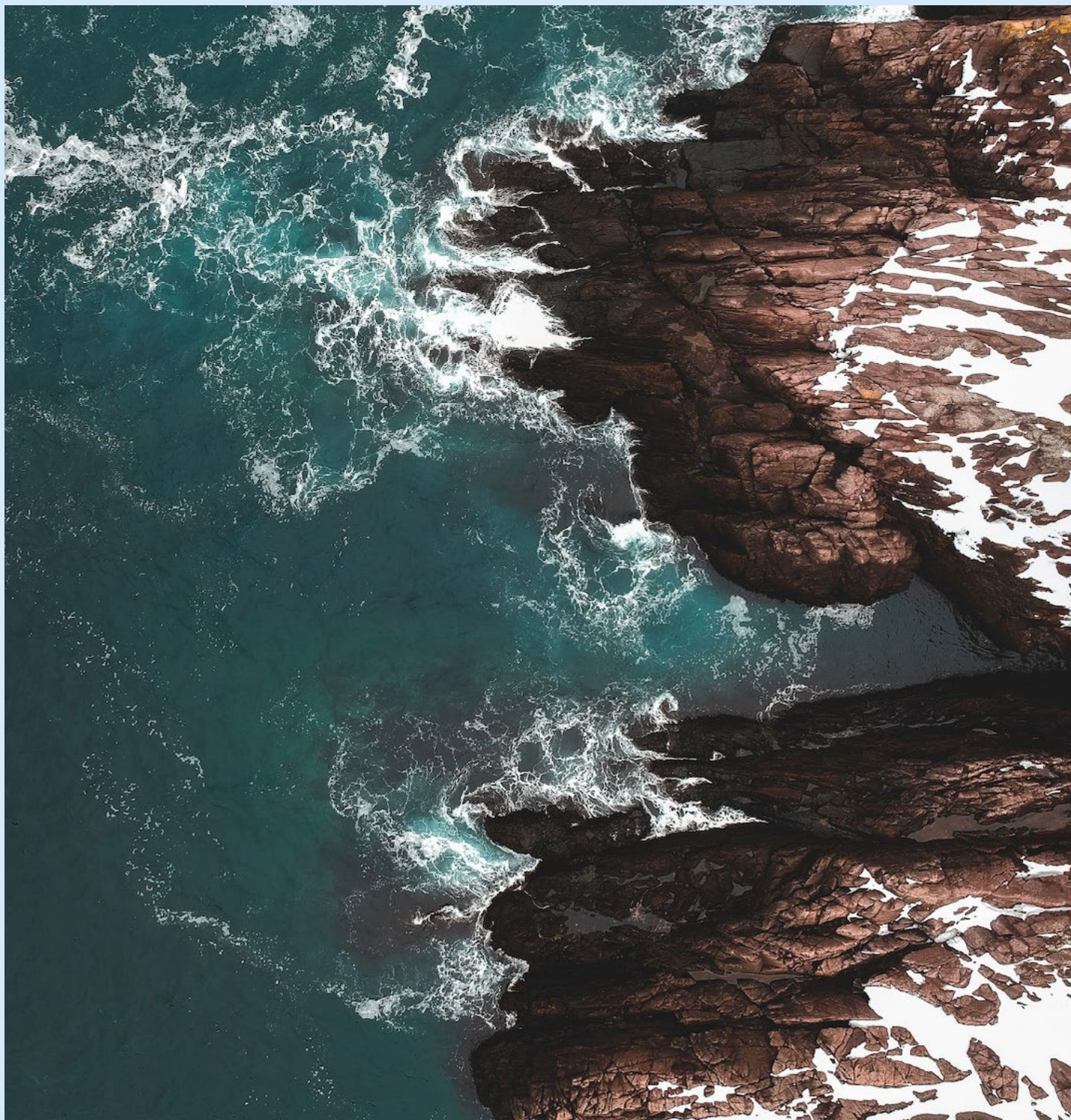


Report on Barriers to Co-Location in Nordic Seas



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1 Executive Summary

The report investigates the **concept** of **co-location** in marine environments within the Nordic region, focusing on integrating various activities such as energy production, aquaculture, and other maritime industries within the same geographic area. This approach, often referred to as marine industrial parks or multi-use at sea, aims to enhance spatial efficiency, reduce environmental impact, and promote sustainable development.

Key Findings:

Opportunities and barriers:

Co-location presents significant opportunities for maximizing the use of marine areas while addressing environmental concerns. However, the report identifies several barriers, including differing national regulations, environmental challenges, and the need for advanced technological solutions. In the Nordic region, most co-location projects are found in Norway, Denmark, Sweden, and Finland, though many projects are still in the research or pilot stages.

Political and business involvement:

Political and business involvement: Political will and robust frameworks are essential for advancing co-location initiatives. The report calls for stronger political signals and the development of spatial plans that prioritize marine industrial parks. The involvement of the business sector, particularly in wind energy and aquaculture, is growing, but there remains caution due to the need for clearer regulatory frameworks and investment security.

Nordic cooperation:

The report emphasizes the importance of Nordic cooperation in overcoming regulatory and operational challenges. Harmonization of regulations and the development of marine spatial plans are crucial for the successful realization of co-location projects at sea. The Nordic Council of Ministers is highlighted as a potential driving force in promoting co-location and ensuring the sustainable use of marine resources.

Environmental and technological considerations:

The report underscores the need for ongoing research and innovation to address the environmental and technological challenges associated with co-location. This includes the development of new methods for sustainable aquaculture and the integration of renewable energy sources. The balance between economic benefits and the preservation of ecosystem services is critical, with particular attention to the potential impacts on marine biodiversity and the need for careful planning.

Future outlook:

The future of co-location in Nordic seas appears promising, but it requires concerted efforts in research, policy harmonization, and cross-sectoral collaboration. The report suggests that with the right political leadership and industry support, co-location can contribute significantly to sustainable development in the region.

Conclusion:

The report concludes that while co-location offers substantial benefits, it requires a coordinated approach involving political, industrial, and environmental stakeholders. The Nordic region, with its strong tradition of cooperation, is well-positioned to lead in the development and implementation of co-location projects, provided that the necessary frameworks and support are in place.





2 Introduction

Nordic Innovation aims to highlight "barriers to co-location in Nordic seas. The report aims to broadly illuminate the topic, drawing on experiences from all the Nordic countries, and including examples from other parts of the world that may be relevant.

Work on the report took place from **February** to **August** 2024.

This report is focused on **co-location** but does not cover **coexistence**.

Coexistence

Coexistence is when multiple activities or users share the same marine area simultaneously without hindering each other, allowing different interests to exist side by side.

Co-location

Co-location refers to the idea of using marine areas for multiple purposes simultaneously, such as combining wind power with aquaculture. This can increase spatial efficiency and reduce environmental footprints.

Utilization

Utilization of marine areas focuses on sustainable and efficient use of sea areas for various activities like energy production, fishing, and tourism, while also considering environmental protection and ecosystem health.

The information and experiences were gathered from all the Nordic countries. However, this topic has so far been most discussed in Norway, Denmark, and to some extent, Sweden. The projects to date have largely been linked to the EU and its initiatives in this area. There are also several groups across industries, organizations, and authorities working to find new solutions in this area.

Methods

To ensure a thorough and reliable review, various methods were employed for data collection and analysis. The report addresses the issue using journalistic methods, meaning a combination of written documentation and interviews. The goal was to write a report that delves into the issue without making it difficult for the reader to access.

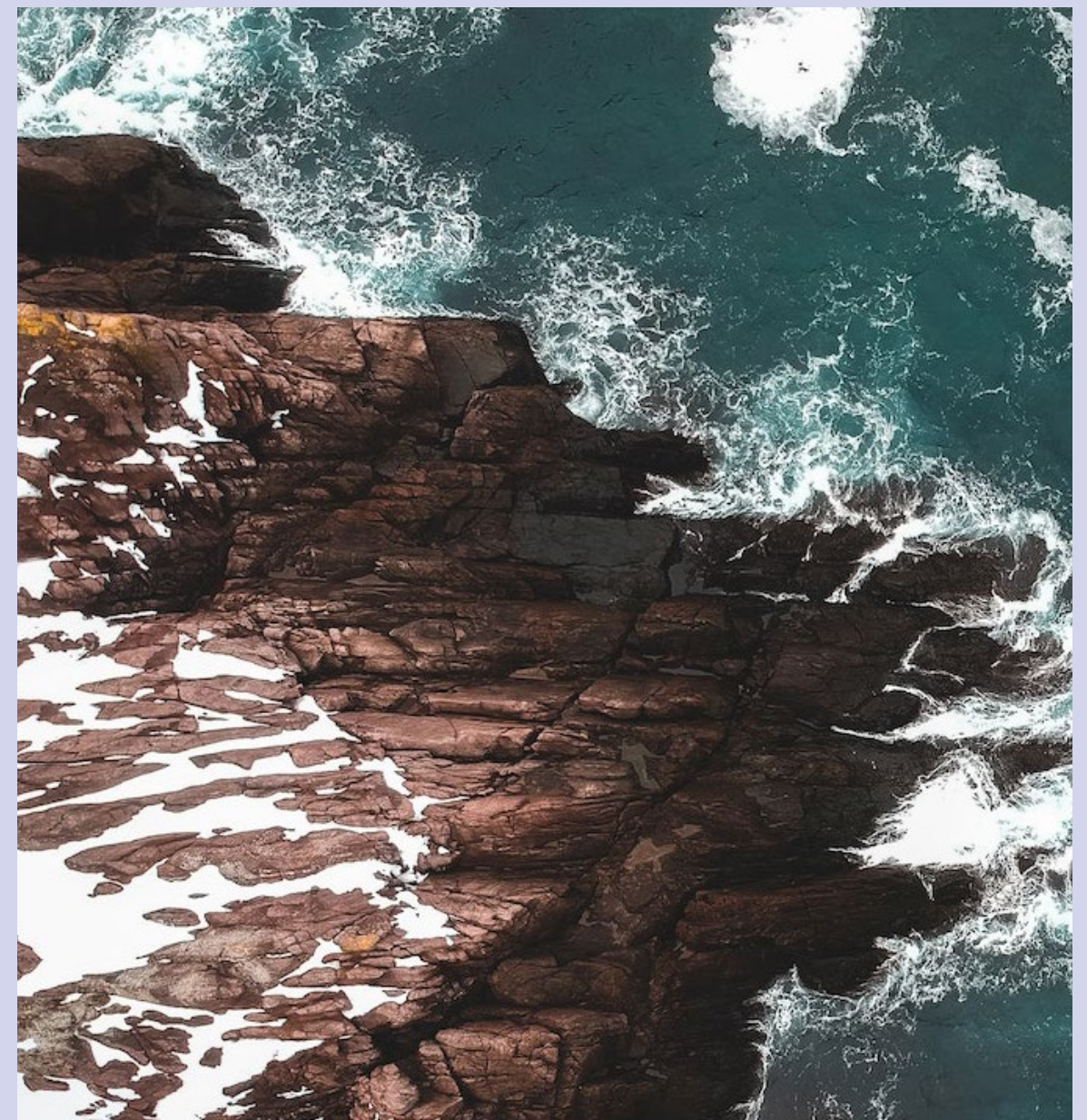
Interviews

In-depth interviews were conducted with key individuals in relevant companies, organizations, and public sector bodies to gain insights from different perspectives. The interviews were structured with open-ended questions to allow for exploratory and detailed answers.

Literature review

A comprehensive search and review of existing literature was conducted to identify previous research, theory, and experiences in the field. This included academic articles, professional literature, reports, and relevant electronic sources.

We worked to find relevant documents such as policies, strategy documents, and public reports to understand the institutional context and framework surrounding the topic.



Collaborators

The report is the result of a collaborative project involving several parties from across the Nordics. It was written by Jógvan H. Gardar (NO/FO), who has a background as a journalist with extensive experience in maritime topics, particularly aquaculture and fishing in the Nordic region and Europe.

Magnar Pedersen (NO) and Ásmundur Guðjónsson (FO) served as subject matter experts, providing input and feedback throughout the process. Mr Pedersen is an independent consultant who was previously a manager at Nofima, a Norwegian food research institute with a specific focus on aquaculture and fisheries. Mr Guðjónsson was the director of NORA (the Nordic Atlantic Cooperation) until 2023.

The report was commissioned by Nordic Innovation, which was primarily represented by Thordur Reynisson (IS), senior innovation adviser and head of the Sustainable Ocean Economy program.



Bilder Ocean Rainforest





3 Marine co-location in the future and today

In the Nordic seas, there are great opportunities to create new industries with ample space for both new and sustainable solutions. Here, in the interplay between the forces of nature and human engineering, we find possibilities for future co-located industrial environments — which can either be co-located or coexist with one another.

Wind farms stand as majestic sentinels, their rotating blades capturing the wind's energy, converting it into clean, renewable power that drives industrial communities at sea. Below the surface, in deep, clear waters, salmon, shellfish, and new aquaculture species thrive in carefully designed facilities that not only contribute to the global food supply but also to a healthy and balanced ecosystem.

Here, too, we find algae reefs. In the air, the buzzing of helicopters can be heard as they maneuver gracefully between platforms, and service ships shuttle back and forth, delivering supplies, personnel, and technical support to the various installations.

In this vibrant, pulsating environment, humans and machines work side by side with a common vision of a sustainable and innovative future.

This is a vision of the future where economic growth and environmental protection go hand in hand. Where today's oil and gas extraction will eventually be replaced by new renewable energy sources. Here, at sea, opportunities abound, where technology and sustainability create a world where we utilize the sea's gifts without depleting its treasures. This is the future marine landscape.

4 Increased Focus on Co-Location

In all the Nordic countries and Europe, there is a political desire to make further and more efficient use of the opportunities above the sea to below the seabed, and on the water surface.

Co-location in marine industrial parks can be a way to achieve efficient use of areas, creating synergies while contributing to combating the climate crisis and the nature crisis.

Increased activity today also means that we use more of the sea area. This has led many to call for new thinking when granting permits and planning the use of the sea, both near the coast and offshore. Co-location in Nordic seas is a topic that is gaining increasing attention, and stakeholders are considering both physical co-location and opportunities for better coexistence with existing activities in an area.

There are significant differences when comparing the West Nordic region to the East Nordic region in this context. Greenland, Iceland, the Faroe Islands, and Coastal Norway have vast ocean areas, unlike Denmark, Sweden, Åland, and Finland. For the West Nordic countries, the question of available ocean space is less of an issue compared to the East Nordic region, where co-location and coexistence are crucial for utilizing ocean areas in the most sustainable way. The challenges in the West Nordic region are more related to harsh weather conditions.

The question we posed is: What does it take for more actors, especially in the private sector, to invest in co-location in maritime environments?

Based on what we see on land, where it has become increasingly common for different types of companies to



benefit from co-location, one may wonder what it takes for actors in the marine space to do the same. If it works on land, why does it seem that we can't achieve it at sea?

The simple answer is that well-functioning co-location projects in maritime environments seem to be a good distance into the future. The reasons are many and partly complex. Still, we see an understanding and willingness to think differently, while the actors call for clearer frameworks and investment security.

***But how can we
utilize marine areas
more efficiently?***

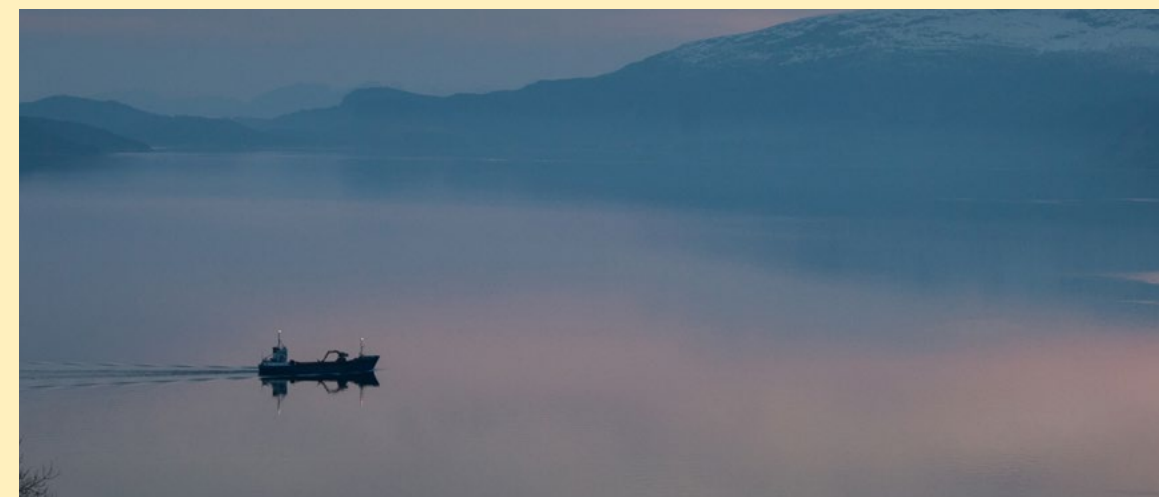
- This question is being discussed in research communities worldwide. Offshore wind farms occupy large areas, and it would be wise to find good ways to have multiple uses of these sea areas, says Øivind Bergh, a researcher at the Institute of Marine Research in Bergen, Norway, and the head of the OLAMUR project.

The OLAMUR (Offshore Low-Trophic Aquaculture in Multi-Use Scenario Realization) project is an EU-funded initiative with 25 partners from European research and industry.

The project aims to demonstrate and document sustainable co-location solutions by cultivating seaweed and mussels in three pilot sites in Europe: two existing offshore wind farms and a rainbow trout farming facility.

The Institute of Marine Research in Bergen leads the project, with a total funding of 8.2 million euros over four years. Their focus includes combining energy production, sustainable food production, and supporting nature and ecosystems.





Need for more area

In the DNV report "Spatial Competition Forecast," it is argued that the world will need significantly more sea area for both food and energy production by 2050. The areas with the most growth will be in China, with Europe in second place.

The battle for space will be in coastal areas, where there is already a lot of activity and traffic. Both the DNV report and other reports point to areas like the North Sea, the Baltic Sea, and areas south of Ireland and eastward to Biscay and into the English Channel as the most interesting.

The North Sea basin is already an area with intense competition for space among various industries. The area is suitable for all known marine industries, from fishing and oil production to wind farms. DNV estimates that in the North Sea, installations will cover 23 percent of the area from two to fifty kilometers from the shore. They estimate that the Baltic Sea will account for about one-fifth of all offshore wind capacity by 2050.

The DNV report concludes that to adapt to the activity competing for space in coastal areas, it is necessary for marine industries to collaborate. They also emphasize that cooperation and multiple uses should become an integrated part of marine spatial planning in such areas. They point out that considering biodiversity when designing wind farms can help achieve goals related to energy transition and the protection of marine ecosystems.

"As offshore wind accounts for 80 percent of the installation area, full utilization of multiple-use platform concepts can reduce global installation area consumption by up to 20 percent," writes DNV.

We should utilize nature gently while benefiting from it. Co-location is a way to achieve more in smaller areas. The sea and fjords have always been an important pantry for humans. The world's oceans have been exploited as much as possible, and there has more or less been room for everyone. But a focus on sustainability means we need to think differently.

Who drives the projects?

Government authorities at both central and regional levels play a key role in shaping and implementing policies that promote more co-location at sea. They do this by establishing spatial plans and providing opportunities for stakeholders to invest in.

In the Nordic region, research communities are crucial, coordinating and developing methods for increased co-location through government-initiated projects. Innovation clusters are also contributing by fostering collaboration between different sectors to advance co-location projects.

While industry and businesses tend to be cautious, there is a growing involvement from wind power companies, particularly in projects that promote both co-location and coexistence. A good example is Vattenfall, which is actively participating in projects that could eventually scale up. Sectors like fishing, aquaculture, and shipping also have the potential to drive forward both co-location and, importantly, coexistence projects. One such project is Utror in Norway, which integrates coexistence into its open-sea salmon farming development.

Although we have not seen large-scale investment from investors and financial institutions in co-location within maritime environments yet, it is likely investors will support sustainable projects in the future.



Nordic and European Projects

There are several projects in Europe and globally that test various forms of co-location. Some of these provide analyses that offer insights into the advantages and disadvantages they have experienced. A common theme in these projects is that they are largely at the test level, and none of the Nordic or EU projects have been tested on a commercial large scale. Most point out that the framework conditions set by the authorities are not secure enough today for commercial actors to dare to invest.

In the EU, several years of work have been dedicated to co-location projects. The most important project in this context is the UNITED project. UNITED was funded through the Horizon 2020 program and completed in 2023. It attempted the co-location of various maritime activities such as renewable energy, aquaculture, bio-resources, environmental restoration, maritime transport, and tourism services. The project was carried out in the North Sea, Baltic Sea, and Mediterranean

One of the project's conclusions is that co-location is economically, socially, and environmentally feasible.

Barriers pointed out in UNITED include:

- **Regulatory complexity:** The need to navigate complex legal and regulatory challenges when multiple activities share the same area.
- **Environmental impacts:** Potential negative effects on marine ecosystems, such as disruption of wildlife and habitat changes.

- **Technical challenges:** Integrating different technologies and infrastructures can be technically demanding and require significant investments in research and development.

Among the Nordic countries, the co-location concept has progressed the furthest in the EU country Denmark, but so far, no large-scale commercial project has been initiated. In the rest of the Nordic region, progress varies greatly, but Norway, Sweden, Finland, and Denmark have advanced further than Iceland, Greenland, the Faroe Islands, and Åland.

There are no practical projects in Finland, but a co-location concept called MariPark has been proposed within the eMSP project.

In Sweden, the companies OX2, Kobb, and Nordic SeaFarm have joined forces to explore the potential for large-scale seaweed cultivation in the planned offshore wind farm Galatea-Galene, located near Falkenberg and Varberg.

In 2023, the Swedish Agency for Marine and Water Management (HaV) conducted a study on coexistence and co-location, with a particular focus on the development of offshore wind power. The study examined how various interests, such as commercial fishing, aquaculture, and nature conservation, can coexist with wind power installations at sea. The goal was to lay the groundwork for updating marine spatial plans to enable a sustainable and balanced development of marine resources.

Norway has extensive experience with both aquaculture and offshore energy, and the possibilities for co-location are significant. In the report "Marine Industrial Parks," by the Center for the Ocean and the Arctic it is pointed out that co-location can free up areas for conservation and other purposes by combining multiple activities in the same area. The same report points out that disadvantages include costs and access to necessary data.

The more visible challenges lie in conflicts of interest, including those between fishermen, aquaculture, and energy companies.

Denmark has developed several initiatives in marine planning that include co-location. One example is Middelgrund (UNITED-pilot). Projects that combine offshore wind turbines with other marine activities show the potential to optimize the use of marine areas. Denmark faces the same challenges as most countries, with strict regulations and the need for regulatory harmonization potentially delaying or hindering co-location.

The weather conditions around Iceland are challenging for all types of marine activities. There are no projects planning for co-location at sea. However, projects in the borderland between land-based industry and seawater, such as in Ölfus, are being worked on.

In the Faroe Islands, the fjords are used for salmon farming. Currently, there are no concrete projects considering co-location of salmon farming with other aquaculture or projects that conflict with the areas controlled by the aquaculture industry. Ocean Rainforest is currently working on developing its projects and needs to maintain a good dialogue with the aquaculture industry.

There are several exciting projects underway in Åland, mainly energy projects involving wind and/or wave power. The planned wind farms, Noatun Nord and Noatun Syd, are expected to supply power to Åland, Sweden, Finland, and Estonia. There is also interest in using offshore renewable energy to power offshore aquaculture.

In Greenland, finally, there are no concrete plans or projects involving co-location in the marine space. Greenland, like Iceland, is weather-exposed, and currently, the types of industries that could benefit from co-location in Greenlandic waters are limited.

Other Projects

Research and testing have been conducted in several countries on projects involving offshore aquaculture and renewable energy. The integration of fish farming facilities with offshore wind turbines, wave power, and solar panels has been investigated to improve spatial efficiency. For example, research articles have examined hydrodynamic responses and technical challenges associated with semi-submersible offshore fish farming facilities in various wave conditions.

The Blue Growth Farm (BGF) is an EU-funded project that aims to develop a multifunctional offshore platform combining modern automated fish production with energy production from wind, waves, and solar energy.

The MERMAID project, also EU-funded, has investigated the integration of offshore wind turbines with aquaculture facilities. They have examined technical solutions and the benefits of combining these two industries, such as cost reductions through shared operations and maintenance costs.

The ETIP Ocean project explored the potential for combining ocean energy and aquaculture. For example, studies have shown that mussel and seaweed farming in areas with offshore wind farms in the North Sea and Baltic Sea can produce significant results in terms of carbon capture and marine product production.

As this summary shows, Nordic and European projects demonstrate that there are opportunities and that it is possible to think differently. However, majority of these projects are at the research or testing stage, and it remains uncertain whether they will ultimately be commercialized.



5 Opportunities in the Sea

For humans, the world's oceans appear vast and limitless. But we have begun to understand that they are not infinite and impossible to deplete. We humans often perceive only what our eyes see. We often limit our understanding of the use of the sea to what is closest to land.

Co-location can be planned both close to land and far offshore. It is an important environmental and political question of how we can best utilize the sea in the future, maximizing resource use without overexploiting the areas.

Political Will Needed

The recurring theme when talking to those concerned with the opportunities in the sea is the need for political will to get started and, not least, to create the frameworks necessary for co-location in marine environments. And we cannot ignore that culture, society, and local communities are aspects that influence how new thinking in an area is achieved. Experiences suggest that it is not enough to make political decisions without rooting them in the communities where co-location will be based. Another aspect is the willingness and ability of businesses to engage in new thinking related to activities in the marine space. It is not certain that private capital will invest if the overarching political frameworks and local enthusiasm are not in place. Investors want security for long-term and committed political support and that the authorities will help build up such initiatives.

A fourth aspect, which was difficult to discuss until a few years ago, but is now one of the first topics raised, is security in maritime environments. Is activity at sea safe, and how and who ensures the security of installations against terrorism?

Willingness to Create Something New

Coastal communities are known for having local initiators who start small projects that can grow into something big over time. They often grow and learn new things along the way. Both in fishing and especially aquaculture, we have seen growth and innovation that fascinates. Many have grown into large publicly traded companies, which was not the initial plan. Although they did not have the co-location concept from the beginning, they see the benefits of utilizing areas together.

Over fifty years ago, Steinar Olaisen and Hans Petter Meland started salmon farming on Lovund in Northern Norway, an initiative that revitalized the local community. This led to the establishment of Lovundlaks. With a focus on local value creation and jobs, Lovundlaks today produces 12-13,000 tons of salmon annually. The company Utror, led by CEO Olav Andreas Ervik, springs from Lovundlaks, aiming to become a leading operator of offshore aquaculture installations on the Norwegian continental shelf.

Utror aims to move salmon farming from the fjords to the open sea. Ervik sees great potential in the co-location concept while pointing out the need to look at opportunities more broadly than just co-locating at the same site.

- Co-location has the potential to transform how we use marine areas. By sharing resources and infrastructure, we can create more sustainable and cost-effective solutions. However, it requires good planning, collaboration, and a willingness to adapt to new ways of operating. We look forward to continuing to work on these projects and contributing to a sustainable future for aquaculture and other maritime industries, says Ervik.

Bakkafrost, the largest salmon farming company in the Faroe Islands, has worked for many years to ensure good and sustainable operations for the company and production. The company started in 1968 and has developed from buying herring from local fishermen to becoming the Faroe Islands' largest company and one of the world's largest aquaculture companies. As the largest private company on the archipelago, they play an important role in ensuring coexistence with the environment and local communities. Today, Bakkafrost also has aquaculture facilities in Scotland.

Bakkafrost does not currently have any facilities located offshore. All facilities are located in fjords or close to land. Faroese aquaculture is characterized by a greater extent of utilizing entire fjords, moving facilities where it is most beneficial, sometimes placing them furthest out in the fjords, what we often call towards the open sea. The company has been working on projects for several years, considering offshore aquaculture, but they have not yet invested in this.

When it comes to co-location with other types of business activities in the areas where the company has aquaculture facilities, nothing concrete has been done yet. There have previously been conflicts with other actors engaged in shellfish harvesting in one of the fjords where they have aquaculture facilities. The parties did not find a solution for coexistence.

- We are not working on any projects directly related to co-location and have not had any concrete contacts with potential actors, says Regin Jacobsen, CEO of Bakkafrost. He says that the company is working on exploring possible alternatives in connection with new projects.

- We have, among other things, looked at the possibilities of using wind turbines or other alternative energy sources such as ocean current, wave, or solar energy. However, we do not have anything concrete in the pipeline at the moment, he says.

Both Jacobsen and Ervik point to the challenges of food fish production and the requirements that food safety authorities impose on them. Before finding a solution to that, it is unlikely that the aquaculture industry will join co-location projects. But they see, like Ervik, the potential to benefit from other activities in the vicinity, such as supply ships that can handle transport to and from various actors in a larger geographical area.



6 Is There Political Will?

One of the biggest challenges for co-location in Nordic seas is the political will to implement such projects. Although there are many initiatives and strategies on paper, the lack of clear and unambiguous political support often hampers progress.



In June 2024, the Norwegian government presented its "Industry Plan for Norwegian Marine Areas" (Næringsplan for norske havområder). In this plan, they address the topic of co-location, specifically mentioning co-location and coexistence:

"Coexistence involves the multi-use of marine areas. There is growing interest in multi-use, where multiple stakeholders use the same or adjacent areas simultaneously, sharing services and possibly common infrastructure. The realization of multi-use areas at sea will depend on whether the benefits for both industry players and society outweigh those of alternative solutions and whether there are any legal obstacles. Multi-use can also involve combining use with the protection of valuable marine ecosystems. The use of space should be minimized to what is necessary, and multi-use of areas is encouraged.

Fredrik Myhre, Senior Advisor, Sustainable Ocean at the World Wildlife Fund (WWF) points out the need for a comprehensive marine spatial plan that includes all sea areas of a country. He believes that sectoral thinking, where different ministries govern different areas, creates significant challenges for a holistic approach. "The biggest obstacle is the political will and ability to think holistically and across sectors," says Myhre.

In the "Industry Plan for Norwegian Marine Areas," the Norwegian government addresses the issue of future spatial needs and outlines the various interests competing for space for activities. However, the plan does not present a solution for how spatial planning will be managed in the future.

Øivind Bergh, researcher and leader of the OLAMUR project, elaborates on how harmonizing regulations across sectors can contribute to better co-location.

- Harmonizing regulations is important to ensure that different industries do not override each other and that nature is preserved.

For example, in Norway, protected areas for fisheries can be overridden by the petroleum sector.

With harmonized rules, we can ensure that all sectors follow the same standards and sustainability goals, which will facilitate collaboration and reduce conflicts, says Bergh.

Both Myhre and Bergh emphasize the importance of political will and support. At the same time, they point out another challenge common to most countries: silo thinking, where one ministry does not coordinate its plans with other ministries operating in the same geographic area. This creates resistance and confusion among actors.

Fredrik Myhre from WWF points to a concrete example of what can happen when management is based on silo thinking.

- A good example is the Viking Bank off Bergen, an important spawning area for sand eel. In 2009, fishermen agreed to protect the area from fishing activity based on recommendations from marine researchers. But in 2017, Equinor received permission to drill in the same area, despite environmental recommendations to the contrary. This created great frustration among fishermen and highlights the need for cross-sectoral legislation that can provide comprehensive protection, Myhre points out.

Ervik says that one of the biggest challenges lies in navigating the regulatory landscape.

- Obtaining the necessary permits and predictable framework conditions from the authorities is challenging. And this comes on top of the technological challenges associated with operating and maintaining facilities far offshore. We are continually working to develop solutions for these challenges, he says.



7 Good Proposals Face Resistance

There is no shortage of wishes and proposals. There are many studies, both publicly and privately conducted, examining co-location in the marine space to better utilize areas and provide more room for new and additional actors. In the report "Marine Industrial Parks – New Opportunities for Cooperation at Sea," published by the Centre for the Ocean and the Arctic (Senter for hav og Arktis) in 2022, it is emphasized that "physically gathering industrial activities at sea can trigger synergies and thus increased value creation. Concentrating activities can free up space for others who use the sea as their workplace and for areas that need protection." The report concludes that "marine industrial parks can be an effective means of achieving increased value creation and strengthened cooperation across sectors, becoming a new tool for developing Norway as a maritime nation."

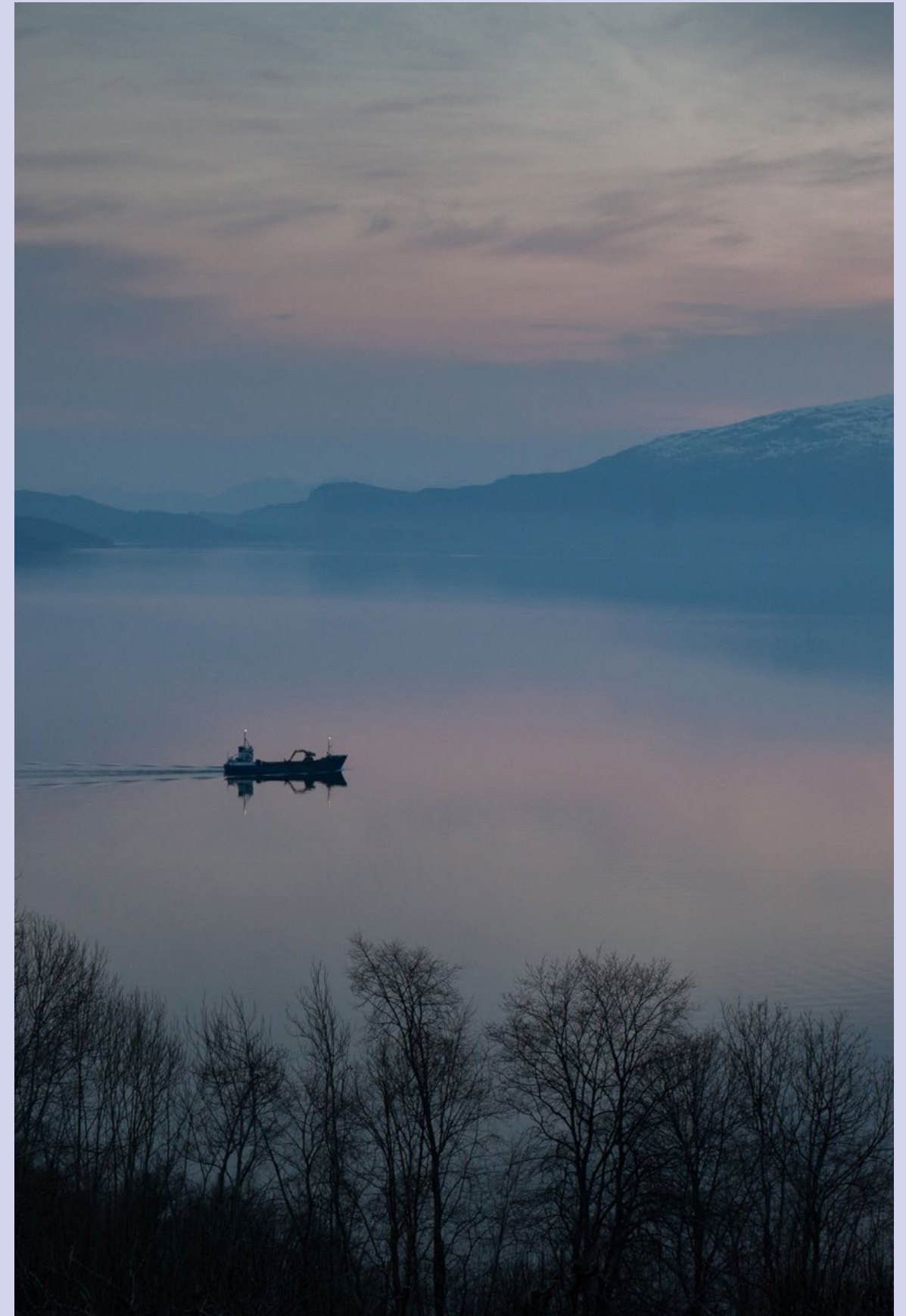
The arguments for why these are good proposals are clear, but finding concrete projects and industry commitment is difficult. Utror is one of the few aquaculture projects exploring the possibilities of operating in open seas while also seeking opportunities to collaborate with other stakeholders in the same area. Co-location with other producers of consumer products is something salmon aquaculture does little of, but Ervik is open to collaboration with other actors.

- We view co-location positively as long as it is feasible without compromising on the conditions crucial for fish welfare and health, environment, and safety. We are working with offshore aquaculture facilities far at sea, and there are not many industries with which we can co-locate due to different requirements. We seek areas with the best water flow and suitable temperatures for the fish. We maintain good dialogue with actors in offshore, oil and gas, offshore wind, and fisheries to find opportunities for coordination and cooperation.

Ervik says that their focus in the current phase has been finding areas that best suit fish farming without conflicting with other activities. Co-location is a sensitive issue for established industries.

The aquaculture industries in Norway, the Faroe Islands, and Iceland have gained access to entire fjord arms where they have their facilities. It has proven difficult to achieve co-location with other types of aquacultures where there are already salmon or trout farming operations. But there is no simple explanation for why this has not been achieved – both laws, regulations, and food production requirements challenge the idea of more co-location for the food fish industry.

Salmon and trout farming need to be able to move their facilities quickly, either due to weather, disease, or other events. Although this is not as common today as before, cages are moved to be able to harvest the fish. Such mobile units are unlikely to be compatible with other activities using the same location with current solutions. But new thinking and new ways of working are needed.



8 Requires Good Planning

Fredrik Myhre from WWF says that one of the main challenges is, as previously mentioned, sectoral thinking, or silo thinking, which is widespread in many countries.



- The different ministries and sectors often sit on their own turf, focusing on their interests without considering how to cooperate across sectors. This makes it difficult to achieve effective and sustainable marine management. Without an overarching plan and common rules, it becomes challenging to get industries to cooperate on co-location, says Myhre.

This is something that receives support from Ida Marie Bonnevie's PhD thesis from Aalborg University in 2022. She points out four key barriers for achieving co-location:

1. Co-location requires advanced decision support tools and extensive data.
2. For co-location to be effective, detailed and harmonized data across borders are necessary.
3. There may be high costs associated with operating areas with co-location.
4. In already existing facilities, there are established routines and tools for spatial management that cannot handle all aspects of co-location.

Myhre adds that for co-location within Norwegian coastal and marine management, the most important thing is to establish marine spatial plans. These are challenges familiar from other Nordic countries.

- Today, we neither have this along the coast nor in Norwegian marine areas in general. This needs to be established through our management plans. Today, we lack a comprehensive marine spatial plan for managing our seas. The Climate Committee 2050 and several parts of the industry, including actors like Equinor and the Fishermen's Association, have already highlighted the need for this, Myhre points out.

In WWF, they are working on various scenarios for how cooperation and co-location can be implemented in the marine space.

- We envision several possibilities, including combining offshore wind and aquaculture. This can include farming salmon and cod, but also growing seaweed, tunicates, mussels, and similar. Note that fish farming must occur without today's high environmental footprint, and closed technology is needed. It is also possible to imagine artificial reefs in wind farms that can contribute to increased biodiversity and carbon capture. But to achieve this, we need much research and innovation, as well as governance tools like marine spatial plans and harmonized regulations, says Myhre.

Øivind Bergh from the OLAMUR project says these are well known issues.

- It is not just about starting; all projects require facilitation, and authorities are not always quick enough or skilled enough to see emerging opportunities. There are several challenges related to laws and regulations in most countries, he says, adding:

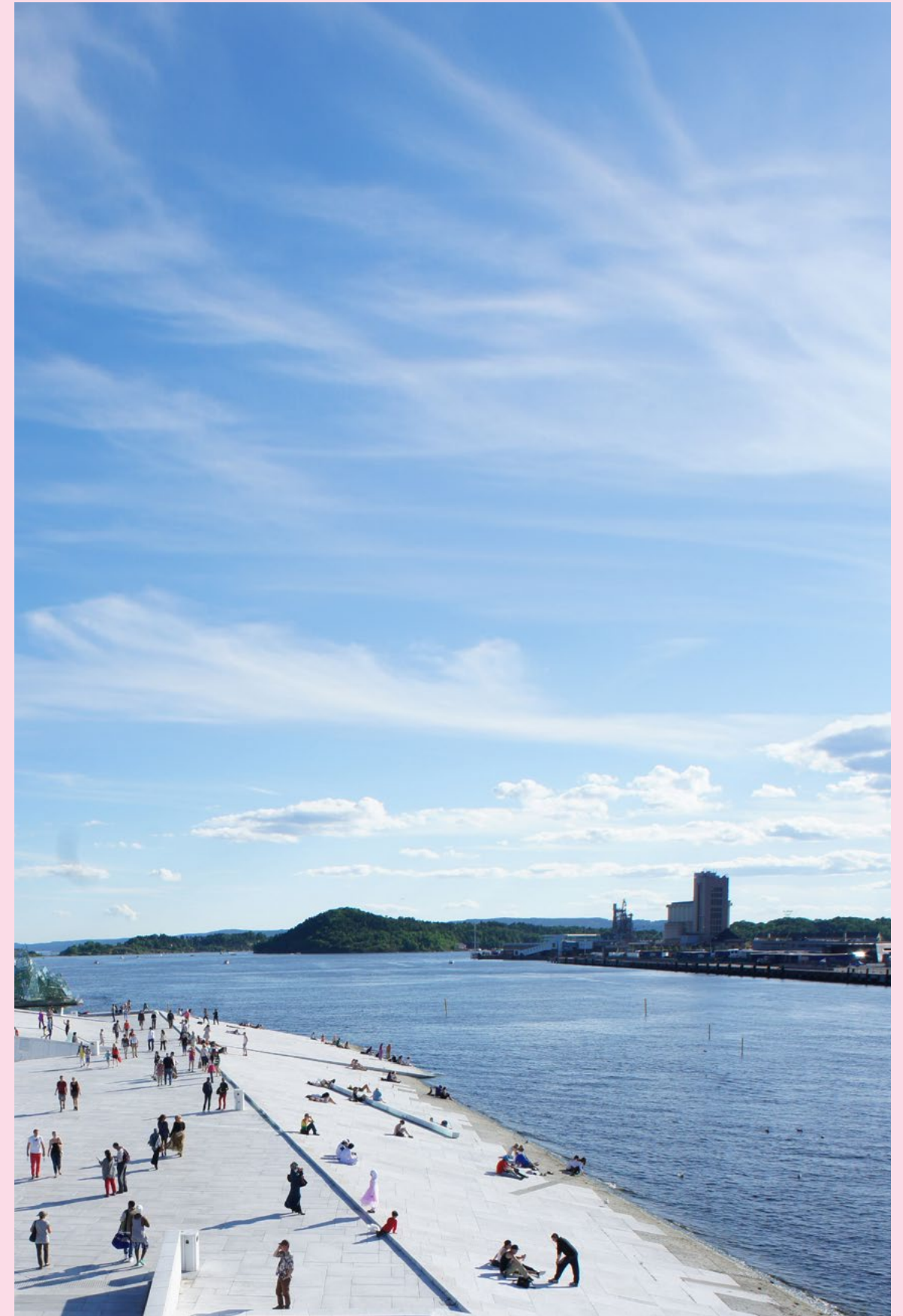
- Laws and regulations vary significantly between European countries and even within certain countries. For example, German states have different laws. The sector-based principle, where different ministries govern different areas, makes it difficult to achieve the seamless collaboration required for multiple uses of areas. This applies both in Europe and the Nordic region, where sectoral thinking often stands in the way of holistic solutions, says Bergh. He elaborates on how he believes harmonizing regulations across sectors can contribute to better co-location:

- Harmonizing regulations is important to ensure that different industries do not override each other, and that nature is preserved. With harmonized rules, we can ensure that all sectors follow the same standards and sustainability goals, which will facilitate collaboration and reduce conflicts, he says.

Bergh also addresses the challenges and background of silo thinking.

- Many fear that changes will negatively impact their own sector, and therefore hesitate to take the necessary steps. Without an overarching plan and clear guidelines, actors withdraw and dare not enter new projects. This is why we need clear and strong political leadership that can set holistic goals and standards for all sectors. The biggest obstacle is the political will and ability to think holistically and across sectors, he says. Bergh is clear on what it takes to increase political will to implement these necessary changes.

- Increased awareness and pressure from both the business community and the public can help increase political will. When more actors see the benefits of a holistic approach and co-location, it will be easier for politicians to take the necessary steps. Furthermore, dialogue and cooperation across sectors are important to find common solutions that everyone can agree on.





9 The Business Community is Open to New Thinking

Although it may seem that business actors do not contribute to discussions about more co-location, this is not because they do not want to contribute, according to Fredrik Myhre. Through his work and contact with actors, he believes they have the will and desire to contribute both with expertise and investments.

- I find that large parts of the business community are willing to listen and look for innovative solutions. Coexistence has been a buzzword in marine management for many years without anyone truly solving it. Many genuinely want to achieve change, but they are also concerned about how this will impact their operations.

He adds, supporting Bergh, that this can create a situation where change is desired but feared for its consequences, hindering practical implementation.

A large Nordic company, Swedish Vattenfall, has helped the OLAMUR project initiate one of its projects. They receive praise from the project management.

One of the core challenges in the OLAMUR project, involving several countries and regions, is, as mentioned above, that laws and regulations vary significantly between European countries. But Bergh points out that they have secured important and forward-thinking partners. In Denmark and Germany, they have seen interest from authorities, and the operators of wind farms are key collaborators.

- For example, Vattenfall is a full partner in the project in Denmark, providing us with access to their infrastructure. This has eased the pressure on the authorities and made it possible to carry out the project. Collaboration with operators like Vattenfall and equivalent local partners has been crucial for obtaining permits and access to necessary resources, points out Bergh.

In OLAMUR, the three pilot sites for low-trophic aquaculture

are: two wind farms in Denmark and Germany and a rainbow trout farming facility in Estonia.

- We are also developing new concepts for mussel farming, including using technology from New Zealand. The pilot sites will be a learning experience for both industry and authorities, focusing on technical solutions, product quality, and regulations to promote multiple uses of wind farms, says Bergh.

- The three sites are already operational, and we are exploring the potential for cultivating seaweed and mussels in these areas. We are looking at the possibility of building artificial reefs that can create a habitat for other species. There are many reasons to cultivate both seaweed and mussels in areas with offshore wind, and where there is trout farming.

But what are the advantages of cultivating seaweed and mussels in areas with offshore wind farms?

- There are both economic and ecological reasons for this. For example, the market for seaweed and mussels is developing interestingly. Seaweed production can help reduce the pressure on wild-harvested seaweed, which has been too high. Mussels can be used as a substitute for fishmeal, which is interesting globally since fishmeal is a limited resource. Seaweed and mussel production have a limited market in Europe, but it is developing. Mussels have a partial market through wild harvesting, and mussel meal can be a substitute for fishmeal, he says.

Bergh says they are exploring alternative uses for the raw materials they research. Not everything can be eaten or made into meal. Many industries are working to find new solutions for products we need.

- For example, technology exists to separate mussel meat from the shell, providing two interesting products. The mussel meat can be used to produce mussel meal, while the shell can be used in the concrete industry.

This can help reduce the carbon footprint in concrete and cement production.

Concrete production is one of the major CO2 emitters globally. By using mussel shells in concrete production, we can significantly reduce emissions, Bergh points out.

A company that has experienced significant interest in its projects is Ocean Rainforest. This is a pioneering company in blue growth, headquartered in the Faroe Islands, with a branch in California, USA. The company was founded in 2007 to cultivate seaweed in open ocean areas, contributing to reducing CO2 levels and meeting the growing demand for sustainable food and feed products.

On their website, they state their goal is to improve human well-being and make a unique contribution to our blue planet by applying science, innovation, and expertise. They cultivate seaweed used in food, feed, cosmetics, and various research projects. The company's cultivation systems are both sustainable and scalable, making them one of the largest commercial seaweed cultivators in Europe.

They believe that co-location is possible and works.

- We cultivate seaweed near salmon farming. It works well as we use areas with greater water depth than 50 meters, while the aquaculture facilities use areas with 20-40 meters depth. We need space between us but benefit from each other. The uptake of nutrients from the fish by the seaweed contributes to a better environment, and the fish living in the seaweed eat Sea lice larvae, reducing the lice infestation on the salmon, says Urd Grandorf Bak, Research Manager at Ocean Rainforest.

They have several projects underway.

- We have collaborated with wind energy companies on co-location. We have not yet had activities at these sites but have explored the possibilities and conducted a study to see what is feasible. Co-location of activities at sea has several advantages. Firstly, equipment can be shared between different sectors, reducing costs and improving efficiency. Additionally, it provides better utilization of marine areas, minimizing spatial conflicts and maximizing usage potential, says Bak.

Ocean Rainforest is also exploring other possibilities, such as how to utilize waste heat better. They seek more sustainable energy use and resource recycling.

Since 2010, Ocean Rainforest has developed an advanced system for cultivating seaweed in the open ocean, proving robust enough to withstand the challenging conditions in both the North Atlantic and the Pacific Ocean.

But what is best suited for co-location in the marine space?

- Offshore wind, wave energy, and solar energy. For example, wind and seaweed can work together, says Urd Grandorf Bak.

The business community often shows a willingness to explore co-location projects but faces significant economic and technological challenges. Olav Andreas Ervik from Utror emphasizes that while they see the potential in co-location, it requires extensive planning and collaboration.

- We view co-location positively as far as it is feasible, says Ervik. They are in 2024 between a feasibility study and a concept study.

- We have chosen a concept to work further with, but further decisions depend on the timeline set by the authorities. An application competition and preliminary allocation are planned for the first half of 2025. We await the qualification criteria for the call for tenders. Based on this timeline, we do not expect to be in production until 2028.

The concept they are working on involves facilities capable of producing 12,000 tons of fish.

- These are large structures divided into several chambers. It is important to find favorable locations that suit the fish and avoid conflict with other maritime activities, says Ervik. The energy supply to the facilities is an important topic, but aquaculture facilities do not require large amounts of electricity.

- For now, it is planned that the facilities will be powered by diesel-electric solutions. We are also considering the possibility of running a cable from other installations and potential co-location solutions with other industries in the long term. We envision diesel-hybrid solutions as a practical solution for powering these facilities in the initial phase.

- Regarding co-location, it is difficult to envision direct co-location due to safety and operational requirements. But we see opportunities for synergies, especially in logistics and emergency preparedness. For example, supply ships can serve both aquaculture, offshore wind, and offshore oil and gas. This can provide cost-effective solutions, he points out.

Utror works closely with the Norsk Industri and other actors to develop framework conditions and regulatory frameworks for offshore aquaculture.

They have also an industrial partner, Abel, involved in the project. Collaboration and organization are crucial for driving such projects forward, he says.



10 Culture, Society, and Local Communities

Culture and social structures play a crucial role in how co-location projects are received and implemented. In the Faroe Islands, for example, both positive and negative reactions to such initiatives have been observed. Local fishermen, including in Norway, have expressed concern about how co-location might impact their traditional fishing areas.



Senior Advisor at the Fishermen's Association of Norway and marine biologist Maria Pettersvik Arvnes from the Fishermen's Association describes how increased use of coastal and marine areas by other industries can lead to the displacement of fishermen, affecting their catch and livelihood.

- A major challenge is that there are more users of coastal and marine areas, she says.

The Fishermen's Association does not work directly with projects related to co-location, but they often have interests in areas where new projects are starting up.

Pettersvik Arvnes has participated in a working group under the auspices of the Centre for the Ocean and the Arctic, exploring the possibilities for marine industrial parks. The Fishermen's Association also collaborates with the Directorate of Fisheries and the Norwegian Petroleum Directorate regarding oil and gas activities, although there is limited coexistence with these industries. They also continually address challenges related to cod and salmon farming.

- A major challenge is that there are more users of coastal and marine areas. This can lead to fishing areas or spawning grounds being occupied by other industries, displacing fishermen or forcing them into less favorable fishing areas. This results in increased time and lower catch for our members, says Pettersvik Arvnes, adding that they currently do not see how co-location can be implemented without compromising the efficiency of the fisheries. Future fishing methods and tools may change this, but as it stands now, it is challenging, she says.

- There have been conflicts, particularly in the North Sea and Tromsøflaket. These conflicts have often involved physical and geophysical surveys, which can disrupt fisheries. There have been conflicts, but we have worked extensively to improve dialogue and cooperation between industries, significantly reducing conflict levels, points out Arvnes

Arvnes explains that they have had annual contact meetings with oil and gas companies, as well as with management agencies.

- This has helped establish a better culture of coexistence and dialogue. Most conflicts have been resolved at a low level through good communication and cooperation.



Bilde: Generert med KI



11 The Safety Aspect

When multiple parties want to use the ocean, conflicts over these areas can arise. The military in various countries is also a user of marine areas and is part of the maritime environment. Because of increased geopolitical uncertainty, it is expected that the military will demand greater access to ocean areas. All other stakeholders must take this into account.

The expansion of NATO, with new member countries Sweden and Finland, along with the current geopolitical situation, means that NATO will increase its presence throughout the Nordic region. The war in Ukraine has led to heightened activity and a visible presence of military vessels from the U.S. and other NATO countries. The fact that the entire Nordic region has gained increased geopolitical significance also means that port and transport infrastructure may be expanded, as noted in the report "Industry Plan for Norwegian Marine Areas."

The North Stream explosion occurred in September 2022, where the gas pipelines North Stream 1 and North Stream 2, transporting natural gas from Russia to Germany through the Baltic Sea, were destroyed. The explosions led to significant gas leaks into the sea.

The incident was quickly regarded as sabotage, and both European and American authorities launched investigations. It remains unclear who is responsible for the explosion, with speculation and theories pointing to various actors, including Russia and Western countries, but no concrete evidence has been presented.

In addition to severe environmental damage and geopolitical tension, the consequences of the sabotage have raised concerns about energy security in Europe, as these sub-sea pipelines were an important source of natural gas for several European countries. This has highlighted the importance of securing offshore installations, both politically and operationally. Protection against threats such as terrorist attacks or interference from foreign powers requires close cooperation between authorities and companies operating in the same area.

Political stability and strong international alliances are important factors in ensuring safe operations. Locally, robust security measures must be implemented, including monitoring, securing infrastructure, and emergency plans to effectively handle any security threats.

These topics are currently on the agenda of Nordic

governments and are also discussed at lower political levels. Security challenges in a time of war and instability in our neighboring countries make it necessary to upgrade security and emergency preparedness at all levels. Old emergency plans are being dusted off, and security authorities are working on new challenges and threats.

Following the North Stream explosion in the Baltic Sea, it has become clear to all engaged in marine activities that installation security must be improved. Even seabed installations are now threatened by powers seeking to create instability. This could also be a strong argument for more co-location, as it means that a smaller area needs to be monitored.

Co-locating different types of offshore activities, such as wind power and aquaculture, requires advanced technological solutions. Developing and integrating systems for multiple uses of marine areas is complex and requires thorough research and innovation. Technological barriers must be overcome to ensure the seamless operation of different systems. Environmental impacts must also be carefully considered to avoid damaging marine ecosystems and ensure the sustainable use of marine resources.

Economic sus

tainability is a critical factor for the successful operation of offshore installations. For example, as Utror plans, the energy supply to such facilities is initially planned as diesel-electric solutions, with possibilities to develop diesel-hybrid solutions in the start-up phase. While direct co-location may be challenging due to safety and operational requirements, synergies can be achieved, especially in logistics and emergency preparedness. Supply ships serving multiple sectors can result in cost-effective solutions, promoting long-term economic sustainability.

The security situation in the world and especially in the neighboring areas of the Nordic countries may be a reason why new projects, which could have become new co-location projects, do not progress beyond only being an idea while investors wait for the world to become more stable again.

12 What is Possible?

To realize the potential for co-location in Nordic seas, strong political support, cross-sectoral cooperation, and investment in research and technology are necessary. Security and environmental considerations must be addressed to ensure sustainable solutions.



With the right approach and willingness, co-location can contribute to more efficient and sustainable use of marine areas, benefiting both the business community and society. There is broad interest in more co-location, while skepticism and hesitation remain, especially in industries already operating at sea, regarding how co-location should be facilitated. Companies with existing activities have built their projects based on guidelines set by authorities at an earlier time. If this is to change, authorities must actively participate in the necessary planning and facilitation, and private actors must be involved as early as possible in the processes.

The DNV report's conclusion is clear: "Early stakeholder engagement: Participation of private sector and civil society stakeholders in the Marine Spatial Planning (MSP) process is essential. Stakeholders are commonly engaged fairly late in the MSP process when the most important decisions have already been made."

Olav Andreas Ervik sees specific benefits in co-location or cooperation with other maritime industries.

- Absolutely. Co-location and cooperation can provide many benefits, especially in logistics and emergency preparedness. Sharing resources and infrastructure can reduce costs and increase efficiency. For example, supply ships serving aquaculture can also be used for offshore wind and offshore oil and gas, providing economies of scale.

Øivind Bergh believes that the future looks promising for multiple uses of marine areas. However, research and work are needed on many fronts before clear results are seen.

- The future for multiple uses of marine areas is promising, but it requires ongoing research and development. It is important to determine how we can produce most efficiently, how much we can produce, and what impact these activities have on the environment.

We must also continue developing technologies and methods for integrating different types of energy production and aquaculture sustainably, says Bergh. In the OLAMUR project, they will continue working with their three pilot sites and develop new concepts and technologies for cultivating seaweed and mussels.

- We also plan to expand cooperation with more international partners and explore new areas for multiple uses of marine areas. We have many exciting plans for the coming years, says Bergh.

- Aquaculture, particularly low-trophic aquaculture like seaweed and shellfish farming, can be a key part of the solution. This can help meet the demand for food and reduce the pressure on wild fish stocks. At the same time, we must ensure that this is done in an environmentally conscious manner, preserving marine biodiversity, says Bergh.

But what is needed to make this change happen? Fredrik Myhre has pointed out that first and foremost, we need an overarching marine spatial plan that includes all ocean areas.

- This plan must be seen as part of the broader management plans and must ensure a holistic approach to the use of marine areas. We also need common rules that protect nature and address the climate crisis. This requires harmonizing regulations across sectors and considering the combined effects of different industries to ensure positive environmental and climate outcomes.

However, he also notes that there is still a long way to go, particularly among those responsible for managing the oceans.

- We still lack the necessary political tools for a comprehensive approach to ocean management.

The management plans are updated every four years, and we hope that the next update will include marine spatial plans. As for the Norwegian Marine Environment Act, which is supposed to protect nature beyond 12 nautical miles, it has been nearly two years since it was promised. We hope it will be implemented soon to ensure fair rules for businesses in preserving nature and creating more and better marine protected areas in line with global commitments to protect 30 percent of the ocean by 2030, says Myhre.

Globally, some countries are far ahead of others in marine spatial planning. EU countries have been working on this for a long time, though there's still progress to be made.

The EU has already implemented its directive for marine spatial planning, and some EU countries, like Denmark, have done a good job of ensuring coexistence between different industries. Island nations like Fiji have also made significant progress in protecting large portions of their marine areas.

The Nordic countries have much to learn from these nations in terms of holistic and cross-sectoral ocean management.

Achieving Coexistence: Challenges and Opportunities

A recurring question is whether it's possible to achieve coexistence among many different stakeholders, particularly when they have very different interests. But it is possible, says Maria Pettersvik Arvnes from The Fishermen's Association of Norway representing members who have experienced losing fishing areas to other uses.

- Marine business parks could be a concrete example of successful co-location. The goal of these parks is to create space-efficient areas where different industries can operate in

the same place without occupying more area than necessary. Even if fisheries aren't always part of these parks, it's positive for us that other industries can co-locate, thereby freeing up space.

She is optimistic about a future with more cross-sector collaboration.

- The future looks brighter with increased dialogue and cooperation. We must continue working to protect the interests of fisheries and ensure they aren't displaced. At the same time, we need to be open to new technologies and methods that can enable better coexistence. It requires effort from all parties, but it's certainly possible to find solutions that work for everyone.

Key Measures for Success

Arvnes says that the most important measures for success include establishing good platforms for dialogue and collaboration.

- It's also crucial to ensure that fisheries have access to necessary resources and good fishing areas. The development of new technologies and methods that can contribute to better coexistence is essential. Clear and fair rules that all industries must follow are also important to avoid unfairness or conflict.

- Our advice is to focus on dialogue and collaboration. Open communication and a willingness to find solutions together are the keys to success. We've found that most conflicts can be resolved through conversation and cooperation, and it's important to remember that all parties have a shared interest in utilizing marine areas in a sustainable and efficient way, Arvnes concludes.

Barriers and Opportunities in Nordic Cooperation

When considering the challenges related to co-location in maritime environments, particularly in the expansive and often harsh conditions of the open sea, the Nordic countries encounter several common challenges. Many of these challenges, particularly those related to regulatory and political aspects, could be mitigated more efficiently through enhanced Nordic cooperation.

Barriers

A major challenge is the difference in national regulations between the Nordic countries. These differences can lead to conflicts and inefficiencies in the co-location of various maritime activities, such as fisheries, offshore energy (e.g., wind farms), and shipping.

Maritime activities on the open sea, such as fishing, shipping, and energy production, pose significant environmental challenges. The Nordic countries face the shared challenge of balancing economic activity with environmental protection, particularly ecologically vulnerable areas like the Arctic and the North Sea. Managing this balance can be complicated as national priorities may differ as well as approaches to environmental protection. Furthermore, each country's economic interests, security concerns and geopolitical issues can make it challenging to achieve a coherent Nordic maritime consensus on all political and regulatory barriers to co-location.

Opportunities

Despite these challenges, there is a substantial opportunity to address them through Nordic collaboration, as the Nordic countries have an exceptional cooperation relationship through the official Nordic cooperation, led by the Nordic Council of Ministers and its institutions and activities. By working together, the Nordic countries can harmonize regulations and standards across the whole region. This harmonization could reduce legal conflicts, streamline operations and facilitate the co-location of different maritime industries. This will lead to a more efficient and sustainable ocean economy in the Nordic region.

In several projects in which the Nordic Council of Ministers has participated, the harmonization of maritime safety protocols has been a central theme. This includes the development of common rules and guidelines that facilitate cooperation among the Nordic countries on maritime safety and preparedness. Additionally, The Nordic Council of Ministers can play a pivotal role in strengthening cooperation on maritime safety and preparedness. With joint emergency response and safety protocols, the collective ability of the Nordic countries to respond to maritime incidents, human and environmental, can be greatly enhanced.

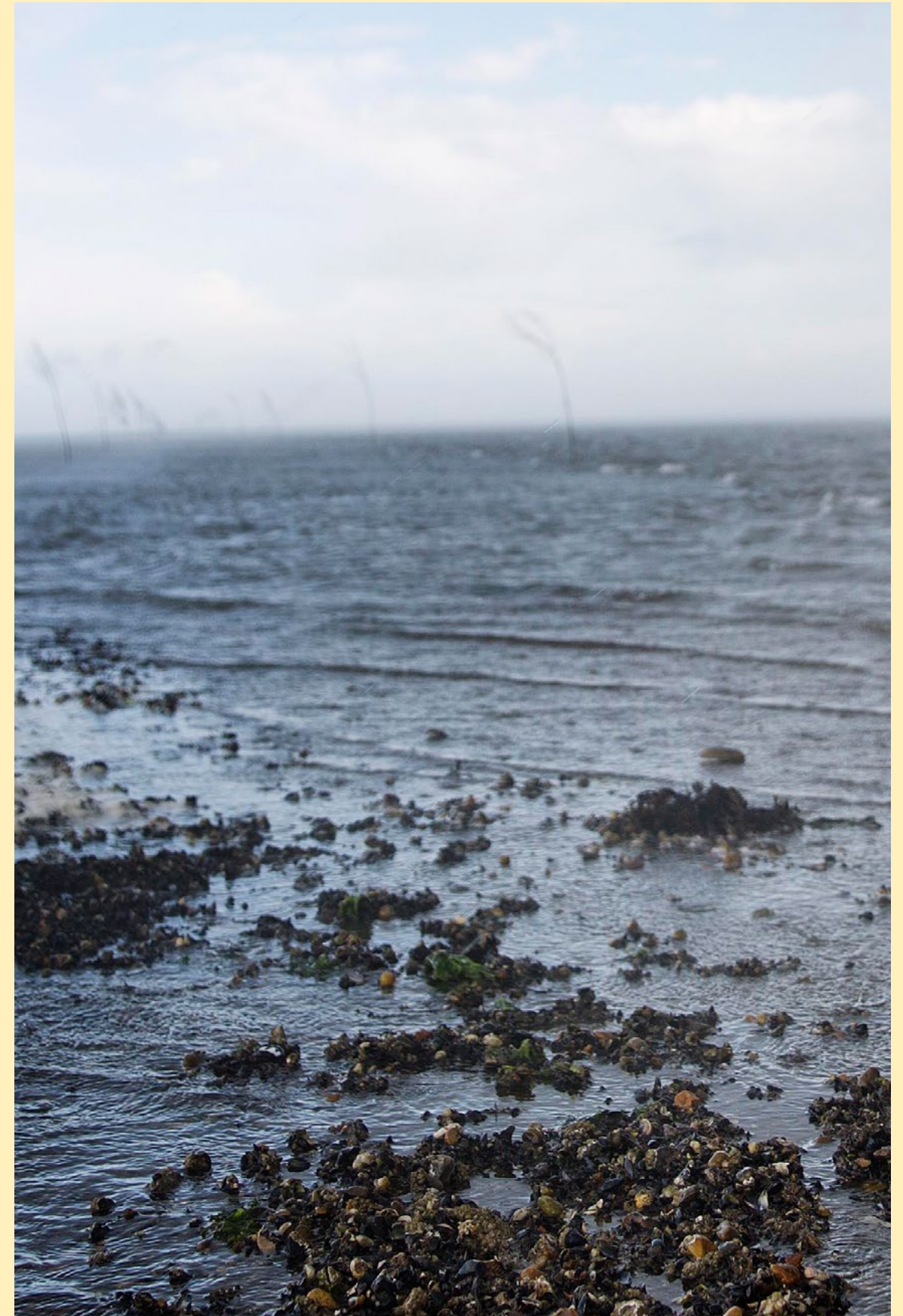
By leveraging the strengths of Nordic cooperation to overcome many of the challenges to co-location at sea, the Nordics should address them in unison and set a global example of how such challenges can be effectively solved through regional cooperation.



13 Conclusions

There is a clear will and desire to achieve more co-location in the Nordic marine areas. It is evident that a driving force is needed to initiate this work. In this context, Nordic cooperation is important and should explore the possibility of becoming a significant driver for progress in this area.

- Politicians in the Nordic countries must act and strongly signal that the concept of “co-location at sea” should be a priority for a more effective and sustainable use of marine areas for business and conservation needs.
- For those marine areas suitable for such activities, spatial plans should be developed.
- Different regulations and decision-making systems appear to be a central challenge in all countries, so efforts should be made to harmonize regulations, align different licensing regimes, and ensure that public authorities (ministries and agencies) are coordinated.
- Further research efforts are still needed, with a focus on applied research.
- There are significant opportunities to achieve more co-location at sea if the Nordic Council of Ministers and the Nordic Council take the lead and encourage member countries to invest more in this area.



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