Report on 2023 scientific research projects

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Grote dank gaat uit naar alle bemanning en vlootmanagers voor de samenwerking in het uitvoeren van wetenschappelijk onderzoek aan boord.

Pelagic Freezer-trawler Association (PFA) /
Redersvereniging voor de Zeevisserij (RVZ)

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Cover photo: AI generated photo of school of pelagic fish

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Executive Summary

This report documents the aim, approach and outcomes of research projects carried out in 2023 that were supported by scientific quota allocated to members of the Redersvereniging voor de Zeevisserij (RVZ). Although the scientific quota that has been used for the projects have been allocated by the Netherlands, the report is written in English to allow for international dissemination of results. This report also reflects additional research that took place within the same context, which was conducted in addition to the research allocated through scientific quota. Different funds were allocated for this research. Scientific quota was only utilized for the projects as previously described and submitted to RVO.

In 2023, pelagic scientific quota has been allocated to the following projects that were divided over two proposals:

Part 1

1.1 Self-sampling the pelagic fleet
1.2 Horse mackerel genetic research
1.3 Mackerel gonad research
1.4 PelAcoustics AI
1.5 Underwater camera techniques
1.6 Pelagic fish around windfarms
1.7 Automatic measurement and identification

Part 2

2.1 Self-sampling the pelagic fleet
2.2 Biological sampling
2.3 Acoustic sampling
2.4 Camera monitoring
2.5 Automatic measurement
2.6 Reducing bycatch
2.7 Increasing welfare

The main results are summarized below.

Self-sampling the pelagic fleet (1.1 & 2.1)

The self-sampling on vessels of RVZ members, as well as on vessels of the members of the RVZ's international sister organisation PFA (Pelagic Freezer Trawler Association), has continued throughout 2023. In addition to the haul registration, several additional vessels started taking length measurements in 2023. This provides detailed insights into the catch compositions and biological parameters on a highly resolved spatio-temporal scale in real time. Most of self-sampling activities are taking place in the Northeast Atlantic (FAO area 27). However, (near to) all trips in FAO areas 34 and 87 are also covered by the self-sampling program. Dedicated annual reports are produced for each of the relevant expert groups (HAWG, WGWIDE, WGDEEP, SPRFMO, CECAF). The self-sampling (M-Catch) software is operational on all vessels and has been expanded to allow for entry of length and biological data sampling as well (test phase) to replace the excel templates. All routinely collected data is now securely stored in Microsoft Azure cloud databases. Data is being shared with Wageningen Marine Research for use in stock assessments for which an extensive quality protocol has been developed. A spatial-specific stock assessment model is under development that takes length sampling of the RVZ fleet explicitly into consideration when estimating stock size.

Horse mackerel genetic research (1.2 & 2.2)

During the 2024 ICES benchmark on horse mackerel, stock structure will be discussed. With the help of samples taken by the RVZ vessels (27 samples in total), and genetic analyses by Identigen, in total 768 additional horse mackerel have been genetically analysed and associated with a stock of origin, making for a better delineation between the Western and North Sea horse mackerel stock component. This delineation helps in appropriate stock size estimation which is the basis of annual advice to the EU. Additional horse mackerel samples have been collected during 2023 in preparation of continued usage by ICES WGWIDE in the near future.

Mackerel gonad research (1.3 & 2.2)

Management of the Mackerel stock is based on an ICES assessment that makes use of tri-annually collected information on egg production, being indicative of the spawning biomass of the stock. During this egg survey however, participating research vessels were having difficulties to catch enough adult fish that could be used for fecundity analyses which makes the calculations for the SSB of mackerel less accurate. On-board PFA vessels, mackerel are caught for commercial purposes and some were used to test if samples collected by the PFA could contribute to the fecundity estimates as input for the SSB indices. A major difference with the process onboard a commercial vessel is that samples need to be frozen rather than put on formaldehyde. The impact of freezing on the analyses of fecundity is studied here. From 392 collected samples, 192 were processed for analyses in 2023. When all samples are processed in 2024 analyses will indicate if frozen samples can be used in the future.

Herring condition research (2.2)

Funding for external partners collaborating with the RVZ to study the condition of North Sea herring has been declined which has let to postponement of the research.

PelAcoustics AI / Acoustic sampling (1.4 & 2.3)

Commercial acoustic data has been collected onboard trawlers routinely for scientific purposes (i.e. biomass estimates). The data has been processed by Wageningen Marine Research to estimate biomass. The automatization of this process is un-going. From acoustic processed data, in combination with environmental indicators such as temperature, predictive models of fish distribution during the fishing season have been developed to aid in reducing the potential to bycatch unwanted fish species. A dashboard has been developed where skippers can visualize their acoustic readings in time and space.

The Dirk Dirk and Wiron 1 were listed as potential vessels to be calibrated in 2023. Calibration is needed to make the acoustic recordings on-board suitable for scientific use. Due to logistical challenges with the partners needed to perform the calibration, including availability of a slot at the Tweede Maasvlakte for sufficient depth for the Wiron 1, as well as a malfunctioning echosounder at the Dirk Dirk, no calibration took place in 2023. New attempts will be made in 2024. With the help of recorded acoustic data on-board several vessels was it possible to continue the seabed based re-calibration and inter-vessel calibration of vessels.

Underwater camera techniques (1.5 & 2.4)

The ambition to better recognize pelagic fish species prior to being caught has been another long-term ambition within RVZ/PFA, as this could further improve the selectivity of the fishery. During 2023 a trial has been set up with the Danish company Atlas Maridan, who have developed a live-view underwater camera (SeaScout). A camera system was mounted on a towed-body that allowed, prior to fishing, to observe fish in the water column for species identification. Challenges to deploy the towed body within the fish school will be further tackled in new studies. The SeaScout work was not part of the scientific quota project.

During 2023, four GoPro camera systems have been deployed by several vessels in the RVZ fleet. The so-called 'Trawlerkits' consist of external cases for 2 lights and 1 GoPro camera and can be mounted at many different positions in or on the outside of the fishing net. These camera's have been used to identify fish behaviour in the net and the functioning of selectivity devices. The systems operate well although they are prone to being damaged during fishing operation.

Pelagic fish around windfarms (1.6)

How many and what pelagic fish species are living in and around windfarms of various ages? As part of the project Acoustic ecology of pelagic fish communities (APELAFICO), RVZ was involved in the study into the effects of construction and operation of wind farms. Over the summer, two surveys were executed within Dutch and Belgian waters near the Borsele windfarm to study the pelagic fish species in the area. Although observations of pelagic fish were limited, the study was executed according to plan.

Automatic measurement and identification (1.7 & 2.5)

Effectively and efficiently measuring both the length and weight of individual fish could supply a vast amount of new information on the condition of fish in different areas and seasons. So far, the additional measurement of lengths has been implemented within the RVZ/PFA, but the combined manual measurement of length and weight has proven to be a too onerous task.

In 2020 RVZ/PFA initiated the development of a demonstration version of a device for automatic weighing and measuring of fish that can be deployed on a vessel. During 2023, the system has been installed on the SCH123

Zeeland, and several sea-trials with the system have taken place. Unfortunately, vibration of the vessel resulted in imprecise measurements and an alternative scale had to be purchased that is equipped to filter out these vibrations. The original supplier of the motion-compensated scale had to terminate its support half-way through 2023 which has resulted in a delay in progress.

In addition to length and weight measurement, innovation is ongoing to measure the fat content of fish. Fat content is a good indicator of overall body condition, which influences important traits such as survival, growth and reproduction. Therefore, condition has an impact on stock productivity and availability to fisheries. With the use of spectral cameras, fish fat is measured from the outside of the fish, making other equipment or chemical analyses obsolete. The method works promising for mackerel but requires additional analyses for herring and horse mackerel.

Routines are currently under development to automate fish recognition and biomass estimates on top of a conveyor belt such as in use at the RVZ vessels. Dedicated trials were executed in a quality lab during 2023 for which further analyses are pending.

Reducing bycatch (2.6)

Incidental bycatch has been identified as one of the major threats to large marine species worldwide. However, a lack of understanding how different species behave and the wide diversity in fish practices in different areas and seasons hampers the development of effective mitigation tools. In this project RVZ and partners contribute to research within a large European consortium of scientists, industry and policy makers to mitigate bycatch. In 2023 several activities took place from individual conversations with skippers on bycatch, an organized session to explore best practices, performing observations at sea in and around the fishing gear of potential bycatch and exploration of technical mitigation measures such as pingers, escapement grids and shark repellent devices. These activities are coordinated with other pelagic industries across Europe to be as effective as possible.

Increasing welfare (2.7)

There is ongoing interest to improve the welfare of fish during the fishing activity out at sea. There is however a trade-off in welfare indicators to be balanced, such as minimizing the possibility for fish to get damaged before processing (and are therefore lost for human consumption) vs implementing individual based humane sedation or stunning methods. RVZ contributed to discussion on this topic during the Catch Welfare Platform meeting and has performed trials during the herring fishery on variability in condition of fish being pumped on-board, depending on haul size and time elapsed at the start of pumping. Fish condition was further monitored during storage in the fish tanks. Since pumping speed during the herring fishery is near to fixed, additional tests were undertaken during a blue whiting fishing trip.

Nederlandse samenvatting

Dit rapport documenteert het doel, de aanpak en de resultaten van onderzoeksprojecten die in 2023 zijn uitgevoerd en die werden ondersteund door wetenschappelijke vangsten die waren toegewezen aan leden van de Redersvereniging voor de Zeevisserij (RVZ). Hoewel de wetenschappelijke vangsten die voor de projecten zijn gebruikt, zijn toegewezen door Nederland, is het rapport in het Engels geschreven om internationale verspreiding van resultaten mogelijk te maken. Dit rapport weerspiegelt ook aanvullend onderzoek dat heeft plaatsgevonden in hetzelfde kader, wat naast het onderzoek dat is toegewezen via wetenschappelijke vangsten is uitgevoerd. Voor dit onderzoek zijn andere fondsen toegewezen. Wetenschappelijke vangsten zijn alleen ingezet voor de vooraf gedefinieerde projecten.

In 2023 zijn pelagische wetenschappelijke vangsten toegewezen aan de volgende projecten, verdeeld over twee voorstellen:

Deel 1

1.1	Zelfmonsterneming van de pelagische vloot
1.2	Onderzoek naar genetica van horsmakreel
1.3	Onderzoek naar gonaden van makreel
1.4	PelAcoustics AI
1.5	Technieken voor onderwatercamera's
1.6	Pelagische vis rond windmolenparken
1.7	Automatische meting en identificatie

Deel 2

2.1	Zelfmonsterneming van de pelagische vloot
2.2	Biologische monsterneming
2.3	Akoestische monsterneming
2.4	Camera monitoring
2.5	Automatische metingen
2.6	Verkleining van bijvangst
2.7	Verbetering van het welzijn

De belangrijkste resultaten worden hieronder samengevat.

Zelfmonsterneming van de pelagische vloot (1.1 & 2.1)

De zelfmonsterneming op schepen van RVZ-leden, evenals op schepen van de leden van de internationale zusterorganisatie PFA (Pelagic Freezer Trawler Association), is gedurende heel 2023 voortgezet. Naast de vangstregistratie begonnen in 2023 ook verschillende andere schepen lengtemetingen uit te voeren. Dit levert gedetailleerde inzichten op in de samenstelling van de vangst en biologische parameters op een zeer gedetailleerde ruimtelijk-temporele schaal. De meeste zelfmonsternemingsactiviteiten vinden plaats in de Noordoost-Atlantische Oceaan (FAO-gebied 27). Echter, (bijna) alle reizen in FAO-gebieden 34 en 87 vallen ook onder het zelfbemonsteringsprogramma. Er worden jaarlijkse rapporten opgesteld voor elk van de relevante expertgroepen (HAWG, WGWIDE, WGDEEP, SPRFMO, CECAF). De zelfbemonsteringssoftware (M-Catch) is operationeel op alle schepen en is uitgebreid om ook de invoer van lengte- en biologische gegevensmonsterneming toe te staan (testfase), wat eerder werd vastgelegd in Excel-templates. Alle routinematig verzamelde gegevens worden nu veilig opgeslagen in Microsoft Azure-clouddatabases. Deze data wordt gedeeld met Wageningen Marine Research voor gebruik in bestandschattingen en waarvoor een uitgebreid kwaliteitsprotocol is opgesteld. Er wordt gewerkt aan de ontwikkeling van een ruimte-specifiek bestandschattingsmodel dat rekening houdt met lengtemonsterneming van de RVZ-vloot bij het schatten van de bestandsgrootte.

Onderzoek naar de genetica van horsmakreel (1.2 & 2.2)

Tijdens de ICES-benchmark van horsmakreel in 2024 zal de bestandstructuur worden besproken. Met behulp van monsters genomen door de RVZ-schepen (in totaal 27 monsters) en genetische analyses door Identigen in 2023 zijn in totaal 768 extra horsmakrelen genetisch geanalyseerd en geassocieerd met een bestand van herkomst, wat zorgt voor een betere afbakening tussen het Westelijke en Noordzee horsmakreel bestand. Deze afbakening helpt bij een passende schatting van de bestandsgrootte, die de basis vormt voor het jaarlijkse advies aan de EU. Extra horsmakreelmonsters zijn verzameld tijdens 2023 ter voorbereiding van voortgezet gebruik door ICES WGWIDE in de nabije toekomst.

Makreel gonaden onderzoek (1.3 & 2.2)

Het beheer van het makreelbestand is gebaseerd op een ICES-bestandschatting die gebruik maakt van driejaarlijks verzamelde informatie over de eiproductie, die indicatief is voor de paaibiomassa van het bestand. Tijdens dit ei-onderzoek hadden deelnemende onderzoeksschepen echter moeite om voldoende volwassen vis te vangen die gebruikt kon worden voor vruchtbaarheidsanalyses, waardoor de berekeningen van de SSB van makreel minder nauwkeurig zijn. Aan boord van PFA-schepen wordt makreel gevangen voor commerciële doeleinden en sommige individuen werden gebruikt om te testen of de door de PFA verzamelde monsters konden bijdragen aan de vruchtbaarheidsschattingen als input voor de SSB-index. Een groot verschil met het proces aan boord van een commercieel schip is dat monsters moeten worden ingevroren in plaats van op formaldehyde te worden gezet. De impact van bevriezing op de vruchtbaarheidsanalyses wordt hier bestudeerd. Van de 392 verzamelde monsters zijn er in 2023 192 verwerkt voor verdere analyse. Wanneer in 2024 alle monsters zijn verwerkt, zullen analyses uitwijzen of er in de toekomst ingevroren monsters gebruikt kunnen worden.

Haring conditie onderzoek (2.2)

Financiering voor externe partners die samenwerken met de RVZ om de conditie van Noordzeeharing te bestuderen, is afgewezen, wat heeft geleid tot uitstel van het onderzoek.

PelAcoustics AI / Akoestische bemonstering (1.4 & 2.3)

Commerciële akoestische gegevens zijn aan boord van trawlers routinematig verzameld voor wetenschappelijke doeleinden (bijvoorbeeld schattingen van de biomassa). De gegevens zijn verwerkt door Wageningen Marine Research om de biomassa te schatten. De automatisering van dit proces is nog gaande. Op basis van de verwerkte akoestische gegevens, in combinatie met milieu-indicatoren zoals temperatuur, zijn voorspellende modellen van visverspreiding tijdens het visseizoen ontwikkeld om te helpen bij het verminderen van ongewenste bijvangst van andere vissoorten. Er is een dashboard ontwikkeld waar schippers hun akoestische metingen in tijd en ruimte kunnen visualiseren.

De schepen Dirk Dirk en Wiron 1 werden in 2023 aangewezen als mogelijke schepen om akoestisch te worden gekalibreerd. Kalibratie is nodig om de akoestische opnamen aan boord geschikt te maken voor wetenschappelijk gebruik. Vanwege logistieke uitdagingen met de partners die nodig zijn voor de uitvoering van de kalibratie, waaronder de beschikbaarheid van een locatie op de Tweede Maasvlakte met voldoende diepte voor de Wiron 1, en een defecte echosounder op de Dirk Dirk, vond er geen kalibratie plaats in 2023. Nieuwe pogingen zullen worden ondernomen in 2024. Met behulp van opgenomen akoestische gegevens aan boord van verschillende schepen was het mogelijk om de her-kalibratie van de zeebodem en inter-scheepskalibratie voort te zetten.

Onderwatertechnieken met camera's (1.5 & 2.4)

De ambitie om pelagische vissoorten beter te herkennen voordat ze worden gevangen, is een andere lange termijn ambitie binnen RVZ/PFA, aangezien dit de selectiviteit van de visserij verder zou kunnen verbeteren. In 2023 is een proef opgezet met het Deense bedrijf Atlas Maridan, dat een onderwatercamera met live-weergave (SeaScout) heeft ontwikkeld. Een camerasysteem werd gemonteerd op een onderwaterframe, voortgetrokken door het schip, dat voorafgaand aan het vissen de mogelijkheid bood om vissen in de waterkolom te observeren voor soortidentificatie. Uitdagingen om het frame binnen een school vissen te zetten zullen verder worden aangepakt in nieuwe studies. De tests van de SeaScout vallen buiten het wetenschappelijk quotum project.

In 2023 zijn vier GoPro-camerasystemen ingezet door verschillende schepen in de RVZ-vloot. De zogenaamde 'Trawlerkits' bestaan uit externe behuizingen voor 2 lampen en 1 GoPro-camera en kunnen op veel verschillende posities aan de binnen- en buitenkant van het visnet worden gemonteerd. Deze camera's zijn gebruikt om het gedrag van vissen in het net en de werking van selectiviteitaanpassingen te identificeren. De systemen functioneren goed, hoewel ze gevoelig zijn voor beschadiging tijdens de visserij.

Pelagische vis rondom windmolenparken (1.6)

Hoeveel en welke pelagische vissoorten leven er in en rond windmolenparken van verschillende leeftijden? In het kader van het project Akoestische ecologie van pelagische visgemeenschappen (APELAFICO) was RVZ betrokken bij het onderzoek naar de effecten van aanleg en exploitatie van windparken. Gedurende de zomer zijn in de Nederlandse en Belgische wateren nabij het windpark Borsele twee onderzoeken uitgevoerd om de pelagische vissoorten in het gebied te bestuderen. Hoewel de waarnemingen van pelagische vissen beperkt waren, werd het onderzoek volgens plan uitgevoerd.

Automatische meting en identificatie (1.7 & 2.5)

Het effectief en efficiënt meten van zowel de lengte als het gewicht van individuele vissen kan een enorme hoeveelheid nieuwe informatie opleveren over de conditie van vissen in verschillende gebieden en seizoenen. Tot nu toe is de aanvullende meting van lengtes geïmplementeerd binnen de RVZ/PFA, maar de gecombineerde handmatige meting van lengte en gewicht is een te zware taak gebleken.

In 2020 startte RVZ/PFA de ontwikkeling van een demonstratieversie van een apparaat voor automatisch wegen en meten van vis dat op een schip kan worden ingezet. Tijdens 2023 is het systeem geïnstalleerd op de SCH123 Zeeland, en er zijn verschillende proeven op zee met het systeem uitgevoerd. Helaas resulteerde trilling van het schip in onnauwkeurige metingen en moest er een alternatieve weegschaal worden aangeschaft die is uitgerust om deze trillingen te filteren. De oorspronkelijke leverancier van de deining gecompenseerde weegschaal moest halverwege 2023 zijn ondersteuning stopzetten, wat heeft geleid tot vertraging in de voortgang.

Naast de meting van lengte en gewicht wordt er voortdurend gewerkt aan het meten van het vetgehalte van vis. Het vetgehalte is een goede indicator van de algehele lichamelijke conditie, die invloed heeft op belangrijke eigenschappen zoals overleving, groei en voortplanting. Daarom heeft de conditie invloed op de productiviteit van het visbestand en beschikbaarheid voor de visserij. Met behulp van spectrale camera's wordt het visvet gemeten vanaf de buitenkant van de vis, waardoor andere apparatuur of chemische analyses overbodig worden. De methode werkt veelbelovend voor makreel, maar vereist aanvullende analyses voor haring en horsmakreel.

Er worden momenteel procedures ontwikkeld om de automatische herkenning van vissen en schattingen van biomassa te automatiseren bovenop een transportband, zoals die wordt gebruikt op de RVZ-schepen. Er zijn speciale proeven uitgevoerd in een kwaliteitslaboratorium gedurende 2023, waarvoor verdere analyses nog in afwachting zijn.

Het verminderen van bijvangst (2.6)

Incidentele bijvangst is geïdentificeerd als een van de belangrijkste bedreigingen voor grote mariene soorten wereldwijd. Een gebrek aan begrip van hoe verschillende soorten zich gedragen en de brede diversiteit in vispraktijken in verschillende gebieden en seizoenen bemoeilijkt de ontwikkeling van effectieve mitigatiemiddelen. In dit project dragen RVZ en partners bij aan onderzoek binnen een groot Europees consortium van wetenschappers, industrie en beleidsmakers om bijvangst te verminderen. In 2023 vonden verschillende activiteiten plaats, variërend van individuele gesprekken met schippers over bijvangst, een georganiseerde sessie om beste praktijken te verkennen om bijvangst te voorkomen, waarnemingen op zee in en rond het visnet van mogelijke bijvangst en verkenning van technische mitigatiemaatregelen zoals pingers, ontsnappingspanelen en haaienafweermiddelen. Deze activiteiten worden gecoördineerd met andere pelagische industrieën in heel Europa om zo effectief mogelijk te zijn.

Verbetering van het welzijn (2.7)

Er is voortdurende interesse om het welzijn van vissen tijdens de visserij op zee te verbeteren. Er is echter een afweging van welzijnsindicatoren die in evenwicht moeten worden gebracht, zoals het minimaliseren van de kans dat vissen worden beschadigd voordat ze worden verwerkt (en dus verloren gaan voor menselijke consumptie) versus het implementeren van individuele humane sedatie- of verdovingsmethoden. RVZ heeft bijgedragen aan de discussie over dit onderwerp tijdens de Catch Welfare Platform-vergadering en heeft tijdens de haringvisserij proeven uitgevoerd om de variabiliteit in de conditie van vissen te onderzoeken die aan boord worden gepompt, afhankelijk van de trekgrootte en de verstreken tijd bij het begin van het pompen. De conditie van de vissen werd verder gecontroleerd tijdens opslag in de visreservoirs. Aangezien de pompsnelheid tijdens de haringvisserij bijna vaststaat, werden aanvullende tests uitgevoerd tijdens een blauwe wijting-visreis.


PFA

1 Introduction

For many years already, the Dutch *Redersvereniging voor de Zeevisserij* (RVZ) and the international *Pelagic Freezer Trawler Association* (PFA) have been active players on the interface between industry, science and management. RVZ and PFA members have all contributed to data collection initiated by scientific institutes (observer trips, catch sampling, logbook information). In addition, RVZ and PFA have initiated and commissioned several scientific research projects.

The RVZ/PFA science programme is developed around the themes of sustainable exploitation including minimizing the impact of fishing on the environment. This includes

- Self-sampling the pelagic fleet
- Using vessel acoustics for stock trends and fish behaviour
- Sampling biological characteristics of fish species that improve stock structure definitions and provide insight into fish condition
- Using camera techniques to improve selective fishing
- Reducing bycatch through technical and behavioural approaches
- Increasing welfare of fish during the fishing process

The utilization of scientific quota provides an important avenue to facilitate the research ambitions of the RVZ and PFA. As RVZ, we are annually submitting an integrated request for the utilization of (Dutch) scientific quota. As RVZ/PFA, we are reporting on the outcomes in this integrated document. In 2023, two requests for scientific quota were submitted and evaluated. These are provided below and details presented in the sections following this overview.

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2.7 Increasing welfare

2 Research projects – Part 1

2.1 Self-sampling the pelagic fleet

The self-sampling program in pelagic fishing was launched in 2014 and now forms a solid basis for the role of pelagic fishing in scientific research. The self-sampling data is now widely used for various applications (stock assessment, MSC, spatial-temporal occurrence of different types). Figure 2.1.1 shows the trips covered through the self-sampling program where trips in which both haul and length sampling took place is given in darker green compared to haul registered self-sampled trips in lighter green. Similar data (not shown) is available for all PFA vessels.

Figure 2.1.1. Overview of self-sampled trips in 2023 from the Dutch flagged vessels in EU waters.

In total, more than 200 trips were self-sampled in 2023 with a total of over 6500 hauls and over 280.000 length measurements. Before data was entered into the databases, quality control by RVZ and Quirijns took place, eliminating erroneous entries or correcting entries based on additional information from the skipper or quality manager. All haul sampling was provided through the M-Catch software while for length-sampling Excel based templates were used.

Table 2.1.1 Overview of number of vessels taking part in the self-sampling, number of trips observed, days sampled, hauls sampled, total estimated catch, percentage of non-target species, number of length measurements and number biological samples taken.

YEAR	VESSELS	TRIPS	DAYS	HAULS	CATCH	NON-TARGET	LENGTHS	BIO SAMPLES
2017	15	123	2,044	4,976	344,213	0.38%	284,262	1,042
2018	17	157	2,489	5,919	469,547	0.28%	329,206	1,871
2019	17	159	2,687	6,655	416,727	0.55%	283,276	1,922
2020	17	171	2,579	6,195	501,391	0.48%	278,318	3,739
2021	20	230	2,895	6,652	512,858	1.30%	289,192	2,507
2022	19	252	2,914	6,797	498,864	0.65%	231,343	4,965
2023	19	217	2,620	6,595	502,833	0.31%	280,352	1,054
(all)		1,309	18,228	43,789	3,246,434		1,975,949	17,100

To make optimal use of the length data collected by the RVZ/PFA, a translation of length to age is needed. RVZ has collaborated with WMR to convert the length information, with the help of the age information collected under the statutory programme (WOT), into ages. For this, an elaborate quality control process was designed in which fishing grounds had to be detected to align sample taking on-board multiple RVZ/PFA vessels and the WOT samples. In Figure 2.1.3 we illustrate the mean and variance around length samples as taken on-board the fishing vessels and a matched WOT sample showing very good consistency between vessels and with the WOT sample.

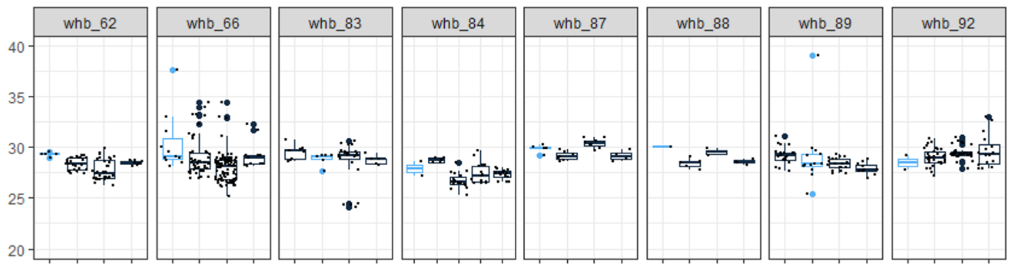

Figure 2.1.3. Boxplot of mean length of the fish in a haul, combining all hauls on the same fishing ground (defined in space and time). Blue boxplot indicates the mean and spread of WOT samples taken and measured by WMR while the black boxplots each represent a different vessel fishing at the respective fishing ground. Each panel represents a different fishing ground.

2.2 Horse mackerel genetic research

For many years, debate has been ongoing on the stock structure of horse mackerel in the North East Atlantic. Originally, one thought the North Sea stock would occupy most of the English channel and the middle part of the North Sea while recent genetic analyses have indicated that in the Channel area substantial stock mixing is on-going and that horse mackerel found north of Spain and Portugal belong to the Western component (Figure 2.2.1). These results were made possible by part of the genetic research carried out up to 2022. In 2023, additional samples have been taken from the mixing area in the Channel and southern North Sea and were analysed, together with other samples collected in years prior to 2023 for stock ID.

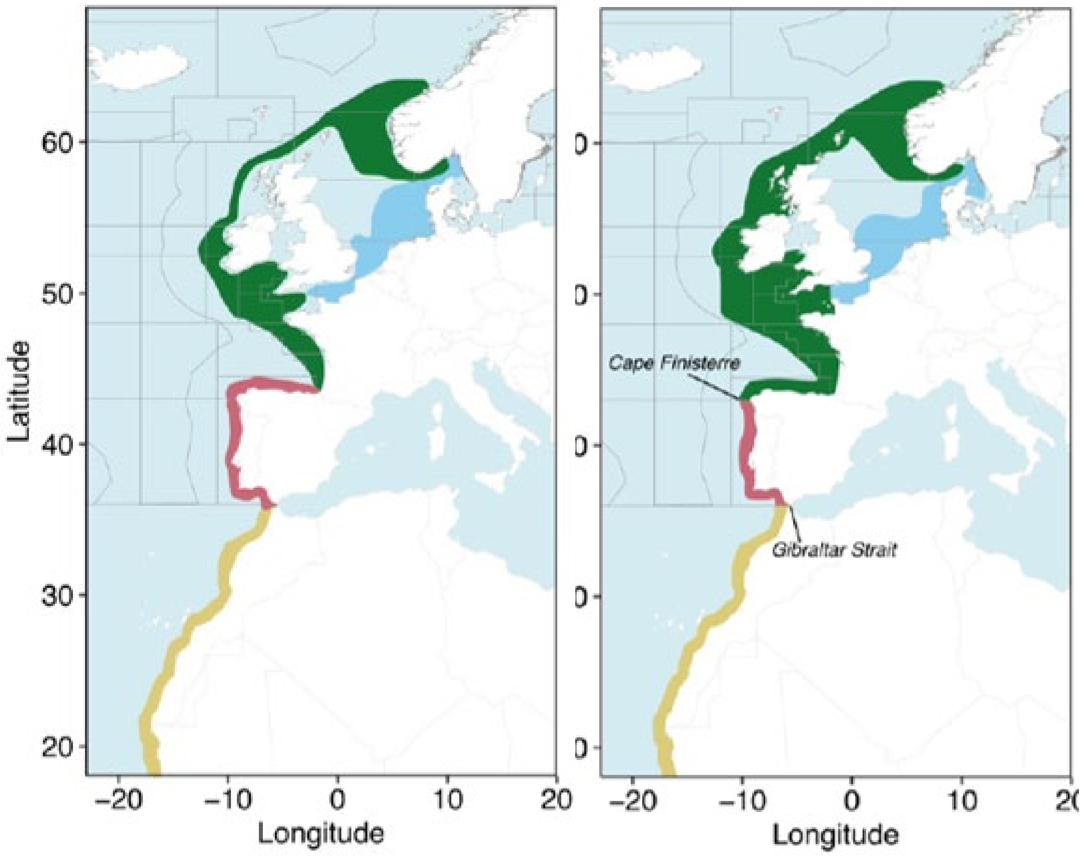

Figure 2.2.1 Left: current assumption on stock structure of horse mackerel in the North East Atlantic, showing in green the Western component, in blue the North Sea component and in red the Southern component. Right: preliminary assignment of stock structure of horse mackerel.

A working document has been prepared of the approach and outcomes of the genetic research that includes all samples as shown in Figure 2.2.2. Several of these samples have been collected on-board RVZ vessels. In total, 12 new samples were taken by RVZ vessels in 2023 to be analysed in 2024.

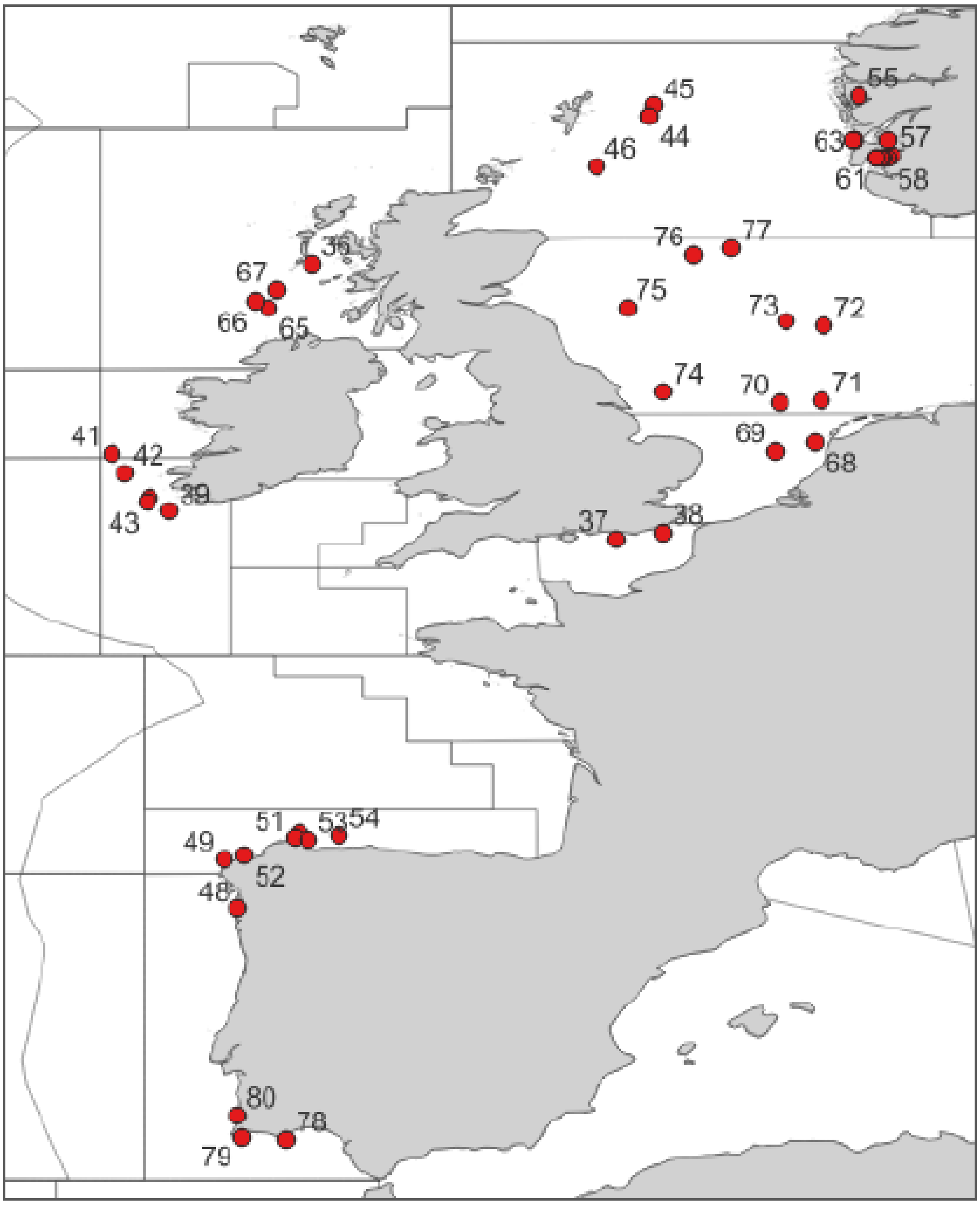

Figure 2.2.2. Location of fishing hauls with horse mackerel that were used to genotype in preparation of the ICES benchmark on horse mackerel.

2.3 Mackerel gonad research

Management of the Mackerel stock is based on an ICES assessment that makes use of tri-annually collected information on egg production, being indicative of the spawning biomass of the stock. During this egg survey however, participating research vessels were having difficulties to catch enough adult fish that could be used for fecundity analyses which makes the calculations for the SSB of mackerel less accurate. On-board RVZ/PFA vessels, mackerel are caught for commercial purposes and some were used to test if samples collected by the PFA could contribute to the fecundity estimates as input for the SSB indices. A major difference with the process on-board a commercial vessel is that samples need to be frozen rather than put on formaldehyde. The impact of freezing on the analyses of fecundity is studied here. From 392 collected samples, 192 were processed for analyses in 2023 (see Figure 2.3.1).

Figure 2.3.1. Collection and notation of mackerel sampled for fecundity research by RVZ.

10 samples from the pool of 192 were used to analyse potential fecundity and another 10 samples were analysed for batch fecundity. Images of the fecundity samples were taken and oocytes were measured and counted. A dedicated software package was used to analyse the oocyte images to annotate the frozen oocytes.

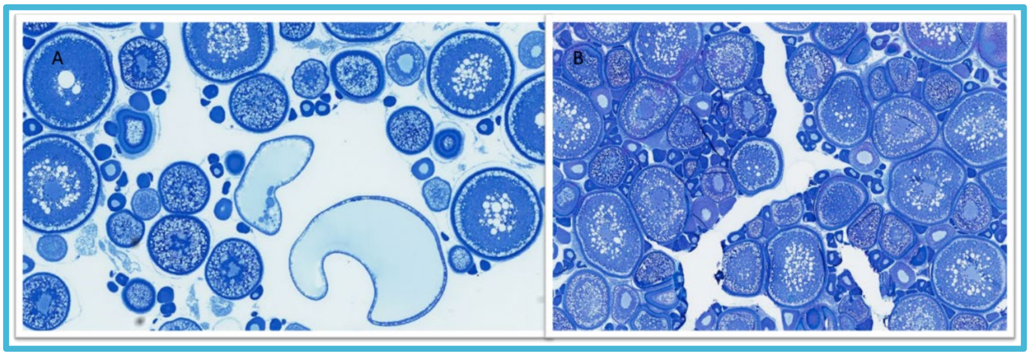

Figure 2.3.2. In image A tissue of the gonad of mackerel is seen that qualified for batch fecundity. For the batch fecundity we are specifically looking for spawning fish to measure the number of eggs being released per fish during a single spawning event. The transparent oocyte in the bottom of the image on the right is a fully hydrated oocyte that is ready to be spawned. In image B tissue of a gonad of mackerel is seen that qualified for potential fecundity. For the potential fecundity we are looking for fish that started develop oocytes but did not spawn yet. Potential fecundity gives the number of oocytes 1 fish could possible spawn during one spawning season.

2.4 PelAcoustics AI

Within the PelAcousticsAI project, partners collect and analyse commercial echosounder data to improve our understanding of the pelagic resource and offer decision support to skippers, fleet managers, and fisheries data analysts.

In the project WMR and IMR focussed on developing Machine learning technologies to automatically process the data. To this end, in 2023 the work focussed on:

- Developing the data pre-processing to construct the database in standardized and easily accessible format (zarr format). The construction of the database over the period 2016-2021 is ~40% complete.
- Further annotating data. The annotations now covers the full range of data available over the period 2016-2021.
- Developing the ML framework, e.g. data sampling scheme for ML training, ML model parametrization and customization.
- Training the first ML models on small data sets. The performance of the models developed to date are not yet satisfactory. Further work is required on model tuning and widening the training to a large set of data.

The pipeline for automatic data processing involves the development of 3 main sets of python software packages and accompanying scripts:

Data preprocessing and conditioning package. This is available publicly on the github of the CRIMAC centre (IMR, Norway, https://github.com/CRIMAC-WP4-Machine-learning). The pelacousticsAI project contributes to the improvement of the code by making it more widely applicable, especially in the context of data collected by industry vessels which are very varied.

Data sampling package. This package provides tools for sampling conditioned data sets in a flexible way. In the context of machine learning, data sampling is essential for the effective training of algorithms. This package was developed from scratch within the pelacousticsAI project and is hosted on the WUR git repository which will be made public once it's fully tested.

Image segmentation package. This package contains the tools for building and evaluating ML data processing algorithms which use image segmentation principles. This package was developed from scratch within the pelacousticsAI project and is hosted on the WUR git repository as well. Similar to the Data sampling package, this package will be made public once it's fully tested.

Next to that, work on deriving stock indices was undertaken. The data of interest for the hereby study were those collected opportunistically by trawlers during fishing operation. In relation with deriving stock indicators from these opportunistic data, the nature of the data poses two main challenges: the bias in data sampling and the lack of spatial coverage. In that context, the work undertaken in 2023 consisted of:

- Furthering the development of the "synthetic transects" approach together with analysis of results and adding of new data sets. This approach allows to alleviate the bias in data sampling but also combine acoustic and catch data to derive abundance at length.

- Derive abundance indices in line with other studies , e.g. averaging of blue whiting acoustic density over ICES rectangles (Figure 2.4.1) or spatial occupation.

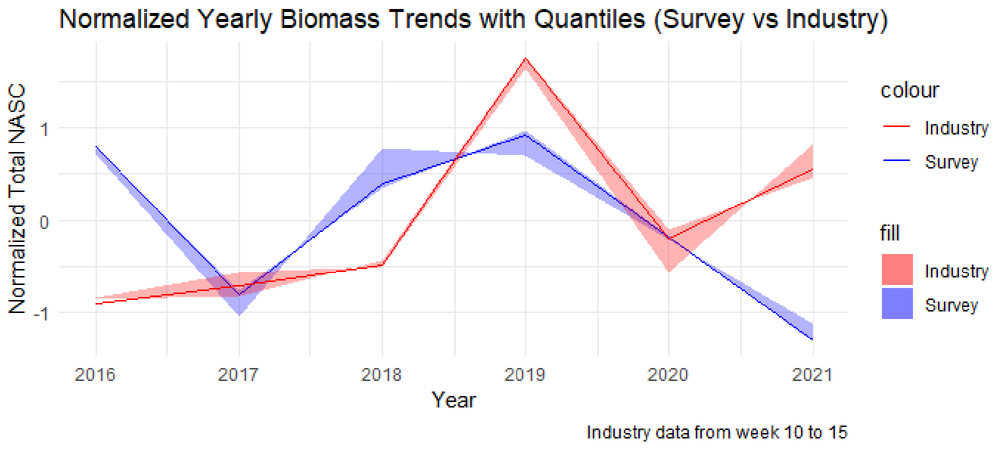

Figure 2.4.1. Trends in acoustic density associated with blue whiting through averaging per ICES rectangles over the period 2016-2021. The results for the survey and the industry data are displayed.

Specific objectives for 2023 focussed on improving the predictive fish geographical distribution model, named 'FishAI model', by adding a Coexistence Index on fish species occurrence. The Coexistence Index can operate independently to predict bycatch probabilities. In 2023, the Coexistence Index has been trained and validated based on echosounder observations by the RVZ/PFA fleet.

The need for a substantial amount of labelled echosounder data for training the Coexistence model (whether fish has been observed or not) prompted the development of an innovative, open-source method to process 10 years of commercial acoustic data. The newly developed method can efficiently (re)process a decade's worth of data (typically around 40 TB) in a matter of hours, representing a substantial improvement over the previous months-long processing duration. This method was used to identify events at locations of fish species absence; this to counter balance the machine learning model which consisted mainly from fish species presence (catch) data. An example of the visual results obtained from the Coexistence Index is provided in Figure 2.4.2.

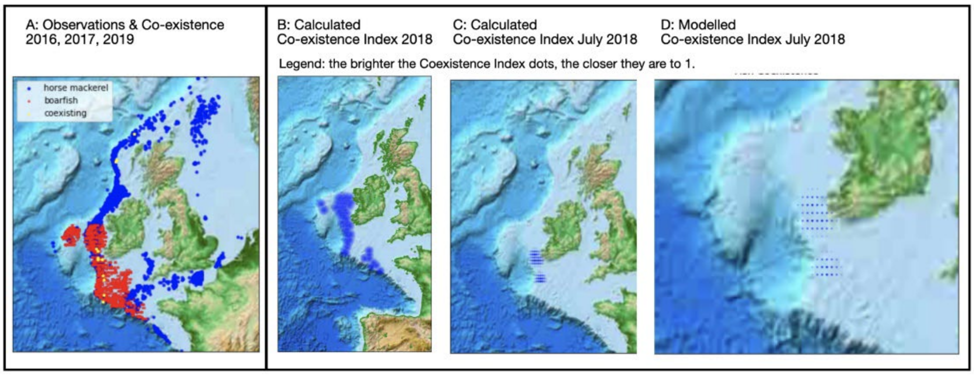

Figure 2.4.2. Horse mackerel and boarfish as observed in July of 2016, 2017, and 2019 (A). The Coexistence Index as calculated using all 2018 observations (B) and specifically from July 2018 observations (C). The modelled predicted Coexistence Index for July 2018 in the same area (D).

Another task centred around visualising through an interactive dashboard the collection and processing outputs of commercial echosounder data. Important improvements have been implemented, including visualisation of echosounder data collection statistics and data quality. The introduction of a new feature, time sliding, now empowers users to navigate through historic data on a weekly basis for more detailed insight. Output from the earlier mentioned FishAI model has now been integrated into the dashboard. The dashboard itself has moved from a development platform to Microsoft Azure for cost efficiency and enhanced security. A change in the visual dashboard's focus, specifically transitioning from skippers to fleet managers as end-users, led to the delay of sea demonstrations.

All components of the work under pelAcousticAI have been presented to scientist within the consortium, at WMR and to fleet managers. Presentation at a conference is scheduled for 2024.

2.5 Underwater camera techniques

Using camera techniques to see what happens underwater can aid in more selective fishing, studying fish behaviour as well gear performance to e.g. allow unwanted bycatch to escape. Historically, underwater camera’s have been bulky, delivering low resolution and were more complex to mount in the fishing gear. With the latest version of the GoPro action camera’s, all very small in size, and the development of robust casings for these camera’s, RVZ vessels have been able to shoot footage underwater at multiple locations in the fishing net in different fisheries. The only limitation being depth rating, as these systems are bound to depths up to 250m.

These underwater housings, developed by Baarsen and colleagues, were 3D printed (Figure 2.5.1). The camera’s have been in action on two RVZ vessels from August onwards and several hours of footage have been collected. An evaluation of the system took place in collaboration with skippers and based of a registration of settings for each deployment as organized by the RVZ. Location of lights in relation to the camera, angle of the camera, delay-recording settings etc. were discussed and lead to an improved manual for use of these Trawlerkits on other vessels.

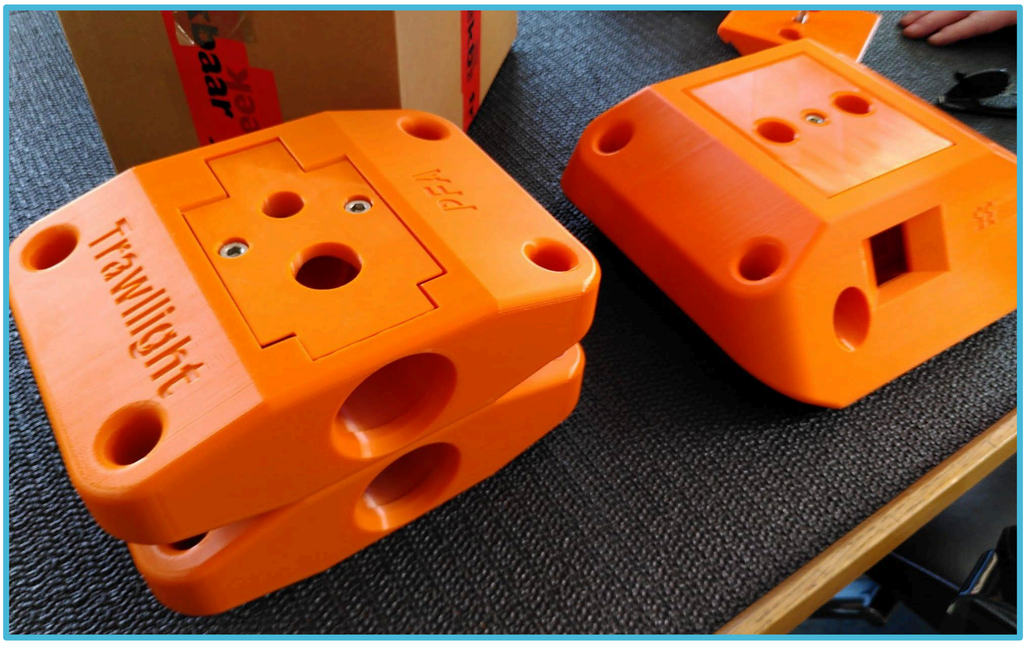

Figure 2.5.1. Trawlkits for two dive lights and one GoPro unit used in the RVZ fisheries.

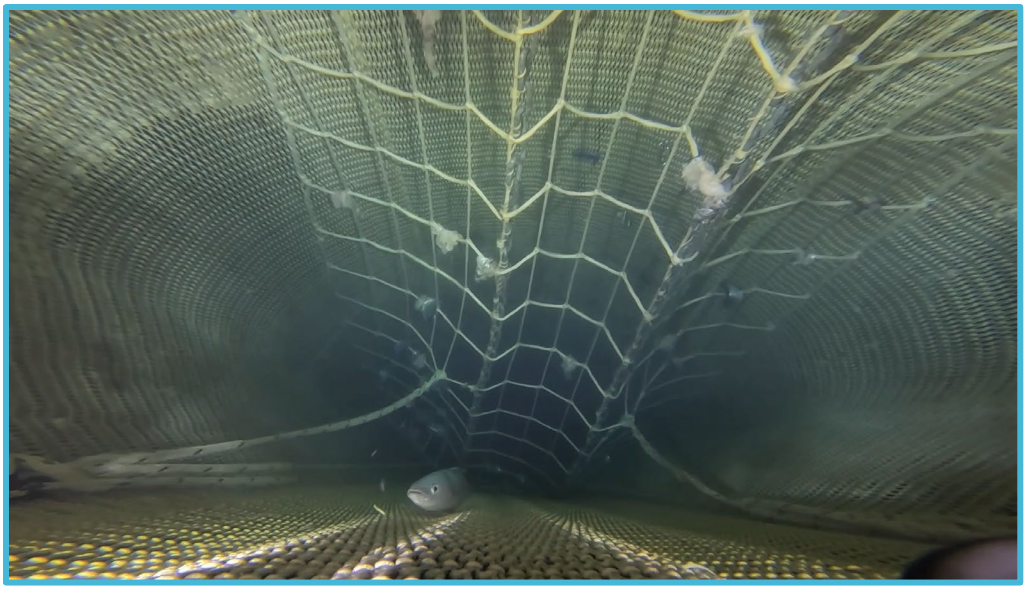

Figure 2.5.2. Still of video footage made with the Trawlerkits.

Additional camera work was carried out outside of the Scientific Quota programme, in which a frame mounted camera (Figure 2.5.3) was deployed in the sea prior to fishing to perform pre-catch species identification and hence aid into more selective fishing. The camera received power and data through an electrical cable directly connected to a screen on the bridge, allowing for life-feed species identification. Most challenging was the accurate deployment of the towed-body inside a school of fish, and further development of more accurate depth sensors are pending.

Figure 2.5.3. Towed-body frame with mounted camera and electrical cable.

2.6 Pelagic fish around windfarms

RVZ was involved in the study into the effects of construction and operation of wind farms and the presence of pelagic fish species in these areas. For this purpose, which is part of a larger project APELAFICO, an acoustic survey was executed near the Borsele windfarm on the 14-15th of June and in the Belgian EEZ near the windfarm area south of Borsele. The survey in the Borsele area was executed with a crew of WMR, RVZ and VLIZ and was considered successful. Acoustic recordings were made for the entire trip. Final results of the survey are currently processed by Wageningen Marine Research. Due to the shallow depth and spikeness of the seafloor area, most stations that were initially marked as fishing stations could not be executed. The survey showed very little acoustic marks of small pelagic fish during the entire trip. The data will be compared by WMR with stationary acoustic devices (BATS) that were deployed in the same area within the wind farm area and were retrieved several days later.

Figure 2.6.1 Footage taken of the Wiron 1 (SCH-27) next to the windmills in the Borsele windfarm area on the 14th of June 2023.

Figure 2.6.1 shows the acoustic transects and planned trawling stations for the second survey that took place near Belgian windfarm area. The survey took place 8-9th of August 2023 with scientific crew from WMR, VLIZ in Belgium and RVZ. The 2-day cruise took continuous acoustic measurements with the echosounder available on-board and performed, where possible due to depth constraints, trawling for pelagic fish with the commercial gear.

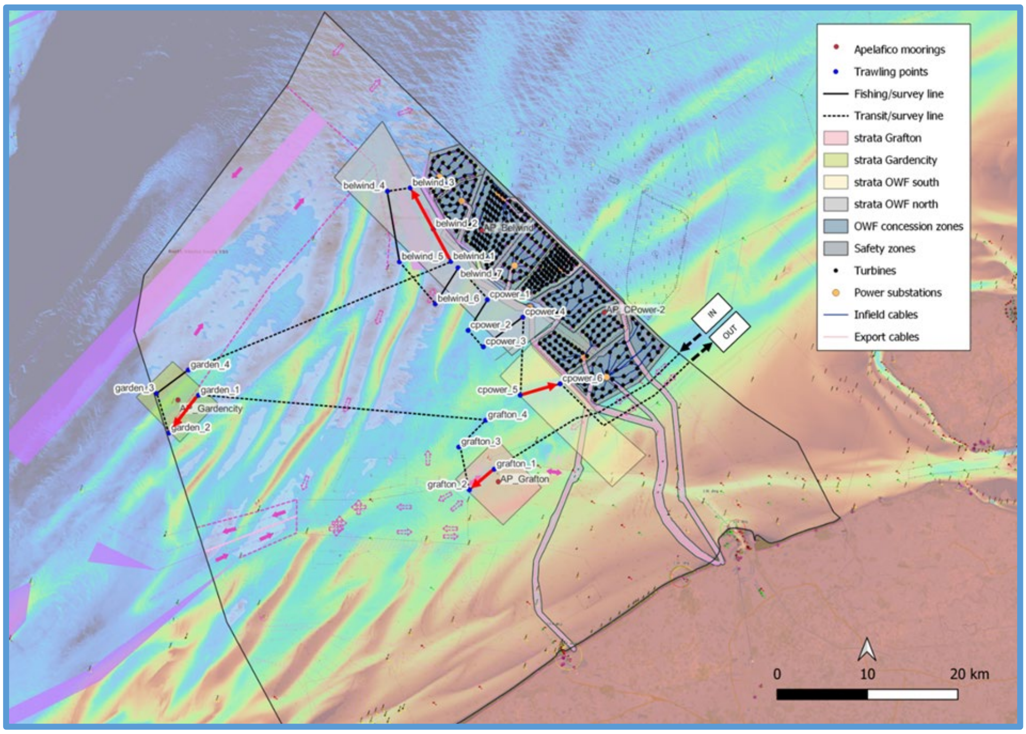

Figure 2.6.2. Survey transect design for the APELAFICO survey making use of a commercial RVZ vessel

Overall, there was very limited recordings of pelagic fish in the area with no distinct schools visible on the echosounder. Environmental samples were taken and in total three fish trawls were undertaken. In these trawls, some herring, mackerel, sprat, pilchard and whiting was caught. Frequency distributions of the lengths measured during this survey for each of the hauls are given in Figure 2.6.2.

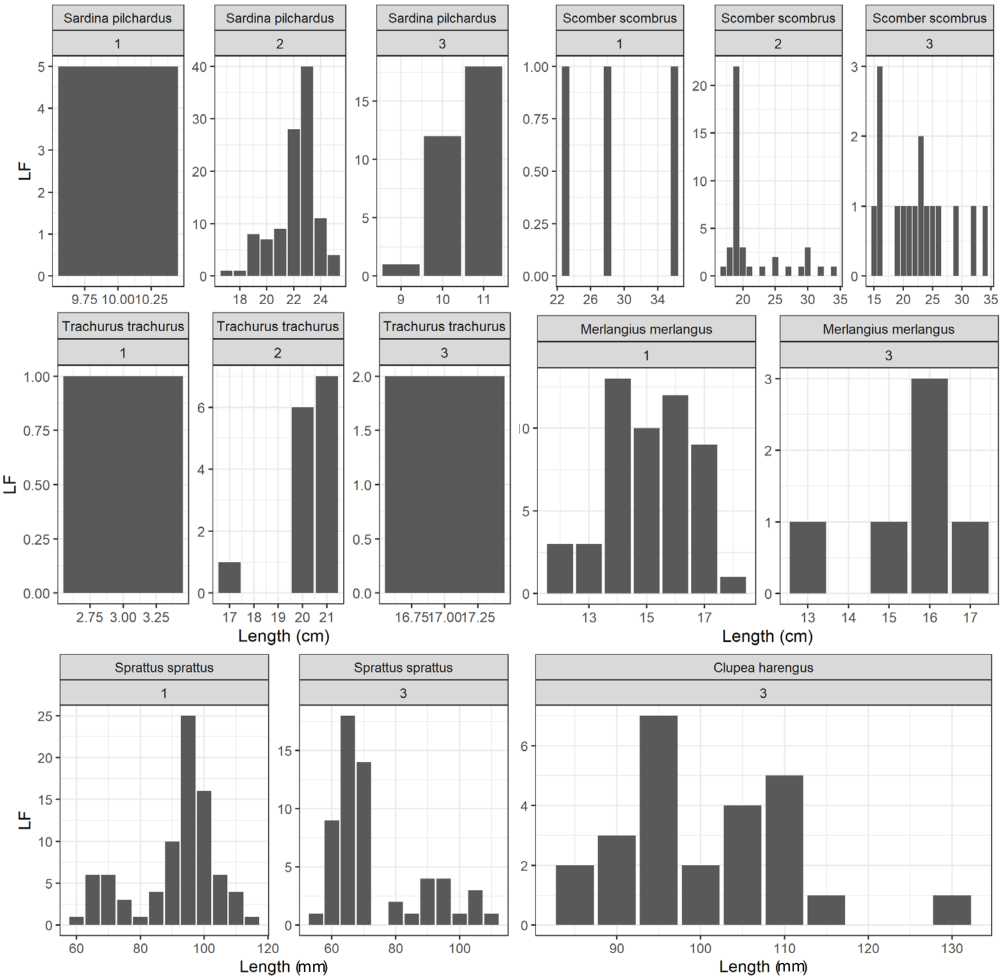

Figure 2.6.2. Length frequency distribution of each of the species caught in three separate hauls.

No gear damage was recorded during the trips.

2.7 Automatic measurement and identification

Effectively and efficiently measuring both the length and weight of individual fish could supply a vast amount of new information on the condition of fish in different areas and seasons. So far, the additional measurement of lengths has been implemented within the RVZ/PFA, but the combined manual measurement of length and weight has proven to be a too onerous task.

In 2020 RVZ/PFA initiated the development of a demonstration version of a device for automatic weighing and measuring of fish that can be deployed on a vessel. During 2023, the system has been installed on the SCH123 Zeeland, and during 4 different trips sea-trials with the system have taken place.

Table 2.7.1 Overview of sampled trips, dates and number of samples and variation in the deviation of the standard weight within the samples

Trip	Dates	Number of trials	Coefficient of Variation
1	24-Feb	1	[2.00 -30.2]
2	18Apr – 24Apr	3	[0.05 – 5.63]
3	3May – 18May	21	[0.41 – 14.9]
4	26Sep – 11Oct	12	[0.11 – 2.21]

During the first trip, it was noted that the variation was very large and the machine was not functioning well. The machine was taken off-board for some changes in the damping of the construction. It was thereafter mounted back again on the vessel before the trip in April and March. During these trips, the variation in the measurements varied greatly. The manufacturer connected to the software of the scale via a TeamViewer connection and made changes in the software during trip 2. After the change, the crew took measurements again. For the trip in May, a similar approach was taken and the over 10 different settings were tested where the scale manufacturer would dial in over a TeamViewer connection to make these changes. The collaboration was time consuming but led to over 20 tests. In between trip 3 and 4, the developer of the scale made substantial changes to the software to account for the vibrations of the vessel. In addition did the electromechanic of the vessel perform several experiments to test if changes in voltage being delivered to the machine could influence the performance, resulting however in no clear suggestion that this would be the case. Finally, in trip 4, a similar exercise was as during trip 3 was undertaken including the help of the manufacturer of the scale. After yet again results that were considered to be too far off the expected value, the scale manufacturer decided to terminate the contract.

Due to the delay in the project, the system was also tested in the quality control lab at one of the companies to evaluate whether the additional on-land sampling could contribute further to biological information becoming available for research. This test went smooth and might result in small modifications to the design of the machine to optimize operations.

In a separate track, images were taken over a bulk of herring and mackerel to estimate volume and number of individuals using image analyses techniques. The results of this analyses are still pending. Within the same project, individual herring and mackerel were photographed with a spectral camera and analysed for fat content (Figure 2.7.1). The initial results, making use of only 50 fish were very promising when comparing the results to the industry standard, the Distill fat meter. Hereafter, the test was scaled up to 300 individuals and results were very promising for mackerel with an average of 80% correct reading of fat content. For herring however, the results were less successful with an average of around 60% correct. Potentially, the thicker skin of herring may have caused the deviation. The project will continue in 2024.

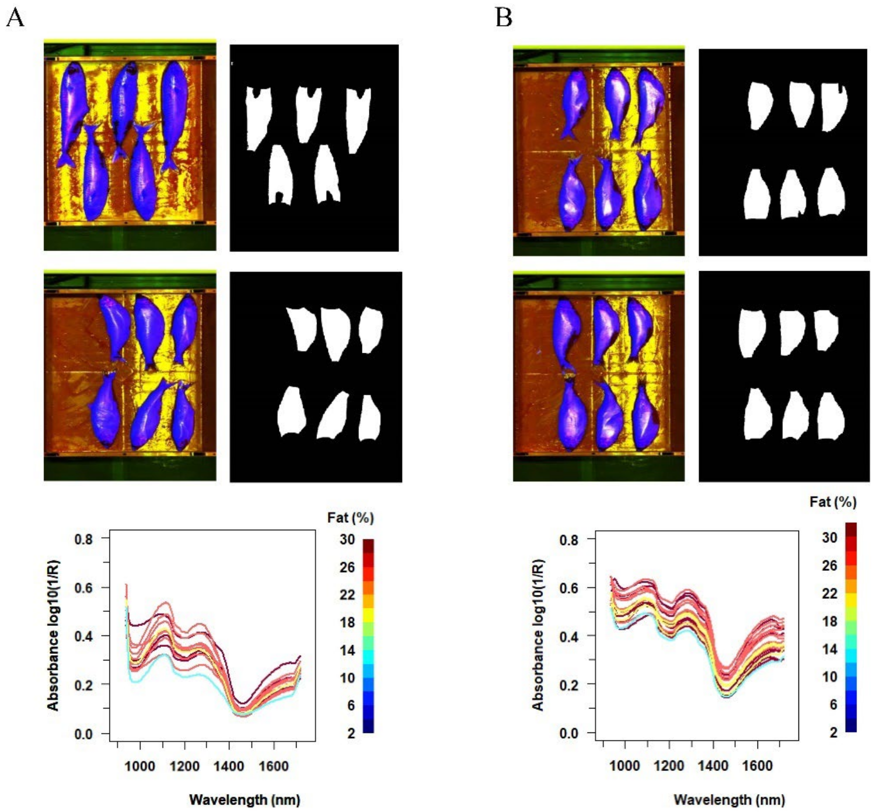

Figure 2.7.2. The Near Infrared (NIR) images and the raw spectra of mackerel (A) and herring (B).


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3 Research projects – Part 2

3.1 Self-sampling the pelagic fleet

The second part of the research project on self-sampling focused on developing new tools, software and hardware to process, handle and store self-sampling data. For this purpose, a start has been made with the development of a spatial stock assessment model that more effectively can handle the self-sampling data and the spatial and temporal resolution in which this data is collected. In the modelling framework, the North East Atlantic was divided into nearly smaller cells with the size of 0.2° longitude by 0.1 ° latitude (for illustration, current stock assessments areas are often as large as 15-35° longitude by 10-30° latitude) where cells closer to each other are assumed to be correlated in space. First results show that a first version of the model is able to capture length differences in space and is computationally efficient (~10sec runtime). Figure 3.1.1 below shows the first version of estimated lengths across the region.

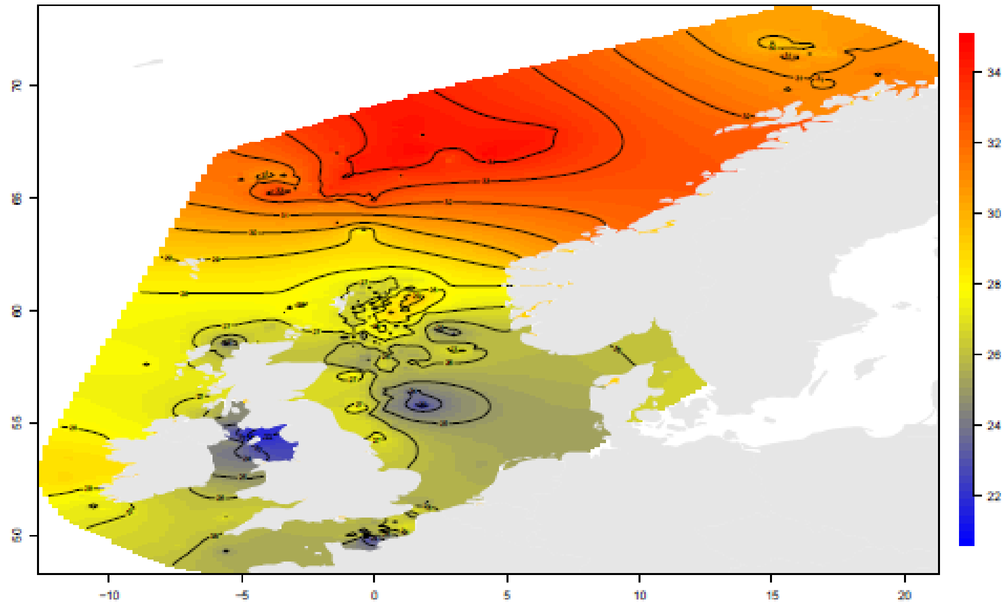

Figure 3.1.1. Estimated spatial distribution of mean length in the catch across for a subsample of PFA self-sampled data.

A sustainable storage solution had to be sought for all self-sampled data. With support from IT consultant VENECO a Microsoft Azure Cloud storage solution has been designed in which RVZ can now store and share files with external partners such as WMR. All previously collected acoustic information (at around 40TB of storage) has been migrated already to the archive cloud (see Figure 3.1.2).

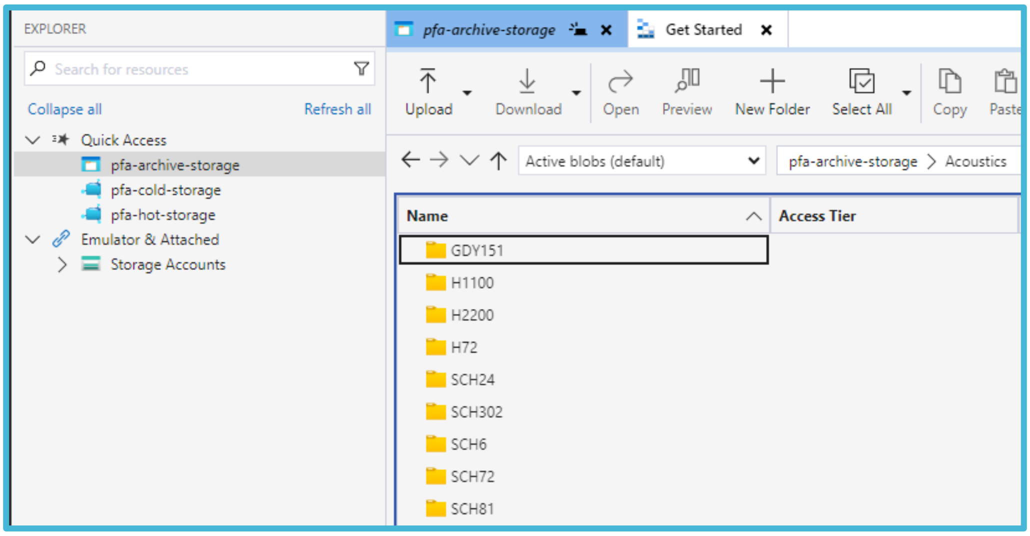

Figure 3.1.2. Overview of Azure storage facility to securely store PFA self-sampling data.

Furthermore, the M-Catch software has been developed to include corporate and scientific sampling data. A first test version is given in Figure 3.1.3 below and illustrates the interface of the biological sampling and associated fields.

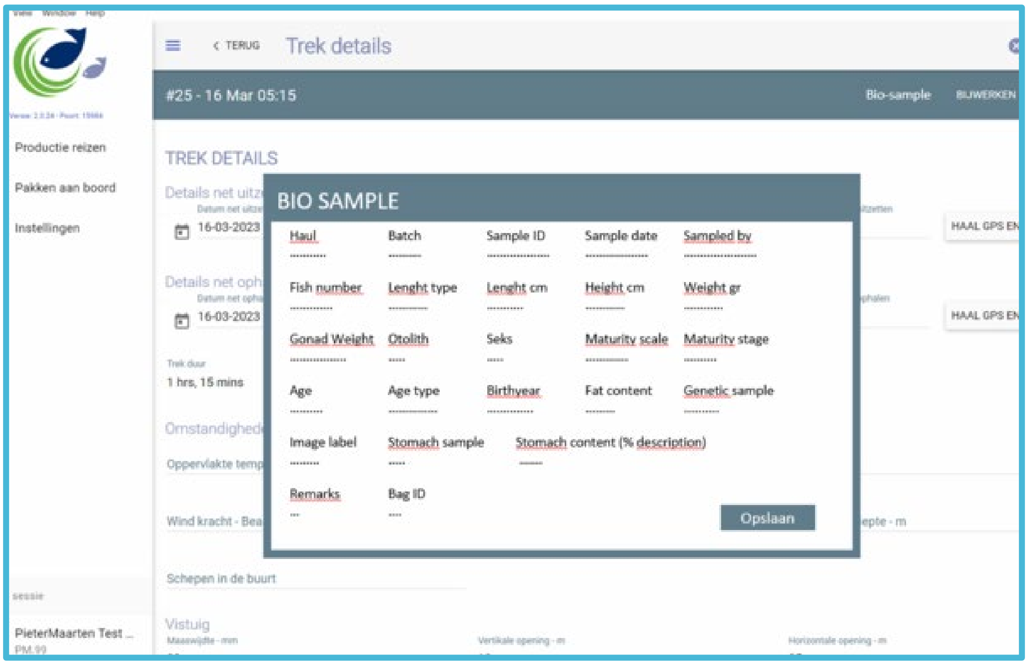

Figure 3.1.3. Illustration of test version of the development of the M-Catch environment for biological samples.

3.2 Biological sampling

Horse mackerel: The research focused on collecting and analysing additional samples. The research is described in paragraph 2.2.

Mackerel: The research focused on analysing frozen mackerel fecundity samples by WMR and is described in paragraph 2.3

Herring: Funding for external partners collaborating with the RVZ to study the condition of North Sea herring has been declined which has let to postponement of the research.

3.3 Acoustic sampling

The Dirk Dirk and Wiron 1 were listed as potential vessels to be calibrated in 2023. Calibration is needed to make the acoustic recordings on-board suitable for scientific use. Due to logistical challenges with the partners needed to perform the calibration, including availability of a slot at the Tweede Maasvlakte for sufficient depth for the Wiron 1, as well as a malfunctioning echosounder at the Dirk Dirk, no calibration took place in 2023. New attempts will be made in 2024. With the help of recorded acoustic data on-board several vessels was it possible to continue the seabed based recalibration and inter-vessel calibration of vessels. Advice on calibration strategies and alternative calibration methods will be developed in 2024.

3.4 Camera monitoring

Two additional GoPro Trawlerkit units have been purchased and put to use on the SCH302 and KW172. The approach to these systems is similar as to what has been described under paragraph 2.5. The footage has been analysed by RVZ and further discussed with WMR who made an analysis of best position of lights and camera in the net to observe the functioning of the grid and detection of potential escapements of unwanted bycatch.

3.5 Automatic measurement

The testing and development of the Length-Weight-Measurement device was more costly and time consuming than foreseen in the first scientific quota application, which ultimately also lead to the termination of support by the scale manufacturer. The funding provided under this task was used to further support the technological development as carried out by Innovotech in collaboration with the Wageningen Research Agro Food Robotics group. Further details are described under paragraph 2.7.

Figure 3.5.1. One of the trials in the Length-weight measuring device tests.

3.6 Reducing bycatch

Incidental bycatch has been identified as one of the major threats to large marine species worldwide. However, a lack of understanding how different species behave and the wide diversity in fish practices in different areas and seasons hampers the development of effective mitigation tools. In this project RVZ and partners contribute to research within a large European consortium of scientists, industry and policy makers to mitigate bycatch.

RVZ/MPFF is coordinating these activities by heading up a team of international experts from fisheries, research, policy and NGOs to develop and deliver the international best practices. In practice this has meant playing a key role in the organization of a kick-off event on bycatch mitigation, held on 7-8 September in Pakhuis de Zwijger.

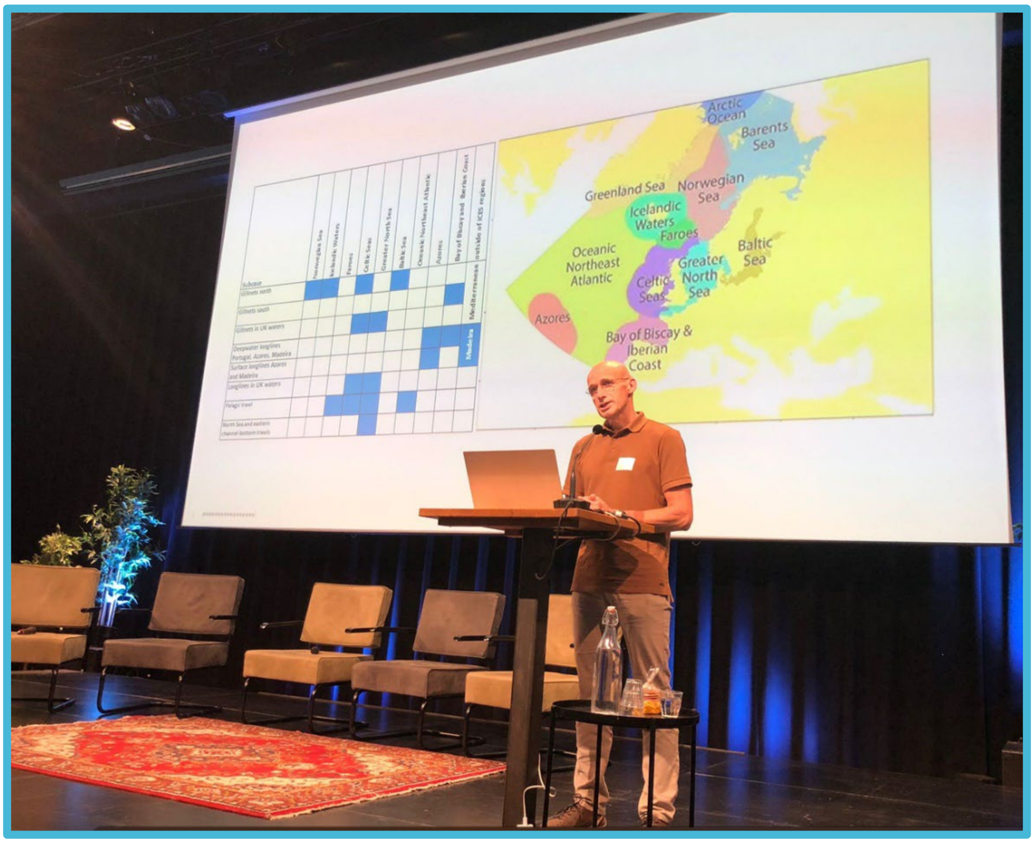

Figure 3.6.1. Martin Pastoors from MPFF presenting the case studies at an international conference on bycatch mitigation.

The second element of the RVZ work relates to the international coordination activities to align the different case studies on bycatch mitigation. Here MPFF has initiated a number of meetings with experts throughout Europe during the second half of 2023. This also included further coordination sessions within the Netherlands between the ministry of LNV, Stichting de Noordzee and academic partners such as Wageningen Marine Research as well as further coordination with other pelagic fisheries in Europe such as the Scottish PFA, the Danish pelagic producer organisation DPPO and the Irish fishermens organisation KFO.

From the more practical fisheries side, several sessions were organised to discuss alternatives to gear design and bycatch deterrent devices such as shark stunners and dolphin pingers. An exploration for the utility of SharkGuards, as produced by FishTek Marine were explored (Figure 3.6.1).

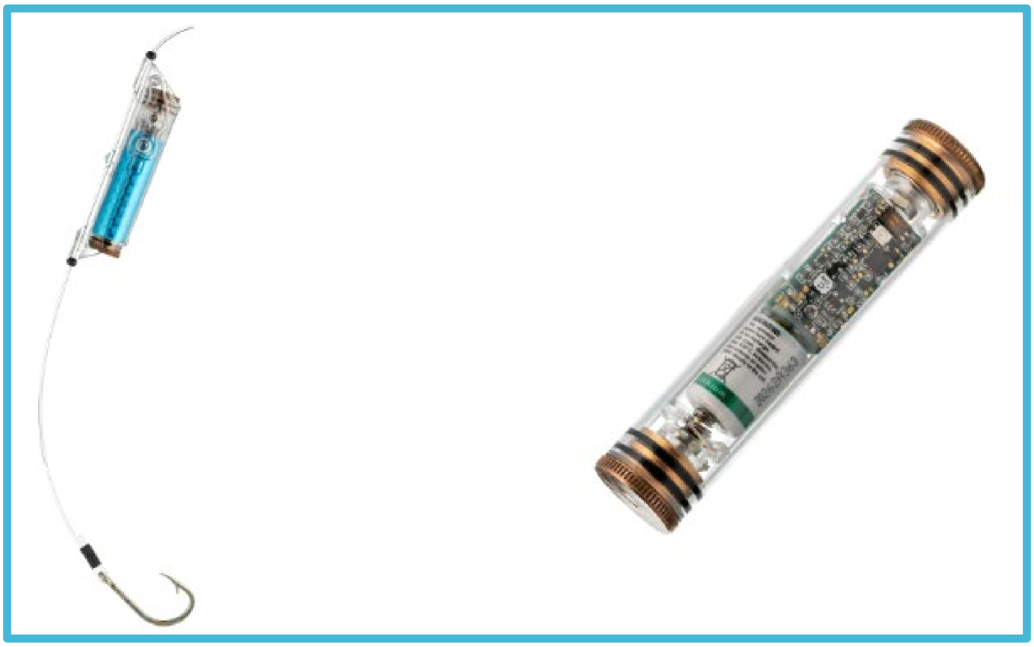

Figure 3.6.2. Sharkguard as developed by FishTek Marine (@fishtekmarine.com)

A visit to Maritiem, a pelagic fishing net producer, resulted in further ideas to improve gear design to mitigate unwanted ETP bycatch. Finally, a workshop with skippers was held to discuss best practices in structurally registering bycatch and avoiding bycatch from a behavioural angle as well as from a technical innovative perspective (Figure 3.6.3). This led to a number of ideas that will be tested in 2024 onboard the fishing vessels.

Figure 3.6.3. Photo of workshop session (image is blurred to prevent identification of individuals) hosted by Wageningen Marine Research.

3.7 Increasing welfare

There is ongoing interest to improve the welfare of fish during the fishing activity out at sea. There is however a trade-off in welfare indicators to be balanced, such as minimizing the possibility for fish to get damaged before processing (and are therefore lost for human consumption) vs implementing individual based humane sedation or stunning methods. RVZ contributed (outside of the Scientific Quota project) to discussion on this topic during the Catch Welfare Platform meeting that took place in Bergen, Norway and was attended by many fishing and science organisations from Europe. RVZ has furthermore engaged with Stichting Vissenbescherming to discuss short and long-term plans to improve welfare and feasibility to implement techniques such as stunning on-board. For tailored activities, RVZ needs to understand what the fish condition is during the catching and processing onboard a vessel.

A sea-trial was therefore executed in collaboration with Wageningen Marine Research to study the condition of fish in relation to haul size, duration, time between end of haul and start of pumping. Next to that, the changes in oxygen and temperature in the fish tanks was monitored. The trip took place early December and data inputs as well as analyses are underway. To this date, only preliminary results from the fish tanks can be presented such as the development of oxygen, temperature and saturation in the fish tank just before filling the tanks with fish and during the hold period (Figure 3.7.1).

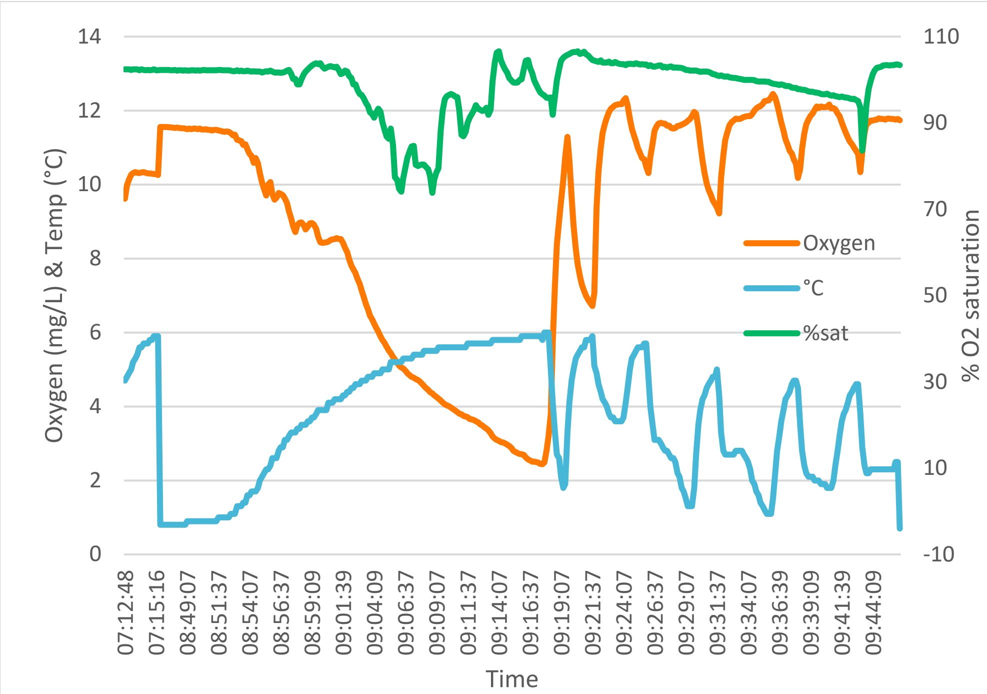

Figure 3.7.1. Oxygen, temperature and saturation development in the fishtank during the entire operation process of preparing the tank with chilled seawater, filling the thank with fish and emptying.

Additionally, tests were undertaken to evaluate the impact of pumping speed on haul size and duration. It was noted that pumping speed was maintained constant in several fisheries but that pumping time increased with haul size, suggesting that less fish go trough the pipes when hauls become larger (See Figure 3.7.2). These results make it clear that changing pumping speed is not a variable to be considered to optimize fish condition.

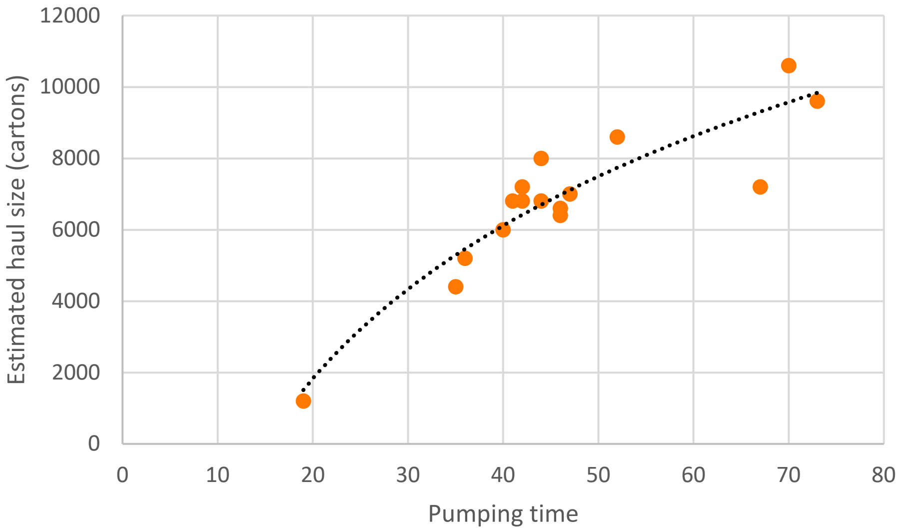

Figure 3.7.2. Relationship between pumping speed (in minutes) and estimated haul size.

4 The way forward

The RVZ/PFA is pleased that it has been able to make a significant contribution to promote the sustainability of the fishery and reduce any other unwanted impact on the ecosystem through a science based approach, supported by among others the Scientific Quota system.

The self-sampling of the fleet and utilisation of the data for stock assessment purposes has been ongoing for several years already and with Memorandum of Understandings in the making with Wageningen Marine Research (WMR) in the Netherlands and the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) to strengthen the collaboration on data sharing and knowledge development, these activities are there to stay. This includes self-sampling, data storage, quality control, development of the mCatch software development of the spatial-temporal stock assessment model. These activities should hence been considered as multi-year projects.

Continued sampling of biological traits of pelagic fish, such a genetic fingerprint of horse mackerel, fecundity of mackerel and condition of herring are all projects that are of crucial importance for science. There is a central role for the industry to take and process these samples as deploying research vessels is often inefficient or too costly.

The automatic processing and analyses of acoustic information collected on-board pelagic trawlers is part of a larger project that will finish in 2025 (PelAcousticAI). Other scientific efforts made towards calibration of acoustic devices, including sonars, remains on the agenda for 2024 and the years after to ensure that the quality that is collected remains high.

With the development of small, but high quality, camera technology, the opportunity to look underwater has become easier and more effective. To confirm functioning of gear innovations to e.g. prevent unwanted bycatch, there is a strong requirement to shooting and analysing underwater footage. As such, in the coming years underwater camera techniques will remain an important part of the RVZ/PFA research agenda, including the automatic analyses through AI of these images.

In 2023, an RVZ vessel took part in two different research surveys (one covered under the Scientific Quota) and there are ongoing discussions to deploy a smaller pelagic trawler in 2024 and 2025 as well for research around windfarms.

Although self-sampling activities are fully supported by the crew on-board the pelagic vessels, being able to reduce their workload and simultaneously increase precision and the amount of information collected, is key. Therefore, the development and testing of the Length-Weight-Measurement System will continue in the future, together with innovations in fat measurements and volumetric measurements through automated image analysis techniques.

The RVZ/PFA is taking part in a project that will conclude in 2029 on bycatch mitigation measures. Under this project, extensive at-sea trials will be needed in the upcoming years to verify if behavioural changes or modification to fishing gear have a desired effect.

A similar approach is taken with respect to increasing welfare. There remain many unknowns on fish condition and welfare throughout the catching process and we will continue to work with scientific partners to unravel these and make effective adjustments to the process at sea to promote human slaughter and improve fish quality.

5 Research output 2023

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5.1 Reports

Pastoors, M. & de Nijs, L., 2023. Report on 2022 scientific research projects, PFA report 2023/01, 30pp

Pastoors, M. de Nijs, L., Quirijns, F., 2023. PFA self-sampling report 2017-2022, PFA report 2023/02, 106pp

Pastoors, M., de Nijs, L., Quirijns, F., 2023. PFA self-sampling report for North Sea herring fisheries, 2017-2022, PFA report 2023/03, 64pp

Hintzen, N.T., Olsen, H., 2023, CPUE Standardization of Silver smelt in 5b and 6a. PFA report 2023/04, 14pp

Hintzen, N.T. 2023, PFA self-sampling report for WGDEEP 2023. PFA report 2023/05, 27pp

Quirijns, F., 2023, PFA self-sampling report for CECAF fisheries, 2016-2022, 52pp

Hintzen, N.T. 2023, PFA self-sampling report for WGWIDE 2023, PFA report 2023/07, 88pp

Hintzen, N.T., Wójcik, I., 2023, Comparison of EU self-sampling and observer data with the objective to supplement observer data for non-observed quarters, PFA report 2023/08, SPRFMO SC11-JM04, 15pp

Hintzen, N.T. 2023, CPUE standardization for the offshore fleet, PFA report 2023/09, 20pp

5.2 Presentations

Heddema, T., Selectivity in the pelagic fishing industry. 8 September 2023

De Nijs, L., 2023. Industry contributions to data collection on Northeast Atlantic mackerel: benefits, lessons and challenges, Session D, ICES Annual Science Conference 2023, 13 September 2023

Hintzen, N.T., 2023, UvA, 15 November 2023