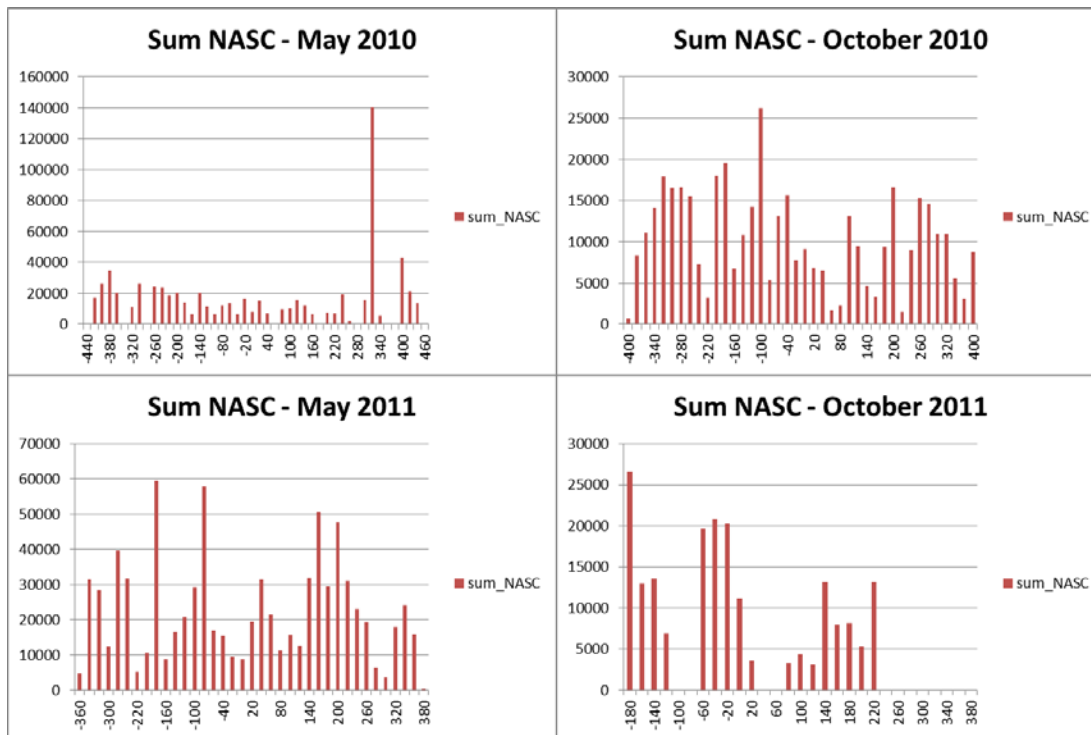


Figure 15 Nautical Area Scattering Coefficient (NASC; m²/nm²) in relation to tide. The vertical axis presents the NASC; the horizontal axis presents the tidal state in minutes relative to low tide (0).

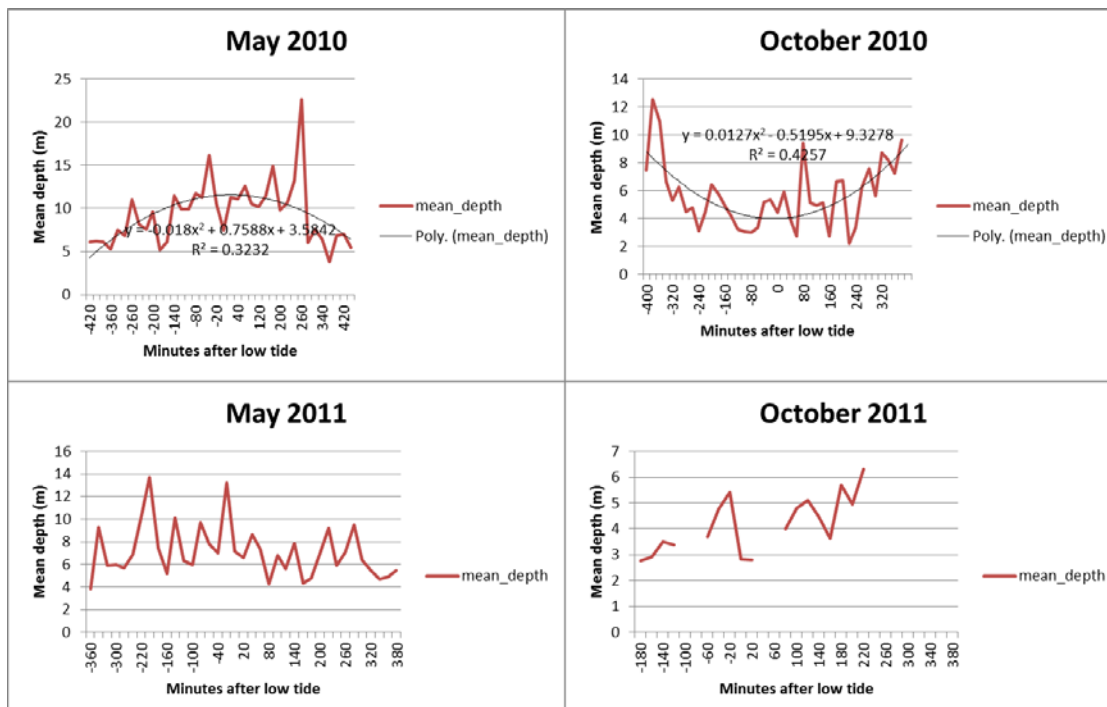


Figure 16 Relative fish abundance per depth layer in May and October 2010 and 2011. The vertical axis presents the NASC; the horizontal axis presents the tidal state in minutes relative to low tide (0).

3.1.2.3 School dimensions

School dimensions are presented in Figure 17. In all surveys schools measure typically a few meters in length and in height. In May the schools are larger than in October when most of the schools were smaller than 1m high. Larger schools are less dense than small schools, except very large schools (> 35m long and >8m high).

May 2010

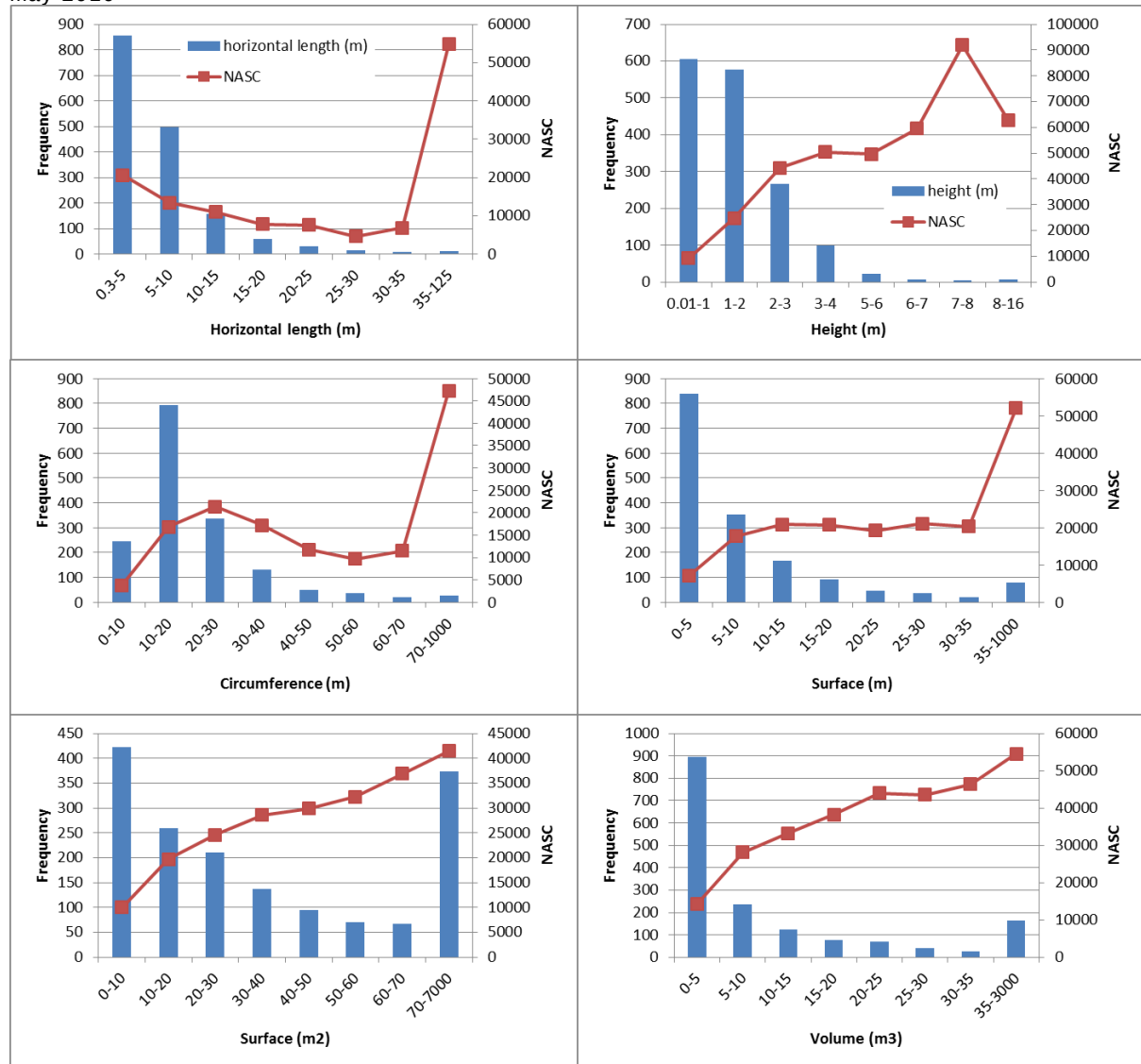


Figure 17 School dimensions in May 2010. The blue bars and the left axis present the dimensions in terms of length (top graphs), surface (middle) and volume (bottom). The red line (right axis) represents the density of the fish schools as Nautical Area Scattering Coefficient (NASC; m^2/nm^2).

October 2010

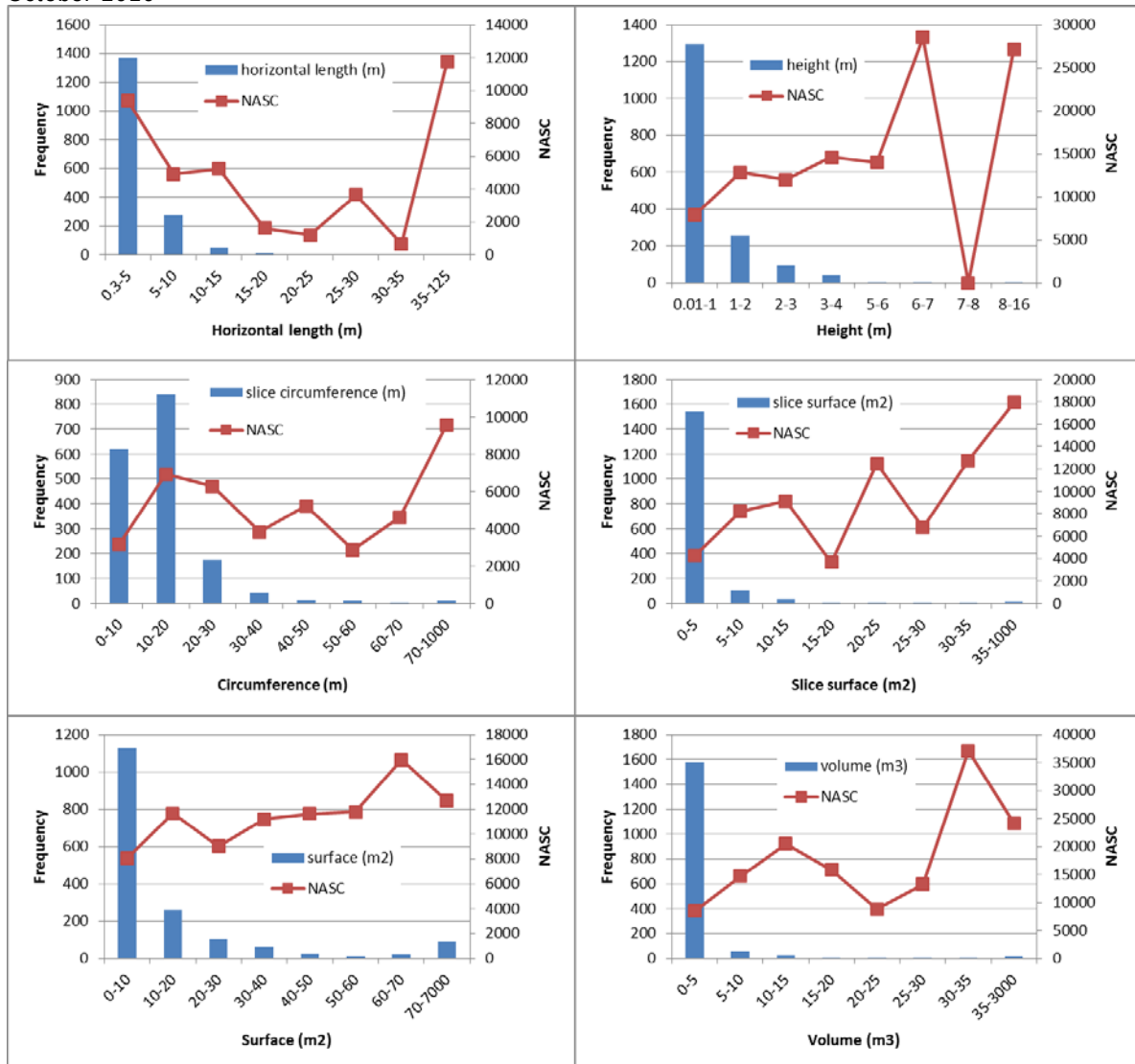


Figure 17- continued. School dimensions in October 2010. The blue bars and the left axis present the dimensions in terms of length, surface and volume. The red line (right axis) represents the density of the fish schools as Nautical Area Scattering Coefficient (NASC; m²/nm²).

May 2011

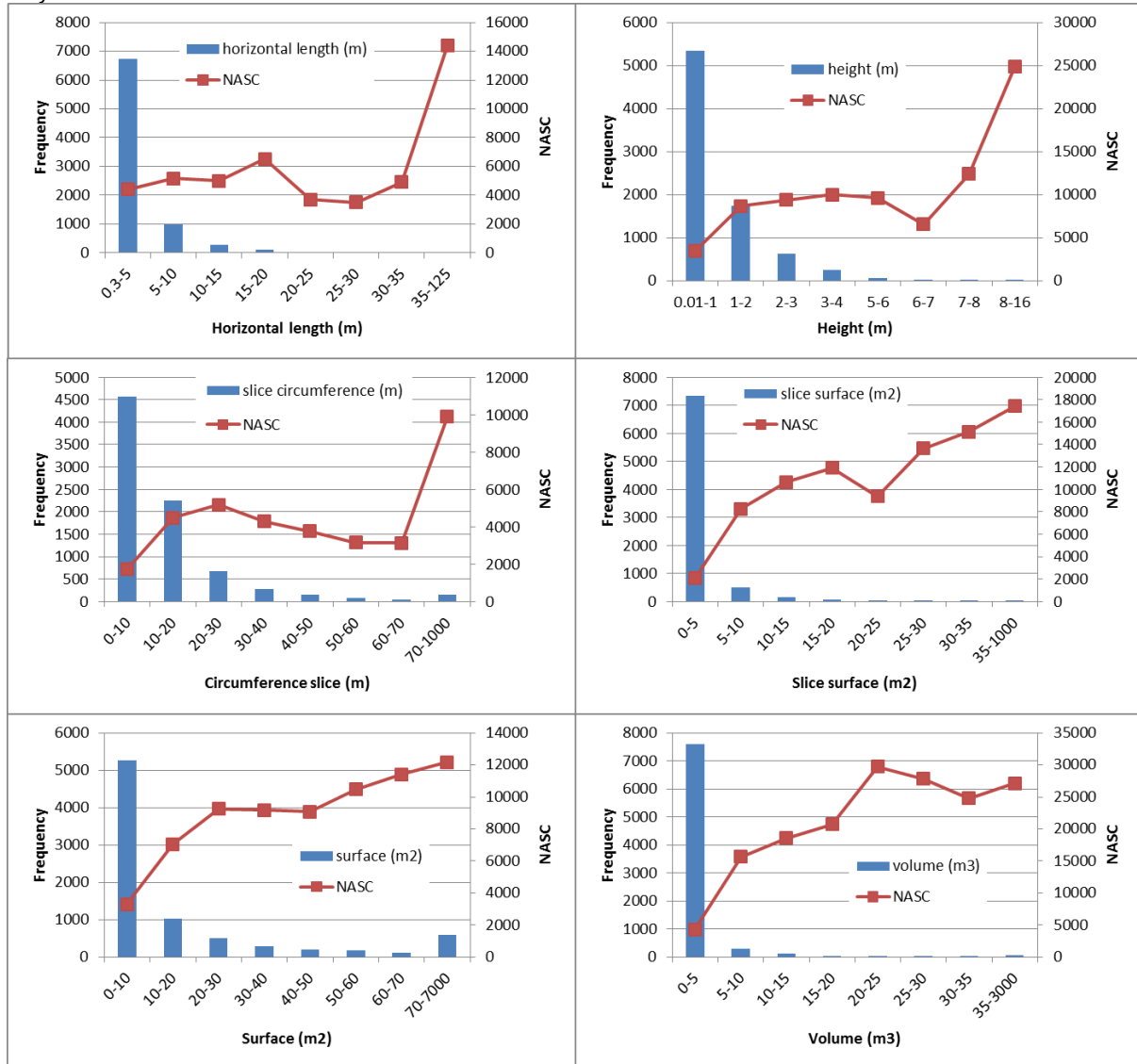


Figure 17-continued. School dimensions in May 2011. The blue bars and the left axis present the dimensions in terms of length, surface and volume. The red line (right axis) represents the density of the fish schools as Nautical Area Scattering Coefficient (NASC; m^2/nm^2).

October 2011

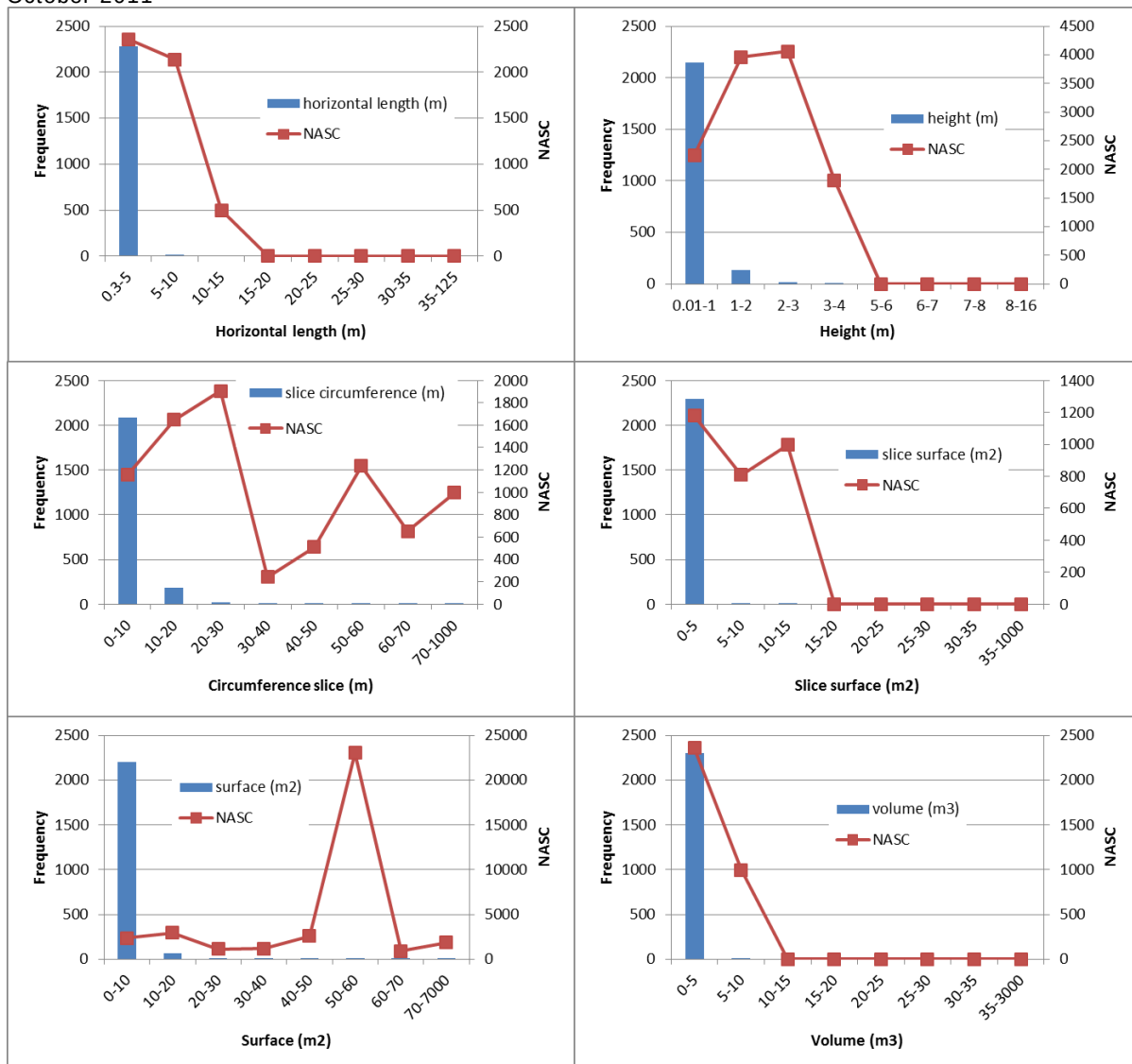


Figure 17-continued. School dimensions in Oct 2011. The blue bars and the left axis present the dimensions in terms in units of length, surface and volume. The red line (right axis) represents the density of the fish schools as Nautical Area Scattering Coefficient (NASC; m^2/nm^2).

3.1.2.4 Catch composition and length frequency distributions

Table 5 gives a summary of the catch compositions in numbers and weight per hour trawling. See Annex V for a complete list of all species caught. Catches in all four surveys are dominated by sprat: 86.9% of the catches in weight consisted of sprat. In May the second frequent species, was sandeel (9.4% and 7.2% in 2010 and 2011). In October this species was caught only in low numbers or incidentally. In all surveys 5% of the catch consisted of herring. The occurrence of anchovy varied from 5.5% in May 2010 to 0% in October 2011. Pilchard was found in high numbers in the catch in October 2011. In the other surveys this species did not show up in the catches at all. The presence of other species was lower than 1% of weight. Some species were caught only incidentally (Annex Vb).

Figure 18 gives the length distributions of herring, sprat, pilchard, anchovy and sandeel.

2010

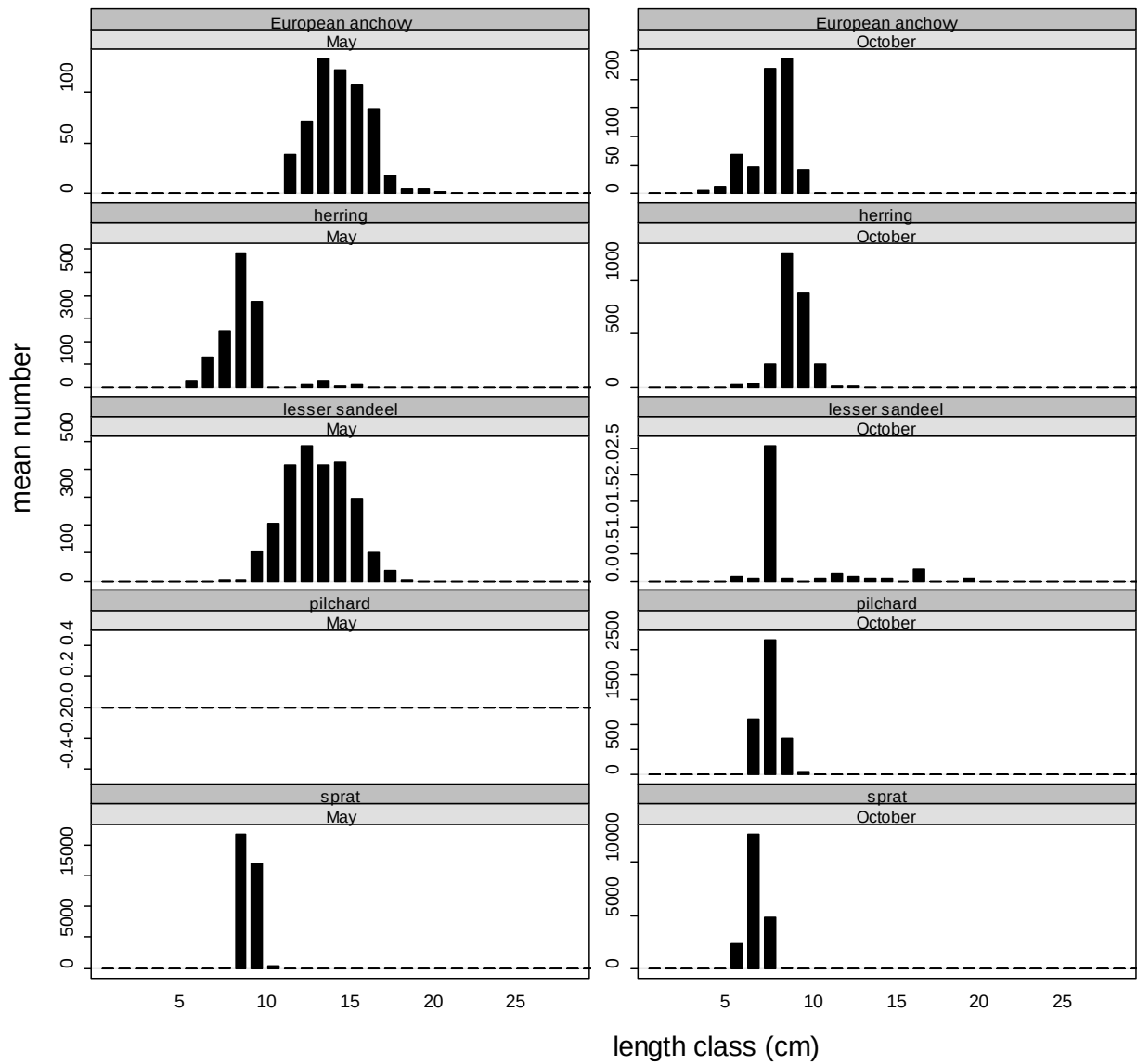


Figure 18 Length distributions of herring, sprat, anchovy, pilchard and sandeel in the catches of the hydro acoustic survey. In 2011, the catches did not contain pilchard.

2011

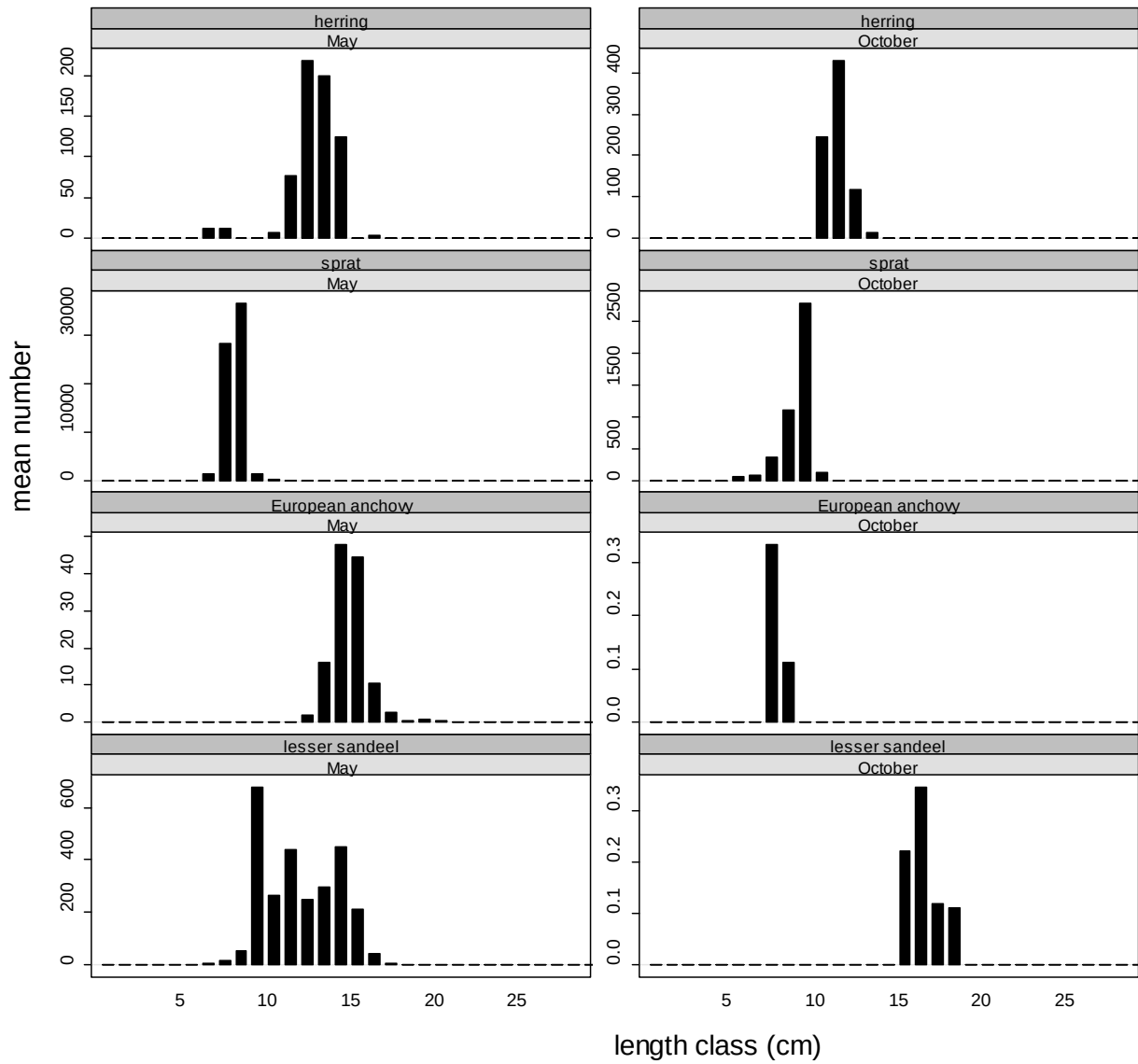


Figure 18-continued Length distributions of herring, sprat, anchovy, pilchard and sandeel in the catches of the hydro acoustic survey. In 2011, the catches did not contain pilchard.

Table 5 Catch composition of the main species caught in numbers and weight per hour for all surveys. Overall contribution in the catch (% of weight) higher than 3% are in bold.

Scientific name	English name	May 2010			October 2010			May 2011			October 2011			All surveys		
		number	weight(g)	% of weight	number	weight(g)	% of weight	number	weight(g)	% of weight	number	weight(g)	% of weight	number	weight(g)	% of weight
<i>Ammodytes</i>	sandeel	2459.8	16101.9	9.4%	3.4	8.3	0.0%	2701.5	13633.4	7.2%	0.8	11.0	0.0%	1291.4	7438.6	4.3%
<i>Aphia</i>	transparent goby	0.1	0.1	0.0%	47.6	11.2	0.0%	12.7	12.8	0.0%	0.0	0.0	0.0%	15.1	6.0	0.0%
<i>Clupea</i>	herring	1430.5	5325.6	3.1%	2697.0	12778.2	6.0%	654.8	8073.8	4.3%	808.7	8283.7	7.1%	1397.7	8615.3	5.0%
<i>Cylopterus</i>	lumpsucker	0.5	32.8	0.0%	1.0	16.3	0.0%	0.0	0.0	0.0%	3.6	64.4	0.1%	1.3	28.4	0.0%
<i>Engraulis</i>	anchovy	587.2	9298.7	5.5%	628.5	1178.2	0.5%	124.9	2178.9	1.1%	0.4	0.8	0.0%	335.3	3164.1	1.8%
<i>Gasterosteus</i>	stickleback	19.4	24.3	0.0%	7.0	2.2	0.0%	300.0	351.7	0.2%	10.8	15.6	0.0%	84.3	98.4	0.1%
<i>Hyperoplus</i>	greater sandeel	5.2	129.4	0.1%	5.5	66.7	0.0%	10.9	327.4	0.2%	4.7	58.5	0.1%	6.6	145.5	0.1%
<i>Osmerus</i>	smelt	0.0	0.0	0.0%	40.4	48.6	0.0%	0.5	4.3	0.0%	0.2	11.4	0.0%	10.3	16.1	0.0%
<i>Sardina</i>	pilchard	0.0	0.0	0.0%	4587.3	9233.4	4.3%	0.0	0.0	0.0%	0.2	1.1	0.0%	1146.9	2308.6	1.3%
<i>Scomber</i>	mackerel	5.1	1018.6	0.6%	1.8	114.3	0.1%	4.2	896.2	0.5%	0.0	0.0	0.0%	2.8	507.3	0.3%
<i>Sprattus</i>	sprat	39269.5	137996.0	80.9%	20125.4	191018.2	89.0%	67655.4	163892.2	86.3%	4495.2	108310.7	92.7%	32886.4	150304.3	86.9%
<i>Syngnathus</i>	pipefish	208.9	49.4	0.0%	34.3	5.1	0.0%	254.4	73.5	0.0%	0.9	0.3	0.0%	124.6	32.1	0.0%
<i>Other species</i>		25.4	527.3	0.3%	13.6	132.2	0.1%	5.4	519.3	0.3%	0.3	85.2	0.1%	11.2	316.0	0.2%
<i>total</i>		44011.5	170504.1		28193.0	214612.8		71724.7	189963.4		5325.9	116842.7		37313.8	172980.8	

3.2 Zooplankton

3.2.1 Ferry trials

A selection of samples from the Ferry MS Vlieland was analysed for zooplankton (Table 6), and photographs of some samples and organisms are presented in Figure 19 and Figure 20.

Table 6 Summary of sample inspections

Sample	Water filtered (m ³)*	Technique	Item	No
20090618-1	n. a.	Gauze scanning	Cypris larva	1
20090618-3	~ 0.69	Rinsing	Cypris larva	< 10
			Gastropod	1
			Copepod	1
20090716-1	~ 0.59	Rinsing	Mysid	1
			Gammarid	1
			Zoea larva	2
20090716-2	0.59	Rinsing	Cypris larva	2
			Zoea larva	1
			Bivalve	1
			Cumacea	1

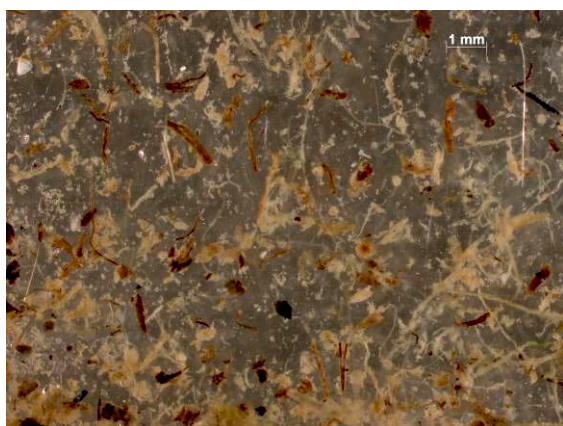


Figure 19 Close-up of sample 20090618-3



Figure 20 Mysid and gammarid amphipod of sample 20090716-1

From the results presented in Table 6 it is evident that zooplankton was sampled in such small amounts that it is impossible to perform quantitative analyses. Especially the mere absence of copepods from the samples is surprising. The density of copepods in the Wadden Sea typically ranges in the order of 10^2 to 10^5 ind.m⁻³ in summer (Frans et al., 1992).

While the implementation of the Autonomous Plankton Sampler (APS) in a commercial ferry was successful and the technical performance of the system is reliable, the sampling efficiency of the APS must be improved. The built-in flow meter of the APS indicated a constant flow that should have been sufficient to capture significant amounts of copepods and other zooplankton organisms. Based on published literature values (Fransz et al., 1992), the amount of zooplankton organisms should have been higher than observed even during times of extremely low zooplankton density. The most likely explanation for the observed low sampling efficiency is that the design of the inflow prevents zooplankton

organisms from entering the system. This could be caused either by escape behaviour of the organisms themselves, or by the hydrodynamic properties of the inflow opening, or by both.

3.2.2 Pilot mobile APS

An additional experimental flow-through system (i.e. APS housing, piping and pump) was built to be used in inflow experiments conducted at different platforms of opportunity (e.g. research vessels). The APS used on the MS *Vlieland* was installed on board of the small research vessel *Zilvervisje*, thus simulating almost identical sampling conditions. Different inflow designs (funnels, opening directions etc.) were studied. The aim of this effort was to identify the ultimate cause for the present low sampling efficiency of the APS and to develop a design of the system that allows the most quantitative sampling of zooplankton possible.

The results of the test on board of the *Zilvervisje* indicate that the adapted mobile APS system using a gauze funnel at the inflow opening yields zooplankton abundances in an order of magnitude realistic for the Wadden Sea (Figure 21). The main components of the zooplankton were copepods (mainly calanoids), and nauplius larvae of barnacles. Also cypris larvae of barnacles were present in relatively high numbers in the samples, as were zoëa larvae of crabs. Total zooplankton densities ranged approximately between 130 and 560 individuals per m³, and copepod densities from about 60 to over 200 per m³.

3.2.3 North Sea trial

The mobile system tested on vessel *Zilvervisje* was installed on research vessel *Tridens*, and samples were taken in the North Sea (see section 2.2.2). The installation functioned well, demonstrating that zooplankton could be sampled for periods of up to 10 hours without need of maintenance. After a maximum running time of 10 hours, the system was stopped due to harsh weather conditions. A preliminary inspection of the gauzes showed that zooplankton was probably sampled in high numbers. However, zooplankton samples were not analysed quantitatively due to limited budget, and because the sampled area was beyond the scope of the project. The test on the *Tridens* demonstrated that the APS with inflow funnel could be implemented in large vessels, and sampling was possible at sailing speeds of commercial vessels (up to 13 kn).

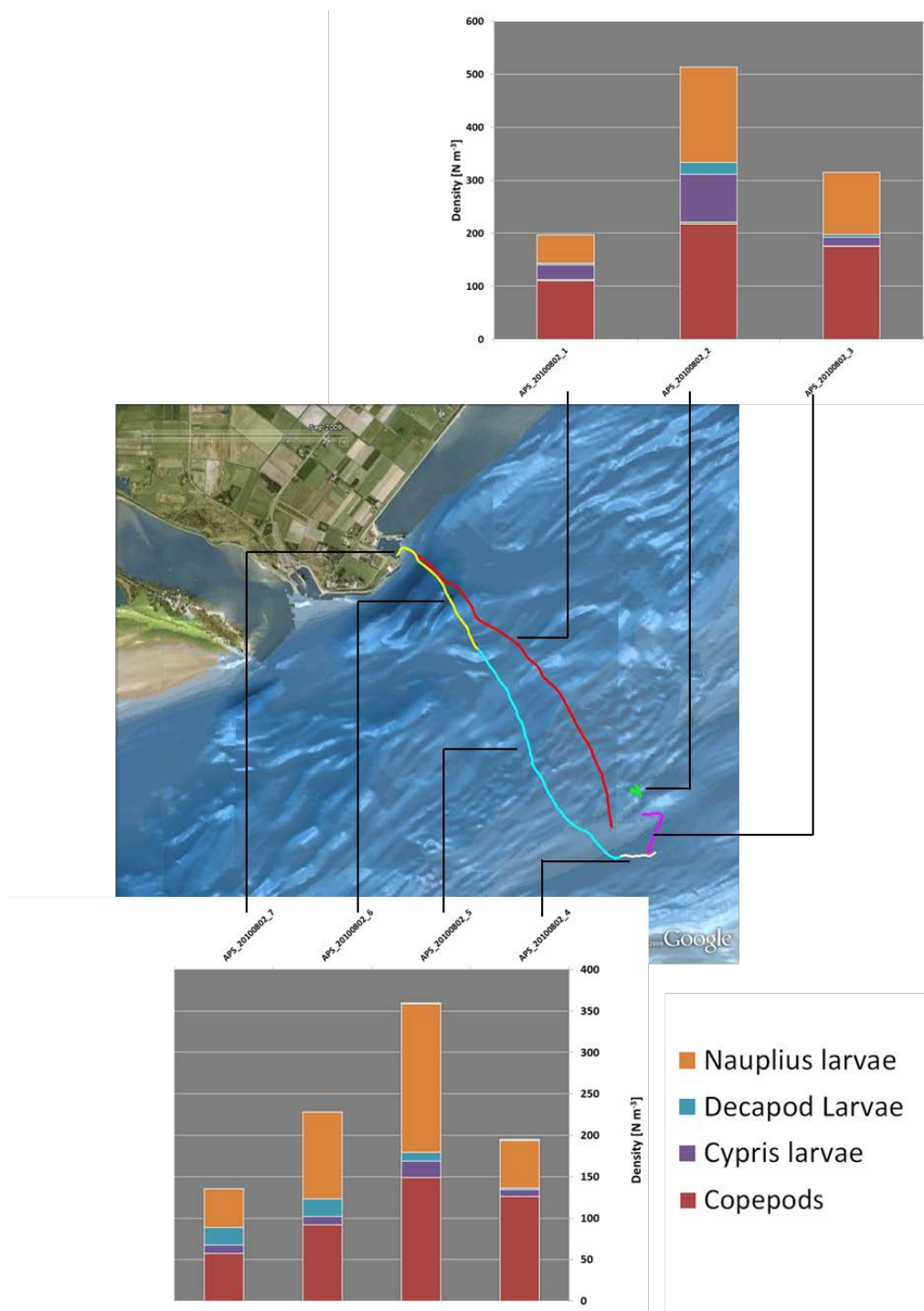


Figure 21 Sampling transect near the NIOZ harbour in the Marsdiep area in the Wadden Sea, and analysed zooplankton samples from Zilvervisje (2010).

3.2.4 Wadden Sea cruises

The system previously tested on RV Tridens was brought to the fishing vessel GO58 (see also section 2.2.2, Table 2), and applied in the Wadden Sea during a cruise in May 2011 (Annex VII).

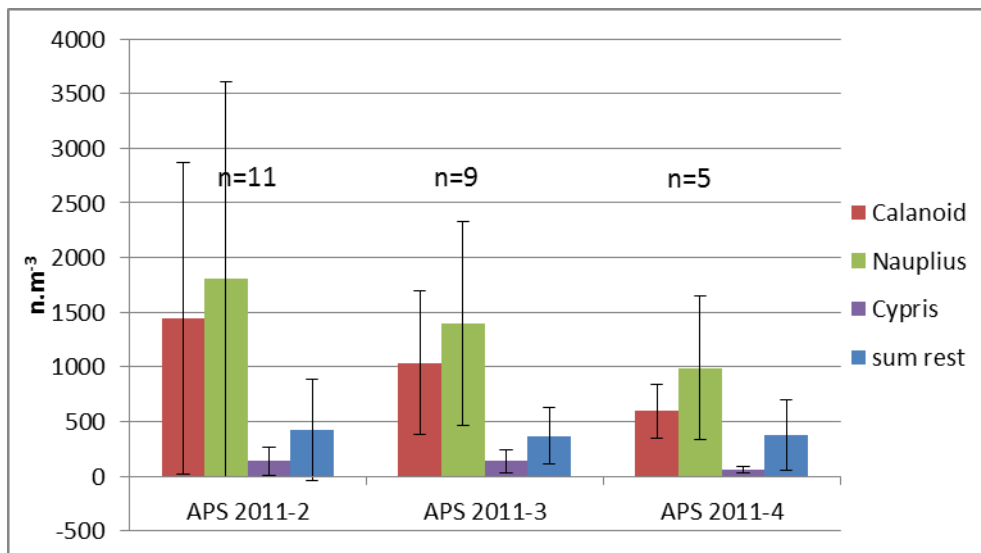


Figure 22 Summary of average zooplankton densities from samples of different surveys with GO58 in the Wadden sea. Bars indicate standard deviations.

Results in Figure 22 and Figure 23 show that different groups of zooplankton were sampled with the on-board system at GO58. Average copepod densities range between 500 and 1500 individuals per m³, within the range of expected range (Frans et al., 1992). Also high densities of nauplius and cypris larvae were sampled. Other zooplankton comprised of larvae from different groups, including bivalve and gastropod molluscs, zoëa larvae of crabs, echinoderms, and polychaetes. Also numbers of cladocerans, and ostracods were caught. Other groups were only present in the samples in very low numbers, such as fish larvae, amphipods, and cumaceans.

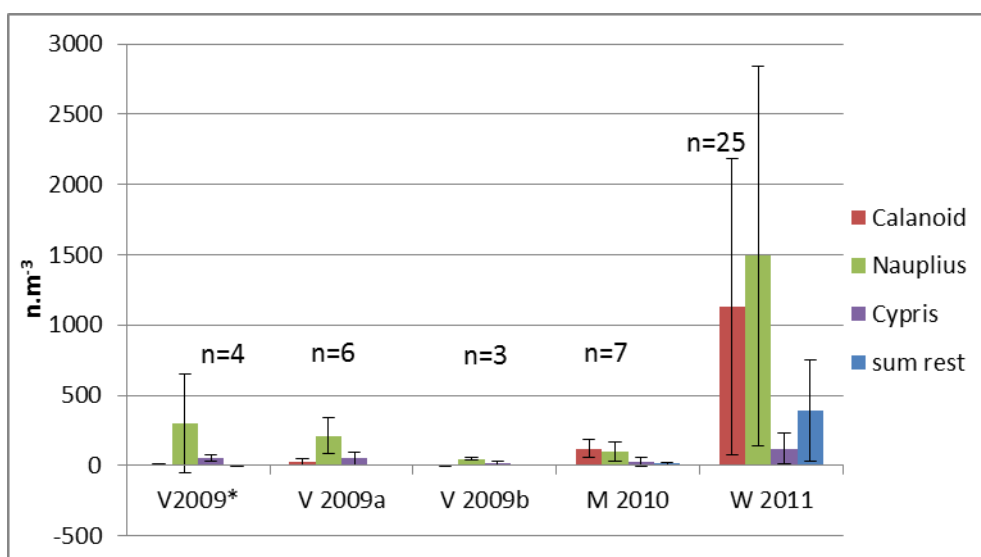


Figure 23 Overview of all analysed zooplankton densities. Average values are presented, bars indicate standard deviations. See Table 2 for legend and Annex VII for data.

4 Discussion and conclusions

4.1 Hydro acoustics

Installation of the echosounder in the hull of the TESO ferry was not successful due to excessive amounts of air bubbles under the hull, causing transmission loss in the echosounder. The acoustic surveys showed that fish schools in the Marsdiep area are found in the upper layers, almost 50% of all fish was found in the upper 6 meters. With a transducer at depth of 5 m, as it has been mounted during this study in the TESO, , most of the fish is out of reach of the acoustic equipment.

Transducer depth is also an issue in the acoustic survey carried out in this study. In every acoustic survey, some fish may be missed, because the transducer depth is 2 m. This effect may partly be compensated by the natural reflex of pelagic fish to escape the vessel by swimming downwards (Simmonds and MacLennan, 2005). In addition, the acoustic biomass estimates may be biased to an unknown degree, because the 38kHz transducer has a “near field” 9m according to the manufacturer. This means that echoes within this distance of the transducer are unpredictably shaped and cannot be properly calibrated. Nevertheless the accuracy of the acoustic estimate is probably higher than the estimate based on trawled area, because it is based on a much higher number of samples: the abundance estimate is calculated from the average of the fish densities in 56-194 samples of 0.5 nmi, whereas the number of trawls samples is (9-19).

Future monitoring of pelagic fish in the area could be carried out by survey by a vessel, similar as in this study. Another possibility is a fixed construction at the bottom of the Marsdiep with a transducer pointing towards the surface. Data could be transported by cable to 't Horntje or to Den Helder. Actual composition of the fish community (with swimbladder) could be verified by means of catch information from pelagic trawl hauls carried out on a regular basis. Distinction between fish with swimbladder and fish without swimbladder – in the Marsdiep area: clupeids and sandeel – may be possible by applying different frequencies, depending to what extend sandeel is mixed with clupeid schools (Korneliusson et al, 2008).

4.2 Zooplankton

The application of an on-board APS (Autonomous Plankton Sampler) system has shown to yield valuable information on zooplankton composition and densities. In contrast to the traditional CPR, which can only be towed in deeper waters, the on-board system enables automated sampling in shallow water bodies, such as the Wadden Sea. However, there are a number of pre-conditions that need to be met in the technical set-up, and in addition, the results from samplings should be interpreted with care.

It appeared from this study that the design of the water inlet system is of crucial importance for the efficiency for catching zooplankton at normal (relatively high) sailing speeds of ferries or commercial vessels. The application of a gauze funnel directed in the sailing direction of the ship yielded the best results. The shape and size of the funnel could be further optimized. Building such an inlet system on board of commercial vessels such as ferries may not always be allowed. Therefore, when developing a monitoring programme, equipping research vessels with an APS may be considered, or the use of mobile systems. Also sampling on moored systems could be considered, where the flow of the water current could be applied.

Although the APS system yielded realistic numbers of zooplankton during the final sampling campaigns, it is not yet known what the sampling efficiency of the APS system is, because parallel net samples were not taken. The question is whether the sampled numbers and species represent the natural composition or not. It is known from CPR data, that different species are caught with different efficiency, and for that reason, empirically established correction factors are applied to estimate zooplankton densities (Batten et

al., 2003). Therefore, a calibration with traditional sampling methods could be considered. However, time-series of the type of data presented in this report would be useful to detect relative changes in species composition, densities and seasonal trends. The detection of such relative changes would be highly valuable in any long-term monitoring programme.

Recommendations

- It is not possible to collect abundance data on pelagic fish with an echosounder mounted in the moon pool of the TESO: the pelagic schools in the Marsdiep area are so high in the water column that most of the schools are missed.
- Future monitoring of abundance of pelagic fish could be carried out by a set of echosounders with different frequencies mounted on a fixed construction at the bottom of the Marsdiep, pointed towards the surface.
- Actual composition of the pelagic fish composition can be verified by carrying out pelagic hauls on a regular basis.
- Zooplankton can be efficiently monitored by means of an on-board Autonomous Plankton Sampler on condition that an appropriate design of the water intake funnel is applied.
- Calibration of the APS is needed with traditional sampling methods to allow comparison with tow net data.

Acknowledgements

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Justification

Report: C094/13
Project Number: 4306300401

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

Approved: O.G. Bos
Researcher

Signature:



Date: January, 2016

Approved: L.J.W. Hoof
Head of Fisheries department

Signature:



Date: January, 2016

Annex I: Calibration of echosounders

```
# Calibration Version  2.1.0.12
#
# Date: 17-5-2010
#
# Comments:
#  teso april 2010 5th
#
# Reference Target:
#  TS          -33.60 dB      Min. Distance      8.00 m
#  TS Deviation    5.0 dB      Max. Distance      11.00 m
#
# Transducer: ES38B Serial No. 345
#  Frequency      38000 Hz      Beamtype          Split
#  Gain           25.57 dB      Two Way Beam Angle -20.6 dB
#  Athw. Angle Sens. 21.90      Along. Angle Sens. 21.90
#  Athw. Beam Angle  6.97 deg    Along. Beam Angle  7.01 deg
#  Athw. Offset Angle 0.00 deg    Along. Offset Angle -0.08 deg
#  SaCorrection     -0.56 dB      Depth              0.00 m
#
# Transceiver: GPT 38 kHz 009072017a3b 2-1 ES38B
#  Pulse Duration  1.024 ms      Sample Interval    0.190 m
#  Power           2000 W      Receiver Bandwidth 2.43 kHz
#
# Sounder Type:
#  EK60 Version  2.2.0
#
# TS Detection:
#  Min. Value      -50.0 dB      Min. Spacing       100 %
#  Max. Beam Comp.  6.0 dB      Min. Echolength    80 %
#  Max. Phase Dev.  8.0        Max. Echolength    180 %
#
# Environment:
#  Absorption Coeff. 7.1 dB/km      Sound Velocity     1484.5 m/s
#
# Beam Model results:
#  Transducer Gain  = 25.51 dB      SaCorrection        = -0.55 dB
#  Athw. Beam Angle = 6.78 deg      Along. Beam Angle   = 6.87 deg
#  Athw. Offset Angle = 0.03 deg      Along. Offset Angle = -0.05 deg
#
# Data deviation from beam model:
#  RMS = 0.17 dB
#  Max = 0.38 dB No. = 204 Athw. = 3.6 deg Along = 2.0 deg
#  Min = -0.90 dB No. = 6 Athw. = 0.6 deg Along = -0.7 deg
#
# Data deviation from polynomial model:
#  RMS = 0.12 dB
#  Max = 0.36 dB No. = 246 Athw. = 0.8 deg Along = -4.9 deg
```

Min = -0.76 dB No. = 6 Athw. = 0.6 deg Along = -0.7 deg


```

# Calibration Version  2.1.0.12
#
# Date: 10/11/2010
#
# Comments:
#   calibration TOR kade 111010 #2
#
# Reference Target:
#   TS           -33.00 dB      Min. Distance      8.50 m
#   TS Deviation    5.0 dB      Max. Distance     11.50 m
#
# Transducer: ES38B Serial No. 31010
#   Frequency      38000 Hz      Beamtype          Split
#   Gain           24.57 dB      Two Way Beam Angle -20.6 dB
#   Athw. Angle Sens. 21.90      Along. Angle Sens. 21.90
#   Athw. Beam Angle  7.02 deg    Along. Beam Angle  7.04 deg
#   Athw. Offset Angle -0.02 deg  Along. Offset Angle -0.06 deg
#   SaCorrection     -0.60 dB      Depth             0.00 m
#
# Transceiver: GPT 38 kHz 009072017a3b 1-1 ES38B
#   Pulse Duration  1.024 ms      Sample Interval  0.192 m
#   Power           2000 W      Receiver Bandwidth 2.43 kHz
#
# Sounder Type:
#   EK60 Version  2.2.1
#
# TS Detection:
#   Min. Value      -50.0 dB      Min. Spacing      100 %
#   Max. Beam Comp.  6.0 dB      Min. Echolength   80 %
#   Max. Phase Dev.  8.0        Max. Echolength   180 %
#
# Environment:
#   Absorption Coeff. 6.4 dB/km      Sound Velocity    1503.3 m/s
#
# Beam Model results:
#   Transducer Gain   = 24.84 dB      SaCorrection       = -0.61 dB
#   Athw. Beam Angle  = 6.92 deg      Along. Beam Angle  = 6.97 deg
#   Athw. Offset Angle = 0.06 deg      Along. Offset Angle = -0.06 deg
#
# Data deviation from beam model:
#   RMS = 0.11 dB
#   Max = 0.26 dB No. = 312 Athw. = 3.2 deg Along = 3.5 deg
#   Min = -0.41 dB No. = 215 Athw. = 1.0 deg Along = -4.9 deg
#
# Data deviation from polynomial model:
#   RMS = 0.06 dB
#   Max = 0.18 dB No. = 343 Athw. = 3.2 deg Along = -3.6 deg
#   Min = -0.25 dB No. = 311 Athw. = 3.0 deg Along = 2.7 deg

```

```

# Calibration Version  2.1.0.12
#
# Date: 15-4-2011
#
# Comments:
#   Europort 150411 38kHz 256us_2
#
# Reference Target:
#   TS           -33.60 dB      Min. Distance      8.00 m
#   TS Deviation    5.0 dB      Max. Distance     11.00 m
#
# Transducer: ES38B Serial No. 31010
#   Frequency      38000 Hz      Beamtype          Split
#   Gain           23.11 dB      Two Way Beam Angle -20.6 dB
#   Athw. Angle Sens. 21.90      Along. Angle Sens. 21.90
#   Athw. Beam Angle  6.83 deg    Along. Beam Angle  6.90 deg
#   Athw. Offset Angle 0.05 deg    Along. Offset Angle -0.03 deg
#   SaCorrection     -0.65 dB      Depth             0.00 m
#
# Transceiver: GPT 38 kHz 00907205fb91 1-1 ES38B
#   Pulse Duration  0.256 ms      Sample Interval    0.047 m
#   Power           2000 W        Receiver Bandwidth 3.68 kHz
#
# Sounder Type:
#   EK60 Version  2.2.0
#
# TS Detection:
#   Min. Value      -38.0 dB      Min. Spacing       100 %
#   Max. Beam Comp.  6.0 dB      Min. Echolength    80 %
#   Max. Phase Dev.  8.0        Max. Echolength    180 %
#
# Environment:
#   Absorption Coeff. 7.2 dB/km      Sound Velocity     1480.4 m/s
#
# Beam Model results:
#   Transducer Gain   = 23.11 dB      SaCorrection        = -0.69 dB
#   Athw. Beam Angle   = 6.90 deg      Along. Beam Angle   = 6.88 deg
#   Athw. Offset Angle = 0.04 deg      Along. Offset Angle = -0.04 deg
#
# Data deviation from beam model:
#   RMS = 0.16 dB
#   Max = 0.36 dB No. = 139 Athw. = 3.0 deg Along = 3.4 deg
#   Min = -0.62 dB No. = 156 Athw. = 4.8 deg Along = -0.5 deg
#
# Data deviation from polynomial model:
#   RMS = 0.10 dB
#   Max = 0.38 dB No. = 153 Athw. = 4.4 deg Along = -2.0 deg
#   Min = -0.34 dB No. = 155 Athw. = 4.4 deg Along = -0.9 deg

```

```

# Calibration Version  2.1.0.12
#
# Date: 3-10-2011
#
# Comments:
# 38 kHz 512 us Max power 3de Kalibratie
#
# Reference Target:
# TS          -33.60 dB      Min. Distance      5.10 m
# TS Deviation    7.0 dB      Max. Distance      6.40 m
#
# Transducer: ES38B Serial No. 38
# Frequency      38000 Hz      Beamtype          Split
# Gain          24.28 dB      Two Way Beam Angle -20.6 dB
# Athw. Angle Sens. 21.90      Along. Angle Sens. 21.90
# Athw. Beam Angle 6.84 deg     Along. Beam Angle 6.93 deg
# Athw. Offset Angle 0.07 deg    Along. Offset Angle 0.03 deg
# SaCorrection    -0.85 dB      Depth              0.00 m
#
# Transceiver: GPT 38 kHz 00907205fb91 3-1 ES38B
# Pulse Duration 0.512 ms      Sample Interval    0.097 m
# Power          2000 W        Receiver Bandwidth 3.28 kHz
#
# Sounder Type:
# EK60 Version 2.2.0
#
# TS Detection:
# Min. Value     -45.0 dB      Min. Spacing        60 %
# Max. Beam Comp. 6.0 dB      Min. Echolength     80 %
# Max. Phase Dev. 11.8        Max. Echolength     180 %
#
# Environment:
# Absorption Coeff. 6.7 dB/km    Sound Velocity      1510.0 m/s
#
# Beam Model results:
# Transducer Gain = 24.40 dB      SaCorrection        = -0.81 dB
# Athw. Beam Angle = 6.97 deg     Along. Beam Angle   = 7.00 deg
# Athw. Offset Angle = 0.04 deg    Along. Offset Angle = 0.01 deg
#
# Data deviation from beam model:
# RMS = 0.13 dB
# Max = 0.29 dB No. = 296 Athw. = -3.0 deg Along = -3.3 deg
# Min = -0.43 dB No. = 267 Athw. = 4.5 deg Along = 1.2 deg
#
# Data deviation from polynomial model:
# RMS = 0.08 dB
# Max = 0.19 dB No. = 15 Athw. = 0.2 deg Along = 3.2 deg
# Min = -0.28 dB No. = 267 Athw. = 4.5 deg Along = 1.2 deg

```

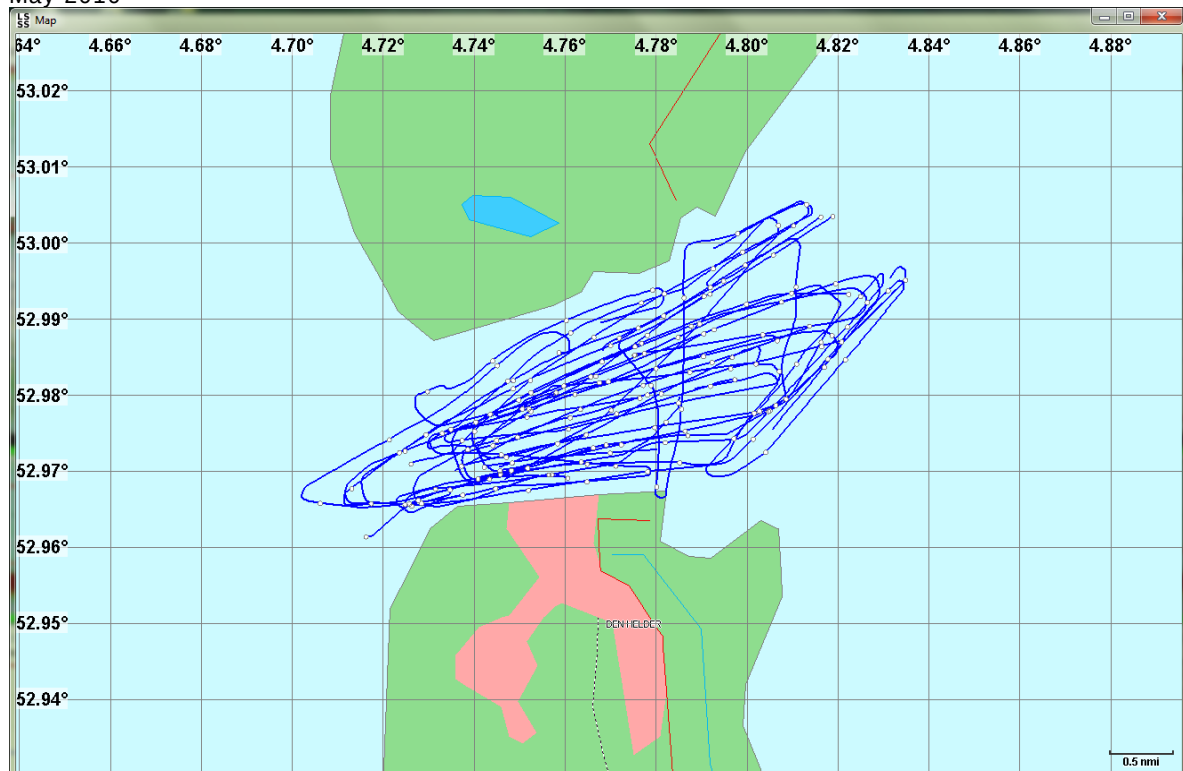
2468

Annex III: Geographical positions (longitude, latitude) defining the Marsdiep polygon for abundance estimation (degrees. decimalized degrees)

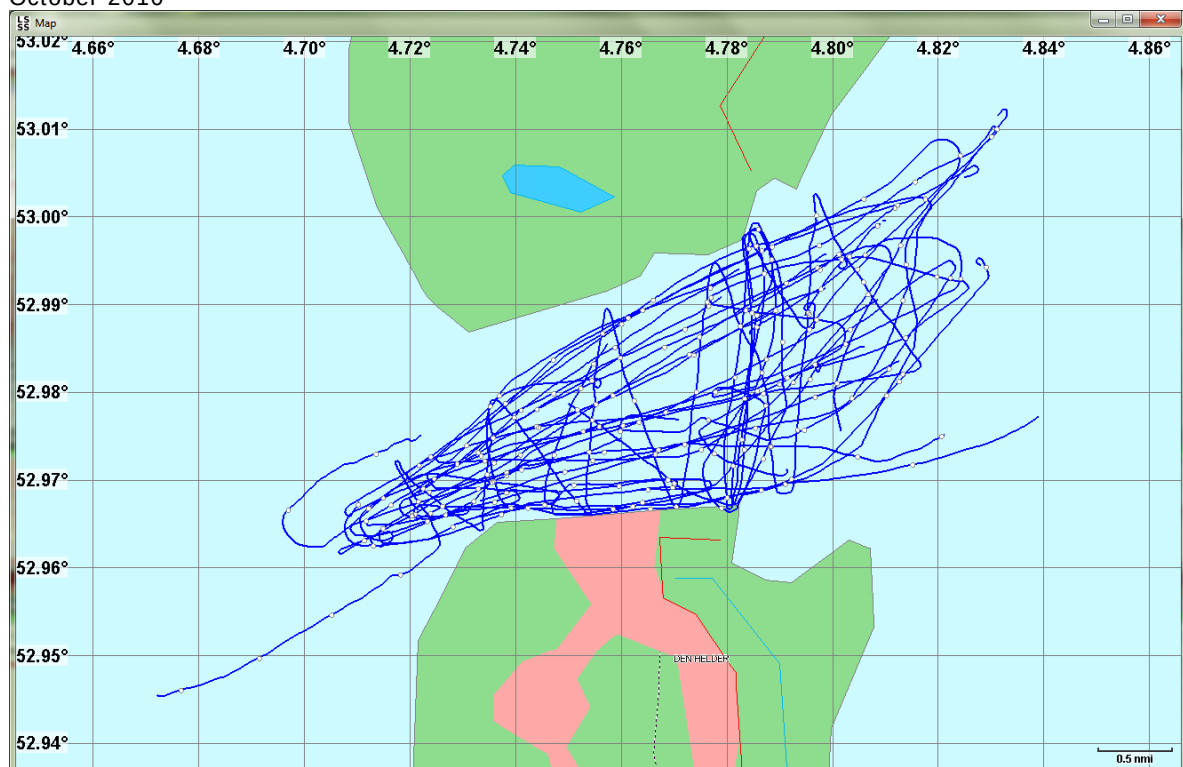
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4.79054074149, 52.9685578509
4.81476227915, 52.9822414472
4.80375248685, 53.0042610048
4.79667477674, 53.0017445024
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4.75751139161, 52.989476459
4.73391900656, 52.978781243

Annex IV: Cruise tracks during the Acoustic surveys

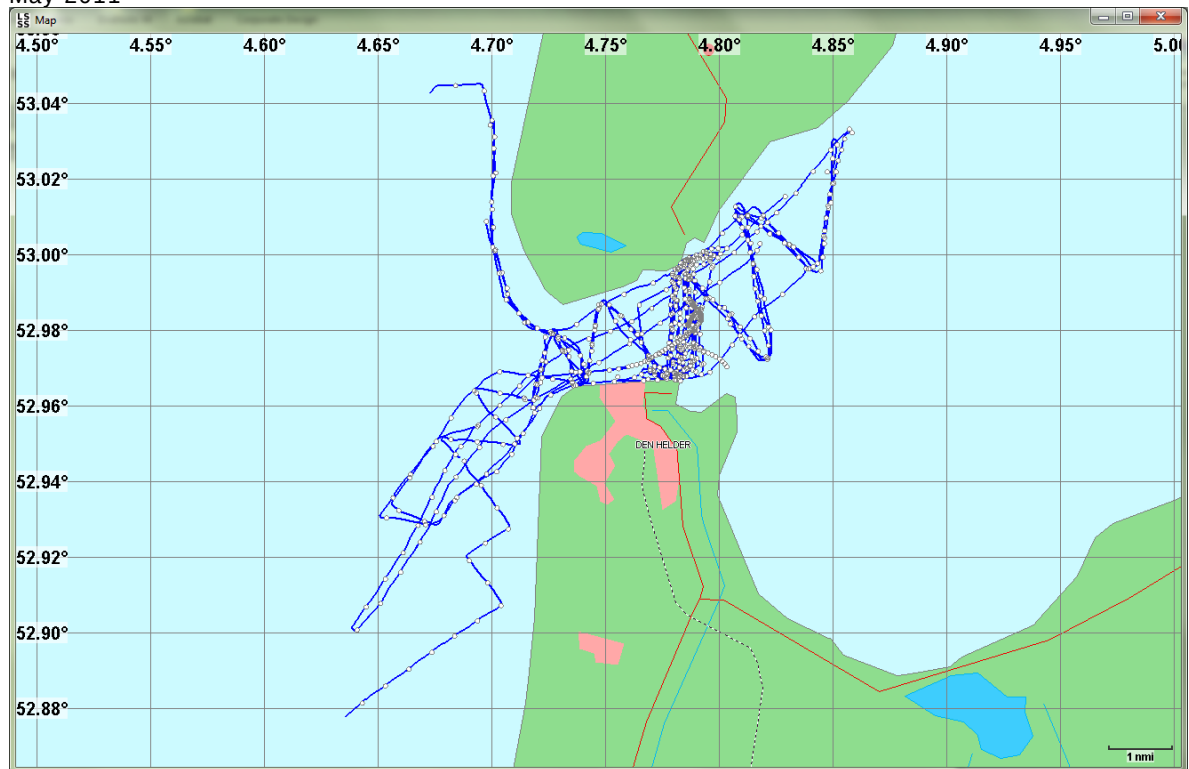
May 2010



October 2010



May 2011



October 2011
[not available]

Annex V: Trawl hauls: haul data (date, time), start and positions, numbers and weight per hour trawling.

a. Table catch – main species. Weight (g) (numbers)

haul number	UTC	year	month	day	latitude shooting	longitude shooting	latitude hauling	longitude hauling	<i>Ammodytes tobianus</i>	<i>Aphia minuta</i> transparent goby	<i>Clupea harengus</i>	<i>Cyclopterus lumpus</i>	<i>Engraulis encrasicolus</i>	<i>Gasterosteus aculeatus</i>	<i>Hyperoplus lanceolatus</i> greater sandeel	<i>Osmerus eperlanus</i>	<i>Sardina pilchardus</i>	<i>Scomber scombrus</i>	<i>Sprattus sprattus</i>	<i>Syngnathus rostellatus</i> Nilsson's pipefish
1	1007	2010	5	18	52.97533	4.767	52.97067	4.73717	50256(7250)		196(8)		9824(556)		94(3)			459(2)	393158(106108)	
2	1307	2010	5	18	52.98783	4.81983	52.97683	4.795	45038(7631)		2388(169)		15843(1046)						49966(15508)	
3	1440	2010	5	18	52.99167	4.77433	52.98317	4.75233	929(184)		1989(283)		114(7)	10(7)	18(1)				621(176)	12(50)
4	1818	2010	5	18	52.98117	4.7935	52.97983	4.7825	14543(2346)		3705(579)		13179(662)	157(76)					216(78)	33(227)
5	601	2010	5	19	52.984	4.76717	52.99667	4.80333	82543(9280)		2789(824)	540(8)	3385(192)	10(8)	233(8)					11(48)
6	749	2010	5	19	52.9695	4.7625	52.96883	4.7525	438(60)		10530(2880)		740(37)		25(1)		3202(17)		74451(21120)	
7	924	2010	5	19	52.99183	4.82917	52.9815	4.81167	47383(8696)		13695(3478)		22987(1304)	65(65)	241(6)		871(3)		256022(75826)	
8	1128	2010	5	19	52.99783	4.79917	53.0045	4.81917	283(46)		81(11)		250(18)	23(24)	361(10)				6873(1859)	2(8)
9	1228	2010	5	19	52.98683	4.772	52.99083	4.78383	1361(255)		49(3)		2559(126)		211(21)		173(1)		28640(21751)	2(6)
10	1338	2010	5	19	52.95967	4.70433	52.96317	4.72033	11644(2426)				2355(41120)		106(3)		7054(35)		1203360(349603)	
11	1502	2010	5	19	52.976	4.794	52.983	4.80867	242(54)		29096(7656)		48205(3915)	3(1)	65(5)				5288(1305)	806(3306)
12	655	2010	5	20	52.97383	4.77933	52.97283	4.76817	6084(907)				6087(3767)	14(16)						20(97)
13	825	2010	5	20	52.97317	4.74967	52.98617	4.79317			5479(1480)	51(1)	1887(132)		176(6)				3734(1085)	1(6)
14	929	2010	5	20	52.97133	4.75583	52.968	4.74133	9533(1728)		3166(1085)		6124(342)						323838(87845)	
15	1132	2010	5	20	52.97867	4.8085	52.9885	4.823	950(225)		68(1)		1968(90)	156(152)	251(13)				16204(4390)	
16	1237	2010	5	20	52.98417	4.768	52.99017	4.78917	6638(1023)	2(1)			1295(59)		270(7)		6576(34)		18083(4239)	
17	1401	2010	5	20	52.98667	4.75933	52.98783	4.76567	1800(420)		1221(48)		1271(90)		16(3)				76151(21386)	2(6)
18	1629	2010	5	20	52.9705	4.74533	52.97867	4.76533	11968(2167)		12922(3478)		8105(516)		262(6)				27323(9072)	1(6)
1	734	2010	10	12	52.97433	4.73983	52.98933	4.75583			17239(3558)		73(123)		648(40)	48(40)			101477(9426)	0(3)
2	913	2010	10	12	52.98983	4.82767	52.98233	4.80967		7(1)	5482(1041)	18(1)	36(66)		125(8)		202(3)		228140(21276)	5(32)
3	1017	2010	10	12	52.96933	4.718	52.97217	4.81667		13(1)	4705(1127)		18025(8160)		41(3)		41127(14401)	886(15)	560090(52480)	
4	1239	2010	10	12	52.98117	4.77167	52.98367	4.77867			1075(192)	25(2)	1157(742)		16(1)		1054(445)	158(2)	199527(18189)	2(37)
5	1344	2010	10	12	52.96517	4.72983	52.9695	4.73783			7692(2463)	11(1)			14(1)		132(58)		153285(19749)	8(58)
6	1520	2010	10	12	52.97967	4.73833	52.98483	4.75183		14(58)	14028(2642)	11(1)							128066(14927)	8(59)
7	1716	2010	10	12	52.969	4.76267	52.96733	4.7415			70990(16063)			16(60)		566(501)			13966(1606)	7(47)
8	724	2010	10	13	52.99367	4.77867	52.988	4.76467	22(7)		3989(1294)	3(1)	26(76)		24(2)	5(4)	21311(12409)		390445(42761)	2(14)
9	906	2010	10	13	53.0095	4.82733	53.002	4.81383	1(1)		60928(11124)	11(1)	14(2)		1(1)	8(2)	1(1)		142534(10794)	7(101)
10	1025	2010	10	13	52.96617	4.72017	52.9755	4.745			3647(1118)	23(2)	1225(736)				16164(6601)	134(2)	482353(48095)	2(7)
11	1238	2010	10	13	52.99117	4.79733	52.99917	4.80917	23(1)	1(16)	74(6)		500(592)				1445(794)		30763(3145)	0(3)
12	1356	2010	10	13	52.97567	4.76167	52.9765	4.77383		2(10)	18(2)	26(1)	51(59)	1(1)	32(3)		8661(5699)		233467(30272)	1(8)
13	1520	2010	10	13	52.98767	4.80483	52.9935	4.81667			11719(2421)	82(3)		0(1)		2(2)	1190(961)		61616(6846)	1(4)
14	1741	2010	10	13	52.976	4.78767	52.9905	4.7845			4570(903)	18(1)		9(21)		37(5)	599(456)		15104(1940)	2(8)
15	1841	2010	10	13	52.972	4.74017	52.98017	4.7925	4(1)		1657(343)					2(2)	238(119)		3989(487)	
16	714	2010	10	14	52.977	4.83817	52.97467	4.82367	15(4)		29308(5725)	18(2)	3(4)		9(1)	245(204)			102185(13312)	38(196)
17	902	2010	10	14	52.983	4.8125	52.97283	4.80233	23(4)	123(498)	3681(1012)	18(1)	272(562)	4(6)	216(33)	8(7)	49259(28865)		373455(45787)	6(29)
18	1139	2010	10	14	52.99183	4.79817	53.00283	4.81833	13(1)	69(278)	651(18)	44(2)	26(20)		122(9)	1(1)	17446(8340)	114(2)	390371(39200)	1(6)
19	1306	2010	10	14	52.9705	4.70483	52.95383	4.67733	38(45)	3(45)	1332(190)		978(801)	11(45)	17(3)		16811(8010)	678(11)	18513(2092)	9(47)
1	640	2011	5	3	53.001	4.80617	53.016	4.82933	1607(438)		3945(222)		2430(122)	2(2)	1212(56)			616(3)	39256(15466)	26(94)
2	958	2011	5	3	52.963	4.71517	52.96583	4.72317	2384(688)	53(63)	5284(473)		469(25)	19(31)	18(1)				17087(5750)	1(4)
3	1208	2011	5	3	53.028	4.7005	53.0135	4.6995	14304(2933)	99(89)	7955(719)		374(20)	94(89)		36(4)			57176(26880)	210(622)
4	1433	2011	5	3	52.96733	4.77367	52.967	4.76333	18253(7980)		902(310)		862(47)	268(305)	56(1)	6(1)		3453(18)	138403(74848)	81(275)
5	1833	2011	5	3	53.03483	4.66917	53.04633	4.68733	38045(4200)		20805(1603)		631(37)				3140(14)		25950(6267)	
6	1732	2011	5	4	52.9795	4.78233	52.97717	4.77583	21979(2857)		51185(4007)		3996(220)		68(2)		1190(6)		542285(221486)	
7	636	2011	5	5	53.01467	4.83267	53.004	4.82583	358(64)	2(1)	478(44)		4737(267)	27(23)	67(3)				6344(2858)	350(1260)
8	118	2011	5	5	52.9875	4.80317	52.9925	4.82083	20748(4190)		97(10)		408(23)	3797(3143)	1896(50)		1308(5)		88776(35095)	
9	956	2011	5	5	52.9745	4.7325	52.9765	4.73767	4541(1200)		4758(331)		2513(140)		227(9)		1047(4)		930897(372400)	
10	1325	2011	5	5	53.01183	4.8375	52.99467	4.80583	179(47)		799(78)		6240(385)	12(7)		10(1)			13204(6250)	103(370)
11	1525	2011	5	5	52.98583	4.801	52.99017	4.83133	41118(7807)		149(16)		2769(173)		317(7)				4902(2567)	111(428)
12	1811	2011	5	5	52.9495	4.68433	52.94667	4.6825	84(15)		531(45)		718(41)		68(2)				102425(42000)	
1	905	2011	10	18	52.98283	4.75667	52.98033	4.74783	43(3)		2803(228)				115(5)				291203(10980)	1(1)
2	1240	2011	10	18	54.02667	4.8395	54.02667	4.81133					6(3)	4(3)					189(8)	0(1)
3	1446	2011	10	18	52.97517	4.78667	52.98033	4.802			69878(6890)	70(5)			39(1)				206152(8857)	
4	634	2011	10	19	52.99433	4.8	52.98817	4.78617			1417(128)	82(4)	1(1)		75(3)	40(1)	6(1)		170467(8036)	
5	840	2011	10	19	53.01167	4.8225	53.00633	4.8135			129(2)	44(2)			50(2)				284393(11291)	1(2)
6	630	2011	10	20	53.004	4.841	53.0165	4.85083	45(3)		45(5)	156(6)		4(4)	75(4)				8258(480)	1(2)
7	733	2011	10	20	52.992	4.81217	53.0105	4.81767			100(8)	156(8)		13(7)	31(2)		4(1)		6268(472)	
8	1105	2011	10	20	53.0015	4.81483	53.01683	4.83583	11(1)		137(13)	62(4)		4(2)	70(3)	62(1)			6246(265)	
9	1324	2011	10	20	52.99033	4.79333	52.99533	4.79833			43(5)	10(3)		116(81)	68(19)				1621(69)	1(2)

b. Species incidental caught, numbers.

total number	frequency of occurrence	scientific name	English name
31	1	<i>Agonus cataphractus</i>	hooknose
1	1	<i>Alosa fallax</i>	twait shad
2	1	<i>Arnoglossus laterna</i>	scalfish
9	5	<i>Atherina presbyter</i>	sand-smelt
23	8	<i>Belone belone</i>	garfish
1	1	<i>Chelon labrosus</i>	thick-lipped grey mullet
3	2	<i>Dicentrarchus labrax</i>	bass
3	2	<i>Eutrigla gurnardus</i>	grey gurnard
1	1	<i>Gymnocephalus cernuus</i>	ruffe
20	8	<i>Lampetra fluviatilis</i>	lampern
4	3	<i>Merlangius merlangus</i>	whiting
5	3	<i>Myoxocephalus scorpius</i>	bull-rout
2	2	<i>Platichthys flesus</i>	flounder
3	2	<i>Pleuronectes platessa</i>	plaice
5	2	<i>Pomatoschistus minutus</i>	sand goby
11	6	<i>Salmo trutta</i>	trout
4	4	<i>Sander lucioperca</i>	zander
2	2	<i>Solea solea</i>	sole
3	2	<i>Syngnathus acus</i>	greater pipefish
28	1	<i>Trachurus trachurus</i>	horse mackerel

Annex VI: Installation of the APS on MS “Vlieland”



Figure 1. Seawater intake with connector for APS bypass.



Figure 2. 1" Fitting (detail).



Figure 3. In the foreground envisaged installation place of APS. In the background seawater pipe with flange for re-introduction of APS water into the ship's seawater system.



Figure 4. Flange for re-introduction of APS water into the ship's seawater system.



Figure 5. MS Vlieland with located seawater inlet 1.5 m below water surface.

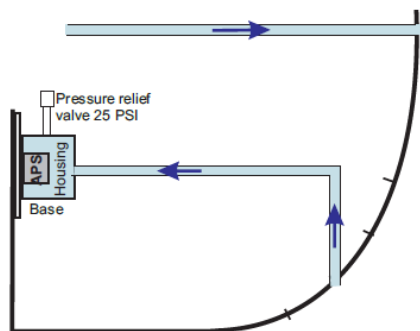


Figure 6. Frontal view of position of APS on board of MS Vlieland.

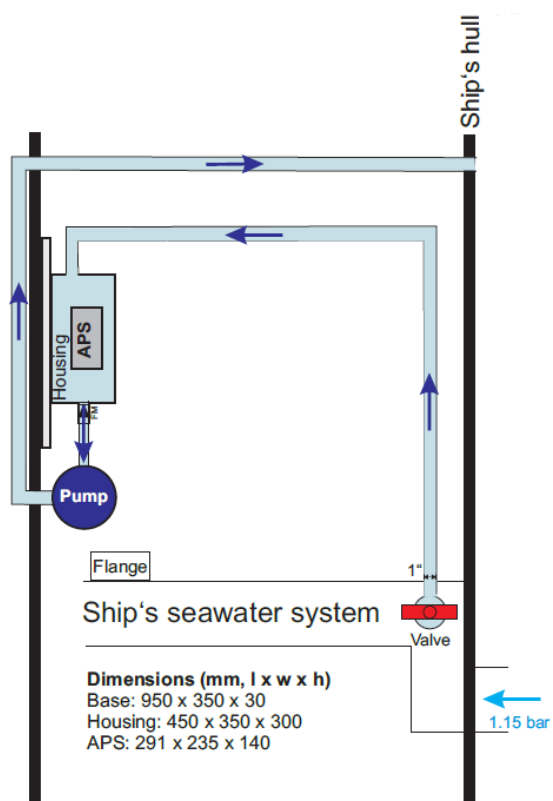


Figure 7. Top view of APS installation on board of MS Vlieland.

Annex VII: Zooplankton samples and densities

Row labels	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	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