Facilitating development of the seaweed cultivation industry in Scotland

Sugar kelp grown off the Isle of Skye (Photo Credit: Kyla Orr)

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February 2022

Contents

1 Executive summary

Seaweed farming is a new industry in Scotland, and is predicted to expand rapidly over the next 5-10 years. The main seaweed species being cultivated in the UK and Europe are large brown macroalgae, known as 'kelp'. However, despite the rapid expansion of seaweed farms, the industry still faces major barriers to development, mainly related to lack of primary processing infrastructure, poor supply-chain coordination, and underdeveloped markets. The aim of this study is to assess these barriers in detail, and identify possible solutions. The focus is principally on post-harvest challenges to the supply chain, and the key role of 'intermediaries' or primary processors (Section 3). The report discusses cooperative enterprises as a mechanism for kelp farmers to "pool stock and help with processing, marketing and coordinating sales", and steps to setting up a cooperative. It also looks at the relative advantages and disadvantages of cooperatives, and alternative models. Examples are given of other agricultural and seafood businesses in the UK that have worked cooperatively or collaboratively to strengthen their supply-chains and market position. The study also draws on case studies of kelp farming in Norway and the USA, both of which have more developed seaweed farming industries than Scotland (Section 4). The report then summarizes funding options available to new businesses, as well as financial interventions required to help build the industry (Section 5).

Key findings and conclusion in the report are summarized below:

National strategy for development of the sector:

- Kelp farmers would benefit from developing a national strategy for growth, including target markets, focus areas for processing innovation, and methods to overcome supply chain bottlenecks.
- This national strategy / development plan could be created through existing industry bodies such as the Scottish Seaweed Industry Association, or by setting up a new formal seaweed cultivation 'platform' for Scotland, which brings together producers, processors, technology providers, researchers and buyers to solve challenges and open new markets.

Infrastructure and supply chain development:

- There is a distinct lack of processing infrastructure available to kelp farmers in Scotland, and this is a major barrier to development of a profitable seaweed cultivation industry.
- In the USA and Norway growers stated that "securing access to processing capabilities prior to initiating the growing process, either via established contracts with processors or investing in first stage processing (typically drying) capabilities, is critical to success". This is an important lesson for new kelp farmers in Scotland.
- There is an urgent need to develop energy efficient methods for rapidly stabilising kelp after harvest in order to increase storage time before processing (e.g. drying and ensiling).
- There is also a need to find efficient solutions for processing large volumes of cultivated seaweed over a relatively short time.
- Kelp farmers should look into opportunities for partnering with processors in other industries that have a low-season during seaweed harvest, for example grain, shellfish, fruit and vegetable industries.
- To ensure sustainable development it will be critical to monitor the true carbon footprint through the whole supply chain. Growing seaweed absorbs carbon, but much of that will then be released during processing.

Improved organisation and cooperation:

- Seaweed growers would benefit from setting up 'shared facilities for cultivated seaweed' that are member/farmer led, and provide farmers with access to processing, storage and marketing of their kelp products. This could take the form of a seaweed farmers' cooperative, community-interest company (CIC), or private company. This would provide access to equipment, resources and markets they otherwise wouldn't be able to access or afford, while not profiteering on the services.
- There is a strong argument for cooperation, however it is a mindset that may not suit all businesses or people. If farmers feel uncomfortable setting up cooperatives based on certain rules (e.g. democratic votes, distribution of surplus), then they can still set-up a shared enterprise that is a hybrid between a co-op and an 'investor-owned firm'. This is common in the agriculture industry in Europe.
- In the US and Norway collaboration and knowledge exchange between producers, technology providers, processors, and end-users were viewed as important for success. Both countries have platforms for knowledge sharing that could be replicated in Scotland.
- The Scottish Government could help cooperation by providing funds to create voluntary 'producers organisations', or 'farmer-owned processing companies', which would help kelp farmers strengthen their market position and overcome supply chain bottlenecks.

Links to research:

- Collaborating with researchers and universities provides access to a network of people, new ideas and technology that business would otherwise not be able to tap into.
- There should be a strong focus on industry-led research, whereby seaweed growers play a large role in writing and developing proposals to solve specific industry problems.
- Positive results of R&D projects should be implemented in industry wherever possible.
- It is recommended that focus areas for future research should include:
    - Primary processing innovation, including low-energy methods to stabilise kelp;
    - Local market opportunities/ development, and;
    - Optimising farming methods to increase efficiencies.

Market development:

- Local market access: successful seafood and agriculture businesses often focus on supplying their local market first rather than competing with larger overseas producers.
- Creating customer demand: seaweed as a food is still a 'niche' market in the UK, and many consumers lack awareness of how to eat or use seaweed. This can be tackled with outreach and education, and by partnering with industry bodies such as Seafish, which run marketing campaigns to get more people in the UK eating seafood.
- Development of new value-added end products will help bring UK seaweed to market.
- Supply chain logistics are poorly developed or understood for farmed seaweed. Seaweed farmers can learn from other seafood businesses to help build their distribution and supply networks.
- Sustainability and environmental benefits of seaweed cultivation are important to buyers. A strong national branding and marketing drive that builds on this will help the industry.
- Scottish seaweed farmers can strengthen their market position by differentiating their products from cheap Asian imports, as well as the wild harvest industry.

Government subsidy and support requirements specifically for kelp farming industry:

- Conventional funding (loans and grants) is difficult for start-ups to access due to repayment terms and match funding requirements.
- Building a new industry comes with huge financial burdens, and the industry would benefit from government-subsidies specifically for seaweed farming businesses, which could be used to purchase capital equipment, conduct pilot studies on farming methods, processing and product development, and to create sales channels and business cases.
- Government funding should also play a role in R&D activities between kelp farmers and researchers seeking to resolve industry challenges, and should focus on progressing the kelp farming industry as a whole in Scotland, rather than a few isolated companies.
- Funding lots could be informed by a 'national seaweed cultivator strategy', which could be developed by the industry to aid business growth.

2 Introduction and Scope

Scotland's seas are ideal for cultivation of seaweeds such as kelp, and interest is rapidly expanding to establish kelp farming as a sustainable and alternative livelihood in coastal communities. It is considered to be a regenerative form of aquaculture, whereby kelp is grown on lines held below the sea surface, and then harvested 6-9 months later. While the kelp is growing it absorbs CO_2 and does not require input of fertilizers, chemicals or pesticides. In some cases, kelp farms have also been found to enhance local biodiversity. Kelp can then be used in a huge array of products, including food, feed, cosmetics, nutraceuticals, textiles, bioplastics and more. These are some of the reasons why individuals, communities, and businesses are so enthusiastic about starting new kelp farms.

However, seaweed farming is a new industry in Scotland that faces some major barriers, including startup costs, lack of processing infrastructure and capacity, market entry and competition with overseas growers and wild harvesters. In a recent report commissioned by the Crown Estate, large internationally owned seaweed farms were identified as the least desirable model for development of the sector, and providing community jobs and benefits were consistently important to stakeholders. In addition, the study concluded that smaller scale farms would benefit from the setup of 'intermediaries', that can pool stock and help with processing, marketing and coordinating sales. Such intermediaries could follow various models, including but not limited to the setup of a dedicated seaweed cultivation co-operative or producer's organization[1]. The same recommendation was made in reports which looked at the feasibility of cultivating seaweed on the Aberdeenshire coast[2] and within waters of Argyll and Bute[3]. Participants of the Argyll and Bute study "agreed that cooperatives were a desirable mechanism for maintaining competition in the global market, providing community benefits, and ensuring that seaweed cultivation businesses in Argyll and Bute are not bought out by large international companies"[3].

However, in all these reports there is little detail on how cooperative enterprises are setup and run, or the advantages and disadvantages to farmers of joining a cooperative. The decision to setup a seaweed farmers' cooperative will ultimately lie with farmers themselves, and so one of the aims of this study is to provide more practical detail on the subject. The study also assesses other industries in Scotland where producers have worked cooperatively or collaboratively to strengthen their supply chains and market position, such as the Scottish Shellfish Marketing Group (SSMG), Scottish Fish Producers Organizations and agricultural co-operatives (e.g., grain dryers / processors). This study also draws on examples of kelp farming in other nations where it is considered a 'new industry', including the USA and Norway, and discusses how the industry has organized itself to overcome some of the challenges Scottish kelp farmers are facing. The report concludes with a summary of measures that could support development of the kelp farming industry in Scotland, funding options available to new businesses, as well as necessary interventions required in terms of funding going forward.

Information was gathered via desk-based review and semi-structured interviews with stakeholders. In total 12 stakeholders were interviewed across the value chain, including industry bodies, regulators, kelp farmers, processors and researchers from the US, Norway and Scotland. In addition, the author (who is both a marine consultant and co-founder of kelp farming business in Scotland) has drawn on her own experiences of challenges faced by the industry. Identity of stakeholders has been kept

[1] Menzies, B., Brook, T., and Parker, A. (2021). Economic Feasibility Study on Seaweed (Cultivation and Supply Scenario). Crown Estate Scotland. 27 pages.

[2] Sandison, M. and Riddle, G. (2021). Aberdeenshire Council Seaweed Cultivation – A new opportunity for Aberdeenshire. Northern Light Consulting Ltd. Published by Aberdeenshire Council. 82 pages.

[3] Stanley, M.S., Kerrison, P.K., Macleod, A.M., Rolin, C., Farley, I., Parker, A., Billing, S-L., Burrows, M. & Allen, C. (2019). Seaweed Farming Feasibility Study for Argyll & Bute. A report by SRSL for Argyll & Bute Council. pp. 190

confidential in line with data protection, and to ensure that all conversations could be as open / transparent as possible. It should be noted that this study does not address licencing, community engagement (social licencing), or the consenting regime for applying for and installing seaweed farms in Scotland, as this has been extensively addressed by other literature and initiatives.

3 Overview of the kelp farming supply chain and challenges

Kelp cultivation is expanding rapidly in the UK and Europe, despite the challenges for the industry relating to the processing of wet biomass that is harvested from kelp farms, and subsequent marketing and sales. The process of kelp farming involves seeding lines with kelp each year at an aquaculture site, then harvesting the kelp from the lines 6-9 months later once it has reached a marketable size and condition. However, fresh kelp contains around 90% water and has a high percentage of natural sugars and microbes, so degrades very rapidly after harvest. The fresh material must be stabilized within a few hours of landing to maintain food safety and quality, and this usually involves either freezing, drying or fermenting the kelp, and sometimes includes blanching (boiling), chopping and grinding steps, known as primary processing steps. The kelp may then be sold onto customers directly (e.g. as dried kelp), or it can undergo secondary processing steps to extract and isolate valuable compounds, for example at a biorefinery. To help illustrate the steps involved in production and supply of kelp, a schematic overview of the value chain for cultivated seaweeds is given below, as taken from a Norwegian study[6], which mirrors the situation in Scotland.

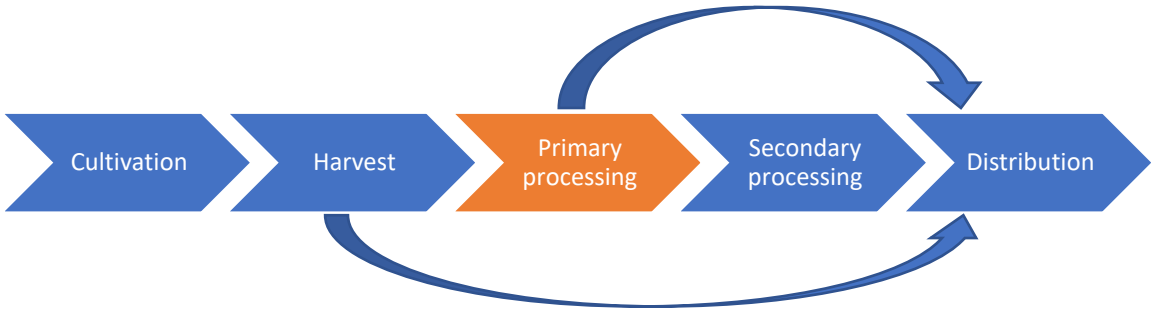


Figure 1: Seaweed cultivation value chain. Primary processing includes stabilization steps such as freezing and drying, and often includes additional steps such as blanching, chopping and grinding. Secondary processing involves further treating the kelp to recover single or multiple products, usually done in a biorefinery (e.g. fractionation and extraction).

The primary processing step is highlighted in orange (Figure 1) as this is where new/emerging kelp farmers are currently most challenged, and so some of the primary processing steps will be described in more detail below.

Fermentation (aka ensiling)

This is a relatively new method of preservation, and can be used to stabilize large quantities of kelp at one time. The process involves adding a mixture of lactic acid bacteria to the harvested kelp to lower the pH, which preserves the kelp. Fermentation is described by Norwegian farmers as being fast and efficient, but the quality and shelf life of fermented kelp is poorly understood, and results can be highly

variable[4]. In addition, ensiling kelp changes its chemical composition, so the method is not ideal for sale of kelp to biorefineries that intend to extract specific compounds from kelp[5]. That said, there are some buyers who purchase substantial quantities of fermented kelp, and it is considered to be the easiest method for scaling up.

Drying

Various low-temperature methods (<45°C) are used to dry kelp, including convective air-drying on shelves, freeze-drying and a combination of fans and dehumidifiers. Once dry, the kelp is versatile and stable for several years, and can be used in a broad range of commercial applications. However, some farmers argue that drying has limitations when upscaling production, which mostly relate to space and energy requirements of drying, as well as manual handling required. In the study by Stevant *et al.* (2021)[4], most seaweed farmers said they lacked efficient methods for industrial drying of kelp, with one suggestion that they "need to be able to centralize the drying process". Storage of dried kelp can also be problematic in damp climates, as kelp absorbs moisture very easily which can spoil the product.

Freezing

Many kelp farmers resort to freezing their biomass; however, the process can be cost prohibitive. Freezing for sale to food manufacture companies involves hand sorting and packing fresh kelp into usable portions, which is both labour intensive, and involves high transport costs. One seaweed cultivator in Norway reported that "Transporting the biomass on land and freezing cost up to 15 NOK [ca. £1.30] per kilo only in working hours"[4]. In addition, freezing has been reported as the most energy intensive preservation method for farmed kelp, with the largest carbon footprint, compounded by the fact that frozen goods require constant energy expenditure to stay cold during their shelf life[4]. Although despite its drawbacks, freezing is often the only readily available method for seaweed farmers to preserve their biomass quickly, as they can make use of existing cold stores that already serve the seafood and agricultural industry.

The type of primary processing required will largely depend on the end market and specific buyer requirements, but all processes generally require expensive equipment and significant capital investment and have an associated energy cost and carbon footprint. Kelp farmers also face major logistical challenges of harvesting, processing and storing large biomasses of kelp over a short seasonal harvest.

Benefits of centralisation

Kelp farmers are often involved in all steps of the value chain (Illustrated in Figure 1), from cultivating seaweed all the way through to product development, manufacturing and retail[4]. This results in a low level of specialization within the industry and can stifle growth because each kelp farm operator needs to become an expert in every step of the supply chain, which can be challenging and expensive for start-ups. Stevant and Rebours (2021) proposed the idea of having centralized "Landing Facilities for Cultivated Seaweed" (LFCS) in Norway to process large volumes of seaweed and have more efficient use of financial resources for upscaling production. They argue that "*centralized solutions for the stabilization and processing of biomass can contribute to a higher degree of specialization in the value chain*", and that shared landing facilities could allow farmers to share the costs of investment and operation required for processing large quantities of cultivated seaweed. Centralized processing facilities may also stimulate innovation and help with the development of high-quality products from seaweed. The idea of LFCS is discussed in more detail in the case study of Norway (section 4.2)

Limited facilities in Scotland

[4] Stevant, P and Rebours, C. (2021). Landing facilities for processing of cultivated seaweed biomass: a Norwegian perspective with strategic considerations for the European seaweed industry. *Journal of Applied Phycology*. 33: 3199-3214

[5] Larsen, S. *et al.* (2021). Ensiling of sugar kelp biomass for biorefining. *Biomass and Bioenergy*. 151: 106134.

The kelp farming sector in Scotland is also hugely limited by the availability of facilities to process the raw material, and this is one of the main barriers to development. There is a well-established wild-harvesting industry for seaweed in Scotland, for example companies that harvest *Ascophyllum nodosum* in the Hebrides (Uist Asco and Hebridean Seaweed), and companies that hand-harvest kelp to manufacture niche food products (e.g. Shore and Mara seaweed). These wild-harvest companies tend to have their own bespoke processing facilities to produce their own branded products, and operate year-round, with limited additional capacity to process seaweed for kelp farmers. This may change in the future as the wild-harvest companies grow and need additional supply from cultivation to meet their production demands. Different processing solutions are also required for seaweed cultivation (compared to wild harvest), because harvest of farmed kelp is seasonal, and substantial biomasses of seaweed must be processed in a very short period of time – leaving the question of what to do with a processing factory for the rest of the year.

Shared processing facilities with other industries

One option is to identify other existing industries with latent capacity that could process kelp in addition to their other core business. For example, it has been suggested that there may be processing capacity within the grain drying sector to dry seaweed[2]. Agricultural grain dryers tend to have underutilized drying capacity during the peak seaweed harvest season of May, and this proposal warrants further investigation, and will be discussed in section 3.5.2. However, the high salt content of seaweed and the fact that kelp doesn't 'flow' across surfaces like grain, means that it is difficult to make a direct technology transfer.

Marketing challenges

In addition to processing challenges, the market for seaweed products in the UK and Europe is still new and emerging. Kelp farmers must work hard to develop and access profitable markets, while facing strong competition from Asia and wild harvest sectors in Europe (which can supply kelp at a small fraction of the price and in greater volumes). So, despite the growing interest from individuals, government and investors to expand the kelp farming industry, the actual commercial outputs from cultivated seaweed (in terms of sales) remain fairly limited in Europe[6].

The growth of seaweed cultivation

Despite these challenges, the number of European-based seaweed startups has expanded rapidly in the last 10 years, with more than 50% of them dedicated to human food and animal feed applications (See Figure 2). Seaweed For Europe predicts that "*the European market for seaweed in 2030 has the potential to represent an industry worth up to €9.3 billion. Under the right conditions, European producers could capture around one-third of this market (€2.7 billion), generating 85,000 jobs*"[7]. Based on these predictions demand for seaweed should outstrip supply in Europe in the near future. However, there are major supply chain barriers and challenges to overcome before this can be a reality.

[6] Stevant, P and Rebours, C. (2021). Landing facilities for processing of cultivated seaweed biomass: a Norwegian perspective with strategic considerations for the European seaweed industry. *Journal of Applied Phycology*. 33: 3199-3214,

[7] Seaweed for Europe. (2021). Investor Memo. The case for seaweed investment in Europe. 52 pages. S4E-InvestorMemo-MainReport-16OCTOBER2021.pdf (seaweedeurope.com)

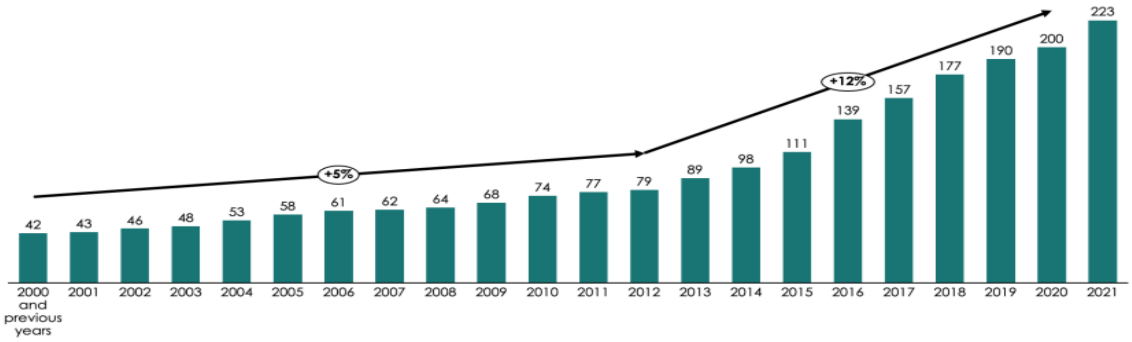


Figure 2: Number of European seaweed innovative companies' broken down by year of creation – taken from Seaweed for Europe[7].

3.1 The role of intermediaries (processors) in the supply chain

In the publication, 'Seaweed Farming Feasibility Study' for Argyll and Bute Council[3]; a major limitation to industry growth was identified as the 'role of the Intermediary', where the 'intermediary' is the processing part of the value chain. Kelp farming as an industry cannot progress in Scotland until farmers have access to suitable processing facilities, and it is extremely important that processing options are put in place either by or for kelp farmers to ensure long-term success of the industry. The actual entity that owns and operates these processing facilities is open for debate, and the idea of shared processing facilities or equipment has been discussed between kelp farmers in several nations. However, there are major challenges related to coordinating use of shared equipment and facilities when all farmers harvest within the same short timespan and weather windows (i.e. calm days during April and May). These challenges are not insurmountable and can be overcome (as can be illustrated by the grain industry) but will take significant coordinated effort by kelp farmers to find a solution.

There are essentially two main forms of business organisations that co-exist and compete in agri- and seafood markets – cooperatives and privately-owned (or investor owned) firms. The majority of Scottish seafood processing businesses are private limited companies, however there is one cooperative enterprise, the Scottish Shellfish Marketing Group (SSMG), which processes, markets and sells shellfish for its 37 members (mainly mussel farmers). A recent report published by the Crown Estate that assessed the various cultivation and supply scenarios for seaweed, suggested that the Scottish seaweed industry would benefit from setting up an enterprise similar to SSMG[1]. The authors state that "A model similar to this (the SSMG) could enable small-scale (kelp) farmers, often operating in remote locations, to pool their resources, and to develop logistics and processing infrastructure, as well as to access markets that otherwise would not have been available to them (e.g. retailers/supermarkets)". As such, a more detailed assessment of cooperative enterprises is provided in the next section, together with the various competitive advantages and disadvantages of cooperatives.

3.2 Cooperative Enterprises

The International Co-operative Alliance defines a cooperative as an "*autonomous association of persons (individuals or businesses) united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically-controlled enterprise*." [8]

[8] https://www.ica.coop/en/cooperatives/cooperative-identity

Global role of cooperatives

Cooperatives play an important role in the global economy, and over the last 40 years they have grown in importance and number. In 2016 there were around 3 million cooperatives worldwide, which together provide jobs for some 280 million people, or 10 % of the world's employed population[9]. Between 2009 and 2015, the number of cooperative enterprises in Europe increased by 12 %[10]. In the UK alone, there were over 7,063 independent cooperatives in 2020, owned by over 14 million members, with a combined turnover of £38.2bn, and employing 241,714 people, making a significant contribution to the economy. There are many different types of cooperatives that operate in all sectors of the global economy, including retail, banking, insurance, health and education, but perhaps the most well-known are agricultural cooperatives, which comprise about 33% of all cooperatives in Europe[9]. Agricultural cooperatives play an important role in European food supply chains, and in 2013 their total annual turnover was €347 billion, increasing by 18% between 2011 and 2013 and holding substantial market shares in some European countries[11]. The Scottish Agricultural Organisation Society (SAOS) is Scotland's expert on agricultural co-ops and has 55 member co-operatives, including the Scottish Shellfish Marketing Group. SAOS provides support to individuals and businesses who want to set-up cooperatives in order to build stronger supply chains and is a wealth of information on the subject.

Key features of cooperatives

Cooperatives are business that are set-up and owned by individual **members (e.g. farmers or growers) who work together to "achieve a commercial objective they could not achieve individually**"[12]. For example, a cooperative may be set-up by farmers to process, market and sell their produce, which they otherwise wouldn't have the resources to do by themselves. **Cooperatives are wholly owned by their members**, and do not have shares that can be bought by external investors. As such, business control is retained by members and **profits are shared among members** or reinvested in the enterprise rather than being distributed to external shareholders. **Members of a cooperatives also actively 'participate' in the cooperative** by inputting to the business. For example, members of a seafood processing co-operative would be individual growers whose produce is sold through the cooperative. In most countries, cooperatives are also governed in a democratic and equal way by the ***'one member, one vote'*** **rule,** where members share equal voting rights regardless of the amount of capital they put into the enterprise[13]. However, in certain countries, such as Sweden, Germany, Finland and, to some extent, Norway, there is provision for proportional representation[9].

Within a cooperative business the profits are called the 'surplus'. If there is any surplus at the end of the year then it is distributed to members in proportion to their 'input' and use of the cooperative's services – usually based per head, tonne, or hectare of commitment. For example, farmers supplying a bigger tonnage of produce to a cooperative would receive greater proportion of the surplus (if available) compared to farmers supplying a lower tonnage to the cooperative. The principal is that any surplus is distributed equitability relative to an individual member's contribution to the coop[13].

[9] Karakas, C. (2019). Cooperatives: Characteristics, activities, status, challenges. European Parliamentary Research Services. PE 635.541. 12 pages.

[10] Cooperatives Europe. (2015). The power of cooperation – Cooperatives Europe key figures 2015, pp. 2-3

[11] COGECA. (2015). Development of Agricultural cooperatives in the EU 2014. Pub (14) 9112:2

[12] SAOS Guidance Document.

[13] International Cooperative Alliance: https://www.ica.coop/en/cooperatives/what-is-a-cooperative.

"*A key distinguishing feature is that cooperatives create wealth for the many members of co-operatives who engage in cooperative businesses as service users, producers, independent business owners, consumers, and workers, not solely for the few who are rich enough to invest capital in investor-owned enterprises. Cooperatives help counterbalance the massive growth of inequality between the world's rich and poor; an issue that, if not addressed, has major economic, social, cultural, environmental, and political consequences*" – From Guidance Notes to the Co-operative Principles, ICA (2015).

The seven cooperative principles

Cooperative enterprises are based on the values of **Openness, Honesty, Self-responsibility, Democracy, Equality and Social responsibility.** In addition, all cooperatives are governed by **'Seven cooperative principles'[14],** which are set out in Table 1 below:

Table 1: The seven principles of cooperatives

1. Voluntary and Open Membership	Cooperatives are voluntary organisations, open to all persons able to use their services and willing to accept the responsibilities of membership, without gender, social, racial, political or religious discrimination.
2. Democratic Member Control	Cooperatives are democratic organisations controlled by their members, who actively participate in setting their policies and making decisions. Men and women serving as elected representatives are accountable to the membership. In primary cooperatives members have equal voting rights (one member, one vote) and cooperatives at other levels are also organised in a democratic manner.
3. Member Economic Participation	Members contribute equitably to, and democratically control, the capital of their cooperative. At least part of that capital is usually the common property of the cooperative. Members usually receive limited compensation, if any, on capital subscribed as a condition of membership. Members allocate surpluses for any or all of the following purposes: developing their cooperative, possibly by setting up reserves, part of which at least would be indivisible; benefiting members in proportion to their transactions with the cooperative; and supporting other activities approved by the membership.
4. Autonomy and Independence	Cooperatives are autonomous, self-help organisations controlled by their members. If they enter into agreements with other organisations, including governments, or raise capital from external sources, they do so on terms that ensure democratic control by their members and maintain their cooperative autonomy.
5. Education, Training, and Information	Cooperatives provide education and training for their members, elected representatives, managers, and employees so they can

[14] International Co-Operative Alliance. (2015). Guidance Notes to the Co-operative Principles. 120 pages.

	contribute effectively to the development of their co-operatives. They inform the general public - particularly young people and opinion leaders - about the nature and benefits of co-operation.
6. Cooperation among Cooperatives	Cooperatives serve their members most effectively and strengthen the cooperative movement by working together through local, national, regional and international structures.
7. Concern for Community	Cooperatives work for the sustainable development of their communities through policies approved by their members

3.3 Steps to setting up a new cooperative:

Starting a new cooperative is a group process from planning to launch and involves founding members reaching an agreement on the purpose of the enterprise and the business plan. The process of setting up a new cooperative, which typically takes between 6 – 12 months generally involves the following basic steps:

1. **Check if there is a commercial opportunity:** Is there a demand and route to market for the produce and products, and will it pay? Do individual farmers have excessive demand they cannot meet themselves? Cooperatives must be commercially viable.
2. **Establish a group of interested parties / founding members:** Promote the idea to ascertain whether there is interest in joint venture co-operation.
3. **Form a steering group:** A cooperative must be producer owned (bottom up), and it is best if all founding members are involved to some extent in setup.
4. **Identify purpose:** Develop a common purpose for the new cooperative enterprise, including the needs and benefits.
5. **Carry out a feasibility study:** This will involve market research and assessment of supply chain scenarios, risks and logistics.
6. **Determine business structure:** identify the best structure to enable the business to succeed.
7. **Prepare a business plan:** This is to enable prospective members to evaluate the potential benefits and risks to their business from joining (should include profit/loss, cashflow, SWOT analysis, market research, definition of products, infrastructure requirements, risks, fundraising required etc).
8. **Raising Finances:** Consider the financial model and how capital and cashflow will be raised.
9. **Decision to proceed or abort:** Obtain a decision from all prospective members on whether or not to proceed. This may require an open meeting at which questions can be openly discussed.
10. **Finalise setup:** Register the business, establish a Board of Directors, recruit management /staff, initiate the business and implement the business plan.

In terms of legal structure, cooperatives are limited liability entities, normally constituted and registered under the 'Cooperative and Community Benefit Societies Act' with the Financial Conduct Authority (FCA) rather than under the Companies Act at Companies House.

3.4 The advantages and disadvantages of cooperatives

Cooperatives play an important role in the social economy and present multiple advantages to farmers; however, they also face challenges and criticisms, and do not suit all business operations and

aspirations. The table below summarises the advantages and disadvantages of cooperative enterprises, based on literature review and interviews with stakeholders.

Table 2: Advantages and disadvantages of cooperatives

Advantages of cooperatives	Disadvantages of cooperatives
• Shared investment and shared costs • Access to markets through larger scale • Organising quality control • Added value food manufacturing and branding • Innovation in production • Shared problem solving • Increased security of market access and risk management (e.g. by farmers pooling stock) • Opportunities to supply new markets and to expand their production (e.g. large retail markets). • Reduce price volatility (if cooperative has a large market share) • Promoting inclusion of local communities • Sharing knowledge	• Lack of capital for start-up (especially for small producers and high-risk businesses) • Generic marketing • Quality control can be an issue due to varied production methods • Slow decision-making process (due to decentralised power) • Deterioration in member relationships • Tensions over distribution of surplus • Voting not proportionate to members input, so main users of coop have limited control over business development • Limited return on capital investment by members • Challenges coordinating shared use of equipment during peak seasons of production

Advantages

Cooperatives clearly have many advantages, including allowing members to realise economies of scale and manage production risks (e.g. by pooling stock to meet orders), reduce costs of manufacture and processing, share knowledge to overcome challenges and innovate, as well as a focus on supporting local communities. All of these benefits can ultimately increase sales of members produce, and provide them with a competitive advantage in global markets. This is particularly true of smaller scale members who might not be able to access larger markets if operating individually. In many countries, farmer's co-operatives are well developed and have created global businesses and brands marketing a vast range of products[15]. They also increase social and economic cohesion, promote sustainable development, and have shown to have high resilience in financial and economic crises[9].

Disadvantages

Despite the many advantages, there are also some disadvantages of cooperative enterprises, and while coops may work for some, they are not feasible for everyone. One of the main challenges mentioned in the literature and by stakeholders was quality control, which is particularly important in many food markets. Cooperatives have been known to suffer from poorer quality, especially in larger co-ops, because it is difficult to control how all individual farmers manage their crops and harvest to avoid spoilage[16]. In addition, there is less incentive for one farmer to produce higher quality than another because the individual member farmer has to bear all costs associated with higher quality of produce delivered to the cooperative, but the benefits of delivering higher quality are then shared

[15] SAOS. Co-op FAQs. Available at: https://saos.coop/membership/faqs. Accessed Oct 2021.

among all members[16]. If farmers don't supply all of their produce to the co-op, then there is a tendency to sell the higher quality produce themselves for greater profit, and the lower quality crop to the co-op. To overcome issues of quality some co-ops state that members must supply 95-100% of their produce to the cooperative and have strict quality control standards in place (SAOS, *pers comms*).

Access to capital

Lack of capital for start-up is also a major challenge[17], as cooperatives by definition can't have external shareholders so can't attract funds from investors (non-members). Funds for start-up must come from members themselves, loans or grants. However, many small farming businesses are cash-poor, and don't have funds to contribute to expensive equipment, and cooperatives can find it difficult to receive loans from banks. As such, the cooperative model may work better for businesses with lower start-up costs. But as the cooperative grows, any profits can be reinvested in the enterprise to advance its facilities, for example to buy new processing equipment.

Surplus

There also tends to be limited return on investment to members, because the primary aim of a cooperative is not to maximise profit, but to provide products or services to members so they can enter certain markets and larger economies. Profit (or surplus) is often reinvested in a cooperative to allow for business growth and take care of future needs[16]. As such, members may opt to invest their funds in an enterprise where they can earn a higher profit share (e.g. investor-owned firm).

Control over marketing

Limited control over a cooperative's direction and generic marketing are also identified as problematic for some individual businesses[16]. Individuals who join a cooperative generally lose control of their unique brand when selling their produce because cooperatives will typically market for all members collectively (due to pooled stock). As such, businesses with a strong regional brand or local story may see this as a disadvantage and choose not to join a coop. This can be addressed by setting up smaller regional cooperatives that specifically build on strong regional branding.

Decision making

Decision making can also be slower in cooperatives, due to the one member one vote rule, as they permit all members to intervene on decisions. In contrast, businesses with centralised management and power can respond more rapidly to issues[16]. In addition, while many consider the "one member one vote" to be a very fair principal, it can lead to tension when one member has contributed significantly more to costs of start-up and operating (e.g., equipment purchase), but then has limited voting influence over how and when that infrastructure is used.

Knowledge sharing

Cooperatives can be a good choice for businesses that seek support from their peers but are generally less attractive to businesses that seek more control over the direction of their enterprise and want to retain their own intellectual property. Industry knowledge and operational experience are hard-earned in seaweed farming and a successful operation typically requires years of trial and error, and great expense. If the market for kelp products is underdeveloped and immature (as it is currently in the UK and Europe), then seaweed farmers will have a tendency to guard their knowledge from

[16] Pennerstorfer, D. and Weiss, C. (2006). On the relative disadvantages of cooperatives. Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Long Beach, California, July 23-26.

[17] Miller, B. (2016). 10 Pros and Cons of Cooperatives. https://greengarageblog.org/10-pros-and-cons-of-cooperatives. Accessed Oct 2021.

potential 'competitors'. Reluctance to share such knowledge and experience is therefore a key reason cited by established seaweed farmers for *not* joining a cooperative. In contrast, new or prospective kelp farmers would see knowledge sharing as a distinct advantage. However, if demand for produce grows and outstrips supply of individual farms, then market competition is reduced and knowledge sharing becomes less problematic for farmers.

Cooperatives and business integration

Cooperatives may also benefit (kelp) farmers who just want to remain 'farmers', and do not want to be involved in processing and marketing. However, cooperatives are less suited to farmers who want to be directly involved in value-adding, product innovation and unique branding and marketing, in which case vertical integration may be a more appropriate model.

Interpersonal relationships

The decision to join a cooperative will also be based on individuals' personalities and their willingness and ability to cooperate with other farmers. Several overseas kelp farmers interviewed stated that they would not join a cooperative because they have 'poor relationships with some other farmer(s) in their region', and have no desire to form a business partnership with them. So ultimately, the decision to setup a kelp farmers' cooperative will be dependent on individual farmers aspirations and social views, as well as their personality types and relationships with others in the industry.

3.5 Case studies of cooperatives or 'societies' in Scotland that serve agriculture and seafood businesses

3.5.1 Mussel farming and the Scottish Shellfish Marketing Group (SSMG)

SSMG – background

The Scottish Shellfish Marketing Group is a cooperative that was set-up in the early 1990s to help mussel farmers with marketing and coordinating sales, but also to enable farmers to access new markets (retail) that could not be individually accessed due to the volume of supply required. Its member farmers mainly produce mussels and oysters, but more recently the SSMG diversified to include other shellfish such as wild-caught lobster and crab. The organisation's website (www.scottishshellfish.co.uk) shows that in 2021 it has 19 member farmers in Shetland and 18 on the West Coast. SSMG sells stock from its member farmers at an agreed fair price, and then takes care of all secondary processing, marketing, sales and distribution logistics, as well as accreditation. The SSMG also carries out required toxicity testing for members and has strict requirements and checks in-place to ensure quality. This ensures that growers can focus on their job of farming, without having to devote resources to downstream processing and logistics.

SSMG – current role

Since its inception, SSMG has become a major player in the shellfish market – it currently dominates the UK market for mussels, is the main supplier of mussels to the retail sector (e.g. Tesco, Morrison, M&S, Sainsburys etc), and accounts for around 70% Scottish production. The balance of Scotland's mussels is sold by independent farmers. Before the establishment of SSMG there was only a small wholesale market for mussels in the UK, and the cooperative worked hard to develop the UK retail market. In terms of production volume (tonnage), Shetland dominates the mussel industry in the UK and accounted for 79% of total mussel production in Scotland in 2019, with the rest being cultivated on the West Coast[18]. SSMG's key strengths are being close to the (UK) market, having economies of

[18] Munro, LA (2020). Scottish Shellfish Farm Production Survey 2019. Marine Scotland Science. Available at: https://www.gov.scot/publications/scottish-shellfish-farm-production-survey-2019/documents/.

scale that allow mussel farmers to collectively supply large retail markets, and being able to serve customers quickly. However, a report commissioned by Marine Scotland[19] concluded that SSMG's dominance in the market is detrimental to smaller growers on the mainland who are non-members (and cannot compete in volume and security of supply). And "the prospects for smaller growers outwith Shetland who do not belong to the SSMG appear to be poor, given their reliance on wholesale markets which are increasingly dominated by Shetland product". The report's authors suggest that "such growers will need to cooperate wherever possible in both production and marketing if they are to have any chance of surviving on an independent basis"[19].

In terms of harvesting and processing, the majority of mussel farmers harvest straight off the ropes into bulk bins which are then brought ashore for grading, cleaning and rewatering. Farmers who are members of the SSMG will then transport the mussels onwards to the SSMG factory in Bellshill (Lanarkshire), for further processing, which is split into two lines, one for fresh mussels and one for cooked vacuum packed and other products[19]. In Shetland, two of the largest mussel farming companies also have sizable onshore facilities, and can offer harvesting, grading, packing and dispatch services to many of the smaller Shetland farmers, before onward transport to SSMG[19]. Mussels are typically harvested 2.5-3 years after seeding /spatfall, with harvesting taking place over an 8–9 month period. However, the exact start and end date of the harvest season varies from region to region[19]. SSMG is in close contact with its member farmers and has well-coordinated harvesting schedules so the coop can match supply with demand. Due to the number of members, SSMG can supply through the year, which is a major competitive advantage.

SSMG –benefits of collaborative working

Setting up the SSMG required significant effort and commitment from farmers, who faced major financial and operational challenges during the early years, including algal toxins, which nearly closed the industry (SSMG founding member, *pers comms*). However, shared problem solving and investment (in the form of loans from members) has helped SSMG survive these challenges and develop what is now a profitable enterprise. The SAOS was also instrumental in helping the SSMG overcome some major supply chain issues and increase sales. For example, the SAOS recognised that there was underutilised and available capacity at mussel farms in Scotland, which was compounded by variable farming practices and inconsistent spat supply. SAOS also identified that overall sales of mussels in Scotland could be increased significantly if there was more coordination between farmers. So it worked with SSMG to redesign the internal supply chains to optimise mussel production, resulting in more than £1m of additional product being processed[20]. The SSMG is a clear example of how joint and collaborative working between farmers can open doors to large markets (e.g. retail sector), stabilise supply and prices, lead to greater diversity of products available (more sophisticated secondary processing), while allowing farmers to focus on improving their own production processes.

SSMG – applicability of the mussel farming model to seaweed farming

However, it would be difficult to transfer the SSMG business model directly to seaweed cultivation. The key differences between farming mussels and kelp are listed in Table 3.

Table 3: Key differences between mussel and kelp aquaculture to consider when setting up shared processing facilities

Mussel aquaculture	Kelp aquaculture
Year-round landings and processing possible because harvesting is coordinated between	Harvest season typically very short, 4-6 weeks during late spring/early summer, resulting in

[19] Scott D, *et al.* (2010). A study of the prospects and opportunities for shellfish farming in Scotland. Stirling Aquaculture, University of Sterling.

[20] SAOS. What we do: case Study Examples: Scottish Shellfish Marketing Group (SSMG): https://saos.coop/what-we-do/scottish-shellfish-marketing-group-(ssmg). Accessed Oct 2021.

Mussel aquaculture	Kelp aquaculture
farmers at SSMG (except few months over spawning period)	huge biomass to be landed and processed in a few weeks.
Well established retail and wholesale markets in UK, which were largely developed by SSMG	Wholesale and retail market underdeveloped in UK.
Demand outstripping supply in UK	Poor link between supply and demand in UK. High risk of supply exceeding demand in near future based on increasing number of licenced sites, however it is also likely that many sites will be underutilised in the first few years of setup (as with Norway and USA examples).
Ex- farm price reasonably well established (based on quality and grade). SSMG instrumental in establishing this price.	Ex-farm price not well established, still up for negotiation, hugely variable.
Clear market segmentation (mainly retail, some wholesale)	No clearly defined market segmentation
Processing methods and equipment now well established (SSMG played key role in development)	Processing methods still in R&D stage, technology still being developed

The harvesting window

With kelp farming the vast majority of cultivated seaweed must be harvested and processed in a 4 to 6-week window before biofouling animals attach to the fronds, which spoils quality and introduces issues with allergens (crustaceans and molluscs). If all of a cooperative's member's fresh kelp was pooled for processing (as with SSMG), this would require access to a large processing facility over a short time. This raises the question of what to do with a factory for the other 10 months of the year when farmed kelp is not harvested (although this challenge remains with or without a cooperative).

One option is for kelp farmers to carry out an initial biomass 'stabilisation' step themselves so that processing can take place over a longer timeframe. For example, ensiling kelp (a low-energy process) to preserve it for several months[6], or freezing it (albeit comparatively energy intensive). The choice of stabilisation methods would depend on the market and buyer requirements. A shared seaweed processing factory could subsequently buy-in the stabilized material from individual farmers though the year, and perform additional processing steps such as drying, chopping and shredding, before distribution to wholesale or retail markets. Value-added secondary processing could also be part of a shared facility and would generate revenue to finance the facility, but would likely come at a later stage of development. A shared processing factory could also offer services to other industries during the 'low season' for example drying of wild-harvested seaweed, vegetables or fish and shellfish 'offcuts' and waste. Such a shared facility could either be a cooperative, a community interest company, or a hybrid of a private company and cooperative structure, for example an investor-owned business where all the shareholders are seaweed farmers.

Market maturity

Another major difference between kelp and mussel aquaculture (and shellfish generally), is that the market for cultivated kelp is still underdeveloped in the UK, and demand is not yet strong enough to justify pooling stock from multiple farms. It may first be necessary to grow the market for farmed kelp in the UK, and when demand cannot be met by individual farms then they would benefit from a facility for pooling stock, sharing processing and coordinating sales. When SSMG was first established there was little/no retail market for farmed mussels in the UK, and it worked hard to develop this market.

This illustrates that cooperatives can play an instrumental role in opening up new sales opportunities that otherwise would have not existed (especially for underdeveloped markets).

Price benchmarking

However, even if kelp farmers feel that pooling stock cannot yet be justified, some form of cooperation between farmers could be valuable in solving supply chain challenges and benchmarking prices. It is important to note that this does not involve price fixing with competitors, which is illegal under UK law[21], but rather developing an understanding of a pricing *range* that reflects the cost of production. This would give buyers a better understanding of the average price per kg required by kelp farmers in order to operate profitable businesses.

Shared facilities

Some larger Norwegian kelp farmers are now reaching a point where they are unable to meet demand for food and feed markets in Europe themselves, and one industrial food manufacturer in Europe stated that it requires significant scaling-up of kelp production before it can include kelp as an ingredient in its products[22] (see case study on Norway in section 4.2). The idea to share landing facilities for cultivated seaweed was recently proposed by researchers from Norway, and was generally well received by producers, processors and buyers, especially for sharing drying technology and stabilising supply. However, the key challenge remains finding a way to stabilise kelp close to the farm site before onward transport to any shared processing facility.

Comparisons with the Norwegian mussel farming industry

To further highlight the importance of cooperation and industry organisation, a simplified comparison can be drawn between the relatively unproductive mussel industry in Norway, and the successful mussel industries in Scotland.

Several Norwegian stakeholders stated that there was formerly a large interest in mussel farming in Norway, with high hopes for a new profitable industry, and many sites licenced since the 1980s. However few mussel farmers have prospered and survived. Furthermore, several mussel processing plants were established in Norway, but later closed[23]. Some stakeholders speculated that "kelp farming in Norway will go the same direction as mussel farming" – that is to say: it will follow a boom-and-bust pattern. However it is argued that this pattern could be avoided.

There are various reasons why blue mussel farming has struggled in Norway, including competition with other European producers, low export prices, toxic algal blooms, invasive species, and predation[23]. Norwegian mussel farmers were also mainly exporting in bulk to Europe, and shelf-life of produce during transit was a major issue.

Crucially, some stakeholders argue that the Norwegian mussel farming industry could have prospered and competed with larger suppliers in Europe if there had been more cooperation between growers. A researcher who compared the declining mussel farming industries in Norway with the successful industry in Canada specifically stated that "*A future strategy of cooperation seems like the only viable strategy, given the status of the Norwegian industry today, but this can only be accomplished if the Norwegian companies see the benefit of cooperation*"[23]. The author also argued that it would have been better for Norway to develop a domestic market for mussels first, before trying to enter

[21]UK Government. (2021). Avoid and report anti-competitive activity: https://www.gov.uk/cartels-price-fixing. Accessed Nov 2021.

[22] Stevant, P., Rebours, C., and Chapman, A. (2017). Seaweed aquaculture in Norway: recent industrial developments and future perspectives. *Aquaculture International.* 25:1373–1390.

[23] Ytrøy, E.H. (2008). Blue mussel farming – a comparison of the Norwegian and the Canadian industries. MSc Thesis, University of Tromso. 119 pages.

competition with more experienced companies in Europe. **The key message that kelp farmers in Scotland can take from this is that cooperation between growers and other industry players is vital for success, especially for smaller operators, as is access to the domestic (UK) market.** That said, cooperation is a mindset that some producers will naturally lean towards or against, and it cannot be forced, but highlighting successful examples of cooperation may provide a persuasive case for greater cooperation amongst Scottish seaweed farmers.

3.5.2 Grain processing cooperatives

Grain cooperatives also provide a useful case study because they face similar processing and logistical challenges to seaweed farmers, in that harvest takes place over a short, usually summer, season. For example, malting barley is harvested in approximately 5-6 weeks. Large volumes of harvested grain must then be processed (dried) - typically within 2-5 days, to avoid spoilage. This is a slightly longer window than kelp, but time between harvest and drying kelp can be extended by a few days with refrigerated storage (< 4°C). Grain must then be stored or transported depending upon conditions of onward sale.

Grain farmers have set-up several cooperatives in Scotland to pool resources and coordinate their activities through the supply chain. Two examples include:

- Highland Grain Ltd who's members grow malting barley in Ross-shire, Inverness-shire, Morayshire and Sutherland; and
- Aberdeen Grain which serves farmers from the east coast of Scotland.

It should also be noted that Scotgrain Agricultural, a private limited company, offers an alternative shareholder-owned business model, whereby the business acts as an "agricultural merchant" that provides a number of services to farmers, including supply of seed, drying and storage of grain, marketing and grain trading, consulting services and price risk management advice[24].

Highland Grain Ltd. has been used as a case study cooperative for this report because it focuses on processing and selling spring barley, which has a short harvest period (approx. 5-6 weeks), which is similar to the short harvesting season for farmed kelp.

Highland Grain Ltd

Highland Grain Ltd. is an agricultural cooperative that was registered in 1977 (under the Co-operative and Community Benefit Societies Act) and is owned and run by its 87 member farmers. Its main role is to dry, condition, store and add value to members produce, which is mainly spring malting barley sold to the Scotch whisky distilling industry[25]. Highland Grain was originally set-up by 12 members, and is an amalgam of two co-operatives, Black Isle Grain Group Ltd and Easter Ross Grain Ltd. Both businesses were founded through a desire of local grain growers to improve their operations and to add value to their products. All members have invested in the cooperative, and the majority of investment to date has been used to purchase fixed plant and equipment, as well as in establishing and retaining markets.

The Highland Grain drying and storage plant is located in the Black Isle, north of Inverness, and was built in 1978 to handle 4,400 tonnes malting barley. The plant has expanded 10-fold over the years and is now capable of drying and storing 40,000 tonnes dried product[25]. Quality and composition of

[24] Scotgrain Agricultural. (2021). Grain Trading. Available at: Grain Marketing - Scotgrain Agriculture. Accessed November 2021.

[25] Highland Grain Limited. (2021). About Us. Available at: https://www.highlandgrain.co.uk/. Accessed November.

malting barley is also critical, and Highland Grain has its own in-house laboratory where grain samples can be analysed for various components (such as protein content) that are important to buyers. If the barley fails quality criteria for maltsters (e.g. in terms of protein content), then the cooperative will seek buyers in the feed sector. Highland Grain can then use the data to inform farmers whether the grain is suitable/ready for harvest. This example of real-time analysis and testing is relevant to seaweed farmers, because some seaweed buyers stipulate the minimum levels of dry matter, protein or nitrogen they will tolerate in kelp, and may reject the harvest if levels are too low or high.

The cooperative also assists members with quality assurance, which is essential for consistency of produce, and in 1995 Highland Grain became the first, and only, business in Scotland that could supply malting barley produced entirely from farms approved under the Scottish Quality Cereals Farm Assurance scheme. This certification is a major competitive advantage, and the cooperative offers buyer's complete traceability of the product, and the assurance that it was produced under strict food safety and the environmental standards.[25]

Highland Grain states it provides the following benefits to its members[25]:

- Cost effective drying, storage, and marketing services for Members;
- Value adding to Members' crops wherever possible
- Professional, and independently verified, laboratory analysis for all crops grown by Members
- Market analysis information
- Fair and cost-effective uplift service from farm
- Effective price risk management services for Members
- Secure route into quality markets
- Reinvests Members' funds, where appropriate, to maintain and modernise the plant complex

Ownership and control

Highland Grain believes that good governance is key to success of the cooperative as a business. It has a Board of Directors which instructs the Chief Executive Officer and senior management on policy matters. All Directors are Members of the cooperative, and Board Meetings are held every 6 weeks. It has 9 permanent staff onsite, and additional staff are recruited from July to October during harvest season so that 24/7 services can be provided to members as and when required[25]. Highland Grain recognises that it takes "work for a co-op to work", and it requires significant effort by all members to set-up and run a cooperative, but the advantages of doing so include security and longevity of trade, focus on quality and assured/reliable access to processing and storage. A representative from Highland Grain also commented that many of their buyers specifically want to trade with a cooperative because they get security of supply and reliable high quality.

A separate company, Highland Grain (Marketing) Limited operates from the same premises as the cooperative, and provides marketing services for Highland Grain. The market for Highland Grain is clearly defined as the Scotch whisky distillery industry, which is hugely valuable and is in close proximity to barley growers. Access to this valuable, local market is a key factor contributing to success of the cooperative. Demand and market segmentation for Highland Grain is clear, which is a factor distinctly lacking in the seaweed cultivation industry at present. **It is striking that these factors (i.e., demand and *local* target market) must be clearly defined if seaweed cultivators were to establish a cooperative, which reflects key learnings from the mussel cooperative case study** (Section 3.5.1).

Highland Grain works with third party haulage companies to coordinate pick-up of grain from farmers after harvest, and drop-off to the processing plant. The factory then operates 24/7 during harvest season to dry and store grain, and most of the drying process is automated, which removes the requirement for hiring a large seasonal labour force. Once the grain is dried it can be stored for several

years, but Highland Grain prefer to sell all stock before the next harvest season otherwise storage space becomes problematic. After the harvest season, staff time is spent meeting with farmers, moving produce onto buyers, and maintaining equipment.

Shared facilities between grain and seaweed

A recent study that assessed the feasibility of kelp farming off the Aberdeenshire coast proposed partnering with the grain industry to use its drying equipment during the seaweed harvest season (April – June), when the dryers are not being used to process grain[26]. Local grain processors on the east coast advised that they would be willing to run a trial on drying seaweed, however there was some debate over the feasibility.

Concerns were raised around the high moisture content of seaweed (90%) compared to grain (~17%), and risks associated with handling large volumes of 'wet salty' product. In addition, not all grain dryers would be suitable for drying kelp, for example continual flow drying silos or 'towers' would not work on seaweed, but conveyor belt-type dryers or floor drying might be feasible. Current grain dryers in Scotland are also capable of processing far larger volumes of produce per day than the amount of kelp currently harvested per month (or year) in Scotland, so significant scaling up of the kelp farming industry would be required to meet capacity of grain dryers. However, that said, a small-scale trial would still deliver valuable insights into what is or is not possible.

3.5.3 Fish Producers Organisations (FPOs)

Fish Producer organisations (FPOs) are officially recognised bodies set up by fishery or aquaculture producers. Most larger UK fishing vessels (>10m) that require quota to fish are members of FPOs. Twenty-three FPOs are currently recognised in the UK, including eleven in Scotland. FPOs operate under a variety of legal structures, but the majority in Scotland are either registered as "Societies" (under the Co-operative and Community Benefit Societies Act) or as "Private companies limited by guarantee without share capital" (See Table 4 below)[27]. Under both structures, these are non-profit making institutions, that are set up for the benefit of their members as any funds raised are continually reinvested in the FPO.

Table 4: Fish Producer Organisations in Scotland and their legal structure

Producer Organisation	Legal Structure
Aberdeen Fish Producers' Organisation Ltd	Private company limited by guarantee without share capital
Scottish Fishermen' Organisation Ltd	
Northern Producers' Organisation Ltd	
Klondyke Fish producers Organisation Ltd	
Scottish Salmon Producer's Organisation Ltd	
Fife Fish Producers' Organisation Ltd	Registered Society
North-East of Scotland Fishermen' Organisation Ltd	
Shetland Fish Producers' Organisation Ltd	
West of Scotland Fish Producers' Organisation Ltd	
Orkney Fish Producers' Organisation Ltd	

[26] Sandison, M. and Riddle, G. (2021). Seaweed Cultivation – A new opportunity for Aberdeenshire. By Northern Light Consulting Ltd. for Aberdeenshire Council. 82 pages.

[27] Information on legal structure available from Companies House: https://find-and-update.company-information.service.gov.uk, and Financial Conduct Authority Mutuals Public Register: https://mutuals.fca.org.uk/Search/Society

Producer Organisation	Legal Structure
Lunar Fish Producers' Organisation Ltd	Private Ltd Company

All FPOs act on their members behalf by managing their members catching activities (quota). They also lobby for their members at a national and international level. Therefore, they play a role in supply chain coordination, as well as policy-making.

Scottish FPOs

FPOs in Scotland vary in size and number of members. Some are characterised by the fish stocks their vessels target (fleet segment) while others target a variety of stocks. For example, most vessels in Aberdeen FPO catch whitefish, Fife FPO vessels mainly target prawns, while SFO (which is the largest FPO) has members from a variety of catch segments.

Role of FPOs

Regardless of the different profiles of their members, the main role of Fish Producer Organisations in the UK is to maximise their members use of Fixes Quota Allocations (FQA or 'quota'), which are fishing allocations granted to vessels each year to catch a share of the national stocks. The process of quota management by FPOs is summarised in simple terms in the box below. But the key principle is that FPOs work for the collective benefit of their members by sharing and managing allocated quota amongst their member vessels in order to maximise catch opportunities.

The quota management process

In order to manage quota for their member vessels, most FPOs have a 'pooled' system whereby quota for a number of vessels is combined and managed collectively by the FPO. This means that if one vessel has underused quota (for example it couldn't get to sea due to breakdown or storms, or fishing was poor in their area), then their quota can be redistributed to another vessel which caught more than its allocation that particular month. If one FPO reaches its maximum uptake of quota for a certain stock, but still has vessels able to go to sea, it may then 'trade in' quota with other FPOs that have surplus quota still available for that month (where trading can be a swap or lease of quota). FPOs are thus able to maximise overall activity and profitability of their vessels (and the whole fleet), while staying within national catch limits for fish stocks. The Scottish Government also manages a pool of quota for vessels that are not in Producer Organisations (called the 'non-sector' vessels), and these are usually the smaller <10m vessels. Uptake of quota is monitored by fisheries administrations, and once all quota has been used for a stock then the fishery is closed.

However, quota management wasn't the original reason FPOs were first established. They were initially introduced as a mechanism to improve price, market stability and quality through managing supply of fish to market[28]. Today FPOs play less of a role in cooperative marketing; fish selling agents/merchants have largely taken on the role of coordinating sales. Although most Scottish (and UK) FPOs no longer play a large role in market access and sales, there are a few exceptions. For example, the Scottish Fisherman's Organisation (SFO) markets members' catch through its own subsidiary business, "Braehead (SFO Enterprises) Limited", and promotes its members products worldwide by regularly attending seafood exhibitions. The SFO also owns two shellfish factories in Scotland (in Fraserburgh and Uddingston) that are dedicated to the high-quality processing of members prawns (*Nephrops*) before sale to domestic and export markets in Europe and the Far East[29].

[28] Nautilus Consultants Ltd. (2006). PO Quota Management Audit: Effectiveness of PO service provision in market/price support, quota management and quota trading. Prepared for the UK Fishery Departments.

[29] Scottish Frishermans Organisation. (2021). What We Do. Available at: https://www.scottishfishermen.co.uk/what-we-do. Accessed Nov 2021.

Another example is the Shetland Fish Producers Organisation (SFPO), which has played an important role in marketing Shetland fish globally, and assisted with set-up of the processing factory Shetland Catch, the Shetland Seafood Auction Company (SSAC), and the new fish market at Lerwick, all of which have increased sales and added value to fish caught by Shetlands fleet[30]. Some FPOs also help develop strong branding for their members produce, and facilitate access to accreditation schemes (e.g. Marine Stewardship Council accreditation).

In the UK (and EU), POs are also responsible for administering the rules and regulations of the "Common Organisation of the Markets of Fisheries and Aquaculture Products (CMO)[31]", which is the Union's policy for managing the market in fishery and aquaculture products, while ensuring their environmental sustainability and economic viability[32]. The main objectives of the CMO are:

- To contribute to the sustainable exploitation of living marine biological resources;
- To enable the fishery and aquaculture industry to apply the CFP at the appropriate level;
- To strengthen the competitiveness of the Union's fishery and aquaculture industry, in particular that of producers;
- To improve the transparency and stability of the markets;
- To ensure that the distribution of added value along the sector's supply chain is more balanced;
- To improve consumer information and raise awareness, by means of notification and labelling providing comprehensible information;
- To contribute to ensuring a level playing field for all products marketed in the Union by promoting sustainable exploitation of fisheries resources;
- To contribute to ensuring that consumers have a diverse supply of fishery and aquaculture products;
- To provide the consumer with verifiable and accurate information regarding the origin of the product and its mode of production, in particular through marking and labelling

Lessons for seaweed farming from FPOs

Many of the principles of a PO are the same as those of a cooperative enterprise, and it may be that kelp farmers will benefit from setting up their own PO once sufficient volumes of kelp are being produced and sold. Producer Organisations, like cooperatives, work for the collective benefit of members to improve supply chain coordination, maximise sales and assist with processing and marketing. One key difference between a PO and a cooperative is that new POs require government approval to start, and certain qualifying criteria must be met that relate to annual turnover and number of members. POs also tend to play more of a role in industry representation and lobbying. In addition, their performance is monitored by devolved administrations, and once established POs will

[30] Shetland Food and Drink Ltd. (2021). Shetland Fish Producers' Organisation. Available at: https://www.tasteofshetland.com/members/shetland-fish-producers-organisation. Accessed Nov 2021.

[31] Council Regulation (EC) No 104/2000 of 17 December 1999 on the common organisation of the markets in fishery and aquaculture products.

[32] European Parliament. (2021). Factsheet: Common Market Organisation in Fishery and Aquaculture Products. Available at: https://www.europarl.europa.eu/factsheets/en/sheet/118/producer-organisations-and-the-common-market-organisation-in-fisheries-products. Accessed Nov 2021.

also need to adhere to EU Council legislation on Common Organisation of the Markets[33]. One benefit of being part of a Producer Organisations is access to funds, and in the past the UK government has provided specific financial support packages for UK POs (albeit fruit and vegetable POs), that have been used to fund improvements in farmers operations, including to storage and processing facilities, and for hiring specialist staff.

They key lesson for seaweed farmers is that community benefit societies exist in a variety of forms within fisheries, aquaculture and agriculture, and whether they are producer organisations or co-operatives, they strive to work for the collective benefit of their members to strengthen their market position. The example of fish POs given above, as well as cooperatives in previous sections should provide compelling evidence to kelp farmers of the benefit of cooperation.

4 International case studies from the kelp farming sector

Case studies are provided for two nations that are relatively new to kelp farming, yet considerably more developed than the UK. Norway and the USA have been chosen because they both have large numbers of licenced kelp farming sites (>200), and several processors, but face challenges in developing the industry further.

4.1 United States of America

National overview

The USA has a relatively well-developed and progressive kelp farming industry, which has been operating for approximately 10-15 years, so has some fairly mature supply chains. There is also a strong relationship between research and industry, and an abundance of open-source information has been published on kelp farming, which have helped the industry grow. Seaweed production in the USA has expanded significantly since 2017, and total domestic edible seaweed production (farmed and wild) is estimated to be slightly less than 540 tones wet harvest per year, with farming accounting for approximately three-quarters this[34]. However, despite the large number of kelp farming sites in the USA, there is a fairly limited set of processors building capacity, developing new products, and creating consumer demand[34].

Regional activity

Seaweed is cultivated in a number of states on the East and West coast of the USA, with a mix of commercial and research sites. The main kelp species cultivated at sea are sugar kelp (*saccharina latissima* or 'Sweet Kombu'), followed by bull kelp and Atlantic wakame (*Alaria esculenta*). At some sites, kelp is grown alongside shellfish and finfish in integrated multi-trophic aquaculture systems (IMTA). There are also several land-based cultivation sites that grow red and green seaweeds in tanks, such as dulse and sea lettuce (see SolSea and West Coast Dulse)[35].

In terms of ocean-based kelp farming, the main producing states are Maine, which has the most licenced seaweed farm sites in the USA (200+) and landed 145 tonnes kelp in 2019, followed by Alaska,

[33] REGULATION (EU) No 1379/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 on the common organisation of the markets in fishery and aquaculture products, amending Council Regulations (EC) No 1184/2006 and (EC) No 1224/2009 and repealing Council Regulation (EC) No 104/2000.

[34] Piconi, P., Veidenheimer, R., Chase, B. (2020). Edible Seaweed Market Analysis. Island Institute In partnership with Pentallect and EPR, Maine, USA.

[35] Robidoux, J., and Chadsey, M. (2021). State of the Sates, Status of U.S. Seaweed Aquaculture. SeaGrant. Available at: https://seaweedhub.org/wp-content/uploads/2020/07/State-of-the-States-Rev_APC_7-16-20.pptx.pdf. Accessed Sept 2021.

which has 22 permitted sites and landed 111 tonnes kelp in 2019 (up from 40 tonnes in 2018)[35]. However, there is huge variation in the size of kelp aquaculture sites in the USA, and many are 'not commercially operational'. For example, in the state of Rhode Island there are 10 permitted farms, but only 3 cultivated kelp in 2021, and landings in 2019 were just 6 tonnes[35].

Each state has different permitting requirements for leases and licences, and one of the reasons why Maine has numerous kelp farms (compared to other states) is because farmers can obtain a 'Limited Purpose Aquaculture licence' (LPA), for a small area (400 square feet, approx. 1 longline) which is valid for 1 year and can be renewed. Individuals can apply for up to four LPAs per year, and the purpose of the LPA is to allow growers to 'try their hand' at kelp farming at a number of locations before applying for a full-scale commercial lease, which is for longer-term and for a larger site[34,35]. In other states longer leases are required from the outset.

Processing and Markets

The primary market for seaweed in North America is value-added food products that are sold through retail and food services[35]. In terms of processing, the seaweed is sold raw, dried, blanched, frozen or fermented. Examples of products include seaweed salads, kimchi, teas, smoothie cubes, kelp jerky, snack bars, beer and spice blends, as well as dried whole leaf, flakes, powders. A smaller proportion of kelp is sold for fertilizer and cosmetics[35,34]. There is a strong focus on 'wet' processing (i.e. blanching, shredding/chopping and freezing or fermenting) rather than drying, and stakeholders interviewed on the East coast of the USA felt this was an important way to differentiate their products from the 'cheap dried kelp available from Asian imports'. In addition, a market report for Maine identified that "product differentiation from imported (dried) items will be critical to achieving sustained success for the domestic edible seaweed industry"[34].

There are a number of processors of farmed kelp in North America (e.g. Atlantic Sea Farms, Maine Coast Sea Vegetables, Oceans Balance, Vitamin Sea Seaweed, Blue Evolution and Springtide Seaweed), plus some emerging food tech businesses. Several processors have their own kelp farms, while others contract buy kelp from independent growers, many of whom are also fishermen or shellfish farmers who have diversified. However, the total processing capacity in North America is still fairly limited relative to the number of kelp farms, and some kelp growers have setup small 'cottage' businesses to process and sell their own kelp products direct to consumers. As such, **processing capacity and market access have been identified as major barriers to development of a profitable seaweed cultivation industry in the US**[34]. To support growth of the seaweed cultivation industry in Maine, it will necessary to expand current processing capacity and distribution network, develop new value-added products, and improve consumer awareness[34].

For most seaweed farmers, "securing access to processing capabilities prior to initiating the growing process, either via established contracts with processors or investing in first stage processing (typically drying) capabilities, is critical to success"[34]. And that final stage processors are in the best position to build awareness and create market demand.

Cooperatives in USA

There appears to be no large-scale shared/communal processing facilities for farmed kelp in the USA, but there is one small seaweed cooperative that was recently set-up in New England, called "The Sugar Kelp Cooperative", which has five member farmers[36]. The **founders state that many small farms are better for the local economy and environment than one large farm, but small farmers face major challenges around logistics like transportation, cold storage, education, sales and marketing.** The main role of the cooperative is therefore to co-coordinate marketing, product development and sales,

[36] New England Kelp. (2021). About The Sugar Kelp Cooperative. Available at: https://newenglandkelp.com/about-sugar-kelp-co-op. Accessed Oct 2021.

and is “a farmer-led response to all the post-harvest challenges and logistical burdens”. Another key aim of the co-op is to ensure there is more efficient use of zero-waste packaging and transport (e.g. through consolidating deliveries), which prevents everyone duplicating efforts and results in more efficient use of resources and more stable supply for buyers.

The Sugar Kelp Cooperative

The cooperative buys kelp from the farmer at a fair price, paying what “sugar kelp is truly worth”, and then sells fresh raw sugar kelp to chefs, restaurants and farmers’ stalls when it is in season (low volume, high value). The cooperative also has a small solar-powered drying facility (similar to a polytunnel or greenhouse) to dry kelp for year-round sales. In 2021 the cooperative partnered with over 40 restaurants and breweries to distribute ~500 kg fresh kelp across Connecticut as part of a weekly celebration (New England Kelp Harvest Week), which helped raise awareness about kelp as a food. However, securing funding is a key challenge, and the enterprise ran a Crowd Funding appeal in 2021 to support its ongoing marketing and sales activities and to grow its network. It also continues to invite corporate sponsors to donate[37].

Figure 3: Slide produced by The Sugar Kelp Cooperative to show the organisations key roles and responsivities[37].

The Sugar Kelp Cooperative model **appears to work well for small farmers who operate in close proximity,** but larger producers stated that shared/central processing is an “ideal rather than a reality” for them because everyone would need to process huge volumes of kelp in the same short timeframe, making it almost impossible to co-ordinate sharing equipment. In addition, poor rapport between farmers can inhibit collaboration and coordination. This emphasises that cooperatives are not a one-size fits all model, and must be member-led initiatives.

It is clear that while there are many factors that have helped the North American seaweed farming industry grow and thrive, it now faces some major challenges and constraints, which are summarised below. While we can learn from their successes, Scotland’s seaweed industry also faces many of the same challenges.

Table 5: Key successes and challenges identified in the US seaweed cultivation industry

Successes / growth drivers in USA	Challenges and constraints in USA
- Low barriers to entry, lots of licenced sites.	• Knowledge sharing is only up to a certain point, know-how on actual manufacturing

[37]Indiegogo. (2021). Introducing the Sugar Kelp Cooperative. Crowdfunding drive. Available at: https://www.indiegogo.com/projects/introducing-the-sugar-kelp-cooperative?fbclid=IwAR115jlQ3rKsX_gdoS4KI92oFSb_R3tKDX-778SX5GC0UQqw0CjWcZhWJeg#

Successes / growth drivers in USA	Challenges and constraints in USA
- Open-source published resources available for setting up a seaweed farm, including licencing steps, seed production (hatchery setup), deployment & harvesting, as well as published guidance on food safety requirements for kelp. - In Maine, short 1-year R&D leases to be granted, so that people can 'try their hand at kelp farming'. - Several suppliers of seed material, which are price competitive. Organic seed also available (although more expensive). - Working/ partnering with fishermen and shellfish growers encouraged to safeguard local jobs and allow for diversification, while making good use of their skills & resources. - Range of new and exciting kelp food products on the market, and fairly broad consumer knowledge about 'sea vegetables'. - Market fairly close to the source (majority of farmed kelp sold locally. - Domestic seaweed products clearly differentiated from Asian imports, and also have higher quality & environmental credentials. - Ongoing outreach and engagement taking place with consumers on benefits of eating kelp (e.g. seaweed festivals, tasting sessions, pop-up seaweed shops). - Strong partnerships between academia and industry (i.e. industry led research). - One example of small farmers working together on marketing and sales through a cooperative.	and markets is tightly guarded by processors. • Large variation in price for buying/selling kelp. • Supply still outweighs demand; finding buyers is a major challenge, farmers report having 'surplus' product in freezers', and many licenced sites not commercially operational. • Processors and chefs state sourcing consistent supply of seaweed in desired format are key challenges. • Competition with wild harvest in some states, which outcompetes on price and volume. • Only a few dedicated processors for farmed kelp. More required. • Lack of infrastructure for scaled processing and transport. • High Iodine content in kelp an issue in human and animal foods, especially for sugar kelp. • Main market challenges are competition with Asian supply, and insufficient local demand for large volumes of kelp currently produced. • Insufficient state funds available to help farmers with cost of purchasing capital equipment (e.g. for processing) or developing markets and sales. • Kelp farmers reported that grant funding available tends to benefit academia and consultants more than actual farmers.

Seaweed industry support networks - US National Seaweed Hub and the Sea Grant Program

The US National Seaweed Hub was established in 2020 to support industry development in North America, and serves as "a collaborative central clearinghouse for available science-based, non-proprietary, practical resources related to previous and current seaweed aquaculture research and extension efforts" (see Seaweed Hub (https://seaweedhub.org). It was established by the National Sea Grant College Program administered by the National Oceanic and Atmospheric Administration (NOAA) within the U.S. Department of Commerce. It provides a framework to share information, address challenges, identify needs, and find opportunities in this emerging industry.

The Sea Grant programme was established by the U.S. Congress in 1966 to create and maintain a healthy coastal environment and economy. A rolling four-year strategic plan identifies and addresses needs of coastal communities around the country. The Sea Grant network consists of a federal/university partnership between NOAA and 34 university-based programs in every coastal and

Great Lakes state, Puerto Rico, and Guam. The network draws on the expertise of more than 3,000 scientists, engineers, public outreach experts, educators and students to help citizens better understand, conserve and utilize America's coastal resources. The National Sea Grant Library provides global access to tens of thousands of full-text digital Sea Grant documents from 1960 through 2020, including many publications on kelp farming: https://nsgl.gso.uri.edu/

In October 2019, federal funding released $16million to 42 Sea Grant programs in the interest of advancing sustainable aquaculture. Of this pot, $1.1million was awarded to a network of 10 Sea Grant programs to establish and advance the Seaweed Hub. Led by Connecticut Sea Grant, the Seaweed Hub is managed and facilitated through partnerships and collaborations with the National Sea Grant Law Centre, and with Sea Grant programs in Maine, Alaska, Washington, New Hampshire, New York, Oregon, Rhode Island and Woods Hole, Massachusetts.

Seaweed Hub work programme

The Hub's first goal is the establishment of a baseline evaluation on current needs and challenges for all seaweed stakeholders through a formal needs assessment that would inform the creation of work groups to address identified needs and challenges. The assessment results were published in February 2021: https://seaweedhub.org/wp-content/uploads/2021/02/Needs-Assessment-Results-1.25.21.pdf

The Hub's second goal is to bring together seaweed stakeholders from across the country to find ways of addressing challenges, identify solutions to needs, and pursue opportunities for growth. This was accomplished through the first National Seaweed Symposium (held March 2019) and will continue in Virtual Work Groups.

The Seaweed Symposium brought together 120 seaweed stakeholders representing current and prospective farmers, regulators, federal agencies, processors, researchers, culinary professionals and non-profit groups from across the country. The group gathered to share information and better understand the current status, emerging needs and challenges, and realistic opportunities of the nascent domestic seaweed industry. Ongoing Virtual Work Groups is stakeholder-driven (made of up a diverse group of individuals from industry), and will determine the next steps required to move the US seaweed industry forward. There are four Virtual Work Groups as part of the Seaweed Hub: Production, Post-harvest & Processing, Marketing, and, Regulations, which are facilitated by Sea Grant staff.

Work Group symposium notes, subsequent meeting notes and lead contact details are available at the foot of this page: https://seaweedhub.org/work-groups/ . The Seaweed Hub also hosts a calendar of events (see https://seaweedhub.org/2021/01/) including planning calls, steering committee calls, and Work Group meetings.

4.2 Norway

Background

Norway has a long and complex coastline, much like the West Coast of Scotland, a well-established aquaculture industry (e.g. for farmed salmon and trout), and accounts for about 60% of the wild-seaweed harvesting in Europe[38]. Norway is also one of the world's largest exporters of seafood, and has well developed supply chains and knowledge related to processing seafood (including seaweeds). There has also been strong interest in Integrated Multi Trophic Aquaculture in Norway,

[38] FAO. (2021b). Global capture production. Online query. https://www.fao.org/fishery/statistics/global-capture-production/en. Accessed Nov 2021.

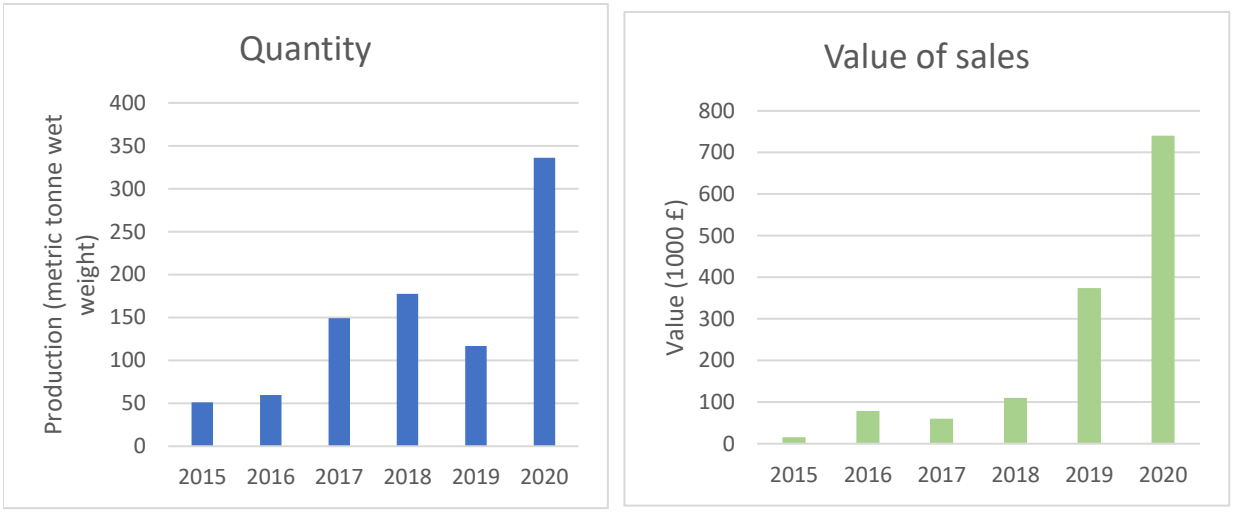
where seaweeds can be grown next to finfish sites to absorb excess nutrients discharged from the fish farms. These factors, combined with policy support for seaweed farming as a new blue bioeconomy in Norway, has resulted in rapid expansion of the industry over the last decade[39].

Experimental cultivation of seaweed started in Norway in about 2005, roughly the same time as the first trials of seaweed farming were taking place in Scotland, and the first commercial permits for cultivating seaweeds in Norway were granted in 2014[39]. Over the following six years there was a dramatic increase in licencing of seaweed aquaculture sites, and by 2020 there were 27 companies that held 228 licenses (although only 93 sites were actually in the water)[40].

Production data

The main species cultivated are *Saccharina latissima* (sugar kelp) and *Alaria esculenta* (Atlantic wakame), both of which are the main species of interest in Scotland. However, despite a dramatic increase in licencing and installation of seaweed farms, the actual biomass of kelp being farmed and sold remains fairly low compared to the total capacity of the sites available. Data from the Fisheries Board (Figure 4) shows that only 50 tonnes (fresh weight) farmed kelp was grown and harvested in 2015, which increased to 336 tonnes in 2020. As a comparison, the annual wild seaweed harvest in Norway was approximately 150 000 tonnes in 2017[41]. The relatively low production figures for farmed kelp may partly be due to the fact that many of the companies are still in the start-up phase, and do not yet have access to sufficient infrastructure (for farming and processing) to maximise use of their sites[39].

Figure 4: Norwegian seaweed aquaculture production (left) and total value of sales (right) from 2015 to 2020. Statistics



from Norwegian Fisheries Board: From: https://www.fiskeridir.no/English/Aquaculture/Statistics/Algae (accessed 15/11/2021)

Markets

[39] Stevant, P., Rebours, C., and Chapman, A. (2017). Seaweed aquaculture in Norway: recent industrial developments and future perspectives. *Aquaculture International.* 25:1373–1390.

[40] Norwegian Directorate of Fisheries: From: https://www.fiskeridir.no/English/Aquaculture/Statistics/Algae. Accessed Nov 2021.

[41] Albrecht, M. and Lukkarinen, J. (2020). Blue bioeconomy localities at the margins: Reconnecting Norwegian seaweed farming and Finnish small-scale lake fisheries with blue policies. *Politics and Space.* 38(7–8):1465–1483.

Despite evidence of underutilised production sites, the total value of kelp sold (fresh weight) has more than doubled each year in Norway since 2018, which shows that the industry is making headway, and the price of kelp per wet tonne has also increased from ~£300/tonne in 2015 to ~average of £2200/tonne fresh weight in 2020[40], revealing that more profitable markets are being accessed. The kelp biomass is sold as an ingredient in both food and feed applications in different forms, i.e. dried, fermented or frozen, which vary according to buyers' requirements[39]. A small proportion is also sold for cosmetics and fertilisers. Food is one of the most valuable markets for cultivated seaweed in Norway, with producers either selling large quantities in bulk to other food manufacturing companies that use seaweed as an ingredient, and/or making value-added food products themselves (e.g. seasonings)[39]. Animal feed is also reported to be an important market in terms of volume of sales in Norway, but tends to be lower value.

Industrialisation of production processes

Significant progress had also been made by some Norwegian kelp farmers to industrialise and automate the kelp farming process, from seeding to harvest. This is enabling certain operators in Norway to harvest more kelp from their lines in one day using large commercial workboats, than a kelp farmer in Scotland could wish to harvest in a month (e.g. from their comparatively small inshore fishing vessel). To compete with Norwegian seaweed producers on volume and price, Scottish kelp farmers will either need to rapidly innovate to become more efficient at seeding and harvesting, or work together to pool resources and stock.

Demand

Although total productions and sales are increasing, "demand for large volumes is currently limited in Norway and Europe since the market for seaweed raw material is under development, and one food manufacture reported "very little demand for seaweeds on the Norwegian market"[39]. However, there appears to be a chicken-and-egg situation, whereby some food manufacturers state the volume of production must increase significantly if seaweed is going to be included as an ingredient in industrial food manufacture. In the study, a member of the food production industry stated that "We want to make it available to the mass market. […]. If we are to put a few percent seaweed in a typical product, it will require almost the entire volume cultivated today in Norway. This will require a significant upscale of the production as well as efficiency through-out the entire value chain. The price of seaweed ingredients is also an important factor"[39].

Processing

The main primary processing methods for stabilising kelp in Norway appear to be drying and lactic acid fermentation (ensiling), with a small amount of freezing[39]. In addition, the kelp typically goes through a grinding or chopping phase, either before or after stabilisation. M**ost Norwegian seaweed farmers are currently involved in multiple parts of the supply chain, from the development of cultivation technology to product development, manufacturing and retail.** This reflects a low level of specialisation but a large degree of responsibility within single companies, which can challenge and stretch resources. It is also felt that it is important to develop high value products from European cultivated seaweeds that differentiate themselves from cheap Asian imports, which reflects views in North America.

Landing Facilities for Cultivated Seaweed (LFCS)

The concept of shared Landing Facilities for Cultivated Seaweed in Norway was investigated by Stévant et al (2021)[39] as a solution to overcome the challenges related to large-scale processing and sales of seaweed biomass.

Several operating models were proposed for the facility, including a cooperative in which the farmers could deliver their kelp and then get back a quantity of processed product of a certain quality. Alternatively, the authors proposed that LFCS could be owned and operated by a private company, which rents equipment to the kelp farmers for processing biomass after harvest.

A LFCS could also potentially be used by other sectors for processing their raw materials (e.g. agriculture, fisheries and aquaculture). The study found that stakeholders had a generally positive attitude towards the concept of LFCS, and for seaweed farmers the biggest advantages would be sharing the investment, operating and infrastructure costs[39]. This was regarded as positive for the seaweed industry in general, especially the smaller producers who do not have the resources to invest in processing equipment. It would also allow the industry as a whole to supply larger volumes of product to market, and reach economies of scale on processing. Buyers of seaweed suggest they don't need to have a main role in a shared factory, but could help define quality requirements and advise towards product development.

LFCS - suggestions and challenges

The following key suggestions and challenges were raised about the concept of a shared Landing Facility for Cultivated Seaweed [39]:

- A share factory must be only a few hours' drive from the kelp farms it serves.
- Ensuring quality is very important, and it is essential that the product from the LFCS is "as good as what we [kelp farmers] produce ourselves".
- Processing methods must minimize risks of contamination to deliver safe products to the market.
- Solutions required for short-term storage of kelp between harvest and processing (e.g. cold storage or fermentation).
- Seasonality of kelp harvest is problematic for operation and profitability of a shared processing facility. Need to find ways to make year-round use of resources at the facility, for example by processing other seafood or wild harvested seaweeds.
- Securing short-term, start-up finances are challenging but critical.
- Whole process, from (from harvest to retail) must be as efficient as possible with reduced costs for manufacturers so that seaweed ingredients can be price competitive.
- A LFCS may act as a platform for collaboration and research between seaweed farmers, processors and industrial users of cultivated kelp to establish quality standards for food products and develop new products and processing strategies.
- A shared facility may also be involved in the marketing and retail of bulk processed products from seaweeds, such as in agricultural cooperatives.

"The dialogue with major industrial actors of the food and feed sectors revealed that the national cultivated seaweed production must drastically increase to become a staple food and a common feed ingredient in livestock or aquaculture production. Stable delivery, high quality and competitive price are important factors for the achievement of this industrial potential". – from Stevant et al 2021[39].

Norwegian seaweed industry support networks

Seafood Research Fund

Norway has a long history of collaboration between researchers and maritime industries, which is supported by numerous funding packages, for example the Norwegian Seafood Research Fund (FHF), which is a state-owned limited company owned by the Ministry of Trade, Industry and Fisheries. FHF is financed by the industry through a 0.3% levy on exports of Norwegian seafood, and its goal is to create added value to the seafood industry through industry-based research and development

(R&D)[42]. FHF identify the most important issues to be addressed through R&D, initiate finance and carry out projects to address specific issues/challenges, and then take steps to ensure that results of the R&D projects can be implemented in the industry. It is thanks to funds like this that Norway has some of the most progressive management of marine resources in Europe, and enables industries to continually innovate to improve their operation.

SINTEF

Another example is SINTEF, which is one of Europe largest independent research organisations, and has a dedicated Norwegian Seaweed Technology Centre, set-up specifically to help develop the seaweed cultivation industry in Norway. The Norwegian Seaweed Technology Centre is described as a 'platform for technology development within industrial cultivation, harvesting, processing and application of seaweed in Norway'. The centre initiated several informative market-relevant projects including; SNAP - Seaweeds for Novel Applications and Products; POLYKELP - Seaweed as feed source for protein-rich polychaetes aimed for salmon feed, PlastiSea - Novel enhanced bioplastics from sustainable processing of seaweed, and the Norwegian Seaweed Biorefinery Platform.
See: https://www.sintef.no/en/ocean/initiatives/norwegian-seaweed-technology-center/ . A similar example in Scotland could be the newly established Seaweed Academy, based at the Scottish Association of Marine Science in Oban.

Norwegian Seaweed Association

Norway also has a very active and progressive industry body for seaweed farmers, called the Norwegian Seaweed Association (https://www.norseaweed.no/). NSA has 28 members (most of which are kelp farmers), and is a platform for member companies to share knowledge and collaborate. NSA also promotes/ markets Norwegian seaweed as a food and feed ingredient (e.g. by attending trade shows), facilitates collaboration and R&D, and assist members with regulatory questions. The NSA also brings in funding to commission market reports that are valuable to members, and to facilitate connections with buyers and technology developers. The Associations key objectives are to 1) promote seaweed farming as a viable industry in Norway, 2) identify and explore national and international markets for seaweed products, 3) create product standards for the seaweed industry and 4) establish good operational frameworks for the seaweed farming companies.

5 Financial assistance and interventions

The process of setting up and running a seaweed farm comes with significant financial costs, and requires both energy and commitment. Once a farm is established, then processing, storing, marketing and selling cultivated seaweeds is also an expensive exercise, requiring substantial investment in capital equipment and expertise. Seaweed farming is a new and innovative industry, and the start-up phase is typically followed by many 'growth cycles' in which challenges are addressed and new solutions are found (for example in efficient processing methods). It will also take time for the industry to optimise production and reach economies of scale. To compound this, the market is also new and evolving, with many innovative food, feed and biorefinery companies still at the R&D stage of their business. As such, there are very few 'quick and easy sales' to be made with cultivated seaweed at the

[42] FHF. (2021). Norwegian Seafood Research Fund. Available at: https://www.fhf.no/fhf/about-fhf-english/ . Accessed Nov 2021.

moment, but the demand for locally grown kelp products is steadily increasing in Europe and market projections look promising[43].

Most new kelp farmers, especially small operators, will need to leverage external finance to support their business through the first few years of start-up before they are able to start trading at profit. The figure below illustrates how accumulated cash-flow normally develops from business set-up until the product is established on the market. For the first few years, kelp farmers expenses are likely to be higher than income from sale of the product, aptly described as the "bloodshed" period by some authors[44]. As revenue increases, the accumulated cash-flow turns positive. However, a large number of innovative businesses and industries never reach this stage because of poor funding, bad planning or simply mismanagement[44].

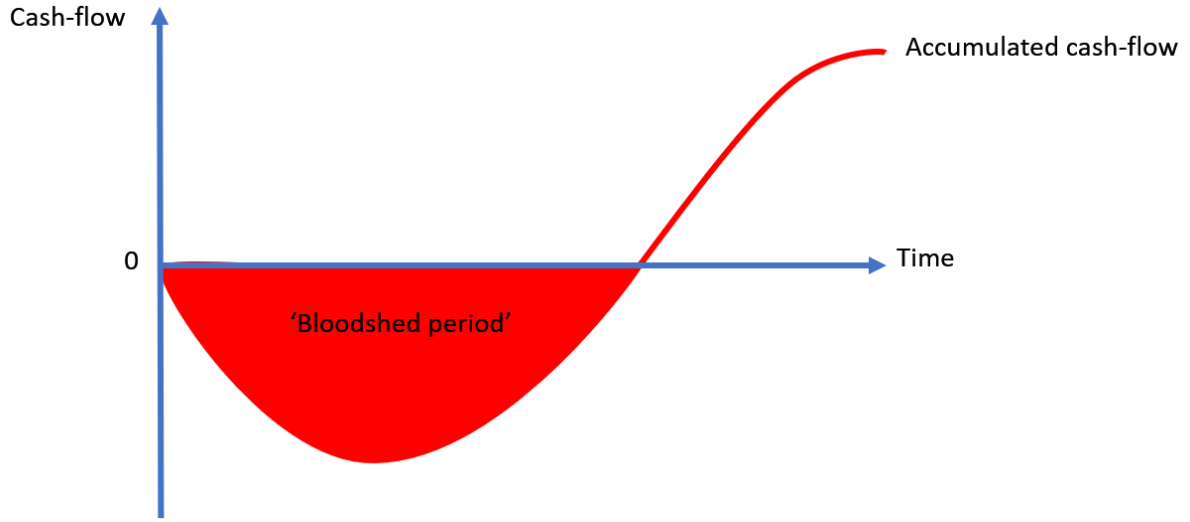


Figure 5: Cash flow

There are various sources of funding available for new businesses, including loans, grants and investment opportunities. In all cases, access to start-up funding is the most challenging, and seaweed farming businesses could benefit from a specific government 'incubator fund' to assist them through the first few years before they are trading. Several traditional financing options are described below:

5.1.1 Debt funding options:

Bank lending is in principle available to seaweed businesses. However UK banks limit lending to new companies within 2 years of start-up, especially if pre-trading. Furthermore, lenders typically require security - usually a charge over a tangible asset (e.g. property, vessel etc.), which new seaweed farming companies are either unlikely to own or reluctant to provide due to the risks associated with entering a new underdeveloped industry with market uncertainties.

Alternatives to bank lending include government-backed loan schemes, including:

[43] Seaweed for Europe. (2021). Investor Memo. The case for seaweed investment in Europe. 52 pages. Available at: S4E-InvestorMemo-MainReport-16OCTOBER2021.pdf (seaweedeurope.com).
[44] Ytrøy, E.H. (2008). Blue mussel farming – a comparison of the Norwegian and the Canadian industries. MSc Thesis, University of Tromso. 119 pages.

- **Business Loans Scotland** (also the trading name for the Scottish Growth Scheme[45]) is led by a consortium of Scotland's Local Authorities to manage loan funds and funding to new and growing SMEs across Scotland. Businesses can borrow up to £25,000 to £100,000 with loans up to £50,000 typically unsecured. See:
- **SME Loan Fund** , administered by Zero Waste Scotland, provides SMEs in Scotland with loans of up to £100,000 for renewable or energy efficiency projects, which could be appropriate for purchasing energy efficient drying or processing technology (e.g. using air source heat pumps). See: https://www.mygov.scot/sme-loan-fund.
- **Scottish Loan Scheme**, administered by Scottish Enterprise, can provide loan funding of £250,000 to £2 million to growth-focused Scottish companies that have a viable business plan and a clear ability to repay the debt. Loans can be used for working capital, capital expenditure, growth funding, internal expansion and marketing investment. See: https://www.scottish-enterprise.com/support-for-businesses/funding-and-grants/accessing-finance-and-attracting-investment/scottish-loan-scheme.

The difficulty that many seaweed businesses will face with loans during start-up (years 1-3) is that most loans require monthly or quarterly repayments, whereas seaweed farmers are only likely to start trading a few years after establishing, or after their first successful harvest (which is seasonal). This means that cash-flow is too variable and unpredictable through the year for new seaweed farming businesses to meet loan repayment terms, and loans may be more appropriate for businesses that are several years old, and are already trading.

5.1.2 Grant Funding Options:

- **Scottish Enterprise** advertises and administers a variety of business grants and has an database of funding available for Scottish businesses seeking support for innovative R&D projects. The database can be accesses here: https://www.scottish-enterprise.com/support-for-businesses/funding-and-grants/business-grants/funding-database
- Crown Estate Scotland has various grant funds available, many of which are specifically for their tenants, others are available for communities more broadly. For example, the Sustainable Communities Fund (SCF) which is designed to support local regeneration and sustainable development, and comprises two individual strands; the Community Capacity Grants and Environmental Grants. See: https://www.crownestatescotland.com/our-projects/sustainable-communities-fund.
- **Marine Fund Scotland** The Scottish Government provides grant funding to replace the European Maritime and Fisheries Fund (EMFF), following the UK's exit from the EU. The fund has a one-year budget of £14 million, is highly competitive, and match funding may be required depending on the project. See: https://www.gov.scot/policies/marine-and-fisheries-grants/
- **Innovate UK** The UK Government offers grant funding and innovation loans to businesses for R&D projects. Applications can be submitted by individual companies or consortiums. New grant opportunities are announced regularly and companies will typically require match funding (between 30%-50%). See: https://apply-for-innovation-funding.service.gov.uk/
- **Seafood Innovation Fund,** Administered by CEFAS on behalf of Defra, this fund offers grants of up to £50,000 for a feasibility study to test new ideas and approaches to benefit the UK seafood sector. See: https://www.seafoodinnovation.fund/

[45] Scottish Government. (2021). Scottish Growth Scheme. Available at: https://www.mygov.scot/scottish-growth-scheme. Accessed Nov 2021.

Note on De Minimus regulations:

Some grants must comply with state aid rules, for example if they are awarded under de minimus regulations[46]. For most industries, de minimus rules state that public funding up to €200,000 can be awarded to a beneficiary over a three-year fiscal period, as this has a "negligible impact on trade and competition". This ceiling takes into account all public assistance given as de minimis funding for the current and previous two fiscal years which can take various forms (grants, loans, subsidised contracts, etc). **However, for aquaculture the de minimus ceiling is set at €30,000 per beneficiary over any period of three years (Commission Regulation No 717/2014)[47].** This low ceiling puts kelp farmers at a distinct disadvantage relative to other industries receiving state aid, especially given it is a new emerging industry that requires significant financial support to grow. Not all funding schemes are awarded under state aid rules, and funders are advised to keep de minimis cover as a backup for when there are no other options available. Seaweed farmers are also advised to be aware of de minimus funding regulations, and only use de minimus funding for absolutely essential projects, as it may limit their ability to apply for state aid in following years.

Recommendation for a government incubator fund:

Although several grant funding options are available, most government funds require match funding of at least 50%. This is usually unachievable for new seaweed start-ups (1-3 years old), and it is recommended that the government introduce a specific 'incubator' fund for seaweed start-ups that are pre-trading, with lower match funding requirements (e.g. < 20% match funding required). Once companies are trading (e.g. after year 3), then match funding requirements can be increased. Government incubator funding could also incentivise collaborative working, for example match funding requirements could be reduced if the applicant can demonstrate that their project would directly benefit more than one business. It is also recommended that the low threshold of de-minimus funding be reviewed for new seaweed farming businesses, as this significantly limits access to state funds.

5.1.3 Investment Options:

Seaweed farming businesses seeking expansion capital may issue shares in the business and sell them to investors (depending on the legal structure of the business), which is known as 'equity finance'. The main advantages of equity finance are that investors understand there is an element of uncertainty/risk and don't typically expect a return or repayment straight away. It is also an alternative to bank lending which can bring new skills and experiences to the company/enterprise. The Scottish Government provides some useful introductory information on selling shares in your business (equity finance) at the following website: https://www.mygov.scot/sell-shares-in-your-business.

Two government-backed investment funds that businesses can consider are:

- Scottish Co-Investment Fund (SCF): is an equity 'gap' fund delivered by Scottish Enterprise via the Scottish Investment Bank in partnership with the European Investment Fund, and can match accredited investment partners up to a maximum of 50% of the total funding package on a commercial basis, and can provide from £10,000 to £1.5 million. Investment can be made in companies from start-up, early-stage to expanding businesses seeking to develop products

[46] Scottish Government. (2020). State Aid Guidance. Available at: https://www.gov.scot/publications/state-aid-guidance/pages/de-minimis-aid/. Accessed Nov 2021.

[47] EUR-Lex. (2020). COMMISSION REGULATION (EU) No 717/2014. *Official Journal of the European Union.* Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014R0717. Accessed Nov 2021.

and/or markets. Scottish Enterprise can help SMEs find accredited partners/investors as part of the programme.
See:https://www.scottish-enterprise.com/support-for-businesses/funding-and-grants/accessing-finance-and-attracting-investment/scottish-co-investment-fund

- Scottish Venture Fund: Similar to the SCF (above), this is gap funding available for SMEs seeking funding to develop products and/or markets. Scottish Enterprise is the 'gap funder' and can provide up to 50% of the total funding packing, with the remainder matched by private sector investors, which businesses need to secure first. Total equity funding available ranges from £10,000 up to £2 million.
  See:https://www.scottish-enterprise.com/support-for-businesses/funding-and-grants/accessing-finance-and-attracting-investment/scottish-venture-fund.

5.1.4 Crowdfunding:

Crowdfunding is another option for new businesses or non-profits to raise money, whereby members of the public give money to a business idea or project they like and want to support. Funders may receive a specific 'reward' or equity in return for their donation, while other donors may be altruistic. There are many crowdfunding platforms in the UK, and they can broadly be broken down into four types:

1. **Reward-based crowdfunding**, in which funders get a reward for their donation, and the reward is related to the project/business that is fundraising, for example a limited-edition copy of a product. Reward-based crowdfunding platforms include Kickstarter and Indiegogo.
2. **Donation-based crowdfunding**, in which funders donate money to a specific cause or project without getting any reward or payback, and is usually used by non-profits or individuals. Platforms that offer donation-based crowdfunding include GoFundMe and Just Giving.
3. **Equity based crowd funding,** is where the public can give money to a business and receive equity (shares) in the business in return. Platforms include Crowdcube, Republic and Wefunder.
4. **Lending-based crowdfunding,** also known as 'peer-to-peer' lending is where the public lend money to business in return for interest payments and a repayment of capital over time.

6 Conclusions and recommendations on support required by industry

Seaweed farming is a new industry to Scotland, and in order to build the industry entirely new infrastructure and supply chains must be developed. New seaweed cultivation businesses face daunting tasks; they need to leverage finance for capital investments and labour costs, learn how to run new operations efficiently, and deal with unexpected events that impact production. In addition, the market must be defined, be reachable and be willing to pay a fair price to kelp farmers. Such challenges are rarely overcome by individual businesses working in isolation, and they need support from other industries, producers, government agencies, researchers and funders to survive and thrive. This is especially true for small operators, who will struggle to compete with larger industrial and more automated kelp aquaculture businesses in future years.

Building a new industry is complex and challenging, and the following areas have been identified as necessary to facilitate development of the seaweed cultivation industry in Scotland:

- **Improved organisation and cooperation between kelp farmers, technology developers and buyers,**
- **Stronger links to research organisations (innovation),**
- **Investment in/developing of processing operations and supply chain logistics**
- **Development of UK market for cultivated seaweed, including development of value-added products and creating customer demand,**
- **Government subsidy and support requirements specifically for kelp farming industry**

Improved organisation and cooperation between kelp farmers:

Case studies from other industries and nations show that collaboration between producers is important for success in new/emerging markets. The Scottish Shellfish Marketing Group, Fish Producer Organisations, and Scotland's grain cooperatives provide powerful examples of how cooperation has led to business growth. It is not easy to cooperate, but farmers are rewarded with security of sales, access to processing and storage facilities, and clear marketing and branding. Cooperation also ensures stable supply and quality for buyers, which is a major competitive advantage.

Seaweed growers could benefit from setting up 'shared facilities for cultivated seaweed', which are member/farmer led, and provide farmers with access to processing, storage and marketing of their kelp products. This could take the form of a seaweed farmers' cooperative, community-interest company (CIC), or private company (either with or without share capital). A key aim of a shared enterprise would be to benefit farmers through providing access to equipment, resources and markets they otherwise wouldn't be able to access or afford, while not profiteering on the services, so that farmers can still be paid a fair price for their produce (kelp). In addition, shared facilities would allow farmers to pool stock so they can enter larger markets. Due to the perishability of fresh kelp, it may be better to set-up several regional 'hubs' for processing seaweed so that farmers do not have to transport their produce more than a few hours.

However, so far, many seaweed farmers have been reluctant to setup cooperatives (both in the UK, Europe and USA) because they do not want to share hard-earned information on buyers and optimal farming methodology with other farmers. This is symptomatic of a new, innovative industry where a culture of IP protection is encouraged. If this attitude continues the industry will probably grow to a point and then stagnate, and, of the many licenced farms, only a few that serve local niche markets are likely to remain, or those that are backed by significant investment and have large industrialised operations. Although the argument for cooperation is persuasive, it is a mindset that may not suit all businesses or people. If farmers feel uncomfortable setting up cooperatives based on certain rules (e.g. democratic votes, distribution of surplus), then they can still set-up a shared enterprise that is a hybrid between a coop and a 'investor owned firm'. This is common in the agricultural industry in Europe, where some farmers organisations have setup private limited companies that are wholly owned by farmers (rather than external investors).

The decision to set-up an enterprise to share/pool resources and marketing will ultimately lie with individual kelp farmers, and cannot be forced. The Scottish Government could help cooperation by providing kelp farmers with funds to create voluntary 'producers organisations', or 'farmer-owned processing companies', which would allow farmers to strengthen their market position and overcome supply chain bottlenecks. Kelp farmers are also advised to start collaborating to develop a national strategy for growth, including target markets, focus areas for processing innovation, and methods to overcome supply chain bottlenecks. This could be done through existing industry bodies such as the Seaweed Industry Association, or by setting up a new formal seaweed cultivation 'platform' for

Scotland, which brings together producers, processors, technology providers, researchers and buyers to solve challenges and open new markets (see example of Seaweed Hub in USA).

Stronger links to research organisations (innovation)

It is well understood that innovation helps businesses grow, stay ahead of competition, and take advantage of new technology. Case studies of Norway and USA revealed that seaweed businesses that collaborate with researchers to overcome specific challenges have greater business success and market traction. Collaborating with researchers / universities provides access to a huge network of people, new ideas and technology that business would otherwise not be able to tap into. In Scotland, there needs to be a strong focus on industry-led research, whereby seaweed growers and processors play a large role in writing and developing proposals to solve specific industry projects. The positive results of R&D should then be implemented in industry wherever possible (e.g. as with the Norwegian Seafood Research Fund, section 4.2). It is recommended that focus areas for future research should include: primary processing innovation, including low-energy methods to stabilise kelp, local market opportunities/ development, and optimising farming methods to increase efficiencies. The recently announced Seaweed Academy, based at SAMS near Oban[48], will hopefully provide more opportunities for such research to take place.

Investment in/developing of processing operations - infrastructure and supply chain development

The entire infrastructure supporting the kelp farming industry still needs to be built and put in place. Processing raw material is associated with high capital investment, and is a major bottleneck limiting development of seaweed aquaculture industry in Europe. There is an urgent need to develop energy efficient methods for rapidly stabilising kelp after harvest in order to increase storage time before processing (e.g. drying and ensiling). There is also a need to find efficient solutions for processing large volumes of cultivated seaweed over a relatively short time. It may be necessary to look beyond the seaweed industry in isolation, and instead partner with processors in other industries that have a low-season during seaweed harvest, for example grain, shellfish, fruit and vegetable industries. Many of these industries operate at fairly low capacity over April-June when seaweed is harvested, and may have latent processing capacity or factory space that seaweed farmers could utilise. This warrants further investigation. Valuable insights could also be gained by understanding how finfish and shellfish supply chains operate, as they shift substantial volumes of seafood from the west coast to centralised processors on a regular basis.

In addition, it will be essential to continually monitor and assess the true carbon footprint of the seaweed cultivation industry, through the whole supply chain. Growing seaweed absorbs carbon, but much of that will subsequently be released during processing. In addition, the whole supply chain will have a carbon footprint associated with energy costs (e.g. during drying or freezing) and transporting bulk material. Processing kelp as close as possible to farm sites, using renewable technologies and energy efficient processes will reduce overall carbon emissions to develop a truly sustainable industry.

Develop UK market for cultivated seaweed

Successful aquaculture and agriculture businesses often focus on supplying their local market first rather than competing with larger overseas producers. Local market access also shortens the supply chain, and reduces costs and emissions associated with long-haul transport and storage. It is advised

[48] Scottish Association for Marine Science. (2021). SAMS news room: Funding will 'kelp' the UK's Blue Economy. Available at: https://www.sams.ac.uk/news/sams-news-seaweed-academy-announcement.html. Accessed Nov 2021.

that Scottish seaweed farmers make every effort to develop and access the local UK market for seaweed, and innovate to differentiate their products from cheap Asian imports. This will involve significant outreach, education and partnership with consumers and industrial partners.

Seaweed for food is a high-value market, which many seaweed farmers are aiming to access. But despite increasing consumer acceptance, seaweed as a food product is still largely a niche market. Consumers lack knowledge and familiarity of how to use seaweed, compounded by the 'conservative UK pallet'. This can be tackled with outreach and education, and by partnering with industry bodies such as Seafish, which run marketing campaigns to get more people in the UK eating seafood, for example 'Love Seafood' marketing campaign (see https://www.seafish.org/promoting-seafood/love-seafood-consumer-brand/). It is also recommended that seaweed businesses hoping to enter the food sector must focus on creating a positive taste experience from seaweed, and take advantage of current trends on local, sustainable, healthy and vegetarian/vegan foods[6].

A strong national branding and marketing drive will also help build the industry, and sustainability aspects and the environmental benefits associated with seaweed cultivation are important to buyers. Positive attributes to focus on include production at sea with no pesticides or synthetic fertilizers, and ability to clean/regenerate local waters. In addition, the national Scottish identity can be used to build a story and market seaweed-based products.

Government subsidy and support requirements specifically for kelp farming industry

It is clear that the seaweed cultivation industry faces major challenges, and many resource-intensive steps are required to overcome them. Although a wide variety of funding options are available to new businesses, they are often challenging for seaweed start-ups to access due to variable cashflow and underdeveloped markets. In addition, many of the grants and loans require match funding or payback terms that cannot be met by small seaweed farming business within the first few years of operation. The industry would benefit from a government-led funding initiative specifically to subsidise development of the seaweed cultivation sector, that new businesses could access to leverage money for capital, conduct pilot studies on farming methods, processing and product development, and to create sales channels and business cases.

Government funding must also play a role in R&D activities between kelp farmers and researchers seeking to resolve industry challenges. The best outcomes for government funded research projects can be achieved by coordination through some common organisation, which can properly identify problems and maximise learning for industry as a whole (which would also make best use of public money). Again, the example of Seaweed Hubs the USA highlights how an industry-led network organisation can be used to inform research questions. In addition, government funding should focus on progressing the kelp farming industry as a whole in Scotland, rather than a few isolated companies. Funding lots could be informed by a 'national seaweed cultivator strategy', which could be developed by the industry to aid business growth.