

European and National Regulations on Seaweed Cultivation and Harvesting

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1. European Legislation Relevant for Macroalgae Cultivation and Harvesting

In Europe, seaweed aquaculture is still at an early stage. The same applies to the legislation of this activity. The EU and individual European countries lack seaweed-specific legislation, apart from the EU rules on organic seaweed (see below). The main EU legislations related to seaweed aquaculture are the Maritime Spatial Planning Directive 2014/89/EU, the Marine Strategy Framework Directive 2008/56/EC, the Water Framework Directive 2000/60/EC, the Alien Species Regulation 2014/1143/EU along with the Regulation on Aliens Species in Aquaculture 2007/708/EC, the Habitats Directive 92/43/EEC, and the Regulation on Organic Production 2018/848/EU. Barbier and collaborators (2019) summarise the mentioned EU regulations and appoint the main challenges of applying these legislations on seaweed aquaculture as described below.

According to the Maritime Spatial Planning Directive (MSPD) 2014/89/EU, each EU Member State needs to have Maritime Spatial Plans (MSP) based on an ecosystem approach to promote sustainable economic development and ecological protection. The development of seaweed aquaculture must be based on good management of space use, by promoting maximum production with minimum impact on the environment and coordinated with other maritime activities (Barbier et al. 2019).

The Marine Strategy Framework Directive (MSFD) 2008/56/EC declares that member states must establish and implement a program of measures to achieve or maintain Good Environmental Status (GES) of the marine areas by 2020. Thus, aquaculture development should not negatively affect biodiversity and intertidal ecosystems, should not contribute to the introduction of invasive species, and should not contribute to eutrophication of coastal areas or the open sea (Barbier et al. 2019). Similarly, for inland surface, transitional, coastal and ground water, the Water Framework Directive (WFD) 2000/60/EC establishes a framework for the protection and enhancement of good status.

Aquaculture development should not negatively affect biodiversity or increase eutrophication (Barbier et al. 2019).

The goal of the Alien Species Regulation 1143/2014 EU is the prevention and management of the introduction and spread of invasive alien species. There is a special regulation 708/2007 for protecting aquatic habitats from the use of alien and locally absent species in aquaculture. According to Barbier et al. (2019), the list of invasive alien species needs to be harmonized in the EU specifically concerning alien species that have long been used in aquaculture.

The goal of the Habitats Directive (92/43/EEC) on the conservation of natural habitats and wild fauna and flora is to promote biodiversity by protecting natural habitats and species, contributing to the sustainable development of ecosystems at the EU level. Natural habitat types of community interest include coastal and halophytic habitats, specifically open seas and tidal areas with reefs. Thereupon, aquaculture development should be compatible with the protection of natural habitats and biodiversity (Barbier et al. 2019). The Environmental Impact Assessment Directive 2011/92/EU and its amendment 2014/52/EU lay down the procedure for conducting environmental impact assessments of private and public granted projects, for instance aquaculture, and before conducting the activity. In the category of fish farming there is no mention of seaweed, but wide-scale operations might require impact assessment.

Organic seaweed has its own regulatory category. The Commission Regulation 2009/710/EC lays down detailed rules on organic seaweed production. The Regulation on Organic Production 2018/848/EU on organic production and labelling of organic products applies, defining the production rules for algae, including harvesting of natural stocks as well as their cultivation (Part III: Production rules for algae and aquaculture animals, 2. Requirements for algae). The collection of wild algae and parts thereof is considered as organic production provided a) the growing areas are suitable from a health point of view and are of high ecological status as defined by Directive 2000/60/EC and b) the collection does not affect significantly the stability of the natural ecosystem or the maintenance of the species in the collection area. Furthermore, the amounts collected do not cause a significant impact on the state of the aquatic environment. Organic algae aquaculture at sea shall only utilize nutrients naturally occurring in the environment, or from organic aquaculture animal production, preferably located nearby as part of an Integrated Multi-Trophic Aquaculture (IMTA) system. Culture density or operational intensity shall be recorded and shall maintain the integrity of the aquatic environment by ensuring that the maximum quantity of algae which can be supported without negative effects on the environment is not exceeded. Ropes and other equipment used for growing algae shall be re-used or recycled where possible.

2. National Strategies, Regulations, and Activities in the Seven GRASS Partner Countries

2.1. National Strategies and Maritime Spatial Planning Processes

All the **GRASS countries** approved different programme or strategies in order to implement the EU MSFD (Table 1). In some of the national strategies, algae(macro) are mentioned as a potential raw marine biomass with industrial value (see Finland, Sweden, Germany and Latvia). In addition, some of

the countries approved their marine spatial plans or are in the process of adopting, in order to implement the MSPD (see below).

In Finland, the Ministry of Agriculture and Forestry, in collaboration with the Ministry of Employment and the Economy, and the Ministry of the Environment, has implemented the Aquaculture Strategy 2022 and the Finnish Bioeconomy Strategy (2014), which is in the process of being updated based on the last EU Bioeconomy Strategy for 2018. Also, the Finnish Government approved the Marine Strategy and the River Basin Management Strategy to adopt the MSFD and the WFD, respectively. The Marine Strategy comprise three parts: 1) Initial assessment of the state of the marine environment in 2012, 2) Monitoring programme in 2014 and 3) Programme of measures between 2016 and 2021. Only the Bioeconomy Strategy mentions seaweed culture with potential for energy production (Ministry of Agriculture and Forestry of Finland, 2014. Regarding the management of the marine space, the Finnish Ministry of Environment, in cooperation with eight Coastal Regional Councils and stakeholders, approved the first MSP for Finland 2030 in December 2020 (MSP for Finland 2030, 2020) based on the Land Use and Building Act (132/1999, amendment 222/2003 included). The Finnish MSP2030 covers the Exclusive Economic Zones (EEZ) and three territorial waters. The regional councils for the three planning areas are: Gulf of Finland–Helsinki-Uusimaa Regional Council and Regional Council of Kymenlaakso; Archipelago Sea and Southern Bothnian Sea–Regional Council of Southwest Finland and Regional Council of Satakunta; Bothnian Sea, Quark and Bothnian Bay–Regional Council of Ostrobothnia, Regional Council of Central Ostrobothnia, Council of Oulu Region and Regional Council of Lapland. The MSP outlines potential sectors for energy industry, maritime transport, fishing and aquaculture, tourism, recreational use, and preservation, conservation and improvement of the environmental. Other important sectors in terms of planning are cultural heritage, maritime industry, extractive sector and blue biotechnology. The vision for 2030 considers blue biotechnology to incorporate innovation and cooperation between sectors and use technology to develop new products from marine biomass. Within the blue biotechnology, micro-and macroalgae cultivation are mentioned as potential biomass with high added value in food, wellbeing products, pharmaceutical and energy source, and also to improve the marine environment by removing nutrients (Finnish MSP2030, 2020). Åland Islands is an autonomous region of Finland and has jurisdiction over its own MSP. The provisions concerning MSP laid down in the Water act (Vesilaki 587/2011). The MSP for Åland Islands was approved in 2021.

In Sweden, the Ministry of Enterprise and Innovation has published the Maritime Strategy 2015 and the Food Strategy, where the need for regulatory simplifications for aquaculture has been recognized. The Maritime Strategy mentions the strong development potential of cultivating micro and macro algae. In 2017 and 2018, the Swedish government held a series of roundtable discussions with the industry to clarify the challenges and possible solutions. Sweden sees that clear regulations and a reduced administrative burden promote business development. The government is aiming to find a favorable and functional way forward. The Swedish government is in the process of adopting the MSP proposed in 2019 by the Swedish Agency for Marine and Water Management. The legal basis of the MSP is the Swedish Environmental Code Ds 2000:61 and the Plan and Building Act (2010:900). The proposed MSP, covers three distinct territorial waters: Gulf of Bothnia, Baltic Sea and Skarregat/Kattegat. The MSP specify thirteen uses: electricity transmission, energy extraction and its

investigation area, defense, general use, culture, nature, recreation, sand extraction and its investigation area, maritime shipping and its investigation area, commercial shipping. Although, seaweed is not included in the MSP proposal, seaweed cultivation is mentioned as a potential aquaculture activity to obtain oils, vitamins and proteins and produce ingredients for food, feed, medicine and fuels. Also, the potential for reducing eutrophication is recognized as another environmental benefit in the MSP. A Strategic Environmental Assessment of the MSP proposal for the three territorial waters was also proposed in 2019. The aim of the Strategy is to integrate environmental considerations into planning and decision-making to promote sustainable development.

The Federal Government of Germany has approved the National Bioeconomy Strategy 2030 where seaweed was recognized as a potential source of raw material with many different applications (Federal Ministry of Education and Research, 2011). Germany has the German algae round table (Bundesalgenstammtisch) for interdisciplinary networking on the topic of micro and macro algae, and the Kiel region has a round table of its own. There is also a yearly event on algae biotechnology, collecting 150 – 160 participants from research, industry, and politics. The organizer is DECHEMA e.V. (German Society for Chemical Apparatus, NGO). Germany has approved an MSP for its two EEZ, in the North Sea and Baltic Sea, and for the three territorial sea areas of the coastal federal states (Länders) of Lower Saxony, Schleswig-Holstein, and Mecklenburg-Vorpommern. The MSP in the two EEZ is regulated by the general Spatial Planning Act (BGBl. I S. 2986) and is implemented by the Federal Government, whereas the MSP for the coastal areas is implemented by the three federal Länders authorities. Currently, the MSP is amended and revised in Lower Saxony, implemented in Schleswig-Holstein and completed in Mecklenburg-Vorpommern. Aquaculture is included in the Schleswig-Holstein and Mecklenburg-Vorpommern MSPs, but seaweed cultivation is not included in the plans.

In Estonia, different Sustainable acts and strategies have been adopted (Republic of Estonia, 2016). In 1995, the Parliament of Estonia (Riigikogu) passed the Sustainable Development Act and in 2005 the “Sustainable Estonia 21”. The last one covered three of the main goals of the 17 global sustainable development goals proposed by the United Nations (growth of welfare, coherent society, and ecological balance). A new national long-term development strategy “Estonia 35” has been approved by the Estonian Government in 2020, which has been based on the global Sustainable development goals. Also, the Estonian Government has approved the Development Plan for Agriculture and Fisheries until 2030 (Ministry of Rural Affairs, 2020). The Plan aims to promote the development of different sectors such as fisheries and aquaculture sustainably and maintain a good environmental status in terrestrial and aquatic ecosystems. It serves as a guideline to develop fisheries policy to ensure an economically viable industry in a good marine environment. Aquaculture is one of the marine sectors tackled in the new draft plan of the Estonian MSP, which also include fisheries, maritime transport, renewable energy production, tourism and recreation, water cultural heritage, natural protection, national defense, mineral resources, and seabed infrastructure, (Ministry of Finances, 2020). Under the aquaculture chapter, seaweed is mentioned as a potential aquaculture activity. The MSP provides guidelines and conditions for the development of seaweed farming, including mapping the natural growth potential of algae and suitable areas for seaweed cultivation (Western part of the Väinameri Sea and the Gulf of Finland). The MSP expects aquaculture to have

positive synergies with wind energy developments; it supports “cluster solutions”- combining nutrient adding fish farm at sea with the nutrient-removing algae and/or shellfish farming. It is clearly specified that seaweed farming must be distinguished from fish farming regarding the need for environmental impact assessments. The Estonian MSP is implemented by the Ministry of Finance and covers the internal waters, the territorial sea and the EEZ based on the Planning Act 2015. Currently, the MSP is in public consultation phase and in the process of adoption. This new Estonia MSP is derived from two pilot MSP projects developed at the area around Hiiu island and Pärnu Bay area, which were adopted in 2016 and 2017, respectively.

In Latvia, the Ministry of Agriculture has developed the Bioeconomy Strategy 2030 where algae are mentioned as a bio-potential resource for pharmaceutical and chemical industries. According to the Strategy, knowledge and innovation is needed for developing innovative and high added value niche products from traditional and non-traditional animal and plant raw materials. The Latvian MSP2030 was adopted in May 2019. The authority responsible for implementing MSP is the Ministry of Environmental Protection and Regional Development and it is regulated by the Spatial Development Law. The plan extends across the Inland Marine Waters of the Republic of Latvia, the Territorial Sea and the EEZ and features the following uses: shipping, ports, nature conservation, fisheries, tourism, military, scientific research, and submarine cables and pipelines. An earlier draft of this document accommodated aquaculture sites. The final plan states that aquaculture installation suitability will be evaluated case by case. The reason is that there are currently no proposals for the development of aquaculture installations. The collection of beach cast macroalgae has not been considered in the existing MSP.

In Poland, the Polish National Smart Specialization Strategy covers marine constructions for the development of aquaculture as well as technologies, devices, and methods for cultivation of marine organisms. This strategy is included in the Strategy for Innovation and Efficient Economy-Dynamic Poland 2020, which is consistent with the EU development Strategy 2020 and the provisions of the National Development Strategy 2020. Also, Poland has adopted the Maritime Policy of the Republic of Poland until 2020 (with forecast until 2030). The aim of this maritime policy is increasing the maritime economy sector by maximizing the sustainable use of the maritime location, sea and ocean resources and increase the awareness of the important role of maritime resources play in the Polish society and its economic development. The Polish MSP process covers Polish Internal Sea Waters, Territorial Sea and EEZ in Scale 1:200,000. The legal framework for the MSP is the Act on Sea Areas of the Republic of Poland and the Maritime Administration March 1991, including the changes adopted in 2015 regarding inter alia, MSP procedure in Poland. The plan has been prepared by the Maritime Offices in Szczecin, Słupsk and Gdynia but the MSP has not been adopted yet. As part of the MSP planning process, the Polish Marine Areas were divided into 94 basins identified with a main function. The Main Functions are the leading way of using a given basin, which cannot be disturbed by other forms of use. None of the basins has defined aquaculture as the main function, but aquaculture is an allowed function in many waters. Aquaculture is seen as having possible synergies with mining constructions and with wind energy production.

In Russia, the Russian policy toward the Baltic Sea region (BSR) has never been clearly stated, but Russia has the Strategy for the Socio-Economic Development of the North-Western Federal District (Makarychev & Sergunin 2017). MSP is not legally defined in Russia and the waters are under the oversight of the federal states. The maritime activities are regulated by sectorial laws referring to the Russian Federation's continental shelf, four EEZ (Atlantic Ocean, Arctic Ocean, Pacific Ocean and Caspian Sea), internal waters, the territorial sea and the contiguous zone of the Russian Federation. Although, there is not a legislative MSP, there are several projects to develop an integrated coastal management in the zones of the Baltic and Barents Sea, the Black Sea and the Far Eastern Sea.

Table 1. Maritime Spatial Plan (MSP) and marine strategies in GRASS countries. The third column shows the mention of seaweed in the MSP (*in black) and/or in the marine strategies (*in red).

GRASS	MSP	MARINE STRATEGIES	SEAWEED included
FINLAND	YES; MSP2030*	Finnish Bioeconomy Strategy 2014* National Aquaculture Strategy 2022 Marine Strategy River Basin Management Strategy	*Mentioned as blue biotechnology: potential raw biomass with high level added value and reduce nutrients *Potential in energy production
SWEDEN	Proposed in 2019; In process of adopting*	Maritime Strategy* Food Strategy	*Potential aquaculture activity to obtain ingredients for food, feed, medicine or energy industry, and reduce nutrients *Macro- and microalgae with potential in aquaculture activity
GERMANY	YES	National Bioeconomy Strategy 2030*	Unknown in MSP *Potential raw materials for different industries
ESTONIA	Proposed in 2019; In process of adopting*	Sustainable Estonia 21 Estonia 35 Development Plan for Agriculture and Fisheries until 2030	*Potential aquaculture activity. Potential Cluster-solutions combining fish and algae farms Not mentioned in the Strategies
LATVIA	YES; MSP 2030	Bioeconomy Strategy 2030*	Not in the MSP *Seaweed with potential in chemical and pharmaceutical industry
POLAND	Proposed in 2019; In process of adopting	Smart Specialization Strategy Maritime Policy of the Republic of Poland until 2020	Not mentioned
RUSSIA	No legally defined	Strategy for the Socio- Economic Development	Not mentioned

2.2. National Permit Systems and Legal Rules

In the GRASS countries, there are no specific seaweed laws at national level. The regulations are based on water, environmental, or fishing laws (Table 2). The same occurs with licensing procedures: there are no specific application farming forms and seaweed permits. As an exception, Estonia has the Fishing Act that includes the regulation for harvesting *Furcellaria lumbricalis* (see below).

In Finland, all aquaculture activities are subjected to the same rules and processes and there is no specific law. The Water Act (Vesilaki 587/2011), implemented by the Ministry of Agriculture and

Forestry (Maa – ja metsätalousministeriö), and the Environmental Protection Act (Ympäristönsuojelulaki 527/2014), implemented by the Ministry of Environment (Ympäristöministeriö), are the main legal instruments ensuring the environmental safety of aquaculture operations. According to the Water Act 587/2011, a water resources management project, for instance seaweed cultivation, may require a permit if cases damage to fishing or harm to waterborne traffic or significantly reduces the beauty of nature, causes deterioration in the amenities of the environment or in cultural values or the suitability of the water body for recreational use (Water Act 3:2§). The permit for a water resources management project will be granted if: 1) the project does not significantly violate public or private interests; or 2) the benefit gained from the project to public or private interests is considerable in comparison to the losses incurred for public or private interests. In order to receive a permit, an applicant must have the right to use the sea area, based on ownership or granted the right to the area belonging to another party (Water Act 2:12§ – 13§). The procedure for receiving the water-legal permit takes about 6 months. If activities carry a risk of harming the environment, also an environmental permit is needed according to the Environmental Protection Act 527/2014. In case the project may significantly weaken nature values in Natura 2000 areas, it must be evaluated according to the Nature Conservation Act (Luonnonsuojelulaki 1096/1996). The Environmental Protection Act allows an exemption on the required environmental permit for short-term activities undertaken on an experimental basis to test an emerging technique or raw material, and if there are no serious environmental impacts (Environmental Protection Act 4:31§). Typically, macroalgae cultivation is not presumed to harm the environment, and the need for an environmental permit for this type of operations is still under discussion. However, a written notification of the experimental activity shall be submitted to the Regional State Administrative Agency (Aluehallintovirasto, AVI) at the latest 30 days before starting the activity. AVI's decision on the experimental activity includes the legal obligations, including the definite amount of time for the experimental activity and water management. AVI is also the authority that process the application for aquaculture operations, for instance seaweed cultivation, and permits. The Centre for Economic, development, Transport and the Environment (Elinkeino-, liikenne- ja ympäristökeskus, ELY) makes the decision of the need of a permit. The applicant may also need to consult the Transport Infrastructure Agency (Väylävirasto) to confirm whether the seaweed cultivation activity is affecting the sea traffic. The Finnish company Origin by Oceans contacted ELY authority to discuss the seaweed cultivation licensing process. The company was asked to fill out an environmental and water management permit application form for fish farming (Ympäristö- ja vesitalouslupahakemus kalankasvatukselle), but only the parts which apply to seaweed farming. Origin by Oceans is the first company that are planning to conduct this type of operations in Finland. More experience in this type of operation would be needed to improve the licensing process. Currently, the company Origin by Ocean is granted with a permission to use the water area by ownership, but experimental permit and water permit are still in process.

In Sweden, there is not a specific Aquaculture law, and all the water activities and water facilities are recognized in the Environmental Code and in the Act (1998/812) with Special Provisions on Water Activities, both implemented by the Ministry of the Environment (Miljödepartementet), Government Offices of Sweden (Regeringskansliet). The definitions contained in the Environmental Code also apply to this Act. Some provisions deal with proceedings by the Land and Environmental Courts (Mark- och miljöödomstolen), like cultivation of seaweed and sea urchins. These activities are recognized as a

different activity from fish, mussels and crayfish aquaculture (Environmental Code – Water operations 11) which entails the execution of an environmental impact assessment. This is a major challenge: receiving the permit for seaweed aquaculture takes time and is demanding. The process of obtaining the license for the company Nordic SeaFarm was 15 months, although they were familiar with the application process. The application is approved by the County Administrative Board (Länsstyrelse), which is the authority that grants the water permit for water operations at sea to access the water area through ownership, agreement, or other right of use it (Water activities - Vattenverksamhe, Länsstyrelsen). The Board is the regional government authority responsible for nature conservation and environmental and public health among others. Operations smaller than 0.3 ha are except of the water permit. These small operations are subject to notification and must be reported to the County Administrative Board. For aquaculture in beach-close environments, one must apply for an exemption from the beach protection regulations according to the Environmental Code. If the area is in a national park, nature reserve, biotope protection or Natura 2000 area, the exemption is applied from the County Administrative Board. For unprotected areas, an exemption can be granted by the municipality. If the algae are to be used for food and feed consumption, there is a need to register as a primary producer with the County Administrative Board. In addition to the sea areas, Sweden has lakes where macroalgae aquaculture operations are possible.

In Germany, the Ministry of Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft – BMEL) is the ministry responsible on fisheries and fish farming. None of the fishery's laws (Fischereigesetz) of the sixteen Länder include explicitly the term aquaculture. Seaweed cultivation is not considered in their legislation, and a licensing procedure is not defined. For seaweed cultivation, only a water permit is needed, in accordance with Section 31 of the Federal Waterways Act – Bundeswasserstraßengesetz, 2007 (WaStrG). The issuing authority for water-legal permits is the Waterways and Shipping Administration (Wasserstraßen und Schifffahrtsverwaltung - WSA) that depends on the Federal Waterways Act and on the Water Acts of the Länder, for example the Water Act of the Mecklenburg Western-Pomerania. After obtaining the permission, the WSA offers a contract to lease the area. In addition to the federal-level permits, further permits are required under state law (nature conservation; coastal protection) and must be applied for from the responsible German state authorities. In Mecklenburg Western-Pomerania, either the Regional State Office for Environment and Nature (Staatliche Amt für Umwelt und Natur) or the lower water authority of the Land (untere Landeswasserbehörde) issues the water-legal permit, depending on whether it concerns 'first category' or 'second category' water bodies as defined in the provincial Water Act (FAO 2005-2021). For cultivating algae in Schleswig Holstein close to shipping areas, a permission to use the waterbody (Schifffahrtspolizeiliche Genehmigung) is needed to cover the protection of wildlife, including species and biotopes. Seaweed harvesting in Germany must only be done in "clean waters": not next to ports, nuclear power plants, wastewater discharges, or fish farms. The harvesting activity can be done only to an extent that allows the stock to rebuild itself and only in a manner that does not harm other living organisms in the sea. Completely removing macroalgae beds is not allowed.

In Estonia, the harvesting of *F. lumbricalis* is the only seaweed industry occurring at present. It is either collected on the shore as beach-cast or the loose-lying form of the algae is trawled from the seabed from two locations in Kassari Bay (between Hiiumaa and Saaremaa islands). *F. lumbricalis* is also the

only aquatic “plant” currently regulated through the Fishing Act (Kalapüügiseadus 2015). Fishing Act set rules on harvesting areas and harvesting frequency of *F. lumbricalis*. This red seaweed in the sea is owned by the state, but when washed ashore it is in the ownership of the owner of the immovable property located on the shore. Commercial fishing authorization is needed for the harvesting of the loose form of *F. lumbricalis*, and it is granted for no longer than one calendar year at a time with the possibility of renovation, whereas the beach-cast seaweed is exempt of license. The quantities allowed to harvest (normally 2000 T per year), harvesting area and gear are stipulated on the authorization. With that, harvesters are allowed to harvest one location per year and that area must be left unharvested for the following year. There is a monitoring program to follow the recovering of the seaweed population. All the harvesting activities must be reported to the Agriculture and Food Board (Põllumajanduse ja Toiduamet - ja Toiduamet) under the Ministry of Rural Affairs (Maaeluministerium) which is the competent authority to give authorization for harvesting seaweed. During the last 30 years, the licenses have been bought by two companies, and it is not possible to apply for new licenses for natural stock preservation reasons. In the case of cultivation, there are no seaweed-specific licenses. Seaweed cultivation is regulated through the Water Act (Veeseadus 1994). Seaweed cultivation follows the same regulations as windmill parks. Thus, developers must apply for a superficies license as well as a building permit (Water Act 4:22§; 5:22§) from the Consumer Protection and Technical Regulatory Authority (Tarbijakaitse ja Tehnilise Järelevalve Amet). The company EstAgar is still in the process of obtaining the license something they started in 2018. A water permit for special use of water may be needed (Water Act 2:9§), where the competent authority is the Environmental Board (Keskkonnaamet) under the Ministry of Environment (Keskkonnaministerium). The Water Act sets requirements on the superficies license and permits for special use of water such as aquaculture. The Nature Conservation Act (Looduskaitseadus 2004) sets requirements on operations in the Natura 2000 areas and on the introduction of non-native species.

In Latvia, the Marine Environment Protection and Management Law (Jūras vides aizsardzības un pārvaldības likums 2010) determines the rights and obligations of the sea users, the necessity of permits, and the permit procedure. A permit for aquaculture can be granted for at the time period up to 30 years. The licensing process can last 400 days and more. The competent licensing authority is the National Board of Fisheries (Valsts zivsaimniecības padome) under the Ministry of Agriculture (Zemkopības Ministrija). Aquaculture producers are registered by its Food and Veterinary Service. The Law on the Conservation of Species and Biotores may become relevant, and the planned activity may also go under the Law on Environmental Impact Assessment. Protection Zone Law applies to seaweed collection from the beach, restricting economic activity in the Baltic Sea and Gulf of Riga coastal protection zone. Law on ‘Specially Protected Nature Territories’ (1993) lists the protected areas in its Annex. ‘General Regulations’ and ‘Individual Regulation on Protection and Use of Specially Protected Nature Territories’ apply. Local land use plans and regulations may determine places and procedures for accessing the coast with mechanized transport that is needed for the collection of the seaweed. The document ‘Procedures for Establishing and Maintaining a Bathing Water Site and Managing its Water Quality’ prescribe that during bathing season, the manager of the bathing water site shall ensure regular and timely collection and removal of waste (including washed out seaweed).

In Poland, there are currently no specific regulations regarding the cultivation and harvesting of algae. Regulations on aquaculture at sea are quite limited. This is mainly due to the lack of tradition, poor hydrological conditions and small, but mostly negative experience with aquaculture in the conditions of the Polish Baltic Sea coast. The legislation in force regulates the cultivation of algae at sea in two aspects: the cultivation of living organisms and the erection and exploitation of structures in marine waters. For the first, cultivation of marine organisms requires a permit from the Ministry of Maritime Economy and Inland Navigation: Fisheries Department (Ministerstwo Gospodarki Morskiej i Żeglugi Śródlądowej: Departament Rybołówstwa) supplied with Decision on Environmental Conditions (Environmental Impact Assessment could be needed), and the permit for the introduction into the marine areas or the translocation of alien species or locally absent species. For the second, the Permission for the construction and use of artificial islands, installations and devices is needed according to the Water Law 2001. The water-legal permit is required for so called 'special water use', and the permission to perform underwater works in maritime areas. The Nature Conservation Act 2004 applies. Laws on nature protection are very restrictive. Two species, potentially the most suitable for aquaculture (*Fucus vesiculosus* and *F. lumbricalis*) are under a special species protection, with additional restrictions that practically prevent aquaculture, and any other activity with these species, even including research activities. The introduction of non-native species into aquaculture is also subject to many regulations.

In Russia, the permit for the harvest of wild reserves of macroalgae and for the aquaculture of macroalgae is issued by the Federal Fisheries Agency (this agency is part of the Ministry of Agriculture of the Russian Federation). In total, the Federal Agency includes 18 Territorial Administrations. Permission to harvest wild macroalgae stocks in the Russian sector of the Gulf of Finland (Baltic Sea), as well as in the White and Barents Seas, the North-West Territorial Administration of the Federal Fisheries Agency (Северо-Западное территориальное управление Федерального агентства по рыболовству) is involved. The harvesting permits are issued by the Department of Organization and Regulation of Fisheries. Permits for the cultivation of macroalgae are issued by the Department of Development of Aquaculture and Reproduction of Aquatic Biological Resources. In the Kaliningrad region, these permits are issued by the Western Baltic Territorial Administration.

Table 2. Seaweed-related laws, permits and authorities involved in the licensing process in GRASS countries.

GRASS	LAWS	PERMITS	AUTHORITY
FINLAND Cultivation	Water Act Environmental protection Act	Water permit	Application: Centre for Economic, development, Transport and Environment Granted: Regional State Administrative Agency
SWEDEN Cultivation	Environmental Code under Act on Water Operations	Water permit (> 0.3 ha)	Application: Land and Environmental Court Granted: County Administrative Board
GERMANY Cultivation	Federal Waterways Act Water Acts of the Länder	Water permit; IMTA also fishing permit; lease water contract	Federal Waterways and Shipping Agency + state-level authorities
ESTONIA Harvesting Cultivation	Fishing Act Water Act Natural Conservation Act	Fishing permit Superficies licenses, building and water permits	Agriculture and Food Board Consumer Protection and Technical Regulatory Agency
LATVIA Cultivation	Marine Environment Protection and Management Law Conservation of Species and Biotopes Law Environmental Impact Assessment Law Protection Zone Law	Aquaculture permit	Ministry of Agriculture: National Board of Fisheries
POLAND Cultivation	Law in cultivation of living organisms Law in Erection and exploitation of structures Water Law Nature Conservation Act	Permit for cultivation of living organisms; water and building permits	Ministry of Maritime Economy and Inland Navigation: Fisheries Department
RUSSIA Harvesting Cultivation		Fishing permit Cultivation permit	Department of Organization and Regulation of Fisheries Department of Development of Aquaculture and Reproduction of Aquatic Biological Resources

2.3. Current Activities in the GRASS countries

All the **GRASS countries** are conducting seaweed-related activities, mainly cultivation, except Latvia (Table 5).

In Finland, Origin by Ocean (<https://www.originbyocean.com/>) is, to our knowledge, the first company (founded in 2019) conducting seaweed and microalgae related activities for commercial purposes. The aim of the company is to establish a biorefinery business to obtain sustainable biomolecule from macro-and microalgae for different purposes such as pharmaceutical, food, cosmetics, and detergents. They are currently developing the technical solutions for seeding bladderwrack (*F. vesiculosus*) and they will run the first trial of scaling up the cultivation of bladderwrack at sea in 2021. The location of the cultivation facility is in the vicinity of Nauvo (Parainen), and the goal is to build a facility of approximately of 90 ha. They are also collaborating with the company Nordic Trout to

combine the cultivation of bladderwrack with fish farming. Besides that, they have a collaboration with Mexican partners to collect *Sargassum* sp. from different locations in the Caribbean. *Sargassum* is an invasive seaweed species causing big environmental and tourist problems in the Caribbean coast. Another business line of interest for Origin by Oceans is the use of blue-green microalgae for the extraction of potential interesting biomolecules. These microalgae form harmful blooms in summer in some coastal areas and lagoons in Finland. They are developing the technique to harvest the microalgae and filter it from the water for further processing in the biorefinery.

In Sweden, there are two companies, Nordic Seafarm and Bohus SeaCulture (<http://www.seaculture.se/>) that cultivate seaweed. The company Nordic Seafarm (<https://www.nordicseafarm.com/>) founded in 2016, cultivates the brown algae sugar kelp (*Saccharina latissima*) and oarweed (*Laminaria digitata*) and the green algae sea lettuce (*Ulva intestinalis*) at sea in the west coast of Sweden, and sea lettuce (*Ulva lactuca*) in tanks on land, aiming to reach a continuous cultivation during the year. They produce their own seeding material in ropes which can be also sold to other companies. The raw biomass is mainly sold to the food industry to produce seaweed burgers, beers and gin and they collaborate with known chefs. This company also have other collaborations with different sectors like animal feed, cosmetics, and biomaterials.

In Germany, there are several companies active: Algenprojekt, Kieler Meeresfarm GmbH & Co. KG and OceanBASIS. Algenprojekt (<https://www.algenprojekt.de/>) is a consulting company that also cultivates and sells sugar kelp (*S. latissima*) to be used in food and cosmetics. Kieler Meeresfarm GmbH & Co. KG (<https://www.kieler-meeresfarm.de/>) was founded in 2014 and extended their operations in 2020 with a permit to run an IMTA system. Currently, they cultivate organic macroalgae (sugar kelp) and mussels, and soon they will introduce Sea trout in the farm. With this system, they will achieve a nutrient neutral cultivation farm that can be recognized as a compensation measure for nutrients. They are also running the first trials to cultivate *F. vesiculosus*. The biomass obtained is sold to OceanBASIS (<https://www.oceanbasis.de/>), a sister company specialized in the extraction of active ingredients for cosmetics.

In Estonia, there are two companies with license for harvesting *F. lumbriicalis*, EstAgar AS and Tinurek OÜ. From the algae, a type of carrageenan (Furcellaran) is extracted with different applications such as stabilizing, thickening, and gelling agent in the food, agriculture, cosmetics, and pharmaceutical industries. Tinurek OÜ, a company founded in 2009, is currently harvesting seaweed in Saaremaa area and supply part of the dry material to EstAgar AS. The company EstAgar AS (<http://estagar.ee/>), founded in 1997, extracts the compound Furcellaran from seaweed and sell it to different clients within the food and cosmetics industry. The company is also interested in exploring new producing lines, such as the extraction of the pigment phycoerythrin from the algae. In 2018, they submitted the application to obtain the license for seaweed cultivation, including a permit for setting up an IMTA. They are in close contact with fish farmers, and they are planning to work together in order to develop an IMTA system to compensate the nutrients produced by fish farms. The application for macroalgae cultivation is still under revision. Vetik OÜ (<https://vetik.eu/>) is a sister company of Tinurek OÜ, founded in 2017. This company uses the biomass collected by Tinurek OÜ to extract the phycoerythrin

pigment for cosmetics purposes and they are seeking new alternatives to valorise the seaweed industry, for instance to develop a biorefinery to obtain different compounds.

In Latvia, there are to our knowledge no seaweed-related commercial activities at the moment (2021). The company Algorithms Ltd ceased operation in 2020.

In Poland, the company J-Tech operates an experimental seaweed farm and supplies equipment for sea farming. A permit for commercial cultivation has been issued by governmental maritime authorities, but production has not yet started as of May 2021.

In the Russian White Sea, Arctic seaweed is harvested by local fishermen from wild communities such as *Laminaria spp.*, *Fucus sp.* and *Ahnfeltia sp.*, and from the beaches and processed by Arkhangelsk Seaweed Factory (<https://av1918.ru/en/>). The company produces food and food supplements and pharmaceutical and cosmetics products. The Archangelsk Seaweed was founded already in 1918. In the early 1980s, biotechnology was developed for cultivating sugar kelp (*S. latissimi*) in a two-year cycle. At present, cultivation is not conducted in the White Sea, because it is cheaper to harvest wild algae. In the Russian Baltic Sea, there are currently no seaweed activities.

3. National Strategies, Regulations and Activities in GRASS neighbouring countries

This chapter discusses the regulations on macroalgae cultivation and harvesting in the neighbouring countries of GRASS partners, covering Iceland, Norway, Denmark, and Lithuania and defined as SUSCULT countries.

3.1. National strategies and MSP processes

The neighbouring countries, so-called SUSCULT countries, also have approved different programmes or strategies in order to implement the EU MSFD (Table 3). Iceland is not an EU member but is part of the Nordic Council and the European Economic Area Agreement and is subjected to EU laws. Within the SUSCULT countries, seaweed is mentioned only in the Danish strategies' (see below). In addition, some of the countries have approved their marine spatial plans (Norway and Denmark), whereas in the other countries are in the process of adopting (Iceland) or under preparation (Lithuania; see below).

In Iceland, the government has not developed a blue bioeconomy strategy but there are several projects and initiatives towards this direction. They are also working on the first MSP for Westfjords and East fjords. For that, the National Planning Agency (Skipulagsstofnun), under the under the Ministry of the Environment and Natural Resources, has developed a National Planning Strategy (NPS) 2015-2026 (Skipulagsstofnun, 2013), based on the Planning and Building Act (No. 73/19997, no. 135/1997 and no. 58/1999) and the Regulation on National Planning Policy (Reglugerð nr. 1001/2011 um landsskipulagsstefnu). The NPS is a policy document intended to ensure common interest in local authorities' plans and implement policies on sustainability and efficient planning, including the protection of the coastal areas and waters. Thus, this strategy sets the base for the development of

an Icelandic MSP legislation, being the first legal document integrating ocean and coastal management (Lehwald, 2020). The National Planning Agency accepted a new act on the organization of the ocean and coastal areas – um skipulag haf- og strandsvæða (Ministry of Environment and Natural Resources, 2018). The Act define the organization of the ocean and coastal areas beyond 115 meters, established in the Planning and Building Act (Lehwald, 2020). This Act includes the Chapter 5 “Coastal Area Plan” (V. KAFLI Strandsvæðisskipulag) that specifies the policies and provisions regarding activities conducted in coastal waters and shows an overview of the first areas where the Plan will be developed and implemented. The sectors included in the MSP are environment, economic development, fisheries, aquaculture, ports, marine mining/aggregate extraction, tourism, and coastal land use.

In Norway, the Ministry of Fisheries and Coastal Affairs adopted the Strategy for an Environmentally Sustainable Norwegian Aquaculture Industry 2009, focused on the environmental aspects of sustainable farming (Ministry of Fisheries and Coastal affairs, 2009). This Strategy provided a guideline to current aquaculture policies and to adopt a new strategy, the Ocean Strategy (Stévant et al 2017). The updated Ocean Strategy was developed to adopt a more sustainable blue economy, and states that Norway has a considerable potential in fisheries and aquaculture, with significant production industry based on fish, crustaceans and other marine resources as raw materials, and also in maritime industry, oil and gas, and emerging ocean industries (Norwegian Ministry of Trade, Industry and Fisheries, 2019). Although, seaweed cultivation is not fully mentioned in the strategies, their adoption contributed to develop a seaweed bioeconomy-based production in Norway and contributed to the success of this industry already from the past decade (Araujo et al 2021). Seaweed related activities are not recognized in the Norwegian integrated management plans for marine areas, and the municipal authorities consider whether the seaweed farm is in concordance with coastal zone spatial plans. The sector included are fisheries and aquaculture, between others. Norway has large marina areas and coastal waters and the management plans helps to exploit the marine resources while maintaining the environmental status (Ministry of Environment and Climate, 2015). There are different integrated marine management plans for the three EEZ: the Barents Sea and Lofoten, the Norwegian Sea, and the North Sea and Skagerrak (MSP Programme. Norway). All these areas are under the Integrated Coastal Zone Planning (ICZP) that integrate the protection and conservation, recreation and uses of the coastal zone, and address the possible conflicts among users and uses of the coastal zone (Tiller et al., 2012). The ICZP is regulated by the Planning and Building Act 2008. The Nature Diversity Act 2009 and Marine Resources Act 2009 also provide the legal framework for the management of the marine areas. The County Councils are responsible for the implementation of the plans, working closely with the Directorate of Fisheries (Fiskeridirektoratet) as part of the Ministry of Trade, Industry and Fisheries, and with the Ministry of Climate and Environment which is the authority responsible for work with the management plans.

In Denmark, the Ministry of Environment and Food includes the Department of the Danish Coastal Authority (DCA), which establishes the regulatory tasks concerning coastal protection and authorizes different activities such as seaweed cultivation. This Ministry adopted the Aquaculture Strategy 2014-2020 that aimed to promote a more sustainable development of the aquaculture sector in Denmark towards 2020 and reduce the carbon emissions from this sector by 25% per ton of fish. In the Strategy is stated that seaweed cultivation, and mussels, can be used as a tool for reducing nutrients at sea,

i.e. compensatory farming with other aquacultures and for use as animal feed. The Danish Maritime Authority, as part of the Ministry of Industry, Business and Financial Affairs, has released the Plan for Growth in Blue Denmark 2018. This plan is based on the recommendations given by the Maritime Strategy Team, a group of experts from different Danish marine sectors. The aim of the Growth in Blue Denmark is to support the Danish maritime cluster by accelerating digitalization in the marine industry, provide green solutions for the shipping sector and promote the sustainable production of food at sea. The Danish Parliament has recently adopted the MSP which is based on the provisions of the Maritime Spatial Planning Act and issued by the Ministry of Business and Growth. The spatial plan applies to the marine internal waters, the territorial sea and the EEZ, and includes different sectors such as offshore energy, maritime transport, transport infrastructure, fisheries and aquaculture, extraction of raw material, and natural and environmental protection areas. In the MSP map is included the cultivation of shellfish but seaweed cultivation is not mentioned.

In the Faroe Islands, the Ministry of Fisheries has adopted the Act on Marine Resources, which came in force in 2020. The act sets the framework for the fishing industry and the management of marine resources and aims to develop an economic, biological, and environmentally sustainable ecosystem. The Faroe Island lacks an MSP imposed by the EU policy since it is not a Member State of the EU. A bilateral fisheries agreement provides a framework to coordinate the fishing related activities between the EU and Faroe Islands. The Ministry of Fisheries of Faroe Islands is the responsible authority to maintain the contact with their counterpart in the EU. The Faroe Islands is an associate Member of the UN Food and Agriculture Organization (FAO) since 2007. Thus, they are committed to implement a responsible Fishing and sustainable aquaculture.

Lithuania has a marine strategy laid out in the “Comprehensive Plan of the Republic of Lithuania” including the part “Maritime territories”. This part covers maritime area, including territorial waters and EEZ. The plan was adopted by the parliament in 2015 and expired in 2020. A new Comprehensive Plan of the Republic of Lithuania is currently in the finalization phase issued by the Ministry of Environment. The document will be valid until 2030 and the proposed vision will be valid until 2050. The aim of the plan is to accommodate the spatial, economic, social and environmental development of the territory in an integrated system in accordance with the provision of the Law on Territorial Planning, and by following a sustainable development scheme. Sustainable blue economy and sustainable use of the resources are important parts of the plan within the “Responsible use of the sea and coast”, which are identified as national territorial elements. Lithuania is also developing the “Lithuania’s Progress Strategy 2030” in order to implement the UN sustainable development goals.

Table 3. Maritime Spatial Plans (MSP) and marine strategies in SUSCULT countries. The third column shows the mention of seaweed in the MSP (*in black) and/or in the marine strategies (*in red).

SUSCULT	MSP	MARINE STRATEGIES	SEAWEED mentioned
ICELAND	In process; Coastal Area Plan for Westfjords and East fjords	National Planning Strategy 2015-2026	Not mentioned
NORWAY	YES ; Coastal Zone Planning for Barents Sea, Norwegian Sea, and North Sea and Skagerrak	Environmentally Sustainable Norwegian Aquaculture Industry 2009 Ocean Strategy 2019	Not mentioned
DENMARK	YES ; adopted in 2021	Danish Aquaculture Strategy 2014-2020* Marine Strategy II (2018-2024) **	Not mentioned in the MSP *Seaweed can reduce nutrients, compensatory farming, animal feed **Algae: NEGATIVE ecosystem effect due to eutrophication, harmful algae blooms
FAROE ISLAND	YES ; bilateral agreement with EU		
LITHUANIA	Preparing for submission; Comprehensive Plan of the Republic of Lithuania 2030	Lithuania's Progress Strategy 2030	Not mentioned

3.2. National Permit Systems and Legal Rules

In the neighbouring countries, there are no specific seaweed cultivations laws at a national level. However, Iceland has approved a specific law on harvesting seaweed and the seaweed cultivation bill is in the parliament (Table 3, see below). Also, some countries have specific seaweed permits (Denmark and Norway).

In Iceland, a new regulation on harvesting seaweed "Reglugerð um öflun sjávargróðurs í atvinnuskyni No 90/2018" (Reglugerð um öflun sjávargróðurs í atvinnuskyni No 90/2018) covers harvesting, permitting, inspections, registration and penalties in the field, establishing the obligation to have a permit to harvest seaweed. The Regulation is issued by the Directorate of Fisheries, Ministry of Industries and Innovation on the basis of the Fisheries Management Act No 116/2006 (Lög um stjórn fiskveiða) and Act No 57/1996 concerning the Treatment of Commercial Marine Stocks (Lög um umgengni um nytjastofna sjavar). Also, the Regulation no 745/2016 on Weighing and registration of marine stocks ('Reglugerð um vigtun og skráningu sjávarafla', no 745/2016) and the Regulation no 746/2016 on Logbooks of catch statistics (Reglugerð um afladagbækur, no 746/2016) may apply to the new regulation. This legislation forms the regulatory framework for seaweed harvesting activity in Iceland (Maack 2019). The regulation establishes a rotation system for harvesting areas every four years (2. gr. Pangsláttur). An annual plan indicating the location (GPS outline) of harvesting must be submitted. Based on the regulation, the access to the marine lands for harvesting purposes is subject to an agreement or signed contract with the landowners, and the Directorate of Fisheries must be granted access to the contract, if request, to register the catch (1. gr. Gildissvið og leyfisbinding). Landowners also must apply for a permit to

harvest seaweed (mainly rockweed) in their properties. The company granted with a license may require paying a fee to the landowners. The company Thorverk is a landowner that pays a resource tax to the Government for harvesting rockweed (*Ascophyllum nodosum*) since seaweed is considered a natural resource (Maack 2019). To obtain the license to harvest wild seaweed, the Directorate of Fisheries must be informed by sending a letter to fiskistofa@fiskistofa.is. The amount of the harvested biomass must be weighed and registered as marine catch following the regulation (4. Gr. Eftirlit, skráningar o.fl). Thorverk applied for a harvesting license and for an exemption of weighing seaweed on a certified port-scale, due to difficulties of adhering to regulations. The permit for seaweed harvesting has been granted in 2020 and there is a certified person who carries out the weighing and reporting. The permit can be revoked in case of violation of the regulation (5. gr. Viðurlög o.fl). The Directorate of Fisheries does not require an Environmental Impact Assessment from the company prior granting the license for harvesting seaweed. This new regulation was introduced due to the growing interest on this industry and the previous lack of a proper regulation and wants to improve the sustainable utilization of wild seaweed to ensure economic and ecological sustainability in a long-term. The regulation is intended for companies that are conducting harvesting for commercial purposes and is set to be revised three years after implementation (Frumvarp til laga bill 1107 issue no 697). Harvesting of seaweed is also subject to the Fisheries Management Act No 116/2006, Art. 15, Chapter A. Seaweed (Lög um stjórn fiskveiða 2006 nr. 116 10. Ágúst. 15 gr. II. kafli A. Sjávargróður). The Act sets that all the harvesters intended to conduct seaweed activities with commercial purposes from a ship must have obtained a special permit from the Directorate of Fisheries for each vessel. The license expires if the vessel has not been used for seaweed activities for 12 months or if a vessel is removed from the register. Before applying for the vessel's license to harvest seaweed, the vessel must have a certificate of seaworthiness. The catch of seaweed from the shore for commercial purposes without using the vessel shall be reported to the Directorate of Fisheries. The Nature Conservation Act No 60/2013 (Lög um náttúruvernd 2013, nr. 60 10. Apríl) and other related environmental acts are applicable to seaweed harvesting. Regarding seaweed cultivation, the existing legal framework, i.e. the Act on the Management of Marine Resources 1997 (Lög um umgengni um nytjastofna sjávar 1996 nr. 57 3), the Fisheries Management Act No 116/2006, the Fishing Fees Management Act (Lög um veiðigjald 2018 nr. 145 18. Desember), the Act of the Planning of the Ocean and Coastal Areas (Lög um skipulag haf- og strandsvæða nr. 88 26. júní 2018), the Act on Aquaculture (Lög um fiskeldi 2008 nr. 71 11. Júní) and the Environmental Impact Assessment Act (Lög um mat á umhverfisáhrifum 2000 nr. 106 25. maí) does not specifically address seaweed aquaculture (Frank 2021). The legislation does not allow cultivation, but a Proposal on an action plan for the utilization of algae (um aðgerðaáætlun um nýtingu þörunga) is in the parliament process (Alþingi 2021). The bill was discussed at the preliminary session in October 2020, and in November 2020 it was at the economics affairs committee. There is also a working group assigned to the parliament to submit a plan of action in spring 2021. The licensing process for fish farming is currently under the responsibility of several different agencies. Smaller operations are reported at the local Environmental and Health Inspection (Heilbrigðiseftirlit Sveitafélaga), and larger operations at the National Planning Agency (Skipulagsstofnun). The Environment Agency (Umhverfisstofnunin) is involved, and ultimately the Directorate of Freshwater Fisheries (Veiðimálastjóri) or the Directorate of Fisheries (Fiskistofa) that grants the license.

In Norway, all the aquaculture activities, including seaweed cultivation are regulated according to the Aquaculture Act (2005). The Directorate of Fisheries (Ministry of Trade, Industry and Fisheries), together with the Norwegian Coastal Administration, the Norwegian Food Safety Authority, the Norwegian Water Resources and Energy Directorate and The County Governor (Directorate of the Environment), Municipality and Public are the public authorities that evaluate the application for seaweed cultivation. The applicant may need to pay several fees as cost related to the application: Processing fee (Saksbehandlingsgebyr), treatment fee from the County Governor (Behandlingsgebyr Fylkesmannen), and requirements for Environmental Survey (Krav til miljøundersøkelse, Chapman et al. 2018). Before starting seaweed cultivation, the company needs a license based on the Aquaculture Act and the Regulations on permits for aquaculture of species other than salmon, trout and rainbow trout (Forskrift om tillatelse av andre arter enn laks, ørret og regnbueørret). This includes a water permit granted by the Coastal Administration, species-specific seaweed permit granted by the Directorate of Fisheries and a permit under the Pollution Act 1981 (§11 and §1) granted by the County. The Pollution Act may not be applicable to seaweed cultivation since this activity does not cause organic pollution and the application of the discharge permit may cause delays in obtaining the license. The County is the authority that grants the final seaweed cultivation license and the Ministry of Trade, Industry and Fisheries is the appeal body. Currently, there are no limitations for granting seaweed farming license while for fish farming is not possibility to obtain new licenses due to stock regulation purposes. The County Governor assesses the location of the farm and whether the facility may conflict with regional and national interests, including recreation and nature conservation. All the interested parties in using the water area must agree on giving the permission to develop the seaweed farm. The objection of one of the interested parties can cause the rejection of the application. The company Lerøy Ocean Harvest AS has a license for seaweed cultivation at several different areas and the process lasted 9 months. For activities larger than 10 ha, it may require performing an environmental survey (Krav til miljøundersøkelse) to prove the sustainability of the operation. According to Stévant et al. (2017), sixteen companies held a license for seaweed cultivation in 2016. Seaweed Production AS, for example, received their license in 2017, after a process of five years. This company operates close to Flekkefjord, a city in the Southwest of Norway. For other companies, this period of obtaining the license has lasted between 6 months to 2 years. Seaweed harvesting in Norway has taken place on industrial scale since 1970s and approximately 150 000 tons of *L. hyperborea* and 15 000 tons of *A. nodosum* is harvested every year (Meland & Rebours 2012). Wild harvesting is regulated by the Directorate of Fisheries (Ministry of Trade, Industry and Fisheries) based on the Marine Resource Act. Designed zones are harvested every 5 years and only from 5-20 m depth. License for harvesting is obtained from the Directorate of Fisheries.

In Denmark, aquaculture is covered by the Fisheries Act (Fiskerilov LBK nr 372 2006) under the Ministry of Food, Agriculture and Fisheries as well as the environmental regulations by the Ministry of the Environment. According to the regulation on the establishment and operation of ocean farms (1991) and the Coastal Protection Act (Bekendtgørelse af lov om kystbeskyttelse LBK nr 267/2009), a license is needed for setting up the structure and for the operation of an ocean farm. An application is sent to the County Council and the license is issued by the Danish Coastal Authority (DCA, Kystdirektoratet). The first license issued can last for five years and after that the DCA will evaluate the long-term effects of the activity on the marine environment. This short licensing period might limit

the interest of possible entrepreneurs to develop seaweed cultivation. The DCA evaluates the possible impact of the seaweed cultivation on international natural reserve, in collaboration with other public authorities, and will determine the effect of the facility in the specific area based on the Regulation in coastal zones (Regulerings i kyst zonen BEK 874/2008). Also, the DCA evaluates whether the facility requires an environmental impact assessment based on the Executive Order on environmental assessment of certain facilities and measures in the maritime territory (BEK 579/2013; Petersen et al. 2016). The licensing of seaweed cultivation in Denmark can be a long process, i.e. 15 months for the company Dansk TANG, although it is recognized as different activity from fish farming. Fish and mussels farming are handled by the Danish Agricultural Agency (DAA), which makes it more difficult to obtain of an IMTA license.

Although part of Denmark, **the Faroe Islands** has exclusive rights to legislate a wide range of areas such as conservation and management of the marine resources, which are property of the people but based on a licensing system (Christensen, 2020). The fisheries and marine resources management is regulated by the Act on Marine Resources under the Ministry of Fisheries and the aquaculture activities are regulated by the Aquaculture Act under the Ministry of Environment, Industry and Trade. Currently, this Ministry grants fisheries licenses to Faroese-owned operators and a quota system has been implemented in the fisheries legislation. The Ministry issues specific licenses for seaweed cultivation applied to the Faroes Food and Veterinary Agency (Heilsufrøðiliga Starvssrovan) while before, seaweed farmers were bound to salmon farming licenses. For instance, the company Ocean Rainforest was operating with a license let by the salmon company Bakkafrost and in 2020 has acquired their seaweed license. Although there are no limitations on issuing seaweed licenses, conflicts with fish farming may occur when defining the location of the farms. The Aquaculture Act states the rights of the fish farmers to request the ocean space occupied by seaweed farms if needed, and the law will fault against seaweed farming. The seaweed license is granted in accordance with the Announcement no. 81 of 14 June 2019 on the auction of licence (aliloyvum - Kunngerð nr. 81 frá 14. juni 2019 um útbjóðing av aliloyvum). On the web of the Faroes Food and Veterinary Agency can be found information of the application forms (Oyðubløð og vegleiðingar), guidance and information about seaweed activities at sea.

In Lithuania, the establishment of new fishery and aquaculture activities is regulated by the administrations of the counties. The Ministry of Agriculture, by the Fisheries Department, is responsible for the administrative control of fishing and aquaculture under the legal Law on Fisheries 2016 No XII-2532 of the Ministry of Environment. While the Fisheries Service issues permits for commercial fishing in the Baltic Sea and for special fishing in marine waters, no licensing is needed for aquaculture in Lithuania (FAO, National Aquaculture sector Overview). The Fisheries Service provides a list of fish species that can be bred.

Table 4. Seaweed-related laws, permits and authorities involved in the licensing process in SUSCULT countries. Macroalgae-specific laws and permits are indicated in red.

SUSCULT	LAWS	PERMITS	AUTHORITY
ICELAND Harvesting	Regulation on the acquisition of Seaweed for commercial purposes no 90/2018	Contract from the landowner	Directorate of Fisheries
Cultivation	Management of Marine Resources Fisheries Management Act Fishing Fees Management Act Marine and Coastal Planning Act Aquaculture Act EIA Act	Seaweed cultivation bill in the parliament Fishing permit	Application: Environmental and Health Inspection (small operations); National Planning Agency (large operations); Environment Agency Granted: National Planning Agency/ Directorate of Fisheries
NORWAY Harvesting	Marine Resources Act	Harvesting permit	Directorate of Fisheries
Cultivation	Aquaculture Act Pollution Control Act	Fishing, water, discharge and seaweed permits Environmental assessment for > 10 ha	Application: Directorate of Fisheries, Norwegian Coastal Administration, Food Safety Authority, Norwegian Water Resources and Energy Directorate, County Governor (Directorate of the Environment), Municipality and Public Granted: County
DENMARK Cultivation	Fisheries Act (LBK nr 372 2006) Coastal Protection Act (LBK nr 267/2009) Impact on natural reserve (BEK 874/2008) Executive order on Environmental assessment (BEK 579/2013) Certificate of organic seaweed	Seaweed farming permit Environmental Impact Assessment	Application: County Council Granted: Danish Coastal Authority
FAROE ISLANDS Cultivation	Act on Marine Resources Aquaculture Act	Seaweed-cultivation license	Application: Food and Veterinary Agency Granted: Ministry of Environment, Industry and Trade
LITHUANIA Cultivation	Law on Fisheries, amended in 2016 No XII-2532	Fishing permit No license needed for aquaculture	For fishing: Fisheries Service

3.3. Current activities in the GRASS neighbouring countries

All the neighbouring countries, countries are conducting macroalgae-related activities except Lithuania (Table 5).

In Iceland, wild seaweed has historically been harvested by local people. The activity is ongoing in areas such as the Bay of Breiðafjörður. This Bay is known for its long record on harvesting rockweed (*A. nodosum*). There are several companies that have developed their harvesting activity in this area. Thorverk hf. (<https://www.thorverk.is/>) was founded in 1975 at Reykhólar, a small village mainly focused on the seaweed harvesting and drying plant. Thorverk is the only large-scale wild harvesting

company in Iceland. The company harvests rockweed (*A. nodosum*) and oarweed (*L. digitata*) by using mechanical methods. They use geothermal heat to dry the seaweed and sell it as dried product for animal feed, fertilizer and for food industry. The other harvesting company in Iceland is Íslensk Bláskel, located in Stykkishólmur and established in 2010. The harvesting process is done by hands, and the seaweed is dried and processed to be sold to the food and cosmetic industries. Other companies such as Íslensk hollusta, Hafkalk and Wild Icelandic sell seaweed Icelandic products. Currently, cultivation of seaweed is gaining interest. One company interested in seaweed cultivation is Eldey Aqua, a start-up company for seaweed cultivation that aims to provide IMTA systems in cooperation with the arctic salmon company Arctic Fish (<http://www.kelp.is/>). Eldey Aqua has developed its farm's design in the fall 2020 and is intended to grow sugar kelp (*S. latissima*) and Icelandic scallops (*Chlamus islandica*). Eldey Aqua has also received support from the start-up company Djupið, a shelter company that offers design, production, marketing and financial support in conducting different projects (<https://www.djupid.net/>).

In Norway, seaweed kelps (Laminariales) have been harvested from the sea for centuries, being *Laminaria hyperborea* and *A. nodosum* the main species harvested for the extraction of alginate. At present, the two main companies harvesting seaweed in Norway are Dupont (<https://www.dupont.com/>) and Nutrimar (<https://nutrimar.no/business-areas/kelp-and-seaweed/>). The experimental cultivation of seaweed started around 2005, and the first commercial seaweed cultivation permits were granted in 2014 (Stévant et al. 2017). There is a long list of seaweed farmers associated with the Norwegian seaweed farms association (<https://www.norwegianseaweedfarms.com/>). These companies are currently growing seaweed such as sugar kelp (*S. latissima*) and winged kelp (*Alaria esculenta*), which are the main species cultivated (Freitas et al. 2019). For instance, the company Seaweed Solutions AS (<http://www.seaweedsolutions.com/>), founded in 2009 and located in the island of Frøya, cultivates sugar kelp (*S. latissimi*) and winged kelp (*A. esculenta*), at sea in bulks (business to business) for the food and feed industries. The company TANGO SEAWEED AS (<https://www.tangoseaweed.no/>), located in Herøy on the west Norwegian coast, cultivates also these species on ropes and sell their products as fresh and dry material, and as condiments. They have two licenses in two different locations to cultivate seaweed, in total 46 ha, but they are currently cultivating in 2 ha running a pilot cultivation. They work closely with HORTIMARE (<https://www.hortimare.com/>), a company specialized on seaweed propagation of cultures by providing seeded material. Within the seaweed industry there are also other associated companies such as seed suppliers and service providers of logistics and consultancy support. The company Lerøy Seafood Group has a long history on capturing, selling and distributing seafood (<https://www.leroyseafood.com/en/>). In 2013, this big company founded a R&D company called Ocean Forest AS, in collaboration with the NGO Bellona Foundation. The aim of Ocean Forest is to improve seaweed cultivation techniques such as seeding of ropes. In 2018, the Lerøy Group founded the company Lerøy Ocean Harvest AS, focused on the cultivation of sugar kelp (*S. latissimi*). The algae are fermented and sold as for animal feed. Their production for human consumption is still on a small scale. The company Lerøy Seafood Group is conducting the cultivation of fish and seaweed in the same locations and are trying to reach a neutral nutrient system by following the mass balance principal. For IMTA, sugar kelp (*S. latissimi*) seems to be one of the most

suitable kelp species, which has already been tested in Norway (Stévant et al. 2017) in addition to other European countries (Freitas et al. 2016).

In Denmark, there is a group of companies that cultivate and harvest seaweed and have founded the Danish Seaweed Organization (<http://www.danish-seaweed.org/>). Dansk TANG (<https://www.danish-seaweed.com/>), a company founded in 2016 and located in the Odsherred peninsula, cultivates and harvests seaweed such as oarweed (*L. digitata*) and sugar kelp (*S. latissimi*) for human consumption. PURE ALGAE (<http://www.purealgae.dk/en/pure-algae-en/>) is mainly growing *Ulva* sp. in a land-based cultivation system.

In the Faroe Islands, there are currently two companies with license for seaweed cultivation. The company Ocean Rainforest (<http://www.oceanrainforest.com/>) started in 2010 with some trials of seaweed cultivation. For several years, it was a project-based company. Currently, they run a continued operation and are scaling up the seaweed farms. The company cultivates sugar kelp (*S. latissima*) by seeding the lines first and putting the lines at the sea nearshore, in both sheltered and exposed areas. Due to the growing conditions, they may also collect other seaweed species such as winged kelp (*A. esculenta*), oarweed (*L. digitata*) and dulse (*Palmaria palmata*). This company is also developing a cultivation technique suitable for open-ocean waters and optimizing the seeding techniques in ribbons. They offer seaweed additives for food and feed animal. Besides their cultivation activities in the Faroe Islands, they are leading the project MacroSystems in California with the aim of demonstrating the economic feasibility of scaling up seaweed farms. This project has been founded by the American Advanced Research Projects Agency (ARPA-E) for three years. The company TARI-Faroe Islands (<https://tari.fo/>) was founded in 2016 and they do wild harvesting and cultivation of sugar and winged kelp at Kaldbaksfjørður. They are part of the EU funded SW-Grow project aiming to boost the seaweed industry in the North Periphery and Arctic region.

In Lithuania, a company called Sirputis (<https://sirputis.com/>) is developing seaweed cultivation technology with the aim to expand the cultivation on the industrial scale and automate the harvesting process of edible seaweed. This technology is oriented to food and food supplement industry. The company was established by a Norwegian investor Valinor AS, a company that invests in sustainable energy and infrastructure projects, in cooperation with a Lithuanian partner company called Metal production.

Table 5. List of companies conducting cultivation and/or harvesting of seaweed in GRASS and SUSCULT countries.

	COUNTRY	COMPANIES
GRASS	FINLAND	Origin by Ocean
	SWEDEN	Nordic SeaFarm, Bohus SeaCulture, Ten Island Seafarm
	ESTONIA	EstAgar, Tinurek OÜ, Vetik OÜ
	LATVIA	
	GERMANY	Kieler-Meeresfarm GmbH & Co. KG
	POLAND	J-tech
SUSCULT	RUSSIA	Archangelsk Seaweed Factory
	NORWAY	Leroy Ocean Harvest AS/Ocean Forest AS, Seaweed Solutions AS, TANGO Seaweed AS, Artic Seaweed, Austevoll Seaweed Farm, Lofoten Blue Harvest AS, Seaweed AS, Seaweed Solutions AS, Tarelaks AS, The Northern Company, Norway Seaweed AS, Dupont, Nutrimar
	DENMARK	Dansk TANG, Pure Algae, Tofteladen-Laeso Tang, Nordisk tang, Hjarno Havbrung, OMO TANG, Organic seaweed-ebeltofto vig
	FAROE ISLAND	Ocean Rainforest, TARI- Faroe Inlands
	ICELAND	Thorverk, Eldey Aqua/Djúpið, Hafkalk, Icelandic Blue Mussel and Seaweed, Islensk hollusta
	LITHUANIA	Sirputis

4. Conclusions

Specific regulations on seaweed cultivation at the EU level are missing but there are several regulations and directives that can be applied to it. Here, we emphasize the importance of the MSPD 2014/89/EU, and the MSFD 2008/56/EC to facilitate the regulation and development of this new industry.

In general, all the GRASS and SUSCULT countries have adopted, or are in the process of adopting, an MSP to manage the use of the marine areas by defining the relevant sectors for human activities and to ensure a sustainable procedure. Based on the EU MSPD, all the EU members must establish their marine spatial plans by 2021. In general, all the countries include aquaculture and/or fishing activities in their plans, but seaweed cultivation is not mentioned. However, in some of the countries such as Finland, Sweden and Estonia, seaweed cultivation is mentioned in their MSP vision towards 2030. These countries emphasize the potential uses of seaweed in different industries, including the blue biotechnology sector, and their environmental benefits by using seaweed cultivation as a compensation measure for removing nutrients. Also, the studied countries have established Marine Strategies in order to achieve, or maintain, a good environmental status based on the EU MSFD regulation, which had to be implemented by 2020. Almost all the GRASS countries, including Denmark, indicate the potential uses of this raw material for different industries. Although it is not sufficient,

the mention of the potential benefit of seaweed in the national MSP and Marine Strategies is a big step towards an improvement in the regulation and licensing process of this activity.

The same occurs at the national level, specific regulations on seaweed cultivation are largely missing in the GRASS partner countries (Finland, Estonia, Latvia, Sweden, Germany, Poland, Russia). In GRASS neighbouring countries (Iceland, Norway, Denmark, Lithuania), the situation is similar. Lithuania is the only country that does not require licenses for seaweed aquaculture. The general aquaculture and fishing permit procedures and the general environmental and water laws apply to seaweed cultivation. However, there are some exceptions: Estonia, Iceland, Norway, Germany and Russia have rules on wild seaweed harvesting and Denmark and Norway have specific seaweed permits. Because the environmental impacts of seaweed cultivation differ entirely from (or in fact counteract) those of fish aquaculture, entrepreneurs, researchers, and regulatory authorities must come together for setting up good regulatory practices that specifically applies to seaweed cultivation. Regulatory collaboration and/or benchmarking between countries is preferable. All Baltic states may want to sign and endorse the UN Global Compact Seaweed Manifesto (2020), which is the first global memorandum of understanding on seaweed.

Licensing aquaculture activities can be a long and tedious process for entrepreneurs, in some cases taking several years. The lack of specific seaweed legislation is one of the main obstacles for seaweed aquaculture. The authorities must understand what seaweed is, and the benefits that it can generate. Having a specific regulation on seaweed aquaculture may accelerate the licensing process, which would benefit all the interested parties including authorities, entrepreneurs and stakeholders. The development and improvement of the seaweed market by promoting this business with workshops, stakeholders' meetings and conferences may increase the interest of the authorities on regulating the seaweed related activities. Awareness-raising and pilot farms are also needed to arouse the interest in politicians and administrators. Governments may refer to global standards, mainly the ASC-MSC Seafood Standard (Aquaculture Stewardship Council and Marine Stewardship Council 2018) in determining the rules for sustainable macroalgae business.

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