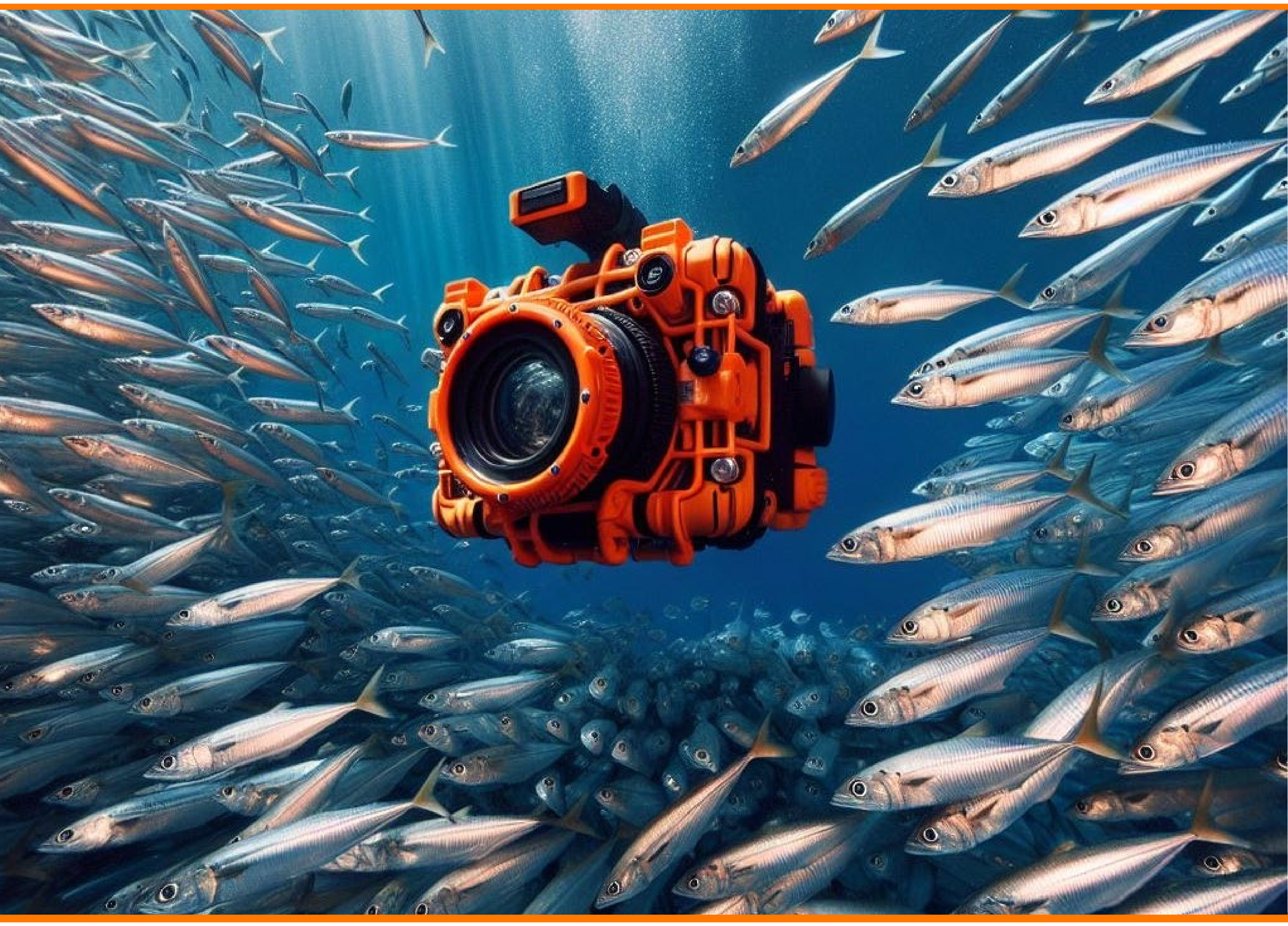
PELAGIC FREEZER TRAWLER ASSOCIATION



Report on 2025 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.

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Redersvereniging voor de Zeevisserij (RVZ)

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Cover photo: AI generated photo of school of herring surrounding an underwater camera

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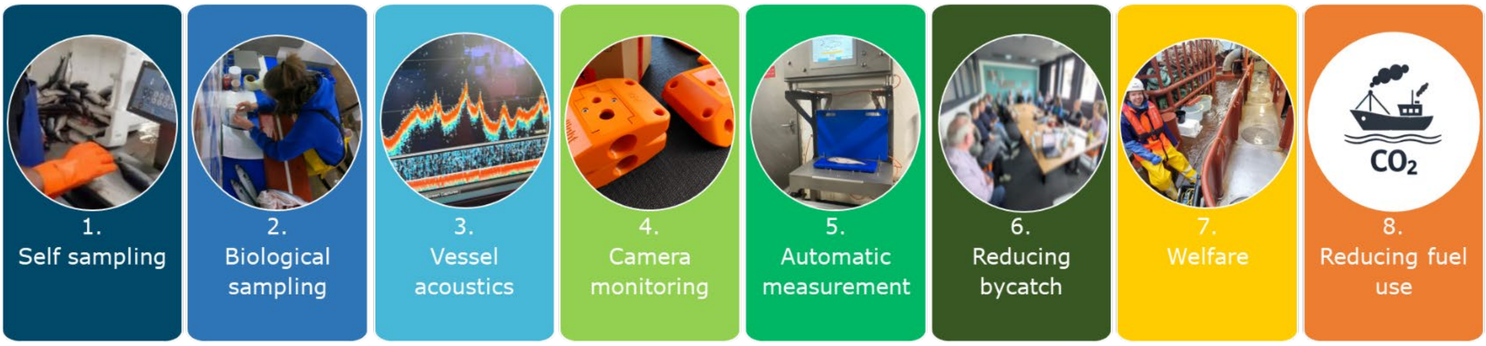
1. Executive Summary

This report documents the aim, approach and outcomes of research projects carried out in 2025 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 2025, pelagic scientific quota has been allocated to the following projects:



The main results are summarized below.

1. Self-sampling

The self-sampling programme of the pelagic fleet has developed into a mature, comprehensive, and indispensable pillar of fisheries science and management. In 2025, close to 200 fishing trips were self-sampled, resulting in more than 6,500 sampled hauls and over 375,000 individual length measurements. These data were subject to extensive multi-layered quality control procedures, including verification against observer data, cross-vessel comparisons within spatial–temporal fishing clusters, and direct feedback loops with skippers and fleet managers. This rigorous approach ensures that self-sampled data are robust, credible, and suitable for use in formal scientific and management contexts.

Self-sampling data are now routinely applied in ICES stock assessments, international working groups, and sustainability certification processes such as MSC assessments. Continuous software development, including maintenance and expansion of the mCatch system and associated data-entry modules, has further streamlined onboard data collection while reducing the risk of recording errors. In parallel, standardized workflows were developed to convert length measurements into age compositions using market sampling data. In 2025, approximately 220,000 herring and 70,000 horse mackerel length observations were successfully translated into age distributions, directly supporting catch-at-age estimates submitted to ICES.

A major methodological advance was the incorporation of self-sampled haul-level length data into newly developed spatial–temporal stock assessment models. These models combine spatial distribution, growth, and fishing mortality processes, providing unprecedented insight into migration patterns, stock structure, and spatial dynamics over time. While the inclusion of self-sampled data does not materially alter overall stock trends, it significantly improves understanding of how stocks use space and respond to fishing pressure.

In addition, the programme explicitly incorporated the systematic documentation of fishers' experiential knowledge. In 2025, 42 structured interviews covering 58 fishing trips were conducted with skippers and mates across all major pelagic species. These interviews captured observations on fish behaviour, acoustic visibility, and spatial distribution, and were analysed by Wageningen Marine Research. The results were actively used to inform ICES working group discussions, demonstrating how qualitative fisher knowledge can meaningfully complement quantitative scientific data.

2. Biological sampling

Biological sampling activities in 2025 focused on improving knowledge of pelagic fish condition, productivity, and ecosystem interactions, with particular attention to emerging spatial pressures and long-term environmental change. A dedicated collaborative survey around offshore windfarm areas was conducted in partnership with Wageningen Marine Research, NIOZ, Groningen University, and Wageningen University. Using an RVZ vessel, active acoustics were collected during daylight hours and targeted verification hauls were performed to determine species composition, while passive acoustic recordings were made at night. The survey successfully followed predefined transects and demonstrated a clear dominance of herring in the sampled windfarm area, generating a unique dataset that is currently being analysed to assess pelagic fish distribution in relation to offshore energy infrastructure.

In parallel, long-term research on herring condition was advanced through the provision of an extensive biological dataset comprising nearly 47,000 individual fat-content measurements collected between 2015 and 2025. To support this work, additional targeted biological sampling was carried out during the summer fishery, including measurements of length, weight, sex, maturity, fat content, and genetic material. These samples are particularly relevant for understanding the link between feeding conditions in the northern North Sea and subsequent reproductive success in the English Channel. Complementary laboratory analyses of stomach contents and larval production, although labour-intensive, provide critical insight into trophic pathways and stock productivity under changing environmental and climatic conditions.

3. Acoustic sampling

Acoustic sampling expanded substantially in 2025 and now represents one of the most data-intensive components of the RVZ research programme. More than 30 fishing trips were fully recorded acoustically, with each trip generating approximately 2.6 terabytes of data. This large and continuously growing dataset supports applications ranging from stock trend monitoring and spatial distribution analyses to behavioural studies and bycatch avoidance research. Managing these data requires significant logistical effort, including onboard recording, physical data transfer, cloud-based storage, and structured access for scientific partners.

To make this growing volume of information accessible and operationally useful, the RVZ further developed its online dashboard in 2025. The dashboard integrates self-sampling, biological, and acoustic data, allowing users to explore catches, haul characteristics, environmental conditions, and acoustic signals across fisheries, vessels, and time periods. Fleet managers have secure access to near-real-time updates, enabling reflection on historical patterns and supporting informed decision-making. The dashboard represents an important step in returning scientific information to the fishers who collect the data.

Ensuring scientific validity of acoustic data remains a core priority. In 2025, multiple sphere calibrations were conducted aboard RVZ vessels, and results from previous years were consolidated to derive stable correction factors. In addition, seabed-based calibration methods were further developed and applied as a complementary approach, providing calibration proxies for vessels where sphere calibration is not immediately feasible and enabling tracking of calibration drift over time. Innovation continued with the development of a prototype autonomous underwater vehicle designed to place calibration spheres accurately and efficiently within the acoustic beam, potentially allowing more frequent and multi-frequency calibrations in the future.

Quality control was further strengthened through the development of a 'WatchDog' monitoring system that continuously evaluates echosounder performance and alerts skippers when data quality degrades. Beyond calibration, research also addressed species recognition challenges using acoustics, particularly the persistent difficulty of distinguishing boarfish from horse mackerel. Structured skipper interviews revealed common risk patterns, behavioural adaptations, and limitations of current equipment, highlighting the need for decision-support tools that integrate multi-frequency information and behavioural cues.

Acoustic data collection was also extended to coastal windfarm areas through the establishment of standardized transit transects from Dutch ports. Although data collected in 2025 followed a semi-structured approach, analyses already revealed clear seasonal patterns in pelagic fish density, demonstrating the value of fishing vessels as cost-effective platforms for long-term monitoring. Finally, exploratory work on omnidirectional sonar demonstrated the feasibility of converting 360° sonar data into quantitative descriptors of school structure, movement, and vessel interaction, opening new avenues for behavioural research and selective fishing applications.

4. Camera monitoring

Underwater camera monitoring continued to expand as a key observational tool supporting selective fishing and bycatch mitigation. In 2025, RVZ vessels deployed trawlviewer systems across a wide range of fisheries, collecting on average around 350 hours of footage per year. Two system configurations were used, including a deep-water version capable of operating to depths of 1,000 metres. Although technical issues affected lighting performance in some deep-sea deployments, the overall dataset of usable footage continued to grow.

A major advancement was achieved in the automated processing of video data. A user-friendly graphical interface was developed alongside transformer-based artificial intelligence models capable of identifying frames of interest and detecting potential bycatch events. This approach dramatically reduces review times from hours to minutes by isolating short video segments that require human verification. The system provides interpretable outputs, including probability estimates and visual attention maps, and can generate standardized reports. While continued collection of training data remains essential to further improve model performance, these developments significantly enhance the scalability, consistency, and operational relevance of camera-based monitoring.

5. Automatic measurement

In 2025, significant progress was made in the development and deployment of automated measurement technologies covering length–weight measurement, fish fat content estimation, and volume estimation. Eight Length-Weight Measurement Systems (LWMS) were purchased by RVZ members. One system was installed onboard in 2025, while the remaining seven entered production with installation planned for early 2026. Design standardisation across vessels, supported by on-site visits, resulted in a more compact and refined LWMS unit. Although large component volumes caused production delays, successful integration with the mCatch software was achieved via an XML-based data workflow using a Raspberry Pi interface, enabling reliable onboard data exchange for vessel, trip, and haul information.

Advances were also made in fish fat content estimation using spectral imaging. Spectral decomposition and PCA analysis demonstrated that up to three principal axes explained most variance, enabling predictive modelling. Fat content predictions achieved correlations of 85% ($R^2 = 0.73$) for mackerel, 64% for herring, and a preliminary 78% for horse mackerel, with overlapping spectral endmembers suggesting potential for a universal small pelagic model.

Volume estimation accuracy improved substantially through the use of hyper-realistic 3D fish models derived from 360° scans and an updated algorithm incorporating depth, stacking density, and empty space detection. Simulations across four density scenarios showed high accuracy, with only minor underestimation attributed to edge effects in conveyor belt footage..

6. Reducing unwanted bycatch

Reducing unwanted bycatch remained a central priority in 2025, supported by technical trials, behavioural insights, and extensive knowledge exchange. Four skipper best-practice sessions were held throughout the year, bringing together fishers, scientists, and gear manufacturers to openly discuss successes and failures of mitigation measures. These sessions facilitated iterative improvements in gear design and reinforced a shared commitment to finding practical solutions.

At-sea trials focused on camera deployments, crew discussions, and direct observation of interactions with protected species. Although few bycatch events occurred during monitored trips, the trials provided valuable operational learning. A novel component was the successful deployment of stereo-hydrophones within fishing nets to record cetacean sounds. This pioneering work generated unique acoustic data on species presence and movement around active fishing gear, supporting the conclusion that cetacean bycatch is extremely rare in the pelagic freezer trawler fishery. Complementary efforts included refinement of species identification guides, particularly for small sharks, improving reporting accuracy and data quality.

7. Increasing welfare

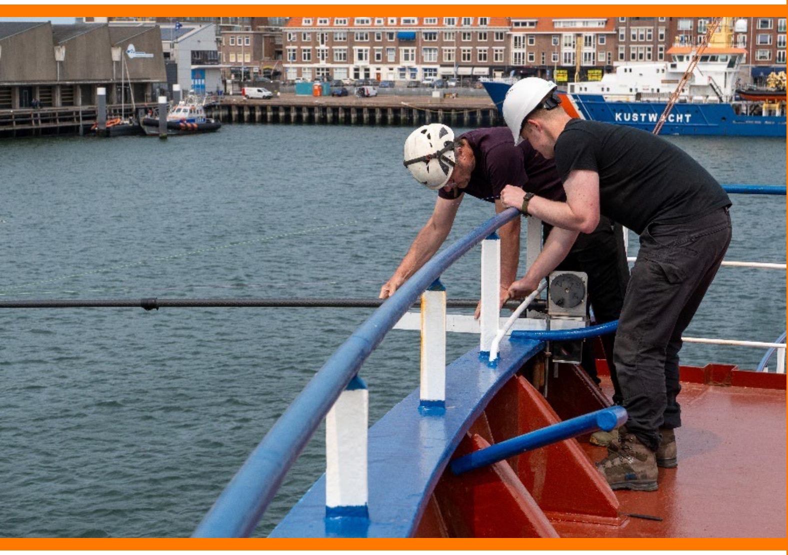
Fish welfare research in 2025 increasingly focused on solution-oriented innovation. Planned experimental work on roe herring condition could not proceed due to permitting constraints, but significant progress was achieved through a comprehensive feasibility study of the KIWIEX concept. KIWIEX aims to achieve a fatal endpoint for the total catch as early as possible in the capture process, thereby reducing suffering during pumping and onboard handling.

Through modelling of oxygen depletion across a range of temperatures and catch volumes, combined with extensive consultation with skippers, net makers, and fleet managers, three design concepts were developed and evaluated. Results indicate that euthanizing the catch before pumping is technically feasible, with the trawl-based KIWIEX offering the fastest welfare improvement. The study provides a robust foundation for future applied research addressing materials, integration into existing gear, regulatory considerations, and combined welfare and product-quality objectives.

8. Reducing fuel use

In 2025, new research was initiated to better understand fuel consumption patterns in pelagic freezer trawler operations. High-resolution fuel, engine, and environmental data from four vessels were combined with haul and catch information, resulting in a dataset of approximately 170,000 observations. Analyses revealed substantial differences in hourly fuel use between vessels, which largely disappeared when fuel use was expressed per tonne of fish caught, highlighting the importance of haul size and fishing efficiency.

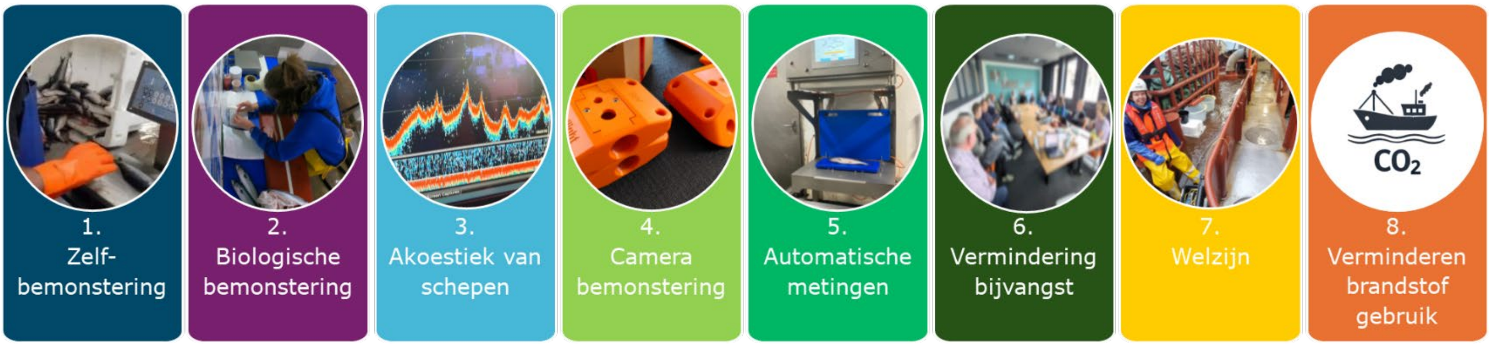
Fuel use per tonne decreased sharply with increasing haul size, while wind speed showed little effect. Greater fishing depths and higher temperatures were associated with increased fuel consumption. Statistical modelling demonstrated that fishing speed, net geometry, and environmental conditions interact to influence fuel efficiency, with fuel use increasing linearly across the normal operational speed range. These findings provide a quantitative foundation for future discussions with skippers on operational practices and behavioural adjustments that could further reduce fuel use and environmental impact.


KUSTWACHT

2. Nederlandse samenvatting

Dit rapport documenteert het doel, de aanpak en de resultaten van onderzoeksprojecten die in 2025 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 2025 zijn pelagische wetenschappelijke vangsten toegewezen aan de volgende projecten:



De belangrijkste resultaten worden hieronder samengevat.

1. Zelfbemonstering

Het zelfbemonsteringsprogramma van de pelagische vloot is uitgegroeid tot een volwassen, integraal en onmisbaar fundament onder het visserijonderzoek en -beheer. In 2025 werden bijna 200 visreizen zelfbemonsterd, wat resulteerde in meer dan 6.500 bemonsterde trekken en ruim 375.000 individuele lengtemetingen. Deze gegevens zijn onderworpen aan uitgebreide, meerlagige kwaliteitscontroleprocedures, waaronder verificatie ten opzichte van waarnemersdata, vergelijkingen tussen schepen binnen ruimtelijk-temporele visserijclusters en directe terugkoppelingsmechanismen met schippers en vlootmanagers. Deze rigoureuze aanpak waarborgt dat zelfbemonsterde gegevens robuust en betrouwbaar zijn en geschikt voor gebruik in formele wetenschappelijke en beheercontexten.

Zelfbemonsteringsgegevens worden inmiddels routinematig toegepast in ICES-bestandsschattingen, internationale werkgroepen en duurzaamheids- en certificeringsprocessen, zoals MSC-beoordelingen. Doorlopende softwareontwikkeling, waaronder het onderhoud en de uitbreiding van het mCatch-systeem en bijbehorende invoermodules, heeft de dataverzameling aan boord verder gestroomlijnd en het risico op registratie-fouten verminderd. Parallel hieraan zijn gestandaardiseerde workflows ontwikkeld om lengtemetingen om te zetten naar leeftijdssamenstellingen met behulp van marktbemonsteringsdata. In 2025 werden circa 220.000 haring- en 70.000 horsmakreellengtes succesvol vertaald naar leeftijdsverdelingen, waarmee direct is bijgedragen aan vangst-op-leeftijdschattingen die bij ICES zijn aangeleverd.

Een belangrijke methodologische vooruitgang betrof de integratie van zelfbemonsterde lengtedata op trekniveau in nieuw ontwikkelde ruimtelijk-temporele bestandsschatmodellen. Deze modellen combineren ruimtelijke verspreiding, groei en visserijsterfte en bieden ongekende inzichten in migratiepatronen, bestandstructuur en ruimtelijke dynamiek door de tijd heen. Hoewel de opname van zelfbemonsterde data de algemene bestandstrends niet wezenlijk verandert, verbetert zij het inzicht in het gebruik van ruimte door bestanden en hun respons op visserijdruk aanzienlijk.

Daarnaast omvatte het programma expliciet de systematische vastlegging van ervaringskennis van vissers. In 2025 werden 42 gestructureerde interviews afgenomen, betrekking hebbend op 58 visreizen, met schippers en stuurmannen over alle belangrijke pelagische soorten. Deze interviews legden waarnemingen vast over visgedrag, akoestische zichtbaarheid en ruimtelijke verspreiding en zijn geanalyseerd door Wageningen Marine Research. De resultaten zijn actief gebruikt in ICES-werkgroepdiscussies en tonen aan hoe kwalitatieve visserskennis een waardevolle aanvulling vormt op kwantitatieve wetenschappelijke data.

2. Biologische bemonstering

De biologische bemonsteringsactiviteiten in 2025 waren gericht op het vergroten van de kennis over conditie, productiviteit en ecosysteeminteracties van pelagische vissoorten, met bijzondere aandacht voor toenemende ruimtelijke druk en langetermijnveranderingen in het milieu. In samenwerking met Wageningen Marine Research, NIOZ, Groningen Universiteit en Wageningen University werd een gezamenlijke survey uitgevoerd rond offshore windparken. Met behulp van een RVZ-schip werden overdag actieve akoestische metingen verricht en gerichte verificatietrekken uitgevoerd om de soortensamenstelling vast te stellen, terwijl ’s nachts passieve akoestische opnames werden gemaakt. De survey volgde succesvol vooraf vastgestelde transecten en liet een duidelijke dominantie van haring zien in het onderzochte windparkgebied. Hiermee is een unieke dataset gegenereerd die momenteel wordt geanalyseerd om de verspreiding van pelagische vis in relatie tot offshore energie-infrastructuur te beoordelen.

Parallel hieraan werd langlopend onderzoek naar de conditie van haring verder verdiept door het beschikbaar stellen van een uitgebreide biologische dataset met bijna 47.000 individuele vetgehaltemetingen uit de periode 2015–2025. Ter ondersteuning hiervan werd tijdens de zomervisserij aanvullende, gerichte biologische bemonstering uitgevoerd, waaronder metingen van lengte, gewicht, geslacht, rijpheid, vetgehalte en genetisch materiaal. Deze monsters zijn met name relevant voor het begrijpen van de relatie tussen voedselcondities in de noordelijke Noordzee en het daaropvolgende reproductieve succes in het Engelse Kanaal. Aanvullende laboratoriumanalyses van maaginhoud en larvenproductie, hoewel arbeidsintensief, leveren cruciale inzichten op in trofische relaties en bestandproductiviteit onder veranderende milieu- en klimaatomstandigheden.

3. Akoestiek van schepen

De akoestische bemonstering is in 2025 sterk uitgebreid en vormt inmiddels een van de meest datarijke onderdelen van het RVZ-onderzoeksprogramma. Meer dan 30 visreizen zijn volledig akoestisch vastgelegd, waarbij elke reis ongeveer 2,6 terabyte aan data genereerde. Deze omvangrijke en continu groeiende dataset ondersteunt toepassingen variërend van monitoring van bestandstrends en analyses van ruimtelijke verspreiding tot gedragsstudies en onderzoek naar het vermijden van bijvangst. Het beheer van deze data vergt aanzienlijke logistieke inspanning, waaronder registratie aan boord, fysieke dataoverdracht, opslag in de cloud en gestructureerde toegang voor wetenschappelijke partners.

Om deze toenemende hoeveelheid informatie toegankelijk en operationeel bruikbaar te maken, heeft de RVZ in 2025 het online dashboard verder doorontwikkeld. Dit dashboard integreert zelfbemonsterings-, biologische en akoestische gegevens en stelt gebruikers in staat vangsten, trek-kenmerken, omgevingscondities en akoestische signalen te analyseren over verschillende visserijen, schepen en tijdsperioden. Vlootmanagers beschikken over beveiligde toegang tot vrijwel real-time updates, wat reflectie op historische patronen mogelijk maakt en geïnformeerde besluitvorming ondersteunt. Het dashboard vormt een belangrijke stap in het terugkoppelen van wetenschappelijke informatie naar de vissers die de data verzamelen.

Het waarborgen van de wetenschappelijke validiteit van akoestische data blijft een kernprioriteit. In 2025 zijn meerdere kalibraties uitgevoerd aan boord van RVZ-schepen en zijn resultaten uit voorgaande jaren samengebracht om stabiele correctiefactoren af te leiden. Daarnaast zijn bodemgebaseerde kalibratiemethoden verder ontwikkeld en toegepast als complementaire benadering, waarmee kalibratieproxies beschikbaar komen voor schepen waarvoor kalibratie niet direct uitvoerbaar is en veranderingen in kalibratie door de tijd gevolgd kunnen worden. Innovatie werd voortgezet met de ontwikkeling van een prototype autonoom onderwatervoertuig dat ontworpen is om kalibratiebollen nauwkeurig en efficiënt in de akoestische bundel te positioneren, wat in de toekomst frequentere en multi-frequentiekalibraties mogelijk kan maken.

De kwaliteitsborging werd verder versterkt door de ontwikkeling van een 'WatchDog'-monitoringsysteem dat de prestaties van echosounders continu evalueert en schippers waarschuwt wanneer de datakwaliteit verslechtert. Naast kalibratie richtte het onderzoek zich ook op uitdagingen in soortherkenning met behulp van akoestiek, met name de hardnekkige moeilijkheid om boarfish te onderscheiden van horsmakreel. Gestructureerde interviews met schippers brachten gemeenschappelijke risicopatronen, gedragsaanpassingen en beperkingen van huidige apparatuur aan het licht en onderstreepten de behoefte aan beslissingsondersteunende systemen die multi-frequentie-informatie combineren met gedragsindicatoren.

Daarnaast is de akoestische dataverzameling uitgebreid naar kustnabije windparkgebieden via de opzet van gestandaardiseerde transittransecten vanuit Nederlandse havens. Hoewel de in 2025 verzamelde data een semi-gestructureerd karakter had, lieten analyses reeds duidelijke seizoenspatronen in pelagische visdichtheden zien. Dit onderstreept de waarde van vissersschepen als kosteneffectieve platforms voor langetermijnmonitoring. Tot slot toonde verkennend onderzoek met omnidirectionele sonar aan dat het mogelijk is om 360°-sonargegevens om te zetten in kwantitatieve beschrijvingen van schoolstructuur, beweging en interactie met het schip, wat nieuwe perspectieven biedt voor gedragsonderzoek en selectieve visserijtoepassingen.

4. Camera monitoring

Het gebruik van onderwatercamera's bleef zich in 2025 uitbreiden als een belangrijk observatie-instrument ter ondersteuning van selectieve visserij en bijvangstmitigatie. RVZ-schepen zetten trawlviewer-systemen in binnen een breed scala aan visserijen en verzamelden gemiddeld circa 350 uur beeldmateriaal per jaar. Er werden twee systeemconfiguraties gebruikt, waaronder een diepwateruitvoering die inzetbaar is tot dieptes van 1.000 meter. Hoewel technische problemen bij sommige diepzeeinzetten de lichtprestaties beïnvloedden, bleef de totale hoeveelheid bruikbaar beeldmateriaal toenemen.

Een belangrijke doorbraak werd gerealiseerd in de geautomatiseerde verwerking van videodata. Er is een gebruiksvriendelijke grafische interface ontwikkeld in combinatie met transformer-gebaseerde kunstmatige-intelligentie-modellen die in staat zijn relevante beeldframes te identificeren en potentiële bijvangstevents te detecteren. Deze aanpak reduceert de analysetijd drastisch van uren naar minuten door alleen korte videofragmenten te selecteren die menselijke verificatie vereisen. Het systeem levert interpreteerbare output, waaronder kansschattingen en visuele attentiekaarten, en kan gestandaardiseerde rapportages genereren. Hoewel verdere uitbreiding van trainingsdata noodzakelijk blijft om de prestaties te optimaliseren, vergroten deze ontwikkelingen de schaalbaarheid, consistentie en operationele relevantie van cameramonitoring aanzienlijk.

5. Automatische meting

In 2025 is aanzienlijke vooruitgang geboekt in de ontwikkeling en implementatie van automatische meettechnologieën voor lengte-gewichtmetingen, vetgehaltebepaling en volumeschatting. In totaal zijn acht Lengte-Gewicht Meet Systemen (LWMS) aangeschaft door RVZ-leden. Eén systeem is in 2025 aan boord geplaatst, terwijl de overige zeven in productie zijn gegaan met geplande installatie begin 2026. Door standaardisatie van het ontwerp, ondersteund door scheepsbezoeken, is een compacter en verfijnd LWMS-model gerealiseerd. Hoewel de productie vertraging opliep door de grote hoeveelheid componenten, is een succesvolle integratie met de mCatch-software bereikt via een XML-gebaseerde data-workflow met een Raspberry Pi-interface, waarmee een betrouwbare uitwisseling van scheeps-, reis- en trekgegevens aan boord mogelijk is.

Ook bij de bepaling van het vetgehalte van vis zijn belangrijke stappen gezet met behulp van spectrale beeldvorming. Spectrale decompositie en PCA-analyse toonden aan dat maximaal drie hoofdascomponenten het grootste deel van de variatie verklaren, wat de basis vormde voor voorspellende modellen. De voorspellingen resulteerden in correlaties van 85% (R^2 = 0,73) voor makreel, 64% voor haring en een voorlopige correlatie van 78% voor horsmakreel. De sterke overlap tussen spectrale eindleden wijst op de mogelijkheid van een universeel model voor kleine pelagische vissoorten.

De nauwkeurigheid van volumeschatting is verder verbeterd door het gebruik van hyperrealistische 3D-vismodellen op basis van 360°-scans en een aangepast algoritme dat naast lengte en breedte ook diepte, stapeldichtheid en lege ruimtes meeneemt. Simulaties met vier dichtheidsscenario's lieten een hoge nauwkeurigheid zien, met slechts een lichte onderschatting die waarschijnlijk wordt veroorzaakt door begin- en eindsegmenten van het transportbandmateriaal.

6. Verminderen van ongewenste bijvangst

Het verminderen van ongewenste bijvangst bleef in 2025 een centrale prioriteit, ondersteund door technische proeven, gedragsinzichten en intensieve kennisuitwisseling. Gedurende het jaar werden vier skipper best-practice-sessies georganiseerd, waarin vissers, wetenschappers en tuigfabrikanten openlijk successen en tekortkomingen van mitigatiemaatregelen bespraken. Deze bijeenkomsten faciliteerden iteratieve verbeteringen in tuigontwerp en versterkten het gezamenlijke commitment om tot praktische oplossingen te komen.

Zeeproeven richtten zich op camerainzet, gesprekken met bemanning en directe observatie van interacties met beschermde soorten. Hoewel tijdens de gemonitorde reizen weinig bijvangstincidenten werden waargenomen, leverden de proeven waardevolle operationele inzichten op. Een vernieuwend onderdeel was de succesvolle inzet van stereo-hydrofoons in visnetten om geluiden van walvisachtigen vast te leggen. Dit pionierswerk genereerde unieke akoestische data over de aanwezigheid en beweging van soorten rond het vistuig en ondersteunt de conclusie dat bijvangst van walvisachtigen uiterst zeldzaam is in de pelagische vriestrawlvisserij. Aanvullende activiteiten omvatten het verder verfijnen van soortherkenningsgidsen, met name voor kleine haaien, wat de nauwkeurigheid van rapportage en de kwaliteit van gegevens ten goede komt.

7. Verbetering van welzijn

Het onderzoek naar viswelzijn richtte zich in 2025 steeds meer op oplossingsgerichte innovatie. Gepland experimenteel onderzoek naar de conditie van kuit-haring kon niet worden uitgevoerd vanwege vergunningstrajecten, maar er werd aanzienlijke vooruitgang geboekt met een uitgebreide haalbaarheidsstudie van het KIWIEX-concept. KIWIEX heeft tot doel een fataal eindpunt voor de totale vangst zo vroeg mogelijk in het vangstproces te realiseren, om lijden tijdens het pompen en de verwerking aan boord te verminderen.

Door modellering van zuurstofdepletie over een reeks temperaturen en vangstvolumes, gecombineerd met intensief overleg met schippers, nettenmakers en vlootmanagers, zijn drie ontwerpconcepten ontwikkeld en geëvalueerd. De resultaten tonen aan dat het technisch haalbaar is om de vangst vóór het pompen te euthanaseren, waarbij de trawl-gebaseerde KI-WIEX de snelste verbetering van het welzijn biedt. De studie vormt een solide basis voor toekomstig toegepast onderzoek naar materialen, integratie in bestaand tuig, regelgeving en de combinatie van welzijns- en productkwaliteitsdoelen.

8. Verminderen van brandstofgebruik

In 2025 is nieuw onderzoek gestart om brandstofverbruikspatronen binnen de pelagische vriestrawlvisserij beter te begrijpen. Hoog-resolutiegegevens over brandstofgebruik, motoren en omgevingscondities van vier schepen zijn gecombineerd met informatie over trekken en vangsten, wat resulteerde in een dataset van circa 170.000 observaties. Analyses lieten aanzienlijke verschillen zien in het uurverbruik tussen schepen, die grotendeels verdwenen wanneer het brandstofgebruik werd uitgedrukt per ton gevangen vis. Dit onderstreept het belang van trekgrootte en visserijefficiëntie.

Het brandstofverbruik per ton nam sterk af bij grotere trekken, terwijl windsnelheid nauwelijks effect had. Grotere visdieptes en hogere temperaturen gingen gepaard met een hoger verbruik. Statistische modellering toonde aan dat vissnelheid, netgeometrie en omgevingscondities in onderlinge samenhang de brandstofefficiëntie beïnvloeden, waarbij het verbruik lineair toeneemt binnen het normale operationele snelheidsbereik. Deze resultaten bieden een kwantitatieve basis voor toekomstige gesprekken met schippers over operationele praktijken en gedragsaanpassingen die het brandstofgebruik en de milieu-impact verder kunnen verminderen.

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 unwanted bycatch through technical and behavioural approaches
- Increasing welfare of fish during the fishing process
- Understanding fuel use and potential for reduction during fishing operations

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 unwanted bycatch
7. Increasing welfare
8. Reducing fuel use

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 (1.1, 1.2)

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 4.1.1.1 Overview of self-sampled trips in 2025 from the Dutch flagged vessels.

In total, 77 trips were self-sampled in 2025 with a total of over 3000 hauls and over 230.000 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
2019	7	68	1,158	2,958	183,836	0.41%	165,572	1,133
2020	6	72	1,201	3,196	228,295	0.62%	163,763	2,371
2021	7	117	1,297	3,267	238,588	0.84%	176,268	1,773
2022	8	133	1,367	3,259	222,895	0.95%	137,135	1,062
2023	8	96	1,204	3,154	213,677	0.48%	150,331	680
2024	7	86	1,300	3,452	236,159	1.19%	218,420	0
2025	8	77	1,324	3,353	220,060	1.75%	232,148	398
(all)		649	8,851	22,639	1,543,510		1,243,637	7,417

Quality control furthermore consisted of checking self-sampled records against observer reports as well as cross-checking within a fishery across vessels. For this a clustering routine has been developed that clusters similar fishing trips in time and space by target species. Within each cluster, we compared average sampled length. We assume that, when vessels fish approximately in the same area at the same time, that biological samples have a similar length distribution. When there is a systematic deviance from one vessel to the other vessels, this may be an indication of improper sampling techniques. Figure 4.1.1.2 shows the inter-vessel comparison for one vessel out of the fleet.

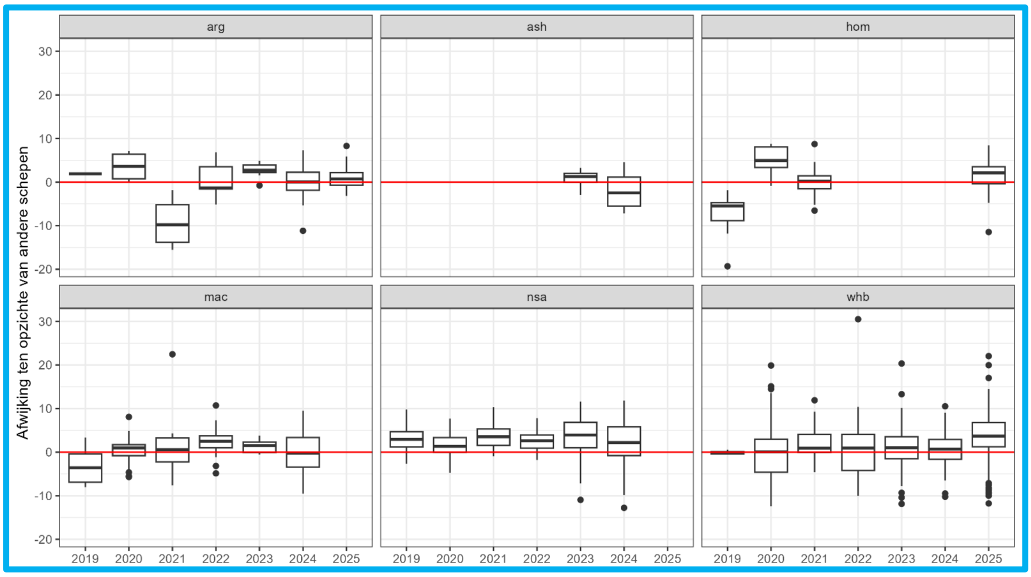


Figure 4.1.1.2. Inter-vessel comparison over the years for one of the RVZ vessels. Boxplots are created based upon all hauls being sampled within a specific year for a target species. Under high quality sampling, we expect the entire fleet to have 0 (red line) deviance from each other. However, given that some vessels target slightly different market segments, deviations can be logical.

4.1.2 Maintaining and development of self-sampling software (1.3)

All haul data was recorded using the M-Catch software, while length data was collected in three different formats in 2025. Most vessels continued to using Excel-based templates while several vessels migrated to using the updated mCatch length entry module (see Figure 4.1.2.1) or the output files from the Length-Weight-Measurement system (see also section 4.5). During 2025 the software was furthermore maintained by EFICE and incremental changes to the functioning were monitored through an online ticket system to which the RVZ and the companies had access.

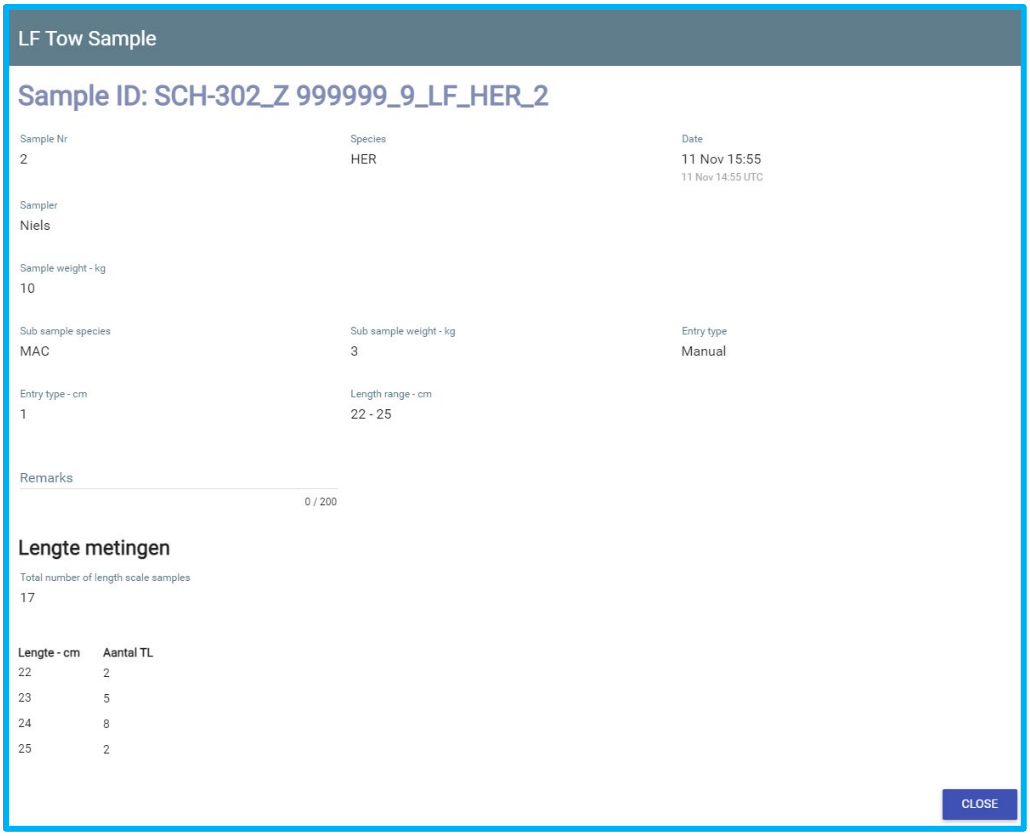


Figure 4.1.2.1 Length sampling entry fields in M-Catch. Credit EFICE.

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 mackerel which included relevant information on the fishery and the sampling of the fishery.

4.1.3 Storing self-sampling data (1.4)

All self-sampled data, including acoustics and camera footage, was stored securely at the Azure cloud storage. With the use of a dedicated access token, external users gain access to the selected parts of the data to perform analyses, relevant for partners such as WMR.

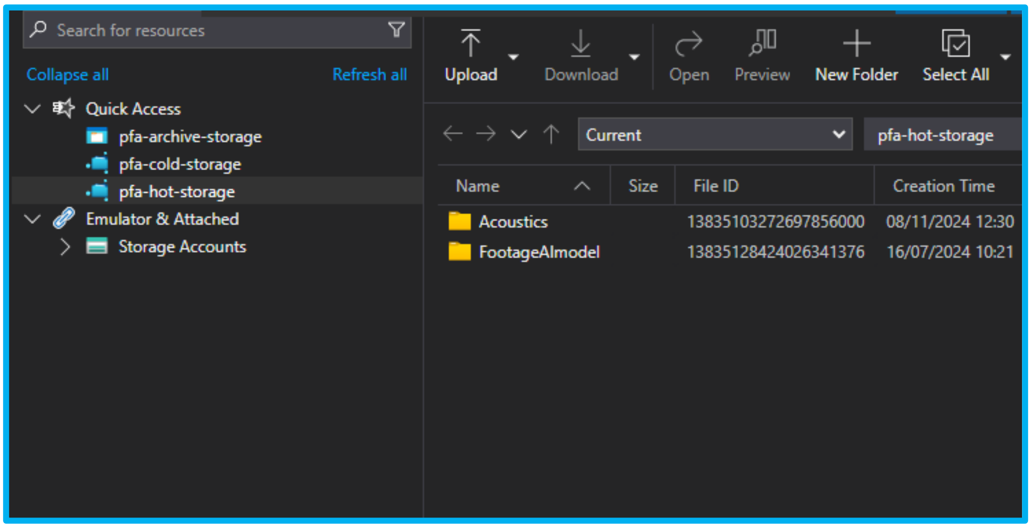


Figure 4.1.3.1. Azure storage account holding back-ups of self-sampled trip, active and passive acoustics and video data. Credit VENECO.

4.1.4 Standardized approaches for use of self-sampling data in stock assessment (1.5)

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, in line with the development of these models in 2024. This lead to a new raised length distribution of the total catch for herring (See figure 4.1.4.1) for the years 2019-2025 and for western horse mackerel for 2019-2025. Given the difficulty in ageing horse mackerel, results were not yet considered of sufficient quality to allow submission to ICES. The routines developed will be used to annually provide ICES with updated catch-at-age data for herring.

A total of 220.000 individual RVZ herring length observations were converted to age (figure 4.1.4.2) while 70.000 horse mackerel length observations were converted to age (figure 4.1.4.3).

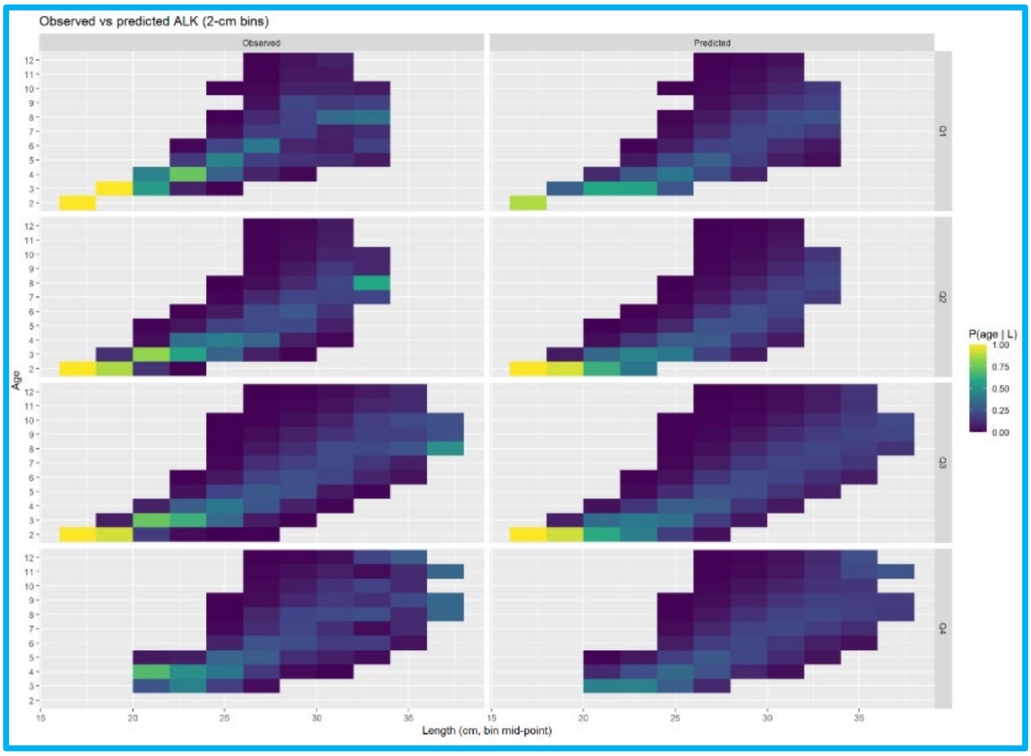


Figure 4.1.4.1. Comparison of observed age-length key from WMR observer programme vs predicted age-lengths from modelling age-length key information for herring. The predicted age-length keys are used to convert RVZ length information to ages and are submitted to ICES.

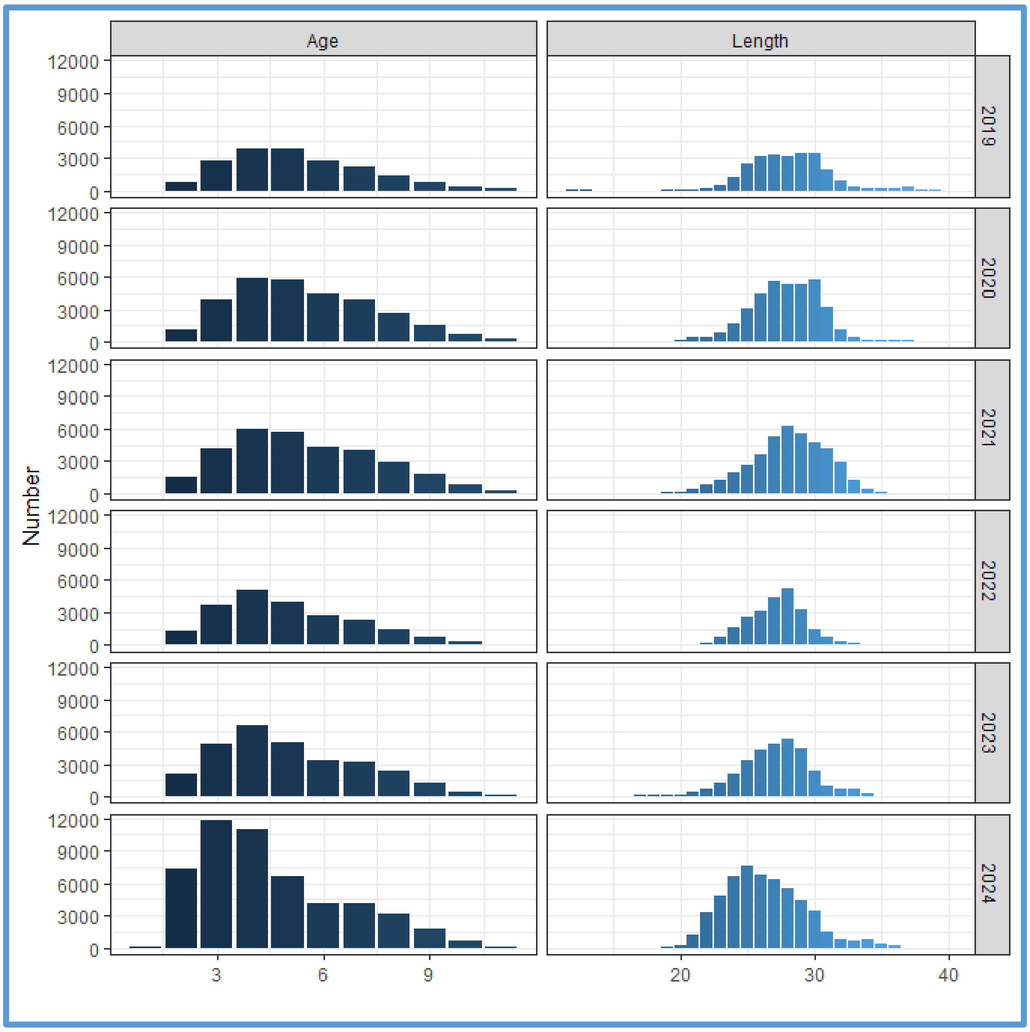


Figure 4.1.4.2. Age distribution as derived from ALK modelling by WMR applied to the RVZ length information for herring

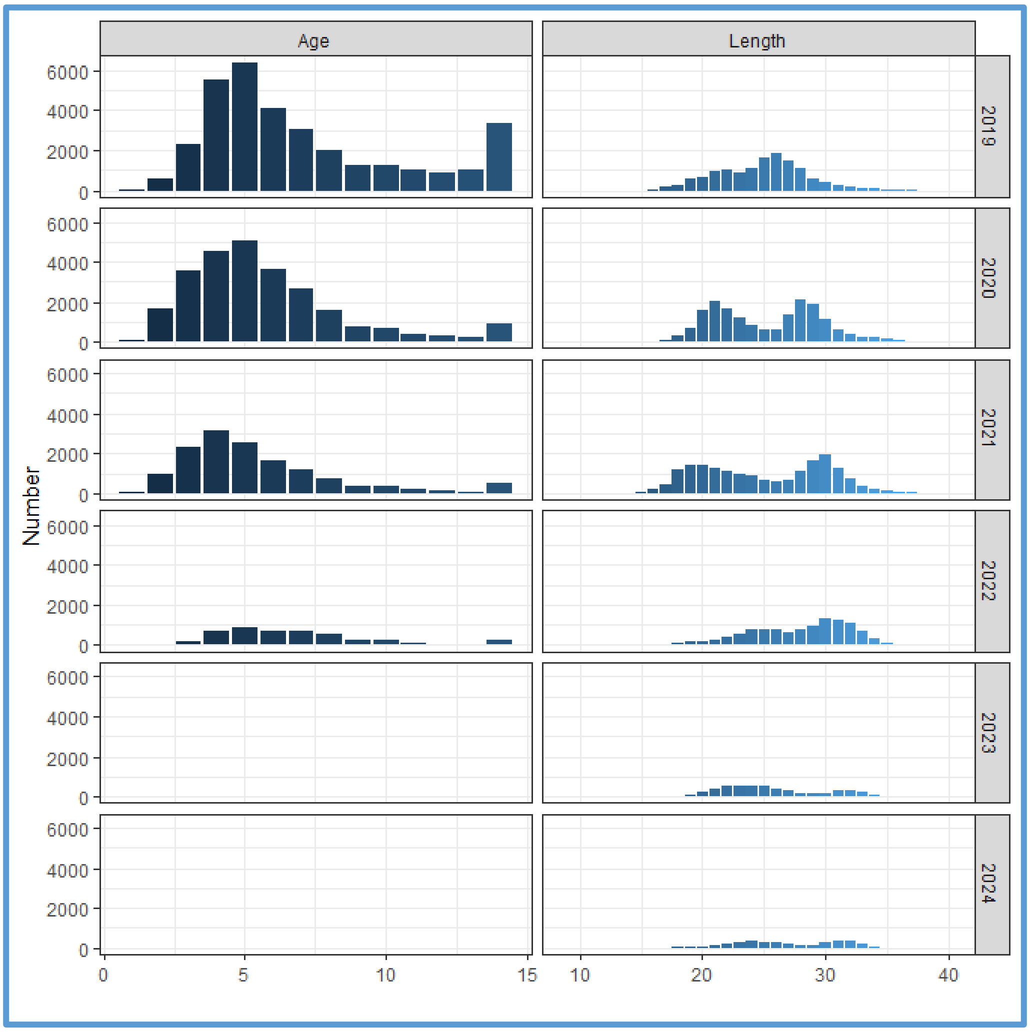


Figure 4.1.4.3. Age distribution as derived from ALK modelling by WMR applied to the RVZ length information for western Horse mackerel

4.1.5 Development of stock assessment models (1.6)

In 2023 the development of a spatial-and-temporal stock assessment model was initiated. 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). In 2025, focus was on combining the spatial component with the temporal component.

One reason spatially explicit assessment models are not used more frequently in management of fish stocks is that the spatial data is not routinely available. Spatially explicit observations may be available for the most recent years, but the historic data series may be available only in spatially aggregated form, or would require substantial effort to acquire. This project has utilized a new data source collected by RVZ, which supplies samples of the length distribution in the catch from individual hauls including geographic coordinates. Furthermore, the computational challenge with spatial assessment models is substantial, which often results in run-times measured in days of fitting a single model to observations. Run-times measured in hours or days will disqualify a model from being used in practical assessment work, because it must be possible to run an assessment model many times within a week long assessment working group. Two different model designs were tested, one in which survey data informs the spatial-temporal distribution of the species and RVZ length data, complemented with existing catch data, informs the biomass and fishing mortality trend. This method is relatively simple in design and robust in estimating stock trends. A more exciting alternative is the model designed in which observed lengths in time-and-space interact with the spatial-temporal estimation process. Figures 4.1.5.1 and 4.1.5.2 show the spatial-temporal part of the newly designed stock assessment model including the incorporation of RVZ length sampling as well as the influence of this data on overall stock trends. As it stands, the length sampling does not markedly affect overall stock trends (as expected) but the results do provide an overall spatial-temporal overview of migration of the stock and will allow going forward survey data to be incorporated into a spatial-temporal fashion as well, reducing the need to artificially aggregate data before stock assessments. This should contribute to our overall understanding of the use of space, migration, predator-prey overlap etc, all relevant for fisheries management. The results for horse mackerel were not in line with current perception by the ICES stock assessment and showed instability in the model performance and therefore require further scrutiny. The scientific survey data quality for horse mackerel is much lower than for herring, leading to issues in estimating the spatial-temporal distribution of the stock.

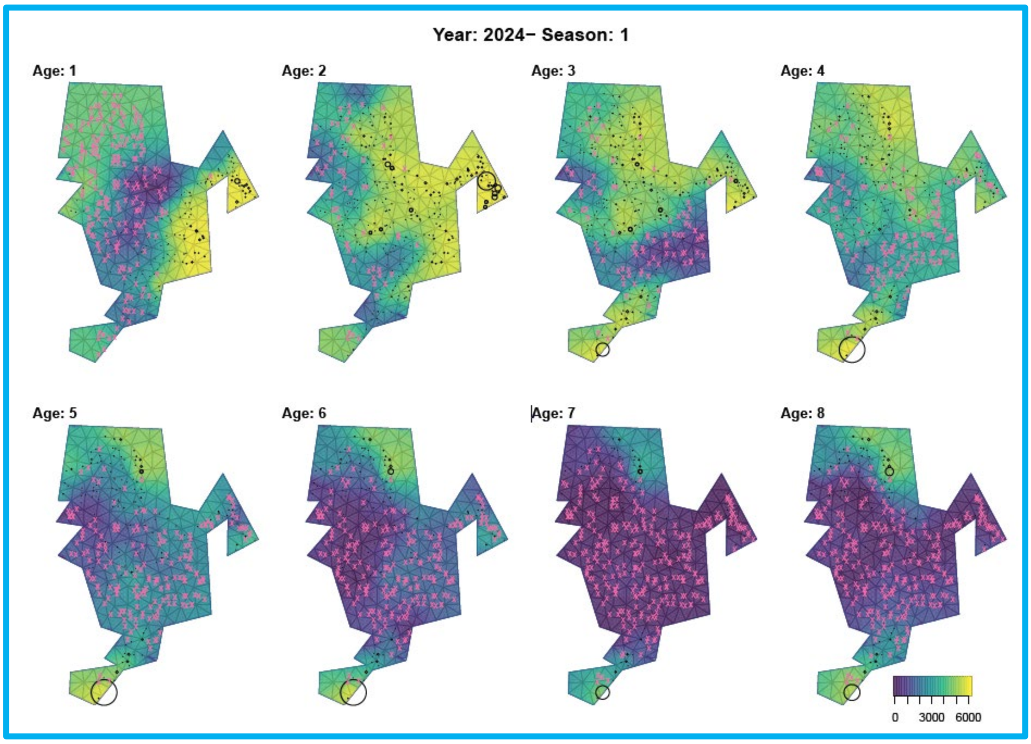


Figure 4.1.5.1: Estimated spatial density of herring of each age group in the first half of 2024. Black circles represent positive observations; circle size is proportional to the number of fish in the haul. Pink 'x' symbols mark hauls with zero observations for the corresponding age group. Credit DTU-Aqua.

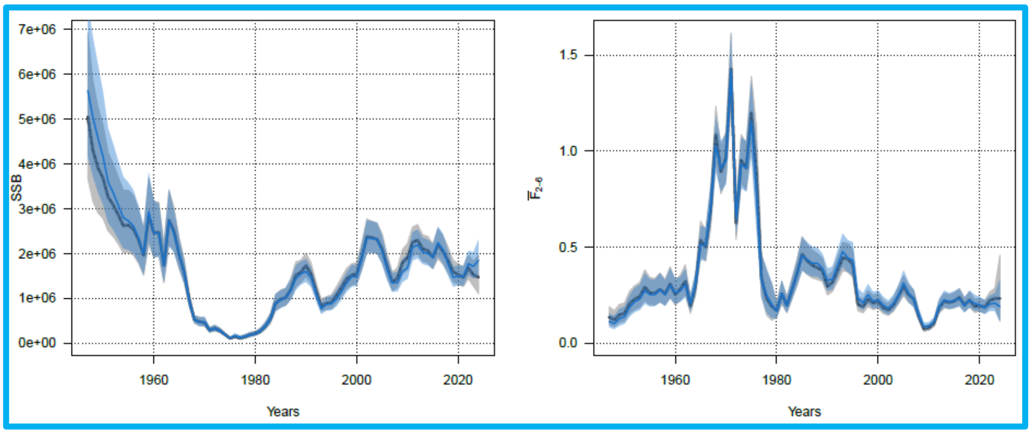


Figure 4.1.5.2. Estimated spawning stock biomass (SSB) for herring and average fishing mortality (F) over selected age classes of the model using the standard data sources (black) and the spatial fully-integrated model (blue). Credit DTU-Aqua.

4.1.6 Documenting fishers knowledge (1.7)

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. In 2025, RVZ continued to collect structured interviews. In total, 42 interviews were held (58 target species trips) covering all small pelagic species within the fishery (23 on WHB, 12 on HER, 11 on HOM, 8 on MAC, 2 on ARG).

The results of the interviews were analysed by WMR and discussed in two sessions with RVZ. Based on the results, further refinements in the interview guide were made. Results were furthermore used as input to ICES HAWG, ICES WGDEEP and ICES WGWIDE where perspectives from the skippers was considered relevant information to aid in the interpretation of assessment results. For example, fishing vessels found that blue whiting was more scattered through the water column and less visible on acoustic equipment in comparison to previous years. This information was documented in the ICES working group reports as well (figure 4.1.6.1).

> The distribution of acoustic backscattering densities for blue whiting for the period 2020-2025 is shown in Figure 2.3.6.1.2. The abundance estimate of blue whiting for IBWSS are presented in Table 2.3.6.1.1. The survey in 2025 was impacted by bad weather. Fishing vessels also experienced trouble finding blue whiting on the acoustic equipment and found blue whiting to be much more scattered throughout the water layer over large distances compared to years before.

Figure 4.1.6.1. Reflection of skipper experiential knowledge in ICES working group report WGWIDE, blue whiting section 2.3.6.1.

4.2 Biological sampling

4.2.1 Pelagic species around windfarms (2.2)

In 2025, the RVZ collaborated with WMR, NIOZ, Groningen University and Wageningen University to setup a scientific survey for small pelagic fish around windfarms. Researchers involved suggested to survey around the Borssele windfarm as recent surveying activity had been taken place in this area and the national MONS research has survey stations complementary to this area. WMR proceeded to develop a survey transect (see section 4.3) and from 1 to 3 December, the actual survey took place on-board of one of the RVZ vessels. During the 3-day trial, active acoustic data was collected during the day and fish hauls were performed to sample the species composition of small pelagics in the area. During the nights, passive acoustics were collected making use of the hydrophone equipment purchased by RVZ earlier in 2025 (see section 4.6). The survey transects were conducted according to plan (see Figure 4.2.1.1) and during the nights passive acoustics were recorded. All data has been shared with the different partners and is currently being analysed. Sorting of fish on-board showed predominantly herring (see Figure 4.2.1.2).

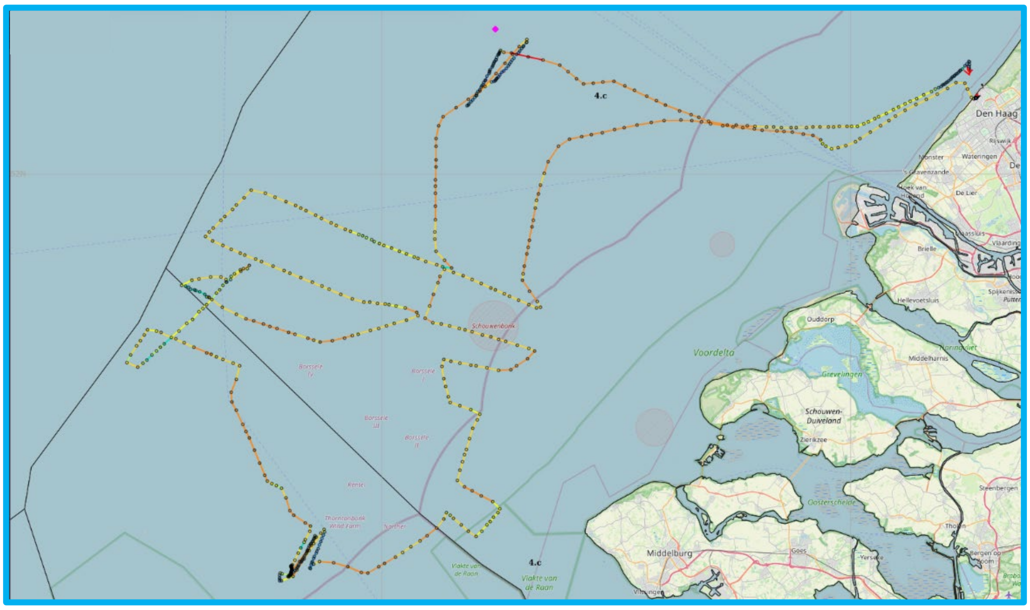


Figure 4.2.1.1: Realized survey transects on-board one of the RVZ vessels around the Borssele windfarm area.

Figure 4.2.1.2: Catch composition of a small verification consisting of predominantly herring along the windfarm area.

4.2.2 Herring condition (2.3)

At the start of the 4-year project, data from RVZ was shared with researchers from WMR and Ifremer. In this case, fat content data from 2015-2025 were shared consisting of in total nearly 47.000 individual measurements of herring fat (See Figure 4.2.2.1 for a distribution map). This meant that in 2025 also additional fat measurements had to be taken, including those in the Channel area later in the year. A large part of the herring population that feeds in the northern North Sea migrates during autumn towards the English channel, the main focus area for this research. Conditions experienced during the summer months, in the northern North Sea might dictate the success of reproduction in winter time in the English channel. As such did RVZ collect additional biological sampling (110 specimen taken for length, weight, sex, maturity, fat content and genetics) during the summer fishery on-board an RVZ vessel in July and August that provides relevant information for the English channel foodweb processes. In the lab researchers from Ifremer and WMR continued sampling herring from the English channel for stomach content (Figure 4.2.2.2) and larvae production, both being very labour intensive activities as stomach contents need to be described at species level while often partly digested specimen have to be examined. Differentiating the different clupeid larvae is a time consuming task as one of the major discriminatory factors is the number of vertebrae of the larvae. These vertebrae have to be counted for each individual to accurately define which ones are herring. Samples collected by RVZ will furthermore be used in a study to describe the productivity of Downs herring in light of global changes such as climate change. Most of the 2025 activities related to setting up the data collection on environmental conditions and relate these to observed condition of herring and making a start to analyse relationships between historic conditions and productivity of the herring stock as is shown in Figure 4.2.2.4 that shows that their main food source, being copepods, has shifted markedly over the past three decades.

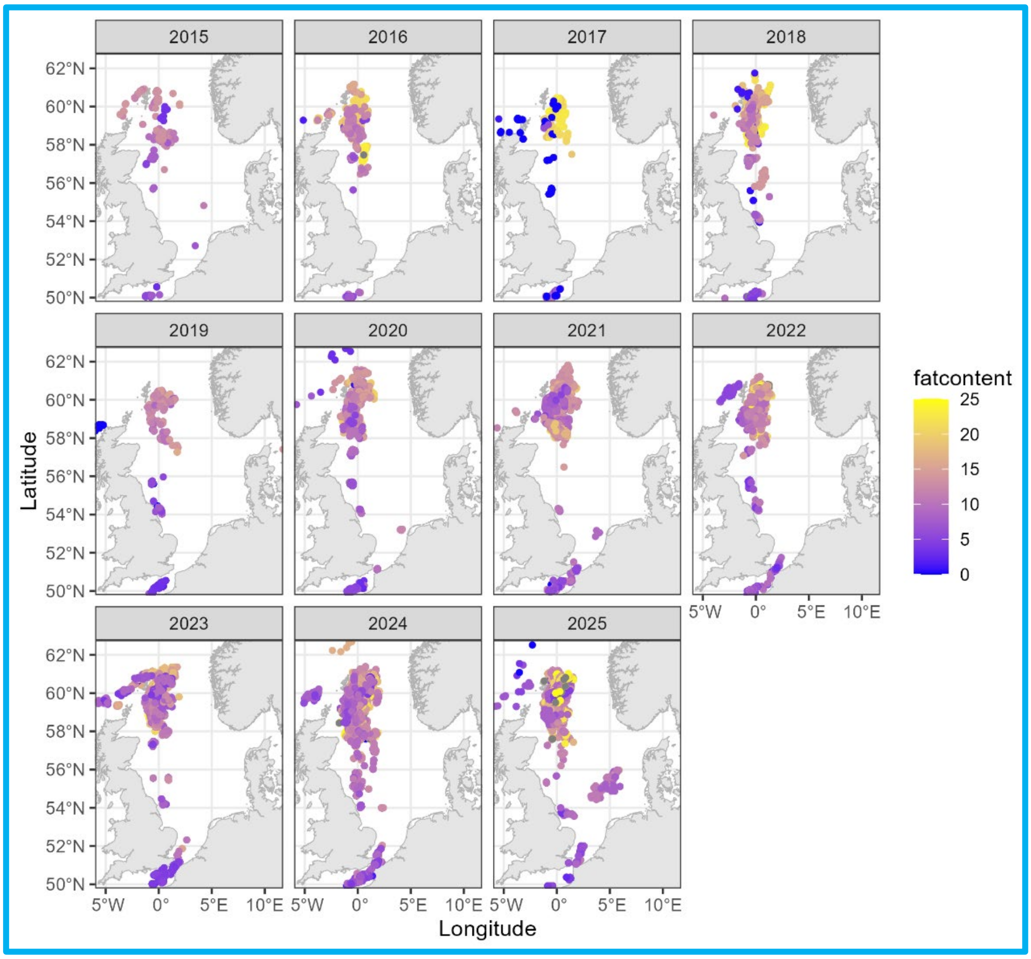


Figure 4.2.2.1. Distribution of fat content samples used to study the condition of herring in the North Sea.

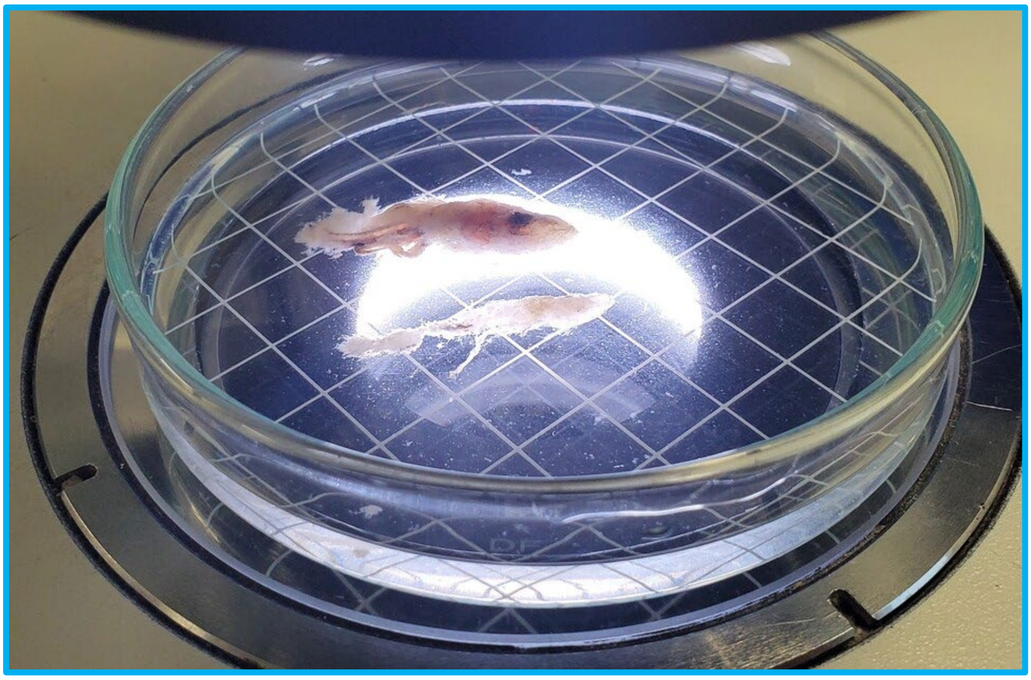


Figure 4.2.2.2. Stomach content of a herring. Credit C. Giraldo.

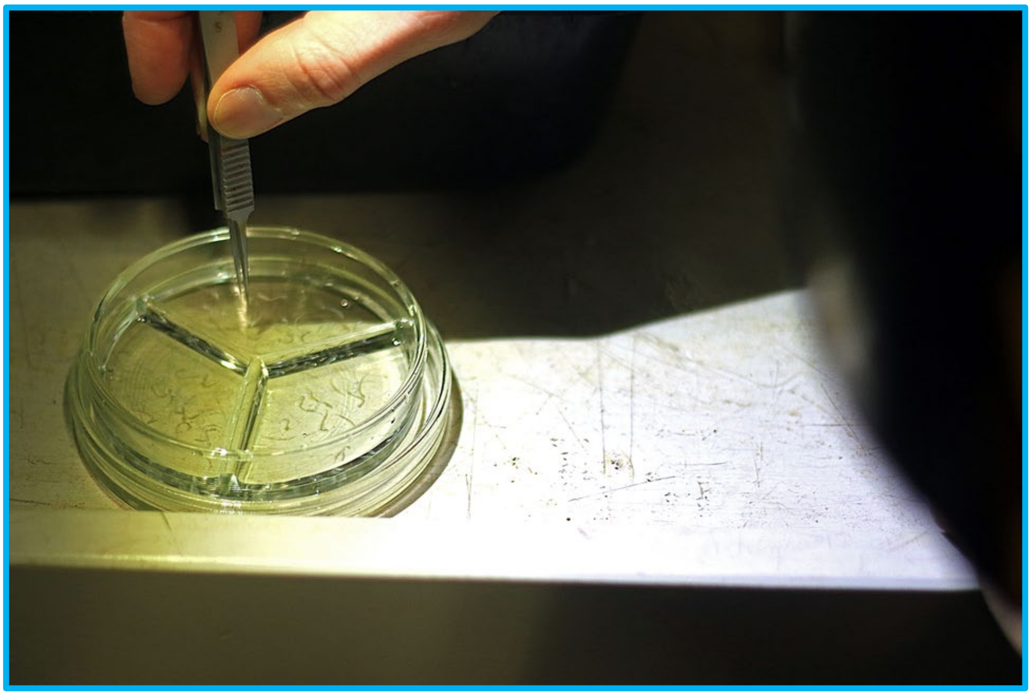


Figure 4.2.2.3. Sorting and analyzing clupeid larvae. Credit C. Giraldo.

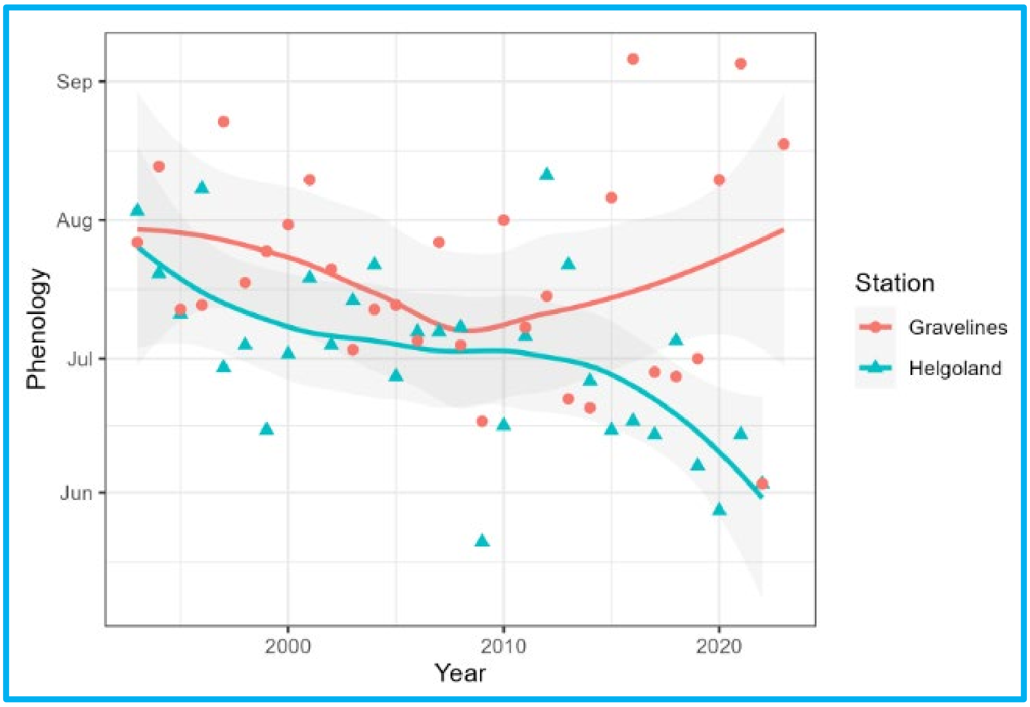


Figure 4.2.2.4 Phenology change in copepods in the German bight area (blue) and the Channel area (red) over the past three decades. Credit Ifremer.

4.3 Acoustic sampling

In 2025, acoustic data was collected aboard all RVZ vessels operating in EU waters. In total, acoustics of more than 30 trips have been collected in 2025, where each trip amounts to ~2.6TB. Hence, 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 2025. However, the larger data volume also necessitates longer processing times.

4.3.1 Dashboard (3.1)

The dashboard including all self-sampled data has been hosted online (https://pfa-dashboard-containerized-v2.azurewebsites.net/) during 2025. In 2025, further developments were made to include acoustic data from the fishing vessels, acoustic surveys, and more functionality to select specific fisheries, trips and environmental data. All fleet managers of the RVZ members have access to a secure environment where the data objects can be found that have to be loaded into the dashboard. When new data routine self-sampling data is provided to the RVZ for processing, an updated input file is automatically generated. This allows the fleet managers to have access to the latest biological insights.

Figure 4.3.1.1. Illustration of dashboard for blue whiting fishery overlaying wind force data with catch and haul duration information. Credit Sustainovate.

4.3.2 Calibration (3.2)

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. Two key calibration activities are presented here. First, the results of two 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 applied, as developed in 2024, and used to derive proxies for calibration gains.

4.3.2.1 Sphere calibration

Figure 4.3.2.1.1 shows the coverage of the sphere calibrations for the SCH302 (18th of July) and SCH123 (3th of June). Calibration of the SCH123 did not cause any delays as it was scheduled during a period without fishery. The SCH302 had to depart one day later to allow for the calibration.

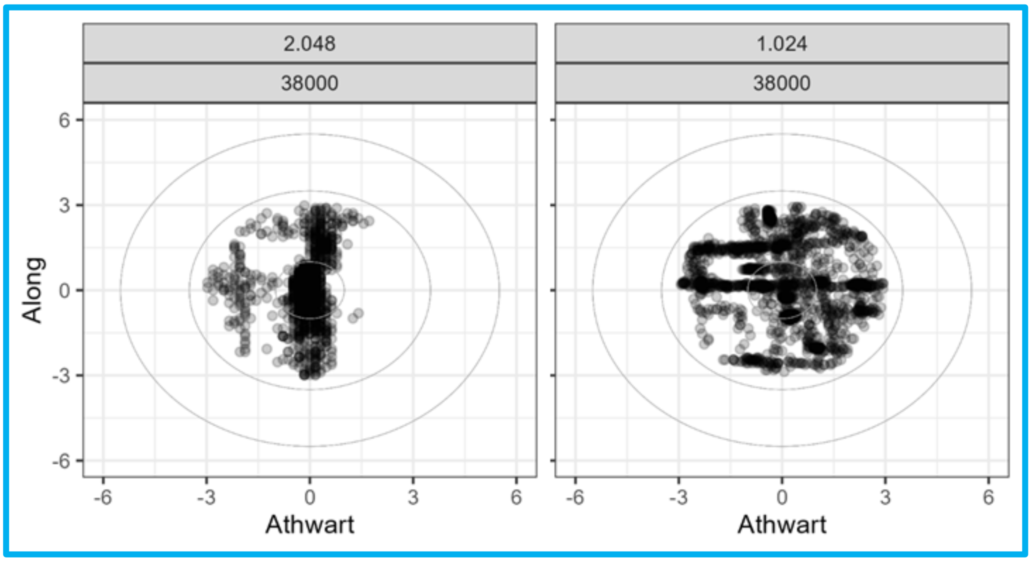


Figure 4.3.2.1. Calibration coverage from the calibration trial on-board the SCH123 (left hand panel) and the SCH302 (right hand panel). Credit WMR

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

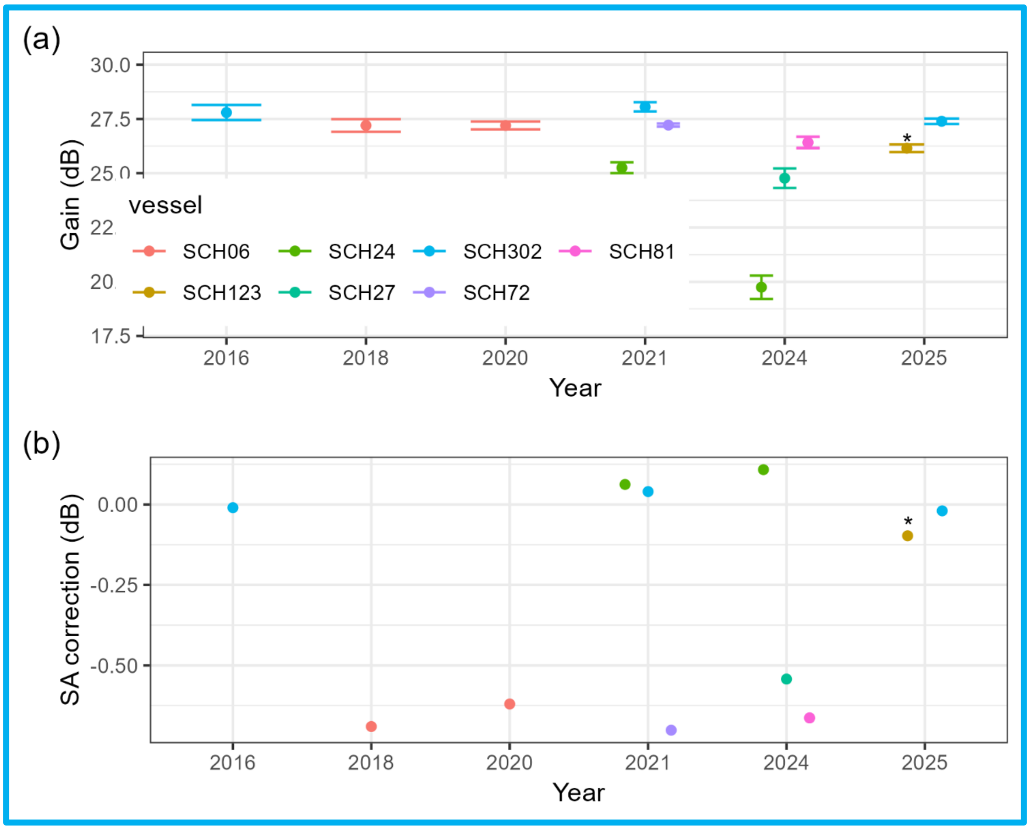


Figure 4.3.2.2. Summary of sphere calibration performed on-board RVZ vessels. Credit WMR.

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.

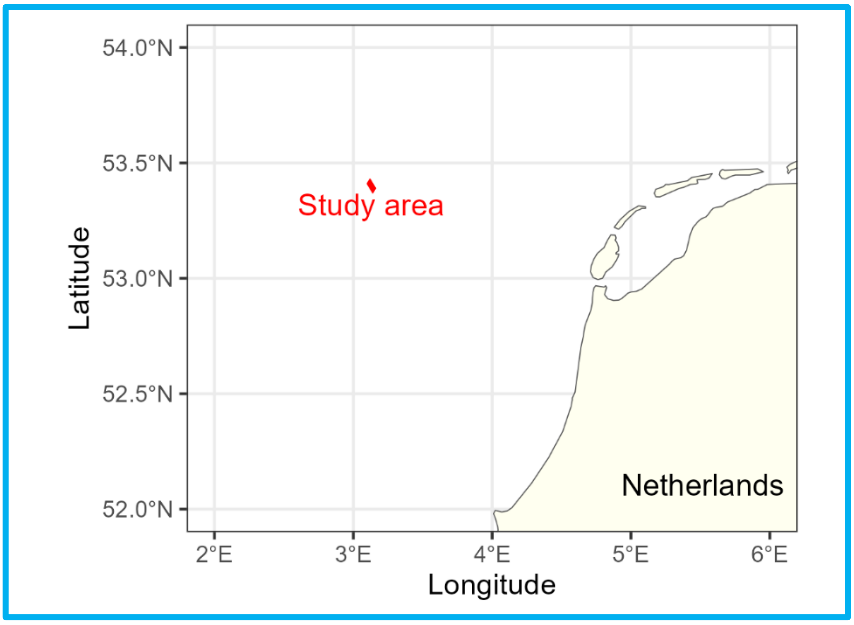


Figure 4.3.2.3. Location of the study area. Credit WMR.

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.

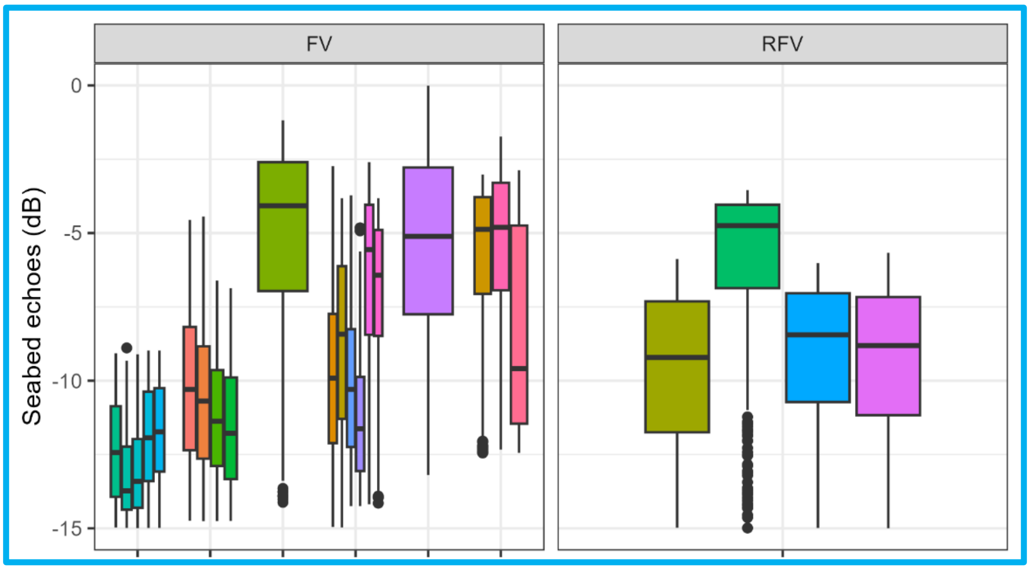


Figure 4.3.2.4. Seabed inferred calibration gains for the different FVs (left). Calibration gains are computed using four reference sets from Tridens (right), collected in 2022-2025. For each instance, the mean distance between the FV data and the reference set are given. Credit WMR.

4.3.2.3 **Development of AUV**

Calibration of acoustic equipment on research or fishing vessels is a notoriously difficult and time consuming job. Over the past years, a dedicated company specialized in calibrating echosounders has been tasked by RVZ together with researchers from WMR to calibrate vessels every 3-5 years. Although this cycle is appropriate for routine data collection, it lacks the precision one usually needs within scientific surveys where calibration occurs at least twice a year before a dedicated survey. On-board research vessels, multiple frequencies are calibrated while on-board the RVZ vessels, only the 38khz frequency gets calibrated. For these considerations, in 2025 we started to develop an AUV that could speed up the calibration process and allow for more frequent calibrations and multiple frequency calibrations. As the AUV is able to place the tungsten sphere within the acoustic beam with high precision at high speed, this allows for faster calibrations. The AUV developed (see Figures 4.3.2.5 and 4.3.2.6) shows thrusters on 6 sides with a large open gap in between where the sphere can be placed. The AUV is controllable by a remote that can be operated from the quayside.

Figure 4.3.2.5. Calibration AUV test version on quayside prior to test. Credit Beijert.

Figure 4.3.2.6. Calibration AUV test version in the water during its first real life test. Credit Beijert.

4.3.3 Quality control (3.3)

When fishers are out at sea, they use acoustic information in a relative manner. In other words, they do not need exact densities but rely on relative indicators of density and school size. For research however, there is this need for absolute indicators of density. Having a partially functioning echosounder may not directly impair the fishing activity, but it will result in unusable acoustic data for science. As such, it is key that skippers are alerted in an early stage if the quality of the echosounder degrades over time, a process that is not uncommon and usually results in repairs or replacement of the echosounder. There is yet no tool at the market that provides the quality indicator of the acoustic data and for this reason, in 2025, RVZ started the development of a so-called ‘WatchDog’, i.e. a sensor (see Figure 4.3.3.1) that provides insight into the quality of the acoustic data that is later on stored on a hard drive for further scientific analysis. The sensor is coupled to software (see Figure 4.3.3.2) that continuously monitors the quality of the acoustic data and sends a warning to the skipper if the quality is insufficient for scientific use.

Figure 4.3.3.1. Watchdog sensor being tested at the RV Tridens. The sensor is shown as the black ring and grey module that measures the amperage of the signal. The sensor is coupled to a handheld device that runs the watchdog software. Credit Beijert.

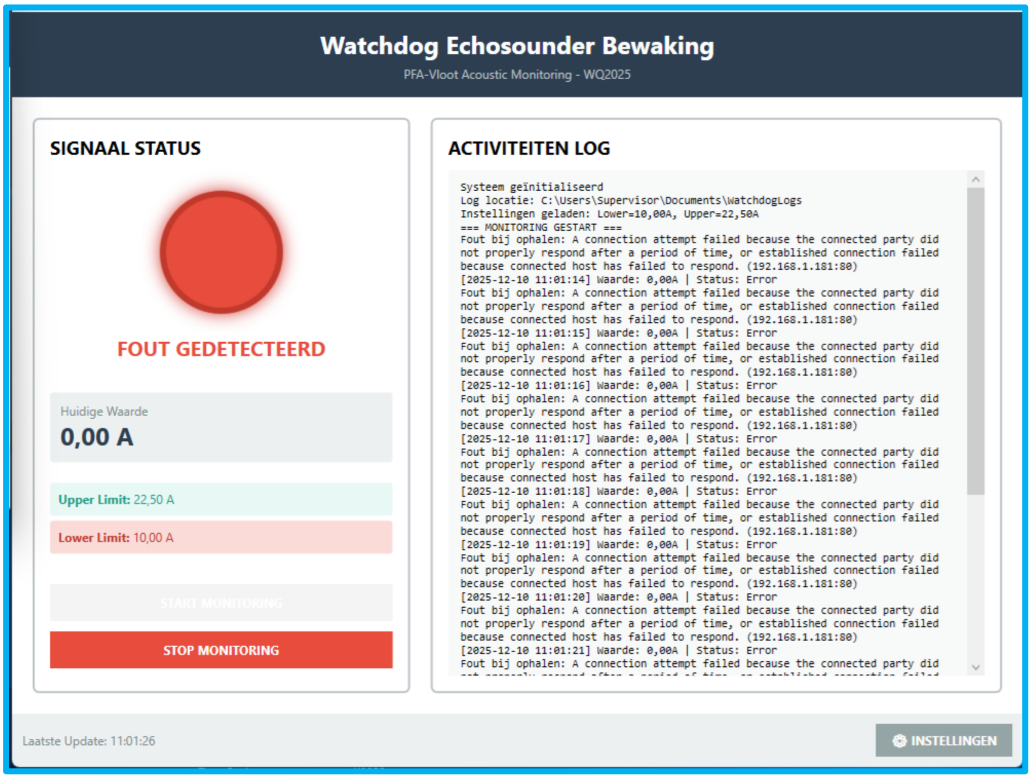


Figure 4.3.3.2. Watchdog monitoring software. Credit Beijert.

4.3.4 Species recognition (3.4)

Avoiding boarfish bycatch in the horse mackerel fishery remains a long-standing challenge. Although fishermen rely heavily on echosounders for operational decision-making, correctly distinguishing aggregations of boarfish from horse mackerel is often difficult due to overlapping acoustic characteristics, mixed-species schools, and dynamic behaviour.

To better understand current practices, limitations, and expectations for technological tools, structured interviews were carried out with skippers from five freezer trawlers between 9–27 July 2025. It was considered more useful to talk one-on-one to skippers than organizing a one-day workshop. While skippers rely heavily on multi-frequency echosounders, consistent acoustic distinction between horse mackerel and boarfish is rarely possible—especially when both species form mixed bottom-associated aggregations along the shelf edge.

Across vessels, several strong patterns emerge. Boarfish risk is highest on the shelf edge (<200 m depth), in the Bay of Biscay, Celtic Sea, waters west of Ireland, and—more recently—areas further north, reflecting a perceived climate-driven expansion. Night-time fishing significantly reduces risk in southern latitudes (below ~54°N), but does not help farther north where horse mackerel remain near the seabed at all hours.

In order to manage risk, skippers perform a combination of short test tows, area switching, multi-frequency comparison, and trawl sensors, but they consistently emphasize that behaviour of both species changes annually, limiting the value of previous-year knowledge. Many highlighted a need for better training to fully exploit modern echosounder capabilities.

Overall, the interviews confirm that there are certain common practices available to avoid boar fish. These practices were shared among the skippers, but there is still a desire for a more technical based decision-support system—especially those integrating multi-frequency information, behavioural cues, and probabilistic warnings, to avoid boarfish catches in the horse mackerel fishery.

4.3.5 Windfarm acoustics (3.5)

To provide additional information on small pelagic fish densities along the Dutch windfarms, Wageningen Marine Research developed two transects, one out of Ijmuiden and one out of Scheveningen, for fishing vessels to routinely collect acoustic data for. The transects were formalized near the end of 2025 after acoustic data had been collected by fishing vessels in this area. As such, the data collected throughout 2025 is not positioned exactly on-top of the transect, although acoustic experts indicate that the opportunistic and semi-structured process as taken in 2025 resulted in good quality data as well. Figure 4.3.5.1 shows the data collected in 2025 and Figure 4.3.5.2 shows the designed transects. A protocol for settings, course of travel and recording details has been developed and shared with the skippers. Preliminary analyses of the acoustic data revealed a clear seasonal pattern in pelagic density (Figure 4.3.5.3).

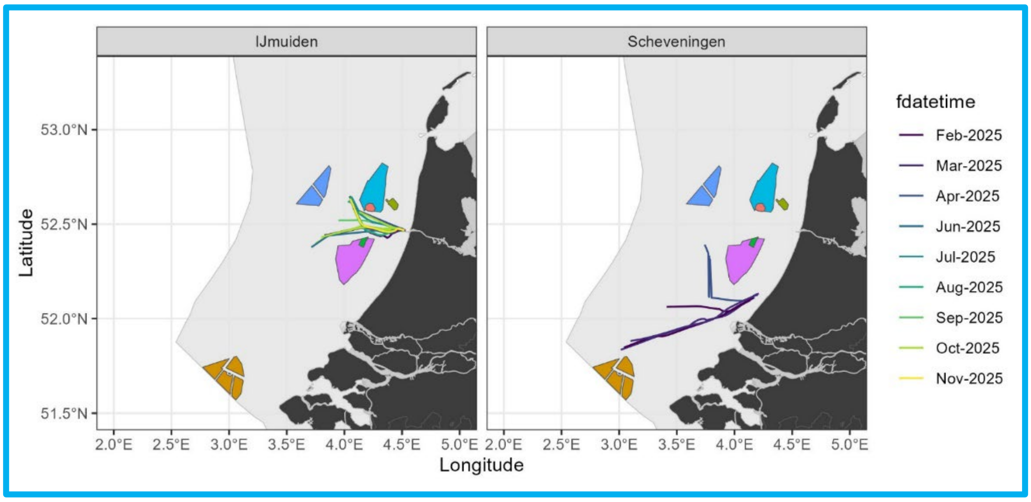


Figure 4.3.5.1. Transit tracks from RVZ vessels departing from IJmuiden (left panel) and Scheveningen (right panel), coloured by month of recording. Tracks are overlaid on the Dutch Exclusive Economic Zone (grey shading) and MONS survey strata (coloured polygons). The temporal colour scale illustrates how the monthly distribution of transits provides near–year-round acoustic coverage of the coastal corridor. Credit WMR.

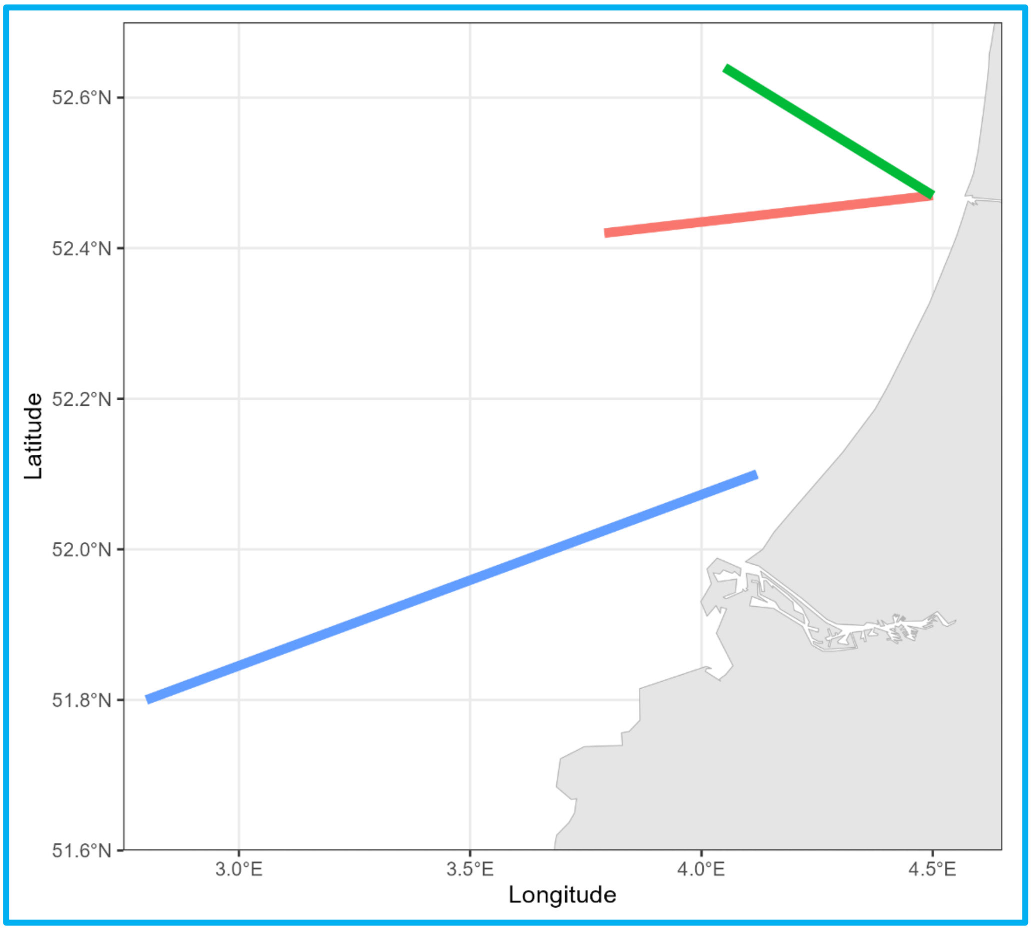


Figure 4.3.5.2. Designed transects out of the Ijmuiden and Scheveningen harbours to routinely collect acoustic data around Dutch windfarm areas.

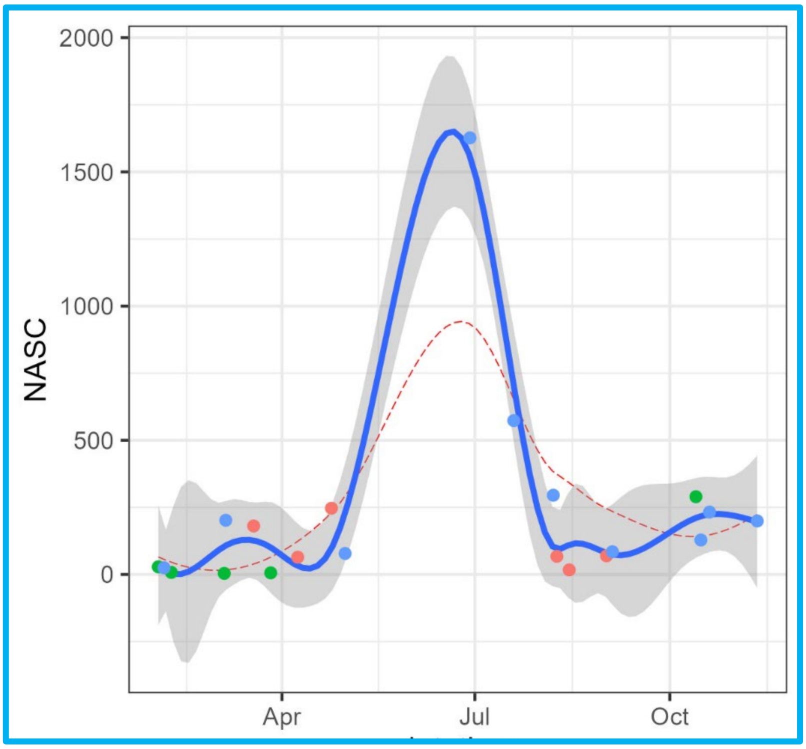


Figure 4.3.5.3 Seasonal pattern in NASC values from all transit datasets, with individual vessel observations (points), a flexible smoother (dashed red), and a GAM smoother with confidence band (blue). The curve shows a clear seasonal peak in early summer and low densities in late winter. Credit WMR.

4.3.6 Sonar (3.6)

In 2025, WMR evaluated whether omnidirectional sonar data collected on fishing and research platforms can be transformed into scientifically usable observations of pelagic fish aggregations. The SU90 sonar, as available on several of the RVZ vessels, provides a unique 360° perspective around the vessel, enabling observation of school structure, movement, splitting/merging, and vessel interaction at spatial and temporal scales that are difficult to capture with hull-mounted echosounders alone. To be able to store sonar data, a licence had to be arranged through the hardware provider as under normal circumstances, storing sonar data is not allowed.

After initial testing on-board the RV Tridens, a protocol was developed to collect sonar data on-board fishing vessels. Two pre-sets were defined, one for herring that is usually caught in shallow water and one for blue whiting that is usually caught in deeper water.

Preset A: "SHALLOW / SHELF" (North Sea Herring)

Parameter	Setting Value	Scientific Rationale
Frequency	30 kHz	Higher frequency provides sharper resolution and narrower beams to separate schools from the seabed.
Pulse Form	FM Auto (or Short)	Shorter pulses improve separation of targets near boundaries (bottom/surface).
Range	1000 m	Long ranges (>1200m) are ineffective in shallow water due to multipath echoes (sound bouncing between surface and bottom).
Tilt Strategy	-5° to -15°	Shallower tilts to scan the upper column. Steeper tilts only for "bottom inspection."
Gain Strategy	TVG: 20 log R	Use standard TVG. Avoid excessive Master Gain to prevent saturating the bottom echo.

Preset B: "Deeper / Open Water" (Blue Whiting)

Parameter	Setting Value	Scientific Rationale
Frequency	20 - 22 kHz	Lower frequency suffers less absorption loss, allowing detection at much greater distances and depths.
Pulse Form	FM Long	Longer pulses inject more energy into the water, increasing the Signal-to-Noise Ratio (SNR) for weak, deep targets.
Range	2000 m	Deep water allows sound to travel cleanly without bottom interference, maximizing search area.
Tilt Strategy	-15° to -35°	Significant downward tilt is required to intersect deep scattering layers (300m–600m depth).
Gain Strategy	TVG: 20 log R	Essential to compensate for massive signal loss over 2km distances.

Figure 4.3.6.1. Protocol for sonar data collection on-board fishing vessels. Credit WMR.

Particular attention was paid to common problems as follows: Schools that intersected blind zones or lay within the blind sector were removed from the analysis, as were candidates whose area or aspect ratio fell outside the pre-defined limits. In periods with fragmented detections, the adaptive threshold was lowered and the maximum of missing pings increased to allow merging of contiguous school fragments. For noisy situations dominated by surface reflections, the upper sampling range was reduced and, where necessary, all schools in the affected range were discarded. The overarching rule was to favour a conservative segmentation—accepting fewer, well-defined schools rather than a large number of uncertain detections.

Converting 360° sonar data into biological metrics requires a specialized pipeline. We have structured this into four logical stages:

1. Pre-processing and Noise Control
2. School detection
3. Tracking and Kinematics
4. Behavioural Metrics

Following this process leads to processed sonar data as can be seen in figure 4.3.6.1.

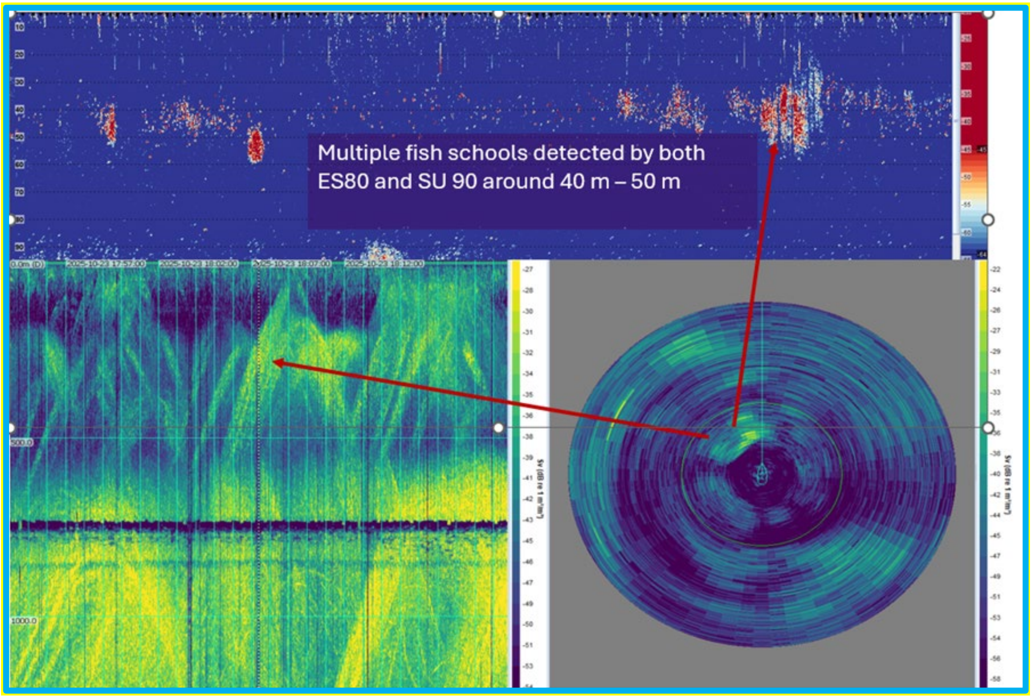


Figure 4.3.6.1. Cross-instrument confirmation of near-surface schools. Top: ES80 echogram showing multiple schools at approximately 40-50 m depth. Bottom-left: sonar SU90 range-time display over the same interval showing a corresponding target moving in range as the vessel passes. Bottom-right: SU90 omnidirectional snapshot highlighting the same aggregation in bearing-range space. Credit WMR.

At the sonar (SU90), the fish targets appear as coherent features in the omnidirectional view and as continuous traces in the range-time display as vessel-school distance changes, providing independent confirmation that the sonar detections represent real schooling events rather than noise. This cross-instrument agreement supports the use of opportunistically logged sonar data for robust school detection/encounter metrics and qualitative interpretation of school dynamics.

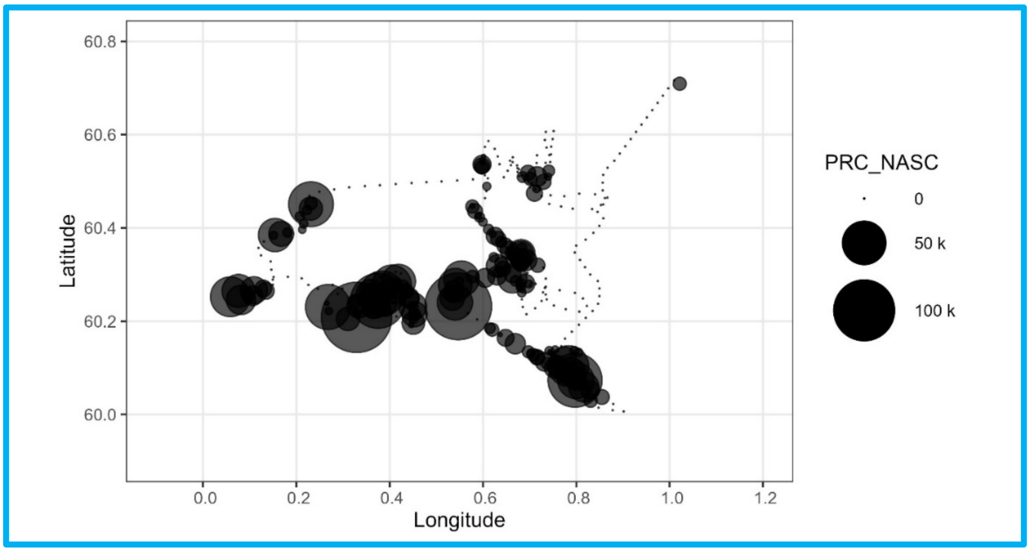


Figure 4.3.6.2. Spatial distribution of preliminary sonar backscatter proxy (PRC_NASC). Points show sequential vessel positions; bubble size is proportional to PRC_NASC, highlighting localized high-intensity encounters along the track against a background of low or zero values. Credit WMR.

During the development, there has been extensive interaction with the skippers as they had to troubleshoot during the recording period. This was more complex and researchers of WMR had to visit the vessel several times to get the system up and running. During the retrieval of a second set of data, feedback was given to the skippers on the results of the first part of the data collection. The final report of the sonar work has been shared with the skippers and will be further discussed early 2026.

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 2025, RVZ vessels successfully captured underwater footage at multiple locations within fishing nets across various fisheries.

4.4.1 Trawlviewer kit development (4.1, 4.2)

In 2025 two designs of the trawlviewer kit were in use by the fleet. The version that is suitable up to depths of 250m is most commonly used and only required maintenance of seals, dehydration substrates and dive lights. An additional version able to reach depths of up to 1000m was purchased, including protective housing, storage casing and batteries. The deep sea units experienced light malfunctioning for which the units had to be send back to the manufacturer in Canada. This resulted in footage supported by only one light rather than the planned two lights. Repairs of the lights resulted in additional costs. Figure 4.4.1.1 shows the number of hauls and trips in which the camera’s were deployed. On average over 2024-2025, around 350h of footage has been collected per year.

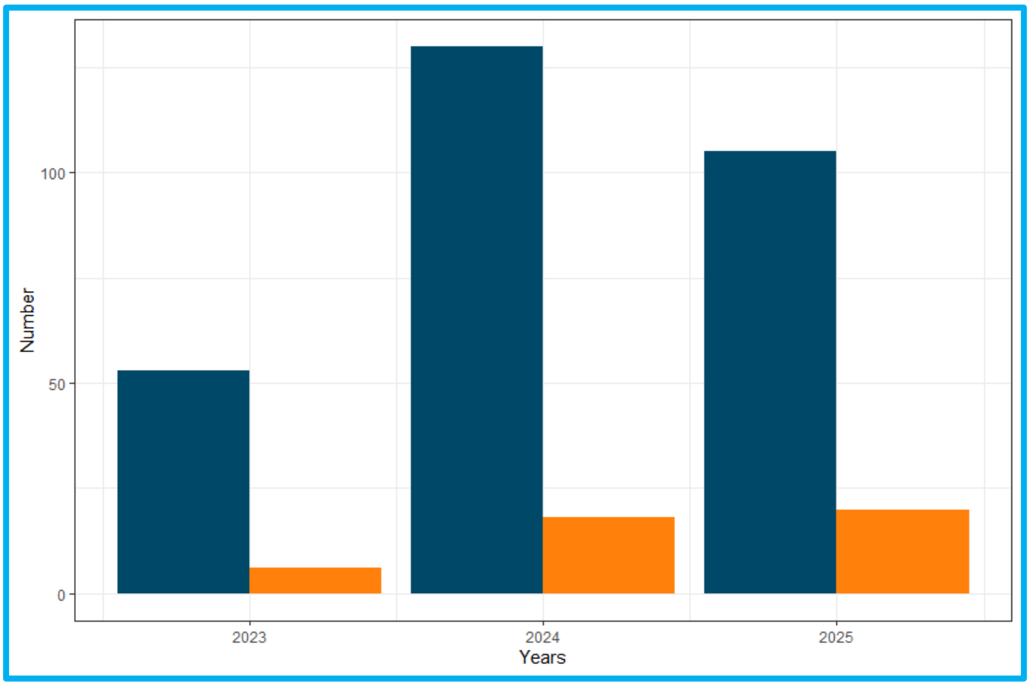


Figure 4.4.1.1. Number of hauls (blue) and trips (orange) recorded with use of trawl viewer kits.

4.4.2 Processing of footage (4.3)

This project aims to accelerate and streamline the review of fisheries video data by developing an automated bycatch-release detection module. In the first part, a user-friendly GUI was created (see Figure 4.4.2.2) to run the detector and automatically stitch collected footage, significantly improving the efficiency of data collection and preparation. Building on this foundation, we introduce a VIT-VAE model capable of isolating video frames of interest and classifying them as above-water or underwater (see Figure 4.4.2.1). The second part focuses specifically on detecting bycatch events in underwater footage, where a bycatch event is defined as any frame in which large bycatch is present. To achieve this, we develop a transformer-based anomaly detection model that separates footage into target catch and bycatch and triggers a signal when bycatch is detected. The user interface shows the following components:

- Real-Time Bycatch Detection – Classifies video frames as target species or bycatch using a Vision Transformer (ViT)-like architecture.
- Anomaly Scoring – Computes per-frame anomaly scores based on reconstruction errors to highlight unusual events.
- Attention Visualization – Generates attention heatmaps overlaid on frames for model interpretability.
- Interactive GUI – PyQt6-based interface with playback controls, real-time probabilities, and system usage monitoring.
- Report Generation – Produces PDF reports with summaries, histograms, correlation heatmaps, temporal analyses, and event logs.
- Multi-Threaded Processing – Background report generation to prevent UI freezing.
- Configurable – Supports user-defined hyperparameters, loss weights, and thresholds.

This method allows to process large volumes of footage in one go and outputs short sections of clips that need a human eye for verification. This limits time needed to review the footage from several hours per recording to only a minute or two. This approach could be rolled out to skippers to allow them to review their recordings while still being on the fishing grounds.

This approach enables more reliable detection and enhances the scalability and consistency of the overall processing pipeline.

The reliability of the AI model highly depends on available training data. For this reason, RVZ has been collecting footage for several years already to ensure high quality data was available for WMR to develop the methods. Still more data is needed to optimize the workflow.

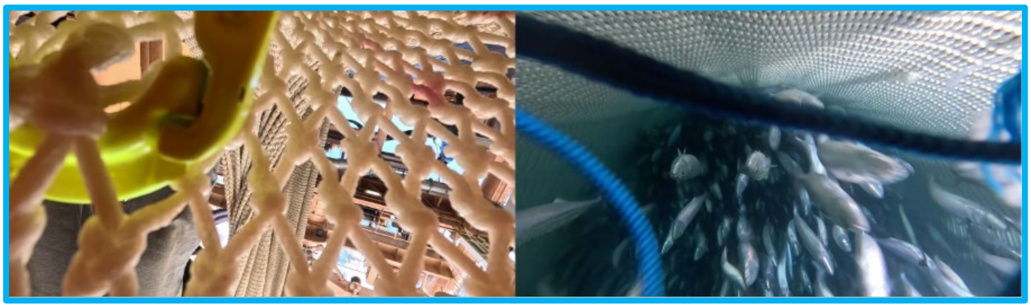


Figure 4.4.2.1. Above water and underwater frame detection. Credit WMR.

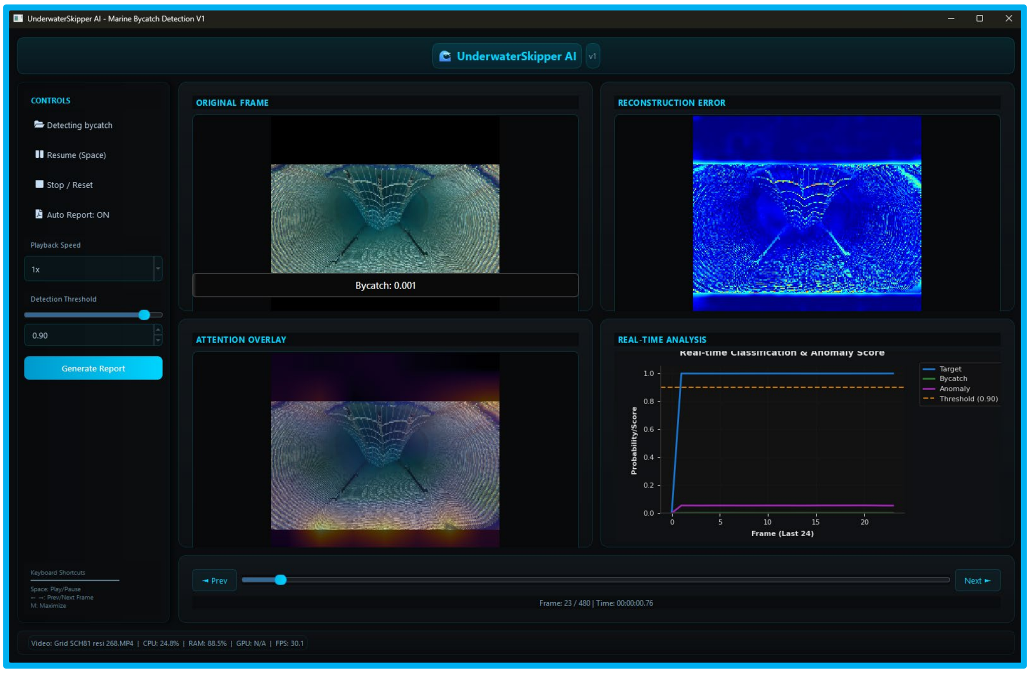


Figure 4.4.2.1 GUI to AI model to analyse underwater footage. The expected bycatch probability is given within the upper-left panel (at 0.001 in the example) and shown for the full clip in the bottom-right panel. Credit WMR.

4.5 Automatic measurement

4.5.1 Length-Weight measurement system (5.1)

In 2025, 8 LWMS had been purchased by RVZ members. The first unit, that was previously used for testing, was placed on-board one of the RVZ vessels. The remaining 7 units went into production in 2025 for which placement is scheduled for January/February 2026. Prior to production, Innovotech visited all 8 vessels to design the correct placement of the units and suggest small alterations to the design to allow a uniform unit to be manufactured suitable for all vessels. This led to further refinements in the design (see figure 4.5.1) that overall made the unit smaller than before. Due to the large volume of components, ordering and production of fully functioning LWMS systems was delayed.

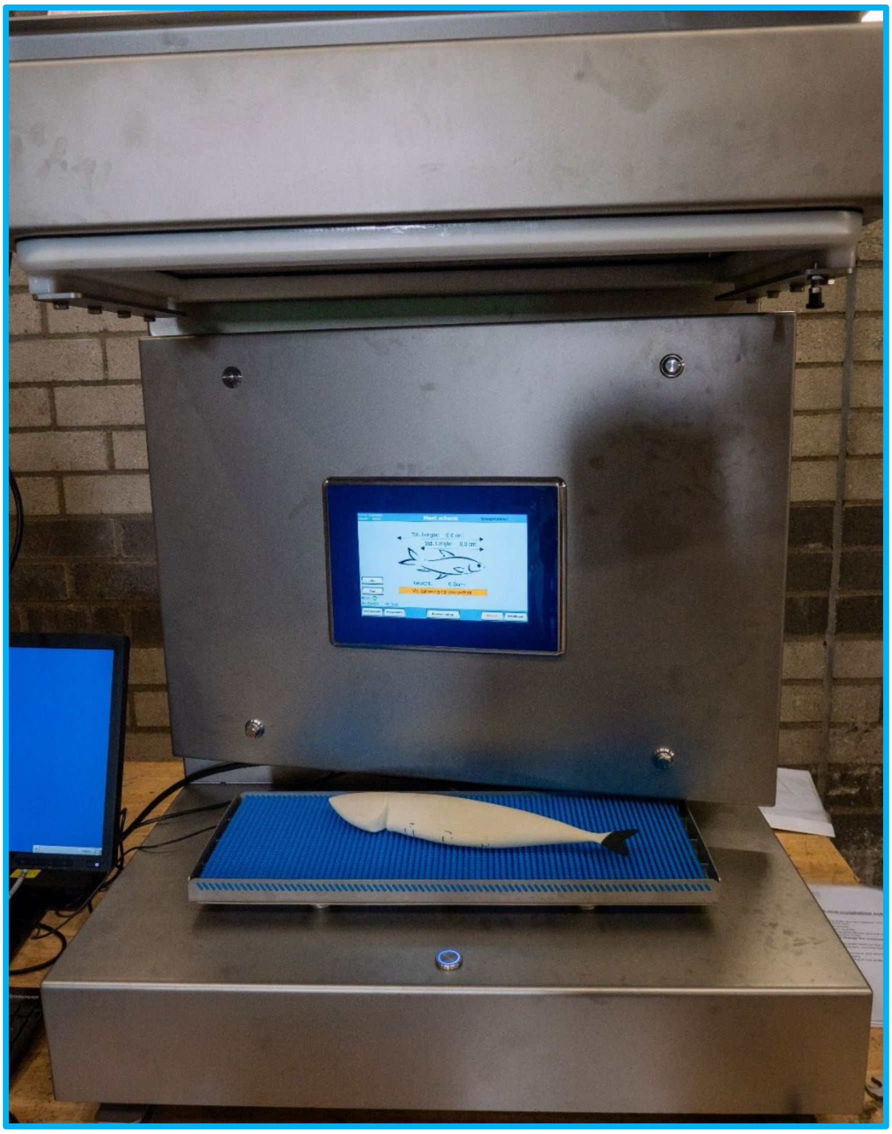


Figure 4.5.1.1. Modified 2025 production model with redesigned touchscreen placement and control box (top part).

Innovotech and EFICE worked together to develop a communication protocol. The data from the LWMS has to be pulled into the mCatch software for a smooth workflow on-board. The LWMS produces an XML-based file containing the information on measured lengths and weights. This file is stored within the LWMS on a hard disk. Via a Raspberry-Pi interface, making use of FTP, the XML file is retrieved and pushed to the mCatch software. For this to work without failure, the server functionality of the Raspberry-Pi is used to retrieve information on vessel, trip and haul/batch information directly from the LWMS while the allowable fields (on vessel, trip, etc) to be generated by the LWMS are restricted by definitions as set in mCatch.

4.5.2 Fish fat and volume estimation (5.2)

Fat content estimation based on spectral imaging focussed on further analysing the spectral images as had been collected before by decomposing the spectrum into elements that could be identified as fat.
The full spectrum of 50 measured fish per species were decomposed into different components that represent a different attribute of the fish, e.g. water content, some background, image glare and unknown endmembers that are assumed to represent fat in the fish. Figure 4.5.2.1 shows the average spectral image of a fish consisting of the different components. Figure 4.5.2.2 contains the relevant ‘endmembers’ for mackerel, horse mackerel and herring. These endmembers do differ per species but there is large overlap in shape and response between the species, potentially allowing us to generate a universal model for small pelagic fish fat.

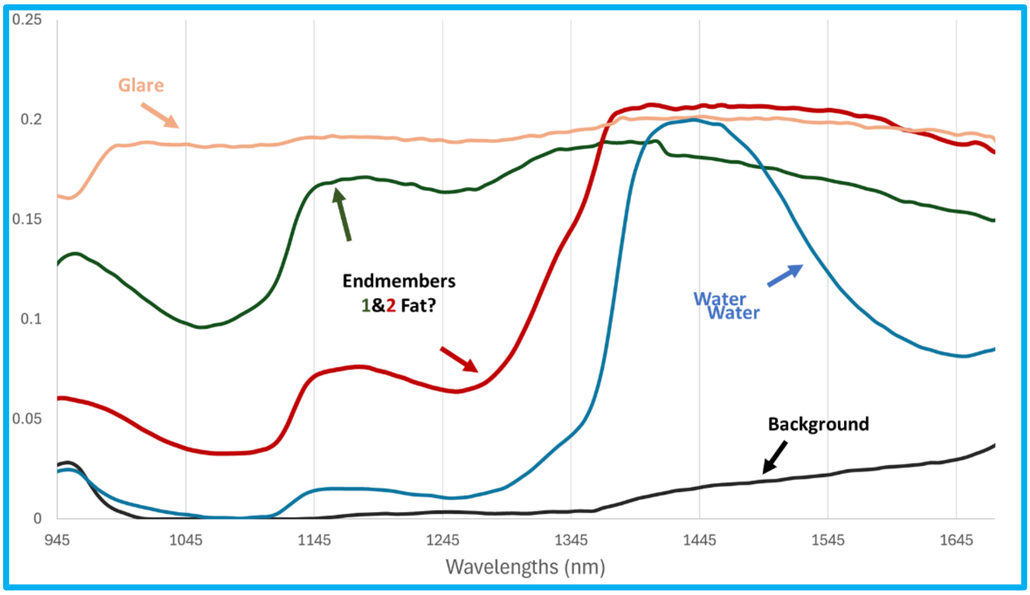


Figure 4.5.2.1. Generic representation of spectral image of a small pelagic fish, decomposed into different components

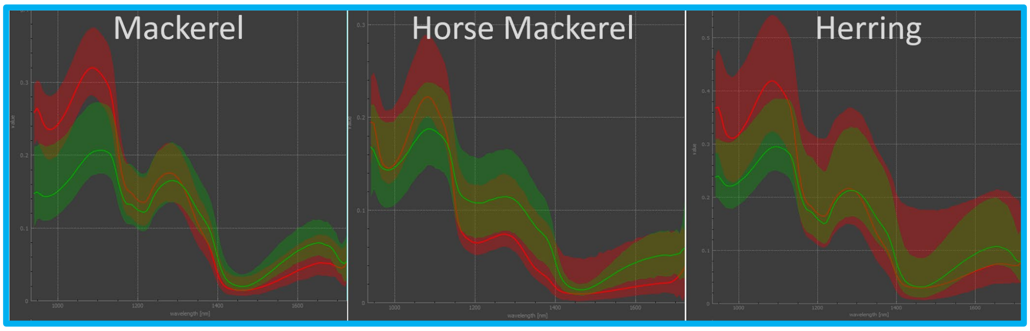


Figure 4.5.2.2. Spectral image of mackerel, horse mackerel and herring showing the two endmembers per species.

The spectra were analysed using PCA statistics and showed very clearly the impact of skin on the spectra. The PCA results suggested that up to three axis could explain the majority of the variance and could be used to design a predictive model of fat content, taking the spectra as input. For herring, mackerel and horse mackerel predictions were made resulting in a 85% correlation (0.73 R^2) for mackerel, a 64% correlation for herring and a preliminary correlation of 78% for horse mackerel.

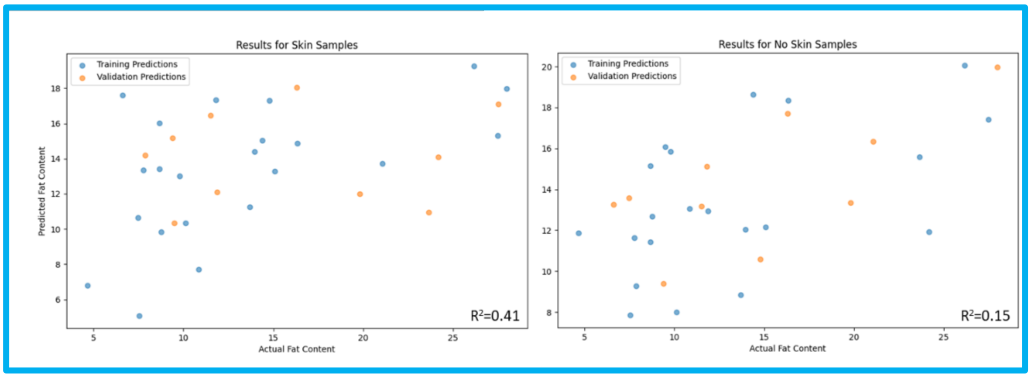


Figure 4.5.2.2. Predictive model for herring with and without skin. Note that the model without skin did not use spectral decomposition techniques. Credit WUR.

Volume estimation continued as in 2024 through a modelling approach. Volume estimates in 2024 were biased which was partially related to the modelled fish shape and flexibility as well as to the routine to estimate volume. In 2025, a 360° camera system had been used to carefully scan a fish and convert the shape into a hyper-realistic model (figure 4.5.2.2). Within the modelling software a skeleton was added to ensure that the fish has the appropriate flexibility when it is stacked together onto a conveyor belt. An updated algorithm has been developed that not only takes into account length and width of the image, but also depth. In cases where fish is stacked, or where individual weights are different, this improves the estimation of volumes. Especially accounting for gaps, i.e. the black sections in figure 4.5.2.3, are relevant as well as the empty spaces in between stacked fish. A direct relationship between these empty spaces and the surface/depth ratio was found. Finally, 4 different scenarios of fish density arriving on the conveyor belt, ranging from 1 to 4 layers thick were tested. For this, 4 different known volumes of fish were simulated (i.e. simulated camera footage) and the volume estimation model was run on the footage to estimate the total weight of a section. The results showed that the model was highly accurate in estimating the volume of the section. There is a small underestimate of weight throughout all simulations which is likely due to lead-in and lead-out segments where fewer fish are present compared to the bulk of the footage.

Figure 4.5.2.2. Hyper-realistic 3d computer model of a mackerel. Credit WUR.

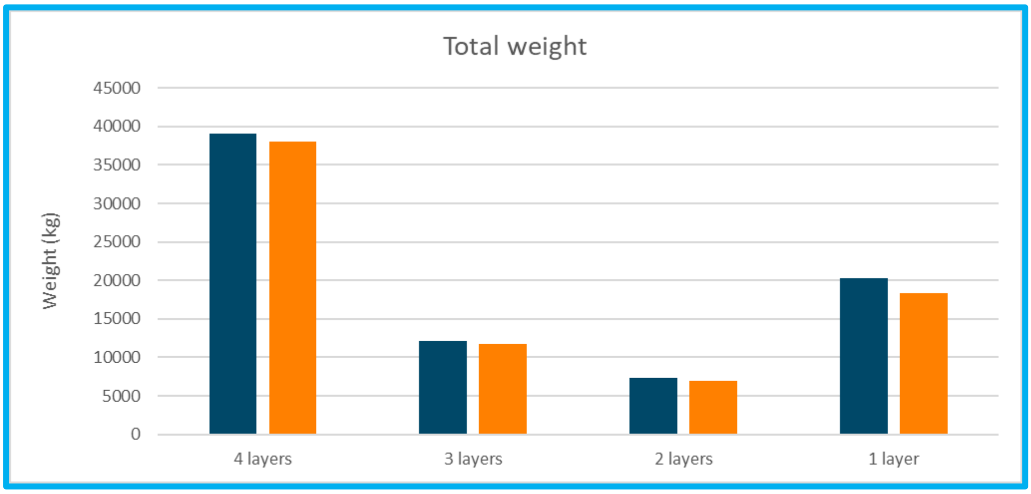


Figure 4.5.2.3. Simulated (known, dark blue) and predicted (orange) volumes of fish under 4 different estimation designs. Credit WUR.

4.6 Reducing unwanted bycatch

The reducing unwanted bycatch project focussed on five different tasks in 2024.

4.6.1 Best practice skipper sessions (6.1)

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 11th (Zoetermeer), June 3rd (Scheveningen), September 3rd (Zoetermeer), and November 27th (Zoetermeer), with approximately 20 participants attending each event. Each session lasted around three hours and included presentations by invited speakers, such as Thomas Noack from the Thünen institute and Bram Couperus from WMR. Discussions covered feedback on field trips conducted by RVZ, experiences with underwater cameras, and advancements in gear development as well as media attention. Skippers talked very openly about the experience with bycatch mitigation solutions and netmakers provided the technical background. During the sessions, suggestions for modifications to the gear were made and over the year, different designs were bought by the companies and tested in the field. Several examples of tests that did not go well were shared and used to further refine the trawls. Changes in fishing behaviour were discussed as well, although the majority of the skippers prefer a technical solution rather than a behavioural change such as avoiding fishing by night, or moving far away from a fishing ground if bycatch is detected.

Figure 4.6.1. Group of skippers, gear manufacturers, scientist and fleet managers discussing progress on reducing unwanted bycatch at the 2nd session in 2025 (Scheveningen).

4.6.2 Knowledge exchange and international coordination (6.2)

Knowledge exchange was facilitated by MPFF, who coordinated international efforts across several key topics and by RVZ who was responsible for organizing a skippers exchange between The Netherlands, Denmark, Ireland and Scotland.

MPFF co-organized the large international event in Vigo (8-10 April) where all bycatch related activities were presented and discussed and where updated workplans for bycatch mitigation were developed. MPFF also co-organized three separate expert exchange sessions on the use of pingers, on the use of cameras in the gear and on bycatch of turtles.

International coordination also took place on the development of an international species identification (ID) guide that was released on 20 May 2025. Elements of the international ID guide were provided by RVZ based on their tailored activity as reported in section 4.6.4. On 8 October 2025, MPFF co-organized an international workshop at the DanFish 2025 Fisheries Exhibition

Figure 4.6.3. Stakeholder session at Danfish 2025. Credit MPFF.

4.6.3 Sea trials (6.2, 6.5)

For the second task, three trips were made (19th July – 7th of August, 3rd of - 8th of September and 19th of October - 11th of November) by Lina de Nijs (RVZ), focussing on six different topics:

1. To experiment with the camera units.

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.

6. To test the hydrophone.

During all three trips, very little bycatch was detected / brought on-board. In several of these trips, there were no ETP bycatches at all. Bycatch excluding devices were mounted in the net but could not effectively be analysed due to the lack of bycatch. This made analysing video footage, identifying species and talking to the crew very difficult as the discussions ended quickly without any material to talk about. During the 1st trip, no ETP species were present around the vessel, while during the 2nd trip primarily orcas were visible from the deck (see Figure 4.6.3.2).

In addition to the first 5 points that were identical to the 2024 scientific quota programme, an additional element was brought in, to record sounds made by cetaceans with a hydrophone. Skippers indicated that cetaceans are often present around the vessels but that they never get bycaught. Likely because all vessels use deterring devices such as pingers to warn cetaceans for the fishing net. However, to provide credible proof that bycatches of cetaceans are extremely rare, RVZ decided for 2025 to use a net-mounted hydrophone to record sounds from cetaceans to identify the species present around the vessel and to reconstruct movement and position of the cetaceans around the net. This latter point is possible since RVZ makes use of a stereo-hydrophone setup. Prior to deploying a hydrophone, the entire setup had to be designed from scratch as, to the experts view, no one had previously experimented with hydrophones in a trawl. A sound-neutral casing had to be designed and a setup to mount the hydrophones into the setup had to be designed. Parts were custom 3d printed and turned out to work very well (Figure 4.6.3.1). Some minor adjustments were made in between trip 1 and 2 to the design.

Figure 4.6.3.1. Internal design of the hydrophones and 3d printed parts to hold all components in place.

During the first two trips, time was spend on finding a suitable place to mount the hydrophone (Figure 4.6.3.3). A hydrophone collects all sorts of sounds and these sounds such a sound of the propulsion, the engine, but also from echosounders, net sensors etc. These sounds should not interfere with the sound spectrum of the cetaceans. Five different positions were tested during the first 2 trips and data was analysed by St. Andrews University. Handling the hydrophone turned out to be complex as retrieving data would first require taking the tubing apart to remove the hydrophone and soundtrap (i.e. dedicated storage unit) from the pipe. As the hydrophone is designed to have a long underwater battery life, extracting data is very slow and hence time consuming while file sizes are very high (several TB of data for a singly haul).

Figure 4.6.3.2. Still of footage of orcas next to the vessel.

Figure 4.6.3.3. Different mounting positions for the hydrophone.

In the last trip, RVZ was able to record cetaceans again. Data was immediately shared with the scientists from St. Andrews University that were able to identify chains of clicks (see Figure 4.6.3.4) and return an interpreted figure of the sounds recorded. Together with the crew, the data was analysed and the sound frequencies from the equipment identified. This may help in the future to turn off certain equipment if there is a temporary focus on recording cetacean sounds.

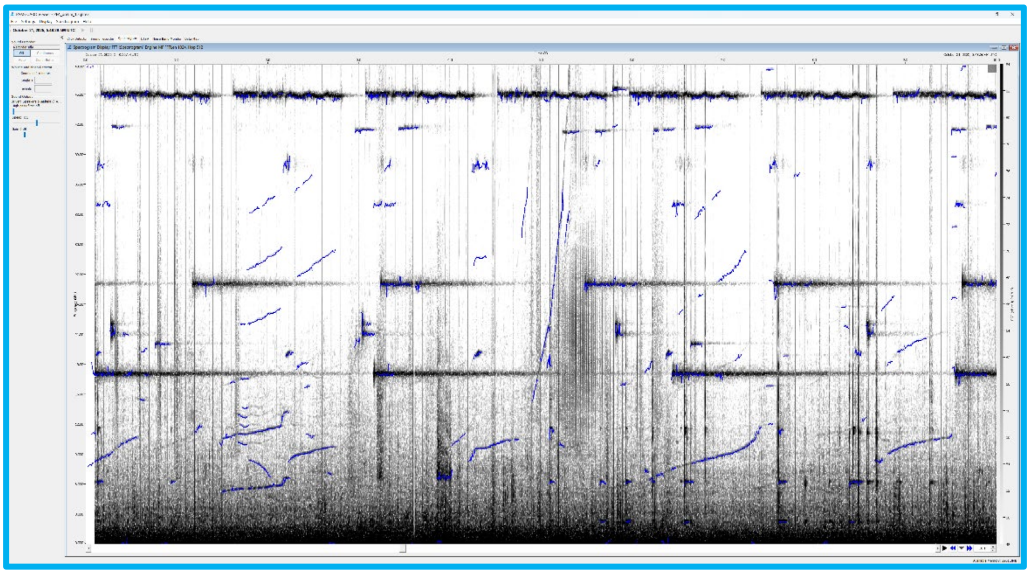
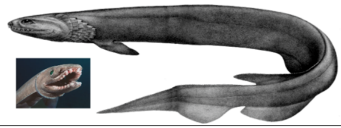
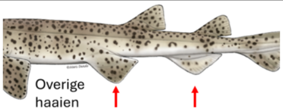
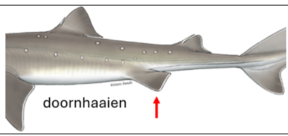
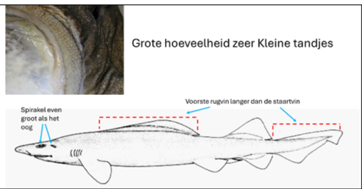


Figure 4.6.3.4. Identification of trains of clicks from cetaceans in blue. In black different constant noise produced by sensors. Bottom row sounds are most likely from the propulsion, the 45kHz band from the catch sensors, the 27Hz band from the Simrad SU90 sonar, the 17kHz band from the Simrad ST90 sonar, the 42kHz band from the door sensors and the 36-39kHz band from the belly sensor. Credit St. Andrews University.

4.6.4 Species identification guide (6.4)

The bycatch guide was further refined. In 2025 specific attention was paid to correctly identifying small sharks. Experts from WMR indicated that it is very difficult to correctly identify small sharks at first glance and that it requires a determination key. Such a key was developed and shared with the crew to allow them to accurately report bycatch species. The key allows any user to start at step 1a (see Figure 4.6.4.1) and work there way through the key up to step 28b if necessary, to arrive at the correct species). Effort was spend to also update the photo’s in the ID guide to come from real-world examples rather than stylised imaged. Finding appropriate photo’s is however difficult as there is general reluctance to take photo’s or share photo’s of bycaught specimen.

Stap	Beschrijving	Visuele kenmerken	Conclusie / vervolgstap
1a	Eén rugvin, langwerpig lichaam, 6 kieuwspleten, rijen tanden met meerdere punten, kieuwen franjeachtig, reptielachtige kop		**Franje haai** (*Chlamydoselachus anguineus*)
1b	2 rugvinnen, 5 kieuwspleten		3
3a	Op de buik: 1 paar borstvinnen, 1 paar buikvinnen, 1 anaalvin		4
3b	Op de buik: 1 paar buikvinnen, 1 anaalvin		12 Zeilvinruwhaai (*Oxinotus paradoxus*) en Doornhaaien (*Squalidae*)
4a	Grote hoeveelheid zeer kleine tanden. Een lange rugvin, minstens zo lang als de staartvin. Gat achter het oog (spirakel) is even groot als het oog.		**Valse kathaai** (*Pseudotriakis midrodon*)
4b	Geen van deze kenmerken		5

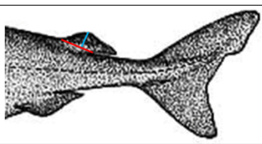
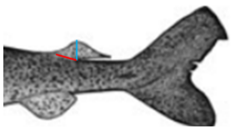
Stap	Beschrijving	Visuele kenmerken	Conclusie / vervolgstap
26a	Dikke, vlezige lippen met dwars-richels. Ondertanden enigszins gezaagd.		**Vliegervinhaai** (*Dalatias licha*)
26b	Lippen niet met dwarsrichels, Tanden niet gezaagd.		27
27a	Kleine soort (max 25cm). Eerste rugvin met doorn, tweede rugvin zonder doorn.		**Dwerghaai** (*Squaliolus laticaudus*)
27b	Beide rugvinnen zonder stekel.		28
28a	Hoogte van de 2de rugvin minder dan de vinbasis (het deel van de vin dat verbonden is met het lichaam). Maximale lengte 100cm.		**Groenlandse haai** (*Somniosus microcephalus*)
28b	Hoogte van de 2de rugvin gelijk aan de vinbasis (het deel van de vin dat verbonden is met het lichaam). Grote soort (maximale lengte 650cm).		**Kleine sluimerhaai** (*Somniosus rostratus*)

Figure 4.6.7. An example page out of the RVZ identification guide for small sharks. Credit WMR.

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 2025 two activities were planned, one welfare field study investigating herring roe quality in relation to the capture process and a feasibility study on the use of a kiwikuil-like pump bag to quickly kill fish while they are still in the net behind the vessel.

4.7.1 Roe herring condition (7.1)

For each at-sea trail, RVZ asks the ethical committee on animal trials to provide advice on whether the planned activities are in need of a permit. For the majority of the work we do on-board, no permit is needed. For the roe content work however, the ethical committee considered it recommendable to apply for a permit to perform the work. The RVZ is strict in doing research along the highest standards, unfortunately however, requiring a permit often takes longer than six months. Since the pre-screening to get the initial response from the ethical committee took already long, there was no time anymore to pursue the avenue of getting a permit and be able to execute the work in time. For this reason, it was decided to cancel the experimental work on roe herring for 2025.

4.7.2 Feasibility study 'KIWIEX' (7.2)

In the catch of pelagic fisheries, a proportion of the fish is pumped alive from the cod-end to the RSW tanks onboard the trawler after an intense and stressful catch process. If improvement of welfare is desired in this fishery, it may be beneficial for the welfare of catch to be euthanized before entering the fish pump. This research provides a technical feasibility study on how to euthanize the total catch as soon as possible after the capture in the cod-end using the KIWIEX concept. The KIWIEX concept focuses on improving catch welfare by minimizing the duration and severity of discomfort of the fish during the capture process of pelagic fish. The primary goal of the KIWIEX is to create a fatal end point of the total catch early in the capture sequence, thereby preventing unnecessary suffering during the later stages of trawling, pumping, and onboard storing or processing. The possibilities of using the KIWIEX as a net extension in the trawl process or as an extension of the fish pump have been explored. This was done through a desk study and extensive consultation with skippers, net makers, crew, and fleet managers. This study project assesses practical, technical, and biological feasibility, including material and design requirements, attachment options, and oxygen depletion modelling across five temperatures and varying catch volumes.

Three design options were generated and evaluated through stakeholder input.

1. Pump KIWIEX – Prioritises fish welfare by ensuring fatal end point of the total catch before the fish are pumped onboard.

2. Trawl KIWIEX – Aims to improve fish welfare and fish quality by achieving fatal endpoint of the total catch before pumping onboard, while being integrated more directly into the trawl body.
3. Acoustic Release KIWIEX – Combines welfare and quality objectives with fatal end point of the total catch prior to pumping and incorporates additional design features to support active regulation (with an acoustic release system (AR)) of the euthanasia process.

Each design can be configured in two ways. As a KIWIEX "tube" constructed from a strong, impermeable material that is capable of holding the forces in the capture process of a pelagic trawl. Or as a KIWIEX "tube" comprised of less strong material that is enclosed by conventional netting, where the netting provides reinforcement against wear and tension forces during the capture process.

The oxygen depletion time calculations for all three KIWIEX designs, suggesting that the total catch is euthanized with hypoxia before the pumping catch onboard process starts is feasible. The trawl KIWIEX enables the quickest fatal end point for the total catch in the trawling process.

The most desired option depends on decision of functionality and might be discussed in follow up meetings with industry partners. For a follow up research, the pump KIWIEX is the most preferred option when catch welfare is the only purpose. If catch welfare and fish quality is a combined goal of the KIWIEX design, the trawl KIWIEX and AR KIWIEX are the best options. To develop an KIWIEX design that can be applied in practice, more extensive research is need on; material, assembly, production, the effect of the KIWIEX designs on net characteristics, effectivity on welfare and quality and exemptions from current regulations.

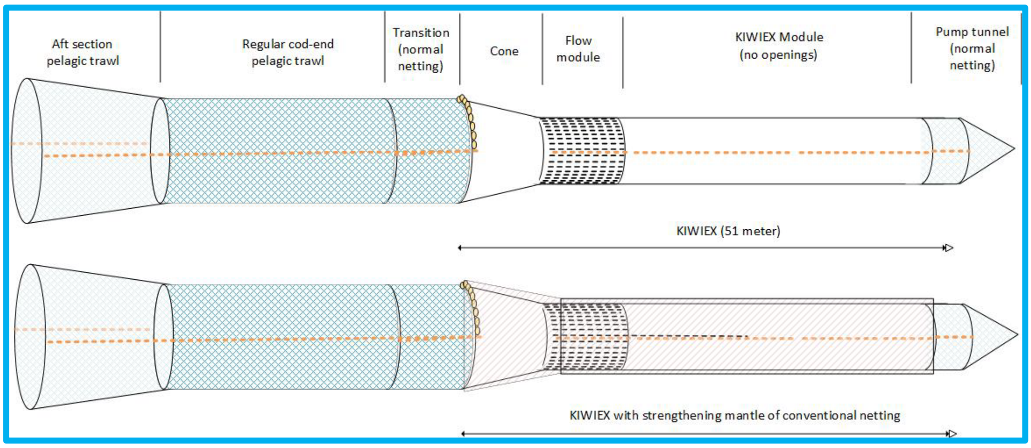


Figure 4.7.2.1. Conceptual drawing KIWIEX design. The KIWIEX is intended as an additional section to a regular pelagic trawl, and consists of a cone, flow module, KIWIEX module (closed section with no water exchange). On the front- and end section of the KIWIEX, a section comprising of normal netting is attached for connecting to the cod-end and fish pump. Credit WMR.

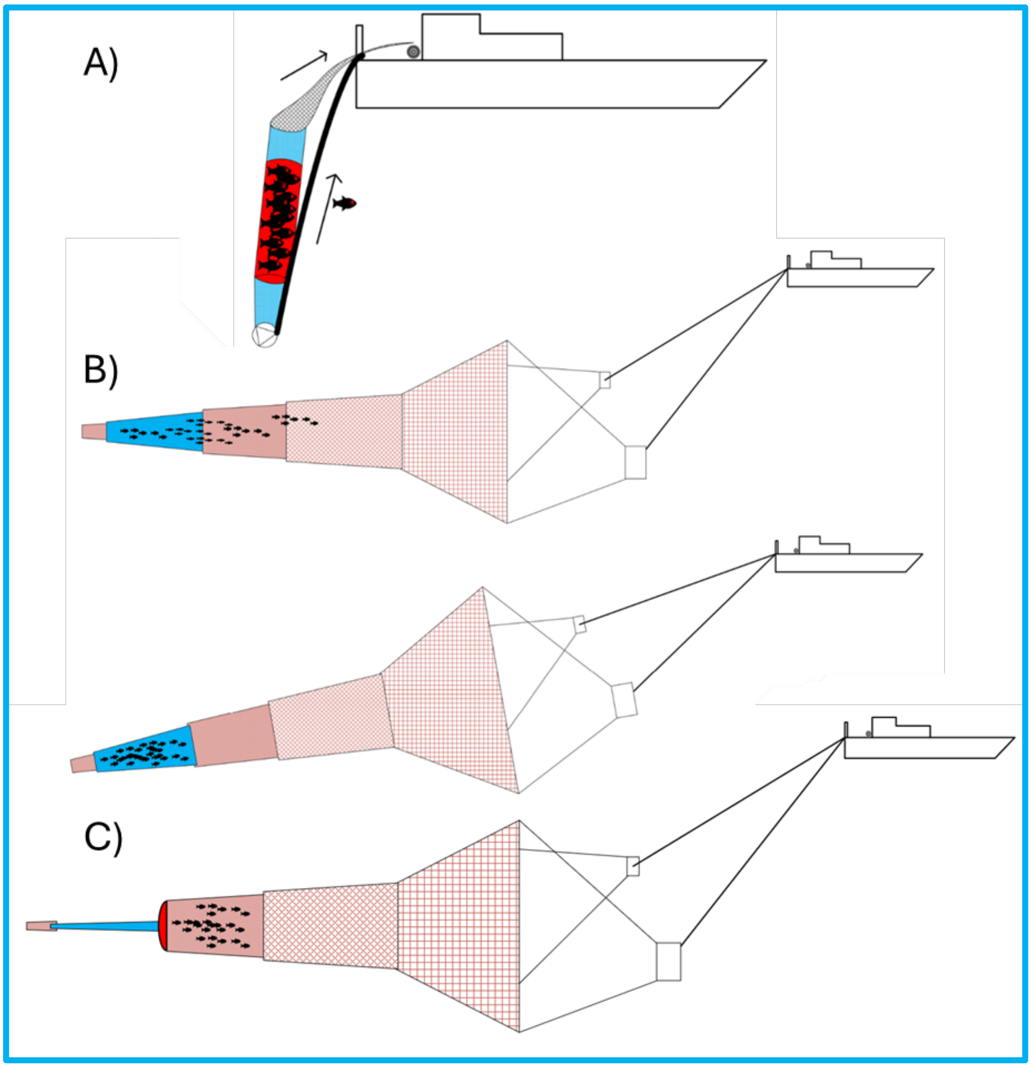


Figure 4.7.2.2. Three KIWIEX designs: A) Pump KIWIEX, B) Trawl KIWIEX and C) Acoustic Release KIWIEX. Credit WMR.

4.8 Reducing fuel use (8.1)

In 2025 new research on fuel use was initiated. Fuel data of four different vessels was obtained for a subset of 2025 to allow for a preliminary analyses. The fuel data available consisted of many different variables, including fuel use of different engines, flow rates, temperatures, GPS positions, torque measurements etc. These data were combined with the self-sampled haul and vessel information to gain access to environmental information such as wind direction, wind speed, seawater temperature but also target species, fishing depth, net dimensions and catch. This let to a dataset of approximately 170.000 observations that were further analysed. To allow for a fair comparison between vessels, indicators of fuel use were standardized to represent fuel use per tonne of fish caught. We considered fuel use in regards to haul size, environmental conditions such as temperature, wind speed, fishing depth and horizontal opening of the net (figures 4.8.1 – 4.8.6). We grouped fishing activity in time and space to improve the ability to compare indicators side by side.

Interestingly, there is a large difference between the three vessels in fuel use per hour, with one of the vessels being markedly more economic than the other two (Figure 4.8.1). However, when expressing fuel use in terms of fuel per tonne of fish caught (Figure 4.8.2), the differences diminish or change direction, indicating that the other two vessels, on average, have larger hauls and hereby compensate for the higher hourly fuel use. The higher hourly fuel use can be directly linked to larger hauls as well.

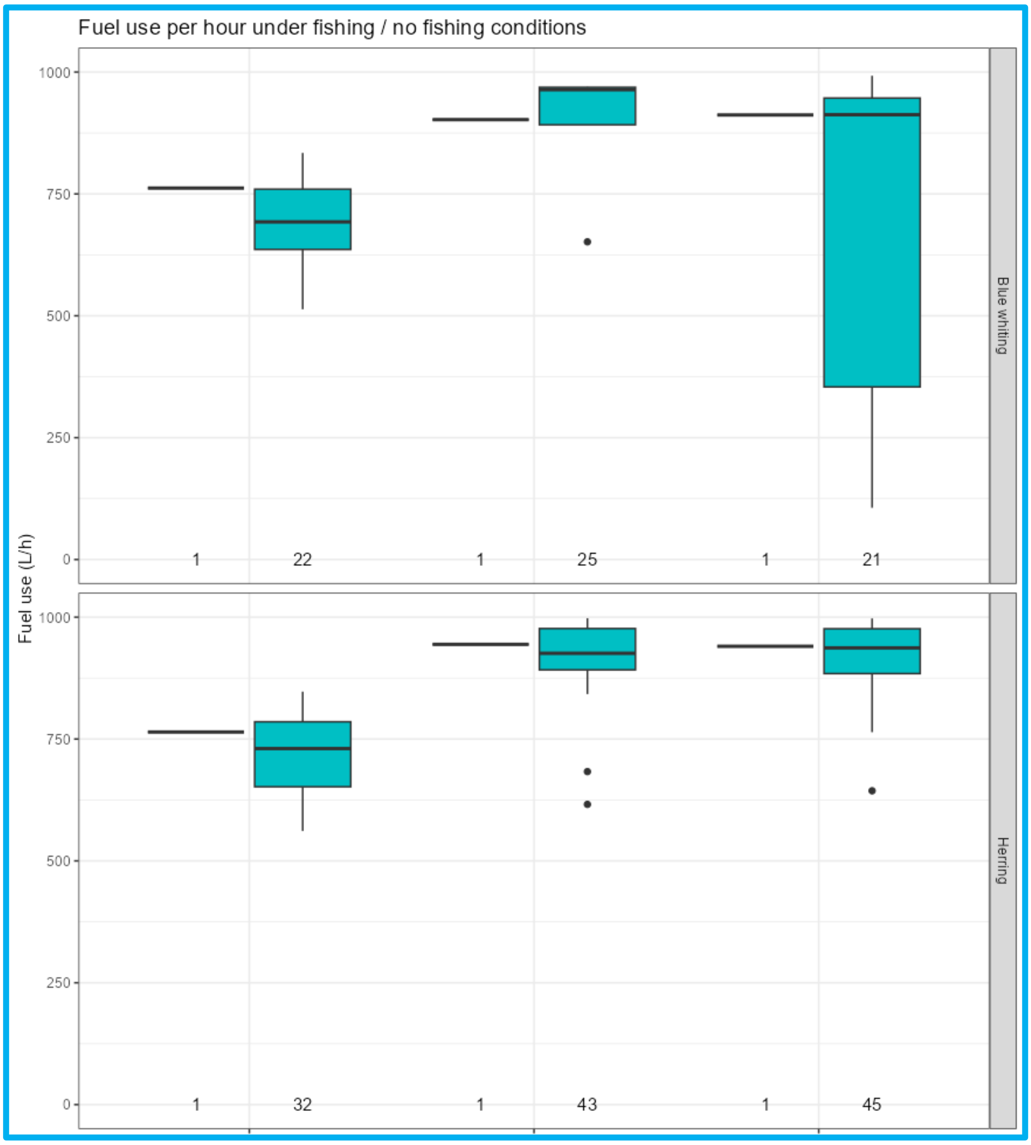


Figure 4.8.1. Fuel use (L/h) for three different vessels in the herring and blue whiting fishery. Datasets were split into fishing (blue boxplots) and no-fishing behaviour (black bars), where the fishing boxplots consist of multiple hauls (number in text at x-axis).

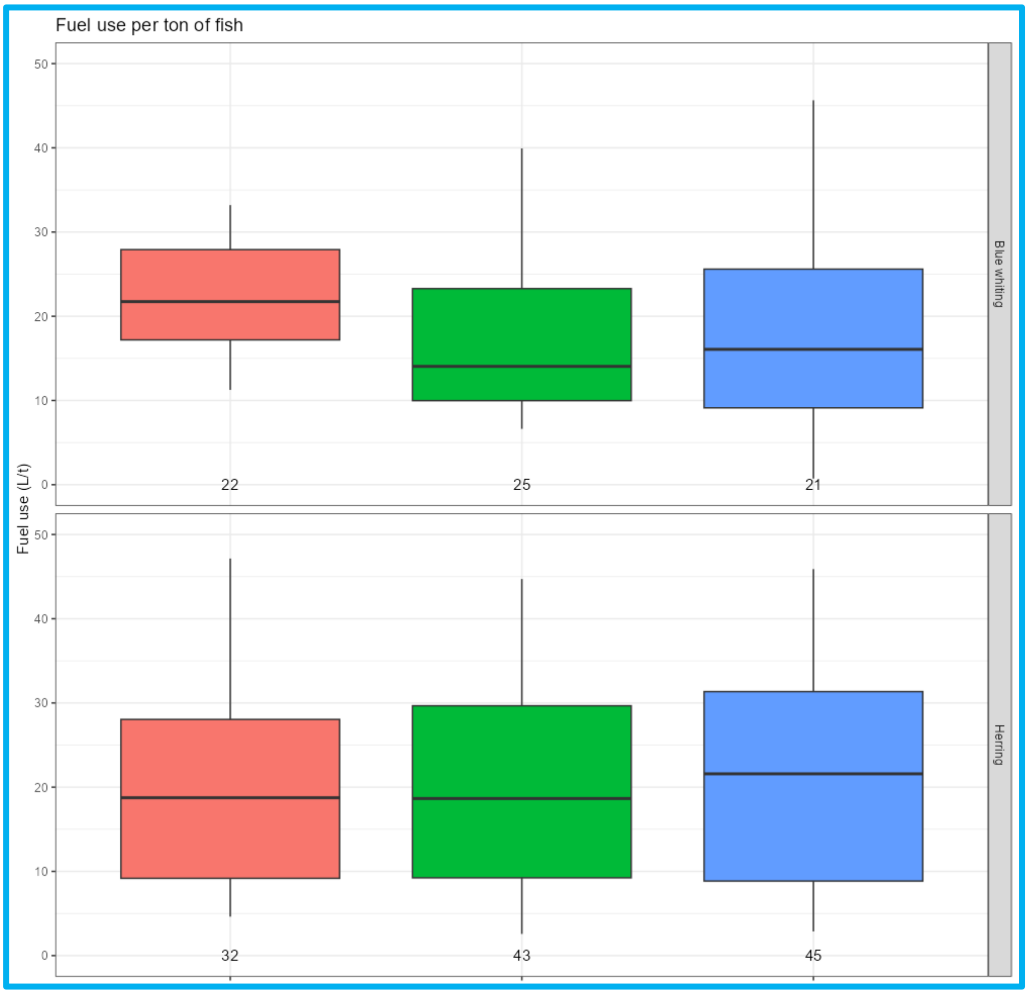


Figure 4.8.2. Fuel use (L/t) for three different vessels in the herring and blue whiting fishery. Boxplots consist of multiple hauls (number in text at x-axis).

When considering haul size, we note a sharp decline in fuel use per haul with over 2 orders of magnitude difference from small hauls (10-20t) to very large hauls (>200t) (figure 4.8.3) although this is fishery dependent. The average haul in the RVZ fleet is at around 100t, varying with season and target species. It is of interest to note that one of the vessels had markedly more smaller hauls than the other two vessels which would be a point of discussion to be had with the skipper to gain better understanding in their fishing behaviour.

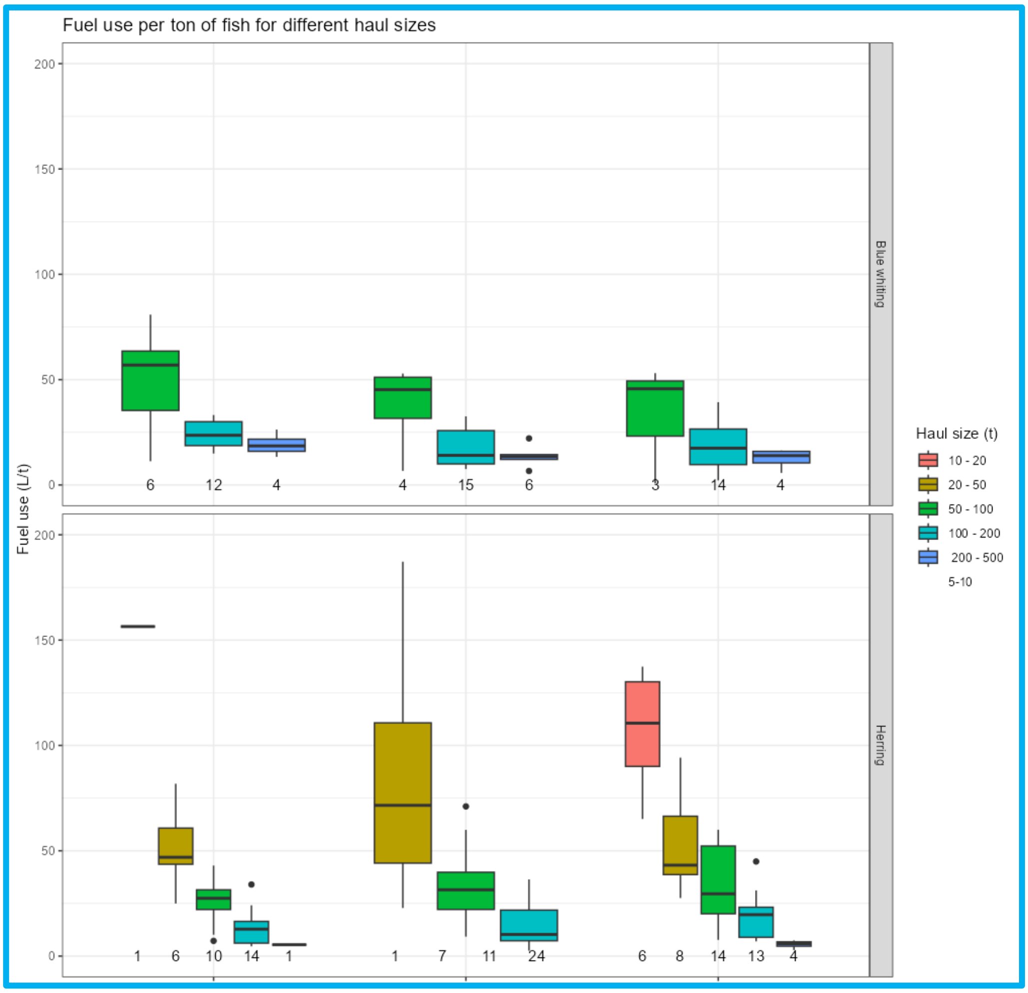


Figure 4.8.3. Fuel use (L/t) for three different vessels under different haul sizes in the herring and blue whiting fishery. Boxplots consist of multiple hauls (number in text at x-axis).

Overall, vessels were hardly affected by windspeed, as can be seen in figure 4.8.4. From very low windspeeds (2-5kn) to rather high windspeeds (10-20kn), there is no significant effect on fuel use.

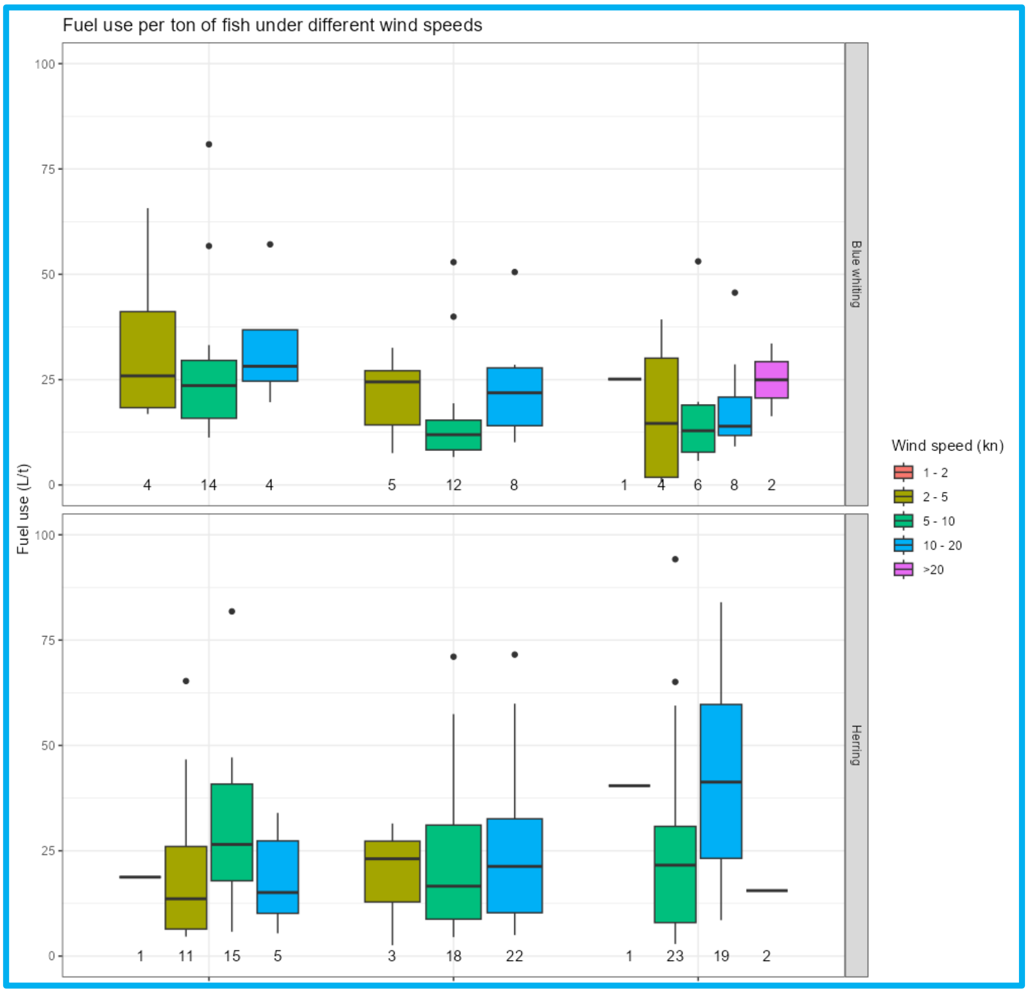


Figure 4.8.4. Fuel use (L/t) for three different vessels under different categories of wind speed in the herring and blue whiting fishery. Boxplots consist of multiple hauls (number in text at x-axis).

Fishing at greater depths seems to influence fuel use negatively in the herring fishery while this plays hardly any role in the blue whiting fishery which already takes place at greater depths. This may well be related to haul duration being longer for deeper hauls as it takes more time to set and haul the gear and hence increases fuel use.

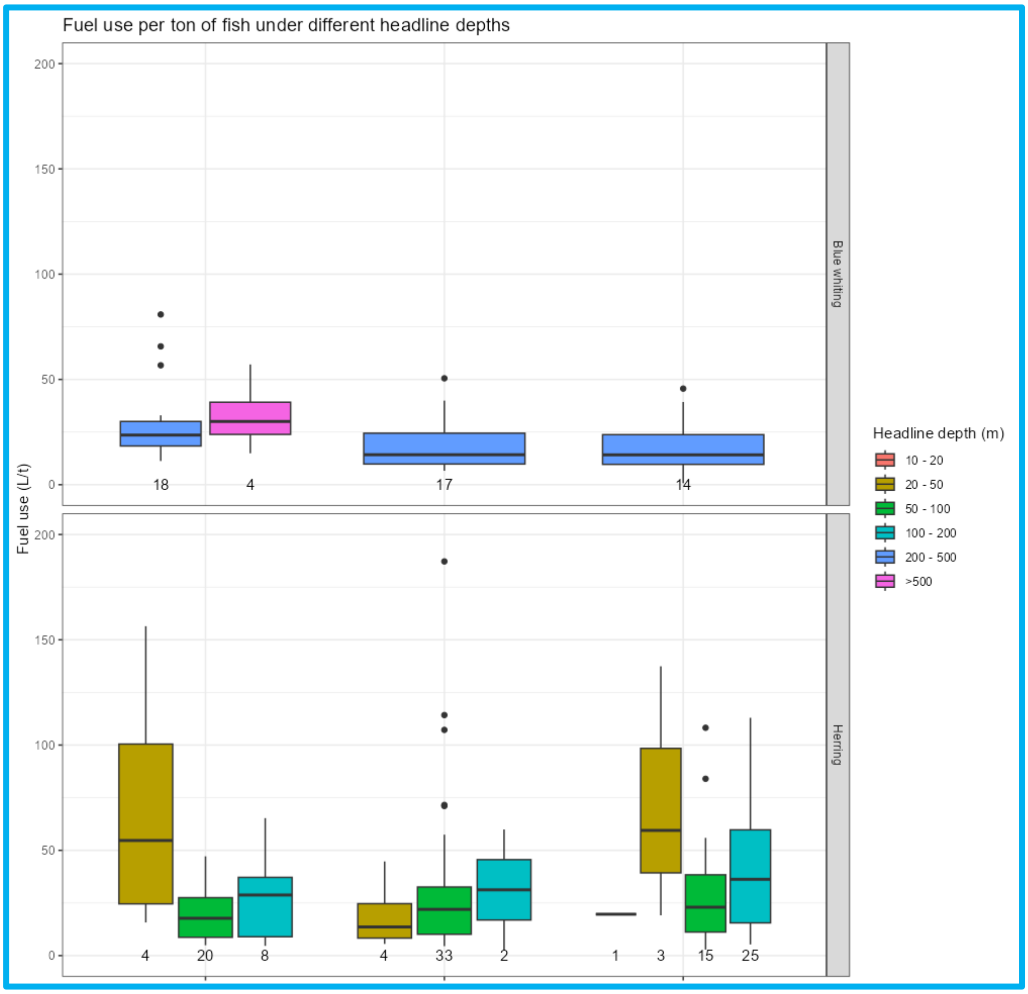


Figure 4.8.5. Fuel use (L/t) for three different vessels under different categories of fishing depth in the herring and blue whiting fishery. Boxplots consist of multiple hauls (number in text at x-axis).

A similar increase was seen in fuel use at higher temperatures. This is somewhat counter-intuitive as one may expect that temperatures decline when fishing deeper. This warrants further analyses but also indicates that some variables change in similar direction while others change in opposite direction.

A statistical model was therefore developed to test the interactions between fuel use and fishing speed, catch volume, surface and fishing depth temperatures, wind force, headline depth and horizontal opening. A statistical model is able to differentiate between variables. Results suggest that both temperature at fishing depth and horizontal opening of the net have a negative impact on fuel use (i.e. lower fuel use) and that with higher surface temperatures, wind force and fishing depth, fuel use increases. All variables were highly significant except for catch volume. The impact of vessel speed on fuel use (Figure 4.8.6) is largely linear between speeds of 0-10, the normal operation window of a trawler. Only when speeds go well beyond the 12kn there seems to be an even larger increase in fuel use. The bump in fuel use around 5kn is likely to be explained by the actual fishing activity while speeds markedly higher and lower than represent the start / end of a fishing event.

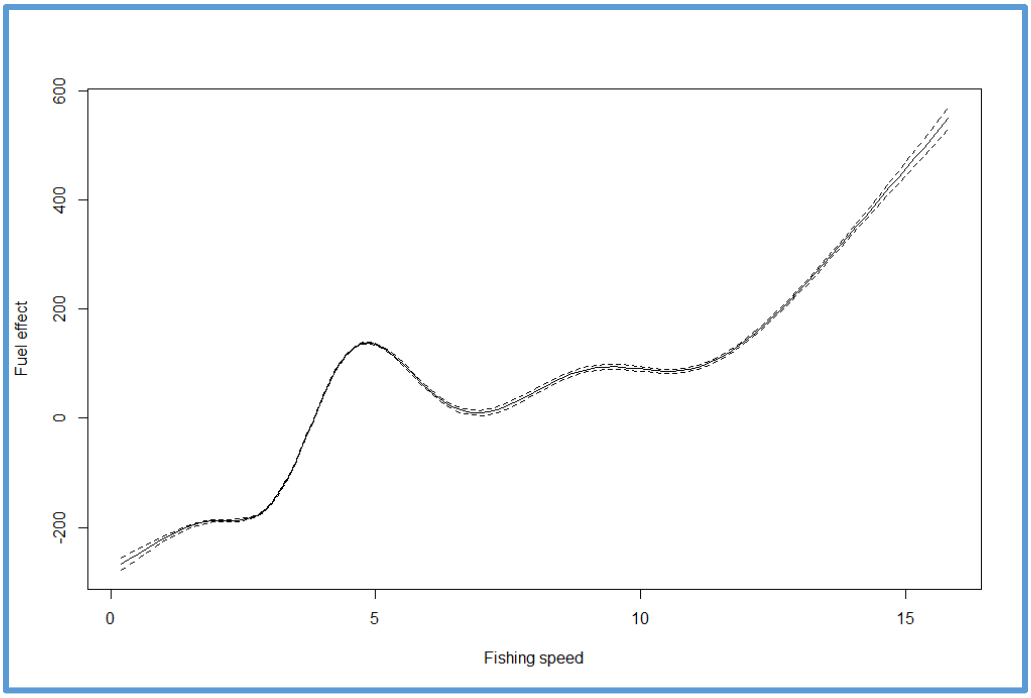


Figure 4.8.6. Gam modelling output where fishing speed was modelled as a smoother function explaining the variance observed in fuel use.

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 2025, The Thünen institute for fisheries research signed an MoU with the RVZ to ensure self-sampled data is utilized for international fish stock management. These initiatives, including self-sampling, data storage, quality control, mCatch software development, spatial-temporal stock assessment model and documenting experiential knowledge from skippers are now firmly established as multi-year projects. These activities rely heavily on the participation of the crew onboard the vessels and the RVZ is very appreciative of their continued efforts.

Continued sampling of the distribution of small pelagic fish around windfarms or sampling herring fat content in the English channel 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 acoustics projects within the RVZ. 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 2026 and beyond to ensure high-quality data collection, alternating seabed and sphere calibrations. The RVZ feels that information collected on-board the vessels should become available to the skippers as well, hence we developed a dashboard in which we make available all data that has ever been collected by the crew since 2015 in a dedicated dashboard. This helps skippers to reflect on historic catches before they commence in a new season of fisheries.

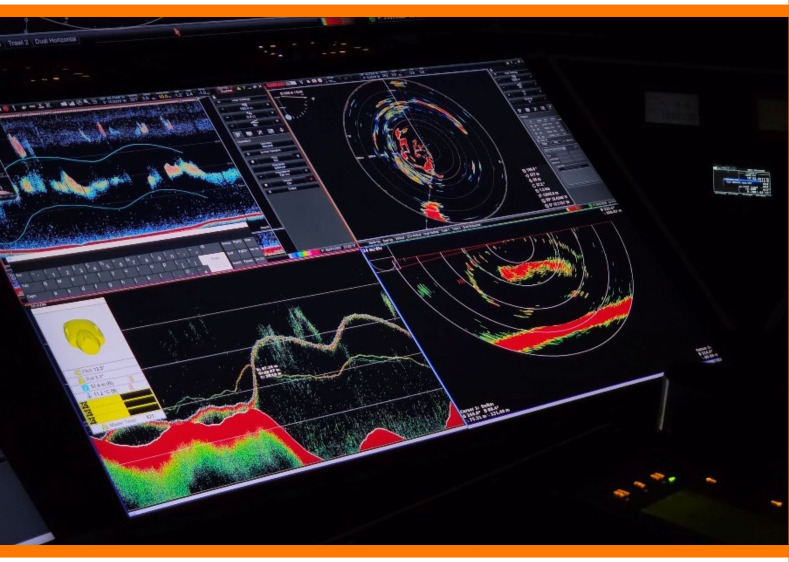
With advancements in compact, high-quality camera technology, underwater observations have become more accessible and effective. These innovations are essential for confirming the effectiveness of gear designed to prevent unwanted bycatch. Underwater camera techniques, including automated AI analysis of footage, will continue to play a key role in the RVZ research agenda in the coming years. Having a first GUI available that simplifies footage analyses is a key step forward and will allow skippers to quickly review the footage before moving to the next. In addition, having these AI trained models available will help us generate far more quickly new annotated data to improve the models and work towards species recognition over time.

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. We are approaching a proof of concept point, which would allow us to move to a next step of developing sensors that provide more reliable and routine observations of fish fat and volume estimation of fish processed.

Efforts to reduce bycatch remain a high priority, with initiatives such as skipper best-practice sessions, extensive at-sea trials, and international collaborations we aim to make a difference. The RVZ is well respected internationally for their pro-active approach to trying to solve bycatch issues. We have started a novel approach in sampling passive acoustics on a fishing trawl and have already harvested unique data. We aim to continue this type of research to contribute on the knowledge of cetacean distribution

A similar commitment is evident in efforts to improve fish welfare. RVZ has worked for several years on understanding impact of fish welfare. In 2025 we made the step to finding solutions to improve welfare. The results are promising and was received with enthusiasm in the entire sector. We will look forward to develop the most promising techniques in 2026 and beyond.

New in 2025 was the addition of research on fuel consumption of the vessels and finding factors that most influence fuel use. This helps understanding how changes in human behaviour can reduce fuel consumption and reduce their ecological footprint even further.



6 Research output 2025

6.1 Reports

Hintzen, N.T. & de Nijs, L., 2025. Report on 2024 scientific research projects, PFA report 2025/01, 64pp

Hintzen, N.T. 2025, PFA self-sampling report for HAWG 2025, PFA report 2025/02, 65pp

Hintzen, N.T. 2025, PFA self-sampling report for WGDEEP 2025. PFA report 2025/03, 27pp

Hintzen, N.T., Mikkelsen, P., 2025, CPUE Standardization of Silver smelt in 5b and 6a. PFA report 2025/04, 12pp

Quirijns, F., 2025, PFA self-sampling report for CECAF fisheries, 2016-2024, PFA report 2025/05, 43pp

Hintzen, N.T. 2025, PFA self-sampling report for WGWIDE 2025, PFA report 2025/06, 102pp

Hintzen, N.T., 2025. CPUE standardization for Western and North Sea horse mackerel, PFA report 2025/07, 23pp

Hintzen, N.T. 2025, PFA self-sampling report for SPRFMO 2025, PFA report 2025/08, 54pp

Hintzen, N.T. 2025, Bangma, T., 2025, SPRFMO Comparison of EU self-sampling and observer data with the objective to supplement observer data for non-observed quarters, PFA report 2025/09, 14pp

6.2 Presentations

Hintzen, N.T. 2025. Presentation North Sea horse mackerel with skippers, 9th of January 2025, Scheveningen

Hintzen, N.T. 2025. Presentation PFA research programme at Ifremer, 27th of January 2025, Boulogne sur Mer, France

Hintzen, N.T., De Nijs, L. 2025. CIBBRiNA skipper session presentation, 11th of February 2025, Zoetermeer

Hintzen, N.T., 2025, Northern Pelagic Working Group presentation on North Sea herring, 16th of February 2025, Online

Hintzen, N.T. 2025. Presentation PFA research programme at Thünen, 10th of March 2025, Online

Hintzen, N.T. 2025. Fish welfare research presentation at the Pelagic AC, 2nd of April, 2025

Hintzen, N.T. 2025. CIBBRiNA presentation on engaging fishers in bycatch solutions, 7th of April 2025, Vigo, Spain

De Nijs, L., 2025. VIN presentation: Inzet van camera's in visserijonderzoek aan boord van PFA schepen, 11th of July 2025

Hintzen, N.T., 2025. The role of industry science in sustainable fisheries management, 9th of September, Wageningen

Hintzen, N.T., 2025, EAPO presentation on the outcomes of the North Sea herring management plan development, 24th of October 2025, Online

Hintzen, N.T. 2025. Presentation PFA research programme at Thünen, 28th of October, Bremerhaven, Germany

De Nijs, L., 2025. Fish Welfare Research in Pelagic Freezer Trawler Fisheries, Catch Welfare Platform, 19th of November 2025, Velzen

Hintzen, N.T. 2025. Ecological impact of windfarm development on small pelagic fish – NO REGRETS kick-off, 26th of November, Texel

Hintzen, N.T., 2025. The role of industry science in sustainable fisheries management, 1st of December, Wageningen

Hintzen, N.T., 2025. Contributions of the PFA research to reducing bycatch, 9th of December, Den Haag