SFI Smart Ocean
Annual Report 2024

SFI SMART OCEAN

Partners

SFI Smart Ocean is a Centre for Research-based Innovation (SFI) funded by the Research Council of Norway (grant number 309612) and Centre partners. Our goal is to enable sustainable ocean management through real-time measurements from autonomous and smart sensor networks. The consortium consists of 6 research partners, 10 user partners from industry, 3 industry clusters, and 2 national authority observers. This year, we welcomed Odfjell Technology as a new partner to our consortium. They will primarily focus on innovative methods for integrity measurements while also expressing interest in other aspects of the Centre's activities.

Research Partners

University of Bergen

Institute of Marine Research

FFI Norwegian Defence Research Establishment

NORCE

Western Norway University of Applied Sciences

NERSC Nansen Environmental and Remote Sensing Center

User Partners / Industry Clusters

GCE NODE Global Center of Expertise

GCE Ocean Technology

NCE Seafood Innovation

User Partners / Industries

Aanderaa a xylem brand

W SENSE Integrated Cableless Solutions

bouvet

tampnet

TSC Part of Eddyfi Technologies

AkerBP

REACH Subsea

imenco Smart Solutions

KONGSBERG

odfjell technology

National Authority Observers

Directorate of Fisheries

Havtil

COVER PHOTO: LORA VAN UFFELEN

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01 Summary

Ingvar Henne, Centre Director
PHOTO: ROY BJØRGE / GCE OCEAN TECHNOLOGY

The Centre is halfway down the SFI road, and the underway assessment has been part of this year's activities. While we have dedicated time to reporting on our progress, working on innovations and looking ahead remains our priority.

Measurement strategy and data quality as well as new sensing technologies have been developed, and further work on networking protocols and access methods for acoustic communications has been carried out. The SFI Smart Ocean data and application platform is an important tool for integrating sensor and communications systems and demonstrating new solutions for smart sensing and data management. We have also prepared a three-year plan for the last part of the Centre period that will be a backdrop for our annual planning of specific work package activities.

Some milestones in Research and Innovation

We started off in January with an internal workshop focused on data quality, and we have made significant strides in autonomous anomaly detection methods. This topic has generated considerable interest among our partners, and we anticipate further development of specific use cases soon. The SFI Smart Ocean data and application platform was evaluated in an April gathering where researchers, students and industry partners discussed its architecture, functionality, and implementation details. We collected valuable feedback on new requirements through interactive web tools.

In June, SFI Smart Ocean hosted its inaugural open conference, entitled "From Ocean to User: Ensuring Quality of Data". This event featured presentations and posters by both senior researchers and students, along with insightful contributions from external guest speakers. The following day, we held our internal plenary meeting, and we plan to make this dual-event format a regular occurrence for the remainder of the Centre's duration.

The Software Defined Modem (SDM) platform continued to evolve, successfully demonstrating communication within a network of multiple devices. Notably, in August, the SDM was used to test a new methodology for validating underwater communication protocols in a spin-off project led by Aker BP. This is an important input to the standardization work in the Subsea Wireless Group (SWiG).

Additionally, Tampnet generously donated approximately 1 km of authentic subsea telecom fiber cable to SFI Smart Ocean, to be deployed at Austevoll and owned by IMR, facilitating realistic field trials of sensing methods using Distributed Acoustic Sensing (DAS) and State of Polarization (SoP).

PhD student Astrid Marie Skålvik qualified for the National final of Forsker Grand Prix in Norway this autumn. PHOTO: PER OLAV SØLVBERG

Dissemination

This year, SFI members published almost 30 scientific articles in international journals and presented our findings at approximately 40 conferences, both nationally and internationally. Topics included anomaly detection, pH sensing, software engineering, and anti-biofouling. Our monthly mini seminars have attracted a good turnout, including participation from individuals outside the consortium.

We also produced a new informational video, created by the UiB learning lab, highlighting the IMR research station at Austevoll and showcasing how smart sensing methods can enhance power efficiency and battery lifespan for sensor nodes with acoustic communication.

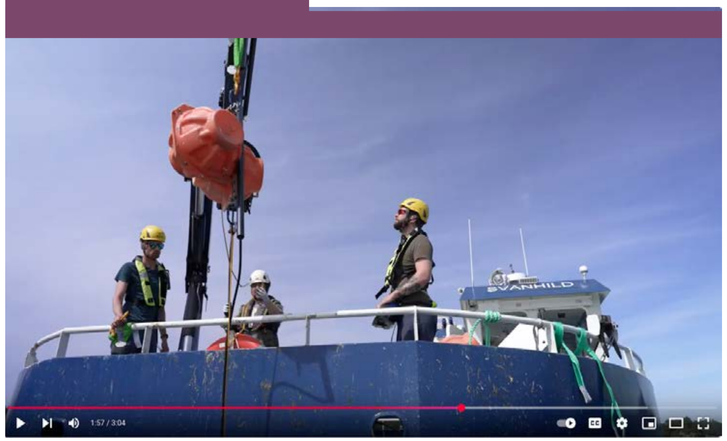
The underway assessment

For those who are involved in the more administrative tasks, the underway assessment has left a mark on the everyday life from May to November. It has been useful to dive into the details of the achievements as well as the need for improvements and plans for the future. Feedback from individual partners has generally been positive, though some adjustments were suggested and will be implemented.

Field trials in SFI Smart Ocean

The IMR research station at Austevoll has been a vital hub for field trials and experiments, fostering collaboration among our partners. The permanent sensor nodes have proven essential as data sources for cloud solutions and have been extensively used in developing the SFI Smart Ocean Data and Service Platform. In addition, FFI has carried out a number of acoustic measurements using their portable NILUS node. This autumn, we also initiated field trials focusing on DAS and SoP for fiber optic cables, with plans to deploy a telecom subsea cable for extended trials early next year. As mentioned, the SDM was also successfully deployed at Austevoll for various testing of protocols and functionality.

CLICK IMAGE for VIDEO LINK



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PhD-student Julián Pelaez-Quiñones monitors DAS-signals in his practical small tent at Austevoll. PHOTO: INGVAR HENNE

New initiatives

Odfjell Technology joined us as a new partner in the autumn. They will primarily work on new methods for integrity measurements, amongst other things through co-supervision of a PhD student, but are also interested in other parts of the Centre's activity.

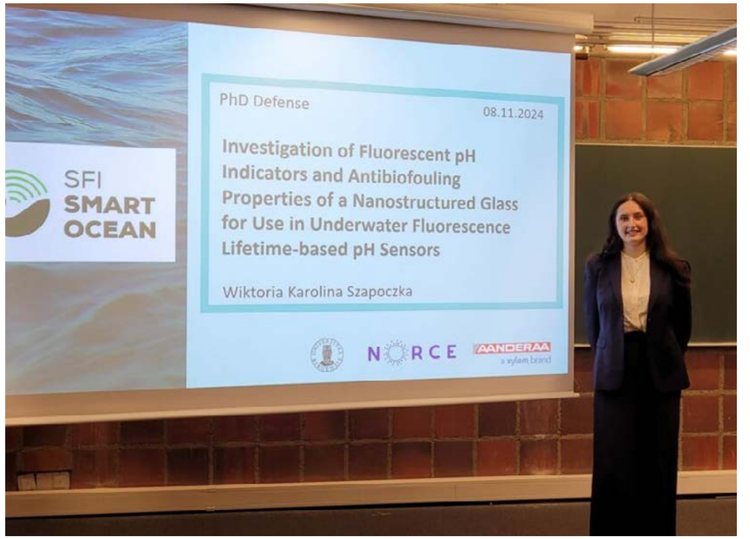
We are reorganizing the communications work package (WP2) to enhance our activities related to network protocols for underwater communication. Equipment will be deployed at large depths and in demanding environments north of Svalbard next summer, and a new task for data analysis is now included in WP2 in addition to the cruise activities already planned in IF1. Furthermore, we will develop an innovative method for converting acoustic communication signals into optical signals using State of Polarization (SoP) for sensor data backhauling via subsea telecommunication cables.

Students

In November, Wiktoria Szapoczka successfully defended her PhD thesis on "Investigation of Fluorescent pH Indicators and Antibiofouling Properties of a Nanostructured Glass for Use in Underwater Fluorescence Lifetime-based pH Sensors." Research on related topics will be continued by SEAS postdocs focusing on antibiofouling and through Aanderaa, NORCE and UiB's efforts in pH-sensor development.

PhD students have also gained valuable insights during their time abroad in various international institutions.

We still have a couple of open positions for PhD students. We have put a lot of effort into recruiting candidates, and aim to fill these positions by the end of 2025. ●



PhD-student Wiktoria Szapoczka at her thesis defense. PHOTO: TERJE RESTAD

02 Vision & Objectives

The Network Intelligent Underwater Sensor (NILUS) from FFI is ready for deployment to perform acoustic channel characterization at Austevoll.
PHOTO: INGVAR HENNE

Our vision is the realization of a generic, autonomous and flexible wireless multi-parameter marine observation system for reliable management of a productive and healthy ocean.

SFI Smart Ocean is focusing on enabling real-time high-quality data for increased autonomy, and increased value of coastal and oceanic management models and systems. This will lead to sustainable and profitable ocean industry operations, and to fact-based ocean resource management. The observation system's key factors are highly cross-disciplinary:

- sensors research and development
- measurement strategy
- flexible and adaptive sampling in time and space
- point measurement vs. monitoring over large areas
- distributed measurements
- measurement uncertainty and reliability
- data quality classification and metadata definitions
- compression methods and embedded signal processing
- time series as input to big-data analysis
- cloud-based data and application services
- data format aggregation and safety
- low power consumption and embedded sensor intelligence

By organizing this initiative as a centre that encompasses multiple scientific disciplines and sectors, we ensure a vendor-neutral approach that fosters a diverse range of applications.

Standardized interfaces and data formats facilitate the integration of various sensor types, promote communication interoperability, and enable effective data sharing both during and after the Centre's operational lifespan. SFI Smart Ocean deploys sensors for monitoring environmental, structural, and marine life parameters.

These parameters are essential for informed decision-making by industry and authorities, supporting the optimization of operations and maintenance, as well as evaluations related to licenses to operate. Collectively, these efforts contribute to bridging knowledge gaps and addressing pressing societal challenges.

Primary Objective
The Centre objective is to create a wireless observation system for multi-parameter monitoring of underwater environments and installations. The system based on autonomous smart sensors will serve as an enabling fundament in realizing flexible, distributed, robust, energy efficient, cost-effective, and safe marine measurements and big-data handling, to support the Centre's vision in respect to societal and industrial challenges.

SEAS Postdoc Håkon Sandven gives a presentation at the Marine Alliance for Science and Technology for Scotland – Annual Science Meeting in Scotland. PHOTO: RUAIRIDH WALLACE

03 Research Plan & Strategy

The primary objective of the research activities at the Centre is to ensure efficient and reliable dataflow from underwater sensors to end-user applications. To concentrate on measurement methodologies, sensor design, underwater communications, and data management, the activities within SFI Smart Ocean are organized into three work packages (WPs) and two integrating functions (IFs). The three WPs represent cutting-edge disciplinary initiatives that necessitate robust mutual interaction. The IFs serve as cross-cutting interdisciplinary functions, facilitating the integration of the three WPs.

WP1: Autonomous Sensors & Measurement Strategies
This work package focuses on enabling and developing autonomous sensor technology for marine environmental and structural integrity measurements. The research and development are both on existing marine sensors and novel sensor technologies for real-time observations in an underwater wireless network.

Marine smart sensors will have embedded pre-processing of data in the sensor, compression of data and headers, acoustic modem compatibility, and smart operation for low energy use. Research and innovation on new sensor technology include guided ultrasonic wave sensors for integrity measurements, distributed fibre optic sensors with acoustic sensing of environmental noise and structural vibrations, nano technology for improved pH sensors, and new or improved optical measurements and research on light propagation in the ocean. Our research also includes nanostructured surfaces for anti-biofouling of sensor and modem surfaces, to ensure higher data quality and longer deployment in the ocean.

Research on measurement strategies aims to reduce measurement uncertainty and ensure trustworthy data. This includes self-validation and self-diagnostic capabilities of the smart marine sensors, and the uncertainty propagation from the marine sensors to the data presented to the end user.

Existing sensors, new sensor technologies, nanostructured self-cleaning surfaces, and the measurement strategies for trustworthy data are tested at pilot demonstrators in the Centre. Metadata definitions and standardization for data quality and measurement conditions are central to the measurement system design.

WP2: Wireless Network Communications
The realisation of the SFI Smart Ocean observation system depends heavily on underwater communications. This work package focuses on wireless communication technology, and aims to develop a low-cost, miniaturized, and a short-range acoustic underwater technology platform assembled to an energy-efficient underwater wireless sensor network (UWSN). Hardware and software will need to be optimized with respect to long-term operations in demanding environments, which puts high demands on energy efficiency and system reliability. To support a wider range of use cases, WP2 will also study longer-range links and/or links with moving platforms like AUVs. Acoustic modem and communication protocols will build on state-of-the-art underwater acoustic communication technology.

The system will be interfaced towards mobile networks (4G, 5G), satellite communications, fibre optic "backbone" networks, and unmanned surface vehicles. The communication requirements for SFI Smart Ocean are established in cooperation with the other work packages. Communication solutions in SFI Smart Ocean are defined according to the application requirements and the limitations and possibilities for communication in the harsh underwater environment.

A testbed is established to investigate different modulation methods and coding techniques and methods for energy optimization. The testbed can be used also for testing compression methods as well as network layer functionality. Different protocols and network architectures, including multi-hop and mesh protocols, are investigated with respect to efficient data transfer and low energy requirements. Field trials are employing the infrastructure of IF1. Underwater communication channel measurements utilizing the Austevoll infrastructure have been employed in international efforts towards standardization of underwater communication test channels.

WP2 is now reorganized to encompass more focus on network protocols, analysis of acoustic measurements north of Svalbard, and finally a new task for innovations on use of fibre cables (using DAS and SoP) as subsea receivers for acoustic data transfer from other units, in tandem with fibre cable sensing studies in WP1.

WP3: Software Technology and Big-Data Middleware

The work package on software technology and big-data middleware focuses on a digital ecosystem providing cloud-based ocean data services and supporting cost-effective development of software applications that provide and consume ocean data services.

The cloud-based SFI Smart Ocean Platform comprise a set of software frameworks enabling the integration of external and internal ocean data sources, data storage and processing, and application deployment. The platform enable data spaces based on a uniform and standardised set of APIs, data and metadata formats. The software technology being developed in the work package is validated through the development of application prototypes linked to consortium pilot demonstrators and through the deployment of a reference implementation that integrates with external systems and data services.

The main topics of the work package include development and implementation of the SFI Smart Ocean data and application platform, system-of-systems software architecture, engineering technology for smart software systems, sensor-cloud integration middleware and protocols, edge computing, interoperability and data service APIs, data quality- and integrity, software security and reliability, machine learning and analytics, and intelligent visualisation of big datasets. The first version of this platform was evaluated by all partners in April 2024. The work package is organised

All partners were invited to evaluate the SFI Smart Ocean Data and Application Platform at HVL. PHOTO: INGVAR HENNE

into subprojects focussing on software system architecture, implementation, and deployment of the SFI Smart Ocean platform; software engineering technology research, modelling, and validation; and end-user application and use cases.

IF1: Test Arenas

This is an overarching Work Package that includes the sites where the results from WPs 1, 2 and 3 are tested in various environments. The list of test sites is dynamic and will be expanded during the life cycle of SFI Smart Ocean.

A local scale environmental monitoring test site is operational at the IMR Research Station at Austevoll near Bergen. This is our main test arena, and the infrastructure is utilized for testing of components and systems developed in SFI Smart Ocean. Here, two modular test rigs with sensors are placed, and a range of sensors and communication systems are included and available for data collection and equipment tests. The research station has provided a permanent infrastructure under continuous development, making modifications and maintenance of the rigs easier. The Austevoll facilities will be further developed to include a mesoscale test facility that will be established as an extension of the local scale system. This will pave the way for longer scale communication, geo-positioning, and mesoscale environmental monitoring, using acoustic tomography and passive acoustics. Logistically, this system will be an extension of the already developed system for local scale tests.

Furthermore, a large-scale system for environmental monitoring will be established in the Arctic Ocean north of Svalbard in 2025 for two years in the Nansen and Amundsen Basin. Our partner NERSC (with project partners including UiB, Kongsberg, IMR) will lead this EU project HiAOOS (High Arctic Ocean Observation System). This system will provide year-round acoustic and oceanographic observations as well as facilitate testing of new technologies for observations and data recovery from underwater installations. The project is also facilitating testing of new technologies in 2025 for observations and data recovery from underwater installations using acoustic communication and docking of ROVs. Complementary to HiAOOS a mesoscale system for environmental monitoring will be established north of Svalbard in 2025, and SFI Smart Ocean contributes to the project with equipment, planning and analysis. This will again facilitate for testing of systems and equipment developed for SFI Smart Ocean in the harsh environment north of Svalbard. HiAOOS provide training events in oceanographic and acoustic methods and tools, and offers a unique opportunity to collaborate with international institutions.

A use case for an aquaculture observation system has been developed, and this will ensure that the fish farmers' needs and requirements are considered and implemented when the SFI Smart Ocean technology is developed. The use case will enable all scientific work packages to maximise the relevance towards, and the value for, the aquaculture industry. A similar use case description will be prepared for petroleum.

The upgraded marine facility at Austevoll research station is very suitable for field trials and interoperability tests. PHOTO: FRODE IMS

Test facilities for offshore wind installations are being prepared for deployment in collaboration with METCentre in Karmøy, Rogaland county. Our activities also include the Norwegian Ocean Observation Laboratory, where several of the partners of SFI Smart Ocean are collaborating.

IF2: Overarching Activities
Integrating Function 2 includes the administration of the Centre, and coordination of overarching activities such as commercialisation, innovation and IPR aspects, internal and external communication.

	Work Packages (WP) and Integrating Functions (IF)	**IF1** Test Facilities		**IF2** Overarching Activities
WP 1	Autonomous Sensors and Measurement Strategy	Coordination of needs and testing facilities	Locations for techno-logical segments: • Environment • Offshore Wind • Oil and Gas • Aquaculture	• Administration • Education • Data Management • Communications • Commercialisation • Innovation & IPR
WP 2	Wireless Network Communication			
WP 3	Software Technology and Big-Data Middleware			

04 Organisation

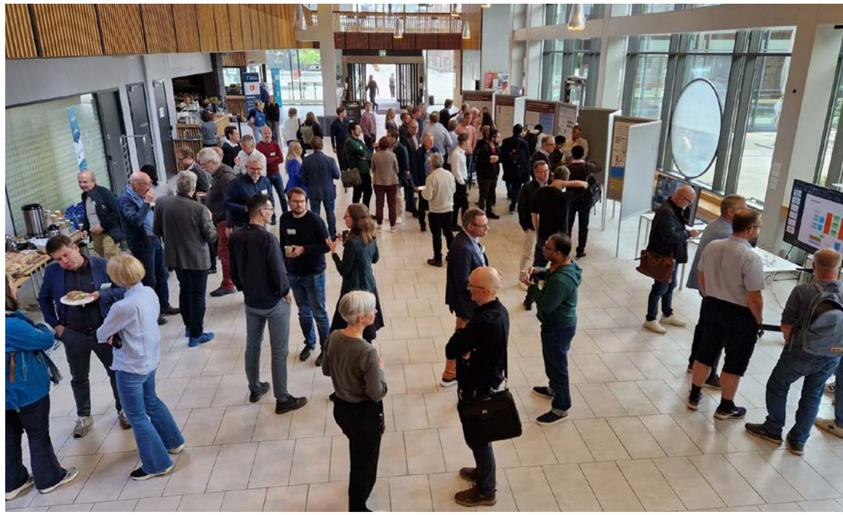
GCE OCEAN Technology provides a very good network of highly relevant and competent actors. PHOTO: ROY BJØRGE / GCE OCEAN TECHNOLOGY

SFI Smart Ocean is hosted by the University of Bergen (UiB), and the Centre is organised to ensure influence and contributions from all partners.

The General Assembly (GA) is the body responsible for major decisions regarding the Centre. All partners are represented in GA, and Dean Gunn Mangerud has chaired the GA on behalf of UiB as host institution. As Gunn Mangerud joins the Centre board for the next period, Vice-dean for research and innovation Øyvind Frette was appointed new chair for GA.

The Centre Board consisted of Tom Fidjeland (chair, GCE Node), Jan Erik Faugstadmo (Kongsberg Discovery AS), Annette Fagerhaug Stephansen (NORCE), Gjermund Mathisen (Aker BP ASA), Morten Mjelde (Bouvet AS), Lise Doksæter Sivle (IMR), and Øyvind Frette (UiB). New board members for the next two years were elected by the General Assembly November 27th. The new board members are Bjarte Fagerås (chair, Reach Subsea), Gunn Mangerud (UiB), Annette Fagerhaug Stephansen (NORCE), Gjermund Mathisen (Aker BP ASA), Steve Greenland (WSense AS), Lise Doksæter Sivle (IMR), and Jon O. Hellevang (GCE Ocean Technology).

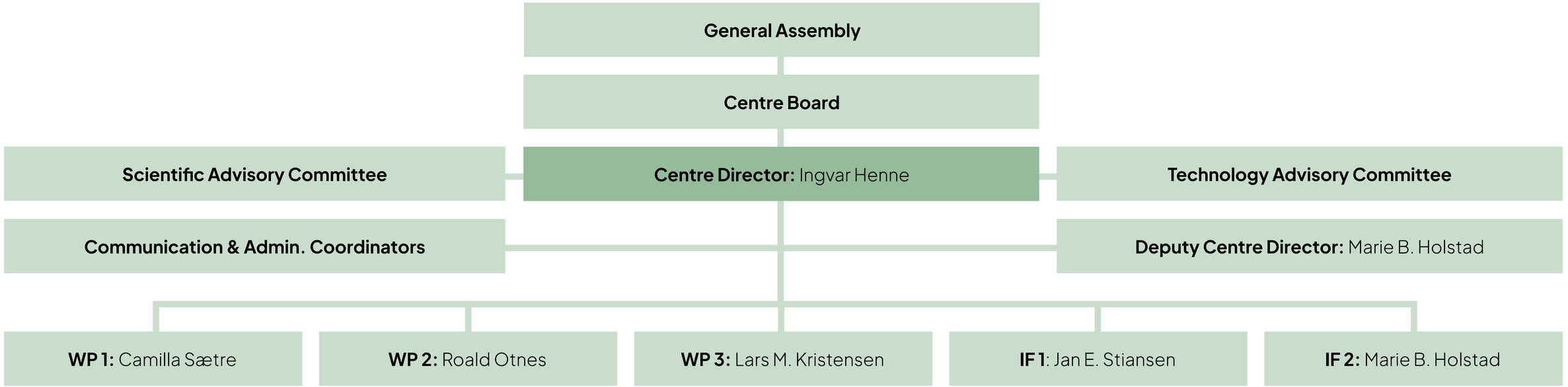
The members of the Scientific Advisory Committee (SAC) are Professor Frank Reichert (University of Agder), Professor João Borges de Sousa (Porto University) and Assistant Professor Paolo Casari (University of Trento). As Frank Reichert is retiring, Professor Leen Lambers (Brandenburg University of Technology) was appointed as new SAC member in December 2024. SAC gives advice to the Centre Board on scientific issues and priorities, to ensure high-quality scientific impact.



Conference participants mingle during the poster session at the Centre's spring conference. PHOTO: INGVAR HENNE

The Technology Advisory Committee (TAC) consists of one representative from each of the Consortium participants and advises the Centre Board via the Centre Director on technical issues and priorities, including IPR questions and possibilities for innovations, to ensure both industrial and scientific value creation. Camilla Sætre (UiB) is chair of TAC.

The Centre management team comprised of Centre Director Ingvar Henne (UiB), Deputy Director Marie Bueie Holstad (NORCE), Communication Manager Kavitha Østgaard (UiB), Administrative Coordinator Terje Restad (UiB) and work package managers Camilla Sætre (WP1, UiB), Roald Otnes (WP2, FFI), Lars Michael Kristensen (WP3, HVL), Øivind Bergh (Acting IF1, IMR) and Marie Bueie Holstad (IF2, NORCE). ●



05 Cooperation between Centre Partners

Constructive dialog between partners at the spring gathering.
PHOTO: TERJE RESTAD

SFI Smart Ocean is working across multiple scientific disciplines, across several ocean industries and ocean management sectors. Our initiative integrates a diverse array of technological components, presenting a complex set of challenges that necessitate close collaboration among our diverse partners. Each partner brings different yet complementary technologies and areas of expertise to the table.

Collaboration among partners is essential for all activities within the Centre. Notably, the increasing engagement in testing various solutions in marine environments, particularly off the coast of Bergen and in the Arctic, has highlighted the need for enhanced coordination across work packages. At our test site in Austevoll, industrial and research partners have collaborated during field trials and preparatory phases, which has provided valuable insights into both individual technology components and integrated systems. The data collected during these activities has been instrumental for numerous scientists and PhD candidates focusing on measurement strategies and software architecture.

In addition to the ordinary, day-to-day collaboration between partners, we are actively developing a framework for student supervision through partnerships that leverage complementary competencies. This initiative aims to enrich students' learning experiences at the Master's and PhD levels. These students are invaluable resources to the Centre, contributing significantly to various projects, meetings, and workshops, and are increasingly recognized as integral members of the project teams.

Moreover, collaboration among partners facilitates access to additional insights from the industry, as both scientific and industrial associates maintain extensive networks of collaborators working on related technological challenges. Industry clusters such as GCE Ocean Technology, GCE NODE, and NCE Seafood Innovation—all of which are partners in SFI Smart Ocean—enhance our efforts by drawing contributions from a broader network of member companies. Notably, this year, NCE Seafood Innovation contributed to the development of a use-case for aquaculture monitoring solutions.

Bichitra Nanda Sahoo and Paul Thomas investigate surfaces for anti-biofouling at the nano-laboratory. PHOTO: TERJE RESTAD

Data quality

Measurement strategies and data quality have been collaborated on across all work packages. In our January workshop, agenda items for discussion were, among others, data quality at the sensor level, communication requirements, and software.

Key research results include automatic diagnostics utilizing insight on sensor technology and correlations of different sensors, providing a transparent data quality assessment. This work was in collaboration with Universitat Politècnica de Catalunya and the OBSEA observatory in Spain. Two ongoing Master's projects are related to real-time quality control for pressure sensors and oxygen optodes. This is in collaboration with Reach Subsea and Aanderaa.

Antibiofouling and pH sensor

SEAS postdocs Paul Thomas and Bichitra Nanda Sahoo have initiated their work on antibiofouling with nano technology treatment for non-transparent and transparent surfaces, in cooperation with industry partners on the requirements and samples for laboratory tests. Wiktoria K. Szapoczka et al. published a paper on transparent antibiofouling window with surface nano structuring.

Wiktoria K. Szapoczka defended her PhD-thesis in November and thus completed her engagement in SFI Smart Ocean as the first fully funded PhD candidate among the fellows at the Centre. Her thesis was entitled “Investigation of Fluorescent pH Indicators and Antibiofouling Properties of a Nanostructured Glass for Use in Underwater Fluorescence Lifetime-based pH Sensors“. Her work was a central part of the activities in WP1–3. An application for a spin-off project on pH sensor is submitted to NFR by Aanderaa, where UiB and NORCE are partners.

Two Master's students also finished their projects in 2024. Denise Dilshener's project was on pH-sensitivity of carbon dots and Mari H. R. Mossestad's was on pH-sensitive materials in optical fibres.

Novel sensor technology

Amr Abboud have worked on guided ultrasonic wave sensing during his research stay in France (more under international collaboration). A new PhD project is initiated in collaboration with the new partner, Odfjell Technologies, with focus on non-destructive evaluation and structural health monitoring of mechanical constructions.

Julián Pelaez-Quiñones has performed initial tests at Austevoll with Distributed acoustic sensing (DAS), in addition to tests in marine lab at HVL, and initial analysis of State-of-Polarization (SOP) with dataset from a Tampnet cable outside of Egersund.

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Marine optics

SEAS postdocs Håkon Sandven and Daniel Koestner have worked on improved optical measurements on autonomous platforms for assessments of marine biogeochemical parameters, and on the light propagation in coastal and polar waters for input to climate and ocean ecosystem models.

Håkon has also collaborated with NORCE on field tests of under-water optical communication, the results presented at the UComms conference.

Master's student Jens Didrik Berg participated on a research cruise in the Central Arctic Ocean, where he measured the surface light, linked to aerosols and cloud cover.

Daniel and Master's student Ole Andrè W. Høydal have been on a research cruise in Fram Strait, where they gathered optical measurements linked to biogeochemical properties that are important for the oceanic carbon pump. Initial findings from both research cruises were presented at the Ocean Optics conference.

Partners in SFI Smart Ocean have also participated in the Useful Arctic Knowledge (UAK) research school/cruises (more under international collaboration).

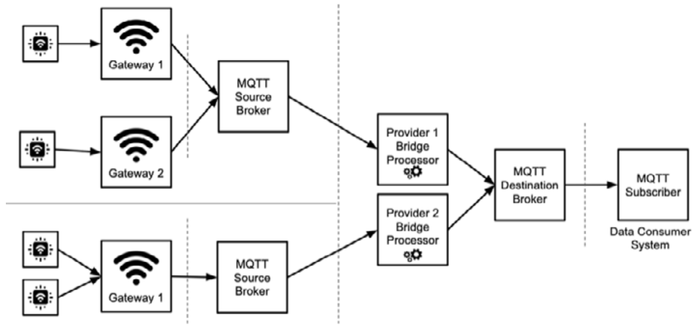
Underwater communications in SFI Smart Ocean

A framework has been developed to estimate point-to-point communication ranges based on simplified acoustic propagation and noise models. In 2024, this framework was expanded with prediction capabilities for communication networks with more than one sender. Part of this work, related to acoustic SNR modelling for underwater communications, was presented at the ICUA conference in 2024. Additionally, NORCE presented at the UComms conference a SFI Smart Ocean-related paper on underwater optical communication experiments in the UNDINA project.

The centre of gravity of this work element was the preparation, execution, and analysis of acoustic measurements at Austevoll in November 2024. This was a joint effort between FFI, NORCE, and IMR, and has resulted in a unique dataset of underwater acoustic recordings that will be submitted for open publication in 2025. A subset of the data was collected for international standardization initiatives, and will among other things result in a standard test channel contributed by SFI Smart Ocean. The Austevoll campaign was also used to demonstrate feeding of subsea measurements to the cloud in near real time, linking WP2 to WP3.

Researchers from FFI check the status of deployed equipment during underwater communication tests at Austevoll. From the left: Jon Kjøll and Roald Otnes.
PHOTO: INGVAR HENNE

Researchers Kristian Nordlie and Concetta Baldone from WSense monitor the field trials in close collaboration with Beatrice Tomasi from NORCE. PHOTO:RUNE ØYERHAMN



SFI Smart Ocean Platform architecture

The last week of August in 2024 was dedicated to testing a new methodology to validate underwater communication protocols and test interoperability. The work focused on waveforms relevant to the Subsea Wireless Group (SWiG).

The goal of this field trial was to test the performance of a novel dual channel protocol in a simulated riser monitoring use case, and to demonstrate interoperability between NORCE and WSense implementations. The trials were all successful.

All this was possible thanks to the strong collaboration within the underwater acoustic communication work package (WP2) led by FFI and the fieldwork work package (IF1) lead by IMR. The involved partners were AkerBP, NORCE, WSense, and IMR. This has been a very fruitful collaboration so far and will be continued both within SFI Smart Ocean and associated spin-off projects.

Student projects related to underwater network protocols

In a Bachelor thesis at HVL in the spring of 2024, Jens Hoff Quirk Mathias, Mjelle Fiske, and Steffen Nanthen Balthasar simulated communication protocols, specifically MAC-layer protocols, using the DESERT simulator. Advantages and disadvantages for two different protocols were investigated and presented, and in particular some problems related to the high and variable propagation delay were identified (for the DACAP protocol). In addition, they described the framework and presented a user guide for the framework that can serve as an introduction for future students.

PhD student Md Al Shayokh, also at HVL, has investigated MAC-layer protocols for different environmental parameters. A conference paper on performance impact of wind speed on MAC protocols was submitted in 2024, and is now accepted. The contribution is, based on simulations, to investigate the performance of MAC protocols for UWSNs in terms of packet delivery rate, energy consumption and delay under different noise levels.

The SFI Smart Ocean Data and Application Platform

Development work has advanced on the SFI Smart Ocean Data and Application platform, which has been continuously deployed in 2024 providing access to the real-time data flows and historical time series data from the Austevoll research station of IMR. This has also included an additional field test with off-loading of acoustics profile data collected by the FFI NILUS node. A technical workshop and tutorial on the practical use of the platform was given by HVL to all partners in the consortium in the spring of 2024, and software development kits for the platform have now been made publicly available with a view towards enabling the wider adoption of the platform.

The SFI Smart Ocean Data Service and Application Platform

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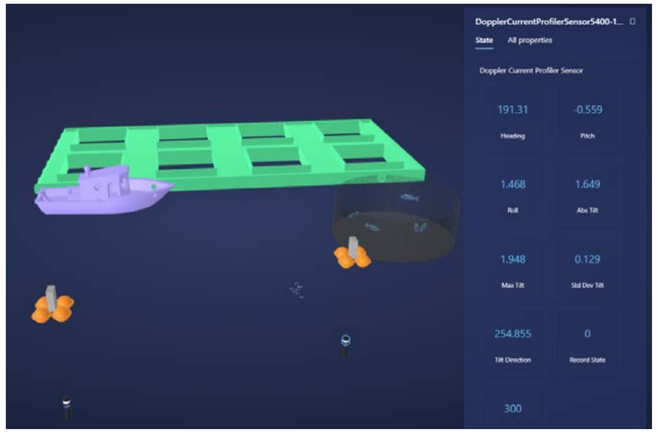
Ivan Spajic
PhD student, HVL



Illustrations of Digital Twin Prototype of Austevoll pilot demonstrator

Additional development has included an improved messaging service for real-time data, and an improved data space service for historical time series data. This was undertaken as part of two Master's thesis projects in software engineering at HVL. A first prototype demonstrator of a joint identity and security management service for the platform has been developed, and key software architectural decisions have been identified for the more advanced support for monitoring of data streams.

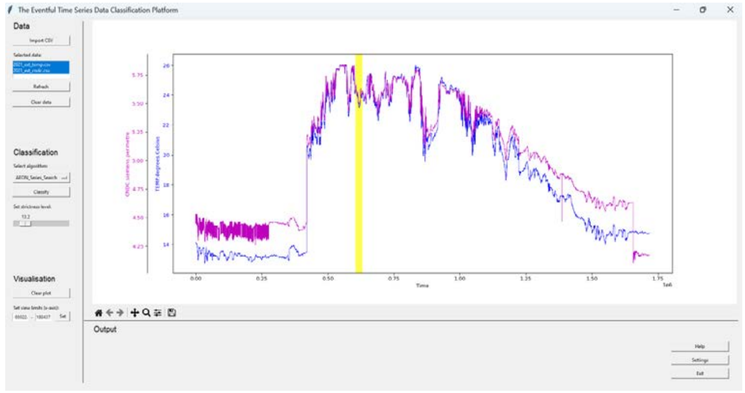
Digital Twin Prototype of Austevoll

Bouvet, HVL, and Aanderaa (Xylem) have in collaboration developed an initial demonstrator prototype of a digital twin (see figures to the left) for the Austevoll pilot demonstrator based upon an aquaculture use case developed earlier with consortium partners. A general software architecture and cloud-infrastructure for digital twins has been developed as part of this work, and the initial digital twin demonstrates contextual visualization of data streams from the Austevoll pilot demonstrator. A key challenge with digital twins in the context of acoustic communication is the limited bandwidth for transfer of data and control. To address this, research into efficient methods for time series compression has been initiated with first experimental results based on a prototype implementation having been accepted for presentation at an international conference..

Algorithms and Software Support for Data Quality

Ensuring data quality has been a key focus of the Centre from the outset, and has involved close collaboration between WP1 on measurement technology and WP3 on software technology. Based upon research initiated in earlier years of the Centre, software tool support for data quality assessment has been developed as a collaboration between Reach Subsea and HVL. As part of a Master's thesis in software engineering, end-user support for data labelling has been developed to support more advanced and automatic approaches based on machine learning. Work is currently ongoing on implementing and evaluating feasibility of on-board and embedded quality assessment based on machine learning and AI directly on the sensor nodes. This is an important step towards the development of smart sensors. An ongoing Master's project in software engineering is currently assessing and developing algorithms to address sensor drift.

Software-assisted labelling of anomalies in sensor data stream



Contents

Locations for field trials

SFI Smart Ocean maintains a continuous presence of equipment in the water to perform short-term and long-term field trials. The IMR Research Station at Austevoll serves as the primary location for local scale experiments, having been developed into a SFI Smart Ocean observatory. A general description of this modular experimental observatory was published late 2024, in the journal “Sensors” covering the work on sensor deployment, the observation rigs, wireless communication and data architecture and data management. IMR has also secured permissions for new sites for instrumentation, which will facilitate experiments at greater distances within fjord environments.

SFI Smart Ocean is collaborating closely with the EU-project HiAOOS (High Arctic Ocean Observation System), which supports the Centre's mesoscale communication initiatives. An extensive array of equipment for underwater observations and communications is scheduled for deployed in the high Arctic during the summer of 2025. Additionally, the Centre is in dialogue with the METCentre to develop a test rig for their floating offshore wind test facility near Karmøy, Western Norway.

Acoustic modems both from NORCE and WSense are ready for deployment outside of the IMR Research Station. PHOTO:RUNE ØYERHAMN

07 International Cooperation

PhD-student Amr Abboud at the I2M laboratory in France.

All Centre partners have international cooperation and/or offices abroad, and cooperation with their international networks directly or via affiliated activities is an important part of the Centre activities. As SFI Smart Ocean aims at a flexible, open, and vendor neutral network technology, cooperation with end users and vendors worldwide is crucial. Such cooperation will ensure that the Centre maximises the impact for the technology solutions developed in the Centre, and also implements standard technology solutions where such are available.

The Centre continues the collaborations with the international industry standardization initiative Subsea Wireless Group (SWiG), and the ERANET Cofund MarTERA project "The underwater robotics with multimodal communication and network-aided positioning system" (UNDINA). In UNDINA, the Centre participants are collaborating with, amongst others, ISEN in France, and this collaboration has during the last year expanded to also include other activities relevant to SFI Smart Ocean.

Further, the Centre continues the cooperation with Helmholz Institute for Environmental Research and Max Planck Institute for Medical Research related to anti biofouling treatments for transparent substrates. This activity is crucial for the Centre to make underwater sensors more robust towards biofouling. The research group in software engineering is cooperating with Chalmers University of Technology (Sweden), and University Sorbonne Paris Nord (France).

Several of our students had stays abroad during 2024. **Keila Lima** visited Kiel University in Germany. The main goal of the research visit was to deepen the background knowledge of software measurement for performance evaluation of established metrics. Moreover, the aim was to perform a quantitative assessment of the software architecture of the Smart Ocean Data and Services Platform prototype, focusing on the operation of its data middleware layer. Knowledge of software architecture quality and evaluation, software monitoring, and especially expertise in benchmarking was crucial for selecting the group in Kiel for the research visit led by Prof. Dr. Wilhelm Hasselbring.

Keila Lima
PHD STUDENT / HVL

During the stay, there was an improvement in the monitoring subsystem of the platform, implementing different standards and tools for collecting the system's runtime operation data.

As a result of the two-month-long research stay in Kiel, we have benchmarked part of the Smart Ocean Data and Services Platform prototype, focusing on evaluating latency and message loss for different deployment architecture configurations when using MQTT as a bridge between data providers and consumer applications. The results of this study will be presented at the end of March in Odense at the 22nd IEEE International Conference on Software Architecture (ICSA 2025) and published in the associated proceedings.

During **Amr Abboud's** research visit to the I2M laboratory in France, he had the invaluable opportunity to collaborate with leading experts in Non-Destructive Testing (NDT) and Structural Health Monitoring (SHM). The lab's staff possesses extensive knowledge of the latest techniques in these fields, which significantly enriched his understanding and practical skills. A major highlight of his visit was working with phased array ultrasonic to launch and receive guided waves, enabling advanced imaging of the tested structure. This hands-on experience provided deeper insight into guided wave behaviour and imaging techniques, which will be instrumental in his ongoing research. Additionally, he had access to state-of-the-art equipment at I2M, which allowed him to characterize the mechanical properties of grout, a critical component in offshore wind turbine monopile foundations. Precisely understanding these properties is essential for optimizing the launching and propagation of guided waves, ensuring effective monitoring and defect detection. The insights gained from this visit will have a direct impact on Amr's PhD research on using ultrasonic guided waves for structural health monitoring of offshore wind turbine foundations. By integrating the knowledge acquired at I2M, he can refine his models and improve defect detection and material degradation assessment in real-world conditions. This experience has not only expanded his expertise in ultrasonic techniques but has also strengthened the foundation of his research by providing access to cutting-edge methodologies and experimental validation.

What happens with Arctic marine ecosystems during the rapid sea ice decline currently taking place? **Håkon Sandven** has been on a long-term research stay in Glasgow, Scotland, where he has been working with David McKee at the University of Strathclyde (UoS) to help answer these questions from an optical perspective. The research stay is funded by the SEAS postdoctoral programme at UiB. Through the programme, Sandven is conducting a research project on the changing light underwater environment, which impacts both primary production and predator-prey dynamics. Together with other collaborators at UoS, UiB-IFT, NPI and UiB-BIO, they have investigated the transmittance of light through snow and sea ice, and assessed changes in the underwater light climate in the Barents Sea across the period 1979–2022. Due to the large sea ice loss seen in spring, primary productivity may now start one month earlier. This research builds upon large Norwegian and British research projects in the Barents Sea in the past decade where Sandven and McKee participated (Nansen Legacy and Arctic Prize). Sandven has presented this work at British and international conferences and meetings and formed connections with several researchers within the UK ocean science and technology community relevant for future collaborations.

PhD-student **Ngoc Thanh Nguyen** (HVL) visited Université Paris Cité in France, and Gran Sasso Science Institute in Italy from March to July in 2024. He chose these universities because of their renowned expertise in data science and software engineering, which are core research topics of his PhD work on automatic data quality control. During his stay there, he built a strong network and

Amr Abboud
PHD STUDENT /UIB

Håkon Sandven
POSTDOC / UIB

Ngoc Thanh Nguyen
PHD STUDENT /HVL

Espen Storheim and Astrid Stallemo from NERSC and Torunn Sandven Sagen from UiB deploy acoustic sensors during the UAK summer school in June. PHOTO: LORA VAN UFFELEN

initiated a new study that has become an important part of his PhD thesis. Besides his scientific pursuits, he also embraced the opportunity to immerse himself in the rich cultures of Paris and L'Aquila, enhancing his understanding of French and Italian traditions.

The SEAS program is a cofund postdoc mobility program at the University of Bergen. In relation to this, an American postdoc has been hired by UiB, and his activities are strongly associated with SFI Smart Ocean. Three more postdocs from abroad were hired in 2023, working closely with the Centre on optics and nanotechnology for sensor development.

The Centre will cooperate with OLAMUR (governed by IMR) related to field trials of components from our observation system. Deployment of equipment at the METCentre in 2025.

SFI Smart Ocean cooperates with The Nansen Environmental and Remote Sensing Centre (NERSC) on two international projects: The EU-funded project HiAOOS – High Arctic Observation System, and the INTPART-project UAK – Useful Arctic Knowledge, both which will work to strengthen education, research, and innovation within ocean observation technologies and include field trials in the Arctic Sea. These projects involve partners like Scripps, University of Rhodes Island, and the University of Laval.

Imenco AS is cooperating with Brazilian partners in the biliteral project “Development of a Stand Alone Subsea Instrumentation (SASI) System for hydrocarbon leak detection”. This project will incorporate learnings from the SFI Smart Ocean and share their experiences and relevant data from that project with SFI Smart Ocean. We also cooperate closely with the Italian researchers in WSense.

Additionally, funding applications have been sent to Horizon Europe and the Research Council of Norway together with a long list of international partners, and both the project development work and future potential cooperation projects strengthen our international cooperation and impact.

Postdoc Daniel Koestner gave a presentation at One Ocean Week at UiB.
PHOTO: TERJE RESTAD

08 Communication & Dissemination

Our website, www.sfismartocean.no, contains public information, along with news about the Centre. Our LinkedIn profile is used for publication of recent, important happenings and upcoming events. We have also set up a YouTube channel for videos.

An open seminar series has been continued throughout 2024. Topics from the seminars cover results from the Centre activities and other associated activities, and both industry and academia are represented. The seminars are always available on Teams, and serve as a channel for information both internally in the Centre and externally.

SFI Smart Ocean invited to a conference entitled "From Ocean to User – Ensuring quality of data" in June. The conference was open to everyone, and 12 presentations both from centre partners and invited speakers were given. Additionally, a poster session was organized as part of the conference, and 11 students presented their work in this session.

We have been very visible in both the scientific communities, industry and in the educational system, particularly at HVL and UiB. A range of publications, presentations and other contributions have been prepared:

- **28** scientific papers published in journals or conference proceedings
- **40** scientific presentations, posters or guest lectures at industrial and scientific conferences, workshops and seminars
- **8** overall presentations of SFI Smart Ocean and activities in the Centre to industry and other users
- **8** contributions to external papers, web pages and exhibition

Some of our senior researches have delivered keynote presentations at international conferences. Research leader Hanne Sagen in NERSC gave a speech on "The evolution of multipurpose acoustic networks in the Arctic Ocean" at IUCA2024, the International Conference on Underwater Acoustics in Bath where also other participants in SFI Smart Ocean gave presentations in the technical sessions. According to tradition, several of our researchers gave presentations at the 47th Scandinavian Symposium on Physical Acoustics, in Norway.

Our industrial partners have also been active at international conferences. Michael Smith in Imenco gave presentations on Advanced Active Acoustics at e.g. Subsea Controls Conference, ONS and UTC. Edmary Altamiranda delivered a key note speech at the Future Digital Twin & Generative AI Conference, and Inger Graves from Aanderaa held a presentation at EOOS Technology forum in London.

08 Communication & Dissemination

Representatives from RCN and UiB management inspect a monitoring buoy at the Aanderaa factory. PHOTO: TERJE RESTAD

Our PhD students and postdocs have also contributed to the dis-seminaton of information about the Centre's activities and the research results. Postdoc Daniel Koestner had the honour to talk about Ocean observing, from space to the deep ocean at the reception for One Ocean Week in the Bergen University Aula. PhD Wiktoria Szapoczka, who defended her PhD in November, gave a presentation on nano technology for anti-biofouling at the 8th International Conference Functional Nanomaterials and Nanodevices in Vienna. Keila Lima and Ngoc Thanh Nguyen both presented their work at the International Conference on Marine Data and Information Systems (IMDIS 24). Keila was also inter-viewed in the podcast "Long Research in Short Space" published by Scholarly Communication.

The Research Council's leadership group visited Bergen to both meet with the management at the University of Bergen and to take a closer look at the established centres for research-based innova-tion (SFI) in Bergen. SFI Smart Ocean and SFI Media Futures had the pleasure to present their activities and have a dialogue with the top management. We also arranged a site visit at Aanderaa to show how the industry interacts with the research centre.

09 Recruitment

We started the recruitment process for one PhD position within acoustic sensing and the preparations for the announcement of the last two positions, one within measurement strategy and another in microelectronics. In addition, two associate PhD candidates have been hired in 2024. **Sejal Pramlall** at UiB is working in the Marine Optics Group, whereas **Espen Oen Lie** at HVL is working on soft-ware technology for data-centric processing..

Sejal Pramlall
PHD STUDENT / UIB

Espen Oen Lie
PHD STUDENT /HVL

Funding

	Amount (1000 NOK)
The Research Council	14 083
The Host Institution (UoB)	6 813
Research Partners*	6 967
Enterprise Partners**	6 898
Public Partners***	144
TOTAL	34 905

Costs

	Amount (1000 NOK)
The Host Institution (UoB)	10 144
Research Partners	18 177
Enterprise Partners	6 440
Public Partners	148
TOTAL	34 905

* NORCE, HVL, NERSC, IMR, FFI

** Aanderaa Data Instruments AS, Reach Subsea AS, TSC Subsea AS, IMENCO Future Technologies AS, Kongsberg Discovery AS, Tampnet AS, Bouvet Norge AS, Odfjell Technology AS, Aker BP AS, WSENSE AS, GCE NODE Service AS, GCE Ocean Technology, NCE Seafood Innovation

*** Directorate of Fisheries, Norwegian Ocean Industry Authority

11 Personnel SFI Smart Ocean 2024

Centre Administration		
Henne, Ingvar	UiB	Centre Director
Holstad, Marie Bueie	NORCE	Deputy Centre Director
Terje Restad	UiB	Administrative Manager
Kavitha Østgaard	UiB	Communication Manager

Key Researchers	Institution	Main Contributions
Hamre, Børge	UiB	Marine Optics Polarization (PoS)
Henne, Ingvar	UiB	Underwater communications: Requirements, limitations, and possibilities
Holst, Bodil	UiB	Novel sensor technology & anti-biofouling: pH sensor
Greve, Martin M.	UiB	Novel sensor technology & anti-biofouling: pH sensor
Lunde, Per	UiB	Guided Ultrasonic Waves (GUW)/Distributed Acoustic Sensing (DAS)
Pedersen, Audun O.	UiB	Guided Ultrasonic Waves (GUW)/Distributed Acoustic Sensing (DAS)
Skodvin, Tore	UiB	Novel sensor technology & anti-biofouling: pH sensor
Sætre, Camilla	UiB	Measurement strategy and uncertainty/Marine optics
Frøysa, Kjell-Eivind	HVL	Measurement Strategy and Uncertainty
Heldal, Rogart	HVL	Software Engineering: Software Quality, Modelling and Validation
Kampen, Anne Lena	HVL	Communication Protocols and Network Architecture
Kristensen, Lars M.	HVL	Cloud computing and data services
Oyetoyan, Tosin Daniel	HVL	Software Engineering: Software Quality, Modelling and Validation
Cook, Jeremy	NORCE	Adaptive Data Retrieval Methods and Visualisation
Henriksen, Bård	NORCE	Underwater communications: Requirements, limitations, and possibilities
Holstad, Marie Bueie	NORCE	Deputy Centre Director
Kocbach, Jan	NORCE	Guided Ultrasonic Waves (GUW)
Langeland, Tor	NORCE	Adaptive Data Retrieval Methods and Visualisation
Thomas, Peter James	NORCE	Distributed Acoustic Sensing (DAS) and State of Polarization (PoS)
Tomasi, Beatrice	NORCE	Underwater communications: Requirements, limitations, and possibilities
Vahlin, Anders	NORCE	Underwater communications: Requirements, limitations, and possibilities
Øyerhamn, Rune	NORCE	Underwater communications: Requirements, limitations, and possibilities
Bergh, Øivind	IMR	Coordinate activities in IF1
Stiansen, Jan Erik	IMR	Coordinate activities in IF1
Sagen, Hanne	NERSC	Geographical testing location Svalbard Nord
Storheim, Espen	NERSC	Geographical testing location Svalbard Nord
Otnes, Roald	FFI	Underwater communications: Requirements, limitations, and possibilities
van Walree, Paul	FFI	Underwater communications: Requirements, limitations, and possibilities

Postdoctoral researchers working on projects in the Centre with financial support from other sources

Name	Funding	Nationality	Period	Sex	Topic
Koestner, Daniel	EU/UiB	USA	06.22 – 05.25	M	Improving the capabilities of autonomous platforms in marine science with optical sensors
Sandven, Håkon J.	EU/UIB	Norway	06.23 – 05.26	M	Development and use of instrumentation for monitoring of light scattering and absorption by marine particles
Sahoo, Bichitra N.	EU/UiB	India	10.23 – 9.26	M	Reinventing anti-biofouling coatings for combating biofouling of marine sensors
Thomas, Paul	EU/UiB	India	11.23 – 10.26	M	Study on bifunctional nanozyme activities of layered double hydroxide derived Zn-Mo films for anti-biofouling and anti-corrosion applications in the subsea environment

PhD students with financial support from the Centre budget

Name	Nationality	Period	Sex	Topic
Szapoczka, Wiktoria	Norway	09.21 – 8.24	F	Novel sensor technology & anti-biofouling: pH sensor
Skålvik, Astrid M.	Norway	1.22 – 12.25	F	Self-diagnostics and self-calibration methodologies for underwater sensors
Lima, Keila	Cape Verde	1.22 – 31.24	F	Software Engineering Methodology: Software Quality, Modelling and Validation
Ngoc-Thanh Nguyen	Vietnam	04.21 – 04.25	M	A framework for real-time marine data quality control
Abboud, Amr	Syria	9.22 – 8.26	M	Guided Ultrasonic waves (GUW)
Al Shayokh, Md.	Bangladesh	6.23 – 5.27	M	Communication Protocols
Pelaez Quiñones, J. D.	Colombia	12.23 – 11.27	M	Distributed Acoustic Sensing

PhD students working on projects in the Centre with financial support from other sources

Name	Funding	Nationality	Period	Sex	Topic
Cheatham, Shea	UiB	USA	12.22 – 11.26	F	Modeling and Measuring Light in Changing Polar Waters
Spajic, Ivan	HVL	Croatia	10.22 – 09.27	M	Digital twins in the maritime domain
Pramlall, Sejal	UiB	S.Africa	08.22 – 07.28	F	Improving the utility of ocean colour remote sensing for monitoring water quality using hyperspectral data
Lie, Espen Oen	HVL	Norway	01.24 – 31.12.28	M	A normative and data-centric approach to data handling systems

Master's Degrees

Name	Sex	Topic
Vestly, Ola F.	M	Condition Monitoring of the Communication Network in a Remotely Operated Vehicle
Hagen, Yngve	M	Measurements of the Hydrodynamic Response on a Full-Scale Closed Fish Farm
Hansen, Nora S.	F	LiFePO_4 Battery Characterization in Arctic Mission Conditions
Løyning, Ragnhild	F	Numeriske beregninger på vertikalt sensor-system forankret på dypt vann
Meland, Martine F.	F	A physics-based approach to wind turbine SCADA data analysis and power curve outlier explanation
Rakvåg, Olga	F	Hydrodynamic Modeling of a Catenary-Moored Floating Off shore Wind Turbine using the Moving Frame Method
Dilshener, Denise F.	F	Theoretical Modeling of pH-Sensitive Spontaneous Decay of Carbon Dots in Solution
Mossestad, Mari H.R.	F	Investigation and Application of pH-Sensitive Materials as Sensing Elements in Optical Fibre pH-Sensor Systems
Jonasson, Jaran	M	Implementation and Evaluation of a Messaging Service for the Smart Ocean Platform
Moldrheim, Mads S.	M	Assessment of turbulence measurement methods for ADCP integration
Gjengedal, Gunnar H.	M	Investigation of measurements of the rate of dissipation of turbulent kinetic energy with ADCP turbulence measurement methods for ADCP integration
Hammerseth, J.	M	Design and evaluation of a data space service for the Smart Ocean Platform

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Sæther, M. M., Lunde, P. and Kocbach, J. M.: "Transducers for gas measurement in the lower hundred kHz range", Proc. 47th Scandinavian Symposium on Physical Acoustics, Geilo, Norway, Jan 28 - 31, 2024

Khezri, E. H. Z., Lunde, P., Thomas, P. J., Kocbach, J. M., Hjelstuen, M., and Brekken, C.: "Propagation of flow noise in multilayered oil pipe systems subject to water and gas injection", Proc. 47th Scandinavian Symposium on Physical Acoustics, Geilo, Norway, Jan 28 - 31, 2024

Brekken, C., Hjelstuen, M., Smith, I. E., Unander, T. E., Thomas, P. J., Klepsvik, I., Arief, H. A., Khezri, E. H. Z., Lunde, P., Kragset, S.:
"Water-break in oil wells. Controlled and labelled DAS data with acoustic reference measurements", SEAFOMTM meeting, Fiberoptic
Monitoring Group, London, UK, February 22–23, 2024

Henne, I.: "Simulations of smart sensor networks under water", UiB IT-Forum 2024, 19. - 20. mars, Solstrand

Koestner, D.W.: "Ocean observing, from space to the deep ocean", One Ocean Week 2024, Reception University Aula, UiB

Mathisen, G. & Maldonado, E.A.: "Data Quality & Performance Metrics for Subsea Systems Data", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Moholt, L.C.: "Needs and requirements – what is the status and what is the challenge – as seen from a data center, SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Graves, I.: "Data quality: Experience and solutions – across ocean business segments", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Henne, I.: "Data quality - Challenges and solutions, SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Fagerås, B.: "The Push & Pull challenge in Research driven Innovation",SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Bjerke, E.: "Seabed subsidence monitoring and data retrieval via acoustic modem", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Sætre, C.: "Emerging technologies; status and challenges", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Casari, P.: "Eliminating the overhead of underwater communications", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Skålvik, A.M.: "Automatic data quality control - based on insights in sensor technology and environmental risk factors ", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Szapoczka, W.: "Transparant, anti-biofouling window", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Quirk, J.H., Fiske, M.M., & Balthasar, S.N.: "Simulation - wireless underwater sensor networks", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Koestner, D.: "Robots, lasers, and the future of ocean observing", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

13 Presentations & Posters (2/3)

Ngaha, D.T.: "Diffraction effects to ultrasonic flow meters for gas flow at high flow rates", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Dilshener, D.: "Theoretical Modelling the pH-sensitive spontaneous decay of surface-functionalized Carbon Dots in solution", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024
Berg, J.D.: "Leveraging Anomaly Detection for Automatic Oceanographic Data Quality Control ", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Lima, K.: "Marine Data Flow Quality Monitoring ", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Nguyen, N.T.: "Hyperspectral radiometric monitoring of atmospheric and oceanic constituents", SFI Smart Ocean Conference: From Ocean to User – Ensuring quality of data, HVL, June 5, 2024

Lima, K., Heldal, R., & Pelliccione, P.: "The need and use of marine data systems monitoring ", International Conference on Marine Data and Information Systems (IMDIS 24), Bergen, 27–29 May, 2024

Nguyen, N.T., Heldal, R., & Pelliccione, P.: "Leveraging Anomaly Detection for Automatic Oceanographic Data Quality Control ", International Conference on Marine Data and Information Systems (IMDIS 24), Bergen, 27–29 May, 2024

Skålvik, A.M.: "Hvordan kan vi stole på målinger fra havet?", Forsker Grand Prix, Bergen, 28 September, 2024

Skålvik, A.M.: "Hvordan kan vi stole på målinger fra havet?", Forsker Grand Prix Finale, Oslo, 28 September, 2024

Szapoczka, W.: "Creating Transparent Anti-Biofouling Windows with Surface Nanostructuring", NANOMAT 2024, 8th International Conference Functional Nanomaterials and Nanodevices, Wien, 25–28 August
Sagen, H.: "The evolution of multipurpose acoustic networks in the Arctic Ocean", IUCA2024

Henne, I.: "Autonome målesystemer for havbruk / Trådløse IoT-systemer for monitorering", Havbrukskonferansen 2024, Kvinesdal, 30–31 October

van Walree, P.: "Acoustic communication and channel characterization at Austevoll Research Station", Seminar series SFI Smart Ocean

Andreassen, S.: "Havtil's Roles and responsibilities", Seminar series SFI Smart Ocean
Tomasi, B.: "Multi-mode (Acoustic, Optical, Magneto-Inductive) Software Defined Modem and positioning system in Mobile Underwater Networks," Seminar series SFI Smart Ocean

Lima, K.: "Long Research in Short Space," Podcast-episode I Scholarly Communication

Heldal, R.: "Is generalisation hindering the adoption of your findings?," ESEM 2024

Lima, K., Heldal, R., & Oyetoyan, T.D.: "The need and use of marine data systems monitoring," International Conference on Marine Data and Information Systems

Nguyen, N.T., Heldal, R., Pelliccione, P.: "Engineering Industry-Ready Anomaly Detection Algorithms," 2024 IEEE/ACM 46th International Conference on Software Engineering

13 Presentations & Posters (3/3)

Smith, M.: “The Imenco subsea leak detection and security," ONS2024

Smith, M.: “Imenco Subsea Leak Detection & Security Systems," Subsea Controls Conference, Kristiansand

Smith, M.: “Subsea CO2 Transport Infrastructure Integrity Monitoring," UTC2024

Altamiranda, E.: “Making digital twins sustainable in driving business change and digital transformation”, Future Oil & Gas Conference, Panel Discussion, June 2024

Altamiranda, E.: "Dual Channel Acoustic Networks”, Technical Sessions, Innovations & Disruptions in Subsea Technology, ONS, August 2024

Altamiranda, E.: "The Role of Digital Twins in Asset Integrity Management and Autonomous Operations", Future Digital Twin Conference, Panel Discussion, Amsterdam, October 2024

Altamiranda, E.: WuWNet'24 SWiG Interoperability Demo, Sibenik, October 2024