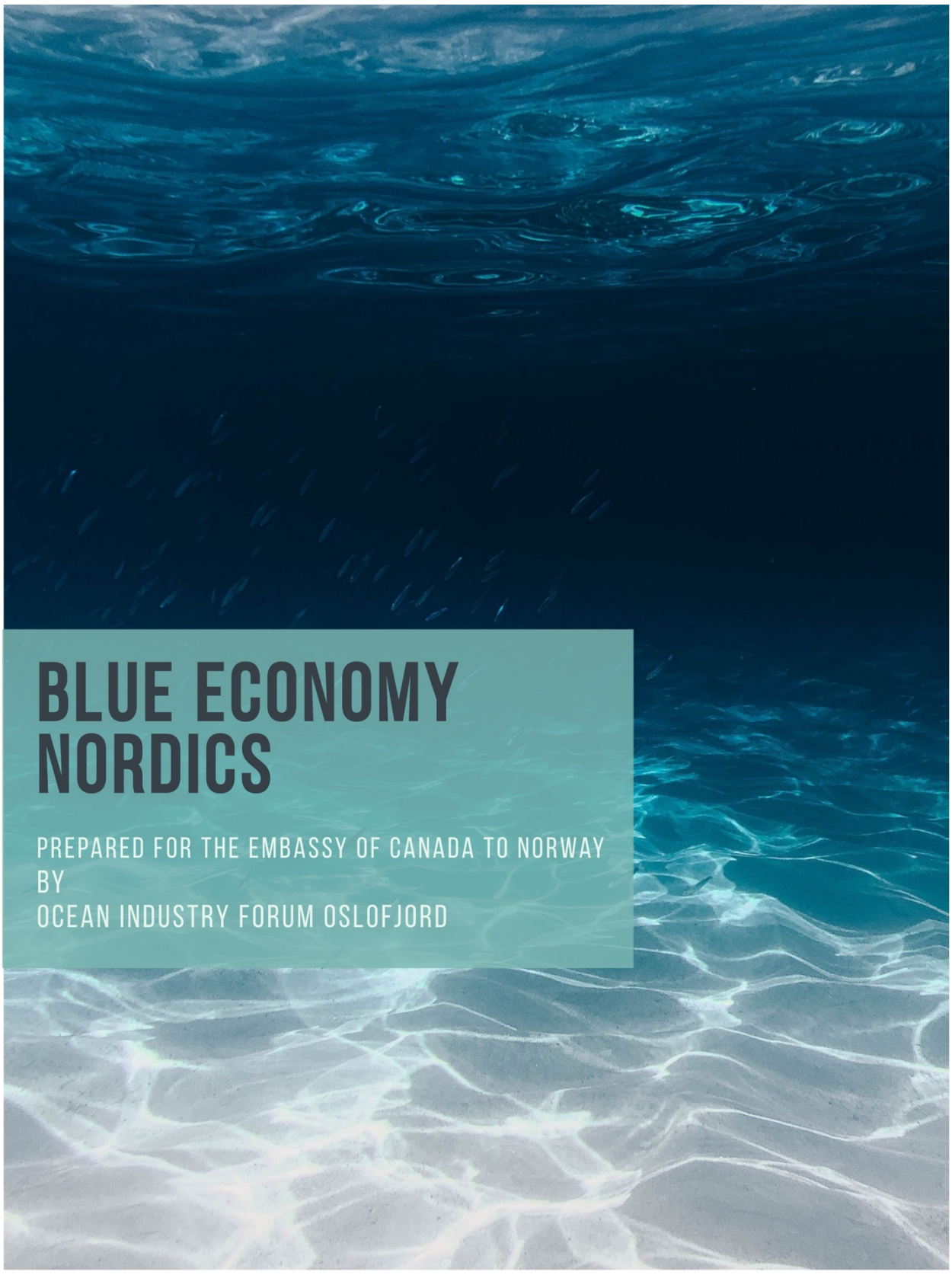


BLUE ECONOMY NORDICS

PREPARED FOR THE EMBASSY OF CANADA TO NORWAY
BY
OCEAN INDUSTRY FORUM OSLOFJORD

2021

AUTHORS MAIKEN MEYER AND TOM KLEPPESTØ
CO-AUTHORS HENRIK ALEXANDER BARRETT OLSEN AND KASPER KROGSET

Table of contents

1. Introduction

This report intends to present the blue economy in the Nordic countries, as well as provide operational recommendations for Canadian authorities and companies. This report is timely due to the:

- Establishment of Canada's Ocean Supercluster[1] in 2018
- Release of the Plan for Growth for Blue Denmark[2] in 2018
- Update of Norway's Ocean Strategy[3] in 2019
- UN Decade of Ocean Science for Sustainable Development (2021-2030)[4]
- Planned launch of Canada's Blue Economy Strategy[5] in 2021
- The Norwegian Shipowner's Association's Zero-Emission Strategy Towards 2050[6]
- The High Level Panel for a Sustainable Ocean Economy[7] Final Report released in December 2020
- The introduction of the EU Taxonomy[8] on January 1, 2022

The report focuses on outlining relevant Canadian ocean technology strengths as well as relevant Canadian cross-sector strengths while identifying expected future areas of opportunity in the Nordic blue economy. Furthermore, it will focus on how Canadian interest aligns with the Nordic blue economy. The purpose of this is to aid Canadian companies obtaining commercial contracts and win public/commercial tenders, identify mutually beneficial innovation partnerships, and attract investment to Canada. In addition, the report will examine key sectors and sub-sectors for each market as follows:

Norway:	Maritime shipping (emission reduction and storage), aquaculture (AI) and offshore wind
Denmark:	Offshore wind, maritime logistics/transport (digitalization)
Sweden:	Maritime informatics, clean tech and fuels
Finland:	Maritime logistics/transport (innovation), and marine engineering technologies
Iceland:	Marine biotechnologies and marine food technologies

Methodology: Ocean Industry Forum Oslofjord has consulted various experts from each country as well as utilizing Nordic country representatives from DNV (Det Norske Veritas). We have used various reports, presentations and publicly available data, referred to in footnotes throughout the report.

Oslo, March 31, 2021

Ocean Industry Forum Oslofjord

Tom O. Kleppestø	Maiken Meyer	Henrik Barrett Olsen and Kasper Krogset
General Manager	Project Manager	Research Assistants and Co-authors

[1] https://oceansupercluster.ca
[2] https://www.dma.dk/Vaekst/VaekstBlaaDanmark/Vækstplan2018/Sider/default.aspx
[3] https://www.regjeringen.no/en/dokumenter/the-norwegian-governments-updated-ocean-strategy/id2653026/
[4] https://www.oceandecade.org
[5] https://www.dfo-mpo.gc.ca/campaign-campagne/bes-seb/index-eng.html
[6] https://rederi.no/en/aktuelt/2020/norwegian-shipping-climate-neutral-by-2050/
[7] https://oceanpanel.org
[8] https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

2. Executive Summary

The recent global shift towards a more sustainable future has led to an increased focus on viable utilization of ocean resources. The Nordic Countries, also referred to as the Nordics, have long traditions living off and in harmony with the ocean and are well positioned to be strong players in the new blue economy.

The Nordics are among the most innovative in the global blue economy. There are few major market gaps. And as most of the blue economy is export-oriented, and the Nordic countries are close trading partners, it is not uncommon that one ocean solution has been engineered in Sweden, developed in Denmark and utilized in Norway, or vice-versa.

This report looks at the different drivers and trends of the blue economy in the Nordics. The main driving force for these countries is the focus on sustainability and emission reduction, driven either by the governments or by large market actors, in addition to new regulations by the EU and the International Maritime Organization (IMO). There is a need for new, sustainable, and creative solutions. Many of these have already been developed, while many are still on the drawing board.

According to conducted interviews, the EU classification system for sustainable activities, i.e. the EU Taxonomy, will likely play a significant role in this sector in the future. This opens up for new business areas to be researched and developed, and new collaborations and partnerships to be established. One such area where there is an identified future need is within ship recycling, both short sea shipping and offshore vessels, and waste management, as part of the increased focus on circular economy. This is part of the taxonomy consideration, but still lacks viable solutions. Another opportunity is within ship management. There is a growing trend, particularly amongst Danish shipowners, to outsource technical management, and to some extent commercial management.

The blue economy in **Norway** is driven by several ocean initiatives and strategies, set by the government and different interest organizations. The Norwegian people have always utilized the ocean, making it a substantial source of revenue for the Norwegian economy. With a growing demand for sustainable solutions – particularly within shipping, aquaculture and energy production, Norwegian companies have the opportunity to take a leading role. Traditionally, a country with a lot of knowledge and experience from shipping and the oil & gas industry, Norwegian maritime companies are using technology and expertise from these sectors to establish themselves in new areas, such as in the offshore wind industry. Norway was the first, and remains the largest, Atlantic salmon farming nation, producing more than half of the world's farmed salmon. Today, the focus on Artificial Intelligence (AI) in aquaculture is increasing, with companies such as Aquabyte and Blue Lice driving innovation and improved fish welfare. Change in the is also being driven by large players such as SalMar, with their Ocean Farm 1- the world's first offshore fish farm, and Stadion Laks, a floating closed salmon farming production unit. Both of these are attempts to improve fish health. The blue economy is the main export source for Norway, and the country plans to continue and expand on this with well-established technologies and new innovations.

Denmark is among the world's leading nations within the maritime industry and offshore wind. The country's relatively long coastline and consistent, strong winds, has made Denmark a driving force in wind technology. As the first country to install an offshore wind farm in 1991, Denmark is considered the cradle of the offshore wind industry. 47 % of the country's electricity in 2019 was produced by wind power. The world's first energy islands to be constructed are in Denmark. Theywill serve as hubs that can create better connections between offshore wind energy and the energy systems in the surrounding regions. As world leaders in digital maritime solutions, the Danes have developed revolutionary platforms that drive change in several areas. One example being; Maersk launched their smart booking platform in 2019, Maersk Spot. Maersk is also one of the founders of the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping – a new research center leading the way for decarbonizing shipping.

The **Swedish Government** has taken a holistic approach to promoting the maritime industries and established a strategy in 2015 that will guide future work in this area. Large players such as Stena, Saab and Wallenius, who all have strong emphasis on sustainability, are locomotives of the industry. The west coast around Gothenburg is considered the maritime center in Sweden, with strong roots in traditional shipping. There is a focus on green ports and their future role in the energy systems. This creates opportunities for innovative port technologies. The Swedish shipping industry has been active in decarbonizing, its industry association has formulated a target of zero-carbon shipping by 2050, and various Swedish shipping companies are pioneers in low-carbon shipping.

Known for its strong technology expertise, **Finland** is one of the leading developers of marine engineering technologies, autonomous ships and icebreakers. About 90% of Finnish import and export is transported by sea. In addition, Finland is the only country in the world where all ports freeze in the winter. Hence the extensive knowledge in building icebreakers - subsequently about two thirds of the world's icebreakers have been designed and/or built in part or fully in Finland. Finnish shipyards are mainly specialty yards. In the last few decades, they have mainly produced cruise ships, passenger- and car ferries, platform supply vessels, roll-on/roll-offs (Ro-Ro), icebreakers, and oceanographic survey vessels. Finland has a long history of delivering smart and environmentally friendly high-tech maritime solutions and is recognized as a global frontrunner in developing digital solutions with world-leading capabilities in artificial intelligence, censoring and wireless technology. From an AI business ecosystem to autonomous shipping and port operations, companies such as Silo.ai and Awake.ai lead the way in Finnish artificial intelligence.

With the **Icelandic** domestic market being quite small, innovation efforts need to be tailored for a global market from the onset. This creates great opportunities for global actors to invest and co-operate with Icelandic biotech companies. The life science sectors, including biotechnology, is a growing and interesting industry in Iceland. A central part of the marine biotechnology industry in Iceland is the microalgae cultivation at the Blue Lagoon. These microalgae can be used for skincare products, colorants and fish feed. Icelandic companies are highly specialized in fish utilization, however remote regions have a high cost of shipping due to the country's infrastructure. A need for the Icelandic market is thereby finding/creating technologies that make fish products both easier and quicker to ship and preserve.

There are some key actors that drive development in much of the blue economy in the Nordics, most of whom have existed for a century or two. Among these are Aker, DNV, Kongsberg, Grieg, and Wilhelmsen in Norway; DFDS, Mærsk Mc-Kinney Møller (Maersk) and Ørsted in Denmark; Stena, Saab, and Wallenius in Sweden, and Wärtsilä in Finland.

Nordic Innovation is an institution that works to promote cross-border trade and innovation between the Nordic countries. Nordic Innovation works under the auspices of the Nordic Council of Ministers, and is located in Oslo. Sustainability and digitalisation are cross cutting dimensions in all their programs. They also integrate the UN's Sustainable Development Goals with emphasise on making The Nordics a carbon neutral region. Nordic Innovation is following up on the Nordic prime ministers' vision for the Nordic cooperation which is by 2030 to be the world's most sustainable and integrated region.

3. Setting the Stage

Sea bordering countries have a profound ecological, economic and social understanding of the ocean. The ocean has always been an important part of the culture for both the Nordic countries and Canada. Traditionally, these nations have seen the ocean as a source of food, for its valued minerals, and as a vast highway for commerce. In recent years, the potential of the ocean for both food and energy has grown in interest, while the importance of ocean health has become apparent to gain ocean wealth. This report stands as a presentation of the blue economy of the Nordic countries.

The Blue Economy defined:

- According to the **World Bank**[9], the blue economy is the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of the ocean ecosystem."
- The **European Commission**[10] defines it as "All economic activities related to oceans, seas and coasts. It covers a wide range of interlinked established and emerging sectors" (see ill.).
- **World Wildlife Fund** begins its report "Principles for a Sustainable Blue Economy"[11] with two senses given to this term: "For some, blue economy means the use of the sea and its resources for sustainable economic development. For others, it simply refers to any economic activity in the maritime sector, whether sustainable or not."

Therefore, the **Blue Economy** can be described as any economic activity that realizes sustainable developments in the inter-relation with the Ocean. **Ocean Industries** can be defined as various productive activities that develop, use and protect the ocean marine industries, ocean sector, marine and ocean industries, maritime industries, marine economy and ocean economy.

About 70% of the earth's surface consists of sea, with a wide range of resources. Understanding, using and conserving the ocean is directly related to the future welfare of the humanity.

On December 2 and 3, 2020, Canada's Prime Minister, Mr. Justin Trudeau and Norway's Prime Minister, Ms. Erna Solberg, along with twelve other heads of state or government in the High-Level Panel for a Sustainable Ocean Economy (the Ocean Panel), announced the countries' endorsement of the "Transformations for a Sustainable Economy: a Vision for Protection, Production and Prosperity". The Ocean Panel developed a transformative set of recommendations and actions to advance a sustainable ocean economy, prioritizing a healthy ocean alongside sustainable production to benefit people everywhere.

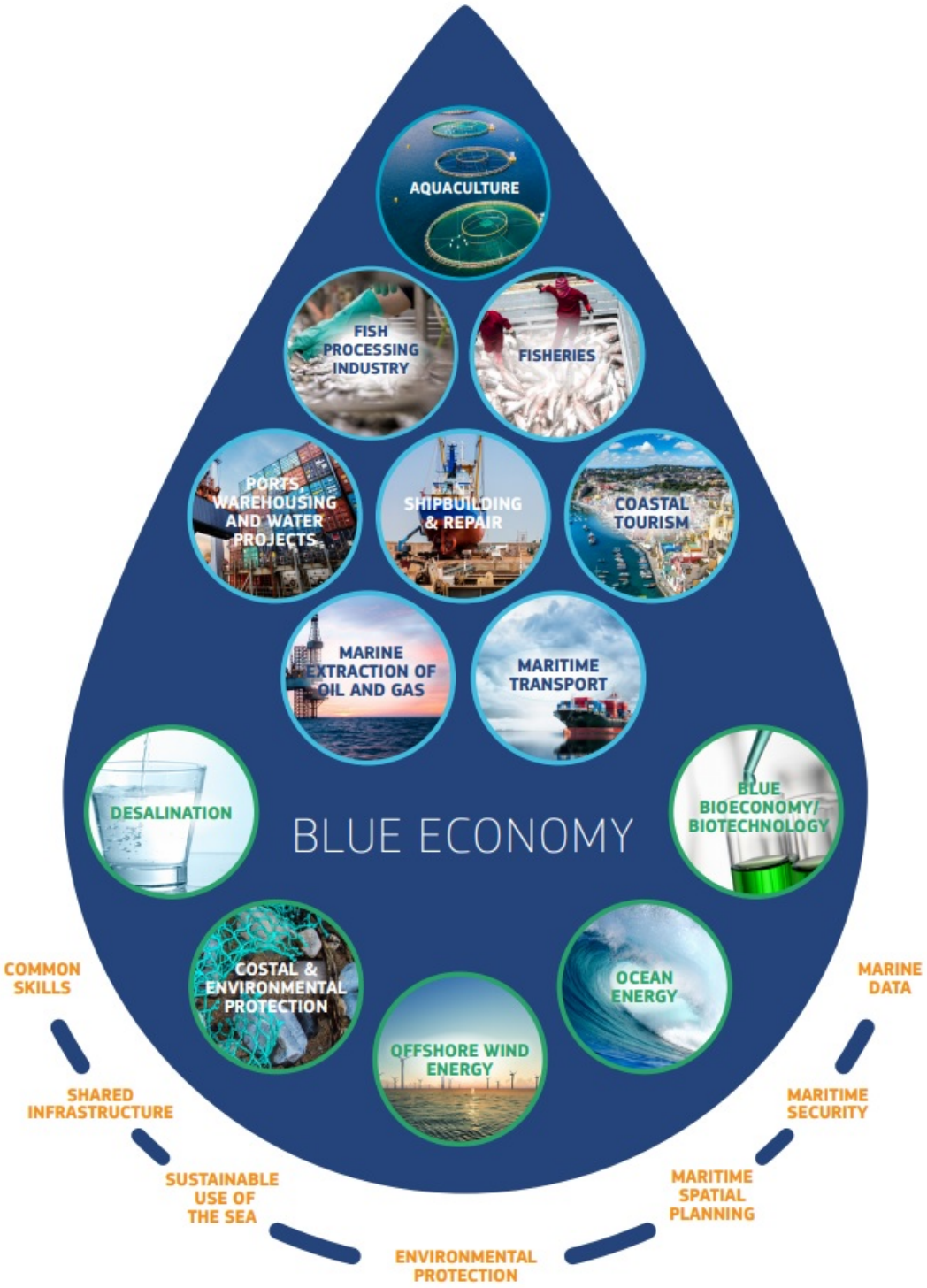
Following this, Minister of Fisheries, Oceans and the Canadian Coast Guard, Ms Bernadette Jordan, participated in a national event to reinforce Canada's commitment to the sustainable ocean economy. The theme centered around Canada's potential to grow its blue economy and how it can push even further towards a sustainable economy.

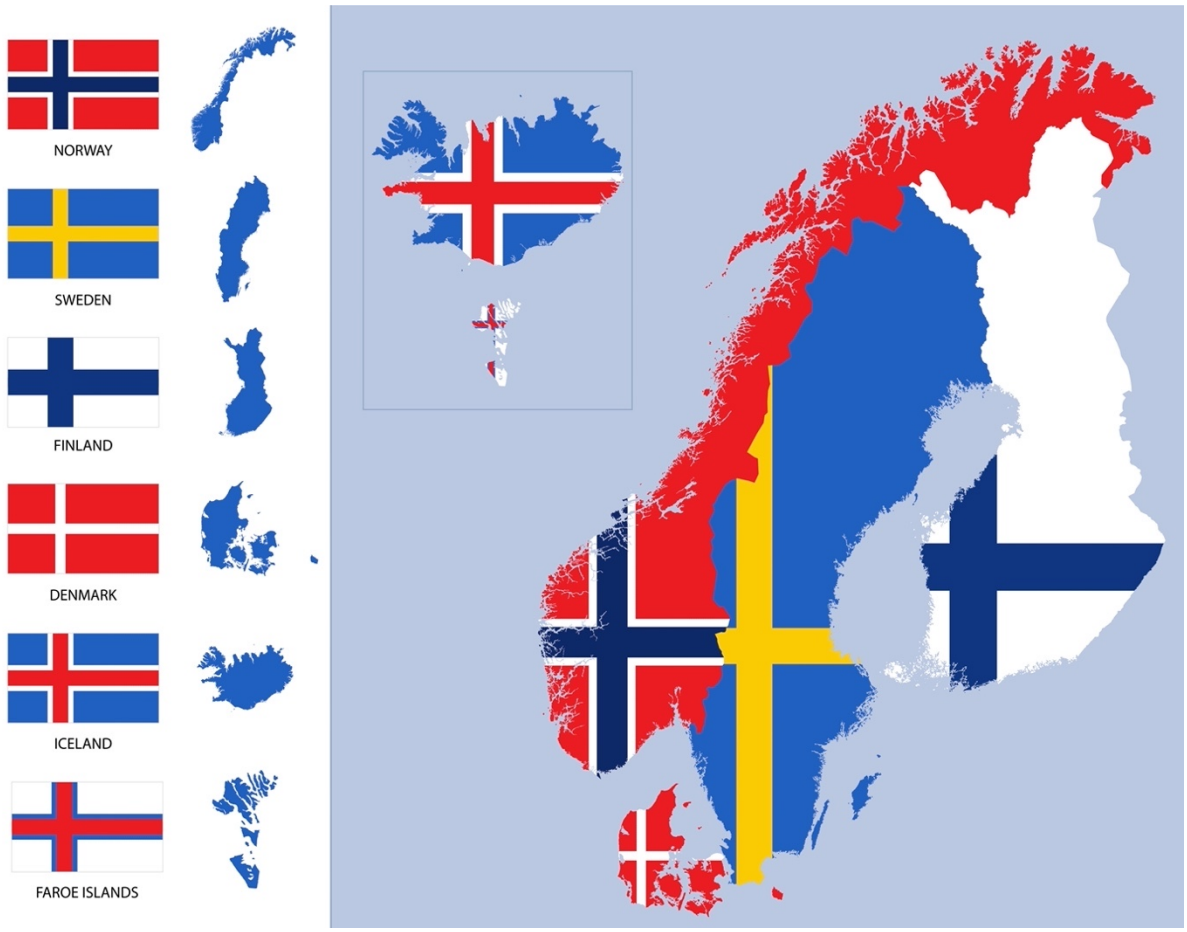
Sustainable ocean resources already account for about $31.65 billion annually of Canada's GDP and is the source of nearly 300,000 Canadian jobs. Through building upon established ocean related sectors, creating new blue sectors and importing from and working with the existing blue sectors in Nordic countries, Canada can become one of the leading blue economies in the world thereby generating higher revenue and increasing its number of jobs substantially.

[9] https://www.worldbank.org/en/news/infographic/2017/06/06/blue-economy
[10] https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/docs/publications/what-is-the-blue-economy_en_1.pdf
[11] http://d2ouvy59p0dg6k.cloudfront.net/downloads/15_1471_blue_economy_6_pages_final.pdf

As an ocean nation, the strength of Canada's economy depends on the health of our oceans. A stronger, more sustainable ocean economy will create new jobs, strengthen our food supply chain, and protect our ocean resources for generations to come. Our Blue Economy Strategy will chart a clear path for Canadians toward a future that is driven by ocean protection and prosperity.

The Honourable Ms Bernadette Jordan, Minister of Fisheries, Oceans and the Canadian Coast Guard





Ill.: Shutterstock

3.2 The Nordic Countries

For the purpose of this report the Nordic Countries, also referred to as "The Nordics", is comprised of Norway, Sweden, Denmark, Iceland and Finland. Norway, Sweden and Denmark constitute Scandinavia, Norway includes Svalbard, and Denmark includes Greenland and the Faroe Islands.

According to Uarctic.org, the Circumpolar North is the area traditionally covered by the terms "Arctic" and "Subarctic," the northern lands of the world's eight northernmost countries (the Arctic Eight): Canada, Finland, Denmark (including Greenland and the Faroe Islands), Iceland, Norway, Russia, Sweden, and the United States (Alaska).

The Nordics all share common values and display striking similarities in the shape of their political landscapes. The countries are all characterized by relatively small, open economies with a high export dependency. Three of the Nordics are members of the European Union (EU): Sweden, Denmark and Finland. Norway and Iceland are connected to the EU through the European Economic Area (EEA) agreement: Notably, Iceland's vast fishing trade and Norway's oil and gas resources have kept them outside of full EU membership. Only Finland uses the EU currency, Euro, while the other Nordic countries use their national currencies. Additionally, Finland has two official languages, Finnish and Swedish, while the other countries speak their native languages. All the Nordics use English as a common second language.

The EFTA States signed a Free Trade Agreement with Canada in 2008. The Comprehensive Economic and Trade Agreement (CETA) is a free-trade agreement between Canada and the European Union. It has been provisionally applied, thus removing 98% of the preexisting tariffs between the two parts. The negotiations were concluded in August 2014. CETA entered into force provisionally in September 2017, meaning most of the agreement now applies.

3.2.1 The Nordics and Canada: Some facts & figures

	NORWAY	SWEDEN	DENMARK	FINLAND	ICELAND	CANADA
Size km^2	385,207[1]	450,295	42,933[2]	338,455[3]	102,775	9,984,670
Population	5.33 mill	10.23 mill	5.84 mill	5.54 mill	364,134	38 mill
Currency	NOK	SEK	DKK	EURO	ISK	CAD
GDP per capita	$67,987	$50,339	$63,829	$48,461	$57,189	$42,080
Capital	Oslo	Stockholm	Copenhagen	Helsinki	Reykjavik	Ottawa
Coastline km	2,650[4]	3,218[5]	7,314	1,250	4,970	243,042
Time zone	CET (UTC+1)	CET (UTC+1)	CET (UTC+1)	EET (UTC+2)	UTC	UTC-3,5 to -8

[1] Norway's size includes overseas territories; land-based size is 323,802 km^2
[2] Denmark's size when including Greenland and the Faroe Islands is 2,210,573 km^2
[3] Finland's size includes Åland Islands with its 1,551 km^2; land-based size is 336,884 km^2
[4] Total coastline Norway (mainland, islands and Svalbard): 100,915 kilometers
[5] Total coastline Sweden including all islands: 48,000 kilometers

Cultural differences, similarities and cultural bias

The Nordics are known for their merits in equality, quality of life, education, and trust in governance. Thus creating an optimal environment for sustainable development. Based on our research, we found the Nordics welcome to doing business with Canadian companies however most Nordic companies prefer to do business with foreign partners that have established themselves in their country beforehand.

The EU Green Deal and the EU Taxonomy – A game changer in the making

The EU's "Green Deal" is a set of policy initiatives by the European Commission with the overarching aim of making Europe climate neutral in 2050. In order to meet the EU's climate and emission targets for 2030 and reach the objectives of the European Green Deal towards 2050, it is fundamental to direct investments towards sustainable projects and activities. To achieve this, a common language and a clear definition of what is 'sustainable' is needed. This is why the action plan on financing sustainable growth called for the creation of a common classification system for sustainable economic activities, or an "EU taxonomy".

The EU Taxonomy is a classification system for sustainable economic activities with a current focus on climate change mitigation and climate change adaption. The classification system will be used to determine when an economic activity is "environmentally sustainable" and, as a result, when an investment is environmentally sustainable. It will make it easier to consider and compare the climate and environmental impact of companies – and assist companies and investors in determining which economic activities can be considered environmentally sustainable.

The Taxonomy Regulation establishes six environmental objectives, with a high relevance for the blue economy:

1. Climate change mitigation
2. Climate change adaptation
3. The sustainable use and protection of water and marine resources
4. The transition to a circular economy
5. Pollution prevention and control
6. The protection and restoration of biodiversity and ecosystems

Reporting obligations for the first two criteria (climate change mitigation and adaption) will be effective from January 1, 2022, covering the financial year 2021, while reporting obligations for the other four criteria will be effective from January 1, 2023, covering the financial year 2022.

There is an increasing focus on the environmental footprint of companies, projects and investments. We expect the EU Taxonomy Regulation and technical screening criteria to be relevant for several market participants as a common ground for determining environmentally sustainable economic activities and

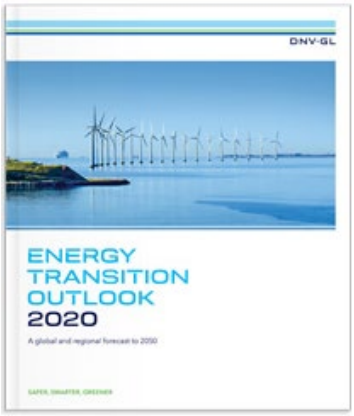
investments. One of the objectives of the Sustainable Finance Action Plan initiated by the EU is to facilitate a major re-allocation in capital towards sustainable investments. The EU Taxonomy Regulation is the building block, determining which investments are sustainable and which are not sustainable. Alignment with the technical screening criteria may represent a potential opportunity for companies with activities recognized as "green" in terms of access to capital and cost of capital.

The EU Taxonomy will also have a great impact on the Nordic countries, particularly Norway, whose GDP to a large extent is based on the exploration, utilization and transport of fossil fuels. It may not be of any direct relevance to Canadian firms, but knowledge about the EU Green Deal and the EU Taxonomy could be useful for Canadian companies who are looking for opportunities entering the Nordic blue economy.

The Nordic Blue Economy future is autonomous, electric and emission free

Norwegian DNV (formerly DNV GL) is the world's largest classification society, as well as the largest technical consultancy and supervisory to the global renewable energy (particularly wind, wave, tidal and solar) and the oil and gas industry. The company currently has about 12,000 employees and 350 offices operating in more than 100 countries, and provides services for several industries including maritime, oil & gas, renewable energy, electrification, food & beverage and healthcare. DNV issues a number of reports and outlooks that are available for free, one of these is their Energy Transition Outlook 2020: An independent, model-based forecast of the world's most likely energy future through to 2050.

An excerpt from the Energy Transition 2020 Outlook[12] executive summary states:



> For most of the current energy system we forecast a rapid energy transition between now and 2050 – effectively, within a generation. By mid-century we expect to see an energy mix split roughly equally between fossil and non-fossil sources, taking into account expected developments in policies, technologies and associated costs. (…) There is a massive, ongoing electrification of the global energy system; where electricity is less than 20% of the energy mix today, it will more than double its share by 2050. During that period, solar PV will grow 25-fold and wind 10-fold, and in roughly equal shares will together be responsible for over 60% of the electricity generated by 2050. The plunging costs and technological advances in renewables are remarkable, and nowhere more so than in fixed and floating offshore wind. Electricity powered by renewables is the main driver of accelerating efficiency gains in our global energy that will outpace both population and GDP growth, such that the world will reach peak primary energy supply in just over a decade from now.

As this report shows, the Nordics are among the leaders in this development, both on governmental and industry level. An illustration of this is ZEEDS – a true Nordic cooperation fueled by Nordic Innovation[13], an entity set up by the Nordic Council of Ministers to foster innovation in the Nordics.

> **Zero Emission Energy Distribution at Sea (ZEEDS)[14]**
> To bring shipping in line with the Paris Climate Agreement, the maritime sector needs to reduce CO2 emissions by 50 % by 2050. This requires major advancements in technology as well as shifts in business models and in the ways of operating, including in the interface between land and sea. To support innovation and collaboration in this interface, Nordic Innovation formulated a NOK 8 million Nordic Innovation Mobility Mission with the aim of decarbonizing Nordic ports, transport

[12] https://eto.dnv.com/2020#ETO2019-top
[13] https://www.nordicinnovation.org
[14] https://zeedsinitiative.com

of people and goods – on and between sea and land. The mission was launched at Nor-Shipping in June 2019. Five projects were awarded support in March 2020, ZEEDS was among those.
The Zero Emission Energy Distribution at Sea (ZEEDS) initiative envisions making zero emissions fuels available to the shipping industry, through a network of offshore platforms that uses wind and/or solar to produce, store and distribute zero emissions fuels in a network of clean energy hubs placed near one of the world's busiest shipping lanes. Though ZEEDS' current focus is on green ammonia, the concept is classified as "fuel agnostic", with the possibility of including fuels such as hydrogen or liquid biogas. Bunkering could be performed by autonomous units named Energy Providing Vessels (EPVs), fueled by their own cargo and with a range of 50 nautical miles around the mother hubs, or fuel storage bases.

The ZEEDS partners are Aker Solutions15, Equinor16 and Grieg Star17 from Norway, DFDS18 from Denmark, and Wärtsilä19 from Finland. For more information, visit the ZEEDS and Nordic Innovation20 websites.

Denmark and Norway are global leaders in maritime industry. Sweden has a strong maritime cluster of technology suppliers and is a powerhouse within sensors, IT networks and connectivity technologies while Finland is a strong cluster for cleantech, ship building and maritime equipment. One commonality is that all the Nordic countries are leaders in digitalization.

Another such Nordic research project as ZEEDS is Connected Ship[21], also financed by Nordic Innovation, a project to develop a more sustainable, digitalized and connected maritime industry. Large ships consume huge amounts of fossil fuel and thereby contribute to global warming. Fuel is the main cost component for many shipping companies. Therefore, boosting energy efficiency is a main driver for innovation in the shipping industry.

This project will build knowledge and enterprises that can successfully make the Nordic shipping industry more sustainable and create new Nordic export business models based on the maritime digitalization. The goal of the project is to demonstrate a digitalization platform on board a ship by utilizating technology, platforms and experiences from smart city projects combined with maritime industry control systems, communication protocols and environmental prerequisites. This will also prepare the ships for future interaction with the smart society - harbors, trucks, cargo, passengers and other smart micro-systems.

The ship digitalization platform will help collect and manage data across the equipment from various suppliers and be a platform for open innovation. The project will also develop business models that gives incentives to the involved companies to share data and thereby support start-ups and smaller companies who can build new services.

We revisit Nordic Innovation in an appendix, as they play an important role in the development of the Nordics into a global leader in sustainability in the maritime industry and blue economy.

Maritime Battery Forum[22], set up by DNV as early as in 2014, is another initiative worth noting. The purpose of this forum is to promote battery-based value creation and make batteries a success within the global maritime market. Among its members is Corvus Energy, established in Vancouver in 2009, however having moved to Norway 10 years later in a recognition of where the primary market is located.

[15] https://www.akersolutions.com
[16] https://www.equinor.com
[17] https://www.griegstar.com
[18] https://www.dfds.com/en/about
[19] https://www.wartsila.com
[20] https://www.nordicinnovation.org
[21] https://theconnectedship.net
[22] https://www.maritimebatteryforum.com

Corvus Energy[23] is the leading supplier of energy storage solutions in the form of modular lithium-ion battery systems for marine, oil and gas and port applications. Its purpose-built, field-proven battery systems provide sustained power to hybrid and all-electric heavy industrial equipment, including large marine propulsion drives. Corvus Energy has amassed unsurpassed experience from 400+ projects, totaling over 300 MWh and more than 3 million operating hours.

Corvus Energy – from Vancouver, Canada to Bergen, Norway

Long before any other supplier had even conceived of deploying large-scale energy storage systems (ESS) for marine use, Corvus Energy was actively exploring the opportunity to create viable power supplies for hybrid and fully electric applications. Founded in 2009 in Vancouver by battery expert Darron Craig, who had been working in the automotive industry, and naval architect Brent Perry, who had been trying to make hybrid ships with lead acid batteries, the company was the embodiment of its creators' in-depth knowledge of both the maritime and battery industries. Having sensed what the future of industrial power might look like, they came together to create a ruggedized lithium-ion model for use in heavy industrial applications, combining their finely-honed skills in battery management with what they have described as their 'maritime DNA'. The first office was in a garage in Richmond, BC.

In 2010, the result of Corvus' initial efforts brought to the marketplace the ESS (Energy Storage System) AT6500 battery module, which in 2012 was to be used on Norwegian Eidesvik Offshore, making their "Viking Lady" the world's first hybrid OSV (Offshore Support Vessel) and the first to validate batteries. The term peak shaving was used: with peak shaving, a vessel reduces power consumption ("load shedding") quickly and for a short period of time to avoid a spike in consumption. This is either possible by temporarily scaling down production, activating an on-site power generation system, or, as in the Corvus case, relying on a battery.

In 2015 Corvus Energy supplied the battery system for the world's first all-electric ferry, Norwegian Ampere. Since then, the ferry has travelled a distance equal to 7 times around the world. Operating cost is reduced by 60% and emissions by 95% compared to a diesel ferry. That same year Corvus Energy opened an office in Bergen, Norway. The company experienced a rapid growth and saw the need for an office in Europe as that was where their main customers were located. Four years later, in 2019, the corporate office was moved from Vancouver to Bergen and a new fully automated factory will be built there.

In 2021, Corvus Energy will start the development of maritime fuel-cell systems with hydrogen fuel-cell technology supplied by Toyota. At the digital launch Norway's Prime Minister Erna Solberg and other prominent guests were present. Combining Corvus Energy's experience from Marine ESS with the world-leading fuel cell technology from Toyota will push technology further towards zero-emission for shipping. The project has received EUR 5.3m in funding from the Norwegian state agency Innovation Norway and is initiated by a powerful cluster headed by NCE Maritime Cleantech. In addition to NCE Maritime Cleantech, the collaboration partners in this new initiative are Equinor, the shipowners Wilh. Wilhelmsen and Norled, ship design company LMG Marin and R&D institution the University of South-Eastern Norway (USN).

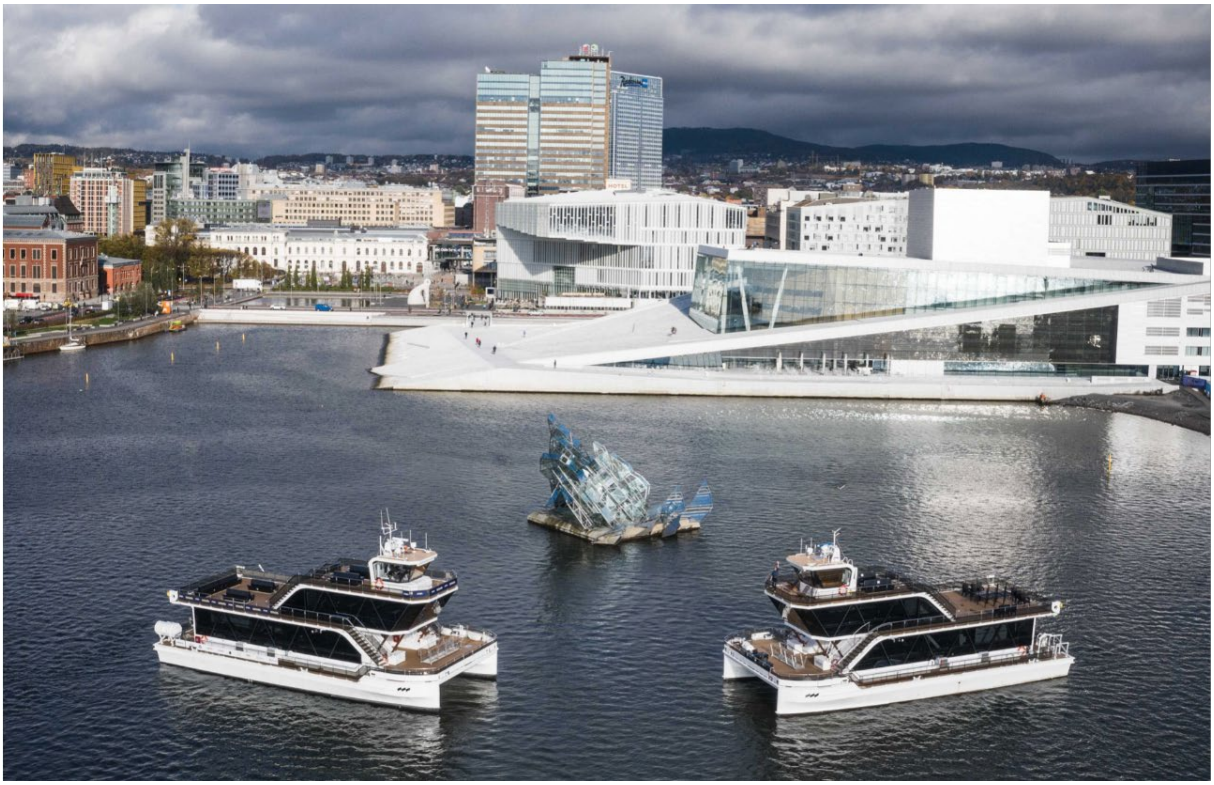
Ownership: In 2013, the global shipping company BW Group invested in Corvus Energy. BW Group is "Bergesen Worldwide", headquartered in Singapore with a strong representation in Oslo. Today, BW Ventures is the largest shareholder in Corvus Energy with nearly 25% ownership. Norwegian Equinor, Hydro and Yara are other major shareholders.

Another Canadian company that is planning to expand into the marine electric market is **Circle K**, through their E-Mobility service. As with Corvus, they see Norway as a natural location from where to expand this business from, much due to the country's high penetration of electric cars. A result of the

[23] https://corvusenergy.com

government's effort to phase out fossil fuel vehicles and replace them with electric vehicles, encouraged by a number of both financial subsidies and practical benefits. As a result, Norway has the highest rate of electric cars per capita in the world.

> According to World Economic Forum, electric vehicles accounted for 4.2% of light vehicle sales worldwide in 2020, almost double 2019's 2.5%. Norway, Iceland and Sweden are leading the charge, with plug-in electric vehicles accounting for 74.8%, 45% and 32.2% respectively in 2020. Various policies have incentivized electric vehicle uptake in Norway - but might not translate well to other countries.



Norwegian Brim Explorer AS with their two hybrid-electric vessels Brim and Bard. The innovative vessels were originally made for silent whale watching in Tromsø, however brought to Oslo by the pandemic. A third vessel will be fully electric. © Brim Holding AS[24]

[24] https://brimexplorer.com

NORWAY

OFFSHORE WIND

MARITIME SHIPPING (EMISSION REDUCTION AND STORAGE)

AQUACULTURE (AI)

4. Norway

The Norwegian people have always exploited the ocean. The ocean is a huge source of revenue for the Norwegian economy. It is estimated that 70% of the exports from Norway are ocean based[25]. In 2016, Menon Economics[26] estimated that there were about 214,000 people employed within the three largest ocean industries; seafood, the maritime industry and offshore petroleum. At this time, the ocean industries created value of nearly NOK 500bn, equivalent to about 25% of the total value created. These industries were responsible for roughly 11% of the employment in Norway. With coastline only second to Canada in size, its 100,915 km (including islands), it has great potential for increased value creation.

> The Government is committed to the oceans and Norway is playing a leading role in the global efforts to promote clean and healthy oceans. More than 200,000 Norwegians work in the petroleum, seafood and maritime industries, generating som NOK 680 billion in value in 2017[27].

Long shipping history and strong maritime cluster

Norway has a long and proud maritime history and for over 150 years Norwegian shipping has been a major player on the world's oceans. Today, Norway has one of the world's largest and most modern fleets. Nearly 1,900 Norwegian controlled vessels and rigs operate worldwide, with half of the Norwegian fleet engaged in the transport of goods and people, while the other half are working on offshore oil and gas worldwide.

The Norwegian maritime cluster comprises world-leading companies that design, build, operate, and trade in ships, as well as deliver equipment and services. With shipping companies acting as the cluster drivers and innovators, and with good links to the research and development community, competent individuals are being educated to work in all segments of the cluster. Norwegian shipowners and maritime companies have been recognized as technology leaders for many years.

Among other accomplishments, the shipping companies are central to the advanced technological development of the oil and gas industry. Specialized vessels, positioning systems and control systems are examples of areas where Norwegian industry is in the forefront. Norwegian maritime companies use technology and expertise from the offshore industry, among other sources, to establish themselves in new markets. This knowledge transfer is crucial for success in other ocean industries. The offshore floating wind market is an area where Norwegian companies see opportunities and have the opportunity to take the lead. Several companies have already invested in both vessels and technology to position themselves in this market.

In the years to come, further opportunities will open up for the exploitation of renewable energy, increased food production and the harvesting of other natural resources such as minerals and medicines. Here too, Norwegian companies have the opportunity to take a leading position. Shipping is increasingly becoming part of complex international logistics systems requiring advanced databases, monitoring systems and means of communication. Stricter requirements are also being placed on safety and the environment, leading to continuous innovations and technology development, for example related to ship design, propulsion systems and ballast water.

Marine minerals supporting the energy transition

The global energy transition is fueling the growth of new value chains like batteries, renewable and electric infrastructure. The rapid growth of these industries will require a significantly higher supply of minerals in the coming decades. The demand for metals will increase in correlation to society's combat

[25] https://www.regjeringen.no/no/tema/naringsliv/maritime-naringer/ny-temaside/forste-kolonne/regjeringens-havpolitikk/id2589226/

[26] https://www.regjeringen.no/no/tema/naringsliv/maritime-naringer/ny-temaside/forste-kolonne/regjeringens-havpolitikk/id2589226/#_ftnref1 – Menon Economics, 2016

[27] https://www.regjeringen.no/en/topics/havet/id2603523/

for climate change. Onshore mines are challenged by controversial working conditions and put severe stress on resources and the environment. A low carbon future requires additional metals supply, which can be provided by marine minerals. The world's spreading ridges host massive sulfides containing especially copper, cobalt and zinc. After Fiji, Norway is the country with the most economic rights to most of these ridges. Much of the technology and competence needed for extracting marine minerals can be found within the oil and gas industry which gives Norway a strong competitive advantage over its peers. With the establishment of a Norwegian marine mineral legislation in 2019, in addition to the 2018-2020 resource mapping performed by the Norwegian Petroleum Directorate, Norway is well positioned for the next and crucial steps towards a marine minerals industry with both great export and domestic value creation potential.

The government regularly creates strategies and plans for the maritime and other ocean industries, some of which are mentioned below. For several years, Norway has aspired to play a leading global role in the ocean industries. Prime Minister Erna Solberg initiated the establishment of the United Nation High Level Panel for a Sustainable Ocean Economy. The Ocean Panel was launched at the World Economic Forum in Davos in January 2018 with Solberg as the chair, in addition to 13 other heads of state from ocean-based nations, including Canada. Their reports and recommendations were presented in December 2020. Norway's focus and dependence on the ocean is also portrayed in its participation to World Expo Dubai, where the topic is "The Ocean; Pioneering Sustainable Ocean Solutions". The participation is funded by a consortium of the government and key market actors.

4.1 Main drivers, trends and future development

The Norwegian Government has committed itself to an enhanced climate target under the Paris agreement. Norway's new and strengthened target is to reduce emissions with at least 50 %, and towards 55 % by 2030 compared to 1990 levels. Traditionally, Norway has been a country with a strong focus on oil and gas. These sectors have been the driving forces in the growing prosperity that Norway has experienced since the 1970s. However, in the recent years there has been a shift towards sustainability and reducing emissions. Although these sectors still represent nearly half the Norwegian export value, the focus has shifted towards finding new export alternatives within the blue economy. This currently represents the main driver for a change towards sustainability the blue economy in Norway.

There are substantial opportunities for future growth and job creation in the Norwegian ocean industries. Norway has a knowledge-based, integrated and responsible ocean management, promoting an international framework for sustainable ocean management with its maritime industry being the only complete cluster in Norway[28]. Norway has the capability of utilizing existing synergies to make the shift into the new wave of sustainability. In fact, various businesses can be said to belong to more than one category within the ocean industries, such as the supplier industry. These industries can supply companies in the maritime industries, while working closely with the oil and gas industry, creating an overlap. In fact, about 55% of value creation in the maritime industry overlaps with the oil and gas industry. For example, PSVs (platform supply vessels) used in the oil and the gas industry can be repurposed and used in the offshore wind sector.

A climate neutral fleet

Norway is the world's fourth largest shipping nation measured by market value. China, Japan and Greece are by far the three largest nations, followed by Norway, Denmark and the United States. In the Norwegian fleet, the offshore segment has the highest market value, and only the USA has an offshore fleet of higher value. As of January 2021, the fleet numbers a total of 1,783 ships with total tonnage of 51.1 million deadweight tonnes.

In May 2020, the Norwegian Shipowners' Association released their climate strategy toward 2050[29]. This strategy launched the goal of a climate neutral vessel fleet by 2050. Under the umbrella of the

[28] "A Competitive Norway" study (Reve et al., 1992)
[29] https://rederi.no/globalassets/dokumenter/alle/rapporter/2020--klimarapport-engelsk.pdf

Norwegian Shipowners' Association, Norwegian shipping companies are acting through adopting some ambitious goals laid out in this climate strategy, on their way to climate neutrality.

4.2 Offshore wind

Following the recent years' increased focus on climate policies and reducing emissions, the phasing out of fossil power generation has started. This creates a demand for rapid growth within the renewable energy markets. Based on their expertise and experience from offshore operations in Norway and internationally, Norwegian companies are well positioned to take significant market shares during the development, construction and operational phases of offshore wind farms. Export Credit Norway asked a project consortium of Multiconsult[30], THEMA[31] and RCG Nordic (Renewables Consulting Group)[32] about the offshore wind market. The expert group identified that the offshore wind industry has the potential to become one of Norway's most important export industries in the future.

Also, the Federation of Norwegian Industries[33] recently published a series of reports on delivery models for the different parts of the value chain of the Norwegian offshore wind industry. Amongst other things, the report discusses the Norwegian offshore wind industry's standing in the global market.

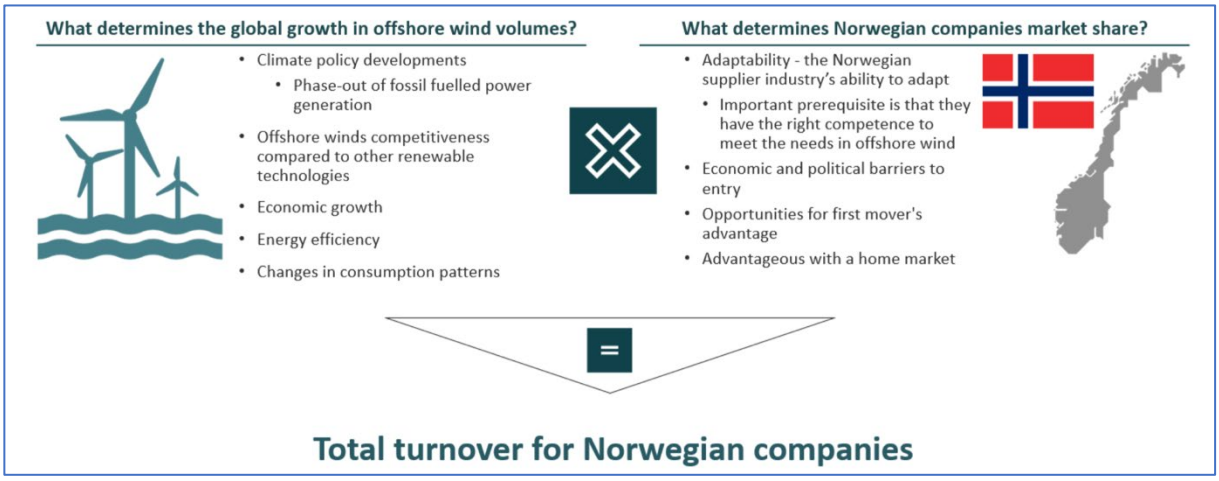


Figure: Growth in global wind volumes and the Norwegian share of cost components determines the Norwegian turnover. © THEMA

In the near-term, bottom-fixed offshore wind will remain the key focus area and key source of turnover for Norwegian players in the offshore wind market. THEMA estimates that bottom-fixed will account for EUR 3bn in the 5-year period from 2026 to 2030, while floating offshore wind will make up slightly below EUR 800m in the same period. It is worth noting that it is estimated higher growth in revenue for floating offshore than for bottom-fixed. However, there is high uncertainty surrounding the market development for floating offshore wind and should be considered. The development of floating could therefor take some time, and development opportunities of offshore wind in the near future will likely be focused on bottom-fixed offshore wind market. This development will likely be affected by national targets and policies. As large parts of relevant areas for offshore wind development in Norwegian waters are deep water areas, floating offshore wind farms could become more relevant and receive an increased focus.

The recent decline in oil prices have hit the offshore oil and gas industry hard. The suppliers of platform/offshore supply vessels (PSV/OSV) services have found themselves looking for alternative

[30] https://www.multiconsult.no
[31] https://thema.no/?lang=en
[32] https://thinkrcg.com
[33] https://www.norskindustri.no/om-norsk-industri/in-english/

uses of their vessels having found them in the offshore wind industry. The needs of the offshore wind industry and the oil and gas industry may look very different however the basic attributes of the oil and gas industry are well suited for the offshore wind sector. This makes them ideal for conversion and redevelopment in maintenance roles to an industry that is likely set for rapid growth. In December 2020, **Rem Offshore**[34] commissioned **Havyard Design & Solutions**[35] and **Norwegian Electric Systems**[36] into a service vessel for offshore wind. The vessel was originally a Havyard PSV. Combining this with Havyard Ship Technology's recent deliveries of windfarm service vessels to the Danish shipping company ESVAGT, the group is quickly establishing itself as a leading supplier of special vessels for the offshore wind industry.

Offshore areas opening for Wind Power – potential for Canadian players

Today, by royal decree, the areas "Utsira Nord" and "Sørlige Nordsjø II" have opened for offshore renewables, including offshore wind power. This means that it will be possible to submit license applications for offshore wind power projects.

Utsira Nord is located to the west of Haugesund, and is suited for floating wind power, which is the most interesting technology from a Norwegian long-term perspective. The size of the area is also substantial with 1,010 square kilometers. The area is close to shore and provides opportunities for both demonstration projects and larger projects. The government proposes to open this area to facilitate the development of such technology.

Sørlige Nordsjø II borders the Danish sector in the North Sea and is relevant for direct export of electricity. The area is 2,591 square kilometers, has depths which makes it possible to develop bottom-fixed wind power, but floating solutions could also be relevant. We consider that this area has high potential for Canadian investments.

Interesting Norwegian companies within the offshore wind industry

The Norwegian offshore wind industry presents several interesting companies throughout the value chain. The largest ones are Equinor[37], Aker Offshore Wind[38], Fred. Olsen Renewables[39], and Dr.techn. Olav Olsen AS[40]. Some of these, such as DNV, produce products and services for the entire value chain, while some produce speciality products such as HVAC and refrigeration systems (Teknotherm AS) and some, such as Østensjø Rederi AS produce purpose-built service operation vessels. For a further selection of companies within the offshore wind industry in Norway, please refer to Appendix B.

4.3 Maritime Shipping

The Norwegian government perspective

The Norwegian Government's action plan for green shipping was presented in June 2019. In December 2020 the Government presented their new Maritime Report "Greener and smarter; the (Norwegian) maritime industry of tomorrow." The overarching goal with this report is to make sure Norway remains a leading maritime nation, keeps its international competitiveness and ability to create value and employment across the country. The government will implement policies which offer good framework conditions and enable the industry to promote climate and environmentally friendly shipping, digitalization and competence. The government wants Norway to make full use of the opportunities arising from the greening of the economy. Renewal of the Norwegian shipping sector will be an important driver in this process. Norway's maritime industry is a world leader in the development of

[34] https://www.remoffshore.no
[35] https://www.havyard.com
[36] https://www.norwegianelectric.com
[37] https://www.equinor.com
[38] https://www.akeroffshorewind.com
[39] https://fredolsenrenewables.com
[40] https://www.olavolsen.no/en

low- and zero-emission solutions, and there are competitive companies in all segments of the industry. The government's ambition is to reduce emissions from domestic shipping and fisheries by 50% by 2030 and promote the development of low- and zero-emission solutions for all vessel categories. To achieve this ambition, it will be necessary to speed up the green transition in the shipping sector.

Norway's leading position in green shipping can become an important competitive advantage, giving the maritime industry's huge growth potential in international markets. By developing new zero- and low-emission solutions for maritime transport, Norway can make an important contribution to global climate and environmental efforts. The focus on green shipping will support government ambitions in several areas. It is important for ensuring that Norway can meet its international climate commitments and its targets for emission reductions in the transport sector. It will also support regional policy by creating opportunities for growth and jobs all along the coast. The development of Norwegian environmental technology with export potential is in line with Norway's industrial policy.

The main approach in the government's action plan is to consider possible measures and policy instruments for different categories of vessels: scheduled passenger vessels and ferries, cruise ships and international passenger ferries, cargo vessels, offshore support vessels, specialized vessels including aquaculture service vessels, fishing vessels and recreational craft. There are considerable differences between these categories in fleet structure and operating patterns. The rapid phase-in of ferries with electric propulsion systems has been driven by requirements included in public procurement processes combined with grants, for example from Enova[41] and the NOx Fund[42], for technology development and for building charging infrastructure. The government will promote the inclusion of requirements for zero- and low-emission solutions in future procurement processes for ferries and high-speed vessels.

In January 2021, the government presented their **Climate Action Plan** 2021-2030, which also affects the maritime industry. Overall, Norway's emissions are to be cut by 55 percent by 2030. This involves the short sea shipping and the fishing industries, the offshore supply industry, Norway's work with the IMO, extended use of Enova, biofuels, CCS (carbon capture and storage) and public procurement policies.

In addition to reducing emissions from specific vessel categories, various instruments are already being used that are relevant across all segments. Enova, Innovation Norway, the Research Council of Norway and the NOx Fund all provide support for the development of new technology and of the necessary infrastructure. Instruments like the carbon tax, a lower electricity tax rate for commercial vessels and differential rates for port fees based on environmental grounds are making green solutions more competitive.

Enova has provided support for vessels and projects in most segments of maritime transport, like projects concerning vessels fitted with batteries or charging facilities for low- or zero-emission vessels using battery technology.

In cooperation with municipalities and port authorities, the Government is aiming for Norwegian ports, wherever feasible, to be emission-free by 2030. Increasing the use of biodiesel and biogas may be an important means of achieving emissions reduction from domestic shipping. To ensure that such an arrangement has global climate and environmental benefits, advanced biofuels should be used, based on feedstock such as biological residues and waste.

The Norwegian **Blue Economy Report**, revised in 2019, describes, in part, future trends in the blue economy markets of Norway. The report envisions several trends that will be relevant drivers of the blue economy will be a drive towards sustainability. For example, as of 2019, Enova had allocated about NOK 1.5 bn towards green shipping. A large part of this funding has been towards development of

[41] Enova contributes to reduced greenhouse gas emissions, development of energy and climate technology and a strengthened security of supply

[42] The NOx Fund: Agreements between Norwegian authorities and industry to reduce NOx emissions in Norway

vessels using battery technology. Offshore wind is one of six priority areas in the national strategy for research, development, demonstration and commercialization of new, climate-friendly energy technology, **Energi21**[43]. The Energi21 is a national strategy for research, development, demonstration, and commercialization of new, climate-friendly energy technology, where offshore wind is one of six priority areas.

The Green Shipping Programme[44] is a public-private partnership which since 2015 aims to advance the Norwegian government's maritime strategies and plans. The programme is the result of a public-private partnership consisting of shipping companies, shipyards, suppliers, harbors, goods owners and freight forwarders, service providers, authorities, and academia, established by DNV to strengthen Norway's position as a leading shipping nation and to find scalable solutions for efficient and environment-friendly shipping. It emerged from collaboration between the classification and consultancy company DNV, the Norwegian Ministry of Climate and Environment, and the Norwegian Ministry of Trade, Industry and Fisheries. There are currently more than 60 partners from all parts of the shipping community – including observers representing the public authorities – and new members continue to join the program.

The program's vision is to develop and strengthen Norway's goal to establish the world's most efficient and environmentally friendly shipping. This is how they sum up what they do:

> **This is the Green Shipping Programme in a nutshell: We perform studies. We start pilots. We transfer knowledge between the two, between theory and practice. And we facilitate dialogue and collaboration between all stakeholders.**

Some 20 large-scale pilot projects have been launched through the program thus far, including two projects focused on the development of green ports, one project to create LNG/VOC/battery-powered shuttle tankers, a hydrogen-powered speed boat, a bunkering vessel as well as two autonomous, zero-emission vessels. All the projects are an important step in making Norwegian domestic shipping greener. Seven of the pilots have been implemented or are under construction.

Norway has also signed agreements for 30–40 battery-powered ferries, with additional investments of roughly USD 228 million in battery and charging technology, and more to come. By 2021, there will be 70 all-electric and hybrid ferries in total.

Ammonia – the ultimate green fuel?

In February 2021 news came that Yara International[45] has partnered with Statkraft[46] and Aker Horizons[47] to establish Europe's first large-scale green ammonia project in Norway, to enable the hydrogen economy and accelerate the green energy transition. The partners will target green hydrogen and green ammonia opportunities within shipping, agriculture and industrial applications, by electrifying Yara's existing ammonia facility in Porsgrunn. Building on their combined expertise, the partners aim to fully remove CO2 emissions from ammonia production, thereby producing emission-free fuel for shipping, carbon-free fertilizer and ammonia for industrial applications.

The conversion of Yara's existing ammonia plant has the potential to become one of the largest climate initiatives in Norway's industrial history, targeting annual CO2 reductions equivalent to the emissions from more than 300,000 fossil fuel passenger cars. Provided that power is available at the site and the required public co-funding is in place, the project could be realized within 5-7 years. In addition to the Porsgrunn project, the three companies plan to explore the potential for green ammonia production in Northern Norway as a future opportunity.

[43] https://www.energi21.no/en/
[44] https://www.dnv.com/maritime/green-shipping-programme/index.html
[45] https://www.yara.com
[46] https://www.statkraft.com
[47] https://www.akerasa.com/en/investments/aker-horizons

Autonomy

Autonomy introduces a new competition area for short-sea shipping and opens a larger market for maritime players. Autonomous vessels provide significant safety benefits, as 75% of maritime accidents are caused by human error. **Massterly's**[48] vision is to enable a shift in transport from road to sea with cost-effective and renewable-energy based logistics. Their main goal is to increase the degree of short sea shipping as a substitute for the cheap but polluting trucks. They apply autonomy as the key to creating a new competition area for ships; by reduced or no crew on board - supported from skilled operators in a remote operations center - the operating costs go down. The company was established in 2018 as a joint venture between Kongsberg Maritime as the technology provider, and Wilh. Wilhelmsen having the shipping and maritime logistics competence. Massterly offers support in the whole value chain for autonomous vessels: project management, design, approval, control systems, logistics services and operations. They are very open to cooperate with ship owners and operators helping them benefit from the possibilities of remote support and autonomous vessels. The name Massterly is derived from IMO's definition of "Maritime Autonomous Surface Ship (MASS)": a ship which, to a varying degree, can operate independently of human interaction"

Autonomous zero emission sea buses could be Norway's next export adventure

Norway comprises an ecosystem of companies and institutes that are world leading in the field of maritime autonomy. Now the industry has established a joint project with financial support from Innovation Norway where the aim is to collaborate on solving challenges and tasks of mutual interest. One of the key areas the ZAWAS (zero-emission autonomous water-shuttles) project will focus on is how to ensure a sound evolution of regulatory frameworks to be adapted to the emerging autonomous maritime mobility systems. The Norwegian Maritime Directorate is already highly acknowledged for designing regulatory frameworks for new maritime technologies, such as LNG fuel and battery power systems, which later has been exported internationally. ZAWAS will together with partners aim for a similar development regarding autonomous maritime systems. Zeabuz[49], a progressive start-up, NTNU[50] spin-off and ZAWAS partner, which is developing autonomy systems for small urban water buses, enters the market by targeting short canal and river crossings to make the regulatory adaptation as simple as possible. Their long-term goal is to establish shortcuts across waterways in cities globally, while ever pushing the boundaries for what regulatory bodies can allow the autonomous maritime technology to be utilized for. First pilots will be demonstrated in the summer of 2022. The ZAWAS project is coordinated by the SAMS[51] (Sustainable Autonomous Mobility System) cluster.

[48] https://www.massterly.com/what-we-do
[49] https://zeabuz.com
[50] https://www.ntnu.edu
[51] https://sams-norway.no

4.3.2 Carbon capture and storage – CCS

Norway is in a good position to contribute to the development of carbon capture and storage (CCS). The country has a strong technological community in the field of carbon capture, transport, and storage. For decades, the development and operation of the CO2 storage projects on the Sleipner and Snøhvit fields have demonstrated safe carbon storage on the Norwegian continental shelf.

The Norwegian government places great emphasis on CCS. The main goal of its CCS policy is to identify measures that can contribute to technology development and cost reductions. In a government white paper to the Norwegian parliament submitted in September 2020, the government proposed to launch a carbon capture and storage project in Norway. The project has been named 'Longship'[52]. The government proposes to first implement carbon capture at Norcem's cement factory in Brevik, in Vestfold and Telemark county. In addition, the government also intends to fund Fortum's waste incineration facility in Oslo, providing that the project secures sufficient own funding as well as funding from the EU or other sources. Longship also comprises funding for the transport and storage project Northern Lights, a joint project between Equinor, Shell and Total. Northern Lights will transport liquid CO2 from capture facilities to a terminal at Øygarden outside Bergen. From there, CO2 will be pumped through pipelines to a reservoir 2,600 meters below the seabed.

According to the UN Intergovernmental Panel on Climate Change, CCS will be necessary to reduce global greenhouse gas emissions in line with the climate targets at the lowest possible cost. There are currently few facilities in operation on a global basis. More projects that bring learning and technological development and reduce cost. If CCS is to become an efficient climate policy instrument, new facilities must be established in Europe and globally.

The total investments in Longship are estimated at NOK 17.1bn. This includes both Norcem, Fortum as well as Northern Lights. The operating costs for ten years of operation are estimated at NOK 8 bn. The total cost estimate is thus NOK 25.1bn.

4.4 Aquaculture

The Norwegian Seafood Council (Sjømatrådet)[53] works together with the Norwegian fisheries and aquaculture industry to develop markets for Norwegian seafood. NSC is a public company owned by the Ministry of Trade, Industry and Fisheries. The Norwegian seafood industry finances the activities of the Council through fees levied on all exports of Norwegian seafood. The NSC aims to increase the value of Norwegian seafood resources, through market insights, market development, market risk management and reputational risk management in select markets around the world. In addition, the NSC works to identify opportunities for Norwegian seafood products in both new and established markets. NSC is the approval authority for Norwegian seafood exporters. The Council also acts as an advisor for the Ministry of Trade, Industry and Fisheries in affairs concerning seafood exports and trade.

The NSC activities focus on three main areas:

1. Marketing
2. Market Insight
3. Communication and market risk management

4.4.1 Aquaculture and fish farming

Historic review of fish farming in Norway

From its humble yet ambitious beginnings along the coast of Norway in the spring of 1970, salmon farming has grown into a global industry at the forefront of new technologies. Norway was the first, and remains the largest Atlantic salmon farming nation, producing more than half of the world's farmed salmon along its ideally placed long coastline providing ample cold and clear waters year-round. It is

[52] https://ccsnorway.com
[53] https://en.seafood.no

hard to imagine a world where salmon, whether served in sushi, smoked on a bagel, or pan-fried with vegetables, didn't exist on menus or dinner plates across the world. But the history of salmon as a mainstream year-round food staple is a relatively new one, and one which perhaps would not have been if it weren't for two seafood loving entrepreneurial brothers. In 1970, on the island of Hitra off the coast of Norway, two brothers put in their floating open net pen the salmon which would grow into the very first successful generation of farmed Atlantic salmon. Together, they lay the foundations of modern aquaculture in Norway and abroad.

Salmon farming has come a long way since then, and today Norwegian salmon is a global commodity. Every single day 14 million meals of Norwegian farmed salmon are enjoyed on dinner tables and in restaurants across the world. As the world looks to more sustainable food production, modern aquaculture technology represents a major contributor both to meet the ever-increasing demand for proteins and as part of the solution to battling climate change.

In the 1980s there were salmon farms along the entire Norwegian coastline. Salmon from Norway conquered the European and US markets. However, with rapid growth came big challenges and illness became a problem for many salmon farms. In 1986 the global sushi trend was born. "Project Japan" aimed to double Norwegian exports of salmon. It marked the start of salmon in sushi – a Norwegian invention. The introduction of salmon in sushi played a major role in Norway's growing exports. In 1980 Norway exported 2 tonnes of salmon to Japan, 20 years later the volume reached 40,000 tonnes.

In the 1990s Norwegian scientists together with the industry introduced some of the first vaccines for fish. Several new vaccines were developed making the use of antibiotics in Norwegian salmon farming almost obsolete. In 2011, Norwegian salmon farmers come together in a joint commitment to reduce escapes and salmon lice, which have been major challenges for the industry. By 2015, Norway was the largest producer of Atlantic salmon in the world, 53 percent of all farmed salmon comes from Norwegian fjords. Technological advances made salmon farms safer and more productive.

"Ocean Farm 1" (pictured below) by Salmar[54] became the world's first remotely operated ocean farm with space for up to 1.5m salmon. The farm is equipped with state-of-the-art sensors and digital systems to control fish health and the environment. Effective vaccination programs meant the use of antibiotics in Norwegian salmon farming has been reduced by 99 percent since 1987. Less than 2 percent of Norwegian salmon has been treated with antibiotics. More offshore salmon farms are starting production, representing a new era for the industry. Norwegian salmon is the most preferred fish in the world, according to NSC Seafood Consumer Index 2020.

[54] https://www.salmar.no

Developed in Norway, built in China

Behind the project is a unique interdisciplinary partnership between world-leading players in Norway within aquaculture, offshore and research. The result is a structure built on the robust technology and principles used at submersible offshore installations, while safeguarding the biological needs of the salmon. When developing technical solutions, every fish farming process has been considered, and new approaches are established for the various operating procedures. The structure complies with the aquaculture industry's own fabrication standards, as well as relevant offshore oil and gas standards. Ocean Farm 1 is built by the China Shipbuilding Industry Corporation (CSIS) in Qingdao, China.

According to Mowi's Salmon Farming Industry Handbook 2019, four of the Top 5 farmed Atlantic salmon players by total harvest volume in 2019 were Norwegian: Mowi, Cermaq, Salmar, and Lerøy.

4.4.2 Fish health and welfare

The health status of the fish can be defined by its ability to withstand infection; the amount of pressure and stress we inflict on the stock, and the environment in which we farm fish is very important to the fish welfare. Understanding fish welfare is critical in fish farming. Ability to provide a farming environment that can support the best living conditions for the fish is not only utmost important to the business, but a given responsibility. Central to fish welfare is the salmon louse. The main and most successful tool that is in use today is the cleaner fish. Both Wrasse and Lumpfish are used, and they are farmed in large numbers. The cleaner fish live within the pen together with the salmon and eat salmon lice in high numbers. However, the cleaner fish need shelter (habitat), trained and skilled personnel and tailor-made feed. This represents a high cost and time-consuming part of the production.

The visionary goal for the Norwegian Aquaculture industry is to reach five million tonnes of farmed fish harvest by 2050. This is an immense challenge. To reach this goal, the industry must submit to public acceptance and acknowledgement. Current farming practices, especially regarding welfare of the fish, salmon lice treatments and escapes, are questioned in the eye of the public. Furthermore, criticism, increasingly backed by independent research, is raised towards the industry regarding the negative impact on wild salmonids stemming from the shedding of salmon louse (Lepeophtheirus salmonis) and escaped fish ending up in local rivers.

The roadmap to visionary 5 million tonnes harvest per year is clearly linked to regaining public confidence and recognition since both the number of sites, and number of fish per site, will have to increase. Even if we recognize that conditions vary along the coast, scaling up with today's technology can come at a very high price.

Today's legislation requires any escape or suspicion of escape is to be notified to the Directorate of Fisheries. The industry has a zero-escape vision and works systematic to register and communicate learning points across the industry. Legislation has also provided a whole set of new technical requirements for fish farms. Certificates are issued per site by third party authorized technical expertise to warrant "ability to perform". Yet, escapes continue to occur far too often due to factors all well known. Considering this, it is understandable that substantial increase in production is often questioned.

4.4.3 Future trends

According to conducted interviews, future trends within aquaculture is largely dominated by AI and new platforms for fish farming, such as the Stadium Pool for salmon farming; **Stadion Laks**[55].

The Stadion Basin is a floating, closed salmon farming production unit in reinforced concrete. Reducing or eliminating challenges related to salmon lice, escape of fish, and organic waste, this innovation project seeks to provide optimal growing conditions for the salmon. The facility will be located in sheltered waters, making use of the excellent natural conditions in Norway. The concept represents a

[55] https://stadionlaks.no/en/home/

major innovation aimed at solving several challenges faced by the aquaculture industry relating to both fish health and the environment, as it will reduce or eliminate challenges involving space, salmon lice, fish escape, disease, and algae, in addition to helping identify better solutions for handling feed residue and waste products. The design resembles an athletics stadium when seen from above, shaped as a semi-circle. The basin is designed for farming of salmon up to a biomass density of 50-75 kg/m3. The facility includes systems for water circulation, oxygen addition, feeding, light control, sludge removal and a control and monitoring system. Water can be taken from varying depths and moved through the basin at variable speed, as the water level inside and outside of the basin is the same unnecessary consumption of energy is eliminated.

Another such new platform for fish farming is **Salmon Evolution**[56], which was established in 2017 to pursue salmon farming on land. Their first production facility is currently under construction on Indre Harøy, close to Ålesund. Strategically located on the Norwegian west coast, the site offers access to an educated and experienced workforce, an established infrastructure for salmon farming, renewable energy and unlimited fresh seawater. This facility is being developed in three phases, with phase 1 due to provide an annual capacity of 9,000 tonnes when completed in the fourth quarter of 2022.

Hauge Aqua[57] has developed The Egg, which is a new robust, enclosed technology for industrial fish farming. The aim of the new technology is to enable sustainable growth in the aquaculture industry.

In November 2020, the seafood cluster **NCE Seafood Innovation**[58] in Bergen held an event with a particular focus on the problem of sea lice in salmon aquaculture. Upcoming Seafood Start-Up is an event for cluster members and an opportunity for start-ups to present their business and receive feedback on selected subjects from an expert panel with in-depth industry and investment expertise. Two of the companies presented AI based solutions.

Aquabyte AS[59]**:** Aquaculture meets machine learning, Designed in Silicon Valley - Made in Norway. Named one of Forbes 25 most innovative agtech start-ups in 2018. Aquabyte surpasses modern farm monitoring products with their holistic software platform. The solution offers easy installation, continuous monitoring and multiple applications. Once the company has optimized its algorithms for salmon, it intends to move on to other kinds of fish as well as other markets.

Fishency Innovation AS[60]**:** Fishency360 is a hardware and software solution for fish welfare that monitors fish health, lice, and growth in the pen. With a 360° view, the entire surface of every passing fish will be scanned and analyzed. Fishency uses technology to promote affordable sustainable development of the aquaculture industry.

According to NCE Seafood innovation, another company worth watching is **Blue Lice AS**[61]. Their concept is to catch salmon lice in the larval stage before they attach themselves to the salmon. This reduces the number of infestations and thus reduces the need for treatment. By exploiting the salmon lice's natural instincts, they eliminate salmon lice without any adverse effects on the fish or the ecosystem.

The **Norwegian Cognitive Center**[62] builds competence on AI (artificial intelligence) across industries and public sector, where they provide infrastructure in terms of personnel, know-how and AI platforms. They deliver a program designed to enhance faster product development and scale-up the AI development and empowering organizations to explore and use AI to gain competitive advantage. Artificial intelligence will be key for future development and competitiveness in all industries in the

[56] https://salmonevolution.no
[57] https://haugeaqua.com
[58] https://seafoodinnovation.no
[59] http://www.aquabyte.ai/index.html
[60] https://www.fishency.no
[61] https://www.bluelice.no
[62] https://norwegiancognitivecenter.com

years to come, also within aquaculture. There is however a large gap between research and the industrials capabilities of using AI to solve major challenges and explore possibilities (Digital Norway). This is why a broad national consortium in Norway, together with IBM, one of the world's leading AI technology and consulting companies, have launched a national center for cognitive technology, aiming to raise expertise and competence in artificial intelligence, and fuel and accelerate implementation of AI by sharing and collaborating on data, resources, competence, insight, innovation and joint projects.

> Norwegian Cognitive Center is a strong industry cross-over initiative to build Norway as a strong European AI hub, and to attract world leading expertise. A wide range of industries, companies, academic institutions and clusters have joined forces in a national consortium to fuel AI research, solutions and expertise.

Artificial Intelligence is quickly transforming business and society and is crucial to all industry competitiveness. In the short term, the center will develop several specific projects within industries such as aquaculture, media, finance, tourism, healthcare, real estate, infrastructure and the public sector, as well as initiate research projects. The long-term ambition is to raise, develop and specialize competence in cognitive technologies and artificial intelligence, and to create new high competence and high-tech jobs, which is strongly demanded by the industry. The center will also bring rich business opportunities for consulting, emerging tech business and new industries.

National consortium: A wide range of strong cross sector industries, entrepreneurship, solid and relevant academic research environments, and a forward-looking public sector lay the foundation for this groundbreaking initiative. The consortium comprises all the industry clusters in the region, representing hundreds of companies, many of them global leaders in their fields. The project is initiated through the close collaboration between IBM and NCE Media, with IBM also being a partner in the Media City Bergen Media Lab. New ecosystem and a way to share data and knowledge in all industries.

Data Sharing and Digital Standards for the Aquaculture Industry: **AquaCloud**[63] connects the industry through four main workflows: Data Platform, Sensor Data Standards, Fish Health Standards, and Environmental Data Standards.

AquaCloud was established in 2017 and is a big data project anchored in the aquaculture industry's need to solve common challenges in order to create sustainable growth. The project is part of NCE Seafood Innovation and began together with cluster members **Lerøy Seafood Group ASA**[64], **Grieg Seafood ASA**[65], **Mowi ASA**[66], **Bremnes Seashore AS**[67], **Lingalaks AS**[68], **Eide Fjordbruk**[69], and **Bolaks AS**[70]. Cermaq, Grieg and Mowi are all established in Canada. The project has developed substantially since 2017, and today the project involves an even broader group of leading aquaculture companies.

The initial scope of this initiative was to establish a secure database for storing data and to use advanced analytics to identify where sea lice outbreaks were probable. This part of the project celebrated some success. However, data quality and dependability were insufficient to reach the ambitious goals at the time. The project has evolved from being a pure sea lice forecasting asset to become a hub of industry activities including companies from multiple sectors in the industry.

[63] https://seafoodinnovation.no/whatwedo/aquacloud/
[64] https://www.leroyseafood.com/en/
[65] https://griegseafood.com
[66] https://mowi.com
[67] http://www.seashore.no/en/
[68] https://lingalaks.no/en/
[69] https://www.efb.no/home-en
[70] https://bolaks.no/english/

4.5 Key industry events, conferences and networking opportunities

Nor-Shipping[71]**:** Nor-Shipping is a globally leading exhibition and event programme that has been held in Norway every other year since 1965. This is the meeting place for leading maritime players, technology innovators, investors, and all the stakeholders interested in realizing ocean opportunities. It is an international arena for building cross industry collaboration, business, and sustainable ocean development. In all nearly 50,000 delegates, from around 85 nations, attend Nor-Shipping's exhibition, conferences, seminars, executive meetings, and social events. The 21,000 square meter exhibition is the beating heart of the week's activity with nearly 900 of the world's leading maritime companies showcasing products and services to the industry, future talent and shipping value chain stakeholders. The fair attracts shipowners, ship builders, classification societies, technology suppliers, shipbrokers, innovators, ship financiers and industry leaders. In 2017, Nor-Shipping was the first global maritime week to base its entire strategy on the UN Sustainable Development Goals and the first maritime event to become ISO 20121 certified. Based on the SDGs Nor-Shipping has created an arena for promoting sustainable ocean solutions and become an official participating partner to the UN Global Compact.

ONS (Offshore Northern Seas)[72]**:** ONS is a global energy meeting place connecting international suppliers, operating companies, and decision makers. ONS takes place every second year in Stavanger, Norway. Founded in 1974, ONS covers today the global energy market. The ONS event started off as an exhibition but has developed into a global energy meeting place with a broad conference program, exhibition, and networking arena. ONS attracts visitors working in oil, gas, renewable energy industry and energy related business at large. Participants from all over the world gather to discuss the future, conduct business, discover new opportunities, and connect with peers in the industry. It is important to emphasize that the business opportunities attract a large number of visitors from other industry segments such as banks, finance, legal service, IT, consultancy companies, etc.

Verftskonferansen (the Shipyard Conference): Every first week of November, some 500 people in the maritime, offshore and shipbuilding industry gather in Ålesund for a two-day conference about political framework conditions and market prospects. The conference is organized by the Federation of Norwegian Industries, but is conducted in Norwegian. Normally the Minister of Industry and Fisheries will be the opening speaker, so the conference is a part of the frequent dialogue between the government and the blue economy industry in Norway.

Nor-Fishing[73]**:** Since 1960, Nor-Fishing has been an important national and international meeting place for the fisheries industry. Today it is one of the largest fisheries technology exhibitions in the world. In recent years, the exhibition has drawn around 15 000 visitors from about 50 countries. Innovations of importance to all sectors of the industry are presented here. The fisheries industry has developed tremendously over the past fifty years, and technology, processes and services related to fishing, processing, transport, and marketing have undergone an incredible development. Most major fishing nations are present either as exhibitors, visitors or in official delegations.

Aqua Nor[74]**:** Since 1979, Aqua Nor has been an important international meeting place for the aquaculture industry, and it is today the world's largest aquaculture technology exhibition. In recent years, the Aqua Nor exhibition has drawn about 20,000 visitors from up to 76 nations to its halls. All the latest innovations of importance are presented to the industry. During Aqua Nor, numerous seminars, mini-conferences, lectures, debates, and presentations are held. During the exhibition, visitors and exhibitors can participate in various social events both during the day and in the evening. The conditions are perfect for meeting old friends as well as new contacts and customers in an informal setting.

Nor-Fishing and Aqua Nor are being held biannually in Trondheim.

[71] https://www.nor-shipping.com
[72] https://www.ons.no
[73] https://www.nor-fishing.no
[74] https://www.aquanor.no/?lang=en

4.6 Key public sector and research actors

The key regulatory office for the blue economy are the **Norwegian Maritime Authority**[75], **Norwegian Environment Agency**[76], the **Ministry of Trade, Industry and Fisheries**[77], **Directorate of Fisheries**[78] and the **Norwegian Coastal Administration**[79]. There is a strong interaction between the government, industry, and R&D institutions in the Norwegian blue economy. Maritime Forum, the Norwegian Shipowners' Association and The Federation of Norwegian Industries are strong industry associations with frequent interaction with the government, in particular the Ministry of Industry and Fisheries as well as the Ministry of Climate and Environment.

4.6.1 Research infrastructure and institutions

There are several research institutions within Blue Economy in Norway, both public and private ones.

RESEARCH ORGANIZATION	DESCRIPTION	RESEARCH AREA
Institute of Marine Research[80]	The IMR is one of the biggest marine research institutes in Europe, with about 1,000 employees. Their main activities are research, advisory work and monitoring.	Sustainable management of the resources in our marine ecosystems and the whole food chain. Their main activities are research, advisory work and monitoring.
Norwegian Ocean Observation Laboratory[81]	A collaboration between The Institute of Marine Research, The University of Bergen, The Norwegian Defense Research Establishment, Western Norway University of Applied Sciences and Christian Michelsen Research. Industrial partners are Equinor, Metas, Argus, Aanderaa Data Instruments, Kongsberg Maritime and GCE Ocean Technology. The Laboratory is funded by the Research Council of Norway.	The laboratory is designed to host world-class research infrastructure and facilitate collaborative cross-border technology development for ocean research. Engineers, researchers and students from both industry and universities work closely together to develop the next generation integrated monitoring technology and methodology, new marine technologies, performing marine research through a combined effort.
Norwegian University of Science and Technology (NTNU Oceans)[82]	NTNU Oceans, one of NTNU's four research areas, addresses complex challenges of great importance for society through interdisciplinary cooperation. Through research and outreach activities (i.e. Ocean Week), NTNU Oceans contributes to Norway's role as a maritime nation.	Sustainable use of the ocean resources (energy and minerals); Mapping and monitoring of the ocean space; Sustainable use of the ocean resources: seafood and marine bio resources; Sustainable coastal management and governance; and Green maritime transport and infrastructure.

[75] https://www.sdir.no/en/
[76] https://www.environmentagency.no
[77] https://www.regjeringen.no/en/dep/nfd/id709/
[78] https://www.fiskeridir.no/English
[79] https://www.kystverket.no
[80] https://www.hi.no/en/hi/about-us
[81] https://www.uib.no/en/oceanlab
[82] https://www.ntnu.edu/oceans/research-areas

Norwegian Institute for Water Research (NIVA) [83]	NIVA is Norway's leading institute for fundamental and applied research on marine and freshwaters.	Their research comprises a wide array of environmental, climatic, and resource-related fields. NIVA's world-class expertise is multidisciplinary with a broad scientific scope, combining research, monitoring, evaluation, problem-solving and advisory services at international, national and local levels.
Norwegian University of Life Sciences (NMBU)[84]	The Norwegian University of Life Sciences is a public university located in Ås, near Oslo. Two other major institutions are co-located with NMBU: key parts of the Norwegian Institute of Food, Fisheries and Aquaculture Research (Nofima)[85] and the Norwegian Institute of Bioeconomy Research (NIBIO)[86].	Their Department of Animal and Aquacultural Sciences (IHA) is a leader in research on farm animals in water, like domesticated animals and farmed fish.
The University of South-Eastern Norway (USN)[87]	The University of South-Eastern Norway is Norway's fourth largest university, spread over eight campuses.	Their faculty of Technology, Natural Sciences and Maritime Sciences (TNM) offers bachelor's and master's degrees in maritime studies as well as a PhD in nautical operations.
BI Norwegian Business School[88]	BI is a main provider of research-based knowledge on business and management disciplines in Norway and the only Norwegian business school that has received the three most prestigious international accreditations.	They have two research centers of relevance to the blue economy: The Center for Sustainability and Energy and Center for Ocean Business (OBZ).
Norwegian School of Economics (NHH)[89]	The Norwegian School of Economics is a business school situated in Bergen. It was founded in 1936 as Norway's first business school and has since its establishment been a leading teaching and research institution in the fields of economics and business administration. Shipping and logistics are traditional research fields at NHH.	Center for Shipping and Logistics develops this work through both theoretical and empirical maritime transport and logistics research in broad interaction with Norwegian industry and an endowed professorship donated by Bergen's Shipowners' Association, chair holder being professor Roar Ådland.

[83] https://www.niva.no/en/about-niva
[84] https://www.nmbu.no/en
[85] https://nofima.no/en/
[86] https://www.nibio.no/en
[87] https://www.usn.no/english/
[88] https://www.bi.edu
[89] https://www.nhh.no/en/

4.7 Clusters

The Norwegian clusters are some of the most organized and structured in the world. **Norwegian Innovation Clusters**[90] was established in 2014 under **Innovation Norway**[91], which has since supported the clusters in the program - both financially and with an array of other resources. The aim of the program is to strengthen and set up cooperative innovation projects in business clusters, focusing on increasing companies' ability to innovate and increase their competitiveness. There are three different levels to the Norwegian Innovation Clusters by Innovation Norway; Arena, NCE (Norwegian Center of Expertise) and GCE (Global Center of Expertise).

In Appendix C we list the most relevant Blue Economy clusters and organizations within the blue economy in Norway, including the Norwegian Shipowners' Association and Maritime Forum.

4.8 Cooperation possibilities with accelerator programs and funding

The Norwegian ocean industry is driven by a large governmental involvement, both through governmental initiatives and investment/ownership in large companies such as Equinor, where the Norwegian government owns 67%. There are also several market actors that strive to drive change in the ocean industry, such as Katapult Ocean.

ORGANIZATION	DESCRIPTION
The Research Council of Norway[92]	The Research Council works to promote research and innovation of high quality and relevance and to generate knowledge in priority areas to enable Norway to deal with key challenges to society and the business sector. In 2019 the Research Council allocated some NOK 10bn to research and innovation on behalf of 15 ministries. Over 2,000 international peer reviewers assess and rank the grant proposals submitted.
Katapult Ocean[93]	Invests in start-ups that build profitable businesses with a positive impact on the ocean. They offer an intense accelerator program that is tailored to ocean start-ups, with hands-on mentorship from top global subject manner experts, serial entrepreneurs, business leaders and investors. Katapult Ocean represents an example of FDI possibilities for Canadian companies.
Motion Ventures[94]	Announced in the end of February 2021, Wilhelmsen Holding has invested in an investment fund called Motion Ventures. The fund is a consortium powered by the Singapore based company Rainmaking. The fund brings together industry legacy, capital, resources, and insight in order to give start-ups the best possible chance to commercialize and find a strategic market fit. It targets early-stage start-ups tackling challenges in the maritime value chain.
The Ocean Opportunity Lab (TOOL)[95]	A lab for entrepreneurs and change agents across ocean industries, sustainable solutions and tech. TOOL aims to connect change makers, experts, innovators, entrepreneurs, clusters, and corporations across the world with a purpose of making a sustainable impact within the ocean and renewable industries.

[90] https://www.innovasjonnorge.no/no/subsites/forside/english/
[91] https://www.innovasjonnorge.no/en/start-page/
[92] https://www.forskningsradet.no/en/
[93] https://katapultocean.com
[94] https://www.motionventures.io
[95] https://theoceanopportunitylab.com

SIVA[96]	The Industrial Development Corporation of Norway (SIVA) is the governmental corporation and national instrument founded in 1968. SIVA aims to develop strong regional and local industrial clusters through ownership in incubators, business gardens, catapult centers, innovation enterprises, innovation centers and industrial real estate. The goal is improvement of national infrastructure for innovation. SIVA's main objective is to contribute to the achievement of the Norwegian government's policy goals in remote areas.
Innovation Norway[97]	Innovation Norway is a state-owned company and a national development bank, as well as the Norwegian government's official trade representative abroad. The company's programs and services are intended to stimulate entrepreneurship in Norway. Its head office is in Oslo, and an office in each of the Norwegian counties. It also has offices in 30 countries around the world. The company has over 500 employees worldwide and has supported maritime transportation, biotechnology, thin film, and alternative fuel. They also operate **The Explorer**[98], the official marketplace for green technology from Norway. Its purpose is to connect international needs with Norwegian companies with sustainable solutions.
Norwegian Catapult[99]	The Norwegian Catapult Program is a governmental scheme designed to assist the establishment and development of catapult centers, with the purpose of accelerating the process from concept to market launch of the product. The purpose of the Catapult program is to support innovative capability of small and medium sized enterprises in specific industry areas in Norway. The Catapult centers assist companies in developing prototypes, offer expertise and equipment for testing, visualization and simulation to turn innovative ideas into new products and services in an effective manner at a lower risk. The Catapult centers provide expertise, contacts and facilities in various technological areas, and can assist companies to access new markets and captivate interest from other potential business partners.
Enova[100]	Enova SF is a Norwegian government enterprise responsible for promotion of environmentally friendly production and consumption of energy. Its stated purpose is to explore new sources of clean energy, reduce overall energy consumption, and to provide educational materials to the public promoting energy-efficient practices. Established in 2001, it is financed through government funding in addition to a tariff of 1 øre per kWh of electricity to consumers. The company is owned by the Norwegian Ministry of Petroleum and Energy and based in Trondheim.
The NOx Fund[101]	The NOx Fund in brief: The NOx Agreements is agreements between Norwegian authorities and industry to reduce NOx emissions in Norway. The NOx Fund is owned by 15 business organizations to reduce NOx in Norway. Enterprises pay a (lower) fee, to the NOx Fund instead of a (higher) fiscal tax to the State. In return collective emission reduction obligations must be met. State sanctions if not. Payments to the Fund is returned to the industry as investment support. Those that invest pay less after the measure is implemented.

[96] https://siva.no/english/
[97] https://www.innovasjonnorge.no/en/start-page/
[98] https://www.theexplorer.no
[99] https://norskkatapult.no/information-in-english/
[100] https://www.enova.no/about-enova/
[101] https://www.nho.no/samarbeid/nox-fondet/the-nox-fund/

Export Credit Norway[102]	Export Credit Norway is wholly owned by the Norwegian Government, and is administered by the Ministry of Trade, Industry and Fisheries. They help Norwegian exporters by offering Norwegian and foreign companies competitive financing when buying goods and services from Norwegian exporters. Their clients come from all over the world, and purchase everything from ships and subsea technology, to solar parks, hydropower turbines and design services. Export Credit Norway deals with the entire loan application process, including commitment, disbursement, and monitoring of loans.
GIEK[103]	GIEK is the Norwegian Export Credit Guarantee Agency, a public-sector enterprise that reports to the Ministry of Trade, Industry and Fisheries (MTIF). GIEK provides long-term guarantees on behalf of the Norwegian state in order to encourage Norwegian participation in international trade and exports. GIEK provides guarantees on commercial terms for loans, investments, and product deliveries. Guarantees are supplied to Norwegian companies, international buyers, and banks. GIEK is a key financing partner for Norwegian exporters, their customers, and banks. Backed by Norway's AAA rating GIEK guarantees provide both additional financial capacity and access to attractive funding. The guarantees can also reduce Norwegian exporters and foreign buyers' risk of a loss in connection with payment and delivery. While its focus has traditionally been oil and gas and shipbuilding followed by fisheries and aquaculture, it has widened its mission to include offshore wind, and more generally banks and investors participating in large international energy-infrastructure projects.

4.9 Market entry situation and key market actors

4.9.1 Market gaps and opportunities

According to conducted interviews, the EU Taxonomy will likely play a significant role and have a larger focus in the future than CO2-emissions. This opens for new business areas to be researched and developed. One area where there is an identified future need without significant actors is waste management. This is part of the taxonomy consideration but still lacks solutions.

Another market opportunity is cost reduction for hydrogen. These fuels are currently more expensive than their less environmentally friendly alternatives. Although willingness to utilize such fuels is high, the cost barriers are currently too high without government funding to achieve wide success.

4.9.2 Some key Norwegian market actors

DNB[104] – Den Norske Bank - is Norway's largest financial services group and the largest in the Nordic region in terms of market capitalization. The Group offers a full range of financial services, including investment and corporate banking, wealth management. DNB has for several decades been among the world's leading maritime banks, and existing and emerging energy banks. The Ocean Industries Division covers five main industry sectors; Oil & Gas, Ocean Services, Shipping, and Seafood, with offices in Oslo, Bergen, New York, London, and Santiago.

DNV[105] – Det Norske Veritas (formerly DNV GL), established in 1864, is the world's leading classification society and a recognized advisor for the maritime industry. They deliver testing, certification and technical advisory services to the energy value chain including renewables, oil and gas, and energy management. DNV is one of the world's leading certification bodies, helping businesses

[102] https://www.eksportkreditt.no/en/
[103] https://www.giek.no/frontpage/
[104] https://www.dnb.no/en/corporate-and-institutions
[105] https://www.dnv.com

assure the performance of their organizations, products, people, facilities and supply chains. The company currently has about 12,000 employees and 350 offices operating in more than 100 countries, and provides services for several industries including maritime, oil & gas, renewable energy, electrification, food & beverage and healthcare. DNV is the largest technical consultancy and supervisory to the global renewable energy (particularly wind, wave, tidal and solar) and oil and gas industry, as well as the world's leading advisory and assurance provider in the wind industry, having had a role one way or the other in 90% of the wind projects in North America. DNV has 6 offices in Canada: Calgary, Dartmouth, Montreal, St. John's, Toronto, and Vancouver.

Kongsberg Maritime[106] is a Norwegian technology enterprise within the **Kongsberg Group**[107]. Other companies in the group are Kongsberg Defense & Aerospace and Kongsberg Digital. Kongsberg Group dates to Kongsberg Weapons Factory, established in 1814. Kongsberg Maritime employs some 7,500 people and operate 117 offices in 34 countries, including three in Canada (Halifax, St. Johns, and Vancouver). Kongsberg Maritime deliver systems for positioning, surveying, navigation, and automation to merchant vessels and offshore installations. Their most well known products exist within dynamic positioning systems, marine automation and surveillance systems, process automation, satellite navigation, and hydro acoustics. In 2019, Kongsberg Maritime acquired Rolls-Royce Commercial Marine, adding propulsion solutions, deck machinery, and ship design capabilities to their product portfolio. Always at the forefront of marine technology, Kongsberg Maritime is a key player in the digital transformation of operations at sea, with a leading position in the development of autonomous vessels. They are also one of the two owners of Massterly AS, the other one being Wilh. Wilhelmsen.

4.9.3 The world's first zero emission, autonomous container feeder

YARA Birkeland will be the world's first fully electric and autonomous container ship, with zero emissions. Kongsberg Maritime is responsible for development and delivery of all key enabling technologies including the sensors and integration required for remote and autonomous ship operations, in addition to the electric drive, battery and propulsion control systems. A 120 TEU (Twenty-foot Equivalent Units) open top container ship. It will be a fully battery powered solution, prepared for autonomous and unmanned operation. The vessel will reduce NOx and CO2 emissions by reducing diesel-powered truck transport by around 40,000 journeys per year. This eco-initiative will help to meet the UN sustainability goals, and improve road safety and congestion. For the first phase of the project a detachable bridge with equipment for manoeuvring and navigation will be implemented. When the ship is ready for autonomous operation this module will be lifted off.

[106] https://www.kongsberg.com/maritime/
[107] https://www.kongsberg.com

Loading and discharging will be done automatically using electric cranes and equipment. The ship will not have ballast tanks, but will use the battery pack as permanent ballast. The ship will also be equipped with an automatic mooring system - berthing and unberthing will be done without human intervention, and will not require special implementations dock-side. The autonomous ship will sail within 12 nautical miles from the coast, between 3 ports in southern Norway. The part of the area carrying most of the ship traffic is covered by the The Norwegian Coastal Administrations' VTS system at Brevik. To ensure safety, three centers with different operational profile are planned to handle all aspects of operation. These centers will handle emergency and exception handling, condition monitoring, operational monitoring, decision support, surveillance of the autonomous ship and its surroundings and all other aspects of safety. An interface towards Yara logistical operation will be implemented at the operational center at Herøya.

The Torvald Klaveness Group[108] was founded in 1946. Operating a fleet of some 100 dry bulk vessels, they have become known for their efforts in finding new ways to improve technology and business models in shipping: **Klaveness Combination Carriers** is the world leader in combination carriers and in carbon efficient deep sea dry bulk and tanker shipping. The company has a fleet of 16 vessels that have up to 40 % lower CO2 emissions per ton mile transported cargo, and go a long way in meeting IMO's 2050 targets of a 50 % reduction in CO2 emissions. **Klaveness Digital** builds intelligent shipping and logistics solutions using the latest advances in machine learning and artificial intelligence (AI). With a team of software engineers, data scientists, shipping, and logistics specialists in Oslo and Singapore, they help global companies take better informed decisions. The products and services are designed to give companies end to end visibility with real-time and predictive shipping and logistics. They work closely with leading companies in the metal and mining, agriculture, energy, shipping and logistics industries. **ZeroLab** was established in 2021 to identify and commercialize scalable and digital business opportunities related to decarbonization of shipping, with real and traceable impact on reducing greenhouse gas emissions within the industry. ZeroLab acts as a laboratory where the team, together with other business units, customers, and partners, can experiment with different ideas and develop new solutions. Klaveness aims to become the leading provider and enabler of zero/low emissions freight for bulk commodities.

The Wilhelmsen Group[109] operates the largest maritime network in the world and has over 2,200 locations world-wide, employing some 15,000 employees from 125 nations. Part of the Wilhelmsen operation involves ships agency, marine products, ship management and other services. To further be able to develop sustainable solutions, Wilhelmsen has started entering more and more partnerships with start-ups, and most recently, with a fund consortium. In interviews conducted for this report, Wilhelmsen stated that they are open for any joint ventures/partnerships with start-ups that develop sustainable maritime solutions, also Canadian ones.

The Wilhelmsen Group (WW) was founded in 1861. Today the still predominantly family owned group is run by the 5th generation. WW conducts shipping activities and specialises in roll-on roll off cargo, especially for large project and awkward cargoes like train coaches, small aircraft and large industrial machinery. Together with its partners (EUKOR and Wallenius Lines), the group controls some 160 car and roll-on/roll-off carriers operating in a global network of trades. Its customers include manufacturers of cars as well as construction and agricultural machinery. In the car carrier market, they are the third largest carrier tonnage wise after Japanese MOL and NYK Line. On an annual basis, WW's shipping companies transport 5 million cars and 12 million cubic metres of high and heavy and non-containerised cargoes. The group both owns and charters vessels, which are deployed in the fleets operated by subsidiaries Wallenius Wilhelmsen Logistics, American Roll-on Roll-off Carrier, United European Car Carriers and EUKOR Car Carriers. This last, corresponding to the former Roll-on/roll-off division of Hyundai Merchant Marine, was jointly acquired for an 80% by Wilhelmsen and Wallenius Line in November 2002, once the European Commission officially cleared the purchase and consequent re-branding.

[108] https://www.klaveness.com
[109] https://www.wilhelmsen.com

Raa labs edge[110] is data infrastructure providing access to vessel data – enabling data driven vessel management. Their goal is to make it easier for firms to navigate through the rapid changing technological landscape. Raa Labs Edge provides data infrastructure with access to vessel data, running the applications on the vessel for crew or onshore headquarters in order to improve visibility and insight.

3D-print Wilhelmsen are currently providing spare parts on demand to vessels around the globe. The savings from reduced costs, time and environmental footprint provided by 3D printing digital inventory and on-demand localized manufacturing of maritime spare parts.[111]

Press Release, December 17, 2020:
Wilhelmsen's Topeka hydrogen project awarded NOK 219m

The Wilhelmsen led project, to construct the world's first zero emission hydrogen vessels, has been awarded NOK 219m by Enova. These funds will enable Wilhelmsen to further develop the technology and additional infrastructure required to support the maritime industry's ambitions towards zero emission fuels. "The funds from Enova are a pivotal step in making Topeka happen, and an important milestone for the maritime industry and for Norway as a nation when considering hydrogen as a fuel", says Senior Vice President at Wilhelmsen, Jan Eyvin Wang.

> **"To reach our ambitions for zero emission ocean transport, new technology has to be developed. Batteries cover many needs, but not all. This means the introduction and usage of zero emission energy carriers such as hydrogen is crucial", says Enova.**

The Topeka project revolves around the construction of two roll-on/roll-off (Ro-Ro) vessels servicing the short sea segment. The vessels will, amongst other tasks, move goods between offshore supply bases along the Norwegian west coast. In addition, the Topeka vessels will transport hydrogen to different filling stations where local ferries and other vessels as well as land transport will have hydrogen as a ready-to-use fuel. "With this new funding, our vision of hydrogen vessels and infrastructure supporting various industries along the coast is much closer to becoming a reality and that is enormously exciting", says Wang.

[110] https://www.raalabs.com/raa-labs-edge
[111] https://www.wilhelmsen.com/maritime-innovation-lab/3d-printing-from-shipping-parts-to-sending-files/

Wilhelmsen aims to be an integral part of the development of hydrogen for marine applications in Norway and also internationally. “We believe we can build and learn in Norway. We have the political will here, and Wilhelmsen has a unique network along the coast through our subsidiary company NorSea Group. Our goal is to start with our two Topeka vessels, and in time expand to be able to support the entire maritime industry with zero emission fuel alternatives. Together with our partners, Enova and aided by the Norwegian government’s ambitions, we can make Norway the Silicon Valley for maritime hydrogen globally”, says Wang. Going under the concept name “Topeka”, the vessels will be the first of their kind to enter commercial service. Providing a two-in-one solution, they will sail on a fixed schedule carrying both coastwise customer cargo and containerized liquid hydrogen (LH2) to the bunkering hubs. Norway’s west coast is dotted with bases serving the offshore industries, with base-to-base transport representing a heavy-duty transport route eminently suited to LH2. The bunkering hubs will in the future supply LH2-powered vessels including ferries and seagoing tonnage.

“Hydrogen as a fuel enables opportunities for low, or zero-emission shipping. Topeka will be our first step towards scalable LH2 fueled maritime operations. We shall create a full LH2 infrastructure and commercial ecosystem, while at the same time removing yearly some 25,000 trucks from the roads”, says vice president of special projects, Per Brinchmann at Wilhelmsen, who is coordinating the project. Mr. Brinchmann is also the chairman of Massterly AS.


PHOTO CREDIT: ØRSTED

DENMARK

OFFSHORE WIND

MARITIME LOGISTICS/TRANSPORT (DIGITALIZATION)

5. DENMARK

5.1 Main drivers and trends

Denmark is among the world's leading nations within the maritime industry and offshore wind. Danish maritime companies account for about one fourth of Denmark's exports and about 4%[112] of Danish jobs are directly or indirectly derived from the blue economy in Denmark. Thereby, the blue economy is in large part embedded into the Danish culture.

> In Denmark, the Blue Economy employs nearly 100,000 people and creates a turnover of DKK 394bn, according to Blue Denmark figures from COWI for 2019[113].

In 2018, the Danish Maritime Authority published their **Plan for Growth in Blue Denmark 2018**[114]. The plan describes the government's vision and direction for Maritime Denmark as a power hub:

- For digitization
- With attractive framework conditions
- Power hub of knowledge and knowhow
- With a global outlook and attractiveness

In April 2017, the **Maritime Strategy Team**[115] presented 52 specific recommendations for how Denmark could maintain its maritime position of strength towards 2025. The Maritime Strategy Team was established in May 2016 and contain key people of the Danish maritime industry. The team was tasked with examining the challenges and barriers to growth in the Danish blue economy as well as developing specific recommendations.

With hundreds of years of being one of the world's most seafaring nations, Denmark has amassed a substantial fleet, much thanks to **A. P. Møller-Mærsk**[116] which currently operates the world's largest container fleet. As with the rest of Scandinavia, Denmark has a high focus on technological advancements that can help reduce inefficiencies in processes and reduce emissions. The industry's legal emissions follow IMO regulations, which by 2020 was to reduce sulphur emissions in ship's fuel oil and is set to reduce CO2 emissions by 30% by 2030 and 70% by 2050[117].

Green hydrogen: Danish actors are opening a 1,3 GW green hydrogen plant in 2030 as a way to store the excess electricity from offshore wind. The clean energy project to develop a "ground-breaking hydrogen and sustainable fuel facility" is based on electrolysis in the greater Copenhagen area. The project will be implemented by 2030 in three stages, achieving the capacity of 10 megawatts (MW) in 2023, 250 MW in 2027, and 1.3 GW in 2030, respectively, the firm said in a statement. The partnership consists of large Danish companies – including **A.P. Møller–Mærsk**, **DSV Panalpina**[118], **SAS**[119], and **Everfuel**[120] – covering the whole value chain for the production, distribution, and consumption of renewable hydrogen and sustainable fuels. As well as significant investment from the companies involved the project, substantial funding from Innovation Fund Denmark has been requested.

The first stage will comprise a 10 MW electrolysis plant producing renewable hydrogen for trucks and, potentially, buses in the capital's wider metropolitan area. By 2027, the stage two facility equipped with

[112] https://www.dma.dk/Vaekst/VaekstBlaaDanmark/Sider/default.aspx
[113] https://www.dma.dk/Documents/Publikationer/2021%20Det%20blå%20Danmark_engelsk%20summary.pdf
[114] https://www.dma.dk/Vaekst/VaekstBlaaDanmark/Vækstplan2018/Sider/default.aspx
[115] https://www.dma.dk/Vaekst/VaekstBlaaDanmark/Vaekstteamet2016/Sider/default.aspx#
[116] https://www.maersk.com/about
[117] https://www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gas-emissions-from-ships.aspx
[118] https://www.dsv.com/en/about-dsv/panalpina
[119] https://www.sasgroup.net
[120] https://www.everfuel.com

a 250 MW electrolysis plant will combine the production of renewable hydrogen with capture of CO2 from combustion of municipal waste or biomass to produce renewable methanol for maritime vessels and renewable jet fuel for planes. Stage three will upgrade the electrolysis plant's capacity to 1.3 GW and capture more CO2. With the large-scale supply of renewable electricity needed, the timing of phases two and three will depend on the execution of the offshore wind power project off the island of Bornholm in Denmark, the news release added.

5.1.1 Denmark's two Energy Islands to be constructed by 2030

The world's first energy islands will be constructed in Denmark, exploiting their immense wind resources in the North and Baltic seas. The energy islands will serve as hubs that can create better connections between energy generated from offshore wind and the energy systems in the region around the two seas. The offshore wind turbines around the islands will be able to supply green electricity with a capacity to power at least five million households. The **Danish Energy Agency**[121] is leading the project and will also be present all the way inside the engine room once the two islands become a reality.

The energy islands mark the beginning of a new era for the generation of energy from offshore wind, aimed at creating a green energy supply for Danish and foreign electricity grids. Operating as green power plants at sea, the islands are expected to play a major role in the phasing-out of fossil fuel energy sources in Denmark and Europe.

The plan envisages the establishment of an artificial island in the North Sea that will serve as a hub for offshore wind farms supplying 3 GW of energy, with a long-term expansion potential of 10 GW. The energy island in the Baltic Sea will be Bornholm, where electrotechnical facilities on the island will serve as a hub for offshore wind farms off the coast supplying 2 GW of energy.

Today, Denmark harnesses the energy from strong ocean winds via isolated offshore wind farms that supply electricity directly to the Danish electricity grid. With these energy islands, the wind turbines can be placed further away from the coast and distribute the power they generate between several countries more efficiently. The islands serve as hubs - or green power plants - that gather electricity from the surrounding offshore wind farms and distribute it to the electricity grid in Denmark as well as directly to other countries, giving households and businesses access to this green electricity. This allows electricity from an area with vast wind resources to be more easily routed to areas that need it the most, while also ensuring that the energy generated from the turbines is utilised as efficiently as possible in terms of demand for electricity. During the first phase, the offshore wind farms around the Danish energy islands will produce 5 GW of electricity; 3 GW coming from the North Sea and 2 GW from Bornholm. In the long term, the energy island and offshore wind farms in the North Sea will have their capacity expanded to allow the generation and distribution of 10 GW of electricity.

The island will be considered critical infrastructure, and it has been decided that the state will have a majority ownership in collaboration with one or more private actors. This is intended to enable facilitation of private competences in regard to project development, technology and finance, and contribute to innovation and green export. The Danish Energy Agency plans to start the tendering process in 2022, with the announcement of the winner of the tender at the beginning of 2023.

The two energy islands are to be completed in 2030, and will be able to supply 5 GW of power. This is enough to meet the average electricity consumption of 5 million households. For more information about the project, contact **Energinet**[122], an independent public enterprise owned by the Danish Ministry of Climate, Energy and Utilities. They own, operate and develop the transmission systems for electricity and natural gas in Denmark.

[121] https://ens.dk/en
[122] https://en.energinet.dk

5.2 Offshore Wind

As a result of the country's relatively long coastline and consistent, strong winds, Denmark early on became a driver in the wind technology. As the first country to install an offshore wind farm in 1991, Denmark is considered the cradle of the offshore wind industry. The country's development strategy for offshore wind has focused on providing both nearshore and offshore projects. Now, Denmark has a total of around 1,701 MW in full operation following the Horns Rev 3 project reaching the COD milestone in August 2019. Wind (both offshore and onshore) has created an important position in Denmark's energy mix by being responsible for 47%[123] of the country's electricity generation in 2019.

> **Ørsted ranked the most sustainable energy company in the world – three years running**
> The Danish offshore wind company Ørsted has developed leading and sustainable technology for the future since 2008. Today, they supply around 15 million people with power, and the goals set for the future promise an exponential growth in production of renewable energy. One of the focus areas for the future is solar energy and onshore wind in addition to the huge offshore wind projects. This includes phasing out the coal industry completely.
>
> Ørsted has a number of pipelines in the North Sea and dispose large parts of the European pipeline system. With these pipelines, they can transport the gas to where the demand is highest at any given time. Besides higher security for supply, the storage facilities provide flexibility by enabling the possibility to use gas from storage rather than buying it in the market when the price is high.

It is important to note that they have approximately 949 MW in the pipeline and 3.9 GW of capacity in the scoping phase. The Danish government has selected a Contracts for Difference (CfD) strategy supporting the planned Thor offshore wind farm. This CfD comprises an allocation of DKK 3.7bn. The Danish wind energy portfolio is dominated by a diverse offshore wind portfolio with small local owners and global international players developing projects.

Policy and regulatory framework

Leasing

- There are two ways in which developers can obtain project approval:
  - Tender procedure: pre-defined areas of sea, which are identified through a spatial planning process, are leased via an auction process.
  - The open-door procedure: allows developers to establish project locations.

Route to market

- The open-door leasing process offers a minimum guaranteed fixed subsidy and can take place in technology neutral tenders.
- The tender leasing process offers CfD-type subsidy support (difference between strike price and market price) and is awarded as part of a competitive auction. Subsidy is awarded for 20 years relating to 50,000 hours of production at full capacity.

Targets

- 2.4 GW of offshore wind capacity by 2030.
- Denmark has already achieved their EU Directive 2009/28/EC. It set a target of 30% share of energy generated from renewables in gross final energy consumption.
- 50% of electricity generation from renewable energy sources by 2030.

Source: NORWEP

5.2.1 Power-to-X collaboration established in Denmark

In 2020, trade groups **Wind Denmark**[124] and **Hydrogen Denmark**[125] joined forces to form a new PtX Alliance to promote the use of renewable energy-powered electrolysis. Wind Denmark said Power-to-X (PtX) is an important element of the country's ambition to reduce carbon emissions by 70% compared to 1990 by 2030. The PtX Alliance will contribute to the dissemination of Power-to-X in Denmark, and to break down regulatory barriers.

[123] https://www.reuters.com/article/us-climate-change-denmark-windpower-idUSKBN1Z10KE
[124] https://en.winddenmark.dk
[125] https://stateofgreen.com/en/partners/brintbranchen-hydrogen-denmark/

The cooperation is to ensure that large-scale production of, for example, hydrogen, as well as secure opportunities for a new export adventure of both green fuels and technology for production. The alliance will aim to establish a strategic direction for connecting wind turbines to electrolysis equipment, to promote innovation and testing of PtX, especially hydrogen, methanol and ammonia, and support export of Danish PtX solutions.

> **Power-to-X (also P2X and P2Y) is a number of electricity conversion, energy storage, and reconversion pathways that use surplus electric power, typically during periods where fluctuating renewable energy generation exceeds load.** Source: Wikipedia

5.2.2 Wind turbine manufacturing in Denmark

On the supply side, there are about 25 manufacturers of wind turbines in the world[126]. The top three major players are **Vestas Wind Systems**[127], Enercon, and Siemens Gamesa. Together they account for two thirds of the total supply. Vestas is Danish and has long maintained its position as the largest manufacturer of wind turbines in the world.

5.3 Denmark, Maritime Logistics/Transport digitalization

Danish shipowners transport approx. 10% of global trade, Denmark ranks 6th on the global list of operator nations in gross tonnes (GT), Denmark has the 4th largest EU-flagged merchant fleet (GT), and Danish shipping is the largest export industry in Denmark and accounts for about 20 % of total Danish exports[128].

5.3.1 Denmark – a digital frontrunner

For decades, Denmark has been at the forefront of innovations within AI and Machine Learning. The infrastructure is in place to use data, tap into engaged consumers, and work collaboratively with world-class research institutions to strengthen R&D, commercialization and product pipeline. Danish public and private research in Tech hold international top positions within Big Data and Security & Monitoring

> Danish IT strongholds: Denmark is a global leader when it comes to AI, drones and robotics, blockchain, as well as cyber security and opportunities with quantum technology.
>
> In 2017, the Digital Economy and Society Index (DESI)[129] ranked Denmark as the EU's most advanced digital economy, followed by Finland and Sweden.

AI and Advanced Analytics are relevant for the maritime industry within the following application areas: Dynamic capacity reallocation, Predictive maintenance, Demand forecasting, Route optimization, and Autonomous vessel navigation.

AI, Robotics and Drones are relevant for Autonomous Shipping.

Quantum Technology is relevant for the maritime industry within the following application areas: Cyber Security, which is essential to secure the implemented technologies from being hacked, security assurance for customer data, and security assurance for automated operations.

The Danish shipping industry has long looked to autonomy as the future of the blue economy. In 2019 an initiative called **ShippingLab**[130] was established by the Danish Maritime Cluster, **Blue Denmark**[131], with the objective to create quantifiable value by technology innovation in three core areas[132]:

[126] https://pure.au.dk/portal/files/12741/Windmill_paper1
[127] https://www.vestas.com
[128] Danish Shipping Fact and Figures 2018, Annual Report Danish Shipping 2019
[129] https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi
[130] https://shippinglab.dk
[131] https://www.dma.dk/Vaekst/MaritimErhvervspolitik/DetBlaaDanmark/Sider/default.aspx
[132] https://shippinglab.dk/about/

- Digital ship operations
- Autonomy
- Decarbonization

The partners of the project vary from all major companies in Denmark that may gain from this partnership, whether it be ship operators, service providers, or technology and software developers. They also have the support of Denmark's top universities in engineering, business, and maritime sciences.

> – Autonomy and digitalization will radically transform the maritime sector by improving vessel and fleet performance, increasing crew, cargo and vessel safety, supporting decarbonization, changing maintenance policies from periodic to predictive, and introducing new business models, to mention a few of the benefits. Associate Professor Roberto Galeazzi, DTU Automation and Control Group[133]

5.3.2 Blockchain

After Bitcoin came to prominence in the early 2010s, many began to recognize creative applications for its defining technology, blockchain. The administration of logistics has traditionally been very time consuming and demanded a lot of paper, with blockchain technology you can eliminate the need for any other components. You can apply blockchain as a ledger system, where every participant in the process gets the information they need to be as efficient as possible, while also being environmentally conscious. In 2018, Maersk and IBM began developing TradeLens, a blockchain system designed specifically for logistics and administrative work. Their current users[134]:

- Shippers and BCOs
- 3PLs and Freight Forwarders
- Intermodal Operators
- Authorities
- Ports and Terminals
- Ocean Carriers
- Financial Services
- Software Developers

There are more such systems, currently competing. As it is such a new technology, no one system has taken the dominant lead in the market. This is where we find market inconsistencies and inefficiency. In the future there needs to be a much higher grade of compatibility between such systems or one lead market operator. The capabilities of blockchain are only limited by imagination and is thought to cause disruption in most industries it may be applied in. As for the ledger aspect and the so called "smart contracts" can be used in any situation where a transaction takes place, securing information, or any type of contract. One example is DNV and Deloitte who have formed a partnership which has led to a live blockchain solution for storing certificates, which is to say, securing information. According to a report by DNV from 2019, Blockchain could boost the transparency of the aquaculture sector by providing a means to trace and record the entire fish supply chain. Data from the 'bait to plate' could be stored in a publicly available blockchain, which will help to appease public, industry and consumer concerns about sustainability and food safety. The report also suggests that blockchain may offer ways to generate new value creation and turn the industry toward more sustainable supply chain management.

Canada has vast experience and knowledge about the capabilities of blockchain, being a leading nation in both development and research of the technology. Considering the possibilities already discussed for the technology's applications within logistics, there are many opportunities for Canada's many start-ups or more established companies to approach Nordic companies dealing with either of the following: Shippers, freight forwarders, authorities, ports and terminals, ocean carriers or software developers.

[133] https://www.marinelink.com/news/partnering-digital-ship-inside-denmarks-481425
[134] https://www.tradelens.com/ecosystem

A world leader in digital maritime solutions, the Danes have developed revolutionary platforms that drive change on several areas. In 2019, Maersk launched their smart booking platform; **Maersk Spot[135],** a digital service that simplifies supply chains and provides customers with a cargo loading guarantee. One of MARLOG's (see below) interesting digitalization projects is the **Connected Ship[136]**, which has already been mentioned and will be again. In the last few decades, the idea of smart buildings and houses has been a hot topic. The idea of this ship is to develop a similar system. The goals are among other things to increase the performance and energy efficiency, improve the demand of maintenance based on big data and AI analysis. The cyber security on board is also prioritized, especially during transfer of data between land and vessel. This technology will reduce costs and increase the overall efficiency. A big part of the innovation is skilled workers with knowledge and qualifications.

5.4 Key governmental actors, clusters and research actors

5.4.1 Clusters

Maritime & Logistics Innovation Denmark (MARLOG)[137] is the national cluster organization for maritime logistics in Denmark and assist companies through the whole value chain. One of their main goals is to endorse the transformation from fossil-based to renewable energy – particularly in terms of transportation. Marlog works to promote Denmark as a sustainable and innovative leading maritime and logistics powerhouse. The cluster can be used as an information and contact hub.

Energy Cluster Denmark[138] is Denmark's cluster organization for the entire energy sector. Their vision is for Denmark to be a leading green nation in the development and demonstration of innovative and global energy solutions. Therefore, Energy Cluster Denmark is a neutral, value-creating and member-driven innovation platform for establishing and facilitating innovation collaborations between small and large companies, knowledge institutions and public players throughout the energy sector. A main focus ares as innovation across the entire energy sector, from energy production and energy infrastructure to energy storage and energy efficiency – with sector coupling, system integration and digitalization as common denominators.

Odense Robotics[139] - Denmark's national robot, automation and drone cluster brings together the entire ecosystem to drive innovation and growth in the industry nationwide. The cluster has regional hubs in Aalborg, Aarhus, Copenhagen, Odense and Sonderborg, with the cluster secretariat in Odense. The cluster is founded on partnerships with leading knowledge institutions: Aalborg University, Aarhus University, Kolding Design School, Danmark's Technical University, FORCE Technology, the University of Southern Denmark and the Danish Technological Institute. Denmark's robotics, automation and drone industry has grown significantly in recent years and is now home to global market leaders, high-growth start-ups, and world-leading research. There are more than 300 robotic, automation and drone companies across the country employing around 8,500 people.

Odense has become the European hot spot for robotics and automation. The ecosystem counts 130+ companies, 3900+ employees, 40+ higher education programs, and 10+ institutes working with knowledge and research. The robotic cluster, Odense Robotics, is among the best clusters in Europe – and has achieved the EU-certified **Gold Label for Cluster Management Excellence[140]**. New companies are joining the cluster every month. In the Odense Robotics Start-Up Hub entrepreneurs get access to a range of equipment, as well as access to business professionals to help develop their business plan, access to expert advisors to assist in developing a prototype and help to secure necessary funding.

[135] https://www.maersk.com/transportation-services/maersk-spot
[136] https://mdc.center/connected-ship
[137] https://www.marlog.dk/en/home
[138] https://www.energycluster.dk/en/
[139] https://www.odenserobotics.dk
[140] https://www.cluster-analysis.org/cluster-management-excellence

5.4.2 Key governmental actors

The Danish Maritime Authority[141] is party of the Ministry of Industry, Business and Financial affairs. The authority publishes a yearly strategic document concluded by the ministry.

5.4.3 Key research actors

RESEARCH ACTOR	DESCRIPTION AND RESEARCH AREA
Maritime and Polytechnic College (MARTEC)[142]	Established in 2001, this college specializes in marine engineering, Ship Mechanic and assistant training programs.
Copenhagen Business School (CBS)[143]	Shipping, logistics and supply chain management education at CBS. The School was established in 1917 and is one of the largest business schools in Europe with more than 19,000 students. The CBS Executive MBA in Shipping and Logistics (the Blue MBA) has a world-class reputation in the maritime industry and has been specifically designed for high-potential shipping executives.
Technical University of Denmark (DTU)[144]	Transport and logistics, Maritime engineering and offshore Wind energy education and research programs. DTU offers 26 different English-taught study programs.
Aalborg University[145]	Aalborg University is a young university with only 40 years of history. Since its establishment in 1974, AAU has been characterised by a problem-based and project-oriented teaching method (PBL) – also called the Aalborg Model, and by extensive collaboration with the surrounding society. Subjects include Wireless communication, Energy & power electronics, Intelligent transport systems, Cyber-Physical Systems, Big Data & AI, VR & Computer Vision.
Aarhus University[146]	Aarhus University is a top 100 university with award-winning research and 50+ Master's and Bachelor's programmes taught in English. Subjects also include Algorithms, Big Data, Machine Learning & AI, Cryptology, Participatory Design & HCI/HMI, Computer Vision.
University of Copenhagen[147]	The University of Copenhagen (UCPH) is a public research university in Copenhagen. Founded in 1479, the University of Copenhagen is the second-oldest university in Scandinavia, and ranks as one of the top universities in the Nordic countries and Europe. Subjects also include Photonics, Algorithms & Machine Learning, NLP, Energy & power electronics, Intelligent transport systems, and Cryptology.
IT University of Copenhagen[148]	The IT University, established in 1999, is a specialized university with a focus on IT. ITU is the university in Denmark that educates most IT specialists. The university collaborates closely with industry, the public sector and international researchers and is characterized by a strong entrepreneurial spirit among students as well as researchers.

[141] https://www.dma.dk/OmOs/Sider/default.aspx
[142] https://www.mitmartec.dk/en
[143] https://www.cbs.dk/en
[144] https://www.dtu.dk/english
[145] https://www.en.aau.dk
[146] https://international.au.dk
[147] https://www.ku.dk/english/
[148] https://en.itu.dk

Maersk Training[149]	Worldwide maritime training with their headquarters located in Svendborg and was established in 1978. Their main research areas are maritime, offshore wind, oil & gas as well as crane operations. Maersk Training is an independent business area within the Maersk group open for all companies.
Svendborg International Maritime Academy Training (SIMAC)[150]	Denmark's largest maritime education center with leading course providers in the maritime and maritime engineering sector.
Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping[151]	Zero Carbon Center is a not-for-profit, independent, research and development center driven by real action to steer the shipping sector on the course to zero carbon emissions. With partners from leading organizations across the world, they are mobilizing the best minds from science, engineering and business into one powerful alliance, committed to accelerating the development and implementation of new energy systems and technologies.

Other AI focused research centers include **Alexandra Institute for AI**[152], **SCIENCE AI Center**[153], **DABAI**[154] (Danish Center for Big Data Analytics Driven Innovation), **MADALGO**[155] (Center for Massive Data Algorithmics), and **DIGIT**[156] (Center for Digitalization, Big Data and Data Analytics.

5.5 Key market actors, market entry situation, events and opportunities

5.5.1 Market entry situation and opportunities

The Danish market is quite open to foreign investors and new partners. When it comes to technological advancements partnerships are highly valuable as they provide potential capital and/or new competence. There are no significant trade barriers, and the market may be more receptive to new capital now than ever before. There is a high level of education in Denmark as well as a general high interest in technology. This results in a large number of tech start-ups and early consumers[157].

According to interviews conducted, a trend amongst Danish shipowners has been an increased amount of outsourcing technical management, and to some extent commercial management, leaving owners to manage the manager more than what has been previously common (exemplified by Hafnia, DS Norden, Celsius, etc). This could create opportunities for Canadian actors. The use of blockchain in the blue economy creates opportunities for Canadian companies within this market. As it is a relatively new market with no major players the market entry barrier is low.

5.5.2 Key market actors

COMPANY	DESCRIPTION
Ørsted[158]	Ørsted provides a perfect example of a company transforming their energy production from fossil-fuel intensive to green energy – mainly in the field of offshore wind. In 2010, Ørsted was one of the most fossil-fuel intensive companies in Europe and was considered an expert in the coal industry. However, in 2020 the company was ranked as the most sustainable company in the world. With a global market share of 30%, Ørsted is the world leader in offshore wind, and they continue to bring renewable energy to new markets

[149] https://www.maersktraining.com
[150] https://simac.dk/en/
[151] https://zerocarbonshipping.com
[152] https://alexandra.dk/about-the-alexandra-institute/
[153] https://ai.ku.dk
[154] https://www.dabai.dk
[155] https://cs.au.dk/research/centers/madalgo/
[156] https://digit.au.dk
[157] https://www.trade.gov/knowledge-product/denmark-market-challenges
[158] https://orsted.com

	across countries. Their vision is to contribute to and help others go green as well. Today, 90% of their total energy generation is from renewable sources.
Vestas[159]	One of the biggest manufacturers of wind turbines. Vestas design, manufacture, install and service wind turbines across the globe. With over 132GW of wind turbines in 83 countries, they have installed more wind power than any other actors.
Maersk[160]	A.P. Møller-Mærsk A/S, just known as Maersk, is a Danish integrated shipping company, active in ocean and inland freight transportation and other services such as supply chain management and port operation. Maersk has been the largest container shipping line and vessel operator in the world since 1996. Maersk is also supplying services with modern vessels to support offshore wind operators. Maersk is a major driving force in the blue economy in Denmark.
J. Lauritzen A/S[161]	A worldwide shipping company based in Copenhagen with offices in the Philippines, Singapore, the USA and Dubai. J. Lauritzen operates a modern fleet of bulk carriers.
DFDS[162]	DFDS provides ferry and logistics services in Europe and Turkey, with over 8,000 employees located across 20 countries. Today, they operate a network of 25 shipping routes with 50 freight and passenger ships on the North sea, Baltic sea and the English channel. DFDS has eight terminals across Europe that offer vessel and cargo handling, warehousing facilities, storage and workshop services withing maritime industry.
Fayard A/S[163]	A family driven yard, FAYARD has throughout generations become a large, modern and efficient repair yard. The yard is involved with MARLOG's the Connected Ship.
Evergas[164]	Evergas is one of the world's leading seaborne transporters of petrochemical gases and natural gas liquids. Their wish is to set new standards for efficient and sustainable gas transport at sea. Evergas is also part of the Connected Ship.
Blue Water Shipping[165]	Blue Water Shipping is a global provider of logistics services in supply chain management, ranging from port service, oil&gas, marine and wind logistics.
TORM[166]	TORM is a major shipping company that owns and operates product tankers. The company was founded in 1889 and is listed on Nasdaq Copenhagen and New York.
DS Norden[167]	Founded in 1871, Norden provides dry cargo and product tankers services globally. They have 11 offices across the globe and work towards finding efficient and agile solutions for long-term benefits. Advanced analytics and digital solutions is a central part of how Norden does business.
Copenhagen Infrastructure Partners (CIP)[168]	Copenhagen Infrastructure Partners, founded in 2012, is an investment firm specializing in infrastructure investments, particularly wind power, primarily in Europe, North America, and East Asia, having invested billions of euros in Taiwan's offshore wind sector.

[159] https://www.vestas.com
[160] https://www.maersksupplyservice.com/industries/
[161] https://www.j-l.com
[162] https://www.dfds.com/en/freight-shipping
[163] https://www.fayard.dk/about-fayard/profile-of-fayard/
[164] https://evergas.net/who-we-are/
[165] https://www.bws.net/about/about-us
[166] http://www.torm.com
[167] https://norden.com
[168] https://cipartners.dk

PEAK Wind[169]	Bridging technical, commercial and financial disciplines, PEAK Wind offers wind industry clients services throughout the entire wind farm life cycle. They deliver operator services to ensure the highest return on investment at the lowest possible cost without compromising HSE or local rules and regulations.
K2 Management[170]	K2 Management is a leading engineering and management consultancy firm, delivering sustainable energy project solutions globally. They offer a wide range of services within engineering, planning, management and due diligence, spanning the entire value chain of an energy project.
EKF - Export Credit Agency Denmark[171]	Eksport Kredit Fonden (EKF) is the export credit agency of Denmark and was established in 1922 as only the third export credit agency in the world. EKF is owned and guaranteed by the Danish state.
Danish Ship Finance[172]	The objective of Danish Ship Finance, founded in 1961, is to provide ship financing in Denmark. In addition, the company provides ship financing in the international market, so long as such activities do not unnecessarily limit the company's Danish operations. Danish Ship Finance is a trusted partner for Danish and international shipping companies. DSF operates a loan book of approximately USD 6bn secured by first priority mortgages in 700 vessels. The ship finance operation is supported by an in-house expertise within shipping research, marine insurance, and marine surveillance.
Global Maritime Forum[173]	The Global Maritime Forum is an international not-for-profit organization dedicated to promoting the potential of the global maritime industry. To serve its mission, their Annual Summit convenes leaders from across the maritime community with policy-makers, experts, NGOs and other influential decision-makers and opinion shapers to discuss collective challenges and to work together on developing new solutions and recommendations for action. In 2019 this Annual Summit took place in Singapore, whereas in 2020 it was digital, like everything else.
Green Innovation Group AS[174]	Green Innovation Group noticed the need for cooperation between municipalities, ministries, foundations, agencies and large companies to find more sustainable alternatives for their organization. They help to accelerate the green transition by matching real needs in the private and public sector with green innovative solutions. The main goal of the initiative is "making green business good business". Their reports are public and some have relevance for the blue economy.
Rambøll[175]	Ramboll is a global engineering, architecture and consultancy company founded in Denmark in 1945. World leading in design of offshore wind turbine foundations, they have designed 60 percent of all installations worldwide.

5.5.3 Key market events

The **World Maritime Technology Conference** (WMTC) will be hosted in Denmark in April 2022[176]. More than 1,000 guests are expetced to come to Denmark when Copenhagen opens its doors to the world leading maritime technology conference WMTC, showcasing the latest innovations within maritime technology at the three-day conference. The conference was first held in 2003 and has since

[169] https://peak-wind.com
[170] https://www.k2management.com
[171] https://www.ekf.dk/en
[172] https://www.shipfinance.dk
[173] https://www.globalmaritimeforum.org
[174] https://www.greeninnovationgroup.com
[175] https://ramboll.com
[176] https://mdc.center/events/2021/4/27/world-maritime-technology-conference-wmtc-2021

then been conducted every third year, most recently in 2015 in Rhode Island, USA, and again in December 2018 in Shanghai, China, before it hits Denmark in 2022. In the setting of Tivoli Congress Center in Copenhagen, Danish and international guests will experience both the conference tracks as well as more than 150 academic posts along with activities for students and an exhibition with all the latest in maritime technology. The conference will be organized by MDC (Maritime Development Center, now MARLOG) in collaboration with the professional conference organizer MCI. The Danish Maritime Fair, founded in 2014, will be held in conjunction with the WMTC.

Press release February 17, 2021

A.P. Moller-Maersk will operate the world's first carbon neutral liner vessel by 2023 – seven years ahead of schedule

Fast-tracked by advances in technology and increasing customer demand for sustainable supply chains, Maersk accelerates the efforts to decarbonize marine operations with the launch of the world's first carbon neutral liner vessel in 2023 - seven years ahead of the initial 2030 ambition. All future Maersk owned new buildings will have dual fuel technology installed, enabling either carbon neutral operations or operation on standard very low sulphur fuel oil (VLSFO).

> – A.P. Moller-Maersk's ambition is to lead the way in decarbonising global logistics. Our customers expect us to help them decarbonise their global supply chains, and we are embracing the challenge, working on solving the practical, technical and safety challenges inherent in the carbon neutral fuels we need in the future. Our ambition to have a carbon neutral fleet by 2050 was a moonshot when we announced in 2018. Today we see it as a challenging, yet achievable target to reach, says Søren Skou, CEO, A.P. Moller-Maersk.

Around half of Maersk's 200 largest customers have set, or are in the process of setting, very ambitious science-based or zero carbon targets for their supply chains, the figure is on the rise. Maersk's methanol feeder vessel will have a capacity of around 2,000 TEU and be deployed in one of its intra-regional networks. While the vessel will be able to operate on standard VLSFO, the plan is to operate on carbon neutral e-methanol or sustainable bio-methanol from day one.

Both the methanol-fueled feeder vessel and the decision to install dual fuel engines on future newbuildings are part of Maersk's ongoing fleet replacement. CAPEX implications will be manageable and are included in current guidance.

A key collaboration partner is the Mærsk Mc-Kinney Møller **Center for Zero Carbon Shipping**[177], an independent, non-profit research and development center, that works across sectors, organizations, research areas and regulators to accelerate the development and implementation of new energy systems and technologies.

[177] https://zerocarbonshipping.com

PHOTO CREDIT: OCEANBIRD WALLENIUS MARINE

SWEDEN

CLEAN TECH

FUELS

6. Sweden

6.1 Blue Economy: Substantial coastline and potential

In a recent survey the Swedish national coastline has been measured to 48,000 km including islands[178]. The Swedish Government has taken a holistic approach to promoting the maritime industries and established a strategy in 2015 that will guide future work in this area[179].

> In 2015, there were 7,182 enterprises in Sweden in maritime industries. There were 34,079 persons in total gainfully employed in these industries, of which women accounted for one third. Value added amounted to SEK 28 bn, not including financial enterprises. [180]

The Swedish shipping industry has been very active in decarbonising shipping. Its industry association has formulated a target of zero-carbon shipping by 2050 and various Swedish shipping companies are pioneers in low-carbon shipping. The country now counts a number of innovative green vessels projects. Stena Line runs a ferry on methanol; Sirius Shipping has developed a ship-to-ship LNG bunkering vessel; numerous Swedish shipping companies - such as Terntank, Erik Thun and Rederi Gotland – have pioneered services with LNG-propelled vessels; and both HH Ferries and Green City Ferries have introduced electric ships.

> *Press Release March 4, 2021*
> *Rederi AB Gotland is planning for a new ferry line between Sweden and Germany*
> In order to reduce emissions from domestic traffic and at the same time bring Sweden closer to the continent, **Rederi AB Gotland**[181] is planning a new ferry line under the working name Hansalinjen. The new route will serve Rostock, Germany and Nynäshamn, Sweden, with stops also in the port of Visby, Gotland in the summer. Rederi AB Gotland has been awarded an environmental bonus by the government to move truck traffic from land to sea on the busy route from southern Sweden to Mälardalen. The ferry line will be at least as time-efficient as today's road traffic between Germany and the Mälardalen region. With this support, Rederi AB Gotland is helping to reduce the climatic footprint of the Swedish transport system. By transferring freight traffic from the road to the sea between Rostock and Nynäshamn, emissions are to be reduced by around 20 percent.

The west coast around Gothenburg is considered to be the maritime center in Sweden, with strong roots in traditional shipping and logistics and with Stena[182] and other shipowners at the island of Donsö in its midst. The east coast around Stockholm has a different profile. **Wallenius**[183], together with government owned **STA Road Ferries**[184] (Färjerederiet) and the association **Skärgårdsredarna**[185] who gathers owners of workboats and smaller vessels, dominate this area. Thanks to **Saab Kockums Shipyard**[186] and the former great shipyard era in Sweden, the southern part of Sweden is still home to internationally renowned expertise in maritime technology - but in the shape of small and medium sized companies, with different specialized areas. These products and services are nearly exclusively export commodities.

---

[178] https://www.mynewsdesk.com/se/sjofartsverket/pressreleases/kusten-aer-klar-sveriges-strandlinje-aer-kartlagd-2346986
[179] https://www.government.se/information-material/2015/12/a-swedish-maritime-strategy/
[180] https://www.scb.se/en/finding-statistics/statistics-by-subject-area/business-activities/structure-of-the-business-sector/maritime-industries/pong/statistical-news/maritime-industries/?fbclid=IwAR2IIsm4TwWngA4EYMHXxjIoC2m0E9YoesUQM2X2sfoc1oVkZd6C-jUPxDg
[181] https://gotlandsbolaget.se/en/
[182] https://www.stena.com
[183] https://www.walleniuslines.com
[184] https://www.trafikverket.se/farjerederiet/Information-in-english/about-the-sta-road-ferries2/
[185] http://www.skargardsredarna.se/start
[186] https://www.saab.com/markets/netherlands/dutch-submarines/about-saabs-shipbuilding-capabilities

While having a history of civil vessel construction, Kockums' most renowned activity is the fabrication of military corvettes and submarines.

6.2 Main drivers, trends and future developments

The main drivers in Sweden at this point are those of sustainable fuel development and various types of energy carriers and their associated powertrain solutions, as well as autonomy. Swedish shipowners are in the forefront of LNG and methanol solutions and the ferries between **Helsingborg and Helsingör**[187] were until recently the world's largest electric powered ferries. Although no technology is favored, there is currently buzz surrounding the potential of hydrogen. There is also a focus on the ports and their future role in the energy systems. Energy efficiency is key and drives the digital development and the wireless communication solutions onboard.

The governmental interest in "roads at sea" is increasing with the recognition of shipping as an cost-efficient alternative to reduce road traffic and move goods from land to sea . Other blue areas under way in Sweden are land-based aquaculture and biomass from the sea, developing new types of foods from the sea, blue biotech and not least harvesting offshore energy from sea, wind, and sun. One such company is Simris[188], located on south-east coast of Sweden. It is important to note that **RISE (Research Institutes of Sweden AB)** has recently decided to invest SEK 12m towards a maritime center in order to better grasp the development of the blue sector. Both the investment and the result of the investment could represent good opportunities for Canadian players.

With regards to autonomy, **Lindholmen Science Park**[189] in Gothenburg is both a dynamic area and an arena for collaboration across geographical borders. It is home to several of Sweden's leading development projects, with a focus on mobility for tomorrow. One of them is MobilityXlab[190], a collaboration hub founded in 2017 by six global companies to create and develop new innovations within future mobility – with each other and with start-ups. The founders were CEVT, Ericsson, Veoneer, Volvo Cars, Volvo Group & Zenseact. MobilityXlab offers companies with pioneering ideas within mobility and connectivity the opportunity to accelerate with the six founding companies. It offers young companies with innovative ideas the opportunity to collaborate strategically on the development of joint projects and future mobility solutions.

> Lindholmen Science Park has developed from shipyard to a modern and inspiring innovation environment for several of Sweden's leading development projects. In the 1980s, Gothenburg experienced one of its deepest crises ever. The crisis in the shipbuilding industry resulted in almost 20,000 redundancies and the Lindholmen shipyards stood empty. Working together, and with a shared vision, the City of Gothenburg, Region Västra Götaland, academia from Chalmers and the University of Gothenburg, as well as the international business community, invested in and purposefully developed this exciting innovation environment. This resulted in the creation of the Lindholmen Science Park concept, which has evolved from a local initiative into a national resource, an epicenter for development, innovation, and collaboration.

6.2.1 Clean Tech

Sweden has a strong land and sea-based industry in clean tech development. Together with strong technology development traditions, this has spurred energy efficiency solutions grounded in a strong environmental awareness and a prestigious ambition from the shipowners to be early movers in this field.

I-Tech AB[191] is a biotechnology company that has developed the product **Selektope**, an active antifouling agent that prevents barnacle attachment on submerged surfaces such as ships and boat hulls,

[187] https://en.wikipedia.org/wiki/Helsingør–Helsingborg_ferry_route
[188] https://eu.simris.com/en
[189] https://www.lindholmen.se/en
[190] https://www.mobilityxlab.com/en/about-us-5
[191] https://i-tech.se

but also other marine installations. The company estimates that the total antifouling coatings market is valued somewhere around USD 3bn.

PowerCell Sweden AB[192] develops and produces fuel cell stacks and systems for stationary and mobile applications with a world class power density. The fuel cells are powered by hydrogen, pure or reformed, and produce electricity and heat with no emissions other than water.

> In 2017, the Digital Economy and Society Index (DESI)[193] ranked Sweden as the EU's third most advanced digital economy, after Denmark and Finland.

There is also cooperation between large companies, contributing to both change and sustainability within the blue economy in Sweden. For example, Wallenius recently announced their investment in hull cleaning through a joint venture with **Saab**[194]. The company called **C-leanship**[195] was founded by Saab and is a provider of hull cleanings and inspections. The idea behind the company is to use robots in order to clean vessels in terminals during port calls.

In 2020, **Wallenius Marine**[196] launched **Oceanbird**[197], a new concept that makes it possible to harness the wind to power the largest ocean-going vessels, the ones transporting heavy cargo over long distances for long periods of time. It is being developed in close collaboration between Wallenius Marine, KTH Royal Institute of Technology and SSPA.

Some facts about the concept: 7,000 cars can be carried in the cargo hold, fueled by 5 rigs with 80 meters tall wing sails for forward propulsion, with 90% lower emissions than a vessel with a diesel engine, and a sailing time of 12 days to cross the Atlantic with the wind as energy source. The 200 meter long and 40 meters wide cargo vessel will be able to cross the Atlantic in 12 days. The wing sails are all of 80 meters tall, giving the ship a height above water line of appr. 105 meters, but thanks to a telescopic construction they can be lowered, resulting in a vessel height above water line of appr. 45 meters.

[192] https://powercell.se/en/start
[193] https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi
[194] https://www.saab.com
[195] https://c-leanship.com
[196] https://www.walleniusmarine.com
[197] https://www.oceanbirdwallenius.com

Sweden has set a target for a 100% renewable electricity system by 2040. It is expected that wind energy will be a major contributor to meet the shift. The Swedish Energy Agency[198] expects up to a total of 100 TWh of wind power capacity by 2040 of which 20-30 TWh will be offshore wind. Despite a low potential for ocean energy off the Swedish coast, there is a strong Ocean Energy industry and innovation cluster network in Sweden[199].

6.2.2 Fuels

Stena Germanica[200] was the world's first methanol powered commercial vessel in the larger engine segment and its development has created a niche competence for Swedish powertrain developers. This was followed by the world's first methanol conversion in the smaller engine segment when a pilot boat, **GreenPilot**[201], was converted to run on bio-methanol in 2017. This points to Swedish shipowners being open to trying new forms of fuels, which could bring new opportunities for Canadian companies.

Another sustainability project by Stena is the **Stena Elektra**[202], is a car ferry intended to operate on the route between Göteborg and Fredrikshavn, solely powered by electricity. As of today, the concept is not yet profitable, but with the rapid increase of capacity and descending prices of batteries, it is only a matter of time, according to the company. The vessel is still on a concept stage, and there are several challenges to overcome before it can be realized, like how to recharge the batteries with 50 MWh of electricity during the 90 minutes in port.

Lean Marine Sweden AB[203] offers innovative solutions for fuel saving and increased operational efficiency for the marine industry through its automated and direct fuel-saving system FuelOpt and performance management and reporting software, Fleet Analytics.

In addition, there are at least two large renewable methanol projects under development in Sweden, in Stenungssund[204] and in Östersund. Both will be using captured CO2 and green hydrogen in their processes to produce sustainable methanol.

6.3 Key clusters, forums, research and funding

In 2019, the **Swedish Shipowners' Association**[205] published a research strategy for the period 2019-2023. The strategy maps out the future focus areas for research and innovation, with focus areas being:

- Vessels and technology
- Fuel and energy
- Digitalization and automation
- Behavior and logistics
- Knowledge and competence

ORGANIZATION	DESCRIPTION
Swedish Maritime Technology Forum (SMTF)[206]	Swedish Maritime Technology Forum (SMTF) is a non-profit member and cluster organization supporting the maritime technology industry in Sweden. SMTF was established in 2007, its mission is to strengthen the Swedish subcontractors to shipping and boost the green development of the maritime industry. SMTF gathers approx. 400 small and medium

[198] http://www.energimyndigheten.se/en/
[199] https://oceanenergy-sweden.se
[200] https://en.wikipedia.org/wiki/MS_Stena_Germanica_(2000)
[201] https://www.sspa.se/how/research/greenpilot
[202] https://www.stenateknik.com/projects/
[203] https://leanmarine.com
[204] https://www.icis.com/explore/resources/news/2020/11/24/10578851/sweden-s-perstorp-to-produce-biomethanol-at-stenungsund-includes-ccu-unit
[205] https://www.sweship.se/in-english/
[206] https://smtf.se/en/

	sized companies with solutions for the maritime sector, thus representing the full spectrum of suppliers and service providers to the shipping, offshore, and leisure boat industry.
Lighthouse - Swedish Maritime Competence Center[207]	Lighthouse gathers leading maritime stakeholders through a Triple-Helix[208] collaboration between industry, society, academia and institutes for research, development, and innovation within the maritime sector. They also have a trainee program with different companies.
Maritime Forum[209]	The Maritime Forum was established in 1996 and is a political lobby and awareness organization based in Stockholm. The association gathers companies, organizations and authorities such as shipping lines, port companies, shipbrokers, universities, schools, unions, banks and finance institutes, technical suppliers and consultants, shippers, shipping organizations, authorities and other companies related to the shipping industry. Please note that their website is in Swedish only.
The Research Institutes of Sweden (RISE)[210]	The Research Institutes of Sweden is a state-owned research institute. RISE has expertise within shipping, renewable ocean energy, aquatic food, marine biotechnology and project management in blue growth and marine operations. The research proposition of the Swedish government states that the overall objective for the RISE group research institutes is to be internationally competitive and work for sustainable growth in Sweden by strengthening industry competitiveness and renewal.
World Maritime University[211]	The World Maritime University (WMU) in Malmö was founded in 1983 by the International Maritime Organization (IMO), a specialized agency of the United Nations, as its premier center of excellence for maritime postgraduate education, research, and capacity building. The University offers unique postgraduate educational programmes, undertakes wide-ranging research in maritime and ocean-related studies, and continues maritime capacity building in line with the UN Sustainable Development Goals. The University plays a significant role in maritime and ocean education, research, capacity-building and economic development while promoting the roles of women in the maritime and ocean sectors.
Kristineberg Center for Marine Research and Innovation[212]	Kristineberg Center is an open partnership founded to accelerate the transition to a sustainable blue economy. The mission is to advance the implementation of research and knowledge. Kristineberg Center offers a marine research and innovation environment including infrastructure and services for researchers, companies, entrepreneurs, and the public sector. We also initiate national and international research projects and participate in strategic initiatives for a sustainable blue economy. The center is physically located at the historic marine research station Kristineberg, west of Fiskebäckskil in Sweden.

[207] https://www.lighthouse.nu/en
[208] https://en.wikipedia.org/wiki/Triple_helix_model_of_innovation
[209] https://maritimtforum.se
[210] https://www.ri.se/en/what-we-do/our-areas/maritime
[211] https://www.wmu.se
[212] https://kristinebergcenter.com/in-english/

Almi Invest[213]	Almi Invest is a venture capital company investing all over Sweden through eight regional venture capital companies, as well as one national GreenTech venture capital company.
The Swedish Agency for Economic and Regional Growth[214]	The Swedish Agency for Economic and Regional Growth is a government agency that works to promote sustainable growth and competitive companies in Sweden. They also monitor that EU funds are invested in projects that promote regional growth and employment.
Vinnova[215]	Vinnova is Sweden's innovation agency, focusing on ten areas that are important for Sweden's opportunities to change to a sustainable society. It is a government agency under the Ministry of Enterprise and Innovation, the national contact authority for the EU framework programme for research and innovation, and also the Swedish Government's expert authority in innovation policy.
Industrifonden[216]	Industrifonden is an early stage venture capital fund. Based in Sweden, they have a reach across the Nordics and look for transformative ventures that define the industries of tomorrow. Key areas of expertise are in Life Sciences, Deep Tech and Transformative Tech.
The Maritime Cluster of West Sweden[217]	The Maritime Cluster of West Sweden is a network for collaboration on innovation and knowledge-based blue growth in the West part of Sweden, aiming to create the best conditions for West Sweden to contribute to a sustainable future for people, the ocean and its resources. The cluster works with marine and maritime issues.
Swedish Mariculture Research Center (SWEMARC)[218]	The Swedish Mariculture Research Center is one of six interdisciplinary research centers at the **University of Gothenburg**[219] with a goal to increase the sustainability of farming food from the ocean through interdisciplinary and socially engaging research.
Ocean Energy Sweden[220]	Ocean Energy Sweden is a business and innovation network consisting of Swedish companies developing products and systems in the area of ocean energy. The network will grow to include suppliers, universities, research institutions, test centers and others.
Offshore West[221]	Offshore West is Sweden's largest innovation platform and cluster focusing on technology and developments in the offshore sector.
Umeå Marine Sciences Center[222]	Umeå Marine Sciences Center is a unit at **Umeå University**[223], supporting marine research and education, and performing environmental monitoring as a part of the Swedish environmental monitoring. The center also provides information to society about research and environmental status, with focus on the Gulf of Bothnia.

213 https://www.almi.se/en/almi-invest/about-almi-invest/
214 https://tillvaxtverket.se/english.html
215 https://www.vinnova.se/en
216 https://industrifonden.com
217 https://www.maritimaklustret.se/en/
218 https://www.gu.se/en/swemarc-marine-aqauculture
219 https://www.gu.se/en
220 https://oceanenergy-sweden.se
221 https://offshorevast.se/en/home/
222 https://www.umu.se/en/umea-marine-sciences-centre/
223 https://www.umu.se/en/

Stockholm University Baltic Sea Center[224]	The **Stockholm University**[225] Baltic Sea Center consists of a unique combination of experts and communicators who collaborate with a wide network of marine scientists to improve knowledge about the Baltic Sea and help society handle its marine environmental problems. The center is a link between science and management, synthesizing and distributing scientific results to the relevant audience in society.

6.3.1 Governmental actors

Behind the maritime strategy announced by the Swedish government in 2015 were four ministries that are now part of the following three: the **Ministry of Infrastructure**, the **Ministry of Enterprise and Innovation**, and the **Ministry of Environment**. Under each ministry there are a number of government agencies that are involved in this sector, including the Swedish Maritime Administration, the Swedish Agency for Marine and Water Management, the Swedish Environmental Protection Agency, and the Swedish Energy Agency. The Regions in Sweden, of which there are 21, also take an active role in this sector. As much as 95 percent of the Swedish foreign trade is carried out by sea. The Swedish Transport Agency formulates rules and recommendations and exercises supervision.

6.4 Market entry situation, relevant market actors and events

6.4.1 Market entry situation

As with the other Nordic countries, Sweden as a market is relatively open and therefore a highly competitive market. This means that Canadian companies face strong competition from Swedish and third-country suppliers – particularly other EU members. As a result, Canadian exporters should offer advanced technologies as well as competitive prices and terms in order to succeed.

6.4.2 Relevant industry events

Another key gathering event is Sweden's biggest shipping event; **Donsö Shipping Meet**[226]**,** outside of Gothenburg. This takes place in September every two years. This meeting place can likely be highly attractive for Canadian actors, as it arranges speed meetings between subcontractors and shipowners.

6.4.3 Relevant market actors:

KEY MARKET ACTORS	DESCRIPTION
Saab[227]	As one of the largest companies in Sweden, Saab delivers several different systems and solutions to the shipping industry. Examples are their maritime traffic management solutions, their maritime service suite, their surface radar and their underwater systems.
Wallenius Lines [228]	Wallenius Lines, with head office in Stockholm, has more than 80 years of experience as investor and active owner in the global shipping industry. In the 1960s, Wallenius Lines developed the RoRo concept, at first in the North Atlantic trade and later from Asia. Wallenius Lines was the first independent shipping line to work with the Japanese car industry. Today, Wallenius Lines owns some of the world's largest RoRo networks. Wallenius Lines owns 37.8% of the worlds' largest RoRo shipping company, Wallenius Wilhelmsen ASA, listed on the Oslo Stock Exchange. Wallenius Lines also owns 50% of the short sea shipping company United European Car Carrier, UECC. It is a joint ownership, together with one of the largest shipping lines in the world, Japanese NYK. The formation of **Wallenius SOL** (see below) is the third part of a

[224] https://www.su.se/ostersjocentrum/english/
[225] https://www.su.se/english/
[226] https://donsoshippingmeet.com
[227] https://www.saab.com/products/naval
[228] https://www.walleniusmarine.com

	portfolio of industrial shipping. **Wallenius Marine** design ships powered by wind. Wallenius Lines do steel cutting for UECC's second LNG Battery Hybrid Powered PCTC European Car Carriers.
Stena AB Group[229]	Stena AB Group is one of the largest family-owned companies in Sweden, dating back to 1939 and based in Gothenburg. The Stena Sphere consists of the three parent companies, Stena AB, Stena Sessan AB and Stena Metall AB, wholly owned by the Olsson family. Stena's maritime activities offer everything from tanker and ferry operations to vessel charter and offshore drilling: **Stena Line** is one of the world's largest ferry operators. The Gothenburg based company has three business areas: Scandinavia, North Sea, and Irish Sea. The route network consists of 18 strategically located ferry routes around Scandinavia and the UK. **Stena Drilling Ltd** is a maritime drilling contractor based in Aberdeen. **Stena RoRo AB** builds, purchases, sells, and charters RoRo vessels. Many of Stena Line's vessels are owned by Stena RoRo. **Stena Bulk AB** operates a fleet of tankers worldwide.
Svenska Orient Linien (SOL)[230]	The Svenska Levant Linjen (SOL) was formed in 1911. In 1927, the shipping line changed names to Svenska Orient Linien, SOL, head-quartered in Gothenburg. SOL offers service routes to and from Scandinavia, the Continent, the UK, the Baltic States, as well as Northern Africa and Eastern Mediterranean. The fleet consists of flexible tonnage, suited for all types of cargo, on a regular basis through our conventional vessels.
Wallenius SOL[231]	In 2019, Wallenius Lines and Swedish Orient Linien (SOL) formed the joint shipping company Wallenius SOL. The fleet consists of five RoRo vessels for the traffic to and from the Gulf of Bothnia. These vessels are filled with paper products (fine paper and cardboard) on their way south, and back north with other cargo. The paper products are loaded on cassettes, as well as SECU and containers. Wallenius SOL has ordered up to four RoRo vessels run by LNG power, to be built by Wallenius Marine. With these vessels, combined with existing fleet, they can offer transport with higher efficiency, while reducing the environmental footprint.

News on Splash 247.com on March 9, 2021

Stena Bulk unveils hybrid zero-emissions concept design

Stena Bulk[232], a Swedish shipowner with a history of launching groundbreaking new ships, has given the world a futuristic, eye-catching, hybrid bulk carrier design: **InfinityMAX**. The zero emissions ship can carry both dry and wet cargoes in modular compartments, something Stena claimed could have as big an impact on shipping as the advert of containerization in the 1950s.

The creation of standardized and modular cargo units that can carry dry bulk, liquid bulk or liquified gas products – such as methane, hydrogen or ammonia – will significantly streamline the process of transporting wet and dry bulk cargoes. The InfinityMAX design, Stena Bulk maintains,

[229] https://www.stena.com
[230] https://www.sollines.se/en
[231] https://wallenius-sol.com/en
[232] https://www.stenabulk.com

drives improved world fleet utilization and the potential for more standardized supply chains, as well as reducing the unnecessary environmental impact of empty tanks being shipped around the world in search of new cargo.

Each of the InfinityMAX's modular cargo units are designed to be totally self-sufficient in terms of their energy use, with wind turbines and solar panels generating all the electricity needed for internal systems. The modular units have also been designed to be able to be dropped off outside of ports and picked up by tugs, avoiding congestion and reducing call times dramatically. The InfinityMAX concept will use hydrogen as a marine fuel and wind turbines to generate further energy. Collapsible wing sails and a shark skin hull have also been incorporated in the concept design to significantly improve efficiency.

Although the vessels will be crewed for safety and flexibility reasons, Stena Bulk has designed the InfinityMAX concept to be semi-autonomous.

Stena Bulk has a long history of bringing new-look ships to the industry, latterly led via its various MAX designs. Across the various divisions at Stena many other transformations are underway including plans to become the world's first decarbonization exploration driller as well as the Stena Elektra[233], a futuristic looking hybrid ferry.

[233] https://www.stena.com/business/stena-teknik/


PHOTO CREDIT: ARCTECH HELSINKI SHIPYARD

FINLAND

MARITIME LOGISTICS/TRANSPORT (INNOVATION)

MARINE ENGINEERING TECHNOLOGIES

7. Finland

In Finland, the Blue Economy includes some 1,100 companies, employs around 30,000 people, with an annual turnover of some EUR 9bn, exporting more than 90%, according to 2019 figures.

7.1 Main drivers and trends

Located at the innermost northern part of the Baltic Sea, Finland has a substantial shoreline along its south-western and southern regions, with most of the maritime activity concentrated in the south-western part. Finland is, as well as the other Nordic countries, focused on efficiency through better and more sustainable technological solutions. Finland is one of the leading developers of autonomous ships, and there is good cooperation throughout the value chain. Finland is essentially an island, as goods cannot easily be transported through Russia. About 90% of Finnish import and export is transported by sea. In addition, Finland is the only country in the world where all ports freeze in the winter. This leads to extensive knowledge in ice breaking, subsequently about two thirds of the world's icebreakers have been designed and/or built in part or fully in Finland.

Finland initiated one of the world's first national AI (Artificial Intellignece) strategies and action plans in 2017 to boost research and education in the field of AI. The public sector is already integrating AI into its operations to increase efficiency and improve services. For instance, the Ministry of Finance initiated the **AuroraAI program**[234] that helps citizens and companies by suggesting services based on their needs. By successfully applying AI, Finland has the potential to double its economic growth rate by 2035 (Accenture and Frontier Economics 2017)[235].

Finland offers top-level AI education in universities and raises the awareness of its citizens through public online courses, such as Elements of AI. The Finns form a tech-savvy society that is not afraid of new technologies and innovations, which makes the country an excellent place for developing and applying novel AI technologies.

Finland has a long tradition in AI research, which has led to cutting-edge expertise. Large Finnish companies have built their own AI development units, but the driving force is the hundreds of innovative start-ups with their roots in universities and research. These innovators are successfully applying AI in various business verticals, most commonly in healthcare, manufacturing, business tools and services.

The **Finnish Center for Artificial Intelligence (FCAI)**[236] and regional initiatives, such as the **AI Hub Tampere**[237]**, Turku Region AI Hub**[238] and the **AI Academy at the University of Turku**[239], drive AI commercialization by effectively transferring knowledge and findings to start-ups and established businesses. **Technology Industries of Finland**[240] (Teknologiateollisuus) has its own AI accelerator, FAIA, to speed up the deployment of AI. Finland's wide offering of data pools is available for businesses to speed up AI development and adoption.

Business Finland[241], the government organization for innovation funding, investment, trade and travel promotion, funds growth companies within the area of AI. Since 2017, over 300 AI companies have received about EUR 200m in funding in total.

[234] https://vm.fi/en/auroraai-en
[235] https://newsroom.accenture.com/news/accenture-report-artificial-intelligence-has-potential-to-increase-corporate-profitability-in-16-industries-by-an-average-of-38-percent-by-2035.htm
[236] https://fcai.fi
[237] https://research.tuni.fi/aihubtampere/
[238] https://turkubusinessregion.com/en/ai/
[239] https://sites.utu.fi/tekoalyakatemia/en/en-frontpage/
[240] https://teknologiateollisuus.fi/en
[241] https://www.businessfinland.fi/en/do-business-with-finland/home

AI growth ecosystems are supported by an enterprise-driven partnership model between companies, research organizations and public actors, which strives to find solutions to global market disruptions and create new growth sectors in Finland.

From an all-encompassing AI business ecosystem to autonomous shipping and port operations, **Silo.ai** in Helsinki and **Awake.ai** in Helsinki and Turku lead the way in Finnish artificial intelligence.

> **Silo.AI**[242] is the largest AI solution lab in the Nordics focused on building human-centric AI as a service. In its Growth Engine project, Silo.AI aims to build an ecosystem around its platform to bring together AI experts and technology partners. The main goals of the ecosystem are to generate new business for operators through AI-driven solutions and processes and to commerialize Finnish top expertise, particularly in global markets. The ecosystem involves the following groups: major companies that have challenges in obtaining sufficient resources for AI activities, SMEs that lack the resources to invest in their own AI development, experts in artificial intelligence and technology partners that often struggle with international sales, and research organizations for whom the AI marketplace offers ideas for projects and corporate collaboration.
>
> **Awake.ai**[243]: Shipping and port logistics play a critical role in international trade. More than 90% of Finnish exports pass through ports. Development is trending toward smarter ports and vessels and even autonomous ships. The goal of Awake.AI is to be the world's most trusted smart ports and autonomous shipping platform and a global ecosystem orchestrator by 2025. Awake.AI is a collaborative and open data platform company that facilitates ecosystem creation for smart ports and evolving autonomous shipping. The underlying objective of the Awake.AI platform is to increase operational efficiencies and create new digital services for all actors in the port ecosystem. Actors range from port service providers to infrastructure utilization to shipping customers and cargo owners. Toward this end, Awake.AI is developing predictive analytics and models for key processes in harbor operations. To facilitate the involvement of new digital service providers for smart ports, the Awake.AI platform is a multi-sided network for many participants to develop smart port cargo flows and a future marketplace for buying and selling and smart port- and ship-related services.

7.1.1 Maritime logistics/transport (innovation)

Finland is traditionally known for shipbuilding and ship design. This particularly applies to icebreakers where they are considered to be the world leaders. There are four major shipyards: **Helsinki Shipyard**[244] (formerly known as Arctech Helsinki Shipyard), **Meyer Turku**[245], **Rauma Marine Constructions**[246], and **Turku Repair Yard**[247]. These shipyards are mainly what one would call speciality yards. This is largely explained by the high cost of labour, which prohibits the building of non-specialized ships. In the last few decades, they have mainly produced cruise ships, passenger and car ferries, platform supply vessels, roll-on/roll-offs (Ro-Ro), icebreakers, and oceanographic survey vessels. Icebreakers have been dominating in terms of ships built, and cruise ships in terms of the largest total gross tonnage. Business Finland has a goal of operating the world's first autonomous maritime ecosystem by 2025[248]. This will require extensive development of better systems, as well as designing and construction of port infrastructure that can accommodate this technology. Such development and goals will require additional technology, creating opportunities for Canadian companies.

[242] https://silo.ai
[243] https://www.awake.ai
[244] https://helsinkishipyard.fi/en/
[245] https://www.meyerturku.fi/en/meyerturku_com/index.jsp
[246] https://rmcfinland.fi
[247] https://blrtyards.com/en/
[248] https://www.businessfinland.fi/492f5c/globalassets/finnish-customers/02-build-your-network/arctic/maritime-and-offshore-from-finland/towards-maritime-autonomous-future2.pdf

As of 2020 there were ten shipyards in Finland. Most of Finnish shipyards focus on new buildings, while some focus on repair work. Blue economy is set to become bigger in Finland, with ever-increasing fleets in every sector, more environmentally friendly fuel alternatives, and an ongoing technological overhauling to smarter systems. This is of course going to have a direct impact on Finland's shipbuilding industry, as well as their dedication to new technologies and autonomous solutions.

The world's first autonomous and remotely controlled car ferry, Falco, operated by Finferries, journeyed from Turku to an archipelago island in Finland in December 2018[249]. Rolls-Royce Commercial Marine developed the technology to allow the ferry to show the way for the future of autonomous vessels. This smart technology increases safety and makes the shipping business more economically viable. Digital connections allow the ship to be steered from a land-based control room, while a captain can take over under demanding circumstances. Earlier in 2018 Rolls-Royce and Finferries began collaborating on a research project called **SVAN**[250] (Safer Vessel with Autonomous Navigation), to continue implementing the findings from the earlier **AAWA**[251] (Advanced Autonomous Waterborne Applications) research project, funded by Business Finland (then Tekes). AAWA included researchers from some of Finland's leading universities: **Tampere University of Technology**[252]; **VTT Technical Research Center of Finland Ltd**[253]; **Åbo Akademi University**[254]; **Aalto University**[255]; and the **University of Turku**[256]; as well as industry representatives from **Rolls-Royce Commercial Marine**[257], Brighthouse NAPA, **Deltamarin**[258], **DNV**[259] (Norway) and **Inmarsat**[260] (UK). In 2019 Rolls-Royce Commercial Marine was aqcuired by **Kongsberg Maritime**[261], Norway.

Shipyard supplier matchmaker **YardMate**[262] is a consortium of over 100 companies supporting industry needs. The consortium brings products, services, tools and resources to shipyards, cruise lines, aviation companies and other fields of industry. YardMate finds and validates the right subcontractors and human resources for the projects in question, opening doors to create business opportunities for all its members to get more assignments in the industry. Canadian companies are welcome to apply for membership.

7.1.2 Marine Engineering Technologies

Finland is known for its strong technology development expertise. Its small size, agility and foundation of mutual trust is reflected in the strong collaboration between the public and private sector. Finnish equipment manufacturers manufacture high quality products such as environmentally friendly LNG fuelled engines aimed at conserving the environment and the most advanced propulsion system for energy efficiency. Other Finnish innovations include the Hi-Fog fire protection system[263], which extinguishes onboard fires. Finland has numerous specialized suppliers of maritime equipment and solutions for the international maritime industry. Business Finland has launched a service called **Finnish Suppliers**[264] which introduces world-class Finnish companies and their solutions. You can browse information according to various business segments, tag words and countries. The information is

[249] https://www.rolls-royce.com/media/press-releases/2018/03-12-2018-rr-and-finferries-demonstrate-worlds-first-fully-autonomous-ferry.aspx
[250] https://breakingwaves.fi/wp-content/uploads/2019/06/SVAN-presentation.pdf
[251] https://www.freightwaves.com/news/aawa-lays-out-vision-for-autonomous-shipping
[252] https://en.wikipedia.org/wiki/Tampere_University_of_Technology
[253] https://en.wikipedia.org/wiki/VTT_Technical_Research_Centre_of_Finland
[254] https://en.wikipedia.org/wiki/Åbo_Akademi_University
[255] https://en.wikipedia.org/wiki/Aalto_University
[256] https://en.wikipedia.org/wiki/University_of_Turku
[257] https://www.kongsberg.com/maritime/about-us/who-we-are-kongsberg-maritime/rolls-royce-commercial-marine-information/
[258] https://deltamarin.com
[259] https://www.dnv.com
[260] https://www.inmarsat.com/en/index.html
[261] https://www.kongsberg.com/maritime/
[262] https://www.yardmate.fi/en/yardmate/
[263] https://www.marioff.com/water-mist/fire-suppression-with-hi-fogr-how-does-it-work
[264] https://www.businessfinland.fi/en/do-business-with-finland/finnish-suppliers#stored

provided by Business Finland customers and reviewed by the team at Business Finland before publishing.

Finland has a long history of delivering smart and environmentally friendly high-tech maritime solutions and and is known as a global forerunner in developing digital solutions with world-leading capabilities in artificial intelligence, sensoring and wireless technology. In 2017, the Digital Economy and Society Index (DESI)[265] ranked Finland as the EU's second most advanced digital economy, after Denmark and followed by Sweden.

> High-performing EU countries were Denmark, Sweden, Finland, the Netherlands, Luxembourg, Ireland, the UK, Belgium and Estonia. Norway and Iceland are not members of the EU.

Rapidly developing digital technologies are connecting people and machines to minimize human error and provide new revenue and value-adding opportunities. Digitalization leads to more efficient operations, user friendliness and effective, streamlined services. Now the maritime industry stands to benefit from the already proven digital success stories in other land-based industries. Finnish companies have also gained a global reputation for creating smart and green innovations. Advanced energy management and fleet performance systems reduce emissions and increase fuel savings.

According to Business Finland, Finland has brought SMS[266], 5G, and the Linux[267] operating system to the world. There are even Finnish sensors on Mars. Finland's education system is fine-tuned to spark geek brainpower throughout the country, with the best availability of scientists and engineers globally and a highly competent and productive workforce. Some of the key protocols behind today's strongest encryption systems were invented in Finland in the early 1990s. For example, the SSH protocol[268] is one of the world's most widely-used encryption protocols. Finland has most digital start-ups per capita in the world. This has taken its innovation environment to a whole new level while providing a continuous source of new growth. No surprise that every year the start-up world braves the Finnish winter to storm Slush, the second-largest start-up event in the world.

Finland's strong tech expertise, high education level and vibrant start-up scene contribute to an attitude of innovation, putting us at the forefront of digitalization, communication technologies and smart & clean technologies. The Finnish cybersecurity scene is outlined by the National Cybersecurity Strategy.

Many of the marine major suppliers are Finnish or have large maritime production activities in Finland, employing approximately just as many people as the shipyards.

Some of the most luxurious public spaces on board cruise ships are made in Finland. Finnish companies have the know-how to build complex areas in cruise ships. Finnish turn-key companies are able to deliver complete modules for vessels, such as fully equipped kitchens, stairways, restaurants and cabins.

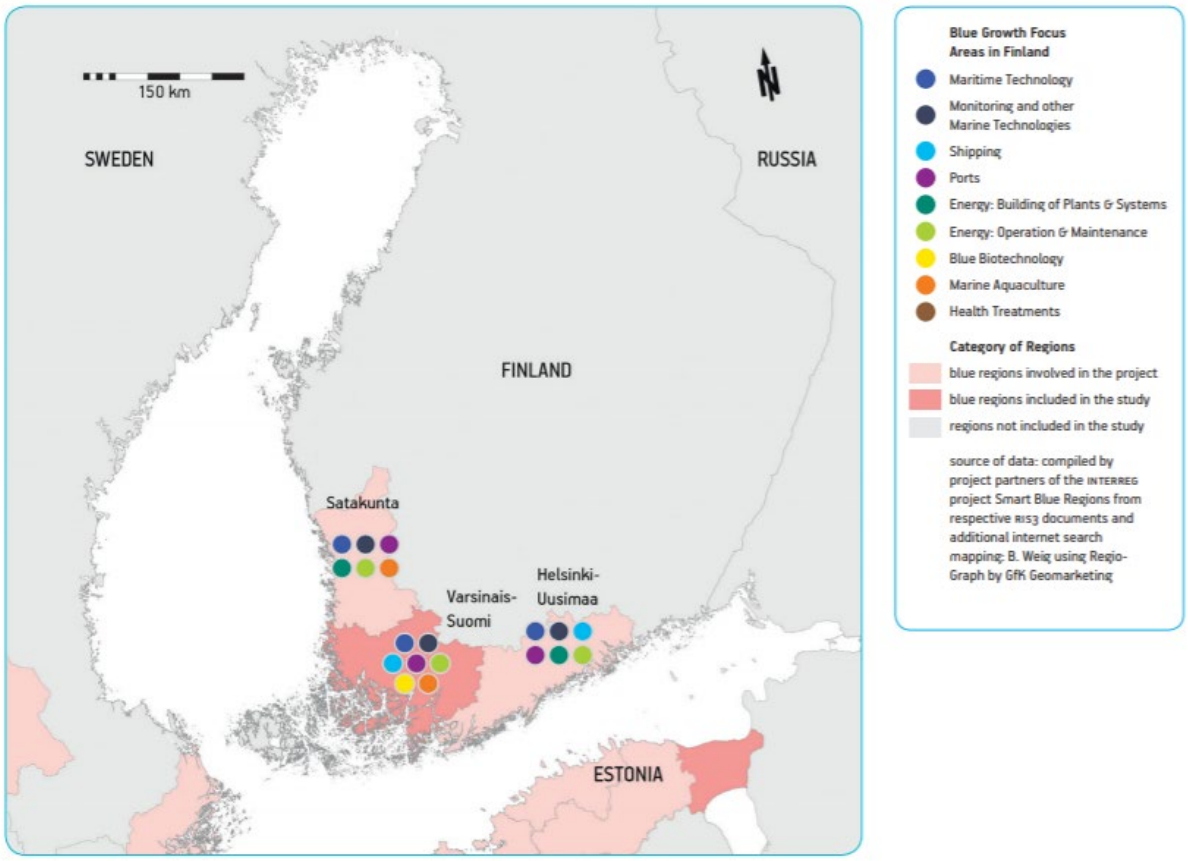
Finnish design offices offer a wide variety of consulting, design, research, and development services as well as software for the design and operation of ships. In addition, they provide feasibility studies and develop tools using the latest technologies.

Finland has over 40 years of experience in completing enormous oil platforms. Most of the floating, deep-sea Spar type oil platforms[269] are designed and constructed in Finland at the **Pori Offshore Constructions**[270] yard. We understand that the construction of oil rigs were stopped due to the construction of the Öresund bridge[271] connecting Copenhagen (DK) and Malmö (S), preventing passage

[265] https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi
[266] https://en.wikipedia.org/wiki/SMS
[267] https://en.wikipedia.org/wiki/Linus_Torvalds
[268] https://en.wikipedia.org/wiki/SSH_(Secure_Shell)
[269] https://en.wikipedia.org/wiki/Spar_(platform)
[270] https://www.porioc.com
[271] https://en.wikipedia.org/wiki/Øresund_Bridge

of large structures. Additionally, the Finnish offshore industry designs and manufactures offshore equipment related to wind power and many types of supply vessels.

The **SUBMARINER Network**[272], based in Berlin, recently presented an interactive map of actors the Baltic Sea that are active in the Blue Bioeconomy[273]. Blue bioeconomy is important for Finland, among their members is the Finnish Environment Institute (SYKE).



Source: SUBMARINER Network

7.2 Key public sector, research actors and clusters

7.2.1 Clusters

Most of the maritime cluster companies are located in southern and south-western Finland, in the provinces of Uusimaa and Southwest Finland. The second most important province for the maritime clusters are Satakunta, Kymenlaakso, Ostrobothnia and Pirkanmaa.

CLUSTER	DESCRIPTION
The Finnish Maritime Cluster[274]	The Finnish Maritime Cluster aims to be a global fore runner in sustainability and digitalization. It also has a goal to increase Blue Growth, Baltic Sea protection and the competitiveness of the Finnish maritime cluster. It is funded by the European Maritime and Fisheries Fund and Center of Economic Development, Transport and the Environment as a part of the Operational Program of Finland, European Maritime and Fisheries Fund in 2019.

[272] https://submariner-network.eu
[273] https://submariner-network.eu/about-us/countries
[274] https://www.finnishmaritimecluster.fi

Finnish Shipowners' Association[275]	The Finnish Shipowners' Association has 25 member companies from different shipping sectors. The association has represented the needs of shipowners in industrial and labor market policies both nationally and internationally since 1917.
Finnish Marine Industries Federation (Finnboat)[276]	Finnboat is the umbrella organization for Finland's marine industry and trade. Their membership represents close to one hundred percent of both the nation's domestic marine industry turnover and the value of boat exports.
Finnish Port Association[277]	FPA brings the position of Finnish port authorities to decision making in Finland and the EU. They represent 30 sea and inland cargo and passenger traffic ports.
One Sea[278]	One Sea is a high-profile ecosystem with a primary aim to lead the way towards an operating autonomous maritime ecosystem by 2025. The collaboration gathers together leading marine experts and is a strategic combination of top research, state-of-the-art information technology and business. The work began in 2016, and the aim is to create an environment suitable for autonomous ships by 2025. Partners are DIMECC (organiser), ABB, Awake.ai., Business Finland, Cargotec, Ericsson, Finnpilot Pilotage, Fintraffic Vessel Traffic Services, Haltian, Inmarsat, Kongsberg Maritime, Mohohakobi Technology Institute, Napa, Tietoevry, and Wärtsilä.

EnergyVaasa[279] is the largest energy technology hub in the Nordic countries. This has made it a world leader within different technologies, such as smart electrical solutions, sustainable energy, flexible power generation and digitalization. The substantial number of high-tech companies in the region makes it a fertile breeding ground for new businesses. Local universities, energy technology companies and municipalities work intensively together on research, product development, innovation and education. The Vaasa region is regarded as the most innovative area in Finland. EnergyVaasa represent more than 160 businesses in the energy industry with a combined yearly turnover of the companies at EUR 5bn, with exports more than 80% of turnover, 12,000 employees in total and some EUR 200m spent on R&D.

The **Vaasa Region Development Company** (VASEK[280]) was founded in 2003 and is jointly owned by seven towns and municipalities on the West Coast of Finland. VASEK promotes and reinforces growth and competitiveness in the region. This is done by improving the preconditions for business activities in the Vaasa region in cooperation with the regional authorities, municipalities, local action groups and enterprises.

Turku Business Region[281], located at Turku Science Park, is a non-profit regional development company for the entire Turku subregion that works in close cooperation with local, national and international actors in the fields of business and economic development. They have launched **Maritime Accelerator**[282], an innovation platform for corporations and start-up. Partners are Rauma Marine Constructions, Meyer Turku and Royal Caribbean International.

[275] https://shipowners.fi/en/finnish-shipowners-association/
[276] http://www.finnboat.fi/en/
[277] https://www.finnishports.fi/eng/organisation/
[278] https://www.oneseaecosystem.net/about/
[279] https://www.vaasa.fi/en/energyvaasa/
[280] https://www.vasek.fi/start/
[281] https://turkubusinessregion.com/en/
[282] https://maritime.turkubusinessregion.com

7.2.2 Key governmental actors

The administration of the various blue industries is governed by the Ministry of Transport and Communications, Traficom, and Fintrafic. The key governmental actor for the blue economy in Finland is the **Finnish Transport Infrastructure Agency**[283]**.** The agency concentrates on planning, developing, and maintaining road, rail, and maritime transport infrastructure and the coordination of transport. In addition, it is also responsible for arranging traffic control and winter navigation. **Business Finland**[284] is a government-owned organization that promotes internationalization of Finnish companies. They are largely involved in the maritime industry. Their Canadian[285] office is located in Toronto and offers advisory services and support for finding local networks and consultants.

7.2.3 Key research actors

Finland ranks high in digital skills, with several top universities and accessible learning opportunities. In a country of 5.5 million people, major universities offer more than 250 individual AI courses, 40 master-level programs, 19 bachelor-level programs and 3 doctoral programs. The universities of applied sciences provide an additional 26 study programs on the subject. Overall, about 6,300 students take at least one course in AI at Finnish universities every year. Several hundreds of students graduate from AI programs annually.

Finland's high level of education and decades of research in machine learning and signal processing have formed a solid basis for Finnish AI know-how and development. Finland has the second largest number of AI experts per capita in Europe (LinkedIn Economic Graph 2019[286]). Active cooperation between companies, universities, and research centers is funded by the state via Business Finland. This strategic support has created an attractive research and innovation environment. The Helsinki region has been recognized as one of the most important AI start-up ecosystems in Europe. Finland has over 300 AI start-ups in total, many of which are research spinoffs.

RESEARCH ACTOR	DESCRIPTION	CONTACT INFO
Aalto University[287]	The Aalto University's school of engineering (research team marine technology) specializes in holistic safety modelling, advanced structural modelling, strength and comfort, vibrations, high strength steel and new structural solutions, energy efficiency, sustainable solutions, hydrodynamics, cruise and ferry conceptual development and design as well as arctic technology.	Professor Pentti Kujala pentti.kujala@aalto.fi +358 400878145
Finnish Meteorological Institute (Marine research institute)	Responsible for physical oceanography and sea ice research in Finland. The marine research institute aims to monitor and examine ocean and sea-ice processes in the Baltic Sea and in the polar oceans.	Dr. Jari Haapala Head of Marine Research +358 40 757 36 21 jari.haapala@fmi.fi
University of Turku[288]	Part of the University of Turku, the Turku School of Economics (TSE) has an internationally established reputation as a highly respected business school, operating on a basis of high quality and	Professor Lauri Ojala (TSE) +358 50 502 70 31 lauri.ojala@utu.fi

[283] https://vayla.fi/en/about/operating-philosophy
[284] https://www.businessfinland.fi/en/do-business-with-finland/explore-key-industries/maritime/in-brief
[285] https://www.businessfinland.fi/en/locations/americas/canada
[286] https://economicgraph.linkedin.com
[287] https://www.aalto.fi/en
[288] https://www.utu.fi/en

	relevant research. They have special expertise in research relating to Arctic shipping economics and port economics. The Center for Maritime Studies at the Brahea Center focuses on port studies, supply chain management and other relevant topics. The Technology Research Center at the university also provides relevant research.	Esa Hämäläinen Research Director (Brahea Center) +358 400538291 esa.hamalainen@utu.fi Teijo Lehtonen, D.Sc. (Tech.) Senior Research Fellow +358 (0)44 440 0005 teijo.lehtonen@utu.fi
University of Vaasa[289]	The University of Vaasa is a multidisciplinary, business-oriented university. Its Renewable Energy Research Group is part of School of Technology and Innovations and mainly under the subject of energy technology, but collaboration is undertaken also with the computer science, electrical engineering, industrial management and the mathematical sciences. Research is carried out in particular in the areas of renewable fuels, flexible hybrid power generation, internal combustion engines, cutting emissions, energy IoT, wind energy and geoenergy.	Ipo Ojala Vice-director School of Technology and Innovation ipo.ojala@univaasa.fi +358 29 449 8339
Finnish Environment Institute (SYKE)[290]	SYKE coordinates and realizes long-term monitoring of the sea and research the ocean in a multidisciplinary way by using modelling, measurements and observations. They act as an expert on the implementation of Finnish marine resource management planning, EU maritime legislation and the Baltic Sea environmental protection convention.	Paula Kankaanpää Director, Marine Research Center Paula.kankaanpaa@environment.fi +358 40 77 77 825

Hydrogen and wind for the vessels of the future – significant EU funding for the University of Vaasa for low-carbon shipping research

A consortium led by the University of Vaasa received significant funding from the EU's Horizon 2020 programme for a research project that promotes low-carbon shipping by combining several energy technologies and innovative ship design. The **CHEK**[291] – deCarbonizing sHipping by Enabling Key technology symbiosis on real vessel concept designs – project involves, in addition to the University of Vaasa, World Maritime University, Wärtsilä, Cargill, MSC Cruises, Lloyds Register, Silverstream Technologies, Hasytec, Deltamarin, Climeon and BAR Technologies.

The CHEK project aims to reduce shipping emissions by bringing low-carbon energy forms and various technologies such as hydrogen, wind power, electric batteries, heat recovery, air lubrication and new anti-fouling technology to vessels, as well as developing the way vessels are designed and operated.

[289] https://www.univaasa.fi/en
[290] https://www.syke.fi/en-US
[291] https://www.univaasa.fi/en/articles/hydrogen-and-wind-vessels-future-significant-eu-funding-university-vaasa-low-carbon

7.3 Key market actors, market entry situation and key events

7.3.1 Market entry situation

There are no real entry requirements for Finland, aside from normal expectations when entering a new market. With existing incentive programs, there are many opportunities for settling or investing in Finland. This coupled with the fact that Finland is part of the EU, which can create opportunities for entry into other countries in the union as well. The Finnish market pose relatively few barriers to trade and market entry. The overall size of the Finnish domestic market is relatively small, with consumers who have high expectations in terms of product innovation, design, quality, and price.

7.3.2 Key market actors

Wärtsilä[292] produce, design and operate everything from engines, propulsion, exhaust gas cleaning systems, electrical solutions, seals and bearings, water and waste treatment, gas solutions, as well as automation, navigation, and communication systems, fleet operations solutions, ship traffic control, simulators and training, and lifecycle solutions. Wärtsilä, founded in 1834, is a global leader in smart technologies and complete lifecycle solutions for the marine and energy markets. In 2020, Wärtsilä's net sales totalled EUR 4.6 bn with approximately 18,000 employees. The company has operations in over 200 locations in more than 70 countries around the world.

Helsinki Shipyard[293] specializes in demanding marine technology and shipbuilding. The shipyard has a long experience in designing and building passenger and cruise vessels. They are also known for their icebreakers and for other special vessels for arctic conditions. Arctech has Russian ownership.

As one of Europe's leading shipyards, **Meyer Turku**[294] is especially known for designing and building cruise ships and ferries. Hull production at Meyer Turku is specialised in hull blocks of different shapes, sizes and weights. Meyer Turku is German owned.

ABB[295] provides its customers solutions for power transmission and distribution, building technology, sustainable transportation, renewable power as well as industry automation and marine solutions.

Rauma Marine Constructions[296] specialise in the construction and maintenance of multi-purpose icebreakers, car and passenger ferries, and Naval warships (e.g., Navy2020 programme). Rauma Marine Constructions is the only domestically owned shipbuilding company of its size.

Turku Repair Yard[297] is the largest dry dock in the northern Baltic sea.

Napa Group[298] is a global leader in software, services and data analysis for the maritime industry; providing data-led solutions for safety, efficiency and productivity in both ship design and operations. Napa is owned by ClassNK, a Japanese classification society.

Cadmatic[299] is a leading developer of digital and intelligent 3D-based design, engineering and information management software solutions for the marine industry, process & other industries, and construction industry. They support advanced digitalization in all project life cycles with data-driven shipbuilding, plant construction, and operation.

[292] https://www.wartsila.com
[293] https://helsinkishipyard.fi
[294] https://www.meyerturku.fi/en/meyerturku_com/index.jsp
[295] https://global.abb/group/en
[296] https://rmcfinland.fi
[297] https://blrtyards.com/en/
[298] https://www.napa.fi
[299] https://www.cadmatic.com/en/

Elomatic[300]**:** Service throughout the entire life cycles of their customers' products, services, and investments. Their areas of expertise range from engineering, technical consulting, turnkey solutions and products, software development, project management, and product and service development.

Foreship's[301] specialty is ship design and engineering. With personnel consisting of more than 100 naval architects, marine & structural engineers, interior & HVAC (heating, ventilation, and air conditioning) designers, and electrical engineers they provide flexible, high quality and personal service available only from a company of the right size. Their customers include the world's largest cruise lines as well as passenger, cargo and offshore shipowners, shipyards, and maritime suppliers.

Deltamarine[302] specialises in providing services within ship design, offshore engineering, and construction support services for marine and offshore industries worldwide. Their expertise covers fit-for-purpose designs in all ship types and offshore vessels. They handle all design disciplines and phases in newbuilding and conversion projects. They are dedicated to delivering services throughout a vessel's lifecycle – from concept development and engineering to project management during shipbuilding and commissioning. For operating vessels, they offer a wide range of services to maintain the fleet in excellent condition, or even upgrade it to the next level. Deltamarine is Chinese owned.

Valmet Marine/Automation's[303] target is to make vessels greener, more efficient, and more profitable, thanks to the use of advanced automation and scrubber solutions. Valmet has a long track record in supplying scrubber systems to container, general cargo, and cruise ships. Also, ship automation systems based on Valmet technology have a long history. Development work on ship automation systems started in the early 1980s with Damatic Classic and has continued through to today's Valmet DNA.

Norsepower[304] was founded in late 2012 with a mission to reduce the environmental impact of shipping through its Rotor Sail Solution technology, based on the 100 year-old concept of the Flettner rotor. Norsepower Rotor Sails provide a reliable and easy-to-operate auxiliary wind propulsion system with a proven savings record. Norsepower Rotor Sails can typically reduce fuel consumption by 5-20%. In 2021, Norsepower has been named a Global Cleantech 100 Company by Cleantech Group for its ground-breaking Rotor Sail Solution. Prior to that, they have received numerous prizes, including the Nor-Shipping Young Entrepreneur Award in 2017.

Cargotec[305] **(Kalmar and MacGregor)**: Kalmar offers the widest range of cargo handling solutions and services to ports, terminals, distribution centers and to heavy industry. Being the industry forerunner in terminal automation and in energy efficient container handling, with one in four container movements around the globe being handled by a Kalmar solution. Through its extensive product portfolio, global service network and ability to enable a seamless integration of different terminal processes, Kalmar improves the efficiency of every move.

7.3.3 Key industry events

NaviGate[306] is Finland's largest maritime trade exhibition. Navigate 2022 brings together shipowners and operators, terminal operators and regulators, and importantly the next generation of industry into one room to collaborate and discuss the future challenges and opportunities. The event is an important meeting place that offers participants the opportunity to network and create new contacts and reinforce existing ones. The programme will feature themes that are currently the industry's hottest topics. The NaviGate Matchmaking Event will offer industry operators an excellent opportunity to find commercial or development partners

[300] https://www.elomatic.com/en/
[301] https://www.foreship.com/en
[302] https://deltamarin.com
[303] https://www.valmet.com/more-industries/marine/
[304] https://www.norsepower.com
[305] https://www.cargotec.com/en/
[306] https://www.turunmessukeskus.fi/en/event/navigate/

EnergyWeek[307] in Vaasa gathers energy actors from all over the world to share information, hear about the latest news and most interesting cases, extend their networks, and conduct business. The annual Energy Week focuses on renewable energies, smart energy, and gas energy. Topics of interest include digitalization, batteries and storage, circular economy, future smart cities, energy regulation, business, and innovation.

Slush[308] is a Finnish start-up and tech event, which also includes a maritime part. Slush facilitates meetings between the founders of start-ups and investors such as venture capitalists, accomplished with events such as matchmaking and pitching competitions. Slush aims to build a worldwide start-up community. The event is held annually, late in the autumn, in Helsinki, Finland. In 2019, Slush gathered 25,000 attendees, with over 3,500 start-ups, 2,000 investors and 600 journalists coming in from over a hundred countries to participate together in this global networking festival. Since 2015, Slush also run events throughout the world under Slush Tokyo, Slush Shanghai and Slush Small Talks events.

NEFCO[309] is an international financial institution (IFI) located in Helsinki that finances the initial scale-up of Nordic green solutions on international markets. Founded in 1990 by the five Nordic countries, they serve the interests of their owners, Denmark, Finland, Iceland, Norway and Sweden, and take concrete actions to accelerate the green transition. Their task is to scale up Nordic green solutions. Nordic green SMEs lead the way in many fields, but they might miss their growth potential without proper funding. Being fairly small they lack the unicorn hype of start-ups, yet they seem too small and risky for mainstream banks. NEFCO's task is to accelerate the shift to green by financing the initial scale-up of Nordic environmentally and climate-friendly solutions in international markets.

Press Release February 23, 2021[310]

Wärtsilä part of expanded future energy coalition unveiling concrete actions for 2021

The Coalition for the Energy of the Future, of which technology group Wärtsilä was a founding member, has identified seven development projects for 2021. At the same time, the coalition welcomes three new corporate members, thereby expanding the original membership of 11 businesses to 14.

The projects to be worked on in cross-industry working groups during 2021 are: Green Hydrogen; New Biofuel for Maritime Needs; Carbon-neutral LNG; Green Electricity; Zero Emissions; Digital Solutions; and Intermodal Green Hubs. The overall aim of the coalition is to define a clear pathway towards carbon neutrality.

– These projects are all areas that Wärtsilä is heavily involved in, and which align closely with the company's Smart Marine and Smart Energy strategies. We fully support the aims of this initiative, and since collaboration is central to achieving real progress, we look forward to working closely with the other members for a cleaner and better future," says Roger Holm, President, Wärtsilä Marine Power.

Launched in 2019 during the French Maritime Economy Conference, the program received the backing of French President Emmanuel Macron. The target is to achieve genuine technological breakthroughs with tangible results by 2030. The three new members of the coalition are Airbus, Bureau Veritas, and PSA International. In addition to Wärtsilä, the original members are Amazon Web Services, Carrefour, CMA CGM Group, Cluster Maritime Français, Crédit Agricole Corporate Investment Banking, Engie, Faurecia, Michelin, Schneider Electric, and Total.

[307] https://www.energyweek.fi
[308] https://www.slush.org
[309] https://www.nefco.int/about-nefco/
[310] https://www.wartsila.com/media/news/23-02-2021-wartsila-part-of-expanded-future-energy-coalition-unveiling-concrete-actions-for-2021-2867895

ICELAND

MARINE BIOTECHNOLOGIES

MARINE FOOD TECHNOLOGIES

8. Iceland

The Fishing Economy in Iceland employs some 8,000 people with an annual turnover of some ISK 128bn[311]

8.1 Main drivers, trends and future developments

There is no formal blue economy strategy from the Icelandic government. Various projects, start-ups and initiatives are the main drivers for development of the blue economy in Iceland. As a result, there are several ocean tech companies coming out of Iceland.

There is no formal strategy for blue economy in Iceland, however, the government's involvement is thoroughly portrayed through different initiatives. They are a partner in the **Blue Bioeconomy Cofund**[312], which involves Norway and 14 other European countries and receives funding from EU research funds. This initiative provides financing to projects working to find new ways to create value in the blue bioeconomy. Iceland was also part of establishing **NordForsk**[313] (formally Nordic Bioeconomy Program) under the intergovernmental Nordic Council of Ministers[314]. The program provides funding and facilitates Nordic research cooperation and research infrastructure.

Despite no formal co-operation, the line from fisherman to scientist is short due to the country's small population. The industry is thereby mostly company driven, with a close-knit value chain. Diving into further research while working with the entire value chain will as a result be a key driver for further utilization of fish and further driving the blue economy in Iceland. Matís[315] plays a pivotal role in connecting fishing companies and scientists; they have worked well in recent years with knowledge sharing and research implemented within the industry.

There are certain internal challenges in Iceland when dealing with shipping. The smaller regions, such as the **Westfjords**[316], struggle with a high cost of shipping due to the country's infrastructure. A need for the Icelandic market is thereby finding/creating technologies that make fish products both easier and quicker to ship and products and solution that makes the fish last longer.

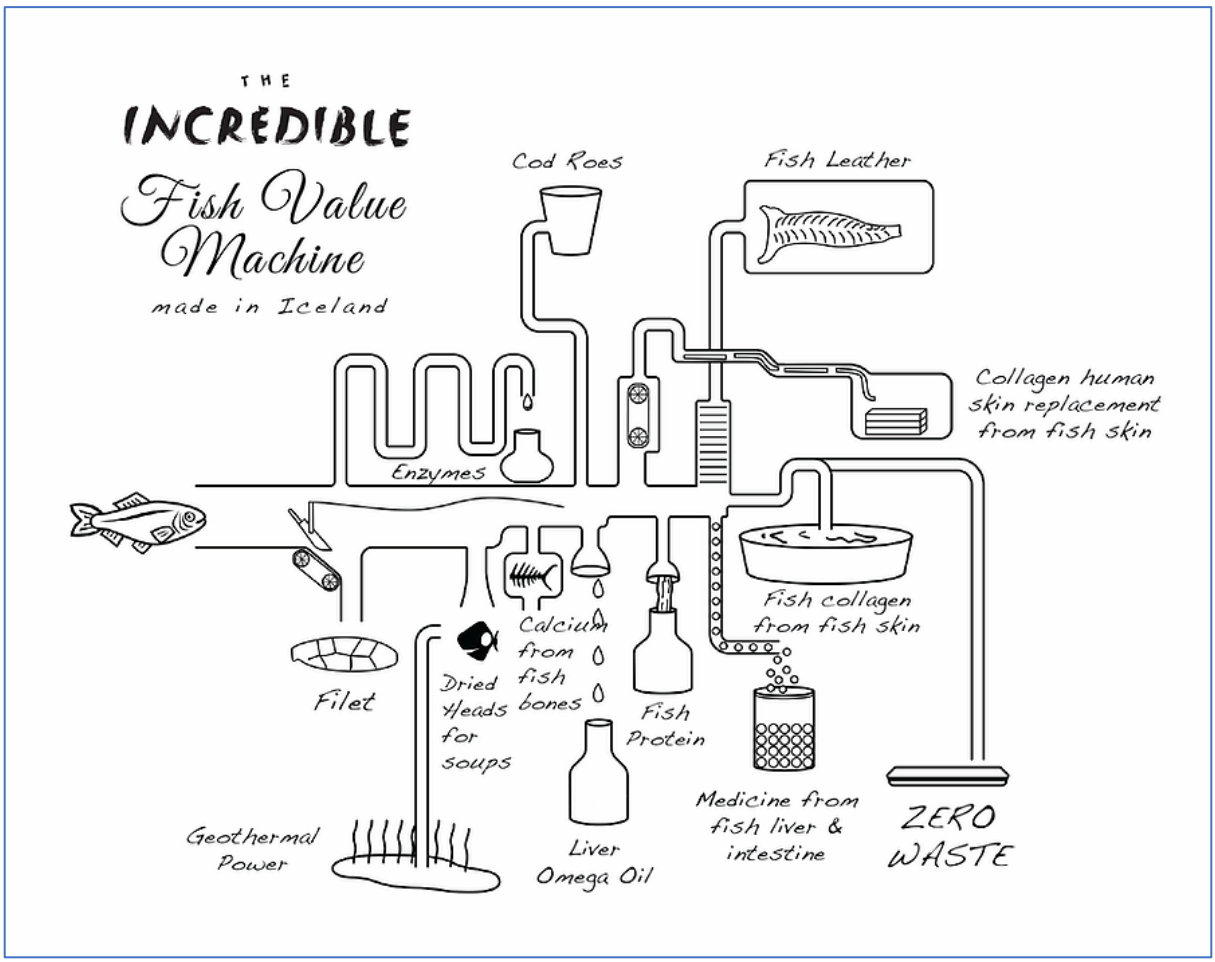
Iceland's individual transferable quota (ITQ) system was first introduced in 1984. Originally, the system was intended to be a short-term experiment, but was made permanent in 1990. This system allocates fishing rights to individual vessels in Iceland. This quota system limited the number of catch, forcing the industry to maximize how much of the fish is used and created a respect for the raw material. Today, Iceland is considered one of the market leaders on utilizing the raw material of the fish and has managed to streamline the process of fish products.

8.1.1 100% Fish Project

The 100% Fish Project was introduced by the **Iceland Ocean Cluster**[317] to inspire the seafood industry and seafood communities to utilize more of each fish, increase employment and decrease waste. The project also works to support new business opportunities and shows how important it is for different sectors to work together to create these opportunities. Studies by the Iceland Ocean Cluster indicates that over 80% of each fish is utilized in Iceland, compared to other fisheries nations who only utilize about 50%. Despite currently being leading in terms of utilizing the raw material of the fish, leading Icelandic fisheries have announced aims to utilize 100% of the fish[318].

[311] https://webgate.ec.europa.eu/maritimeforum/en/node/4449
[312] https://bluebioeconomy.eu/about-2/
[313] https://www.nordforsk.org
[314] https://www.norden.org/en
[315] https://matisiceland.org
[316] https://en.wikipedia.org/wiki/Westfjords
[317] http://www.sjavarklasinn.is/en/
[318] http://www.sjavarklasinn.is/en/100-fish/

Increasing the utilization of landed fish can increase revenue for fisheries and companies within aquaculture substantially. The use of byproducts in the Icelandic fisheries have increased by around 3,000 % in the last 25 years and has led to an independent industry that has created 600-700 direct jobs in Iceland and created an annual value of over USD 500m. It is worth noting that many of these jobs have been created in rural areas. This increase in fish utilization and the drive for utilization of available resources drives innovation in marine biotechnology and marine food technologies.



Source: Iceland Ocean Cluster

8.1.2 Marine Biotechnologies

The life science sectors, including biotechnology, is a growing and interesting industry in Iceland. As the Icelandic domestic market is small, innovation efforts need to be tailored for a global perspective from the onset. This creates great opportunities for investment and co-operation with Icelandic biotech companies. The biotech sector has strong governmental support and has done comprehensive academic work. Iceland as a country has an advanced health care system, as well as abundant natural energy resources. The Icelandic people are known to be well educated, open-minded and with a high willingness to embrace new technology[319]. This makes Iceland a great testing bed and offers opportunities for knowledge-based industries, such as biotechnology. A central part of the marine biotechnology industry in Iceland is the microalgae cultivation at the Blue Lagoon. These microalgae can be used for skincare products, colorants and fish feed. One company focusing on investing in microalgae production in Iceland is **Algalif AS**[320], which focuses on high-grade natural astaxanthin products from microalgae.

[319] https://www.iceland.is/press/press--media-kit/industry-services-and-innovation/health-and-biotechnology-in-iceland/
[320] https://algalif.is/about-algalif/

8.1.3 Marine Food Technologies - Seaweed (Macroalgae)

It is estimated that the global seaweed market could have a market potential of EUR 9.3bn by 2030. The perception of seaweed differs around the world and while it is commonly used in Asian cuisine, most Europeans are unaware of the potential applications and benefits of this ocean resource. However, on closer examination, it quickly becomes apparent that seaweed is rather underappreciated and has yet to be fully utilized as a resource. The global seaweed industry has in the recent years been experiencing a consistent, yet significant growth. From 2010 to 2018, global annual harvests of seaweed increased from 19 million metric tons to an estimated 36 million metric tons – an almost 100% increase. Worldwide, it is by many considered to be one of the most underexploited resources. Seaweed is known to have an abundance of macro nutrients, micronutrients and vitamins. Seaweed oils contain long-chain Omega-3 fatty acids, which makes them comparable to fish oils. It can be used for a growing range of applications from food products and animal feed to cosmetics and chemicals for various industries. Many of these applications provide sustainable, low-carbon and less harmful alternatives to existing options.

> The Icelandic capacity to sustainably harvest and process seaweed has been proven by the company **Thorverk**[321], located in the Westfjords. Thorverk harvest wild seaweed from Breiðafjörður to produce geothermally dried and milled seaweed. These products can be used for fertilizer, animal feed, cosmetics and pharmaceuticals. In the recent years, Thorverk have gone from producing for low-value products, but more recently, their seaweed has been used in the cosmetic and pharmaceutical industry. These products have a higher value, generating a higher possible revenue for Thorverk and their seaweed harvesting. Companies such as **Algae Náttúra**[322]**, Taramar**[323] and **Zeto**[324] use Thorverk's products to create skincare that benefits both skin and health.

In Iceland, the seaweed industry has been solely based on wild cultivation. There are approximately 15 companies and start-ups utilizing seaweed in their products and research. Iceland has a unique opportunity to increase their seaweed-based food industry. Through further developing both current and emerging uses of seaweed, Iceland can, in an environmentally soundly and economically significant manner, diversify their maritime industries. This could potentially create opportunities for Canadian companies with experience in the seaweed industry to enter the Icelandic market.

USE OF SEAWEED	EXAMPLE APPLICATION	PRIMARY FUNCTIONS	BENEFITS
Food	Raw salads, chips, spaghetti, burgers.	Source of energy, protein and vitamins.	Supports healthier diets due to high minerals, vitamins, protein and fiber contents; lower environmental footprint than animal or land-based alternative protein sources.
Additives	Gelatine substitutes, processed meat and dairy.	Provision of thickening, stabilizing and emulsifying properties.	Natural and vegan-friendly, lower environmental footprint than animal-based alternatives.
Animal feed	Livestock feed supplements, aquafeed supplements, pet food additives.	Promotion of positive immune response and gut health, as well as improvement of digestive process.	Improvement in animal health and production yields, reduction of methane emissions from livestock.

[321] https://www.thorverk.is
[322] https://www.sjavarsmidjan.is/algae-nattura
[323] https://taramar.com
[324] https://zeto.is

Biostimulants	Seed treatments.	Stimulation of plant growth, protection against abiotic stress.	Lower environmental footprint than nitrogen fertilizer alternatives. Promotes plant health, productivity and soil regeneration.
Pharmaceuticals & nutraceuticals	Gastrointestinal protectors, biodegradable wound care products/nutrient health supplements.	Source of bioactive and nutrient-rich ingredients.	Disease prevention and treatment, natural health enhancers.
Cosmetics	Anti-aging moisturizers, toothpaste.	Source of bioactive and nutrient-rich ingredients, provision of thickening, stabilizing and emulsifying properties.	Natural and vegan-friendly, supports skin health.
Bio-packaging	Packaging, coatings and plastic films for food containers.	Source of marine-safe and compostable plastic molecules.	Replaces substances that cause environmental damage in production (fossil fuels) and after end-of-life (ocean leakage).
Biofuels	Biodiesel for use in cars.	Source of energy.	Replacement for fossil fuels or land-intensive biofuels, made from seaweed processing by-products.

Source to the table above: Rhein Knudsen, Ale and Meyer, 2015[325]; Fleurence and Levine, 2016[326]; Li, et al., 2016; Kinley, de Nys, Vucko, Machado and Tompkins, 2016; Machado, Magnusson, Paul, Kinley and de Nys, 2016; Maia, 2016; Bleakley and Hayes, 2017; Kinley et al, 2020; Leandro, Pereira and Gonçalves, 2020; Seaweed for Europe report: Hidden champion of the Ocean[327]

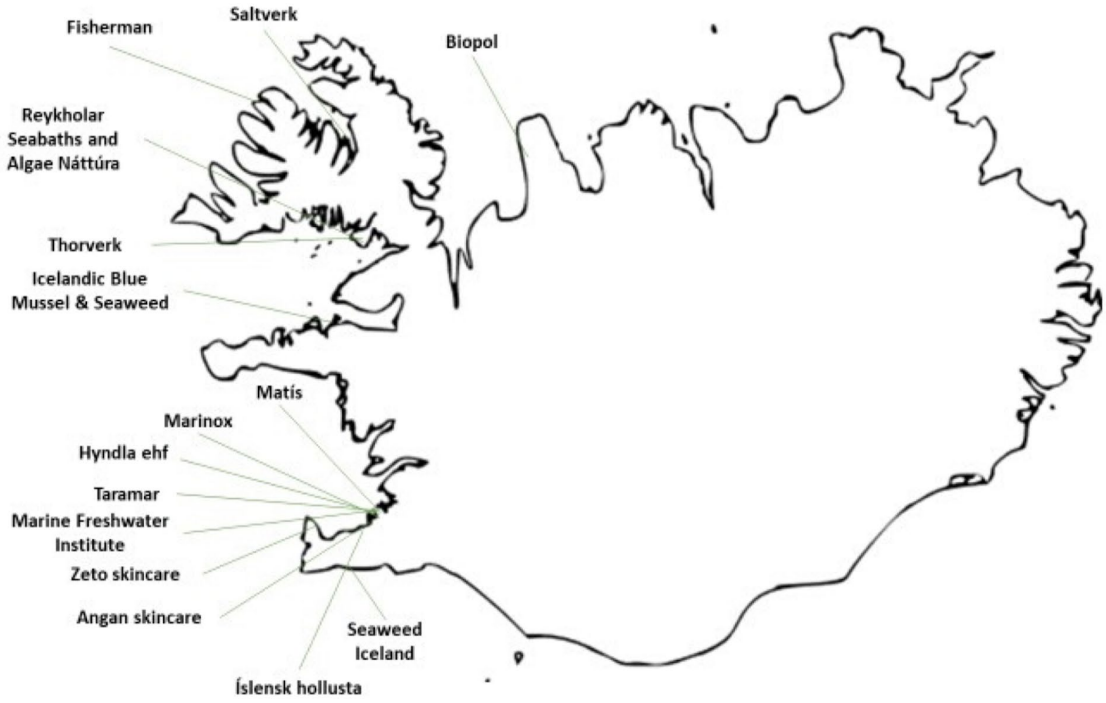
Another company in the Icelandic seaweed industry worth noting is **Hyndla[328]**. They have teamed up with the Marine Freshwater Research Institute to experiment with cultivating seaweed for the food supplement and pharmaceutical industry. So far, they have successfully cultivated Schizymenia, a red seaweed. This success has indicated that under controlled conditions and in utilizing relevant water and technology, seaweed can be cultivated in considerable quantities, reducing the need for wild harvesting. Such technology can be relevant to adopt to Canadian interests.

325 https://www.researchgate.net/publication/277968129_Seaweed_Hydrocolloid_Production_An_Update_on_Enzyme_Assisted_Extraction_and_Modification_Technologies

326 https://www.sciencedirect.com/book/9780128027721/seaweed-in-health-and-disease-prevention

327 https://www.seaweedeurope.com

328 https://hyndla.is/english/



Picture 1. The location of seaweed companies- and startups in Iceland.

Source: Iceland Ocean Cluster

8.2 Key public sector, clusters and research actors

The Icelandic infrastructure is largely affected by the country's small size. This has caused a close-knit value chain with strong international connections – stemming from researchers who have completed advanced research degrees in other countries[329].

8.2.1 Clusters

The Iceland Ocean Cluster[330] started in 2011 and has a mission to create value by connecting entrepreneurs, businesses and knowledge in the marine industries. The cluster provides services within networking, incubation, research, consulting and more. The Iceland Ocean Cluster also operate a cluster collaboration facility with over 70 companies. The companies are of different sizes and represent most parts of the ocean value chain, from fisheries to seafood biotech companies. Recent studies conducted by the Iceland Ocean Cluster shows that over 70% of the companies here have collaborated with another company in this facility.

8.2.2 Key Governmental Actors

The Icelandic **Ministry of Fisheries and Agriculture** is a cabinet-level ministry[331]. The ministry is considered important due to the high focus on fishery in Iceland. The same applies to the **Directorate of Fishery**[332] (Fiskistofa). This is an agency under the **Ministry of Industries and Innovation**. The Directorate's task is to monitor fisheries and the daily administration of the fisheries management system in Iceland.

[329] https://www.iceland.is/files/idnadur-press-kit-enska-april-2016.pdf
[330] http://www.sjavarklasinn.is/en/
[331] https://www.government.is/ministries/ministry-of-industries-and-innovation/minister-of-fisheries-and-agriculture/
[332] http://www.fiskistofa.is/english/about-the-directorate/

8.2.3 Key research actors and research funding

In September 2020, a new policy on science and technology was signed aiming to increase the contribution to a competitive fund in science and innovation. The policy is a three-year initiative and funds will increase 50% from 2020 to 2021. This could increase the amount of research being conducted in Iceland and open up for research cooperation.

RESEARCH ACTOR	DESCRIPTION
The Icelandic Center for Research (Rannís)[333]	Rannís mainly supports research, innovation, culture and education in Iceland. The center administers the national competitive funds in fields of research and innovation.
The Icelandic Research Fund[334]	The IRF awards funding to student research projects and research projects led by individuals, research teams, universities, research institutes, and companies. The target groups are Researchers at Icelandic universities, research institutes or companies. Research students at Icelandic universities.
University of Iceland[335]	The University of Iceland is the largest university in Iceland and a leading research university, particularly in terms of arctic related research and teaching. It is worth mentioning that the university is responsible for a research fund with the purpose of strengthening research activity at the university.
University of Akureyri[336]	The university was established in 1987 and is located in the northeast of Iceland. A notable study here is their polar law program which has a rising national and international interest
Hólar University[337]	Hólar is a rather small university with three departments, where one is aquaculture and fish biology. Their Department of Aquaculture and Fish Biology is an international center for research, instruction, and continuing education in aquatic biology, aquaculture and fish biology.
University Center of the Westfjords[338]	A small center for higher education, the University Center of the Westfjords focuses on coastal and marine management. It's primary language of teaching and general communication is English.
Reykjavík University[339]	An academic institution responsible for advanced education, research and scientific projects. Amongst main research areas is maritime law.
Iceland Funds (Íslandssjóðir)[340]	Iceland Funds Ltd. is one of the largest Icelandic fund management companies, established in 1994. It is a wholly owned subsidiary of Íslandsbanki and is supervised by the Icelandic Financial Supervisory Authority (FME).

[333] https://en.rannis.is
[334] https://en.rannis.is/funding/research/icelandic-research-fund/
[335] https://english.hi.is
[336] https://www.unak.is/english
[337] Department of Aquaculture and Fish Biology. Retrieved 14.03.2021: https://www.holaraquatic.is/
[338] https://www.uw.is/coastal/
[339] https://en.ru.is
[340] https://www.islandssjodir.is/english/home

8.3 Key market actors, market entry situation and industry events

8.3.1 Market Entry Situation

Iceland is a small country and society. As a result, personal relationships matter. The value chain is quite short. Therefore, companies wishing to establish themselves in Iceland should visit the country and use agents to aid in market establishment. As the market is small, it is common for Icelandic companies to act as agents for foreign companies.

Even though Iceland is not part of the EU, their membership in the EEA means that Iceland and Icelandic companies adhere to most EU laws and regulations. However, Iceland does not adhere to common EU fisheries policies and regulations.

8.3.2 Key Market Actors

COMPANY	DESCRIPTION
Matís[341]	Known as one of the biggest market actors in Iceland, Matís is also a large contributor to research. They have a focus on value creation within the bioeconomy and the development of policy and infrastructure in the food business.
Haustak[342]	Haustak specializes in dried fish products that has a shelf life of a minimum of two years. The company mainly exports to the Nigerian market.
Codland[343]	Codland is a company established by the Iceland Ocean Cluster and Haustak and specializes in calcium supplements from fish bones, omega-3 rich oil, animal feed and marine collagen, which as a supplement can reduce skin aging and maintain healthy joints. The main goal of Codland is to increase fish utilization.
Primex Iceland[344]	Icelandic marine biotech company and is a global leader in the manufacturing and supply of pure chitin and chitosan derivatives. This is produced from shrimp shell.
Samherji Ltd[345]	Founded in 1983, Samherji is one of the largest companies in Iceland within the fish industry. It is a vertically integrated company, operating a fleet of vessels, fish factories and fish farming. This reflects the close-knit value chains in Iceland and further reflect the Icelandic way of no part of the fish going to waste. Samherji currently has two land-based fish farms located in Dalvik and Akureyri. The plants produce a wide variety of fresh and frozen fish products.
Arnalax[346]	Located in the Westfjords, Arnalax is the biggest farmer and producer of Icelandic salmon. The company recently went public through its Norwegian holding company, Icelandic Salmon AS and can be traded on Euronext Growth in Oslo.
Biopol[347]	A marine biotechnology company located in Skagaströnd in Northwest Iceland. The goal of the company is to examine the biota of Húnaflói-bay, undertake research in the field of biotechnology and support innovation in the field of marine biotechnology.
Marinox[348]	Marinox works on extracting bio-actives extracted from seaweed in order to create increased value from wild cultivated seaweed found on Iceland's coasts. Their mission is to become a leader in the development and production of high-quality bio-actives

[341] https://matisiceland.org
[342] https://haustak.is
[343] https://codland.is
[344] http://www.primex.is
[345] https://www.samherji.is/en
[346] https://www.arnarlax.is/en/about-us/our-story
[347] https://www.biopol.is/efni/english
[348] http://marinox.is

	extracted from seaweed, creating an increased value from the under-utilized resource. As a result, they have developed and launched an UNA skincare, containing unique bio-active substances from Icelandic seaweed. There has also been a recent focus on developing seaweed based bio-plastics and bio-textiles.
Marorka[349]	Marorka is the leading global provider of data-driven energy management and operational performance solutions for the international maritime industry. Their technology enables customers to reduce fuel consumption, cut emissions and increase fleet performance and their data-driven systems can lead to significant financial savings. Marorka's combined onboard/onshore systems have been installed on more than 600 vessels.
Ankeri[350]	The company was founded in 2016 and has developed a tool for chartering, operations, and technical teams. Their cloud-based platform allows shipowners and charterers to communicate and stay on top of fleet performance and potential chartering prospects.
Klappir[351]	Klappir Green Solutions is a driving environmental force in Iceland, having created a leading sustainability management solution for carbon footprint reporting which is now in use both across the country and internationally. Their customers have derived significant benefits from using Klappir's smart sustainability management platform; lower carbon footprints, transparent and reliable ESG reporting, as well as operational savings and better compliance to environmental laws and regulations.
Carbon Recycling International[352]	Carbon Recycling International (CRI) is a world leader in power to methanol technology, producing renewable methanol from carbon dioxide, hydrogen and electricity for fuel applications, greener chemicals, and products. They work with partners to develop transformative projects, increasing resource efficiency and creating valuable products from waste gases and renewable energy. They design, engineer, and implement methanol production plants based on their Emissions-to-Liquids (ETL) platform.

8.3.3 Key Industry Events

The 2-day **Fish Waste for Profit**[353] conference provides attendees with knowledge on how to maximize their return on investment from potentially discarded parts of the catch that can be turned into high value products for non-food sectors. It is a must attended event for those looking to discover new innovations and industry insights, and to develop relations with key industry stakeholders. Fish Waste for Profit 2021 will be the 4th edition of the Icelandic Fisheries Conference, and will run alongside the IceFish Exhibition from 16-17 September 2021.

The **Icelandic Fisheries Exhibition**[354] (IceFish) will take place on 15-17 September 2021 at the Smárinn, Fifan Halls Kópavogur, Iceland. This is an event for all commercial fisheries organizations and associated businesses, Icefish hosts the latest developments from the industry showcasing new and innovative products and services, covering every aspect of the commercial fishing industry from catching and locating to processing and packaging, right through to marketing and distribution of the final product. Around 500 companies, products and brands are showcased over the three days by exhibitors from 22 different countries including Denmark, Norway, and the Faroe Islands.

[349] https://www.marorka.com
[350] https://www.ankeri.net
[351] https://klappir.com
[352] https://www.carbonrecycling.is
[353] https://www.icefishconference.com/the-conference
[354] https://www.icefish.is

9. Acknowledgements

The authors would like to thank all those who have offered their time and knowledge through interviews, reviews and sharing of relevant information.

NORWAY
Anders Mikkelsen, Regional Business Development Manager North Europe, DNV
Jon Rysst, Senior Vice President & Business Development Director, DNV
Jon Dugstad, Director Wind & Solar, Norwegian Energy Partners (NorWep)
Arvid Nesse, Cluster Manager, Norwegian Offshore Wind Cluster
Per Martin Tanggaard, Director, Nor-Shipping
Narve Mjøs, Director, Green Shipping Programme
Randi Lunnan, Professor, BI Norwegian Business School
Bjørn Haas Brubakk, VP Strategy and Business Development, Wilhelmsen Ships Service
Magnus Sande, VP, Head of Strategy and M&A Wilh. Wilhelmsen Holding
Per Brinchmann, VP Special Projects, Wilh. Wilhelmsen Holding
Solveig Holm, Project Manager, The Seafood Innovation Cluster

DENMARK
Henrik Bach, Area Manager, DNV
Frederik van Deurs, CEO, Green Innovation Group
Kasper Teilmann, Partner, GEMBA Seafood Consulting
Øystein S. Sandvik, Investment Manager, Invest in Denmark
Axel Klafstad, fmr. Senior Advisor, Royal Danish Embassy to Denmark
Richard Higginson, Jakob Schmidt and Michael Willmott, Canadian Embassy
Torben Nørgaard, Head of Energy & Fuels, Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

SWEDEN
Eva Errestad, Process Manager, SMTF (Swedish Maritime Technology Forum)
Mikael Lind, Associate Professor, RISE Viktoria
Lena Göthberg, Owner, The Shipping Podcast
Anders G. Swerke, Country Chair – Sweden, DNV
Inga-Lill Olsson, Canadian Embassy

FINLAND
Ulla Lainio, Commercial Counselor, Embassy of Finland, Washington D.C.
Katja Eriksen, Senior Advisor, Business Finland, Oslo
Magnus Hellström, Associate Professor, Åbo Akademi University
Seppo Vihersaari, Canadian Embassy
Aki Repo, Head of Service Line, DNV
Päivi Haikkola, Ecosystem Lead, DIMECC
Klas Blomqvist, CEO, Infoverde Consulting

ICELAND
Vilhjalmur Jens Arnason, Project Manager, Iceland Ocean Cluster
Ágústa Ýr Þorbergsdóttir, Managing Partner, Navigo
Saemundur Finnbogason, Canadian Embassy
Sighvatur Fridriksson, Senior Surveyor, DNV
Kristinn A. Aspelund, Co-Founder & CEO, Ankeri Solutions
Alexander Irgens, student

And last, but not least, we want to thank Ms. Tone Nymoen at the Embassy of Canada to Norway for trusting us with this task and for inspiration and helpful reviews, and Ms. Andrea Imbsen for valuable proofreading and comments.

10. Appendix A: Nordic Innovation

Nordic projects to reduce CO2 emissions in the maritime sector

To bring shipping in line with the Paris Climate Agreement, the maritime sector needs to reduce CO2 absolute emissions by 50 % by 2050. This requires major advancements in technology as well as shifts in business models and in the ways of operating, including in the interface between land and sea. To support innovation and collaboration in this interface, Nordic Innovation launched a Mobility Mission: Sea Meets Land with the aim of decarbonizing Nordic ports, transport of people and goods – on and between sea and land. As a result of a long co-creation process, workshops and matchmaking events seven projects were formulated. In March 2020, five of these projects were awarded funding:

Zero Emission Distribution at Sea (ZEEDS)
ZEEDS aims to create a network of offshore platforms that uses wind and/or solar to produce, store and distribute zero emissions fuels in a network of clean energy hubs placed near one of the world's busiest shipping lanes. Partners: Wärtsilä, Aker Solutions, DFDS, Grieg Star, Kværner, and Equinor.

The Maritime Energy Transition project (MAREN)
MAREN is a Nordic Network that aims to speed up the transition from conventional to green energy sources in maritime sector. The network will involve businesses, raise awareness about needs and possibilities, develop and share knowledge, and be a platform for further cooperation-based development in the sector. Partners: Renewable Energy Cluster, RISE, Vaasa Region Development Company VASEK, Erhvervshus Fyn, and Future Innovations AS.

New Offshore Wind Ports in the Nordics
This project aims to uncover specific opportunities for collaboration and strategic innovation between stakeholders at Nordic ports by creating capabilities for joint direction and execution to foster long-term business opportunities to Nordic companies and ports in the offshore wind industry. Partners: Energy Innovation Cluster, Norwegian Offshore Wind Cluster, Offshore Väst, Roenne Port, Karmsund Port, and Trelleborg Port.

Nordic Green Ammonia Powered Ships
The project will develop a holistic proof of concept and roadmap for the construction of the world's first ammonia powered deep sea vessel. Partners: Global Maritime Forum, Lauritzen-Kosan, Yara, Wärtsilä, MAN Energy Solutions, DNV; Ørsted, Danish Shipping Finance, and DNB.

On Shore Power Supply in the Nordic Region
This project consists of a feasibility study of on shore power supply, including a campaign to show the technical possibilities as well as grants available for investments. Partners: Danish Maritime, NCE Maritime Cleantech, Powercon, SSPA, Danish Ports, World Maritime University, and Danfoss Drives.

Background: In 2019 Nordic Innovation invited experts and stakeholders within the maritime and land-based transport sectors and blue economy to a series of workshops in Reykjavik, Turku and Gothenburg to explore opportunities for potential joint Nordic mobility missions. These workshops were organised by Ocean Industry Forum Oslofjord on behalf of Nor-Shipping. Based on inputs from the workshops, a NOK 8 million Nordic Innovation Mobility Mission was formulated with the aim of decarbonizing Nordic ports, transport of people and goods. The mission was soft-launched at Nor-Shipping in June 2019 with an application deadline in January 2020. The Nordic Innovation Mobility Mission: Sea Meets Land is part of the Nordic Smart Mobility and Connectivity program. The Connected Ship project is also a part of this program. See Nordic Innovation[355] for more information.

[355] https://www.nordicinnovation.org/news/nordic-projects-reduce-co2-emissions-maritime-sector

11. Appendix B: Norwegian offshore wind companies

Equinor ASA[356]	Offshore windfarms	Equinor ASA (formerly Statoil) is a Norwegian state-owned multinational energy company headquartered in Stavanger. It is primarily a petroleum company, operating in 36 countries with additional investments in renewable energy. The company is present in more than 30 countries around the world with some 21,000 employees and a turnover for USD 45bn (2020). Equinor is building material offshore wind clusters in the UK, the US North East and in the Baltic Sea. Hywind Scotland is the world's first floating wind farm, powering some 20,000 British homes. Dogger Bank, a large sandbank around 130 km off the North East coast of England, breaks the bounds of what size an offshore wind farm can be. The GBP 9bn wind farm will have a lifetime of up to 35 years, and is operated by Equinor. The project, a 50:50 joint venture between Equinor and SSE Renewables, is being built in three equal phases, with Italy's Eni taking a 20% stake in the first two phases.
Aker Offshore Wind AS[357]	Offshore windfarms	Aker Offshore Wind is an offshore wind developer with focus on assets in deep waters. With global operations, the current portfolio consists of development projects and prospects located in Asia, North America and Europe. The company is majority owned by Aker Horizons, an investment company dedicated to creating value and reducing emissions from renewable energy and decarbonization technologies. Aker Offshore Wind has strong backing from the Aker sphere of companies, including Aker ASA, Aker Horizons, Aker BP, Aker Solutions, ix3 and Cognite. Aker Offshore Wind also collaborates with the charities in the corporate family, REV Ocean, Ocean Data Platform and the Center for the 4th Industrial Revolution (Ocean). Aker Offshore Wind has a global and expanding portfolio, including active projects in South Korea and North America. They also have a pipeline of prospects in Europe, the U.S. and Asia.
DNV[358]	Feasibility, development, engineering, construction and operation	With a broad spectrum of knowledge and capability, DNV provides several services to the offshore wind industry throughout the entire value chain, from strategic advice and market intelligence to performance and condition monitoring.
Baggerød AS[359]	Doors for windfarms	Supplier of doors for windfarms, which has been the core business of Baggerød for several years.

[356] https://www.equinor.com
[357] https://www.akeroffshorewind.com
[358] https://www.dnv.com/power-renewables/themes/offshore-wind/index.html
[359] https://www.baggerod.no

Dokka Fasteners AS[360]	Wind power fasteners	Wind power fasteners for more than 30 years with state-of-the-art automated robotic manufacturing, heat treating, coating and inspection system in Europe.
Teknotherm AS[361]	HVAC and refrigeration systems	Delivers HVAC and refrigeration systems, commissioned to deliver systems for three windfarm service vessels built and designed for Esvagt by the Havyard Group.
Aibel AS[362]	Engineering, procurement and installation	Traditionally a company oil & gas, Aibel has recently established themselves in the European offshore wind market, having delivered the DolWin Beta platform, one of the largest power converter stations offshore Germany. They also supported Equinor in its Hywind Scotland floating wind power projects, from design of the floating wind turbine structures through to installation and commissioning support.
Fred. Olsen Windcarrier AS[363]	Transport, installation and service solutions	Part of the Fred. Olsen & Co group of companies, Fred. Olsen Windcarrier AS supplies expertise, hardware, vessels, and solutions to help establish wind parks.
Fred. Olsen Renewables AS[364]	Developer, owner and operator	Part of the Fred. Olsen & Co group of companies, Fred. Olsen Renewables is a leading developer, owner and operator of renewable energy assets, primarily onshore wind farms, currently engaged in four markets and have a substantial portfolio of projects under development, under construction or in operation.
Østensjø Rederi AS[365]	Purpose-built service operation vessels (SOV)	Vessels to provide access for personnel to Wind Turbine Generators, combined with accommodation at sea. Their vessels are equipped with a 23-meter heave-compensated walk-to-work gangway to allow maintenance personnel to walk between the vessel and WTGs. The vessels also have a daughter craft for transfer of personnel and cargo to WTGs.
Edda Wind AS[366]	Provider of SOVs and CSOVs	Edda Wind is a provider of purpose-built SOVs (Service Operation Vessels) and CSOVs (Commissioning Service Operation Vessels) to the global offshore wind market since 2015. The vessels accommodate wind turbine technicians and provide services during the commissioning and operation of offshore wind farms. The company owns and operates two vessels working for Ørsted. In addition, there is a newbuild program of two SOVs and four CSOVs, of which one SOV is contracted on a long-term charter with Vestas and one CSOV is contracted on a long-term charter with Ocean Breeze. All vessels are managed by Østensjø Rederi AS. Edda Wind is owned 50% by Johannes Østensjø dy AS and 50% by Wilh. Wilhelmsen Holding ASA.

[360] https://www.dokkafasteners.com
[361] https://www.teknotherm.no
[362] https://aibel.com
[363] https://windcarrier.com
[364] https://fredolsenrenewables.com/
[365] https://ostensjo.no
[366] https://ostensjo.no/edda-wind-orders-two-additional-csovs-and-prepares-for-initial-public-offering/

Awilco[367]	Construction vessels and SOVs	Awilco AS, an A. Wilhelmsen company, will establish a new company called Integrated Wind Solutions and is reported to be ordering a fleet of new construction and service operation vessels according to analysts at Clarkson Platou Securities. The first of the ships for the new service are reportedly already on order in China due for delivery in 2023. The A. Wilhelmsen family has deep roots in the shipping industry dating back to 1939.
Magnora ASA[368]	Offshore wind project developer	Renewable energy investment company Magnora's strategy is to develop wind projects in Norway and abroad from early phase greenfield to ready-to build. Magnora has entered into an agreement with a global offshore energy technology and service company to establish a joint floating wind company called Magnora Floating Wind.
NorSea Group[369]	Integrated services provider	NorSea Group AS provides supply bases and integrated logistics solutions to the energy industry. NorSea and its associates and joint ventures operate nine supply bases along the coast of Norway, as well as supply bases in Denmark and the UK. **NorSea Wind AS**[370] is a provider of integrated services to the offshore wind industry – its service lines include O&M (operations & maintenance) activities for both wind turbines and HVDC platform, in addition to marine support.
Elevon AS[371]	Project advisory, logistics management, and technical services	Elevon is a new venture between Abnormal Load Services (ALS) and NorSea, companies already established within the wind industry. They will combine their strengths in large and complex project logistics and offshore supply logistics. Further in the background, Wallenius Wilhelmsen and the Wilhelmsen group, owners of ALS and NorSea respectively, will provide additional support through global networks, enabling Elevon to punch way above its weight. Elevon will provide project advisory services, logistics management and solutions, as well as technical services.
Dr.techn. Olav Olsen AS[372]	Engineering, marine technology consultancy and foundations	Based on their long experience from the offshore oil and gas industry, the company has developed several concepts, studies, and solutions for offshore wind, wave, tide, and thermal energy. The company has developed unique foundation solutions for bottom fixed wind turbines (OO-Star). The company offers packages related to risk, development of tools for cycle of energy, model tank testing procedures, industrialization in addition to development of recommended practices and guidelines for design of floaters for large wind turbines.

[367] http://www.awilco.no
[368] https://magnoraasa.com
[369] https://norseagroup.com
[370] https://norseagroup.com/companies/norsea-wind
[371] https://elevon.group
[372] https://www.olavolsen.no/en

12. Appendix C: Norwegian clusters & associations

ORGANIZATION	DESCRIPTION
Arena Ocean Hyway Cluster[373]	The leading network for maritime hydrogen in Norway. The cluster is broad with both a comprehensive national and international network. Its goal is to work closely with the industry to exploit the commercial opportunities of new hydrogen technology solutions in order to make Norway a global leading maritime hydrogen player.
Norwegian Offshore Wind Cluster[374]	Has the goal of becoming the strongest supply chain for floating offshore wind worldwide. Membership in this cluster is open for any type of organization or company, international as well.
Sustainable Autonomous Mobility Systems Norway (SAMS)[375]	Focuses on development of systems for sustainable autonomous transport solutions used on land, air, and sea. One of their focus areas is building test areas for autonomous systems.
NCE Aquatech Cluster[376]	One of the largest aquaculture clusters globally and has more than 100 partners. The clusters focus area is sustainable aquaculture food production - and the participants standing and common ambitions towards an international market.
NCE Seafood Innovation[377]	Aims to contribute to sustainable seafood growth by focusing on innovation. The cluster focuses on mobilizing joint forces and contributes through sustainable innovation projects and by facilitating interaction across the industry. The cluster is seen as one of the most complete clusters and knowledge hubs in the seafood industry and has 70 partners. The cluster plays a leading role in the sustainable development of the seafood industry and makes considerable investments in R&D and innovation.
NCE Maritime Cleantech[378]	Represents one of the world's most complete maritime commercial hubs. The cluster uses the Norwegian maritime expertise as a springboard for the development of new, energy-efficient and environmentally friendly technologies. The cluster shall strengthen the cluster partners' competitiveness by developing and launching innovative solutions for energy-efficient and clean maritime activates.
GCE Ocean Technology[379]	An industry driven initiative within ocean technology with more than 120 partners and members. The cluster develops and supplies innovative ocean technology within a wide range of applications, including: ▪ Subsea oil and gas production ▪ Marine renewable energy production ▪ Exploration of marine mineral resources

[373] https://www.oceanhywaycluster.no
[374] https://offshore-wind.no
[375] https://sams-norway.no
[376] https://aquatechcluster.no/?lang=en
[377] https://seafoodinnovation.no
[378] https://maritimecleantech.no
[379] https://www.gceocean.no

The Ocean Autonomy Cluster[380]	Develops and commercializes world leading autonomous solutions for the ocean space. The cluster consists of both companies and R&D institutions, combining research and technological development, suppliers of technology, components and systems, as well as forward-leaning investors.
NORWEP (Norwegian Energy Partners)[381]	Norwegian Energy Partners' main objective is to promote Norwegian energy industry in overseas markets and provide market information to our partners.
Energy Network Norway[382]	The network for LNG, hydrogen, and hybrid energy. The network operates as a think tank for creating and presenting new business opportunities to the LNG, hydrogen and hybrid sectors and acts as enabler between product and services companies and governmental bodies. The network is sponsored by Innovation Norway.
Maritime Battery Forum[383]	Promotes battery-based value creation and aims to make batteries a success within the global maritime market. They are a meeting place for exchange of knowledge based on experience from the usage of batteries of batteries within the shipping and offshore industries. The forum promotes the members' interests and ambitions to become world leading in their respective fields activity towards a sustainable maritime industry with green growth.
Maritime Forum[384]	Maritime Forum is an interest organization gathering the entire maritime industry in Norway. Its 700+ members have developed a world leading, complete maritime cluster. Maritime Forum has 8 offices in the most important maritime regions in Norway. Maritime Forum was established in 1990 by the Norwegian Shipowners' Association, The Federation of Norwegian Industries, Norwegian Shipbrokers' Association and DNV. The purpose was to gather the maritime community in Norway and showcase its complete maritime cluster.
The Norwegian Shipowners' Association[385]	The Norwegian Shipowners' Association (NSA) is a trade and employment organization for Norwegian controlled companies within the shipping and offshore industry established in 1909. The primary fields are national and international industry policies, employer issues, competence and recruitment, environmental issues, and innovation in addition to safety at sea. Its members are the core and driving force in the Norwegian maritime cluster. NSA's members employ about 50,000 seafarers and offshore workers from nearly 50 different nations.
The Federation of Norwegian Industries[386]	The Federation of Norwegian Industries is part of the overall Confederation of Norwegian Enterprise (NHO). The federation represents more than 2,850 member companies with approx. 127,500 employees. Their most important task is to ensure that society understands how important a viable industry is for the future welfare of the country.

[380] https://oceanautonomy.no
[381] https://www.norwep.com/About/Contact-us/Worldwide/Canada-office
[382] https://www.ennorway.com
[383] https://www.maritimebatteryforum.com
[384] https://www.maritimt-forum.no
[385] https://rederi.no/en/
[386] https://www.norskindustri.no/om-norsk-industri/in-english/

13. Supplement: Canada

13.1 Start-ups, accelerators, entrepreneurs

COVE

The Center for Ocean Ventures & Entrepreneurship (COVE) is a collaborative facility for applied innovation in the ocean sector. Located in the Halifax Harbour, the hub is home to local and global ocean technology businesses post-secondary institutions, researchers and marine-based and service businesses supporting the ocean sector.

Kongsberg Maritime from Norwegian Kongsberg Group is the only Nordic member of COVE.

"Our presence at COVE is a logical extension of our established Dartmouth office," says Nick Burchill, Sales Manager for Kongsberg Maritime, Canada. "COVE keeps us in touch with developments in the local ocean tech sector and brings us closer to our customers and industry partners. We look forward to expanding on our relationships and finding new ways to introduce Canadian ocean tech to the world."

13.2 Governmental ideas and initiatives

Atlantic Canada Opportunities Agency - Investments and Initiatives

Currently, Atlantic Canada's high growth potential sectors are largely (though not exclusively) limited to oil, gas and aquaculture. Sectors with more moderate growth potential include defense, security, simulator and sensor technologies. More modest growth potential sectors include fisheries, tourism, and transportation.

The marine transportation sector is already responsible for 20% of Canada's total international trade. As the ocean provides critical links across the globe, including to the Nordic countries, the demand for shipping is expected to grow.

Ocean Protection Plan (OPP)

With a $1.5 billion investment, the Oceans Protection Plan aims to ensure cleaner, healthier and safer oceans for years and is the largest investment ever made by the Government of Canada.

Atlantic Fisheries Fund

The Atlantic Fisheries Fund is a contribution program funded by federal, provincial and territorial governments. Its plan is to invest over $400 million over 7 years to support Canada's fish and seafood sector. The aim of the fund is to help the Canadian seafood sector to transition to the growing market demands for products. These are high quality products that add value and are sustainably sourced. The Atlantic component of the fund focuses on innovation, infrastructure and science partnerships. Innovation shall encourage the development of new products and technologies in harvesting, aquaculture and processing. Infrastructure shall encourage the use of new technologies or processes to improve sustainability, while science partnerships will form industry-based R&D-collaborations.

Marine Spatial Planning

Marine Spatial Planning (MSP) is an approach meant to help balance the increased demand for human activities with the need to protect marine ecosystems. Approximately 65 countries are currently using this approach.

IOC inventory of MSP Activities
IOC = Intergovernmental Oceanographic Commission, UNESCO

DENMARK	EEZ and Territorial Sea - No national MSP plan exists; the Danish Parliament has adopted Act on Maritime Spatial Planning in 2016; The Danish Maritime Authority is the competent authority; Sectoral plans exist for energy, fisheries, infrastructure, environmental protection, etc.; as a Member State of the EU must have maritime spatial plan in place by 2021.
FINLAND	EEZ and Territorial Sea - Legal authority for MSP transposed in October 2016; MSP underway in the territorial sea by eight regional councils that will develop three plans; A plan for the Kymenlaakso region has been completed; as a Member State of the EU must have maritime spatial plan in place by 2021.
ICELAND	National Planning Strategy (2015-2026) - MSP underway through Skipulagsstofnun, the Icelandic National Planning Agency, since 2013.
NORWAY	Integrated Ocean Management Plan for Norwegian Sea - Ecosystem-based MSP plan for Norwegian Sea approved in 2009; updated in 2017; covers Norwegian Sea part of Norwegian EEZ.
SWEDEN	Marine spatial plans for Gulf of Bothnia, Baltic Sea, and the Skagerrak / Kattegat - No MSP plans in place; National MSP legislation passed in 2014; MSP regulations in place in 2015; New Swedish Agency for Marine and Water Management created in 2011; Three marine spatial plans will be produced by municipal-level governments for the Gulf of Bothnia, the Baltic Sea, and Skagerrak / Kattegat, covering the entire EEZ; as a Member State of the EU must have maritime spatial plan in place by 2021; In December 2016 SwAM published early draft MSP-proposals for all three national MSP areas; In January/February 2017 environmental impact assessments were published for the three areas; publication of first round proposals for the plans with environmental impact assessments is scheduled for 2018; four new Natura 2000 areas have been established in the Baltic Sea.

Ocean Frontier Institute (OFI)

Under the Canada First Research Excellence initiative, the federal government along with provincial and industry partners established the $220 million Ocean Frontier Institute partnership announced in September 2016. Dalhousie University, in partnership with University of PEI and Memorial University of Newfoundland, leads the OFI, with a mandate to advance ocean research focused on changes in ocean environments and the development of solutions.

Canada's Ocean Supercluster (OSC)

As one of five superclusters under ISED's Innovation Supercluster Initiative, the OSC represents an industry and government investment of over $300 million to advance innovation and improve Canada's competitiveness in its ocean-based industries. The OSC is focused on ocean industry verticals including fisheries (both wild and sea farming), defense and security, oil and gas, and marine renewables. The Supercluster is based in Atlantic Canada, but has a national mandate and expects to create more than 3,000 jobs nationally and increase the value of Canadian products and services by $14 billion over 10 years.

One year into its initial four-year mandate, the industry-led OSC is focused on building upon Canada's world-class ocean-related business activity, research capacity, and proven technology expertise.

The OSC expects to foster much of the anticipated growth in Canada's blue economy by building on the strength of the existing regional ocean cluster in Atlantic Canada.

Defense Procurement Strategy

Announced in February 2014, the DPS has transformed Canada's Industrial and Regional Benefit Policy into the Industrial and Technological Benefit Policy. This change helps ensure that future defense and security procurements are better leveraged, securing and creating jobs and economic growth in Canada. One of the core elements of this strategy is a rated and weighted Value Proposition. This creates more motivated bidders that wish to advance their best value proposition for Canada in bid proposals, as industrial considerations now directly influence which bidding firm wins a contract.

National Research Council (NRC) Facilities and Programs

NRC's research spans a broad spectrum, including ocean-related activities. Their research enables its partners to accelerate commercial development and advance research that leads to scientific breakthroughs and innovation. In St. John's, the Ocean, Coastal and River Engineering (OCRE) Research Center has extensive expertise researching the effects of ice and waves on ships, structures and shorelines, and is a leader in developing and evaluating tools and technologies for harsh marine conditions. In Halifax, the Aquatic and Crop Resource Development (ACRD) Research Center operates an Industry Partnership Facility that accommodates scientists from companies demonstrating commercial potential for new bio-based products and processes. The ACRD also has a Marine Research Station at Ketch Harbour (a marine cultivation facility) and the Zebrafish Research Facility (a unique fusion of oceans and pharmacology research). The Industrial Research Assistance Program (IRAP) provides advice, connections, and funding to help Canadian SMEs increase their innovation capacity and take ideas to market. With a wealth of expertise in ocean technology, NRC IRAP not only invests in ocean-related R&D; it also provides significant advice and strategy development to help companies grow.

OCEAN INDUSTRY FORUM OSLOFJORD

This report is produced by Ocean Industry Forum Oslofjord for the Embassy of Canada to Norway.

Ocean Industry Forum Oslofjord is Maritime Forum Oslofjord (est. 2012), and one of three associations in the Maritime Oslofjord Alliance. The other two are Oslo Shipowners' Association (est. 1905), which is the Oslo Chapter of the Norwegian Shipowners' Association, and Shipping & Offshore Network (est. 1981). The latter is an international association with members from several countries, incl. Danish Ship Finance (Denmark), Wallenius Marine (Sweden) and Norsepower (Finland), all mentioned in this report. Canadian companies are welcome to become a member of this association for better access to the ocean industry and blue economy in Norway.

MEMBER OF THE ALLIANCE
Maritime Oslofjord

For more information, please visit https://maritimeoslofjord.no