Report on 2024 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) /
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Cover photo: AI generated photo of school of mackerel carrying measuring tapes

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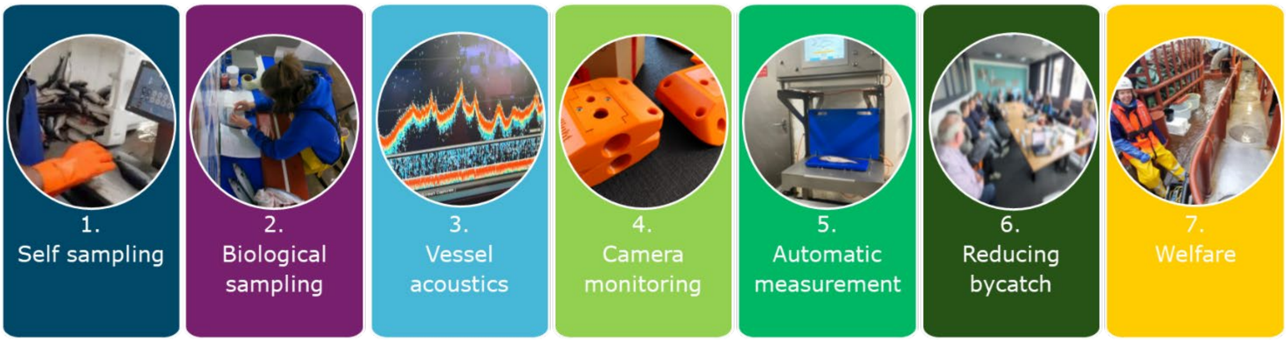
1. Executive Summary

This report documents the aim, approach and outcomes of research projects carried out in 2024 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.

In 2024, pelagic scientific quota has been allocated to the following projects:



The main results are summarized below.

1. Self-sampling

The self-sampling program on vessels of RVZ members, as well as those of the RVZ's international sister organization, the Pelagic Freezer Trawler Association (PFA), continued throughout 2024. While the majority of self-sampling activities are conducted in the Northeast Atlantic (FAO area 27), nearly all trips in FAO areas 34 and 87 are also included in the program. These activities undergo rigorous quality control before being integrated into the central databases. Dedicated annual reports are prepared for relevant expert groups, including HAWG, WGWIDE, WGDEEP, SPRFMO, and CECAF. The M-Catch software, operational on all vessels, has been enhanced to support the entry of length and biological data. Quality managers have tested these updates extensively on board. All routinely collected data is securely stored in Microsoft Azure cloud databases. The data is shared with Wageningen Marine Research for stock assessment purposes, with procedures for designing Age-Length Keys developed and applied to RVZ data. Additionally, a spatially specific stock assessment model is being developed, incorporating length sampling from the RVZ fleet to improve stock size estimation. Lastly, a protocol for systematically documenting fishers' knowledge has been developed and successfully field-tested.

2. Biological sampling - Horse mackerel genetic research (2.1)

In preparation for the 2024 ICES benchmark on horse mackerel, genetic analyses were conducted to estimate the degree of mixing between Western and North Sea horse mackerel populations in the Channel area and the northern North Sea. Additional horse mackerel samples were collected throughout 2024, with contributions from RVZ vessels. Using these samples and genetic analyses performed by Identigen, it was determined that horse mackerel in area 27.4.a belong entirely to the Western component, while approximately 50% of the horse mackerel in area 27.7.d are also of Western origin. However, the available sample size was insufficient to provide annual estimates of mixing.

2. Biological sampling - Mackerel gonad research (2.2)

Management of the mackerel stock relies on an ICES assessment that utilizes triennially collected data on egg production, which serves as an indicator of the stock's spawning biomass (SSB). However, during the egg survey, research vessels faced challenges in catching sufficient adult mackerel for fecundity analysis, leading to less precise SSB calculations. Onboard RVZ vessels, mackerel are caught for commercial purposes, and some were used to test whether samples collected by the RVZ could contribute to fecundity estimates as input for the SSB indices. Unlike research vessels, commercial vessels must freeze samples rather than preserve them in formaldehyde, a method not permitted onboard fishing vessels. Building on findings from the 2023 study, which identified anomalies in freezing effects, 317 samples were collected in 2024, with 142 processed for analysis. Initial results suggest that freezing affects egg counts compared to formaldehyde preservation. However, the impact appears limited, and the frozen samples were of sufficient quality to support the overall fecundity study.

3. Acoustic sampling – PelAcoustic AI (3.1)

Commercial acoustic data has been routinely collected onboard trawlers for scientific purposes, primarily to estimate biomass. Wageningen Marine Research has processed this data to generate biomass estimates. While the automation software for processing acoustic data has been finalized, based on machine learning techniques, it requires separate 'training' for each species. Good results have been achieved for blue whiting, while training for herring and horse mackerel is still ongoing. Using processed acoustic data combined with environmental indicators, such as temperature, predictive models of fish distribution during the fishing season have been developed. These models help reduce the likelihood of bycatch involving unwanted fish species. Additionally, a dashboard has been created, enabling skippers to visualize their fishing activities and acoustic readings in both time and space.

3. Acoustic sampling – Calibration (3.2)

Three vessels were successfully calibrated in 2024. Calibration for one of the vessels took place at the Tweede Maasvlakte to ensure sufficient depth for the calibration equipment beneath the vessel. The other two were calibrated in the IJmuiden harbor, with all procedures completed successfully. No self-calibration was conducted for the fourth vessel due to its operations outside EU waters, however, several vessels collected acoustic data from a seabed transect within the Dutch Exclusive Economic Zone (EEZ) for calibration purposes. Wageningen Marine Research (WMR) analyzed this data and proposed calibration adjustments based on the findings. Additionally, WMR's analysis indicated that inter-vessel calibration is feasible for RVZ/PFA vessels, as some vessels operating in fishing grounds are properly calibrated using sphere-based methods.

3. Acoustic sampling – Sonar (3.3)

Sonar data was collected by Wageningen Marine Research aboard the research vessel Tridens to initiate testing of sonar data analyses from commercial vessels. However, it was not yet possible to begin this work on commercial vessels. The continuation of this project is proposed for 2025.

4. Camera monitoring

In 2024, eight additional GoPro camera systems were deployed across several vessels in the RVZ/PFA fleet. These so-called Trawlviewer kits consist of external cases for two lights and one GoPro camera, which can be mounted in various positions inside or outside the fishing net. These cameras have been used to observe fish behavior within the net and evaluate the effectiveness of selectivity devices. Two types of Trawlviewer kits are utilized by the vessels: one designed for shallower waters (up to 250 meters depth) and another, the deep-sea Trawlviewer kit, capable of operating at depths greater than 250 meters, suitable for the blue whiting and Greater silversmelt fisheries (one 250m system and two >250m system were supported by the Scientific quota project). A newly designed Trawlviewer kit was fabricated in 2024, featuring enhanced durability compared to previous versions. Wageningen Marine Research (WMR) developed a software package to automate the stitching of GoPro footage and eliminate irrelevant segments, such as those captured while setting the trawl. Training of the associated AI model is ongoing and requires significant amounts of footage, which is actively being collected by the vessels. The footage is initially stored on hard drives onboard and subsequently migrated to a secure Azure cloud, where it is shared with WMR for further analysis.

5. Automatic measurement

Effectively and efficiently measuring both the length and weight of individual fish can provide valuable insights into fish condition across different areas and seasons. While the additional measurement of fish length has been implemented within the RVZ, the manual combined measurement of both length and weight has proven too labour-intensive. In 2020, the RVZ initiated the development of a device for automatic fish weighing and measuring, designed for use aboard vessels. Testing of the machine in 2024 led to improvements in the algorithms for estimating fish length. Following final tests, the device was found to be highly accurate in measuring both length and weight, making it suitable for routine self-sampling processes on vessels.

Innovation is also underway to measure fish fat content using camera-based techniques. Fat content serves as a reliable indicator of body condition, influencing key traits such as survival, growth, and reproduction. Using spectral cameras, fat content is measured externally, eliminating the need for additional equipment or chemical analyses. The method has proven effective for mackerel; however, tests in 2024, building on 2023 findings, revealed that herring skin likely hinders proper light transmission for fat estimation. Fat measurements from skinless herring produced results similar to those for mackerel. Current analyses are focused on reverse-engineering fat estimates from the light spectrum for herring and horse mackerel with their skin intact.

In 2023, video footage of mackerel on a conveyor belt was collected to estimate individual fish counts and volume directly in the fish factory. However, the amount of footage was insufficient to train AI models, which require extensive data. To address this, a 3D model of mackerel was developed, enabling the generation of computer-simulated footage. This approach is now being used to train the AI model, meeting the need for a large volume of training data.

6. Reducing bycatch

Incidental bycatch is recognized as a significant threat to large marine species worldwide. However, limited knowledge of species-specific behaviours and the wide variation in fishing practices across different areas and seasons hinder the development of effective mitigation tools. This project, led by RVZ in collaboration with a European consortium of scientists, industry representatives, and policymakers, aims to address these challenges and mitigate bycatch. In 2024, several key activities were undertaken, including individual consultations with skippers about bycatch, quarterly sessions bringing together skippers, scientists, net makers, and invited experts to discuss best practices, and at-sea observations in and around fishing gear to study potential bycatch incidents. Additionally, technical mitigation measures, such as pingers, escapement grids, and shark repellent devices, were explored and tested. These efforts were closely coordinated with other pelagic industries across Europe to maximize effectiveness. Skippers reported that the organized sessions were highly beneficial, leading to an increase in trials of new gear designs. Various excluder designs and shark repellent devices were tested, and pingers are now commonly used throughout the fleet, with their usage tracked via the mCatch software. Furthermore, a first version of a species identification guide was distributed to skippers, along with a more comprehensive species ID book to support bycatch mitigation efforts.

7. Increasing welfare

There is a growing interest in improving fish welfare during fishing activities at sea. However, this requires balancing trade-offs between welfare indicators, such as minimizing damage to fish before processing (to preserve them for human consumption) and implementing humane sedation or stunning methods on an individual basis. There are knowledge gaps on all these aspects however. Trials were conducted during the herring fishery to investigate the impact of oxygen concentration changes in the codend and the variability in fish condition when pumped onboard, depending on haul size and the time elapsed before pumping began. Fish condition was also monitored during storage in fish tanks to assess its variability throughout the process.


Lina

2. Nederlandse samenvatting

Dit rapport documenteert het doel, de aanpak en de resultaten van onderzoeksprojecten die in 2024 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.

In 2024 zijn pelagische wetenschappelijke vangsten toegewezen aan de volgende projecten:

De belangrijkste resultaten worden hieronder samengevat.

1. Zelfbemonstering

Het zelf-bemonsteringsprogramma op schepen van RVZ-leden, evenals die van de internationale zusterorganisatie van de RVZ, de Pelagic Freezer Trawler Association (PFA), is in 2024 voortgezet. Terwijl het grootste deel van de zelf-bemonsteringsactiviteiten wordt uitgevoerd in de Noordoost-Atlantische Oceaan (FAO-gebied 27), worden bijna alle reizen in FAO-gebieden 34 en 87 ook geregistreerd. Deze activiteiten ondergaan strikte kwaliteitscontroles voordat ze in de centrale databases worden geïntegreerd. Jaarlijkse rapporten worden opgesteld voor relevante expertgroepen, waaronder HAWG, WGWIDE, WGDEEP, SPRFMO en CECAF. De M-Catch-software, operationeel op alle schepen, is verbeterd om invoer van lengte- en biologische gegevens te ondersteunen. Kwaliteitsmanagers hebben deze updates uitgebreid getest aan boord. Alle routinematig verzamelde gegevens worden veilig opgeslagen in Microsoft Azure-cloud databases. De gegevens worden gedeeld met Wageningen Marine Research voor doeleinden van bestandschattingen, waarbij procedures voor het ontwerpen van Leeftijd-Lengte-Sleutels zijn ontwikkeld en toegepast op RVZ-gegevens. Bovendien wordt een ruimtelijk specifiek bestand beoordelingsmodel ontwikkeld dat lengtemetingen van de RVZ-vloot expliciet gebruikt om de schatting van de bestandschatting te verbeteren. Tot slot is een protocol voor het systematisch documenteren van de kennis van vissers ontwikkeld en succesvol getest in de praktijk.

2. Biologische bemonstering – horsmakreel (2.1)

Ter voorbereiding op de 2024 ICES-benchmark voor horsmakreel zijn genetische analyses uitgevoerd om de mate van menging tussen Westelijke en Noordzee horsmakreelpopulaties in het Kanaalgebied en de noordelijke Noordzee te schatten. Gedurende 2024 werden extra horsmakreelmonsters verzameld, dankzij bijdragen van RVZ-schepen. Uit deze monsters en genetische analyses uitgevoerd door Identigen bleek dat horsmakreel in gebied 27.4.a volledig tot de Westelijke component behoort, terwijl ongeveer 50% van de horsmakreel in gebied 27.7.d ook van Westelijke oorsprong is. Het aantal beschikbare monsters was echter onvoldoende om jaarlijkse schattingen van verdeling te maken.

2. Biologische bemonstering – Makreel gonaden onderzoek (2.2)

Het beheer van het makreelbestand is afhankelijk van een ICES-beoordeling die om de drie jaar verzamelde gegevens over eiproductie gebruikt als indicator voor de paaibiomassa (SSB). Tijdens de ei-surveys hadden onderzoeksschepen echter moeite om voldoende volwassen makrelen te vangen voor vruchtbaarheidsanalyses, wat leidde tot minder nauwkeurige paaibiomassaschattingen. Aan boord van RVZ-schepen worden makrelen commercieel gevangen, en sommige werden gebruikt om te testen of monsters verzameld door de RVZ konden bijdragen aan vruchtbaarheidsschattingen als input voor de SSB-indices. In tegenstelling tot onderzoeksschepen moeten commerciële schepen monsters invriezen in plaats van ze in formaldehyde te bewaren, een methode die niet is toegestaan aan boord van vissersschepen. Op basis van bevindingen uit 2023, waarin afwijkingen in invrieseffecten werden vastgesteld, zijn in 2024 317 monsters verzameld, waarvan er 142 zijn geanalyseerd. De eerste resultaten suggereren dat invriezen invloed heeft op het tellen van eieren in vergelijking met bewaring in formaldehyde. De impact lijkt echter beperkt, en de ingevroren monsters waren van voldoende kwaliteit om de vruchtbaarheidsstudie te ondersteunen.

3. Akoestiek van schepen – PelAcoustic AI (3.1)

Commerciële akoestische gegevens worden routinematig verzameld aan boord van trawlers voor wetenschappelijke doeleinden. Wageningen Marine Research heeft deze gegevens verwerkt om biomassa schattingen te genereren. Hoewel de automatiserings-software voor het verwerken van akoestische gegevens, gebaseerd op machine learning-technieken, is voltooid, vereist deze afzonderlijke ‘training’ voor elke soort. Goede resultaten zijn behaald voor blauwe wijting, terwijl de training voor haring en horsmakreel nog aan de gang is. Verwerkte akoestische gegevens, gecombineerd met milieu-indicatoren zoals temperatuur, zijn gebruikt om voorspellende modellen voor visdistributie tijdens het visseizoen te ontwikkelen. Deze modellen helpen bij het verminderen van de kans op bijvangst van ongewenste vissoorten. Daarnaast is een dashboard ontwikkeld waarmee schippers hun visactiviteiten en akoestische metingen in tijd en ruimte kunnen visualiseren.

3. Akoestiek van schepen – Kalibratie (3.2)

Drie schepen zijn in 2024 gekalibreerd. Voor een van de schepen vond de kalibratie plaats bij de Tweede Maasvlakte om voldoende diepte onder het schip te garanderen voor de kalibratieapparatuur. De kalibratie van de andere twee schepen was mogelijk in de haven van IJmuiden en waren allebei succesvol. Er is geen zelfkalibratie uitgevoerd door een vierde schip vanwege haar activiteiten buiten EU-wateren. Echter, verschillende schepen verzamelden akoestische gegevens van een zeebodemtransect in de Nederlandse EEZ voor kalibratiedoeleinden. Analyses werden uitgevoerd door WMR om deze gegevens te analyseren en kalibratie-aanpassingen voor te stellen op basis van de verzamelde gegevens. Een analyse door WMR gaf bovendien aan dat inter-scheepskalibratie mogelijk is voor RVZ/PFA-schepen, gezien het feit dat sommige schepen op de visgronden correct zijn gekalibreerd met behulp van kalibratiesferen.

3. Akoestiek van schepen – Sonar (3.3)

Sonargegevens zijn verzameld door Wageningen Marine Research aan boord van het onderzoeksschip Tridens om te beginnen met het testen van de analyse van sonargegevens van commerciële schepen. Het was nog niet mogelijk om het werk op commerciële schepen te starten, en voortzetting van dit project wordt voorgesteld voor 2025.

4. Camera monitoring

In 2024 zijn acht extra GoPro-camerasystemen geïnstalleerd op verschillende schepen in de RVZ/PFA-vloot. De zogenaamde ‘Trawlviewer-kits’ bestaan uit externe behuizingen voor 2 lampen en 1 GoPro-camera en kunnen op veel verschillende posities in of aan de buitenkant van het visnet worden gemonteerd. Deze camera's zijn gebruikt om het gedrag van vissen in het net en de werking van selectiviteitspanelen te identificeren. Twee soorten Trawlviewer-kits worden door de schepen gebruikt: één die opereert in ondieper water tot een diepte van 250 meter en één die werkt op diepten groter dan 250 meter (diepzee-Trawlviewer-kit), die ook geschikt zijn voor de blauwe wijting- en Grote zilversmelt visserij (één tot 250m systeem en twee >250m systemen zijn aangeschaft onder het Wetenschappelijk Quotum Project). Ook is er een nieuw ontwerp gemaakt voor de Trawlviewer-kit die een stuk sterker en robuuster is dan de eerdere versies.

Een softwarepakket om het proces van het samenvoegen van GoPro-opnames en het verwijderen van ongewenste beelden, zoals het uitzetten van het net, te automatiseren is ontwikkeld door WMR. De training van het AI-model is nog gaande en vereist aanzienlijke hoeveelheden beeldmateriaal die door de schepen worden verzameld. Het beeldmateriaal wordt eerst opgeslagen op harde schijven aan boord van de schepen en daarna geüpload naar een beveiligde Azure-cloud en gedeeld met WMR voor verdere analyse.

5. Automatische meting

Het effectief en efficiënt meten van zowel de lengte als het gewicht van individuele vissen kan waardevolle inzichten bieden in de conditie van vissen in verschillende gebieden en seizoenen. Hoewel de lengtebemonstering al is geïmplementeerd binnen RVZ, is de handmatige combinatie van lengte- en gewichtsmetingen te arbeidsintensief gebleken. In 2020 heeft RVZ de ontwikkeling gestart van een apparaat voor automatische gewichts- en lengtemeting van vissen dat op een schip kan worden ingezet. In 2024 hebben tests van het apparaat geleid tot verbeterde algoritmen voor het schatten van de vislengte. Na afrondende tests bleek het apparaat zeer nauwkeurig te zijn in zowel lengte- als gewichtsmetingen en is het nu geschikt voor routinematige zelfbemonstering aan boord van de schepen.

Er wordt ook gewerkt aan innovaties om het vetgehalte van vis te meten met behulp van cameratechnieken. Vetgehalte is een goede indicator van de algemene lichaamsconditie, die van invloed is op belangrijke kenmerken zoals overleving, groei en reproductie. Door gebruik te maken van spectrale camera's wordt het vetgehalte van vis extern gemeten, wat andere apparatuur of chemische analyses overbodig maakt. Deze methode is effectief gebleken voor makreel. Tests in 2024, voortbouwend op resultaten uit 2023, hebben aangetoond dat de huid van haring de lichttransmissie waarschijnlijk belemmert. Hierdoor worden waarschijnlijk nauwkeurige vetmetingen beperkt. Vetmetingen van haring zonder huid toonden zeer vergelijkbare resultaten als voor makreel. Huidige analyses richten zich op het ontwikkelen van methoden om vetgehaltes nauwkeurig te schatten voor haring en horsmakreel met hun huid intact.

In 2023 is videomateriaal verzameld van makreel op een transportband om individuele tellingen en volume direct in de visfabriek te schatten. Het beschikbare materiaal was echter onvoldoende om AI-modellen te trainen, die grote hoeveelheden data vereisen. Om dit probleem op te lossen is een 3D-model van makreel ontwikkeld, waarmee via computersimulaties voldoende gegevens worden gegenereerd om het AI-model effectief te trainen.

6. Verminderen van bijvangst

Incidentele bijvangst wordt wereldwijd erkend als een belangrijke bedreiging voor grote mariene soorten. Een gebrek aan kennis over soortspecifiek gedrag en de grote variatie in visserijpraktijken in verschillende gebieden en seizoenen vormt echter een obstakel voor de ontwikkeling van effectieve mitigatietechnieken. Dit project, geleid door RVZ in samenwerking met een Europees consortium van wetenschappers, industrievertegenwoordigers en beleidsmakers, richt zich op het aanpakken van deze uitdagingen. In 2024 werden verschillende belangrijke activiteiten uitgevoerd, waaronder individuele gesprekken met schippers over bijvangst, kwartaalbijeenkomsten met schippers, wetenschappers, nettenmakers en uitgenodigde experts om best practices te bespreken, en observaties op zee om potentiële bijvangstsituaties te bestuderen. Daarnaast werden technische mitigatiemaatregelen onderzocht, zoals akoestische signalen (pingers), ontsnappingspanelen en haaienafweermethoden. Deze activiteiten zijn gecoördineerd met andere pelagische industrieën in Europa om maximale effectiviteit te bereiken.

Schippers meldden dat de georganiseerde sessies zeer nuttig waren, wat leidde tot een toename in het testen van nieuwe netontwerpen. Diverse ontwerpen van ontsnappingspanelen en haaienafweermethoden werden getest, en pingers worden nu algemeen gebruikt in de vloot. Het gebruik van deze apparaten wordt geregistreerd in de M-Catch-software. Daarnaast is een eerste versie van een soortenidentificatiegids gedeeld met de schippers, evenals een meer uitgebreide soortenidentificatieboek.

7. Verbetering van welzijn

Er is een groeiende interesse in het verbeteren van het welzijn van vissen tijdens visserijactiviteiten op zee. Dit vereist echter een balans tussen verschillende welzijnsindicatoren, zoals het minimaliseren van beschadigingen aan vissen vóór de verwerking (om ze geschikt te houden voor menselijke consumptie) en het implementeren van individuele, diervriendelijke verdovingstechnieken. Er is echter beperkte kennis over deze aspecten. Zodoende zijn tijdens de haringvisserij proeven uitgevoerd om de invloed van zuurstofconcentraties in het net en de variabiliteit in visconditie bij het pompen aan boord te onderzoeken. De conditie van vissen werd ook gemonitord tijdens opslag in vistanks om eventuele trends beter te begrijpen.


RESCUE

3. 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
- Sampling biological characteristics of fish species that improve stock structure definitions and provide insight into fish condition
- Using vessel acoustics for stock trends and fish behaviour
- Using advanced sensors to automate fish measurements
- 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. As RVZ, we are annually submitting an integrated request for the utilization of (Dutch) scientific quota. We report on the outcomes in this integrated document. In 2024, a request for scientific quota was submitted and evaluated. Details on the projects are presented in the sections following this overview.

1. Self-sampling the pelagic fleet
2. Biological sampling
3. Acoustic sampling
4. Camera monitoring
5. Automatic measurement
6. Reducing bycatch
7. Increasing welfare

4 Research projects

4.1 Self-sampling the pelagic fleet

The self-sampling program for pelagic fishing, initiated in 2014, has become a cornerstone for integrating pelagic fishing into scientific research. Today, self-sampling data is widely utilized for various purposes, including stock assessments, MSC certifications, and analyses of the spatial and temporal distribution of different species.

4.1.1 Self-sampling and quality control

Figure 4.1.1 shows the trips covered through the self-sampling program where trips in which both haul and length sampling took place are given in darker green compared to haul registered self-sampled trips in lighter green.

Figure 4.1.1. Overview of self-sampled trips in 2024 from the Dutch flagged vessels in EU waters.

In total, close to 200 trips were self-sampled in 2024 with a total of over 6500 hauls and over 375.000 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.

Table 4.1.1 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
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	250	2,914	6,797	498,864	0.65%	231,343	4,965
2023	19	213	2,586	6,502	495,374	0.31%	277,074	1,918
2024	17	194	2,610	6,526	503,617	1.01%	376,337	605
(all)		1,374	18,743	45,216	3,397,621		2,063,755	17,239

4.1.2 Maintaining and development of self-sampling software

All haul data was recorded using the M-Catch software, while length data continued to be documented using Excel-based templates. In 2024, maintenance of the M-Catch software was carried out, alongside further development and testing of the length registration and biological sampling modules.

To support these efforts, two dedicated sessions were held between Quality Managers (QMs) and the software developers (EFICE). These sessions led to the creation of a test version, which was tested on several RVZ vessels. Feedback from the QMs highlighted the need for additional modifications to the software. This feedback was incorporated in 2024, and the final version of the software is scheduled for release in early 2025.

Figure 4.1.1. Sessions between EFICE and QMs to develop and test the length-measurement component in M-Catch.

For each of the self-sampled trips, a report was send to the vessel company and the vessel to report back on the information provided for research purposes. Working documents had been prepared for HAWG, WGDEEP, WGWIDE, SPRFMO, CECAF, the ICES benchmark on horse mackerel and the ICES benchmark on mackerel which included relevant information on the fishery and the sampling of the fishery.

4.1.3 Storing self-sampling data

All self-sampled data, including acoustics and camera footage, was stored securely at the Azure cloud storage.

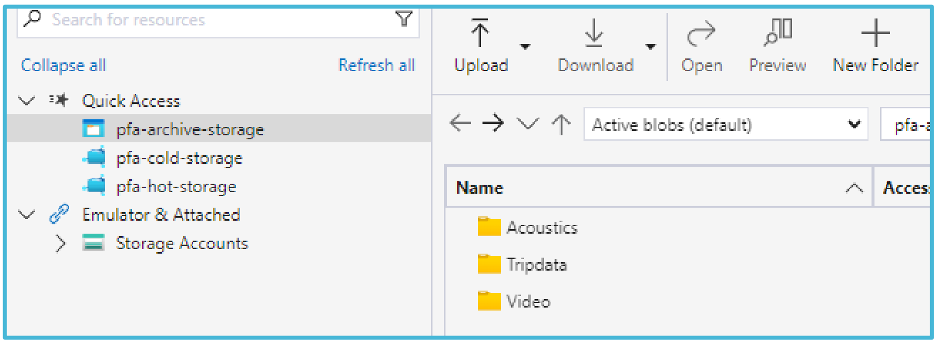


Figure 4.1.2. Azure storage account holding back-ups of self-sampled trip, acoustics and video data

4.1.4 Standardized approaches for use of self-sampling data in stock assessment

To make optimal use of the length data collected by the RVZ, a translation of length to age is needed. The market sampling executed by WMR was used for this purpose and standardized scripts were developed to convert length samples from the RVZ. This lead to a new raised length distribution of the total catch for mackerel (See figure 4.1.3) for the years 2019-2023. The routines developed will be used to annually provide ICES with updated catch-at-age data.

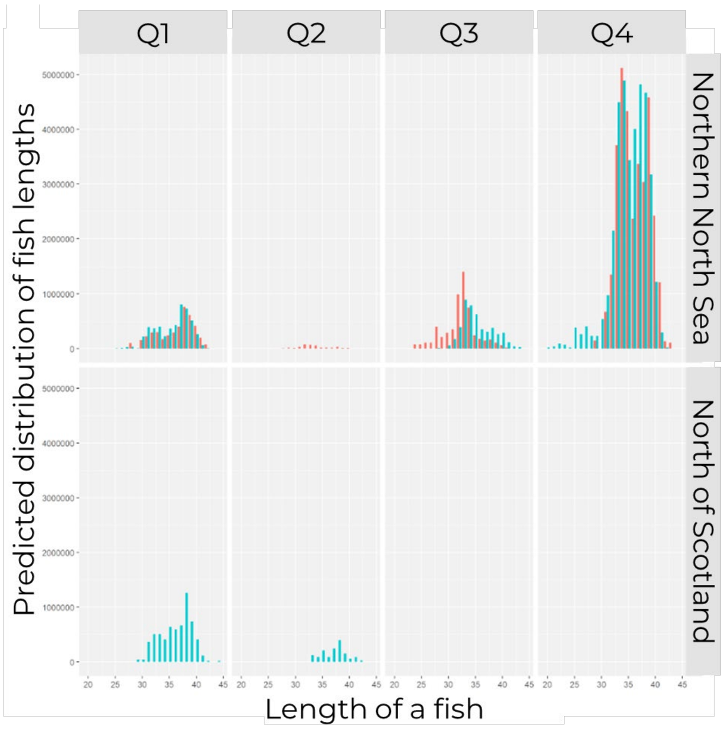


Figure 4.1.3. Comparison of original raised length distribution for mackerel based on WMR market sampling (red) and the raised length distribution based on WMR and PFA sampling (blue) for 2023.

4.1.5 Development of stock assessment models

In 2023 the development of a spatial-and-temporal stock assessment model was initiated (and expected to be completed by 2025). In 2023, development focused on the spatial modelling. In 2024, the development focused on incorporating a length- and growth-based extension (i.e. the temporal aspect). The primary objective was to ensure alignment between age- and length-based selectivity, so that age-specific fishing mortality rates correspond directly to length-based mortality rates at the lengths associated with those ages (Figure 4.1.4). Initial tests of the model are presented in Figure 4.1.5.

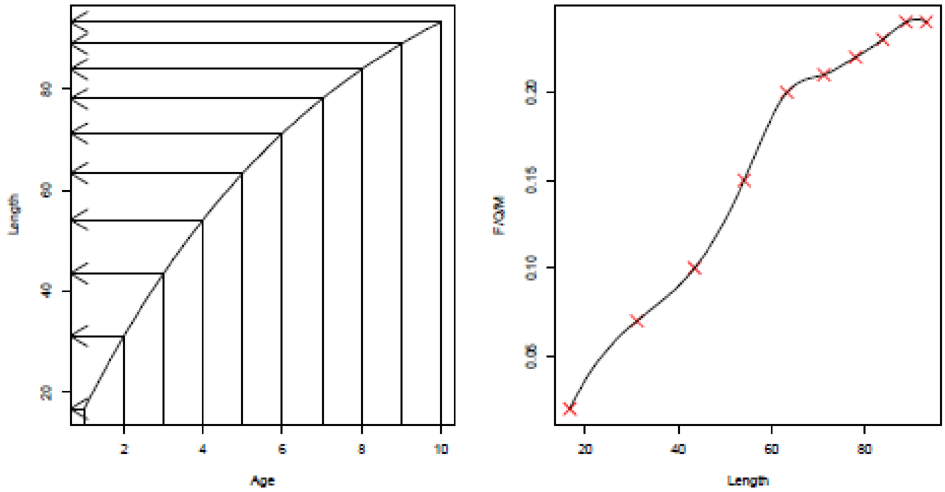


Figure 4.1.4: Definition of length-based selection functions: The left frame shows an example of a growth curve and how ages map to lengths. The right frame illustrates how the length-based selection is defined from smoothing between a number of points with lengths defined from the growth curve.

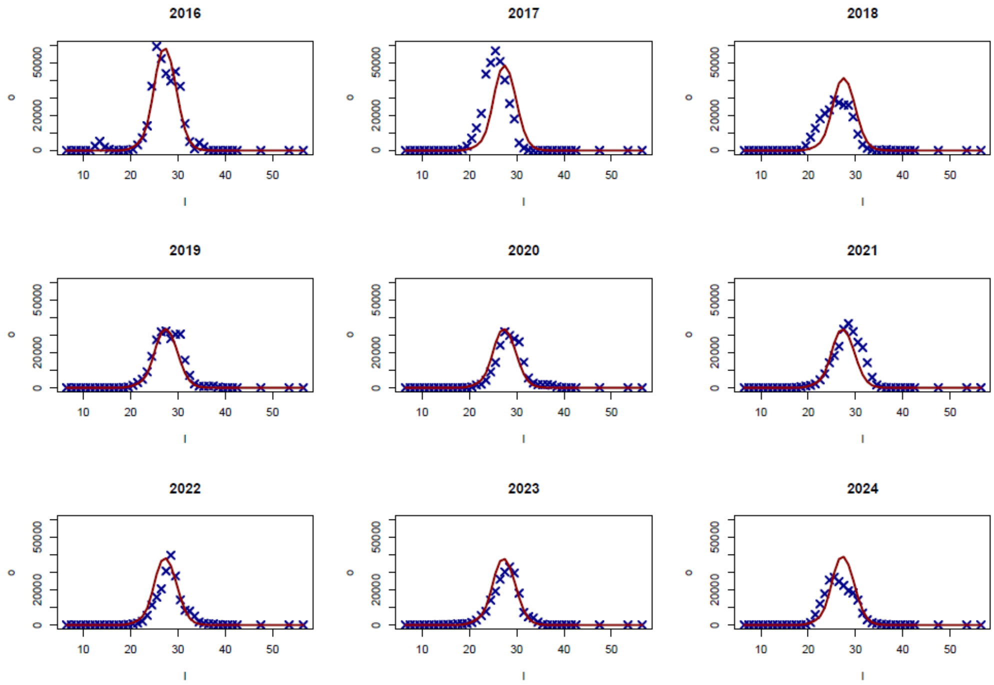


Figure 4.1.5. Observed (x) and predicted (red solid line) length distributions in the length-based catch per unit effort index for North Sea herring.

4.1.6 Documenting fishers knowledge

In 2024, the RVZ initiated the systematic collection of fishers' knowledge through structured interviews with skippers and first or second mates. Wageningen Marine Research (WMR) designed a structured interview guide, while the RVZ conducted the interviews. The initial results were analysed collaboratively by WMR and RVZ.

Based on these findings, WMR updated the interview guide, and additional interviews were conducted following the revised format. In total, 19 interviews were completed, covering topics related to Norwegian Spring Spawning herring, blue whiting, North Sea herring, horse mackerel, and mackerel. Observations included anomalies in searching behaviour, haul duration, catch efficiency, bycatch, environmental conditions, and gear innovations.

4.2 Biological sampling

4.2.1 Horse mackerel genetic research

For many years, the stock structure of horse mackerel in the Northeast Atlantic has been a topic of debate. It was originally believed that the North Sea stock predominantly occupied the English Channel and the central North Sea. However, recent genetic analyses have revealed significant stock mixing in the Channel area and indicated that horse mackerel found north of Spain and Portugal belong to the Western component. These insights were made possible through genetic research conducted up to 2023. In 2024, six additional samples were collected from the mixing area in the Channel and the southern North Sea (see Figure 4.2.1.1 for an overview of the location of these samples). These samples, along with others gathered in previous years, were analysed for stock identification.

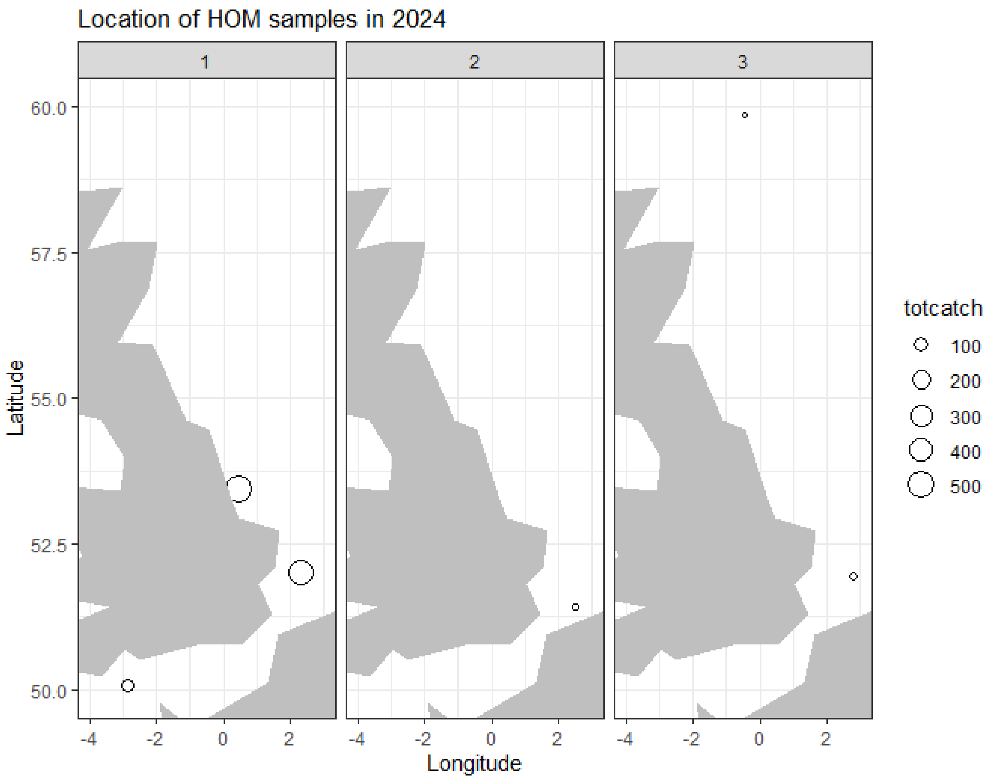


Figure 4.2.1.1 Location of HOM samples collected in 2024.

The genetic data analyses culminated in a working document that was presented at the ICES benchmark on horse mackerel. Figure 4.2.1.2 illustrates the predicted proportion of North Sea horse mackerel based on all samples collected over the years.

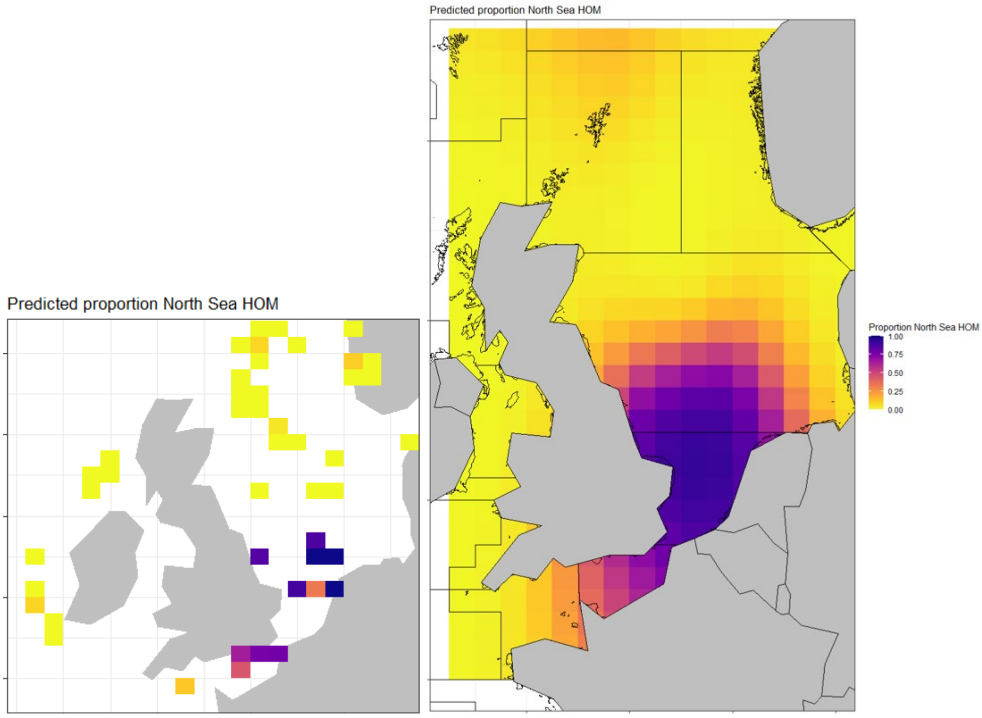


Figure 4.2.1.2 Left: Predicted proportion by ICES rectangle of North Sea horse mackerel sampled areas. Right: Smoothed predicted proportion of North Sea horse mackerel from the statistical model fitted to the genetic data.

The results were used to re-define the ICES stock boundaries for these stocks (assigning area 27.4.a to the Western component) and assessment models were updated accordingly. For area 27.7.d no annual degree of mixing could be estimated given the low number of samples taken and hence stock boundaries were maintained for this area.

4.2.2 Mackerel gonad research

The management of the mackerel stock is based on ICES assessments, which rely on triennially collected data on egg production as an indicator of the spawning biomass (SSB) of the stock. However, during the egg survey, participating research vessels faced challenges in catching enough adult fish for fecundity analyses, leading to reduced accuracy in the SSB calculations for mackerel. Onboard RVZ vessels, mackerel are caught for commercial purposes, and some were used to test whether samples collected by the RVZ could contribute to fecundity estimates as input for the SSB indices. A significant difference between commercial vessel operations and research vessels is the need to freeze samples onboard commercial vessels instead of preserving them in formaldehyde. This study evaluates the impact of freezing on fecundity analyses. Of the 317 samples collected in 2024, 142 were processed for analysis (see Figure 4.2.2.1).

Figure 4.2.2.1. Collection of gonad from mackerel

10 samples from the pool of 142 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 4.2.2.2). Overall, analyses for the years 2022-2024 indicate similar patterns in the results.

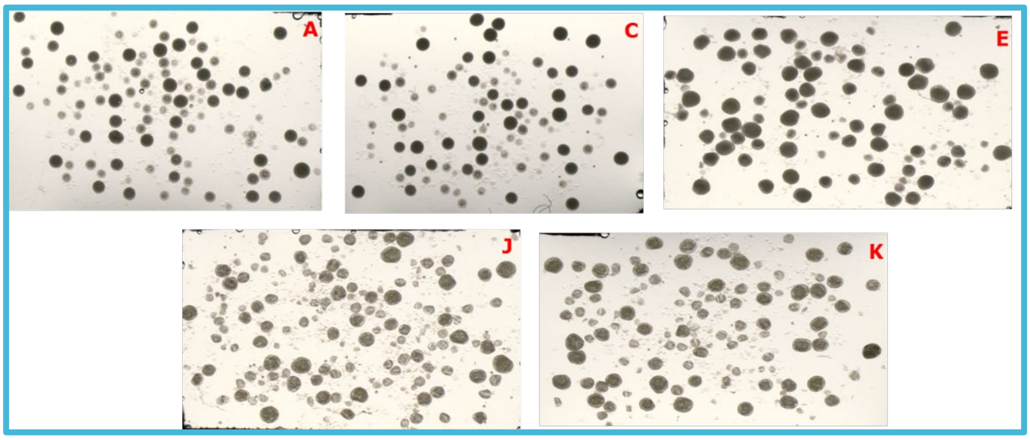


Figure 4.2.2.2 Oocyte images using (A) the normal pipet sample with formaldehyde, (C) with Biopsafe formaldehyde, (E) dry sample in tube, (J) sample taken after freezing first followed by fixation in formaldehyde and (K) sample taken after freezing first followed by fixation in Biopsafe formaldehyde.

When the type of medium or fixation method (formaldehyde, Biopsafe, or freezing) has no significant impact, the distribution of oocyte diameters should remain nearly identical, allowing for some variation due to the sampling of new oocytes from the same gonad. Figure 4.2.2.3 illustrates that methods A, C, and E yield reasonably similar diameter distributions, whereas methods J and K deviate significantly. The total number of oocytes was consistent across methods A, C, E, and J. These findings will be presented to the ICES working group on mackerel and horse mackerel eggs for discussion, with a decision to be made on how to proceed based on the observed discrepancies.

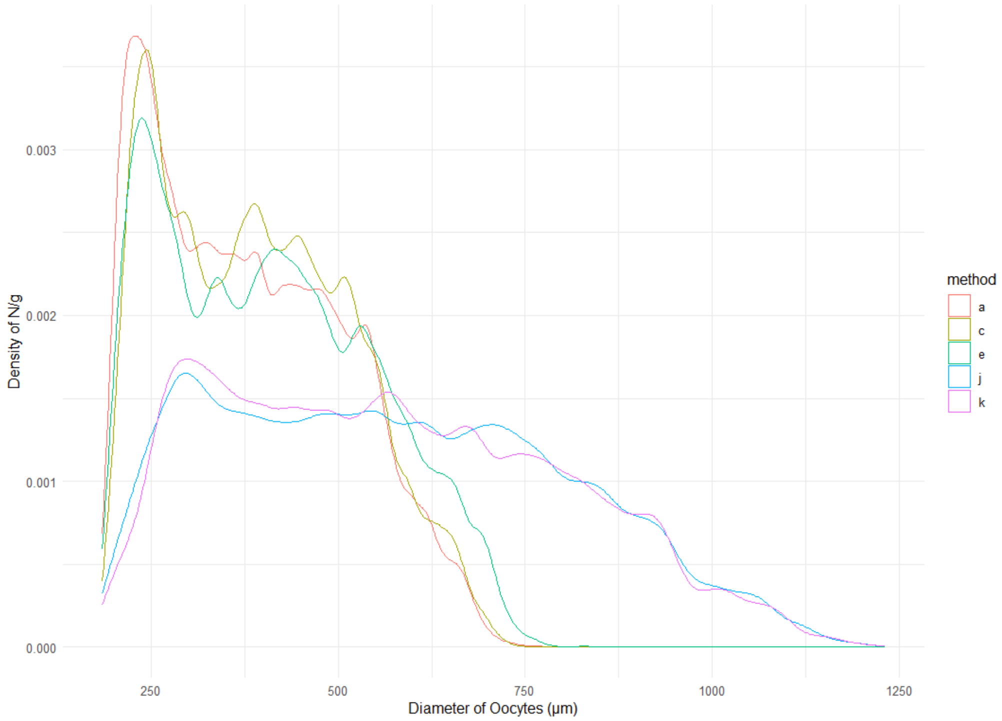


Figure 4.2.2.3. Distribution of Oocyte diameters for the different methods of storing the samples.

4.3 Acoustic sampling

In 2024, acoustic data was collected aboard all RVZ vessels operating in EU waters, representing a significant expansion compared to previous years. The logistics of data collection are considerable, requiring crew members to record and process data onboard, hard drives to be routinely collected, data to be uploaded to secure cloud services, and hard drives to be returned to the vessels to ensure continuous recording. As a result, the information available to the projects below increased substantially in 2024. However, the larger data volume also necessitates longer processing times.

4.3.1 PelAcoustic AI

4.3.1.1 Software development

The development of the software package for automatically analysing acoustic files from fishing vessels has continued from previous years. In 2024, significant progress was made in refining the Python packages and scripts. The software for automated data processing is now finalized, resulting in further annotated data from blue whiting trips conducted between 2022 and 2024. These annotations encompass the full range of data available for the period 2016–2024.

The machine learning (ML) algorithm, based on a Convolutional Neural Network (CNN), underwent additional fine-tuning in 2024. This included the implementation of a data sampling scheme for ML training (Figure 4.3.1.1), as well as enhancements to the ML model's parameterization and customization.

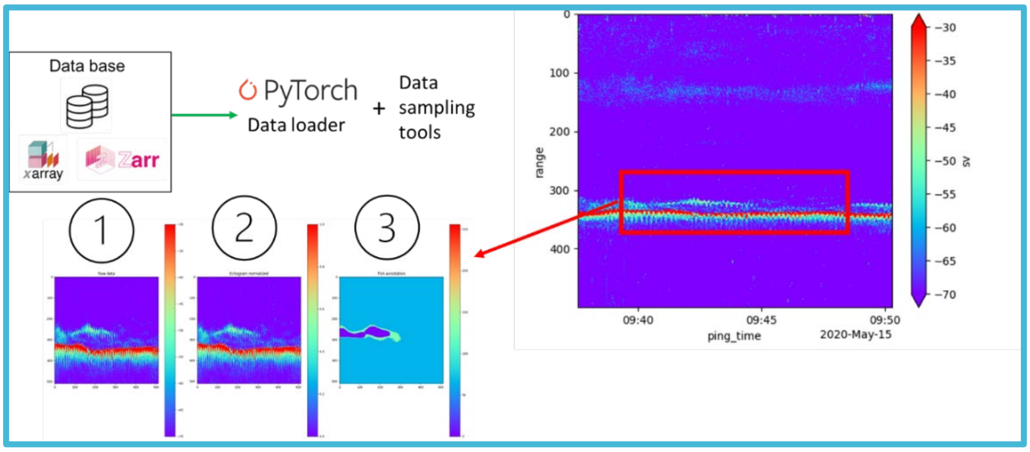


Figure 4.3.1.1 Pipeline for the sampling of data to input the learning process of the convolution neural network. From the database with data converted into multi-dimensional arrays, the data sampling takes the raw (1), normalizes it (2) and links annotations to it (3). The pipeline is fully python based.

The initial models were trained on large datasets and demonstrated promising performance, clearly differentiating between fish biomass, noise in the water column (e.g., plankton), and the seabed. The performance of the machine learning (ML) predictions closely matched manually annotated data, showing a strong resemblance. Automatically annotated data was subsequently converted into biomass estimates for each 'ping' obtained from the acoustic equipment, often down sampled to a signal per 1 nautical mile. However, for this data to be effectively used in stock assessments, further processing was required to address issues such as the double counting of fish biomass, which is common when targeting specific resources. To tackle this, a survey design method (the "synthetic transect method") was developed in 2022–2023, though it required refinement and additional testing. The initial approach reduced the data to randomly placed, equally spaced transects, but this method struggled to capture the full spatial complexity of observations from fishing vessels.

In 2024, an alternative method was developed to overcome these limitations. It assumed that fishing vessels consistently target high-density central areas, resulting in repeated cross-sectional movements across fish schools. This behaviour generates a recognizable pattern in acoustic recordings: a peak density as the vessel crosses the aggregation centre, followed by a drop (trough) as it moves away, and another peak when it encounters a new high-density zone. A peak detection procedure was implemented to identify these high-density aggregation patterns. The data was then smoothed using a Loess smoother, with detected peaks segmented and converted into spatial densities on a gridded raster. When the fisheries acoustic data processed using this method was compared to the research survey on blue whiting, the two datasets showed a very close relationship (see Figure 4.3.1.2).

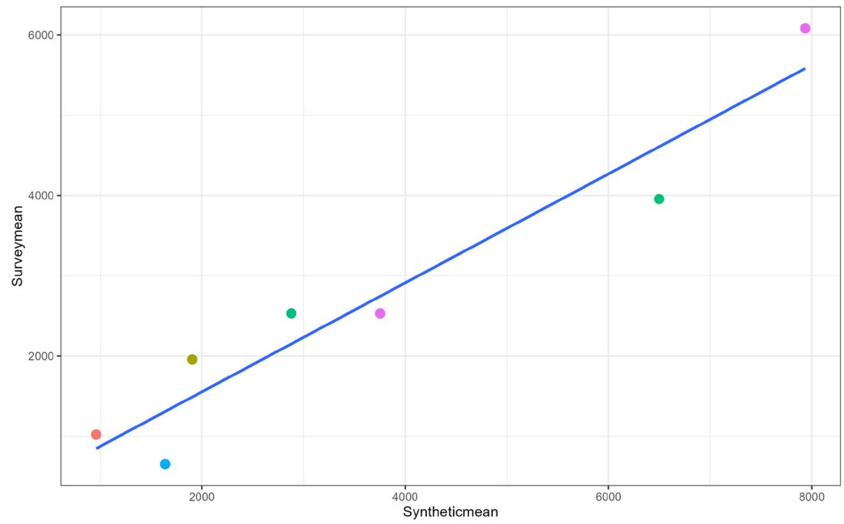


Figure 4.3.1.2. Survey vs fishing vessel data compared using transect method where the fitness was optimized by testing different parameters. Dots represent biomass estimates for different years while the blue solid line indicates their relationship with predicted biomass estimates.

Next, we evaluated whether focusing solely on predefined high-density areas, rather than the full distribution area, would yield similar stock dynamics over time. This assumption was validated for the International Blue Whiting Spawning Stock Survey (IBWSS), simplifying the validation of methods developed in this study. High-density fish aggregation areas (hotspots) were identified by setting yearly acoustic backscatter thresholds and applying kernel density estimation (KDE). Persistent hotspots were determined by overlaying yearly maps and identifying grid cells that consistently met the threshold. These persistent hotspots were further refined, compared with the full IBWSS survey data for biomass representation, and analysed over time to monitor trends relative to the overall population. Figure 4.3.1.3 illustrates the difference in stock trends, revealing that trends observed in the hotspots are closely aligned with those derived from the full survey data.

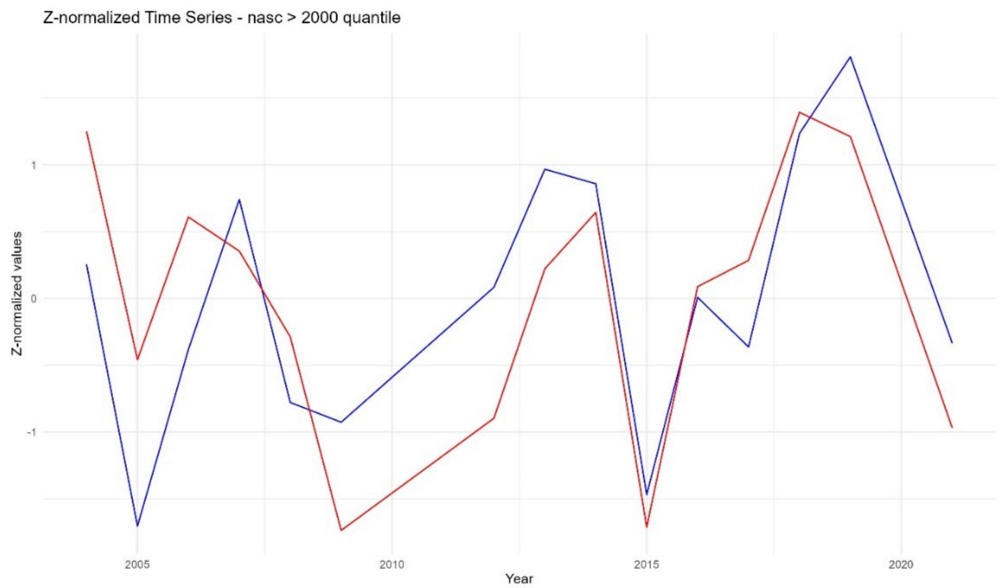


Figure 4.3.1.3. Population size trends from IBWSS survey data (Red line) versus a smaller subset of data defined as hotspot within a fixed spatial section (Blue line). The values transformed as Z score and the results show that smaller subset show the trends in population density similar to the full survey.

When comparing hotspot data with data from fishing vessels, it was found that for fishing vessel data to serve as a reliable indicator of overall population density trends, the spatial overlap must reach at least 40%. Within the existing dataset from 2016 to 2023, only the data from 2019 met this coverage criterion (updates for 2024 data are pending). Despite this limitation, the finding is significant as it provides valuable guidance for future data collection efforts. Specifically, it helps determine how to allocate resources effectively, including which fishing grounds to prioritize, which vessels to involve, and the optimal timing for data collection.

4.3.1.2 Fish mapping

Fish mapping was further advanced in 2024 by integrating acoustic data and developing three additional models: one using commercial (RVZ) acoustic data, another using scientific (ICES) acoustic data, and a third combining both datasets. The models underwent two types of validation:

1. Internal Validation: Testing whether each model could accurately predict fish presence using data similar to what it was trained on. For instance, does the catch model accurately predict the presence of species in catches?
2. External Validation / Generalization: Evaluating whether a model trained on one type of data (e.g., catch data) could accurately predict the presence of species in a different dataset (e.g., acoustic surveys).

The model based solely on catch data scored very low on accuracy, often over-predicting fish biomass and assuming fish presence almost everywhere. In contrast, the acoustics-based model performed significantly better, particularly in predicting the absence of fish. However, it still showed too many instances where fish presence was incorrectly assumed. When the commercial and acoustic datasets were combined, model performance improved dramatically, achieving accuracy levels beyond human capabilities (over 80%), demonstrating the complementary strengths of these data sources.

Table 4.3.1.1. Key results for catch based model

Model training dataset	Predicted dataset	Accuracy	Precision
Catch data (RVZ)	Catch data	96	96
	Acoustics (scientific)	63	40
	Acoustics (commercial)	53	34
	Acoustics (commercial + scientific)	7	50

Table 4.3.1.2. Key results for acoustics based model

Model training dataset	Predicted dataset	Accuracy	Precision
Acoustics (scientific)	Acoustics (scientific)	97	96
Acoustics (commercial)	Acoustics (commercial)	87	73
Acoustics (commercial + scientific)	Acoustics (commercial + scientific)	99	56

Table 4.3.1.2. Key results for combined model

Model training dataset	Predicted dataset	Accuracy	Precision
Acoustics (scientific)	Catches	72	81
Acoustics (commercial)	Catches	45	42
Acoustics (commercial + scientific)	Catches	82	82

4.3.1.3 Dashboard

A dashboard has been developed to share acoustic data and fisheries self-sampled data with fleet managers and skippers. This dashboard, implemented as a Shiny App (see Figure 4.3.1.4), enables users to upload catch and acoustic (NASC) data and customize the analysis. Users can filter the data based on fishery type, specific vessels, date ranges (years/months), and gridding settings.

The dashboard provides powerful visualization tools. For instance, NASC data can be overlaid with catch data, as shown in Figure 4.3.1.4. Additionally, the length distribution associated with these catches is displayed in the bottom panel of the interface. The app also allows users to generate various maps and works through a standard browser, enabling multiple tabs to be opened and compared side by side to track changes in the environment or fishery over time. Several environmental datasets have been integrated into the dashboard, including sea surface temperature, bathymetry, wind force observations, and temperature at fishing depth. These features make the dashboard a comprehensive tool for monitoring and analysing fisheries data.

Figure 4.3.1.4. Illustration of dashboard for blue whiting fishery overlaying acoustic backscatter (NASC) with catch and length frequency information.

Figure 4.3.1.5. Illustration of dashboard for blue whiting fishery overlaying wind force data with catch and haul duration information.

4.3.2 Calibration

The RVZ is actively involved in acoustic data collection to enhance the knowledge base on fish stocks and improve stock management practices. For the acoustic data collected by commercial trawlers to be scientifically valid, echosounders must be calibrated. This calibration ensures that echosounders measure absolute scattering levels rather than relative measurements, which is critical for scientific applications. Echosounder calibration typically involves the use of specific target spheres, a process that is time-consuming and often impractical aboard commercial vessels. Although calibration trials have been conducted on numerous vessels in the PFA fleet, several echosounders remain uncalibrated. Additionally, it is considered best practice to update calibration values regularly. Three key calibration activities are presented here. First, the results of three new sphere calibrations conducted aboard PFA trawlers are reported, along with a summary of recent sphere calibration trials. Second, an alternative calibration method using seabed echoes was developed, tested, and used to derive proxies for calibration gains. Third, the feasibility of calibrating vessels during fishing trips was explored using selected datasets.

4.3.2.1 Sphere calibration

Figure 4.3.2.1.1 shows the coverage of the sphere calibrations for a first vessel (3-4th of January 2024), the second vessel (3rd of June) and the third vessel (13th of June). Calibration of the first vessel took approximately 1.5 days including steaming in and out of the Tweede Maasvlakte harbour. The calibration for the other two vessels took 1 and 2 days respectively but no vessel compensation is requested from Scientific Quota as all activities could be carried out while the vessels were in harbour. There was a delay in departure for the third vessel due to the difficulties in calibrating the vessel.

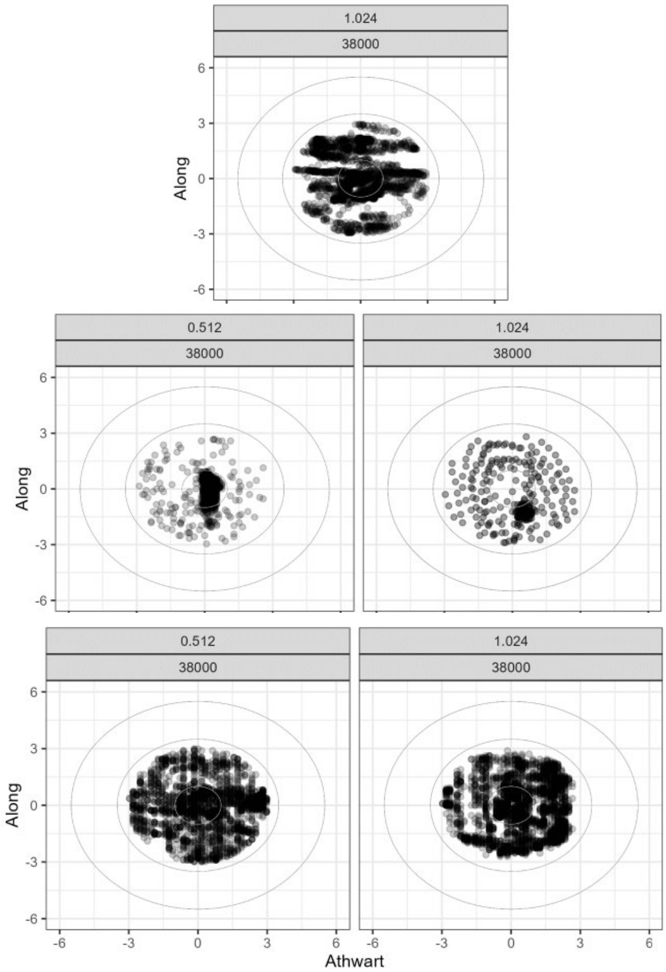


Figure 4.3.2.1.1. Calibration coverage from the calibration trial on-board the three vessels.

These calibrations, together with the calibration results of previous years resulted in a correction factor as given in Figure 4.3.2.2.

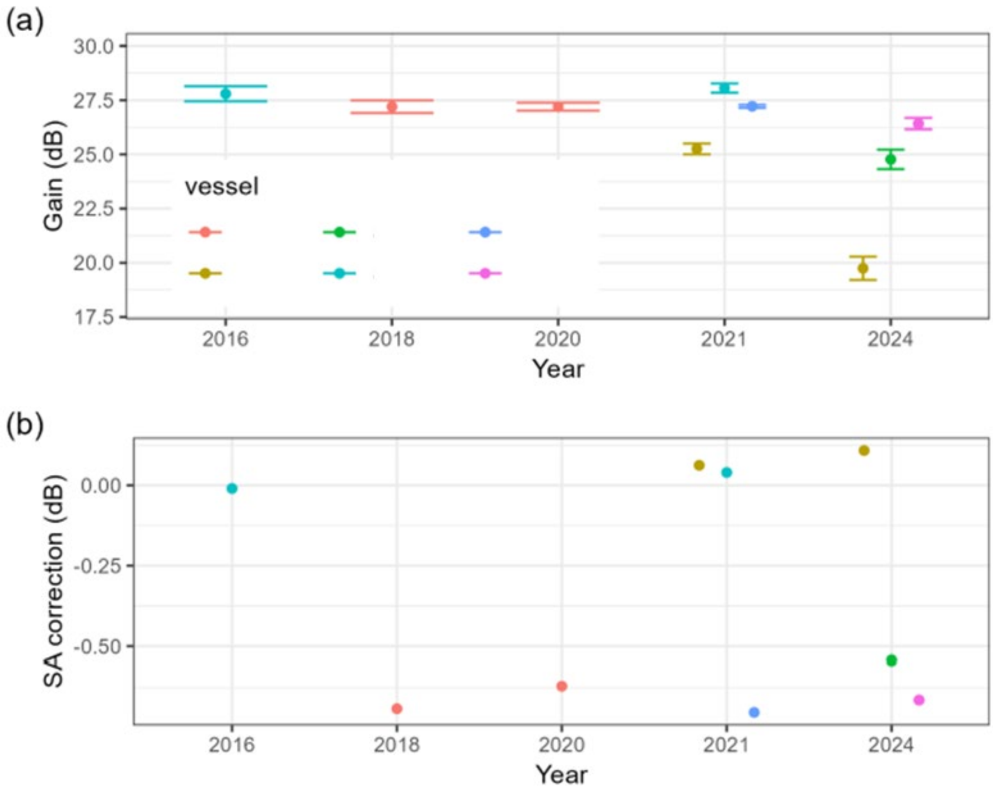


Figure 4.3.2.1.2. Summary of sphere calibration performed on-board RVZ vessels

4.3.2.2 Seabed calibration

An alternative method for calibrating vessel echosounders involves using seabed echoes relative to a reference vessel following a predetermined track. This approach can enhance the quality of data collected onboard fishing vessels (FVs) by providing proxies for calibration gain for uncalibrated echosounders and tracking changes in calibration gain over time, which can help identify potential malfunctions. However, it is important to emphasize that alternative calibration methods cannot replace the standard sphere calibration method, which remains the most accurate calibration technique under optimal at-sea conditions. Instead, calibrating vessels against seabed echoes should be viewed as a complementary approach to sphere calibration. For this purpose, a flat, sandy, and geologically stable region in the southern part of the North Sea (53.20° to 53.55°N and 3.08° to 3.26°E) was identified as an ideal calibration site.

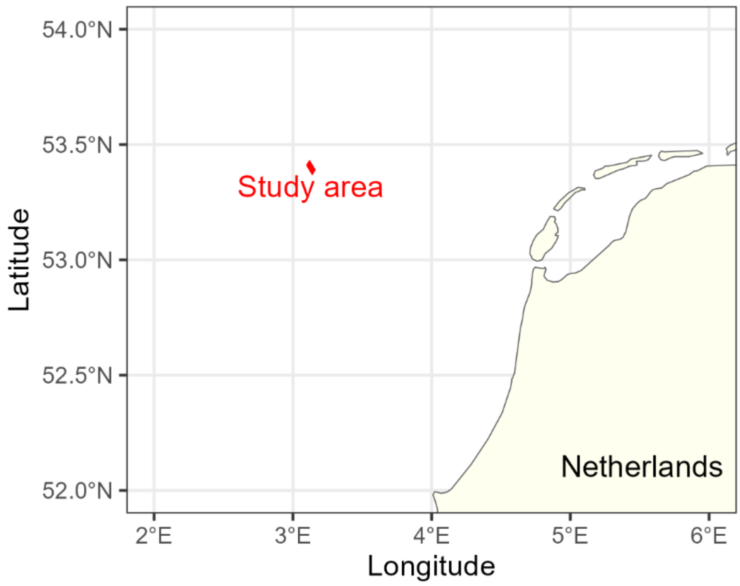


Figure 4.3.2.2.1. Location of the study area

This region exemplified good repeatability of acoustic measurements over time because this transect matches the passage of FVs to northerly fishing grounds. To calibrate the vessels, skippers were asked to pass through the region with a constant speed of 10 knots and an echosounder ping rate of 1.024ms. It is known that the backscatter for different types of seabed is very variable alongside composition (e.g. grain size for sandy seabed).

Results from several vessels over several years were used to analyse the accuracy of seabed calibration. The research vessel Tridens was used as a reference (Figure 4.3.2.2.2).

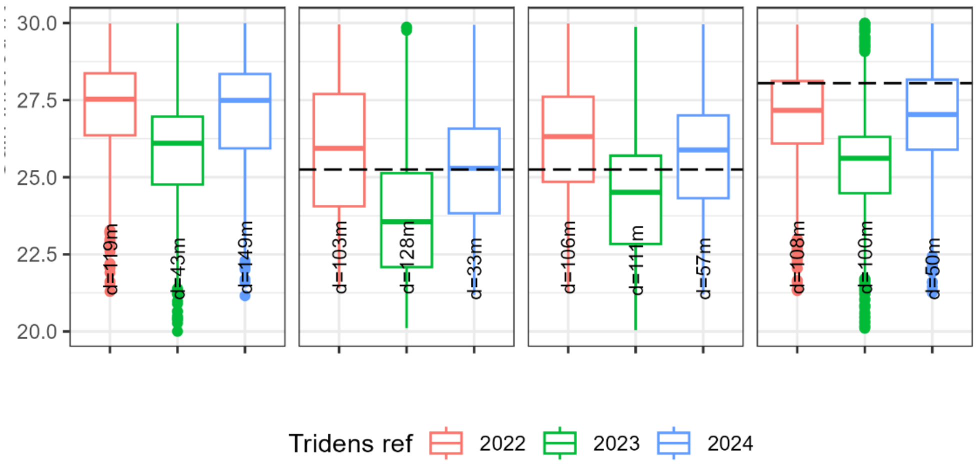


Figure 4.3.2.2.2. Seabed inferred calibration gains for the different FVs. Calibration gains are computed using three reference sets from Tridens, collected in 2022, 2023 and 2024. For each instance, the mean distance between the FV data and the reference set are given. Different panels refer to different fishing vessels.

4.3.2.3 Inter-vessel calibration

The first step in comparing the echo levels of fish schools involves spatial grouping based on point density. The results of this process are presented in Figure 4.3.2.3.1. Each point represents a labelled fish school, with colour coding indicating the different datasets under consideration. This analysis revealed significant overlap of fish schools between datasets within two specific polygons, notably polygons 1 and 14.

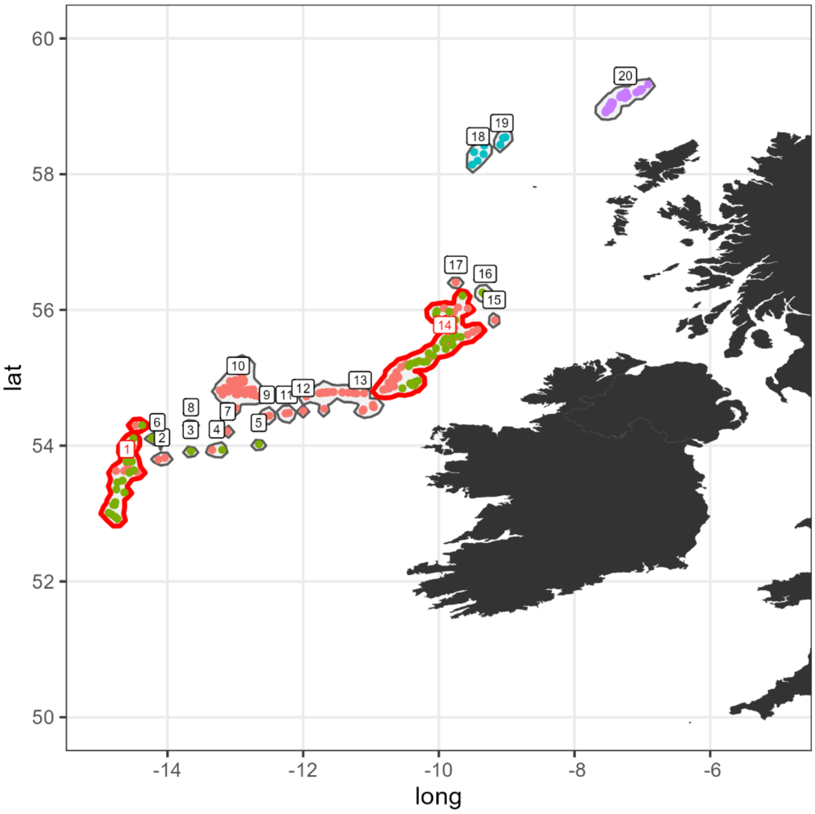


Figure 4.3.2.3.1. Map of fish schools recorded by two separate RVZ vessels. The polygons highlighted in red (number 1 and 14) are those that exemplified significant overlap in fish school between two separate data sets.

A zoomed-in view of polygons 1 and 14 is provided in Figure 4.3.2.3.2, clearly illustrating the overlap between the datasets. In polygon 1, the overlap is concentrated in the northern section, while the southern part contains fish schools observed by only one vessel. In contrast, polygon 14 shows a more uniform spatial distribution between the two datasets. The resulting distributions of mean Sv (μ) values are shown in panel B. For polygon 1, there is a 1.3 dB difference in the mean Sv value, likely due to the lack of coverage in the southern area. For polygon 14, the mean Sv (μ) values are nearly identical (-59.6 dB). This comparison, conducted across more than 30 fish schools for each vessel, ensures the robustness of the analysis.

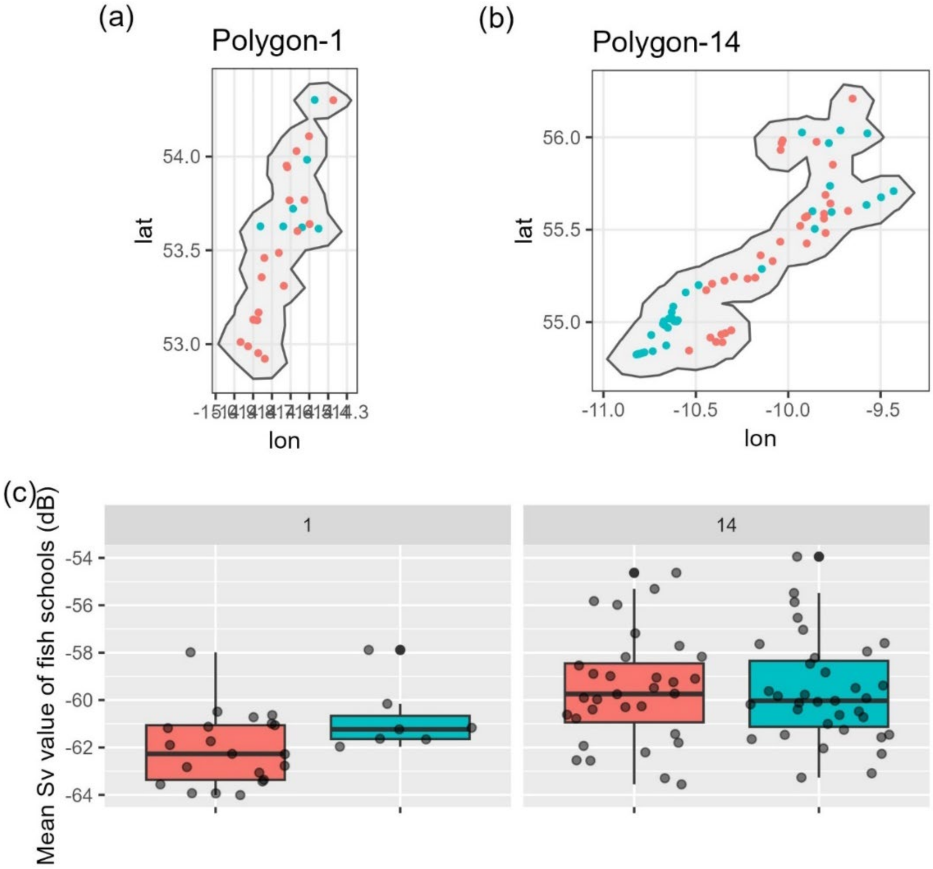


Figure 4.3.2.3.2. comparison between the fish school data collected by the RVZ vessels during the Blue whiting fishery. The comparison is made for the two polygons that presented significant presence by the two vessels, i.e. polygons 1 and 14, as shown in (a). The comparison for the distributions in mean Sv (μ) is shown in (b) for both polygons.

Based on all calibration activities, it is recommended to perform sphere or seabed calibrations every five years and conduct annual vessel cross-calibrations.

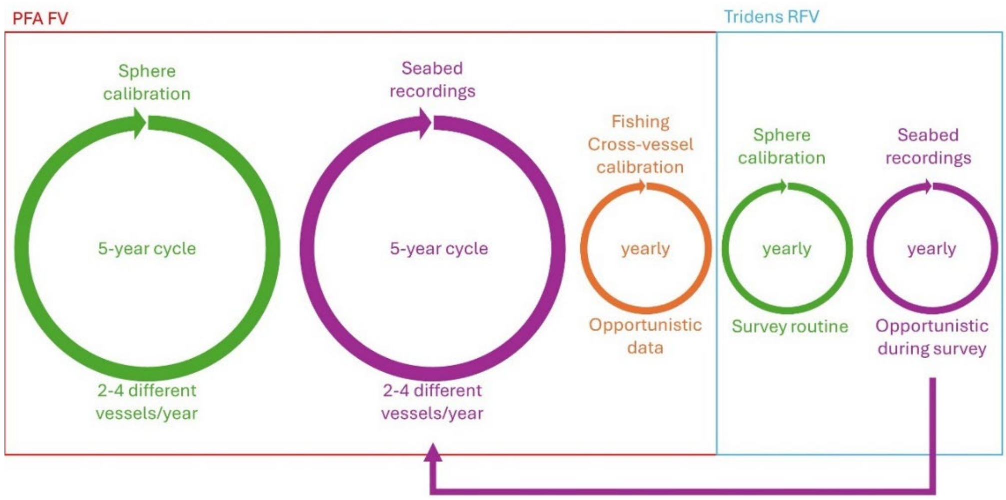


Figure 4.3.2.3.3. Schematic of a tentative strategy for the fleet-wise calibration of RVZ vessels. The vision is over a 5-year cycle, involving measurements onboard RVZ FVs and RFV Tridens.

4.3.3 Sonar

In 2024, WMR explored the potential of using omnidirectional sonar onboard commercial fishing vessels to better understand the migration behaviour of blue whiting. A long-term objective of this initiative was to collaborate with the commercial fishing industry and establish standardized routines for data collection across various vessels. The first step involved a pilot trial, conducted aboard the Tridens during the International Blue Whiting Survey, to assess the feasibility of data collection and to develop protocols for large-scale implementation. The pilot focused on testing different sonar settings, evaluating their effects on data quality, and generating insights to inform the development of generic protocols for fishing vessels. As planned, data collection was carried out during the survey by testing these settings and observing their impact. While the trial provided a better understanding of potential issues and the effects of different configurations, the overall results were less beneficial than anticipated. This limitation arose due to the nature of the fish aggregations, which appeared as continuous layers rather than distinct individual schools, making them unsuitable for tracking with sonar. As a result, extracting key information—such as migration direction and speed—was not feasible. Consequently, the requested scientific quota was not used for a detailed analysis of this dataset.

4.4 Camera monitoring

Using underwater camera techniques provides valuable insights that can support more selective fishing practices, improve understanding of fish behaviour, and evaluate gear performance—for example, enabling unwanted bycatch to escape. In 2024, RVZ vessels successfully captured underwater footage at multiple locations within fishing nets across various fisheries.

4.4.1 Trawlviewer kit development and testing

In 2024, an additional eight vessels in the RVZ/PFA fleet were equipped with Trawlviewer kits (TVKs). While only one of these is part of the Scientific Quota project, all footage collected is used to enhance knowledge of fish behaviour and gear design. The primary limitation of these systems is their depth rating, as they are restricted to depths of up to 250 meters. Therefore, two vessels were equipped with deep-sea camera units capable of operating at depths of up to 2000 meters. A complete overview of the setup is provided in Figure 4.4.1.

Figure 4.4.1. Deep Sea Trawlviewer kit for two lights and one GoPro unit.

A new design for the trawlviewer kit was developed by 3Dshapes and is shown in Figure 4.4.2. The new design is no longer 3D printed but shaped from a solid block of POM plastic. This plastic is considered the most robust type of plastic available and should withstand substantial impacts.

Figure 4.4.2. New design of the Trawlviewer kit.

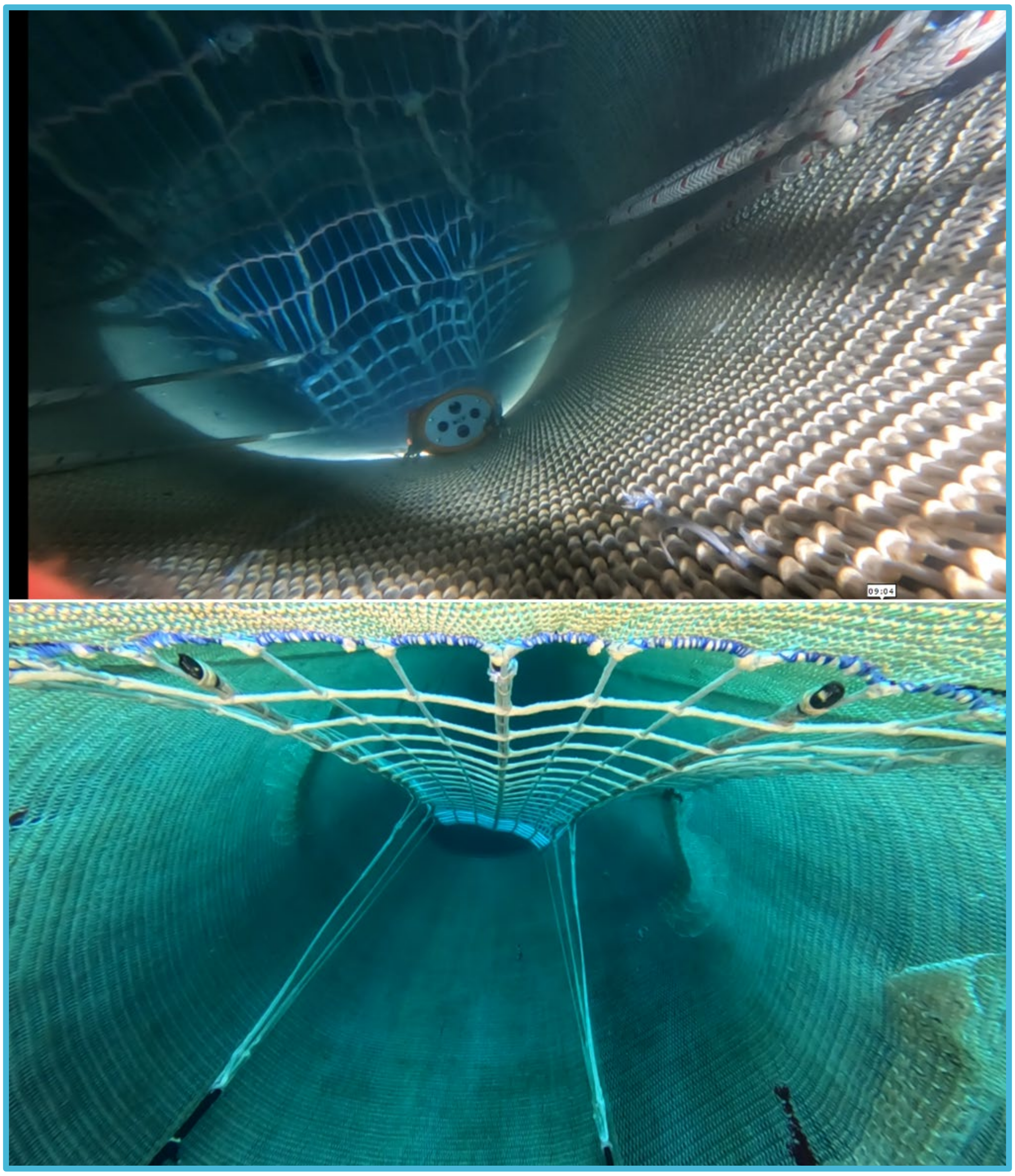


Figure 4.4.3. Stills of video footage made with the Trawlviewer kits.

4.4.2 Processing of footage

In 2024, nearly 4000 gigabytes of footage were collected by the vessels and are currently being analysed by Wageningen Marine Research to identify anomalies in catch composition. To streamline this process, computer vision technology is being implemented to automate the evaluation, making the review faster and more efficient. As part of this effort, an automated by-catch-release detector module was developed. During the project's first phase, a simple Graphical User Interface (GUI) was created to apply the detector module, enabling the stitching of collected footage. This development marks a significant step forward in improving the efficiency of the video data collection process (see Figure 4.4.4). The stitching process is seamless and highly efficient, significantly accelerating video analysis.

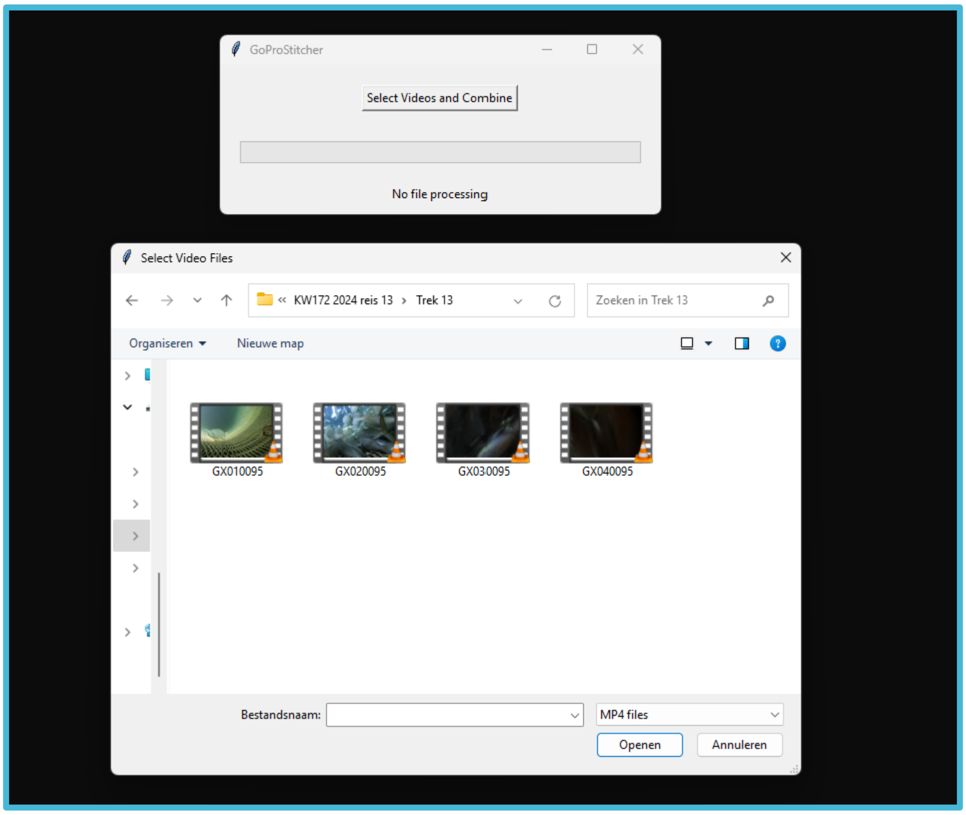


Figure 4.4.4. GUI to stitch video fragments together.

In the second phase of the project, the automation of data processing was further enhanced through the development of a Convolutional Neural Network (CNN) capable of isolating video frames of interest. The inherently rare occurrence of bycatch presents a challenge for training the neural network. To train the network effectively, fragments of footage containing incidental bycatch must be identified and isolated, a process that is both time-consuming and labor-intensive. Additionally, for the analysis of video footage, images must be reconstructed in a simplified format that retains all essential information. This reconstruction process is illustrated in Figure 4.4.5.

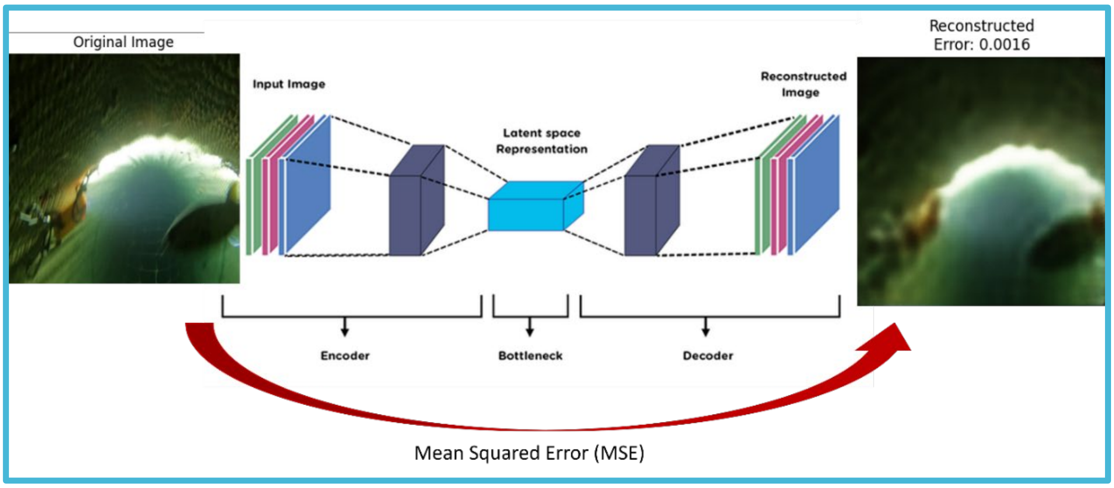


Figure 4.4.5. Process of analysing video footage.

4.5 Automatic measurement

4.5.1 Length-Weight measurement system

Effectively and efficiently measuring both the length and weight of individual fish can provide valuable insights into fish condition across different areas and seasons. While the additional measurement of lengths has already been implemented within the RVZ/PFA, the combined manual measurement of both length and weight has proven too labour-intensive. In 2020, the RVZ initiated the development of a demonstration version of a device for automatic weighing and measuring of fish, designed for deployment on vessels. In 2024, the system was installed on one of the vessels to conduct weight measurements (Figure 4.5.1.1). Initial results demonstrate near-perfect accuracy in weight measurements.

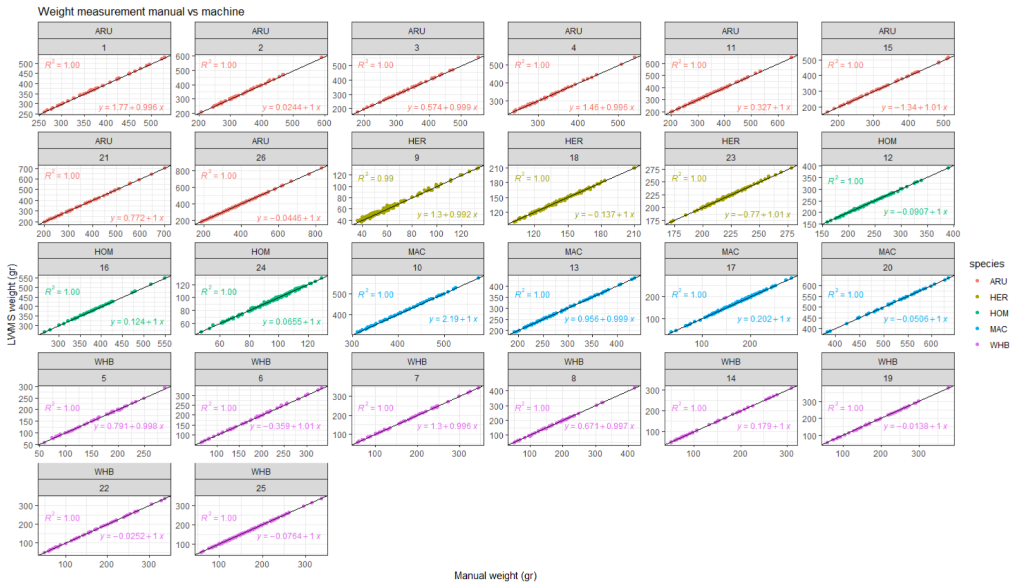


Figure 4.5.1.1. Overview of 26 weight measurements by the LWMS machine and a separate scale.

Subsequently, the system was relocated on land to focus on refining length measurements by improving the visual component of the process. The refinements specifically targeted the measurement of the fish tail, resulting in the development of three distinct options: Tip Length (TL), the average of Tip and Tail Length (TLAVG), and Tail Length (TLtail) (see Figure 4.5.1.1).

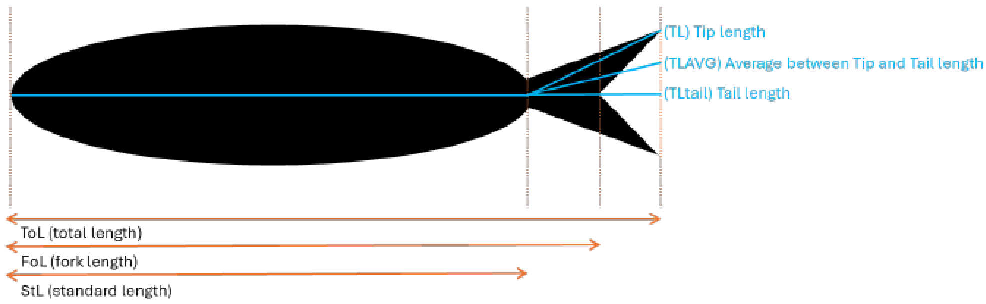


Figure 4.5.1.2. Overview of different length measurement standards.

To verify the performance of the Length and Weight Measurement System (LWMS) for length measurements, three trials were conducted on June 18th, October 10th, and November 12th. During these trials, hand measurements were performed by two experienced RVZ employees and compared to the machine's measurements. The results indicate that for the five main target species of the RVZ vessels, the machine provides highly accurate fish length readings.

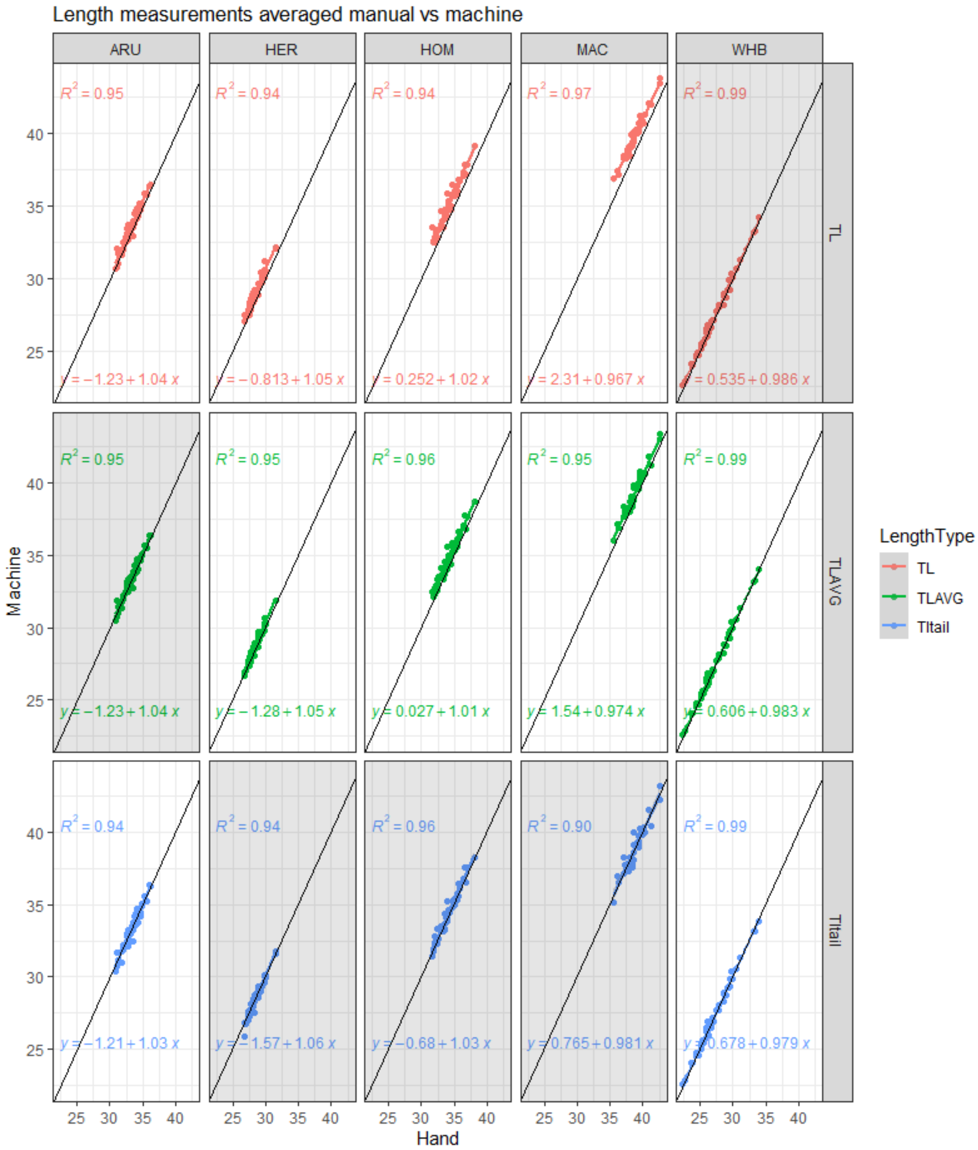


Figure 4.5.1.3. Overview of hand vs machine length measurement for five different fish species taking three different length measurement types. Grey boxes indicates the selected length measurement for the fish type.

Based on these results, it was concluded that the development of the LWMS is complete. RVZ companies are now encouraged to adopt these machines for use on their vessels.

4.5.2 Fish fat and volume estimation

In 2023, it was determined that mackerel could be accurately measured for fat content using a spectral camera. However, similar results were not achieved for herring and horse mackerel. Consequently, another study was conducted in 2024 to analyse fat measurements using the spectral camera, both with and without the skin, and compare these results with those obtained using the Distell fat meter. Figure 4.5.2.1 illustrates the process undertaken during the 2024 trial. The procedure involved taking fat measurements with the Dorsett fat meter (yellow device), followed by skinning mackerel, horse mackerel, and herring for subsequent spectral imaging. In total, 32 individuals of each species were measured both with and without their skin.

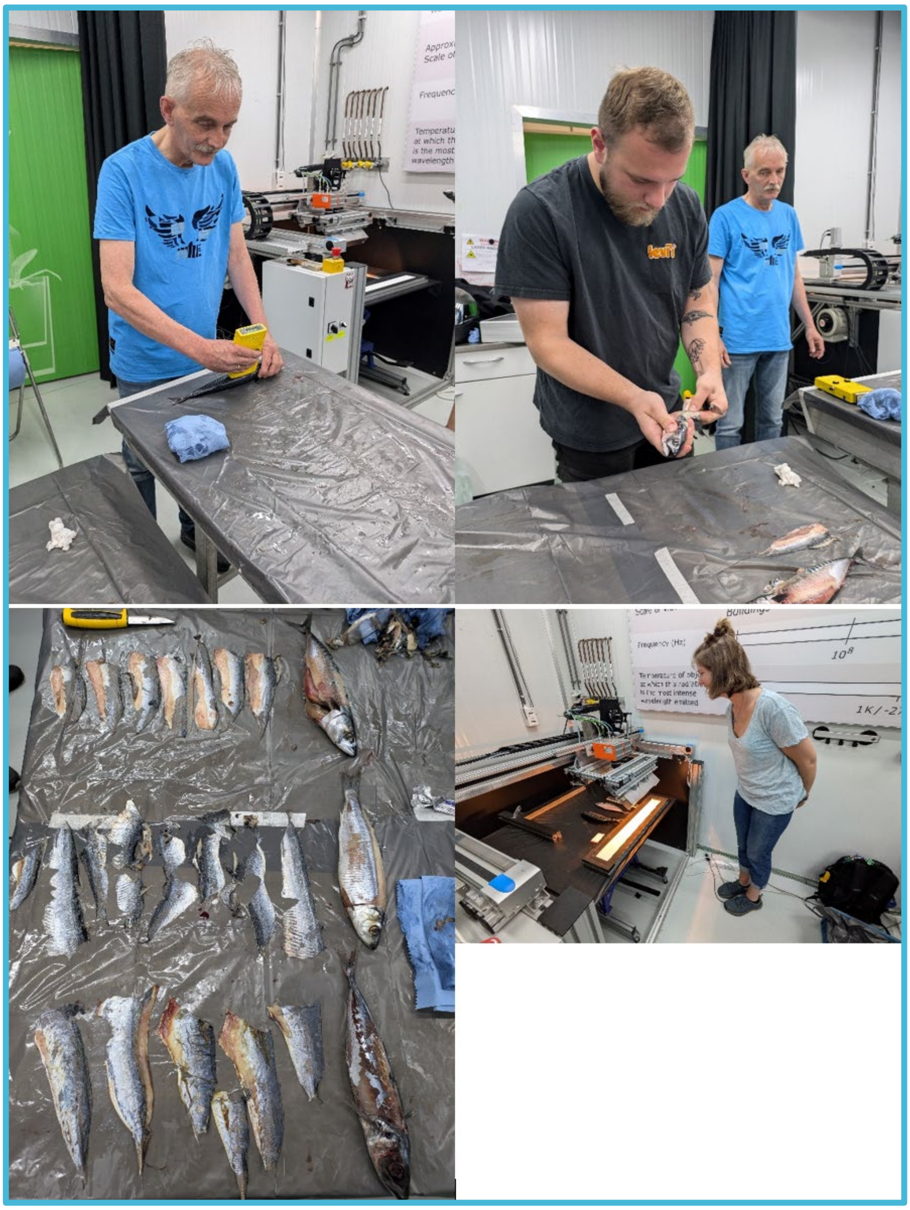


Figure 2.5.2.1. Top left: taking fat measurement with the Dorsett fat meter. Top right: removing the skin from the fish. Bottom left: skinned and fillets of the samples. Bottom right: spectral imagine of the fish.

Each fish was imaged twice using the spectral camera, once with the skin intact and once without. From the spectral images, the area used for fat measurement was marked, and any residual skin was identified and corrected for in subsequent analyses. Figure 4.5.2.2 illustrates the process of identifying the fat measurement area and detecting residual skin for further correction.

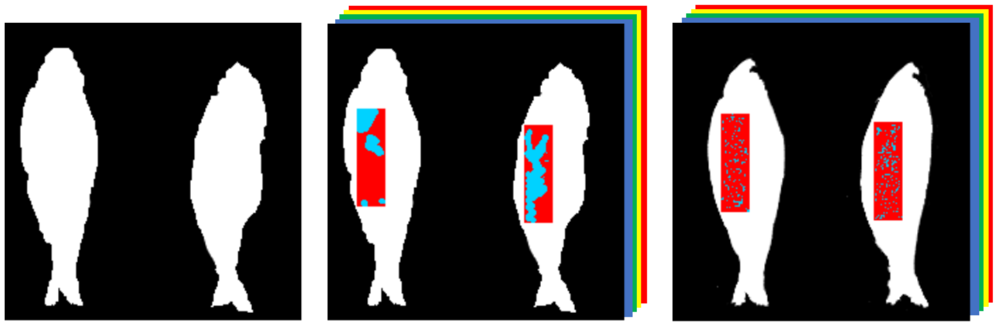


Figure 4.5.2.2. Spectral imaging workflow from the full spectral image on the left to the notation of the area of interest in red and the residual skin in blue in both the middle and right-hand panel.

Using Principle Component Analyses (PCA), the resulting spectra were analysed and showed that there was a market impact of skin on the results, especially for herring. When comparing the results of mackerel and herring for unskinned fish, it showed that the spectra were very similar.

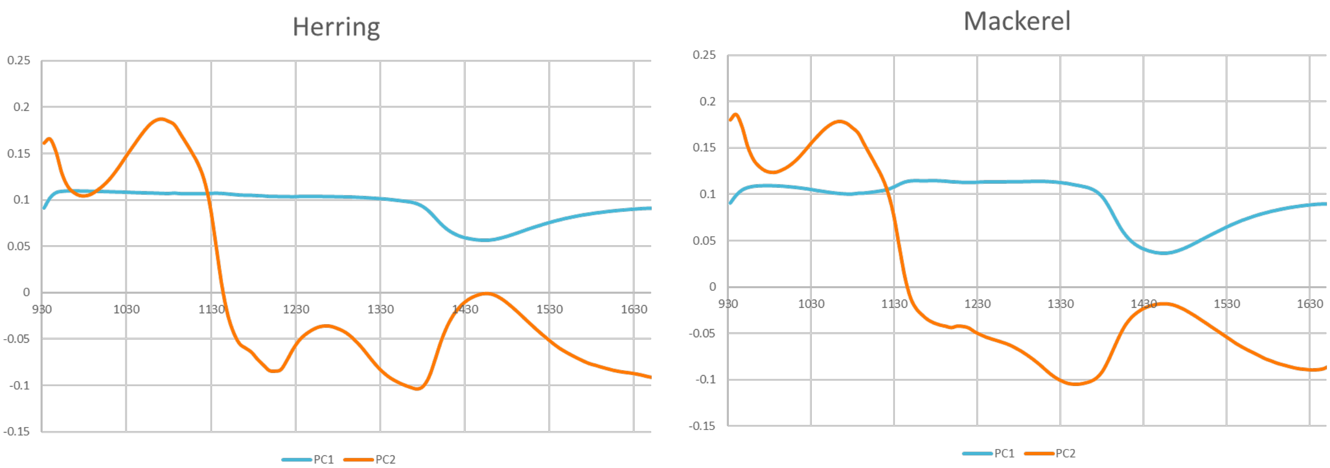


Figure 4.5.2.3. Resulting spectra from unskinned herring and mackerel for two axis of the PCA.

The results indicated that fish species could be accurately measured using spectral imaging. Ongoing analyses aim to determine whether the effect of skin on measurements can be reversed using the spectral data from the skin itself.

The initial goal for estimating fish volume was to account for both the number of individual fish and their sizes when placed on a conveyor belt, as used on Freezer Trawlers. However, this process is challenging because multiple fish can often be stacked on top of each other. In such cases, the focus shifts from counting individual fish to estimating the total volume. Accurate volume and size estimation requires training a computer model on data or actual footage of fish on a conveyor belt, where the exact numbers and sizes are known. Generating sufficient data for training would typically require weeks of manual effort. To overcome this limitation, a 3D model of mackerel was created, enabling the computer to render simulated fish on a conveyor belt in various stacked configurations as needed.

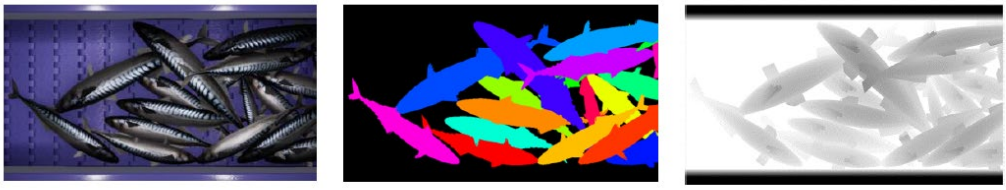


Figure 4.5.2.4. Generation of 3D model of mackerel on a conveyer belt (left), segmenting the fish into individuals (middle) and adding a field of depth (right).

The method was tested on 100 images containing one, two, and three layers of fish. The number of fish was underestimated by 11%, 14%, and 31%, respectively. A significant portion of this underestimation is likely due to the way the ground truth was determined: fish that were only partially visible in the camera frame were still counted as whole individuals. As a result, the baseline counts used for comparison were inflated, and this discrepancy needs to be accounted for in future analyses.

4.6 Reducing bycatch

The reducing bycatch project focussed on four different tasks in 2024.

4.6.1 Best practice skipper sessions

In the first task, skippers, representatives from gear manufacturers, and scientists convened to discuss progress in developing mitigation devices to reduce bycatch and to share insights from experiences in other countries. A total of four sessions were organized on February 6th (IJmuiden), June 18th (Scheveningen), September 17th (IJmuiden), and December 16th (Zoetermeer), with approximately 20 participants attending each event. Each session lasted around three hours and included presentations by invited speakers, such as Marije Siemensma from Marine Science & Communication, Claus Reedtz Sparrevohn from DDPO Denmark, and Jamie Macaulay from St. Andrews University. Discussions covered feedback on field trips conducted by RVZ, experiences with underwater cameras, and advancements in gear development.

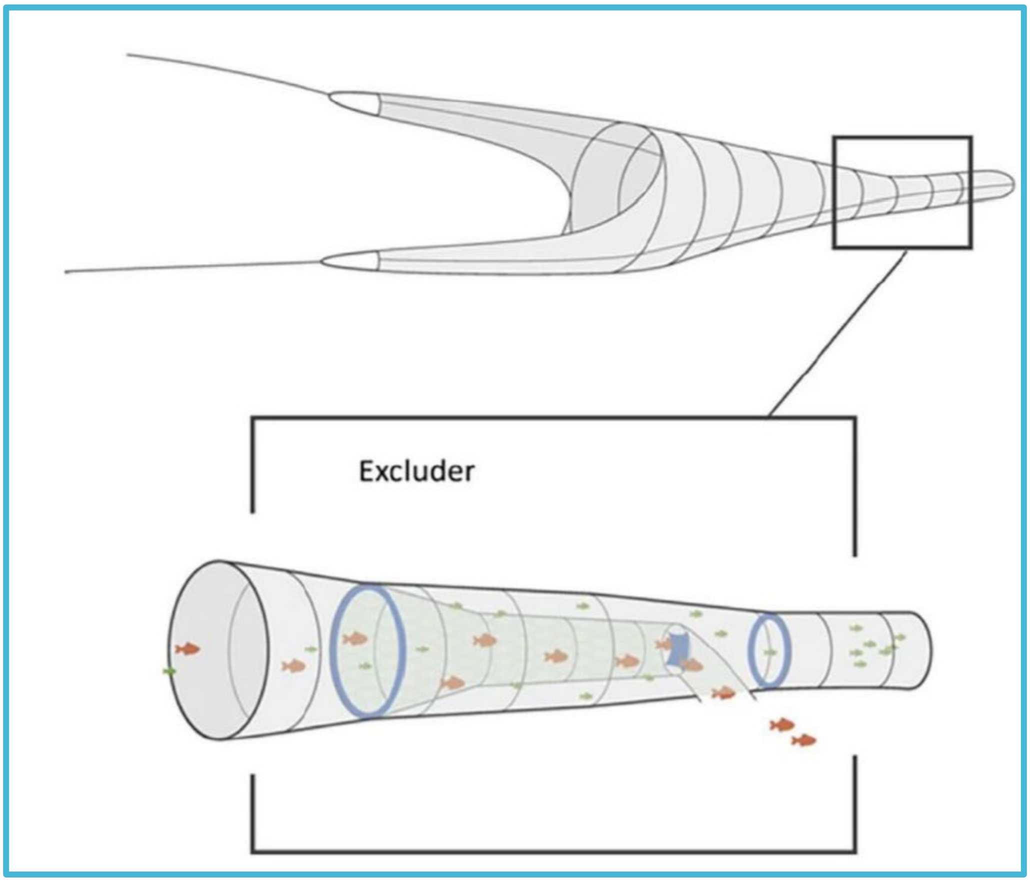


Figure 4.6.1. Illustration of the gear developments in Denmark as presented during the 2nd skipper session in 2024 by Claus Reedtz Sparrevohn.

Figure 4.6.2. Group of skippers, gear manufacturers, scientist and fleet managers discussing progress on reducing bycatch.

4.6.2 Knowledge exchange and international coordination

Knowledge exchange was facilitated by MPFF, which coordinated efforts across several key topics. These included stakeholder engagement strategies (five sessions, see Figure 4.6.3), data sharing strategies (six sessions), effort estimation of fishing activities (six sessions), bycatch estimation (three sessions, including one workshop), mitigation trials, and experiences with gear design and bycatch-repellent devices such as pingers. Collaboration extended to international partners, including the Killybegs Fishermen's Organisation, the Scottish Pelagic Fishermen's Association, and Danmarks Pelagiske Producentorganisation. These organizations, all involved in small pelagic fishing, coordinate their efforts quarterly to ensure timely sharing of trial results and successes. This collaboration also includes sharing experiences with using cameras and other sensors, such as oxygen and temperature sensors, to monitor fishing conditions. International coordination also took place on the development of species identification (ID) guides, exploring opportunities to utilize existing resources like Sharktrust guides. Additionally, MPFF organized several sessions for RVZ to discuss potential new tools, such as the use of sonar for bycatch detection, apps for monitoring bycatch events, and the possibility of hosting a skipper best-practice session at DanFish 2025.

Figure 4.6.3. Stakeholder session: paying a visit to a Pelagic Freezer Trawler.

4.6.3 Sea trials

For the second task, two trips were made (2nd April - 8th of May and 7th of August – 27th of August) by Lina de Nijs (RVZ), focussing on five different topics:

1. To experiment with the Deep Sea camera unit.

2. Analysing the video data, and discuss encounters with ETP species with the crew.

3. In case of bycatch of an ETP species, identify it and make good/real world photo’s for a species ID guide.

4. Talk with the crew on the bridge whether they had noticed anything on the acoustic equipment that could be related to the bycatch incident.

5. Spotting from the (bridge)deck to check whether there are ETP species present around the vessel.

Figure 2.6.3. real-world photo of a spurdog that was bycaught in a fishing trip.

Experiments with the Deep Sea camera unit proved successful, with various setups tested during the trip by altering how the camera was mounted in the net. It became evident that only backward-facing cameras produced sufficiently clear footage. However, it was noted that catch rates in hauls with the camera and lights mounted were lower compared to hauls without lights. The target species during the first trip was Greater silversmelt, a species with large eyes that may be particularly sensitive to light. This sensitivity likely caused the species to avoid the net, resulting in reduced catch rates. This hypothesis was confirmed when acoustic data from the echo-sounder and belly sensor were analysed. An increase in acoustic backscatter around the net was detected immediately after the lights turned off (when the battery ran out), indicating the species' return to the vicinity of the net. A total of 10 hauls were filmed during the trip, with the charging of batteries requiring approximately 15 hours per cycle.

Figure 4.6.4. Image of a Greater silversmelt showing its very large eye.

During the trip, Lina spent significant time on the bridge, both during day and night, discussing the information displayed on the screens to better understand and interpret the data. Identifying fish proved challenging during the trip, and no indications of bycatch species were observed. Based on the available information, bycatch of ETP (Endangered, Threatened, and Protected) species was deemed unlikely during this trip.

Wildlife and ETP species monitoring around the vessel was conducted only during daylight hours. Identification efforts were supported by a marine mammal identification guide and an app called "PRIMA," which allowed filtering species by specific characteristics. No wildlife was detected during the entire trip.

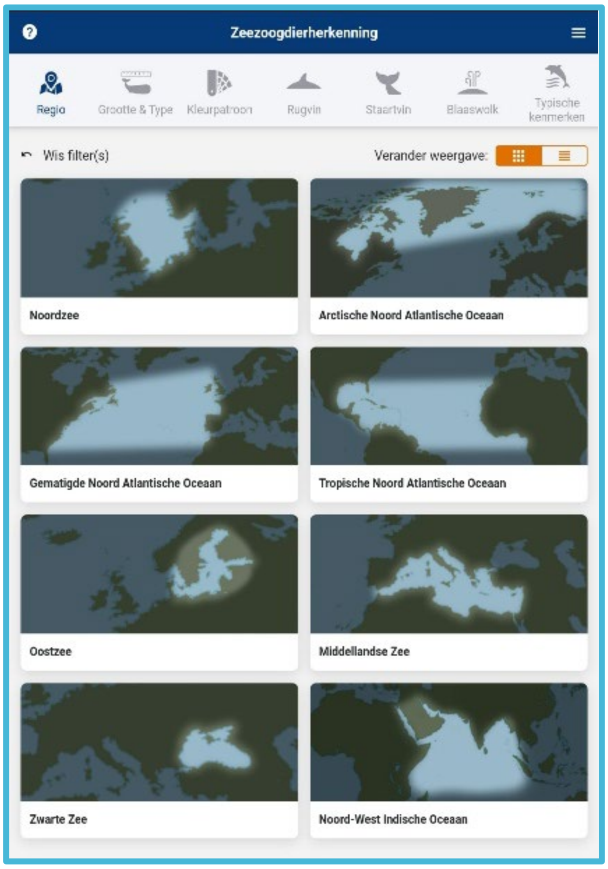


Figure 4.6.5. Interface of the PRIMA application for marine mammal identification.

The second trip followed the same design as the first trip. However, during the second haul, the underwater housing of the Deep Sea camera broke.

Skilled technicians onboard the vessel constructed an external casing to continue the experiment (Figure 4.6.6).

Figure 4.6.6. Broken underwater housing (left) and external casing created (right).

During this trip, no wildlife was observed around the vessel, and the skipper reported being unable to identify any bycatch using the available equipment. Bycatch during the trip was minimal.

The manufacturer of the remotely controlled escapement panel was unable to deliver a functional device in time for trials. As a result, efforts were redirected toward improving the integration of shark repellent devices mounted on the existing excluder grid. Multiple iterations of design adjustments were carried out through collaboration between the gear manufacturer and the skippers. These included making the grid steeper, repositioning the escapement panels, and optimizing the placement of the shark repellents. As the technology is still under development, no results are yet available to confirm whether the new design has improved bycatch mitigation.

4.6.4 Species identification guide

A first version of a bycatch identification guide has been developed. The guide provides comprehensive information, including the species name and FAO code, habitat details, stock status based on the IUCN Red List and ICES/ICCAT assessments, and any potential catch constraints. Additionally, it features photos or images with identification tips and management-related aspects, such as landing obligations. The current version of the guide includes information on tuna, marine mammals, sharks, and rays.

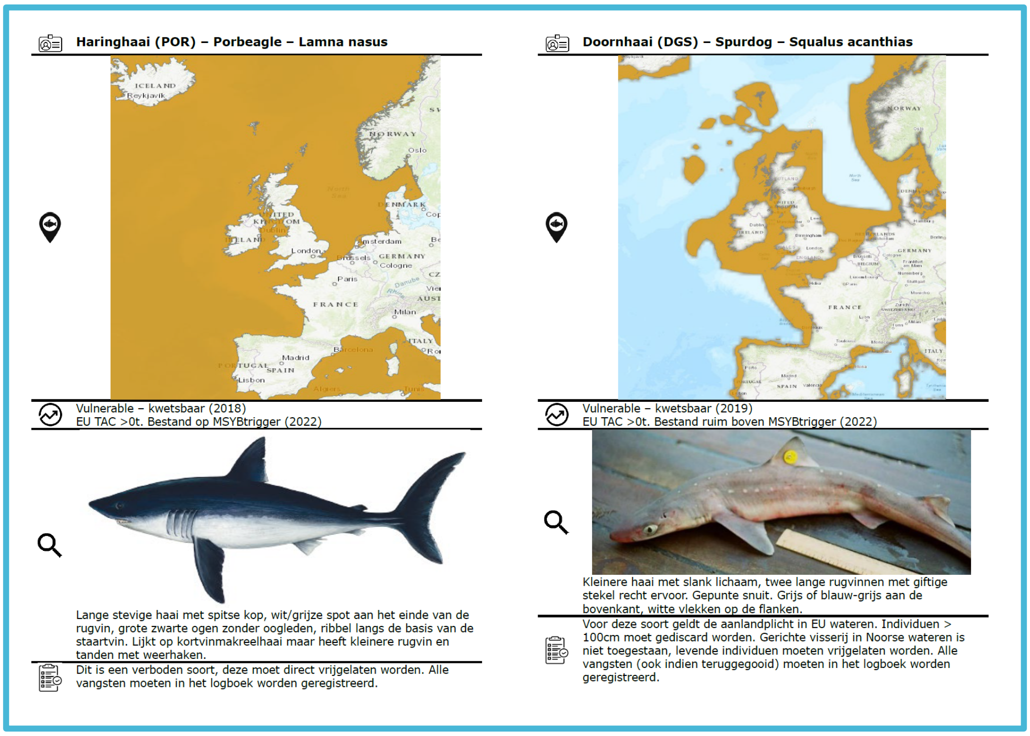


Figure 4.6.7. An example page out of the RVZ identification guide.

4.7 Increasing welfare

Over the past years, the RVZ has enhanced its understanding of fish condition during capture and processing phases, with the dual objective of improving both fish welfare and flesh quality, as these factors are often interlinked. In 2024, a trial was conducted to establish connections between codend conditions during fish pumping, onboard catch processing, the condition of fish as they arrive onboard, and the resulting product quality. Specifically, the research focused on four key areas:

1. Fish condition assessment: Evaluate the condition of herring (RAMP score and percentage alive) upon arrival on the trawler, considering operational factors such as tow duration, catch size, crowding time in the codend, and pumping duration.
2. RSW tank management: Assess the effect of RSW (refrigerated seawater) tank operations on dissolved oxygen depletion and the condition of herring stored in the tanks.
3. Oxygen consumption in codend: Explore oxygen consumption by herring in the codend during trawling and crowding, focusing on fish in the middle of the codend and those near the netting.
4. Muscle pH: Investigate the muscle pH of trawl-caught herring tissue after storage in the trawler's RSW tank.

For the RAMP score, an average of 63% (n=151, 14 hauls, Table 4.7.1) of sampled fish were alive upon arrival on deck and entry into the RSW tanks. Among the live fish, 46% exhibited impaired reflexes. The proportion of live fish varied significantly across the eight sampled hauls, ranging from 2.5% to 100%.

Table 4.7.1. Specifics of the 2024 fish condition sampling in the summer herring fishery.

Sampled hauls	**14**
Total catch weight all sampled hauls (ton)	1899
Minimum haul size of the sampled hauls	27.9
Maximum haul size of the sampled hauls	368
Total number of fish sampled	890
Assessed total number of fish alive	372
Proportion alive of sampled fish	0.416
Minimum proportion alive per haul	0.025
Maximum proportion alive per haul	1
Average RAMP score all sampled fish	0.639
Average RAMP score sampled fish assessed as alive	0.803

The time between the arrival of the codend at the sea surface behind the trawler ("end of capture process") and the moment of sampling, as well as the catch size, appears to influence fish condition and the proportion of fish arriving on deck alive (Figure 4.7.1). Larger catches (150–300 tons) exhibited a lower proportion of live fish at the start of the pumping process and higher RAMP scores, indicating poorer condition, compared to smaller catches. Since the time required to pump the entire catch onboard increases with catch size, the effects of catch size and pumping time are closely intertwined. This interdependence makes it challenging to distinguish the specific contributions of these variables to fish condition and the proportion of fish arriving alive.

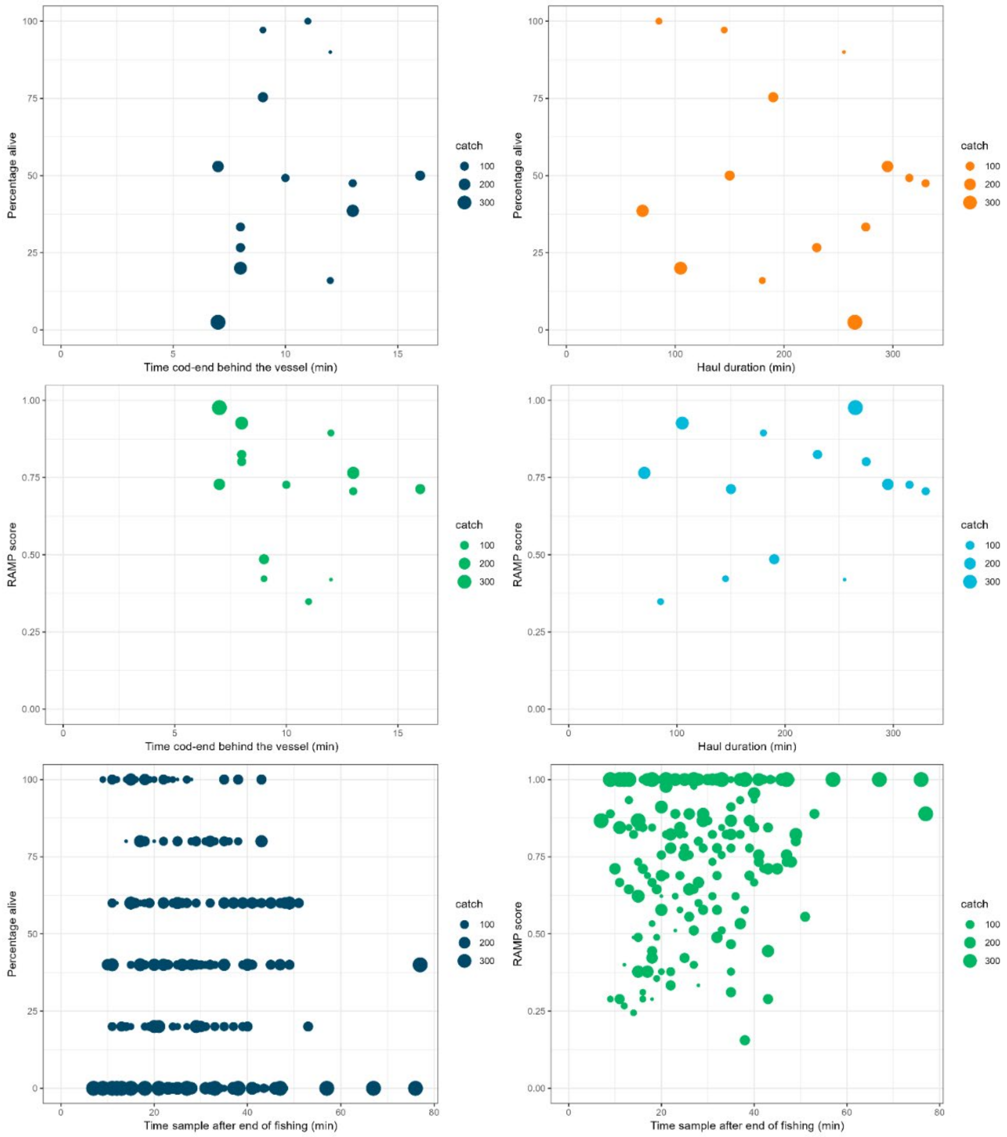


Figure 4.7.1 Mean RAMP score and proportion of fish alive (%) per haul (n=14) for time codend behind vessel before start pumping, haul duration, and time between end of trawling process and the sample being taken. The last variable equals crowding time in the codend behind the vessel before the fish in that particular sample are pumped on board. Marker size indicates total catch size (tons).

Initial oxygen levels in the RSW (refrigerated seawater) tanks were approximately 100% saturation, likely due to a combination of mixing during tank filling and the use of surface seawater, which is typically fully saturated with oxygen. The introduction of fish into the RSW tanks resulted in a drop in oxygen levels for all hauls. This oxygen drop is likely attributed to the oxygen consumption of live fish entering the tanks.

Partial circulation of tank water, primarily for cooling purposes, not only counteracts temperature increases (green lines) but also replenishes oxygen levels in the RSW tanks (blue and orange lines).

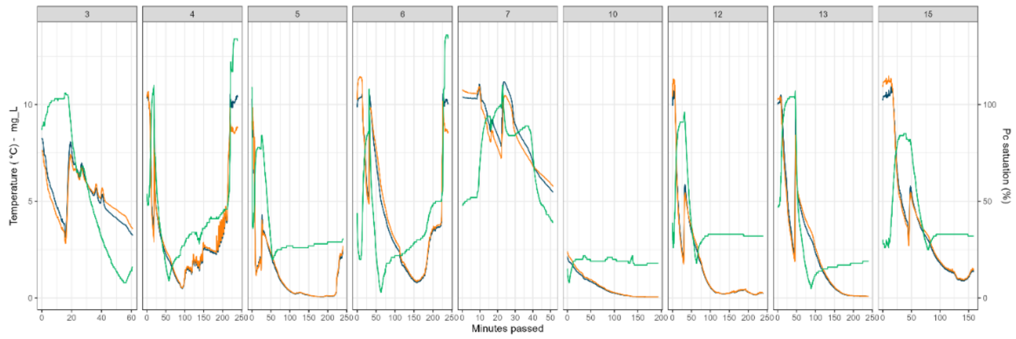


Figure 4.7.2. Dissolved oxygen concentration (mg/L, orange, left Y-axis) , oxygen saturation (%, blue, right Y-axis) and water temperature (degree Celsius, green, left Y-axis) measured inside RSW tanks for up to 250 minutes after filling the tank with fish.

Two oxygen sensors were installed inside the codend of the net - one positioned at the edge and the other at the centre of the codend (see Figure 4.7.3). This setup enabled the measurement of oxygen concentration as fish accumulated in the codend during the capture process.

Figure 4.7.3. Oxygen sensor (left), mounted within the codend (right).

The results indicate that when the second net sensor signaled the codend was full, oxygen concentrations dropped to very low levels, both in the center and at the edges of the net. Hauls 1 and 5, which were smaller (<50 tons), showed higher oxygen levels compared to hauls 2–4, which exceeded 100 tons. This clearly demonstrates that oxygen concentration decreases as more fish accumulate in the codend. Interestingly, no significant differences were observed between the two sensors. It was anticipated that oxygen concentrations would remain higher at the edges of the net compared to the center; however, this was not evident in the results (Figure 4.7.4).

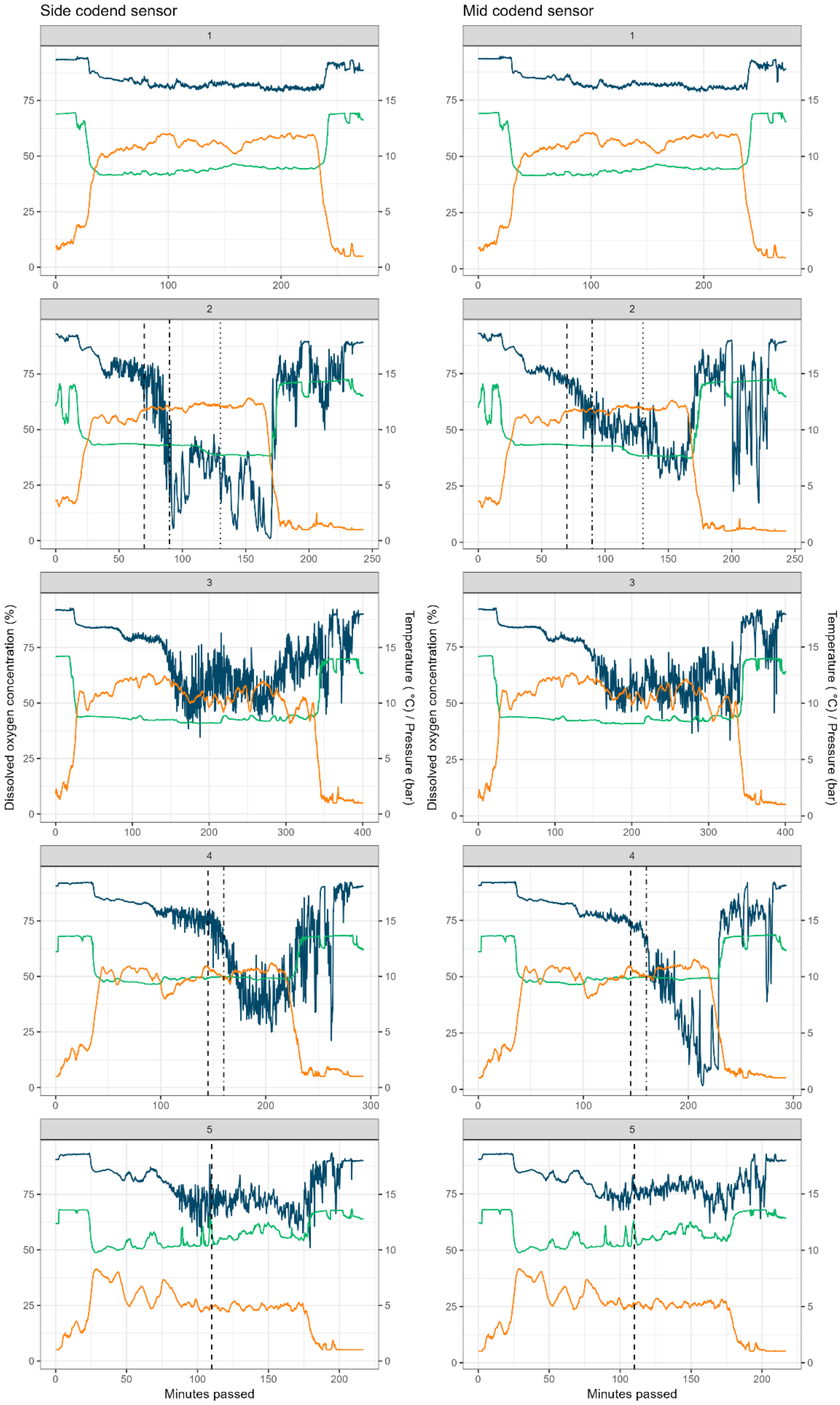


Figure 4.7.4. Temperature (green), dissolved oxygen (blue) and pressure (orange) in the codend. Dashed vertical lines indicate when sensors in the net indicate the codend is full. Panels represent the first 5 hauls (out of 56).

Furthermore, fish were tracked throughout the capture process, starting from being pumped onboard, assessed for condition, tagged, and eventually processed in the factory, where pH samples were extracted (Figure 4.7.5). The results of the pH measurements were inconclusive and require further investigation.

Figure 4.7.5. Tissue pH measurement set up for Herring. Note three measurements were done over the section where the skin was removed. Fish were marked to identify their condition before entering the RSW tank for temporarily storage.

5 The way forward

The RVZ is proud of its significant contributions to promoting the sustainability of fisheries and minimizing their impact on the ecosystem through a science-based approach, supported in part by the Scientific Quota system.

The fleet's self-sampling program and the use of its data for stock assessment have been ongoing for several years. In 2024, Wageningen Marine Research (WMR) in the Netherlands signed a Collaboration Agreement with RVZ to ensure self-sampled data is utilized for international fish stock management. Additionally, RVZ signed a Memorandum of Understanding with the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) to strengthen collaboration on data sharing and knowledge development. These initiatives, including self-sampling, data storage, quality control, mCatch software development, and the spatial-temporal stock assessment model, are now firmly established as multi-year projects.

Continued sampling of biological traits of pelagic fish—such as the genetic fingerprint of horse mackerel, mackerel fecundity, and herring condition—remains crucial for scientific research. The fishing industry plays a central role in collecting and processing these samples, as deploying research vessels is often inefficient or prohibitively expensive.

The automatic processing and analysis of acoustic data collected onboard pelagic trawlers is part of the larger PelAcousticAI project, set to conclude in 2025. Efforts to calibrate acoustic devices, including sonars, and to expand the use of this technology for selective fishing and bycatch reduction, will remain priorities in 2025 and beyond to ensure high-quality data collection, alternating seabed and sphere calibrations.

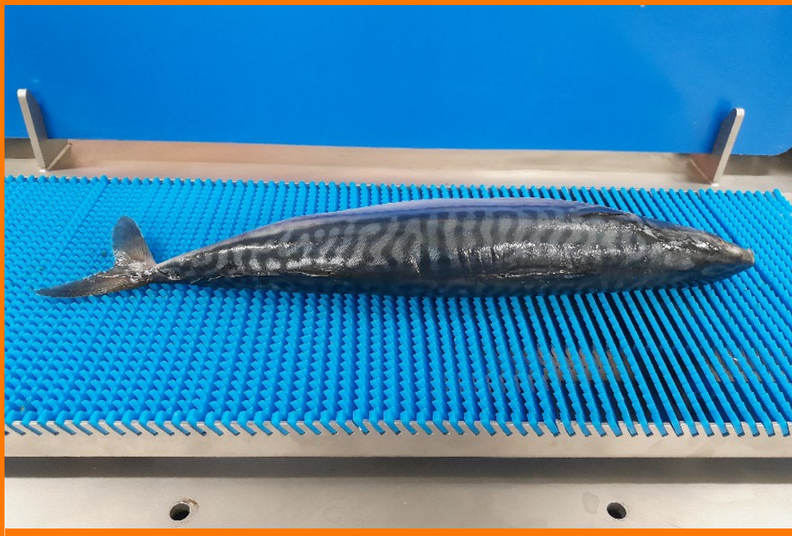
With advancements in compact, high-quality camera technology, underwater observations have become more accessible and effective. These innovations are essential for confirming the effectiveness of gear designed to prevent unwanted bycatch. Underwater camera techniques, including automated AI analysis of footage, will continue to play a key role in the RVZ research agenda in the coming years.

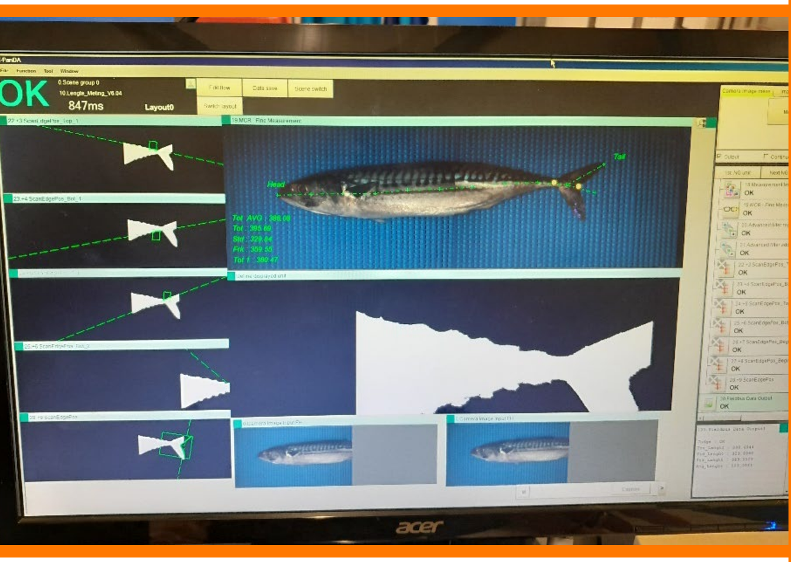
In 2023, an RVZ vessel participated in two research surveys (one covered under the Scientific Quota). Discussions are underway to deploy a pelagic trawler in 2025 and beyond for research in and around wind farms.

While self-sampling activities are fully supported by the crew onboard pelagic vessels, reducing their workload while simultaneously improving data precision and collection efficiency is critical. Over the years, the volume of data collected has increased, as has the crew's workload. As a result, the RVZ continues to develop automation technologies for data collection at sea, alongside innovations in fat measurements and volumetric analysis through automated image processing techniques.

Efforts to reduce bycatch remain a high priority, with initiatives such as skipper best-practice sessions, extensive at-sea trials, and international collaborations.

A similar commitment is evident in efforts to improve fish welfare. Significant gaps remain in understanding fish condition and welfare throughout the catching process. RVZ will continue working with scientific partners to address these challenges, making adjustments to promote humane practices and improve fish quality at sea.

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6 Research output 2024

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6.1 Reports

Hintzen, N.T. & de Nijs, L., 2024. Report on 2023 scientific research projects, PFA report 2024/01, 42pp

Hintzen, N.T., 2024. CPUE standardization for Western and North Sea horse mackerel, PFA report 2024/02, 16pp

Hintzen, N.T., Farrell, E., 2024. Predicting proportion North Sea horse mackerel by ICES rectangle, PFA report 2024/03, 25pp

Hintzen, N.T. 2024, PFA self-sampling report for HAWG 2024, PFA report 2024/04, 65pp

Hintzen, N.T. 2024, Overview of PFA self-sampling coverage, PFA report 2024/05, 7pp

Hintzen, N.T. 2024, Fishing activity within MPAs and Windfarms, PFA report 2024/06, 16pp

Hintzen, N.T. 2024, PFA self-sampling report for WGDEEP 2024. PFA report 2024/07a, 27pp

Hintzen, N.T., Olsen, H., 2024, CPUE Standardization of Silver smelt in 5b and 6a. PFA report 2023/07b, 59pp

Quirijns, F., 2024, PFA self-sampling report for CECAF fisheries, 2016-2023, PFA report 2023/08, 43pp

Hintzen, N.T. 2024, PFA self-sampling report for WGWIDE 2024, PFA report 2024/09, 107pp

Hintzen, N.T., Bleijenberg. J., Campbell, A., 2024, Calculating the trade-off in monitoring TAC for North Sea horse mackerel, PFA report 2024/10, 13pp

Hintzen, N.T. 2024, PFA self-sampling report for SPRFMO 2024, PFA report 2024/11, 53pp

Hintzen, N.T. 2024, SPRFMO CPUE standardization for the offshore fleet, PFA report 2024/12, 20pp

Hintzen, N.T., de Nijs, L., 2024, Testrapportage Lengte-Weeg-Meet Systeem, PFA report 2024/13, 8pp

6.2 Presentations

Hintzen, N.T. 2024. Research programme introduction to Seas at Risk, 3rd of April, Brussels

Hintzen, N.T. 2024. Scientific Quota 2024 discussion with RVO, 17th of April, Zoetermeer

De Nijs, L. 2024. Catch Welfare Research, 6th of May, Online

Hintzen, N.T., 2024, Pelagic AC focus group Horse mackerel, 14th of May, Online

Hintzen, N.T., De Nijs, L., 2024. RVZ mid-year event, 28th of May, 2024, Katwijk aan Zee

Hintzen, N.T. 2024. Scientific Quota 2024 discussion with LNV, 25th of June, Zoetermeer

De Nijs, L., 2024. How do you determine if a fish is alive or dead when it's brought onboard the fishing boat?, Podcast by Catch Welfare Platform, 5 September 2024

De Nijs, L., 2024. Fish Welfare Research in Pelagic Freezer Trawler Fisheries, Session M, ICES Annual Science Conference 2024, 11 September 2024

Hintzen, N.T. 2024. PFA science event – The impact of 10 years self-sampling in the pelagic fleet, 28th of November, Scheveningen

De Nijs, L., 2024. PFA science event – Levering industry scientist experience in fisheries, 28th of November, Scheveningen