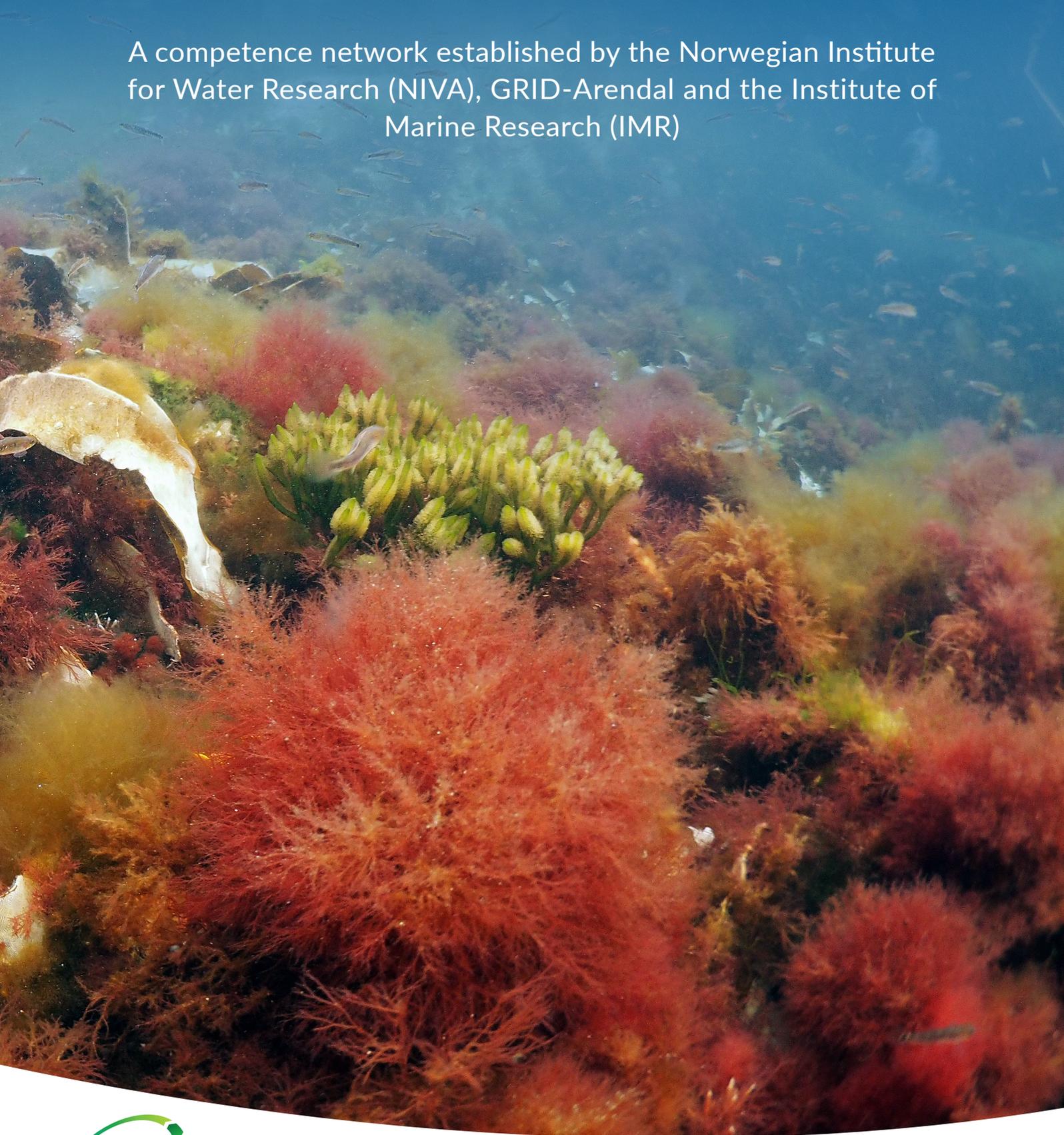


NORWEGIAN BLUE FORESTS NETWORK (NBFN)

ANNUAL REPORT 2019

A competence network established by the Norwegian Institute for Water Research (NIVA), GRID-Arendal and the Institute of Marine Research (IMR)



Awareness raising

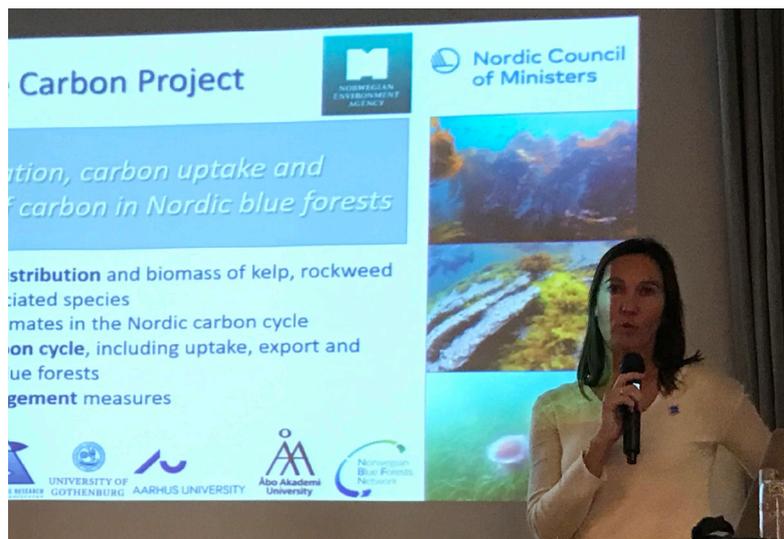
Blue forests communication package

In order to better convey the importance of blue forest ecosystems within Norway, there is a need to develop communications products targeting the Norwegian general public and informed citizens, rather than scientists and policymakers. The project started analysing the needs and making a list of options for an improved communication package for the network. The aim of the communication package is to inform the general public about blue forests ecosystems and their value. The package includes a flyer about blue forests ecosystems, a PowerPoint presentation, a photo library and videos.

The NBFN held an event during Arendalsuka in partnership with Raet National Park. With speakers from GRID-Arendal, the Institute of Marine Research, NIVA and the National Park Manager, the evening sailing tour showcased the blue forest ecosystems of Raet National Park. It was a very successful event with the boat sailing at full capacity (70 people).

The International Blue Carbon Initiative meeting in Copenhagen

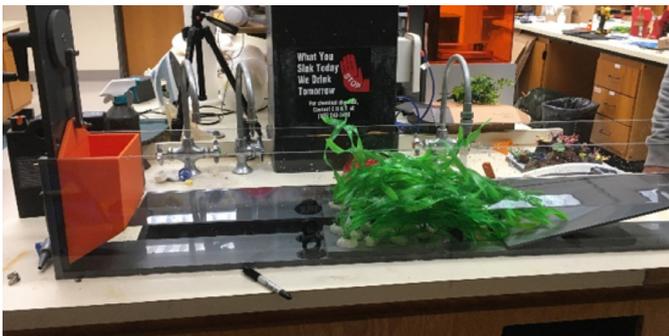
The Blue Carbon Initiative (BCI) Scientific Working Group met in Copenhagen, Denmark, from September 9 to 13, 2019. The focus of this meeting was on Blue Carbon habitats in the Nordic countries. One of the central questions of the workshop was: "How can Blue Carbon contribute to achieve the Nationally Determined Contributions (NDCs) and the goals of the Paris Agreement?"



In total, near 80 researchers, environmental managers, and policy makers participated in the workshop – many contributing with their knowledge on restoration, protection and management of different Blue Carbon ecosystems around the world. Norway was represented by five participants from the Norwegian Blue Forest Network (Helene Frigstad, Kasper Hancke and Hege Gundersen from NIVA, Jonas Thormar from IMR, and Steven Lutz from GRID-Arendal) and two representatives from the Norwegian Environment Agency (Åsa A. B. Pedersen and Marianne Olsen).

The result of this workshop will be two papers that are in the pipeline: "Designing a Nordic Roadmap for Blue Carbon ecosystems" and "The status of Blue Carbon habitats in the Nordic countries".





Task 1.3 Wave Tank

This portable wave tank will help raise awareness on the shore protection value of blue forest ecosystems through the demonstration of wave action and 3D printed ecosystems including seagrass, kelp and coral reefs. It will tangibly demonstrate the nature-based shore protection value of blue forest ecosystems. This product will be developed in collaboration with scientists from the University of Miami and is intended for demonstration at conferences.

Research and action-oriented projects

There were action-oriented studies undertaken in 2019 on assessing the role of blue carbon including evaluating the carbon sequestration of seagrass and kelp.

SEAME – Seagrass Carbon Sequestration

Nature-based solutions are increasingly seen as a key part of efforts to cope with and reduce impacts of increasing atmospheric greenhouse gas concentrations. Coastal ecosystems, in particular mangrove forests, intertidal marshes and seagrass meadows, hold vast carbon reservoirs. These Blue Carbon ecosystems sequester atmospheric carbon dioxide through photosynthesis and deposit carbon as plant biomass or in the underlying sediments. Seagrass ecosystems have been identified as important ecosystem services providers. They contribute to coastal protection and fisheries provision, and mitigate climate change by sequestering and storing carbon, among others. SEAME has undertaken the baseline carbon assessments of *Zostera marina* meadows in Southern Norway, contributing both to science and policy at the national and international level.

More specifically, in a scientific context:

- on a national level, we provide seagrass carbon stocks estimates reported for the first time for Norway, and;
- on an international level, we provide data on the net contribution of seagrasses to carbon stocks by including bare sediments, which has been greatly overlooked in the seagrass literature.

At a policy context, we attempt to analyse Norway's international commitments and see how these can be met through managing and restoring seagrass meadows.

The scientific manuscript entitled: "The carbon storage capacity of seagrass meadows in Norway" is currently in the final stages of preparation with further dissemination plans in 2020.

Kelp Carbon Sequestration

Kelp is exported from hard bottom to shallow and deep soft bottom areas where it can be sequestered. The fate of kelp carbon is being studied through modelling the dispersal of kelp particles (KELPFLOAT) and the burial of kelp carbon in deep sediments.



KELPFLOAT

Within KELPFLOAT, NIVA has developed a kelp drift model that tracks pieces of kelp (lamina, stipes and lamina fragments) released from randomly selected points within intact and grazed kelp forests in Malangen (Troms). The kelp drift model uses a high resolution (160 m) 3D ocean current model developed by IMR based on hindcasting of tide, wind and current data. This is incorporated with the influence of bathymetric variation within the fjord and the surrounding deep sea and offshore coast.

Through different simulation experiments the following variables are altered:

- Timing and frequency of particle release (between August 2015 and August 2016),
- density and type of kelp material (old or new lamina, stipe, and lamina fragments) released,
- amount of kelp particles released, and
- source kelp areas that the particles are released from.

The fate of the kelp pieces from the release points within each simulation experiment need to be analysed and visualised using programming tools. R and python scripts have been developed for this purpose, aiming to spatially identify and visualise the following: how far the different kelp pieces travel, how deep the particles are transported, where the kelp matter accumulates, and the fraction of the different types that are exported out of the kelp forest areas, subsidising organic matter to the surrounding ecosystems.

In 2018, KELPFLOAT simulated the drift pattern and landing end points of five simulation experiments performed at Malangen, using theoretical derived sinking rates of different types of kelp debris. One paper is published using the results from these simulation studies (Filbee-Dexter et al 2019). In 2019, the same simulations were run using field validated sinking rates. The scripts have been further refined to visualise, analyse and quantify the fate of the various particles given different scenarios on storm frequency, seasonal variations in the release pattern of kelp derived matter, and different levels of sea urchin grazing. Further dissemination plans and outputs will be discussed among the co-authors in the new year

Published paper:

Filbee-Dexter K, Foldager Pedersen M, Fredriksen S, Norderhaug KM, Rinde E, Kristiansen T, Albretsen J, Wernberg T (2019). *Carbon export is facilitated by sea urchins transforming kelp detritus*. *Oecologia*.

<https://doi.org/10.1007/s00442-019-04571-1>



BURSE – Burial Of Kelp Carbon In Deep Water Sediments

The aim of BURSE (Burial of kelp carbon in deep water sediments) is to quantify kelp carbon burial from deep sediments in two areas: Malangen (Troms) and Frohavet on the mid-western Norwegian coast (Trøndelag).

The Malangen task was performed by the University of Oslo in collaboration with the Institute of Marine Research (IMR). Sediment core data from Malangen was compared to data from Kaldfjorden, Troms (available to NBFN through the JellyFarm NFR project no. 244572/E40). Both Kaldfjorden and Malangen were sampled so that a fjord to coast gradient was covered. However, unlike Malangen, Kaldfjorden has no recorded kelp forests in its direct vicinity, which is supported by observations made during drop camera deployment. The working hypothesis is that the data from Kaldfjorden, with presumably no kelp, could function as a reference for the Malangen sediments, which potentially store kelp. Sediment cores collected from Malangen cruises in 2017 and 2018 were dated and the total organic carbon and nitrogen content was analysed. Additionally, stable isotopes from drift kelp were analysed to serve as a signal reference of kelp to core isotopes, which should

aid in identifying kelp carbon in sediment cores. The results will be published in a scientific paper describing a fjord to coast gradients and carbon storage in Northern Norwegian fjords (submission in 2020).

The Frohavet task was executed by Kasper Hancke, Gunhild Borgersen, Anders Ruus and Marc Anglès d'Auriac at NIVA. The funding from NBFN was used to supply the NEA project Nordic Blue Carbon ("blått karbon") to increase the sample size of three to five sediment cores, thus being able to investigate carbon burial in a depth gradient from 300 down to 500 m. A field campaign was carried out 16 to 17 October 2018 at Frohavet in Trøndelag – an area assumed to have high kelp deposition rates. The sediment cores were sliced, dated and analysed for different parameters to estimate the decomposition rate of organic carbon. The parameters analysed were contents of total organic carbon and chlorophyll, as well as different methods to identify source of carbon, such as genetic markers (DNA), lipids and stable isotopes. A manuscript on the degradation rates and long-term storage of kelp organic matter in Norwegian sediments is planned to be submitted to a peer review scientific journal by the end of the year. Results were presented during the Nordic Blue Carbon meeting for the Norwegian Environmental Agency 21-22th November 2019..



Communication and publication of scientific results

Results from NBFN are being communicated and published to the international scientific community.

The Euromarine Workshop

Sixteen researchers from Europe, Australia and USA were in April gathered in Granada, Spain to discuss the role of macroalgae in the global carbon budget. Participants from the Norwegian Blue Forest Network were Kasper Hancke and Hege Gundersen from NIVA, and Karen Filbee-Dexter from IMR. Carlos Duarte and Dorte Krause-Jensen, the authors of the 2016 Nature paper “Substantial role of macroalgae in marine carbon sequestration”, were in charge of the workshop. The researchers shared knowledge about the distribution, production, export to other ecosystems, and final destiny of kelp forests and other macroalgae. The results of the discussions are being collated into several outcomes expected to be finalised in 2019/2020. Hence are some new pieces added to the puzzle on the role of kelp and other macroalgae in the carbon budget, and thereby their role in the climate budget.

SUKER Workshops – Broadscale Fate of Kelp Carbon

Compelling evidence suggests that macroalgae production contributes an underappreciated but important flux of carbon in the global ocean, but the ultimate fate of this organic carbon is largely unknown. Here we used a broadly distributed litter bag experiment across the northern hemisphere to measure in situ rates of biomass loss and degradation of kelp detritus. This project is one of the first

collaborative experimental networks in marine ecology, and the approach shows promise for improving predictive ability of global scale ecological processes, such as decomposition. In May 2019, SUKER had a successful workshop, where 12 key authors met in person and over Skype at Flødevigen (IMR) to discuss the data analysis and final manuscript preparation. The project results were also presented in a conference talk by Filbee-Dexter at the Canadian Ecology and Evolution Society Meeting in Fredericton in August 2019. The final manuscript entitled: “Hotspots of blue carbon storage occur with increasing latitude in kelp forests across the northern hemisphere” is currently in the final stages of preparation, with planned submission to Nature Ecology and Evolution in early 2020 (see abstract below). Further dissemination plans and outputs will be discussed among the co-authors in the new year. The key findings of SUKER are that exceptionally slow macroalgal carbon turnover rates occur in high latitude regions, suggesting geographic hotspots of potential carbon burial and storage exist at the cooler, northern ranges of macroalgal forests. Ocean temperature explained the most variation in kelp decomposition rates, with faster loss in warmer regions. Yet, overall decomposition of kelp was slower than other dominant forms of marine organic matter. The latitudinal gradient in carbon turnover suggests that the expanding macroalgal forests along subarctic and cold temperate coasts have higher potential for long-term carbon residence time and storage, and could be targeted by climate mitigation strategies to increase organic carbon sinks. However, the importance of temperature in driving rapid decomposition suggests that turnover rates will quicken with climate change, leading to a reduction in global carbon sequestration by current kelp forests.



All 16 participants from the workshop. From left: Mike Burrows, Morten F. Pedersen, Jean-Pierre Gattuso, Kira Krumhansl, Pippa Moore, Karen Filbee-Dexter, Thomas Wernberg, Sarah Bachmann Ørberg, Jack Middelburg, Dorte Krause-Jensen, Carlos M. Duarte, Isabel Sousa Pinto, Hege Gundersen, Jorge Assis, Kasper Hancke and Albert Pessarrodona.

Knowledge Support For Policy

Blue Forests and Parks

Raet National Park covers approximately 607 square kilometers of coastal nature and ocean outside the municipalities of Tvedestrand, Arendal and Grimstad. As much as 98% of the area is defined as sea and seabed. This area extends from the coast and far out at - up to 12 nautical miles (22 km) from the outer islands and islets in the archipelago. The creation of the Park in 2016 laid the foundation for future generations to create memories of beautiful and generous coastal nature. Raet National Park is located in and near areas with high population density and strong business and outdoor interests. The interaction between protection and sustainable use is therefore important.

The NBFN's publication on the ecosystems of Raet National Park shows the diversity and interaction of marine ecosystems. It highlights five key ecosystems and ecosystem services that the park contributes to. It is designed so that people who do not have a strong connection to the marine environment can understand and appreciate the values of the park.

Providing Input to New Norwegian 'Oceans for Development' Program

The Norwegian Government through Prime Minister Erna Solberg announced at the Our Oceans conference held in Oslo in October that it would strengthen Norwegian development cooperation on marine governance and management through a knowledge-based program titled «Oceans for Development». Upon request from the planning agency for the new program, Norad, the NBFN prepared a brief input proposal suggesting blue forest related themes, activities and specific countries where NBFN have cooperative partners. The work program for this new development program will be launched in 2020.

NBFN Lifting "The Value of Kelp" at the Arctic Frontiers Conference

The Arctic Frontiers series of conferences held in Tromsø annually is one of the most prominent meeting places for the Arctic policy, business and science community. This year's conference had "The Power of Knowledge" as its focus. The NBFN convened a side-event at the first evening of the conference, attended by an international and active audience of about 50. The focus of the side-event was to lift the numerous values offered by the Arctic kelps forests, ranging from the global climate perspective to the national and local, but also to address the knowledge dimension - what we know and what the knowledge gaps are.

Four prominent speakers provided insightful presentations on these topics - two taking the global and UN perspective,



while two were representing national - local perspectives from Norway, Scotland and Greenland. Prof. Peter Haugan, IMR, enlightened the audience with insights from the report of the Erna Solberg-led High-level panel for a Sustainable Ocean Economy on Ocean-Based Climate Action to accelerate progress on five key ocean-based climate actions to support the achievement of the Paris Agreement and the Sustainable Development Goals (SDGs). The first of these actions was to invest in nature-based climate solutions by restoring, protecting and managing coastal and marine ecosystems to enhance their ability to sequester and store carbon, adapt to the effects of climate change, and improve coastal resilience. While recognising the huge role of the naturally growing kelp forests in the global carbon cycle, the report did not prescribe any action towards natural kelp forests. Seaweed cultivation, however, was defined as a mitigation measure with potential. Dr Kirsten Isensee, UNESCO IOC, continued with a global perspective and mentioned that in the coming United Nations Decade of Ocean Science for Sustainable Development (2021-2030), more knowledge on the kelp forests should be given priority. Dr Susse Wegerberg, Aarhus University, with a vast experience from Greenland, explained the state of the art regarding plans and ambitions for both kelp harvesting and seaweed cultivation, the latter complicated by floating icebergs. Dr. Marianne Karlsson, NIVA, spoke about the diametrically different views to kelp harvesting in Scotland and Norway. In Scotland a recent proposal to start kelp harvesting was turned down by the Scottish Parliament following an intense campaign by environmentalists supported by Sir David Attenborough. In Norway, however, large scale kelp harvesting has been ongoing for decades, yet contested in some areas. An emerging issue is the potential value and use of kelp forests along the Norwegian northern coasts recovering from retreating sea urchins due to rising sea temperatures, a dilemma being dealt with in the project OPTIMAKELP. Following the presentations some of the issues presented were explored further in a panel discussion, also with active contributions from the audience.



Norwegian
Blue Forests
Network

