MONS monitoring plan small pelagic fish

Food for higher trophic levels

Author(s): Bram Couperus, Ralf van Hal, Isabelle van der Ouderaa, Joey Volwater

Wageningen Marine Research
IJmuiden, March, 2022

CONFIDENTIAL No

Wageningen Marine Research report C009/22

Keywords: Pelagic, Monitoring, MONS

Client: Ministerie van Infrastructuur en Waterstaat
postbus 20901
2500 EX Den Haag

This report can be downloaded for free from https://doi.org/10.18174/565923
Wageningen Marine Research provides no printed copies of reports

Wageningen Marine Research is ISO 9001:2015 certified.

Contents

Summary

This report contains an outline of a working plan for the monitoring of small pelagic fish on the Dutch Continental Shelf. Pelagic fish include species that are not connected to the bottom and live large parts of their life in schools in midwater.
Stakeholders within the North Sea Counsel (*Noordzeeoverleg*) discussed what kind of research is required in the context of sustainable economic use of the North Sea. This resulted in the North Sea Agreement (*Noordzeeakkoord - NZA*). Part of the North Sea Agreement is the Monitoring-Research-Nature Restoration-Species Protection (Monitoring-Onderzoek-Natuurherstel-Soortbescherming - MONS). A commission has defined the research questions that are at stake and the sort of research that is required to answer these questions from 2022 onwards. Part of this research has received priority - labelled "No regret studies" - of which the monitoring of small pelagic fish is one. The MONS commission has asked Wageningen Marine Research (WMR) to make a proposal for the monitoring of small pelagic fish in the next five years. The first year is a pilot year meant for testing (parts) of proposed methods. The key questions of the client are "What is the distribution of small pelagic fish species in Dutch waters, by season and from year to year?" and "How can these geographical and temporal distributions be explained by the known natural history of the species involved, in terms of known behaviour and habitat requirements?". This information is required to describe the starting situation for future impact assessments of windfarms construction and other offshore infrastructural building.
In addition, the client asks that the plan consists of the following components: (1) A year-round beach sampling of the shallow surf zone and (2) A year-round and annual sampling of small pelagic fish.

A summary is given of existing and innovative survey methods. Followed by an overview of historic research on small pelagic fish and of coordinated international surveys in the (Dutch) North Sea. Potential monitoring techniques are briefly described, including both standard and innovative techniques. Furthermore, a limited inventory is made of wishes and requirements of the MONS monitoring proposals for other animal groups. This is followed by practical considerations and the actual monitoring proposal.
The proposal consists of two hydro acoustic surveys per year along the Dutch coast in a zone of 20 nautical miles, which includes the (proposed) near coast locations of wind farms. Each of these surveys covers approximately 750 nm with a duration of 3 weeks. One survey is proposed to take place in January/February simultaneous with the International Bottom Trawl Survey (IBTS). The other survey is proposed to take place in June immediately preceding the international Hydro Acoustic Survey for Herring and Sprat (HERAS). The proposed surveys will provide a small-scale distribution map of pelagic fish species in the Dutch coastal zone and will thus give relative distributions of all pelagic species in the Dutch coastal zone.
The international data from the IBTS and HERAS are publicly available. HERAS is an acoustic survey and will provide biomasses for sprat and herring on predefined areas in the North Sea (strata) for comparison.
For the IBTS – a trawl survey - it is proposed to collect acoustic data during the Dutch part of the survey. This requires some additional effort and training of personal involved. The gathering of acoustic data from foreign vessels in the IBTS, requires consultation with international partners and will therefore take longer than one year. After five years comparison of indexes of the acoustic surveys with the IBTS and HERAS indexes will give answer to the questions (1) "Can abundance changes from year to year in the Dutch coastal zone be explained by shifts in distribution or can it be explained by changes in abundance in the North Sea?", which contributes to the description of the starting situation mentioned above.

It is proposed to fill the temporal gaps between these two surveys without running into extensive costs using standalone hydro acoustic stations (Wbat). For this two methods are being tested during the pilot year: (1) two standalone echosounders in a frame on the bottom, pointing upwards to the surface and (2) a drone that sails repeated transects in a windfarm. As a third supportive method (3)

qualitative fish information will be collected by means of gill net sampling. Measurements will be carried out simultaneous during the month of June. In order to get additional temporal reference data over time it is proposed to deploy the Wbat and the gill nets at least in the period during and between the acoustic surveys, preferably the whole year.

For the sampling of small pelagic fish in the surf zone, a proposal is made, containing a two weekly sampling scheme running for a large part of the year with a hand towed beam trawl from the beach and sampling with a gill net. It is expected that this sampling scheme – although not tailored to sample pelagic fish – will contribute to a better understanding of pelagic fish distribution, by direct comparison of the gill net catches with the offshore sampling and by providing information on the seasonal occurrence of species and their lengths.

The second key question “How can these geographical and temporal distributions be explained by the known natural history of the species involved, in terms of known behaviour and habitat requirements?” is harder to be answered by monitoring. The monitoring data might provide some insight into habitat use and possibly even into schooling behaviour. However, additional studies will have to be initiated in the future, focusing on life history questions and accessory behaviour of the small pelagic fish species in the Dutch coastal zone. For these studies and for studies addressing the impact of offshore constructions on the DCP, the proposed monitoring will provide the necessary baseline information.

1 Introduction

Maintaining the marine environment, including the North Sea, in a “healthy” condition is of importance for everyone. It is already under pressure as a result of human activities and especially in the already heavily used North Sea there are serious worries. These worries have intensified now that there are plans for a change in use (in manner and energy transition). However, it is questioned if the change can happen within the ecological carrying capacity of the North Sea. The ecological carrying capacity is a precondition for the individual and cumulative use of the North Sea by various activities.

Policy development for protection, restoration and sustainable use is hampered by a structural lack of knowledge. This certainly applies to the species that are most sensitive to the major transitions in the North Sea. These species are therefore indicators for the major changes that are to be expected in and on the North Sea.

The North Sea Agreement (NZA) wants to tackle the challenges of a changing use and aims to find a new balance. The NZA outlines the need for an integrated and systematic research and monitoring program that forms the base for knowledge about the functioning of the North Sea. The Monitoring-Research-Nature Recovery-Species Protection (MONS) program aims to answer the central question of how the changing use of the North Sea fits within the ecological capacity of the North Sea. The program should provide the knowledge needed for achieving a healthy and resilient ecosystem in the North Sea in which nature, the generation of sustainable wind energy and profitable food production go hand in hand. This knowledge is necessary to be able to determine how the NZA transitions can be implemented in such a way that the ecosystem functioning is not jeopardized, nature objectives are achieved, fisheries are ready for the future and remain within the carrying capacity of the North Sea.

To this end an integral and systematic monitoring program is needed that focuses on the physical, chemical and biological parameters for the functioning of the ecosystem and on (the variation of) the occurrence of birds, bats, benthic animals, fish and marine mammals. The MONS program provides an initial indication of the research that will be carried out over the next ten years in order to be able to answer the knowledge questions as formulated in the NZA (Asjes et al. 2021). A large part of this research will consist of monitoring activities to fill gaps in existing monitoring programs.

A substantial part of the existing monitoring has a fisheries aim. For a long time, the fish stocks of many commercially important fish species have been monitored annually. The design of this monitoring is driven by the needs of the assessment and advice process of the commercial species, which requires year-on-year dynamics of fish stocks. Consequently, these surveys provide little information about seasonal dynamics and not the entire fish community gets monitored. This includes species that are important for ecosystem functioning, that are crucial for understanding the distribution of fish, and that are crucial factors that can determine the carrying capacity of the North Sea. In the Dutch part of the North Sea this mainly concerns pelagic fish species that are not sampled properly with commercial fishing gear and/or used sampling gear, with life stages that only occur in places where no sampling or fishing is being done (the shallow surf zone), and for species not landed by fishermen (such as sharks and migratory fish). However, precisely the (small) pelagic fish are of great importance as food for top predators as marine mammals and birds, which are protected under various national and international laws and treaties.

As part of the MONS program, we are requested to fill this gap and design a monitoring program directed at (small) pelagic fish species in the North Sea. The assignment was to design two separate programs 1) directed at the temporal and spatial distribution of pelagic fish in the offshore open waters, and 2) directed at the temporal distribution in the surf zone. The designs should consider existing monitoring and cooperate where possible with other MONS monitoring programs that are being developed, e.g., on zooplankton.

1.1 Knowledge question and objective

The overall objective of MONS is to collect and analyze data of the North Sea ecosystem in order to understand and assess the potential impacts of anthropogenic activities.

The two monitoring designs must contribute to this overall objective by providing data on the temporal and spatial distribution of (small) pelagic fish. The central knowledge questions that the monitoring programs should answer are:

1) ***What is the distribution of small pelagic fish species in Dutch waters, by season and from year to year?***
2) ***How can these geographical and temporal distributions be explained by the known natural history of the species involved, in terms of known behaviour and habitat requirements?***

In the context of the carrying capacity and food web interactions: the focus should be on the pelagic species with a key role in the food web, specifically on pelagic species that are the major food source of apex marine predators (i.e., birds and marine mammals) and predatory fish. Thus, knowledge of the distribution of the pelagic fish should provide knowledge on how much food is available for predators and where this food is located through time.

Additionally, the request is to consider how the monitoring could contribute to the knowledge required for answering other fish related questions in MONS. These questions are:

- Migration patterns: is migration a gradual journey or a short swim without stops?
- Seasonal dynamics in occurrence and behaviour (e.g., spawning, foraging).
- Behaviour of fish in general: how much time does a fish spend on looking for food, on food digestion and does a fish have specific spawning/courtship behaviour?

The spatial and temporal distribution of fish is for a large part determined by the presence of food and suitable habitats (i.e., for living, spawning and growth). A suitable habitat is a complex combination of biotic (e.g., food) and abiotic (e.g., temperature) factors, which differ per species and per life stage within species. The monitoring programs should also consider monitoring the environmental conditions in order to explain the found patterns in distribution.

Another knowledge gap related to pelagic fish is that there is limited knowledge on some species that are currently less common in the North Sea, but which are very common in the adjacent southern area: The Channel and the Bay of Biscay. These are pilchard, anchovies and sea bass. These are species that, as a result or climate change, are likely to increase in the coming years in the entire North Sea and adjacent coastal areas. Monitoring this emergence and possible fluctuations is a knowledge gap, even more so because their emergence will likely affect the occurrence of current dominant pelagic species such as herring and sprat.

1.2 Expected Result

Based on an inventory of historical and current research, the MONS report (Asjes et al. 2021) already provides a concrete expectation of the implementation of the monitoring. The result of the project consists of a draft plan for monitoring and supporting research on small pelagic fish species that are important food resources for birds and marine mammals in the Dutch part of the North Sea. It also includes an estimation of the costs for the implementation of this plan. The draft plan has been expanded and set up in such a way that it serves as a preparation for the monitoring, so this can start in 2022.

The draft plan will consist of the following two requested components:

1. A year-round beach sampling of the shallow surf zone
2. A year-round and annual sampling of small pelagic fish

Both designs will be developed regarding the seasonal dynamics of the pelagic fish, while linking to seabird and marine mammal observations, or any other additional proposals, in order to combine these with pelagic sampling. The draft plan will also include the sampling of additional environmental variables such as depth, temperature and salinity, etc. The draft plan will examine the options for linking pelagic fish samplings to existing (international) surveys of the North Sea.

1.3 Demarcation

The project only drafts the monitoring plan for the above-mentioned two components and an estimation of the costs for these plans. It is not a part of this project to reserve ship time in anticipation of 2022 or to initiate other matters necessary for the execution.

The MONS program contains a preliminary budget for the pelagic monitoring. This preliminary budget requires considerations in added value. Continuous measurements provide the best information on temporal aspects, however the available budget limits continuous monitoring over the full spatial scale.

Ship time is the main cost of a monitoring program. However, the availability of ships that can perform acoustic monitoring and their specific costs are not yet known at this moment. This makes it hard to make a comprehensive cost estimate. Therefore, ship costs are not included in the cost estimate and the necessity of the vessels is only presented in the required ship time. The governmental shipping company (*Rijksrederij*) has some vessels that might be used for acoustic sampling, however not all their vessels are able/equipped to handle pelagic fishing gear. Besides that, most Rijksrederij vessels have a full agenda, and it is unlikely that the preferred research vessel Tridens II is available in the preferred periods. This makes it likely that a commercial vessel needs to be hired, which will probably involve a tender-procedure which is not incorporated in the proposed plans.

It is impossible to design a monitoring plan that will provide answers to every thinkable (future) question. The workplan that we present in this report must be considered as a rough outline of what a baseline monitoring program for small pelagic fish should look like.

1.4 Layout of this report

Chapter 2 provides a brief overview of:
- Ongoing international monitoring of pelagic fish in the North Sea
- Existing research on small pelagic fish in the Dutch coastal zone
- Existing research in the surf zone

Chapter 3 describes methods for collecting data on pelagic fish

Chapter 4 provides the considerations behind the proposed plan

Chapter 5 contains the work plans

Chapter 6 provides an overview potential additional data to be collected
- Fish
- Zooplankton
- Birds/marine mammals
- Innovative monitoring methods

Chapter 7: the conclusions indicating which questions will be answered with the proposed monitoring.

1.5 Species list

See Annex 3 for an extended table with species information.

English name	Dutch name	Scientific name
Allis shad	Elft	*Alosa alosa*
Anchovy	Ansjovis	*Engraulis encrasicolus*
Garfish	Geep	*Belone belone*
Grey mullet species	Harders	*Liza sp. Chelon sp*
Greater sand eel	Smelt	*Hyperoplus lanceolatus*
Herring	Haring	*Clupea harengus*
Horse mackerel	Horsmakreel	*Trachurus trachurus*
Lesser sand eel	Kleine zandspiering	*Ammodytes tobianus*
Mackerel	Makreel	*Scomber scombrus*
Raitt's sand eel	Noorse zandspiering	*Ammodytes marinus*
River lamprey	Rivierprik	*Lampetra fluviatilis*
Salmon	Zalm	*Salmo salar*
Sand smelt	Koornaarvis	*Atherina sp.*
Pilchard	Pelser	*Sardina pilchardus*
Sea bass	Zeebaars	*Dicentrarchus labrax*
Sprat	Sprot	*Sprattus sprattus*
Three spined stickleback	Driedoornige stekelbaars	*Gasterosteus aculeatus*
Transparent goby	Glasgrondel	*Aphia minuta*
Twait shad	Fint	*Alosa fallax*
Zeeforel	Sea trout	*Salmo trutta*

2 Past and current national and international research relevant for pelagic fish in the North Sea

2.1 Regular international ICES-coordinated fish monitoring

The Netherlands is involved in international (fish) monitoring that is coordinated by the International Council for the Exploration of the Sea (ICES). The Netherlands participates in the following surveys, which are conducted annually in the North Sea: The International Bottom Trawl Survey (IBTS), the Bottom Trawl Survey (BTS), the Demersal Young Fish Survey (DYFS), the Sole Net Survey (SNS), the International Haring Larvae Survey (IHLS) and the Acoustic Survey for Haring and Sprat in the North Sea (HERAS). In addition, a mackerel-egg survey is carried out once every three years in June in the northern North Sea. Of these surveys, the relevance of the beam trawl surveys (BTS, DYFS, and SNS) targeting demersal (flat)fish for pelagic fish is limited.

The IBTS, carried out in January-February (Q1) and August-September (Q3) (the Dutch involvement is limited to the first quarter), uses a ground trawl with a relatively high vertical opening. As a result, this survey has limited suitability for monitoring pelagic fish. However, in addition to indices for a range of demersal fish species, the IBTS also provides indices for one-year old herring and sprat. Additionally, to the fishing, sampling is done at night with a Midwater Ring – or “MIK” net (mesh size 1.6mm or 500 µm). The MIK-net is aimed at larger herring larvae based on which a recruitment index of the herring stock component spawning in the Channel during winter is calculated (ICES 2021b).

The IHLS, executed in December, January and September focuses on herring larvae near the known spawning areas in the Channel and the North Sea. This survey provides an index of herring larvae which is used as a proxy for the spawning biomass of herring (ICES 2021a).

The HERAS, in July, aims to estimate the biomass of adult herring. This survey covers a large part of the North Sea, of which the Netherlands covers the Scottish coast. To do this it uses a Simrad EK80 in combination with a 38 kHz splitbeam transducer (installed in the dropkeel of the research vessel Tridens II) to make acoustic recordings of the water column. These acoustic recordings are supplemented by pelagic fishing tows for species identification and collecting biological samples for the targeted species (ICES 2021c).

The aim of the mackerel-egg survey, once every three years in June, is to provide an index of mackerel spawning biomass. It uses a plankton-torpedo to catch the eggs. The sampling frequency of this survey is very low, while it only covers the northern part of the survey. Additionally, pelagic fishing is performed to collect biological data on adult mackerel (ICES 2021d).

The MIK-net survey, the IHLS, HERAS and the mackerel-egg survey provide potential options for the inclusion of the taxa of zooplankton and small pelagic fish in their surveys. Now these surveys are mainly focused on herring and mackerel. For the herring-focused surveys, data is mainly collected in the periods that herring is present in known spawning areas and to a lesser extent on the coverage of the area.

2.2 Historic sampling of pelagic fish in open water

In the past, programmatic research on small pelagic fish has been done on the Dutch Continental Shelf (DCS): Flyland, MEP-NSW, ZKO, Shortlist Master plan Wind, *Natuurlijk Veilig* and a few studies on the availability of food for seabirds in the areas of the Frisian Front and the Bruine Bank.

2.2.1 Flyland

At the end of 1999, the government decided for limited growth of Schiphol Airport at its current location for the short and medium-long term. For the long term it was decided to investigate the feasibility of an airport island in the coastal water. This was investigated by means of a multi-year research program, Flyland.

For Marine Ecology, which includes fish, the contractors were the MARE Combination, consisting of: DHV Environment and Infrastructure BV (also secretary), Stichting Waterloopkundig Laboratorium (WL), Royal Netherlands Institute for Sea Research (NIOZ), Netherlands Institute for Fisheries Research (RIVO), Alterra and the Dutch Organization for Applied Scientific Research (TNO). As part of this project, RIVO conducted a hydro-acoustic survey targeting pelagic fish in the Dutch coastal waters in June 2001.

At the end of 2002 it appeared that, as a result of various global developments in aviation, a possible alternative to Schiphol Airport would not be addressed until much later than had been foreseen in 1999. This led to the adjustment of the priority of this research and to the stalling of Flyland (Anonymus 2003). The consequence was that the research results remained unpublished.

2.2.2 MEP-NSW

The Monitoring- and Evaluation Program Near Shore Wind Farm (MEP-NSW) was developed around the construction of the first offshore wind farm, constructed in 2006 in the Dutch waters, Offshore Windfarm Egmond aan Zee (OWEZ). As a baseline study, the Dutch coastal waters were sampled twice both in April and October 2003 for pelagic fish using a towed body equipped with a EK60 with a 38 kHz and a 200 kHz splitbeam transducer used from a commercial fishing vessel (eurocutter). Acoustic recordings were made on the large spatial scale of the Dutch coast, and with a small spatial resolution in the planned location of the wind farm and two reference locations (Grift et al. 2004). This study was supplemented with unpublished data from hydro-acoustic surveys conducted under Flyland (June 2001) and the “Birds and Fish” project (*Vogels en Vis*; November 2001). The combination of these four studies made it possible to describe the pelagic fish community throughout the year.

After the construction of the wind farm, acoustic monitoring took place again in 2007 and 2011 in the Dutch coastal waters (van Hal et al. 2012; Ybema et al. 2009). For pelagic fish the conclusion was that, although the species composition, distribution and biomass strongly differed between T0, T1 and T5, there are no indications that conclude that this was related to the construction of the wind farm (Lindeboom et al. 2011; van Hal et al. 2012).

Next to the large-scale acoustic sampling of pelagic fish in the Dutch waters, the MEP-NSW programme zoomed in on the spatial distribution of pelagic fish in the wind farm itself. Using a DIDSON (an acoustic high frequency camera using sonar) the water column of transects around and between different monopiles of the wind farm was visualised in three seasons. This showed the presence of individual pelagic fish and pelagic schools of fish near the monopiles and in the areas between. No species identification was possible despite the use of demersal multi-mesh static gear at the same time (van Hal et al. 2012; van Hal et al. 2017). The DIDSON work was an extension of the work done in the WE@SEA-project covering only the summer period (Couperus et al. 2010).

2.2.3 ZKO

The Sea and Coastal Research (ZKO) Wadden Sea project ran from 2010 to 2012 and included, amongst others, sampling of pelagic fish and zooplankton. This pilot study consisted of two parts: (1) testing the possibility of mounting a scientific depth gauge on the TESO ferry between Den Helder and Texel in order to monitor the abundance of pelagic fish in the Marsdiep area and (2) testing the possibility of sampling plankton by means of an Autonomous Plankton Sampler on board the ferry MS Vlieland between Harlingen and Vlieland. The study also included four hydro-acoustic reference studies aimed at pelagic fish in the Marsdiep in May and October 2010 and 2011. Hydro-acoustic data collection with a depth gauge on the TESO ferry was not possible due to air bubbles causing noise and transmission loss. The expectation was that this could be solved by making special adjustments to the hull onto which the equipment is mounted. However, most pelagic fish schools were in the upper layers of the water column and nearly 50% of the fish are distributed in the top 6m. The depth of the hull mounted transducer on the TESO ferry is 5m, thus it was to be expected that most of the fish would not be recorded. Therefore, for future monitoring of pelagic fish it was recommended to install a fixed installation on the bottom aimed towards the surface (Couperus, Jak, et al. 2016).

Analysis of the hydro-acoustic data from the four surveys conducted in the Marsdiep showed that there was a clear relationship between the amount of observed Clupeids and the tide. The amount of Clupeids in May was much greater than in October. The main conclusion was that the amount of pelagic fish was tens of times greater than the estimated amount of demersal fish. This finding was remarkable because while almost all survey efforts off the Dutch coast are focused on demersal species, this ecologically important group remained underrepresented (Couperus, Gastauer, et al. 2016).

2.2.4 Shortlist Master plan Wind

As part of the program Shortlist Master plan Wind the southern North Sea was sampled every month for a year (2001/2011) with a Gulf-7 plankton-torpedo (mesh size 280 µm). This has provided an overview of the year-round distribution of fish larva and eggs (van Damme et al. 2011), including pelagic species.

In 1989, similar activity took place by executing eight egg surveys in the southeastern North Sea (van der Land 1991).

2.2.5 Natuurlijk Veilig

In the context of a series of studies on the effects of sand nourishments off the Dutch coast, Wageningen Marine Research conducted a multidisciplinary study on behalf of Rijkswaterstaat in the Dutch coastal waters in June 2018, focusing on pelagic fish, among other things. The purpose of the study was to determine the distribution and abundance of fish in the coastal zone and to collect data on (a)biotic factors that determine this distribution. The aim was to use these data to predict the possible effects of sand nourishment in the coastal zone on fish.

The objectives regarding small pelagic fish and zooplankton were exploratory: (**1**) How variable is the distribution of pelagic fish along the coast in time and space? (**2**) Are the variations in the distribution of pelagic fish correlated with tide and/or time of day? (**3**) Can the catches of a beam trawl be used as an index for pelagic fish in the sandy zone off the Dutch coast? (**4**) Do schools of fish remain undetected by escaping in front of the ship in the shallow area of the coast?

Hydro-acoustic measurements were performed in the coastal zone using a Simrad EK80 echo sounder with a splitbeam 200 kHz transducer which was deployed at the bow of the vessel. The measurements were taken in four areas, Zuid-Holland, Noord-Holland, Texel and Schiermonnikoog. The acoustic measurements were performed in the 3-12 m depth zone during and between the samplings with the beam trawl. To test whether schools of fish are missed at the bow due to escaping behavior (4), additional acoustic measurements were performed simultaneously with a 200 kHz transducer mounted in a towed 'towed body' that skims away from the vessel.

The main conclusions of this study were: (**1**) The observed densities of pelagic fish varied widely between and within the different sites, which is not unusual for pelagic fish. The densities in 2017 along the west coast ranged from 29 to 209 kg/ha and were comparable with the ZKO study in the Marsdiep. The densities were also much higher than the densities of demersal fish observed in annual coastal fish surveys (Couperus, Gastauer, et al. 2016). The observed density at Schiermonnikoog in 2018 was much lower (4 kg/ha). (**2**) A GAM analysis comparing the effects of time of day, tide and depth with estimated fish abundance showed that the large variations in richness observed could not be explained by these factors. (**3**) Beam trawl catches were dominated by the pelagic fish species herring and sprat, making it seem likely that most of the acoustically recorded schools of fish consisted of these species. However, no relationship was found between the amount of herring and sprat in the beam trawl catches and the acoustically observed schools of fish. There even seemed to be a negative relationship: when high concentrations were observed on the echo sounder, virtually no pelagic fish species were found in the catch. This clearly indicates that beam trawling is unsuitable for the sampling of pelagic fish. For future coastal research it was recommended to use a (semi) pelagic net that is suitable for catching fish that swim in schools. (**4**) No significant difference was found between the amount of fish recorded at the bow of the ship and the amount of fish 8 m next to the ship. This indicates that the number of schools of fish is unlikely to be underestimated due to the possible evasion of the ship by the schools before they can be detected. This further indicates that the used setup with a transducer mounted in a depressor at the bow was suitable for studying changes in the distribution of pelagic species in the shallow coastal zone, on the condition that suitable fishing gear is available. The study found no indication of a possible direct influence of sand suppletion (Couperus et al. 2020).

2.2.6 Research projects concerning food availability at the Frisian Front and the Bruine Bank

Two surveys were conducted in the area around the Bruine Bank in February and March 2014. The surveys were aimed at mapping the distribution of birds and at mapping potential prey species. The surveys consisted of simultaneously executed bird counts, acoustic fish surveys and fish sampling. The acoustic fish sampling showed the following fish species to be most abundant: herring (14.1 cm), transparent goby (2.98 cm), sand eel (6.6 cm), greater sandeel (average catch length 21.6 cm) and sprat (10.2 cm). These species are part of the winter diet of both razorbill and guillemot and are present throughout the area, mostly in the upper meters of the water column. No relationship was found between the number of birds and the amount of potential prey. This is caused by the fact that the top 3 meters of the water column could not be sampled properly, and that the data contained a lot of noise. Also, insufficient distinctions could be made between the different fish species in the acoustic survey and no direct link could be made between foraging auk species and individual schools of fish.

Weather conditions complicated the fish survey. The schools of fish were too high in the water column for them to be detected. The schools that were detected were acoustically “polluted” by air bubbles. Fish catches in February (executed with a so-called ‘zwever’; Annex 1) and in March (executed with a shearing net: a so-called SURF net; Annex 2) were very low (Geelhoed et al. 2014).

A hydro-acoustic survey was carried out in the area of the Frisian Front in July 2006 and in July/August 2009 to determine the food availability for lesser black-backed gulls. Most of the catch consisted of sprat, which was mainly present in the first few meters below the water surface (Baptist et al. 2019a).

2.2.7 Swimway

In 2021-2022, sampling of small pelagic fish will take place in the Wadden Sea as part of SWIMWAY project. During a continuous period of one year, fishing will take place every month for a week with a stow net (mesh size 18mm) in the Wadden Sea. Two two-week acoustic surveys will be conducted in 2022, covering all inlets between the Wadden Islands. In a selected area, stationary echosounders record data to monitor horizontal and vertical migration and schooling behaviour.

2.2.8 Main conclusions of the pelagic monitoring in the Dutch open waters.

The most important insight that these studies have provided is that the amount of pelagic fish off the Dutch coast is many times greater than the amount of demersal fish, while most existing monitoring is focused on this latter group.

Based on the above-mentioned projects and information available from surrounding areas, a classification can be made according to the abundancy of the different pelagic species (in italics: especially off the Dutch coast).

- Very common: *Herring*, *sprat*, *small sand eel* and Raitt’s sand eel

- General: horse mackerel, mackerel, pilchard, greater sand eel, *anchovy*, *sand smelt*, sea bass, *three spined stickleback, transparent goby*
- Fairly common: garfish, river lamprey, *twait shad*
- Very rare: allis shad, salmon

Although the spawning periods and areas of most of these pelagic species are known from literature, uncertainty remains especially about small sand eels and sand eels in the Dutch coastal zone.

Internationally, it is obvious to seek affiliation with the IBTS and HERAS.

2.3 Historic sampling of (pelagic) fish in the surf zone

Even though the surf zone is not routinely sampled, a few monitoring activities have been carried out in the Dutch and Belgian surf zone in recent decades. In the 1970s and 1980s, coastal sampling was carried out using a dinghy with a 2m beam trawl. Sampling was largely performed opportunistically, i.e., good weather conditions, availability of a dinghy and availability of trainees formed the preconditions. As a result, for most years the sampling was not set up consistently, but all species caught were counted and measured. The most useful results of this research have been presented within the “Natuurlijk Veilig” project of Rijkswaterstaat (RWS) as “historical beach sampling” (Teal and van Keeken 2011; van Hal et al. 2021).

In 1992, from March to October, fishing was done at four locations along the coast of Texel at different depths (2, 4, 6 and 10 m; the shallowest part of 0-2 m of the coastal zone was not sampled) with a 2m beam trawl pulled by a small boat. The focus of this sampling was on plaice (Mengedoht 1995).

In Belgium in 1996, catches of commercial shrimp fishermen were sampled for the presence of flatfish. These shrimpers fished along the Belgian coast near Oostduinkerke traditionally with horses, whereby the horses pulled a 3m beam trawl at a depth of 1 – 1.5m (Beyst et al. 1999). In the same and the following year, the bottom community was sampled monthly at four locations along the Belgian coast at a depth of approximately 1m with a ‘sort of’ beam trawl (hyperbenthic sled). The focus of this study was to obtain the seasonal dynamics of the benthic community in the surf zone, analysing all captured species including herring-like species (Beyst et al. 2001). Also, in 1996 the fish community was sampled three times at a depth of 1m over a 24-hour cycle, using a 2m beam trawl. Highest densities of fish were found during low tide (Beyst et al. 2002). Both the hyperbenthic sled and the beam trawl were pulled through the surf by two people while walking.

In the Netherlands, the surf zone was only sampled again in June 2002. As a pilot project, the surf zone was sampled over a depth gradient (maximum 7m deep) at the locations Castricum and Egmond using a huge tripod on wheels. To sample fish, a 2m beam trawl was pulled by this tripod. The focus of this research was to get a picture of the species composition and densities of, among other things, fish over depth (Janssen et al. 2008). As part of the evaluation of the ecological impact of the Sand Engine (*Zandmotor*), the surf zone was sampled in 2012 and 2013 around the Sand Engine (Kijkduin) and in the lagoon present at the time. A 2m beam trawl was pulled with a dinghy that sampled the fish community in the zone up to 4.5m deep, with the focus on benthic fish (flatfish) (van Hal et al. 2014; van Keeken and van Hal 2012).

Commissioned by Rijkswaterstaat in the context of "Natuurlijk Veilig", beach sampling was carried out in 2017 and 2018 with a 2m beam trawl and a beach seine in five areas along the coast: Sand Engine, Noord-Holland coastline, Texel, Ameland in 2017 and Schiermonnikoog in 2018. In 2019, beach sampling was carried out twice a month from March to June at three locations along the Dutch coast, namely Katwijk, Castricum and Texel. The surf zone was sampled with a net with a single door, the fishing gear was pulled and held straight by four people. Target species of this study were all flatfish species (in particular the arrival of juvenile plaice had the focus) and in addition all other fish species were measured (van der Geest 2019). The most recent sampling of the surf zone took place near IJmuiden and was routinely performed by WMR-volunteers in 2020 (March to October) to get a picture of the seasonal dynamics in this underexposed zone of the Dutch coast. A 2m beam trawl pulled by two people was used for fishing (Couperus, Volwater, and van Hal 2021). This beach sampling at IJmuiden was followed up in 2021, but the results have not yet been reported.

2.3.1 Main conclusions of sampling the surf zone

In most cases the sampling in the surf zone was targeting the juvenile flatfish with beam trawls. However, the beach seine, the net with a single door and the Belgium hyperbenthic sled were also targeting the pelagic species. Despite not being designed for catching pelagic species, also the beam trawl is able to catch pelagic species in shallow and turbid water.

Mainly juveniles were caught, partially because they are most dominantly present in these shallow waters, but also because of the design of the used gears and slow fishing speed: large fish such as large specimens of sea bass and grey mullets simply escape in front of the net while these are frequently visually recorded and are being caught with rods from the beach.

In the most recent sampling from the beach of IJmuiden, various pelagic fish species were caught. The most dominant were Clupeids (herring and sprat), but also sand eel, sand smelt, sea bass and golden grey mullet were caught.

Sampling throughout the year provides insight in arrival time of juveniles followed by growth in the surf zone.

3 Methods for sampling pelagic fish

3.1 Hydro acoustic surveys

The preferred method for sampling of pelagic fish is an acoustic survey by means of echo integration (Simmonds and MacLennan 2008; Simmonds and MacLennan 2005). Using acoustic equipment designed for water column observations the whole water column is monitored while sailing. This way large areas can be covered while the acoustic data provides information about the amount of scattering caused by objects in the water. Different objects, including different fish, have a different acoustic target strength. When it is known which species were in the area, backscatter can provide a biomass estimate of the whole area covered. Knowledge is required of the species composition and target strength per species (in relation to length). While the knowledge on the length depended target strength of commonly observed small pelagic fish is available in the literature, data on species composition requires regular fishing on the observed schools. Thus, acoustic surveys require targeted fishing activities, otherwise the interpretation would require large assumptions on the expected species composition.

3.2 Trawl surveys

Regular trawl surveys in which trawl hauls are being carried out at a fixed distance or duration according to a predefined grid are mostly done with demersal gears targeting demersal species. Examples are the above mentioned BTS and IBTS. These surveys catch pelagic species but are in principle not suitable for sampling pelagic fish due to the schooling behaviour of the fish. Trawl catches are in this case determined by chance without confirmation of whether the acoustically observed schools are caught or not during fishing. In addition, pelagic species move quickly, and their distribution can change continuously as schools/concentrations of fish redistribute.

Despite this the IBTS originally started as the young herring survey. The idea at the time was that young herring is more evenly distributed in winter and occurs less in schools. Since the 1960s the data of the IBTS is used as the index of the abundance of one-year herring (and later also sprat). Despite the limitations, the IBTS data is also used for indices on the abundance of juvenile mackerel, specifically the third quarter data.

While not being ideal, the data of trawl surveys - specifically with a gear with a high net opening (like the gear used in the IBTS) - can be used to gather data on at least some pelagic species.

3.3 Egg and larvae surveys

Within fisheries research, annual egg and larvae surveys are a proven method to provide an index of the spawning biomass of a species. van Damme et al. (2011) show nicely how the eggs and larvae of different species in the southern North Sea can be mapped. In addition, the monthly presence or absence of larvae gives a rough indication of the spawning period. A major disadvantage is that the distribution found does not correspond to the distribution of (spawning) fish, as eggs and larvae are transported by currents. In addition, there is no insight into the distribution of juveniles. The costs of a monthly sampling would be high, and a sampling executed once a year would only give an index of the spawning biomass for a limited number of species.

3.4 Gill net sampling

Gill nets are highly selective and therefore in general not suitable for fish sampling.

However, it is a cheap method which can be applied by a small (and therefore cheap) vessel or even without a vessel directly from the beach. In addition, this method does not require substantial re-rigging in commercial vessels. Therefore, it can be used for year-round sampling. In the offshore wind farm Egmond aan Zee gill nets have been used to study fish around the monopiles. The study did not focus on, but the catches contained, small pelagic fish (van Hal et al. 2012).

3.5 Seine fishing

Seine fishing is a fishing method that employs a surrounding net, called a seine, that hangs vertically in the water with its bottom edge held down by weights and its top edge buoyed by floats. Seine nets can be deployed from the shore or from a boat.

In the RWS project *Natuurlijk Veilig* a light version was used from the beach. However, this light version was heavily impacted by waves and, due to the waves, larger fish jumped over the headline. Using the seine from the beach would require a heavier/larger net, however that would also require more staff than the two people that were able to handle the *Natuurlijk Veilig* net.

3.6 Echosounder on a fixed location

Autonomous echosounders such as Wbat (Wide Band Autonomous Transceiver) are suitable equipment to study trends in the abundance and behavior of fish and zooplankton. Measurements with such equipment although covering a very limited area can be representative of a much larger area (Robertis et al. 2018), because there is often a strong spatial correlation in the distribution of fish aggregations when they occupy the area for a long period of time (i.e., spawning /feeding grounds). Hence, when the measurements are averaged over larger periods such measurements can be representative of much larger areas. A study focusing on walleye pollock during spawning season in Alaska found that the concurrent measurements by the Wbat were correlated with a survey area of 50 nmi^2 of ship survey. Furthermore, in addition to spatial representativeness, the continuity in the data collection allows for resolving changes in different scales from diel to seasonal periods that could be used to infer fish behaviour relevant for connecting them to other components of the ecosystem such as their prey and predators.

3.7 Drones

Use of drones is a relatively new technique. Several companies offer drones and services to monitor remotely. Saildrone is one of the first and has a track record of successful deployments.
Saildrones are unmanned surface vehicles (USVs) that can perform autonomous long-range *in situ* data collection in the ocean. The drones are powered by a wind propulsion system and solar power, resulting in a minimal carbon footprint. Under wind power the drones can travel with an average speed between two and six knots and can execute missions with a duration up to one year. The drones can be equipped with an acoustic system that continuously records sensor data. To ensure the safety of these brightly colored vehicles during operations at sea, the drones are equipped with and automatic identification system transceiver, radar reflector, lights and cameras.

4 Considerations

The first key question, as formulated above, is: what is the distribution of small pelagic fish species in Dutch waters, by season and from year to year? This key question is comprehensive and allows for a very extensive research program that easily overshoots the available budget. This requires choices, and here we extend upon the considerations behind our choices.

Take a snapshot…
Around 15 fish species occur on the Dutch Continental Shelf that can be called pelagic (i.e., school-forming, not bound to the seabed, although sand eels are dependent on the seabed for a part of the time). Twelve of these species are common to very common. Although the spawning periods and areas, as well as migratory behaviour are known from literature, uncertainty remains, especially regarding small sand eels (*Ammodytes tobianus*) and sand smelt (*Atherina presbyter*) in the Dutch coastal zone. All these pelagic species can move rapidly through the area - the Northeast Atlantic area, the North Sea, the European coasts - while continuously redistributing into larger and smaller concentrations, which in turn can consist of larger and smaller schools. It is therefore necessary to choose a survey method with which the area can be covered quickly. If a survey takes too much time, there is a greater chance that concentrations will be missed or that concentrations will be detected more than once. In addition, the area should be chosen broadly in order to avoid missing part of the population.

… of a large area
According to the key question it is not necessary to make an absolute estimate of the biomass of different populations of pelagic fish on the DCS. However, in the context of carrying capacity and the availability of food for higher trophic levels, this would be relevant information. To gain insight into the distribution of pelagic species as food (for birds and marine mammals) and as predators (of zooplankton), it is therefore important to study a large area. If one examines a limited area – for example the DCP in relation to the larger ecological unit, the North Sea – one will never know for sure whether observed fluctuations in numbers or biomass really take place or whether they can be attributed to movements on a larger scale.

… by means of a hydro acoustic survey simultaneous with existing large-scale surveys,…
Therefore, the first decision is to survey the area by means of a hydro acoustic survey and to connect with regular international surveys that cover a much larger area (the North Sea) than the DCS to get more value for the same effort. The candidates for this are the HERAS and to a lesser extent the IBTS Q1.

… considering winter – and summer distribution of sea birds…
Discussing this first proposal with bird experts made it clear that a summer and winter distribution of pelagic fish would indeed provide valuable information on food for birds. However, from discussions it appeared that, from a bird’s perspective, sampling slightly earlier than the HERAS would match better with the crucial period in which birds require food for their young. Practically, this is helpful as well, as in that case the acoustic experts involved in the Dutch HERAS would still be available.

… and the location of existing - and planned wind farms.
From the same discussions with the bird experts, it became clear that a dense monitoring in the coastal areas is preferred over al full scale DCP monitoring. This is the main consideration for the choice of the extend of the area. Additionally, the presence of wind farms and those planned in the future (energy areas) are considered. It is considered that including these areas to be covered by the acoustic surveys could support latter research on the potential impact of these wind farms.

Fill the spatial- and temporal gap between the surveys with data from fixed stations
Repeating this proposed acoustic survey more often would provide a better insight in the temporal distribution of pelagic fish. However, apart from the absence of other connecting international surveys, it would require more than the available budget. To get insight in the temporal changes, we propose a fixed station setup with two stations collecting acoustic information semi-continuously.

... but first study the value of such data and test different options.
This would be setup as a pilot as it hasn't been used much yet. Firstly, it should be tested what additional knowledge fixed acoustic stations would bring. Secondly different methods should be tested. Preferably, the stations would be placed in areas that overlap with the coastal acoustic survey and in expected hotspots of food for birds. However, practically speaking it is safer to place the stations in a wind farm, as in open waters there are collision risks with local marine traffic, or they could be caught or damaged by fishing activities.

Fixed acoustic stations require fishing information
The fixed stations would only provide the acoustic information: it is possible to "see" fish schools and quantify the densities, but it is not possible to identify species. Interpretation of such data is therefore limited without combining it with catch composition from the area. Regular fishing in the vicinity of the fixed station to get an impression of the fish composition is required. This doesn't have to be very intensive or advanced. Therefore, a multi mesh gill net activity is proposed, that could easily and flexibly be executed by a commercial vessel. The used stretched mesh sizes will be compatible with the set net used in the surf zone sampling scheme.

5 Proposed monitoring programs for pelagic fish

5.1 Offshore pelagic monitoring

The proposed monitoring plan described the first year of the year-round monitoring of small pelagic fish. The plan consists of two parts: one directed at spatial monitoring and the other part directed at temporal monitoring (***Figure 5.1***). The spatial monitoring includes two coastal hydro-acoustic surveys comparable in time with the regular internationally coordinated surveys in the North Sea and a pilot study using a standalone drone collecting acoustic data continuously.

The temporal monitoring includes a pilot with a fixed standalone station (Wbat). The idea is that a fixed station provides an abundance index for the period between the two coastal surveys. The fixed station can only provide acoustic information that provides insights in the species composition at the time. In addition to this a pilot pelagic gill net sampling in the vicinity of the Wbat is planned.

The WBAT with gill net and the drone are considered as pilots, as such combination hasn't been used as a continuous monitoring tool in the region before.

	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Spatial monitoring												
Coastal acoustic survey												
Drone (Pilot)												
HERAS												
IBTS												
Temporal monitoring												
Wbat (Pilot)												
Static gear (Pilot)												

Figure 5.1 *Schematical representation of the working plan. In italic the international surveys not part of this plan. The pale green blocks represent sampling that is not directly necessary for the assessment of the pilot results.*

5.1.1 The coastal hydro-acoustic surveys

Two coastal hydro-acoustic surveys are proposed, one in February and one in June. The survey in February is simultaneous with the international IBTS, while the survey in June is prior but adjacent to HERAS.

Preferably, the survey should be done with a vessel having a dropkeel in which the required acoustic equipment is installed (the *Rijksrederij* vessel RV Tridens II). If this vessel is not available, acoustic data could be gathered with a Simrad EK80 echo sounder with 38kHz and 200kHz splitbeam transducers, mounted on a towed body (***Figure 5.2***). This towed body can be towed by a variety of vessels; however, the vessels should additionally be able to use pelagic fishing gear which reduces the potential vessels.

Fish sampling must be carried out with a pelagic or a semi-pelagic trawl (***Figure 5.3***). Standardization of the gear is not required, if it is designed to fish for fast swimming, schooling fish. In the previous hydro-acoustic surveys a so called "zwever" was used (Annex 1). Alternatively, the SURF net (Annex 2) may be used (Baptist et al. 2019b). The latter is designed to target surface schools. Both nets can be operated by cutters, provided they have an A-frame and a net-winch or space on deck to store the trawl.

The vessels must sail predefined transects with the towed body. The transects should extend to 20 nautical miles from the coast (**Figure 5.*4***), in agreement with the knowledge on feeding birds. The total distance of the transects to be sailed is approximately 750 nautical miles. The cruise speed of a vessel during an acoustic survey should be about 8-10 knots. With an average of two fishing hauls per day, the average speed is about 6 knots. If one day for calibration of the echosounder, bad weather, repairs and (additional) sampling in the wind farm are considered, the time it takes to cover the Dutch coastal area as presented in **Figure 5.*4*** is three working weeks. This means six sea going weeks are required for both surveys. The transects presented in Figure 5.4 are a preliminary draft. They may or will have to be adjusted to avoid wind farms or to extend transects to specific area, for example *De Bruine Bank* and *Het Friese Front*.

Figure 5.2 *Towed body with 38 and 200kHz transducers. The purple hose protects the electrical cable that is connected to the EK80 in the steering house.*

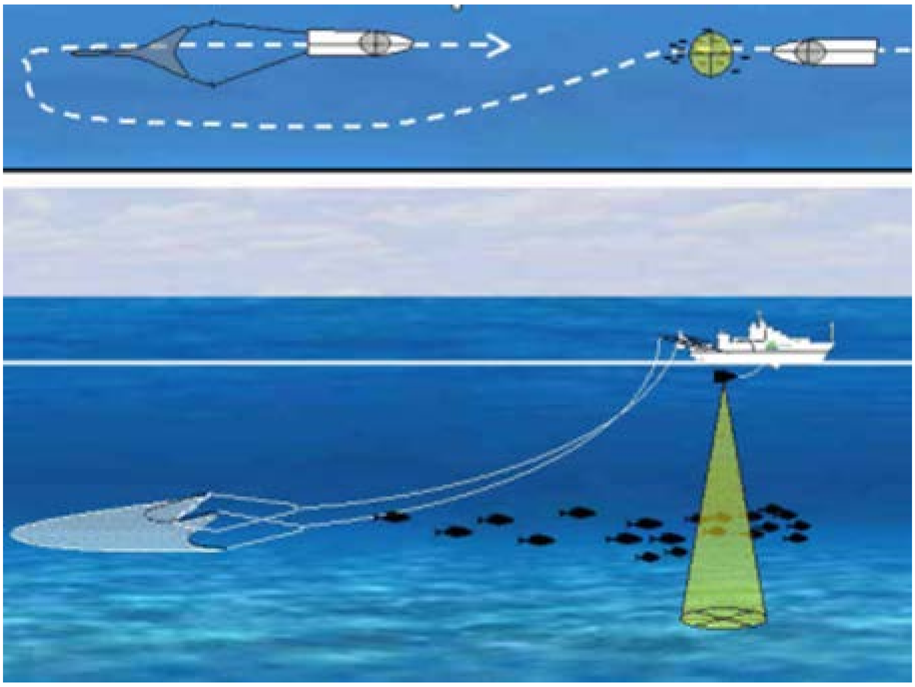


Figure 5.3 *The use of a pelagic, or semi-pelagic, trawl during a hydro acoustic survey. Fish concentrations are encountered during sailing of an acoustic transect. The vessel interrupts the survey, turns and shoot the net to target the fish schools.*

Additionally, hydrological data must be collected and this can be done by attaching a CTD (Conductivity, Temperature, Depth device) to the towed body. Attached to the towed body it will continuously record the water temperature and conductivity. It is possible to record turbidity as well, however in the coastal waters these measures are often of lower quality. Therefore, it is proposed to collect also Secchi-depth observations by hand at each fishing station.

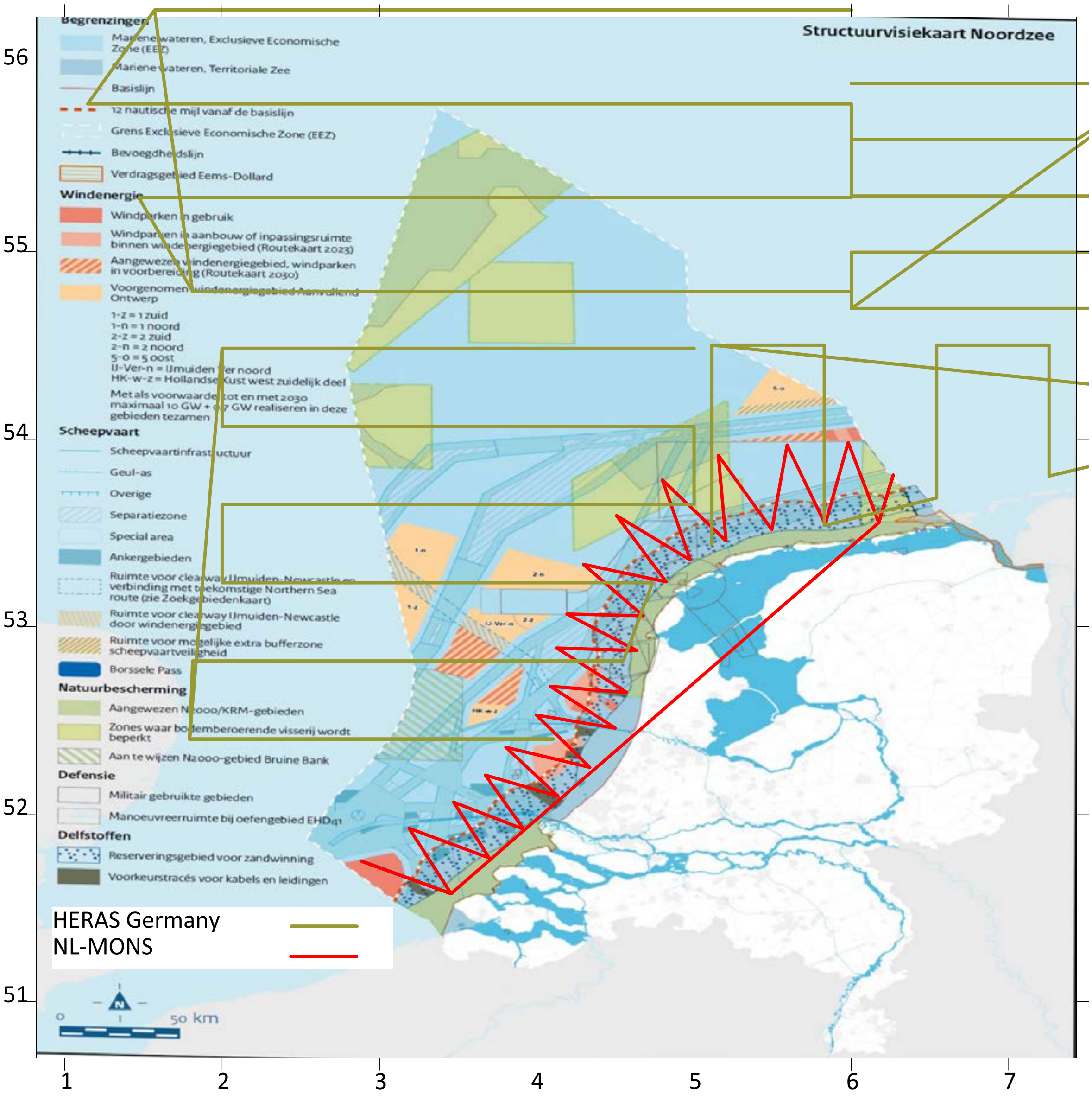


Figure 5.4 *The proposed zigzag transects along the Dutch coast for the coastal hydro-acoustic surveys in summer and winter. These transect are preliminary and do not account for (extra) transects in the wind farm where stationary acoustics will take place. Note that international wind farms (Germany, Belgium) are not visible on this map.*

5.1.2 Connection of the coastal surveys with the international surveys

The data of the International Bottom Trawl Survey (IBTS) are available and can potentially be used to assess the coastal MONS survey in the context of the North Sea, including small pelagic fish. However, the IBTS is not tailored for pelagic fish, as only bottom fishing hauls are performed. In the routine situation the echo sounders on board are not used during the IBTS. However, with some training and some preparatory work the current staff on board during the IBTS should be able to work with the acoustic equipment with little effort. This could mean acoustic data being collected during the whole IBTS. However, the transit speed of the vessel required between the hauls is too high for collecting proper acoustics data, thus there is no need to collect the acoustic data continuously. The speed while fishing is lower and lies within the range to collect quality acoustic information. This means acoustic data can be collected during the fishing hauls, of which the catches can be compared to provide qualitative information on the presence of pelagic species.

The spatial coverage of the IBTS is such that two countries fish in the grid cell (ICES-rectangle), and that the whole North Sea is covered this way. The Netherlands covers in the first quarter most of the ICES-rectangles of the DCP, the overlapping countries are: France and Denmark (**Figure 5.5**).

The data collected in these ICES coordinated surveys are publicly available. However, the data are not tailored to the requirements for a direct connection with the proposed MONS survey. The true connection with the international surveys must be built in the coming years, by cooperating with the international participants. The proposal is to collect acoustic data during the fishing hauls of the Dutch IBTS and to request to France and Denmark to investigate the possibility to collect similar data. This means that international data from will probably not immediately be available at the start of the proposed acoustic survey. The provision of these data will develop over time.

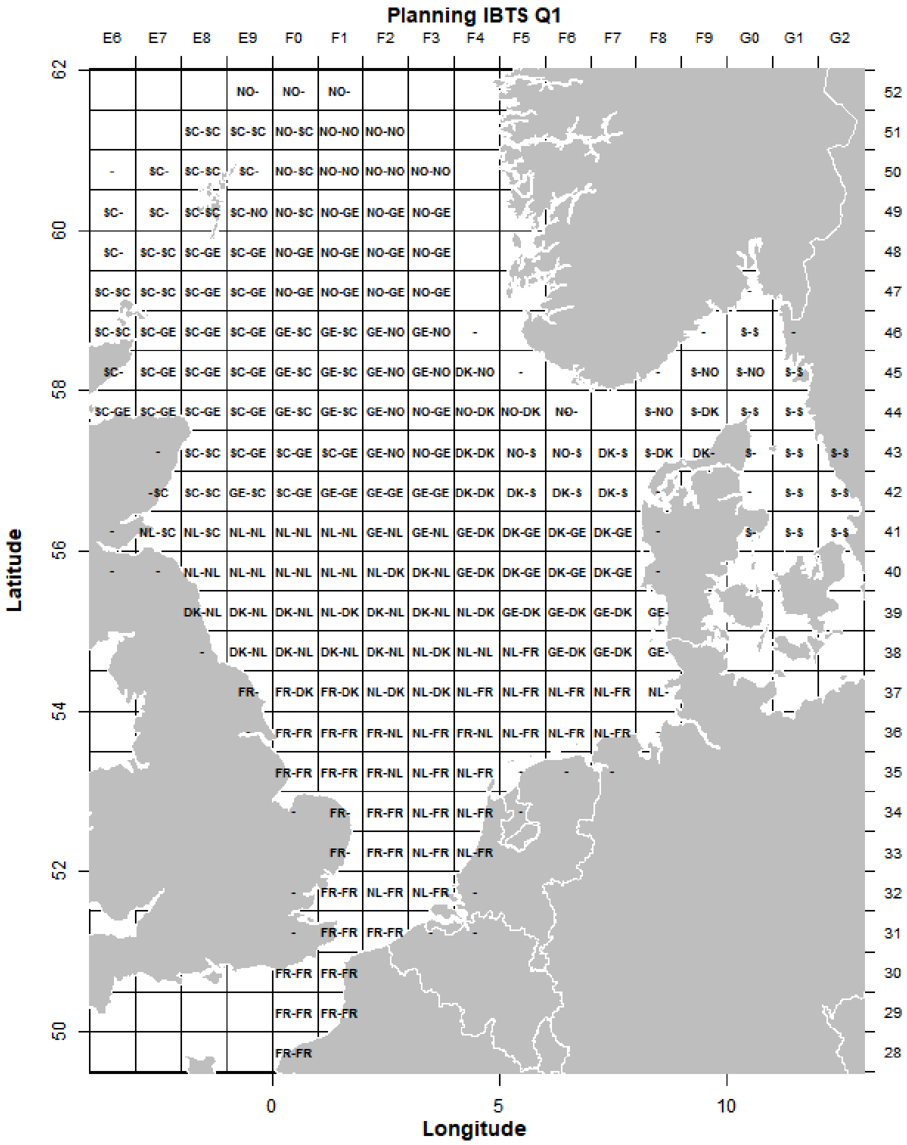


Figure 5.5 *Rectangle allocation by country for the North Sea IBTS in Q1 2021 (DK: Denmark, GE: Germany, NO: Norway, SC: Scotland, S: Sweden; NL: Netherlands; FR: France).*

HERAS is the hydro-acoustic survey in the North Sea: the method applied during the MONS coastal survey is very similar to the method used during the HERAS survey. The survey transects are sailed yearly by the German vessel. In contrast to the scrutiny of echograms by the Scottish, Norwegian and Dutch vessel where species are assigned to individual schools, the scrutiny of the echograms by the German scientists is carried out by applying the composition of the catches directly to the acoustic values. This is done because of the many mixed species aggregations present in the area. This is also the case for the Dutch coastal zone (Grift et al. 2004; Couperus, Gastauer, et al. 2016). Therefore, in MONS we propose to follow the German method.

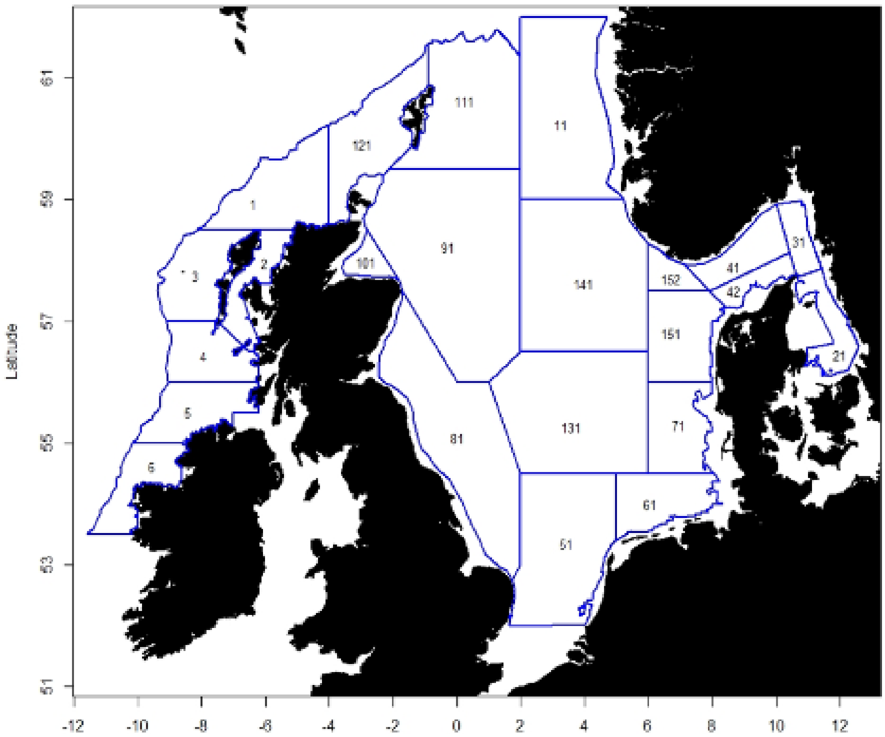


Figure 5.6 *Strata for acoustic and biological fish sampling during HERAS. The DCP is covered by strata 51, 61 and 131.*

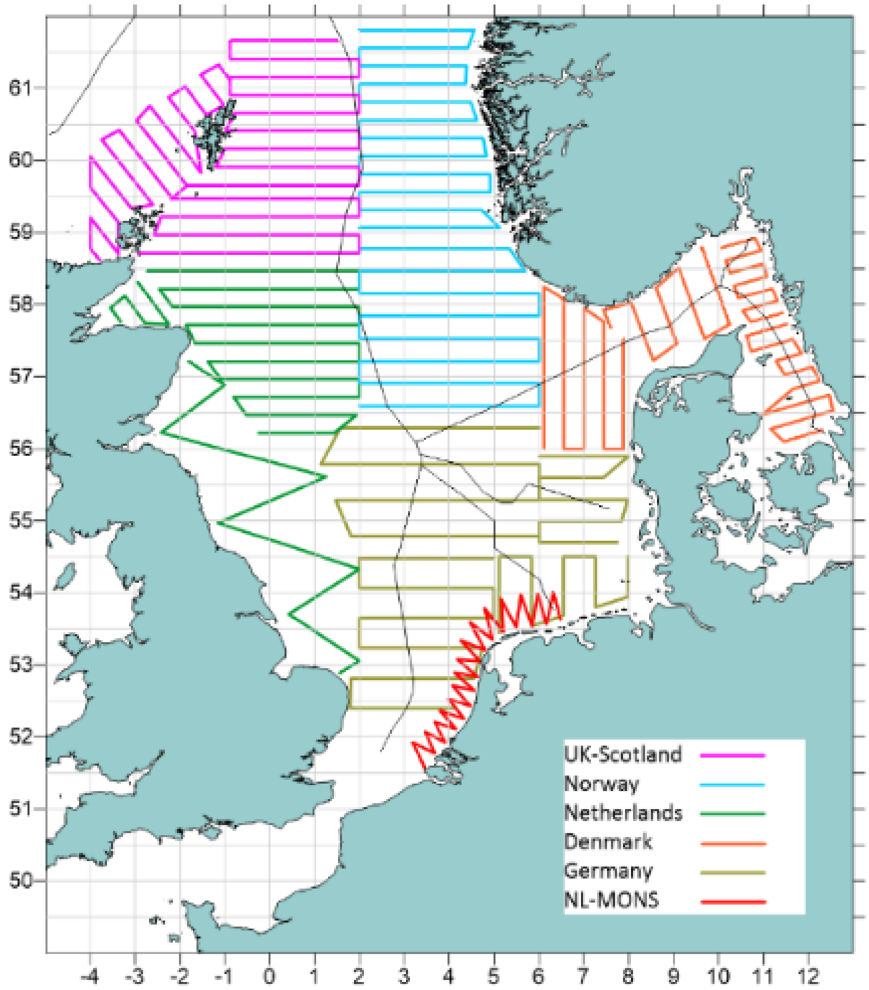


Figure 5.7 *Transects sailed during the yearly hydro acoustic survey for herring (HERAS) in the North Sea. Red zigzag transect are the proposed MONS transects overlapping with the German transect.*

We propose to carry out the surveys with calibrated echosounders with two frequencies, 38kHz and 200kHz. By operating these two frequencies, it will be possible to distinct swimbladdered fish (Clupeids, anchovy) from non-swimbladdered fishes (mackerel and sand eel species). The echos per fish (target strengths) for swimbladdered fishes are far stronger (200x) than those of non-swimbladdered fishes, approximately by a factor of 250. This means that if the recorded fishes swim in mixed concentrations, the swimbladdered fishes will create extensive noise in the abundance estimates for non-swimbladdered fishes whereas the opposite situation is not problematic. As a consequence the expectation is that we will be able to estimate biomasses of dominant swimbladdered fishes in the survey zone (Couperus, Gastauer, et al. 2016).

These surveys will provide a small-scale distribution map of pelagic fish species in the Dutch coastal zone and will thus give relative distributions of all pelagic species in the Dutch coastal zone. Within the coastal zone, for the dominant swim bladdered species (herring and sprat), biomasses will be estimated for the whole area covered. For other species it will at least be possible to provide distribution maps with relative indications of abundance in a resolution in the order of a 5-15 nmi grid.

5.1.3 Stationary year-round sampling: Wbat (pilot)

We propose to deploy one or two stationary echosounders on the seafloor. The preferred location would be in open water which is covered by the coastal acoustic surveys. However, the open water location bears a lot of risks as of which a safer location in a wind farm is proposed. From a practical point of view offshore Wind farm Egmond aan Zee is proposed as one of the locations, as this location is easily reachable from the IJmuiden harbour. The other location could be offshore wind farm Luchterduinen, also reachable from IJmuiden, or Borssele depending on the possibility to combine visits of the stations with other projects active in Borssele. Working in the wind farms requires permissions and extensive safety measures, the work for this is not fully included in the costs of the proposal.

The Wbat consists of a 38 and 200 kHz acoustic receiver, the Wbat needs to be attached to a metal frame of sufficient weighed to keep it stable on the bottom (**Figure 5.*8***). The frame requires a vessel of a reasonable size to place the Wbats at the preferred location. After placement, the Wbat requires three monthly maintenance (battery exchange, data retrieval, fouling removal). Buoys will be attached to the frame with an acoustic release, which is released when a maintenance vessel or the final retrieval vessel is in the vicinity. During the period on the bottom, there is no lining to buoys for marking the specific location. That is to minimise the impact of the equipment on the presence of pelagic fish.

The Wbat is operated with a Simrad 38 and 200 kHz transducer. This enables the acoustic operator to distinguish between swimbladdered fish (for example Clupeids) and fish without swimbladder (for example sand eel species and mackerel). The Wbat is stationed at the bottom while the transducers will be pointing in an upward direction. It will collect data in pre-programmed intervals, which yet needs to be determined, depending on more detailed research questions, available storage and battery capacity. This means it is not measuring continuously but it enables a good temporal coverage of appearance of pelagic species on that specific location.

Like the acoustic survey, the echograms (**Figure 5.9**) cannot directly be assigned to species. Hence the interpretation of the echograms requires additional catch information. To provide this catch information it is proposed to sample monthly with a small meshed pelagic gill net in the vicinity of the Wbat. As pelagic fish migrate vertically at night and the nets do cover only part of the water column (3m versus a bottom depth of 15-20m) the nets should be set in the evening and hauled in the morning to increase the catch of as much species as possible.

In the months of the coastal acoustic survey, the species composition of acoustically recorded schools can be determined. During the time gaps between the acoustic surveys the gill net catches give a rough indication of the observed schools on the echograms that are collected by the Wbat.

The frame that holds the Wbat offers the opportunity to connect other sensors to record continuously environmental parameters, such as temperature, salinity, current (speed and direction) and turbidity (NTU), which is proposed to be included.

Figure 5.8 *RVS frame with Wbat, as deployed in the Marsdiep.*

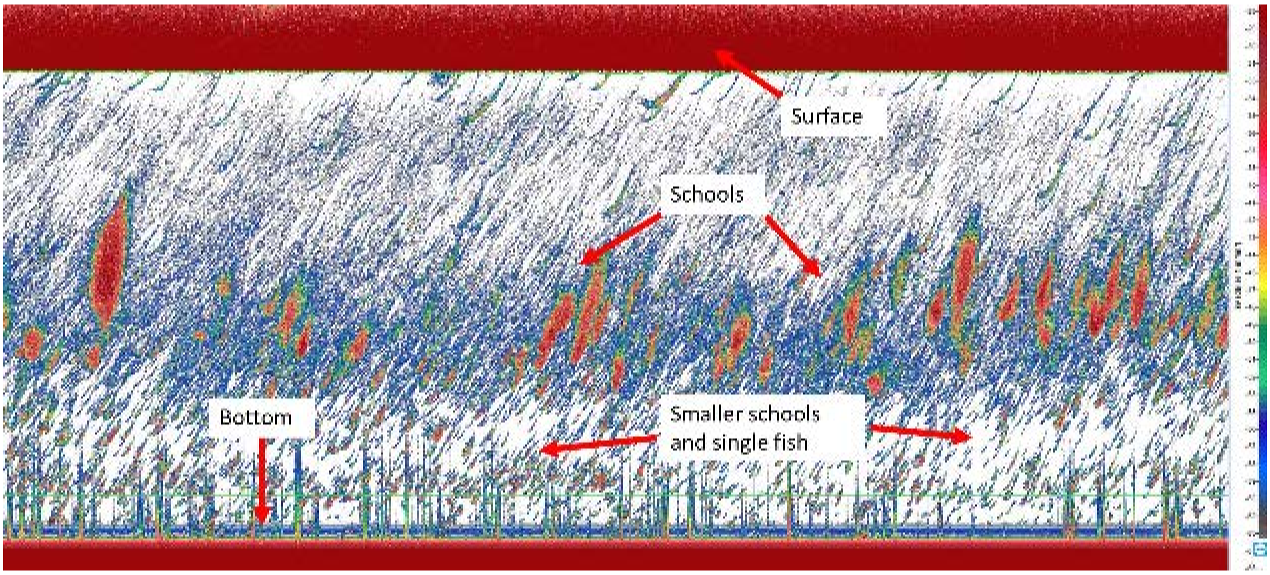


Figure 5.9 *Example of an echogram from a bottom deployed Wbat, 38kHz. This echogram origins from the Marsdiep area. The depth is 26m.*

5.1.4 Stationary year-round sampling: Saildrone (pilot)

A Saildrone is a wind and solar-powered unmanned surface vehicle (USV) that can provide high quality oceanic and atmospheric observations (***Figure 5.10***). With a speed through the water of 2-8kts, they have a range of more than 16,000 nautical miles, and endurance of up to 12 months. Saildrone is the name of the company that operates these USV's. Companies and institutes can buy service – I.e. provision of data - from Saildrone, not the actual vehicles.

The latest design is that of a 7m (23 ft) hull and a deeper, heavier keel. They are powered by a 5m (15 ft) wing, which is effectively a sail like on a sailboat. They are equipped with GPS and an onboard computer, enabling the vehicles to navigate following prescribed waypoints, while staying in a safety corridor, taking winds and currents into consideration autonomously. All vehicles are supervised 24/7 by operators of the company.

Each Saildrone carries a standard set of sensors to measure atmospheric and oceanographic environmental variables in real time (**Figure 5.12**). One of the available standard sets contains a 38 kHz echosounder, which gives possibilities for surveying pelagic fish. They have been deployed on data collection missions in ocean-areas around the world and in the northern North Sea. Saildrone

USVs can be deployed from a seaside dock, which can be a station in an offshore construction at sea. Routes can be altered during missions by scientists via the online company's Mission Portal.

The USV's carry Automated Identification System (AIS) transceivers, enabling it to see and be seen by surrounding commercial traffic. Each is equipped with a radar reflector, high visibility colors for daytime visibility, and a bright navigation light for nighttime awareness. Each vehicle carries four onboard cameras to provide domain awareness to operators.

Saildrones have been used safely in open sea. However, deployment in the southern North Sea and the Channel should be treated with caution due to the traffic in this area. The manufacturer has confirmed that it can be operated in a wind farm with several hundred-meter distance between the monopiles. Fishery research vessels are at present not allowed in wind farms, with the result that these areas are not sampled (anymore).

We propose to collect acoustic data with a 38 kHz echosounder, which enables direct comparison with the data from the Wbat. The Saildrone can be programmed to collect data in (approximately) the same sequence as the Wbat. While the Wbat records data from the bottom upwards, the echosounder on board the Saildrone sails pre-programmed transects (***Figure 5.11***) which can be altered by remote control. The collected echograms are very similar to the echograms that are produced during the acoustic surveys as the operational frequency (38KHz) is the same and the depth of the transducer is approximately the same (2m).

Figure 5.10 *Saildrone (picture from en.reset.org blog, Mike Newton)*

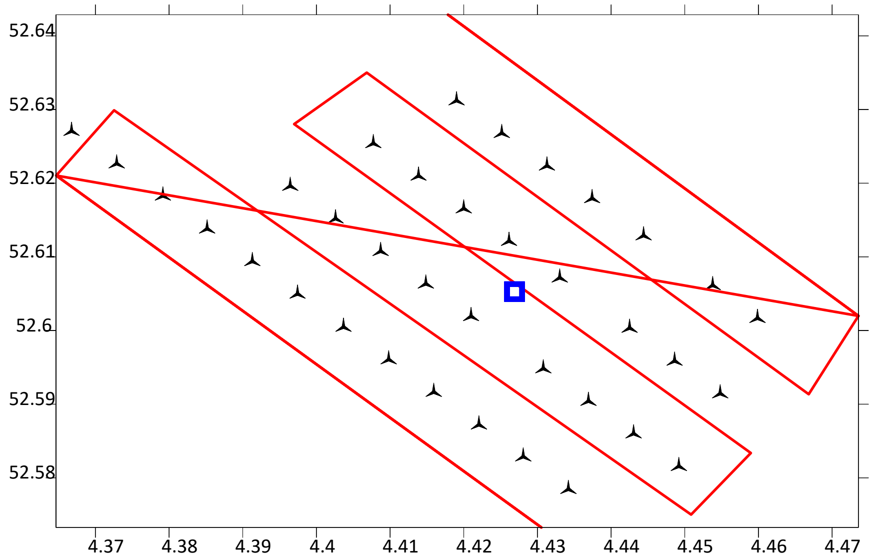
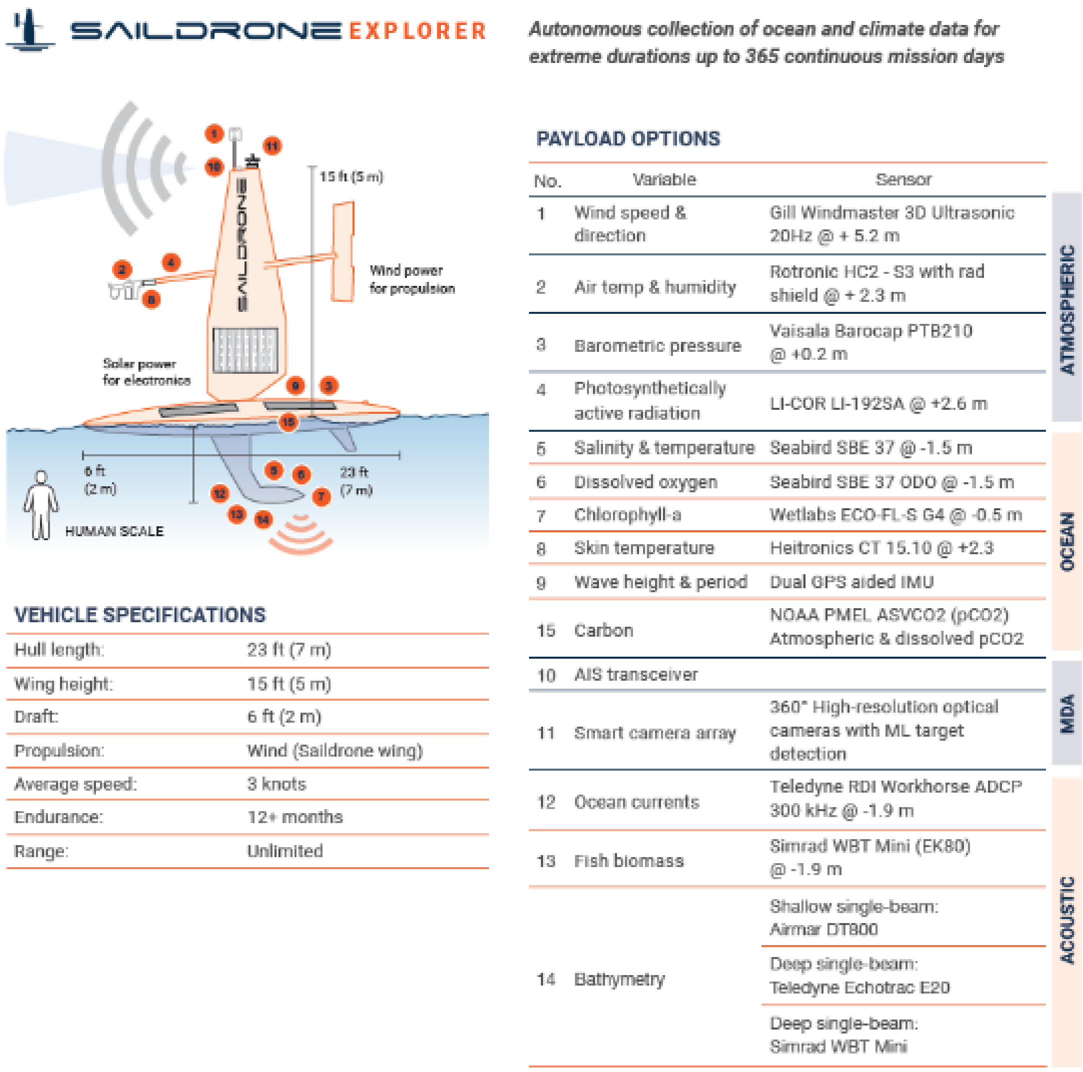


Figure 5.11 *Example of possible repetitive transect sailing (red line) of a Saildrone in a wind farm (Egmond aan Zee). The blue rectangle is the location of the Wbat which simultaneously collects acoustic data at one spot.*



VEHICLE SPECIFICATIONS

Hull length:	23 ft (7 m)
Wing height:	15 ft (5 m)
Draft:	6 ft (2 m)
Propulsion:	Wind (Saildrone wing)
Average speed:	3 knots
Endurance:	12+ months
Range:	Unlimited

PAYLOAD OPTIONS

No.	Variable	Sensor	
1	Wind speed & direction	Gill Windmaster 3D Ultrasonic 20Hz @ + 5.2 m	ATMOSPHERIC
2	Air temp & humidity	Rotronic HC2 - S3 with rad shield @ + 2.3 m	ATMOSPHERIC
3	Barometric pressure	Vaisala Barocap PTB210 @ +0.2 m	ATMOSPHERIC
4	Photosynthetically active radiation	LI-COR LI-192SA @ +2.6 m	ATMOSPHERIC
5	Salinity & temperature	Seabird SBE 37 @ -1.5 m	OCEAN
6	Dissolved oxygen	Seabird SBE 37 ODO @ -1.5 m	OCEAN
7	Chlorophyll-a	Wetlabs ECO-FL-S G4 @ -0.5 m	OCEAN
8	Skin temperature	Heitronics CT 15.10 @ +2.3	OCEAN
9	Wave height & period	Dual GPS aided IMU	OCEAN
15	Carbon	NOAA PMEL ASVCO2 (pCO2) Atmospheric & dissolved pCO2	OCEAN
10	AIS transceiver		MDA
11	Smart camera array	360° High-resolution optical cameras with ML target detection	MDA
12	Ocean currents	Teledyne RDI Workhorse ADCP 300 kHz @ -1.9 m	ACOUSTIC
13	Fish biomass	Simrad WBT Mini (EK80) @ -1.9 m	ACOUSTIC
14	Bathymetry	Shallow single-beam: Airmar DT800	ACOUSTIC
		Deep single-beam: Teledyne Echotrac E20	ACOUSTIC
		Deep single-beam: Simrad WBT Mini	ACOUSTIC

Figure 5.12 *This diagram shows the Saildrone Standard Sensor Suite. Please note that the ADCP (sensor 12) and the Echo Sounder (sensor 13) cannot be placed on the same USV as they cannot run simultaneously. In the MONS setup, the Saildrone carries a WBT Simrad Mini (EK80).*

5.1.5 Gill net monitoring in the wind farm

The qualitative presence of small pelagic fish in the vicinity of the Wbat and the drone will be monitored by fishing once a month by means of set gill net fishing. For this a commercial fisherman should be hired.

Five nets of 80m length and 3.7m high will be set for 24 hours, typically overnight. Each net of 80m consists of 12 panels with different stretched mesh sizes: 12, 34, 40, 48.5, 55 and 65 mm (***Figure 5.13***). The catches of the gill nets must be identified to species level and need to be measured. This data will be collected by mesh size.

Additionally, measurements of the Secchi-depth and the water temperature and salinity at the time of setting and hauling the net is proposed.

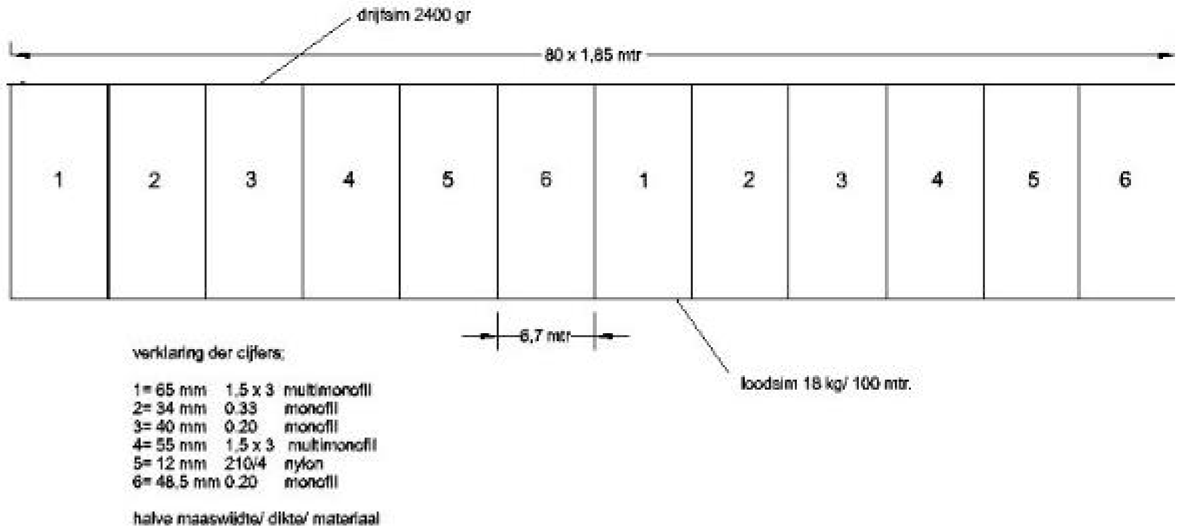


Figure 5.13 *Example of two multi-mesh gill nets, each with 6 panels of different mesh size attached to each other.*

5.1.6 Environmental parameters

Environmental parameters will be collected during all proposed activities, though in different configurations.

During the acoustic surveys water temperature and salinity will be recorded continuously by means of a self-logging CTD attached to the towed body that holds the acoustic equipment. During the trawl hauls transparency will be measured with a Secchi-disk.

During gill net sampling a CTD-downcast and a Secchi-disk measurement will be carried out at hauling (not when the net is being shot).

We propose to mount a ACDP and a CTD on the frames for the Wbats for continuous measurements of temperature, salinity and current (speed and direction).

The Saildrone will be rigged with sensors for continuous measurements of temperature and salinity. Note that is not possible to for a Saildrone to carry an echosounder and an ADCP at the same time.

5.1.7 Reporting and evaluation of the pilot

The coastal acoustic surveys follow a known concept that is used in the regular surveys and has been used in various project over the years. Those surveys will provide spatial abundances of the pelagic species that can used in other MONS projects. Following each of the surveys a cruise summary report should be produced.

The other parts of the proposal are considered as pilots, which require some development and potentially adjustment during the year. These parts also require an evaluation followed by an advice for the consecutive years, which is included in the cost of the proposal.

5.1.8 Estimated costs

A detailed overview of the estimated cost can be found in Annex 3. The personal cost estimated in this proposal are based on the WMR tariffs for RWS. The basic and pilot parts together the total cost in the first year is estimated at 361,590-euro excl. BTW. The division over the separate parts is:

-	Acoustic survey February:	55,771	180h ship time
-	Acoustic survey June:	53,671	180h ship time
-	IBTS-acoustics (Pilot):	16,396	
-	Stationary echosounders (pilot)	58,912	
-	CTD's and ADCP units (2 x 2)	40,000	
-	Saildrone (pilot)	97,664	
-	Gillnet monitoring (pilot)	67,672	
-	Pilot- analysis and reporting	22,680	

As state before these costs are without the ship's costs for the acoustic survey. For the other parts charter cost of the vessels is included.

The cost of the acoustic surveys will stay similar (inflation correction) when continuing these in the following years. The cost of the pilot activities is likely to change, depending on the final proposal and required materials.

5.2 Monitoring program for the surf zone

5.2.1 Target species

In principle the target species are all fish species that can be found in the surf zone, with extra focus on pelagic fish. All fish species will be identified, measured and recorded. If possible, the benthos will also be identified and counted. It is expected that a sampling scheme with a beam trawl – although not designed to sample pelagic fish – will contribute to a better understanding of pelagic fish distribution.

5.2.2 Sampling location

Monitoring will take place at one single location. Sampling multiple locations will for sure provide a better insight in spatial differences in occurrence of fish species, but practically and financially speaking this is considered of less importance than ensuring proper sampling at one single location.

The beach of IJmuiderslag (IJmuiden) is proposed as location. This site is selected because sampling was also done here in the 1970s and 1980s and to continue the sampling of the surf zone near IJmuiderslag done in 2020 and 2021 in order to create a time series. Also, the beach at IJmuiderslag is considered representative of the Dutch coast with a “natural dune system” in the hinterland and the Kennemerland National Park. The Dutch coast (prominent candidate Natura 2000 area) has also already been identified as an important bird area. Finally, the location in relation to the research institute in IJmuiden is very favorable regarding feasibility.

5.2.3 Temporal coverage

Over a period of 4 years, in the period from March to October, sampling will take place every two weeks at IJmuiderslag (IJmuiden). During this sampling at least three fish hauls will be carried out parallel to the coast in the surf zone. In order to limit tidal variation in the presence and catchability of fish, fishing will only take place around low tide. Beyst et al. (2002) found the highest densities of fish during low tide, with densities varying strongly with the tide. Besides tides, the catches were also different for day and night, but this effect was less strong. In order to collect the data in a comparable way it is therefore decided to sample during the day just before the start of low tide. The tide is decisive for the planning.

From March to August, various target species settle in the shallow coastal zone. Most of the target species spawn at sea and the larvae come to shore with ocean currents, sometimes supported by behaviour. When they spawn and when they arrive in coastal waters does not only differ per species, but also per year (up to 2 months difference between years) (Bolle et al. 2009). The timing of the sampling has been chosen in such a way that it is likely that the arrival of almost all species can be followed from the start. Species that arrive first in the surf zone are: Herring, sprat and plaice. Later in the year, larvae/juveniles from, among others, anchovies, golden grey mullet, turbot, brill and sea bass arrive.

5.2.4 Biotic and abiotic habitat variables

The beach sampling is not suitable for finding a possible relationship between the fish catches and water depth, as sampling can only be done in the shallowest zone (0-1m). Water temperature is considered to be (one of) the most dominant environmental variable driving seasonal dynamics and year-to-year variation in fish. In addition to the water temperature, it is important to register all possible environmental variables. If this data cannot be used in the current research it may be relevant for later research, since little data has been collected in the surf zone. The following environmental variables are recorded in any case:

- Time to/from low tide
- Air temperature
- Wind direction and force
- Wave height
- Cloud cover percentage
- Precipitation
- Flow direction
- Water temperature
- Salinity

5.2.5 Sampling equipment

Fish is primarily sampled with a 2m beam trawl with a 10mm mesh size net in the cod end, tickler chain and ground rope. The beam trawl is pulled through the water (0-1m depth) over approximately 100 meters, determined using a Garmin GPS. A rope is attached to both sides of the beam trawl, this way the beam trawl can be pulled by two people (in a V-formation), meaning both people walk outside the track that the beam trawl is fishing. This has a number of advantages over the net with the single door used in the 2019 beach sampling (van der Geest 2019). Firstly, in the past (and on the Balgzand (NIOZ)) beam trawls were used in most monitoring, which makes it easier to compare data between the different samples. The beam trawl can also be pulled by two people, so in a minimal setup only two people are needed for sampling (in contrast to 4 to 5 people with the other net). Due to the design and weight of a beam trawl it remains on the bottom, while the lighter cornet will sometimes float and is less stable, sometimes causing it to tilt due to the current and wave action. Finally, a beam trawl at the fished depth of 0-1m fishes a significant part of the water column in the surf zone, therefore making this gear also suitable for catching (small) pelagic fish at these depths.

With the beam trawl described above mainly juvenile fish (0-group and to a lesser extent I-group) are caught, while the larger older fish are only sporadically caught with this active fishing gear. Presumably because the disturbance caused by people in the water is too high and the fishing speed too low for larger fish to be caught. In addition, the occurrence of large fish in the surf zone is likely limited. In order to also gain insight into the occurrence of the older age groups in the surf zone, a passive fishing gear, i.e. a gill net with different panels (multi mesh), is used as a pilot.

For each sampling day, the air, water temperature and salinity will be determined with a multimeter at the starting point of each haul. Salinity measurements with a multimeter depend on temperature. Therefore, the multimeter will be suspended in the seawater until the temperature remains stable, after which temperature and salinity are read.

The exact coordinates of the start and end points of a transect will be determined using a Garmin GPS.

5.2.6 Setup of the beach monitoring

At IJmuiderslag, three transects of approximately 100m in the surf zone parallel to the coastline are fished per sampling day (during daylight). In order to be able to slightly correct the effects of the current direction, one fish trawl will be carried out in a northerly direction and one in a southerly direction in both the surf zone and the tidal lagune(s) present. This way a total of four fishing hauls will be carried out. First, the hauls in the surf zone will be executed and then at the time of lowest water the hauls in the channels will be executed. Alternating (random) sampling will first start in a northerly direction or in a southerly direction. An attempt is made to keep the same starting locations as determined in the first sampling (March).

Individuals that cannot be identified to species-level in the field will be stored in jars containing 95% ethanol. These will be examined in the lab and sorted by type later. This mainly concerns species of grey mullets, sand eels and gobies, but also the smallest flatfish. Also, it is not always possible to distinguish between larvae of Clupeidae on the base of their appearance.

The processing of the beam trawl catch in the surf zone is done according to the protocols drawn up in the manual of the regular surveys (van Damme et al. 2021), with the following adjustments:

- All fish species are measured to the millimeter
- Shrimp are measured to the millimeter (sub-sample)
- Registration is done on standard forms, which are later entered in the WMR program Billie Turf
- An effort is made to identify sand eels as small sand eels (*Ammodytes tobianus*) or Raitt’s sand eels (*A. marinus*).
- An effort is made to identify gobies as sand goby (*Pomatoschistus minutus*) or Lozanoi’ s goby (*P. lozanoi*).
- If juvenile (larvae of) herring and sprat cannot be identified (Clupeidae), a sample can be taken to the lab to be identified.

Other variables are recorded before the start of the first haul of that day, with the water temperature and salinity being determined with the multimeter at the starting point of the first haul.

5.2.7 Short overview of actions per haul

1) Determine the start and end position of each fishing trip with GPS
2) Record environmental variables
3) Take temperature and salinity measurements (note units as indicated on multimeter)
4) Carry out a haul (distance ± 100m; the aim is to perform this at a constant speed of 30m per minute so that the duration is 3-4 minutes): write down the fished distance and duration.
5) Sort and measure fish (mm accurate). Then fill out the catch form
6) Sort benthos by type (if possible) and count numbers. Then fill out the catch form.
7) If a permit is granted, a sample is taken from fish that cannot be classified by species for further identification in the lab
8) Return catch to the sea

5.2.8 Preconditions

Good weather (little wind and limited wave height) is required to carry out sampling in the surf zone. The mix of conditions (wave height, wind, rain, temperature) have to be friendly enough to be able to work. There is a risk that the sampling cannot be performed completely on some days due to “bad” weather conditions, therefore some back-up days are planned. With a wave height above 0.7m it makes no sense to go to the beach. At lower wave heights, it will have to be assessed on site whether fishing is possible taking the local conditions (wind, currents) into account.

On the day before the sampling, a definitive answer will be given about whether the sampling will take place. Rules of thumb for this are:

- Expectations of wave heights > 0.7m: sampling is cancelled
- Expectations for wave heights are 0.5-0.7m and persistently strong wind from the sea (from wind force 4): sampling will not take place
- Expectations of wave heights are 0.5-0.7m and clearly decreasing wind on the day of sampling: discuss and decide.
- Expectations wave heights up to 0.5m: sampling continues.

5.2.9 Pilot static gear in the surf zone

In order to also gain insight into the occurrence of the older age classes in the surf zone a passive fishing gear, a set gill net with different panels (multi mesh; DCF-code GNS), is used as a pilot. Panels with different mesh sizes (12, 34, 40, 48.5, 55 and 65mm) will be assembled into one standing net of approximately 25m long and 1.5m high (**Figure 5.13**). The mesh sizes used are equal to mesh sizes of the static nets that will be installed in the wind farms as part of the open water program, thereby allowing for comparisons.

Before the start of the first fishing haul with the beam trawl, the multi-mesh static gear is set. It will be tested whether the net is placed parallel or perpendicular to the coast, however the preference will be to place the net parallel to the coast, thereby ensuring that it is at the same depth over its entire length. The net can then be dragged in by pulling both ends up onto the beach. The catch is processed by mesh size panel, in the same way as the beam trawl catch.

5.2.10 Connection with the off shore pelagic sampling scheme

A beam trawl is not designed to sample schooling pelagic fish. However, according to experience at WMR, small specimens of clupeids, anchovy, sand eel, grey mullets and seabass show up regularly in the catches to such and extend that it is possible to follow the increase of length (“cohorts”) during the year for these species. A “batch” of a species can be completely missed during a sampling session, but the sampling frequency seems to compensate for that (Couperus, Volwater, and Hal 2021). Most likely these comparatively successful catches can be explained by the shallowness of the surf zone (the large relative vertical coverage of the water column) and the poor transparency of the water in the surf zone.

Beach sampling by means of the beam trawl can add to the off shore sampling program because it fills the gap in the zone where it is not possible to operate with a vessel. In addition the sampling with gill nets in the surf zone allows for direct comparison of results from the gill net sampling with the off shore sampling provided that the panel hold the same mesh sizes.

5.2.11 Global phasing

In November, after all planned samplings have been executed, a logbook will be presented in which all catches and additional notes are reported.
For the months of March to October, a “1” stands for one sample in the that month and a “2” for two samples in those months.

	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov
Materials check	X									
Determining sampling days	X									
Sampling		1	2	2	2	2	2	2	2	
Data entering & check										X
Logbook										X

5.2.12 Estimated costs

An extended cost estimate is given in Annex 3. The estimated cost of the beach sampling program based on WMR tariffs for RWS is in total 22,000-euro excl. BTW. This is divided in

Beach sampling with beam trawl: 16,374 euro
Beach sampling with gillnets (pilot): 5,626 euro

The sampling with the gillnets is additionally to the sampling with the beam trawl. Standalone, the gill net sampling would have a similar cost as the beam trawl sampling. These are the yearly costs, continuation in the following year will lead to similar costs (inflation correction).

6 Opportunities for additional sampling under MONS

The proposed monitoring plan is focused on the specifically the first research question. However, the proposed plan allows for the collection of additional information and the acoustic surveys could merely function as a platform of opportunity for other projects under MONS.
Below we have tried to highlight some of these possibilities. These activities are not budgeted in the working plan presented above.

6.1.1 Additional information on pelagic fish

In the current plan (pelagic) fish is caught in the coastal acoustic surveys, the gill nets and the beam trawl. The fish caught is identified to species level and the length is measured.

For a number of research questions it could be relevant to collect additional biological data of these species. For example, commonly collected information on the age (otoliths), diet (stomachs), gender and maturity. The otoliths could also be used for yearly or daily growth studies by assessing the increments between the ring structures. In case of herring the otoliths could also be used to determine population structures, however this could also be done on or combined with genetic information (Berg et al. 2021). Tissue sample could be used to assess recent growth rates (RNA-DNA-ratios), to assess trophic level (stable isotopes), and energy content relevant in relation with their predators.

This type of information requires additional handling of the fish, which in nearly all suggested possibilities falls under the Experiments on Animals act (*Wet op de Dierproeven* - WoD). This requires the approval of the Central Authority for Scientific Procedures on Animals (CCD). Next to that, in most of these cases it would require additional staff to collect these samples and to further assess these samples in the lab.

6.1.2 Zooplankton

The zooplankton in the North Sea mainly consists of small copepods (up to approx. 3 mm), jellyfish and larvae of benthic animals. The functioning of zooplankton is of great importance for the transfer of primary production (phytoplankton) to the higher trophic levels in the water column, especially (small) fish.

Due to the lack of existing monitoring, relevant data (from monitoring) and insight into the functioning of zooplankton is one of the topics of MONS. Therefore, also for zooplankton a monitoring plan is in development. That plan proposes a first phase of data collection consisting of a 1-year pilot study with a high resolution in space and time, and the development and deployment of new innovative monitoring techniques. Which resolution in time (season) and space is required for the setup of a monitoring program for zooplankton is being investigated. Based on the results of the pilot study, a 4-year monitoring program will be executed to determine whether the knowledge questions (*kennisvragen*) can be answered. The monitoring program focuses on the development and testing of (new) measuring techniques, and on the evaluation and determination of the spatial and temporal resolution of the measurements and analyses that are performed. This monitoring program proposes regular monitoring done by the permanent staff of specialized research institutes. The anticipated ship time is 6 weeks (1 week per month) spread throughout the year.

The hydro-acoustic techniques used for small pelagic fish would not serve as good monitoring techniques for zooplankton as zooplankton forms too small a target of which the reflection received would be too weak. However, the collection of zooplankton samples could potentially be combined with the two coastal hydro-acoustic surveys for small pelagic fish. This would require the installation of a water pump on board or sampling with a plankton net.

These seem feasible additions to the current proposal, however they should not interfere too much with the acoustic monitoring. It should not lead to deviations of the transects, to extensive time for handling the plankton nets etc. as in that case additional ship time will be required.

6.1.3 Sea birds and mammals

The setup of the working plan is strongly tailored towards the distribution of birds. The proposed transects for the hydro acoustic surveys cover approximately the period and geographical zone where wintering bird species are distributed and where terns and gulls collect food during the breeding season. The reason for tuning the acoustic surveys according to the bird distribution in June, is that the fish distribution along the coast may be limiting for breeding birds. Otherwise, for adult birds and sea mammals, individuals of the species involved are well able to swim wherever their food is. Once chosen for a survey area in summer, this can be used as a reference for the winter distribution.

6.1.3.1 Input birds and mammals from small workshop 19-11-21

The diet of mammals and birds in the Dutch coastal zone differs strongly in space and time on different scales. In general birds and mammal are opportunistic and are there where the food is. The food consists of pelagic and demersal fish species. It is not known what the cause of these varieties in diet is and one should be very careful drawing conclusions on the basis of stomach content data that originate from stranded animals: these animals often end up on the beach because their condition is very poor. The remains (otoliths) in a stomach are only evidence of the last meal, which may not reflect the bulk diet in the Dutch coastal zone, nor does it mean that the nutritional value is good or poor. Likewise, in general food found in stomachs – including from specimens that were killed unexpectedly, for example by bycatch – does not necessarily reflect an optimal or preferred diet. It was therefore suggested that a sub question under MONS-small pelagic fish is “What governs prey choice in space and time?”.

On board observers carrying out line transect counting for birds and mammals can contribute to the knowledge of distribution of bird – and mammal species in relation to fish distribution on a larger scale (the Dutch coastal zone). Carrying out line transect counts during acoustic surveys is logistically possible and has been done before, including in the Dutch coastal zone for example by Grift et al. (2004). However it should be noted here that the merit of line transects counting during acoustic survey is the fact that the vessel can be used as a platform of opportunity. Historic research in the Dutch coastal zone has shown that it is often not possible to directly relate bird distribution to individual fish schools and fish species (Geelhoed et al. 2014).

The acoustic surveys provide the opportunity to collect samples of fish for several goals, for example bacterial sampling to find the cause of disease outbreaks under birds and mammals and the role of fish species.

It was also mentioned that incidental bycaught animals - for example in the proposed gill net fishery – should be collected and made available for health and diet research.

7 Conclusions

How does this working plan answer the first key question raised in the introduction: What is the spatial distribution of small pelagic fish species in Dutch waters, by season and from year to year?

The proposed hydro-acoustic surveys in the coastal waters will provide a small-scale distribution map of pelagic fish species in the Dutch coastal zone and will thus give relative distributions of all pelagic species in the Dutch coastal zone. Within the coastal zone, for the dominant swimbladdered species (herring and sprat), biomasses will be estimated for the whole area covered. For other species it will at least be possible to provide distribution maps with relative indications of abundance in a resolution in the order of a 5-15 nmi grid. These maps can be used as proxies for the availability of food for birds, marine mammals and other predators.

In combination with the IBTS and HERAS indexes the surveys will answer the questions:

- Can abundance changes in these two periods from year to year in the Dutch coastal zone be explained by shifts in distribution? or, alternatively…
- Can abundance changes in these two periods from year to year in the Dutch coastal zone be explained by changes in abundance in the North Sea?

Additionally, the observed abundances can be related to the collected hydrological data or those available from models (DELTARES) to gain knowledge on the drivers behind the distribution and potential changes. These types of analyses can provide knowledge on the habitat requirements of the pelagic species in the coastal waters. This knowledge helps with understanding changes caused by human activities.

The overlap of the surveys with the existing wind farms and some of the energy development zones provides the opportunity to assess the potential impact of the existing wind farms (for example higher abundances in wind farms compared to outside) and those to be developed.

The use of vessels to provide two snapshots in time is a costly activity. Therefore, to fill in the temporal gaps to gain actual year-round data the pilots are proposed. The Wbat will provide semi-continuous data, however only from a relatively small part of the water column. Combining this information with the other sources like the surveys should indicate how representative the data of this small part of the water column is. Next to that the Wbat will be able to provide information on local behaviour: "Is there more activity during day or nighttime?" and "Are there differences in schooling behaviour during seasons or weather conditions?".

The drone is considered as a potential replacement of the vessels. For that it should be necessary to sail transect throughout the whole DCP where it could semi-continuously record the water column. From a safety point of view, it is now proposed to only sail within a wind farm, in order to get the knowledge on the usefulness of the final data. By running the drone and the Wbat simultaneous with the June acoustic survey, we will be able to assess the data from these two experimental set ups:

- To what extend do the set ups represent the abundance of pelagic fish in the coastal zone?
- Which of the two set ups gives the best results, in data quality and budget wise?

Additionally, the gill nets are proposed as the acoustic data cannot provide trustworthy information on species composition without catch information. The gill net sampling is supposed to provide the species information to scrutinize the acoustic data of the two pilot setups. For the gill nets the question is: "Will it provide enough qualitative data for the interpretation of the echograms of both acoustic methods?".
On itself the gill nets will provide data on the presences of species and their lengths throughout the year.

This last will be similar for the gill net catches from the beach. These will provide information on the temporal changes in species composition especially when this data is collected for multiple years in order to get some knowledge on the consistency of these changes and patterns. The beam trawl used from the beach has already shown to provide data on temporal changes in the species composition. Related to the pelagic species it provided knowledge on time of arrival and the presences in the surf zone of pelagic juveniles. This information could be an indication of year class strength, and as the species are followed throughout the year it might also provide an indication of the habitat quality by analyzing the growth rate.

The second key question “How can these geographical and temporal distributions be explained by the known natural history of the species involved, in terms of known behaviour and habitat requirements?”

This is harder to answer with the proposed set of monitoring. Some aspects related to habitat use and behaviour have been mentioned already for the first question. To gain more in-depth knowledge additional studies will have to be initiated, focusing on life history questions and accessory behaviour of the small pelagic fish species in the Dutch coastal zone. However, for any of these or these studies the proposed plan will provide necessary information: How many fish are there? What species? Where are they? In what season? Only after answering these baseline questions will it be possible to address questions like “Why is species A abundant in this part of the coastal zone? “and “How can inter years changes of species B be explained?”. And – to take it a step further – “How does this affect seabirds sea mammals and fish predators in the area”? In the previous chapter some options for collecting additional data as part of proposed plan are provided, which might help in answer the second question and other questions within MONS.

8 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. The organisation has been certified since 27 February 2001. The certification was issued by DNV.

References

Anonymus. 2003. *Eindrapportage Flyland*

Asjes, J., H. Merkus, O. G. Bos, J. Steenbergen, S. Stuijfzand, I. Van Splunder, T. Van Kooten, R. S., and G. A. J. Vis. 2021. *Monitoring en Onderzoek Natuurversterking en Soortenbescherming (MONS)*

Baptist, H. J. M., R. Van Bemmelen, M. Leopold, D. De Haan, H. Flores, A. S. Couperus, S. Fassler, and S. C. V. Geelhoed. 2019a. Self-foraging vs facilitated foraging by Lesser Black-backed Gull (Larus fuscus) at the Frisian Front, the Netherlands. *Bulletin of Marine Science* 95 (1): 29-43.

Baptist, M. J., R. S. van Bemmelen, M. F. Leopold, D. De Haan, H. Flores, B. Couperus, S. Fassler, and S. C. Geelhoed. 2019b. Self-foraging vs facilitated foraging by lesser black-backed Gull (Larus fuscus) at the Frisian front, the Netherlands. *Bulletin of Marine Science* 95 (1): 29-43.

Berg, F., H. D. Østgaard, A. Slotte, L. Andersson, and A. Folkvord. 2021. A combination of genetic and phenotypic characterization of spring- and autumn-spawning herring suggests gene flow between populations. *ICES Journal of Marine Science* 78 (2): 694-703. http://dx.doi.org/10.1093/icesjms/fsaa046.

Beyst, B., A. Cattrijsse, and J. Mees. 1999. Feeding ecology of juvenile flatfishes of the surf zone of a sandy beach. *Journal of Fish Biology* 55 (6): 1171-1186. http://dx.doi.org/10.1006/jfbi.1999.1120.

Beyst, B., K. Hostens, and J. Mees. 2001. Factors influencing fish and macrocrustacean communities in the surf zone of sandy beaches in Belgium: Temporal variation. *Journal of Sea Research* 46 (3-4): 281-294. http://dx.doi.org/10.1016/S1385-1101(01)00087-9.

Beyst, B., K. Hostens, and J. Mees. 2002. Factors influencing the spatial variation in fish and macrocrustacean communities in the surf zone of sandy beaches in Belgium. *Journal of the Marine Biological Association of the United Kingdom* 82 (2): 181-187. http://dx.doi.org/10.1017/S0025315402005337.

Bolle, L. J., M. Dickey-Collas, J. K. L. van Beek, P. L. A. Erftemeijer, J. I. J. Witte, H. W. van der Veer, and A. D. Rijnsdorp. 2009. Variability in transport of fish eggs and larvae. III. Effects of hydrodynamics and larval behaviour on recruitment in plaice. *Marine Ecology Progress Series* 390: 195-211. http://dx.doi.org/10.3354/meps08177.

Couperus, A., R. G. Jak, H. Flores, S. Gastauer, and S. Fassler. 2016. *Towards monitoring zoöplankton and small pelagic fish in the Wadden Sea*, IMARES

Couperus, A., J. Volwater, and R. van Hal. 2021. Kornetbemonstering in de brandingzone van IJmuiden. *De Levende Natuur* 122 (5): 202-207.

Couperus, B., S. Gastauer, S. M. M. Fässler, I. Tulp, H. W. van der Veer, and J. J. Poos. 2016. Abundance and tidal behaviour of pelagic fish in the gateway to the Wadden Sea. *Journal of Sea Research* 109 (Supplement C): 42-51. http://dx.doi.org/https://doi.org/10.1016/j.seares.2016.01.007.

Couperus, B., S. Sakinan, and D. Burggraaf. 2020. *Small pelagic fish and zooplankton in the Dutch coastal surf zone during the EGS-II survey in 2017-2018*, Wageningen Marine Research

Couperus, B., J. Volwater, and R. v. Hal. 2021. Kornetbemonstering in de brandingszone van IJmuiden. *De Levende Natuur* 122 (5): 202-207.

Couperus, B., E. Winter, O. van Keeken, T. van Kooten, S. Tribuhl, and D. Burggraaf. 2010. *Use of high resolution sonar for near turbine fish observations (DIDSON) – We@Sea 2007-002*, IMARES, IJmuiden.Report number C138/10

Geelhoed, S., O. G. Bos, D. Burggraaf, A. Couperus, and S. Lagerveld. 2014. *Verklarende factoren voor de verspreiding van alken en zeekoeten op de Bruine Bank: Project Aanvullende Beschermde Gebiede Noordzee*, IMARES

Grift, R., I. Tulp, M. Ybema, and A. Couperus. 2004. *Base line studies North Sea wind farms: final report pelagic fish*, RIVO

ICES. 2021a. *ICES Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS; outputs from 2020 meeting)*

———. 2021b. *International Bottom Trawl Survey Working Group (IBTSWG)*, Copenhagen

———. 2021c. *Working Group of International Pelagic Surveys (WGIPS)*, Copenhagen

———. 2021d. *Working Group on Mackerel and Horse mackerel Egg Surveys*
(WGMEGS) Copenhagen

Janssen, G., H. Kleef, S. Mulder, and P. Tydeman. 2008. Pilot assessment of depth related distribution of macrofauna in surf zone along Dutch coast and its implications for coastal management. *Marine Ecology* 29 (s1): 186-194. http://dx.doi.org/10.1111/j.1439-0485.2008.00233.x.

Lindeboom, H. J., H. J. Kouwenhoven, M. J. N. Bergman, S. Bouma, S. Brasseur, R. Daan, R. C. Fijn, et al. 2011. Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. *Environmental Research Letters* 6 (3): 035101.

Mengedoht, D. M. 1995. *Growth and Mortality of O-group Plaice Pleuronectes Platessa L. in Dutch Coastal Waters*

Robertis, A. D., R. Levine, and C. D. Wilson. 2018. Can a bottom-moored echo sounder array provide a survey-comparable index of abundance? *Canadian Journal of Fisheries and Aquatic Sciences* 75 (4): 629-640. http://dx.doi.org/10.1139/cjfas-2017-0013.

Simmonds, J., and D. MacLennan. 2005. *Fisheries Acoustics — Theory and Practice*. Oxford: BlackwellScience Ltd.

Simmonds, J., and D. N. MacLennan. 2008. *Fisheries acoustics: theory and practice*: John Wiley & Sons.

Teal, L. R., and O. A. van Keeken. 2011. *The importance of the surf zone for fish and brown shrimp in The Netherlands IJmuiden : IMARES, (Report C054/11) - p. 80.*

van Damme, C., U. Beier, L. Bolle, I. de Boois, D. Burggraaf, B. Couperus, R. van Hal, and T. Pasterkamp. 2021. *CVO Handboek en protocollen voor bestandsopnamen en routinematige bemonsteringen op zee en in estuaria Versie 15, maart 2021*

van Damme, C., R. Hoek, D. Beare, L. Bolle, C. Bakker, E. Van Barneveld, M. Lohman, et al. 2011. *Shortlist Master plan Wind Monitoring fish eggs and larvae in the southern North Sea: final report Part A en B*

van der Geest, M. 2019. *Veldverslag strandsurvey Natuurlijk Veilig: Maart-juni 2019*, Wageningen Marine Research

van der Land, M. A. 1991. Distribution of flatfish eggs in the 1989 egg surveys in the southeastern North Sea, and mortality of plaice and sole eggs. *Netherlands Journal of Sea Research* 27: 277-286.

van Hal, R., A. S. Couperus, S. M. M. Fassler, S. Gastauer, B. Griffioen, N. T. Hintzen, L. R. Teal, O. A. van Keeken, and H. V. Winter. 2012. *Monitoring- and Evaluation Program Near Shore Wind farm (MEP-NSW): Fish community IJmuiden : IMARES, (Report / IMARES C059/12) - p. 161*

van Hal, R., A. B. Griffioen, and O. A. van Keeken. 2017. Changes in fish communities on a small spatial scale, an effect of increased habitat complexity by an offshore wind farm. *Marine Environmental Research* 126 (Supplement C): 26-36. http://dx.doi.org/https://doi.org/10.1016/j.marenvres.2017.01.009.

van Hal, R., O. van Keeken, and L. Meeuwissen. 2014. *Monitoring en Evaluatie Pilot Zandmotor Fase 2: Datarapport groei juveniele vis Zandmotor voorjaar en zomer 2013*, IMARES/Deltares

van Hal, R., J. Volwater, F. Soudijn, and I. Tulp. 2021. *Visecologie in de vooroever*, Wageningen Marine Research, IJmuiden.C077/21

van Keeken, O. A., and R. van Hal. 2012. *Visbemonstering de Zandmotor; maart - augustus 2012*, IMARES, IJmuiden

Ybema, M., D. Gloe, and R. Lambers. 2009. *OWEZ pelagic fish, progress report and progression after T1*, IMARES Wageningen UR

Justification

Report C009/22
Project Number: 4316100282

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: Serdar Sakinan
Researcher

Signature:

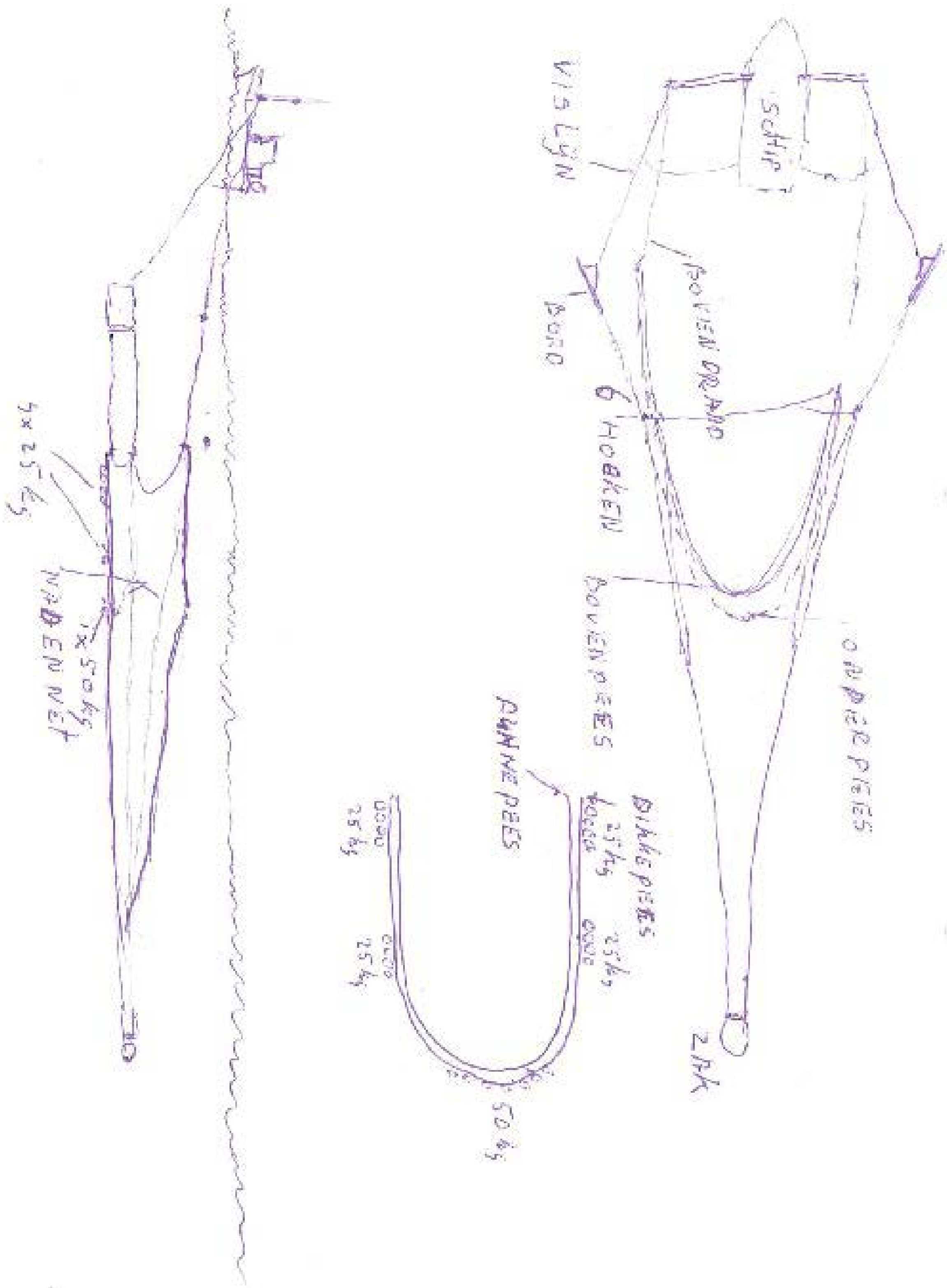
Date: 7th of March 2022

Approved: Drs. J.Asjes
Member MT - Integration

Signature:

Date: 7th of March 2022

Annex 1 Sketch of the semi-pelagic net “zwever”



Annex 2 Description of the SURF-net

The pelagic surface net (SURFnet) has a circumference of 450 meshes and was manufactured in 2008 by Maritiem Katwijk BV to the specifications of WMR (Annex 1). The net is laid out for a theoretical net opening of 12 m horizontally and 5 m vertically and has a total length of 51.5 m. The net is made of knotless mesh (white nylon 210/42) from 40 mm down to 16 mm in the codend. Round slings are provided to ensure the tapered shape of the net while fishing. The net is equipped with 17 mm nylon upper/lower and side ropes and weighting of the ground rope (16 mm 5 kg/m, 5 lengths of 1 m divided over the cams and ground rope). The net is pulled from the wake line from the port boom by means of a 2.5 m2 board (Thyboron type 15). The layout of this board is not symmetrical so that the fishing gear can only be used on the port side. Additional standard weight 5 x 7 kg is attached at the bottom of the board. Portside fishing board connections: Fishing line in second eye from top; Upper cable in 5th eye from rear, lower cable in 4th eye from rear. The length of the board slings are 4 m, on the port side they are extended with 1 m of chain (picking out fishing board).

The starboard fishing line was pulled from amidships and coupled to the standard "center wire" facility of the fishing winch. A smaller board (type ground board model) of approximately 1 m2 was applied to this fishing line, so that a counter force is supplied and the fishing gear will spread sufficiently horizontally (design starting point approximately 12 m). The starboard fishing board was connected in the most passive configuration, the fishing line in the 2nd eye from the top, the cables in the rear holes. The fishing lines were made of 14 mm 6x19S steel cable, each 200 m in length, and fitted with mice to ensure even spacing and retrieval. The four cables of the fishing net were made of steel cable 12 mm 6x19S, and had a length of 25 m. The (chain) extension in the lower cables is 1 m. The vertical opening is obtained by cam weights of approximately 60 kg on the starboard ridge (3 links) and 80 kg on the port ridge (4 links). The top cover was provided with removable buoyancy capacity consisting of two air-filled rubber fenders of type polyF8, 100 liters accommodated on the top cams (these are attached during expansion by means of clip hooks). The codend section was 8 m long, halfway through this section a provision (collar) was made for making a fine-meshed inner codend.

Later Modifications based on the trials.
The vertical opening was limited to 3 m (limiter sling of 3 m between the top and bottom ridges). The side panels are taken in on the centerline along the legs of the mesh with a 0.5 (this adjustment is not final and can be easily reset).
The rear net is fitted with an inner codend of 10 mm stretched mesh. The weight of the ground rope (5 x 16 mm 6 kg/m) was reduced to 2 lengths of 1 m, each at 2 m from the center of the ground rope.
The headline is centrally fitted with 100 permanently mounted epoxy floats of 150 mm, type U-100, which are permanently placed on a separate rope along the headline. The third round sling was removed from the rear net.
Extension lower ridges reduced to approx. 0.3 m. Port fishing line shifted from second eye from top to bottom eye.

Operational aspects
The starboard fishing line is pulled from amidships and coupled to the standard "center wire" facility of the fishing winch. From the stern, the port fishing line is pulled to the stern gallows via a pulley, so that it was possible to (un)couple the port fishing board from the rear portal. A separate winch drum/control is therefore required for this function.
The port fishing board is pulled from the port jib boom. During the test week, the pulling force in the port fishing line was 32-40 kN and in the starboard fishing line 15-18 kN. Under this condition, when fishing a straight course, approximately 40° is given against the rudder.
The average speed based on GPS during the survey was approximately 2.5-3.2 miles.
A one-off test carried out without ridge limits showed that the vertical net opening hardly increased. If larger vertical openings are required, the side panels must be returned to their original condition. At a

limitation of 1 m, the vertical opening was found to decrease to 2.80 m. It is necessary that speed is maintained during hauling and setting in order to prevent the fishing gear from sinking. It can happen that the lower string reaches a depth of 20 m, so if these towing conditions cannot be met there is a risk for fishing in shallow water (< 20 m).

Photo's SURF-net

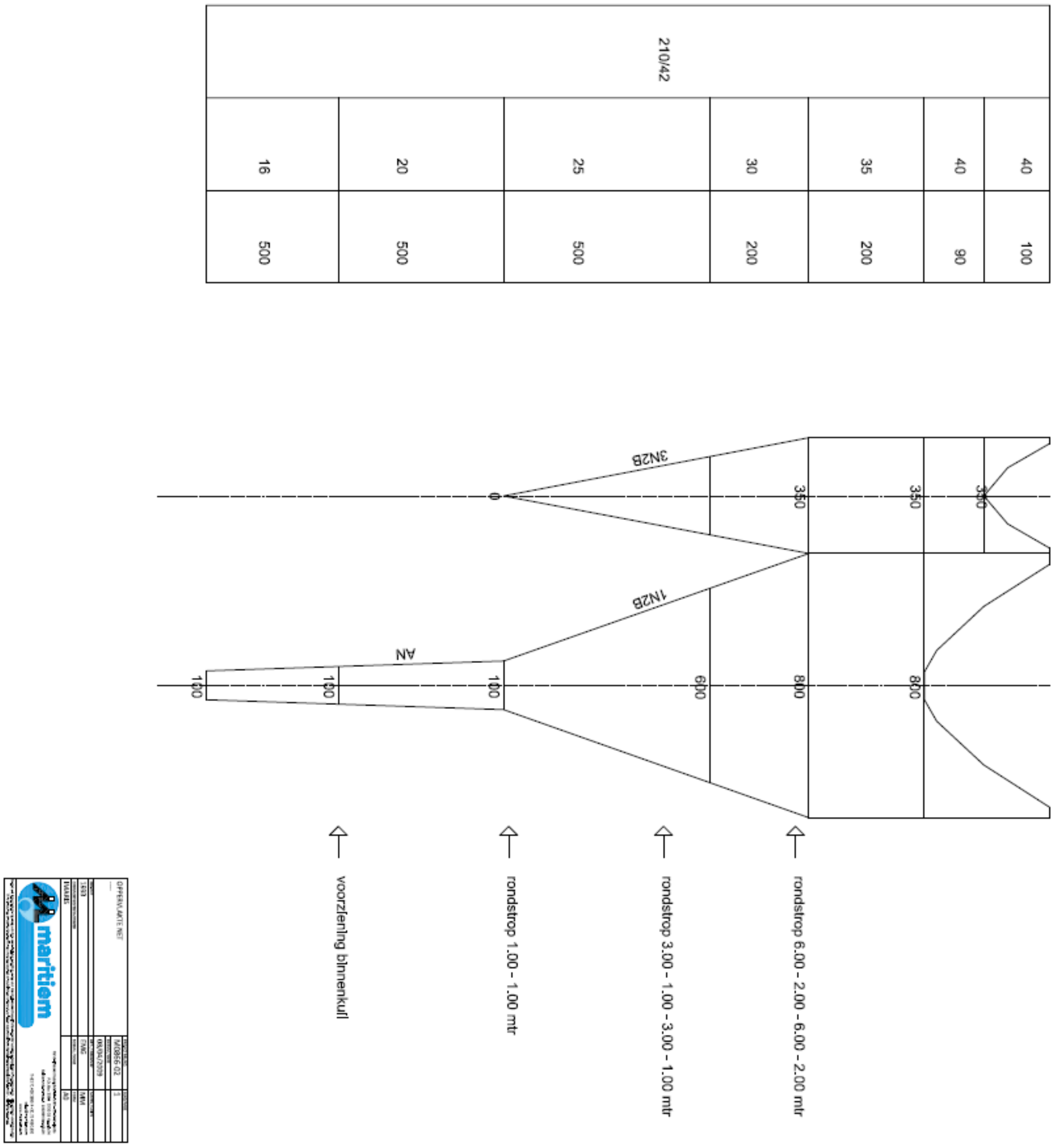
BB visbord met vislijn in 2e trekoog van boven

SB visbord met vislijn in voorste trekoog

Stuurboordsnokgewicht

Optuiging BB nokgewicht 2009-05 (op 2009-07 werden de achterste schakels weggenomen)

Nettenrol SC41


210/42
16
20
25
30
35
40
40
500
500
500
200
200
90
100
3N2B
1N2B
AN
350
350
350
800
800
600
100
100
100
rondstrop 6.00 - 2.00 - 6.00 - 2.00 mtr
rondstrop 3.00 - 1.00 - 3.00 - 1.00 mtr
rondstrop 1.00 - 1.00 mtr
voorziening binnenkuil
maritiem

Annex 3 Extended species information

English name	Dutch name	Scientific name	habitatrichtlijn	commercial	schooling	winter	spring	summer	autumn	surfzone/estuarine	comment
Allis shad	Elft	Alosa alosa	x		x	-	-	-	-	spring	(almost) extinct; spawns in spring in estuarine waters
Anchovy	Ansjovis	Engraulis encrasicolus		x	x	+	++	+	+	spring	spawns in spring in estuarine waters
Garfish	Geep	Belone belone		x		+	++	++	+	spring	spawns in spring in estuarine waters
Grey mullet species	Harders	Liza sp. Chelon sp		x	(x)	++	++	++	++	all year	several spawning periods
Greater sand eel	Smelt	Hyperoplus lanceolatus				(++)	++	++	(++)	no	
Herring	Haring	Clupea harengus		x	x	+++	+++	+++	+++	summer/autumn	juveniles in estuarine and near coastal waters
Horse mackerel	Horsmakreel	Trachurus trachurus		x	x	++	++	++	++	no	
Lesser sand eel	Kleine zandspiering	Ammodytes tobianus			x	(+++)	+++	+++	(+++)	all year	at night an in winter buried in the sand
Mackerel	Makreel	Scomber scombrus		x	x	-	+	+++	++	summer	
Raitt's sand eel	Noorse zandspiering	Ammodytes marinus		x	x	(+++)	+++	+++	(+++)	no	at night an in winter buried in the sand
River lamprey	Rivierprik	Lampetra fluviatilis	x			+	++	++	++	autumn	adults migrate up river in autumn
Salmon	Zalm	Salmo salar	x		(x)	-	-	-	-	autumn	(almost) extinct; adults migrate up river in autumn
Sea Trout	Zeeforel	Salmo trutta			(x)	+	+	+	+	autumn	adults migrate up river in autumn
Sand smelt	Koornaarvis	Atherina sp.			x	++	++	++	++	all year	
Pilchard	Pelser	Sardina pilchardus		x	x	+	+	++	++	autumn	juveniles in estuarine and near coastal waters
Sea bass	Zeebaars	Dicentrarchus labrax		x	(x)	++	++	++	++	summer/autumn	juveniles in estuarine and near coastal waters
Sprat	Sprot	Sprattus sprattus		x	x	+++	+++	+++	+++	summer/autumn	juveniles in estuarine and near coastal waters
Three spined stickleback	Driedoornige stekelbaars	Gasterosteus aculeatus			x	++	+	-	++	autumn	adults migrate up river in autumn
Transparent goby	Glasgrondel	Aphia minuta			x	++	++	++	++	no	
Twait shad	Fint	Alosa fallax	x	(x)	x	+	+	+	+	spring	spawns in spring in estuarine waters

Annex 4 Detailed cost estimates

	CAT I	CAT II	CAT III	CAT IV	CAT V	CAT VI	material	subtotal	**totals workpackage**	
	67	84	105	133	169	245				
Acoustic survey February										
Coordination			40	8				5264		
Request permits for N2000 area's			20					2100		
At sea		180	180					34020		
Preparation		48						4032		
Scrutinizing			35					3675		
Cruise report			16					1680		
Materials							5000	5000		
Charter vessel		3 working weeks x 5 days x 12 hours = 180 vessel hours								
									55771	
Acoustic survey June										
Coordination			40	8				5264		
At sea		180	180					34020		
Preparation		48						4032		
Scrutinizing			35					3675		
Reporting			16					1680		
Materials							5000	5000		
Charter vessel		3 working weeks x 5 days x 12 hours = 180 vessel hours								
									53671	
IBTS-acoustics										
Coordination			8	8				1904		
At sea		60						5040		
schooling personnel		40								
Preparation		8						672		
Analysis			20					2100		
Reporting			16					1680		
Materials							5000	5000		
									16396	
Subtotal routine surveying:										***125838***
Pilot:										
Gillnet monitoring										
Coordination			40	8				5264		
At sea		288						24192		
Preparation		40						3360		
Cruisereport			16					1680		
Materials (5 x 2000/80m net)							10000	10000		
Charter vessel (12 x 1000)							12000	12000		
									56496	
Stationairy echosounders										
Coordination		40		8				4424		
At sea (8 single days)		80						6720		
Preparation		40						3360		
Analysis			80					8400		
Cruise reporting		12						1008		
Materials (2 CTD's & 2 ADCP's)							40000	40000		
Maintenance							10000	10000		
Charter vessel		8 separate working days: 8 x 8 = 64 hours								
									73912	
Saildrone										
Coordination			80	8				9464		
analysis			40					4200		
Saildrone charter ($2700/day)							74000	74000		
Travel and shipping							10000	10000		
									97664	
Pilot - analysis and reporting										
Database support			16					1680		
Analysis			80					8400		
Report			80					8400		
Workshop with experts (5 persons * 8 hours)			40					4200		
									22680	
Subtotal pilot										***250752***
Grand total									**376590**	
Vessel costs for two coastal acoustic surveys excluded										

Beach sampling:

Cost item	Hours	Amount
Personnel costs WMR CAT II (executing sampling)	120	
Personnel costs WMR CAT III (executing sampling)	40	
Personnel costs WMR CAT II (data entering)	16	
Travel costs		250
Material costs (wetsuit or dry suit and a storage box)		500

Pilot gill net:

Cost item	Hours	Amount
Personnel costs WMR CAT II (executing sampling)	20	
Personnel costs WMR CAT III (executing sampling)	20	
Personnel costs WMR CAT III (reporting the findings)	8	
Material costs (gill net)		1006

Wageningen Marine Research

T: +31 (0)317 48 70 00
E: marine-research@wur.nl
www.wur.nl/marine-research

Bezoekers adres:

- Ankerpark 27 1781 AG Den Helder
- Korringaweg 7, 4401 NT Yerseke
- Haringkade 1, 1976 CP IJmuiden

Wageningen Marine Research levert met kennis, onafhankelijk wetenschappelijk onderzoek en advies een wezenlijke bijdrage aan een duurzamer, zorgvuldiger beheer, gebruik en bescherming van de natuurlijke rijkdommen in zee-, kust- en zoetwatergebieden.

Wageningen Marine Research is onderdeel van Wageningen University & Research. Wageningen University & Research is het samenwerkingsverband tussen Wageningen University en Stichting Wageningen Research en heeft als **missie**: 'To explore the potential of nature to improve the quality of life'