Dsolve

Centre for Research-based Innovation

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Biodegradable plastics for marine applications

Annual Report 2021

Photo: D Stepputtis

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Content

Summary

A busy year has passed, and we are pleased with the progress despite of many covid-19 related restrictions. We had our kick-off meeting on TEAMS January 13th, where most of the partners participated and research area leaders gave a brief overview of planned activities for 2021.

The official opening of Dsolve took place April 28th with most of the participants on TEAMS. We are grateful for contributions and greetings from the Minister of Trade, Industry and Fisheries Odd Emil Eriksen, the Dean of UiT Anne Husebekk, Executive Director of the Research Council of Norway Kristin Danielsen, Board leader Isabelle Sande, members of the partner group represented by senior adviser Jan Henrik Sandberg from the Norwegian Fishermen's Association, and CEO Håvard Olsen from aquaculture company Kvarøy Fiskeoppdrett. Invited speaker drs. Wouter-Jan Strietman, Wageningen Economic Research, gave an interesting overview of marine plastic-based litter in the North Atlantic.

In the end of November, we managed to arrange the first physical Board meeting at Kjerringøy Bryggehotell outside Bodø. The two-days meeting ended with a guided tour and presentation of company Løvold AS in Bodø.

During the year two of the three PhD students have started their projects, i.e., related to research area (RA) 3: Tests and demonstrations at sea and RA 4: Governance incentives. The third PhD candidate, i.e. at RA 2: Assessment of biodegradability has been identified, and for practical reasons will start in the beginning of 2022. The candidates come from Latvia, Viet Nam and Thailand.

Inside all RA's, we have had good activity during the year. There has been a comprehensive progress in testing biodegradable resin from LG-Chem with the aim to develop new materials to be used in fisheries and aquaculture. These products are taken further on to various degradation tests. Data have been collected from fishing gear trials like gillnets, longlines, pots, bottom trawls and demersal seines during trials in Norway, Denmark and Germany. Some of the results are reported, and several publications are in process. Three BSc students have produced reports on issues related to marine plastic pollution and associated problems. One MSc student is working with a new set of gillnet trials and will present the data in a MSc thesis and a peer-review article during 2022.

Apart from tests with bio-degradable fishing gears built from PBSAT and compared to petro-based materials as nylon and polyethylene and polypropylene, we have tested other natural materials like wood-fibers and cowhide as substitutes to petro-based ropes and fibers ("dolly-ropes"). Some results of these tests will be published in a MSc thesis in 2022. The PhD candidate within RA 3 has done field work on gillnet and longline fisheries in Denmark and Norway, while PhD candidate within RA 4 has started a literature study to build a baseline based on published literature related to ghost fishing.

Throughout 2021, RA leaders have organized meetings. Within RA 1, 2 and 3 there have been regular meetings every second month to discuss results from laboratories and field trials. In several of these meetings, our international industry partners LG-Chem and S-Enpol have participated. These meetings have been essential for further development of biodegradable plastics, and the reports are very positive. The pandemic has created delays in all sectors of production and shipment. However, field tests with a new generation of plastic materials will start in Norway and Croatia during the second half of 2022. In RA's 4: Governance incentives, 5: Circularity of plastics and 6: Communication, dissemination and exploitation, members have joined workshops and meetings also outside the consortium, with presentation for the MarILCA project and made close links to the NTNU led EU-project ATLANTIS. In addition to preparation of peer review articles, an important report on "Defining status quo for the material flow of fishing gear on a national and regional level" was produced in RA 5 together with industry partners. Activities in and between work-packages will be fully addressed in the section of Scientific activities and results.

Under the lead of RA 2, a workshop on degradation of plastics used for marine applications was organized in November. The webinar gathered many participants from research institutions and companies with interest in developing and producing new, biodegradable plastics. As a result of the webinar, new contacts were created with several companies and research institutions aiming at building partnerships and identifying funding possibilities together with Dsolve. Among these were Gaia Biomaterials (Sweden), Kompost-it (South Africa), Senbis (the Netherlands), Fraunhofer Institute for Applied Polymer Research (Germany), Institute of Plastics and Circular Economy, life cycle of biobased and conventional plastics (Germany), University of Latvia, Institute for Mechanics of Materials (Latvia), Hydra Marine Sciences GmbH (Germany), Wageningen Economic Research (the Netherlands), AZTI (Spain). Three of our research areas are linked to a two-year project funded by the Norwegian Seafood Research Fund (FHF) on "Alternative materials for demersal seine ropes and dollyropes for bottom trawl codends".

The Dsolve administration has participated in various arrangements like the Joint Working Group-meeting between Norway and Brazil on ocean related science (March 11th) and the Peter Hjort Seminar (March 25th). We have produced new articles, participated in a podcast and presented the project on regional radio (NRK Troms og Finnmark). We have planned and applied at the UiT to start a new PhD course be on subject "Marine litter and Arctic fisheries: Challenges and solutions", (10 ects). The lectures and supervision will be shared between Dsolve personnel, and will start in autumn 2022.

Summary

We have identified common areas of interest between us and SFI HAREVST led by SINTEF Ocean AS. UiT participate in two of the research areas of SFI HARVEST and it is therefore natural to join forces in several areas, including the combat against marine plastic litter. We are also working to identify mutual interests between us and SFI Visual Intelligence (at UiT), especially regarding techniques for machine learning on microfiber level in degradation studies. We participate (vice leader) in the Thematic Network on Arctic Plastic Pollution in UArctic (The University of the Arctic). UArctic, is a cooperative network of universities, colleges, research institutes and other organizations concerned with education and research in and about the North.

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 focus on gender balance. Our board leader, three out of six research area leaders, two of three PhD students, our administrative leader and several members of the board are women. The Dsolve team is pleased with the progress during 2021 and we look forward to a productive 2022.

Tromsø, April 1st 2022

Roger B. Larsen
Centre Director

Comparing petro-based synthetic fibres ("dolly-ropes") with natural materials such as chafing gear on bottom trawl codends.
Photo: R.B. Larsen, 2021

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.

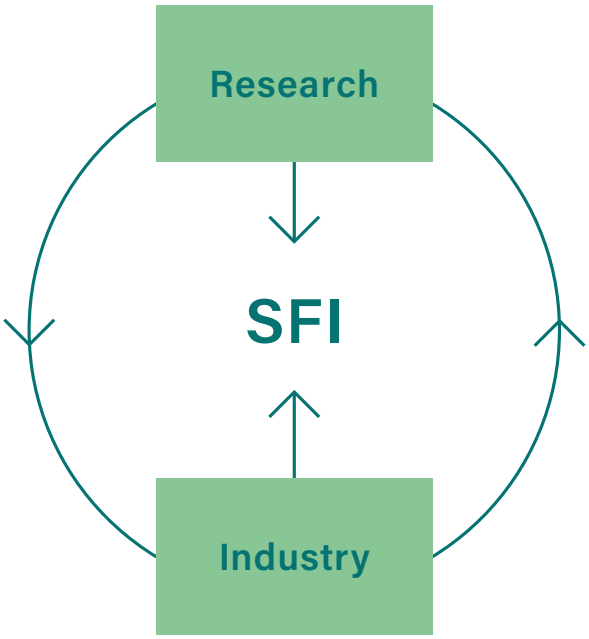


Photo: Espen Mortensen

Objectives

The **main objective of SFI Dsolve** is to reduce plastic litter and its associated problems such as macro-, 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 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.

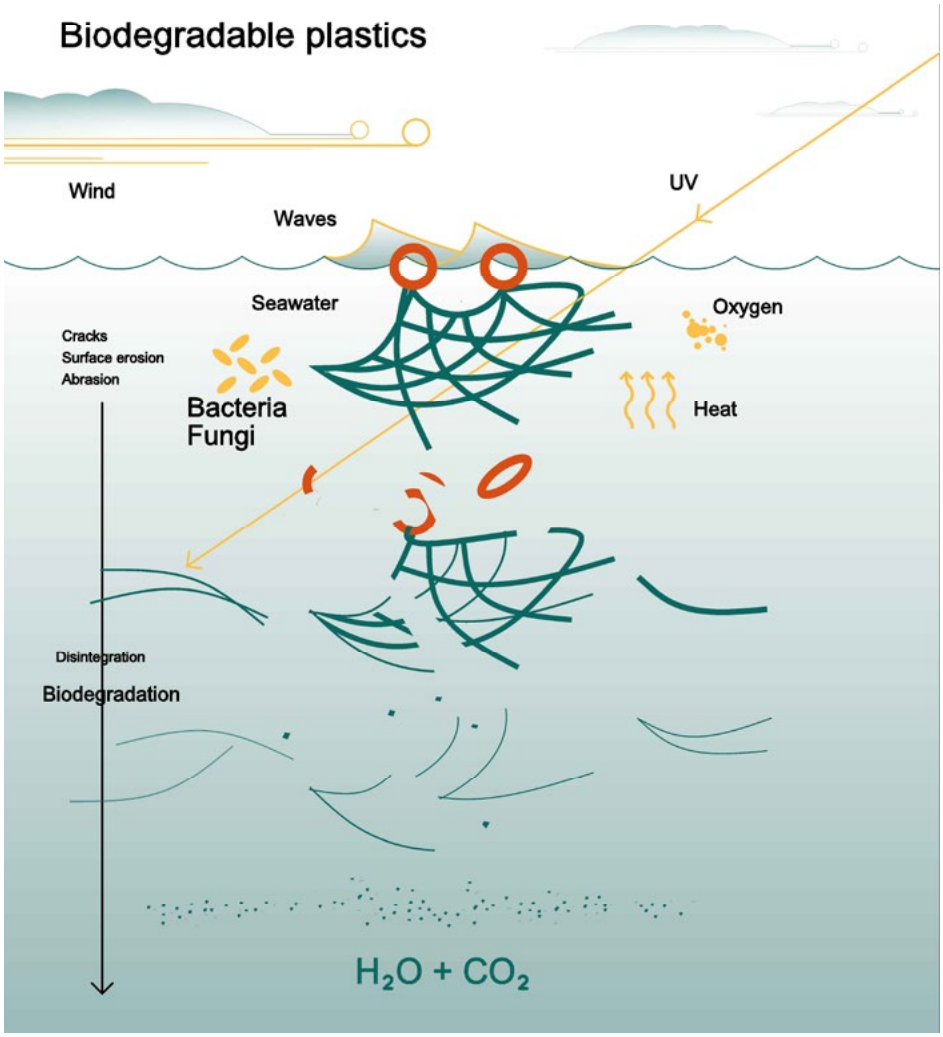


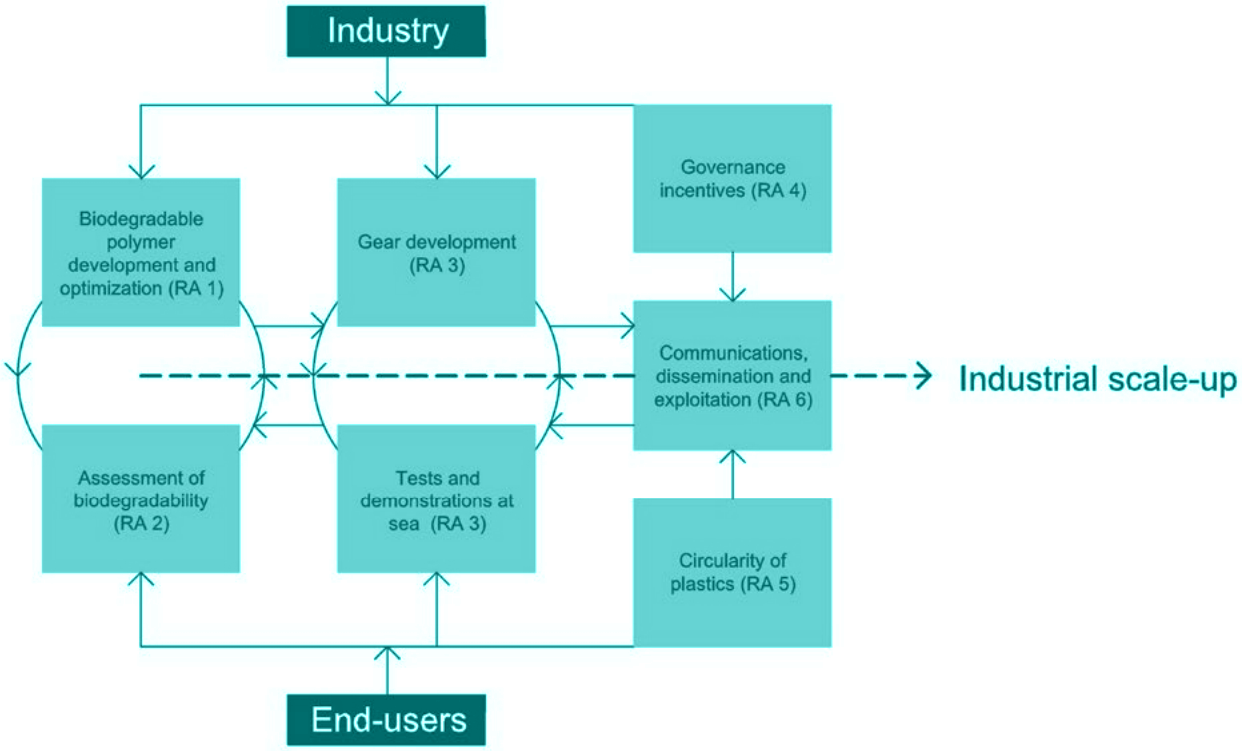
Illustration: SALT

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

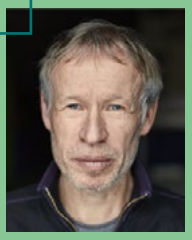
Develop a range of biodegradable plastic materials with controlled biodegradability and the properties needed for products used in the fishing and aquaculture industries

RA 2

Dr. Christian 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



Prof. Bent Herrmann
SINTEF Ocean/UiT

Sea trials in the Norwegian, North, 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

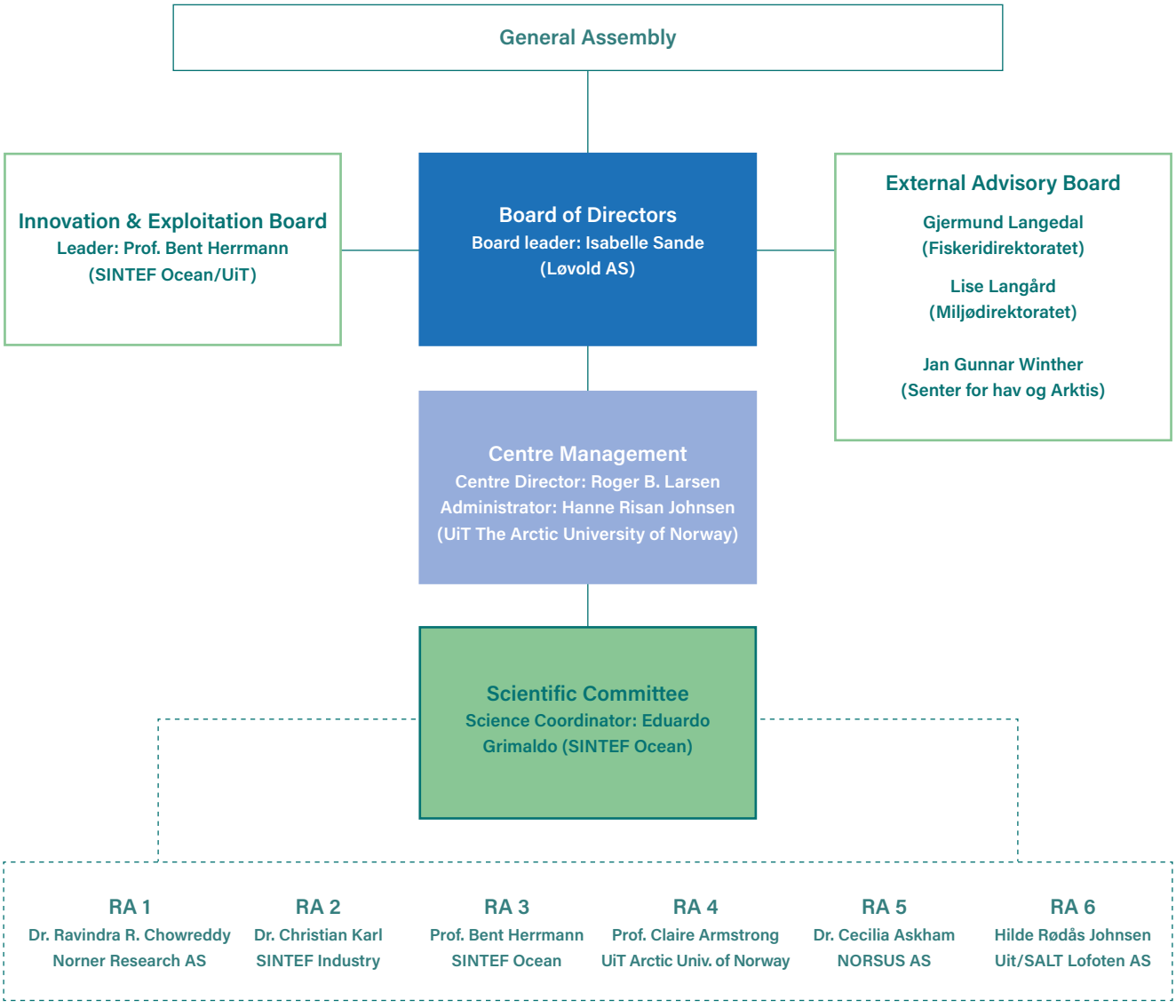
Develop sustainable circular solutions for existing non-degradable and future biodegradable fishing gear. The goal is to develop environmentally sustainable value chains which also take the level of circularity into account.

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



Centre organisation

The centre is organized as described in the figure above. The General Assembly consist of representatives from each partner institution and have the uppermost decision-making power in the centre. A Centre Board of 11 members is chosen among the partners. The board decide on organisation, budget, activities and working plans, and is responsible for the progress and scientific quality of the centre research activities. Isabelle Sande, Løvold AS has been leading the board in 2021. All partners will be represented in the board for a minimum of two years of the centre lifespan, while research partners and the host institution (UiT) will have a permanent representation.

Members of the Centre Board 2020 - 2022

ROLE	MEMBER OF CENTRE BOARD	AFFILIATION
Leader of the Board	Isabelle Sande	Løvold AS
Host Institution	Kathrine Tveiterås /Terje Aspen	UiT-BFE
Research Partners	Klaus Schöffel	Norner Research AS
	Hans Bjelland	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
	Jan-Henrik Sandberg	Norges Fiskarlag
Observer	Inger Austrem	The Research Council of Norway

The Centre Board is advised by the Innovation and Exploitation Board and the External Advisory Board. The Innovation and Exploitation Board is 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. The goal of the EAB will be to guarantee quality of the research and to maximise its impact.

Partners

Host Institution

UiT – The Arctic University of Norway

National Research Partners

Norner Research AS

SINTEF Ocean

SINTEF Industry

NORSUS AS

International Research Partners

DTU-Aqua (Denmark)

Thünen Institute of Baltic Sea Fisheries (Germany)

University of Split (Croatia)

International Industry Partners

LG Chem (South Korea)

S-EnPol (South Korea)

National Industry partners - suppliers

Nofi Tromsø AS

Mørenot Fishery AS

Løvold AS

Mustad Autoline AS

National Industry partners - users

Øra AS (coastal gillnetting)

Tustern AS (demersal seining)

Hermes AS (demersal trawling)

Legøy Rederi AS (gillnetting)

Martin Solhaug (longlining)

Opilio AS (snowcrab potting)

Loran AS (mechanical longlining)

Kvarøy Fiskeoppdrett AS

Organisations

Norges Fiskarlag

Norges Råfisklag

External Advisory Board

Senter for Hav og Arktis

Miljødirektoratet

Fiskeridirektoratet

Fiskeri- og Havbruksnæringens Forskningsfinansiering (FHF)

Scientific activities and results

The goal of our centre for research-based innovations is to develop technologies and new products, improve the governance framework, and foster innovations that enable the plastic value chains to become more circular and resource efficient. This will reduce the carbon and greenhouse gas footprints to be 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 microplastics while lost and abandoned fishing gears can cause "ghost fishing", resulting in unaccounted fishing mortality. The centre is designed to address these challenges.

The section below describes the status for the various research areas, plans and achievements in 2021. 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 one (RA1) is to develop a range of biodegradable plastic materials with the properties needed for 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 this research area is that the conventional plastic materials used in 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 materials, which have shorter lifespan for fishing gear and aquaculture equipment would reduce the plastic pollution and ghost fishing. None of the commercial biodegradable plastics meets the performance and biodegradability requirements. The research area one intends to develop biodegradable alternative materials with needed performance and biodegradability requirements for fishing gear and aquaculture equipment.

Key research tasks

- Selection, identification, sourcing, and suitable modification of biodegradable plastic materials for marine fishing and aquaculture applications.
- Development of the biodegradable materials with optimal processability, performance for fibre applications (twines, netting, ropes, etc.).
- Development of the biodegradable materials with optimal processability, performance for injection moulding applications (pots, traps, boxes, etc.).
- Development of the biodegradable materials with optimal processability, performance for coating applications (steel rope coatings).
- Investigation of potential microplastics formation from the biodegradable plastics and prediction of the degradation products.
- Establishing collaborations with materials suppliers to ensuring 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

Gas permeation chromatography (GPC) analysis to measure molecular weight, polydispersity and branching index.

Photo: Norner Research, 2021

Capillary rheometer (Haul-off) to determine melt strength and melt spinnability.

Photo: Norner Research, 2021

aquaculture applications.

Achievements for 2021

- Identified the state-of-the-art material solutions for fishing gear and aquaculture equipment.
- Mapped critical performance requirements of polymers for fishing gear applications.
- Conducted a desktop study to identify the potential biodegradable plastic materials for fishing gear and aquaculture applications.
- Conducted desktop study to identify the state-of-the-art fiber processing methods and equipment.
- Initiated collaboration with S-EnPol, and LG Chem to secure material sourcing.
- Identified alternative biodegradable plastic material suppliers.
- Sourced and characterized a range of biodegradable plastics and reference conventional plastics.
- Initiated desk-top study to identify methods for formation, separation, quantification, and characterization of microplastics.

RA 2 Assessment of biodegradability

Objectives and motivation

In the second research area (RA 2), Assessment of biodegradability, the aim is to investigate more closely the degradation behaviour of fishing gear and other equipment for marine applications made of biodegradable polymers. The aim is for these fishing gears to have the same or better mechanical properties and catch efficiency than the non-biodegradable plastics currently used by the fishing and aquaculture industries to reduce plastic waste and the associated problems. Materials currently used include synthetic fibres such as polyamide (PA6 or nylon).

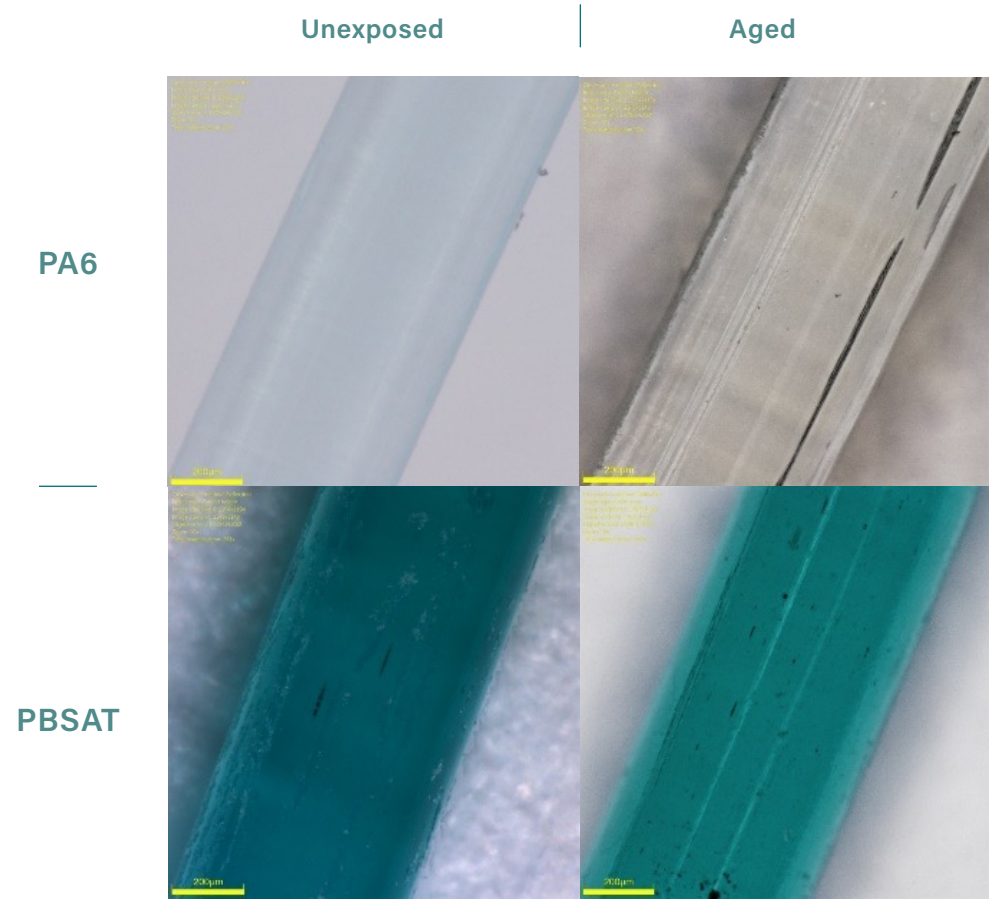
It has been shown so far that gillnets made of synthetic materials are durable and have a high tensile strength. The problem of ghost fishing, as well as marine pollution from plastic, hazards to shipping and the introduction of synthetic material into the marine food-chain, etc. have become much more severe with the introduction of synthetic fibres and the associated increase in fishing activities. As a replacement for conventional nylon gillnets, biodegradable gillnets made of e.g. polybutylene succinate co-adipate-co-terephthalate (PBSAT) which can be degraded by naturally occurring microorganisms in seawater, have been increasingly discussed and researched in recent years. The catch efficiency of these nets made of biodegradable polymers is in some cases comparable to nets made of polyamide (PA), polyethylene (PE) and polypropylene (PP). However, much research is still needed to improve the mechanical properties, catch efficiency and biodegradability of these gillnets and other devices of interest for future applications. Furthermore, the degradation of smart biodegradable polymers with controllable and non-linear degradation profiles, which have stable mechanical properties during their service life and degrade rapidly thereafter, shall be investigated. The consortium of the Dsolve project will work closely with academic and industrial partners to make biodegradable plastics commercially available and economically accessible to end users.

Photo: Espen Mortensen

Key research tasks

One of the main focuses of this research area 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 industry. 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:

- Task 2.1 Investigation of the marine biodegradation of gillnets and twines with PBSAT as test and PA as control material in situ in different marine habitats (seabed, water column) in different climate zones (Skagerrak Sea, 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 and marine sediments and microbial biodegradation and microbiome analyses (PBSAT and PA as reference) and analysis of the materials 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 PA as control.



Monofilaments (PA6 and PBSAT) before and after ageing (circa 600 hours).

Photo: Sintef, 2021

Achievements 2021

- The samples described in task 2.1 have been successfully deployed at the different testing sites end of June and beginning of July 2021. A report describing the details of the testing sites has been prepared and is being continually updated.
- Accelerated weathering experiments of the monofilaments (PA6 as reference and PBSAT as biodegradable polymer, see Fig. 1) were carried out in task 2.3 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 task 2.1 and for the controlled laboratory experiments in task 2.2).
- A popular science contribution in collaboration with SINTEF Ocean about the SFI Dsolve and the RA 2 has been published in Norwegian
- (https://gemini.no/2021/05/gar-til-kamp-mot-marint-soppel-og-spokelses-fiske/) and in English (https://norwegianscitechnews.com/2021/06/combating-marine-waste-and-ghost-fishing-with-new-materials/).
- A 2-hour guest lecture ("Plastics in the Ocean") in the Polymer Chemistry Course TKP4130 at the NTNU (organizer: Kristofer G. Paso) was held in April 2021.
- A podcast about the SFI Biodegradable plastics has been published on the Dsolve website in collaboration with UiT and Norner: https://soundcloud.com/sfidsolve/hva-er-bionedbrytbar-plast-dsolve
- A workshop (topic: Degradation of plastics used for marine applications) including important stakeholders working on the field of degradable polymers and fishery sciences was successfully conducted in November 2021. Various stakeholders from abroad gave presentations on different topics (Materials and Material Development-Degradation Standards and Certifications-Characterization Modelling-Marine Litter).
- One review article about modelling of environmental ageing has been published as open access articles:
- Modelling of Environmental Ageing of Polymers and Polymer Composites—Modular and Multiscale Methods: https://www.mdpi.com/2073-4360/14/1/216 (Accepted: 29 December 2021/Published: 5 January 2022)

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 utilisation, circularity, and regulatory support of plastic use in Norway.

Publications

- Går til kamp mot marint søppel og spøkelsesfiske: https://gemini.no/2021/05/gar-til-kamp-mot-marint-soppel-og-spokelsesfiske/
- Combating marine waste and ghost fishing with new materials: https://norwegianscitechnews.com/2021/06/combating-marine-waste-and-ghost-fishing-with-new-materials/
- Modelling of Environmental Ageing of Polymers and Polymer Composites—Modular and Multiscale Methods: https://www.mdpi.com/2073-4360/14/1/216
- Modelling of Environmental Ageing of Polymers and Polymer Composites—Durability Prediction Methods: https://www.mdpi.com/2073-4360/14/5/907

The full length of the footrope of a Demersal seine was fitted with natural fibres made from wood and cowhide. The experiments were conducted in the Norwegian Sea and organized by research partner SINTEF Ocean (RA3) .

Photo: J Vollstad, 2022

RA 3 Tests and demonstrations at sea

Objectives and motivation

This research area (RA 3) will develop, test, validate, and optimize biodegradable gears for specific applications in fisheries and aquaculture. The industry will need robust and convincing results before production, sales, and practical use (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 to new smart biodegradable materials must include performance, catch pattern, 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.

Coastal vessel used for trials in the Barents Sea, where the main objective was to test biodegradable snoods in inshore/coastal longlines. The experiments were organized by research partner SINTEF Ocean.

Photo: K Cerbule, 2021

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 published statistical methods and models. Catch quality will be assessed if needed. Assessing the extent of unaccounted fishing mortality of lost 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 made of conventional PE rope and biodegradable ropes. The codends will be fished simultaneously in a twin trawl setup and used by a trawler during an entire 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.

The footrope of a Demersal seine with visible damages and abrasion of the synthetic ropes. The experiments were conducted in the Norwegian Sea and organized by research partner SINTEF Ocean.

Photo: J. Vollstad, 2021

Key research tasks

- Task 3.1 For gillnets (inshore and deep-sea gillnetting) focus on finding 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 nylon and polyester snoods are used every season and a large proportion of these get lost at sea.
- Task 3.4 Identify several possibilities for replacing PE, PA, 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 chafing mats for use in demersal (bottom) trawling.
- Task 3.6 Develop an alternative to combination ropes (30–60 mm thick PE coating with steel-wire core) 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 by the seabed.

Achievements for 2021

- Comparison of the efficiency and modes of capture for biodegradable gillnet versus nylon gillnets in the fishery for Northeast Atlantic cod (*Gadus morhua*). Experimental fishing was conducted during March 2021 in Northern Norway. This study investigated catch efficiency and modes of capture between biodegradable and nylon gillnets in commercial cod fishery. On average, new biodegradable gillnets caught 25% fewer cod compared to new nylon gillnets. The main capture modes were by the gills and by the body in used and new biodegradable gillnets, respectively. Differences in catch efficiency are related to specific modes of capture that may be related to differences in material properties. A manuscript for a scientific publication was submitted based on this work as part of PhD in RA 3.

- Manuscript "Can biodegradable materials reduce plastic pollution without decreasing catch efficiency in longline fishery?" Experimental longline fishing was conducted in Northeast Norway during November 2021. During longline fishing, some of the snoods connecting the hooks to the mainline are often lost at sea. Since snoods are made of nylon or polyester, lost snoods contribute to marine plastic pollution. Replacing nylon or polyester with a new material made of biodegradable plastics can potentially reduce macro- and microplastic pollution that is caused by lost snoods. In this study, we estimated the risk for snood loss in a longline fishery targeting haddock and Atlantic cod in Barents Sea. Further, we compared catch efficiency in this fishery for snoods made of biodegradable and nylon materials. No significant differences were found between the two materials. Therefore, catch efficiency does not represent a barrier for using biodegradable materials in snoods. A manuscript for a scientific paper has been prepared based on this work as part of PhD in RA 3.

Emptying the codend of a bottom trawl during a research cruise in the Barents Sea where dolly-ropes and cowhide were used as chafing gear.

Photo: D. Stepputtis, 2021.

Plaice caught in the North Sea during trials with biodegradable gillnets. The experiments were organized by research partner DTU Aqua.

Photo: K Cerbule, 2021

- A scientific publication on methodology for assessing the modes of capture in gillnet fishery was accepted for publication in ICES Journal of Marine Science during 2021. Title "A new method for estimating length-dependent capture modes in gillnets: a case study in the Danish cod (*Gadus morhua*) fishery". Experimental fishing was conducted in commercial gillnet fishery targeting cod in Denmark. This paper describes a new method of estimating the length-dependent fish capture modes in gillnets. Using this method, we investigated the length-dependent capture modes for cod in commercial monofilament nylon gillnets. Cod is a target species for several fisheries in the Northern Atlantic. This is the first time the capture mode was formally related to fish size with a direct representation of the experimental observations. The results demonstrated that gillnets are clearly designed for gilling. However, capture modes were size dependent, with small fish being caught by the mouth and larger fish by the maxillary. The application of the method is relevant when used by gear technologists to evaluate different gear characteristics to improve size or species selectivity. Changing the hanging ratio, for instance, or replacing nylon twine by thicker biodegradable material may considerably change the

capture modes and their effect on gear efficiency.

- Experiments using biodegradable gillnets were carried out in Danish gillnet fishery targeting European plaice (*Pleuronectes platessa*) during spring and autumn fishing seasons in 2021. Two scientific papers are in preparation based on these data collections:

  1) Catch efficiency and capture modes of the biodegradable compared to nylon gillnets for European plaice.

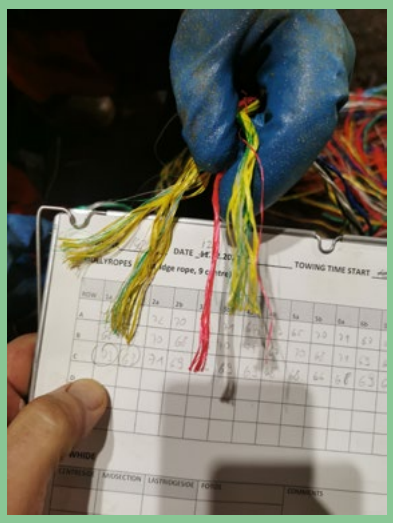
  2) Capture, landing and discard patterns for traditional and biodegradable gillnets in fishery targeting European plaice. This study investigated patterns in captured, landed, and discarded catch for nylon and biodegradable gillnets in a gillnet fishery targeting European plaice fishery. No significant differences were observed between the two materials, demonstrating that biodegradable gillnets display similar capture, landing and discard patterns as nylon gillnets in the observed fishery. Therefore, capture patterns would not represent a barrier for using biodegradable materials in this fishery.
  Both papers will be linked to PhD in RA 3.

- PhD candidate recruited for the research area – started August 2021.

The dollyropes are made from PE (polyethylene) and PP (polypropylene) and the yarns are made from very thin single monofilaments. The image was taken during a test in the Barents Sea during experiments were organized by UiT.

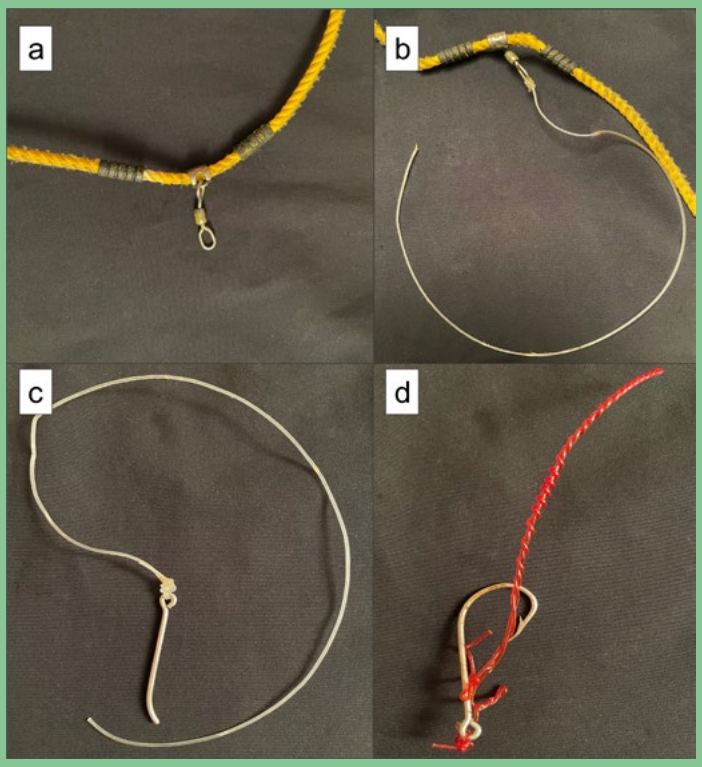
Photo: D Stepputtis, 2021

Dolly-ropes are used primarily in fishing gears like bottom trawl as a chafing gear to protect the codend (i.e. the aft end of a trawl net) from wear, tear and breakage caused by contact with the seabed. The use of non-degradable plastics in dollyropes is heavily debated international. During a research cruise in December 2021, we tested chafing gears based on petrol-based materials such as PE (polyethylene) and PP (polypropylene) and natural products like cowhide. Cowhide was a common material as chafing gear for bottom trawls until the synthetic fibres (woven mats and dollyropes) took over by the end of the 1970s. The results from this study will be published in a MSc thesis.



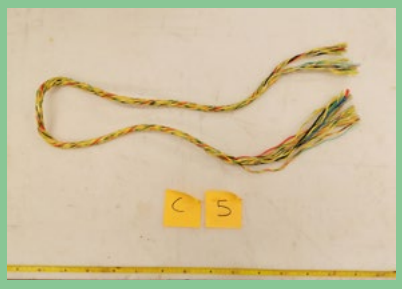
Recording data from several dolly-rope yarns.

Photo: C. Kittel, 2021.



Examination of nylon and biodegradable (PBSAT) snoods used in longline trials in the Barents Sea . Examples of cases when snoods were lost (pictures a and b) or needed replacement (pictures c and d) for the next longline deployment during rebaiting. (a) snood missing after deployment; (b) broken snood; (c) removed broken hook; (d) removed damaged snood.

Photo: K Cerbule, 2021



Measurement of a single yarn from a dolly-rope mat.
Photo: C. Kittel, 2021.

RA 4 Governance incentives

Objectives and motivation

The central objectives of this research area (RA 4) are to:

- Assess economic effects of non-biodegradable materials used in fisheries and aquaculture (Task 4.1).
- Determine costs and benefits related to ecosystem services from introducing biodegradable materials in the fisheries and aquaculture industries (Task 4.2).
- 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 (Task 4.3).

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.

Key research tasks 2021

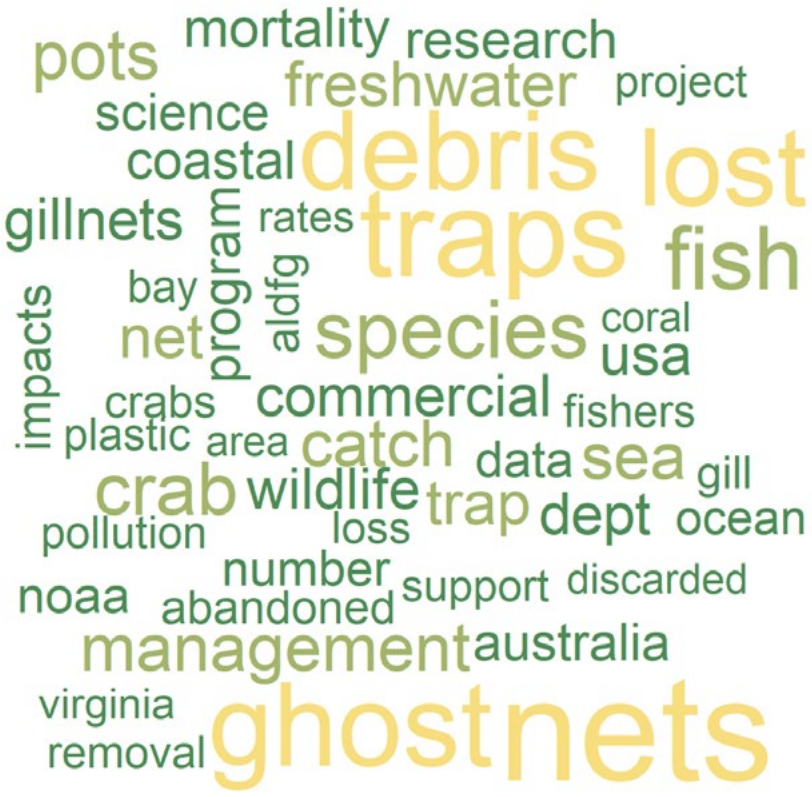
RA 4's research tasks are closely linked to the objectives. Early tasks have therefore, focused on ghost fishing as a central consequence of non-biodegradable materials in fisheries, specifically gathering relevant knowledge and data:

- Literature survey of ghost fishing, identifying a broad set of elements relating to ecosystem service impacts, and economic assessment.
- Gathering of data regarding lost fishing gear and gear retrieval in Norwegian waters.

Achievements 2021

Since the employment of PhD student Huu-Luat Do on November 1st, 2021, he has been working extensively on carrying out literature review of ghost fishing and collecting data regarding reports and retrieval of lost fishing gear. In the following are some preliminary observations from the literature, and data collection of lost fishing gear:

A collection of 96 studies about lost fishing gear and its consequences are finally shortlisted to provide the overview of the situation on the global scale. After removing common phrases, a word cloud is created in the figure on the next page showing the frequency of words in the abstracts of the collected studies.
Among the consequences of lost fishing gear, debris and ghost fishing are found to be the most common impacts mentioned. The majority of the reviewed references report on lost traps and nets while fish and crabs are found to be dominant species affected by lost fishing gears. From the result of geographic locations, it is noticeable that studies about lost fishing gear are mainly located in USA and Australia. Out of 96 references, there are only four studies located in Norway.



The most common words in collected studies' abstracts.

***Note*: Words are grouped into: 1) Consequences of lost fishing gears (i.e. "ghost", "debris", "plastic", "pollution", "mortality"); 2) Locations conducted (i.e. "USA", "Australia", "Virginia", "NOAA"); 3) Fishing gears (i.e. "nets", "traps", "pots", "gillnets"); 4) Species mentioned (i.e. "fish", "crab", "wildlife"); 5) Impacts (i.e. "coral", "support"); 6) Environment (i.e. "sea", "freshwater", "ocean", "bay", "coastal").**

Figure 1 shows the number of lost fishing gear, reported by Norwegian fishing vessels over 15 meters in length, from 2011 to 2020, in which the figure for gillnets was taken into account in more detail. It is interesting to note that the number of lost gillnets reported by fishers was very low and remained stable from 2011 to 2020, while the quantity of other fishing gears was recorded with considerable fluctuation. Based on the data collected from the Norwegian Directorate of Fisheries in the period between 1983 and 2020, an upward trend in the retrieval of lost gillnets was observed (Figure 2), despite there being no clear increase in the effort exerted to retrieve lost fishing gear.

The line graphs in Figure 3 provide information on the quantity of gears that were retrieved in Norway over a 5-year period.

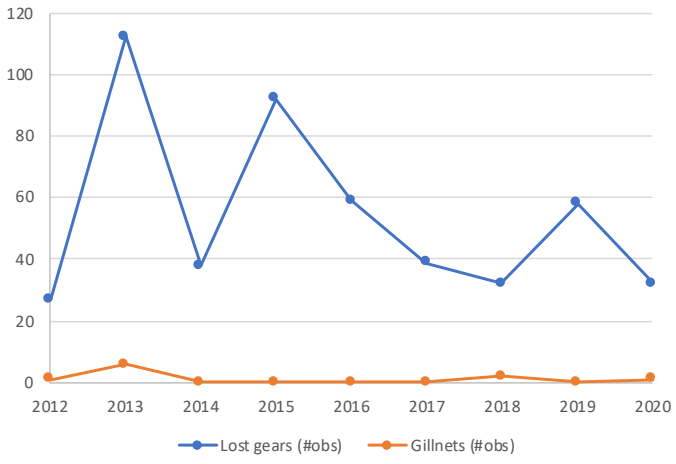


Figure 1. Descriptive statistics of lost gillnets reported in the electronic logbooks for vessels over 15 m *Source: Norwegian Directorate of Fisheries.*

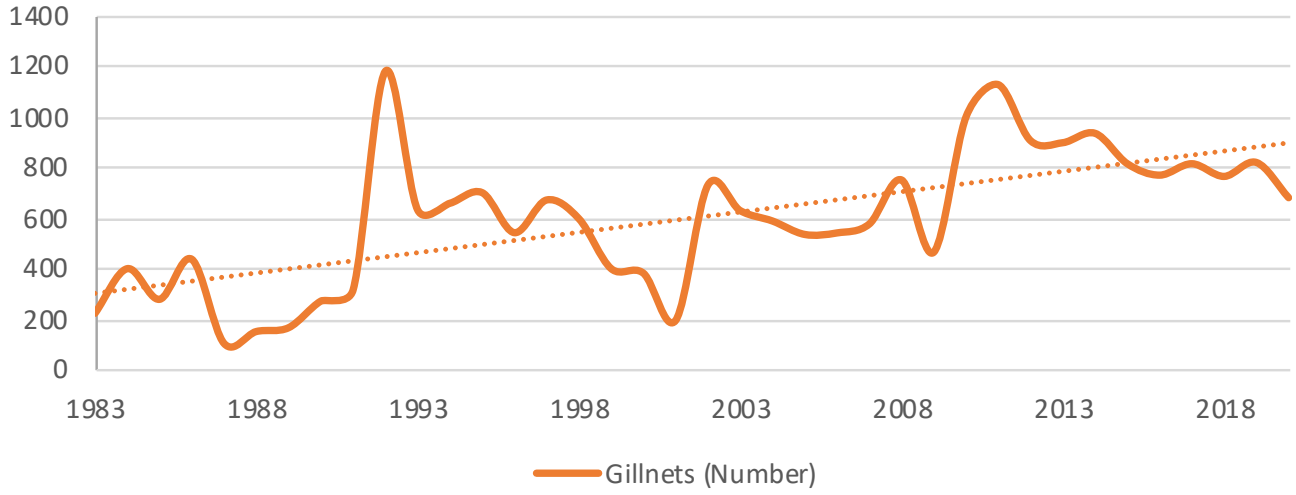


Figure 2. **Retrieval of lost gillnets and trend (1983-2020)**
Data source: *Norwegian Directorate of Fisheries*

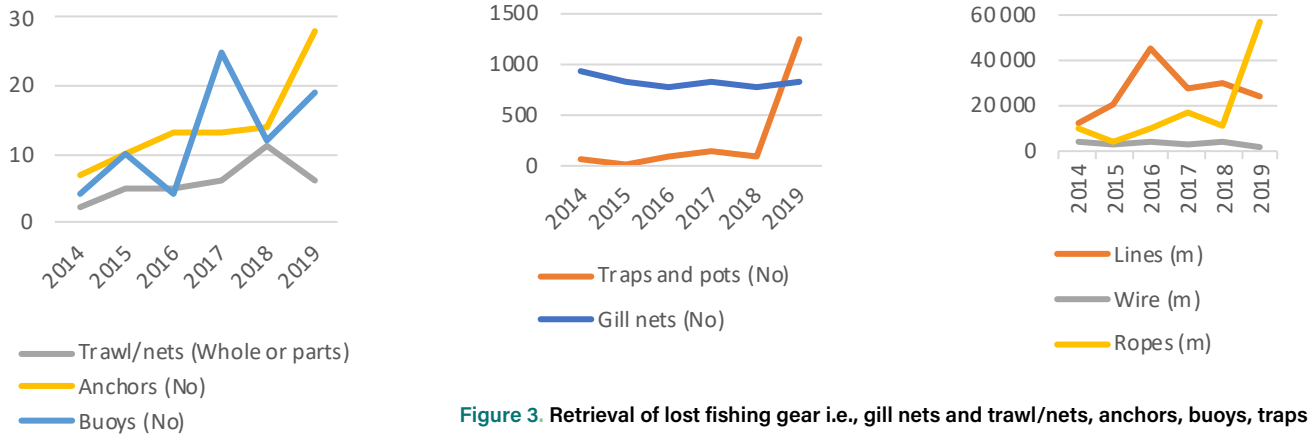


Figure 3. **Retrieval of lost fishing gear i.e., gill nets and trawl/nets, anchors, buoys, traps and pots, lines, wire, and ropes.** *Data source: Norwegian Directorate of Fisheries*

Figure 3 shows the retrieval of lost fishing gears i.e., gillnets, trawl/nets, anchors, buoys, traps and pots, lines, wire, and ropes. In general, there is an upward trend in the number of trawl/nets, anchors, buoys, traps and pots, lines, and ropes retrieved while an opposite trend was presented for gillnets and wire during the time period between 2014 and 2019. In 2014, the number of traps and pots retrieved was recorded at approximately 50, which was significantly lower than that of gillnets, at 935. In the following 5 years, there was a slight decrease of 115 in the number of gillnets retrieved, but that of traps and pots exceeded even the number of gillnets at 1242 in 2019. There is no indication from the retrieval surveys that there is any substantial decline in lost fishing gear in Norwegian waters.

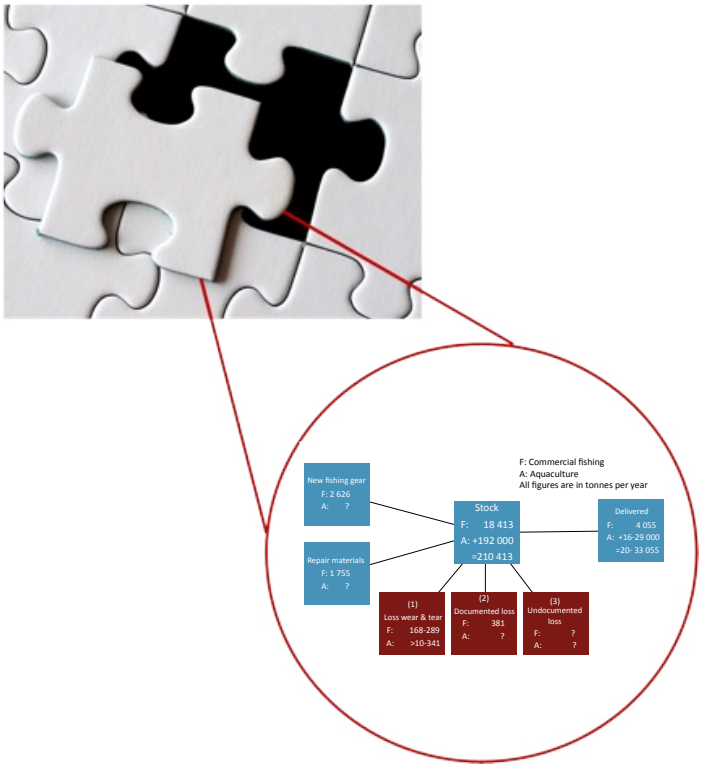
RA 5 Circularity of plastics

General perspectives

It is important that any new biodegradable plastics that are developed for use in fishing and aquaculture can be part of a circular materials value chain. In order to represent a truly sustainable innovation, they must also have lower potential environmental impacts than materials conventionally used.

Research Area 5 (RA 5) focuses on circularity and sustainability. The research work focusses on the level of circularity in the value chain and life cycle assessment (LCA) for different options for innovation for different types of fishing gear. This work area is also concerned with ensuring the material and product systems developed are sustainable through knowledge transfer and partnership building concerning LCA. LCA will be used to compare possible alternatives, contributing to ensuring that the systems developed are real improvements on the existing systems, and will contribute to sustainable consumption and production patterns (SDG 12). RA 5 directly addresses the issue of plastics leakage from human activities in the marine environment and the potential environmental impacts this can have (and thus also SDG 14).

Mapping gear losses from Norwegian fisheries and aquaculture activities will contribute to establishing a current level that innovations in the product system and value chains can be mapped against. This will facilitate benchmarking of the importance of given innovation options identified by the SFI team.



Mid-2021: R&D for Status Quo report and to identify data gaps

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, 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.

Benchmarking and modelling of gear losses based on data from Norwegian partners will enable quantification of the scale of the impacts and potential benefits of innovative solutions.

November/December 2021: Interviews with fishermen started for data acquisition stage of Work Area 5.

Photo: Fjellfrosk Media

Key research tasks

- Define the status quo for the material flow of fishing and aquaculture gear on a national and regional level with goals to document: i) the proportion of used fishing gear delivered for further processing and depositing; ii) loss of mass due to wear; iii) documented loss of gear; and iv) undocumented loss of gear.
- Develop dynamic modelling for gear losses from Norwegian fishing and aquaculture activities.
- Perform LCA assessments of different fishing gear systems and materials.
- Identify research gaps.
- Contribute to international development of LCA methodology, in order to include plastic losses and marine litter.

Achievements 2021

The R&D activities in 2021 have resulted in a report on state-of-the-art knowledge for fishing and aquaculture gear losses in publicly available sources (scientific publications and technical reports, both Norwegian and international).

This work also identified several data gaps and assessed the suitability of the Plastic Leakage Project and other relevant international initiatives for relevance in closing the data gaps identified.

Specific data gathering from relevant SFI partner companies has started on i) the proportion of used fishing gear delivered for further processing and depositing; ii) loss of mass due to wear; iii) documented loss of gear; and iv) undocumented loss of gear. This work will be continued in 2022.

Figure 4: Figure 1 from De Sadeleer et al. 2021. Defining status quo for the material flow of fishing gear on a national and regional level (NORSUS report OR.44.21).

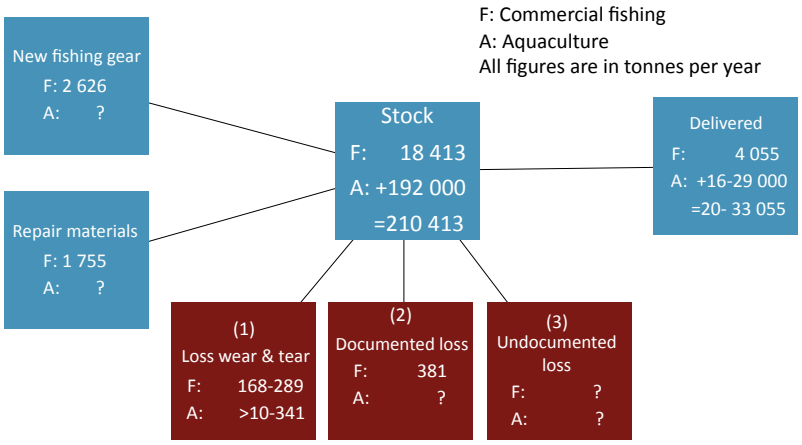


Figure 4. Quantified mass of plastics and knowledge gaps for commercial fishing and aquaculture, numbers in tons per year. *Based on: Deshpande et al. (2020a), Hognes and Skaar (2017), Tore Syversen (2020), Vangelsten (2019) and Gomiero et al. (2020).*

LCA Assessments of defined fishing gear systems and materials need to start by defining the goal and scope for the different types of gear. This LCA work will start in 2022 as planned. LCA includes calculation of potential environmental impacts using life cycle impact assessment, or LCIA. As part of our ambition to contribute to international development of LCA methodology in order to include plastic losses and marine litter, the SFI Dsolve and RA 5 work has been presented to the Scientific Committee of the MarILCA project in 2021. The MarILCA project is a collaboration between the Life Cycle Initiative and FSLCI (Forum for Sustainability through Life Cycle Innovation) with the goal of fostering the development of marine impact assessment in LCIA, starting with plastic litter. In 2021, the MarILCA project presented a framework for the assessment of marine litter impacts and is working towards filling methodological gaps in LCIA related to marine litter. RA 5 researchers participate in the scientific committee of MarILCA to contribute to this work. Another international collaboration activity in 2021 has been to establish potential links with the EU-funded ATLANTIS project Whales, waste and sea walnuts: incorporating human impacts on the marine ecosystem within life cycle impact assessment. Through these collaborations RA 5 is contributing to fostering collaboration and complementing ongoing international research efforts.

Valentina Pauna has joined the NORSUS team and is working on Dsolve as well as other projects at NORSUS. We also have Ragnhild Bjerkvik Alnes who is doing her MSc at NTNU connected to the Dsolve project. These are included in the personnel list for 2021.

https://norsus.no/publikasjon/defining-status-quo-for-the-material-flow-of-fishing-gear-on-a-national-and-regional-level/

The NORSUS team participating in Dsolve. From left: Irmeline de Sadeleer, Valentina H. Pauna and Area Leader Dr. Cecilia Askham. (*Dr. Hanne Lerche Raadal was also part of the team until the start of 2021) Photo: NORSUS, 2021*

RA 6 Communication, dissemination and exploitation

Objectives and motivation

The results of SFI Dsolve provide valuable and fact-based knowledge essential for research, innovation, documentation, and design of new biodegradable products for the sustainable and circular economy. These innovations are important to enhance Norway`s leading global fishery and aquaculture positions, and the ambition to be in the forefront of research and innovation addressing the problems of marine plastic pollution.

Through Research Area 6 (RA6), SFI Dsolve is to have a comprehensive communication approach and agenda with the aim to maximise the visibility of the centre, its goals, challenges, and results towards industry, the scientific community, authorities, policy makers, and the general public. The objectives can further be described as: 1) Develop and carry out measures to maximise the impact of the SFI research. 2)Ensure wider dissemination and uptake of the results of the SFI. 3) Ensure close relations between the academic community and industrial partners at the operative level and a low threshold for later exploitation of the results and technology transfer.

Communication, dissemination, and exploitation of results within Dsolve is organised in RA 6, led by UiT, and carried out in cooperation with SALT Lofoten AS (SALT) as subcontractor.

Key Research tasks

The aim of the RA 6 is to develop and carry out a dynamic plan for outreach to maximise the impact of the results from the SFI. The key tasks of this research area are: *6.1 Dissemination activities, 6.2 Communication activities* and *6.3 Exploitation of results.*

A plan for communication, dissemination, and exploitation of results (DEP) has been developed in the beginning of the SFI and is to be updated on a regular basis during the centre's life span. The plan includes not only plans for suitable conferences, trade fairs, and national and international exhibitions, but also specifications about the promotion channels to be used, the timing for awareness raising about results, and the responsible partners. The main communication measures are described in the yearly annual plans. The outcome of the RA is to include among others seminar and workshop proceedings, a public website, presentations at major events, publications in specialised and extension journals and magazines, press releases, video productions, a social media strategy, and public datasets used in the SFI. Dialogue with affected industries and stakeholders through seminars, workshops, and networking is to be emphasized, and existing meeting arenas within industry and networks to be used for effective outreach to industry and stakeholders.

Achievements 2021

Task 6. 1 Dissemination activities

- Communication and dissemination Plan 2021- 2028
- Social media strategy
- Annual plan 2021
- Dsolve videos
- Podcast biodegradable plastics

The dynamic dissemination and exploitation plan (DEP) 2021-2028 has been further developed and carried out in 2021. This includes a yearly activity plan for the RA, a social media (SoMe) strategy and a detailed SoMe plan for 2021. Two Dsolve videos have been produced focusing on the aim of the project and the goal to reduce plastic litter and associated problems such as ghost-fishing and microplastics caused by the seafood industry, through biodegradable plastics – one general video focusing on fishery, and one aimed at the aquaculture sector for dissemination at Aqua Nor 2021. A podcast aimed to explain biodegradable plastics for a broad audience has been produced in cooperation with relevant SFI partners, and distributed.

Task 6.2 Communication activities

- Webpage
- Facebook, LinkedIn, Twitter
- Profile material, photos and graphics
- Press release
- Poster, flyer and fact sheet

The website https://uit.no/research/biodegradableplastics built to provide public information about the project, including goals, status, major deliverables and events, towards stakeholders and the general public, as well as internal target groups, has been further developed and updated in 2021. The website is available in both English and Norwegian. Publications and news from the SFI Dsolve have been continuously published at the website, including both scientific articles, and popular science.

A Facebook- and a LinkedIn page has been built up and developed to continuously provide public information about the progress of the SFI towards stakeholders and general public, and to raise awareness, and a Twitter account has been established. Updates of research, purposes, results, and events have been posted in social media according to the social media strategy described in the DEP.

Fact sheet about biodegradable plastics, project poster and flyer providing information about the project have been produced for communication and dissemination at trade fairs, conferences and annual meetings held in 2021. Press releases and news articles about Dsolve, as well as info-graphic, have been produced.

Task 6.3 Exploitation of results

- Annual report 2021
- Aqua Nor
- Webinar - Alternative materials for dolly rope
- The Artic Circle Conference (international)

Representation and presentation of the SFI on relevant trade fairs, meetings and events have been facilitated, including the Aqua Nor 2021, the General Assembly of Norges Fiskarlag and The Arctic Circle conference in Reykjavik. A webinar about alternative materials for dolly ropes were arranged in cooperation with Sintef, SALT, UiT and FHF at the 17th of June, gathering 27 participants from fishery, science, management and gear producers. Due to the Covid-19 situation, several trades and conferences relevant for exploitation of the SFI have not been arranged in 2021. Digital attendance have been facilitated when relevant, such as at the General Assembly of Norges Fiskarlag.

Some of our Dissemination Activities in 2021

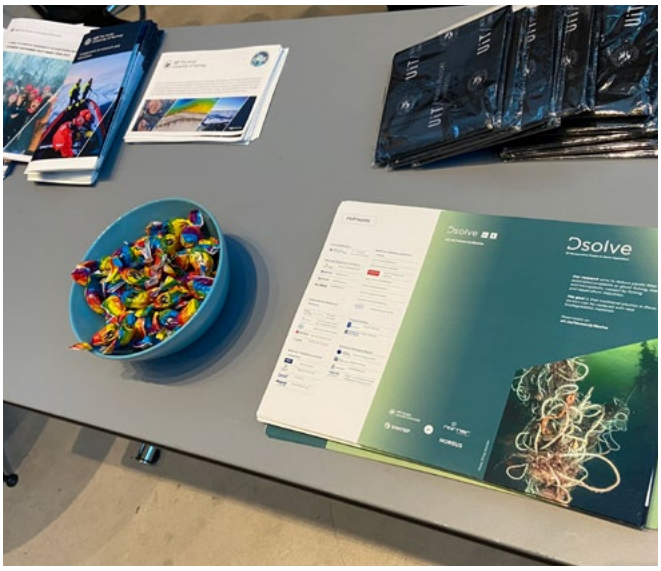
Photo: UiT

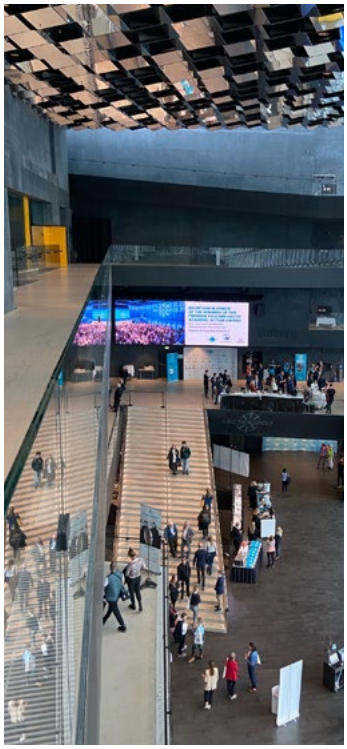
Aqua-Nor 2021:
Dsolve was represented at the Aqua-Nor trade fair 24.- 27. August 2021 meeting students, researchers, and representatives from the aquaculture industry to promote the SFI, and to gather input for our research from stakeholders within the aquaculture sector. At our stand together with the UiT Arctic University of Norway, we invited stakeholders to learn more about biodegradable plastics for fishery and aquaculture.

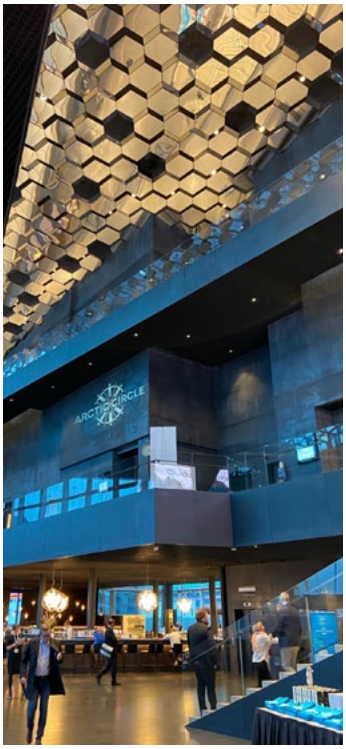
The Arctic Circle conference:

The Arctic Circle conference in Reykjavik in October 2021 brought together more than 1000 politicians, researchers, and students from the Arctic countries. The SFI Dsolve was well represented at the UiT Arctic University of Norway`s stand were conference participants got to know more about research, collaboration, and study opportunities.

Photo: UiT







What is biodegradable plastic?

A podcast for the purpose of explaining to a wide audience what biodegradable plastics are, has been produced and distributed in 2021. The podcast is available at both Spotify and Soundcloud, as well as at the SFI website and social media channels. The podcast produced in cooperation with UiT students and SFI partners SINTEF and Norner, was also distributed to industry actors and fishers participating at the General assembly of Norges Fiskarlag.

https://lnkd.in/gmXjTtfy

Dsolve video:

A video promoting the SFI Dsolve and the research to reduce harmful effects of marine plastic pollution caused by the seafood industry has been produced in cooperation with SFI partners, and widely distributed. The video is made available in two different formats, 16:9 and 1:1, and with both Norwegian and English subtitles. A customized version of the video aimed specially at the aquaculture sector was produced for Aqua Nor and showed for participants at the trade fair.

The video can be downloaded from Vimeo and is available at both the SFI website and social media channels.

Personell

Key Researchers

NAME	INSTITUTION	MAIN RESEARCH AREA
Roger Larsen	UiT	Centre leader
Claire Armstrong	UiT	Leader Area 4
Christian W. Karl	SINTEF Industry	Polymer materials and degradation mechanisms/ polymer characterization/tribiology
Stephan Kubowicz	SINTEF	Microplastics/polymer characterization
Kjell Olafsen	SINTEF Industry	Polymer characterization/ chemical analysis
Rune H. Gaarder	SINTEF Industry	Polymer characterization
Bjørnar Arstad	SINTEF Industry	Polymer characterization
Szymon Bernat	SINTEF Industry	Polymer characterization/ tribology
Gaute Stenerud	SINTEF Industry	Polymer characterization/ tribology
Sergio Armada N.	SINTEF Industry	Polymer characterization/ tribology
Eduardo Grimaldo	SINTEF Ocean	Fishing gear
Sigrid Hakvåg	SINTEF Ocean	Microbial biodegradation and microbiome analyses
Lisbet Sørensen	SINTEF Ocean	Analytical chemistry
Heidi Moe Føre	SINTEF Ocean	Structural Engineering
Esther Savina	DTU Aqua	Fishing gear/gillnet
Rikke P. Frandsen	DTU Aqua	Fishing gear/fisheries
Jure Brčić	University of Split	Fishing gear/fisheries
Juan Santos	Thünen Institute	Fishing gear technology
Ravindra Reddy Chowreddy	Norner Research AS	Bioplastics/Polymer structure and property relationship
Siw Bodil Fredriksen	Norner Research AS	Sustainable feedstocks and bioplastics/Advisor/ Steering member
Vinh Cao	Norner Research AS	Rheology
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

Key Researchers

NAME	INSTITUTION	MAIN RESEARCH AREA
Hilde Rødås Johnsen	UiT	Project manager Area 6
Cecilia Askham	NORSUS	LCA Area 5
Hanne Lerche Raadal	NORSUS	LCA Area 5
Irmeline de Sadeleer	NORSUS	LCA Area 5
Valentina Pauna	NORSUS	LCA Area 5

Key Personell

NAME	INSTITUTION	MAIN RESEARCH AREA
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
Ann-Karin Kvernbråten	SINTEF Industry	Lab engineer
Arezoo Banaei	Norner Research AS	Administrative support
Ole Jan Myhre	Norner Research AS	Marketing manager/ Polymer expert
Thor Kamfjord	Norner Research AS	Sustainability advisor/ Polymer expert
Jake Chang	LG Chem	Bio-Business development
Ryan Yoon	LG Chem	Bio-Business development
Kim Seihoon	S-EnPol Company	Biodegradable Polymer R&D
Niclas Risvoll, adviser,	SALT (subcontractor)	Web and graphics Area 6
Malin Jacob	SALT (subcontractor)	Communication and outreach, Area 6
Helene Skjeie Thorstensen	SALT (subcontractor)	Communication and outreach, Area 6
Tomas Brage	SALT (subcontractor)	Graphics Area 6
Terje Lindal	Mørenot	
Gunnar Kupen	NOFI	
Olav Småbakk	NOFI	
Isabelle Sande	Løvold AS	Styreleder
Jan Henrik Sandberg	Norges Fiskarlag	

PhD candidates with financial support from the Centre budget

NAME	NATIONALITY	PERIOD	SEX M/F	TOPIC
Kristine Cerbule		210815-250814	F	Field experiments with passive fishing gears like gillnets, longlines and crabpots. The trials will be carried out in Norway (Arctic), Denmark and Croatia. The experiments will focus on efficiency and catch patterns when changing from petro-based to biodegradable gears.
Luat Hoo Do	Vietnamese	211101-251031	M	Modeling social cost and optimal management of ghost fishing

Master degrees

Name	Period	Sex M/F	Topic
Ragnhild Bjerkvik Alnes	2021-2022	F	Examine the status quo of quantities of plastic polymer(s) from fishing gear on a national level and investigate how to evolve current models with a dynamic material flow analysis approach.
Ilmar Brinkhof	2021-2022	M	Comparing the efficiency and catch modes of fish in two types of nylon gillnets. The data and analyses will produce new and necessary knowledge about properties of gillnet capture. The results are important for the design of biodegradable fishing gears.
Clemens Kittel	2021-2022	M	This is a study on how alternative materials, e.g. natural products like cowhide, can replace synthetic fibres like dolly-ropes as chafing gears for bottom trawls.

Funding (1000 NOK)	Amount
Research Council	8 693
Host institution (UiT)	5 181
Research Partners*	3 049
Industry Partners**	6 282
Organizational partners***	51
Total	**23 256**

Costs (1000 NOK)	Amount
Host institution (UiT)	5 356
Research Partners*	6 357
Industry Partners**	4 032
Organizational partners ***	51
Equipment	7 460
Total	**23 256**

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

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

*** Norges Fiskarlag, Norges Råfisklag

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