Submission on Ireland's *'Bioeconomy Action Plan Consultation and Discussion Document'* by the *Ascophyllum nodosum Processors Group (ANPG)*

Contents

Ref: Bioeconomy Action Plan Consultation

For correspondence:

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Introduction:

This document represents a submission on Ireland's 'Bioeconomy Action Plan Consultation and Discussion Document', made on behalf of the **Ascophyllum Nodosum Processors Group (ANPG).** The ANPG consists of Arramara Teo., BioAtlantis Ltd., Brandon BioScience Ltd., Ocean Knowledge Ltd. and Oileán Glas Teoranta (OGT). Each of these companies have commonality in relying on one species of wild seaweed, *Ascophyllum nodosum*, for continuation and growth of their respective commercial enterprises on the western seaboard. Collectively, ANPG members employ directly more than 150 people, generating over €30 million of economic activity in rural Ireland. This industry is predicted to grow to €60M turnover by 2030. In this submission, the ANPG highlight the importance of seaweed as a sustainable and renewable raw material resource, and its importance to the Irish bioeconomy. This document also provides answers to questions listed in Annex 1 of the Action Plan Document, and provides specific recommendations for ensuring that the potential of the bioeconomy is realised.

Benefits of products and technologies based on seaweed.

In the context of developing this Bioeconomy Action Plan, it is important to highlight the environmental and public health benefits associated with products and technologies based on seaweed as a raw material. In particular, seaweeds are an essential source of compounds used by members of the ANPG and other Irish SMEs in the development of products and technologies that provide a range of environmental and public health benefits, including:

- **Plant Biostimulants:** Most seaweed extracts produced in Ireland are used in the manufacture of products' for the plant biostimulant industry, particularly by members of the ANPG. Plant biostimulants contain substance(s) which when applied to plants stimulate natural processes to enhance/benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress and crop quality. This industry has developed from growers worldwide recognising that crops require certain non-synthetic compounds to strengthen plant health in order to avoid bacterial, fungal or viral infection. Thus, the requirement for fertilisers, fungicides and other chemical compounds can be reduced. These products are certified organic.
- **Alternatives to in-feed antibiotics:** The United Nations regards antibiotic-resistant diseases as a serious global health concern that must be addressed urgently (ref: United Nations, 2022). In addition, Ireland's Second 'One Health' National Action Plan on Antimicrobial Resistance 2021-2025 (Department of Health and Department of Agriculture, Food and the Marine, 2021) also cites Antimicrobial Resistance as a key issue impacting on human health, animal health and welfare and also our shared environment. A member of the ANPG has developed a technology based on immune-priming compounds that can replace antibiotics in animal husbandry. A case study on this topic has been published by scientists in UCD (ref: UCD, 2016).
- **Benefits of harvesting seaweed:** Seaweeds are washed ashore every year as part of their life-cycle where they decay, emit toxic gases and cause pollution. Emissions from decaying seaweeds affect coastal communities in Europe, including Ireland (Irish Examiner, 2022). Beach cast seaweeds can also contribute to pollution, as they can influence the survival of faecal indicator organisms in beach areas and can provide a protected environment for *E. coli* (Quilliam *et al.,* 2014). Seaweed flies in the presence of decaying seaweeds may also facilitate environmental survival and transmission of *E. coli* (Swinscoe *et al.,* 2018). Therefore, storm cast seaweeds may pose a potential risk to public health, particularly to beach users and those exposed to seaweed on the shore. As such, there are public health benefits to harvesting seaweed before it is washed ashore.

Answers to questions listed in Annex I of the Action Plan.

1. Are you satisfied the outlined Pillars represent the structure of the Irish bioeconomy?

Recommendations: An additional, stand-alone pillar on ***"Public Health"*** should be added to cover the use of biological resources to enhance public health. For instance, biological resources such as seaweed are an essential source of compounds used by Irish SMEs in the development of products and technologies which provide a range of **Public and Human Health Benefits** (see previous section on page 2 for more details). The ***"Public Health"*** pillar should support actions of companies in the bioeconomy who are working to enhance public health in Ireland.

2. Are there specific key performance indicators and/or targets the bioeconomy should be setting out to achieve to measure its implementation?

The Government should **set targets to remove barriers to growth in the bioeconomy**. As outlined in "Ireland's Ocean Economy Report, 2022" (pg. 52, Norton *et al.,* 2022), barriers to Ireland's seaweed, marine biotechnology and bio-products industry include *"securing supply of raw materials and issues with licensing"*. The report states *"The outlook for the seaweed, marine biotechnology and bio-products industry is positive, as demonstrated by recent increases in turnover and employment. A significant number of companies in this industry are involved in research and development, particularly on higher value-added products with larger companies focused on export markets. The industry still faces certain barriers and risks. Higher energy prices for processing of raw materials, securing supply of raw materials and issues with licensing were seen as barriers by respondents to the company surveys, while those reliant on export markets are open to currency risks"*. Specific recommendations for the bioeconomy action plan are outlined as follows:

(a) Develop a policy on seaweed harvesting: There is currently no Government policy on seaweed harvesting in Ireland. This is a major barrier for members of the ANPG and prevents license applications from being prioritized and assessed, which causes major delays. A lack of policy also prevents the issuing of licenses based on sustainable management plans in line with the EU Birds and Habitats Directives.

Recommendations: The Government should develop a policy on seaweed harvesting based on established European models for the sustainable harvesting of wild seaweeds, covering:

- Commercially relevant species *(A. nodosum, Laminaria digitata* and *Laminaria hyperborea).*
- Harvesting of seaweeds in Marine Protected Areas (MPAs).
- An inclusive approach, considering both mechanical and hand harvesting methods and not precluding any particular method.
- The policy should follow European models for harvesting wild seaweed in Norway, Iceland and France, countries which have sustainably managed commercial harvesting for >50 years.
- The policy should be written in consultation with the seaweed industry who form a key part of the bioeconomy, and therefore have substantial knowledge of what is required.

Further details pertinent to the development of a seaweed harvesting policy in Ireland, are outlined in **Appendix 1.**

(b) Reform the licensing system for seaweed harvesting: There is an urgent need to develop a seaweed harvesting licensing system that facilitates a multi-company industry in Ireland. Processors should be granted licences within clearly defined geographical areas without any

overlap with other licensees. This does not exclude the rights of any individual stakeholders who may have legal rights under the existing appurtenance laws or small non-commercial users. As outlined on pg. 167 of the National Marine Planning Framework (NMPF), *"the ANPG supports reforms of the licensing system for sustainable seaweed harvesting taking account of Appurtenant and Profit-à-Prendre harvesting rights. The ANPG supports the National Marine Planning Framework as it provides a mechanism to protect the marine environment, whilst also facilitating the expansion of Ireland's seaweed processing industries and their continued development of innovative technologies from this valuable and renewable resource".*

Recommendation: The licensing and regulatory system for sustainable seaweed harvesting should be upgraded to facilitate a multi-company industry. The ANPG is of the view that subject to proper regulation and science-based resource management practices, there can be sufficient quantities of biomass harvested to support a multi-company industry. General recommendations for reforming the licensing system were previously provided by the ANPG during public consultation on the NMPF – these recommendations are outlined in **Appendix 2.**

(c) Reform of the legal system:

In order for the Action Plan to be effective, significant changes to the legal system are required. At present, the legal system is being used to block developments and activities in coastal and marine areas on spurious grounds, lacking scientific foundation in some instances. This is untenable and is stifling the development of the bioeconomy and marine biotechnology sectors.

Recommendations:

- **Conflict resolution- Arbitration:** A system of arbitration should be put in place to deal with conflicting opinions on foreshore license applications. An arbitration board will consist of independent technical experts spanning engineering, ecology, legal and administrative aspects. The arbitration team should hear the arguments from both parties, request written submissions if necessary, request expert evidence if required and then make a decision on their findings. The decision of the board is final. However, either party should be allowed appeal to the courts on specific grounds or the arbitration board could recommend that the case should be heard in the courts if considered necessary.

  In the event of the decision being disputed or referred to the court, the arbitration body should provide a report to both legal teams and the judge that is assigned to the case. The report should include the following:

  (a) An outline of the issues in the case and whether the plaintiff has a justifiable complaint.
  (b) A statement of agreed facts and issues that are still in dispute.
  (c) An assessment of the legal implications.
  (d) A summary of the case law pertaining to the area.

  The judge should be required to read this report in advance of a case being listed, identify missing information and assess the merits of the case. The judge should have the option to refer the case back to the arbitrator with direction that the arbitrator's decision is valid; if not, the judge will proceed to hear the case. This will allow for cases to be determined in an expeditious manner, preventing the waste of court time and avoid enormous costs to the parties involved. Arbitration is a system that is used to settle disputes worldwide, therefore there are many examples of how it should be regulated and incorporated into a country's legal system.
- **The Aarhus Convention:** Some individuals bring cases to the High Court under the guise of being "environmental in nature". However, if a case cannot be proven to be environmental in nature, the plaintiff should be liable to pay the defendant's legal costs. The ability to pay the costs of the defendant should be verified in advance.

- **Transparency over sources of funding:** Any person bringing an environmental case to the courts should be required to fully disclose their source of funds. At present, there is no such requirement. This renders the legal system open to abuse by unknown outside parties and facilitates the bringing of multiple cases with significant costs in terms of time and money to the defendant. These cases lead to continuous costs on behalf of the defendant whilst no costs to the plaintiff are incurred, as they typically operate on a "No Foal, No Fee" basis.
- **Appeal process:** The appeal process for foreshore licenses and developments in the bioeconomy should not exceed a period of 6 months.

3. What other key issues should the Governance Pillar deal with?

It is essential that the Governance Pillar makes impartial decisions based on scientific facts, rather than unsubstantiated claims, particularly in relation to carbon sequestration and aquaculture:

- **Claims regarding carbon sequestration:** There have been claims that seaweeds are important for carbon sequestration, and therefore should be protected in MPAs. However, such claims are inaccurate and do not reflect the more limited role that seaweeds appear to play. For example:
  (a) Field *et al.,* (1998) show that phytoplankton account for >97% of marine photosynthesis of carbon, and is therefore the main contributor to carbon sequestration in the ocean. In contrast, seaweeds account for <3% of marine photosynthesis and <1% of global photosynthesis. Therefore, seaweed's contribution to carbon sequestration is extremely low.
  (b) A report commissioned by the Marine Institute suggests that the long-term deep-water or sediment sequestration of carbon from Irish Kelp species may be limited (Cott *et al.,* 2021).
  (c) Data presented by Gallagher *et al.,* (2022) suggests that seaweed is unlikely to have any significant role in reducing greenhouse gas emissions.
  (d) Sujeeth *et al.,* (2022) describes these issues in greater detail (see **Appendix 3**).
- **Limitations of Aquaculture:** It has been suggested that seaweed culture may meet demand for seaweed products in Ireland. However, >98% of all seaweed-related products from Ireland are manufactured using harvested wild seaweed, with seaweed aquaculture accounting for <2%. *A. nodosum* accounts for the majority of commercially harvested wild seaweeds in Ireland (>98%), with the majority used to supply the ANPG. While aquaculture may be suited to growing certain species of seaweed in Ireland that require to 1-2 years to grow, it cannot be applied to *A. nodosum* for the following reasons:
  (a) Due to its demographic characteristics (Aberg *et al.,* 1992A and B), *A. nodosum* has *"low potential as a candidate for production in aquaculture which could thereby decrease the pressure on wild stocks"* (Borges *et al.,* 2020; Sujeeth *et al.,* 2022 and references therein).
  (b) Culturing *A. nodosum* would require extensive infrastructure to be installed along inshore areas of Ireland, which could have impacts and would not be commercially viable.

  Difficulties faced by seaweed aquaculture are described in greater detail in **Appendix 4.**

Recommendations: The Governance Pillar should ensure the following:

- Decision-making and actions should be impartial and based on examination of the facts in each case.
- Decision-making, actions & policy should be accurate and not influenced by unsubstantiated claims.
- Policy should focus on proven and viable means of developing the bioeconomy, building on the expertise of indigenous Irish SMEs.

4. What key issues should the Research, Development & Innovation Pillar deal with?

The RD&I pillar should focus on key societal issues in the area of public health, agriculture, environment and the economy. ANPG members have a proven track record in this area, using bioactive compounds from seaweed to manufacture products and technologies which have

significant environmental, public and human health benefits. Marine-derived compounds are utilized by Irish SMEs to develop high-value products and technologies which are exported worldwide, including:

- Extracts that enhance crop tolerance to abiotic stress (drought, heat, cold, water logging),
- Compounds that can be used to enhance soil health,
- Compounds that can be used to reduce the levels of synthetic agrichemicals in agriculture,
- Immune-priming compounds that can replace antibiotics in animal husbandry and
- Minerals, trace elements and vitamins necessary for optimum ruminant animal health.

Research is also underway on methods to reduce carbon emissions on farms, including dairy herds.

Recommendations: The RD&I pillar should focus on solving key societal issues in the area of public health, agriculture, the environment and the economy, by closely collaborating with Irish SMEs who have expertise in these areas.

5. How could the RD&I bioeconomy approach be best structured to support the enhancement, application and scaling-up of biological knowledge and bioeconomy solutions?

To ensure that the Bioeconomy Action Plan is successful, the RD&I strategy should be based on strong science and involve close collaboration with Irish SMEs. Members of the ANPG have a proven track record in RD&I and the development of cutting edge technologies. They also have well established collaborations in place with leading universities at national and international level.

Recommendations: The RD&I Pillar should be structured in a manner that prioritizes and centres on actions that meet the following criteria:

- Involve close collaboration with Irish SMEs which have a proven track record of delivering in the Irish bioeconomy sector. Irish SME-led actions/projects should be prioritized.
- Focused on products and technologies that are commercially viable.
- Focused on well-established methods that are technically feasible.
- Capable of being up-scaled and manufactured at industrial level.
- Based on a strong scientific hypothesis, rather than unproven claims.
- Capable of delivering public benefits spanning societal, environmental, economic and human health aspects.

6. What key issues should the Nature, Climate & Circular Pillar deal with?

Recommendations:

- The Nature, Climate & Circular Pillar should not support ideas or claims that are unsupported by scientific research or lack a strong scientific hypothesis.
- The Nature, Climate & Circular Pillar should focus on:
  - **Technologies to reduce fertilizer and agrichemical use:** Plant biostimulants can potentially reduce the requirement for fertilisers, fungicides and other synthetic compounds, which in turn may lead to improvements in water quality and the lowering of emissions on farms.
  - **Technologies to enhance livestock health:** Natural compounds from seaweed can be used to improve herd health and in turn lower emissions per unit of product. This is in line with "AgClimatise" (DAFM, 2020) which states: *"**Improvements in the herd health status of the national Irish dairy and beef herd leads to increased productivity and ultimately reduced emissions per unit of product.** Animal breeding can make significant contributions to the development of more healthy animals. There is an onus on the entire sector to work collectively to make targeted improvements over the coming decade. This will not only reduce the carbon footprint of Irish farms, but it will also increase farm profitability. Much like nutrient use efficiency, it is a win-win for the farmer and the environment. The*

development of antimicrobial resistance is a concern in veterinary, as well as human medicine, and to protect the efficacy of such products into the future, ***the EU Farm to Fork strategy requires a reduction in the use of antimicrobials over the coming decade".***

7. What key issues concerning consumption patterns need to be examined to close the gap between sustainable supply of biological resources and demand?

Recommendations: Members of the ANPG require certainty over the supply of their primary raw material, *A. nodosum*. To achieve this, the following issues need to be addressed:

- A harvesting policy is required, focusing on commercially relevant species of wild seaweed, i.e. *A. nodosum, Laminaria digitata* and *Laminaria hyperborea.*
- Licensing reform is required to facilitate a multi-company industry.
- The legal system should be reformed to ensure that companies can operate effectively.

This is outlined in greater detail in the answer to question 2 of this submission.

8. What key issues should the Agriculture, Food & the Marine Pillar deal with?

Recommendations: As described in point 1 and 4 of this submission, members of the ANPG specialize in the development of technologies for the sustainable Agri-sector. The Agriculture, Food & the Marine Pillar should work closely with Irish SMEs to build upon key strengths that currently exist in the Irish bioeconomy, in order to deliver solutions to the following important issues:

- Susceptibility of crops to adverse weather events associated with climate change, such as drought, heat, cold and water logging (i.e. 'abiotic stresses').
- Poor soil health,
- The overuse of certain synthetic agrichemicals in agriculture,
- The need for technologies that can replace the need for in-feed antibiotics in agriculture.
- Methods to reduce carbon emissions on farms, including dairy herds.

9. What key issues should the Communities Pillar deal with?

Recommendations: Irish SMEs play an important role in delivering well-paid, sustainable employment in rural and coastal areas of Ireland. They are essential to the success of the bioeconomy, given their strong scientific knowledge base and capacity to manufacture products at large-scale for export to global markets. As such, SMEs should play a key role in the Communities Pillar.

10. Are local and regional policies ensuring the consideration of bioeconomy opportunities are in scope, and are coordinated approaches on such services in place at regional assembly and local authority level?

Some local authorities lack an awareness or understanding of the needs of SMEs working in the bioeconomy. In addition, some local authorities may not have the necessary expertise to deal with certain planning applications. This must be addressed given that SMEs are the corner-stone of the bioeconomy - without SMEs, the bioeconomy will not grow.

Recommendations: Local authorities should be required to prioritise and fast-track applications by SMEs that are focused on the bioeconomy.

11. What key issues should the Industry & Enterprise Pillar deal with?

Recommendations:

- SMEs should be involved in actions that concern "innovation performance".
- This pillar should focus on the identification and removal of major barriers to the bioeconomy (see answer to question 2 for details).

12. What lead market initiatives could support entrepreneurship, development, innovation and the commercialisation of bio-based products, processes, information, and services?

Recommendations:

- The EU's "Lead markets initiative for Europe" (2007) is focused on coordination of policies affecting the innovation performance of sectors and on removing barriers to technological advances, in 6 key areas: renewable energy, recycling, bio-based products, sustainable construction, textiles and health. As members of the ANPG specialize in the areas 'bio-based products' and 'health', it is recommended that these two areas are prioritized.
- In line with the EU's "Lead markets initiative for Europe", barriers to technological advances should be identified and removed, e.g. the lack of policy on wild seaweed harvesting, licensing reform and reform of the legal system. Barriers to Ireland's seaweed, marine biotechnology and bio-products industry have recently been cited in "Ireland's Ocean Economy Report, 2022" (Norton *et al.,* 2022; see answer to question 2 for details).

13. Due to the requirement for capital and operational investment what innovations aimed at financing infrastructures and technical and economic evaluation of innovation are necessary to scale up the bioeconomy?

Recommendations: In order for any innovation to be successful, it must be technically feasible, commercially viable and capable of being up-scaled to industrial level. Members of the ANPG have a proven track record in this regard. It is recommended therefore that the Government focus on existing and well-established innovations in the Irish bioeconomy and to build on this success by facilitating companies working in these areas.

14. What key issues should the Knowledge & Skills Pillar deal with?

The vision of "Impact 2030: Ireland's Research and Innovation Strategy", is that Ireland will be a country where *"Enterprises, particularly SMEs, start, succeed and transform through innovation, knowledge exchange, research commercialisation and access to highly skilled people"* (Government of Ireland, 2022). Therefore, the key role of SMEs in Research and Innovation is recognised at Government level. ANPG members have a proven track record in this area, e.g. research commercialisation, development of high-value added products, patented technologies and employing a diverse range of highly skilled people in R&D, the natural sciences and engineering.

Recommendations:

- SMEs should be central to key actions in this pillar:
  - All research actions/programmes on the subject of the bioeconomy should be required to include SMEs as research partners/collaborators.
  - SME-led research programmes should be prioritised.
- The following "Challenges and Opportunities" are listed in the "Impact 2030: Ireland's Research and Innovation Strategy", and therefore should be addressed by this pillar: (i) Agriculture, Food and the Marine, (ii) Climate, Environment and Sustainability, (iii) Economic Competitiveness and (iv) Health and Wellbeing.

15. Can the regional skills and regional enterprise approaches better support bioeconomy development?

SME's are the main drivers of economic growth and innovation in the bioeconomy. Therefore, without industry involvement in the Knowledge & Skills Pillar, the contribution of 'regional skills and regional enterprise approaches' to the bioeconomy may be limited.

Recommendations:

- As the main driver of the bioeconomy, the SME sector should be front and centre to approaches by Government to better support bioeconomy development, particular in relation to the Knowledge & Skills Pillar.
- Industry-academic collaborations should be industry-led to ensure that methods and approaches taken are (a) commercially viable, (b) capable of being up-scaled to industrial level, (c) capable of meeting market demands and (d) meet regulatory requirements in national and international markets.

16. An important part of developing the bioeconomy is to determine the most appropriate practices, treatments, technologies, logistics and business models to valorise ecosystem services, primary and secondary biomass resources. What role do advisory systems play in addressing this challenge?

Advisory systems which lack an SME focus or lack SME membership may have a more limited role in addressing challenges facing the bioeconomy.

Recommendations: In order for Advisory systems (e.g. R&I Advisory Forums) to contribute positively to developing the bioeconomy, they should be SME-focused and include a range of SMEs relevant to the bioeconomy in their membership. This is particularly important in relation to R&I Advisory Forums that may advise and provide policy direction to Government.

17. Are there any further Pillars/Issues which this Action Plan should address?

Recommendations: As outlined in point 1 of this submission, ***"Public Health"*** should be included as an additional, stand-alone pillar of the bioeconomy. This pillar should support actions of companies working in the bioeconomy to enhance public health in Ireland.

18. Indicate what the top 5 priorities for action in the bioeconomy over the next 3 years should be?

(1) A ***"Public Health"*** pillar should be included in the Bioeconomy Action Plan, building on the existing expertise of Irish SMEs working in this area.
(2) Major barriers to the bioeconomy must be identified and removed. For example, a lack of policy on seaweed harvesting, licensing reform and legal system reform.
(3) Wild seaweeds should be recognised as essential raw materials for the indigenous Irish bioeconomy and should be prioritized in actions aimed at driving the bioeconomy.
(4) Actions/projects associated with the bioeconomy should be SME-led or involve close collaboration with SMEs.
(5) Governance, policy development, actions and decision making should be based on accuracy and impartiality and should focus on proven and viable means of developing the bioeconomy, building on the existing expertise of indigenous Irish SMEs.

Appendix 1: The need for a seaweed harvesting policy in Ireland.

Seaweed harvesting is an important component of the bioeconomy in Ireland. However, there is currently no policy in place in Ireland governing this activity, despite the fact that over 98% of Ireland's harvested seaweed comes from commercial harvesting of wild resources, with less than 2% derived from aquaculture. To ensure the economic potential of seaweed resources in Ireland is realized, it is essential that a policy is put in place. This document summarizes the models for seaweed harvesting in Norway, Iceland and France, including regulatory aspects, quantities harvested, methodology and rotation periods involved. Information on seaweed harvesting in Ireland is provided for comparison. Overall, the Norwegian, Icelandic and French models provide a good framework for the sustainable management of seaweed resources, particularly given their focus on collaboration between industry and relevant scientific bodies. It is recommended that the Irish Government develops a seaweed harvesting policy in line with Norwegian, Icelandic and French models, covering:

- Commercially relevant species including *Ascophyllum nodosum, Laminaria digitata* and *Laminaria hyperborea.*
- Harvesting of seaweeds in Marine Protected Areas (MPAs), both mechanically and by hand.
- The policy should be written in consultation with the Irish seaweed industry who form a key part of the bioeconomy, and therefore have substantial knowledge of what is required.

Regulatory aspects (National level):

(a) Norway: The Norwegian Ministry of Fisheries and Coastal Affairs, FKD, regulates seaweed harvest by laws and instructs the Directory of Fisheries, FD, which sets the regulations together with industry, Institute of Marine Research (IMR), researchers and other relevant stakeholders (Meland *et al.,* 2011). Licenses to commercial companies are obtained from the Directorate of Fisheries (Gómez *et al.,* 2021). Harvesting is monitored through collaboration between industry, scientific bodies and experts in academia (Steen *et al.,* 2016).

(b) Iceland: In 2018, a new regulation on commercial seaweed harvesting was issued, "Regulation on the acquisition of Seaweed for commercial purposes No 90/2018", covering permits and regulatory aspects. The Regulation was issued by the Directorate of Fisheries, Ministry of Industries and Innovation based on the Fisheries Management Act No 116/2006 and Act No 57/1996 concerning the Treatment of Commercial Marine Stocks. It was adopted with the intention to "Improve the conduct of exploited marine stocks and promote sustainable utilization that ensure long-term maximum yield for the Icelandic Nation" (Gómez, 2021; Maack, 2019).

(c) France: Commercial seaweed harvesting is regulated at national and regional scale in France. Seaweed harvesting takes place in the Parc naturel marin d'Iroise (PNMI), a Marine Protected Area (MPA) located in waters off the north west coast of France, where human, commercial and industrial activities operate according to a set of defined criteria. The French Research Institute for the Exploitation of the Sea (Ifremer) monitors kelp harvesting in the PNMI and advises administrations involved in the management of seaweed harvesting (ref: Mesnildrey *et al.,* 2012).

(d) Ireland: Commercial harvesting is regulated by Government departments and licensed under the Foreshore Act, 1933 and the Maritime Area Planning Act 2021. License decisions are made following consultations with expert groups and prescribed bodies including the Marine Institute, National Parks and Wildlife Services, Inland Fisheries Ireland, Sea Fisheries Protection Authority, Marine Survey Office, Underwater Archaeology Unit and other relevant Government bodies and Departments. Licenses are issued in line with EU regulations and involve collaboration between industry and scientific experts to monitor the resource.

Quantities:

Most brown seaweeds harvested in Europe come from Norway, Ireland, Iceland and France, including commercially important species such as *A. nodosum, L. hyperborea* and *L. digitata:*

(a) Norway: Wild seaweed has been harvested in Norway for over 50 years. Approximately 162,824 tonnes of brown seaweed were harvested in Norway in 2019, including *A. nodosum* and *L. hyperborea*, *Alaria esculenta* and other brown seaweeds (FAO, 2021).

(b) Iceland: Wild seaweed has been commercially harvested in Iceland since the 1970s, with approx. 15,000 to 20,000 tonnes of *A. nodosum* and 1,700 to 3,700 tonnes of *L. digitata* mechanically harvested per annum. *L. hyperborea* is mechanically harvested (Maack, 2019). In 2019, 17,533 tonnes of *A. nodosum, L. digitata* and *L. hyperborea,* were harvested in Icelandic waters (FAO, 2021).

(c) France: Wild seaweed has been harvested in France for over 50 years. Approximately 51141.92 tonnes of brown seaweed were harvested in France in 2019 (FAO, 2021). Species harvested include *L. hyperborea, L. digitata, A. nodosum* and *Himanthalia elongate* . Most of the seaweed harvested in France comes from the PNMI Marine Protected Area (Mesnildrey *et al.,* 2012).

(d) Ireland: Wild seaweeds have been harvested in Ireland for 100s of years. *A. nodosum* has been commercially harvested for decades and is currently the main seaweed harvested in Ireland. It is estimated that at least 29,500 tonnes was harvested in 2019 (FAO, 2021). Harvesting of *L. digitata* and *L. hyperborea* is also licensed in Ireland.

Methodology and rotation periods:

(e) Norway: Mechanical harvesting of *L. hyperborea* occurs along 40% of the Norwegian coastline and is managed on a 3 to 4/5 year rotational basis, regenerating within 4 years post-harvesting (Steen, 2016, Gómez, 2021). Kelp is mechanically harvested commercially by boat at depths between 5- 20m depth, using a 3-meter-wide dredge with pointed prongs that when towed across the seabed, removes kelp plants from the substratum (Gómez, 2021, Steen, 2016). Following canopy removal, understory kelp plants flourish with the improved light conditions, ensuring a short regeneration time of the canopy which grows back at higher densities compared to control sites (Steen, 2016). Mechanical harvesting is sustainable as evidenced by the recovery of biomass between 2 and 6 years post-harvesting, depending on the location (Christie, 1998, Sjøtun, 2006, Steen, 2016).

(f) Iceland: Regulations specify a 4 year rotation system for seaweed harvesting (Gómez, 2021).

(g) France: *L. digitata* is mechanically harvested by boat with a gear called a 'scoubidou'. *L. hyperborea* is also mechanically harvested by boat using a large rake-like dredge device. *A. nodosum* is harvested by hand. Mechanical harvesting appears to be sustainable as evidenced by the recovery of *Laminaria* spp. biomass post-harvesting to levels comparable to unharvested zones (Davoult 2011; Leclerc 2015).

(h) Ireland: *A. nodosum* is hand harvested in sheltered intertidal zones along the west coast of Ireland. The mechanical harvesting of *L. digitata* and *L. hyperborea* in subtidal waters is a licensed activity in Bantry Bay, County Cork, Ireland and involves the cutting of kelp at a minimum of 200mm above the holdfast, without making contact with the seabed, along with scientific monitoring of kelp regeneration rates and flora and fauna 3 and 5 years post-harvesting (BioAtlantis Ltd., 2014).

EU Context:

Harvesting of seaweed in the wild should be undertaken in a manner that is sustainable in both the short and long term, allowing for regeneration of the resource and preventing negative impacts on the marine and coastal ecosystems, habitats and species (Werner and & Kraan, 2004, Kelly *et al.,* 2001 and 2005). In a European context, harvesting must be carried out in line with the habitats and birds directives (Habitats Directive 92/43/EEC, Birds directive 2009/147/EC), particularly when working in protected areas such as Natura 2000 sites, Special areas of Conservation (SACs), Special Protection Areas (SPAs) and Marine Protected Areas (MPAs). In particular, measures are required to ensure that activities associated with seaweed harvesting do not impact on the conservation objectives and targets set for qualifying interests (habitats, species, etc.) within protected sites (NPWS, 2012). Conservation objectives and targets are typically assigned to protect a wide array of marine and coastal species and habitats listed on Annex I/II of the E.U. Habitats Directive, including harbour/common seal *(Phoca vitulina)*, otter *(Lutra lutra),* specific bird species, reefs, shingle, tidal mudflats and sandflats, estuaries, inlets and bays, salt meadows and sand dunes and a range of harbour seal haul out sites and bird wintering or breeding sites (Nelson, 2019, NPWS, 2019). Adherence to conservation objectives and targets form a key part of legal frameworks aimed at ensuring that activities such as seaweed harvesting are undertaken in a sustainable manner, thus ensuring no significant impacts on protected habitats and species in the marine zone.

The regulatory and sustainability aspects to harvesting wild seaweed resources in Europe are described in greater detail by Sujeeth et al. (2022).

Appendix 2: Upgrading of the regulatory and licensing system for seaweed harvesting:

On the 30th of April, 2020, the ANPG made a submission regarding the draft National Marine Planning Framework (NMPF). The submission recommended that the licensing and regulatory system for *A. nodosum* harvesting be upgraded to ensure the following:

- **Environmental sustainability:** Harvesting should be undertaken in a manner that ensures compliance with conservation objectives for Natura 2000 sites, Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). Agriculture must move towards a more sustainable industry and the use of seaweed extracts can help this process by enhancing the uptake of fertilisers by crops thus lowering the carbon footprint of farms. In addition, seaweed extracts also reduce the necessity for pesticides due to the crop strengthening effects.
- **Appurtenant rights:** ANPG recognises existing appurtenant rights to harvest, gather or remove seaweed from the shore and will support the non-harvesting by members in such areas, save with the permission of the rights holder. Such rights are described in property folios as appurtenant rights or burdens.
- **Profit-à-Prendre:** Where Profit-à-Prendre rights to harvest seaweed are successfully registered with the PRAI, the ANPG support the need to adjust harvesting plans to ensure that those individuals can continue to harvest *A. nodosum*.
- **Resource Use:** ANPG support the use of a "use it or lose it" clause to any license application. This will ensure that this critically important resource can continue to be utilized into the future.
- **Geographical areas:** Applicants should be granted licences within clearly defined geographical areas without any overlap with other licensees. This does not exclude the rights of any individual stakeholders who may have existing legal rights or small non-commercial users.
- **Quota system:** Some members of the ANPG have or are in the process of applying for licenses to harvest *A. nodosum*. ANPG supports the operation of a quota system in each licensed area, subject to compliance with environmental regulations and ensuring that over harvesting does not occur.
- **Management of the resource:** ANPG support a scientific data-based approach to improving the management of the resource and thereby guaranteeing that harvesting continues to be an activity that co-exists with other activities in a sustainable and environmentally responsible manner. The very future of ANPG members depends on the resource.
- **Stakeholders:** The rights and needs of all stakeholders must be respected. In particular ANPG recognises and supports the traditional harvesters and are committed to them remaining central to the industry in the future. The regulatory authorities should recognise the long term investment by processors in research, marketing and manufacturing and the need to guarantee access to seaweed raw material to justify such investment.
- **Policy led approach:** ANPG recommend a policy led approach to decision making, that allows for the expansion of commercial-scale seaweed harvesting in a manner that is sustainable and in compliance with EU laws. Sustainable harvesting means that seaweed is harvested on a rotational basis, whilst ensuring steps are taken to prevent or minimize impacts on the environment.
- **Multi-company Industry and licensing system:**
  ANPG recommend a multi-company based licensing system where licenses are provided on the basis of objective criteria. The criteria for the awarding a licence should include the following:
  - Ability of the company to manage the resource sustainably and meet licence requirements.
  - The value added to the resource by the company and in turn, the value from a national perspective.
  - Exports generated from the processing of the resource.
  - Job creation in the western seaboard.
  - The harvest plan of every applicant must be realistic and verifiable.

Appendix 3: Seaweeds do not play a significant role in carbon sequestration.

Although primary producers, macrophytes such as seaweed have a relatively low share of total global photosynthesis; therefore, their role in carbon sequestration may be limited. Overall, marine phytoplankton account for over 97% of marine photosynthesis of carbon and is therefore the main contributor to carbon sequestration in the ocean, while marine macrophytes (marine plants and seaweeds) account for less than 3% (Field *et al.,* 1998). An excerpt from Sujeeth *et al.,* (2022) describes these issues in further detail:

*"**Carbon sequestration:** Although primary producers, macrophytes, (e.g., seaweeds, seagrass) account for <1% of global photosynthesis (global net primary production, NPP) [94] and about 3% of marine NPP ([95] and references therein). Non-macrophytes, (e.g., phytoplankton) contribute to >97% of marine NPP and >45% of global NPP. Land plants/habitats are responsible for >53% of global NPP [94]. As macrophytes' share of global NPP is low, their role in carbon sequestration may be limited. Seaweeds with buoyancy mechanisms may float, degrade and sink to deep-sea sediments, for long-term carbon storage ([96] and references therein). However, European kelp species may have a lesser contribution to carbon sequestration, as large amounts of their biomass is washed ashore annually to decay as part of their life cycle. This happens to an estimated 20% of L. hyperborea stocks in Ireland annually, a country with approximately 3 million tonnes of standing kelp stock [97]. Given the absence of floating devices in European kelps and the nature of coastal areas of north-western Europe as receivers of decaying biomass, the long-term deep-water or sediment sequestration of their carbon may be limited. Carbon sequestration may be limited to refractory carbon associated with undisturbed beds of Fucales [96]. Approximately 12% of NPP by macroalgae may be sequestered [98], which is low given that macrophytes account for <1% of global NPP [94]. A new study also suggests that seaweed ecosystems may not mitigate CO2 emissions [99]. Further research is warranted, as the contribution of macroalgae to NPP may be higher in coastal areas ([95] and references therein)."*

Appendix 4: Difficulties faced by aquaculture in meeting industry demands.

It has been assumed that seaweed culture could meet demand for seaweed products in Ireland. However, this assumption is incorrect for reasons outlined below:

(a) Aquaculture cannot meet the demand for *A. nodosum* in Ireland:

Over 98% of seaweed-related products from Ireland are manufactured using seaweed harvested from the wild, with seaweed aquaculture accounting for <2%. *Ascophyllum nodosum* accounts for the majority of commercially harvested wild seaweed in Ireland (>98%), with the majority used to supply the ANPG group. Members of the ANPG manufacture high value-added products based on *A. nodosum* as a raw material. While aquaculture may be suited to growing certain species of seaweed in Ireland that require to 1-2 years to grow, it cannot be applied to *A. nodosum* for the following reasons:

(a) It is well established that due to its demographic characteristics (Aberg *et al.,* 1992A & B), *A. nodosum* has *"low potential as a candidate for production in aquaculture which could thereby decrease the pressure on wild stocks"* (Borges *et al.,* 2020, Sujeeth *et al.,* 2022 & references therein).

(b) Culturing *A. nodosum* would require extensive infrastructure to be installed along inshore areas of Ireland, which could have impacts and would not be commercially viable.

(b) Aquaculture in Ireland faces many technical challenges:

Challenges and life-cycle constraints to expanding aquaculture to seaweed are outlined as follows:

(a) The highly exposed Irish coast is not conducive to culturing commercial seaweed species:

The cultivation of seaweeds in exposed environments faces challenges due to the low survival rate of aquaculture structures and insufficiently durable equipment to withstand rough conditions (reviewed by Sujeeth *et al.,* 2022 and references therein). This is particularly the case

in coastal areas of the North Atlantic Ocean, which experience stronger sea surface winds and wave heights which can be very problematic. *A. nodosum* is highly sensitive to wave movement and cannot withstand exposed or stormy conditions. Cultured *A. nodosum* would therefore be lost due to the highly exposed nature of Ireland's coastline.

(b) Life-cycle constraints to culturing commercial seaweed species:
In addition to *A. nodosum,* other commercial seaweed species also have biological constraints which may limit the expansion of aquaculture. For example, the cultivation of bulk species such as kelp is not considered economically feasible in Europe (Werner and Kraan, 2004); e.g., *Laminaria hyperborea. L. hyperborea* grows at lower densities in sheltered areas, which otherwise favour cultivation, and at higher density in exposed areas which are less conducive to aquaculture. Therefore, culturing *L. hyperborea* may not be technically feasible or commercially viable in Ireland. While the culturing of *L. digitata* is possible, the yields may be too low to meet commercial demands in key markets.

An extract from Sujeeth *et al.,* (2022) outlines these issues in greater detail:

"Seaweed Aquaculture: *While seaweeds are cultured worldwide ([44] and references therein), their use as raw materials for plant biostimulants may be limited. Ascophyllum nodosum has a low potential for production by aquaculture [45] due to its demographic characteristics [46,47], while the cultivation of bulk species such as kelp is not considered economically feasible in Europe [48], e.g., Laminaria hyperborea. The cultivation of seaweeds in exposed environments faces challenges due to the low survival rate of aquaculture structures and insufficiently durable equipment to withstand rough conditions ([49] and references therein). Wave heights may be problematic for offshore aquaculture in coastal areas of the North Atlantic Ocean and Norwegian Sea, (e.g., Ireland, Norway, northwest France), Chile, Namibia and South Africa [50], which experience stronger sea surface winds. Calmer conditions may be more suitable for aquaculture, for example, in regions near Indonesia, India, the North Sea and parts of the South Atlantic [50]. Life cycle and biological constraints may limit the expansion of aquaculture to commercial species. For example, L. hyperborea grows at lower densities in sheltered areas, which otherwise favour cultivation, and at higher density in exposed areas [51,52,53]. Thus, given the challenges faced by aquaculture in exposed environments, culturing L. hyperborea may not be technically feasible or commercially viable."*

References:

- **Aberg, P.** Size-Based Demography of the Seaweed Ascophyllum nodosum in Stochastic Environments. Ecology 1992, 73, 1488–1501. https://esajournals.onlinelibrary.wiley.com/doi/abs/10.2307/1940692
- **Aberg, P.** A Demographic Study of Two Populations of the Seaweed Ascophyllum nodosum. Ecology 1992, 73, 1473–1487. https://esajournals.onlinelibrary.wiley.com/doi/abs/10.2307/1940691
- **BioAtlantis Ltd. (2014).** Foreshore licence application for mechanical harvesting of seaweed in Bantry Bay, FS006061. https://www.gov.ie/en/foreshore-notice/e62b9-bioatlantis-ltd-bantry-bay/
- **Borges, D.;** Araujo, R.; Azevedo, I.; Pinto, I.S. Sustainable Management of Economically Valuable Seaweed Stocks at the Limits of Their Range of Distribution: Ascophyllum nodosum (Phaeophyceae) and Its Southernmost Population in Europe. J. Appl. Phycol. 2020, 32, 1365–1375. https://link.springer.com/article/10.1007/s10811-019-02002-5
- **Christie, H.;** Fredriksen, S.; Rinde, E (1998). Regrowth of Kelp and Colonization of Epiphyte and Fauna Community after Kelp Trawling at the Coast of Norway. Hydrobiologia, 132, 49–58.
- **Cott, G.; Beca-Carretero, P.; Stengel, D (2021).** Blue Carbon and Marine Carbon Sequestration in Irish Waters and Coastal Habitats. Marine Institute, Ireland. Available online: https://oar.marine.ie/handle/10793/1685
- **Davoult et al. (2011).** Cahiers de Biologie Marine, 52(4), 429–434.
- **Department of Agriculture, Food and the Marine (DAFM, 2020).** AgClimatise, A Roadmap towards Climate Neutrality; Department of Agriculture, Food and the Marine: Dublin, Ireland. https://www.gov.ie/en/publication/07fbe-ag-climatise-a-roadmap-towards-climate-neutrality/
- **Department of Health and the Department of Agriculture, Food and the Marine (2021).** Ireland's second One Health Action Plan on Antimicrobial Resistance 2021–2025 (iNAP2). https://www.gov.ie/en/publication/d72f1-joint-action-on-antimicrobial-resistance/
- **European Commission (2007a):** A lead market initiative for Europe (2007).
- **FAO.** Global capture production 1950-2019. www.fao.org/fishery/statistics/software/fishstatj/en
- **Field, C.B.; Behrenfeld, M.J.; Randerson, J.T.; Falkowski, P. (1998)** Primary Production of the Biosphere: Integrating Terrestrial and Oceanic Components. Science, 281, 237–240. https://www.science.org/doi/abs/10.1126/science.281.5374.237
- **Gallagher, J.B.; Shelamoff, V.; Layton, C (2022).** Seaweed Ecosystems May Not Mitigate CO2 Emissions. ICES J. Mar. Sci. 2022, 79, 585–592. https://academic.oup.com/icesjms/article/79/3/585/6525671
- **Gómez *et al.,* 2021.** European & National Regulations on Seaweed Cultivation and Harvesting. (SUSCULT) Project Report. https://www.submariner-network.eu/images/grass/FINAL-GRASS_GoA_3.2._SYKE_regulation_report.pdf
- **Government of Ireland (2022).** Impact 2030: Ireland's Research and Innovation Strategy. https://www.gov.ie/ga/foilsiuchan/27c78-impact-2030-irelands-new-research-and-innovation-strategy/
- **Irish Examiner, 2022.** Waterville investigating to determine the origin of mystery smell in Kerry village. SUN, 02 OCT, 2022. https://www.irishexaminer.com/news/munster/arid-40974056.html
- **Kelly, L.,** Collier, L., Costello, M. J., Diver, M., McGarvey, S., Kraan, S., Morrissey, J. & Guiry, M. D (2001). Impact Assessment of Hand and Mechanical Harvesting of Ascophyllum nodosum on Regeneration and Biodiversity", Marine Resource Series, Marine Institute. https://oar.marine.ie/handle/10793/207
- **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 & Local Government, Dublin, Ireland. https://www.npws.ie/sites/default/files/publications/pdf/IWM17.pdf
- **Leclerc *et al.,* (2015).** Community, trophic structure and functioning in two contrasting Laminaria hyperborea forests. Estuarine, Coastal and Shelf Science, 152, 11-22. https://www.sciencedirect.com/science/article/abs/pii/S0272771414003254
- **Maack A (2019).** Ways to encourage sustainable exploitation and improve the regulatory framework on wild seaweed in Iceland. The Int. Inst. for Ind. Env. Econ. Lund University. Thesis. https://www.lunduniversity.lu.se/lup/publication/8997131

- **Meland, *et al.,* 2011.** Introduction to the management and regulation of the Norwegian seaweed industry. Bioforsk, 7, pp.278-279.
- **Mesnildrey, *et al.,* 2012.** Seaweed industry in France. Report Interreg program NETALGAE. https://hal-agrocampus-ouest.archives-ouvertes.fr/hal-00840572/document
- **National Marine Planning Framework (NMPF, 2021).** Project Ireland 2040. Prepared by the Department of Housing, Local Government and Heritage. https://www.gov.ie/en/publication/60e57-national-marine-planning-framework/
- **Nelson B,** Cummins S, Fay L, Jeffrey R, Kelly S, Kingston N, Lockhart N, Marnell F, Tierney D and Wyse Jackson M (2019). Checklists of protected and threatened species in Ireland. Irish Wildlife Manuals, No. 116. National Parks and Wildlife Service, Department of Culture, Heritage & the Gaeltacht, Ireland. https://www.npws.ie/sites/default/files/publications/pdf/IWM%20116%20Checklists%20Protected%20and%20Threatened%20Species%202019.pdf
- **Norton, D., Hynes, S., Lanser, M. C., O'Leary, J., O'Donoghue, C., and Tsakiridis, A. (2022).** Ireland's Ocean Economy, 2022. SEMRU, University of Galway and Marine Institute. https://oar.marine.ie/handle/10793/1807
- **NPWS (2012).** Marine Natura Impact Statements in Irish Special Areas of Conservation. A Working Document. National Parks and Wildlife Service (NPWS). Department of Arts, Heritage & the Gaeltacht.https://www.npws.ie/sites/default/files/general/Marine%20Assessment%20Working%20Document.pdf
- **NPWS (2019).** The Status of EU Protected Habitats and Species in Ireland. Volume 1: Summary Overview. Unpublished National Parks and Wildlife Service (NPWS) report. https://www.npws.ie/sites/default/files/publications/pdf/NPWS_2019_Vol1_Summary_Article17.pdf
- **Quilliam, R.S.; Jamieson, J.; Oliver, D.M. Seaweeds** and Plastic Debris Can Influence the Survival of Faecal Indicator Organisms in Beach Environments. Mar. Pollut. Bull. 2014, 84, 201–207. https://www.sciencedirect.com/science/article/abs/pii/S0025326X14002896
- **Sjøtun, K.;** Christie, H.; Helge Fosså, J (2006). The Combined Effect of Canopy Shading and Sea Urchin Grazing on Recruitment in Kelp Forest (Laminaria hyperborea). Mar. Biol. Res. 2, 24–32.
- **Steen, *et al.,* (2016).** Regrowth after kelp harvesting in Nord-Trøndelag, Norway. ICES Journal of Marine Science: Journal Du Conseil, (July). https://academic.oup.com/icesjms/article/73/10/2708/2647119
- **Sujeeth, N., Petrov, V., Guinan, K.J., Rasul, F., O'Sullivan, J.T. and Gechev, T.S., 2022**. Current Insights into the Molecular Mode of Action of Seaweed-Based Biostimulants and the Sustainability of Seaweeds as Raw Material Resources. *International Journal of Molecular Sciences*, *23*(14), p.7654. https://www.mdpi.com/1422-0067/23/14/7654
- **Swinscoe, I.; Oliver, D.M.; Gilburn, A.S.; Quilliam, R.S.** The Seaweed Fly (Coelopidae) Can Facilitate Environmental Survival and Transmission of E. Coli O157 at Sandy Beaches. J. Environ. Manag. 2018, 223, 275–285. https://www.sciencedirect.com/science/article/pii/S030147971830687X
- **UCD (2016).** UCD Impact Case Study: UCD Helps BioAtlantis Develop Novel Animal Health Product. https://www.ucd.ie/t4cms/CASE_STUDY11_John%20ODoherty.pdf
- **United Nations, 2022.** Resistance to antibiotics and other drugs a global concern. 2 February 2022. https://www.un.org/africarenewal/magazine/february-2022/resistance-antibiotics-and-other-drugs-global-concern
- **Werner, A., & Kraan, S. (2004).** Review of the potential mechanisation of kelp harvesting in Ireland. Marine Environment and Health Series No. 17, Marine Institute. https://oar.marine.ie/handle/10793/261