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Recommendations for sustainable wild seaweed harvesting and beach collection of seaweed on European coasts

Annex to the Final Report

European Maritime, Aquaculture and Fisheries Fund (EMFAF)

Written by Anda Ikauniece, Ieva Bārda (LIAE),
Céline Rebours (Moreforskning)
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LATVIJAS HIDROEKOLOĢIJAS INSTITŪTS

EUROPEAN COMMISSION

European Climate, Infrastructure and Environment Executive Agency
Unit D3— Sustainable Blue Economy

Contact: CINEA EMFAF CONTRACTS

E-mail: CINEA-EMFAF-CONTRACTS@ec.europa.eu

https://cinea.ec.europa.eu/

European Commission
B-1049 Brussels

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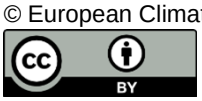

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Executive summary

The report examines wild-harvested and beach-cast macroalgae in the EU, focusing on harvest volumes, resource management, data practices, and future directions under Action 16 of the EU Algae Initiative (COM(2022) 592).

Wild seaweed harvesting is a commercially significant sector in 2 countries of the European Union (EU) – France and Ireland, and to lesser extent takes place in Denmark, Estonia, , Portugal and Spain. Annual yields range from 10 tonnes in Denmark to 60 thousand tonnes in France, with 2 species harvested in Estonia and over 20 in France, Spain and Portugal. In the past 5 years, an increase in wild seaweed harvesting has been observed in Portugal after the collapse of stocks in early 2000s, with red macroalgae Gelidium being harvested again in the range of 300 – 500 tonnes annually. In total, approximately 100 to 130 thousand tonnes of algae is harvested from the wild annually in the EU. Resource management procedures are present in all respective countries via licensing or permit systems and these are in line with EU environmental policies. Harvest data collection is partly fragmented and most recent information is available in national databases. A stakeholder survey on the use and needs related to the EU EMODnet Data Portal revealed a decline in both awareness and usage of the Portal's services.

Beach cast collection practices in the EU countries vary by region. Along the North Sea and Atlantic Ocean, beach cast collection often complements wild harvesting, while in the Baltic Sea countries it typically aligns with beach cleaning. In the Mediterranean region, beach cast mainly consists of seagrass Posidonia, which is a major component of coastal habitats and should be protected. Data collection for beach cast is complicated due to the large areas to cover; therefore, data is collected once in a period of several years and most frequently in the frame of research projects. Any centralised data portal for reporting beach cast data is however missing. Drone-based methods for remote control and estimation are under development. Recorded beach cast volumes range between 50 tonnes in Lithuania to over 50 thousand tonnes in France. Local permits for beach cast collection are necessary in France, Ireland, Spain and Latvia, while in Sweden the LOVA scheme was established to collect and compost the beached algae in order to mitigate eutrophication of the Baltic Sea. According to the available data, obtained from 12 EU countries, total annual amounts of beach-cast across the EU beaches of these 12 countries reach 1,17 M tons, from which 0,13 M tons are collected.

Although the future of EU seaweed production emphasises cultivation, harvesting still sustains coastal workplaces and rural communities. Beach cast collection for composting and use as soil fertiliser could be the most useful use of this resource

in areas where eutrophication needs to be mitigated. Importantly, in all cases the use of seaweed resource should be performed sustainably. Additional knowledge on wild seaweed stocks and beach cast amounts should be collected where gaps exist. Moreover, permit systems for harvesting, and restrictions of beach cast collection in marine protected areas are recommended. Collecting, reporting, and sharing seaweed data across the EU is essential, and the EMODnet Data Portal is the most suitable platform for making this information accessible and coordinated at the EU level.

1. Wild harvesting of seaweed

1.1. Data on wild harvested seaweed, harvesting techniques, management schemes and data collection policies

Seaweeds, or macroalgae, are critical components of marine ecosystems. They provide a diverse array of essential ecosystem services, including significant contributions to global primary production and the efficient absorption of dissolved nutrients from their environments. Seaweeds play a crucial role in coastal protection against the erosive forces of wave action and contribute significantly to carbon sequestration. Additionally, seaweeds serve as keystone species that shape habitats within coastal ecosystems.

Currently, in Europe, the utilisation of algae is growing across various commercial sectors. The majority of global macroalgal biomass is derived from cultivation, with an annual production of approximately 36 million metric tonnes (wet weight). Wild harvesting contributes around 1.2 million metric tonnes. In the EU, wild harvesting yields approximately 0.1 million metric tonnes, accounting for roughly 98% of algae biomass production.

This section of the report addresses topics related to wild-harvested seaweed, including data, harvesting methods, resource management strategies, and data collection processes.

1.1.1. Data on wild harvested seaweed and harvesting techniques

Wild seaweed harvesting is most prominent in Chile, China, and Norway ([1]; [2]). In Europe, wild seaweed harvesting has stayed steady for 20 years, yielding about 0.25 million metric tonnes (wet weight), while cultivated seaweed produces 700 metric tonnes (data of 2014-2016 ([3])). As a result, wild-harvested macroalgae account for approximately 98% of biomass production and is considered the most crucial raw material for the European seaweed industry. In the EU, biomass from

([1]) FAO, (2018). The global status of seaweed production, trade and utilization. Globefish Res. Program. 124. Rome. 120pp.

([2]) Camarena-Gómez, M. T., Lähteenmäki-Uutela, A., & Spilling, K. (2022). Macroalgae production in Northern Europe: Business and government perspectives on how to regulate a novel blue bioeconomy. *Aquaculture*, 738434. https://doi.org/10.1016/j.aquaculture.2022.738434

([3]) Joint Research Centre (2019). Brief on algae biomass production. doi:10.2760/402819

wild harvested seaweed constitutes about 100 - 130 thousand tonnes annually, the majority of which is collected in France and Ireland. All available data on wild harvested macroalgae by countries in 2019 - 2024 is included in **Annex 1**. Notably, France harvests around 70 – 90 thousand tonnes ([4]; [5]) while Ireland harvests 25 - 40 thousand tonnes ([6]).

Manual harvesting is the oldest method of seaweed collection, practiced for several centuries ([7]). Currently, hand harvesting of seaweed in Europe is predominantly conducted for personal consumption or use rather than on an industrial scale. An exception to this trend is Ireland, where the macroalgae *Ascophyllum nodosum* constitutes approximately 95% of the total Irish seaweed landings, with the majority being harvested manually. In the United Kingdom, manual harvesting of seaweed is common for both commercial and recreational purposes, although precise data records are not available ([8]). In Ireland, **hand cutting or picking** involves harvesting living species by hand at low tide using tools such as serrated sickles or scythes. Depending on their experience and skills, seaweed harvesters are typically capable of cutting between 1 to 4 tonnes in a single tide cycle ([9]). In the UK, hand harvesting methods usually involve selective cutting of the frond with scissors or a small knife, although some harvesters (presumably more recreational than commercial) are thought to pluck seaweeds by hand. In Portugal and Spain, **divers** harvest *Gelidium corneum* from boats. Each boat holds 4 divers who collect seaweed at depths of 4–10 m during calm seas. They scour rocks, placing seaweeds in mesh bags with a capacity of about 80–100 kg. On average, 12 bags per hour are pulled into the boat, resulting in 3–4 tonnes or more of fresh seaweed per trip ([10]).

Mechanical harvesting has been widely used in Northern Atlantic countries since the middle of the 20th century. In Europe, mechanical harvesting is

([4]) Le CRPMEM de Bretagne (n.d.). Chiffres clés de la production d'algue en Bretagne. https://www.bretagne-peches.org/la-peche-bretonne/recolte-dalgues-et-algoculture-en-bretagne/chiffres-cles-de-la-recolte-dalgues-de-rive-en-bretagne/

([5]) Marfaing, H. (2023) Harvesting seaweed in France: what quantity of biomass is harvested? https://sensalg.fr/en/harvesting-seaweed-in-france-what-quantity-of-biomass-is-harvested/

([6]) MTU (2022). Socio-Economic Study of Seaweed Harvesting in Ireland. Report, 164 p. https://ctc-cork.ie/projects/socio-economic-study-of-seaweed-harvesting-in-ireland/

([7]) Buckley, S., Hardy, K., Hallgren, F., Kubiak-Martens, L., Milauskiene, Ž., Sheridon A., Sobkowiak-Tabaka, I., Subira, M.E. (2023) Human consumption of seaweed and freshwater aquatic plants in ancient Europe. Nat Commun 14, 6192. https://doi.org/10.1038/s41467-023-41671-2

([8]) Wilding, C., Tillin, H., Stewart, E.J., Lubelski, A., Burrows, M. and Smale, D. (2021). Hand harvesting of seaweed: Evidence review to support sustainable management. NRW Evidence Report Series Report No: 573, 275pp, NRW, Bangor.

([9]) Mac Monagail, M., L. Morrison, L. (2020) The seaweed resources of Ireland: a twenty-first century perspective, J. Appl. Phycol. 32, 1287–1300, https://doi.org/10.1007/s10811-020-02067-7

([10]) R. Gaspar et al. (2019). Seaweed resources of Portugal. Botanica Marina 62(5): 499–525. https://doi.org/10.1515/bot-2019-0012

currently carried out by boats, mainly in Norway (Rogaland to Sør-Trøndelag), France (Brittany and Normandy), Estonia and, to a lesser extent, the Basque Country (Spain) and Ireland. The development of the mechanization of seaweed harvesting occurred in the middle of 1970s in France and Norway ([11]). Excluding tractors or other vehicles, the two main methods of harvest transportation are **trawling/sledging/dredging** and mechanical **'hedge' cutting.** For species in deeper waters like kelps, trawling uses a device to remove larger plants while leaving smaller ones to regrow. Examples include Norway's kelp dredge for *Laminaria hyperborea* and France's Scoubidou trawl for *Saccharina latissima*, which uses a crochet-hook-like tool ([12]). These devices operate in areas of rocky substrate and therefore differ from other forms of dredging (e.g., scallop dredging) that physically disturb the underlying substrate. The **mechanical 'hedge' cutting** technique utilises mechanical seaweed harvesters, which are specialised vessels that operate near the shore. These vessels cut the live seaweed as the stalks float above the seabed. The most prominent example is the Norwegian suction/cutter harvester ([13]), which was designed to harvest *Ascophyllum nodosum*. These large industrial harvesting machines can harvest up to 150 tonnes of wet weight per hour, which can potentially improve the economics of seaweed production through increased yields.

1.1.2. Resource management schemes and data collection policies

There are two seaweed certification schemes worldwide that advocate for the sustainable harvesting and farming of seaweed: Standards of Aquaculture Stewardship Council and Marine Stewardship Council (ASC-MSC) and World Sustainability Organization 's "Friend of the Sea". The principles of both standards include sustainable approach towards wild populations, need for environmental management and monitoring, and social responsibilities.

On the level of EU regulatory documents, at the time of the report writing, the Organic Food Regulation 2018/848/EU is the only document containing specific rules for the cultivation of organic algae, and which also covers wild harvesting

([11]) Mesnildrey L., Jacob C., Frangoudes K., Reunavot M., Lesueur M. (2012). Seaweed industry in France. Report Interreg program NETALGAE. 2012, 42 p. ⟨hal-00840572⟩

([12]) Wilding, C. Tillin, H. Corrigan, S. E. Stuart, E. Ashton I. A. Felstead, P. Lubelski, A. Burrows, M. Smale D. (2021b). Seaweed aquaculture and mechanical harvesting: an evidence review to support sustainable management. Natural England Commissioned Reports. Natural England Report NECR378.

([13]) Chopin, T., Ugarte, R.(2006). The seaweed resources of Eastern Canada. In book: World Seaweed Resources. An Authoritative Reference SystemPublisher: BioOnformatics Publishers. https://www.researchgate.net/publication/267374852_THE_SEAWEED_RESOURCES_OF_EASTERN_CANADA

(collecting the algae). The collection of wild algae and their parts is considered as organic production provided that:

- The growing areas are suitable from a health point of view and are of high ecological status as defined by Water Framework Directive 2000/60/EC; and

- The collection does not significantly affect the stability of the natural ecosystem or the maintenance of the species in the collection area. Furthermore, the amounts collected do not have a significant impact on the state of the aquatic environment. This "do no significant harm" ([14]) principle on not damaging the ecosystem is based on past experiences in e.g., Portugal ([15]).

Several environmental directives indirectly guide seaweed harvesting management. Seaweed is included as a biological quality element in the Water Framework Directive 2000/60/EC and the Habitats Directive 92/43/EEC, making its ecological status crucial for assessing the ecological condition of EU water bodies. Marine Strategy Framework Directive 2008/56/EC implementation focuses on achieving good ecological status for various descriptors, including seaweed.

The regional conventions of EU marine areas, specifically OSPAR (North-East Atlantic) and HELCOM (Baltic Sea) impact the management of wild seaweed by promoting the conservation of marine environments and supporting sustainable practices across multiple countries. A report by OSPAR noted declines in brown macroalgae forest habitats and highlighted the increasing threat to marine ecosystems posed by global change. Consequently, appropriate management measures need to be collectively agreed upon and effectively implemented to mitigate pressures on this habitat and restore its resilience ([16]). Seaweed in the HELCOM area is part of the benthic habitat quality framework and its biodiversity. The Baltic Sea Action Plan aims for good environmental status and includes actions to protect and restore macroalgal habitats ([17]).

([14]) European Commission. (2021). Do No Significant Harm. Knowledge for Policy. https://knowledge4policy.ec.europa.eu/glossary-item/do-no-significant-harm_en

([15]) Patarra, R.F. 2017. Culture studies of economically important seaweeds. Doctoral thesis in Biology. Faculdade de Ciências e Tecnologia, Departamento de Biologia, Universidade dos Açores. pp. viii + 157 +Appendix. https://www.researchgate.net/publication/335796135_Culture_studies_of_economically_important_seaweeds

([16]) de Bettignies T., Hébert C., Assis J., Bartsch I., Bekkby T., Christie H., Dahl K., Derrien-Courtel S., Edwards H., Filbee-Dexter K., Franco J., Gillham K., Harrald M., Hennicke J., Hernández S., Le Gall L., Martinez B., Mieszkowska N., Moore P., Moy F., Mueller M., Norderhaug K. M., Parry M., Ramsay K., Robuchon M., Russel T., Serrão E., Smale D., Steen H., Street M., Tempera F., Valero M., Werner T., La Rivière M. (2021). Case Report for kelp forests habitat. OSPAR 787/2021, 39 pp. ISBN 978-1-913840-16-7

([17]) HELCOM (2021) Baltic Sea Action Plan. https://helcom.fi/baltic-sea-action-plan/

Data collection on seaweed wild harvests is not strictly regulated at EU level. The Regulation on submission of nominal catch statistics by Member States fishing in the north-east Atlantic is currently in force; however, it is intended to serve as a documentation tool rather than a source of binding legal obligations. Seaweed species are listed for reporting, but none are mandatory. Therefore, seaweed catch data in international databases such as Eurostat and ICES is fragmented and updates face delays. Only a few countries with lower commercial seaweed diversity and harvests have consistently reported data. The Regulation also excludes some EU marine areas.

At the national level within the EU27 countries, specific management strategies and data collection efforts are executed where seaweed is considered a significant natural resource, whether through wild harvesting or cultivation. Management schemes for 6 EU27 countries—*Ireland, France, Spain, Portugal, Denmark, and Estonia*—are described in the following sub-sections. Additionally, the approaches of Norway and Iceland are included for comparative context, as they are important European seaweed providers. The data on macroalgae species, harvesting methods, and harvested biomass in these countries are compiled in **Annex 1**.

1.1.2.1. Denmark

The Ministry of Environment and Food of Denmark sets the requirements for seaweed harvesting in the country. Gathering seaweed for personal use or sale is permitted because there is no law against it. However, due to the relatively new practice of using Danish seaweed resources, sustainable harvesting guidelines for coastal waters are lacking. Furthermore, there is minimal documentation on the impact of seaweed harvesting on species distribution and habitats, threatening coastal biotopes in several areas. The scientific basis for regulation is nearly non-existent for Danish waters, leaving environmental impact assessments largely to the producers. Therefore, knowledge on seaweed growth and re-growth for sustainable management is still currently being collected ([18]). Companies harvesting seaweed for trade must conduct an ecological risk assessment of the area, define species composition, clarify how seaweed is handled, and manage the seaweed following regulations. While routine sampling is not required for seaweed used as food or supplements, these products must

([18]) Nielsen, M. M., Schmedes, P. S., & Thomasberger, A. (2023). Forvaltningsgrundlag for bæredygtig høst af vilde bestande af tang – kystnær blæretang og sargassotang. DTU Aqua. DTU Aqua-rapport No. 422-2023. https://www.aqua.dtu.dk/-/media/institutter/aqua/publikationer/rapporter-401-450/422-2023-forvaltningsgrundlag-forbaeredygtig-hoest-af-vilde-bestande-af-tang.pdf

comply with specific rules ([19]). In cases when individual permits are issued, up to 10% of stock can be harvested with a fallow period of 3 years.

1.1.2.2. Estonia

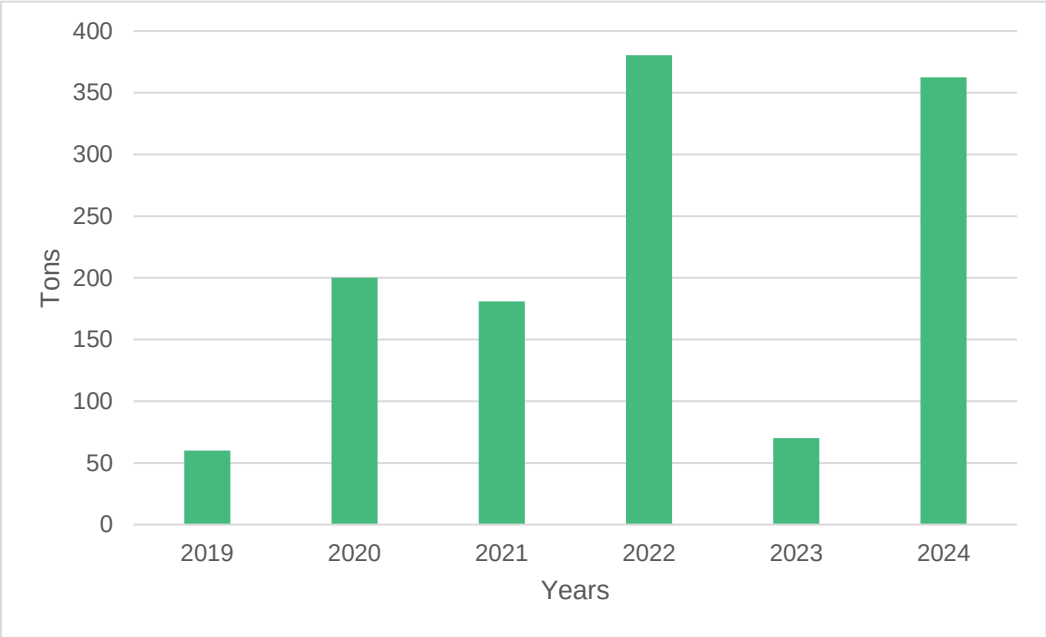
Furcellaria lumbricalis is the only species currently being harvested in Estonia. It is either collected on the shore as beach-cast or the loose-lying form of the algae is trawled from the seabed at two locations in Kassari Bay (between Hiiumaa and Saaremaa islands). *F. lumbricalis* is also the only aquatic plant currently regulated through the Fishing Act. This Act sets rules on harvesting areas and harvesting frequency of *F. lumbricalis*. The state owns seaweed in the sea, but once it washes ashore, it belongs to the landowner. To harvest the loose form of *F. lumbricalis*, a commercial fishing authorisation is required, which is valid for one calendar year and can be renewed. However, harvesting beach-cast seaweed does not require a license. The authorization specifies the quantities allowed to harvest (usually 2000 tonnes per year), the harvesting area, and the gear used. Harvesters are permitted to harvest from one location per year, and that area must remain unharvested in the following year.

All the harvesting activities must be reported to the Agriculture and Food Board under the Ministry of Rural Affairs, which is the competent authority granting authorisation for harvesting seaweed. During the last 30 years, licenses have been purchased by two companies, and it is not possible to apply for new licenses for natural stock preservation reasons ([20]). A monitoring programme for the recovery of the seaweed population is in place. The Estonian Marine Institute at the University of Tartu is responsible for the monitoring of wild seaweed areas. Every two years, the Estonian Marine Institute calculates a new quota by measuring the quantity of *F. lumbricalis* and evaluating biodiversity. Harvesting locations are also assessed based on the proportion of seaweed mass, coverage, and potential impact on other species, including both plant and animal species. Wild seaweed harvests in Estonia over last 5 years are depicted in Figure 1.

([19]) Camarena-Gómez, M. T., Lähteenmäki-Uutela, A. (2021). European and National Regulations on Seaweed Cultivation and Harvesting. Project GRASS (Growing algae sustainably in the Baltic Sea) report, Pp 33. https://www.submariner-network.eu/images/grass/FINAL-GRASS_GoA_3.2._SYKE_regulation_report.pdf

([20]) Camarena-Gómez, M. T., Lähteenmäki-Uutela, A. (2021). European and National Regulations on Seaweed Cultivation and Harvesting. Project GRASS (Growing algae sustainably in the Baltic Sea) report, Pp 33. https://www.submariner-network.eu/images/grass/FINAL-GRASS_GoA_3.2._SYKE_regulation_report.pdf

Figure 1 – Wild seaweed harvests in Estonia, 2019 – 2024



Source: https://www.kalateave.ee/en/publications

1.1.2.3. France

In France, the beach, foreshore and sea are included in the maritime public domain and are under the responsibility of the state. The use of this maritime space is at the discretion of public authorities, particularly Directorate of Maritime Affairs, Fisheries and Aquaculture (*Direction generale des Affaires Maritimes, de la Pêche et de l'Aquaculture, DGAMPA)*. Seaweed harvesting is managed by DGAMPA together with regional committees of fisher's organisations – e.g., in Brittany, Normandy and Provence ([21]). Seaweed gathering onshore or at sea is regulated at the national and regional levels. National regulations are universally applicable; however, given that the majority of seaweed production occurs in Brittany, specific regulations are also implemented at both the regional and local levels. An annual information campaign is carried out before the harvesting season, covering environmental protection policies in the area, licence fees, the number of licences, periods of harvest, restricted areas, quotas and specific conditions ([22]). A description of collection methods, minimum size for collection, harvest periods, and quotas is provided for each relevant species ([23]). In addition

([21]) Picault, D., Lesueur, M. (2014). Inshore fishing and governance (France). The governance of fishing within French territorial waters. GIFS Project. Les publications du Pôle halieutique AGROCAMPUS OUEST No 20, 20 p. https://halieutique.institut-agro.fr/files/fichiers/pdf/4636.pdf

([22]) Le CRPMEM de Bretagne (n.d.). Licence récolte algues de rive. https://www.bretagne-peches.org/reglementation/licence-recolte-algues-de-rive/

([23]) Mesnildrey L., Jacob C., Frangoudes K., Reunavot M., Lesueur M. (2012). Seaweed industry in France. Report Interreg program NETALGAE. 2012, 42 p. ⟨hal-00840572⟩

to fisher's organisations, the administration of marine protected area (marine park) can intervene in matters of resources and biodiversity conservation, for instance by imposing the use of more friendly fishing gears, by banning the use of some fishing gears or by allocating geographical areas to fisheries or to others uses ([24]).

French seaweed resources are classified by regulations addressing coastal zones as:

(i) Deep water seaweed – harvested by boat or low tide, mainly *Laminaria digitata*, *L. hyperborea* and *Saccharina latissima*;
(ii) Shore seaweed – harvested on foot, including *Ascophyllum nodosum*, *Fucus vesiculosus, F. spiralis, Himanthalia elongata, Pelvetia canaliculata, Chrondrus crispus, Mastocarpus stellatus*, *Palmaria palmata, Porphyra umbilicalis* and *Codium* spp; and
(iii) Stranded seaweed – all kinds of seaweed but typically *Ulva* spp. in spring ([25]).

In Brittany, the following number of licenses were issued in 2021: 152 licenses for shore (manual) collectors (including 73 licenses on a seasonal basis) and 28 licenses for mechanical harvesting in the sea by 33 vessels ([26]).

1.1.2.4. Ireland

In Ireland, the government policy and formal regulation of seaweed harvesting is scarce, with little guidance on allowable species or quantities for harvesting. Licences for harvesting are issued in the format of a foreshore licence, which allows the holder to remove 'beach material' from the shore. In addition, the traditional rights to harvest seaweed are sometimes included as part of property rights. Given the existing practice of harvesting, the ambiguity in terms of legislation, and the slow pace of the licensing process, the full extent of seaweed harvesting in Ireland is not known ([27]). Many coastal householders have the right to harvest unattached, storm-cast seaweed from above the high-water mark and harvest attached seaweed material from below high water, along the boundary of their property for use as fertiliser, food and extracts for both personal and commercial purposes, i.e., traditional rights originated before Ireland's

([24]) Frangoudes K. (2011). Seaweeds Fisheries Management in France, Japan, Chile, Norway. Cahiers de Biologie Marine, 2011, 52 (4), pp.517-525.
([25]) BIM report. (2020). Scoping a Seaweed Biorefinery Concept for Ireland. https://bim.ie/wp-content/uploads/2021/02/BIM-Scoping-a-seaweed-biorefinery-concept-for-Ireland.pdf
([26]) Le CRPMEM de Bretagne (n.d.). Chiffres clés de la production d'algue en Bretagne. https://www.bretagne-peches.org/la-peche-bretonne/recolte-dalgues-et-algoculture-en-bretagne/chiffres-cles-de-la-recolte-dalgues-de-rive-en-bretagne/
([27]) MTU (2022). Socio-Economic Study of Seaweed Harvesting in Ireland. Report, 164 p. https://ctc-cork.ie/projects/socio-economic-study-of-seaweed-harvesting-in-ireland/

independence (folio right). The process of registering such rights on a property folio is a matter for the Foreshore Act and neither can any other entity be licensed to harvest in that area. In addition, however, the seabed and the shore below the line of high water at mean tide, and extending outward to twelve nautical miles, are the responsibility of the State under the 1933 Foreshore Act (revised and amended up to 2017). Under the original 1933 Act, persons are prohibited from gathering seaweed material unless in possession of a "foreshore licence" from the Department of Housing, Local Government and Heritage (DHLGH). Where the foreshore is privately owned, the provisions of the Foreshore Act do not apply to the taking of seaweed from the foreshore ([28]). This complex situation creates unclarity regarding ownership. This is the main obstacle in further developing the seaweed industry in Ireland, with industry wary of fostering investment/expansion as it exerts little control over either the methods of harvesting, and/or access to the resource ([29]). Several applications for the commercial harvesting of wild seaweed have been made, but few were approved by the Minister (DHLGH) since March 2014. Moreover, no additional entity is allowed to be licensed to harvest in that area.

Self-imposed fallow periods have been observed when harvesting seaweed in Ireland. For rockweed (*Ascophyllum nodosum)* after cutting, beds are left fallow for 3–7 years to allow regeneration depending on the harvesters' local knowledge and experience. Recovery also depends on the exploitation rate and the amount of actively growing shoots remaining. The self-imposed implementation of fallow periods following harvest ensures the recovery of seaweed beds and allows for a well maintained and sustainably exploited resource ([30]).

In 2023, the Maritime Area Regulatory Authority (MARA) was established, and oversight of wild seaweed harvesting is expected to shift from the Department of Housing, Local Government and Heritage (DHLGH) to MARA. MARA's recently issued strategy aligns with the Government of Ireland's objective to implement robust, transparent, and effective maritime regulatory frameworks. The strategy aims to support sustainable development by enabling coherent and transparent decision-making and providing regulatory certainty for maritime area development ([31]).

MARA may also end up supervising mechanical harvesting, which has been until now the responsibility of the National Parks and Wildlife Service (NPWS) at the Department of Tourism, Culture, Arts, Gaeltacht, Sport and Media. The NPWS is in charge of the conservation and protection of Ireland's seaweed resources and for advising the licensing authority (Marine Section within the DHLGH) on the

([28]) Morrissey J., Kraan S. & M. D. Guiry (2001). Guide to Commercially Important Seaweeds on the Irish Coast. Report, Bord Iascaigh Mhara.
([29]) MARA (2024) Statement of Strategy 2024 – 2027. https://www.maritimeregulator.ie/wp-content/uploads/2024/11/MARA-Statement-of-Strategy_2024_Final.pdf
([30]) Morrissey J., Kraan S. & M. D. Guiry (2001). Guide to Commercially Important Seaweeds on the Irish Coast. Report, Bord Iascaigh Mhara.
([31]) MARA (2024) Statement of Strategy 2024 – 2027. https://www.maritimeregulator.ie/wp-content/uploads/2024/11/MARA-Statement-of-Strategy_2024_Final.pdf

issuing of harvest licenses to new entrants ([32]). The NPWS has repeatedly expressed its opposition to kelp mechanical harvesting in Ireland, stating that "… such activities are not compatible with the conservation objectives of and should not be permitted in Natura 2000 sites". Furthermore, the Irish Government aims to increase the amount of Marine Protected Areas (MPAs) to 30 % of Ireland's marine area. This would certainly limit the wild harvesting potential, as activist groups have called for a ban of all mechanical harvesting in these areas ([33]).

1.1.2.5. Portugal

As in France, the beach, the foreshore and the sea are public domain in Portugal and are under the responsibility of the State. The use of this maritime space is at the discretion of public authorities. Regulations were first established in 1964, creating a harvest season and licensing policy. The national fisheries authorities have the competency to manage the area within the 12 nautical miles, in addition to all fisheries activity. The National Fisheries Authority (DGRM) monitors and controls catches and fishing effort levels as well as the harvesting of marine plants and animals. Data on environmental factors and harvested biomass amounts are collected. In Portugal, six different harvesting areas are defined and annual licenses issued to enable harvesting for commercial purposes, with the harvesting season occurring mostly from August to November ([34]).

Approximately 10 years ago, only one commercial harvesting area was in use in the country, due overexploitation of the resource, the socioeconomic situation, and climate change impacts ([35]). Wild harvest landings declined substantially from the end of the twentieth century until the beginning of the twenty-first century, leading to the cessation of economic activities for several species (Figure 2). This situation changed after 2020, and DGRM has issued a regulation in late 2023 on the wild harvesting of seaweed in all six harvesting areas again (in force

([32]) Kelly, E. (ed.) (2005) The role of kelp in the marine environment. Irish Wildlife Manuals, No. 17. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland. https://www.npws.ie/sites/default/files/publications/pdf/IWM17.pdf

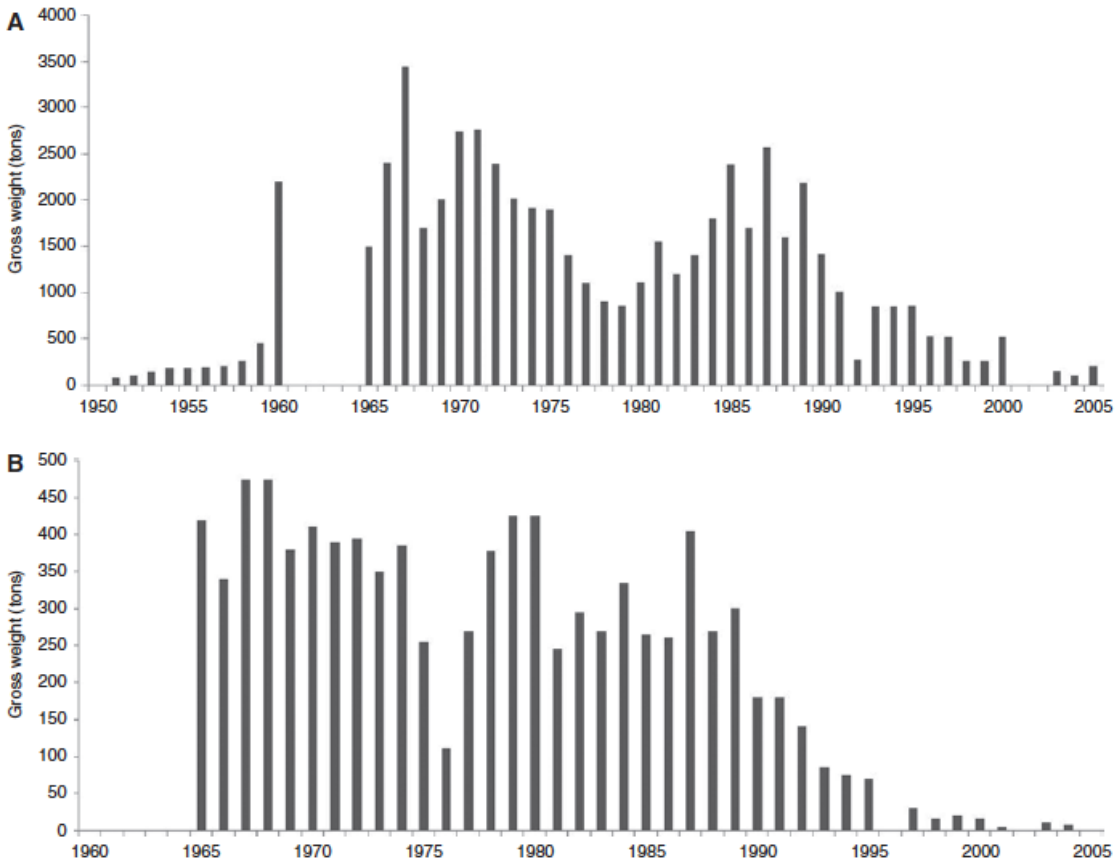
([33]) Vance et al.,(2023). Sustainable scale-up of Irish seaweed production: Quantifying potential environmental, economic, and social impacts of wild harvesting and cultivation pathways. Algal Research 75 (2023) 103294, https://doi.org/10.1016/j.algal.2023.103294

([34]) Lusa (2024). Lusa - Business News - Portugal: Harvesting of seaweed for commercial use authorised until 15 November https://www.aman-alliance.org/Home/ContentDetail/79385

([35]) Santos R. & Melo R. (2018). Global shortage of technical agars: back to basics (resource management). Journal of Applied Phycology (2018) 30:2463–2473, https://doi.org/10.1007/s10811-018-1425-2

until the end of 2026) ([36]), Figure 3. The number of licences in each zone fluctuates between 20 to 90.

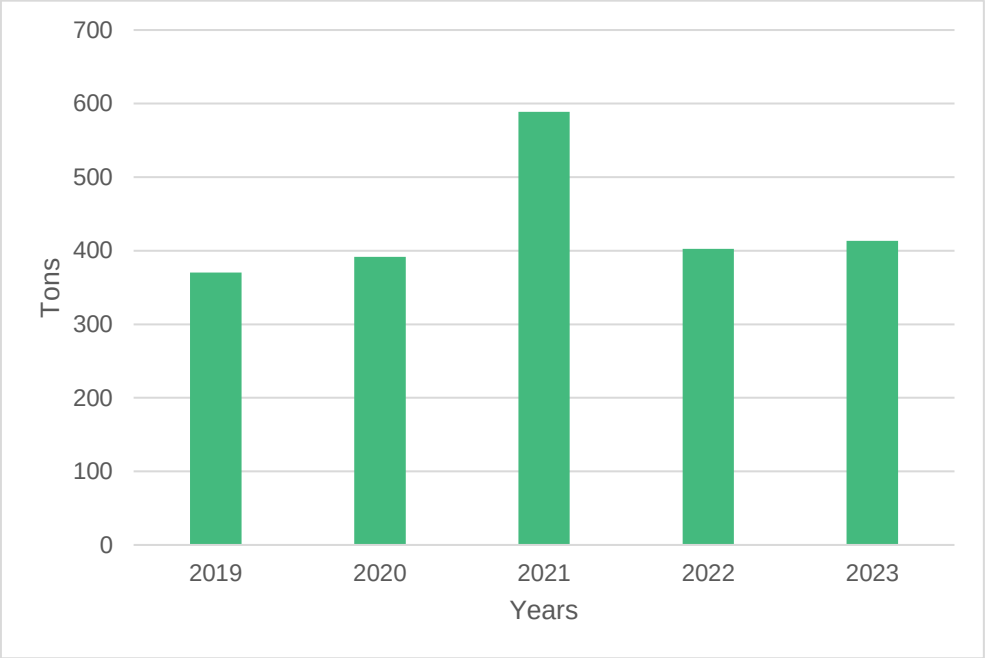
Figure 2 – Annual landings (gross weight, tonnes) of (A) agarophytes and (B) carrageenophytes



Source: R. Gaspar et al., 2019.

([36]) Diário da República (2023). AGRICULTURA E ALIMENTAÇÃO. Portaria n.o 391/2023 de 23 de novembro https://files.diariodarepublica.pt/1s/2023/11/22700/0004500050.pdf

Figure 3 – Wild harvest of *Gelidium* spp. in Portugal, 2019-2023



Source: https://www.dgrm.pt/en/recursos-da-pesca-dgrm

Seaweeds washed ashore can be collected year-round. While non-commercial harvesting is not regulated by the Portuguese government, the collection of beach-cast macroalgal biomass using tractors requires authorisation from local authorities. However, tracking the quantities collected is challenging, as most of the biomass is used directly by farmers and often goes unrecorded ([37]).

1.1.2.6. Spain

Harvest regulations in Spain were first introduced in 1932 due to the use of brown algae for iodine production and were further developed in 1945 with the establishment of the phycocolloid industry ([38]). Since then, the management of wild-harvested seaweed resources has gradually improved, supported by growing research and understanding of seaweed ecosystems and the impacts of harvesting.

([37]) Pereira L. & Correia F. (2015). Algas marinhas da costa portuguesa – ecologia, biodiversidade e utilizações. Prémio do Mar Rei D.Calos. 18ª Edição. Nota de Rodapé Edições. Paris. pp. 340. https://www.researchgate.net/publication/322619611_Algas_Marinhas_da_Costa_Portuguesa__Ecologia_Biodiversidade_e_Utilizacoes

([38]) Sosa, P., Gómez Pinchetti, J. L., Juanes, J. A.(2006). Seaweed resources of Spain. In: World Seaweed resources, ETI Information Services, ISBN 90-75000-80-4https://accedacris.ulpgc.es/bitstream/10553/73693/2/Theseaweedresources.pdf

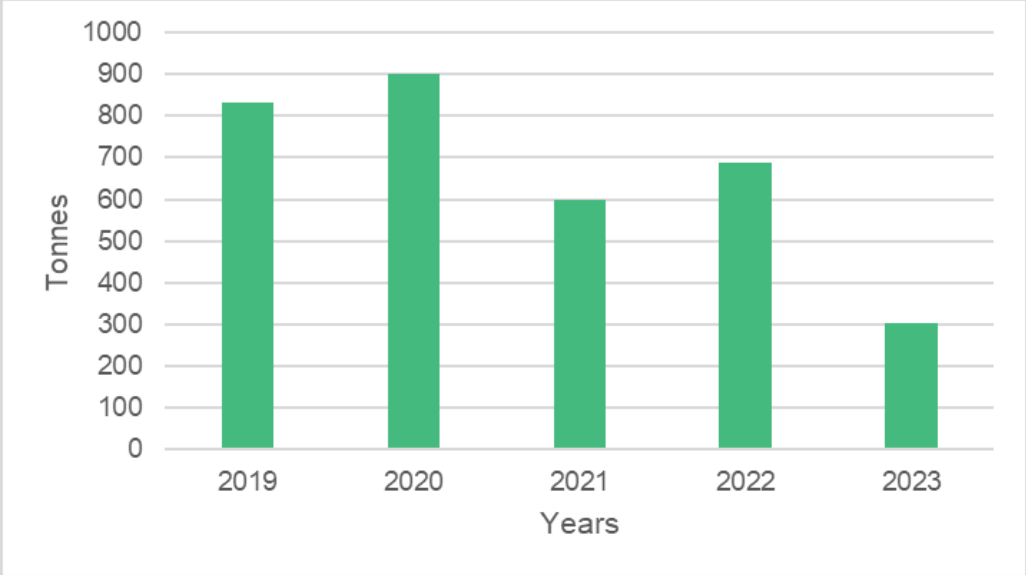
Aquaculture and wild harvesting are primarily regulated by regional governments, which have jurisdiction over aquatic activities, alongside general legislation from the central government. The Ministry of Agriculture, Fisheries and Food oversees national-level regulation. Rules include area restrictions, minimum coverage requirements for harvesting zones, seasonal limits, and biomass quotas. Regional authorities—such as those in Asturias, Cantabria, the Basque Country, and Galicia—manage seaweed resources and issue licenses. Annual quotas and regulatory conditions are published by each authority through official bulletins or websites. The most commercially important species in Spain is *Gelidium corneum*, harvested for agar production, mainly through the collection of storm-cast algae and by divers operating from small boats, especially in Asturias.

The harvest of *Gelidium corneum* began during World War II, with landings steadily increasing until the 1980s, when exploitation peaked at around 6,000 tonnes. However, during the 1990s, harvest levels dropped sharply to about 300 tonnes and remained low through the 2000s. Currently, harvesting continues in Asturias, Galicia, and Cantabria. The decline in landings since the early 1990s is attributed not to overexploitation but to the poor quality of storm-tossed seaweed, often contaminated with sand and other species. These fluctuations created challenges for an industry reliant on a consistent supply of high-quality raw material. The 2002 Prestige oil spill led to a temporary ban on *Gelidium* harvesting, prompting many harvesters to leave the sector. Although studies showed no significant impact of the spill on macroalgal communities ([39]), the industry further declined in the 2010s, with no official statistics recorded for landings or agar production at national or regional levels. Between 2018 and 2023, the total wild seaweed harvest in Galicia and Asturias was estimated at around 4,000 tonnes ([40]), though detailed data exists for less than 1,000 tonnes (Figure 4).

([39]) Lobón C.M. et al. (2008). Effects of the 'Prestige' oil spill on macroalgal assemblages: Large-scale comparison. Marine Pollution Bulletin, Vol. 56, Issue 6, 1192-1200, https://doi.org/10.1016/j.marpolbul.2008.02.009

([40]) Xunta de Galicia (n.d.) Publicacións https://www.pescadegalicia.gal/gl/publicacions

Figure 4 – Wild harvested seaweed - reported data in Spain, 2019-2023



Source: https://www.pescadegalicia.gal/gl/publicacions

1.1.2.7. Iceland

The Regulation on the acquisition of Seaweed for commercial purposes No 90/2018 was established in 2018. It introduced the obligation to have a permit to harvest seaweed and covers harvesting, permitting, inspections, registration and fines of the sector. In addition, the Regulation no 745/2016 on Weighing and registration of marine stocks and the Regulation no 746/2016 on Logbooks of catch statistics may apply to the seaweed regulation. The regulation establishes a rotation system for harvesting areas every four years. An annual plan indicating the location 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 requested, to register the catch. Landowners also must apply for a permit to harvest seaweed (mainly rockweed) in their properties. The company granted with a license may be obliged to pay a fee to the landowners. The amount of the harvested biomass must be weighed and registered as marine catch following the regulation. The permit can be revoked in case of violation of the regulation. ed, to register the catch. 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 amount of the harvested biomass must be weighed and registered as marine catch following the regulation. The permit can be revoked in case of violation of the regulation.

The Directorate of Fisheries does not require an Environmental Impact Assessment from the company prior granting the license for harvesting seaweed. 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 and other related environmental acts are also applicable to seaweed harvesting ([41]). The most relevant commercial species are *Ascophyllum nodosum* and *Laminaria digitata*, and both are collected mechanically ([42]). The total wild seaweed harvest in Iceland amounts to approximately 20,000 tonnes ([43]).

1.1.2.8. Norway

Seaweed harvesting in Norway has taken place on industrial scale since the 1960s. Approximately 150,000 tonnes of *Laminaria hyperborea* and 15,000 tonnes of *A. nodosum* are harvested every year. In 2023, this amount has increased to reach 187,000 tonnes in 2023 (Figure 5) ([44]).

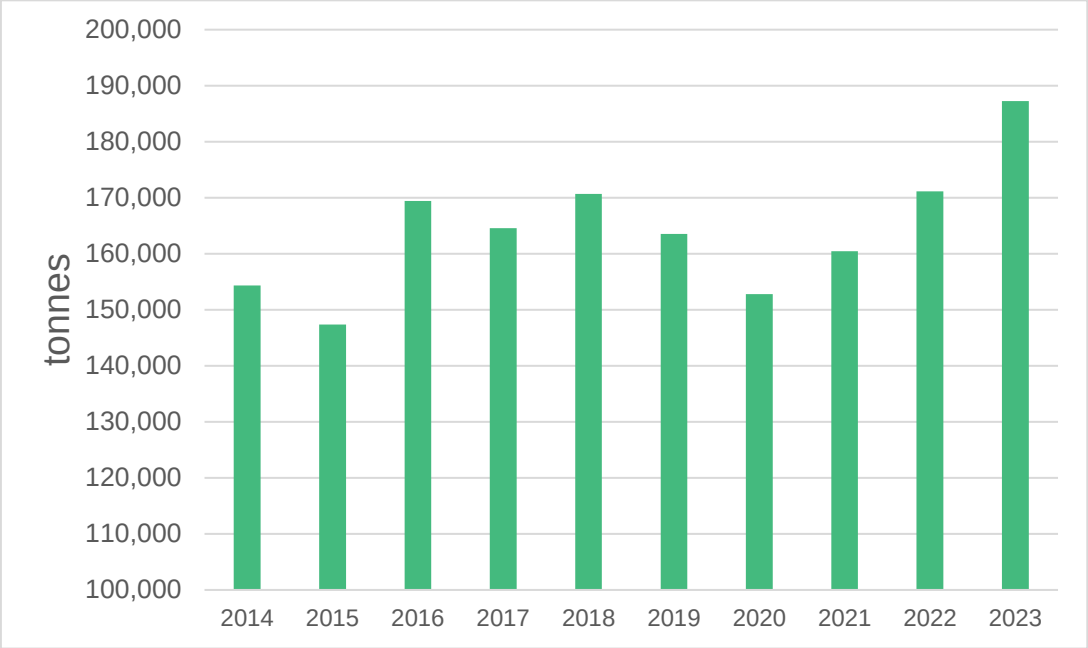
([41]) Camarena-Gómez, M. T., Lähteenmäki-Uutela, A. (2021). European and National Regulations on Seaweed Cultivation and Harvesting. Project GRASS (Growing algae sustainably in the Baltic Sea) report, Pp 33. https://www.submariner-network.eu/images/grass/FINAL-GRASS_GoA_3.2._SYKE_regulation_report.pdf https://submariner-network.eu/wp-content/uploads/2024/01/FINAL-GRASS_GoA_3.2._SYKE_regulation_report.pdf

([42]) Araújo R. et al. (2021) Current Status of the Algae Production Industry in Europe: An Emerging Sector of the Blue Bioeconomy.Front. Mar. Sci. 7:626389. doi: 10.3389/fmars.2020.626389

([43]) Mack, A. (2019). Wild Seaweed Harvesting. Ways to encourage sustainable exploitation and improve the regulatory framework on wild seaweed in Iceland, Master Thesis, Lund University, https://www.lunduniversity.lu.se/lup/publication/8997131

([44]) Directorate of Fisheries (n.d.) Statistics. https://www.fiskeridir.no/English/Fisheries/Statistics/Economic-and-biological-key-figures

Figure 5 – Wild harvest of seaweed in Norway, the last decade, all species.



Source: Economic and biological figures from Norwegian fisheries 2023, https://www.fiskeridir.no/English/Fisheries/Statistics/Economic-and-biological-key-figures

Wild harvesting is regulated by the Directorate of Fisheries (Ministry of Trade, Industry and Fisheries) based on the Marine Resource Act. The Regulation FOR 1995-07-13 nr 642 (Forskrift om høsting av tang og tare) applies to the exploration and harvesting of seaweed and kelp in internal Norwegian waters, Norwegian territorial waters, and Norway's economic zone. Designed zones are harvested every 5 years and only from 5-20 m depth (*Laminaria hyperborea*). Licenses for harvesting are obtained from the Directorate of Fisheries. The purpose of this Regulation is to ensure a sustainable use of macroalgae by conducting the activity during harvesting seasons and forbidding the activity in waters deeper than 20 m. The right to harvest between 5 and 20 m belongs to the State, but a permission can be granted to actors based on regional regulation.

Two specific regional regulations govern macroalgae harvesting in Norway: one for the regions of Rogaland and Vestland, one for the regions of Møre og Romsdal and Trøndelag. The regional regulations define the periods and the areas allowed for harvesting ([45]). Species in the coastal zone under private ownership are not regulated, and access to the resource is to be agreed with the landowner. The sustainable harvesting of *L. hyperborea* has been established by carefully planned and implemented schemes for its management and monitoring.

([45]) Camarena-Gómez M.T. et al., 2022. Macroalgae production in Northern Europe: Business and government perspectives on how to regulate a novel blue bioeconomy. Aquaculture, Volume 560, https://doi.org/10.1016/j.aquaculture.2022.738434

Based on a strong knowledge of the ecology and biology of *L. hyperborea*, and organised in close cooperation between researchers, national authorities and industry, the seaweed management plan was developed more than a decade ago. The plan is based on the following principles: 1) harvesting is organized in a rotating five-year cycle (four years in certain areas) to ensure kelp regrowth; 2) regrowth monitoring has been an integral part of the Institute of Marine Research's annual program since 2004; and 3) commercial oversight is conducted in harvesting areas to ensure full utilisation throughout the year and that the target volume for each area is achieved ([46]).

1.2. Analysis of parameters of wild seaweed harvesting in EMODnet with proposal for inclusion of additional parameters

The European Marine Observation and Data Network (EMODnet), established in 2009, is the European Commission's (EC) *in situ* marine data service of the European Commission Directorate-General Maritime Affairs and Fisheries (DG MARE) funded by the European Maritime Fisheries and Aquaculture Fund. The EMODnet Portal serves as a single access point to marine in-situ data, metadata and data products. EMODnet covers seven disciplinary themes – bathymetry, geology, physics, chemistry, biology, seabed habitats and human activities.

Topics relevant for wild seaweed and their wild harvesting are included under several themes of the EMODnet. **Bathymetry** provides, inter alia, digital terrain data of the sea bottom, used for comprehension of bottom substrate, depth and coastal borders. **Seabed habitats** now possess the broad-scale seabed habitat map for Europe or EUSeaMap, and various data products containing also physical and chemical information on marine habitats. **Biology** embraces data and data products on temporal and spatial distribution of marine species (planktonic and benthic organisms, birds, fish, mammals, reptiles) and species traits from European regional seas. The taxonomic basis for this data theme is linked with the World Register of Marine Species thus having possibility to update changes in species names and lists. **Human activities** contain geographic information on 20 different activities carried out in European marine areas. Specific information on seaweed wild harvesting and aquaculture is included as one of them. The theme Human activities also hosts the national maritime spatial plans of European countries.

([46]) Vea, J., & Ask, E. (2011). Creating a sustainable commercial harvest of Laminaria hyperborea, in Norway. *Journal of Applied Phycology*, *23*(3), 489–494. https://doi.org/10.1007/s10811-010-9610-y

1.2.1. Review of current parameters and use cases of EMODnet

Current parameters related to seaweed wild harvesting in EMODnet data base have been analysed. The activity named “Algae production” is found under the theme *Human activities*. The dataset of this activity provides information on the location (geographic coordinates and country) of the production facilities and their related information: the group of produced organism (macroalgae, microalgae and *Spirulina*), the step in the value chain (Producer, Processor, Technology provider, Consultancy, Research and Development, Trader/Exporter), the production method (Fermenters, Harvesting, Photobioreactors, Open ponds, Semi Open ponds, land-based or at sea Aquaculture, Integrated multi-trophic or not) and the species farmed. The dataset has been established in 2018 and the latest update has occurred in 2022 ([47]). The following seaweed wild harvesting data is therefore accessible: country, location of companies in each country, list of species harvested at each company, production method, i.e., harvesting type – manual or mechanical (Figure 6).

Figure 6 – Example of the map view of EMODnet portal, displaying information on seaweed-related economic activities

Source: https://emodnet.ec.europa.eu/geoviewer/

The current scope of parameters provides information on species of interest for wild harvesting, the geographical distribution of wild harvesting companies across Europe, and indications on collection methods. This information can be used to infer the relative intensity overview of macroalgal harvesting, which is useful for potential newcomers in the respective business sector. This information has been

([47]) EMODnet (n.d.) EMODnet Human Activities, Algae Production. https://emodnet.ec.europa.eu/geonetwork/srv/eng/catalog.search#/metadata/7b849214-e6ae-4199-a3f0-d4539f1f1289

also used in recent studies by Araújo et al. ([48]) and Vazquez Calderon & Sanchez Lopez ([49]) to describe the algae production industry in Europe (Figures 7 and 8).

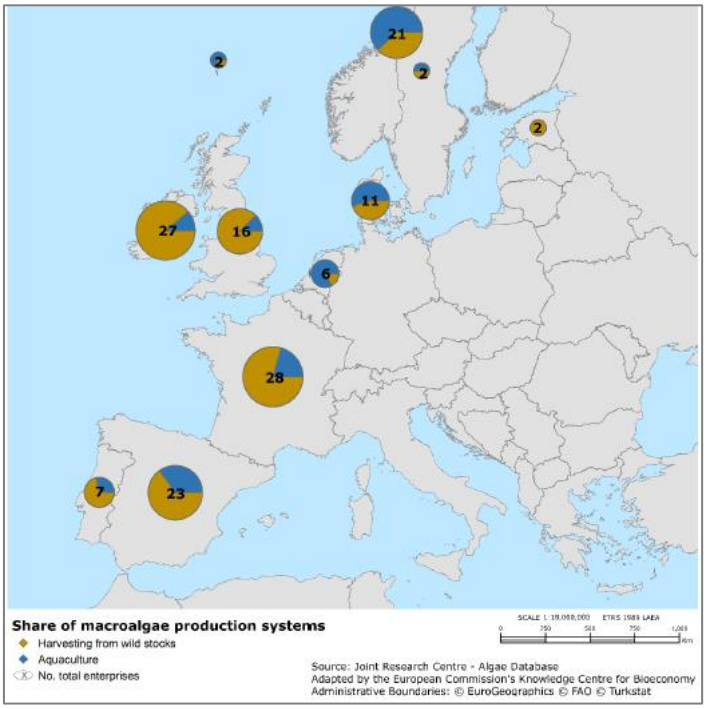
Figure 7 – Share of companies in Europe producing seaweed biomass by wild harvesting

Source: Araújo R. et al., 2021.

([48]) Araújo R. et al., (2021) Current Status of the Algae Production Industry in Europe: An Emerging Sector of the Blue Bioeconomy. Front. Mar. Sci. 7:626389. doi:10.3389/fmars.2020.626389

([49]) V azquez Calderon, F., Sanchez Lopez, J., (2022). An overview of the algae industry in Europe. Producers, production systems, species, biomass uses, other steps in the value chain and socio-economic data, Guillen, J., Avraamides, M. editors, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/813113, JRC130107.

Figure 8 – Proportion and distribution of macroalgae sourcing in Europe



Source: Vazquez Calderon&Sanchez Lopez,2022.

The EMODnet portal compiles use cases for its various data themes, with 16 recorded under Human Activities - primarily related to offshore energy. To explore additional uses of EMODnet data, Google Scholar and general Google searches were conducted using keywords such as “EMODnet algae production” and “human activities.” Each result was reviewed to determine its relevance to wild seaweed harvesting. Of 27 Google search results, only one was directly related to wild macroalgae harvesting, while none of the approximately 50 results from Google Scholar were relevant. This suggests that the visibility and accessibility of EMODnet data could be improved to encourage wider use. It should also be noted that data on macroalgae production has only been added relatively recently.

1.2.2. Recommendations for potential improvements on wild seaweed harvesting in EMODnet

An online survey was launched to assess awareness on EMODnet dataset options and usage preferences, specifically targeting national authorities and companies engaged in seaweed wild harvesting. The focus of the survey questions was harmonised with the EMODnet secretariat. A link to the survey was directly sent to the following recipients listed in Table 1, and the survey was announced to partners of the EU projects “SeaMark” and “Algae ProBANOSp” and promoted via the community platform Blue Bio Match.

Table 1 – List of recipients for the online survey

Country	Authority	Company
Denmark	Seaweed Network Denmark	Danish Seaweed organisation
Estonia	Agriculture and Food Board under the Ministry of Rural Affairs	Estagar
France	CRPMEM de Bretagne	Algorythme Symbiomer SETALG OLMIX
Iceland	Directorate of Fisheries	Matis
Ireland	National Parks and Wildlife Service	Wild Irish Seaweeds Arramara Teo The Irish Seaweed Company
Norway	Norwegian Seaweed association	Lofoten Seaweed Polar Algae
Portugal	National Fisheries Authority	Iberagar Easy Harvest
Spain	Xunta de Galicia Principality of Asturias	Algamar Porto-Muinos

A total of 43 responses were received. The survey was completely anonymous; therefore, no breakdown of responses per country of origin is available.

Survey results indicate that use of the EMODnet data portal is quite limited. Most respondents reported not using the portal's services, and none had accessed the specific dataset on algae production under the Human Activities theme. For wild seaweed harvesting, licenses or permits are generally required, with sanctions in place for non-compliance. Harvest data is reported, and in some cases made publicly available, serving as a basis for resource management. Both regulatory authorities and research representatives are involved in managing wild seaweed resources. A more detailed description of the survey results is provided in Annex 2.

There is no urgent need to add new parameters in any of the EMODnet data themes relevant for wild seaweed harvesting, as the awareness on and usage of existing services is low. Moreover, it is impossible to assess whether parameter insufficiency exists if usage of the specific data theme is very passive and if the needs of users are not known. Therefore, it is recommended to:

- Expand the promotion of EMODnet existence, services, and possibilities;
- Organise more initiatives targeting specific practical topics, like the recent webinar organised by EUSPA on the use of Copernicus Earth Observation

and EMODnet data for seaweed farming ([50]) and the EMODnet Open Sea Lab 4.0 Virtual hackathon for ocean restoration ([51]) to widen the understanding of data usage and necessity of reporting;

- Gradually introduce mandatory data reporting to EMODnet for international projects working on wild seaweed harvesting;
- Ultimately, implement mandatory reporting for national contact points on relevant data themes.

([50]) Lopez-Martinez, M. (2025) Copernicus/EMODnet Demonstrator for seaweed farming. https://www.linkedin.com/posts/manuel-lopez-martinez-1b6b75b4_copernicus-emodnet-seaweed-activity-7301221762103496704-0qSB?utm_source=share&utm_medium=member_desktop&rcm=ACoAAALmucIBDOoAcwzbpR227v-ZCyJBPDwe5Vg

([51]) EMODnet (n.d.) Save the Date for the EMODnet Open Sea Lab 2025! https://emodnet.ec.europa.eu/en/events/save-date-emodnet-open-sea-lab-2025

2. Beached seaweed collection

Beached seaweed (also beach cast or beach wrack) displays a lot of variation across Europe. In the North Sea and Atlantic coast, where tides are present, the collection of beached seaweed partly overlaps with wild harvesting, performed intertidally. In the Baltic Sea, where tides are absent, the beached seaweed is distinctly visible. While in Ireland, UK, and France the beach wrack is a resource for harvesting and further processing or consumption, in the Baltic Sea countries it is mostly seen as a nuisance. Estonia is an exception, particularly in its western regions, where beach cast composed of the red alga *Furcellaria lumbricalis* is commercially harvested for furcellaran production. Not surprisingly, the approach is highly related to the species composition of the beach cast. In the Baltic Sea, beach cast seaweed often contains a high proportion of annual green and brown algae, not regarded as valuable for processing.

The collection of beach cast should be treated as cautiously as the wild harvesting of macroalgae. In many cases, beach-cast algae provide an essential food source for beach invertebrates and play a vital role in coastal food webs ([52]). The removal of beach cast can also affect nutrient flows - when decaying nutrients from the seaweeds are re-mineralised and exported back to the sea. Without this recycling, the primary production capacity of coastal ecosystems for both phytoplankton and macroalgae would decrease. It is also known that cleaned, i.e. managed beaches are wider, have much less vegetation, lower biodiversity, fewer “natural” dunes and a much flatter topography than unmanaged beaches ([53]).

In contrast, in eutrophic ecosystems like the Baltic Sea, where the overgrowth of opportunistic filamentous algae occurs, beach cast can disrupt important habitats and species, leading to substantial negative effects. In such situations, removing the beach cast is considered advantageous for the coastal ecosystem. Moreover, the removal of excess nutrients from the coastal area helps reduce the adverse effects of eutrophication ([54]). In addition, evidence exists on beach cast containing high volumes of pathogenic bacteria, especially close to river outflow

([52]) Orr, K.K., (2013). Predicting the ecosystem effects of harvesting beach-cast kelp for biofuel. PhD thesis. University of Aberdeen.

([53]) Woelfel J., Hofmann J., Müsch M., Gilles A., Siemen H., Schubert H., (2021). Baltic beach wrack — challenges for sustainable use and management: Report of the Interreg Project CONTRA. Rostock, 49 pp., www.beachwrack-contra.eu

([54]) Möller T., Woelfel J., Beldowski J., Busk T., Chubarenko B., Gorbunova J., Hogland W., Kotwicki L., Martin G., Quintana C.O., Sachpazidou V., Schmieder F., Schubert H., Schätzle P.-K., Taevere T., Torn K. (2021): Environmental aspects of beach wrack removal, Tallin, 104 pp. Report of the Interreg Project CONTRA – https://www.beachwrack-contra.eu/removal

areas. During the decay process, changes in both bacterial consortia and physicochemical conditions occur, which might favour potential pathogens ([55]).

2.1. Report on data of beached seaweed, harvesting techniques, management schemes and data collection policies

Data on beached seaweed across European Union countries has been summarised in Annex 3. Available country information on beached seaweed has been screened and shows that, in most cases, beached seaweed is harvested – or gathered – either in small amounts for personal use or collected as waste. Therefore, management schemes specific for the beached seaweed are quite scarce, as this activity is often unregulated. Existing cases and approaches are described in following subchapters.

2.1.1. Review of data on beached seaweed and harvesting techniques

Naturally occurring values range from several hundred to tens of thousands of tonnes; however, estimates based on modelled data may be positively or negatively biased. Beached seaweed data is typically collected only once every few years, as cost-effective assessment methods are still under development ([56]). Beach cast seaweed in Mediterranean countries is mostly composed of the seagrass species Posidonia, which creates habitats for invertebrates ([57]). Notably, bordering the North Sea in Belgium and the Netherlands, beached seaweed is mostly absent due to the type of sediment substrate (soft mud), as macroalgae cannot attach and grow. The occurrence of beached seaweed is also uncommon along the Finnish coast, where steep and rocky shorelines prevent the accumulation of macroalgal cast.

([55]) Kalvaitienė, G., Espinosa, R.P., Vaičiūtė, D., Kataržytė, M. (2024) Diverse sources of fecal contamination in macroalgae wrack-affected environment adjacent to river outflow along the Baltic Sea coast. Environmental Pollution, 357, 124429, ISSN 0269-7491. https://doi.org/10.1016/j.envpol.2024.124429

([56]) Pan, Y., Flindt, M., Schneider-Kamp, P., Holmer, M. (2021) Beach wrack mapping using unmanned aerial vehicles for coastal environmental management. Ocean & Coastal Management, 213, 105843, https://doi.org/10.1016/j.ocecoaman.2021.105843

([57]) Beltran, R., Beca-Carretero, P., Marbà, N., Jiménez, M. A., Traveset, A. (2020). Spatio-temporal variation in macrofauna community structure in Mediterranean seagrass wrack. Food Webs, Vol. 25, e00178, https://doi.org/10.1016/j.fooweb.2020.e00178

Two main beach cast harvesting methods exist: hand gathering, which involves collecting beach-cast species from the strandline by hand; and mechanical gathering which entails collecting beach-cast species from the strandline using tractors. Numerous tools are used to gather beach cast, including a variety of hand rakes, forks and spades, buckets, bags, wheelbarrows or handcarts, nets, horses, and larger vehicles used for transport ([58]). Beach cast removal using vehicles including tractors, bulldozers and lorries is common ([59]). An effective method of beach cast collection combines simultaneous removal of macroalgae from beach and coastal water ([60]).

2.1.2. Resource management schemes and data collection practices

Within the European Union legislative framework, beached seaweed can be classified in at least two ways: as waste and as a component of natural habitats.

Currently, EU and national regulations do not distinguish between seaweed and man-made waste. Organic materials like seaweed, seagrass, and algae collected from beaches are treated the same as general beach waste, even when they are intended for further processing. As a result, beach cleaning is typically outsourced to municipal or specialised cleaning companies, and the contracts they operate under usually only include broad requirements to comply with applicable regulations. Once beach wrack is removed from the shore and the public authority has approved its removal, it becomes legally classified as waste. The absence of clear legal frameworks specifically addressing beach wrack management and reuse means that its potential as a usable resource is often overlooked ([61]).

The Habitats Directive 92/43/EEC focuses on the conservation of natural habitats and wild flora and fauna, aiming to protect Europe's most valuable wildlife areas and preserve biodiversity. Among the protected features under this Directive is the "annual vegetation of the drift lines." According to this Directive, it is prohibited to damage natural coastal habitats, including the intentional picking, collecting, cutting, uprooting, or destruction of plants in their natural environment. Additionally, it is forbidden to keep, transport, sell, exchange, or offer for sale any

([58]) Mac Monagail, M., Cornish, L., Morrison, L., Araújo, R., & Critchley, A. T. (2017). Sustainable harvesting of wild seaweed resources. *European Journal of Phycology*, *52*(4), 371–390. https://doi.org/10.1080/09670262.2017.1365273

([59]) Wilding, C., Tillin, H., Stewart, E.J., Lubelski, A., Burrows, M. and Smale, D. (2021). Hand harvesting of seaweed: Evidence review to support sustainable management. NRW Evidence Report Series Report No: 573, 275pp, NRW, Bangor. https://www.mba.ac.uk/wp-content/uploads/2022/05/Wilding_et_al_2021_NRW_Hand-harvesting-seaweed.pdf

([60]) Warguła, Ł. et al. (2021).The Problem of Removing Seaweed from the Beaches: Review of Methods and Machines. Water 2021, 13, 736. https://doi.org/10.3390/w13050736

([61]) CONTRA (2020). Legal aspects of beach wrack management in the Baltic Sea region. Project report. www.beachwrack-contra.eu

specimens of protected species collected from the wild. In the case of beach wrack, special care must be taken to protect the annual drift line vegetation, as beached seaweed often serves as a substrate for the growth of terrestrial plants.

The regional conventions – HELCOM and OSPAR – do not specifically address topic of beach wrack. The protection of biodiversity and respective habitats – including beach areas – is among the central goals of the conventions.

Member states apply a variety of management approaches, depending mostly on the abundance of beached seaweed and the season when it is present. As aforementioned, Baltic Sea countries with sandy beaches (Germany, Poland, Lithuania, Latvia, Sweden (Gotland Island) and Denmark) regularly collect beached seaweed during the tourism season to keep the beaches clean. The cleaning is concentrated at the Blue Flag beaches where certain requirements should be fulfilled, while in Natura 2000 areas no beached seaweed removal occurs. In Valencia (Spain), Northern Portugal, Italy and Greece, beached seaweed are considered as necessary compounds of beach habitats ([62], [63]). Permits are required to remove the beached seagrass Posidonia in Valencia. Beach wracks and piles of Posidonia known as *banquette* are included among the priority habitats to be preserved and protected in the Mediterranean area, according to the Barcelona Convention ([64]). In several countries bordering the North Sea and the Northern Atlantic (Denmark, France), methods are being developed to remove large quantities of invasive red algae Sargassum sp. In Normandy (France), a couple of projects have been devoted to estimate the amounts of Sargassum and look for possible valorisation options ([65]). In the Mediterranean, beached seaweed is entangled with large amounts of plastic litter, raising issues of plastic degradation and potential microplastic pollution ([66]).

([62]) Andreu T. (2024).La posidonia se queda: prohibido retirarla en las playas de Dénia de les Rotes, el Raset, el principio de les Marines, Molins y Deveses. Levante de la Marina. https://www.levante-emv.com/marina/2024/06/25/posidonia-queda-prohibido-retirarla-playas-104265442.html

([63]) Guerrero-Meseguer,L., Veiga, P., Rubal, M. (2023). Spatio-Temporal Variability of Wrack Along the Northern Portuguese Sandy Beaches. Estuaries and Coasts. https://doi.org/10.1007/s12237-023-01176-z

([64]) Tomasello, A., Bosman, A., Signa, G., Rende, S.F., Andolina, C., Cilluffo, G., Cassetti, F.P., Mazzola, A., Calvo, S., Randazzo, G., Scarpato, A., Vizzini, S. (2022). Reconstruction of a Giant Posidonia oceanica Beach Wrack (Banquette): Sizing Biomass, Carbon and Nutrient Stocks by Combining Field Data With High-Resolution UAV Photogrammetry. Front.Mar.Sci., Vol. 9. https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2022.903138

([65]) Bouasria, M. et al. (2021).Valorisation of stranded Laminaria digitata seaweed as an insulating earth material. Construction and Building Materials, 308 https://doi.org/10.1016/j.conbuildmat.2021.125068

([66]) Kolda, A. et al. (2024). Beach wracks microbiome and its putative function in plastic polluted Mediterranean marine ecosystem. Marine Environmental Research, 202, https://doi.org/10.1016/j.marenvres.2024.106769

The litter quantities in beach wrack at the waterline can be 3–13 times higher than what is found on bare sand. Moreover, old and scattered beach wrack may entrap 181 times more litter, highlighting that it serves as a sink of litter on beaches ([67]).

Data collection on beached seaweed is mostly used by local administrations to estimate the costs of beach cleaning, using the total volumes of seaweeds. Species composition or proportion of dominant species are therefore not identified. Taxonomic information and distribution of various species are assessed during specific research projects by academic institutions, NGOs or nature protection agencies. Management approaches and data collection in the countries is compiled in Annex 3.

2.1.3. Survey results on beached seaweed collection

The survey described in section 1.2. also addressed beach cast management approaches and data collection policies. The few responses received showed that beach cast macroalgae are less considered than seaweed cultivation. According to the survey results, the amounts of beached seaweed are not estimated, the data is not analysed for future management, and seaweed is not collected for further processing.

The full set of survey results is accessible in Annex 2.

([67]) von Thenen, M. et al. (2025) Beach Wrack on Baltic and Mediterranean Sea Beaches: Litter Pollution and Management Perspectives. Estuaries and Coasts, 48:61, https://doi.org/10.1007/s12237-025-01497-1

3. Recommendations for sustainable activities

3.1. Existing management practices from global to national for wild seaweed harvesting

This chapter describes the results of the SWOT analysis of existing global standards, EU-wide recommendations and national management practices for sustainable wild seaweed harvesting. The SWOT analysis provides a structured framework to evaluate the multifaceted factors that influence the success and viability of suggested approaches**.** A structured assessment is critical for identifying internal strengths and weaknesses together with external opportunities and threats. Internal strengths include existing advantages - traditional knowledge, existing sustainable practices, and resource abundance. Weaknesses are represented mostly by internal limitations - research gaps, potential overharvesting issues, or limited monitoring possibilities. External opportunities are characterised by possibilities - increasing market demand for natural products, rising policy support, and technological innovations. Threats include external challenges such as environmental degradation due to climate change, inconsistent regulations, and market fluctuations.

For the purpose of the SWOT analysis, the two most relevant global standards were chosen, as well as several European Union directives, suggestions from related project results and studies, and national management approaches. Regional environmental conventions like OSPAR and HELCOM are not included in the analysis as their scope is more general and not directly applicable to wild seaweed harvesting.

3.1.1. SWOT analysis of documents

The range of documents used for the analysis of wild seaweed harvesting management is provided in Table 2.

Table 2 – International legal and governance documents on wild seaweed harvesting management

Title	Scope	Coverage
ASC/MSC Seaweed Standard	Detailed framework for sustainable wild seaweed harvesting and farming by setting criteria and performance indicators	Global
Friend of the Sea Certification Criteria Checklist for Seaweed Products	Comprehensive framework to promote sustainable practices in seaweed harvesting and farming. Contains specific requirements across ten key areas	Global
Organic Food Regulation	Set of rules for organic production and labelling in the EU	European Union
Strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021 to 2030	A long-term vision for the development of the EU aquaculture sector.	European Union
Water Framework Directive	Water quality and management, aiming for good ecological status.	European Union
Habitats Directive	Protection of habitats and species, importance of ecosystem conservation	European Union
Marine Strategy Framework Directive	Good Environmental Status in EU marine waters, covering 11 descriptors and multi-sector management.	European Union

3.1.1.1. ASC-MSC Seaweed Standard

The ASC-MSC Standard is designed to recognise and reward sustainable practices in seaweed production in general, thereby providing assurance to consumers and adding market value to certified operations.

Strengths:

- The document is based on internationally recognised, science-based criteria developed collaboratively by sectoral organizations ASC and MSC;
- It outlines some performance indicators for monitoring the stock status and harvest strategies, thus providing a good technical basis for sustainable management.

Weaknesses:

- The complexity and breadth of the criteria may require extensive data and technical capacity, which could be a barrier for smaller operations;
- The document does not provide specific criteria for wild harvesting of seaweed;
- Strict certification requirements might limit flexibility or impose high administrative and operational costs.

Opportunities:

- Certification under this standard can add market value and consumer trust by demonstrating commitment to sustainability;
- The framework encourages continuous improvement, potentially opening access to new markets and partnerships in sustainable seafood.

Threats:

- Changes in environmental conditions or regulatory frameworks could challenge compliance with the standard;
- The risk of non-compliance or inconsistent application across regions may undermine the sustainability goals if not carefully managed.

It is possible to assess internal and external factors affecting sustainable wild seaweed harvesting by analysing the guidelines, performance indicators, and certification processes detailed in the standard. Thus, the standard supports decision-making and strategic planning for sustainable practices. Nonetheless, the standard is not applicable for specific practical need, as its main focus is on seaweed cultivation aspects.

3.1.1.2. Friend of the Sea Certification Criteria Checklist for Seaweed Products

The “Friend of The Sea ([68]) Certification Criteria Checklist for Seaweed Products, 2014” is a detailed audit tool designed to verify that seaweed harvesting and farming operations meet sustainability standards.

([68]) The World Sustainability Organization (WSO), founded in 2008 by environmentalist Paolo Bray, is a global entity dedicated to ecosystem conservation through internationally recognized certification programs like Friend of the Sea and Friend of the Earth. List of certified companies available https://friendofthesea.org/certified-products-and-services/

Strengths:

- The checklist provides a comprehensive, multi-faceted framework that covers environmental management broadly (water and air quality, waste, and energy), social accountability, and traceability;
- The criteria are clearly categorised into essential, important, and recommendations, which helps organisations understand priorities and timelines for compliance;
- Independent verification and third-party certification add credibility and build consumer trust in the sustainability of certified products.

Weaknesses:

- The comprehensive nature of the framework may result in a complex and administratively heavy process, especially for smaller or emerging operators;
- Compliance with the detailed requirements, e.g., continuous monitoring, extensive record-keeping, and strict chemical controls may increase operational costs;
- The rigidity of timelines (three-month for essential non-conformities) could be challenging to meet in rapidly changing production environments.

Opportunities:

- Certification can provide a competitive market advantage by enhancing brand reputation and consumer confidence, with an option to open new markets for sustainable seaweed products;
- The checklist can drive industry improvements by encouraging innovation in sustainable practices and fostering better traceability systems;
- It offers a clear benchmark for businesses to improve their environmental and social performance, which can lead to partnerships and collaborations with eco-conscious buyers and regulators.

Threats:

- Shifts in national or international regulations or policy changes might render some criteria less relevant or more difficult to implement over time;
- If the standard is perceived as too burdensome, certification uptake may be affected, leading to fragmentation in market practices;
- External factors – such as environmental variability due to climate change or unforeseen market disruptions – could challenge the practical implementation of the criteria, risking non-compliance despite best efforts.

This analysis highlights that while the Friend of the Sea standard is robust and comprehensive, its complexity and cost of compliance may pose challenges. Nonetheless, the potential for market differentiation and the promotion of sustainable practices provides opportunities for the seaweed harvesting industry.

3.1.1.3. Organic Food Regulation (2018/848/EU)

The Regulation establishes the principles of organic production and lays down rules concerning organic production, related certification and the use of indications referring to organic production in labelling and advertising, as well as rules on controls. The EU organic regulation (Regulation (EU) 2018/848) states that wild seaweed harvesting must be sustainable and must not compromise the long-term stability of the ecosystem. Harvesters must ensure natural regeneration by collecting seaweed at a rate and method that allows regrowth, avoiding depletion of the resource ([69]).

Strengths:

- Uniform and credible standards: the regulation sets a harmonised framework across the EU, ensuring that all organic products (including wild-harvested seaweed) ([70]) adhere to consistent criteria, which can build consumer trust in the sustainability and quality of organic seaweed products;
- Environmental and sustainability focus: the regulation emphasises natural production methods, low chemical inputs, and ecosystem-friendly practices. This aligns well with the principles of sustainable wild seaweed harvesting, where minimal intervention and natural growth are key;
- Traceability and transparency: a robust record keeping and certification processes are required, which can help verify that wild seaweed is harvested in an environmentally responsible manner.

Weaknesses:

- Limited specificity for wild harvesting: the regulation is primarily designed for cultivated organic products. Wild-harvested seaweed may face challenges when being certified under standards that assume production control and input management;
- Complexity and administrative burden: meeting the strict documentation, monitoring, and certification requirements may be challenging for wild

([69]) Hand or manual harvesting only, removing a part of canopy. For some kelp and and wrack species (for example L. hyperborea, H. elongata, and F. serratus) removal of the adult canopy allows more light into the understory, which in pristine habitats allows for rapid growth of juveniles or germlings (d'Avack & Garrard, 2015; Stagnol et al. 2015; 2016).

([70]) Conditions for wild seaweed (algae in the Regulation) described in Annex II Part III

harvesters, particularly small-scale operators with less capacity than large farms;

- Interpretation issues: there can be ambiguity when applying rules developed for controlled agricultural systems to naturally occurring resources. This may lead to inconsistencies in how wild seaweed is evaluated and certified as organic.

Opportunities:

- Market differentiation and added value: certification under the organic regulation can provide wild-harvested seaweed with a market advantage, appealing to eco-conscious consumers and niche markets;
- Driving sustainable practices: the pressure to comply with organic standards may motivate wild harvesters to adopt better monitoring, traceability, and sustainability practices, thus further supporting the long-term health of natural seaweed stocks;
- Innovation in certification models: the unique nature of wild-harvested seaweed creates an opportunity to develop additional certification schemes that bridge the gap between the organic regulation and the realities of wild harvesting.

Threats

- Risk of exclusion: if the required criteria prove too strict for wild-harvested products, many wild seaweed harvesters might be unable to obtain organic certification, which would limit market access for sustainable wild seaweed;
- Cost and resource barriers: the administrative and monitoring costs required for certification could discourage small-scale or traditional harvesters, possibly pushing the market toward larger operators and reducing local participation;
- Regulatory uncertainty: as the regulation was primarily designed for agricultural production, evolving interpretations or future amendments may further complicate the certification process for wild-harvested seaweed.

While the Organic Food Regulation offers a robust framework supporting sustainability and traceability, its direct application to wild seaweed harvesting faces challenges due to the intrinsic differences between controlled cultivation and natural resource extraction. Adapting certification models to better reflect the characteristics of wild-harvested seaweed could help capitalise on market opportunities.

3.1.1.4. Water Framework Directive

The Water Framework Directive (WFD) focuses on ensuring good quality and quantity of natural waters via reducing and removing pollution and ensuring that there is sufficient water to support both wildlife and human needs.

Strengths:

- Ecosystem-based approach: the WFD promotes integrated water management and aims to achieve "good ecological status" for all water bodies. This holistic, ecosystem-based framework ensures healthy coastal and marine environments that support resilient seaweed populations;
- Monitoring and data collection: the Directive requires regular monitoring and reporting on water quality and ecosystem health. These data can be used to assess the sustainability of wild seaweed stocks and guide adaptive management practices.

Weaknesses:

- Broad scope and lack of specificity: the WFD is designed to cover all water bodies and a wide range of pollutants and pressures, meaning it is not specifically tailored to wild seaweed harvesting;
- Implementation variability: the effectiveness of the WFD can vary among EU Member States due to differences in implementation and enforcement;
- Potential over-regulation: in striving to achieve "good ecological status", authorities might impose strict measures that inadvertently limit or complicate sustainable harvesting activities if seaweed's natural variability is not fully accounted for.

Opportunities:

- Integrated resource management: the Directive's focus on improving the ecological status of water bodies can be leveraged to develop specific management plans for wild seaweed resources. This may encourage best practices that align harvesting with overall water quality improvements;
- Innovation in adaptive management: the regular review cycles and adaptive management requirements offer a framework for refining harvesting techniques over time, potentially integrating innovative monitoring technologies directly beneficial to wild seaweed management.

Threats:

- Strict compliance pressures: if water bodies fail to meet the WFD standards, authorities might impose corrective measures that could restrict or alter harvesting practices;

- Regulatory uncertainty: the broad and evolving nature of the Directive may create uncertainty in how its requirements are applied to sectors not originally considered.

Although WFD sets a robust framework for protecting water quality and ecological status, its broad scope and implementation challenges mean that direct application of it to sustainable wild seaweed harvesting is not fully feasible. However, its ecosystem-based approach and emphasis on monitoring offer significant opportunities to support sustainable harvesting practices.

3.1.1.5. Marine Strategy Framework Directive (MSFD)

This MSFD's goal is to protect the marine ecosystem and biodiversity upon which our health and marine-related economic and social activities depend.

Strengths:

- Ecosystem-based management: the MSFD aims to achieve Good Environmental Status (GES) across EU marine waters through a holistic, ecosystem-based approach using 11 environmental descriptors. This comprehensive framework can help maintain the environmental conditions necessary for healthy wild seaweed populations;
- Integrated monitoring and adaptive management: the Directive requires regular monitoring, reporting, and review of marine environmental status. This creates opportunities to gather data on seaweed habitats and ecosystem functioning;
- Stakeholder involvement: stakeholder participation and the integration of various sectors in marine management is emphasised, potentially fostering collaboration among wild seaweed harvesting industry, scientists, and policymakers.

Weaknesses:

- Broad and indirect focus: while the MSFD covers many aspects of marine environmental quality, it is not specifically tailored to extractive activities like wild seaweed harvesting. Its general focus may lead to ambiguity in how wild harvesting is regulated;
- Variable implementation: the degree of implementation and enforcement of the MSFD can vary significantly across Member States, leading to inconsistencies how wild seaweed harvesting is managed.

Opportunities:

- Integration of sustainable harvesting practices: the adaptive management and regular review processes offer a chance to incorporate specific

guidelines for wild seaweed harvesting within broader marine ecosystem management plans;

- Enhanced research and monitoring: the monitoring framework could be used to develop dedicated indicators for wild seaweed, enabling more precise management and improvement of harvesting techniques.

Threats:

- Administrative and compliance burdens: the need for comprehensive monitoring and reporting under the MSFD might impose high administrative costs on wild harvesting companies, particularly small-scale ones, potentially discouraging compliance;
- Uncertainty and inconsistency: differences in the interpretation and enforcement of the MSFD across regions could lead to regulatory uncertainty for wild seaweed harvesters, possibly hindering long-term sustainable practices.

The Marine Strategy Framework Directive offers a strong framework for protecting marine ecosystems through integrated, adaptive management. However, its broad scope and variable implementation pose challenges when directly applying its principles to sustainable wild seaweed harvesting. Balancing the MSFD's environmental targets with the natural regenerative capacity of wild seaweed will be key to leveraging its opportunities without stifling sustainable economic activities.

3.1.2. National management practices

This subchapter presents the national management practices in use for wild seaweed harvesting. In all Member States, the practices for governance and management of wild seaweed harvesting are following EU environmental directives and respective restrictions. A summary of these national practices is provided in Table 3. Experience and knowledge from Iceland and Norway are included to obtain a wider geographical overview.

Table 3 – Summary of EU national management practices for wild seaweed harvesting

Country	Regulations and responsible bodies	Licenses	Quotas	Fallow Period	Monitoring body
Denmark	Ecological risk assessment Ministry of Environment and Food of Denmark	Required when seaweed harvested for food	No more than 10% of the stock in the specific location	Three years	Company harvesting the seaweed
Estonia	Fishing Act Agriculture and Food Board under the Ministry of Rural Affairs	Issued with quantity limits	Around 2000 tonnes per year	Unharvested the following year	Biannual by Estonian Marine Institute
France	Rural and Maritime Fisheries Code DPMA together with fisher's organisations	Annual licensing campaigns	Quotas are specific for species and harvesting method – 5000 t manually, 60000 t mechanically	Is foreseen, specific for species	IFREMER together with regional organisations
Ireland	1933 Foreshore Act MARA, since 2023	Traditional rights and foreshore licenses	Harvesting zones are limited and quotas are set per boat	3–7 years	Marine Institute
Portugal	Acts on Water, Fishing and Environment, Ordinance 391/2023 National Fisheries Authority	Licensing system in place	Defined quotas	Seasonal harvest periods, limited harvesting areas	National Fisheries Authority
Spain	Regional and national regulations on fisheries Ministry of Agriculture, Fisheries and Food; regional governments	Licensing system	Annually defined quotas	Seasonal harvesting periods, harvesting zones, minimum area coverage	In Galicia – regional government, IIM, IGAFA In Asturias – CEP

Country	Regulations and responsible bodies	Licenses	Quotas	Fallow Period	Monitoring body
Iceland	Regulation on the acquisition of Seaweed for commercial purposes No 90/2018 Directorate of Fisheries	Permit to access the shore and permit to harvest seaweed	Quota defined per permit	Rotation of areas in a 4 year cycle	Marine Fisheries Research Institute
Norway	Marine Resource Act, regional regulations Directorate of Fisheries	License for harvesting and regional permits	Target volume for each harvesting area	Rotation of areas in a 5 year cycle	Institute of Marine Research

Countries are following the status of their seaweed populations, and – in areas where overexploitation has been observed, e.g. Basque County in Spain ([71]) – harvesting has been prohibited. In addition, in fragile ecosystems like the Baltic Sea, the wild harvesting is not allowed widely due to the low abundance of seaweed stocks and need to protect the habitats from anthropogenic pressure ([72]). However, seaweed harvesting restrictions are inadequate if all factors are not known.

A recent Danish study covered scientific ground for the management of wild seaweed harvesting and provided necessary evidence for sustainability of this activity ([73]). It still faced limitation as it only evaluated the short-term impact of wild harvesting (two years) and was performed across a small area. A best practice study from the UK prioritises obtaining knowledge of existing seaweed stock as the first task before any monitoring and management procedures ([74]).

([71]) NETALGAE project (2012). Seaweed industry in Europe. https://www.seaweed.ie/irish_seaweed_contacts/doc/Filieres_12p_UK.pdf

([72]) HELCOM ACTION (2021) Restoration measures for coastal habitats in the Baltic Sea: cost-efficiency and areas of highest significance and need. https://helcom.fi/wp-content/uploads/2021/11/Restoration-measures-for-coastal-habitats-in-the-Baltic-Sea.-cost-efficiency-and-areas-of-highest-significance-and-need.pdf

([73]) Møller Nielsen, M., Søndergaard Schmedes, P., Thomasberger, A. (2023). Forvaltningsgrundlag for bæredygtig høst af vilde bestande af tang – kystnær blæretang og sargassotang. DTU Aqua. DTU Aqua-rapport No. 422-2023. https://orbit.dtu.dk/en/publications/forvaltningsgrundlag-for-bæredygtig-høst-af-vilde-bestande-af-tan

([74]) Wilding, C., Tillin, H., Stewart, E.J., Lubelski, A., Burrows, M. and Smale, D. (2021a). Hand harvesting of seaweed: Evidence review to support sustainable management. NRW Evidence Report Series Report No: 573, 275pp, NRW, Bangor https://www.mba.ac.uk/wp-content/uploads/2022/05/Wilding_et_al_2021_NRW_Hand-harvesting-seaweed.pdf

To avoid environmental risks when scientific uncertainty still is high, it could be advisable to follow the precautionary principle (as enshrined in Article 191(2) of the Treaty on the Functioning of the European Union).

3.1.3. Conclusions

Sustainable seaweed harvesting is supported by market-driven standards, while it is not a focus of the EU regulatory framework. The EU Directives addressing topic of wild seaweed in the context of marine ecosystems are only considering protection and conservation aspects. The related national management practices are in line with EU frameworks.

1) The ASC-MSC and Friend of the Sea standards demonstrate that robust, science-based certification systems can add market value and promote sustainable practices. However, the complexity and administrative demands of these standards may limit their accessibility for smaller harvesters.
2) The Organic Food Regulation, while ensuring uniform and credible standards across the EU, is primarily designed for controlled agricultural production. This is challenging when applied to wild-harvested seaweed – a subject to natural variability and less controllable conditions. A cautious manual, species specific small-scale harvesting could be an approach to fulfil the requirements of the Regulation.
3) The EU Directives provide a solid regulatory foundation for protecting marine environments. These provide tools for monitoring, stakeholder involvement, and adaptive management, but they do not specifically support or guide wild seaweed harvesting. However, none of the documents reviewed were found to encourage activities that would harm wild seaweed populations.

3.2. Management of beach cast seaweed collection

This subheading contains SWOT analyses of EU management practices for beach cast seaweed collection, and an overview of national approaches. Although several overarching environmental directives are the same as for wild seaweed harvesting, the issue of beach cast seaweed is more complex and thus less specifically regulated. Geographical and biological differences determine national management practices, with beach cast seaweed treated as a valuable resource or a nuisance waste.

3.2.1. SWOT analysis of documents

There are no legal acts specifically on beach cast seaweed in the EU legal framework. The EU Environmental Directives are mostly analysed, as also no international standards exist concerning the collection of beach cast seaweed for commercial purposes. The list of most relevant documents is summarised in Table 4.

Table 4 – EU legal documents on collection of beach cast seaweed

Title	Scope
Bathing Water Directive (BWD)	Maintaining and improving the quality of bathing waters, ensuring safety for human health.
Waste Framework Directive	Framework for waste management within the European Union, promoting waste prevention, reuse, recycling, and sustainable resource use.
EU Circular Economy Action Plan (CEAP)	Pathway to a sustainable economy by reducing waste, increasing resource efficiency, and promoting the reuse of materials.
Water Framework Directive	Water quality and management, aiming for good ecological status.
Habitats Directive	Protection of habitats and species, importance of ecosystem conservation
Marine Strategy Framework Directive	Good Environmental Status in EU marine waters, covering 11 descriptors and multi-sector management.
Birds Directive	Protection of wild bird species and their habitats across Europe, particularly within Special Protection Areas (SPAs).

3.2.1.1. Bathing Water Directive

The Bathing Water Directive seeks to ensure that the quality of bathing water is monitored, improved management measures are introduced, and information is made available to the public. Considering the overlap of zones of bathing and beach cast seaweed collection, the directive could be one of the most specific regarding the beach cast.

Strengths:

- Improved water quality standards: reduces pollution and contamination risks, leading to cleaner coastal environments that may enhance seaweed quality;

- Public health protection: regulates microbial contamination, ensuring that collected seaweed is not exposed to harmful pathogens from polluted waters;
- Monitoring and data collection: provides valuable data on water conditions, which can be used to assess the suitability of beach cast seaweed for various applications;
- Increased public awareness: promotes public responsibility and better waste management, potentially reducing plastic and other compounds in beach cast seaweed**.**

Weaknesses:

- Strict regulatory requirements**:** may impose restrictions that limit access to beach cast seaweed collection, especially in areas classified as protected bathing waters;
- Focus on aesthetics over ecology: seaweed accumulation is sometimes removed for aesthetic reasons under the directive's influence, without considering its ecological benefits;
- Limited consideration for sustainable collection: the focus is primarily on water quality, with limited provisions for the sustainable management of natural coastal materials, including beach cast seaweed;
- Potential conflict with seaweed-based industries: if beach cast seaweed is removed primarily for aesthetic and hygiene purposes, the availability of raw material for commercial use could be reduced.

Opportunities:

- Environmentally-friendly seaweed management strategies: the Directive can encourage sustainable collection methods, balancing tourism interests with environmental conservation;
- Integration with circular economy initiatives: the use of collected seaweed in industries such as bio-fertilisers, bioplastics, and animal feed can be promoted, reducing waste and supporting sustainability goals;
- Collaboration with environmental policies: an alignment with the WFD and the MSFD could promote biodiversity conservation while allowing responsible seaweed harvesting;
- Potential for policy evolution: future updates to the Directive could include clearer guidelines on managing seaweed accumulation in a way that benefits both tourism and the environment.

Threats:

- Unintended negative impact on coastal ecosystems: excessive removal of seaweed to maintain "clean" beaches can disrupt natural coastal processes and biodiversity;
- Regulatory conflicts with local authorities: differing interpretations of the Directive may lead to inconsistencies in seaweed collection regulations across various regions;
- Tourism-driven policies overriding environmental needs: pressure from tourism industries might prioritise beach aesthetics over the ecological benefits of leaving seaweed in place.

The Directive has both positive and negative implications for beach cast seaweed collection, therefore requiring a balanced approach ([75]) to the harmonise needs of public health, tourism, and nature conservation, as well as potential industry interests in beach cast seaweed.

3.2.1.2. Waste Framework Directive (WFD)

The WFD sets the EU legal framework for waste management, promoting waste prevention, reuse, recycling, and sustainable resource use. The WFD is relevant to beach cast seaweed because it defines how this material should be managed once it is collected from beaches. The classification as waste or by-product will determine how it is handled, and the directive's waste hierarchy promotes sustainable use (e.g., recycling or reuse) rather than disposal. Proper classification ensures that beach cast seaweed can be used effectively, either as waste or a valuable resource, in line with EU sustainability goals ([76]; [77]).

([75]) Although the proportion of the beach cast to be left or removed varies substantially between locations and seasons, in the Baltic Sea sandy beaches it has been observed that beach cast should not be removed if the share of fresh cast near water line does not exceed 10%. In Valencia on urban beaches 50% of Posidonia remains is allowed to be removed, while on natural beaches no collection is allowed.

([76]) Šarauskienė, D., Akstinas, V., Jurgelėnaitė, A., Meilutytė-Lukauskienė, D. (2020). Report on potential of cast seaweed & policy frameworks in South Baltic Sea area. Coastal Biogas project, https://www.coastal-biogas.eu/resources/D33_Report_on_potential_of_cast_seaweed_and_policy_frameworks.pdf

([77]) Nathaniel, H. (2023). Insights to beachcast management on Gotland, Sweden: An Industrial Ecology perspective on waste-resource ambiguity. KTH Royal Institute of Technology, Doctoral Thesis. https://www.diva-portal.org/smash/get/diva2:1810838/FULLTEXT01.pdf

Strengths:

- Encourages resource recovery and circular economy: the reuse of organic materials is supported in fertiliser, biofuel, and bioplastics, therefore reducing landfill waste;
- Defines clear waste hierarchy: prioritises prevention, reuse, and recycling over disposal, encouraging innovative approaches also to beach cast seaweed utilisation;
- Regulates proper handling and disposal: uncontrolled dumping or burning is prevented, which reduces environmental pollution;
- Provides legal framework for by-products: when classified as a by-product rather than waste, beach cast seaweed can be legally used in commercial applications.

Weaknesses:

- Potential classification as waste: if beach cast seaweed is categorised as waste under the directive, it requires special handling, permits, and disposal, making collection and utilization more expensive and complex;
- Inconsistent implementation across regions: local authorities may interpret regulations differently, leading to diverging approaches for seaweed management;
- Lack of specific guidelines for seaweed: the directive does not explicitly address beach cast seaweed, leading to uncertainty over its classification and use;
- Potential for bureaucratic barriers: commercialisation of beach cast seaweed may face legal and administrative hurdles, slowing down innovation and investment.

Opportunities:

- Promotes innovation in waste utilisation: research and development of new applications is supported, including for beach cast seaweed:
- Aligns with the EU Green Deal and bioeconomy strategies: nature-based solutions and sustainable practices are encouraged, thus beach cast seaweed could be an important component of the EU's transition to a circular economy;
- Supports sustainable coastal management: the directive can be integrated with marine conservation efforts, ensuring seaweed collection does not disrupt ecosystem services;

- Potential for incentives and funding: the directive can be leveraged to secure grants, subsidies, or tax incentives for sustainable beach cast seaweed-oriented industries.

Threats:

- Over-regulation could hinder sustainable use: strict waste classification and handling requirements could hinder the financial feasibility of repurposing beach cast seaweed;
- Conflict between waste disposal and resource recovery: coastal municipalities may prefer quick disposal (landfilling, incineration) over sustainable reuse, undermining circular economy efforts;
- Potential contamination issues: beach cast seaweed collected from polluted waters may be unsafe for commercial use, limiting its applications. Decomposing beach cast seaweed can itself be a source for microbial contamination.

The EU Waste Framework Directive clearly presents both opportunities and challenges for beach cast seaweed management. To streamline the efforts and maximise benefits, a clearer classification of beach cast seaweed as resource is needed. Moreover, circular economy applications should be promoted to present seaweed a valuable asset rather than as waste.

3.2.1.3. EU Circular Economy Action Plan (CEAP)

The CEAP aims to transition Europe to a sustainable economy by reducing waste, increasing resource efficiency, and promoting the reuse of materials. Beach cast seaweed can play a role in this strategy as a renewable, biodegradable resource within a range of various applications (packaging, soil fertiliser).

Strengths:

- Promotes sustainable resource use: encourages reuse and valorisation of natural materials as beach cast seaweed, reducing reliance on synthetic fertilisers and plastics;
- Supports bioeconomy and innovation: aligns with the EU Bioeconomy Strategy, fostering research and development of various products manufactured from beach cast seaweed;
- Encourages waste-to-resource transition: helps classify beach cast seaweed as a valuable resource rather than waste, reducing disposal costs and environmental impact.

Weaknesses:

- Regulatory uncertainty and inconsistencies: lack of clear legal classification for beach cast seaweed (waste vs. resource) can create barriers for commercialisation;
- Potential conflict with conservation goals: large-scale collection, if not properly managed, could disrupt coastal ecosystems and biodiversity, conflicting with EU environmental policies.

Opportunities:

- Integration with other EU sustainability initiatives: the CEAP aligns with the Farm to Fork Strategy, the Zero Pollution Action Plan, and the Blue Economy Strategy, enhancing policy synergies;
- The development of new technologies for processing: advancements in biorefinery techniques, enzymatic treatments, and drying technologies can improve the efficiency of beach cast seaweed utilisation and its perception as a valuable resource.

Threats:

- Overexploitation risks: unregulated or excessive harvesting may lead to loss of habitat for marine species and coastal erosion issues;
- Climate change and environmental uncertainty: changes in beach cast seaweed occurrence patterns due to ocean warming, acidification, and pollution may affect availability and quality.

The EU Circular Economy Policy offers opportunities for integrating beach cast seaweed into sustainable industries. As with the Waste Framework Directive, some regulatory and environmental challenges need to be addressed. The legal status of beach cast seaweed needs to be clarified, and sustainable harvesting practices are needed to protect coastal ecosystems.

3.2.1.4. EU Birds Directive

The Bird's Directive aims to protect wild bird species and their habitats across the EU, particularly within Special Protection Areas (SPAs). Since beach cast seaweed provides an essential habitat for coastal and migratory birds, its management is of high relevance to balance biodiversity conservation with economic and commercial interests. Birds use beach cast areas for feeding on

invertebrates living there, and for nesting purposes using older beach cast higher on the shoreline ([78]).

Strengths:

- Protects critical bird habitats: ensures that coastal and migratory bird species depending on beach cast seaweed are safeguarded;
- Promotes research based conservation approaches: ecological assessments are encouraged before beach cast seaweed collection to ensure minimal disruption to bird populations;
- Supports sustainable coastal management: aligns with other EU environmental regulations;
- Contributes to wider marine and coastal protection efforts: legal backing is provided for restricting large-scale or mechanised beach cast seaweed collection in important bird areas.

Weaknesses:

- Potential restrictions on beach cast seaweed collection: strict rules in SPAs (Special Protection Areas) may limit or prohibit commercial or large-scale harvesting of beach cast seaweed;
- Lack of specific guidance: the Directive does not clearly define how beach cast seaweed should be managed regarding its role in bird habitats, leading to interpretation inconsistencies across EU Member States;
- Limited awareness of bird-seaweed ecosystem connections: coastal authorities and industries may not fully recognise the importance of beach cast seaweed in bird conservation, leading to conflicts over beach management.

Opportunities:

- Integration with sustainable collection practices: the Directive encourages the adoption of low-impact collection techniques that allow for controlled harvesting while preserving bird nesting and feeding areas;
- Research and monitoring of bird-seaweed interactions: it supports studies on linkage between beach cast seaweed and bird populations, helping refine sustainable management strategies;
- Alignment with other EU biodiversity policies: connections with the EU Biodiversity Strategy, Marine Strategy Framework Directive, and

([78]) Defeo, O., McLachlan, A., Schoeman, D.S., Schlachter, T., Dugann,J., Jones, A., Lastra, M., Scapini, F. (2009) Threats to sandy beach ecosystems: A review. Estuarine, Coastal and Shelf Science 81:1–12. http://dx.doi.org/10.1016/j.ecss.2008.09.022

Natura 2000 network are strengthened, ensuring harmonised conservation efforts.

Threats:

- Conflicts between conservation and economic interests: restrictions in some areas may limit beach cast seaweed collection, creating tensions between coastal businesses, conservation groups, and authorities;
- Climate change impacts on habitats: rising sea levels and coastal erosion may alter natural beach cast seaweed deposition patterns, affecting also bird nesting and feeding sites.

The Birds Directive has a substantial role in ensuring that beach cast seaweed collection does not negatively impact bird populations, especially in during nesting and wintering periods ([79]). Clear guidelines would be helpful to promote sustainable beach cast seaweed harvesting in bird habitats. Moreover, research on the ecological functions of beach cast seaweed would secure a solid basis for management practices.

Other environmental Directives – the WFD, the MSFD and the Habitats Directive – have common SWOT results for wild seaweed harvesting. Frameworks are robust and holistic, ensuring that environmental data and information is collected, supporting integration and an ecosystem approach, and providing opportunities for adaptive management, balancing beach cast seaweed collection with protection. The main weaknesses are no specific guidance or emphasis on beach cast seaweed thus providing a ground for inconsistent approaches over EU countries, and a possibility of too strict protection measures prohibiting collection of beach cast seaweed.

3.2.2. National management practices for beach cast seaweed collection

Most of the existing national legislation does not specifically cover beach cast. The topic is complicated due to its dual nature, serving as a resource, habitat and compound of beach food webs, and creating secondary eutrophication and bacterial contamination in coastal waters. Therefore, national monitoring practices mostly relate to the composition of dominant beached seaweed species and periods of its highest abundance. These differences are largely defined by geographical location of countries. Table 5 summarises the national management approaches.

([79]) Orr, K.K. (2013) Predicting the ecosystem effects of harvesting beach-cast kelp for biofuel. Dissertation. University of the Highlands and Islands, Scotland.

Table 5 – National management practices for beach cast seaweed collection

Country	Regulation and responsible authority	Management practices	Permits and licenses	Monitoring and data collection
Denmark	Environment Protection Act Fisheries Act Ministry of Environment Local municipalities	Mechanical collection from a beach and water, also dumping back into the sea.	Not required	Ad hoc estimations during research projects
Estonia	Fishing Act Nature Conservation Act Local authorities	Collection from a beach by local inhabitants or clean-up by local municipality	Not required	Ad hoc estimations by universities and companies
France	Directorate of Marine Resources and Aquaculture Regional maritime authorities	Collection from a beach by commercial and recreational harvesters or mechanically by local municipality for clean-up	Licensing system for commercial harvesters	Wet weight estimations by local authorities for a purpose of cost analysis and cost assessment
Ireland	Maritime Area Regulatory Authority National Parks and Wildlife Service	Hand collection on shore or at intertidal area, mostly for personal use.	Landowner's permit to access the shore	Estimations by NGOs during annual surveys
Latvia	Waste management law Nature Protection law Regional environmental boards Local municipalities	Hand collection by local inhabitants Mechanical beach clean-up by some municipalities	Municipal permit for collection when using mechanical vehicles	Estimations by local authorities or on ad hoc basis during research studies
Lithuania	Law on the protection of the marine environment National Hygiene standard Ministry of Environment Protection Ministry of Health Local municipalities	Mechanical collection from a beach for treatment as a beach litter.	Not applicable	Estimates by local municipalities for assessment of costs

Country	Regulation and responsible authority	Management practices	Permits and licenses	Monitoring and data collection
Poland	Environmental Law Chief Inspectorate General Directorate	Collected mechanically as a litter	Not applicable	Local municipalities for estimation of costs
Portugal	National Fisheries Authority Local authorities	Mechanical or hand collection for personal use.	Permit by local authority	Data collected during research projects
Spain	Ministry of Agriculture, Fisheries and Food Regional authorities	Mechanical or hand collection from a beach, also protection of beaches - should be left without removal of beach cast.	Permit by regional authority	Data collected mostly during research studies
Sweden	Environmental Code County Administrative Boards	Collection as a measure to mitigate eutrophication	No specific permits, cooperation within LOVA scheme	By participants of LOVA

The national management practices are implemented according to local needs and concerns. Ways to improve and ensure environmentally friendly seaweed collection could include:

1. Limited or prohibited collection of beach cast seaweed in Natura 2000 areas (already followed in most of the countries).
2. Fixed periods of time or seasons for collection (e.g., summer only).
3. In the areas with high eutrophication, collection during vegetation period and shortly afterwards to avoid coastal erosion.

A summary of the SWOT analysis of beach cast seaweed collection is provided below:

1) Strengths include the potential to alleviate eutrophication by collecting and removing beach cast seaweed. It is also a locally available resource, which reduces the need for imported materials, and its usage aligns well with the goals of the European Green Deal. Furthermore, the collection of beach cast seaweed can provide economic opportunities for local communities, particularly under schemes like LOVA ([80]).

([80]) The LOVA scheme is a funding initiative designed to support local actions aimed at protecting, restoring, and ensuring the sustainable use of freshwater resources and seas. Administered by the Swedish Agency for Marine and Water Management (Havs- och vattenmyndigheten), this program offers grants covering 80–90% of project costs, with expected proposal budgets

2) Weaknesses are related to regulatory challenges, as there is no clear definition of beach cast seaweed nor targeted legislation in most of the countries. The collection practices need to adhere to environmental codes and restrictions, especially in protected areas like Natura 2000.
3) Opportunities lie in the development of more precise management practices and regulatory frameworks, which could allow for environmentally friendly and sustainable collection methods. Additionally, innovative uses of beach cast seaweed - in biostimulants and bio-based fertilisers, present new market opportunities that could enhance the economic viability of this resource.
4) Threats include potential overharvesting, which could lead to degradation of coastal ecosystems if not managed properly. Insufficient stakeholder cooperation and non-compliance with regulations could also be an issue, which might undermine the benefits of beach cast seaweed collection ([81]; [82]).

While there are clear advantages to utilising beach cast seaweed, addressing the regulatory, environmental, and operational challenges is crucial for its sustainable integration into the EU algae industry.

3.3. Recommendations most valid and realistic for promotion of environmentally friendly wild seaweed harvesting and beached seaweed collection

3.3.1. List of recommendations for wild seaweed harvesting

There are no EU-wide or national policies and practices directly prohibiting or supporting wild seaweed harvesting. However, the level of support and alignment varies. Practical recommendations to further improve the governance are provided below:

1. **Obtain knowledge of the stock:** for any management approaches, the abundance of wild seaweed is the first parameter to be clarified.

ranging from less than €50,000 to €100,000. Eligible applicants include local authorities, administrative bodies, NGOs, and social, cultural, and educational institutions.

([81]) Möller et al. (2021) Ecological aspects of sustainable beach wrack management: Report of the Interreg Project CONTRA. Rostock, 2021. 57 pp. www.beachwrack-contra.eu

([82]) Hyndes, G.A., Berdan, E.L., Duarte, C., Dugan, J.E., Emery, K.A., Hambäck, P.A., Henderson, C.J., Hubbard, D.M., Lastra, M., Mateo, M.A., Olds, A. and Schlacher, T.A. (2022) The role of inputs of marine wrack and carrion in sandy-beach ecosystems: a global review. Biol Rev, 97: 2127-2161. https://doi.org/10.1111/brv.12886

Knowledge on the biomass volume, seaweed coverage and species composition provides a needed baseline for both harvesting and monitoring. A combination of methods for resource assessment is recommended: direct surveys for species composition, ROV observations for coverage and modelling for biomass estimation.

2. **Implement sustainable harvesting practices:** in any seaweed harvesting activity, it is important to consider the specific species being harvested and to use appropriate methods and equipment suited to each species. Fallow periods in line with species biology and ecology should be observed. The harvesting season should be scheduled to minimise impacts on coastal and marine ecosystems.
3. **Implement data management and monitoring system**: the system for collecting and recording harvest data should be put in place by regional authorities or research organisations. In addition, an independent environmental monitoring should be performed to follow the status of seaweed ecosystems and data should be reported to the relevant institutions working on sustainable resource management.
4. **Establish clear system of licensing and/or permits**: a licensing process should be required as compulsory but should be also clearly explained, easy to access, and should involve local stakeholders (e.g., fisher's organisations, groups of active citizens).
5. **Including wild seaweed harvesting areas into maritime spatial plans** (national or regional) is recommended and should be actively promoted by local and regional authorities**.**

3.3.2. List of recommendations for beached seaweed collection

The high spatial variability of beach cast seaweed in terms of taxonomic composition – and thus of management approach in being treated as resource or waste – also determines the further fate of collected material. However, the following actions to secure environmentally friendly collection apply to all beaches:

1. **Enhance the understanding of beach cast seaweed's ecological role:** where knowledge is limited, invest in research to better understand its importance to coastal marine ecosystems and food webs. This foundational knowledge should guide collection practices that respect and preserve ecosystem balance.

2. **Restrict collection to specific time periods:** prioritise harvesting during suitable seasons, such as summer, and avoid winter months when storms are more frequent and intense, increasing the risk of coastal erosion and habitat disturbance.

3. **Define spatial limits and allowable quantities for collection:** clearly designate collection zones and maximum amounts to be harvested. Exclude protected areas from any collection activities, unless beachcast cause negative effects (e.g. eutrophication). Utilise remote sensing technologies, such as UAVs or Earth Observation data, to monitor and estimate beach cast seaweed volumes for sustainable planning.
4. **Implement a permit and data registration system:** establish a local permitting system managed by municipalities or relevant authorities, ensuring all collection activities are tracked and aligned with environmental objectives.

3.4. Policy recommendations for conceptual alignment of national and EU level legislative frameworks towards environmentally friendly wild seaweed harvesting and beached seaweed collection

The alignment of EU and national legislative frameworks for sustainable wild seaweed harvesting and beach cast seaweed collection is crucial for ensuring environmental protection, economic viability, and regulatory consistency across member states. In the following assessment of the possible conceptual alignment, opportunities targeted at these activities are considered.

3.4.1. Sustainable wild seaweed harvesting

Opportunities for alignment:

- **Develop EU-level guidance for wild seaweed harvesting**: procure a targeted research study or pilot project to define best-practice protocols and draft an informal guidance document.
- **Harmonise sustainability standards across Member States**: initiate drafting of a unified protocol for sustainable wild seaweed harvesting with the respective business or sectoral organisations, in the form of an informal guidance. This guidance document should include ecosystem-based management principles, science-based harvesting quotas, seasonal and spatial restrictions in sensitive areas, and low-impact collection methods.
- **Enhance monitoring and data sharing at EU scale**: promote the interoperability of the monitored data by following the FAIR principles (findable, available, interoperable, reusable). Activate the submission of ecosystem-impact monitoring data via the EMODnet portal.

3.4.2. Environmentally friendly beach cast seaweed collection

Opportunities for conceptual alignment:

- **Harmonise with existing EU Directives:** procure a research-led study to define best-practice protocols identifying when and how beach-cast seaweed may be removed without adverse impacts on coastal biodiversity. Establish minimum retention thresholds based on location-specific ecological roles of beach-cast seaweed to ensure that essential ecosystem functions are preserved. As a result of the study, prepare an informal guidance on beached seaweed collection to clarify potential conflicts between beach-cast removal (Bathing Water Directive) and habitat protection (Habitats and Birds Directives).
- **Develop a sustainability framework**: initiate a comprehensive review of national coastal management policies to prepare an informal EU-level guidance on sustainable beach-cast seaweed collection. Allow for regional adaptation by incorporating criteria for local seaweed composition, seasonal occurrence and biomass dynamics. Embed core sustainability measures, including temporal and spatial harvesting restrictions, adoption of low-impact collection techniques and biomass-based collection limits to prevent over-removal.
- **Enhance Data Collection and Monitoring**: pilot a real-time monitoring system for beach-cast seaweed accumulation, leveraging remote sensing and citizen-science contributions. Require systematic recording of harvested volumes under existing reporting frameworks (e.g., Habitats and Birds Directives). Cooperate with EMODnet Data Portal to implement the integration of the collected data to facilitate trend analysis, inform adaptive management and underpin future policy updates.

A sustainable management strategy for beach cast seaweed in the EU need to balance ecosystem protection with local economic benefits. Selective and seasonal removal and avoiding ecologically sensitive periods can help preserve habitats while maintaining beach aesthetics. Harvested material can be repurposed for agriculture (as biofertiliser), bioplastics, or bioenergy, supporting local economies and reducing waste. Monitoring and adaptive management, based on scientific assessments, can ensure long-term ecological sustainability while providing new economic opportunities.

Annex 1 - Wild harvested macroalgal (seaweed) species and biomasses

Baltic Sea						
Country	**Macroalgae/ Seaweed**		**Production method**	**Amount, ww, t, 2018-2024**	**Notes**	**Source**
Denmark	Brown	*Chorda filum*	MAN	less than 0,5 t	If the macroalgae are not collected in the framework of organic food production, the harvests are not registered or reported. The amounts are assumptions of researchers.	https://www.aqua.dtu.dk/-/media/institutter/aqua/publikationer/rapporter-401-450/422-2023-forvaltningsgrundlag-forbaeredygtig-hoest-af-vilde-bestande-af-tang.pdf Klausen, L.(2023). Agroecological Mariculture.Master's Thesis, SLU.
		Fucus serratus	MAN	less than 0,5 t		
		Fucus vesiculosus	MAN	2020 - 1-10 t		
		Fucus sp.	MAN	less than 0,5 t		
		Laminaria digitata	MAN	less than 0,5 t		
		Saccharina latissima	MAN	less than 0,5 t		
	Red	*Chondrus* sp.	MAN	less than 0,5 t		
		Delesseria sanguinea	MAN	less than 0,5 t		
		Furcellaria lumbricalis	MAN	less than 0,5 t		
	Green	*Ulva* sp.	MAN	less than 0,5 t		
Estonia	Red	*Coccotylus truncates*	MCH	2024 - 362.4 t, 2023 - 70t; 2022 – 380.5t; 2021 - 181t; 2020-200t; 2019 – 60t	Limited to 2000 tonnes/year. Species are harvested together and therefore data reported together for both species.	https://pta.agri.ee/ettevotjale-tootjale-ja-turustajale/kutseline-kalapuuk/puugistatistika

		Furcellaria lumbricalis	MAN, MCH			
North Sea and Northeastern Atlantic						
Spain	Brown	*Brown algae - without identification*	MAN	2023 - 25 t; 2022 - 21 t; 2021 - 69 t; 2020 - 0 t; 2019 - 0 t	Galicia	https://www.pescadegalicia.gal/Publicaciones/
		Ascophyllum nodosum	n/a	2023 - 9,5 t; 2022 - 8,2 t; 2021 - 2019 - 0 t.	Galicia	
		Fucus vesiculosus	n/a	2023 - 8,2 t; 2022 - 7 t; 2021 - 6 t; 2020 - 6,4 t; 2019 - 0 t.	Galicia, all Fucus species reported together	
		Fucus spiralis	MAN			
		Fucus sp.	MAN			
		Himanthalia elongata	MAN	2023 - 40,9 t; 2022 - 21,8 t; 2021 - 19,5 t; 2020 - 22,8 t; 2019 - 42,5 t	Galicia	
		Himanthalia sp.	MAN			
		Laminaria ochroleuca	MAN, n/a	2023 - 62,5 t; 2022 - 156 t; 2021 - 152 t, 2020 - 49 t; 2019 - 62 t	Galicia	
		Laminaria sp.	MAN, n/a	2023 - 154 t; 2022 - 373 t; 2021 - 203 t; 2020 - 238 t; 2019 - 209 t	Galicia	
		Saccorhiza polyschides	MAN, n/a	2019 - 0,17 t	Galicia	
		Undaria sp.	MAN, n/a	2020 - 238 t; 2019 - 210 t		CIRCALGAE report https://zenodo.org/records/13375431

	Red	*Chondrus crispus*	MAN	2023 - 0 t, 2022 - 0 t, 2021 - 0,14 t, 2020 - 0 t, 2019 - 3,8 t	Galicia	https://algalup.eu/wp-content/uploads/2022/07/E.1.3.1-Informe-de-análisis-socio-ambiental-de-la-explotación-de-macroalgas.pdf
		Dilsea carnosa	MAN			
		Gelidium corneum	n/a			
		Gelidium sp.	MAN	2020 - 230 t; 2019 - 220 t; 3843–4426 t from 2017 to 2020	Asturias	CIRCALGAE report https://zenodo.org/records/13375431; Higgins 2022
		Gigartina pistillata	MAN			
		Gigartina sp.	MAN			
		Gracilaria sp.	MAN	2023 - 4,9 t; 2022 - 9,8 t; 2021 - 7,6 t; 2020 - 2,5 t; 2019 - 3,9 t	Galicia	https://www.pescadegalicia.gal/Publicaciones/
		Grateloupia turuturu	MAN			
		Mastocarpus stellatus	MAN			
		Porphyra sp.	MAN, n/a			
		Palmaria palmata	n/a			
		Osmundea pinnatifida	MAN			
	Green	*Codium* sp.	MAN	2023 - 4,3 t; 2022 - 6,9 t; 2021 - 4,9 t; 2020 - 9, 1 t; 2019 - 15 t	Galicia	https://www.pescadegalicia.gal/Publicaciones/
		Ulva sp.	MAN	2023 - 89 t; 2022 - 85 t; 2021 - 135 t; 2020 - 104 t; 2019 - 66 t	Galicia	

		Salicornia sp. - leafless annual salt-marsh plant	MAN			
France	Brown	*Alaria* sp.	MAN			
		Alaria esculenta	MCH			
		Ascophyllum nodosum	MAN	2021 - 2907 t; 2020 - 2008 t; 2019 - 2107 t	Intertidal harvesting in Brittany, these species reported together	https://www.bretagne-peches.org/wp-content/uploads/2023/09/analyse-des-donnees-declaratives-de-recolte-des-algues-de-rive_vf.pdf
		Fucus sp.	MAN	2021 - 2279 t;2020 - 1023 t; 2019 - 1618 t	Intertidal harvesting in Brittany, these species reported together	
		Fucus vesiculosus	MAN, MCH	2019 - 1839 t	These species are reported together	CIRCALGAE report https://zenodo.org/records/13375431
		Himanthalia elongata	MAN			
		Himanthalia sp.	MAN			
		Laminaria digitata	MAN, MCH	2020 - 38202 t; 2019 - 35686 t		CIRCALGAE report https://zenodo.org/records/13375431
		Laminaria hyperborea	MCH	2020 - 16163 t; 2019 - 12939 t		
		Laminaria sp.	MAN	2021 - 210 t; 2020 - 144 t; 2019 - 205 t	Intertidal harvesting in Brittany, these species reported together	https://www.bretagne-peches.org/wp-content/uploads/2023/09/analyse-des-donnees-declaratives-de-recolte-des-algues-de-rive_vf.pdf
		Pelvetia sp.	MAN			
		Saccharina latissimi	MAN, MCH			
		Undaria sp.	MAN, MCH			
	Red	*Asparagopsis armata*	MAN			
		Corallina sp.	MAN			

		Chondrus crispus	MAN	2019 - 101 t		CIRCALGAE report https://zenodo.org/records/13375431
		Gelidium corneum	MCH	2021 - 938 t, 2020 - 2009 t, 2019 - 1838 t	Trawling at Southern France	CIRCALGAE report https://zenodo.org/records/13375431
		Lithothamnium calcareum	MCH			
		Mastocarpus stellatus	MAN	2021 - 112 t; 2020 - 121 t; 2019 - 76 t;	Intertidal harvesting in Brittany, this species reported together with Ch.crispus	https://www.bretagne-peches.org/wp-content/uploads/2023/09/analyse-des-donnees-declaratives-de-recolte-des-algues-de-rive_vf.pdf
		Palmaria palmata	MAN, MCH	2021 - 460 t; 2020 - 458 t; 2019 - 226 t	Intertidal harvesting	CIRCALGAE report, https://zenodo.org/records/13375431; https://www.bretagne-peches.org/wp-content/uploads/2023/09/analyse-des-donnees-declaratives-de-recolte-des-algues-de-rive_vf.pdf
		Palmaria sp.	MAN			
		Porphyra umbilicalis	MAN			
		Porphyra sp.	MAN	2019 - 21 t		Stévant P. et al., 2023 https://doi.org/10.1007/s10811-022-02899-5
		Solieria sp.	MCH			
	Green	*Ulva lactuca*	MAN, MCH	2021 - 67 t; 2020 - 57 t; 2019 - 51 t	Intertidal harvesting in Brittany, these species reported together	https://www.bretagne-peches.org/wp-content/uploads/2023/09/analyse-des-donnees-declaratives-de-recolte-des-algues-de-rive_vf.pdf
		Ulva sp.	MAN, MCH			
		Salicornia sp. - *leafless annual salt-marsh plant*	MAN			

Ireland	Brown	*Alaria esculenta*	MAN	2020 - 14,8 t		Socioeconomic study of seaweed harvesting in Ireland, 2023
		Ascophyllum nodosum	MAN, MCH	2020 - 33 700 t; 2019 - 28 000 t;		
		Fucus serratus	MAN	2020 - 220 t		
		Fucus vesiculosus	MAN	2020 - 143 t		
		Fucus spiralis	MAN	2020 - 2,5 t		
		Himanthalia elongata	MAN	2020 - 58,5 t		
		Laminaria digitata	MAN	2020 - 45,5 t		
		Undaria pinnatifida	MAN	2020 - 6,7 t		
		Saccharina latissima	MAN	2020 - 12,3 t		
		Pelvetia canaliculata	MAN	2020 - 4 t		
	Red	*Chondrus crispus*	MAN	2020 - 37,5	Reported together	
		Mastocarpus stellatus	MAN			
		Osmundea pinnatifida	MAN	2020 - 1,6 t		
		Palmaria palmata	MAN	2020 - 143 t		
		Asparagopsis armata	MAN	2020 - 1,6 t		
		Porphyra sp.	MAN	2020 - 1,9 t		
	Green	*Ulva intestinalis*	MAN			
		Ulva lactuca	MAN	2020 - 3,4 t		
		Ulva sp.	MAN			
Iceland	Brown	*Alaria esculenta*	MAN			

		Ascophyllum nodosum	MCH	2017-2018 - 15 000 t – 20 000 t		CIRCALGAE report https://zenodo.org/records/13375431
		Fucus vesiculosus				
		Laminaria digitata	MCH	2017-2018 – approx. 1,8 t		CIRCALGAE report https://zenodo.org/records/13375431
		Laminaria sp.	MAN			
		Saccharina latissima	MAN			
	Red	*Chondrus* sp.	MAN			
		Lithothamnium calcareum	n/a			
		Palmaria palmata	MAN			
		Vertebrata lanosa	MAN			
Norway	Brown	*Alaria esculenta*	MAN			
		Ascophyllum nodosum	MCH, MAN	2020 - 17015 t; 2019 - 19540 t		CIRCALGAE report https://zenodo.org/records/13375431
		Fucus serratus	MAN			
		Fucus vesiculosus	MAN			
		Laminaria digitata	MAN			
		Laminaria hyperborea	MCH	2020 - 134209 t; 2019 - 143872 t		CIRCALGAE report https://zenodo.org/records/13375431
		Saccharina latissima	MAN			
	Red	*Chondrus crispus*	MAN			
		Palmaria palmata	MAN			
		Porphyra umbilicalis	MAN			

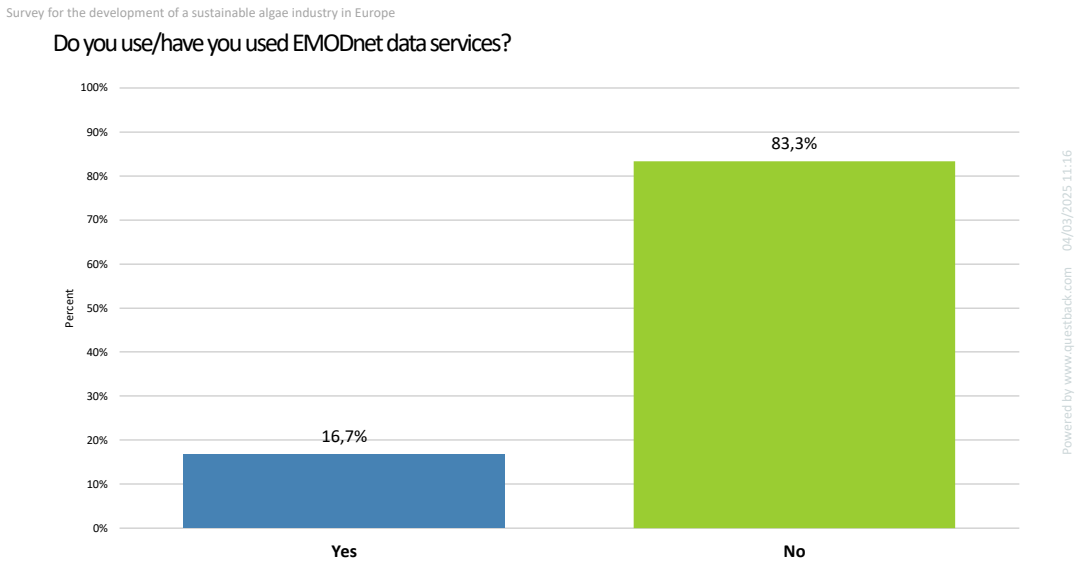
		Vertebrata lanosa	MAN			
	Green	*Ulva* sp.	MAN			
		Ulva lactuca	MAN			
Portugal	Brown	*Cystoseira abies -marina*	MAN			
		Cystoseira humilis	MAN			
		Fucus spiralis	MAN			
		Halopteris scoparia	MAN			
		Padina pavonica	MAN			
		Petalonia binghamiae	MAN			
		Sargassum vulgare	MAN			
		Zonaria tournefortii	MAN			
	Red	*Asparagopsis armata*	MAN			
		Asparagopsis taxiformis	MAN			
		Gelidium corneum	MAN	2023 - 413,2 t; 2022 - 402,3 t; 2021 - 588,6 t; 2020 - 391,6 t; 2019 - 370,5 t	The only group appearing in official statistics, named as agarophytes, not by species	https://www.dgrm.pt/en/recursos-da-pesca-dgrm
		Osmundea pinnatifida	MAN			
		Porphyra umbilicalis	MAN			
		Pterocladiella capillacea	MAN			
	Green	*Ulva intestinalis*	MAN			
		Ulva rigida	MAN			

Annex 2 - Results of stakeholder survey on use of EMODnet services, wild harvesting and beach cast management and data reporting practices

Q1. Do you use/have you used EMODnet data services?

Most responses indicate that services are not or have not been used (Figure 9). As we did not have any assumptions about the usage of the portal, questions on reasons for not using were not included. Instead, when answering “no” the responder was guided towards webpage of EMODnet for introduction.

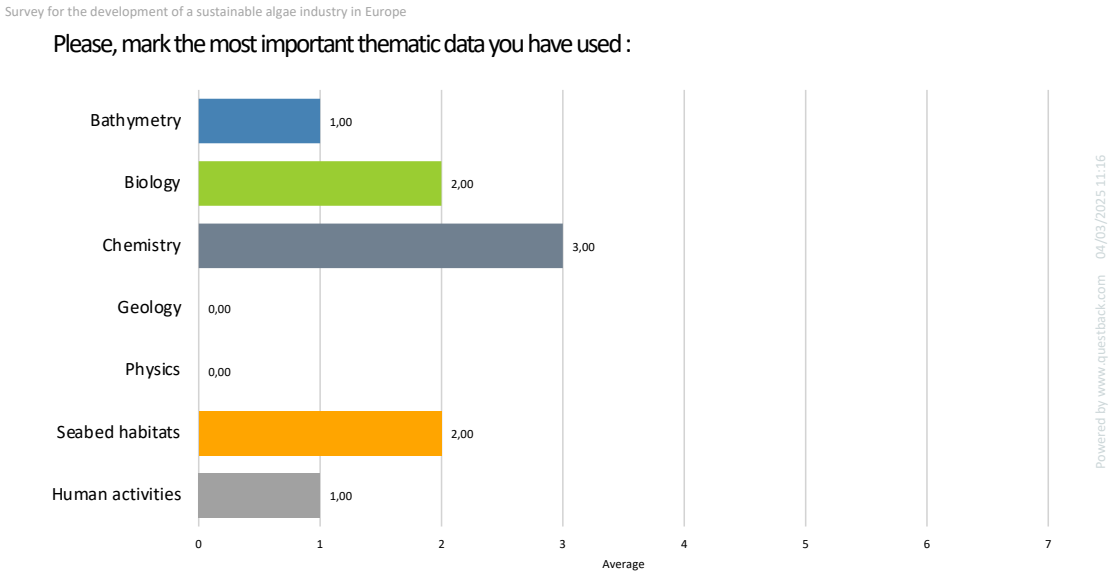
Figure 9 – Responses to survey regarding use of EMODnet data services



Q.2 Please, mark the most important thematic data you have used.

Seven data themes available in the Portal had to be arranged in the order of priority. Chemistry has been selected as the most relevant (Figure 10). The number of cases is low due to small number of respondents using data services.

Figure 10 – Survey results on the use of thematic data



Q.3 Have you used "Algae production" data under the theme **Human activities**?

All responses to this question were "No", from a total of 2 answers.

Q.4 For what purpose do you use the EMODnet Platform?

Answers included "Access bathymetry and biogeochemical data" and "Seabed assessment (2nd source) + vessel traffic".

Q.5 Is the EMODnet Platform fitted for your needs?

Criteria included "Easy to use", "Relevant dataset", "Design" and "Other". The offered criteria had to be assessed in the scale 1 to 5, where 1 = no and 5 = highly. All responses were set to "1" indicating a lack of fit.

Q.6 To increase your use of the EMODnet data website, what suggestions could you make to improve this platform?

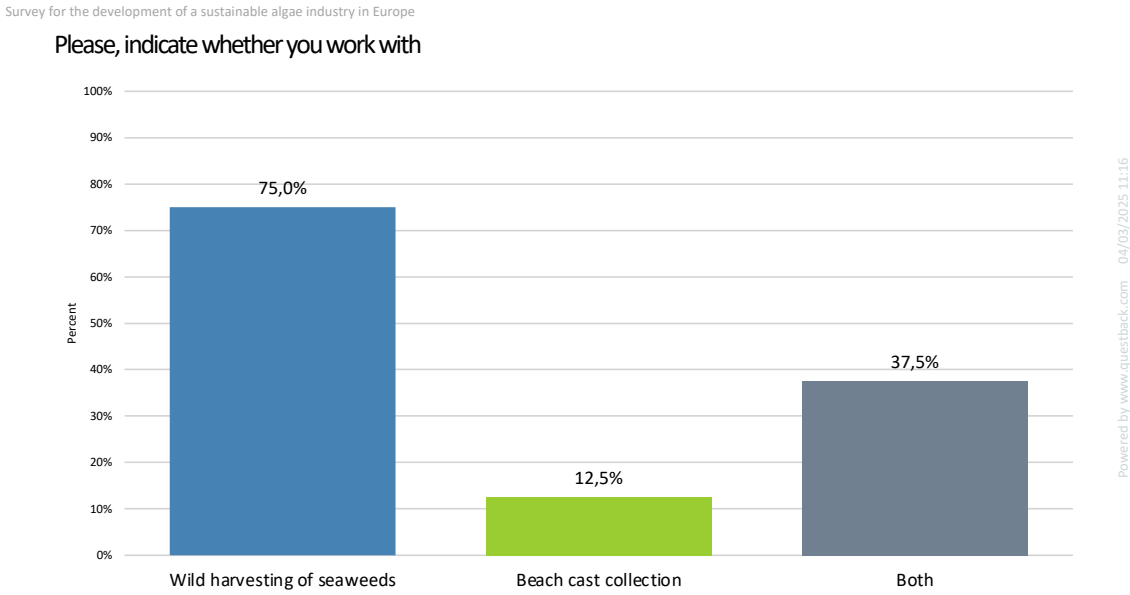
The only suggestion received was "Easier to access -better user interface (UX design)".

The next part of survey addressed harvesting management practices of seaweed. Respondents indicated their whether they worked with wild harvesting, beach cast seaweed, or both.

Q.7 Please, indicate whether you work with wild harvesting of seaweeds, beach cast collection or both.

Wild harvesting was the most common type of activity for the respondents (Figure 11).

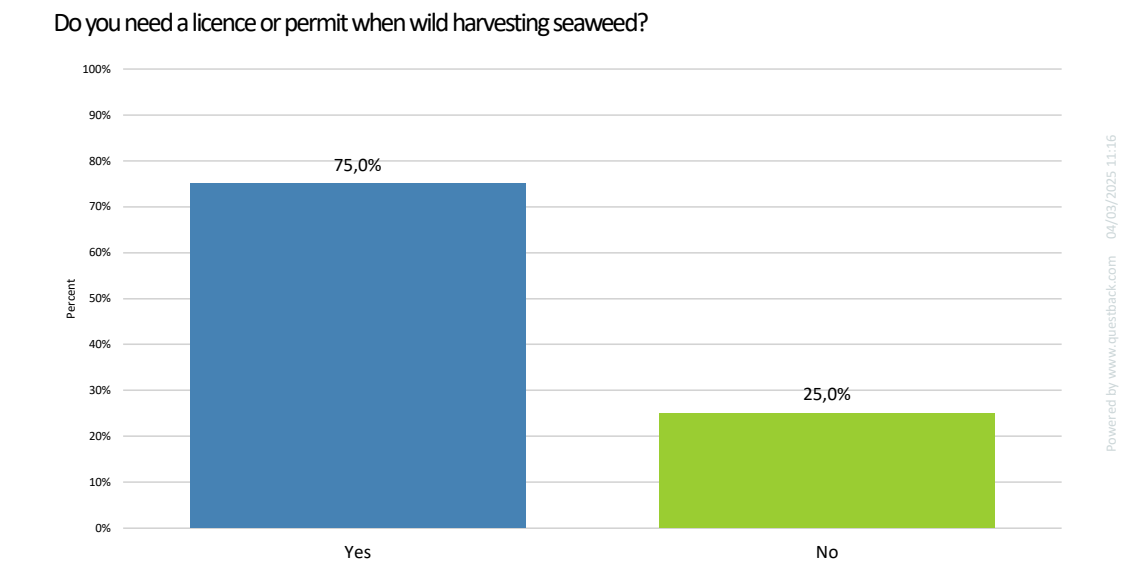
Figure 11 – Distribution across types of activities for survey respondents



Q.8 Do you need a license or permit when wild harvesting seaweed?

In the majority of cases, a license or permit is necessary for wild harvesting of seaweed (Figure 12).

Figure 12 – Necessity of license or permit for survey responders



Q.9 For how long is the licence or permit issued?

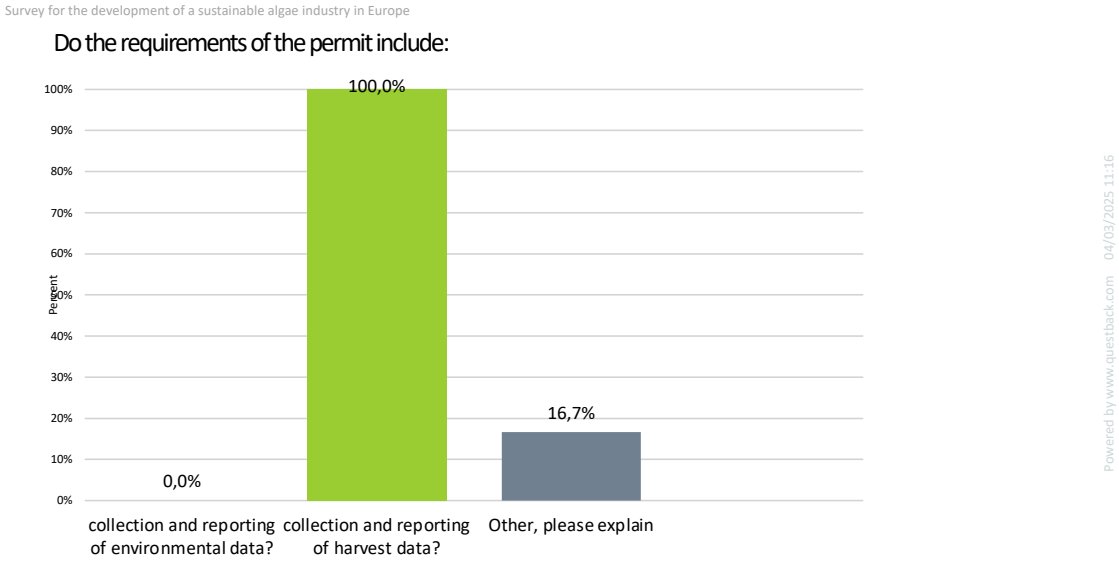
The responses included a variety of time periods, between 6 months and 10 years, although the most common answer was 1 year.

Q. 10 Do the requirements of the permit include:

collection and reporting of environmental data?
collection and reporting of harvest data?
Other, please explain

Requirements of permits in all cases include the need to collect and report harvest data but never the environmental data (Figure 13). For the other requirements, a link to a website of fisheries regulations in Brittany was provided.

Figure 13 – Data needs identified in permit requirements for wild seaweed harvesting



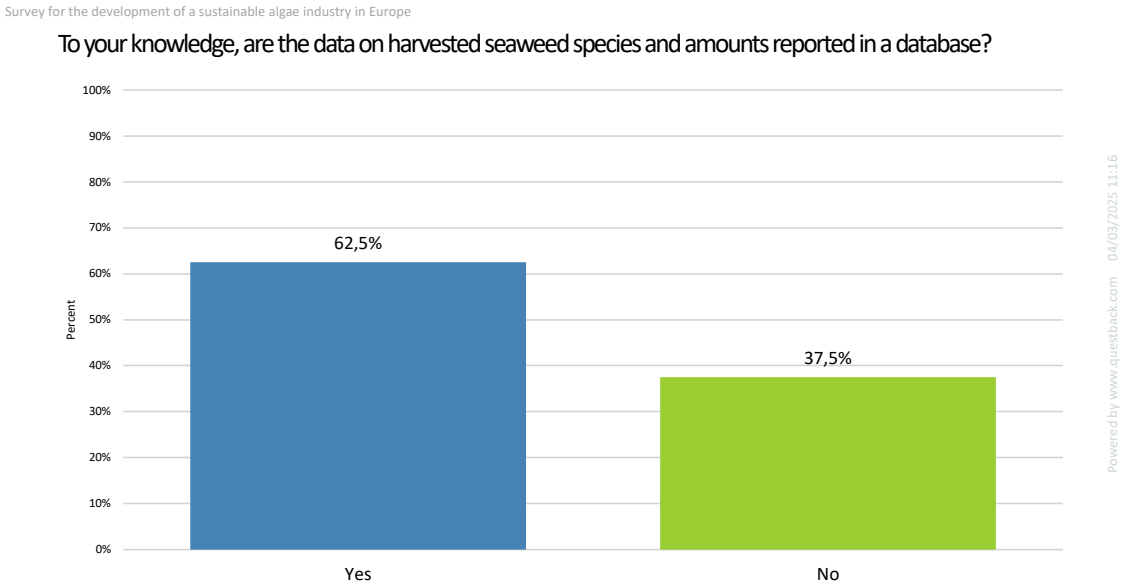
Q.11 Can you describe what are consequences of not fulfilling the permit requirements?

Permit requirements must be followed; otherwise, the permit can be revoked or not re-issued. The answers included options like “The licence will be revoked”, “Anyone harvesting without a licence is liable to heavy fines”, “Warning and penalties and possible no renewing of the permit”, “Not able to renew the permit”.

Q.12 To your knowledge, are the data on harvested seaweed species and amounts reported in a database?

Most respondents aware that collected data ends up in a database (Figure 14).

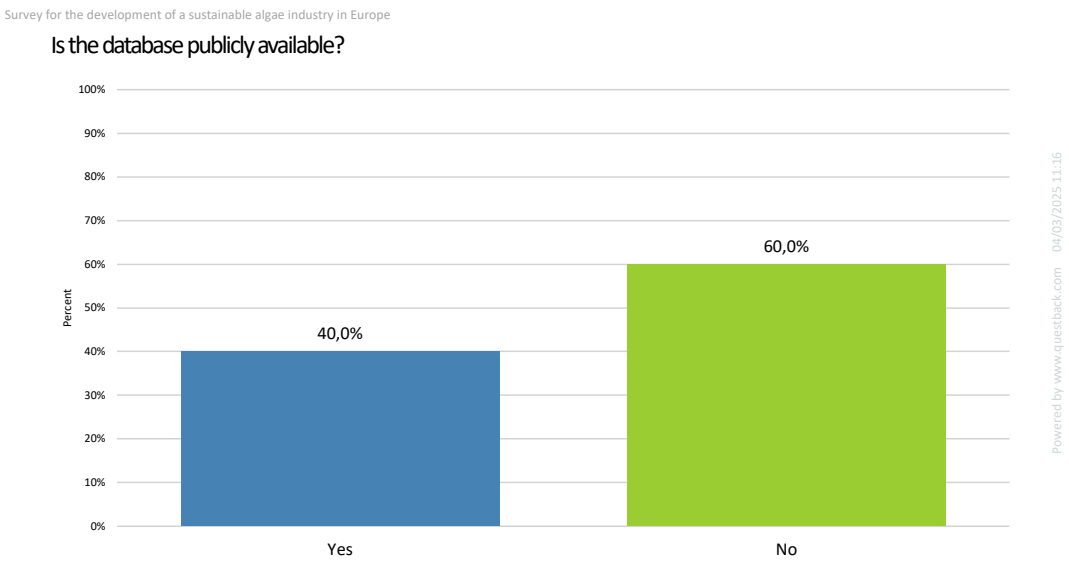
Figure 14 – Share of collected data reported to a database



Q.13 Is the database publicly available?

However, the availability of the data was limited in more than a half occasions (Figure 15).

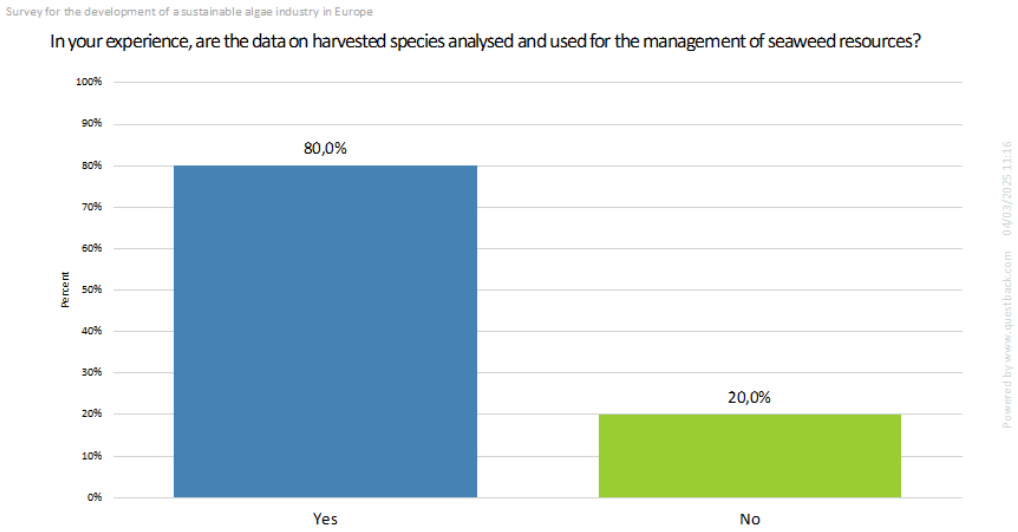
Figure 15 – Public availability of the collected and reported data



Q.13. In your experience, are the data on harvested species analysed and used for the management of seaweed resources?

Analysis and use of the collected data for management is a common practice according to the responses (Figure 16).

Figure 16 – Exploitation of reported data for management purposes



Q.14. To your knowledge, how is the sustainability of seaweed stocks ensured:

fallow periods

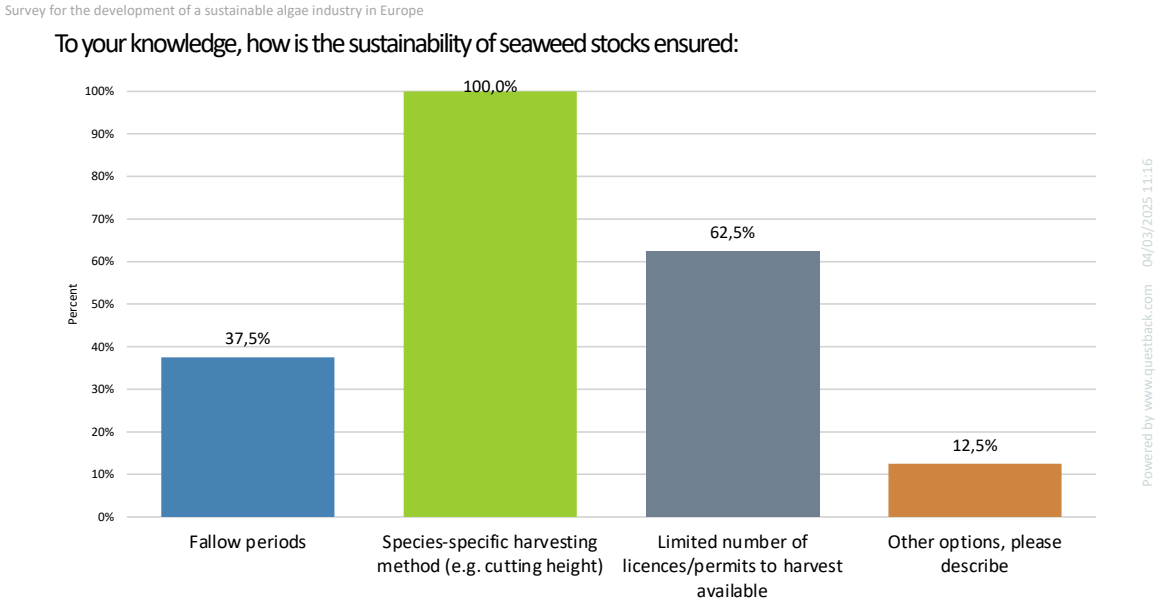
species-specific harvesting method (e.g. cutting height)

limited number of licences/permits to harvest available

other options, please describe.

All responses indicate that practices of wild harvesting are considering the species biology, and that harvesting method is chosen accordingly. Other options for stock sustainability are also taken into account (Figure 17). The response for *Other options* included “stock assessment, harvest impact assessment, minimum harvest size, good practices”.

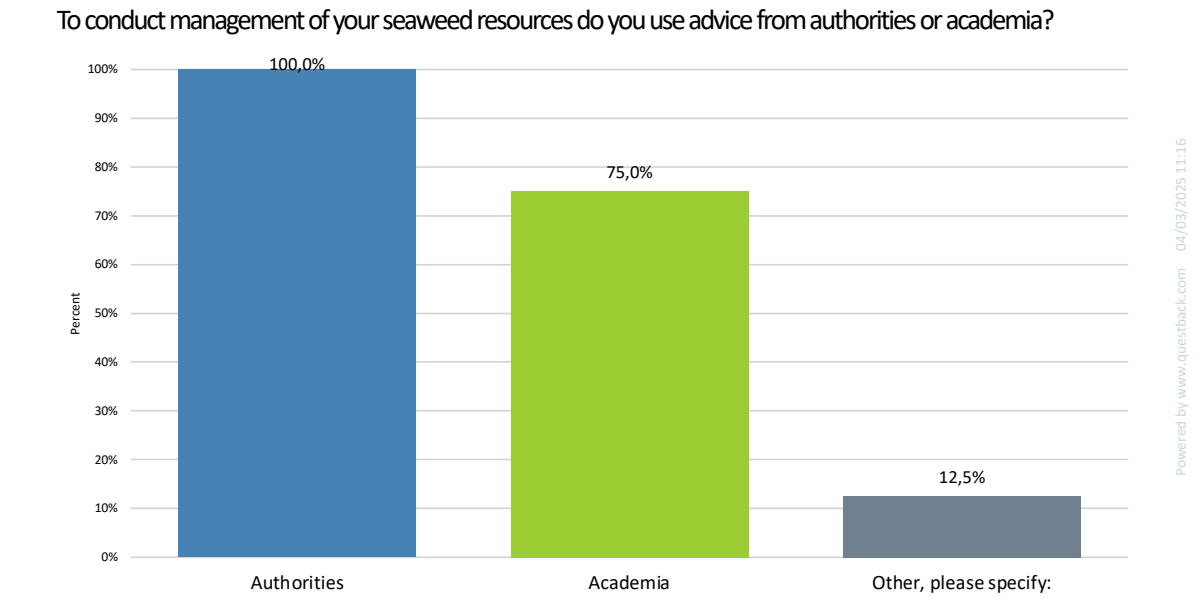
Figure 17 – Use of options in wild harvesting for seaweed stock sustainability



Q.15 To conduct management of your seaweed resources do you use advice from authorities or academia?

Authorities have the most important role in management of seaweed resources, followed by research institutions (Figure 18). The option of "Other" included a working group of harvesters, related to research station.

Figure 18 – Priorities in advice provision for seaweed resource management

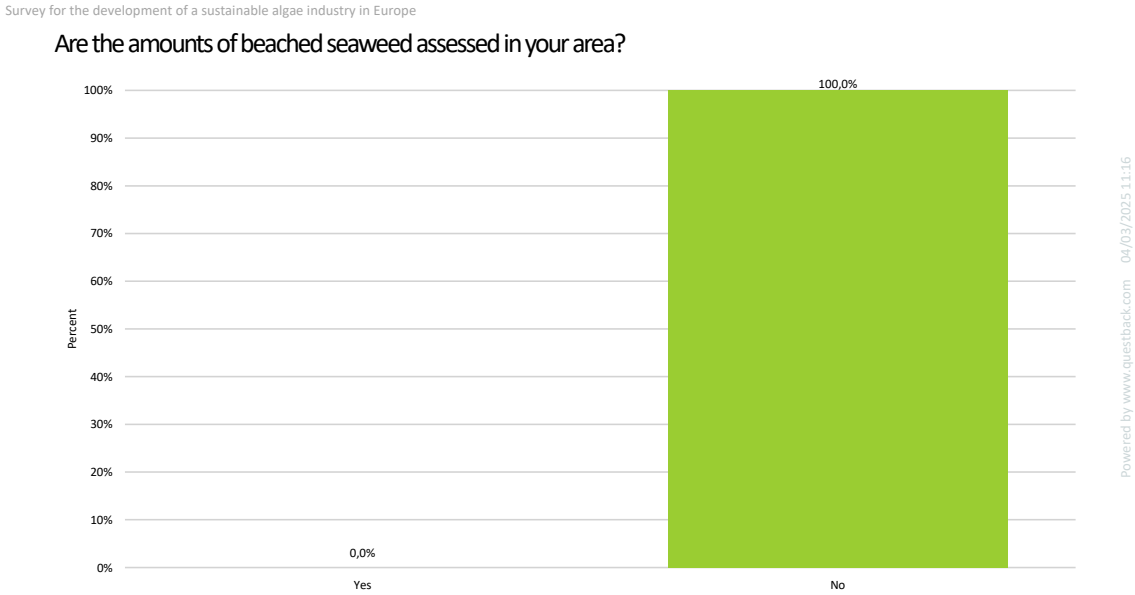


Questions and responses on beached seaweed

Q.1. Are the amounts of beached seaweed assessed in your area?

All answers were negative (Figure 19).

Figure 19 – Assessment of beached seaweed amounts

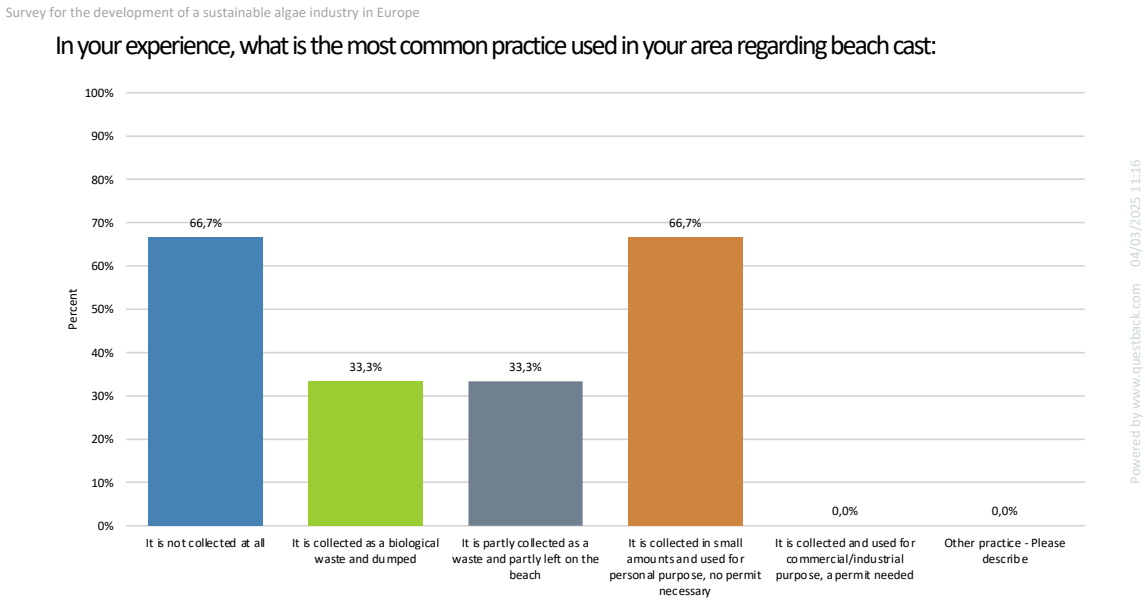


Q.2. In your experience, what is the most common practice used in your area regarding beach cast:

It is not collected at all
It is collected as a biological waste and dumped
It is partly collected as a waste and partly left on the beach
It is collected in small amounts and used for personal purpose, no permit necessary
It is collected and used for commercial/industrial purpose, a permit needed
Other practice - Please describe

The responses included options of no collection, treatment as a waste and collection for personal use (Figure 20).

Figure 20 – Most common practices for the use of beach cast



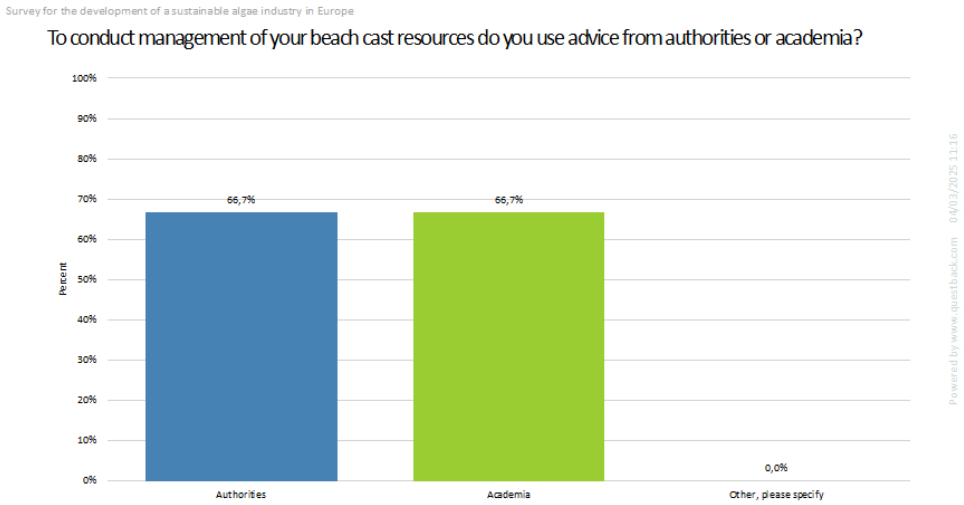
Q.3. To your knowledge, are the data on collected beach cast analysed and used for future management of resources?

Responses were only negative.

Q.4. To conduct management of your beach cast resources do you use advice from authorities or academia?

Answers indicate that advice from either authorities or academia is used (Figure 21).

Figure 21 – Advice for management of beach cast seaweed



Annex 3 - Data base on beach cast seaweed

Country	Naturally occurring amount, tonnes/year, dw	Collected amount, tonnes/year, dw	Species (when identified)	Collected amount of particular species, tonnes/year (when estimated)	Management practices	Data collection practices	Sources
Denmark	420 000	42 000 (Koge Bay)	not identified	not estimated	Mechanical collection from a beach and water with a tractor for biogas production, but also dumping back into the sea.	No specific data reporting.	https://www.coastal-biogas.eu/resources/D3 3_Report_on_potential _of_cast_seaweed_and _policy_frameworks.pdf , https://www.coastal-biogas.eu/resources/D3 2_Report_on_operating _biogas_facilities_utilisi ng_anaerobic_digestio n_of_cast_seaweed.pdf , https://www.coastal-biogas.eu/resources/D3 2_Report_on_operating _biogas_facilities_utilisi ng_anaerobic_digestio n_of_cast_seaweed.pdf , https://doi.org/10.1016/j .scp.2023.101169

Estonia	1000	120 (Saaremaa)	Furcellaria lumbricalis	120	Hand or mechanical collection from a beach by local inhabitants.	No specific data reporting.	https://www.sciencedirect.com/science/article/pii/S0964569120303203, https://www.agri.ee/sites/default/files/documents/2024-10/välitööd-2024-sinimajanduse-seminar-estagar.pdf
France	72 000	44640 (Normandy)	Laminaria digitata, Sargassum muticum	Sargassum 12 000 (ww)	Mechanical collection from the beach by local authorities.	Wet weight estimations by local authorities for a purpose of cost analysis and cost assessment	https://doi.org/10.1016/j.conbuildmat.2021.125068
Germany	45 000	not assessed, but up to 80% removed as waste	Zostera spp., Fucus sp.	not estimated	Mechanical collection from a beach for treatment as a biowaste by local authorities.	No specific data reporting, the estimates only by research/NGO projects.	doi:10.5751/ES-12759-260443, https://doi.org/10.1515/bot-2019-0019
Ireland	not estimated	not estimated	Ascophyllum nodosum, Chondrus crispus	not estimated	Hand collection on shore or at intertidal area, mostly for personal use.	No specific data reporting, the estimates only by research/NGO projects.	MTU, 2022. Socio-Economic Study of Seaweed Harvesting in Ireland
Latvia	8000	400	Fucus sp., Furcellaria lumbricalis, Cladophora sp., Enteromorpha sp.	not estimated	Mechanical collection from a beach with a tractor, as biowaste. Hand picking on shore for a personal use - a permit should be acquired in one municipality.	Wet weight estimations by local authorities for a purpose of cost analysis and cost assessment	https://baltijaskrasti.lv/wp-content/uploads/2019/03/Algu-sanesumu-izvertesana.pdf, https://pmc.ncbi.nlm.nih.gov/articles/PMC9666566/pdf/13280_2022_Article_1774.pdf

Lithuania	55	50 (Palanga)	Fucus sp., Furcellaria lumbricalis, Cladophora sp., Enteromorpha sp., Ulva sp.	not estimated	Mechanical collection from a beach for treatment as a beach litter. No specific data reporting.	Wet weight estimations by local authorities for a purpose of cost analysis and cost assessment.	https://www.coastal-biogas.eu/resources/D3_Report_on_potential_of_cast_seaweed_and_policy_frameworks.pdf, ESMIC project results
Malta	3500	1500	not identfied	not estimated	Mechanical or hand collection from a beach by local authorities	Wet weight estimations by local authorities for a purpose of cost analysis and cost assessment	https://www.independent.com.mt/articles/2019-05-06/local-news/More-than-1-500-tonnes-of-seaweed-collected-from-several-beaches-around-Malta-6736207744
Poland	9 500	500 (Tricity)	Zostera marina, Potamogeton pectinatus, Pylaiella sp.	not estimated	Mechanical collection from a beach by local authorities for treatment as a beach litter.	Wet weight estimations by local authorities for a purpose of cost analysis and cost assessment	https://www.coastal-biogas.eu/resources/D3_Report_on_potential_of_cast_seaweed_and_policy_frameworks.pdf, https://eucc-d-inline.databases.eucc-d.de/files/documents/00001264_CONTRA-Output03-WEB.pdf
Portugal	600 (Northern Portugal)	not estimated	Saccorhiza polychides, Laminaria, Fucus, Codium, Palmaria palmata, Chondrus crispus, Gelidium spp.	not estimated	Mechanical or hand collection from a beach., mostly for personal use.	Data collected in the frame of research projects.	https://doi.org/10.1515/bot-2019-0012, https://doi.org/10.1016/j.seares.2021.102079, https://www.dgrm.pt/en/recursos-da-pesca-dgrm, https://doi.org/10.1007/s12237-023-01176-z, https://www.vliz.be/en/imis?dasid=8049&doiid=677

Spain	5000-7000 (Galicia), 3500 - 6500 (Asturias), 9000 (Valencia)	not estimated	Gelidium corneum, Gracilaria spp., Ascophyllum nodosum, Fucus spp., Laminaria sp.,Sacchoriza sp., Ulva sp., Posidonia oceanica	not estimated	Mechanical or hand collection from a beach. Valencia has manual for protection of beaches (Posidonia beach cast), the natural beaches should be left without removal of beach cast. For removal a permit should be acquired.	Data collected mostly in the frame of research projects.	https://doi.org/10.1016/j.tifs.2021.11.026, https://www.programapleamar.es/sites/default/files/fv_1.1_informe_de_valoracion_sobre_escenario_inicial_en_galicia_y_asturias_final.pdf, https://www.levante-emv.com/marina/2024/06/25/posidonia-queda-prohibido-retirarla-playas-104265442.html
Sweden	590000, of which 12 000 in Gotland	43 000 (Scania), 500 (Gotland)	Laminaria, Furcellaria lumbricalis, Fucus sp., Zostera sp.	not estimated	LOVA marine policy scheme for reduction of eutrophication in the Baltic Sea - collection and piling of beach wrack for composting. Municipality should join the scheme and distribute it to local inhabitants.	LOVA marine policy scheme, having data collection protocol. The biomass is analysed for dry matter, N, C, P, Na, Mg, Ca, K, S, Cu, Fe, Mn, Zn, Cd	https://pmc.ncbi.nlm.nih.gov/articles/PMC9666566/pdf/13280_2022_Article_1774.pdf, https://doi.org/10.1016/j.teadva.2024.200110, https://doi.org/10.1016/j.resconrec.2021.106031

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