Dsolve

Centre for Research-based Innovation

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Biodegradable plastics for marine applications

Annual Report 2023

Photo: SINTEF Ocean

Norwegian Centre for Research-based Innovation

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Content

Summary

The Dsolve consortium has completed another year of progress towards the aim of replacing ordinary plastics with biodegradable materials in fisheries and aquaculture industries. The goal of our Centre for Research-based Innovation (CRI) is to develop technologies and new products, improve the existing governance framework, and foster innovations that enable plastic value chains to become more circular and resource efficient. Dsolve is focused on challenges produced by marine plastic littering and ghost fishing from fisheries and aquaculture industries. A gradual transition from oil-based to biodegradable materials in these sectors is expected to reduce the carbon and greenhouse gas footprints such that they are more in line with the UN climate, energy, and sustainable development goals, e.g. 12 (responsible consumption and production), 13 (climate action) and 14 (life below water). Dsolve is designed to address the challenges described above.

During the second half of 2023 we made changes in the administration and personnel in one of the research areas, and we included one more industry partner in the consortium. Dr. Eduardo Grimaldo has left SINTEF Ocean and has been replaced by senior researcher Valentina Pauna at NORSUS as our new scientific coordinator of Dsolve. Senior engineer Jørgen Vollstad and researcher Anja Alvestad from SINTEF Ocean have succeeded Dr. Bent Herrmann and have taken over the responsibility as research leaders of Research Area (RA) 3, Tests and demonstrations at sea.

In March we established the International Advisory Board with IPIMAR, Portugal, Memorial University of Newfoundland, Canada, and Marine and Freshwater Institute, Iceland. Then, in September the Innovation Board was assembled by members from our industry partners, represented by fisheries (Øra AS), gear suppliers (Mustad Autoline AS and Løvold AS) and aquaculture (SalMar ASA). The world's second largest salmon producer, SalMar ASA, became partner in Dsolve at an extraordinary general assembly in October. We have had several meetings between the industry and scientific partners, including two board meetings and two general assemblies. Our research partner at the University of Split in Croatia invited the consortium and organized our annual meeting with physical participation in Split from March 29.-30., and industry partner Mustad Autoline organized a board meeting in Gjøvik from September 12.-13.

During the year, the RA leaders have led several seminars, and we have joined a side-project funded by FHF- the Norwegian Seafood Research Fund called Gentle and Effective Bottom Trawling for Groundfish. Further, we have joined as partner in the EU Horizon SEARCULAR project HORIZON-MISS-2022-OCEAN Marine litter and pollution – Smart and Low Environmental Impact Fishing Gears, led by AZTI (Spain), together with Norwegian partners and international companies like SENBIS (Holland), GAYA biomaterials (Sweden), Kompost-it and Catchgreen (South-Africa). We have further established a formal co-operation with the Norwegian Directorate of Fisheries to assist and utilise data from their fishing gear recovery missions.

Our four PhD candidates (from Latvia, Viet Nam, Thailand and Croatia) related, respectively to research area RA 3: Tests and demonstrations at sea, RA 4: Governance incentives, RA 2: Assessment of biodegradability and RA 5: Inclusion of ghost fishing and its effects on ecosystems and biodiversity in LCIA have progressed well. Their activities include compulsory university courses, presentations, and scientific publications. Furthermore, they have been active in applying external funding from the Norwegian Retailers` Environment Fund, Erasmus and UArctic North2North to enhance research and mobility (USA, Canada and Croatia). A new PhD position was announced for RA 4 on incentives related to aquaculture and it has been accepted by a candidate from Italy. In RA 3, a PhD position focusing on the use of biodegradable materials in longlines and demersal seining has been established through co-financing with SINTEF Ocean. A candidate from Norway has accepted the position. Both candidates will formally start working at UiT by January and March 2024. We have arranged seminars for undergraduate students and supervised students at the MSc level with works related to marine plastic pollution. Two MSc candidates started working on their thesis with focus on challenges identified by Dsolve, i.e. on the use of various types of material in a trap fishery for humpback salmon (*Oncorhynchus gorbuscha*).

The activity at sea has been limited compared to plans which is explained mainly by difficulties in fiber-spinning from new biodegradable polymers and, therefore, challenges with the production of twines, nets and ropes for fisheries and aquaculture. Most of the work by our partners has been directed towards gillnet, longline, demersal seine, and bottom trawl fisheries. New types of biodegradable materials for components like codend chafing mats ("dolly ropes") in bottom trawls were made during March 2023. Experiments to examine ghost fishing with self-baited snow crab pots were conducted in the northeast Atlantic and trials with bottom trawls focusing on ground rope were performed during experiments in the central Barents Sea by December 2023. Additional samples of various materials have been placed at a depth of 80 m close to Tromsø for long term examination of biofouling and degradation processes.

Basic research in laboratories by our partners to identify properties of existing materials and new resins for the use in fishing gears, is a continuing process. All the materials that have been tested in fisheries were analysed in laboratories at SINTEF Ocean and SINTEF Industry for parameters like breaking strength, abrasion resistance, degradation profiles, microplastic formation, and more. Fishing gears like gillnets and sections of longlines, i.e. snoods, and protecting chafers in bottom trawls and herding ropes of demersal seines contribute much to the marine littering from fisheries. Samples from the tested gears in Croatia, Germany, Denmark, and Norway, undergo long term experiments to calculate degradation from various marine environments. The tests are done at SINTEF laboratories in Oslo, Trondheim and at UiT. In RA 2, the PhD candidate brought part of the samples for further analyses to the University of Northern British Columbia (Canada) during a UArctic funded exchange period.

Summary

Our industry partners in South Korea have produced a new type of biodegradable polymer for fiber production based on PBSA (polybutylene succinate-co-adipate), that more closely resembles the important properties of nylon like elasticity and tensile strength than the former PBSAT material. The latest tests in Croatia show that there are some challenges regarding use of this material in gillnets. Further tests with PBSA polymer in trammel net fishery in Croatia during 2023 were performed targeting flatfish species sole. We have identified new applications for this material to replace nylon and expect positive results during 2024 test programs (i.e., primarily gillnets and longlines). Provided that the material shows comparable properties to nylon and polyester regarding efficiency and service time, we believe an important barrier in polymer development has been passed.

The RA leaders have continued their organized meetings every second month (RAs 1-6) to discuss the results from laboratories and field trials. Our international industry partners LG-Chem and S-EnPol have participated in several of the meetings. These meetings have been essential for further development of biodegradable plastics. The Dsolve administration continues to participate in various arrangements and give presentations in various fora.

Dsolve has produced several news articles, presentations about the Centre at national and international events like Håp i Havet, SETAC (Dublin), NOSCA conference (Bergen), Norsk kjemisk selskap (Brumunddal), CRI Forum, Aqua-Nor (Trondheim), TV (Science days), International Conference on Polymeric Materials in Automative PMA (Smolenice), Plast- og kompositt konferansen (Gjøvik), the First International Conference on Ghost Gear (Arendal), The 7th International Symposium Frontiers in Polymer Science (Göteborg), Clean Oceans Arena (Bergen) and Arctic Plastic Symposium (Reykjavik). We have produced two new podcasts during the year. Published results and news are consecutively uploaded on the Dsolve webpage and communicated on LinkedIn, Facebook and Twitter.

The fisheries sector is male dominated where discrimination and harassment has been observed. Dsolve is proud to proclaim that we follow the ethical standards of UiT which has zero tolerance for discrimination. Dsolve has a focus on gender balance. Three out of six research area leaders, our administrative leader, two of four PhD candidates, and several members of the board are women. The Dsolve team is satisfied with the development during 2023. Finally, we are eager to produce new results that bring us closer to our goal.

Tromsø, 31. March 2024

Roger B. Larsen
Centre Director

CRI Dsolve presented at the annual meeting of Norges Råfisklag in Tromsø, May 2023.
Photo: Dsolve

Vision and Ambitions

Vision:

Reduce plastic litter and associated problems (macro-, microplastics and ghost fishing) caused by the fishery and aquaculture industries.

Ambition:

Place Norway at the forefront of research, development, and use of smart biodegradable materials to reduce the global problem of marine litter from fisheries and aquaculture.

Timeline

Illustration: SALT

Photo: Erling Svensen/SALT

Objectives

The main objective of CRI Dsolve is to reduce plastic litter and its associated problems such as macro- and microplastics and ghost fishing in the marine environment caused by fishing and aquaculture industries, by replacing the traditional plastics used in gears and gear components with new biodegradable materials. This primary objective will be achieved by accomplishing the following **secondary objectives:**

- Develop new smart biodegradable polymers with controllable (non-linear) degradation in the marine environment.
- Develop biodegradable filaments, twines, ropes, and netting for fisheries and aquaculture purposes.
- Create governmental incentives and restrictions to incorporate biodegradable plastics in an ecosystem-based management approach.
- Help to establish a supplier industry that can deliver biodegradable gears and services to the end-user sectors (fisheries and aquaculture).
- Develop sustainable downstream solutions and LCA for biodegradable fishing gear.
- Optimize and validate waste sorting technologies and circular waste processing options for biodegradable materials.
- Educate at least 8 PhD candidates, 4 post docs, and 30 MSc candidates.

Test of biodegradable fishing gear in Norwegian waters.

Photo: Waranya Wataniyakun, UiT

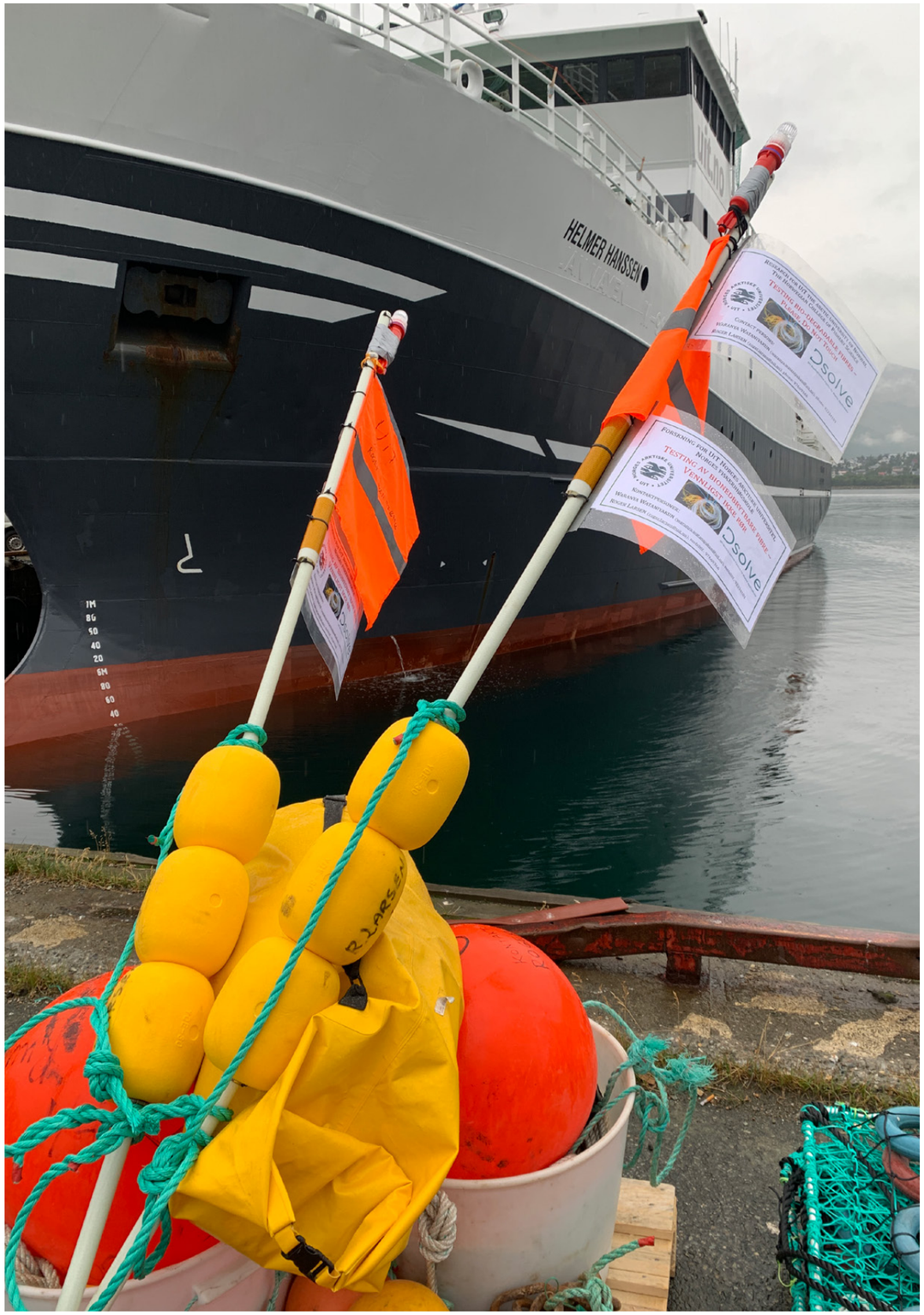
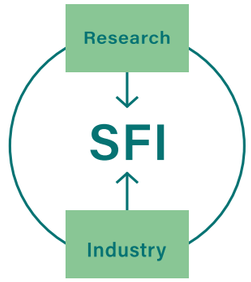


Photo: Waranya Wataniyakun, UiT

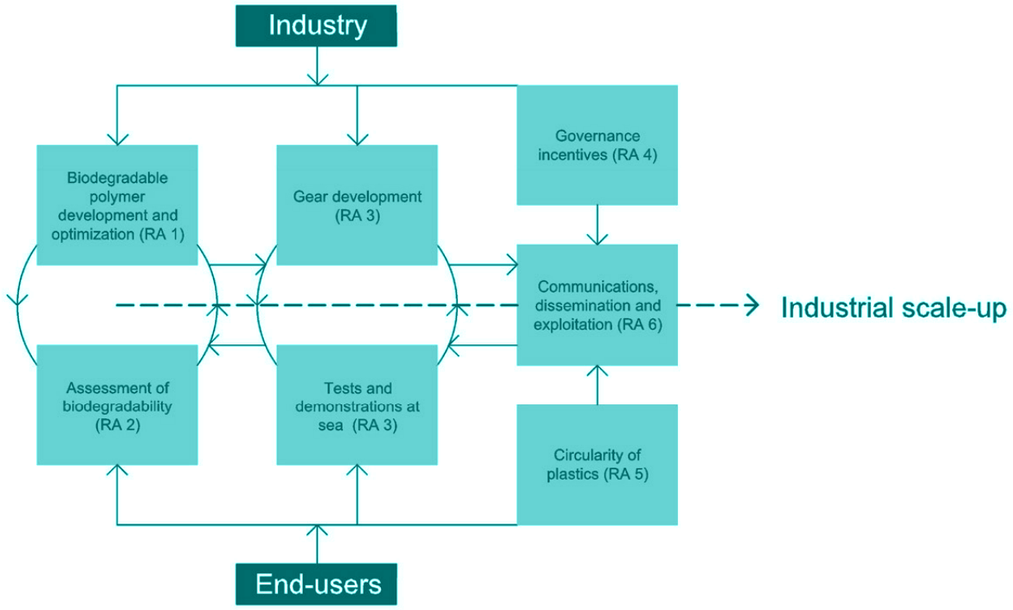
Research strategy

Our main research hypotheses are:

- By replacing traditional non-degradable plastics with smart biodegradable and controllable ones, we can reduce marine litter caused by the fishing and aquaculture industries.
- By reducing ghost fishing and macro- and microplastic pollution, value creation will increase in the fishing and aquaculture industries.
- By introducing effective incentives, the fisheries management can facilitate the use of biodegradable plastics, in order to enhance the ecosystem-based management approach.
- New sustainable downstream solutions and LCA can facilitate the circularity of existing fossil-based non-degradable and biodegradable plastics.



Dsolve focus on six Research Areas that jointly address these hypotheses:



Specific objectives for the Research Areas (RAs) are:

RA 1

Dr. Ravindra R. Chowreddy
Norner Research AS

Develop a range of biodegradable plastic materials with controlled biodegradability and the properties needed for products used in the fishing and aquaculture industries

RA 2

Dr. Christian W. Karl
SINTEF Industry

Create a sustainable framework for testing biodegradability and environmental impact. Lab and field testing will be carried out in conditions representing different marine environmental factors, and marine biodegradation tested in different marine habitats and climate zones. Biodegradable and conventional tools will be compared.

RA 3

Jørgen Vollstad
SINTEF Ocean/UiT

Anja Alvestad
SINTEF Ocean/UiT

Sea trials in the Norwegian, Northsea, Baltic and Adriatic Seas including performance, catch pattern, and efficiency analyses of existing and new technology. Obtain data about the performance of biodegradable twines and ropes, the catch efficiency of nets, and how degradation varies in relation to different environmental conditions.

RA 4

Prof. Claire Armstrong
UiT Arctic Univ. of Norway

Assess the economic effects of non-biodegradable materials used in fisheries and aquaculture and evaluate costs and benefits on ecosystem services from introducing biodegradable materials in the marine industries. Further analyse institutional incentive mechanisms and assess public support systems to reduce risk and promote implementation of biodegradable innovations.

RA 5

Dr. Cecilia Askham
NORSUS AS

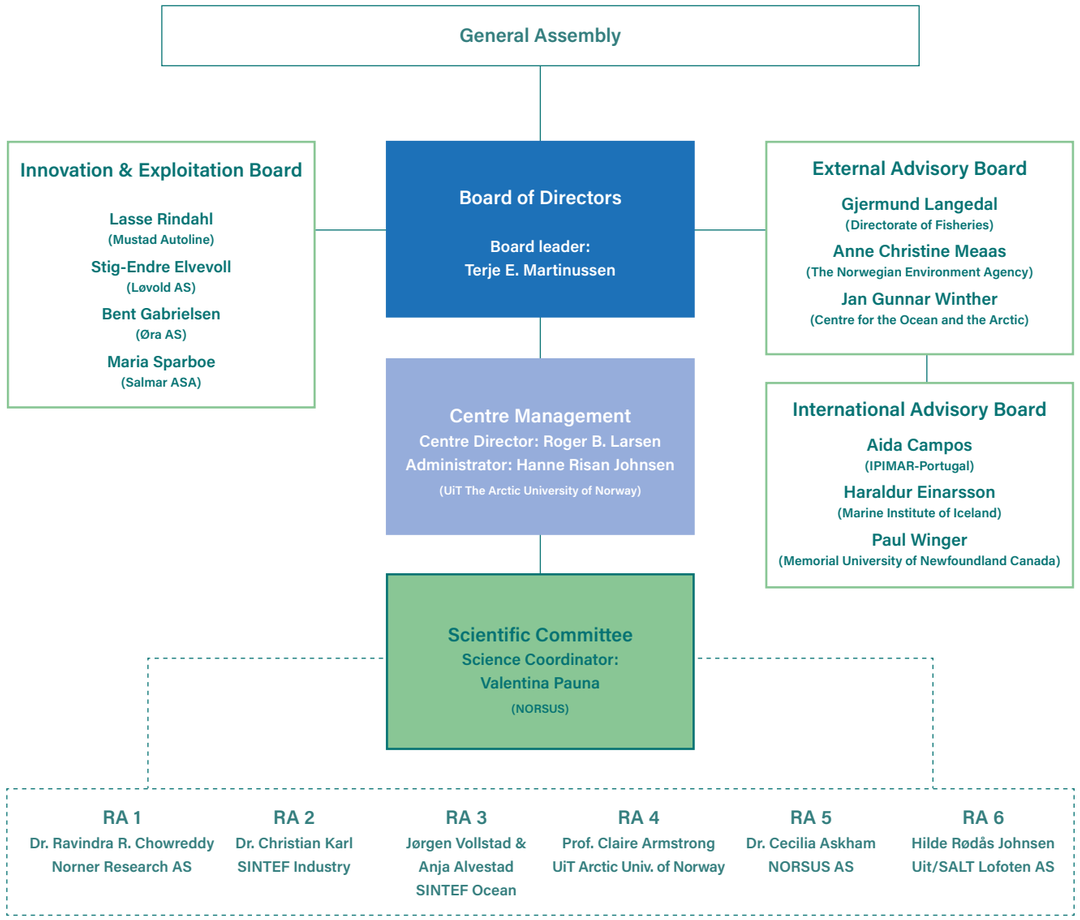
Develop sustainable circular solutions for existing non-degradable and future biodegradable fishing gear. The goal is to develop environmentally sustainable value chains which also take the level of circularity into account.

RA 6

Hilde Rødås Johnsen
UiT/SALT Lofoten AS

Develop and carry out a dynamic plan for outreach through communication, dissemination and exploitation of results in order to maximize the impact of the project results.

Organisation



The figure above describes the Centre's organisation. The General Assembly consists of representatives from each partner and have the uppermost decision-making power in the Centre. As from 2022 all partners have permanent representation in the Centre's board, including research partners and the host institution (UiT). The board decide on organisation, budget, activities and working plans, and is responsible for the progress and scientific quality of the centre research activities. Leader of the board during 2023 has been Terje E. Martinussen. Martinussen has long experience from the seafood industry as former director for the Norwegian Seafood Council, Institute leader at UiT, and long-term experience from, amongst other insitutes, Nofima (former Fiskeriforskning). During 2023 Jørgen Vollstad and Anja Alvestad from Sintef Ocean have succeeded Professor Bent Hermann as leader for Research Area 3, while Dr. Valentina Pauna from NORSUS has succeeded Eduardo Grimaldo in the role as Scientific Coordinator of CRI Dsolve.

Consortium

The CRI partners are presented at pages 18 and 19. As of October 2023 the Norwegian fish farming group SalMar ASA has entered the consortium as an industry partner. Together with Kvarøy Fiskeoppdrett AS, SalMar ASA will strengthen research under the auspices of CRI Dsolve to develop and test new biodegradable materials for the aquaculture industry, as well as research on how various incentives can contribute to increased use of new degradable materials in the farming sector as well as the fishing sector.

SalMar ASA will, in addition to strengthening the competence in aquaculture in Dsolve, also help to encourage more students to choose research tasks that are in the field of interest for Dsolve. SalMar ASA is the second largest salmon breeder in the world, and the new partner's contribution in the program period up to 2028 is valued at NOK 10 million, both in the form of own efforts and direct support for student-related activities. With the entrance of SalMar ASA in the consortium, CRI Dsolve also strengthens its partnership with international actors within the seafood industry.

Members of the Centre Board 2023

ROLE	MEMBER OF CENTRE BOARD	AFFILIATION
Leader of the Board	Terje E. Martinussen	Private
Host Institution	Terje Aspen	UiT-BFE
Research Partners	Thor Kamfjord	Norner Research AS
	Bård Wathne Tveiten	SINTEF Ocean
	Einar Hinrichsen	SINTEF Industry
	Ellen-Marie Forsberg	NORSUS AS
Industry and organisations	Bent Gabrielsen	Øra AS
	Arne Birkeland	Opilio AS
	Lasse Rindahl	Mustad Autoline AS
	Terje Lindal	Mørenot AS
	Håvard Olsen	Kvarøy Fiskeoppdrett AS
	Gunnar Kupen	Nofi AS
	Benedicte Nielsen	Norges Råfisklag
	Martin Solhaug	Martin Solhaug AS
	Rune Sand	Tustern AS
	Kristian Kalgraff	Legøy Rederi
	Signor Antonsen	Hermes AS
	Jan-Henrik Sandberg/Maria Pettersvik Arvnes	Norges Fiskarlag
	Stig-Endre Elvevoll	Løvold AS
Observer	Inger Austrem	The Research Council of Norway

The Centre Board is advised by the Innovation and Exploitation Board and the External Advisory Board. As from 2022 the board is also supported by an International Advisory Board. The Innovation and Exploitation Board has been led by Professor Bent Herrmann, chief scientist at SINTEF Ocean. The External Advisory Board (EAB) is selected from experts in policy and bioeconomy, governance institutions, public organisations, and NGOs, while the International Advisory Board (IAB) is selected from experts within marine research. The three members of the IAB have comprehensive networks and hold important positions in their research communities as members of ICES (the International Council for the Exploraition of the Sea) and the FAO (Food and Agriculture Organisation of the United Nations). The goal of the EAB is to guarantee quality of the research and maximise its impact, while IAB will be involved in advising and evaluating the progress of Dsolve, and in international outreach of results.

Dsolve annual meeting in March 2023 was hosted by the University of Split, Croatia 29.- 30 March. *Photo: Dsolve*

Annual meeting and General assembly

This year's annual meeting and general assembly were held at the Hotel Briig in Split, Croatia, from the 29th - 30th of March, hosted by our international research partner The University of Split. A total of 25 representatives from the research and industry partners gathered in Split, including several international partners, as well as some digital participants. The meeting offered the opportunity to connect with international partners including members of the EAB and IAB, as well as providing a platform for industry partners to present views, status, and plans for the various research areas, and get input from both the EAB and IAB to the progress and work of the CRI. The general assembly 2023 were held in connection to the annual meeting on the 30th of March. An extraordinary General Assembly was further held on the 13th of October to approve the entry of SalMar ASA as a new partner in the consortium.

The annual meeting 2023 gathered participants from both industry and scientific partners to joint discussions.
Photos: SINTEF Ocean

Examples of biodegradable products and materials for the seafood industry produced by partners and presented at the annual meeting.
Photos: SINTEF Ocean

Partners

Host Institution

UiT – The Arctic University of Norway As hosts institution, UiT contributes to the CRI with expertise in Arctic and marine biosciences, economy, and subjects relevant to the fisheries and the aquaculture industry, as well as infrastructure for lab testing and fishing gear trials. UiT is leading Research Area 4 Governance incentives, Research Area 6 Communication, Dissemination and Exploitation, and is involved in Research Area 3 Tests and demonstrations at sea.

National Research Partners

Norner Research AS contributes to the CRI with expertise in Polymer R&D services, material and analytical testing, evaluation of physical and chemical properties, environmental influence on material properties, and plastic processing techniques. Norner is leading Research Area 1 Biodegradable polymer development and optimalization.

SINTEF Ocean contributes to the CRI with expertise in ocean-based industries, including fishery and aquaculture, and with R&D infrastructure. Sintef Ocean is leading Research Area 3 Tests and demonstrations at sea, and has been head of the Scientific Committee of CRI Dsolve.

SINTEF Industry contributes to the CRI with expertise in the entire value chain from manufacturing to finished product, for all types of plastics, including thermoplastics, plastics composites, elastomers, and gels. Sintef Industry is leading Research Area 2 Assessment of biodegradability.

NORSUS AS contributes to the CRI with expertise in LCA for analysis of environmental and resource efficiency for products and services. NORSUS is leading Research Area 5 Circularity of plastics and has also the role as Science Coordinator of the CRI.

International Research Partners

DTU-Aqua (Denmark) Research, advice, education and innovation in sustainable exploitation and management of aquatic resources. Contributes to Research Area 3 Tests and demonstrations at sea.

Thünen Institute of Baltic Sea Fisheries (Germany) Research, advice, and monitoring on fisheries and environment in the Baltic Sea. Contributes to Research Area 3 Tests and demonstrations at sea.

University of Split (Croatia) Research, science, and innovation within oceanography and fishing, nautical science, and a range of other specific disciplines. Contributes to Research Area 3 Tests and demonstrations at sea.

International Industry Partners

LG Chem (South Korea) Supplier of biodegradable polymers and fishing gear. Contributes to the CRI with materials for testing and expertise on biodegradable plastics.

S-EnPol (South Korea) Supplier of biodegradable polymers and fishing gear. Contributes to the CRI with materials for testing and expertise on biodegradable plastics.

National Industry partners - suppliers

Nofi Tromsø AS Supplier of fishing gear. Contributes to the CRI with expertise on fishing gear, and in particular nets.

Mørenot Fishery AS Supplier of applications to the fisheries and aquaculture industry. Contributes to the CRI with expertise on fishing gear and aquaculture equipment.

Løvold AS Supplier of applications to the fisheries and aquaculture industry. Contributes to the CRI with expertise on fishing gear and aquaculture equipment, and in particular ropes.

Supplier of fishing gear. Contributes to the CRI with expertise on fishing gear, and in particular longlines.

National Industry partners - users

Øra AS (coastal gillnetting)	Contributes to the CRI through full-scale tests of biodegradable fishing gear at the 11 m coastal gillnet-vessel "Karoline".
Tustern AS (demersal seining)	Contributes to the CRI through full-scale tests of biodegradable fishing gear at the 30 m seine-vessel "Fortuna".
Hermes AS (demersal trawling)	Contributes to the CRI through full-scale tests of biodegradable fishing gear at the 62 m trawler "Hermes".
Legøy Rederi AS (gillnetting)	Contributes to the CRI through full-scale tests of biodegradable fishing gear at a 15 m coastal gillnet-vessel.
Martin Solhaug (longlining)	Contributes to the CRI through full-scale tests of biodegradable fishing gear at the 15 m coastal longliner "MS Vibeke Cathrin".
Opilio AS (snowcrab potting)	Contributes to the CRI through full-scale tests of biodegradable fishing gear at the snowcrab vessel "Northeastern".
Loran AS (mechanical longlining)	Contributes to the CRI through full-scale tests of biodegradable fishing gear at the mechanized longliner "Loran".
Kvarøy Fiskeoppdrett AS	Contributes to the CRI as end user within salmon farming. Owns and operates two ordinary salmon farming licenses and one R&D license.
SalMar ASA	New partner from 2023. Contributes to the CRI as end user within salmon farming. SalMar ASA is the world's second largest breeder of salmon, and produces in Norway, Shetland, Orkney Islands, Iceland and Scotland.

Organisations

Norges Fiskarlag	Contributes to the CRI as representative for Norwegian fishers. Participate in Research Area 6 Communication, dissemination, and Exploitation.
Norges Råfisklag	Contributes to the CRI as representative for Norwegian fishers. Participate in Research Area 6 Communication, dissemination, and Exploitation.

External Advisory Board

Senter for Hav og Arktis	Contributes to the CRI with expertise on blue sustainability in the arctic and partnerships for sustainable blue business.
Miljødirektoratet	Contributes to the CRI as representative for Norwegian authorities with authority on environmental management and legislation.
Fiskeridirektoratet	Contributes to the CRI as representative for Norwegian authorities with authority on fishery and aquaculture management and legislation, and expertise on retrieval of lost fishing gear.

International Scientific Advisory Board

Institute for the Ocean and the Atmosphere, Portugal	Contributes to the CRI with expertise in ocean science and technology research.
Marine and Freshwater Research Institute, Iceland	Contributes to the CRI with expertise in marine and freshwater research.
Memorial University of Newfoundland	Contributes to the CRI with expertise in fishery research.

Scientific activities and results

The goal of our Centre for Research-based Innovations is to develop technologies and new products, improve the existing governance framework, and foster innovations that enable plastic value chains to become more circular and resource efficient. This is expected to reduce the carbon and greenhouse gas footprints such that they are more in line with the UN climate, energy, and sustainable development goals. The main working hypothesis is that the problems associated with marine plastic litter caused by the fishery and aquaculture sectors can be significantly reduced if traditional plastics in these sectors are replaced with new biodegradable materials. Today marine litter from non-degradable plastics end up as macro- and micro-plastic pollution while lost and abandoned fishing gears can cause "ghost fishing", resulting in unaccounted mortality. The Centre is designed to address these challenges.

The section below describes the status for the various research areas, plans and achievements in 2023. Status and results for each research area is described with a summary of objectives and motivation, key research tasks, and achievements.

RA 1 Biodegradable Polymer Development and Optimization

Objectives and motivation

The main objective of Research Area 1 (RA 1) is to develop a range of biodegradable plastic materials with the properties needed for the products used in fishing and aquaculture industries (e.g., twines and netting, ropes, gillnets, coatings, pots and traps, foils and boxes, pipes, and connectors). The developed materials should meet a range of processing and performance requirements, including biodegradability.

The motivation behind RA 1 is that the conventional plastic materials used in the construction of fishing gear and aquaculture equipment are not biodegradable and remain in the aquatic environment when they are lost during operation. This leads to plastic pollution, microplastic formation and ghost fishing issues. Utilisation of biodegradable plastic materials in fishing gear and aquaculture equipment would reduce plastic pollution and ghost fishing due to the shorter lifespan of biodegradable plastic materials. None of the commercial biodegradable plastics meets both performance and marine biodegradability requirements needed for fishing gear and aquaculture equipment. Therefore, RA 1 in the Dsolve project intends to develop a range of biodegradable alternative materials that will meet the requirements of both performance and marine biodegradability for the fabrication of fishing gear and aquaculture equipment.

The key research tasks of Research Area 1, prioritised research tasks and achievements in 2023 are presented below.

Key research tasks

- Selection, identification, sourcing, and suitable modification of biodegradable plastic materials for marine fishing and aquaculture applications.
- Development of biodegradable materials with optimal processability, and performance for various applications, such as for fibres (twines, netting, ropes, etc.), for injection moulding (pots, traps, boxes, etc.), and for coatings (steel rope coatings).
- Investigation of potential microplastic formation from the biodegradable plastics and prediction of the degradation products.
- Establishing collaborations with materials suppliers to ensure availability of biodegradable plastics in the project.
- Develop new material and design concepts to meet the requirements of marine biodegradability, processability and performances for marine fishing and aquaculture applications.

Key research tasks prioritised in 2023

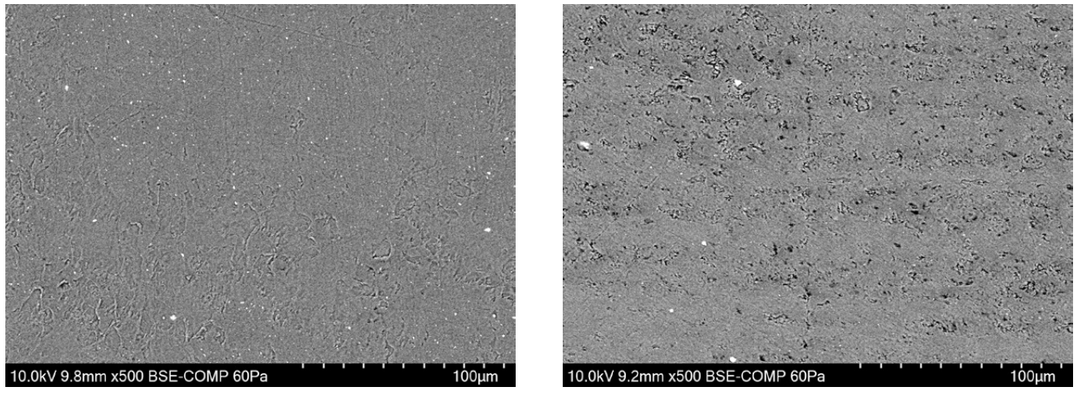
- Desktop study to screen the commercial bioplastics for further development and recommendations for materials development for different applications in Dsolve project.
- Modification of selected commercial bioplastics to meet the process, performance, and marine biodegradability requirements in the Dsolve project.
- Processing and performance evaluation of biodegradable fibres produced from selected commercially available and development biodegradable plastics.
- Identification, selection, and sourcing of biodegradable plastics for moulded/extruded products.
- Processing and performance evaluation of moulded/extruded biodegradable plastic products, identify gaps and propose methods to close gaps.
- Development of methods for investigation of microplastics, and investigation of the role of additives in microplastic formation was planned for RA 1 but moved to RA 2 PhD study.
- Scouting, sourcing, and preliminary characterization of selected biodegradable materials.

Achievements in 2023

- A range of compatibilized and un-compatibilized bioplastic blends were processed and characterised for rheological, mechanical, and morphological properties during 2023. Some of the selected bioplastic blends shall be processed into monofilaments and shall be characterised for their suitability for fishing gear applications during the year 2024.
- In addition to bioplastic blends, bioplastic compounds with various inorganic fillers and organic fillers (e.g., clays and wood fibre) were processed and characterised during 2023. Some of the selected bioplastic compounds shall be processed into moulded/extruded parts and shall be investigated for their suitability in fishing gear applications during the year 2024.
- About eight different bioplastic materials were sourced and processed into monofilaments and were stretched at different rates. The fibres produced were characterised by physical and mechanical properties. The results of fibre processability of different bioplastic materials and the results of the mechanical testing were summarised in technical deliverable report D2.2 (NR230450).
- The materials sourced during 2022 were extensively characterised for basic properties and the findings of the characterization were summarised in deliverable report D6.2 (NR230571).
- A manuscript was drafted in collaboration with other research area leaders of Dsolve project and will be soon submitted for publication. Some of the desktop study findings from RA 1 were incorporated into the manuscript. Contributed to the production of Dsolve podcast (English version).

Publications

- NR230125 Potential modification strategies for biodegradable plastics in Dsolve project, Norner, Ravindra Chowreddy
- NR230450 Summary of 1st round of monofilament spinning trials on bioplastics and results of mechanical testing, Norner, Ravindra Chowreddy and Vinh Cao
- NR230571 Summary of characterization results of bioplastics sourced in 2022, Norner, Ravindra Chowreddy



SEM images of polished cross-section of bioplastic blend specimens showing voids in un-compatible blend and voids-free in compatible blend.

Photos: Norner

Photo: SALT

RA 2 Assessment of Biodegradability

Objectives and motivation

In Research Area 2, Assessment of Biodegradability, the degradation behaviour of fishing gear or other equipment for marine applications made of biodegradable polymers will be investigated in more detail. These fishing gears should have the same or better mechanical properties and fishing efficiency as the non-biodegradable plastics. These common polymers currently used in the fishing and aquaculture industries include primarily polyamide (PA). Gillnets made from synthetic materials are durable and have high tensile strength, which becomes problematic when lost at sea as they contribute to ghost fishing. Issues such as ghost fishing, marine plastic pollution, shipping risks, and the introduction of synthetic materials into the marine food chain have become much more acute with the increase in fishing activity. In recent years, biodegradable gillnets (e.g. made of PBSAT) that can be degraded by naturally occurring microorganisms in seawater have been increasingly discussed and researched as a replacement for conventional PA gillnets. The catch efficiency of these nets made of biodegradable polymers is in some cases comparable to nets made of PA, polyethylene (PE), and polypropylene (PP). However, significant research is still needed to improve the mechanical properties, catch efficiency and biodegradability of these gillnets and other devices of interest for future applications. In addition, the degradation of biodegradable polymers with controllable and nonlinear degradation profiles that exhibit stable mechanical properties during their lifetime and degrade rapidly thereafter will be investigated. Additional suitable materials are currently being investigated. The Dsolve project consortium will work closely with academic and industrial partners to make biodegradable plastics commercially available and economically accessible to end users.

The key research tasks of Research Area 2 and achievements in 2023 are presented below.

Key research tasks

One of the main focuses of this work package is to investigate modified and unmodified biodegradable polymers for fishing gear that have the same or better mechanical properties and catch efficiency than the non-degradable plastics currently used by the fishing and aquaculture industries The physical and chemical integrity and degradation of biodegradable and conventional nets and twine will be evaluated in laboratory and field tests over an extended test period (5 years or complete degradation). Accelerated weathering tests in the laboratory, especially the influence of UV radiation and temperature, will be compared with field tests and experiments conducted under controlled laboratory conditions. The work plan describes in more detail the activities planned to achieve these objectives. The following main tasks are relevant:

- 2.1 Investigation of the marine biodegradation of gillnets and twines with PBSAT as test and PA6 as control material in situ in different marine habitats and in different climate zones (Skagerrak, North Sea, Baltic Sea, Adriatic Sea, and Norwegian Sea) to cover a wide temperature range from 4 to 27°C and analyse the samples.
- Task 2.2 Investigation of the biodegradation in laboratory systems (controlled conditions) consisting of natural seawater. Analysis includes monitoring microbial biodegradation, performing microbiome analyses, and analysing the materials (chemical and physical properties) during and after degradation.

- Task 2.3 Evaluation of the effects of UV radiation with simultaneous changes in temperature, humidity, and pollutants (and the combination of these factors) on the physical properties of PBSAT nets and yarns and PA6 as control.

Achievements in 2023

The monofilament polymer samples described in Task 2.1 were collected in June/July 2023 after 24 months from all testing sites (Norway, Denmark, Germany, and Croatia) and initial analyses have been performed after 24 months from all testing sites. A report describing the collected samples at the testing sites has been finalized accordingly (T2.1 report). The photo below shows a temperature logger and monofilament samples from the Norwegian test area fixed in a pot. Accelerated weathering experiments of the monofilaments (PA6 as reference and PBSAT as well as PBSA as biodegradable polymer) were carried out in T2.3 and methods (chemical, physical, surface characterization) for characterization were selected, which are important for the whole Research Area in the future (especially for the field experiments in T2.1 and for the controlled laboratory experiments in T2.2). A test report summarizing the results from the field and lab-based degradation studies in T2.1 (after 24 months) and T2.3 has been finalized.

Temperature logger and monofilament samples fixed in a pot.
Photo: SINTEF Ocean

Related projects

POCOplast: Pathways to sustainable post-consumer plastics in aquaculture.

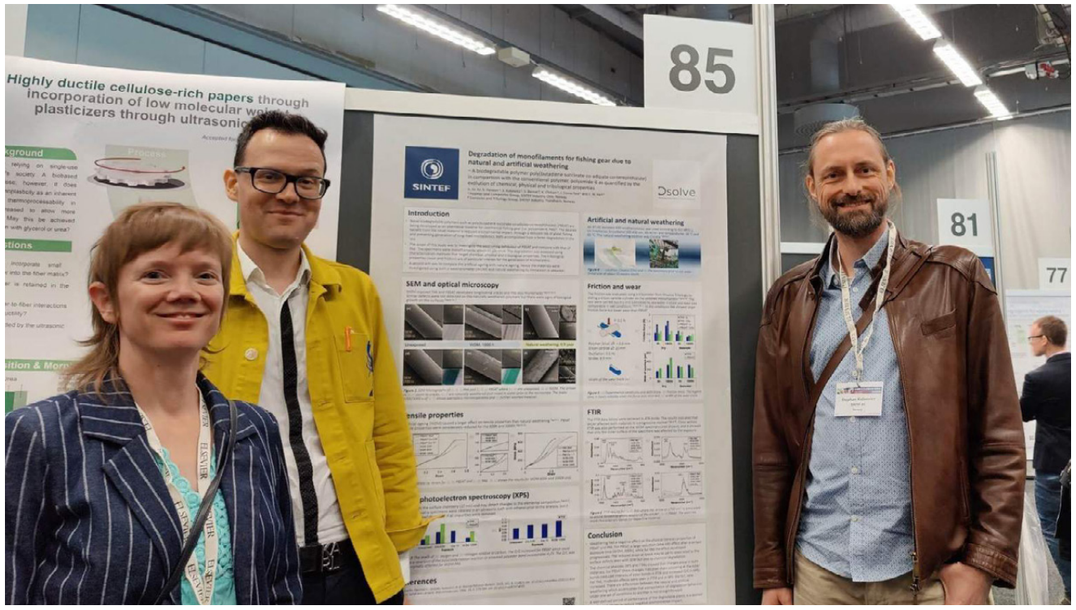
In-No-Plastic: Innovative approaches towards prevention, removal and reuse of marine plastic litter.

SHIFT-PLASTICS: Shifting to sustainable circular values chains for handling plastics in the fisheries and aquaculture sector.

PLASTICENE: Development of tools for increased resource utilization, circularity, and regulatory support of plastic use in Norway.

Publications

- Reducing plastic pollution caused by demersal fisheries (1): https://www.sciencedirect.com/science/article/pii/S0025326X2301069X?via%3Dihub
- Enabling transition thinking on complex issues (wicked problems): A framework for future circular economic transitions of plastic management in the Norwegian fisheries and aquaculture sectors (2): https://www.sciencedirect.com/science/article/pii/S0959652624008680?via%3Dihub



Poster presentation ("Degradation of monofilaments for fishing gear due to natural and artificial weathering") at the Frontiers in Polymer Science Conference in Gothenburg,Sweden (from left to right: Anna-Maria M. R. Persson, Christian W. Karl, Stephan Kubowicz, all from Polymer and Composite Materials Group/SINTEF Industry.

Photo: SINTEF AS

Dissemination and public outreach

- A guest lecture about the degradation of bio-based materials in the marine environment and ghost fishing ("Hvordan foregår nedbryting av biobaserte materialer i marine miljø og på hvilken måte kan nye materialer hindre marin forsøpling og spøkelsesfiske?") in the course Sustainable fisheries (module interdisciplinary seminar no. 1) FSK-2020 at the UiT (organizer: Roger B. Larsen) was held in September 2023.

- A podcast about the CRI Biodegradable plastics has been published in July 2023 on the Dsolve website in collaboration with UiT and Norner: https://www.buzzsprout.com/1841404/13151878-what-is-biodegradable-plastic-dsolve

- A SINTEF podcast "Smart forklart - Kampen mot spøkelsesfiske" (focus: ghost fishing and microplastics) has been published in August 2023 in collaboration with UiT and SINTEF Ocean:
- https://shows.acast.com/60b75c5b8c26f80013d5ebce/episodes/kampen-mot-spkelsesfiske?

- Presentation "Bionedbrytbar plast til marine applikasjoner og resirkulert plast fra fiskeri og havbruk" (NOSCA workshop, organiser: NOSCA/NORCE) in February 2023, Bergen, Norway.

- Presentation "Biodegradable plastics for marine applications" (NKS Makro: Polymer-based materials, today and in the future, organiser: NKS/Norwegian Chemical Society) in March 2023, Brumunddal, Norway.

- Invited key lecture "Recycled plastics for marine and automotive applications" (9th International Conference on Polymeric Materials in Automotive PMA 2023 & the 25th Slovak Rubber Conference, organiser: Slovak University of Technology in Bratislava) in May 2023, Smolenice, Slovakia.

- Presentation "Senter for utvikling av bionedbrytbar plast til marine applikasjoner (CRI Dsolve) - Materialutvikling og nedbrytningsstudier" (Plast og kompositttkonferansen 2023, organiser: NCMT) in september 2023, Gjøvik, Norway.

- Invited lecture "Recycled and biodegradable plastics for marine applications: challenges and solutions" (The International Conference on Ghost Gear 2023, organiser: Institute of Marine Research) in November 2023, Arendal, Norway.

- Invited lecture "Biodegradable plastics for marine applications: challenges and possible solutions" (Clean Oceans Arena, organiser: NOSCA Clean Oceans and Marine Recycling Cluster) in November 2023, Bergen, Norway.

- Poster contribution "Degradation of monofilaments for fishing gear due to natural and artificial weathering" (see Fig. 2, Seventh International Symposium Frontiers in Polymer Science, organiser: Elsevier) in May/June 2023, Gothenburg, Sweden.

The photos below exhibits demersal seine ropes before and after being used. Further details and the latest results of studies on demersal ropes and possible biodegradable alternatives can be found in Publication 1.

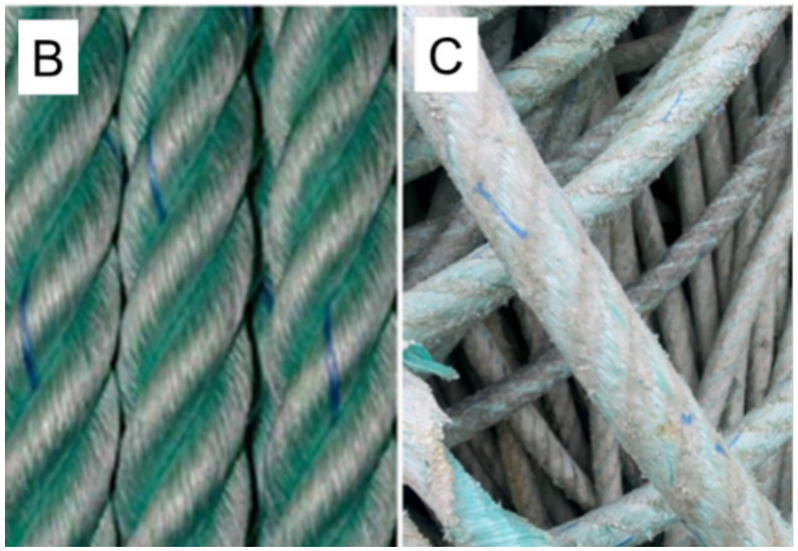


Photo (B) 50 mm demersal seine ropes when they are new, and (C) the same ropes after being used for one season. Source: SINTEF Ocean).

Photo: SINTEF

RA 3 Tests and Demonstrations at Sea

Objectives and motivation

This research area will develop, test, validate, and optimize biodegradable gears for specific applications in fisheries and aquaculture. The industry will need robust and convincing results before the production, sale, and practical use (e.g. fishing) on a large scale can take place. We expect that identification of accurate needs, development of products, and testing (documentation) will take several years for each research area. Furthermore, a change from traditional petro-based to new smart biodegradable materials must include performance (including catch pattern), service time, handling and mending costs and efficiency analyses (in the case of fishing gears) of existing and new technology. Sea trials will be conducted in Norway, Denmark, Germany, and Croatia. Testing in the Norwegian, North, Baltic, and Adriatic Seas will ensure that we obtain data about the performance of biodegradable twines and ropes, the catch efficiency of nets, and how degradation varies in relation to different environmental conditions. This will enable extrapolation to other fisheries and help to promote use of biodegradable fishing gears internationally. In Norway, sea trials will be conducted under commercial conditions on board fishing vessels. Catch comparison analysis will be based on comparing length size distributions of species caught and will be carried out using appropriate software and following established statistical methods and models for scientific journals. Catch quality will be assessed if needed. Assessing the extent of unaccounted for fishing mortality of gillnets and pots will be conducted by simulating lost gears in pre-defined and controlled areas. Full-scale testing will be conducted by building codends with "dolly-ropes" (one type of chafing mat for trawl codends) made of conventional PE filaments and biodegradable filaments. The codends will be fished simultaneously in a twin trawl setup and used by a trawler during the fishing season. Researchers will weigh the amount (and measure the length) of dolly-ropes in the codend before and after the fishing trials, and they will measure the length of the dolly-rope fibres monthly. In Denmark, Germany, and Croatia, a similar methodology will be used to evaluate catch efficiencies and gear degradation.

Key research tasks

- Task 3.1: For gillnets (inshore and deep-sea gillnetting), find a combination of strength/elasticity and catchability that is comparable to or better than existing PA twines during multiple trials conducted on board commercial gillnetters.
- Task 3.2: Develop pots and traps based on biodegradable materials targeting brown crab, snow crab, red king crab, and lobster, including recreational pot fisheries.
- Task 3.3: Develop biodegradable ropes and components for coastal and deep sea longlines, because millions of nylons and polyester snoods are replaced every season and a substantial proportion of these get lost at sea.
- Task 3.4: Identify several possibilities for replacing PE, PA, PP and PES fibres with biodegradable fibres for use in twines, ropes, and netting (all fishing gears), as all fishing gears and aquaculture equipment are composed of a range of twines with various tensile strengths, abrasion resistance, twine surface area, etc.
- Task 3.5: Full-scale tests of dolly-ropes and other types of chafing mats for use in demersal (bottom) trawling.
- Task 3.6: Develop an alternative to combination ropes (30–60 mm thick steel wire ropes coated with PE fibres) for demersal seining; while they help to herd fish, thus increasing catch efficiency, they lose almost half their mass as microplastics during their service time due to abrasion against the seabed.

Photo: Jørgen Vollstad, SINTEF Ocean

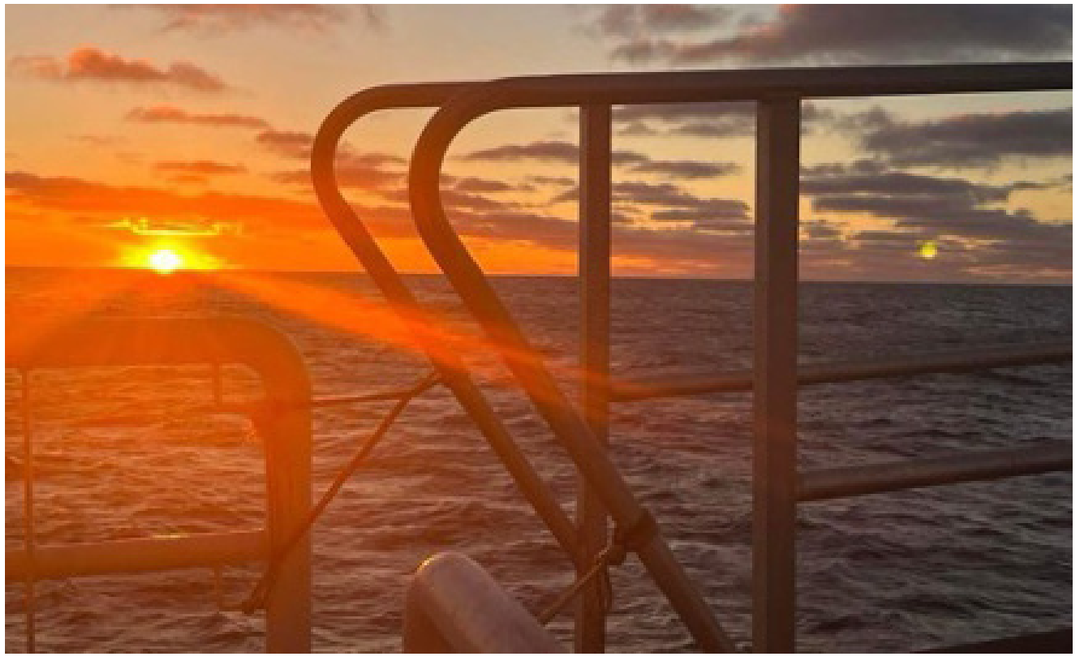


Photo: Jørgen Vollstad, SINTEF Ocean

Experiments

Snow crab pots

During 2023, we conducted experiments to estimate continuous capture or so-called "ghost fishing" by self-baited pots in snow crab (*Chionoecetes opilio)* fishery. The risk of ghost fishing in pots could be high due to potential self-baiting resulting from mortality of ghost fished catch, and earlier study has shown a considerable initial ghost fishing efficiency by such lost gear even without any bait present (https://doi.org/10.1016/j.marpolbul.2023.115249). Self-baiting in pots caused by mortality of such trapped ghost-fished crabs may increase ghost fishing by further attracting more crabs to the lost gear. Self-baiting effect in pot fisheries is seldom investigated. Therefore, our experiments, conducted in December 2023, aim to quantify ghost fishing efficiency by simulated self-baited snow crab pots containing dead snow crab relative to catch efficiency of actively fished baited pots. In addition, study investigating additional size selection mechanisms to improve snow crab size selectivity was finalized in 2023. Further use of fully biodegradable materials in such mechanisms in pot netting could be considered due to the potential to reduce continuous capture of marine animals by lost pots.

Photos: Kristine Cerbule, UiT

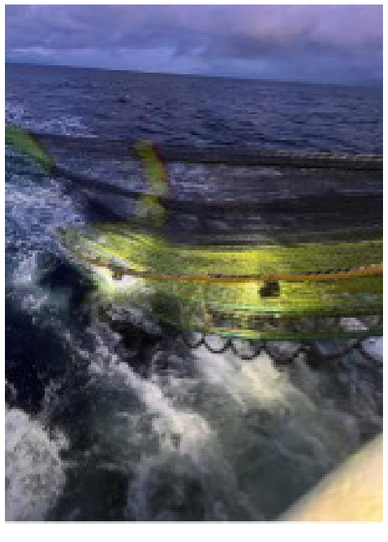
Trammel nets

Throughout November and December 2023, fishing trials were carried out in Croatian fisheries in the Adriatic Sea focusing on testing and comparing the performance of trammel nets made of PBSA and PA materials when targeting common sole (*Solea solea*). These experiments aim to evaluate the efficiency and fishing performance of both types of gear in coastal commercial fishery. The intention is to continue with experiments in the Adriatic Sea in 2024, including also longline fisheries.

Gillnets

During the end of 2023, we conducted experiments comparing catch efficiency and performance of biodegradable and nylon gillnets along the coast of Northern Norway. The trials were conducted onboard the commercial gillnet vessel "Karoline" targeting saithe (*Pollachius virens*). The data will be processed during 2024.

Photos: Jørgen Vollstad, SINTEF Ocean



Publications

Use of biodegradable materials to reduce marine plastic pollution in small scale coastal longline fisheries.

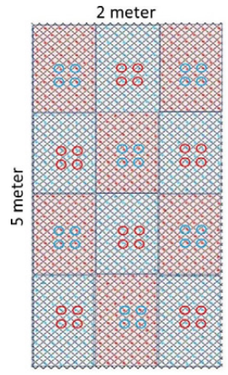
The aims of this study were to estimate marine pollution resulting from coastal longline fishery in Croatia following the earlier trials in Norway and investigate the use of new biodegradable materials. We estimated what is the loss of snood lines in longlines that has a risk to be lost at sea during the fishing process. Further, we compared the use of biodegradable materials in snood lines compared to commonly used nylon material. The results showed that the risk for nylon snood loss in this longline fishery is 3 % for each snood for each deployment, demonstrating that the use of more environmentally friendly materials is necessary to reduce plastic pollution. No significant differences between the performance of nylon and biodegradable materials were found during initial use in the fishery.
Cerbule, K., Herrmann, B., Trumbić, Ž., Petrić, M., Šifner, S. K., Grimaldo, E., Larsen, R.B., Brčić, J. (2023). Use of biodegradable materials to reduce marine plastic pollution in small scale coastal longline fisheries. Journal for Nature Conservation 74, 126438. doi: 10.1016/j.jnc.2023.126438.

Ghost fishing efficiency by lost, abandoned or discarded pots in snow crab (*Chionoecetes opilio*) fishery

This study was designed to estimate the extent of continuous capture of marine animals, so-called "ghost fishing" in lost, abandoned or otherwise discarded fishing gear (ALDFG) in snow crab pot fishery. Knowledge of the ghost fishing efficiency would provide information to understand the extent of the negative effect pots have on snow crab mortality as well economical losses for the fishery. The results showed that on average, the ghost fishing pots captured over 8 % target-sized snow crab compared to the actively fished baited pots, demonstrating that lost pots can continue fishing even when the bait is decayed.
Cerbule, K., Herrmann, B., Grimaldo, E., Brinkhof, J., Sistiaga, M., Larsen, R.B., Bak-Jensen, Z. (2023). Ghost fishing efficiency by lost, abandoned or discarded pots in snow crab (Chionoecetes opilio) fishery. Marine Pollution Bulletin 193, 115249. doi: 10.1016/j.marpolbul.2023.115249.

Reducing plastic pollution caused by demersal fisheries.

This study was focused on wear and tear of various section made from plastics in bottom trawls and demersal seines. In Norway, these fishing gears account for more than 70 % of the landings of demersal fish species, but they are also the leading sources of microplastics generated by fisheries. Because these two fishing gears are widely used around the world, replacing fossil-based non-degradable plastics with more abrasion-resistant materials, including biodegradable polymers, should contribute to the reduction of marine litter and its associated environmental impacts.
Eduardo Grimaldo, Christian W. Karl, Anja Alvestad, Anna-Maria Persson, Stephan Kubowicz, Kjell Olafsen, Hanne Hjelle Hatlebrekke, Grethe Lilleng, Ilmar Brinkhof (2023). Marine Pollution Bulletin, 196, 115634, doi.org/10.1016/j.marpolbul.2023.115634.



Photos: Grimaldo et al., 2023.

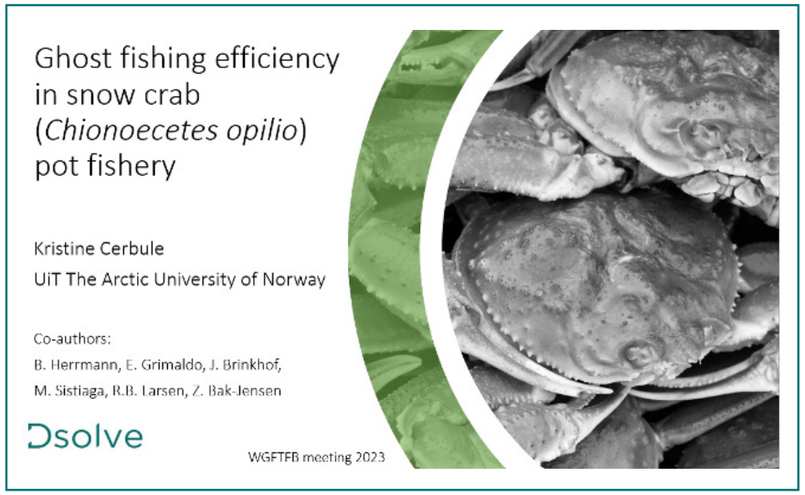
Effect of gillnet twine thickness on capture pattern and efficiency in the Northeast-Arctic cod (*Gadus morhua*) fishery

This study aimed to evaluate the feasibility of increasing the thickness of gillnet twine. One potential method to mitigate the environmental impact of discarded or lost gillnets is by introducing a biodegradable alternative to nylon in gillnet construction. Previous research on biodegradable PBSAT gillnets has indicated a notable decrease in catch efficiency compared to polyamide gillnets (Grimaldo et al., 2018, Grimaldo et al., 2018b, Grimaldo et al., 2019, Grimaldo et al., 2020, Grimaldo et al., 2020). This decline in catch efficiency has been attributed to the physical properties of the gear material, such as elasticity and breaking strength, which are influenced by twine thickness. However, the findings of this study demonstrate that it is feasible to use a range of twine thicknesses without compromising the effectiveness of gillnets. Consequently, future biodegradable gillnets could potentially utilize thicker twine to offset the loss of catch efficiency reported by Grimaldo et al. (2018a). By doing so, the insights gained from this study could have beneficial implications for reducing marine pollution, as they encourage further advancements in biodegradable materials and the production of more robust gillnet twines, thereby decreasing the amount of plastic waste stemming from abandoned and lost gear.
Brinkhof, I., Herrmann, B., Larsen, R. B., Brinkhof, J., Grimaldo, E., & Vollstad, J. (2023). Effect of gillnet twine thickness on capture pattern and efficiency in the Northeast-Arctic cod (Gadus morhua) fishery. Marine Pollution Bulletin, 191, 114927. https://doi.org/10.1016/j.marpolbul.2023.114927.

Photos: Jure Brčić, University of Split

Meetings and outreach

Results on ghost fishing in a snow crab pot fishery (doi: 10.1016/j.marpolbul.2023.115249) were presented during **ICES/FAO Working Group on Fishing Technology and Fish Behaviour** meeting in February 2023 in Kochi, India during a Topic Group meeting *ALDFG - Abandoned, lost, or otherwise discarded fishing gear.* The presentation was entitled *Ghost fishing efficiency in snow crab (Chionoecetes opilio) pot fishery.*



Two presentations were made during the **Arctic Frontiers** conference in early 2023 in Tromsø, Norway ("Moving North 2023"). One of the presentations was about the potential of using biodegradable materials in longline fishery to reduce marine plastic pollution. The second presentation discussedthe research regarding marine plastic pollution resulting from seine fisheries.

The project *Networking for increasing sustainability in snow crab fisheries in the Arctic* was funded by **UArctic Project Grants**. The project aims to address sustainability challenges in snow crab fisheries, specifically focusing on challenges caused by lost fishing gear and plastic materials used in snow crab pots. The aim of this project links with objectives of CRI Dsolve by specifically focusing on challenges caused by lost fishing gear and plastic materials used in snow crab pots.

Presentation during the **59th Croatian & 19th International Symposium on Agriculture** took place in 2023, showing the resutls regarding the potential of using biodegradable materials in the Adriatic longline fishery.
Jure Brčić, Kristine Cerbule, Bent Herrmann, Željka Trumbić, Mirela Petrić, Svjetlana Krstulović Šifner. The potential use of biodegradable materials in the Adriatic Sea small scale longline fishery. // 59th Croatian & 19th International Symposium on Agriculture / Carović-Stanko, K., Širić, I. (ur.). Zagreb: Sveučilište u Zagrebu, Agronomski fakultet, 2023. pp. 152.

During the first week of May 2023, Maritime High School from Split, Croatia welcomed 17 students and 7 teachers from Germany, Italy, and Portugal through the ERASMUS+ project *Be brave - help us fight the plastic wave: Getting aware of plastics (GAP)*. During that week the students visited University of Split (University Department of Marine Studies and Faculty of Maritime Studies) where they were given several lectures about marine plastic pollution. Within the lecture titled *The use of biodegradable materials in fisheries,* students were introduced with the problem of ghost fishing and the plastic pollution coming from fisheries and the role that the Dsolve project has in combating marine plastic pollution.

PhD candidates

Kristine Cerbule – The Faculty of Biosciences, Fisheries and Economics (BFE), Norwegian College of Fishery Science, UiT.
The research interests focus of this PhD is on testing the performance of fishing gears made using new biodegradable plastic materials, and assessment of challenges caused by lost, abandoned, or otherwise discarded fishing gear.

Photo: Dsolve

RA 4 Governance Incentives

Objectives and motivation

The central objectives of Research Area 4 are to:

- 4.1 Assess economic effects of non-biodegradable materials used in fisheries and aquaculture.
- 4.2 Determine costs and benefits related to ecosystem services from introducing biodegradable materials in the fisheries and aquaculture industries.
- 4.3 Investigate institutional incentives to increase the use of biodegradable applications used in marine industries and help supporting the public support systems to reduce risk and promote implementation of biodegradable innovations.

The motivation for these objectives is to broaden our understanding of the consequences of non-biodegradables materials in fisheries and aquaculture to also include economic aspects. Furthermore, this work will provide input into how these consequences could be lessened by governance actions.

The key research tasks of Research Area 4 and achievements in 2023 are presented below.

Key research tasks

RA 4's research tasks are closely linked to the objectives. Early tasks have therefore focused on ghost fishing, as a central consequence of non-biodegradables in fisheries, specifically involving gathering relevant knowledge and data, and in order to gauge governance issues, start understanding fishers' attitudes towards biodegradable fishing gear. Below are some key research tasks:

- Submit and revise paper on ghost fishing in the snow crab fishery in the Barents Sea.
- Develop a survey, in collaboration with UiT researchers, on the attitudes of fishers towards biodegradable fishing gears.
- Develop and submit paper studying data obtained on fisher attitudes.
- Develop paper on bioeconomic modelling of ghost fishing.
- Develop and carry out second fisher survey (1st survey funded by The Norwegian Retailers Environment Fund) on the willingness to accept compensation by fishers for using biodegradable fishing gear.
- Start developing survey (funded by The Norwegian Retailers Environment Fund) on the willingness to pay for policies that involve biodegradable fishing and aquaculture gear and instigate collaboration with researchers at Norwegian University of Life Sciences and in Canada for finalization of the survey. Develop survey such that it may provide non-use values that can be applied in bioeconomic models.

Achievements in 2023

Submitted papers:

Standal, D. and Hersoug, B.: Walking sideways? Management of the Norwegian snow crab fishery. Revise and Resubmit Marine Policy.

Do, H-L. and Armstrong, C.W. Navigating Transition: Understanding Fishers' Perceptions of Biodegradable Fishing Gear Adoption. Submitted Economic Analysis and Policy.

Presentation

Huu-Luat Do: Ghost fishing and retrieval of lost fishing gear - A case study of the Norwegian snow crab fishery in the Barents Sea, NAAFE 2023 conference, USA.

Below is some material from the two fisher surveys carried out in 2023:

RA4 conducted a survey on Norwegian fishers' preferences for biodegradable fishing gear, yielding 800 responses. In terms of the issue of lost fishing gear, nearly 98% of fishers in the sample have been informed about and express concern regarding the problems associated with lost fishing gear in Norway, as illustrated in Figures 1 and 2.

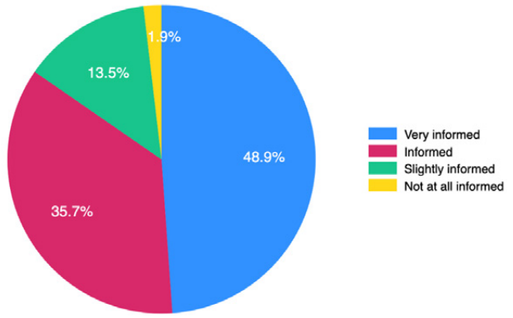


Figure 1. Fishers' degree of being informed about the problem of lost fishing gear.

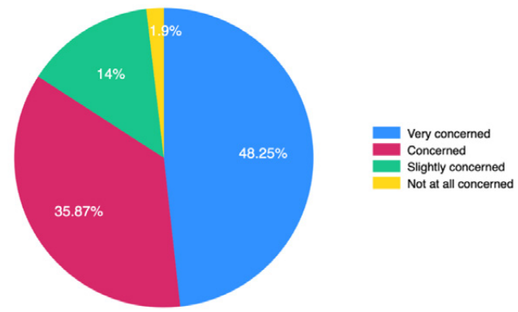


Figure 2. Fishers' concern regarding the problem of lost fishing gear.

Figure 3 illustrates fishers' perspectives on support for a program to develop biodegradable fishing gear. The hypothetical scenario presented to them was as follows:

"Now consider a hypothetical research program of the Research Council of Norway aiming at developing biodegradable fishing gear. The biodegradable fishing gear will be produced from materials that are more degradable than plastic/nylon and will significantly mitigate the negative impacts from lost fishing gear. How much would you support or oppose a program to develop biodegradable fishing gear?"

The results show that over 60% of fishers in the sample support the program, with approximately 30% expressing strong support. However, around 18% of fishers opposed the program for developing biodegradable fishing gear. When asked about supporting a policy that required all fishers to adopt biodegradable fishing gear, over half of the fishers in the sample did not support the policy, while around 41% expressed support, as depicted in Figure 4.

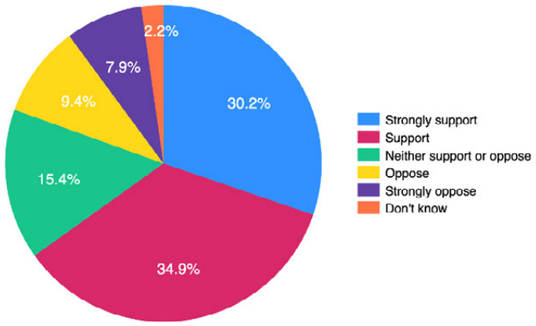


Figure 3. Fisher support for a program to develop biodegradable fishing gear.

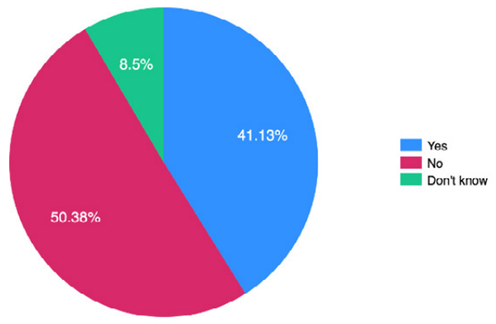


Figure 4. Fisher support for a program that requires all fishers to adopt biodegradable fishing gear.

In terms of fishers' perspectives on incentivizing the use of biodegradable fishing gear, respondents were asked to indicate their level of agreement or disagreement with statements. The results show that nearly 43% of fishers disagreed or strongly disagreed with a statement suggesting that fishers using plastic fishing gear should pay more for the impact of lost fishing gear, as shown in Figure 5. Interestingly, almost one third of the fishers agreed or strongly agreed that fishers using plastic gear should pay more for the impacts of lost gear.

In a second survey, a telephone survey of 921 fishers, the respondents were asked about their awareness of biodegradable fishing gear. It was found that over 65% of fishers knew of the existence of biodegradable fishing gear, while about 35% of the fishers in the sample were not aware of biodegradable fishing gear.

As can be seen in Figure 6, fishers' perspectives regarding biodegradable fishing gear, based on a number of different statements, indicate that most fishers agreed or strongly agreed with costs increasing due to biodegradable fishing gear, and that subsidies were required. The perspectives regarding fisher and public attitudes to biodegradable and non-biodegradable fishing gear were more mixed. There was substantial disagreement regarding the statements related to increased regulation or fees for use of non-degradable gear, and potential increases in market prices for use of biodegradable gear.

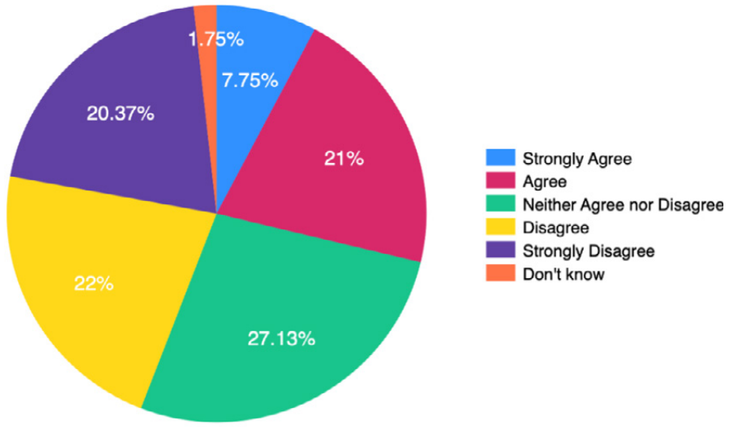


Figure 5. Fishers using plastic fishing gear should pay more for the impacts of lost gear.

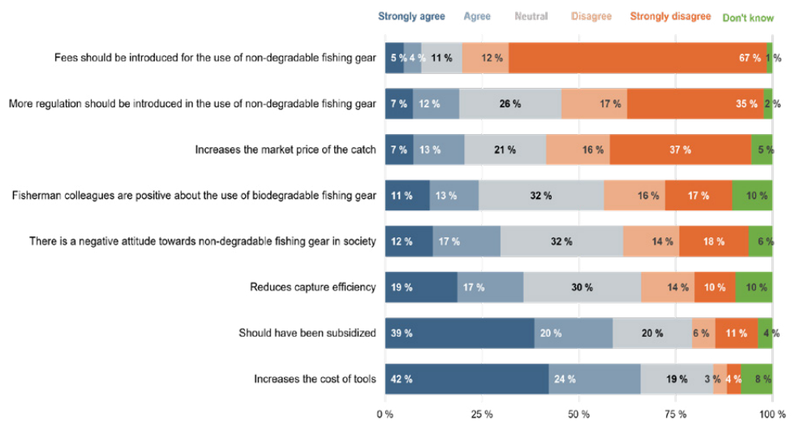


Figure 6. Fishers' perspectives regarding non- and biodegradable fishing gear

RA 5 Circularity of Plastics

Objectives and motivation

Ghost fishing and plastic littering caused by losses of gear from fishing and aquaculture are environmental problems causing impacts on marine ecosystems. These impacts are only partially understood and due to the longevity and strength of this gear, these problems accumulate over time, meaning that the impacts from these losses are felt for the long lives of the durable materials they are made from.

Development of sustainable circular downstream solutions for existing fossil-based, non-degradable and future bio-based and biodegradable plastic fishing gear and aquaculture equipment will benefit the fishing and aquaculture industries and marine ecosystems.

Understanding key aspects of the value chains involved, analysed using life cycle assessment (LCA), will enable the value chain partners involved in Dsolve to understand the positive and negative impacts associated with different materials that can be used to develop innovative solutions to the ghost fishing challenge.

The key research tasks of Research Area 5 and achievements in 2023 are presented below.

Key research tasks

In 2023 the research activities focussed on gathering data and developing LCA models in order to perform Task 5.2: to Perform LCA assessments of the defined fishing gear systems and materials based on data from Task 5.1, taking into account the entire value chain from production to end-of-life. The LCA methodology is based on systems engineering and the software used is SimaPro.

Other research tasks to be carried out in 2023 were:

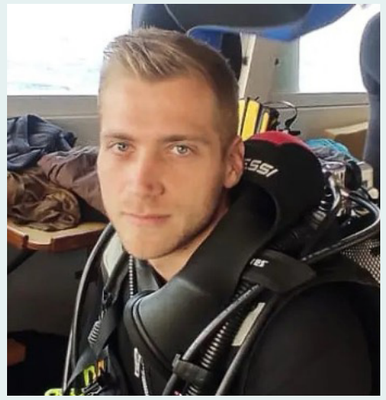
- To recruit a PhD candidate for Work Area 5
- Identification of relevant aquaculture equipment for potential substitution with biodegradable materials
- To make progress on data gathering for biodegradable materials production with partners in Korea
- Collaboration and methodology development for marine litter impacts with MarILCA (https://marilca.org/), including participation at MarILCA scientific committee meetings
- Collaboration with the UNEP Life Cycle Initiative GLAM (Global Guidance for Life Cycle Impact Assessment Indicators and Methods), including continuation of Cecilia Askham's co-chairing work for the subtask on weighting.

Achievements in 2023

Ghost fishing PhD

Dorian Vodopia started work as the PhD student in Research Area 5 in 2023. We are excited to see how his work on quantifying the impacts of ghost fishing will progress in the coming years.

We are very pleased that Professor Francesca Verones from NTNU will be a key supervisor for Dorian, in addition to Professor Roger Larsen (UiT) and Dr. Cecilia Askham (NORSUS)



PhD candidate Dorian Vodopia

Photo: Alessia Vodopia

Professor Franscesca Verones

Photo: NTNU

Dorian Vodopia joined the Norwegian Directorate of Fisheries' annual abandoned, lost, and discarded fishing gear (ALDFG) retrieval operation in September 2023. The retrieval operation endeavours to locate ALDFG at locations predetermined by researchers from the Norwegian Directorate of Fisheries, based on fishermen's reports of lost fishing gear.

It was an important experience to see the clean-up operation and observe the ghost fishing catch in the retrieved nets. The objective of the work was to introduce an approach to assess the impact of ghost fishing on marine ecosystems and biodiversity through ALDFG retrieval operations. Dorian has investigated the relationships between ghost fishing catch abundance, catch biomass and the mass of retrieved ALDFG using data from the retrieval operation. The catch recorded is only a snapshot in time of the ghost fishing potential of the retrieved ALDFG, but still provides important data for Dorian's work. Dorian recorded the catch in the recovered nets and pots, counting the number and measuring the size of the fish and crabs caught. The data gathered on this trip is the basis for the first paper to be written in Dorian's PhD journey.

Photos: Dorian Vodopia, UiT

LCA work

A parameterized model framework has been developed in SimaPro software for E-LCA of different fishing gear systems and materials, including a framework for circular materials. Data for different types of conventional gear has been provided by fishing gear suppliers, such that the model could be populated with gear data for five different cases: fishing for cod (Gadus morhua) using gillnets, trawl, demersal seine nets, auto line and fishing for snow crabs using pots. These systems are the reference cases that will be compared to gear systems where biodegradable plastic can be used. Data for biodegradable plastics is the data gathering focus for 2024.

Communication and dissemination

The Dsolve project was presented by NORSUS in the following presentations in scientific and popular science forums in 2023.

At the SETAC Europe Conference, Cecilia Askham was one of the chairs for the session 5.07 - Reducing Plastics Impacts: Integrating Risk Assessment, Life Cycle Analysis and Material Flow Analysis Towards a Circular Economy. Valentina Pauna was one of the chairs of the session: Understanding Microplastic Fate and (Eco) Toxicity Through Interdisciplinary Collaboration.

Dr. Pauna and Dr. Askham at the Society of Environmental Toxicology and Chemistry's (SETAC) 33rd Annual Meeting in Dublin, May 2023.
Photo: Simon Saxegård

Cecilia Askham was asked to explain "Plastikk er ikke bare plastikk" (Plastic is not just plastic) in a popular science way in her presentation at the Gartner 2023 event in Lillestrøm, Norway in October.

Dr. Askham was also invited to present Generating environmental sampling and testing data for micro- and nanoplastics for use in life cycle impact assessment at the event Recent advances in plastic and plastic additives research - Can we transition to risk-based prioritization, organised by University of Bergen Plastics Network in November.

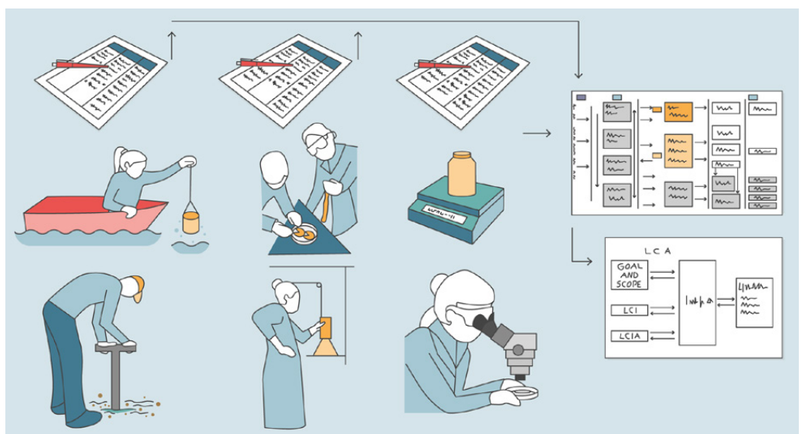
Dr. Valentina Pauna joined the Clean Oceans Arena 2023 to talk about the Dsolve project and circularity in alternative materials. Clean Oceans Arena was arranged by the Norwegian innovation clusters NOSCA Clean Oceans and Marine Recycling Cluster.
Students at the Norwegian University of Life Sciences (NMBU) also heard about the Dsolve project during a guest lecture by Cecilia Askham as part of their course Life Cycle Assessment - Environmental Impacts of Energy and Waste Systems.

LCA Methodology

In connection with the Dsolve project and as part of NORSUS' international methodological work, Cecilia Askham and Valentina Pauna are part of the MarILCA Scientific Committee and participated in their meetings and work in 2023 (www.marilca.org).
Weighting is a part of LCA methodology that can be employed when comparing product systems with different types of environmental impacts. This aids in decision-making when the impact results point in different directions. Weighting of different environmental impacts and areas of protection to facilitate decision-making is difficult and can be controversial. Dsolve project impact assessment calculations will use the factors developed by the GLAM project. GLAM is a project for the United Nations Environment Programme's Life Cycle Initiative. These impact assessment methods are planned to be published in 2024.

Publications

The publication we announced in 2022 as accepted in Science of the Total Environment appeared in the print version of the journal in February 2023.
Cecilia Askham, Valentina H. Pauna, Anne-Marie Boulay, Peter Fantke, Olivier Jolliet, Jérôme Lavoie, Andy M. Booth, Claire Coutris, Francesca Verones, Miriam Weber, Martina G. Vijver, Amy Lusher, Carla Hajjar *Generating environmental sampling and testing data for micro- and nanoplastics for use in life cycle impact assessment,* Science of The Total Environment, Volume 859, Part 2, 2023, 160038, ISSN 0048-9697. https://doi.org/10.1016/j.scitotenv.2022.160038,



Dorian Vodopia: Circularity of biobased, biodegradable, and non-degradable plastics (youtube.com)

Photo: Dorian Vodopia

The presentation was part of the second Famnits' Biological Evening: https://www.famnit.upr.si/en/news/second-famnits-biol. Additionally, a more in-depth seminar was conducted for master's and PhD students at FAMNIT, University of Primorska, Koper, Slovenia (photo). Furthermore to Marine Science bachelor's degree students at the University of Pula.

Key researchers and key personnel

Dr. Cecilia Askham, Senior Researcher.

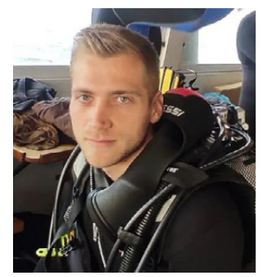
Dr. Valentina Pauna, Senior Researcher

Mafalda Silva, Researcher.

Photos: NORSUS

PhD candidates and Master students

Dorian Vodopia has begun his PhD position on the theme of inclusion of ghost fishing and its effects on ecosystems and biodiversity in life cycle impact assessment in 2023.



Dorian Vodopia, PhD candidate.

Photo: Alessia Vodopia

RA 6 Communication, Dissemination and Exploitation

Objectives and motivation

Research Area 6 (RA 6) will develop and carry out a dynamic plan for outreach through communication, dissemination, and exploitation of results to maximize the impact of the CRI. Dialogue with affected industries and stakeholders through seminars, workshops, and networking is particularly emphasized. Further dissemination will occur through a publicly accessible website https://dsolve-sfi.no/ and social media, as well as publications in specialized journals and magazines, presentations, press releases, popular science publications, video and other media productions. RA6 is led by UiT and carried out in cooperation with Salt Lofoten AS (SALT).

The results of the CRI Dsolve will provide valuable scientific knowledge on biodegradable products necessary for the sustainable, circular economy. The work undertaken by Dsolve is essential for advancing the research, innovation, documentation, and design of these novel products. The resulting innovations will be important to enhance Norway`s leading position in global fishery and aquaculture and reflect its ambition to be at the forefront of research and innovation on marine plastic pollution. Through the activities in RA 6, the CRI has adopted a comprehensive communication approach, aimed at maximizing the visibility of the Centre, its goals, and challenges. The communication agenda also aims to make making results visible for stakeholders, including industry, the scientific community, authorities, policy makers, and the public. The concrete objectives of the agenda can be described as: 1) Develop and apply actions to maximize the impact of the CRI research. 2) Ensure a wide dissemination and uptake of the results of the CRI. 3) Ensure a close relationship between the academic community and industrial partners and facilitate the exploitation of results and the transfer of technology.

A dynamic dissemination and exploitation plan (DEP) was developed in a preliminary phase at during startup of the CRI Dsolve and is regularly updated throughout the Centre's life span. The main communication activities for each year are described in the respective annual plans and publication plans, including a) the participation in conferences, trade fairs, and national and international exhibitions; b) specifications about the promotion channels to be used; c) timing for outreach activities and raising awareness of results, and d) partners responsible for the various activities.

The key research tasks for Research Area 6 and achievements in 2023 are presented below.

Key Research tasks

- Dissemination activities
- Communication activities
- Exploitation of results

Achievements for 2023

Dissemination activities

- Communication & dissemination Plan 2021-2028
- Social media strategy/publication plan and Annual plan 2023
- New website https://dsolve-sfi.no/
- Social media videos
- Social media Campaign Week (week 35)
- Promotion at Aqua-Nor and Arendalsuka
- Podcast episode – What is biodegradable plastic (English version)
- Web site and social media updates

The dynamic dissemination and exploitation plan (DEP) 2021-2028 has been further developed and carried out in 2023 through the determination of an annual activity plan for the RA, and a publication plan for social media. The research area has amongst other things, produced the following outcomes: 1) A new and improved publicly accessible web site to further strengthen the dissemination of the CRI, its research, results, and public awareness of the work and existence of the CRI. The new website https://dsolve-sfi.no/ is available in both Norwegian and English language 2) Web and social media have been frequently updated to communicate the progress of the CRI, its research, scientific results, publications, participants, and cooperation. Presentations of industry partners on web and social media have been specially emphasized. 4) Social media videos in cooperation with industry and scientific partners. 5) A social media campaign week (week 35) focusing on biodegradable materials for the fishery and aquaculture industry. During the week scientists from the CRI Dsolve answered questions submitted by stakeholders about the CRI and biodegradable materials. The campaign week was promoted to stakeholders in advance at both Aqua-Nor and Arendalsuka. 4) A poster focusing on the environmental impact and use of plastic ropes in the aquaculture industry was presented at Aqua-Nor. 5) An English version of the CRI Dsolve podcast on biodegradable plastics was produced in cooperation with the partners UiT, Sintef Industry and Norner, and made available at popular streaming services for an international audience. Lastly, 6) News and results from the project have been disseminated through traditional and social media as well as presentations at relevant conferences throughout the year, in cooperation with the scientific partners.

Communication activities

- Social media (SoMe) and web production; Facebook, LinkedIn, Twitter
- Media kit for industry partners
- Poster presentations
- Profile material
- Partner workshops

The CRI website was continuously updated in 2023 and a new and improved website produced and launched during the year. Publications and news from the Centre were continuously published on the website, including both scientific and popular science articles. Summaries of relevant scientific articles were produced and published on the website. The Centre`s Facebook, LinkedIn and Twitter pages were continuously updated in line with the social media strategy and publication plan, to communicate information about the Centre, its research, progress, and results. The website was also used to inform the public about relevant events, and to raise awareness on biodegradable plastics. Profile materials, such as posters, flyers, fact sheets, roll ups etc. were produced, as needed, to promote the Centre at conferences, fairs, and events, including poster presentations for Aqua-Nor and Arendalsuka. QR-coding was used to direct the audience to the project website and podcasts. A media kit has been produced for industry partners and distributed to them to strengthen their communication about the CRI. Finally, a series of digital workshops has been arranged to strengthen communication among partners, and the dissemination of research status and results within the CRI. The workshops gathered a high number of research and industrial participants from national and international partners.

Exploitation of results

- Annual report 2022
- Arctic Frontiers: Poster presentation
- Seminar – Extended producer responsibility (EPR) and new material solutions (Lofotfishing 2023)
- The First International Ghost Gear Conference, Arendal: Lecture (RA2) and poster presentations
- Research Summary (popular science)
- Web site and social media updates
- Other conferences and events

CRI Dsolve was presented at selected national and international conferences by research partners, in fairs, meetings, and events, where RA 6 contributed to facilitate and/or disseminate the representation of the Centre in collaboration with scientific and industry partners. Activities included lectures and presentations by research partners at *Håp i Havet* (UiT) 16.02, *SETAC* (WP5) 30.04-04.05, *Annual Meeting Norges Råfisklag* (UiT) 10.05, *The International Ghost Gear Conference* (WP2) 08.11, *Clean Oceans Arena* 2023 (WP5) 21.-22.11, *#Arctic Plastics 2023* (UiT) 22.-23.11. Poster presentations at *Arctic Frontiers* 30.01-02.02, *Arendalsuka* (WP6) 14.-18.08, *Aqua-Nor* 22.-24.08, and *The International Ghost Gear Conference* 7.-8.11. CRI Dsolve was represented in cooperation with partners at both *Lofotfishing* 2023 and *Aqua-Nor* 2023. A seminar on the topic *Producer responsibility and new material solutions* were arranged during Lofotfishing 17.03.23, gathering 26 participants from industry, gear producers, waste companies, partners, and relevant stakeholders. Among represented partners in the seminar were Sintef Ocean, Norges Råfisklag and Norges Fiskarlag. A summary (popular science) of the scientific article *Can biodegradable materials reduce plastic pollution without decreasing catch efficiency in longline fishery?* (Cerbule, Kristine; Grimaldo Eduardo; Hermann, Bent; Larsen, Roger, B.; Brcic, Jure; Vollstad, Jørgen) was produced and published on the website.

Some of our Dissemination activities in 2023

Photo: SALT

#Arcticplastic:
CRI Dsolve contributed to the #Arcticplastic 2023, the Second International Symposium on Plastics in the Arctic and Sub-Arctic Region, in Reykjavik, Iceland 22.-23. November. CRI Dsolve took part in the panel discussion on Innovate plastic pollution Reduction.

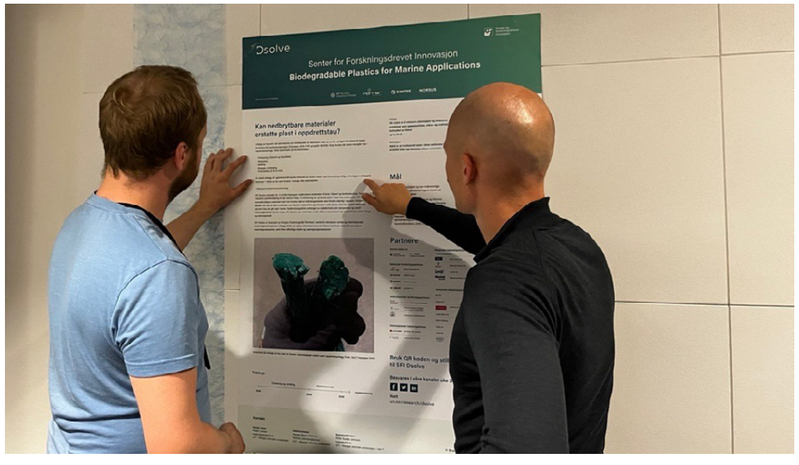


Photo: Sintef

Aqua-Nor:
In cooperation with the research partner Sintef Ocean, CRI Dsolve was represented at the Aqua-Nor 2023, 2nd-24th August. Amongst other, CRI Dsolve presented a poster focusing on the environmental impact and use of plastic ropes in the aquaculture industry, and the potential of new materials. The poster was developed in cooperation with industry partners within aquaculture and gear production.

Lofotfishing 2023:
CRI Dsolve invited fishing industry, gear producers, partners, waste handlers and relevant stakeholders to a two-hour lunch seminar during the industry fair trade Lofotfishing 2023 in Lofoten, 17th of March. The seminar discussed the topic Producer responsibility and new material Solutions and was arranged in cooperation with the Marine Recycling Cluster (MRC). Nearly 30 representatives, including several gear producers and the CRI partners Sintef Ocean, Norges Råfisklag and Norges Fiskarlag participated.

Photo: SALT

Ghost gear conference
CRI Dsolve presented a lecture and two poster presentations at the first International Ghost Gear Conference, in Arendal Norway 7th- 8th November 2023. The conference was hosted by the Norwegian Marine Institute, The Norwegian Directorate of Fisheries, and the Norwegian Retailers' Environment Fund in partnership with the Global Ghost gear Initiative and the Norwegian Centre Against Marine Litter. The conference brought together managers, researchers and specialists in ghost gear removal, as well as gear producers to find solutions on how to reduce the effects of ghost gear on marine populations and ecosystems. Dr Christian Karl from Sintef, leader of RA2 on assessment of biodegradability, presented challenges and solutions for recycled and biodegradable plastics for marine applications.

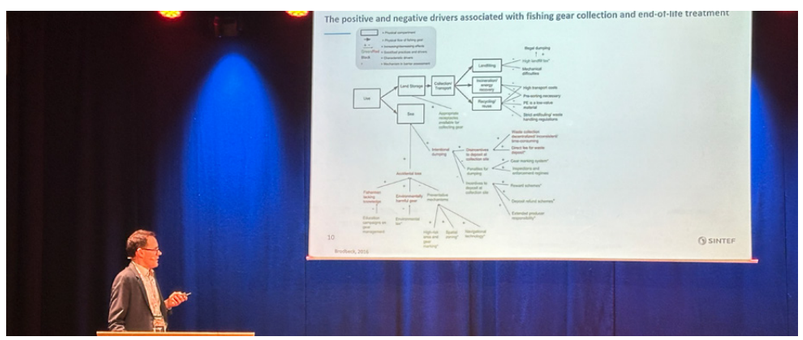


Photo: SALT

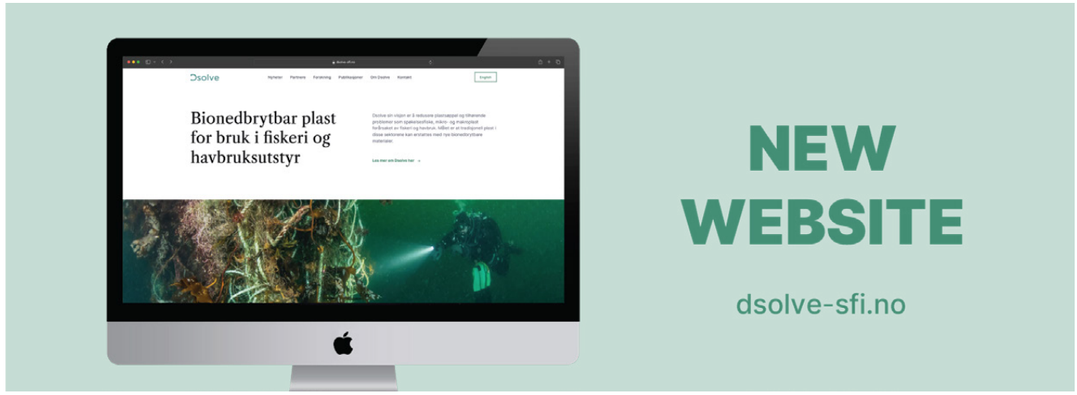


Illustration: SALT

New website
A new and improved CRI Dsolve website was launched in 2023 and promoted to stakeholders, partners and the public. The new website is available in both Norwegian and English languages, with the purpose of strengthening the dissemination of the CRI, its research, results, relevant news, and the public awareness of the CRI.

Photo: Erling Svensen/ CRI Dsolve

Social Media Campaign:
As in previous years, a Dsolve Campaign Week was carried out in social media in August 2023. In advance, the possibility to submit questions was promoted at Aqua-Nor and during Arendalsuka. The event invited industry, stakeholders, and the public to ask questions and voice concerns related to biodegradable materials for fishery and aquaculture equipment. These questions and concerns were answered in cooperation with CRI scientists and work package leaders during week 35.

Podcast
CRI Dsolve and the battle against ghost fishing was the topic for the CRI Partner Sintef`s podcast "Smart forklart" ("Cleverly explained") in August 2023, with Centre leader Roger Larsen, RA2 leader Christian Karl and Jørgen Vollstad representing RA 3 as guests in the studio. In addition, an English version of the CRI podcast episode "What is biodegradable plastics" was produced and made available on Spotify, Soundcloud, and Buzzsprout, as well as the CRI website and social media in 2023.

Illustration: SINTEF

Personnel

Key Researchers

NAME	INSTITUTION	MAIN RESEARCH AREA
Roger B. Larsen	UiT	Centre leader
Claire Armstrong	UiT	Leader RA 4. Bioeconomic modelling
Jesse Brinkhof	UiT	
Hilde Rødås Johnsen	UiT	Leader RA 6
Eduardo Grimaldo	UiT/SINTEF Ocean	Supervisor, RA 3
Bent Herrmann	UiT/SINTEF Ocean	Leader RA 3, leader Innovation and exploitation Board
Ravindra Reddy Chowreddy	Norner Research AS	Leader RA 1. Bioplastics, polymer structure and property relationship
Siw Bodil Fredriksen	Norner Research AS	Sustainable feedstocks and bioplastics
Vinh Cao	Norner Research AS	Polymer rheology
Christian W. Karl	SINTEF Industry	Leader RA2. Polymer degradation mechanisms/polymer characterization/tribology
Stephan Kubowicz	SINTEF Industry	Microplastics/polymer characterization
Kjell Olafsen	SINTEF Industry	Polymer characterization/chemical analysis
Bjørnar Arstad	SINTEF Industry	Polymer characterization
Szymon Bernat	SINTEF Industry	Polymer characterization/tribology
James Comerford	SINTEF Industry	Polymer characterization/polymer chemistry
Anna-Maria Persson	SINTEF Industry	Polymer characterization/chemical analysis
Anja Alvestad	SINTEF Ocean	Leader RA3, Fishing gear
Jørgen Vollstad	SINTEF Ocean	Leader RA3, senior engineer, Fishing gear
Dag Standal	SINTEF Ocean	Governance, RA 4
Sigrid Hakvåg	SINTEF Ocean	Microbial biodegradation and microbiome analyses
Lisbet Sørensen	SINTEF Ocean	Analytical chemistry
Heidi Moe Føre	SINTEF Ocean	Structural Engineering
Einar Hinrichsen	SINTEF Ocean	Research manager/polymer expert
Marianne Aas	SINTEF Ocean	
Hilde Wanvik	SINTEF Ocean	
Monika Pilz	SINTEF Ocean	
Halvard Aasjord	SINTEF Ocean	
Andrew Booth	SINTEF Ocean	
Gunvor Øie	SINTEF Ocean	
Ludvig Krag	DTU Aqua	Fishing gear
Esther Savina	DTU Aqua	Fishing gear/gillnet
Rikke P. Frandsen	DTU Aqua	Fishing gear/fisheries
Jure Brčić	University of Split	Fishing gear/fisheries
Mirela Petrić	University of Split	Fishing gear/fisheries

Names from Uni. of Split:

Mirela Petrić; Željka Trumbić; Svjetlana Krstulović Šifner

NAME	INSTITUTION	MAIN RESEARCH AREA
Željka Trumbić	University of Split	Fishing gear/fisheries
Svjetlana Krstulović Šifner	University of Split	Fishing gear/fisheries
Juan Santos	Thünen Institute	Fishing gear technology
Daniel Stepputtis	Thünen Institute	Fishing gear technology
Ulf Böttcher	Thünen Institute	Fishing gear technology
Aldo Raffaelli	Thünen Institute	Fishing gear technology
Chun Hwa Lee	LG Chem	Biodegradable polymer development
Yong Man Lee	LG Chem	Biodegradable polymer development
Kyung Min Min	LG Chem	Biodegradable polymer development
Ji Hyun Choi	LG Chem	Biodegradable polymer development
Hyung Joon Jeon	LG Chem	Biodegradable polymer development
Hyo Jin Bae	LG Chem	Biodegradable polymer development
Jae Hyeong Park	LG Chem	Biodegradable polymer development
Eunji Jang	LG Chem	Biodegradable polymer development
Su Bin Park	LG Chem	Biodegradable polymer development
Sung-Kyoung Park	LG Chem	Biodegradable polymer development
Geunheyeong Moon	LG Chem	Biodegradable polymer development
Dr. Cecilia Askham	NORSUS	Leader RA5. LCA
Valentina Helen Pauna	NORSUS	Science coordinator, LCA, RA 5
Mafalda Silva	NORSUS	LCA, RA 5
Francesca Verones	NTNU	RA 5. PhD supervisor

Key Personell

NAME	INSTITUTION	MAIN RESEARCH AREA
Hanne Risan Johnsen	UiT	Administrator of CRI Dsolve
Terje E. Martinussen		Leader of the Board
Terje M. Aspen	UiT	Faculty BFE director, Board member
Ivan Tatone	UiT	Technician, RA 3
Ilmar Brinkhof	UiT	Technician, RA 3
Bård Wathne Tveiten	SINTEF Ocean	Board member, research leader
Charlotte Ramberg	SINTEF Industry	Administrative support
Einar L. Hinrichsen	SINTEF Industry	Research manager/polymer expert
Birgitte Vågenes	SINTEF Industry	Lab engineer
Britt Sommer	SINTEF Industry	Lab engineer
Huiting Jin	SINTEF Industry	Lab engineer
Marius Johansen	SINTEF Industry	Lab engineer
Sivakanesar Luxsacumar	SINTEF Industry	Lab engineer
Paul Mc Mahon	SINTEF Industry	
Valeriya Føreland	Norner Research AS	Administrative support
Ole Jan Myhre	Norner Research AS	Marketing manager/Polymer expert
Thor Kamfjord	Norner Research AS	Board member, Sustainability advisor /polymer expert
Jan Lyberg	Norner Research AS	
Papasana Kalpana	Norner Research AS	
Albrecht Dix	Norner Research AS	
Sara Rud Herum	Norner Research AS	
Pål Mofossbakke	Norner Research AS	
Heidi Houghton	Norner Research AS	
Asbjørn Noraberg	Norner Research AS	
Ingeborg Paus Wik	Norner Research AS	
Hany Fakhry Anear	Norner Research AS	
Anders Galland Andersen	Norner Research AS	
Øystein Eksner	Norner Research AS	
Hanne L Raadal	NORSUS	LCA, Science advisor RA 5
Irmeline de Sadeleer	NORSUS	LCA, Science advisor RA 5
Ellen Marie Forsberg	NORSUS	Board member, director
Hanne Møller	NORSUS	
Majvi Brandbu- Opsahl	NORSUS	
Jake Chang	LG Chem	Bio-Business development
Ryan Yoon	LG Chem	Bio-Business development
Kim Sei-Hoon	S-EnPol Company	Biodegradable Polymer R&D

NAME	INSTITUTION	MAIN RESEARCH AREA
Niclas Risvoll, adviser,	SALT (subcontractor)	Web and graphics, RA 6
Vilde Sørnes Solbakken	SALT (subcontractor)	Communication and outreach, RA 6
Helene Skjeie Thorstensen	SALT (subcontractor)	Communication and outreach, RA 6
Tomas Brage	SALT (subcontractor)	Graphics, RA 6
Terje Lindal	Mørenot	Fishing gear supplier
Gunnar Kupen	NOFI	Fishing gear supplier
Olav Småbakk	NOFI	Fishing gear supplier
Stig-Endre Elvevoll	Løvold	Gear supplier
Rune Sand	Tustern	Fisheries
Ståle Dyb	Loran	Fisheries
Sigve Drønen	Opilio	Fisheries
Mikal Solhaug	M. Solhaug	Fisheries
Kristian J. K. Kalgraff	Legøy Rederi	Fisheries
Signor Antonsen	Hermes	Fisheries
Jan Roger Lerbukt	Hermes	Fisheries
Åsmund Breivik	Hermes	Fisheries
Håvard Olsen	Kvarøy Fiskeoppdrett	Aquaculture
Alf Jostein Skjærvik	SalMar ASA	Aquaculture
Maria Pettersvik Arvnes	Norges Fiskarlag	RA 6, End users
Benedicte Nielsen	Norges Råfisklag	RA 6, End users
Thor Kalsaas	Norges Råfisklag	RA 6, End users
Gunn Norvik	Norges Råfisklag	RA 6, End users
Aida Campos	IPMA	International Advisory Board
Haraldur Einarsson	Marine & Freshwater Research Institute	International Advisory Board
Paul Winger	Marine Institute	International Advisory Board
Gjermund Langedal	Fiskeridirektoratet	External Advisory Board
Anne Katrin Normann / Jan Gunnar Winther	Senter for Hav og Arktis	External Advisory Board
Inger Lise Nerland Bråte	Miljødirektoratet	External Advisory Board
Maria Sparboe	SalMar ASA	Innovation Board. Aquaculture
Stig-Endre Elvevoll	Løvold	Innovation Board
Bent Gabrielsen	Øra	Innovation Board
Lasse Rindahl	Mustad Autoline	Innovation Board. Gear supplier
Jahn N. Hoel	Mustad Autoline	Gear supplier

PhD candidates with financial support from the Centre budget

NAME	NATIONALITY	PERIOD	SEX M/F	TOPIC
Kristine Cerbule	Latvian	2021-2025	F	RA 3. Field experiments with gillnets, longlines, and crab pots in Norway (Arctic), Denmark and Croatia. The focus is on efficiency and catch patterns when changing from petro-based to biodegradable gears.
Huu-Luat Do	Vietnamese	2021-2025	M	RA 4. Modeling social costs and optimal management of ghost fishing.
Waranya Wataniyakun	Thai	2022-2026	F	RA 2. Testing and analyzing the processes in degradation of petro-based and bio-based fishing gears
Dorian Vodopia	Croatian	2023-2027	M	RA5. Quantifying the impacts of ghost fishing based on in situ data and real time observations
Anja Alvestad	Norwegian	2023-2027	F	RA 3, Field experiments with longlines and demersal seine to compare biodegradable materials to conventional plastics

Master degrees

Name	Period	Sex M/F	Topic
Simon Eliseussen	2023-2024	M	Capture technology for humpback salmon
Dag Støme	2023-2024	M	Capture technology for humpback salmon

Budget and costs

Funding (1000 NOK)	Amount
The Research Council	11 328
The host institution, UiT	11 589
Research partners*	615
Industry partners**	18 337
Organizational partners***	206
Total	**42075**

Costs (1000 NOK)	Amount
The host institution, UiT	15 586
Research partners	7878
Industry partners	18 475
Organizational partners	136
Equipment	8 500
Total	**42 075**

* SINTEF Ocean, SINTEF Industry, Norner Research AS, NORSUS, University of Split, Thünen Institute of Baltic Sea Fisheries, and DTU-Aqua

** Hermes, Kvarøy FiskeoppdrettAS, LG Chem, Løvold AS, Mustad Autoline AS, Mørenot Fishery AS, NOFI, Tustern AS, Øra AS, and S-EnPol

*** Norges Fiskarlag, Norges Råfisklag

Publications 2023

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