



# Annual report 2025





TO BE KEPT  
CLOSED AT ALL

TO BE KEPT  
CLOSED AT ALL

# Contents

<b>Summary</b>	<b>4</b>	<b>WP5</b>	
Centre director	4	Improving precision by autonomous platforms and survey and experimental design	<b>29</b>
CRIMAC Board	5		
<b>Vision and objectives</b>	<b>6</b>	<b>WP6</b>	
Vision	7	WP6 and extracting gains for science and industry	<b>32</b>
Objectives	7		
Research plan	7	<b>User stories</b>	<b>32</b>
<b>Organisation</b>	<b>8</b>	<b>Associated projects</b>	<b>34</b>
Organisational structure	9	<b>Cooperation</b>	<b>35</b>
Partners	10	<b>Students</b>	<b>36</b>
<b>Scientific activities and results</b>	<b>18</b>	PhD students	36
<b>WP1</b>		Associated students	41
Understand the broadband echo spectrum for classification	<b>19</b>	Master students	42
<b>WP2</b>		<b>Communication and dissemination activities</b>	<b>44</b>
Experimental measurements of backscatter	<b>22</b>	<b>Appendices</b>	<b>45</b>
<b>WP3</b>		<b>Personell</b>	<b>49</b>
Ground truthing methods	<b>24</b>	<b>Annual accounts 2024</b>	<b>52</b>
<b>WP4</b>			
Machine learning and species categorization methods applied to fisheries acoustics and ground truthing data	<b>26</b>		

# Summary



*Nils Olav Handegard*

## **CENTRE DIRECTOR**

In 2025 the centre enters its final phase, focusing on the plans developed from the mid-term evaluation.


We have established the capacity to model acoustic backscatter, conduct net-pen observations of broadband acoustics, apply classification methods, and perform efficient in-situ observations from drones and vessels. Image-based methods for classification have also been improved. We are now applying these tools to the challenges identified by our user partners.

Products and services arising from collaborations with our user partners are now emerging. Last year we developed plans for how CRIMAC will support implementation of USVs at IMR, reduce bycatch of undersized herring in fisheries, and help our

aquaculture partner process large volumes of acoustic data. Look at the user stories section to learn more about this.

Training the next generation of researchers remains important for both the field and the centre. Ahmet Pala successfully defended his thesis, and several more PhD students are now entering the final phase of their projects. As in previous years, we have highlighted student projects; you can read more about them in this report.

We continue to organise workshops on topics relevant to the centre. Last year we ran a major workshop on applying in-trawl and towed-camera systems to scientific surveys. We are preparing workshop summaries for publication in the primary literature to strengthen the workshops' impact and increase the centre's international visibility.



Our bi-weekly Monday meeting series, open to all centre partners, continues, and combined with the annual meetings, this provides an arena to maintain the collaboration within the centre. In 2025, the University of Bergen hosted the annual meeting, providing partners with an overview of work beyond CRIMAC topics — many thanks to the University for hosting and coordinating the event.

Finally, I would like to thank everyone who makes the centre possible, and the Research Council of Norway for providing this unique opportunity to advance our field. Without the sustained effort of all involved there would be no centre. As we enter the final phase, we can already see several methods being adopted in marine science and fisheries. We have achieved a great deal, and there are still time and funding to go further. It will be exciting to see how far we can take this work.

## CRIMAC BOARD

As we enter the last phase of SFI CRIMAC, we have achieved significant theoretical advancements and developed several key elements. In the second half of CRIMAC, we will continue to advance basic theory and create new essential components, while also increasing our focus on the applications within ocean ecosystem management, sustainable fisheries, aquaculture, and energy production.

The relevance of CRIMAC continues to grow, particularly considering the heightened emphasis on sustainable and efficient operations. The recent strategic review of the Institute of Marine Research (IMR) by Deloitte underscored this importance. One of the primary recommendations from the review is the "Comprehensive digitalization of IMR and increased utilization of new technology and data." This recommendation aligns closely with the objectives of CRIMAC. The innovations developed within CRIMAC will be essential for IMR to implement these recommendations in their daily operations. A significant milestone was the sprat survey

in the Hardangerfjord, where IMR incorporated several CRIMAC innovations into their survey methodology. We are all enthusiastic about contributing to this important development.

Norway's leadership in marine resource management, sustainable fisheries, and aquaculture has also garnered strong international interest in the results and innovations generated by CRIMAC. This interest is evident in the high level of international participation in the workshops organized by CRIMAC. These workshops facilitate valuable discussions and knowledge sharing with the global community and support the dissemination of CRIMAC's results and innovations internationally. We will continue strengthening both national and international partnerships.

As we continue to navigate the challenges and opportunities in marine research, we remain committed to our vision of creating a sustainable and prosperous future for our oceans. We extend our sincere gratitude to all our partners, researchers, students, and supporters for their unwavering commitment and contributions to CRIMAC's success.

Thank you for being part of this remarkable journey. Together, we can make a lasting impact on sustainable and efficient ocean ecosystem management, fisheries, aquaculture, and energy production.

An underwater photograph showing a crab in the center, surrounded by various jellyfish and other marine life. The water is clear and blue. The crab is positioned in the middle of the frame, facing towards the right. It has a light-colored body with darker spots. Several jellyfish of different sizes and colors (pink, purple, white) are scattered around it. The background is a deep blue, suggesting a clear ocean environment. The overall scene is serene and captures the beauty of marine biodiversity.

# Vision and objectives

## VISION

Sustainable, healthy food production and clean energy production for a growing population are important global goals. Important elements to achieve these goals are technology development and knowledge, and CRIMAC contributes to these by obtaining accurate underwater observations of gas, fish, nekton, and other targets.

Underwater observations are challenging both due to the additional spatial dimension compared to terrestrial systems and the unfavourable optical properties of the water. To overcome this, advanced underwater acoustic systems offer both range, observation volumes and resolution for descriptive and quantitative observations of the ocean interior. A gamechanger, both for research and the fishing industry, occurred with the introduction of commercially available scientific broad band echo sounders and sonars. It represents an expansion of the current multifrequency methods both in the frequency domain and in the time-domain, enabling improved acoustic classification of targets and increased resolution.

CRIMAC will contribute to the understanding of the echo spectra, how to process them and how to utilize them in a range of different sectors. Improved quantification and classification of targets and mixtures may prevent unwanted bycatch and suboptimal fish size for the fishing industry, provide information on key parameters for modern aquaculture farms, indicating size, density, growth and animal welfare, improved identification of gas releases in the ocean floor relevant for, e.g., CO<sub>2</sub> sequestration for the energy sector, and monitor key features like abundance and distribution of key species in a changing marine ecosystem.

## OBJECTIVES

The primary objective of the SFI is to advance the frontiers in fisheries acoustic methodology and associated optical methods, and to apply such methods to 1) surveys for marine organisms, 2) fisheries, 3) aquaculture and 4) the energy sector. This will be achieved via the following secondary objectives:

1. Improve automatic interpretation of (wideband) fisheries acoustics, including sizing of targets (fish and bubbles), target identification and increased spatial resolution.
2. Aid the target classification of fish and zooplankton by experimental measurements of known target and backscatter modelling.
3. Collect reference data for machine learning projects on research vessels and in the commercial fishery with similar, calibrated instrumentation.
4. Develop better verification methods using optical systems and dropped probes and working- drones.
5. Develop automated classification systems based on modern machine learning methods.
6. Work with the user partners to apply the techniques and instruments developed in 1) to 4), in scientific surveys, for sizing and species classification in fisheries, for sizing, growth and behavioural measurements in aquaculture, and improved gas and bubble detection systems for the energy sector.

## RESEARCH PLAN

The research plan is updated annually and follows the work package structure. A selection of current tasks from the plan are reported under the “scientific activities” chapter.

# Organisation



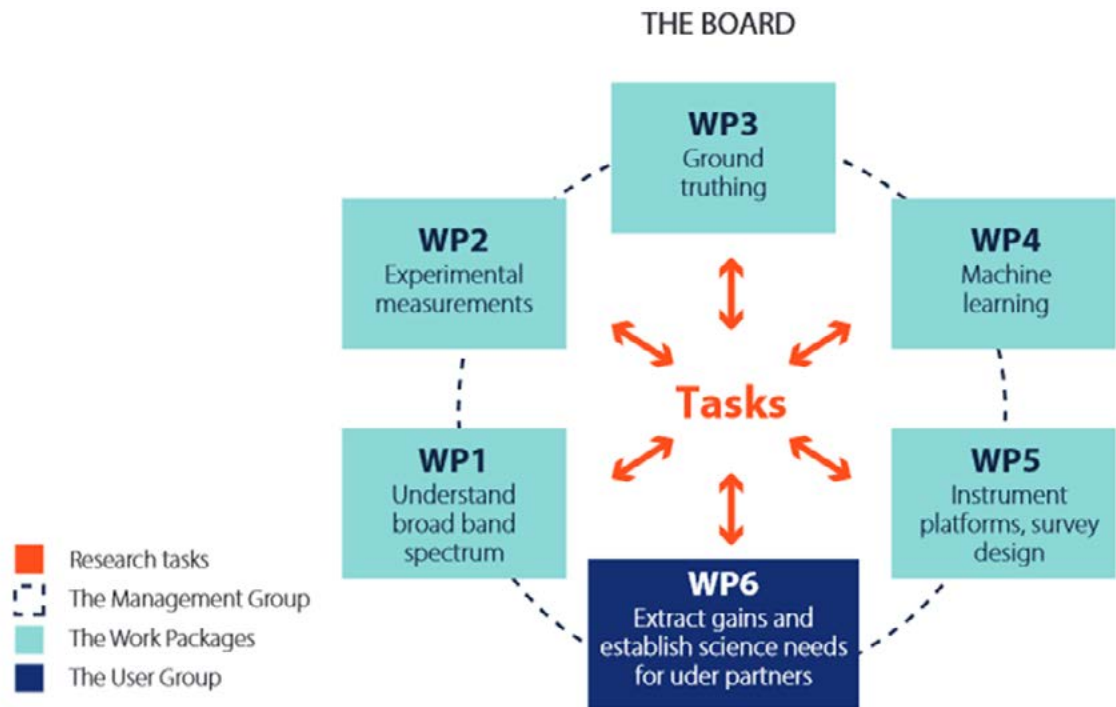


Figure 1. Relationships between work packages. The science WPs (1-5) will cover the different scientific fields and maintain the overview of state of the art within each field. The management group will set up research tasks to deliver methods and knowledge. The tasks may be fundamental science projects as well as projects that facilitates the implementation and uptake by the industry. The feasibility of the methods and the needs from the user partners industry will be assessed by WP6.

## ORGANISATIONAL STRUCTURE

The research tasks and scientific methods are structured into work packages (Figure 1) which follow five research frontiers (WP1-5), plus a work package (WP6) that keeps track of the user needs and facilitate uptake of the methods by the user partners. The remaining work package (WP0) coordinates and manages the centre and outlines the governing structure of the project in more detail.

### Centre leader and project coordinator

Nils Olav Handegard is appointed centre leader. Turid Loddengaard is appointed project coordinator and will assist the centre leader in administrative matters.

### Work Package leaders

Each of the work packages (WP) have a WP manager appointed by the Board. Each work package leader is

responsible for maintaining an overview of state of the art within the field the WP is covering. Geir Pedersen (IMR), Tonje Nesse Forland (IMR), Maria Tenningen (IMR), Ketil Malde (IMR) and Arne Johannes Holmin (IMR) is leading WP1-5. WP6 is led by Tonny Algrøy (KM) representing the user partners.

### The Management Group (MG)

The MG will be responsible for the day-to-day operation of the Centre. The MG consists of the WP leaders and centre leader, the leader of the Marin Ecosystem Acoustics research group at IMR, and one representative from NORCE (Inge Eliassen), NR (Ingrid Utseth) and UiB (Audun Oppedal Pedersen) to ensure representation from all each science partners. A major responsibility of the MG will be to develop annual work plans with budgets and oversee the activities. The MG could also start new activities to respond to new developments within the field.

### Tasks

The centre will establish a set of dynamic tasks that is associated to a work package. The WP leader is responsible for the tasks, and a task leader will be assigned to each task. Personnel from several partners will ideally be involved in each task, and part of the work should ideally be carried out while staying at the centre. Each task reports briefly to the MG on the weekly update meetings.

### The board

The Board will approve the appointment of the Centre director and project managers and will be responsible for decisions on annual work plans and budget. All partners will be represented on the Board, chaired by the partner contributing most economically (Kongsberg Maritime).

### The International scientific advisory committee (ISAC)

The committee will consist of three persons and will be appointed by the board. The ISAC will provide a report to the board at the annual meeting to assist the board in terms of the scientific performance of the centre. The ISAC members are Dr Pierre Petitgas (France), acoustics and survey implementation expert, Director, Dr Paul Winger (Canada), trawling and fisheries expert and professor Laura Uusitalo (Finland), expert in Machine Learning and Artificial intelligence.

### Host institution, location, and facilities

IMR will serve as the host institution. IMR will provide the necessary administrative support systems for the Centre. IMR will provide office space to the Centre, including offices for industry partners and visitors from the international cooperating research institutes.

### Meeting schedules

There will be a bi-weekly update meeting for everyone working actively on a task, and the task leader will be responsible for providing a brief update. MG meetings will be held when necessary. There will be an annual “fagsamling”, and there will be 2 board meetings a year.

## PARTNERS

### Research partners

#### *The Institute of Marine Research (IMR)*

The Institute of Marine Research is one of the largest marine research institutes in Europe with approximately one thousand employees. Our main activities are monitoring, research, and advice for the marine environment. IMR's head office is in Bergen. We also have a department in Tromsø and research stations in Matre, Austevoll and Flødevigen. In addition, we operate a fleet of research vessels. These vessels are an important tool for collecting acoustic data and will be central to CRIMAC. IMR has a strong track record for innovation and method development within the field of fisheries acoustics. This includes the first scientific publication utilizing underwater acoustics on fish distributions, the development of the echo integrator commonly used worldwide in acoustic trawl surveys, and experimentally establishing the basic acoustic linearity principle. IMR has worked extensively with scientific multibeam sonars and echosounders in cooperation with KM and IFREMER. IMR has been a driving force for international cooperation within the field, e.g., by hosting the ICES fisheries acoustics symposium several times and through significant contributions to the development of acoustic methods through several ICES Cooperative Research Reports. CRIMAC will support the continuation of this effort.





Figure 2. NORCE.

## NORCE

NORCE is an independent research institute with around 750 employees that undertakes research for both the public and the private sector. NORCE has a long tradition for cooperation with IMR, UiB and KM within the topic of SFI CRIMAC, due to a strong competence within acoustics and data science.

NORCE has been a key contributor for the development and implementation of acoustic methods in postprocessing systems, and the effect of nonlinear loss in fisheries acoustics. Together with IMR, NORCE has developed the software LSSS which is used by several hundred researchers for better to monitor and analyse fish resources. NORCE will contribute to broadband spectrum modelling, develop methods/use machine learning for broadband noise removal and automatic categorization of backscatter. They will also be involved in training and education of researchers and PhD students.

## The Norwegian computing Center (NR)

The Norwegian Computing Center (NR) conducts research and is one of Europe's largest environments within statistical modelling and machine learning. We

carry out research assignments for Norwegian and international business, the public sector and within national and international research programs, with a vision to contribute with research that is used and seen.

We have more than 30 years of experience in developing image analysis methods for automatic analysis and extraction of information from various types of image data. Our strategy is also to contribute with specialist expertise in image analysis to other research environments in Norway.

CRIMAC fits very well with this strategy where we work with image analysis based on artificial intelligence to extract information about the occurrence of fish and fish species from fishing acoustics.

The work in CRIMAC builds on collaboration that was started with the Institute of Marine Research in this field several years ago. We also have a long-term collaboration related to statistical modelling for stock estimation. Through CRIMAC, we look forward to a further strengthening of this successful collaboration.



Figure 4. University of Bergen.

### The University of Bergen (UiB)

The University of Bergen is a world leading university in marine science and technology. UiB participates in CRIMAC with three departments: the Department of Biological Sciences, the Department of Physics and Technology, and the Department of Mathematics.

The Department of Biological Sciences oversees the supervision and education of two PhD candidates (one funded by UiB and the other by the Research Council of Norway), as well as the supervision and education of master's candidates, all focusing on "Ground truthing methods" related to organisms and targets that produce broadband acoustic backscatter. The Department of Physics and Technology is involved in supervising and educating two PhD candidates (one funded by UiB and the other by the Research Council of Norway), as well as master's candidates, within fisheries acoustics. The Department of Mathematics is supervising and educating one PhD candidate (funded by the Research Council of Norway) and master's candidates in machine learning for acoustic target classification.

UiB has established a longstanding collaboration with the Institute of Marine Research (IMR) and other relevant centre partners. The supervision and education of master's and PhD candidates are conducted through a collaborative effort between UiB, IMR, and other centre partners.

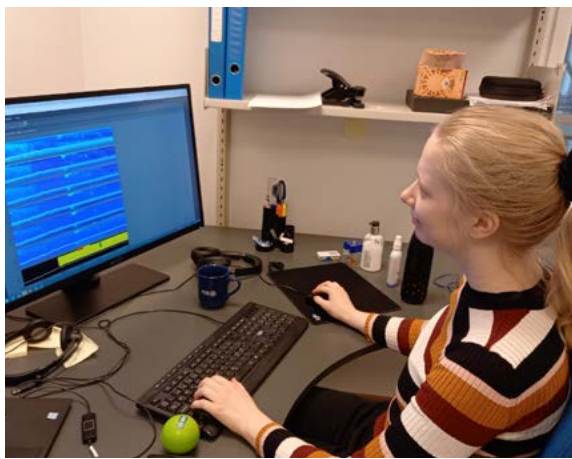


Figure 3. Ingrid Utseth (NR) working on acoustic target classification problems.

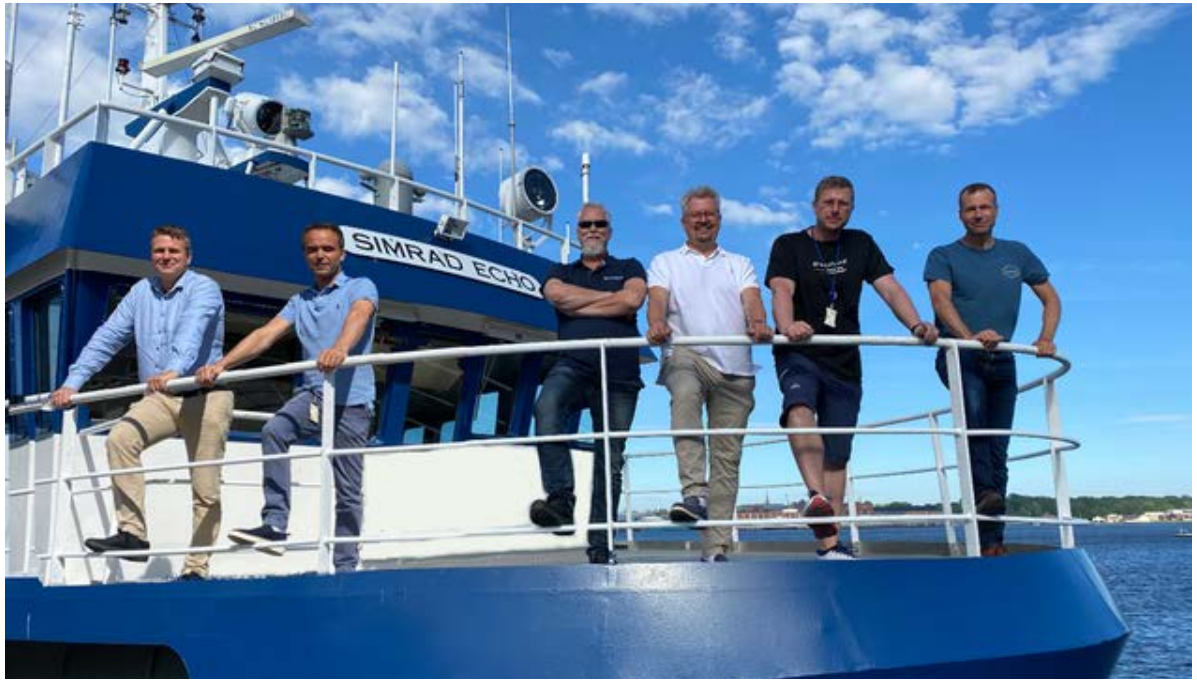


Figure 5. Kongsberg Discovery.

## INDUSTRY PARTNERS

### Kongsberg Discovery (KD)

Kongsberg Discovery specializes in cutting-edge technology that provides vital insights and key data about life in the oceans and ecosystem conditions. From shallow water wind farms to the deepest oceans, we offer a comprehensive range of systems optimized for ultimate ocean mapping and subsea positioning accuracy, enhancing operational efficiency.

Sustainable development of the oceans and their resources is an integrated part of KD's strategies, through the commercial fishery and marine research sector. The main reason for KD's participation in SFI CRIMAC is to further improve our offerings to these sectors as well as to bring this competence into other marine industries such as offshore energy production and aquaculture.

The KD contribution to the CRIMAC centre is mainly focused on wideband acoustics, and how products in these areas can be improved through the introduction

of new digital infrastructure for machine learning and seamless data flow. This applies to both vessels as well as alternative sensor platforms such as marine drones and stationary observatories.

SFI CRIMAC is a natural development of a research and scientific based collaboration with centre partners such as the Institute of Marine Research and the industrial partners which we believe will continue to believe innovative solutions to both marine industry and ocean management. Through CRIMAC KD wishes to position as highly relevant supplier of scientific based products and solutions for users of the coastal and ocean areas.



Figure 6. Scantrol Deep Vision AS.

### Scantrol and Scantrol Deep Vision

Scantrol AS and Scantrol Deep Vision AS are located in Bergen, Norway. Scantrol has delivered control systems to trawls and cranes all over the world for more than three decades and has an extensive experience with developing technology for the marine research and trawl fisheries markets.

Scantrol was a partner in the CRISP Centre for Research-based Innovation (SFI) led by the Institute of Marine Research in Bergen. The Deep Vision trawl camera and sorting technology was developed in this centre

and led to the spin-off company Scantrol Deep Vision. Today, the technology is commercialized for marine research and used to sample fish from images in the trawl without bringing any catch onboard. The technology is being further developed into a catch identification and sorting device for commercial trawlers.

In CRIMAC, the companies will leverage the force of collaboration between leading scientific institutions and private companies to bring the successful technology even further. Deep Vision will both complement and support the interpretation of acoustic data.

### Eros AS

EROS AS is a fishing company based in Fosnavaag with a history going back to 1917. Today's «Eros» is the seventh vessel carrying the same name. The vessel is a 77 metre modern pelagic trawler/purse seiner fishing for Herring, Mackerel, Capelin and Blue Whiting in the North Atlantic, Norwegian Sea, North Sea and Barents Sea.

«Eros» is equipped with a drop keel and echo sounders/sonars for doing scientific research and has over the last 15 years been employed both by the Norwegian Marine Institute and the Greenland Nature Institute on a number of research trips. The vessel has an experienced crew with more than 20 years fishing

experience. Eros AS is also operating the pelagic trawler «Herøyfjord» and is involved in the white fish business being the majority shareholder of the factory trawler «Ramoen» producing fresh frozen fillets of Cod, Haddock and Saithe for the Norwegian and International markets.

Our obligation to the consortium is to test acoustic sonars and echo sounders in a real fishery and in specific surveys when hired as a research survey by CRIMAC. Improved quality in such instruments will make the fisheries more efficient as it put the industry in a better position with respect to selecting the correct fish species, estimation of the biomass, size of the fish and movement of the fish prior to shooting the fishing gear.



Figure 8. MS Eros.

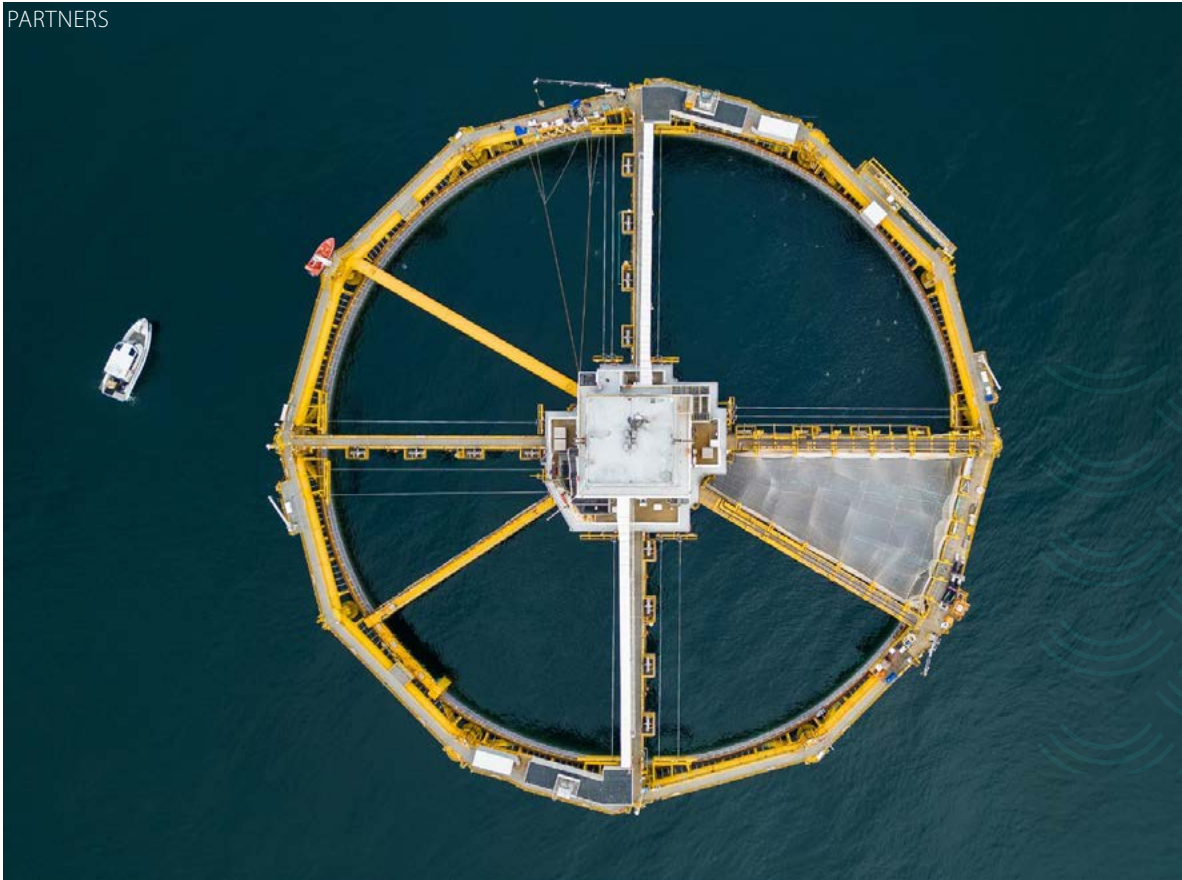


Figure 9. Salmar Aker Ocean's Ocean Farm.

### Salmar ASA

Salmar ASA is a Norwegian aquaculture company listed on the Oslo Euronext. Our product is Atlantic salmon, and we have aquaculture activities in Norway, Scotland, and the Westfjords of Iceland. Salmar is the world's second-largest producer of Atlantic salmon. In 2022, Salmar delivered 193,700 tons of salmon.

Salmar is continuously working to improve their biological results, including the development of new production technology, to address challenges related to our environmental footprint and location challenges. Through our subsidiaries Arctic Offshore Farming (AOF) and Ocean Farming (OF), organized under SalMar Aker Ocean (SAO), two new production technologies are being developed, which are suitable for more exposed sea areas and for offshore aquaculture.

There is a lot happening in instrumentation for monitoring the aquaculture environment and fish. Having good observations and measurements of the environment, fish growth, behaviour, and health status provides better decision-making support. This is a desired development for scaling up offshore aquaculture units and for submerged farming, such as in AOF.

New instruments and methods developed in the CRIMAC program may be suitable for salmon and trout farming, and our interest is to test this in commercial/full-scale aquaculture units in Salmar, especially instrumentation that can contribute to success in exposed aquaculture and offshore aquaculture.

We are proud to be a partner in the CRIMAC program.

For more information about the company, please visit [www.salmar.no](http://www.salmar.no).



### **CodeLab**

CodeLab AS was established in 2013 and is located in Bergen, Norway. CodeLab is a technology company focusing on Business development, software development and signal processing. They have broad experience taking a concept from idea to product. Some of the developed products are Subsea Active acoustic leak detection system, deployed on Troll B. Fare evasion detection system tested in cooperation with Delhi Metro Rail Corporation and Metropolitano de Lisboa. System for counting people in passing cars deployed at Halhjem ferry pier and MF Nesvik. Health diagnosis system to decrease diagnosis time and improve diagnosis

precision for chronic diseases as COPD, Asthma, Migraine, Heart failure, Diabetes and Osteoporosis. We have long time experience in real time data processing, acoustic wide band processing, and machine learning. We also have an ambition to develop software solutions for the fishing industry and aquaculture, using algorithms developed by the research partners on data both from optical and acoustic sensors of particular relevance to CRIMAC. We deliver both independent products and libraries that can be interfaced into, e.g. Kongsberg software.

A photograph of a blue fishing net and orange floats on the water. The net is draped over the top edge of the frame, with its mesh and ropes extending down into the water. Several orange floats are attached to the net, floating on the surface. The water is dark and reflects the net and floats. A decorative blue pattern of concentric arcs is overlaid on the bottom half of the image. The text "Scientific activities and results" is written in white in the upper left quadrant.

Scientific activities  
and results

# WP1

## Understand the broadband echo spectrum for classification

**Scientific questions:** *What are and how do the various parts of marine organisms contribute to broadband backscatter, and how can we improve the amount of information extracted from the acoustic signal?*

WP1 focuses on understanding how the complex broadband frequency responses from marine organisms are generated and how to enhance the amount of information which can be extracted from marine backscatter. Knowledge of the broadband backscatter contributes to the development of methods for automatic classification of marine targets. Further development of broadband acoustic signals and processing will enhance the amount of information available for classification. Numerical modelling of backscatter and in situ and ex situ measurements from individual and groups of marine organisms carried out in WP2 forms the basis for understanding the broadband response.

## Prolate spheroid representation of the herring swimbladder for acoustic scattering by individual fish and fish schools

Acoustic species identification and sizing are important tools for both fisheries management and commercial fisheries. To understand and interpret acoustic measurements of herring schools, we need realistic models of how individual fish scatter sound. A key contributor to the echo from a fish is its swimbladder, whose elongated shape is not well represented by simple standard models.

We therefore developed a numerical model that represents the herring swimbladder with an equivalent “prolate spheroid”. This shape is close enough to the real swimbladder to allow efficient calculations, while still capturing the main features that affect acoustic backscatter. The model is implemented using a hybrid finite element/boundary element approach (FEM–BEM), which combines the strengths of both methods for complex geometries and a broad range of frequencies. We validated the prolate spheroid model by comparing its predicted target strength with that of the detailed 3D swimbladder geometry over a range of tilt angles and found good agreement (Figure 9). This provides a computationally efficient and accurate single-fish model that can be used as a building block for school-level simulations (Figure 9).

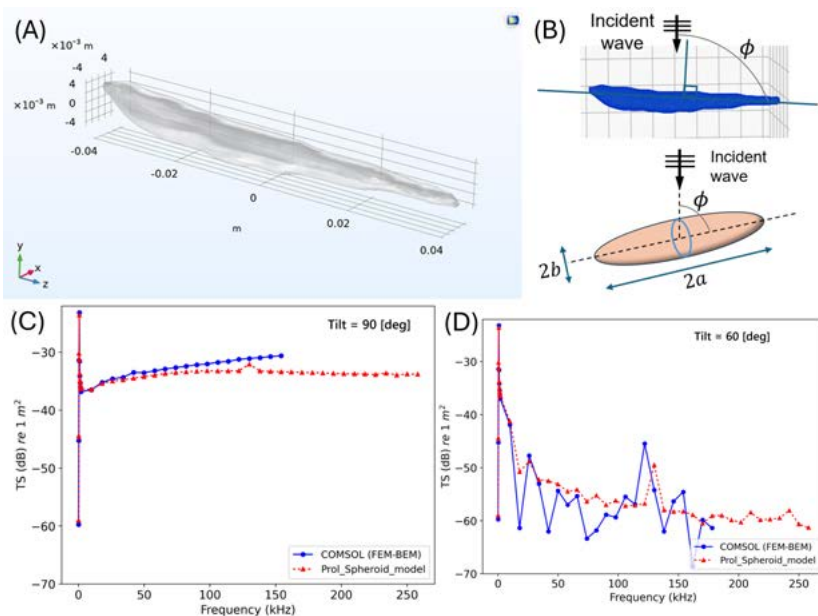


Figure 9. Herring swimbladder geometry (A) and its equivalent prolate spheroid representation (B), with example comparisons of target strength (TS) for two tilt angles (C,D).

Using this efficient single-fish model, we then investigated how groups of fish scatter sound. In many practical applications, the backscatter from a school is approximated by summing the sound scattered from individual fish (a “superposition” approach). We tested when this approximation is valid by comparing it to full numerical simulations that include multiple scattering (i.e., fish affecting each other’s scattered sound). The results show that for low to moderate densities—when the distances between fish are not too small—the superposition approach provides a good approximation and can be used to estimate volume backscattering strength ( $S_v$ ) for schools.

Finally, we applied the model to synthetic herring aggregations with prescribed size and orientation distributions (Figure 10). This allows us to explore how changes in fish size, tilt angle and school density influence  $S_v$ , and to investigate under which conditions different size classes within a school may be distinguished from acoustic data. This approach allows us to test under what conditions, and to what extent, we can estimate size distributions of herring within schools. Our numerical methods will be tested against in situ measurements in 2026.

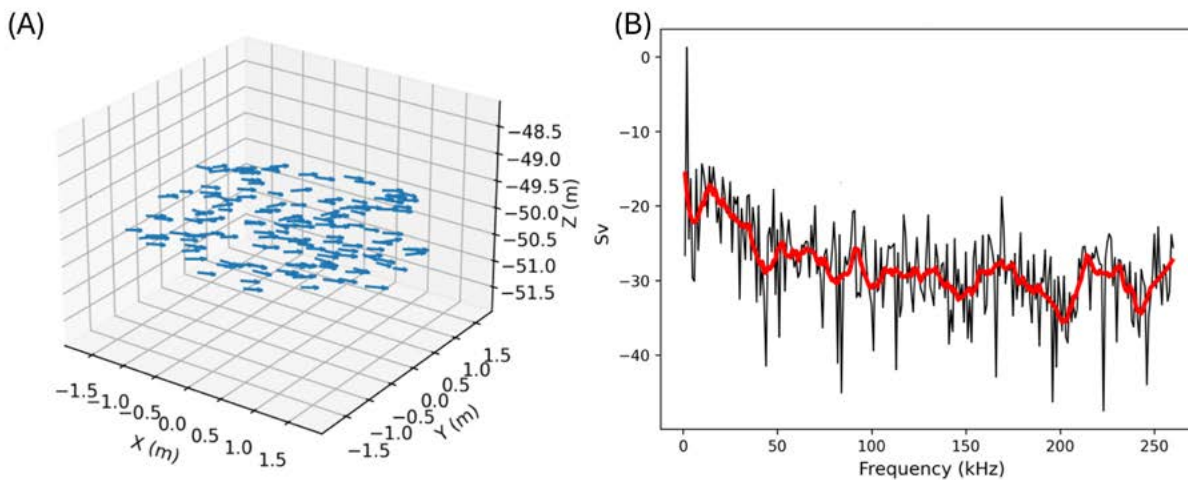


Figure 10. (A) An example of aggregate herring with a given size distribution and tilt angles. (B) Estimated volume backscattering from the aggregate (thin-black) curve and its smoothed curve (Thick-red).

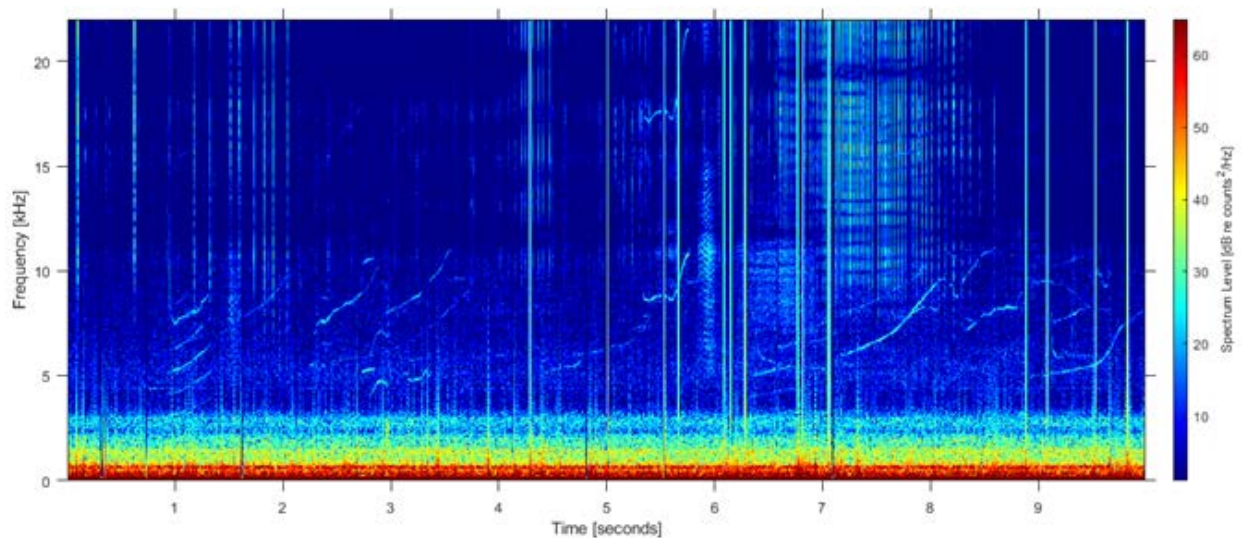


Figure 11. Example visualization of sounds recorded while G.O. Sars was steaming at 11 knots, showing vessel-radiated noise below ~3 kHz and marine mammal clicks and frequency-modulated calls (killer whales). The data was originally collected at 768 kHz sampling frequency.

### Vessel condition monitoring and marine mammal detection

Continuous monitoring of vessel-generated noise can support improved vessel operations (condition monitoring) and provide data on underwater radiated noise. Continuous passive acoustic monitoring (PAM) of marine mammals—either for research or as an early-warning system—is another potential application of hull-mounted hydrophones.

In 2025, a Kongsberg Discovery (KD) hydrophone system was temporarily installed on board G.O. Sars. The setup consisted of a single hydrophone mounted in the hull, with dedicated hardware for data acquisition

and real-time visualization. The objective was to gain experience with operating the KD hull-mounted system and to investigate the feasibility of both vessel condition monitoring and marine mammal monitoring.

Initial tests were promising and showed that high-frequency vocalizing marine mammals can be detected even at normal cruising speeds (11 knots), despite the presence of strong vessel-radiated noise. Figure 11 illustrates an example recording, where low-frequency vessel noise dominates below about 3 kHz, while marine mammal clicks and frequency-modulated calls (killer whales) are clearly visible at higher frequencies.

# WP2

## Experimental measurements of backscatter

**Scientific questions:** *What are the broadband frequency responses of marine organisms and other scatterers?*

This WP is developing methods for controlled measurements of broadband backscatter from a wide range of marine organisms and other scatterers. Important categories of organisms and targets are fish, gas bubbles, fish larvae, krill, copepods, and jellyfish. Existing knowledge about these organisms has been reviewed and are used to prioritize our efforts. Experimental measurements will occur in large tanks and net pen mesocosms at IMR's Austevoll and Matre research facilities, at-sea from vessels using hull-mounted echosounders, and offshore wind farms instrumented with acoustics and close-range probing systems.

### Testing suspension methods of calibration spheres at the CRIMAC survey

Calibration of wideband echosounder systems is essential for accurate scaling of acoustic backscatter. Broadband systems are more susceptible to noise than

narrowband systems, particularly at higher frequencies. One important source of systematic error is the sphere suspension: tank experiments have shown how a calibration sphere is suspended can influence measured backscatter (Renfree et al. 2020).

At IMR the standard practice is to suspend the sphere with a single knot at the top. This places the suspension line over the top/front of the sphere and can allow the acoustic field to interact with the knot or line, producing measurable perturbations. Renfree et al. (2020) recommended a triple (three-point) suspension that leaves the top/front region of the sphere free from nylon to avoid such interference. This triple suspension has not yet been adopted operationally at IMR because it was judged more difficult to handle in practice. Nonetheless, it is important to quantify how large the difference is between the commonly used single-knot method and the triple suspension.

To evaluate this, we tested both suspension methods during the CRIMAC survey 2025. Two WC38.1 spheres (Spherical-Trafalgar) were netted with 0.40 mm diameter nylon line; the triple suspension used the same line and materials, configured as three attachment points to keep the top/front clear.



Figure 12. Left: calibration sphere with the knot on the top, right: calibration sphere with trippel suspension.



Figure 13. Observations of acoustic properties of shrimp (left) using the infrastructure developed in Austevoll for CRIMAC (right).

The calibration gain obtained with the two suspension methods differed slightly. Above 200 kHz, target strength (TS) differences of up to ~1 dB were observed between suspension types. It is not yet clear which configuration is closer to the true (unbiased) TS, so further controlled experiments are planned for 2026 to isolate and quantify suspension-related biases

#### Test dataset for broadband data processing – broadband echosounder test datasets

We compiled and published a collection of broadband echosounder test datasets (ships, net-pens, towed bodies) containing Kongsberg Discovery EK80 raw files, metadata, calibration data, and ground truth (when available) for targets including fish (with and without swim bladders), larger zooplankton, and calibration spheres; a data publication describing these datasets has been prepared for the primary literature, and we have developed a Python based processing workflow built on top of Korona that converts the raw data to self-documented NetCDF files — processing instructions and the code are available at <https://github.com/CRIMAC-WP4-Machine-learning/CRIMAC-FM-testdatapaper> and the datasets can be accessed at <http://metadata.nmdc.no/metadata-api/landingpage/f0bdafac077ee736926b57c42221f27>

#### Broad band backscatter from shrimps

The echo-sounder gimbal developed for the CRIMAC experiments was used to perform broadband measurements on individual dead shrimp suspended in thin nylon for modelling purposes. The shrimp were kept submerged when it was moved from the holding vessel to prevent air bubbles from disturbing the acoustic signals and were euthanized with an anaesthetic in water shortly before the measurements. A bar weight was applied to stretch each specimen. Five Kongsberg Discovery EK80 echo sounders, covering 34–380 kHz, were used. These empirical measurements will be compared to the shrimp backscatter predictions produced by the CRIMAC WP1 model and used to calibrate and improve the model's accuracy for shrimp.

# WP3

## Ground truthing methods

**Scientific questions:** *What are the organisms and targets that generate broadband backscatter?*

WP3 develops and implement techniques for identifying and measuring the sources of broadband backscatter using mainly optical verification tools, such as stereo camera systems. The WP also evaluates and further develops sampling methods for acoustic surveys. We are especially focussing on developing in-trawl camera systems that can improve the temporal and spatial resolution of trawl samples. When combined with open codend, it is also a less invasive sampling method. The WP cooperates closely with the industry partners and aims to identify applications to commercial fisheries.

## Active selection systems for opening and closing the trawl

FishNext Research in collaboration with Kongsberg Discovery has developed an active selection device that automatically opens and closes the trawl (ActSel) (Figure 14). The system operates together with the Simrad FX80 system with live cameras (Kongsberg Discovery). During the 2025 CRIMAC survey we tested and optimize ActSel for the Harstad survey trawl. The aim was to evaluate practicality and reliability and monitor herring behaviour in relation to the selection panel in red and white light conditions.

The ActSel system was successfully adapted to the survey trawl and demonstrated that it operated as anticipated. The net panel was efficiently moved between release and capture modes. The ability to deploy two live-feed cameras provided real time video of the selection system and fish entering the trawl. However, significant quantities of herring were observed to escape over the top of the ActSel panel when it was in the capture configuration. There were also a risk of the entanglement and some challenges with using the 3rd wire on board GO Sars. Before fully operational further development is required.

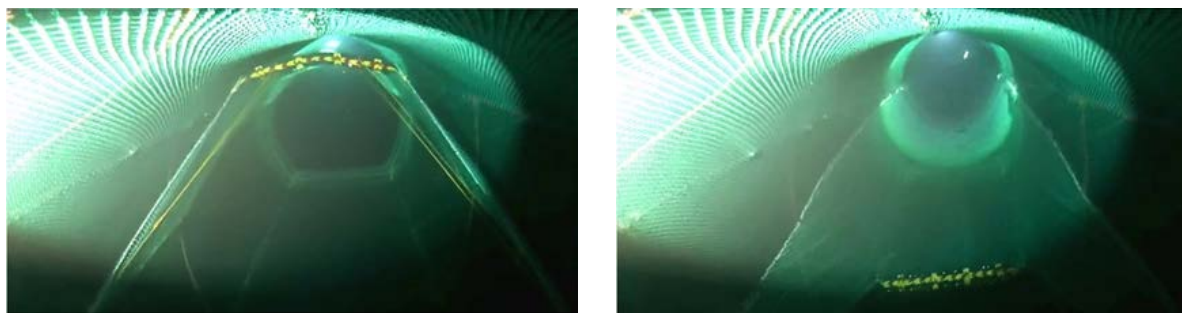


Figure 14. Right: ActSel in catch mode (panel is up and the entrance to the codend is open). Left: ActSels in release mode (the panel is down, codend is closed and the fish are guided out thorough an opening in the upper panel).

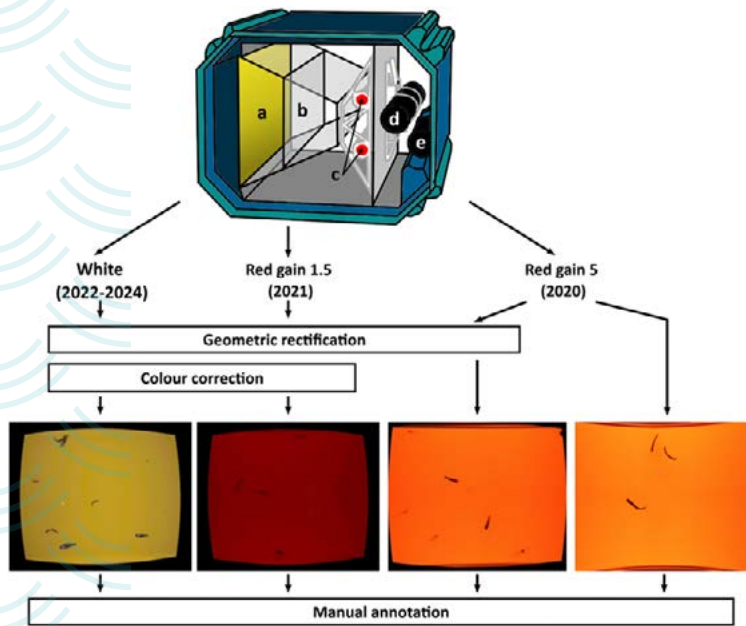


Figure 15. Detailed anatomy of the Deep Vision: (a) imaging chamber, (b) divider to reduce the volume of the imaging chamber, (c) two stroboscopic lights, (d) stereo camera, and (e) battery. Image processing steps applied after collection using the “Deep Vision HMI” software (Scantronic Deep Vision AS, Bergen, Norway): geometric rectification to facilitate length measurements from images (final images with rounded sides); colour-correction applied to all images collected after the year 2020. (Image from Westerberling et al., 2026)

### A deep learning-based model for automatic identification of mesopelagic organisms from in-trawl cameras

Mesopelagic organisms play an important role in the ocean’s carbon transport and food webs and have been regarded as a potential harvestable resource. However, information on biomass, population dynamics and behaviour needed to assess and manage mesopelagic populations is scarce. In CRIMAC we have trained a deep learning-based object detection model (YOLO11s) to automate the identification of seven mesopelagic groups common in the North Atlantic Ocean. The species include lanternfish, silvery lightfish, barracudina, krill, pelagic shrimp, gelatinous zooplankton, and squid along with a group of larger pelagic fishes. The in-trawl images were collected using the Deep Vision system (Figure 15) under white and red-light with two gain settings. The effect of image resolution and light on the model precision were investigated. The results demonstrate that employing the latest machine learning algorithms enables the detection of small-sized mesopelagic species from in-trawl camera images, allowing for rapid extraction of depth-stratified data and records of fragile species that are typically lost in the codend meshes.

### CRIMAC Workshop on applying in-trawl and towed camera systems to scientific surveys

In-trawl and other towed camera systems are becoming increasingly available and offer less invasive

sampling with higher spatial and temporal resolution. Combined with machine learning algorithms for automated image analyses and near real time data processing and transfer, the systems offer great potential as sampling tools in scientific surveys. However, only a few surveys have so far implemented trawl-camera based sampling as a routine praxis.

In March 2025 CRIMAC arranged a 2-day workshop on implementation of in-trawl cameras to scientific survey, 106 people from 21 countries and 47 different organizations and companies attended. The aim of the workshop was to share knowledge on the latest developments and initiatives within the application of cameras to scientific trawl surveys. Topics that were covered included 1) image data collection, processing and transfer methods, 2) collection of representative physical biological samples (e.g. open/close codend systems) and 3) how to include the data in assessment models. Through several interesting presentations we heard how underwater camera systems are already used in research, including for abundance estimation, to support interpretation of acoustic data, studies of fish behaviour and trawl selectivity, and for improved understanding of ecosystems. The workshop has given us valuable knowledge that will help us move forward with this initiative. The goal is also to produce a scientific manuscript that provides recommendations on the use of underwater cameras in stock assessment.

# WP4

## Machine learning and species categorization methods applied to fisheries acoustics and ground truthing data

**Scientific questions:** *Can machine learning techniques reliably and accurately categorize acoustic backscatter?*

This WP develops and applies machine learning tools on large volumes of acoustic data, with a focus on categorizing acoustic backscatter. Developing machine learning models and other analytic tools require access to large amounts of training data, and a core activity of the WP is collecting, organizing, and curating historical and new acoustic data.

This includes supervised methods, using a combination of historical labels, experimental data, simulation, and ground truthing information (WP3) as well as semi-supervised and unsupervised methods to extract classes that are not the target species. The ability to process data without explicit labels is particularly relevant for gas seep detection, plankton layers and other non-labelled categories. Classes also includes bottom detections and samples dominated by noise. By clustering historical data and comparing the classes with the classes derived using broadband data, we expect to see an improvement in acoustic target classification.

### KoronaScript

The KORONA library provides a large set of functions to process and manipulate echo sounder data. KORONA is normally run as a graphical application, either from the LSSS application, or using its own interface for configuring the processing pipeline. For automation (in particular, the data processing pipeline described below), a programmatic interface accessible from Python is needed. To these ends, we have designed and implemented a Python package, KoronaScript, that implements an API to the various KORONA modules. KoronaScript is now considered complete, and a paper describing it is in preparation.

<https://github.com/CRIMAC-WP4-Machine-learning/CRIMAC-KoronaScript>

cruiseseries	cruise	sv.zarr	bottom.zarr	labels.zarr
Atlantic Ocean West of British Isles INT blue whiting spawning survey in spring	19	12	11	11
Coast of Norway costal sprat acoustic survey yearly	17	17	15	15
North Sea INT Mackerel cruise	6	4	2	4
North Sea NOR Sandeel cruise in Apr_May	21	20	18	19
Norwegian Sea International ecosystem cruise in May	24	19	15	16
Norwegian Sea NOR Norwegian spring-spawning herring spawning cruise in Feb_Mar	30	26	21	24
Porsangerfjorden Tanafjorden Kvænanen NOR ecosystem mapping in spring_autumn	10	6	0	0

Figure 16: Historical data sets (research cruises) in the process of being converted for reanalysis and training machine learning models.

### Data processing pipeline

Broadband measurements result in large amounts of data where the acoustic broad band signals include information in the frequency domain which is not straightforward to interpret due to the complexity of the backscatter of moving objects like fish. For this reason, efficient signal processing methods are needed to adapt the data to a format, like NetCDF, which can serve as input to algorithms using artificial intelligence. An important part of this effort is the conversion of the large archive of historical acoustic survey data and making it available for training machine learning methods as well as other types of analysis. In 2025, several new cruise series have been added. Apart from that, much of the focus has been on moving data and processing onto Azure cloud services. This work has contributed

to the implementation of a framework for automated transfer and processing of acoustic data from ship to land, for use with UAVs for data collection.

### Target detection and tracking

Broadband echosounders have a very high spatial resolution, making it possible to distinguish individual objects even at high densities in the data. Detections can be identified from peaks in the received signal, either directly or after pulse compression. The detections are then linked across channels (transducers), and across pings using a tracking algorithm. This allows us to extract the received frequency spectrum for individual targets over multiple observations and use it to identify fish, plankton, or other objects.

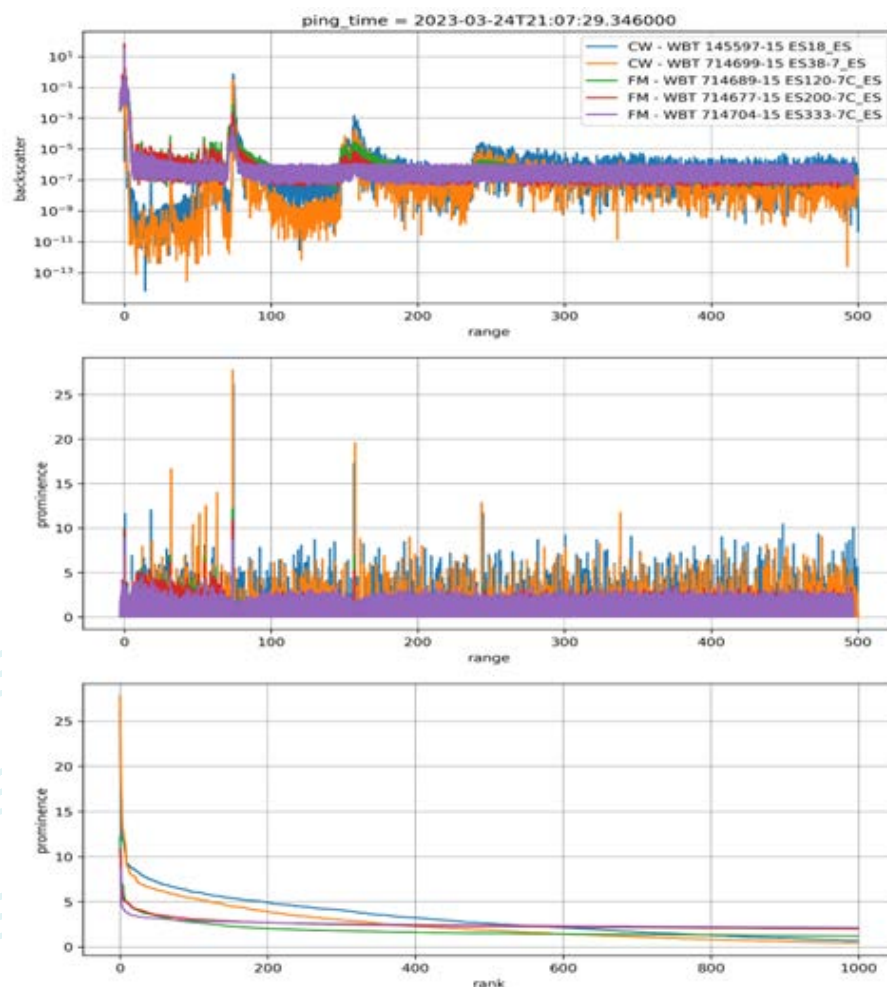


Figure 17. Single target detection using prominence, a peak finding algorithm that is independent on actual signal level and robust against noise.

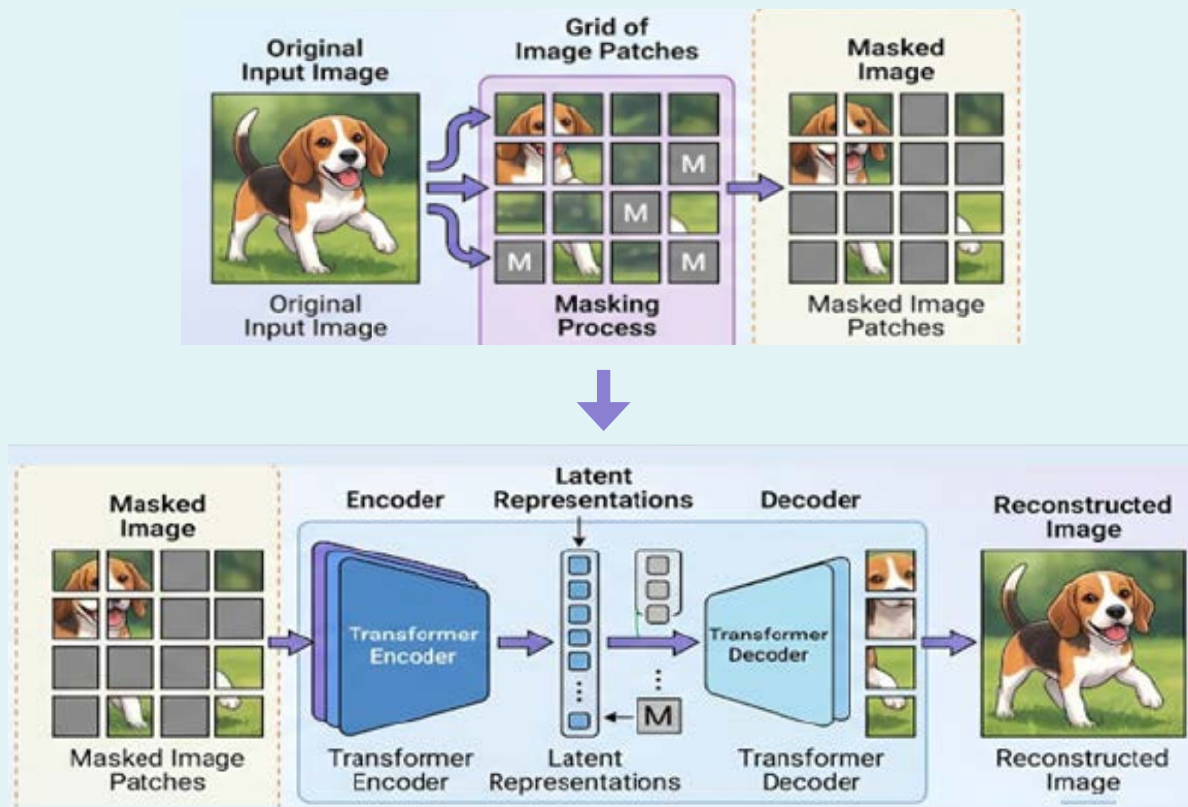


Figure 18. The illustration shows how the mask autoencoder works. By masking out (large) parts of the input, the model has to learn how to reconstruct the masked parts in order to reconstruct the input image. This forces it to learn an efficient representation for the input domain, and the representation captures semantically important information which can then be used in downstream tasks.

### Foundation models for acoustic classification

Where semi-supervised methods leverage unlabelled data in conjunction with scarcer labelled data, unsupervised and self-supervised methods aim to derive a representation directly from unlabelled data. Most existing methods are targeted to image data, while we have had some success with our DINO-based approach (Pala, et al, 2024) adapting these methods to acoustic is challenging. Based on successful applications for seismic data, we are currently exploring masked autoencoders to learn embeddings for echograms. A prototype model has been implemented, and we are now waiting for access to national computer resources to train it on large scale data.

# WP5

## Improving precision by autonomous platforms and survey and experimental design

**Scientific questions:** *How to utilize acoustic sensors on autonomous platforms, assess uncertainty and utilize the effect of behaviour on acoustic backscatter?*

WP5 is responsible to establish methods for utilizing autonomous or remotely operated platforms as an efficient way for deploying acoustic sensors. The platforms can either be run stand-alone or in conjunction with ships. They can also be used in a range of different applications, including scouting vessels for fishing operations and to augment research vessel based acoustic surveys. Different approaches to utilize these platforms are being explored, including various static and adaptive survey designs. How the uncertainty in automated acoustic target classification propagates to the use cases will be addressed, and WP5 will use survey time series from a range of IMR surveys to test the impact of automating target classification.

### Joint sprat survey in Hardangerfjorden with research vessel and remotely operated USV

The coastal sprat survey was in 2025 conducted using a combination of the uncrewed surface vessels Frida and Frigg and the research vessel Prinsesse Ingrid Alexandra (Figure 19). The data from the USV was used in the advice and are our first example of a full implementation of uncrewed vessels in fisheries advice issued by IMR. The survey covered the fjords Hardangerfjorden, Sognefjorden, Nordfjord and Trondheimsfjorden. The operation was remotely operated from the Remote Operation Centre ROC in Nykirkekaaien in Bergen. CRIMAC contributed with data processing components for data compression, acoustic target classification, see also user story on the Blue Insight implementation.



Figure 19. The Research vessel “RV Prinsesse Ingrid Alexandra” and the USV “Frigg” used for the coastal sprat survey in 2025.

### Integrating and assessing machine learning acoustic target classification models for fish survey estimations

Scientific acoustic-trawl surveys provide time-series data used to monitor fish and zooplankton populations. Current practice relies primarily on manual annotation for acoustic target classification. We evaluated a framework for testing deep-learning acoustic classification models and integrating their outputs into the official survey estimation pipeline. Three U-Net based architectures were trained and compared (Figure 20).

Overall biomass estimates derived from model predictions were broadly similar to official (manual) estimates but inter-annual variation occurred. The baseline model occasionally misclassified surface layers as sandeel and

was susceptible to bottom contamination, producing larger deviations from official estimates.

A model trained using similarity-sampling produced discrepancies caused by an incorrectly applied SoftMax threshold that resulted in missing school interiors and highlights sensitivity to threshold choice. A depth-aware model showed improved handling of vertical context relative to the baseline in several cases (but did not fully eliminate errors).

Full automation is not yet reliable across all survey years, but it is assumed to improve when retraining the model on more recent years. Model predictions are useful as pre-annotations that can substantially reduce the manual workload.

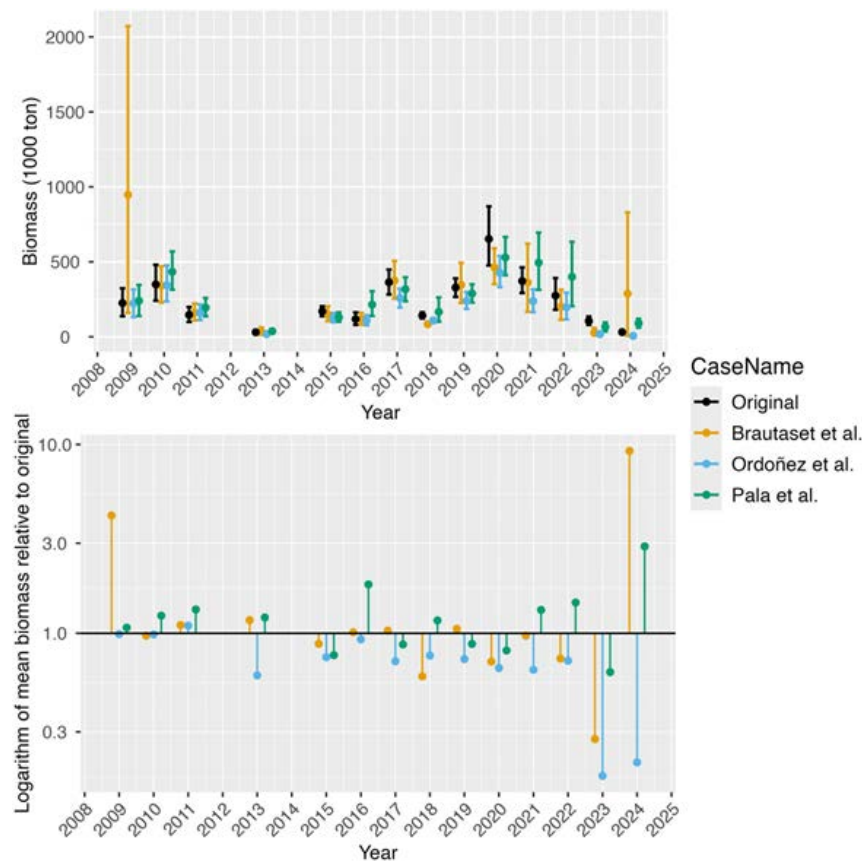


Figure 20. Upper panel: Total biomass of sandeel (age 1+) with a 90% confidence interval (5%–95%) for all survey areas combined per year, estimated from the acoustic sandeel surveys (Johnsen and Kvamme 2024). The original is the official estimate, whereas the three others are the estimates from Brautaset et al. (2020), Ordoñez et al. (2022), and Pala et al. (2023), respectively. Note that 2012 is missing since the data set lacked the 120 kHz echosounder data. The 2014 data failed due to missing data. Lower panel: the absolute difference between the prediction point estimate and the original estimate (Handegard et al. 2025, CC-BY 4.0).

# User stories



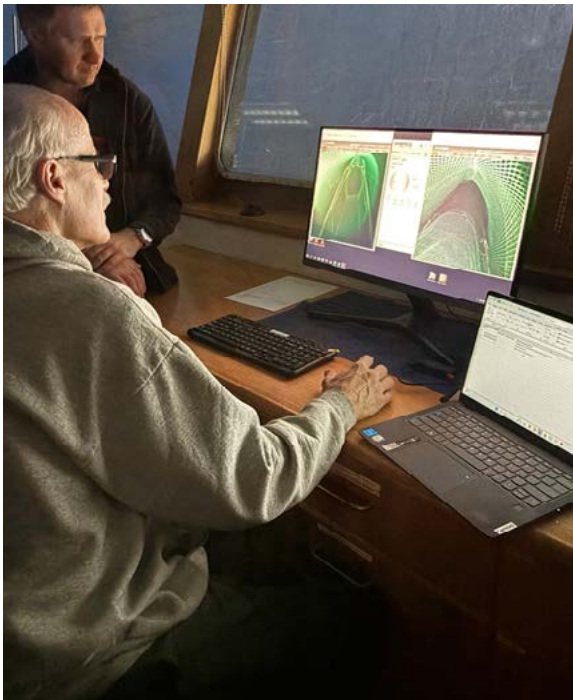
# WP6

## WP6 and extracting gains for science and industry

The overall goal of WP6 is to link the ongoing research and development in the CRIMAC SFI with the needs of the centre user partners. The consortium spans both scientific and industrial end users as well as suppliers, ensuring that quantified gains would cover both new methods as well as the commercialization of solutions from the centre. The goal of the SFI is to foster innovation and value creation. CRIMAC has identified four key sectors to target, on which the success of this work package will be measured:

- Science & Management
- Commercial Fishery
- Aquaculture
- Marine Energy

The user stories below highlight examples of the links between the science and user partners in CRIMAC.



### User story: Sustainable trawl operations

Overfishing and by-catches are challenging the sustainability of fisheries. The proportion of stocks harvested at sustainable levels is estimated to be 63% and has been decreasing since 1970s. Discards have been estimated to be 9 million tonnes annually (~10% of total catch), main proportion from demersal trawls (Pérez Roda et al., 2019). Commercial fisheries are generally heavily regulated with little control of what is being caught. CRIMAC develops in-trawl camera and active selection systems that aim to provide fishermen with real time catch information and a possibility to open the trawl and release unwanted catches.

In 2025, the CamSounder in-trawl camera system (Scantrol DV) was deployed on fishing and research vessels collecting image data. The data have been used to develop machine learning algorithms for automatic detection, identification and counting fish by species as well as optimizing image quality and practical operation. In 2026 the focus will be on developing edge computing and acoustic data communication for real-time image data processing and transfer.

In-trawl camera systems have great potential in reducing fish mortality in scientific surveys and making sampling more efficient. IMR is aiming for routine-based use of in-trawl cameras on scientific trawls. Image data will provide higher resolution data on distribution and interaction of organisms. By replacing deck sampling with image-based sampling for species and length distributions, sampling efficiency can be improved and fish mortality reduced. CRIMAC has developed image algorithms and compares results with catch-based samples. Preliminary experiments have also been carried out with two systems that open and close the trawl that will allow for selective sampling, only bringing the required amount of fish on deck. The aim in 2026 is to test a complete prototype with active selection and camera system in the CRIMAC survey.



**User Story:**

**Next generation acoustic trawl surveys**

The remotely operated Sounder USV, developed by Kongsberg Discovery, was deployed to collect acoustic data during the 2025 sprat survey in Hardangerfjorden, Sognefjorden, Nordfjord, and Trondheimsfjorden (see WP5). The platform was equipped with the KD Blue Insight system (Figure 21), enabling CRIMAC processing workflows to run on the analytics workflow engine (AWS). The workflow tasks included data compression and acoustic target classification.

CRIMAC-developed processing modules were successfully integrated and executed on Kongsberg’s infrastructure. The system enabled telemetry of data to shore, allowing IMR to retrieve data from the KD cloud in near real time. This marked the first time the system was used as part of IMR’s standard survey operations.

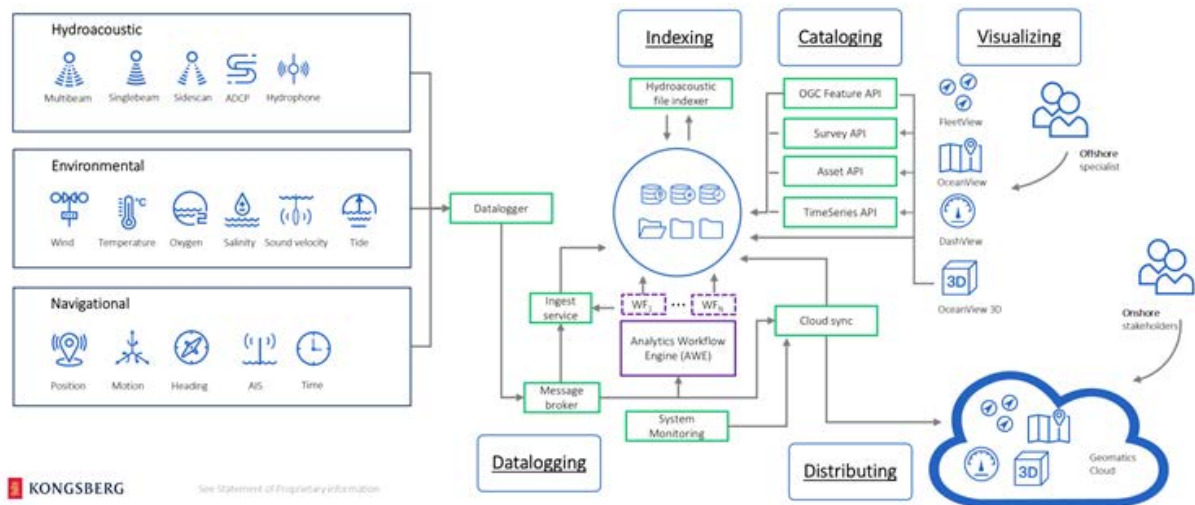
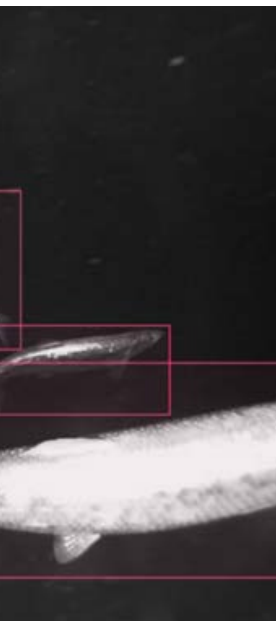


Figure 21. The Web based software architecture used by the Kongsberg discovery Blue Insight system for logging, indexing, cataloguing, visualizing and distributing data (Kongsberg Discovery).

# Associated projects

**CRIMAC IS COLLABORATING WITH OTHER SFI'S AND HAVE SEVERAL ASSOCIATED PROJECTS FUNDED TO STRENGTHEN THE ACTIVITY IN THE CENTRE.**

## Acoustic detection and identification of shrimp

This is a project financed by The Norwegian Seafood Research Fund funded project (FHF). Sustainable, profitable and environmentally friendly shrimp fisheries in the future there is a need to improve efficiency and reduce the negative impacts on the environment. To solve some of these challenges this project (1) investigates and develop improved methods for detecting or predicting shrimp aggregations before and during trawling, (2) improve knowledge of the behaviour and vertical distribution of shrimp in the water column and (3) investigate the potential for pelagic trawling. Austevoll setup with EK80 broadband echosounders were used to measure target strength of shrimp.

## Analyse data from long term monitoring

The CRIMAC data-processing pipeline was used in the EU project Bluecho (*BlueEcho | Discover Sustainable Marine Solutions - Get Informed*) to demonstrate how large, long-term echo-sounder and hydrophone datasets from the LoVe ocean observatory can be analysed, enabling investigation of the effects of continuous noise on fish.

The work has been accepted for publication in the book: [The Effects of Noise on Aquatic Life IV | Springer Nature Link](#)

## Effects of floating wind farms on the marine ecosystem, with a focus on pelagic fish

The processing pipeline was also used in the project "Effects of floating wind farms on the marine ecosystem, with a focus on pelagic fish" (project no. 336334) to investigate potential effects of floating offshore wind turbines on pelagic fish.

## Smart AUVs for detection and quantification of greenhouse gas seepage in the oceans (Smart AUV)

The Research Council of Norway funded project "Smart AUVs for detection and quantification of greenhouse gas seepage in the oceans" aims to improve the monitoring capabilities of AUV by applying artificial intelligence and signal processing technics to enable

UAV decision autonomy. CRIMAC tools were tested for detection and characterization of CH<sub>4</sub> and CO<sub>2</sub> seeps measured with scientific echosounders during a field campaign in 2024. The project will contribute to improved monitoring of the oceans and sound management of marine activities. The project is coordinated by The Norwegian Geotechnical Institute (NGI).

## Harvest SFI

HARVEST SFI and the CRIMAC SFI is collaborating on platform navigation methods. This collaboration is through co-supervising a PhD student, c.f. the student presentation in this report. The work addresses automated USV control with data quality as a metric for the operation.

## Visual Intelligence SFI

Visual Intelligence SFI focus on deep learning-based solutions for cutting-edge complex image analysis, and SFI CRIMAC and SFI Visual Intelligence work together on image-based acoustic target classification methods and error propagation from deep learning model predictions.

## Data from Ocean to FAIR

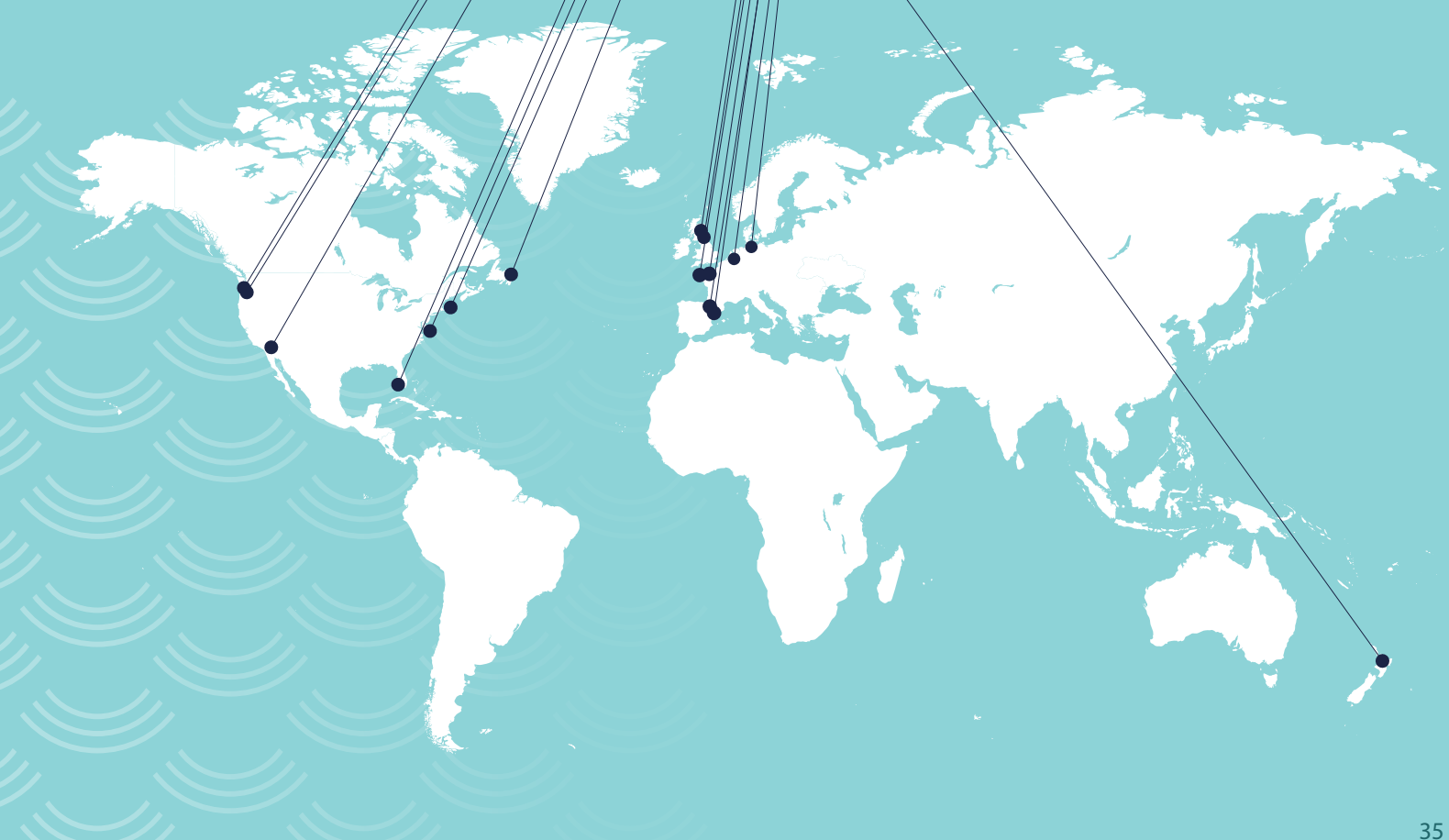
The IMR project Data from Ocean to FAIR focuses on the acoustic data flows, including edge processing, data transfer from vessels to shore, and infrastructure for delayed mode processing in IMRs data platform. CRIMAC contribute to this project by KDs Blue Insight development and the development of data processing flows for acoustic data.



# Cooperation

## INTERNATIONAL COOPERATION

- Northwest Fisheries Science Centre, NOAA, Seattle, United States of America
- Alaska Fisheries Science Centre, NOAA, Seattle, USA
- Southwest Fisheries Science Centre, NOAA, United States of America
- Florida International University, USA
- Woods Hole Oceanographic Institution, United States of America
- NOAA Fisheries, Office of Science and Technology, United States of America
- Memorial University of Newfoundland, Saint Johns, Canada
- Cupar Analytics Ltd, Great Britain
- Heriot-Watt University, United Kingdom
- Ifremer Centre de Brest, France
- Ifremer, Nantes, France
- Instituto Español de Oceanografía, Spain
- Universitat Politècnica de València, Spain
- Wageningen University & Research, Wageningen, Netherlands
- Thünen Institute, Germany
- Aqualyd Limited, New Zealand
- Fisheries, National Institute of Water and Atmospheric Research, New Zealand
- National Institute of Water and Atmospheric Research, New Zealand



# Students

**Training of the next generation researchers within the field is vital for future development, and CRIMAC contributes to this by supervising six PhD students. Five of these are hired within the centre and one is funded by the HARVEST project and co-supervised by CRIMAC. We are also active in attracting master students by promoting the centre in undergraduate courses at UiB and by proposing CRIMAC-associated projects to students that are starting on their master programme within biology, mathematics, or physics.**

## PhD STUDENTS

### Ahmet Pala

Ahmet Pala has a master's degree in industrial engineering on machine learning and successfully defended his Ph.D. (Pala 2025) in Applied Mathematics at UiB in 2025. He worked mainly in work package 4 where he worked on machine learning techniques for acoustic target classification. The first project dealt with imbalance in data distribution between target species and background classes for acoustic target classification (Pala et al. 2023). A challenge lies in balancing the sampling process prior to identifying the correct class.

In his second project he tested several machine learning models and tested what would be the result if these were blindly used for the target classification (Pala et al. 2024).

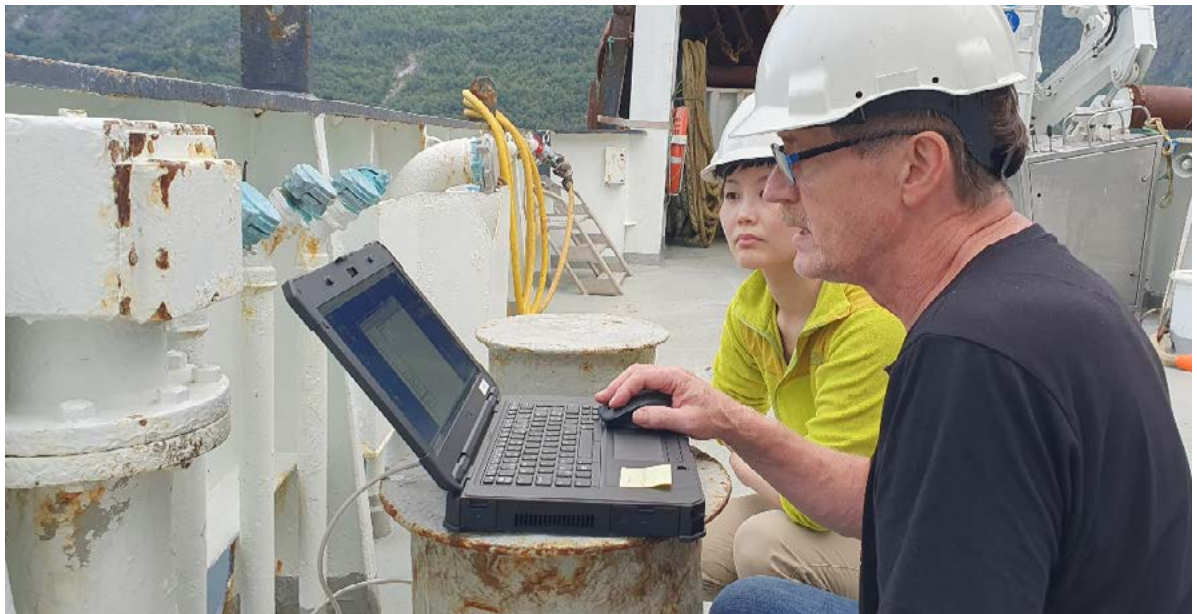
In his third project, he adapted unsupervised methods typically used in image processing to address acoustic target classification problems (Pala, Oleynik, and Handegard 2025). This adaptation enabled deep learning models to be trained on raw data without the need for labelled samples. Such an approach proves particularly advantageous when analysing datasets from new surveys or experiments.

In his fourth project he contributed to a work that demonstrated the implications of automating the acoustic target classification for acoustic trawl surveys (Handegard et al. 2025).

Ahmet was supervised by Guttorm Alendal and Anna Oleynik from UiB and Nils Olav Handegard from IMR.



Figure 22. Ahmet presenting his thesis work.



### Sakura Komiyama

Sakura Komiyama received her second master's degree in biology and currently works for the CRIMAC project as a PhD research fellow. Her overarching interests are fish behaviour and species interaction within marine ecosystems, observing through up-to-date instruments such as broadband echosounders and uncrewed surface vehicles (USVs).

Sakura has work on time dependent (seasonal and diurnal) vertical distribution of sandeel schools based on echosounder data from Saildrone, which provides undisturbed observations of this strongly schooling fish species. Sandeel bury into the sediments for protection from predators but also need to migrate higher up

in the water column to feed. This induces two components to the vertical distribution, one close to the bottom and one mid-water. Explaining this behaviour is of interest to Sakura, particularly in relation to the zooplankton layer. Her paper on this phenomenon was accepted late 2024 and published in February 2025.

In her current project, she works on inter-platform changes in acoustic backscatter and fish behaviour, aiming to provide insight into USV sourced acoustic data.

Sakura is supervised by Espen Johnsen and Arne Johannes Holmin from IMR and Arild Folkvord from UiB.

### E. H. Taraneh Westerberling

Taraneh Westerberling completed an international Master's program in Marine Biological Resources (IMBRSea) in 2021. She is now a PhD Research Fellow at the Department of Biological Sciences at the University of Bergen and part of WP3 in CRIMAC. In her master's thesis she worked with applying the Deep Vision in-trawl camera system to pelagic fish research. The higher temporal and spatial resolution of trawl image data compared to trawl catches can aid interpretation of acoustic data and in the future image data may replace some of the trawl catch samples. Taraneh continues with the same topic in her PhD, but with focus on mesopelagic species.

Taraneh is now in her fourth year of the PhD. She has submitted her first paper where she studied fish behaviour in the trawl and how that affects the quality and accuracy of image-based fish counts and length distributions. In her second paper she is developing algorithms that can automatically detect, identify and count a range of mesopelagic species in trawl images. This will allow for scientific data collection of mesopelagic species (commonly lost in the codend) in traditional pelagic fish surveys. She will use the methods and algorithms in her final paper to describe the spatial distribution of mesopelagic species in the Norwegian Sea.

Taraneh is supervised by Maria Tenningen and Shale Rosen from IMR and Anne Gro Salvanes from UiB.



Figure 23. Taraneh using echosounders to look at biological organisms in the water column.



Figure 24. Taraneh Westerberling is presenting her work at the ICES ASC in 2025.

### Yngve Bøe

Yngve Bøe has a Master in Instrumentation and Measurement Science and a bachelor's in physics. He started his Ph.D. in physics in September 2023. Yngve is working on echosounder measurements and simulations on wide band backscatter from marine organisms, and he uses the salmon data set from Austevoll where 5 TB of acoustic echo sounder data from a netpen with salmon measured on six size groups of fish are available. The purpose is to estimate the size of the salmon based on frequency dependent target strength (TS) measurements. Parts of the signal processing pipeline combined with tracking with korona in LSSS provided TS(f) for each ping in each track for each transducers for the whole dataset. The information from the different channels/transducers are combined in the postprocessing to include TS(f) for the whole frequency range from 34 – 380 kHz. Information about the swimming angle of the fish is also found from the tracking, in addition to the position in the sound beam. The dataset supports development of salmon size-estimation methods and can serve as a template for other species. The first sizing approach tested is the standard log-length relationship between TS and fish length. A submitted paper explores how the slope and intercept parameters of the log-length relationship varies with frequency. Ongoing work uses AI (including CNNs trained on TS versus frequency and tilt) to predict individual fish lengths from wideband spectra; early outcomes are encouraging.

Yngve is supervised by Tonje Nesse Forland from IMR and Audun Oppedal Pedersen from UiB.



Figure 25. Yngve connecting transducer cables for the echo sounder rig in Austevoll.

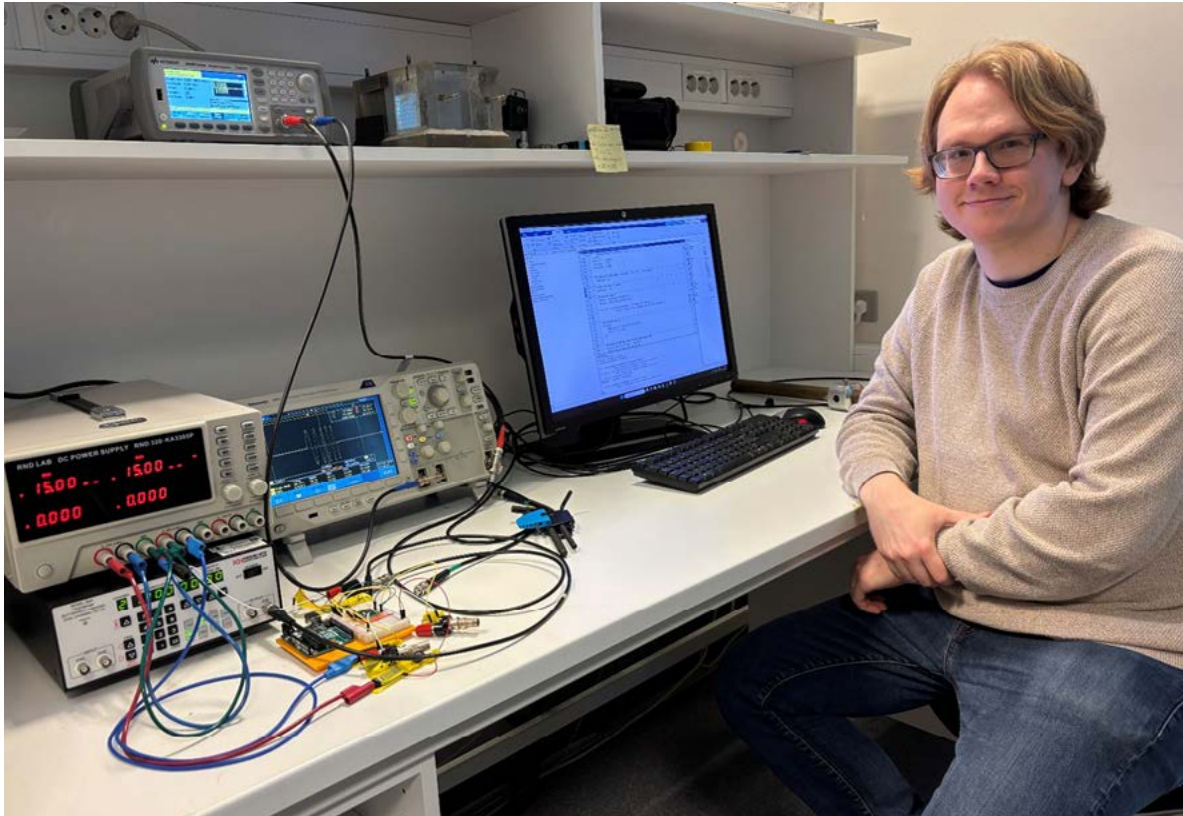


Figure 26. Helge in the acoustics lab at UiB Department of Physics and Technology.

### Helge Brøndbo Plassen

Helge Brøndbo Plassen holds a Master's degree in particle physics and a Bachelor's degree in physics from the University of Bergen. He began his Ph.D. in physics in September 2023. His work forms an important part of Work Package 1 in CRIMAC. The main goals of his Ph.D. project are to improve our understanding of broadband acoustic processes and to enhance our ability to extract information from broadband acoustic signals.

He has developed a simulation framework for broadband echosounder transducers that follows the entire process from generating the electrical signal to receiving the echo. He also uses an experimental setup in the acoustics lab at the University of Bergen, where he

can test different signals and data processing methods under controlled conditions. By combining computer models with laboratory measurements, he is now exploring new ways to improve how broadband transducers are calibrated. For example, he has proposed a method to create a reference signal that corrects for how the transducer itself distorts the received signal, so that the final processed signal more closely matches an ideal, well-defined target signal.

Helge is supervised by Audun Oppedal Pedersen (UiB) and Geir Pedersen (IMR).

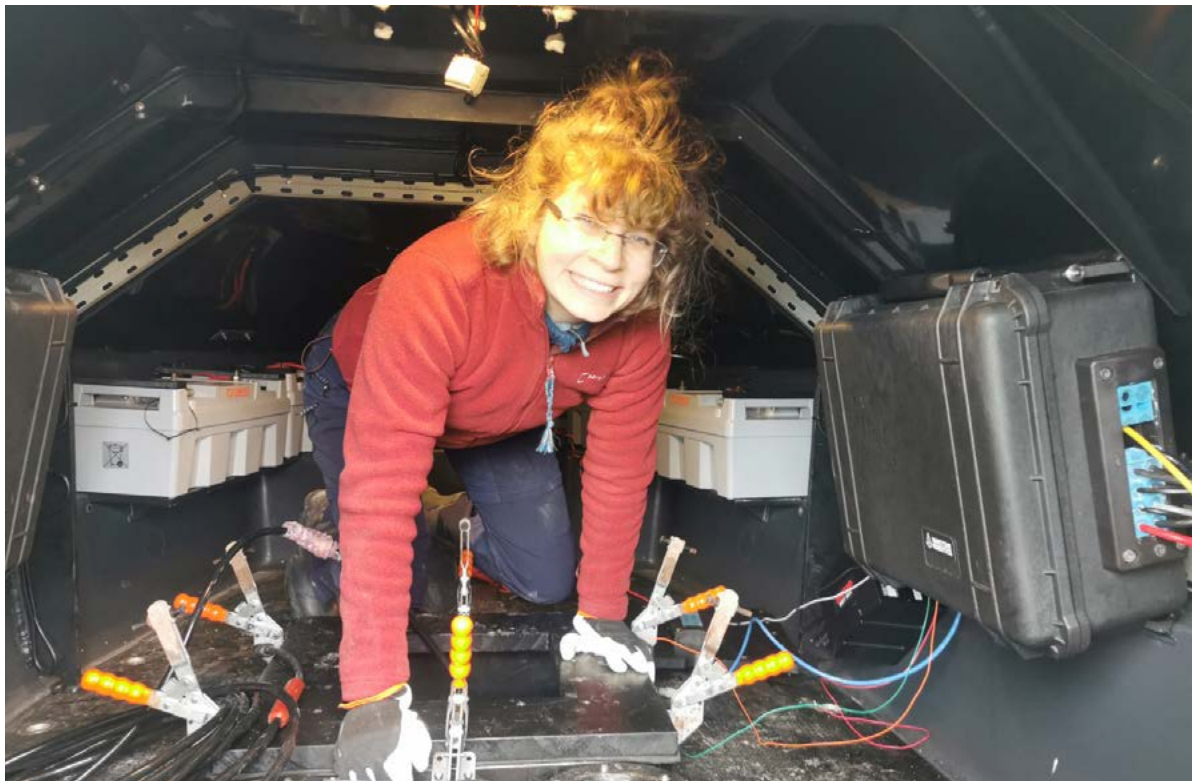
## ASSOCIATED STUDENTS

### Rabea Rogge

Rabea Rogge has a master's degree in electrical engineering and information technology from ETH Zurich, Switzerland, and she is currently employed as a PhD candidate at the Department of Marine Technology at NTNU. She is funded through the HARVEST SFI, and her work is associated with work package 5 in CRIMAC. Her PhD topic is Data-driven navigation, guidance and control for autonomous surface vehicles in harsh conditions.

She participated at the CRIMAC cruise in November 2023 and contributed to the USV noise estimation work as well as her own project on control systems for the USV using the backseat driver functionality in the Maritime Robotics control system on the Sounder USV.

Rabea is supervised by Asgeir Johan Sørensen (NTNU), Eleni Kelasidi (Sintef) and Nils Olav Handegard (CRIMAC, IMR).





## MASTER STUDENTS

### Adrian Røslund

Adrian Røslund defended his masters project in spring 2025. The title of his thesis is "In-Trawl Stereo Camera Systems for Mackerel Monitoring: Development, Evaluation, and Applications in Swept-Area Trawl Surveys". The main objective was to investigate if and how an in-trawl stereo camera system could be used for sampling in the international Ecosystem Summer Survey in the Nordic Seas (IESSNS) trawl swept area survey.

### Vilde Strand Dybevik

Vilde's master project is titled "Transmit-Receive Switching for Ultrasound Pulse-Echo Measurements". She sought a new solution for switching between high-voltage transmission and sensitive reception for sonar and other ultrasound measurements for the Acoustics laboratory at UiB, enabling precise measurements and undistorted signals upon both signal transmission and reception. The main deliverable from the project was a prototype for a versatile switching unit for laboratory use. Existing equipment was characterized, and solutions found in industry and scientific literature were reviewed and discussed, as basis for the chosen solution. Vilde defended her thesis in June 2025.

Supervised by Audun Oppedal Pedersen (UiB) and Mathias Sæther (UiB).

### Mats Nicolai Hübschle

Nicolai defended his master's thesis in June 2025. His project was titled "Nonlinear sound propagation in fisheries acoustics - comparison between numerical solutions". The linear wave equation assumes negligible sound pressure amplitude and particle velocity. When the amplitude of a sound wave becomes so high that the linearity assumption introduces significant model error, the sound wave is said to be of finite amplitude. This is sometimes the case in fisheries acoustics, where target strengths (TS) and volume backscattering coefficients (sv) are measured quantitatively. Two second-order finite-amplitude effects become significant: (1) «Nonlinear loss» at the fundamental (transmitted) frequency component leads to underestimation of measured TS and sv if it is not accounted for in the measurement model. The practical effect of nonlinear loss is complicated further when there is also significant nonlinear loss upon echosounder calibration. (2) Harmonic overtones are generated in finite-amplitude sound propagation and can cause «nonlinear crosstalk» in multi-frequency and wideband echosounder systems. Such crosstalk can act differently in different system configurations and may be more challenging to manage through the measurement model than nonlinear loss.

The main goal of the Master project was to quantitatively compare the outputs from two numerical solutions of the Khokhlov-Zabolotskaya-Kuznetsov equation. The equation describes finite-amplitude sound propagation in a sound beam to the second order. One numerical solution, known as the «Texas code», operates in the time domain. The other solution is known as the «Bergen code» and solves the equation in the frequency domain. This version of the equation does not include relaxation terms, but frequency dependent absorption coefficients are enforced for each harmonic frequency. This code has been used, and is still in use, in collaboration between UiB, IMR, and KD.

Supervised by Audun Oppedal Pedersen (UiB) and Babak Khodabandelloo (IMR)



### Jaroslav Kamrla

The aim of Jaroslav's master's thesis is to develop an acoustic model to detect mesopelagic fish. This will primarily be achieved using an 18 kHz broadband echosounder, which provides frequency resolution suitable for close to the expected resonance of these species. The project will also characterize the size structure of the scattering layers using Deep Vision imagery. An acoustic scattering model will be fit to the data for estimating swimbladder size and tilt. Because swimbladders at these depths frequently rupture during trawling, direct length-to-swimbladder-size correlations are challenging; however, by integrating non-invasive Deep Vision observations with acoustic measurements, such correlations may be attainable in principle.

### Sander Marx

Sander graduated in 2025 with his thesis titled "Machine learning architectures for simulated broadband data", with Ketil Malde and Babak Khodabandelloo as supervisors. Sander optimized the physical model for oblate spheroids for computational efficiency, improving execution times by an order of magnitude. This made it feasible to use it to generate a large set of broadband spectra, and train different machine learning models and architectures to recover the geometric and physical properties of the simulated objects from the spectra. The models were applied to real data sets with known targets to estimate their efficacy in a real setting, and the results were presented at IARIA COCE 2025. An extended paper based on the results have recently been submitted.

# Communication and dissemination activities

Disseminating our activities and results to selected target audiences as well as the broader public is central to achieving CRIMAC's objectives.

In addition to CRIMAC's own web page, stories and updates from the centre are regularly featured on IMR's web page and social media channels, where they reach a wide audience.

An overview of CRIMAC news can be found here: <https://crimac.no/nyheter>

# Appendices

## Publications

A complete list of results can be found through NVA Sikt

<https://nva.sikt.no/projects/2497164>

Peer reviewed publications and master theses are listed here.

## Peer reviewed publications

**Allken V, Rosen S, Handegard NO et al.** A deep learning-based method to identify and count pelagic and mesopelagic fishes from trawl camera images. ICES J Mar Sci Nov. 2021;(fsab227).

<https://doi.org/10.1093/icesjms/fsab227>

**Allken V, Rosen S, Handegard NO et al.** A real-world dataset and data simulation algorithm for automated fish species identification. Geoscience Data Journal 2021;8(2):199–209.

<https://doi.org/10.1002/gdj3.114>

**Andersen LN, Chu D, Handegard NO et al.**

Quantitative processing of broadband data as implemented in a scientific split-beam echosounder. Methods in Ecology and Evolution 2023;n/a(n/a).

<https://doi.org/10.1111/2041-210X.14261>

**Bandara K, Basedow SL, Pedersen G et al.**

Mid-summer vertical behavior of a high-latitude oceanic zooplankton community. Journal of Marine Systems 2022;230:103733.

<https://doi.org/10.1016/j.jmarsys.2022.103733>

**Choi C, Kampffmeyer M, Handegard NO et al.**

Semi-supervised target classification in multi-frequency echosounder data. ICES Journal of Marine Science Aug. 2021;(fsab140).

<https://doi.org/10.1093/icesjms/fsab140>

**Choi C, Kampffmeyer M, Handegard NO et al.**

Deep Semisupervised Semantic Segmentation in Multifrequency Echosounder Data. IEEE Journal of Oceanic Engineering 2023:1–17.

<https://doi.org/10.1109/JOE.2022.3226214>

Criteria for Consistent Broadband Pulse Compression and Narrowband Echo Integration Operation in Fisheries Echosounder Backscattering Measurements | MDPI. n.d.

<https://www.mdpi.com/2410-3888/10/8/389>

(20 Mar. 2026, date last accessed).

**Doksæter Sivle L, Pedersen G, Zhang G et al.** Behavioural responses of overwintering herring to candidate whale deterrent signals.

ICES J Mar Sci 2025;82(11):fsaf199.

<https://doi.org/10.1093/icesjms/fsaf199>

**Dunn M, Pedersen G, Basedow SL et al.** Inverse method applied to autonomous broadband hydroacoustic survey detects higher densities of zooplankton in near-surface aggregations than vessel-based net survey. Can J Fish Aquat Sci published online 10 Nov. 2022.

<https://doi.org/10.1139/cjfas-2022-0105>

**Dunn M, Pedersen G, Daase M et al.** Broadband acoustic classification of Atlantic cod, polar cod, and northern shrimp in in situ mesocosm experiments. Fisheries Research 2025;286:107388.

<https://doi.org/10.1016/j.fishres.2025.107388>

**Handegard NO, Algroy T, Eikvil L et al.** Smart Fisheries in Norway: Partnership between Science, Technology, and the Fishing Sector. Journal of Ocean Technology 2021;16(2).

<https://hdl.handle.net/11250/2767785>

**Handegard NO, De Robertis A, Holmin AJ et al.** Uncrewed surface vehicles (USVs) as platforms for fisheries and plankton acoustics.

ICES Journal of Marine Science 17 Sep. 2024:fsae130.

<https://doi.org/10.1093/icesjms/fsae130>

**Handegard NO, Eikvil L, Jenssen R et al.** Machine Learning + Marine Science: Critical Role of Partnerships in Norway. The Journal of Ocean Technology 2021;16(3).

<https://www.thejot.net/current-issue/>

(6 Oct. 2021, date last accessed).

**Handegard NO, Holmin AJ, Pala A et al.** Integrating and assessing machine learning acoustic target classification models for fish survey estimations. ICES Journal of Marine Science 2025;82(5):fsaf069.

<https://doi.org/10.1093/icesjms/fsaf069>

**Handegard NO, Smith-Johnsen S, Holmin AJ et al.**

Operationalizing and Testing Machine Learning Models for Acoustic Target Classification. 26 Oct. 2025:23–6. [https://www.thinkmind.org/library/COCE/COCE\\_2025/coce\\_2025\\_1\\_40\\_30021.html](https://www.thinkmind.org/library/COCE/COCE_2025/coce_2025_1_40_30021.html)

(27 Oct. 2025, date last accessed).

**Khodabandelloo B, Agersted MD, Klevjer TA et al.**

Mesopelagic flesh shear viscosity estimation from in situ broadband backscattering measurements by a viscous–elastic model inversion. *ICES Journal of Marine Science* Sep. 2021;(fsab183). <https://doi.org/10.1093/icesjms/fsab183>

**Khodabandelloo B, Heggelund Y, Ystad B et al.**

High-precision model and open-source software for acoustic backscattering by liquid- and gas-filled prolate spheroids across a wide frequency range and incident angles: Implications for fisheries acoustics. *Journal of Sound and Vibration* 2025;616:119227. <https://doi.org/10.1016/j.jsv.2025.119227>

**Khodabandelloo B, Ona E, Macaulay GJ et al.** Nonlinear crosstalk in broadband multi-channel echosounders. *The Journal of the Acoustical Society of America* 2021;149(1):87–101.

<https://doi.org/10.1121/10.0002943>

**Khodabandelloo B, Ona E, Pedersen G et al.**

Mesopelagic fish gas bladder elongation, as estimated from wideband acoustic backscattering measurements. *J Acoust Soc Am* 2022;151(6):4073–85. <https://doi.org/10.1121/10.0011742>

**Khodabandelloo B, Pedersen G, Forland TN et al.** Pulse duration, frequency band, and sweep direction effects on crosstalk in wideband backscattering measurements. *The Journal of the Acoustical Society of America* 2024;156(1):391–404.

<https://doi.org/10.1121/10.0027912>

**Komiyama S, Holmin AJ, Pedersen G et al.** Silent uncrewed surface vehicles reveal the diurnal vertical distribution of lesser sandeel. *ICES Journal of Marine Science* 2024;82(2):fsae159.

<https://doi.org/10.1093/icesjms/fsae159>

**Kubilius R, Bergès B, Macaulay GJ.** Remote acoustic sizing of tethered fish using broadband acoustics. *Fisheries Research* 2023;260:106585. <https://doi.org/10.1016/j.fishres.2022.106585>

**Lekanda A, Boyra G, Handegard NO et al.**

Abiotic and biotic drivers shaping the schooling behavior of small pelagic fish in multispecies environments. *Marine Environmental Research* 23 May 2025:107243.

<https://doi.org/10.1016/j.marenvres.2025.107243>

**Leveraging Foundation Model Adapters to Enable Robust and Semantic Underwater Exploration. n.d.**

<https://www.visual-intelligence.no/publications/leveraging-foundation-model-adapters-to-enable-robust-and-semantic-underwater-exploration> (20 Mar. 2026, date last accessed).

**Liessem PL. Object Tracking Approach for Catch Estimation on Trawl Surveys.**

Master thesis, The University of Bergen, 2023. <https://bora.uib.no/bora-xmlui/handle/11250/3073842>

(24 Oct. 2023, date last accessed).

**Lunde P, Pedersen AO.** Criteria for Consistent Broadband Pulse Compression and Narrowband Echo Integration Operation in Fisheries Echosounder Backscattering Measurements. *Fishes* 2025;10(8).

<https://doi.org/10.3390/fishes10080389>

**Ona E, Zhang G, Pedersen G et al.** In situ calibration of observatory broadband echosounders. *ICES Journal of Marine Science* 2020;77(7–8):2954–9. <https://doi.org/10.1093/icesjms/fsaa177>

**Ordoñez A, Utseth I, Brautaset O et al.** Evaluation of echosounder data preparation strategies for modern machine learning models. *Fisheries Research* 2022;254:106411.

<https://doi.org/10.1016/j.fishres.2022.106411>

**Pala A. Advanced Machine Learning Methods for Multifrequency Acoustic Data.** 2025. <https://bora.uib.no/bora-xmlui/handle/11250/3190360>

(17 Dec. 2025, date last accessed).

**Pala A, Oleynik A, Handegard NO.** Feature-based cluster selection framework for binary classification on imbalanced acoustic data. *Fisheries Research* 2025;292:107598.

**Pala A, Oleynik A, Utseth I et al.** Addressing class imbalance in deep learning for acoustic target classification. *ICES Journal of Marine Science* 25 Oct. 2023:fsad165.

<https://doi.org/10.1093/icesjms/fsad165>

**Pedersen G, Johnsen E, Khodabandelloo B et al.** Broadband backscattering by Atlantic herring (*Clupea harengus* L.) differs when measured from a research vessel vs. a silent uncrewed surface vehicle. *ICES Journal of Marine Science* 30 Apr. 2024:fsae048.

<https://doi.org/10.1093/icesjms/fsae048>

**Roa C, Pedersen G, Bollinger M et al.** Taxonomical classification of reef fish with broadband backscattering models and machine learning approaches. *The Journal of the Acoustical Society of America* 2022;152(2):1020–34. <https://doi.org/10.1121/10.0012192>

**Rong MF.** The application of CW and FM sonar technology to detect a decrease in air in the swim bladder of Atlantic salmon, measurements and modeling. Master thesis, The University of Bergen, 2022. <https://bora.uib.no/bora-xmlui/handle/11250/3000819> (22 Nov. 2022, date last accessed).

**Rubbens P, Brodie S, Cordier T et al.** Machine learning in marine ecology: an overview of techniques and applications. *ICES Journal of Marine Science* 3 Aug. 2023:fsad100. <https://doi.org/10.1093/icesjms/fsad100>

**Tenningen M, Rosen S, Taraneh Westerbergerling EH et al.** How to obtain clear images from in-trawl cameras near the seabed? A case study from the Barents Sea demersal fishing grounds. *Fisheries Research* 2023;268:106856. <https://doi.org/10.1016/j.fishres.2023.106856>

**Totland A, Johnsen E. Kayak Drone** – a silent acoustic unmanned surface vehicle for marine research. *Frontiers in Marine Science* 2022;9. <https://www.frontiersin.org/articles/10.3389/fmars.2022.986752> (12 Sep. 2022, date last accessed).

**Westerbergerling T, Tenningen M, Enberg K et al.** Effects of fish behaviour on abundance and length frequency estimates from in-trawl stereo cameras. *ICES J Mar Sci* 2025;82(6):fsaf094. <https://doi.org/10.1093/icesjms/fsaf094>

### Masters thesis

**Berg, K. U. 2022.** Welfare indicators of Atlantic Salmon (*Salmo salar*) observed with broadband acoustic in a submerged cage. <https://app.cristin.no/results/show.jsf?id=2114501> (Accessed 4 March 2025).

**Berge, D. S. 2023, June 2.** Spatiotemporal variation in the growth and size distributions of lesser sandeel (*Ammodytes marinus*) in the north-eastern North Sea. The University of Bergen. <https://bora.uib.no/bora-xmlui/handle/11250/3073098> (Accessed 24 October 2023).

**Holager, K. T. A. 2022.** Selecting Maximally Informative Frequency Subsets for Acoustic Surveys. University of Bergen, Department of informatics.

**Juraco, N. 2024, June 3.** How well is fish density measured with acoustics represented in a trawl sample of the same water mass – a case study on acoustic trawl survey on pelagic species. The University of Bergen. <https://bora.uib.no/bora-xmlui/handle/11250/3158652> (Accessed 4 March 2025).

**Liessem, P. L. 2023, June 16.** Object Tracking Approach for Catch Estimation on Trawl Surveys. The University of Bergen. <https://bora.uib.no/bora-xmlui/handle/11250/3073842> (Accessed 24 October 2023).

**Marx, S. 2025.** Learning acoustic target classification from simulation. Department of Informatics, University of Bergen. <https://nva.sikt.no/registration/0198f110c776-d75157d9-446d-4ac1-b3d1-ee39ad4a27b>

**Rong, M. F. 2022, June 1.** The application of CW and FM sonar technology to detect a decrease in air in the swim bladder of Atlantic salmon, measurements and modeling. The University of Bergen. <https://bora.uib.no/bora-xmlui/handle/11250/3000819> (Accessed 22 November 2022).

**Skaale, C. K. 2023.** Using split beam, broadband acoustics to measure behaviour of salmon in normal and sea lice preventative submerged cages with either air dome or bubbles for swim bladder refilling. <https://app.cristin.no/results/show.jsf?id=2115778> (Accessed 4 March 2025).

**Stiti, D. J. S. 2022, June 1.** Spatiotemporal variation in the density distribution of sprat (*Sprattus sprattus*) in Hardangerfjorden and Sognefjorden. The University of Bergen. <https://bora.uib.no/bora-xmlui/handle/11250/2998932> (Accessed 24 November 2022).



# Personell

## KEY RESEARCHERS

Name	Institution	Main research area	Gender
Nils Olav HANDEGARD	IMR	Center leader	M
Geir PEDERSEN	IMR	WP1 manager	M
Tonje N. FORLAND	IMR	WP2 manager	F
Maria TENNINGEN	IMR	WP3 manager	F
Ketil MALDE	IMR	WP4 manager	M
Arne J. HOLMIN	IMR	WP5 manager	M
Shale ROSEN	IMR	Researcher	M
Frode OPPEDAL	IMR	Researcher	M
Rokas KUBILIUS	IMR	Researcher	M
Hector PENA	IMR	Researcher	M
Espen JOHNSEN	IMR	Researcher	M
Vaneeda S.D. Alken	IMR	Researcher	F
Rolf Korneliussen	IMR	Researcher	M
Babak Khodabandeloo	IMR	Researcher	M
Neil Anders	IMR	Researcher	M
Guttorm ALENDAL	UiB	Professor, Department of Mathematics	M
Anna OLEYNIK	UiB	Researcher, Department of Mathematics	F
Per LUNDE	UiB	Professor, Head of the Acoustics Group, Department of Physics and Technology	M
Audun Oppedal PEDERSEN	UiB	Associate Professor, Acoustics and Ocean Technology, Department of Physics and Technology	M
Anne Gro V. SALVANES	UiB	Professor, Head of the Fjord and Coastal Ecology Research Group, Department of Biological Sciences	F
Rune ØYERHAMN	NORCE		M
Inge K. ELIASSEN	NORCE		M
Yngve Heggelund	NORCE		M
Bjørnar Ystad	NORCE		M
Ingrid UTSETH	NR		F
Muhammad Sarmad	NR		M

## KEY RESEARCHERS

### KEY RESEARCHERS, TECHNICIANS, RESEARCH INSTITUTES

Name	Institution	Main research area	Gender
Turid S. LODDENGAARD	IMR	Centre management - Finance	F
Liz B.K. KVALVIK	IMR	Engineering, instrument development	F
Jostein SALTSKÅR	IMR	Engineering, instrument development	M
Silje Smith-Johnsen	IMR	Engineer, data science	M
Jørgen Høyer	IMR	Engineer, instrument	M
Guosong Zhang	IMR	Engineer, instrument	M

### KEY PERSONELL, INDUSTRY PARTNERS

Name	Institution	Main research area	Gender
Lars N. ANDERSEN	Kongsberg Discovery	Sonar technology and fisheries instrumentation and Board leader	M
Ivar WANGEN	Kongsberg Discovery	Sonar technology and fisheries instrumentation	M
Tonny ALGRØY	Kongsberg Discovery	Commercialization and applications	M
Leif BILDØY	Kongsberg Discovery	Sonar technology and fisheries instrumentation	M
Jens HEINSDORF	Kongsberg Discovery	Sonar technology and fisheries instrumentation	M

## KEY RESEARCHERS

Arne FURDAL	Kongsberg Discovery	Sonar technology and fisheries instrumentation	M
Martin TOLLEFSEN	Kongsberg Discovery	Sonar technology and fisheries instrumentation	M
Robert SØRHAGEN	Kongsberg Discovery	Sonar technology and fisheries instrumentation	M
Helge HAMMERSLAND	Scantrol AS	Visual fish classification/Management	M
Kristoffer LØVALL	Scantrol Deep Vision AS	Visual fish classification	M
Jacob Grieg EIDE	Scantrol AS	Visual fish classification	M
Eirik Svoren OSBORG	Scantrol Deep Vision AS	Visual fish classification	M
Hege HAMMERSLAND	Scantrol Deep Vision AS	Visual fish classification/Marketing	F
Ruben PATEL	CodeLab	Software/Sonar technology and fisheries instrumentation	M
Espen LIE DAHL	Salmar Aker Ocean	Aquaculture	F
Kjersti BRUSERUD		Aquaculture	F
Per Magne EGGESBØ	EROS AS	CEO	M
Pål Cato REITE	EROS AS	Captain	M

## PHD STUDENTS WITH FINANCIAL SUPPORT FROM THE CENTRE BUDGET

Name	Nationality	Period	
Ahmet Pala	Turkey	2021-2024	M
Taraneh Westergelring	Germany	2021-2025	F
Sakura Komiyama	Japansk	2022-2025	F
Yngve Bøe	Norsk	2023-2026	M
Helge Brøndbo Plassen	Norsk	2023-2026	M

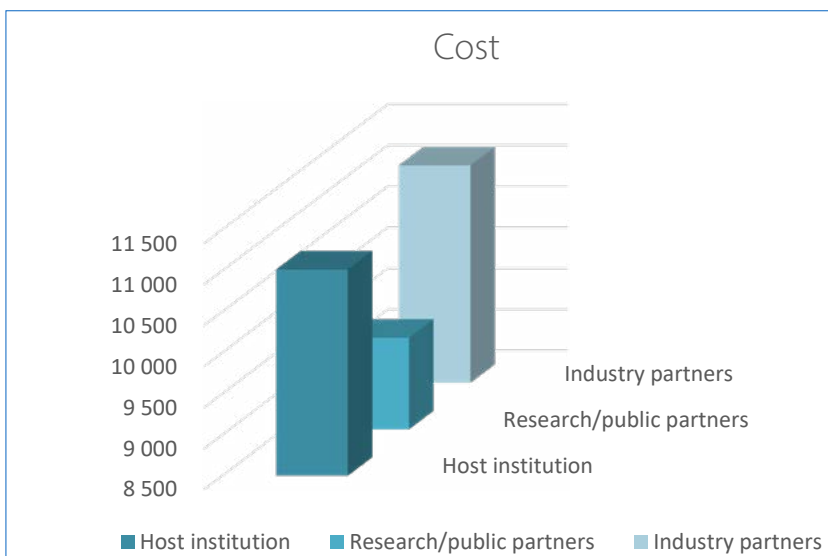
## MASTER STUDENTS

Name	Nationality	
Maren Rong	Norsk	F
Kristin Utne Berg	Norsk	F
Cecilie Kahrs Skaale	Norsk	F
Miranda Veim	Norsk	F
Daniel Jarl Skåtøy Stiti	Norsk	M
Knut Thormod Aarnes Holager	Norsk	M
Robert Løland	Norsk	M

**Host institution:**  
Havforskningsinstituttet

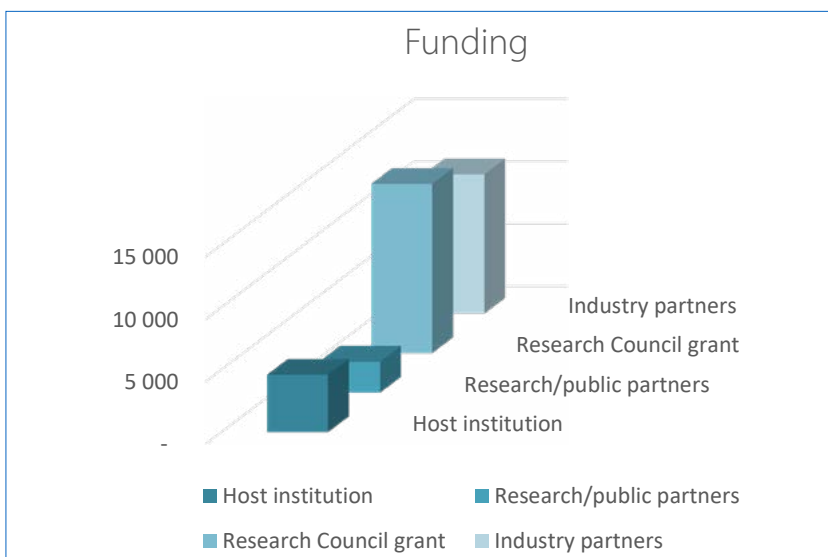
**Research/public partners:**  
University of Bergen, Norce,  
Norsk Regnesentral

**Industry partners:**  
Kongsberg Discovery, Scantrol Deep  
Vision, Lie Gruppen, EROS, CodeLab,  
Salmar Aker Ocean



### COST

Host institution	10 691
Research /public partners	7 036
Industry partners	4 899



### FUNDING

Host institution	4 148
Research/public partner	2 381
Research Council grant	11 198
Industry partners	4 899



