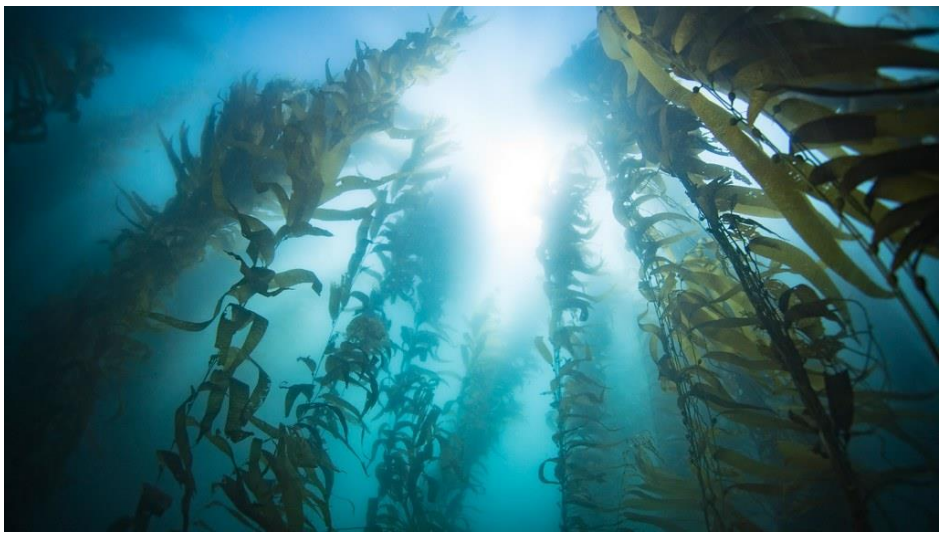
Aberdeenshire Council
Seaweed Cultivation – A new opportunity for Aberdeenshire



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Executive Summary

Northern Light Consulting (NLC) were appointed by Aberdeenshire Council to undertake a Coastal Industries Diversification Study aimed at determining whether seaweed cultivation is a viable and acceptable proposition for the North Aberdeenshire Coast.

It was concluded that there is a viable business opportunity for seaweed cultivation along this coastline; and the recommended next steps are a small-scale grant funded trial with confirmed project partners for each stage of the value chain. Potential partners are detailed in Chapter 10 of this report.

Analysis of the growth of the seaweed market in the UK has shown that there are potential new entrants striving to break into this market; yet the key limitation is currently the lack of an intermediary, and processing and logistics providers in the value chain.

The target species for cultivation in the region have been identified through analysis of a number of factors including existing species growing wild along the coast, harvesting options and species currently industrially cultivated. *Saccharina lattissima* and *Alaria Esculenta* have been identified as the primary and secondary preferred options respectively.

In line with the findings detailed in this report, the methodology undertaken to complete the study are outlined below.

1. Introduction to Seaweed Cultivation. The global development of seaweed farming has provided benefits to multiple remote and rural communities including boosting local incomes and improving food security. At a local level, this project has the potential to create employment, increase levels of innovation and entrepreneurism, facilitate diversification and improve the sustainability of existing operations.
2. Target Species for Cultivation. It is recommended that Sugar Kelp should be considered as the primary target species, with Dabberlocks as a secondary option.
3. Identification of Sites. In order to identify the best possible locations for a seaweed farm within the target search area, factors including physical characteristics, biological diversity and existing infrastructure have been taken into consideration. Boyne Bay, Portsoy, Gamrie Bay, Gardenstown and Aberdour were identified as potential sites. Follow up engagement showed us that Aberdour Bay may be the most attractive as the other 2 options identified are popular squid fishing spots. Macduff Harbour has been identified as the most attractive facilities to act as a hub for seaweed cultivation.
4. Equipment and facilities required. Consideration was then given to the farm design and the equipment and facilities required for this. Two potential options have been detailed further with cost estimations – a small farm, identified as 3000m of long line and a medium farm, identified as 6000m of long line – in line with current Scottish Government guidance. A grid based system was identified as the most suitable for this project. Cost modelling has laid out the start-up costs and operating costs for both a small and medium sized operation.
5. Guidance for Operators. Marine licensing and the consent process has been detailed. Seaweed cultivation, or “Algal Farms” are regulated by Marine Scotland, with the Marine Scotland Licensing Operations Team (MS-LOT) providing marine licensing services and enforcement under the Marine (Scotland) Act 2010 within Scottish inshore waters. Additionally, permission must be granted by Crown Estate Scotland for lease of the seabed, which incurs an annual fee. In advance of submitting a marine licence application, a Pre-Application Consultation (PAC) under the Marine Licensing (Pre-application Consultation) (Scotland) Regulations 2013, may be required.

6. Timescales. In order to understand planning and timescales - constraints and activities have been identified with a Gantt Chart detailing timescales for establishment of a new seaweed farm.
7. Routes to market. Following identification of Saccharina lattissima and Alaria esculenta - potential routes to market include exploration of processing options and end users. Engagement was carried out with potential processors leading to the conclusion that the markets for human grade food products initially is the key areas of interest. Other areas, such as animal feed, may be options for the future when high volumes of cultivated product can be grown and processed. In order to proceed further engagement must be undertaken to confirm potential trial partners.
8. Cost benefit analysis. From the cost benefit analysis carried out it indicates that the lowest risk model is to construct a 6000m farm and initially supply wet material. To achieve a similar breakeven position for a 6000m farm supplying dry product, a sales price of circa £85 per kg is required. Analysis has also found little or no risk to the local communities or supply chain from the establishment of seaweed farms.
9. Case Studies. Case studies were undertaken detailing the only commercial farming operation currently in Scotland and some other relevant projects.
10. Potential partners. In order for a seaweed cultivation farm to be set-up in the area, potential farmers, processor and end users must be confirmed, and there are opportunities for diversification into a new market at various levels of the value chain, and for third sector organisations. Funding options have also been outlined in this section.
11. Social licence. Engagement with a small sample of stakeholders following an information event can see the diversification opportunities within this project. The concept of a social license is yet to be explored fully. Outcomes from initial engagement with inshore fisheries demonstrated that it is critical that stakeholders from local communities, organisations and businesses must be involved and supportive from the early stages. Further engagement was carried out following the project presentation.
12. Summary & recommendations. In summary, there is a technically feasible, socially and environmentally beneficial, commercially viable opportunity for seaweed cultivation to be carried out in the Aberdeenshire area. Financial modelling confirms that seaweed cultivation is a viable business opportunity. Further micro-siting and a project trial would be an advised next step.

CIDS: Seaweed Study

The aim of this study is to analyse and determine if seaweed cultivation is a viable and acceptable proposition for the north Aberdeenshire Coast. Aberdeenshire Council commissioned NLC to deliver the study due the extensive opportunities exploring this emerging and fast-growing industry may provide for the area.

NLC is a multi-disciplinary consultancy operating principally in the blue economy, providing project management, engineering and strategic business consultancy with a focus on innovation in the aquaculture and construction sectors.

To date, small-scale seaweed harvesting and foraging is more widely associated with the West Coast of Scotland. Whilst the marine environment on the northeast Coast is different to the sheltered west coast, seaweed is still to be found in abundance.

Due to the harbour and infrastructure facilities along the shoreline, the necessary skillset for marine businesses and established industrial grade processing factories, it was noted that this feasibility study would assess whether the seaweed industry is one in which the region should further pursue.

The project has been overseen by the Aberdeenshire Council Regeneration Team which is tasked through Regeneration Action Plans to identify opportunities for key sectoral interventions and projects across the four coastal regeneration towns of Banff, Macduff and Fraserburgh and Peterhead. Diversification of the coastal economy has been recognised as a key part of the Aberdeenshire Council Developing Excellence in North Coast Communities Regeneration Action Plans. This project is focused on the 'Banff and Buchan' Council area, from Sandend in the West to Inverallochy in the East.

1. Introduction to Seaweed Cultivation

Global Seaweed Market

In 2018, farmed seaweeds represented 97.1% by volume of the total of 32.4 million tonnes of wild-collected and cultivated aquatic algae combined. Seaweed farming is practised in a relatively small numbers of countries, dominated by countries in East and Southeast Asia. (FAO, 2018)

Estimates from the FAO indicate that China alone accounts for 50.8% of the world production of aquatic plants (in 2014). In the period 2009-2013, Indonesia, Peru, and France saw the biggest growth in production of seaweeds from wild harvest, while Solomon Islands and Indonesia made the biggest advance in seaweed production from aquaculture.

The world production of marine macroalgae, or seaweed, has more than tripled, up from 10.6 million tonnes in 2000 to 32.4 million tonnes in 2018. A major driver in production has been the growth of tropical seaweed in species in Indonesia as raw material for carrageenan extraction.

According to a report published by Allied market Research: Seaweed Market by Product and Application: Global Opportunity Analysis and industry Forecast, 2018-2024, the global seaweed market size was valued at $4,097.93 million in 2017, and is projected to reach $9,075.65 million by 2024, registering a CAGR (compound annual growth rate) of 12% from 2018 to 2024.

UK Seaweed Market

In a report produced for CEFAS entitled 'Seaweed in the UK and abroad – status, products, limitations, gaps' 27 seaweed-related businesses were identified, based on web searches; 16 of them use

seaweeds harvested in the UK. The study states that the majority of UK seaweed related businesses produce seaweeds for food (or "sea vegetables"), condiments or cosmetics. It is important to note that most of the companies identified are harvesting wild seaweeds, with a very small number cultivating their own algae. Other products, based on seaweeds and produced in the UK, include animal feed and supplements, chemicals (e.g., hydrocolloids), fertilizers and nutraceuticals (e.g., nutrients and dietary supplements).

Production of seaweeds for other uses such as bioremediation, or biofuel production (via anaerobic digestion), is still at the development stage. (Capuzzo & McKie, 2016) The seaweed market in the UK is expanding with nutritional food benefits and supplements being of key interest to millennial generations, led by increased demand in sustainable, vegan, and organic products.

Scottish Seaweed Market

The Scottish market although not a new industry has seen significant growth in recent years. There is considerable opportunity for small farmers to establish presence yet - the industry is still relatively new and so there are significant barriers within the supply chain, specifically in terms of processing capabilities, licensing, and regulation.

It is widely publicised that the seaweed market in Scotland is in its infancy. In December 2019, Argyll and Bute Council commissioned a study to determine the feasibility and opportunities for establishing a seaweed cultivation industry in the region, and the markets potential growers could access. This identified a barrier to the growth of the sector, in that there is an unintegrated supply chain, and the role of the "intermediary" between producer and customer is not clearly defined. As a result of this, there are challenges with logistics and processing preventing small producers from entering the market.

Within the same feasibility study, the key areas of weakness within the seaweed industry in Scotland are identified as:

- Unknowns regarding food standards and what is required of them
- The logistical implications of a fully functioning sector
- The development of a contract model that allows everyone to invest in their respective functions.

A further study by Crown Estate Scotland, released earlier this year, looks at supply chains in Scotland to identify the optimal commercial viability for potential seaweed farming businesses.

The Scottish industry is expanding with an increasing number of companies and media coverage on the promising opportunities available within this sector. Yet the key issue identified is both the importance AND the need for the intermediary within the supply chain. Within Scotland we are currently lacking this key role. The intermediary/processor is key in driving the industry forward. For the sector to grow drying and processing facilities must be established and developed at scale.

Hebridean Seaweed Company Limited is the largest industrial seaweed processor in Great Britain, and is based on the Isle of Lewis. Starting in 2006 the company manufactures seaweed products for use in animal feed supplements, soil enhancement, alginate, and nutraceutical sectors. There is also smaller processors of wild harvested product – these include Shore based in Wick and Uist ASCO, based in North Uist.

For the purposes of this study, along the Aberdeenshire coast there are many industrial-scale food grade processing factories and so the role of the intermediary may be easier to fill than on the West Coast where this style of industrial processing is less common.

Benefits of Seaweed Cultivation

Macroalgae – seaweeds or sea vegetables – have numerous commercial end uses as outlined below but one of the most attractive attributes of seaweed cultivation is the environmental benefits - with the potential to create large carbon sinks.

Macroalgaes are self-sustaining plants containing chlorophyll which essentially uses sunlight to produce its food source – through photosynthesis. The seaweed uses energy from the sun to convert carbon dioxide into organic molecules and in the process produces oxygen. The algae absorbs nutrients from the water column via their blades. As a result, seaweed cultivation is a self-sustaining food source, requiring no feed, freshwater, or fertiliser. There is also no waste, meaning seaweed cultivation is arguably one of the most sustainable forms of agriculture in the world.

There has also been a large amount of research carried out on the benefits of kelp forests in sequestering carbon, while releasing oxygen. Kelp also serves as an ecosystem foundation: feeding and sheltering diverse ocean species, creating vital habitats for schools of fish, as well as reducing coastal erosion and serving as a buffer against strong storm-borne waves. Since climate change will likely heighten the severity of weather events like storms, the protection kelp forests provide may be a major benefit for coastal communities.

As well as environmental benefits, the social benefits of seaweed cultivation are significant as it can create an additional revenue stream for communities – including fishermen in the off season. This will be explored further in subsequent sections.

End uses of Seaweed

Seaweed is used for a wide variety of applications, and it is important to consider that the potential end users have a significant influence on how the product is primary processed. Listed below are several potential end uses for seaweed cultivated on the Aberdeenshire Coast.

- **Food Grade Product**: Seaweed can be used in a variety of products from pestos, crisps, wraps/breads, pasta, flaked toppings, salts and tapenades. Japan has one of the highest human life expectancies in the world. The most significant dietary habit of Japanese people is their regular consumption of seaweeds.
- **Nutraceuticals/Pharmaceutical/Supplements**: Seaweed is widely known as a super food with high levels of minerals such as calcium, copper, iodine, and iron, as well as being rich in protein, fibres, vitamins, and folic acid. As a result of this seaweed is often sold as a supplement with products such as kelp capsules, brown seaweed supplements and iodine capsules. A 2011, American Journal of Agricultural and Food Chemistry, found that seaweed may be used to lower blood pressure and promote heart health.
- **Cosmetics:** Algae masks and seaweed branded skincare ranges are seeing a rise in demand, with large brands such as The Body Shop, Mario Badescu and ESPA carrying seaweed skincare ranges. Seaweed is seen as a natural antioxidant which can protect and prevent skin damage and aging, by supporting collagen production.
- **Animal Feed:** Seaweed is an excellent source of amino acids, antioxidants and fatty acids – all of which are essential elements in both human and livestock diets. Feeding seaweed to livestock (cattle) has been proven to increase overall health and growth rates but more

recently preliminary research has indicated a small amount marine algae added to cattle feed can reduce methane emissions from cattle gut microbes by as much as 99% (All about feed, 2019) . Livestock emissions are a high contributor to global warming, as one cow can produce up to 220 pounds of methane a year (University of California, 2021). There are 1.4 billion cattle in the world, and that number is growing as demand for beef and dairy increases; together with other grazing animals, they contribute about 40 percent of the annual methane budget (National Geographic, 2021). The recent ClimeFeed project is currently investigating whether brown seaweeds, such as kelps, can help reduce methane emissions in cattle – traditionally more associated with red seaweeds. There is also recent research being done by Faroese Seaweed cultivator, Ocean Rainforest, with preliminary results in Denmark showing promising results in using fermented seaweed as a probiotic in pig feed as well as improving overall all health of the Sows. Interestingly, results show that by introducing seaweed as 2-5% of the pigs diet it has increased their antibodies by 30-40% and had a direct impact on piglet health, reducing mortalities by 3-4% and producing more piglets.

- **Chemicals (Hydrocolloids):** Seaweed 'industrial gums' or hydrocolloids. There are three categories that can be extracted – alginates, solely extracted from brown seaweeds and agars and carrageenans extracted from red seaweeds. It is to be noted that there is not significant differences identified between the red and brown algae, as they both revealed low fat and high fibre content (Dawczinski et al.) Uses of alginate hydrocolloids include sterile wound dressings. Seaweed hydrocolloids (specifically agars and carrageenans) can also be used as gelation and thickening agents in different food, pharmaceutical and biotechnical applications.
- **Fertilisers:** Nitrogen, potassium, phosphate, and magnesium are essential plant nutrients. For production of fertiliser (both organic and non-organic) seaweed can be dried or liquidised to produce a useful additive. Fresh seaweed, is also a useful substitute for farmyard manure, and does not need to be rotted down before use. It is best dug in fresh in winter or spring before it has had time to dry.
- **Bio Plastic:** Use of seaweed as a bioplastic can offer a sustainable alternative to oil-based plastic, alleviating waste issues. Seaweeds fast growth rate and ease of farming, at scale, could enable the use of bioplastics to assist in the transition from the use of fossil fuels. In 2015, the EU Commission launched the EU action plan for the circular economy. Within this was a 1.49m Euro grant for the SEABIOPLAS project, which is looking at developing the bioplastic model - sustainably cultivating seaweeds as feedstock for biodegradable bioplastics. Scottish company Oceanium are looking at current R&D trials into various sustainable seaweed uses in our everyday lives, with home compostable Bio packaging being one of them.

2. Target Species for Cultivation

In order to inform site selection, identification of equipment/facilities, routes to market, and other sections of the study, it is necessary to first establish the target species for cultivation.

This requires an understanding of the existing seaweed species present within the specified study search area of the Aberdeenshire coast (from Sandend to Inverallochy) to determine which species will be suited to these waters; and to avoid disturbance to existing naturally occurring seaweeds which provide a habitat for other marine life, including shelter for schooling fish, and species valuable to the local economy such as crabs and lobsters.

There are various resources available but the most comprehensive is the National Biodiversity Network (NBN) Atlas, an online resource which details recorded observations of flora and fauna throughout the UK. Using the search function, it was established that there are 474 recorded observations of species in the Chromista group in Aberdeenshire, and 91 different species identified. The Chromista group includes seaweed, mosses, algae, and amoeba-like valves.

From analysis of the data, a spreadsheet was produced which includes the 12 most common types of seaweed found on the Aberdeenshire coast (all those with more than 5 recorded observations) and expanded to include the locations where they were observed.

The list was cross-referenced with a Scottish Government consultation paper "Wild seaweed harvesting: strategic environmental assessment – environmental report" (2016) which identifies target species for commercial harvesting, and information from the Marine Life Network (online resource) about biology, depth range, habitat etc.

From this analysis, nine potential species were identified, split broadly into two groups: Laminariales (Kelps) and Fucoids (Wracks). The output from the analysis is reproduced in table 1.1 below, ranked in order of prevalence (highest number of recorded observations).

Table 2.1 – Potential Species for Cultivation

Species	Common Name	Record	Sandend	Portsoy	Whitehills	MacDuff	Mains of Melrose	Gardenstown	Troup Head	Pennan	Aberdour	Rosehearty	Pitullie	Fraserburgh	Inverallochy	Target Species for Harvesting	Depth
Laminaria Hyperborea	Cuvie	26	Y	Y		Y		Y	Y	Y	Y	Y	Y			Y	1-36m
Fucus Vesiculosus	Bladder Wrack	20	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y			Y	Intertidal
Laminaria Digitata	Oarweed	20		Y	Y	Y		Y	Y	Y		Y	Y			Y	+1-20m
Saccharina Latissima	Sugar Kelp	17	Y	Y		Y		Y	Y	Y		Y	Y			Y	<30m
Fucus Serratus	Toothed Wrack	14				Y		Y		Y		Y	Y			Y	Intertidal
Fucus Spirali	Spiral Wrack	13				Y		Y		Y		Y	Y			Y	High Water
Halidrys Siliquosa	Sea Oak	13						Y		Y		Y	Y			N	
Laminariales	Kelp (General)	13	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y		N/A	Subtidal
Alaria Esculenta	Dabberlocks	10				Y		Y		Y		Y	Y			Y	0-8m
Ascophyllum Nodosum	Egg Wrack	8				Y				Y		Y	Y	Y		Y	Intertidal
Cladostephus Spongiosus		7								Y						N	
Pelvetia Canaliculata	Channelled Wrack	7								Y		Y	Y			Y	High Water

The colour coding used in the table is as follows:

- Green highlight – kelps
- Yellow highlight – wracks
- Orange highlight – non-target species for harvesting

The total number of recorded observations of kelp is 86; for wracks it is 62. Kelp is the dominant group of species overall, and forms 86/168 (51%) of all recorded observations of the most common 12 species in the study search area.

Kelp is the most widely cultivated group of seaweed species, and in 2017 the industrial cultivation of two species found predominantly in Asia totalled 12.5Mt, more than a third of global seaweed production (FAO, 2018). Methods developed in China in the 1950s have been adapted for European kelps, with successful cultivation of Oarweed, Sugar Kelp and Dabberlocks already in progress in Scotland and Northern Ireland.

Harvesting of wild kelp in Scotland is limited, as it must be hand-cut and (with the exception of Oarweed) tends to prefer deeper water, so divers are usually engaged in harvesting. In contrast wrack is not typically cultivated, as it can be harvested relatively easily and cheaply due to its preferred habitat at shallow depth in the inter-tidal range. Some species of wrack may also be harvested by mechanical seaweed harvesting vessels. As a result, supply of fresh kelp is limited, and kelp achieves a significantly higher market price than wrack.

In the last two years there has been a total of nine marine licence applications to Marine Scotland for algal farms, of which three were for sites within the Moray Firth at Culbin, Burghead and Covesea. The applications within the Moray Firth have all been made by the Highland Seaweed Company and are all proposals to develop kelp farms.

The conclusion from the above is that the target species for cultivation should be selected from the kelp group of seaweeds.

Cuvee (*Laminaria hyperborea*) is the most prevalent species growing in the study search area and is commercially harvested in Scotland for the alginate industry, providing emulsifiers and gelling agents for cosmetics, pharmaceuticals, and food production. Yet, there is no known cultivation of the species at this time. Whilst not suitable for the most wave-exposed sites, it grows at depths up to 30m dependent on water clarity. It is however very slow growing.

Sugar Kelp (*Saccharina latissima*) is fast growing and is the most cultivated European seaweed, including in Scotland. It can thrive in wave-exposed sites and grows at depths up to 30m dependent on water clarity. It has value primarily as a food, but can also be used for bio-packaging, for cosmetics, and is being explored as an ingredient for biofuels.

Dabberlocks (*Alaria esculenta*) is fast growing and is naturally found in exposed locations. It is cultivated in Northern Europe as sea temperatures are too warm further South – as a result it has good potential value as a food ingredient for export markets. It thrives in exposed locations and normally grows at depths up to 8m, although up to 35m has been recorded.

Oarweed (*Laminaria digitata*) is slower growing and can be naturally harvested at low tide, hence there is little demand for cultivation. It is harvested for its alginate content.

Other seaweed species are cultivated globally, and some may have value in the future, but work to cultivate these successfully in Northern Europe is still at developmental stage and they are not considered within the scope of this study.

In conclusion, it is recommended that Sugar Kelp should be considered as the primary target species, with Dabberlocks as a secondary option.

3. Identification of Sites

For the purposes of this study, the location considered is the Banff and Buchan coastline from Sandend in the West to Inverallochy in the East. A variety of factors which must be considered when selecting a suitable site for a seaweed farm. These include:

- physical characteristics such as bathymetry/seabed geology, water depth, wave height, tidal range etc
- water quality (including salinity, temperature, light, sediment and water flow, sewage/industrial waste effluent discharges)
- biological diversity, protected areas, habitats etc
- existing commercial fisheries, marine tourism/leisure and recreation or other competing interests
- existing infrastructure (physical and non-physical) to support development of seaweed farming.
- existing businesses which could support or benefit, considering additionality.
- socioeconomic factors e.g., employment, skills, health etc

Physical Characteristics

The physical characteristics of the North Aberdeenshire coast are broadly similar along much of the study search area, with steep cliffs and rocky foreshore, broken up by small pockets of raised beach deposits and sandy beaches in more sheltered coves. East of Sandhaven, the land elevation is closer to sea level and sandy beaches become more prevalent.

Various academic studies into seaweed farming, undertaken by NAFC Shetland and Scottish Association for Marine Science (SAMS) have proposed that the ideal depth for establishing a seaweed farm is between 5m and 25m depth of water (based on trials undertaken in relatively sheltered locations). However, through engagement with Aquamoor – a seaweed farm equipment supplier, advice has been received that siting a farm in deeper water may be advantageous, in that wave intensity will significantly less in deeper water further from the shore. On this basis, it is recommended that farms are sited around the upper limit of the depth range recommended in academic studies.

From reviewing Admiralty Marine Charts, it has been established that suitable water depth for seaweed farming (around 25m) can be found along the entire length of the coast, with 25m depth between around 500m and 2.25km offshore. Two areas potentially to be avoided are the northwest side of Troup Head and approx. 2km East of Rosehearty where the water depth increases sharply very close to shore. An extract from the relevant Marine Chart (BA1409 Buckie to Arbroath) is reproduced below in Figure 2.1.

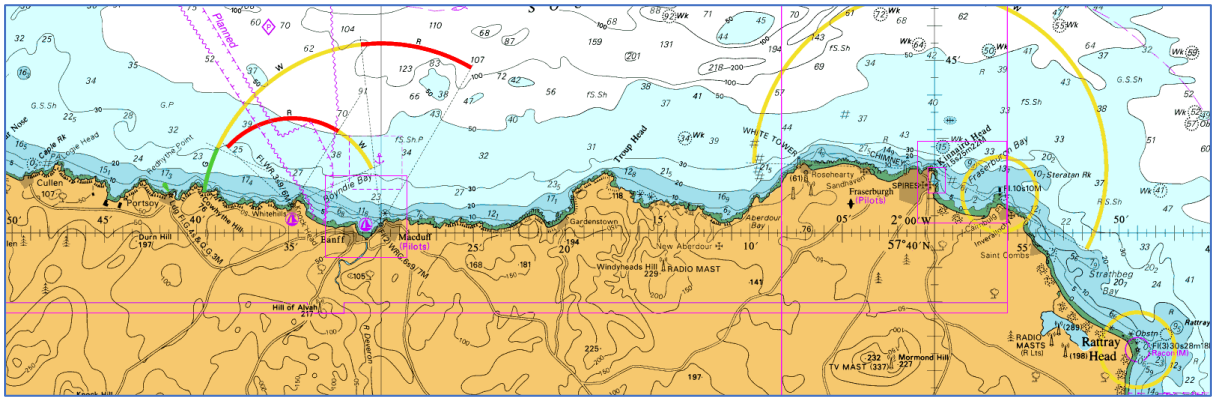


Figure 3.1 – Marine Chart *© Crown Copyright, All rights reserved*

From reviewing Marine Scotland Maps NMPI (online resource) is has been identified that the wave exposure index, and tidal range are almost identical along almost the entire length of the study search area.

The annual mean wave power increases from west to east, at 4.12 - 5.91kW/m west of Banff rising to 6.98 - 10.47 kW/m from Banff to Fraserburgh and then over 12.25kW/m East of Fraserburgh. The annual mean significant wave height for these locations also increases from 0.92 - 1.14m west of Banff to 1.22 – 1.48m from Banff to Fraserburgh and then over 1.61m East of Fraserburgh. Hence for locations further west, mooring systems, a not insignificant proportion of the capital cost of setting up a seaweed farm, will be cheaper(lower wave power/wave height = lighter moorings) than for locations further east.

Limited data is available for similar sites on the west coast of Scotland as they tend to be sheltered in the lee of islands or in sea lochs – although four shellfish aquaculture sites were identified which are more exposed and appear to have similar or higher energy wave environments (Colonsay, west of Mull, Sound of Harris, Bernera). By means of comparison however, there are proposals for seaweed farms (and marine licence applications in progress) for 3 sites in the inner Moray Firth – data available for Burghead shows annual mean wave power of 3.17kW/m and a mean significant wave height of 0.83m – not radically different to what is found to the west of Banff, but significantly lower than east of Banff.

The data is not sufficiently detailed to identify the effects of localised features such as headlands or coves which provide a degree of shelter, although for a seaweed farm located (for example) 500m to 1km off the coast this is unlikely to make a significant difference.

Wind rose data from website meteoblue shows that the prevailing wind blows generally from the SSE, but is variable from SE round to NW. Hence a degree of shelter is provided by the land, and locations which are to the northeast of headlands, whilst more exposed to wave action from the open sea, will be more sheltered from the wind. Wind speeds in excess of 50km/h are reached on 55 days per annum. The strongest winds blow more often from SSE, so locations NNW of and close to sea cliffs will be the most sheltered. Due to the variability of the wind direction and exposure to the open sea it is not anticipated that wind direction or exposure to the open sea will be particularly relevant to selecting potential sites. The wind rose for Fraserburgh is shown in Figure 3.2. Data for Whitehills is broadly similar so is not reproduced to avoid duplication.

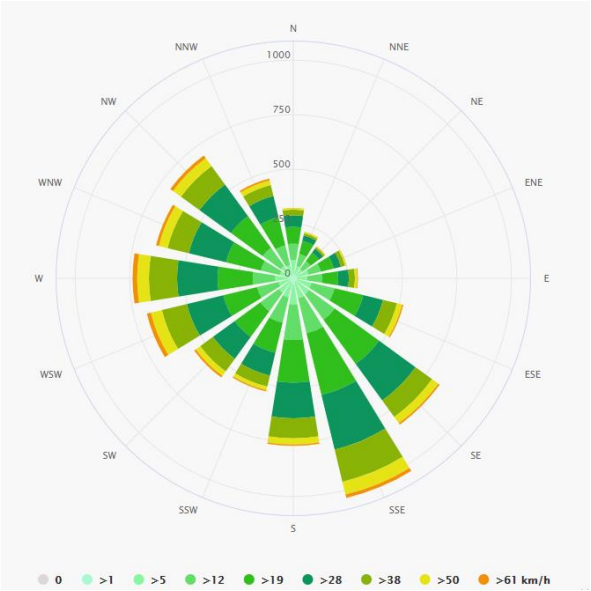


Figure 3.2 – Wind Rose (Fraserburgh)

© meteoblue

From reviewing British Geological Survey Seabed Mapping, the seabed geology, as expected based on what is visible above water level (steep cliffs and rocky shoreline) comprises a narrow band of solid rock, typically extending between 100m and 500m out to sea. This gives way to sandy gravel and gravelly sand to over 3km offshore, then becoming sand and other marine sediments. The exceptions to this are East of Fraserburgh, where little or no rock is present and muddy sand is present instead, along with a smaller sandy area in Sandend Bay. Superficial geology is shown in Figure 3.3 below.

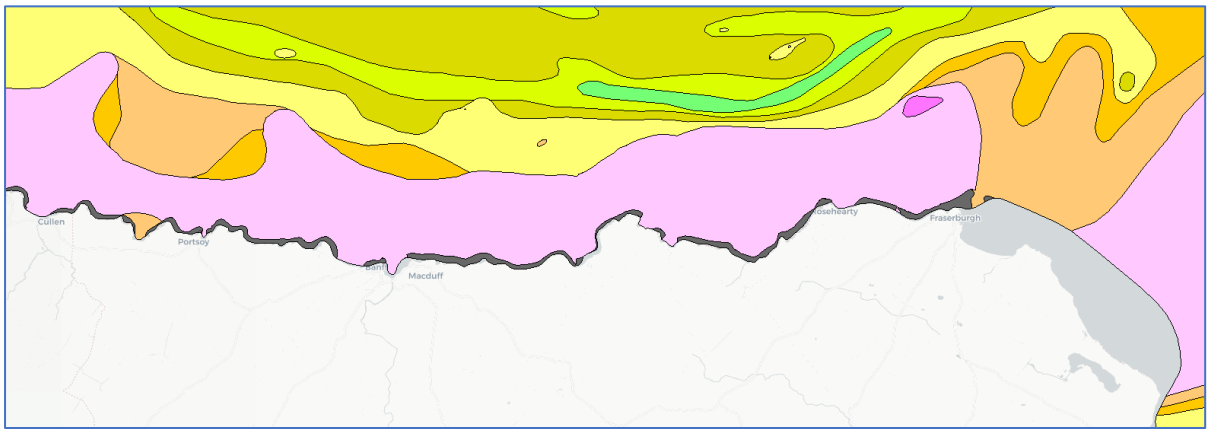


Figure 3.3 – Superficial Geology. *Based upon BGS Offshore 1:250,000 scale seabed sediment, with the permission of the British Geological Survey*

Key to map:

- Black – Solid Rock
- Pink – Sandy Gravel
- Orange – Gravelly Sand
- Grey – Muddy Sand
- Yellow - Sand

Based on the above, it is assumed that in terms of the physical characteristics, it appears that there are no barriers to seaweed farming anywhere along the north Aberdeenshire coast that cannot be overcome by careful micro-siting or appropriate mooring design to suit local conditions – whilst noting that sites west of Banff benefit from less exposed (and hence lower strength) wave conditions and conditions east of Fraserburgh are likely to be too rough. Allowance for significant additional cost for heavier-duty gear has been considered. Brief engagement was carried out with existing suppliers/installers of seaweed farm infrastructure in Scotland and none had any significant concerns – stating they have deployed in higher energy environments.

Water Quality

SEPA's Water Framework Directive (WFD) Waterbody Classification 2007-2017 shows that for the entire study search area the water quality is rated as "Good" or "High" depending for which year the data is reviewed.

From reviewing Marine Scotland MAPS MPNI (online resource) there are very few wastewater and industrial discharges recorded, those that have been identified are listed as follows:

- Macduff Harbour (Industrial discharge - shipbuilding)
- Macduff, off Tarland swimming pool, approx. 150m offshore (Macduff WWTW effluent discharge – tertiary treatment)

- Gardenstown (WWTW effluent discharge, secondary treatment)
- Pennan (WWTW and Outfall – preliminary/primary treatment)
- Between Sandhaven and Fraserburgh approx. 600m offshore (Fraserburgh WWTW effluent discharge – tertiary treatment)
- Fraserburgh Harbour (Industrial discharge - shipbuilding)
- Fraserburgh fish processor - seafood waste outfall pipe

From local knowledge there is also a small WWTW between Whitehills and Banff which does not appear in the results (it is possibly too recent).

Figure 3.4 below shows water quality classification (good to high) in light green, and locations of wastewater and industrial discharges.

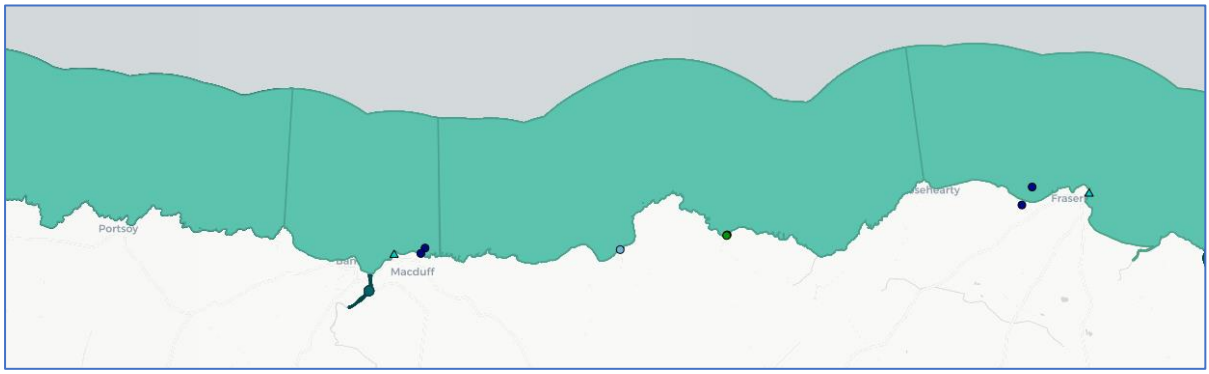


Figure 3.4 – Water Quality and WWTW/Industrial Discharges *© Crown Copyright, All rights reserved*

While there is currently a lack of evidence to suggest that releases of sewage and other effluent pose a risk to human consumers of farmed or wild harvested seaweed, those involved in growing seaweed should be aware that a contamination risk may exist, depending on current flow characteristics, historic discharges, and accumulation in the environment (i.e., for heavy metals).

As such, the seaweed sector is advised to locate in designated shellfish waters, where water quality is already protected for harvesting products for human consumption. There are no designated shellfish waters on the north Aberdeenshire Coast.

A report commissioned by the Food Standards Agency in 2015 Review of approaches for establishing zones for shellfish harvesting around sewage discharge points concluded that "there are no easy options for establishing future evidence-based exclusion zones to manage Norovirus risk". In the absence of a recommendation, it is suggested that a precautionary approach is adopted.

Zone controls are used in Europe for example in Italy and the Netherlands, with exclusion zones ranging from 50m to 1,500m from wastewater discharges. For this purpose of this study a worst-case scenario of 1,500m is adopted.

Subject to avoiding siting seaweed farms close to any of the recorded discharge locations, there appear to be no issues with water quality for seaweed farming anywhere along the North Aberdeenshire coast.

Biological Diversity, Protected Species and Habitats

A search was undertaken using the Marine Scotland MAPS MPNI (online resource) to identify protected areas within the study search area.

The whole of the seabed off the coast, from a few hundred metres offshore, is a designated Nature Conservation Marine Protected Area, the "Southern Trench MPA". Protected species include marine habitat (burrowed mud), Minke whale, and large scale and geomorphological features. MPA status does not preclude development but requires protection of specified features and NatureScot will advise on conditions for development.

At Sandend, and extending about half-way to Portsoy, the sea is a designated Special Protection Area, the "Moray Firth SPA" due to the presence of 12 seabird species. SPA status does not preclude development but requires protection of specified species and NatureScot will advise on conditions for development.

There are several SSSI sites covering around 80% of the coastline, generally extending only a short distance inshore and offshore, where rocky cliffs are found:

- Cullen to Stake Ness Coast SSSI
- Whitehills to Melrose Coast SSSI
- Gamrie and Pennan Coast SSSI
- Rosehearty to Fraserburgh Coast SSSI
- Cairnbulg to St Combs SSSI

The protected features are primarily rock formations, raised shorelines, dry heath, saltmarsh, shingle and springs. From Gamrie to Pennan Eastwards the designation also applies to several species of seabird. Operations requiring consent from NatureScot are primarily land-based activities, and not specifically relevant to seaweed farming, unless it is considered necessary to construct new access roads, erect structures, undertake engineering works or alter rock faces (for example to construct a new jetty or slipway).

At Troup Head, there is an RSPB reserve, and adjacent sea is protected by the Troup, Pennan and Lion's Head Special Protection Area, which is designated due to the presence of 6 species of breeding seabirds.

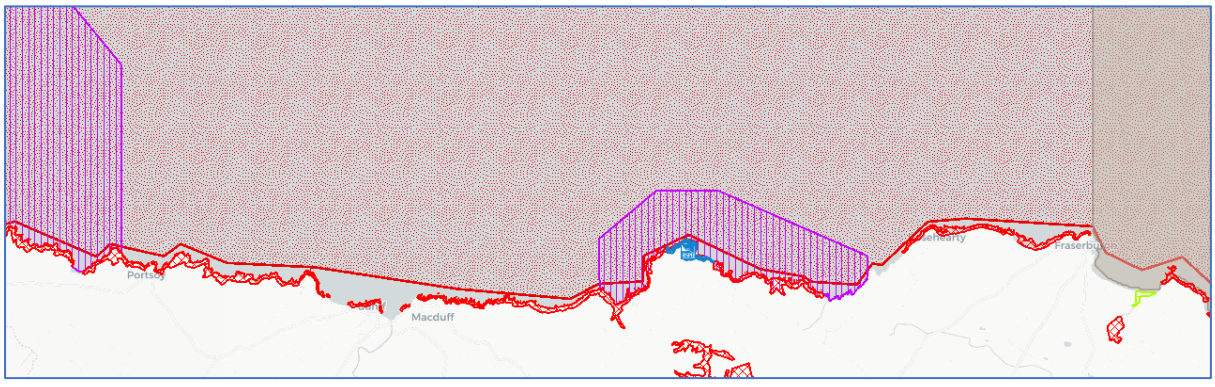


Figure 3.5 – Designated and Protected Areas *© Crown Copyright, All rights reserved*

Whilst Kelp beds themselves are Priority Marine Features (PMFs) some of which are protected under legislation or other designations, it should be noted that the north Aberdeenshire coast lacks the extensive kelp beds that are found elsewhere around the coast of Scotland. This is primarily due to the seabed geology out beyond the rocky coastline, which typically consists of sandy marine sediments, which do not provide good conditions for attachment. Where seaweed observations (of all species) are recorded, these are likely to be attached to rocky outcrops at or close to the intertidal

zone. The sandy seabed does not present a barrier to seabed cultivation, as the seaweed farm will include a mooring system, and the seaweed cultivated on ropes suspended between buoys.

There are suitable habitats, nursery, and spawning grounds for several marine species off the north Aberdeenshire coast, but nothing specific that gives rise to concern for relatively low-intrusion development such as seaweed farming.

It was not initially considered that any of the protected species, habitats or areas identified present a significant barrier to the development of seaweed farming on the north Aberdeenshire coast, and that seaweed cultivation could exist harmoniously with (for example) Troup, Pennan and Lion's Heads SPA. Consultation with Nature Scotland about matters potentially impacting on the SPA has been undertaken on 22 separate occasions since 2004, with only one objection raised (to an offshore wind development). Further consultation would be undertaken as part of the PAC process (Section 6).

For the purposes of this study, brief consultation was carried out with Nature Scotland, in which it was advised that having seen preliminary drawings of specific equipment type / configuration that may be used in Aberdeenshire, bird entanglement is unlikely to be an issue, yet possible disturbance would need a bit more thought and would require site-specific advice from their marine ornithology team. It was identified that the risk of entanglement to Minke whales would also need to be considered further, and advice from Nature Scotland's marine mammal advisors would be sought as part of the licensing process. Minke whale consideration will be the same along the entire North Aberdeenshire coast and so regardless of the areas identified as suitable sites, this will remain a key consideration as part of the marine licensing and consents – as discussed further in section 6.

Existing Commercial Fishing

The Scottish Parliament Information Centre briefing on Inshore Fisheries (2019) notes that there are over 1,400 vessels fishing in Scotland's inshore waters, making up two-thirds of the Scottish fleet. Inshore vessels are typically smaller boats under 10m in length, and these vessels fish in waters that extend from the coast out to 12 nautical miles (nm), with the majority of activity taking place within 6nm. 118 of these vessels (8.5%) are based within the study search area.

The 2015 Scottish Gov publication "Management of The Scottish Inshore Fisheries; Assessing The Options For Change" identifies that within the study search area (Fraserburgh administrative port) 77% of inshore vessels under 10m are engaged in creel fishing. Within the wider North East coast Inshore Fisheries Group area (Durness to Sandhaven) the total catch value by all vessels in the 0-1 nm zone (likely location for seaweed farming) was £3.5m in 2012; estimated at around 55% (£1.9m) for the north Aberdeenshire coast.

Clearly inshore fishing is important to the local economy and seaweed farming will potentially restrict access to fishing grounds, in particular restricting where creels can be located. Several recent studies and articles have concluded that seaweed farming results in little impact on the surrounding natural environment, and furthermore can provide valuable habitat for juvenile fish and shellfish. Current small-scale cultivation projects are considered environmentally 'low risk' (Campbell et al, 2019).

ScotMap is a Marine Scotland project which provides spatial information on the fishing activity of Scottish registered commercial fishing vessels under 15 m in overall length. The dataset, as of July 2013, is based on interviews of 1,090 fishermen. Individuals defined their fishing areas with variable levels of precision. Users of the data should be aware of this, particularly of the coverage provided by the ScotMap data set which varies regionally.

Review of mapping data suggests that there is/are:

- 4-5 vessels operating Nephrops (Norwegian Lobster) trawls at any given location within the study search area.
- 1 vessel operating scallop dredges as far East as Gardenstown
- Many vessels operating crab and lobster pots along the whole of the coastline, with the greatest concentration (21) around Aberdour Bay, fewer vessels around Macduff/Banff (7-12) and Sandend Bay (11-12)
- Many vessels operating mackerel lines (30-39) East of Gardenstown, a significant number (15-26) between Portsoy and Gardenstown, and smaller number (5-10) West of Portsoy

The level of detail available from the spatial database is insufficient to inform site selection for this study, therefore consultation and engagement with relevant stakeholders involved in inshore fisheries was undertaken.

This mainly confirmed the intensity of fishing in the various areas identified above. A secretive squid fishery was also identified, which operates from June to October between Banff and Portsoy, with boats coming in almost to shore. It was also noted that creel fishing is undertaken on hard ground (rock) only at up to half a mile from shore.

Other shipping traffic is monitored in real-time using an Automatic Identification System (AIS). AIS transceivers must be fitted to various classes of ship, including all fishing vessels over 15m long and all passenger vessels. It should be noted that there is no requirement for small commercial vessels or yachts to carry AIS, and many small vessels used for inshore fishing will be exempt.

Historic AIS data was reviewed on the European Marine Observation and Data Network (EMODnet) website and Figure 3.6 below shows vessel density within the study search area. Unsurprisingly the highest vessel is associated with vessels entering and leaving harbours, most notably Banff/Macduff and Fraserburgh, with other "hotspots" around Whitehills, Crovie, Troup Head and Aberdour Bay. It is suspected that vessel density around Troup Head is driven by marine tourism and leisure activities, and vessel density around Aberdour Bay results from its use as a safe anchorage by Oil & Gas support vessels.

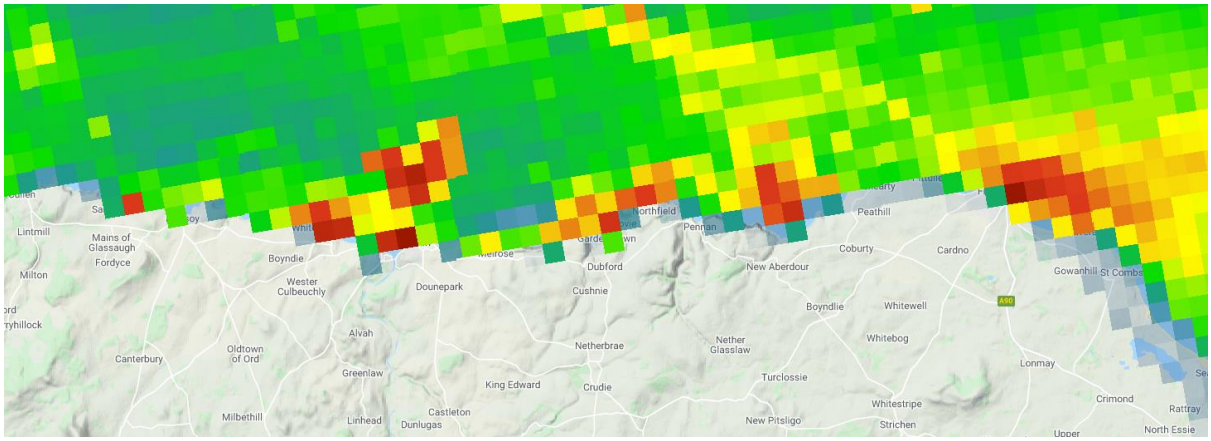


Figure 3.6 – AIS Vessel Density (2019) *Data is made available by the EMODnet Human Activities project, www.emodnet-humanactivities.eu, funded by the European Commission Directorate General for Maritime Affairs and Fisheries*

Out with these “hot-spots”, vessel densities are typically less than 5 hours per square kilometre per month. Consideration should be given to hazards to navigation in higher density areas and Northern Lighthouse Board would be consulted as part of the marine licensing process.

As a result of engagement with both creel fishermen and squid fisherman, it will be essential in order to progress with site selection to carry out further micro-siting of potential suitable areas with a representative from each. Local knowledge of the activity and the weather conditions safety will be key in further narrowing down specific sites. Engagement identified Aberlour Bay and surrounding areas as a potential option as well as Cullykhan beach area. Cullykhan beach to Rosehearty it is advised has few trawlers along that East side (later ruled out due to rocky seabed). Troup head to Pennan area was ruled out as extensive commercial activity takes place from 0.01 miles of the shore.

Marine Tourism/Leisure and Recreation

Marine tourism and the leisure and recreation sectors, whilst less important to the local economy than fishing, are still a significant employer with various tourist accommodation (hotels, campsites, self-catering, B&Bs) and marine leisure operators (sea angling trips, sailing, surf schools, scuba diving trips) active in the study search area.

A search was undertaken using the Marine Scotland MAPS MPNI (online resource) to identify important locations including marinas/harbours (and recreational boating areas), bathing waters, and popular locations for surfing and wind-surfing, which identified the following:

- Sandend Bay – surfing and wind-surfing
- Portsoy – scuba diving
- Whitehills - sailing
- Boyndie Bay – surfing and bathing waters
- Banff Bay – surfing and sailing
- Pennan – scuba diving
- Aberdour Bay (East end) – scuba diving
- Rosehearty – bathing waters, scuba diving and sailing
- Sandhaven – scuba diving and sailing
- Fraserburgh Bay – bathing waters, surfing, and windsurfing

Locations where marine tourism/leisure and recreation are popular are shown on Figure 3.7 below.

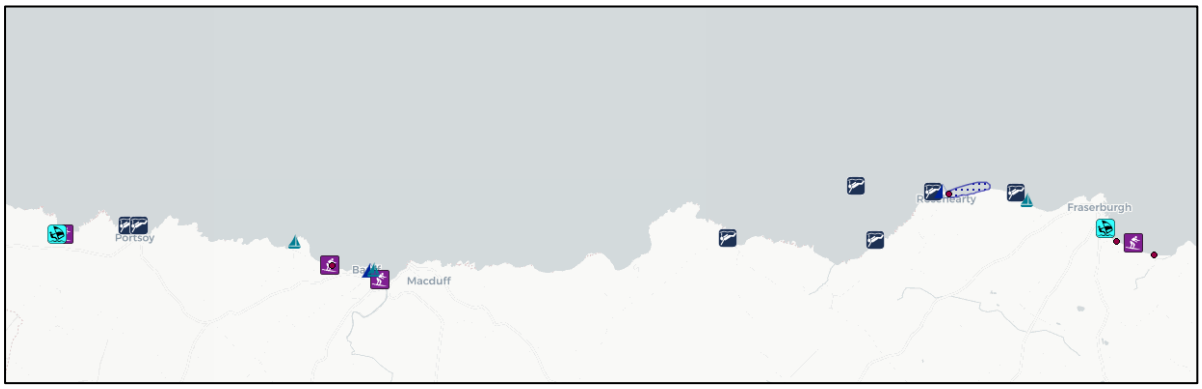


Figure 3.7 - **Marine/Tourism areas of activity**

As seaweed farms are likely to be sited at least 500m off the coast, they are unlikely to affect bathing waters, surfing, or windsurfing activities. By micro-siting, popular scuba diving locations can also be

avoided. Whilst there are several marinas and harbours used for recreational sailing, only one specific recreational sailing area is identified by the Royal Yachting Association, East of Rosehearty, and this should be avoided.

However, although the visual impact of a seaweed farm is relatively non-intrusive, there are likely to be concerns raised in communities and by marine tourism/leisure and recreation businesses about loss of amenity, spoiling of views and potential loss of business. Sensitive receptors immediately off the coast of communities, popular beaches, and areas where there is tourist accommodation should be avoided for this reason.

Impact on marine tourism/leisure and recreation and communities is explored further in the consultation and engagement undertaken during this study.

Existing Infrastructure

The only essential infrastructure requirement to support seaweed farming is a safe means of access to the farming site for operation and cultivation, that is a harbour or other safe location to get access to the water. Day-to-day operations and cultivation can be carried out from a small vessel (<10m length and shallow draft) with a cruising speed of 15-20 knots in favourable conditions. Hence for a maximum travel time to/from site of 15 minutes, it must be less than 7km from a suitable harbour.

Unloading harvested product, which may involve a larger vessel, is only undertaken in late Spring for a short period, hence a longer travel time to a suitable location with off-loading, lay-down areas, access to primary processing facilities etc could be tolerated.

A review of existing harbours within the study search area was undertaken based on existing local knowledge and visual inspection by Google Streetview and other online mapping and photographic resources. Observation of the type, number and size of vessels already using these harbours suggested that the majority appear to be suitable for the type of vessel required and as such a detailed inspection and/or engineering audit was not believed to be necessary.

However, engagement with inshore fishermen and harbour operators identified that several harbours do not provide safe access or berthing in winter storm conditions. Following engagement, it is understood that the harbours at Macduff, Whitehills, Sandhaven, Fraserburgh and Gardenstown are suitable for access all year round.

In terms of facilities which could support harvesting and processing of seaweed, Macduff, Whitehills and Fraserburgh are significantly better prospects than Sandhaven or Gardenstown. Existing infrastructure at all three appears to be in reasonable condition, no improvements or new infrastructure are required exclusively to support seaweed cultivation.

Engagement was carried out with Duncan Mackie, Macduff Harbour Master, who confirmed the only Aberdeenshire Council owned/operated harbour on the Moray Firth coast to provide safe operational access and mooring to a range of vessels, is Macduff harbour. He advised that Macduff can safely moor vessels up to 60 metres in length and will remain open when other smaller surrounding harbours are closed due to adverse weather conditions and tidal restrictions. Portsoy harbour can be hazardous to enter in high Northerly winds and is also tidal. Banff harbour is primarily a leisure marina and not suited to commercial operations. Macduff Harbour also has the required infrastructure to support aquaculture operations such as, loading space for transport, maintenance facilities, cranage, 24 hour harbour operations staff, storage facilities etc. The former fish market building could also provide indoor space for drying.

Macduff Harbour has all the necessary requirements to become the hub for seaweed cultivation. The harbour also has chill facility at the harbour which could be used as a holding facility whilst the seaweed awaits further transportation. It would be recommended that Macduff harbour is identified as a project partner for initial trial stage cultivation.

Preliminary Sites Identified

Considering all of the information above, the key parameters for site selection are as follows:

- Sandy seabed is essential
- Suitable harbour facilities nearby
- Avoid:
    - environmentally sensitive and protected habitats, areas, or features
    - locations where there are competing uses of the sea, including commercial fishing, marine tourism, leisure, and recreation
    - existing settlements (visual impact, vessel traffic, WWTW and industrial discharges)
    - locations where the depth of the seabed increases sharply very close to shore

Hence the target areas where opportunities to develop seaweed farming exist were initially identified as follows:

- Portsoy to Whitehills (Strathmarchin Bay to Stake Ness) from Whitehills harbour
- Macduff to Gardenstown (Old Haven to Gamrie Bay) from either harbour

Although suitable in many ways, there is a question mark over further consideration of locations between Pennan and Rosehearty (Pennan Head to Pike Rock) due to:

- significant levels of activity relating to lobster and crab pots
- significant levels of activity relating to mackerel line fishing East of Gardenstown
- significant increase in annual mean wave power East of Gardenstown (at least 8.22kW/m) which is double that of locations further West.

That is not to say that seaweed cultivation is not viable East of Gardenstown, but rather for a nascent industry it is a higher risk strategy than trying to develop farms in lower energy wave environments with less impact on existing commercial fishing activities.

One exception in this area is potentially Aberdour Bay, which is sandy until quite far out, and more sheltered, although the water is not particularly deep. It is not creel fished but may have value for other species and would have to be serviced by boats from Sandhaven, or Fraserburgh which is further away than is ideal.

Sites are therefore proposed which meet the various suitability criteria but are subject to verification and micro-siting dependent on:

- Accurate seabed geology and depth of water from ROV and bathymetric surveys
- Metocean data for wave height direction etc obtained from deployment of monitoring devices such as Waverider buoys
- Further detailed consultation with multiple stakeholders to minimise impact on existing inshore fishing activities

The specific locations proposed as potential sites are as follows:

- Boyne Bay, Portsoy

- Gamrie Bay, Gardenstown
- Aberdour Bay

Site Name	Grid Ref	Dist from MLWS	Depth of Water
Boyne Bay	NJ 62208 67070	950m	17.4m approx
Gamrie Bay, Gardenstown	NJ 79238 65532	450m	15 - 20m
Aberdour Bay	NJ 89064 65812	900m	16.9m approx

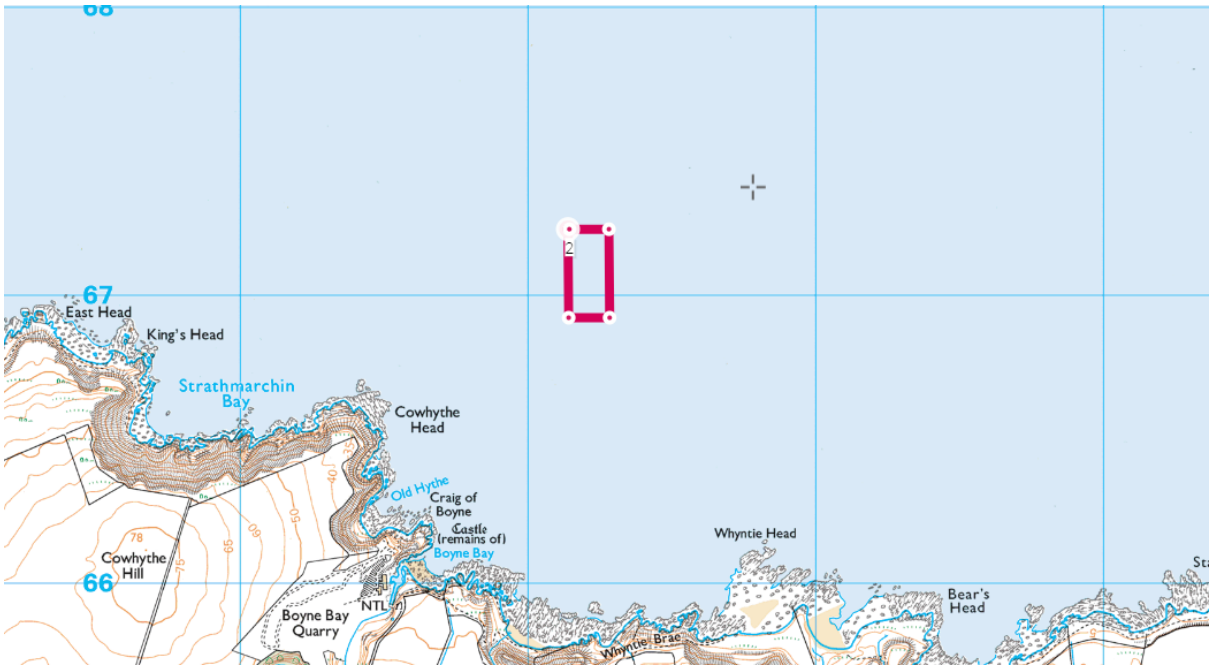
Table 3.1 – Specific locations proposed as potential sites

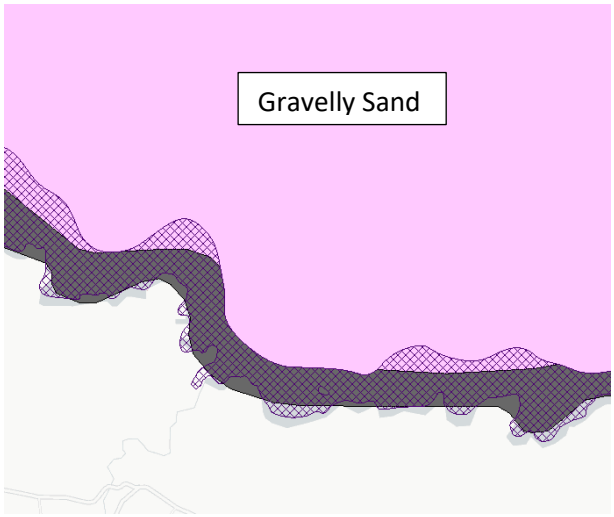
Of the three, Boyne Bay near Portsoy is considered to be the most suitable site for the first seaweed cultivation on the North Aberdeenshire Coast, due to lower wave intensity further West and to minimise the potential for delays in dealing with consenting, as the other two sites are within an SPA (Troup, Pennan and Lion's Head). All three sites can be accessed via Macduff harbour.

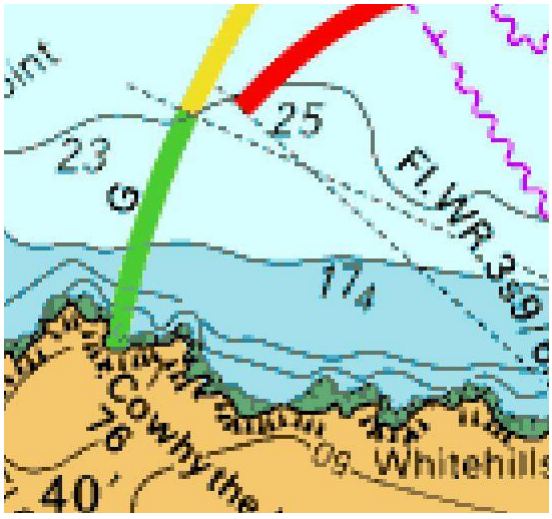
Further assessment of sites against the key parameters identified, and maps, geological information and marine charts, are provided on the following 3 pages.

Boyne Bay, Portsoy

For	Against
• Sandy, gravelly seabed • 15-20m depth of water • No protected designations or habitats • Lower fishing vessel density • Relatively close to Whitehills Harbour • No conflict with leisure activities/marine tourism	• Less sheltered than other locations but lower wave intensity further West • Portsoy harbour itself is tidal and can be difficult to access in certain sea states

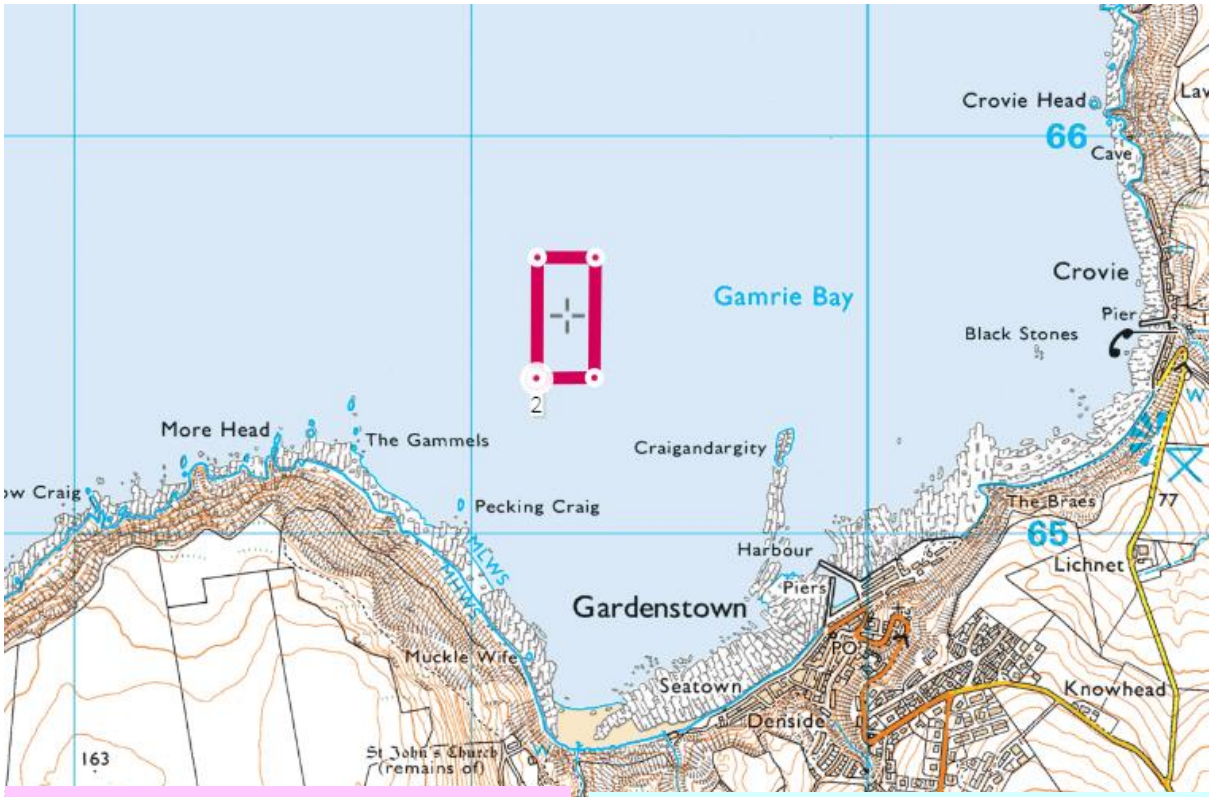


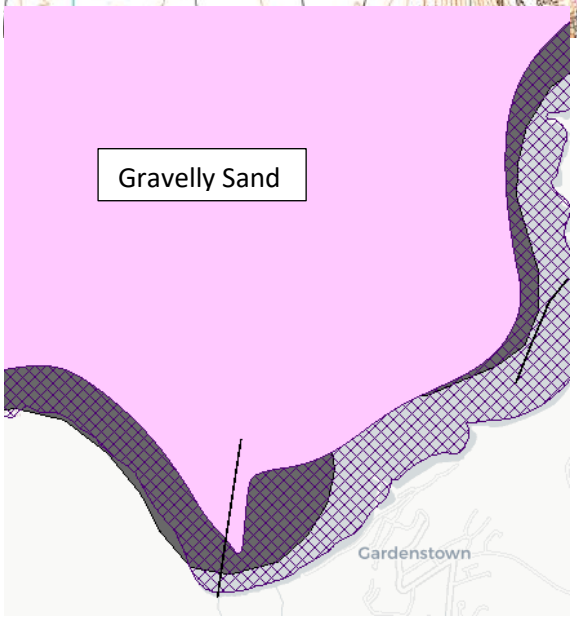


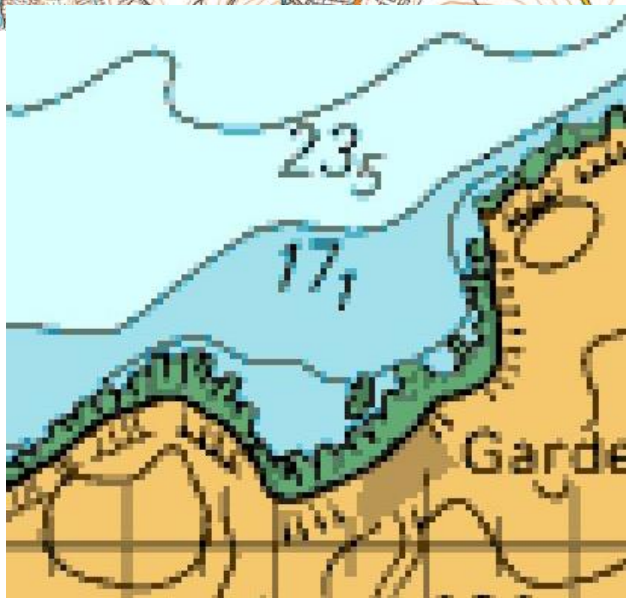


Gamrie Bay, Gardenstown

For	Against
• Sandy, gravelly seabed • 15-20m depth of water • Lower fishing vessel density • More sheltered from prevailing wind and open sea • Very close to harbour • No conflict with leisure activities/marine tourism	• Within the Troup Head SAC but unlikely to be significant development impact • 1km from secondary treated WWTW discharge • Potentially visible from Seatown and Crovie

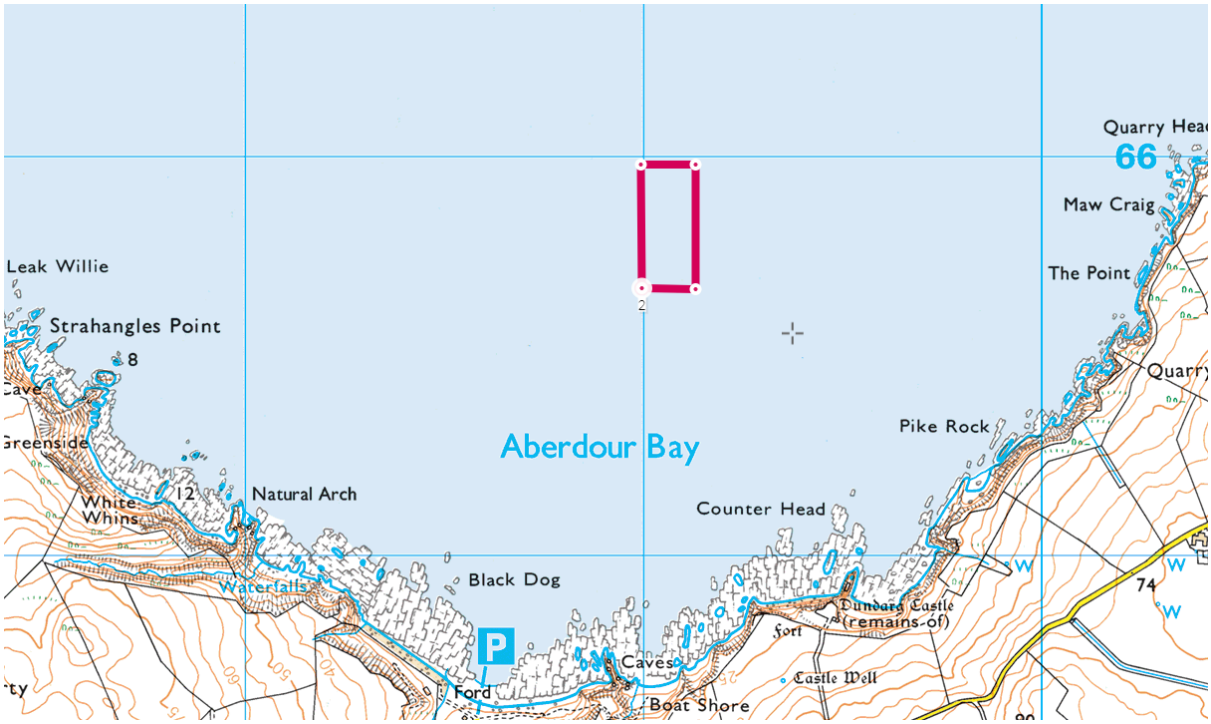


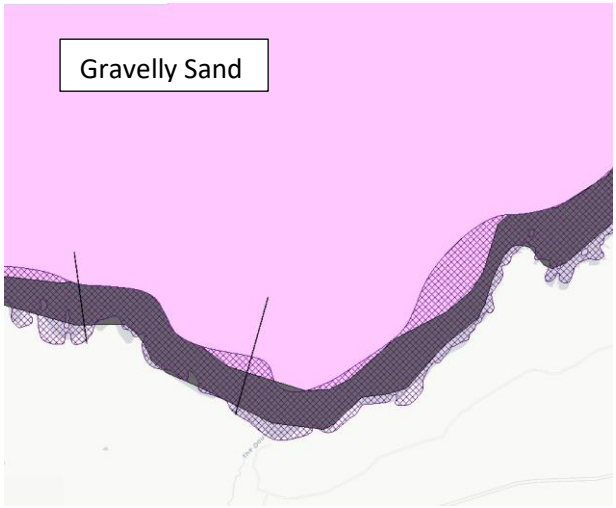


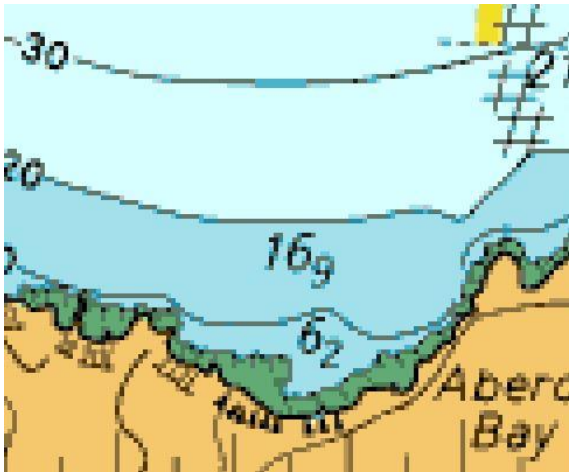


Aberdour Bay

For	Against
• Sandy, gravelly seabed • 15-20m depth of water • More sheltered from prevailing wind and open sea • No settlements nearby • No WWTW or industrial discharges	• Within the Troup Head SAC but unlikely to be significant development impact • Higher vessel density (safe anchorage) • Marine leisure activities (scuba diving) at East end of bay







4. Equipment and Facilities Required

Seaweed farm design consists of two main components, moorings and long lines, supported by floatation buoys. A mooring system is deployed at each end of the long line and depending on the length of longline and/or wave conditions it may be necessary to deploy one in the middle. When constructing the farm, the first phase consists of setting the moorings followed by the second phase of setting and seeding the longlines.

When considering farm design, the key goal is to ensure that the infrastructure and design chosen will keep the seaweed material in a stable position for the duration of the cultivation cycle. Variables such as volume of seaweed, intended end-use of the biomass and harvesting method will contribute to deciding the most appropriate farm design.

Farm design options include individual longlines, grid-based systems and double header longlines, all detailed below.

Individual Longlines

An individual longline seaweed farm set up consists of moorings every 100m. This could be seen as a relatively cost-effective option as construction is simple. Yet these may not be as economically viable at a large scale due to the number of moorings required. This set up is often used when carrying out trial farming. The system consists of 100m to 200m long seeded lines suspended in parallel lines.

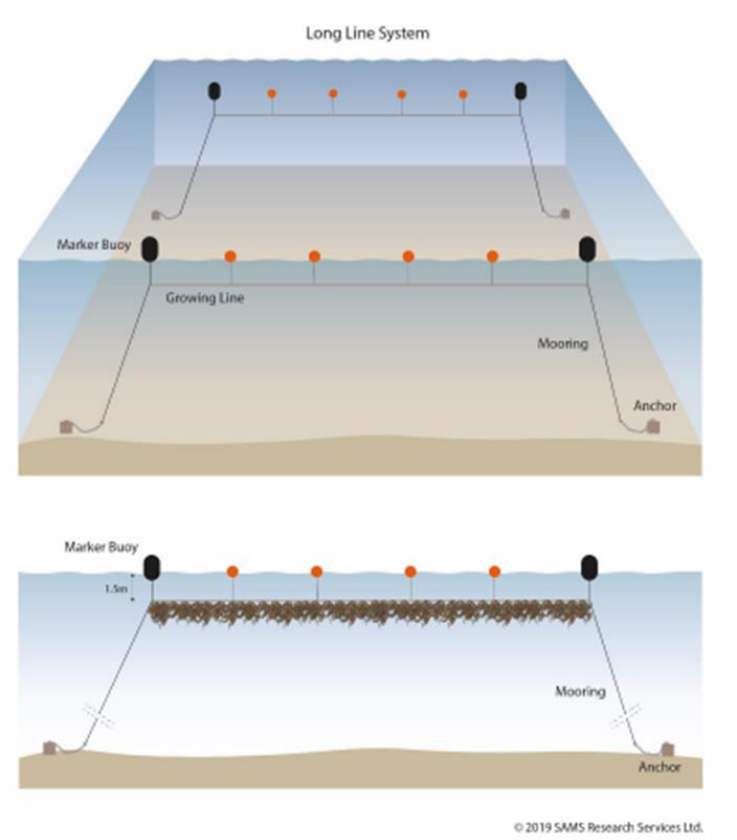


Figure 4.1 – Diagrammatic view of a pair of double headed rope mussel systems used for seaweed cultivation.

Grid Based System

A grid-based system is most suitable for the small/medium farm systems i.e. more than 3,000m of longline that are considered the purposes of this study. A sub-surface rope is positioned at a depth below the surface (around 2 to 3m). This is then anchored in all directions using embedded anchors or pilings, supported by surface buoyancy aids. Seeded rope is then positioned in the grid system a set distance apart. The main disadvantage of this system is the need for mechanical harvesting as the grid being tensioned below the water means it can be more difficult to access without mechanical aid.

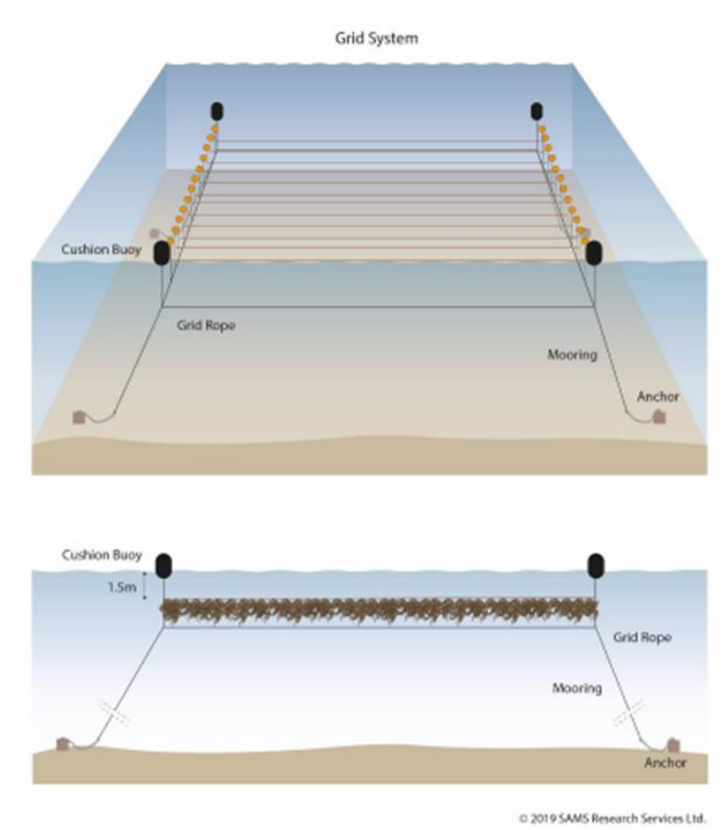


Figure 4.2 – Diagrammatic view of a grid based system used for seaweed cultivation. *© SAMS Enterprise Copyright, All rights reserved*

Double Header Longlines

Double header longlines are most commonly used when the seaweed farm is being set up on a disused mussel farm. The double header system is only suitable when a small amount of biomass is being produced and is only economically viable when setting up using repurposed equipment from a mussel farm.

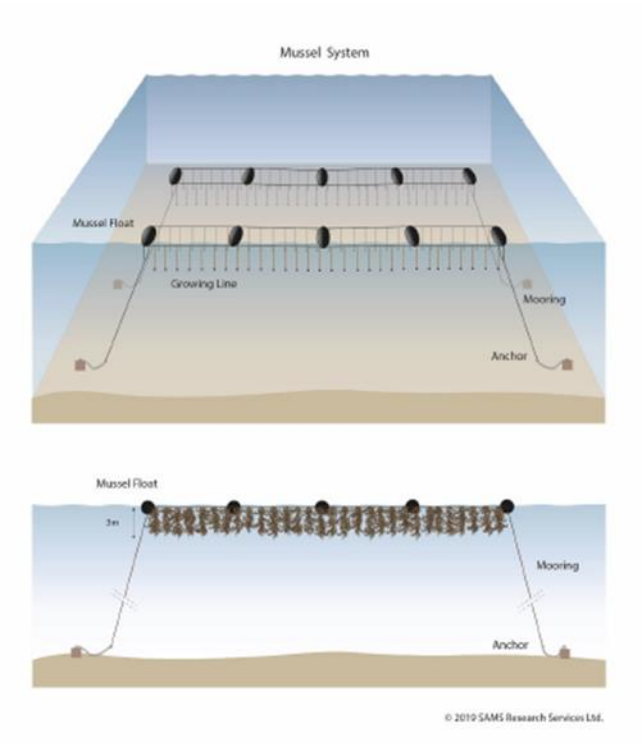


Figure 4.3 – Diagrammatic view of a pair of double-headed rope mussel systems used for seaweed cultivation.

When setting up a small/medium sized farm, depending on size and site conditions, a grid based farm design would be the most desirable option.

Cost Modelling

Start-up costs for a Seaweed Farm depend mainly on the size of the farm, with economies of scale dictating smaller costs (per linear metre of growing line) the bigger the farm, if a tightly spaced grid system is adopted in preference to individual long-lines. However, a tightly spaced grid introduces the risk of losing crops, particularly in high energy wave environments, as the seaweed can grow to in excess of 4m and become entangled with seaweed on adjacent lines, making it too heavy to lift for harvest. For this reason, a spacing of 8-10m between lines is recommended.

Initial equipment/capital must include (quantities and sizing dependent on farm size):

- Anchors
- Heavy chain link
- Anchor rope and buoy
- Header rope
- Buoys
- Marker and navigation buoys

Start-up costs will consist of:

- Infrastructure set up costs
- IT/Computer
- Telephones/broadband
- Capital equipment expenditure (as above)
- Tools
- Vehicles
- Professional fees (e.g divers)
- Insurance
- Marine License
- Wage/recruitment
- Vessel hiring/ operating costs

Operating costs:

- Salaries
- Vessel running costs
- Refrigerated transport
- Hiab hire
- Consumables/ materials
- Marketing
- Bank Charges
- Accountancy fees
- Crown Estate lease costs
- General office costs (printing, post, stationary)
- Drying/processing costs

From research into seaweed farms currently in production in Scottish waters, there is limited information to be made due to the relative infancy of the seaweed farming industry – many facilities are so small they would be considered "trials" rather than commercially viable as stand-alone businesses.

In order to establish the cost of capital equipment for a seaweed farm start-up, we have compared and analysed the costs submitted as part of algal farm Marine License applications submitted.

Southwest Mull and Iona Development Trust (SWMID) have been granted a planning application (00008878) for Aird Fada site on the Isle of Mull. The proposed site consists of 6nr x 200m double headlines (similar to that of double mussel growing line) with 22 anchors. The site will be 500,000m² with a total length of 30,000m of growing line. Estimated cost of the infrastructure for this farm is £150,000, which equates to £5 per linear metre of growing line.

Kelp Crofting are currently growing kelp within an existing aquaculture site off Skye, which has been used to cultivate shellfish for many years and has an algal licence in place. The company have also recently been granted a marine licence for a new kelp farm in the waters of South Pabay, which will be installed in 2021. KelpCrofting are currently in year 1 of operation, with their first harvest. The site is currently in year 1 of operation, with their first harvest completed (commenced April 2021). The Pabay site, when fully operational, will consist of two grids of 150m longlines, spaced 5-8m apart. The total growing area is 131,250m² with the full area of development 3.5 hectares. This site has 40nr

150m longlines, meaning a total capacity of 6,000m longline and an estimated cost of works being £43,600, coming in at £7.27 per metre.

New Wave Foods Ltd have submitted an application for Sound of Insh site located at West of Seil, Argyll. It is suspected that this site is using existing mussel growing infrastructure as they are using grid systems - 24 x 50m x 50m grids (600m x 100m). Each grid can hold 24- 48 50m longlines – totalling an estimated 36 longlines. The site will have capacity for 43,200m of longlines, with an estimated cost of £200,000, which equates to £4.63 per metre.

Several other marine licenses for seaweed farms have been submitted over the last 3 years, however:

- their total growth of longline comes in at 500m or below and for the purposes of this study they have been discounted them as trial sites.
- Quantity or quality of information provided within the application is inadequate to undertake meaningful assessment.

Engagement with suppliers of seaweed farm infrastructure has revealed that the actual costs are likely to be higher than the £4.63 to £7.27 per metre of growing line above. Some operators are using existing infrastructure or second-hand equipment, spacing long-lines closer together than recommended, or operating with reduced quantities or lower specification moorings, buoys etc. Given that the wave exposure of the North Aberdeenshire coast is generally higher than the sheltered locations proposed on the west coast of Scotland, it is recommended that a cost of £10.00 per metre of growing line should be adopted as a conservative estimate.

For the purpose of this study, a "small" seaweed farm is defined as having 3,000m of growing line, and a "medium" seaweed farm is defined as having 6,000m of growing line. This is in line with Scottish Government policy based on the belief that there is likely to be limited environmental impact from such sites (as described in Section 6).

The footprint of a 3,000m farm, with growing lines spaced at 8m, would be approx. 150 x 150 metres (22,500m^2) and a 6,000m farm would be approx. 300 x 150 metres (45,000m^2).

Through publicly available information and industry engagement we have listed below the estimated costs of a seaweed farm start up and operating costs. (Further detailed in Section 9)

Table 4.1 – Estimated costs of a seaweed farm start up and operating costs

Cultivation & Recurring Costs

Length of Growing Line	3000	6000
Seeded Rope	£9,000	£12,000
Staff Costs	£36,000	£60,000
Office Costs (IT/Comms)	£1,200	£1,200
Insurance	£1,600	£2,000
Crown Estates Lease	£2,500	£5,000
Vessel Operating Costs	£4,500	£6,000
Consumables	£1,000	£1,500
Additional Labour/ Boat for Harvest	£9,000	£15,000
Sub Total	£67,800	£108,700

Table 4.1 Notes:

1. purchase of a suitable boat is excluded from costs, as it is anticipated that seaweed farms will be operated initially by the inshore fishing fleet. A suitable vessel is likely to cost in excess of £20,000.

Capital Equipment		
Length of Growing Line	3000	6000
Ropes & Shackles	£3,000	£5,000
Anchors, chain and large cushion buoys	£6,000	£10,000
Small trawl buoys	£1,500	£2,500
Mooring node rings	£4,800	£8,000
Navigation lights (x2)	£2,000	£2,000
Marine safety equipment	£2,500	£2,500
Installation	£12,000	£20,000
Sub Total	£31,800	£50,000
£/m Growing Line	£11	£8

Table 4.2 – Estimated costs of a seaweed farm start-up capital equipment costs

Table 4.3 – Estimated costs of a seaweed farm start-up one-off up-front and optional equipment costs

One-Off Up-Front Costs		
Site Survey	£2,400	£4,000
Consultancy Support - PAC and Marine Licence	£1,500	£3,000
Marine Licence	£750	£750
Advertising and Public Notices	£1,000	£1,000
Tools	£2,000	£2,000
Sub Total	£7,650	£10,750

Optional Equipment*		
Work Boat	£20,000	£20,000
Sub Total	£20,000	£20,000

Total	£59,450	£80,750

**Work Boat not required if seaweed farming business started by inshore fishermen*

A key cost will be seeded rope for cultivation. SAMS is currently the only seeded rope supplier of scale. Indicative costs (for both *Saccharina latissima* and *Alaria esculenta*) would be as follows: range from ca. £4 per m to £2 per m. The latter for larger scale farms. Other potential suppliers include GreenOcean in Pembrokeshire, various suppliers in Holland, and potentially in future by existing seaweed producers such as Kelp Crofting (who have their own nursery) diversifying their offering.

The above shows indicative costs and times for year 1 of cultivation for a farm in Scotland. It must be caveated that the need for the above may be dependent on the scale of product produced and/or requirements of the end user. For example, if a food grade product is being produced there may be further costs associated for industry certifications such as: ASC – MSC Seaweed Standard, Soil Association Organic Seaweed Standard and MSE Seaweed Farmer Certification. All may have costs

associated but also may yield a higher cost per tonne from the end user. This is a section that may be looked further when discussing requirements of the end user.

The operation of the kelp farm is similar to any farmer or fisherman's work. Each phase of the operation has requirements which vary over time. Once the seeded rope has been placed on site the frequency of visits will drop to weekly (as outlined in the marine license). When approaching harvest visits may become more frequent as long-lines become heavier as the seaweed grows, so lines start to sink and floats must be added to keep them up near the surface.

5. Guidance for Operators: Marine Licencing & Consents

Introduction

The aquaculture industry is covered by the Town and Country Planning (Scotland) Act 1997 and The Town and Country Planning (Marine Fish Farming) (Scotland) Regulations 2013, which is defined as the breeding, rearing or keeping of fish or shellfish (including any kind of crustacean, mollusc or sea urchin). Seaweed cultivation is excluded and is not covered by either act.

Seaweed cultivation, or "Algal Farms" are regulated by Marine Scotland, with the Marine Scotland Licensing Operations Team (MS-LOT) providing marine licensing services and enforcement under the Marine (Scotland) Act 2010 within Scottish inshore waters.

In addition, permission must be obtained from the landowner of the seabed, which in this case is Crown Estates Scotland (CES), and a lease agreement obtained, which incurs an annual fee.

The Scottish Government published a "Seaweed cultivation policy statement" in 2017 which was broadly supportive of this nascent industry sector, with the following policies adopted:

- **Policy 1 - In principle, the SG is supportive of small-medium farm seaweed cultivation, subject to regulatory consideration; the General Policies set out in Chapter 4 of Scotland's' National Marine Plan; and any other relevant policies within that Plan. Applications for such seaweed farms should demonstrate that mitigation measures have been considered to prevent adverse environmental impacts, and set out how these will be delivered.**
- **Policy 2 - Only species native to the area where seaweed cultivation will take place should be cultivated, to minimise the risk from non-native species.**
- **Policy 3 - Where seaweed is grown for human consumption, cultivators should site farms away from sewage outfalls and other potential sources of pollution.**
- **Policy 4 - Equipment used in seaweed cultivation should be fit for purpose to withstand damage from adverse weather conditions.**
- **Policy 5 - Other marine users and activities should be considered in the siting of farms.**
- **Policy 6 - Small-medium size farming is unlikely to be spatially limited, and may be located anywhere in Scotland, subject to agreement and appropriate local conditions.**
- **Policy 7 - The SG is supportive of IMTA.**

With respect to development size, a distinction is made between "small to medium" farms, with 0 – 50 x 200m lines (up to 10,000m of growing line) and "large" farms with more than 50 x 200m lines. At the time, it was believed that smaller scale seaweed farms with up to 30 x 200m lines may grow significantly in the short-to-medium term, and that there is likely to be limited environmental impact from such sites.

There was no consensus over the size or viability of large farms over 50 x 200m lines, as the industry was very much in its infancy, and potential for biofuel production was limited by technical feasibility, economic and environmental considerations.

There is a presumption in favour of supporting development of small to medium seaweed farms providing the policies above are adhered to, in particular compliance with Chapter 4 of Scotland's National Marine Plan.

In the last three years, there have been 15 Marine Licence applications for Algal Farms in Scotland with 6 applications to date being granted.

Any proposed seaweed cultivation site located within the Troup Pennan and Lion's Head Special Protection Area would require a Habitats Regulation Appraisal (HRA). Initial engagement was carried out with NatureScot who advised that; It is likely that the key interaction with the SPA would relate to possible disturbance, primarily as a result of construction works and operational activities but possibly also as a result of the infrastructure itself. Potential entanglement of diving species may also be a consideration, but this is likely to depend on the specific equipment that is being proposed. Any possible interactions would need to be considered on a site-by-site basis and they would be happy to provide further detailed advice should there be any desire to progress a proposal at any of these locations. They also advised that; another important consideration for this broad location, and indeed much of the North Aberdeenshire Coast, relates to possible interaction with cetaceans. This is particularly relevant to minke whale, which are known to be vulnerable to entanglement. The location's highlighted within section 4 are within the Southern Trench MPA which supports minke whale as a protected feature. Any proposal in this location would therefore need to have an MPA appraisal carried out to consider any risk posed to the minke whale feature of the MPA . In addition to minke whale, common dolphins from the Moray Firth SAC will also utilise this area and an HRA is therefore likely to be required.

The HRA is carried out by the regulatory body, MS-LOT, with advice from NatureScot. The actual HRA does not incur a cost, however, NatureScot would seek that the information required to carry out an HRA is provided by the applicant who wishes to develop the site. The information that is required will be site and species specific and will depend on various factors. In some cases simple information relating to the operations and equipment is sufficient, in which case there would be very minimal cost. In other cases there may be a need for specific survey work to obtain the required information, in which case there could be more significant costs incurred. To date NatureScot have not required site-specific survey work for any seaweed farm in Scotland, but they advised that is not to say there will never be a requirement for such work.

Another important consideration for this broad location, and indeed much of the North Aberdeenshire Coast, relates to possible interaction with cetaceans. This is particularly relevant to minke whale, which are known to be vulnerable to entanglement. The location highlighted is within the Southern Trench MPA which supports minke whale as a protected feature. Any proposal in this location would therefore need to have an MPA appraisal carried out to consider any risk posed to the minke whale feature of the MPA . In addition to minke whale, common dolphins from the Moray Firth SAC will also utilise this area and an HRA is therefore likely to be required also.

Marine Licence – Pre-application Consultation (PAC)

In advance of submitting a marine licence application, a Pre-Application Consultation (PAC) under the Marine Licensing (Pre-application Consultation) (Scotland) Regulations 2013, may be required.

The normal trigger for a PAC is where the area of works exceed 1,000m^2, or if there are exceptional site specific challenges (environmental, local sea conflicts etc).

If the proposal is on the cusp, or unsure, then a prospective applicant for a marine licence may request a PAC Statement from MS-LOT to confirm whether a PAC is required.

Although perceived by many in the sector to be onerous and un-necessary, a PAC offers advantages in that it allows issues to be resolved in advance of the full application submission; and can be used to demonstrate that other requirements are met to the satisfaction of statutory consultees, potentially avoiding the need for Environmental Impact and other Assessments, thus smoothing the progress of the full application.

Guidance on the PAC process is available online:

https://www.webarchive.org.uk/wayback/archive/3000/https://www.gov.scot/Resource/0043/00439649.pdf

The relevant sections of the guidance are reproduced below:

> *Public pre-application consultation consists of at least one public event where local communities, environmental groups, NGOs, regulators and other interested parties are given the opportunity to consider and comment upon a prospective application for those marine licensable activities that are prescribed in the Regulations.*
>
> *The prospective applicant must notify the following statutory consultees that an application for a marine licence for a prescribed activity is to be submitted to MSLOT:*
>
> - *The Commissioners of Northern Lighthouses*
> - *The Maritime and Coastguard Agency*
> - *The Scottish Environment Protection Agency*
> - *Scottish Natural Heritage*
> - *Any delegate for the relevant marine region or regions, when such delegates have been established under Section 12(1) of the Marine (Scotland) Act 2010*
>
> *The notification should include basic information relating to the application and include the time and location of the consultation event. The notification must be made at least 6 weeks in advance of the event.*
>
> *No less than 6 weeks in advance of the public pre-application consultation event, the prospective applicant must also publish in a local newspaper a notice containing:*
>
> - *A description, including location, of the marine licensable activity.*
> - *Details as to where further details concerning the activity may be obtained.*
> - *The date and place of the pre-application consultation event.*
> - *A statement explaining how persons wishing to provide comments may do so and the date by which this must be done.*
> - *A statement clarifying that comments are made to the prospective applicant and not to MS-LOT and that there will be an opportunity for representations to be made to MS-LOT on the application.*

The consultation event must be held in a suitably accessible venue local to the algal farm, and, providing that the application is made within one year of the event, no further consultation is required.

There is no formal guidance on what information should be provided to consultees (either interested parties attending the event or statutory consultees). Therefore, in-keeping with the Marine Licence Application, as a minimum, it is recommended that the following is provided:

- Referencing the PAC requirements under the Marine (Scotland) Act 2010.
- A description, including location, of the proposed works/ activity.
- Identification of protected areas e.g., SAC, SSSI, SPA, MPA, Ramsar or similar conservation area boundary; and protected species.
- Environmental Impact Assessment (EIA) Screening to determine if an EIA is required. It should be noted that, to date, no algal farms have been required to submit an EIA.
- Stakeholder Engagement: As a minimum, the below should be consulted:
    - Northern Lighthouse Board (NLB).
    - Maritime and Coastguard Agency (MCA).
    - Scottish Environment Protection Agency (SEPA).
    - Scottish Natural Heritage (SNH).
    - Crown Estate Scotland (CES).
    - Local trawl and creel fishermen.
    - Royal yachting Association (RYA).
    - Local residents/ members of the public.
    - Local community councils.
    - Any harbour authorities/ associations.
    - Other local users within the immediate vicinity of the proposed activity.
- Details of the key areas discussed, how the information will be reported and recorded, feedback received and how concerns will be addressed.
- Post application and how any future stakeholders will be engaged with, and how the original group will be updated.

Crown Estates Scotland (CES)

For use of the seabed for any proposed activity, a form of agreement and associated fees with CES are required. The fees are discussed with the CES agent, Bidwells, and are broken down as follows:

- the cost of processing the application, based on the complexity of the works. The area where the works are proposed will be reviewed against CES records to verify if and how the proposed activity is likely to affect the Crown foreshore and seabed as well as any potential impacts on existing tenants.
- an annual fee, which is dependent on the type of works and profit of the proposed activity, rather than per square metres.

MS-LOT Marine Licence Application

Timescales

The determination timeframe for a Marine Licence (ML) is 14 weeks, which should be met, providing the applicant has submitted all required information. If at any point MS-LOT requires to go back to the applicant for further information, then the timeframe would be paused to allow for the applicant's response.

Once approved, a ML is normally valid for 6 years from the ML start date.

Application Information and Documentation

A lot of the information as detailed within the PAC, will be similar to the specific information and documents required for the application, which are outlined below:

- Algal Farm Details:
    - Deposits/ removals of algal farm component parts/ equipment as a number (e.g., 4 lines). Provide details of any component parts/ equipment not included in the list and specify the quantity as a number.
    - Total area of proposed works in square metres.
    - Start dates. *Note that it is a legal offence to commence work without a licence in place.*
    - Value of the works seawards of the tidal limit of MHWS, inclusive of the cost of materials, labour fees etc.
    - Location of the proposed works (latitude and longitude of co-ordinates for the boundary points of the moorings area.
    - Photographs of project location.
    - Ordnance Survey map, 1:2,500 scale (and not more than 1:10,000) or Admiralty Chart; marked to indicate the full extent of the works, co-ordinates, MHWS level, adjacent protected areas (outlined in PAC above).
    - If the farm is located within the jurisdiction of a statutory harbour authority (SHA) and where relevant, provide details of the SHA.
- Project Drawings.
- Method statements of how the works will be constructed/ installed and then maintained.
- Pre-application Report (if applicable).
- PAC Report (If applicable).
- Provide details of the assessment of the potential impacts the works may have on other users of the sea (if undertaken, stakeholder engagements from the PAC); and mitigation measures.
- Noise Registry.
- Show due consideration (and provide details) of the project with reference to Scotland's National Marine Plan policies, including but not limited to General Policy 7 (GEN 7).
- Consultation (other than carried out under pre-application consultation).
- Confirm, and where relevant, provide details of any other marine projects (e.g., pontoon, moorings etc) that the project is associated with.

6. Timescales

The timescales for establishing seaweed cultivation by a new operator using this report as a basis are estimated below, however it must be noted that there are several constraints (mainly seasonal) which have the potential to slow development.

Constraints

Several constraints to setting up a new farm have been identified and are outlined below.

- The seaweed growing seasons is typically Oct/November to April/May/June.
- Food grade for human consumption is likely to be harvested in late May/early June to mitigate risk of bio-fouling - the yield should be around 8kg per metre of growing line.
- Non-food grade can be harvested later in August, when a higher yield can be expected, up to 12kg per metre of growing line.
- In some locations, it is essential to harvest seaweed before the end of May to avoid excessive biofouling which reduces the value of the crop.
- In the start-up phase, it is desirable (though not essential) to deploy Waverider buoys to gather wave data to inform the design of the farm infrastructure, preferably in the winter when wave strength is highest, and more extreme events occur.

Activities

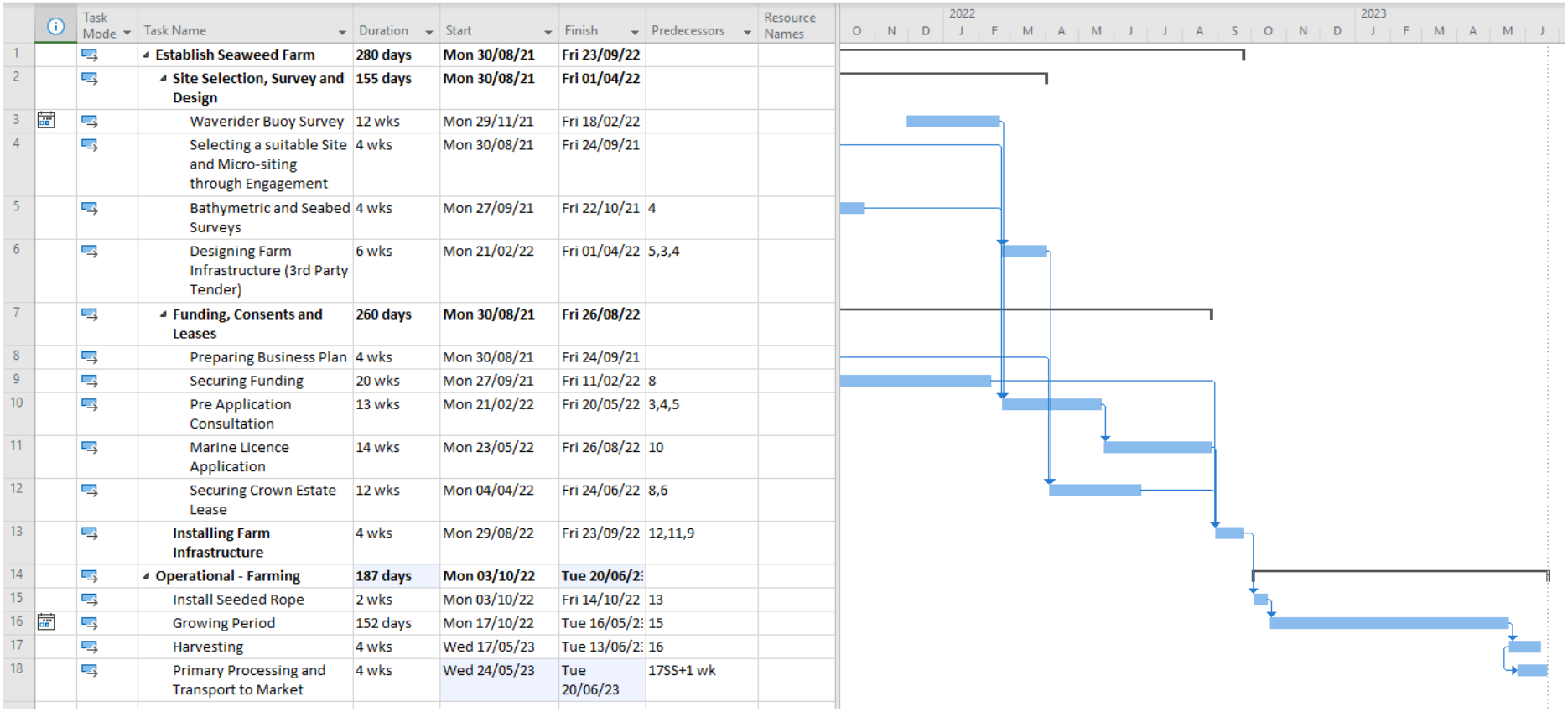
The activities required to be undertaken to set up a farm, along with the estimated timescales are detailed below. The duration and dependencies are further detailed on the programme on page 43.

- Select a suitable site and micro-site the farm infrastructure through engagement with existing marine users e.g. inshore fishermen – allow 4 weeks.
- Undertake bathymetric and seabed surveys to verify depth and seabed surface conditions – allow 4 weeks.
- Waverider buoy deployment – allow 12 weeks (may run concurrently with engagement and bathymetric and seabed surveys).
- Once these activities are complete, a tender can be issued to 3rd parties to design the farm infrastructure and provide cost estimates – allow 6 weeks.
- A business plan based on budget costs can be prepared at any time – allow 4 weeks. Then work can commence on securing funding (for example grant funding applications, bank loans) – allow 20 weeks.
- Once the site surveys are complete, Pre-Application Consultation can commence for the Marine Licence – allow 13 weeks.
- Marine Licencing Application – allow 14 weeks.
- Work on securing the Crown Estate Lease can commence as soon as the farm infrastructure design is complete – allow 6 weeks.

- Once funding is secured, Crown Estates lease signed, and Marine Licence granted, work can commence to install farm infrastructure – allow 4 weeks.

In summary, the process from selecting a suitable site to completing installation of infrastructure is estimated to take in the region of 285 working days (Mon-Fri) or 57 weeks, assuming no delays during the Marine Scotland consenting process.

The risk for potential operators is that the critical path follows the Waverider buoy survey and consenting process, and any delay in securing consent could result in a reduced or missed growing season.



	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1		**Establish Seaweed Farm**	**280 days**	**Mon 30/08/21**	**Fri 23/09/22**		
2		**Site Selection, Survey and Design**	**155 days**	**Mon 30/08/21**	**Fri 01/04/22**		
3		Waverider Buoy Survey	12 wks	Mon 29/11/21	Fri 18/02/22		
4		Selecting a suitable Site and Micro-siting through Engagement	4 wks	Mon 30/08/21	Fri 24/09/21		
5		Bathymetric and Seabed Surveys	4 wks	Mon 27/09/21	Fri 22/10/21	4	
6		Designing Farm Infrastructure (3rd Party Tender)	6 wks	Mon 21/02/22	Fri 01/04/22	5,3,4	
7		**Funding, Consents and Leases**	**260 days**	**Mon 30/08/21**	**Fri 26/08/22**		
8		Preparing Business Plan	4 wks	Mon 30/08/21	Fri 24/09/21		
9		Securing Funding	20 wks	Mon 27/09/21	Fri 11/02/22	8	
10		Pre Application Consultation	13 wks	Mon 21/02/22	Fri 20/05/22	3,4,5	
11		Marine Licence Application	14 wks	Mon 23/05/22	Fri 26/08/22	10	
12		Securing Crown Estate Lease	12 wks	Mon 04/04/22	Fri 24/06/22	8,6	
13		**Installing Farm Infrastructure**	4 wks	Mon 29/08/22	Fri 23/09/22	12,11,9	
14		**Operational - Farming**	**187 days**	**Mon 03/10/22**	**Tue 20/06/2**		
15		Install Seeded Rope	2 wks	Mon 03/10/22	Fri 14/10/22	13	
16		Growing Period	152 days	Mon 17/10/22	Tue 16/05/2	15	
17		Harvesting	4 wks	Wed 17/05/23	Tue 13/06/2	16	
18		Primary Processing and Transport to Market	4 wks	Wed 24/05/23	Tue 20/06/23	17SS+1 wk	

Figure 6.1 – Indicative Programme showing the timescale for the establishment of a new Seaweed Farm

7. Routes to Market: Market Intelligence Report

Product Opportunities

From both the site and target species selections we have established that for seaweed cultivation on the Aberdeenshire coast, the most attractive species identified in section 1 are: main option, *Laminaria saccharina* (Sugar Kelp) and secondary option, *Alaria esculenta* (Dabberlocks, Winged Kelp).

Laminaria saccharina, commonly known as sugar kelp, can be dried, and milled into a powder and then sold on in its bulk state. The alginate contains polysaccharides. These molecules have significant benefit to improving skin properties as they essentially hydrate and form a protective layer over the skin. They also contain other polysaccharides – one called laminarin, that has significant decongestant and lipid-reducing benefits that are scientifically proven to help acne prone skin. Another benefit of

Laminaria saccharina extracts is a phenolic compound that has antioxidant properties that have been proven to give skin a significant level of protection against polluted urban air. As a result of the above *Laminaria saccharina* extracts are becoming significantly more popular for use in skin care and make up products with multi-national brands such as Clinique, Estee Lauder and L'oreal Paris to name but a few. Currently there are 13,000 macroalgae's identified across the world. In order to put the use of seaweeds in cosmetics in context, it is important to state that currently only 50 species are used in cosmetic production – meaning there is a whole world of product opportunities still out there to explore. Brown macroalgaes are the most market evolved of the seaweed products, compared with green or red, as more research has been undertaken and its scientific properties, resulting in significantly more information available on the safety and health benefits of using *Laminarina saccharina* as a food grade product – in its bulk state on salads/poultry dishes, as an extract used in health supplements and as mentioned as an animal feed additive.

For the purposes of this study and the possible routes to market in the Aberdeenshire area, the markets for human grade food products initially is the key areas of interest. Other areas as listed below may be options for the future when high volumes of cultivated product can be grown and processed.

***Alaria esculenta*,** commonly known as Dabberlocks or winged kelp, is also a brown kelp that is historically used as fodder for cattle or fertiliser for plants. Similarly, to sugar kelp, the product can be consumed in its raw wet state or milled and used/sold as a dried powder. As a food grade product *Alaria esculenta* is seen as a 'slightly sweetish' taste and so can be used in a variety of culinary dishes. With very similar properties to *Laminaria saccharina*, it is also used in cosmetics products claiming benefits such as antioxidant, hydrating and anti-aging properties. Again, as the product has similar properties to sugar kelp, production of both food grade and animal feed products would be comparable. For the purpose of this study, the best macroalgae species to be cultivated in bulk in Aberdeenshire would depend on the demand of the end user – but both Sugar kelp and Dabberlocks would be considered the most commercial and naturally wide-ranging species and so the best place to start.

Primary Processing Opportunities

The seaweed cultivation sector in Scotland is limited by the availability of facilities to process the raw product. The market in Scotland currently consists of fewer than 20 small/medium companies that are predominantly harvesting wild seaweeds for use in their own branded products. As detailed further in the case study section of this report, apart from small scale trial cultivation sites in Scotland, KelpCrofting is the only company currently trading that is cultivating and growing their own product. It is clear therefore that the seaweed sector in Scotland is still very much in its infancy and so in order for the sector to scale-up there is a significant need for additional processing capability to handle raw bulk product.

In the recent SAMS publication, 'Seaweed Farming Feasibility Study' for Argyll and Bute Council; the major limitation to industry growth was identified as the 'Role of the Intermediary.' SAMS stated that:

Key areas of weakness within the seaweed industry in Scotland were as follows:

1. Unknowns regarding food standards and what is required of them.
2. The logistical implications of a fully functioning sector.
3. More broadly the development of a contract model that allows everyone to invest in their respective functions.

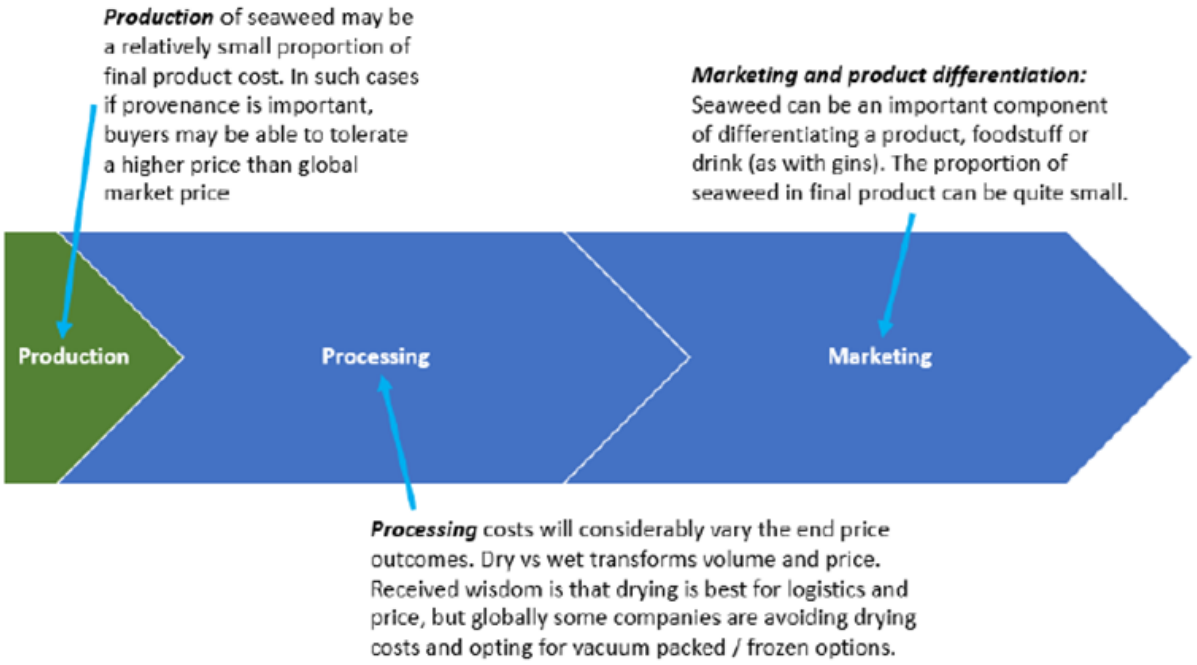


Table 7.1 – Full value chain potential for seaweed, *taken from SAMS 'Seaweed Farming Feasibility Study' publication.*

The role of the intermediary is as identified above in the processing element of the value chain. The primary seaweed product would be cultivated by the farmer and formulated into a branded product by the end user but there is a significant gap in the middle. The existing processors in the UK are:

- Hebridean Seaweed based in Stornoway, Isle of Lewis (as discussed further in the case study section).
- Uist Asco, based in North Uist – who carry out primary processing of wild harvested product.

- SHORE (The Scottish Seaweed Co.), based in Wick, carry out small-scale processing of wild harvested product.
- Calsea (Caledonian Seaweeds), based in Argyll, are a Scottish company looking at co-ordinating the sector by using an online forum to bring together all partners in one place – including seaweed producers, sellers and buyers. Their plan is to develop a 'foundation' model in order to nurture the Scottish industry and ensure that it scales up with partner farmers. As stated on their website they aim to: *"act as 'the hub of the wheel', establishing the new Partner-Farms, and the Partner-Farmer commits to managing the farm on a daily basis. Through clustering these farms, together, a new and exciting Scottish seaweed sector will be created."*

The SAMS study (as mentioned above) and the identification of the limiting factor of the role of the intermediary was more specifically relevant to the West Coast of Scotland, where currently most of the seaweed cultivation is carried out. Although – still limiting – the situation is slightly different in Aberdeenshire. The region is significantly more industrialised and so processing factories and logistics options are significantly better.

Processing Capabilities

Once grown and harvested, the seaweed will either be sold on as a wet bulk product (less common but customer requirement dependent) or as a dried/milled product. In order to cater for customer requirements, it is extremely important for the long-term commercial success of seaweed cultivation in Aberdeenshire that there are processing (specifically drying) options in place – once there is sufficient production volume to justify this.

Initially, it was considered that due to the similarities between bulk drying of seaweed product and cereal/grains this was as a possible processing option. Following engagement with local grain processors this was initially ruled out. As the seaweed would be initially transported to the grain factory in a wet bulk state, it may cause a hazard as the factory currently would only deal with dry cereal products. It was therefore considered not to be an option due to cross contamination between relatively dry and wet seaweed.

Following engagement with Frontier Agriculture/ Aberdeen Grain, it is now believed that there may be processing capability within this sector. It was stated that the seasonality of seaweed would align well with grain processing in the northeast, as 10.5 months of the year there is huge underutilised drying capacity available.

Frontier/Aberdeen Grain described the drying methods they currently carry out in the area:

- Continual flow drying (silo) - not applicable for seaweed.
- Mobile flow drying (silo)
- On floor drying – many growers would have availability for this.
- Trays with controlled temperature and air flow circulating, both important in avoiding adverse effects on the nutritional/structural integrity of the product.

It was advised that they may have 100-150t capacity in many locations and would be very happy to coordinate a trial batch with potential growers (e.g 20t). This could be a potential processing option to explore further.

The processing of cultivated seaweed may be as simple as drying/ milling and/or freezing. The most beneficial processing option would be a food-grade processing factory that currently carries out these processes with other food products. Following desk-based research into food processing factories in

the region – with 24 hours to/from travelling distance from the coast. Mapco was identified as a suitable option.

Based in Peterhead, the Mapco Group specialises in dehydration of food products such as vegetables, pelagic fish, and salmon. During an initial phone consultation with the company, it was explained that seaweed processing was a market they considered entering pre-covid 19. It was stated they would definitely be interested in learning more about this project and that they are interested in entering the seaweed market. As an initial approximate figure, it was stated that if cultivation was to be carried out in the area initially Mapco would have capability to process 100 tonnes wet bulk product per week.

The recommendation going forward would be – if trial scale cultivation of seaweed were to be carried out in Aberdeenshire, Mapco would be interested in being a potential processing partner to the project.

Potential buyers of raw material

From initial research undertaken, requirements for wet bulk seaweed would be very much dependent on the end user – specifically the scale of their operation, their processing capabilities, and the end use of the product. As seaweed is a perishable product, transportation to a nearby factory with 24hours of harvest would be required with chilled and covered facilities a requirement. As the product would be in its wet state this will mean there is a high-water content and so transportation costs would be at a higher price point dependent on tonnage.

Unless specific end users made a requirement for wet bulk product e.g., for manufacturing of mulch or liquid fertiliser, it would be assumed that the primary product would be transported to a nearby factory to be processed e.g., dried or milled and/or frozen.

Food Grade

The health and well-being benefits of seaweed in the human diet is extensive including minerals, trace elements, vitamin groups, amino acids, polysaccharides, and antioxidants to name but a few. Countries such as Japan, China and South Korea feature cuisines such as sheets of nori used in dashi broth and green wakame used in salads and soups. In recent years, Western countries have adopted the use of seaweed in their diet more and more. Supermarkets such as Asda and Tesco both stock fresh seaweed in products such as sea spaghetti and sausages. Seaweed produce sold as an end product is one potential market for food grade products.

Seaweed is often eaten whole or milled with the most popular species in the UK being noted as laver or nori, dulse, carrageen or Irish moss, sea lettuce, sea spaghetti, Alaria esculenta and kombu. The largest consumption of seaweed comes from dried Porphyra and nori sheets used for sushi, most often imported. It is noted that the cost of seaweed is relatively high, with people of lower incomes unlikely to include seaweed in their diets unless they have harvested it themselves. A common seaweed product for human consumption in the UK is Welsh Laver Bread from South Wales; often wild harvested and prepared for the household or farmers markets.

Although the food market is there, it is in very small quantities and so the option to compete on a larger scale with cheap imports of product is simply not commercially feasible unless there is a dramatic surge in consumer demand for the product in a UK diet. For the purposes of this study, we believe that producing small quantities of high value food grade product is the most appropriate place to start in Aberdeenshire. For the purposes of the initial trial, food grade market is the key area of interest.

Considering the size and industrial nature of the food and drink industry in the Aberdeenshire area; there are potential options for seaweed being used as an extract in products. One option may be Kelp Ales – utilising the sustainability and flavour values of local companies such as Brew Dog. Another may be ice cream products such as those made by Mackies of Scotland. Carrageenan gum extracted from seaweed used in most milk products such as ice cream, chocolate milk and puddings. Carrageenan is obtained from several kinds of species belonging to the Rhodophyceae class (Red Algaes). Although not a species looked at for growing in the initial stages, if the market were there this could be a hugely profitable diversification option.

This could be used in local markets/outlets such as Humbug Aberdeen or City of Aberdeen Distillery. Use of seaweeds in popular distilled gins is on the rise and with the company ethos for City of Aberdeen Distillery stated as: 'For Aberdeen, by Aberdeen.' The use of a locally grown sustainable flavoursome product may be attractive.

When looking at growing and selling on the seaweed produce as a human or animal grade food product, certifications and standards should be considered. These may include:

- SOIL Association
- SALSA
- Vegan Society
- Biodynamic Agricultural Association
- FEMAS from PAI for animal feed

As with all food grade products within the UK and the EU, food certifications are key to unlocking markets. Manufacturers should undertake further research into each individual certification and at what stage of the production process their procedures apply.

- Does each accreditation require specific growing processes?
- Does each accreditation require specific drying processes?
- Do they have time limits; detailing how long the product can be out of the water before being processed?
- Does each accreditation have specific requests on logistics and movement of product?
- Can accreditations align with each other or is one of higher importance/priority?

Animal Feed

Seaweed is an excellent source of amino acids, antioxidants and fatty acids making it beneficial in both human and livestock diets. Feeding seaweed to livestock (cattle) has been proven to increase overall health and growth rates but more recently preliminary research has indicated a small amount of the marine algae added to cattle feed can reduce methane emissions from cattle gut microbes by as much as 99%. As a high contributor to global warming, one cow can produce up to 200kg of methane a year – this is significant and potentially key to mitigating climate change.

There is also recent research being done by Faroese Seaweed cultivator, Ocean Rainforest, with preliminary results in Denmark showing promising results in using fermented seaweed as a probiotic in pig feed as well as improving overall all health of the sows. Interestingly, results show that by introducing seaweed as 2-5% of the pigs diet it has increased their antibodies by 30-40% and had a direct impact on piglet health, reducing mortalities by 3-4%, thereby producing more piglets.

In Aberdeenshire there are a number of feed manufacturers such as Norvite and Pelagia. In order to understand if this would be a potential route to market within the area, initial engagement was carried out with the manufacturers mentioned.

Pelagia produce animal feed ingredients in the form of fishmeal and fish oil derived from fresh fish material. Their product is then sold onto markets where formulations are prepared to manufacture animal feed pellets which in turn are fed to livestock. Currently Pelagia only purchases fresh fish/co-products. If Pelagia were to be an end user of seaweed it would be a new business model albeit with a similar end user market.

Following engagement with the company, it was established that in order for seaweed to a commercially viable option, extensive volumes would be required. For context, Pelagia can process 700t per day of fish and co-products. As the product is perishable it is moved quickly into the factory and processed when fresh. It must be therefore for Pelagia there are natural synergies with seaweed as a marine ingredient, the challenge would be generating sufficient scale.

The recommendation given was: "If we can establish the output is valuable and people will pay for it and that there is volume, then there is a natural synergy and opportunity with Pelagia to use seaweed as a marine ingredient."

Norvite Animal Nutrition, based in Insch, consists of a mineral plant and two further blending plants in Scotland, producing high quality feed for livestock. Currently, they do use a small amount of dried Seaweed (sourced from Hebridean Seaweed) in their mineral supplements.

In recent years there has been more interest and coverage on the vast benefits of seaweed production. Both for consumption and for the environment. Norvite's main focus is ruminant and mono gastric feeds, which could potentially link in well with the use of algae products. Norvite advised that when seaweed is used as a mineral contributor it reduces the need for trace elements to be added such as copper, zinc and copper sulphites. Norvite advised that at present there can be challenges obtaining these elements from the Middle East due to greater competition from the car battery manufacturing industry.

Norvite would not use the seaweed directly as a feed material, which would demand scale, but as a supplement. Norvite can see potential use as feed material (fibre, small amount of protein) from sugar kelp if the high-volume quantities were available. Currently Norvite is using small proportions of seaweed but can see potential to increase these quantities.

The recommendation given: "Would be keen to investigate further and understand volume." Output of this study to be shared with them.

In conclusion, if correct volumes and necessary further engagement were to take place, we believe following initial research there would be a potential market for use of seaweed in animal products in Aberdeenshire.

Cosmetics

As discussed earlier in the report (Section 1) the use of seaweed in cosmetics products has seen a rise in recent years with large multi-national corporations as well as small boutique brands, utilising and promoting the use of seaweed in their products.

Local companies that may utilise seaweed products could include Natural Skincare Products and Blushberry Botanicals.

Pharmaceuticals

As discussed earlier in the report (Chapter 1) the use of seaweed in pharmaceutical and medical products is also an option. Alginate hydrogels have been particularly beneficial in wound healing, drug delivery, and tissue engineering applications to date. Two academics are currently working in this field. Mark Dorris from Edinburgh University is looking at the process to make nanocellulose from seaweed and Cherry Wainwright from Robert Gordon University is looking at novel agents to overcome obesity. If this were an industry chosen to explore further, both would be interesting contacts to engage with.

Chemicals (hydrocolloids)

Seaweed also has many uses as a source of hydrocolloid or industrial gum. Alginates are extracted from brown seaweeds (often kelps) that can be used as a thickening agent in aqueous solutions and forming gels. *Saccharina laminaria* is a species that can be used as a high-quality source of alginate.

At present the most common uses of seaweed in food manufacturing consumption in the UK are in hydrocolloids, alginate, agar and carrageenan as a stabiliser or thickener in products.

Another option and perhaps the most marketable option is seaweed extract for use in a variety of different everyday products. Seaweed extracts such as agar, carrageenan and alginates are used in a variety of food grade consumer products from toothpaste to ice-cream to beers. Recent studies have shown that animal derived carrageenans can have links to gut problems including tumours and ulcers. As an alternative carrageenans derived from red algae have been proven to have anti-cancer activity by improving immunity and targeting key apoptotic molecules and therefore deemed as potential chemotherapeutic or chemo preventive agents. (Liu & Gao, 2019)

Bioplastics

The sustainability benefits of using seaweed as a source of bioplastics has been gathering pace in recent years with Scottish company Oceanium looking at using high quality seaweed to create products with excellent sustainability credentials such as all-natural home compostable bio-packaging material. In May 2021, Oceanium announced first close of a seed funding round worth £2m led by Green Angel Syndicate and the World Wildlife Fund (WWF). The round follows early investment from ocean impact venture capital firm Katapult Ocean and Sky Ocean Ventures, as well as Scottish Enterprise. Oceanium noted that they plan to use the funds to scale up its bio-refinery and processing model to open up the market for the nascent sustainable seaweed farming industry. WWF noted in the press release (Paul Dobbins, senior director of impact investing at WWF) that "Oceanium's pioneering expansion of processing capacity for farmed seaweed is an exciting step for the industry. Brought to scale, cultivated seaweed could help achieve conservation goals by providing a nutritious source of food and livestock feed with less land and resource inputs - developing an innovative bio-refinery process will also help create feedstock for biodegradable packaging alternatives to petroleum-based plastics." This might be a company to engage with further to explore whether they have the capability to use seaweed produced in Aberdeenshire.

Another UK based company looking at utilising seaweed derived bioplastic options in manufacturing is Notpla. Their product is made from brown seaweed and has been used in products like digestible juice shots at the London Marathon, sauce sachets, juice sachets and alternative takeaway products. Currently the company is using brown seaweeds imported from Northern France (as stated on their website) so this may be a target market to engage with.

As a growing market with significant government backing to find more sustainable options for the manufacturing of plastic products this may be a beneficial sector to explore.

Other options

Whilst investigating other potential options for locally cultivated seaweed there may be interest from R&D projects currently ongoing. Professor Alison Hester of the James Hutton Institute, is currently at the very early stages of a project looking at the potential for seaweed feed supplements to mitigate ruminant methane emissions. Prof Hester is willing to consider the use of seaweed as part of a wider project called - Glensaugh Climate-Positive farming Initiative. This project is looking at climate and biodiversity crises and current transformative and technological advances that may be able to mitigate them.

Initial engagement was also made with Dr Waheed Afzal, a chemical engineering lecturer at the University of Aberdeen. An online search flagged a PHD project Dr Afzal supervised on called 'Harnessing natural biopolymers for industrial applications'. Following initial interest from himself and colleagues on the production of liquid biofuels using macroalgae and on the benefits use of macroalgae in industrial and agricultural applications. Dr Afzal and his colleagues would welcome any further discussion from Aberdeenshire Council about trials or collaborations in this area.

Another area of interest that could be relevant to the Aberdeenshire area are studies currently being carried out on the potential cultivation of seaweed on wind turbine sites. One specific project is called the 'Wier and Wind Project' a 2 year trial in Belgium which started in 2020.

The Norther wind farm in the North Sea will host the two-year Wier & Wind project that will deploy seaweed production equipment between its 44 MHI Vestas turbines. The company (a joint partnership between energy provider Elico and Dutch utility Eneco and Mitsubishi) states that "Seaweed is the biomass of the future. It can be used for many large-scale applications, such as food, animal feed and biomaterials," the company said. "There are too few suitable locations along the coast to meet the increasing demand. Wind farms at sea would be a suitable alternative."

The Wier & Wind project aims to harmonise offshore wind development with aquaculture. China last year unveiled plans for unified offshore wind and fish farming off Shandong province. The initial idea for this project came about via a German study looking at how to develop an integrated approach combining different commercial activities on the North Sea coasts.

As Aberdeenshire has a bustling and thriving coastline with many commercial activities and four wind farm sites in its waters; this may be a future option to consider.

Recommendations

At this stage it would be recommended that Aberdeenshire Council consider a small-scale trial for seaweed production using the above identified contacts as potential partners in this trial.

It is recommended that an initial trial and the first commercial farm the main route to market would be food grade sold wet to an existing processor – which offers a viable business opportunity with a reasonable return on investment.

As the industry grows and production capacity increases, the agriculture sector provides opportunities for seaweed to be used as a feed supplement for livestock, with higher yields off-setting lower sale prices.

In order to scale up to the necessary volume for other industries, food-grade will generate the income required to ensure short-term viability.

8. Cost Benefit Analysis (CBA)

This analysis looks at alternate scenarios to identify the breakeven point for different:

- configurations of farm
- types of product

The details of investment and operating costs included in Chapter 5 'Equipment and Facilities Required' have been used in all modelling.

Assumptions

- Limited alternate uses on the identified sites – opportunity costs are considered zero,
- The size of the farm 3,000m or 6,000m
- Wet yield 6 kg per m to 12 kg per m
- Operating costs do not vary as a function of yield
- Shrinkage wet to dry 90%
- Non-food yield 12kg per m
- Food yield 8kg per m
- Drying costs vary as a function of the mass being dried. The table below estimates the cost of drying per kg as a function of load size.

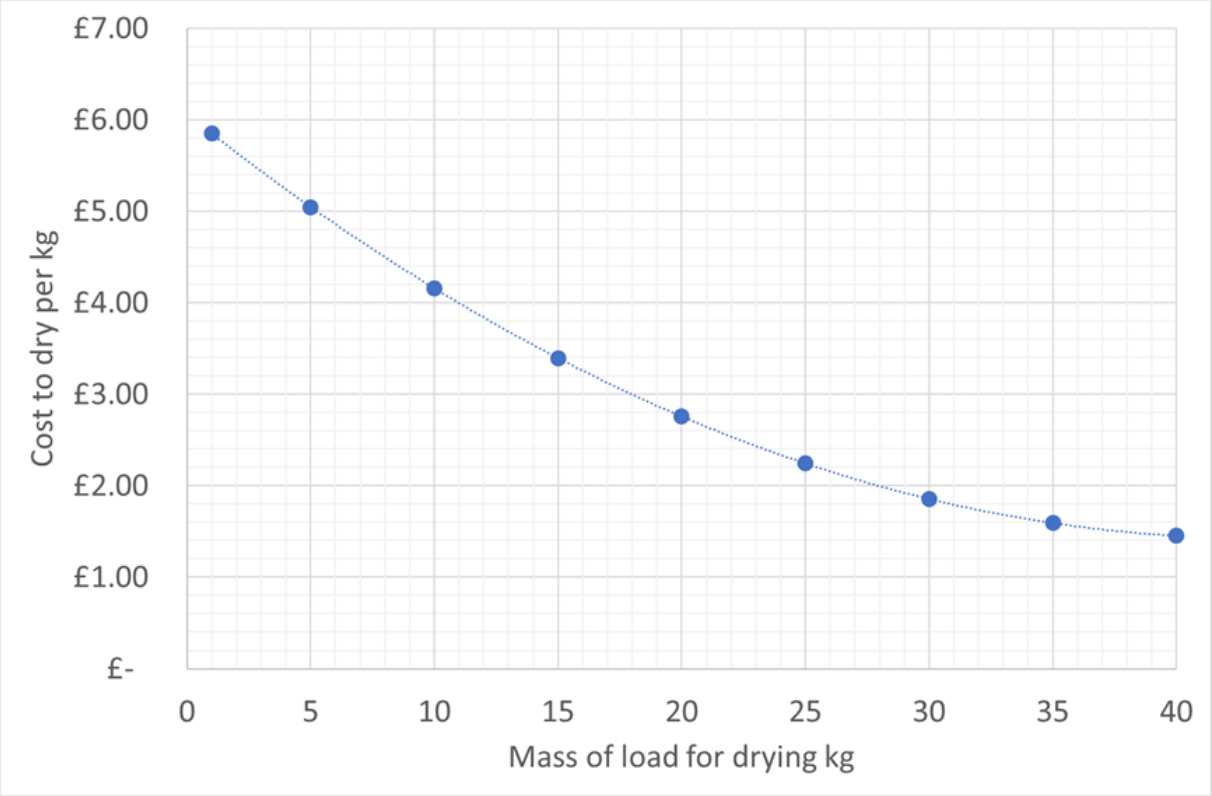


Figure 8.1 – Estimate cost of drying(per kg) as a function of load size

Investment costs and optimism bias

HMRC provides guidance to address the tendency for projects to be optimistic. The 'Green Book' provides adjustments based on experience gained from past or similar projects. Using guidance provided by HMRC we have assumed that this initiative is a Non-Standard Civil Engineering Project. This classification indicates that without mitigation capital expenditure could be +66% of projected costs.

HMRC recommends that mitigation be provided to address recognised issues that could create cost overruns. These include Procurement, Project specification, Client specification, Environment and External influences. Table 8.1 summarises the potential impact of each of these factors and describes the proposed mitigation.

Table 8.1 – Potential impact of recognised issues

Contributory factor	Issue	Gross % Contribution to Optimism Bias	Mitigation	% Mitigation impact	Net % Contribution to Optimism Bias
Procurement	Other	2			2.0
Project	Design complexity	8	Proven design concepts utilised	100	Nil
	Degree of innovation	9		75	3.0
	Environmental impacts	5		80	1.0
Client	Inadequate business case	35	Detailed business case developed	90	3.5
	Funding availability	5	Project will not proceed without funding	100	Nil
	Project team	2	Experienced project team appointed	100	Nil
	Poor project intelligence	9	Detailed business case developed	90	0.9
Environmental	Site characteristics	5	Detailed assessment completed	50	2.5
External influences	Economic	3	Limited inflation drivers	100	Nil
	Legislations	8	Legislative impacts assessed	100	Nil
	Technology	8	Proven design concept utilised	90	0.72
	Other	1			1.0
Impacts		100			14.6

The impact of the proposed mitigation is to reduce risk to 14.6% of maximum. The correction factor being applied to the initial capital expenditure being [66% x 14.6%] = 9.6%. Table 8.2 below shows the initial costs of development of sites and the revised, following the application of net % contribution to optimism bias.

Farm type	Initial estimate (ex-workboat)	Revised estimate (ex-workboat) +9.6%
3000m	£42,150	£46,196
6000m	£62,750	£68,774

Table 8.2 – Initial and revised costs of development of sites

Income

Typical prices for product are:

- Wet: non-food grade, £1.50 per kg
- Wet: food grade, £3.00 per kg
- Dry: food grade, £70.0 per kg to £80.00 per kg

The graph below shows gross income for alternate scenarios.

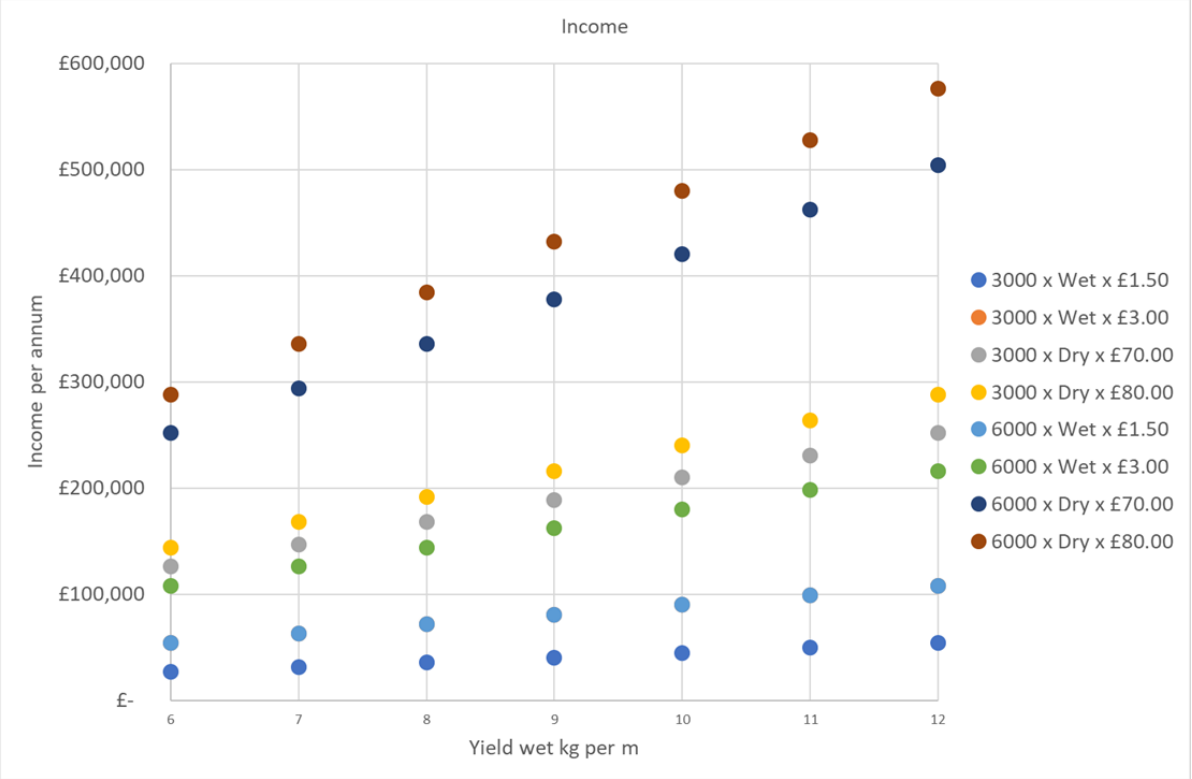


Figure 8.2 – Gross income for alternate scenarios

Profitability

Figure 8.3 shows projected Earnings before Interest and Tax for alternate scenarios.

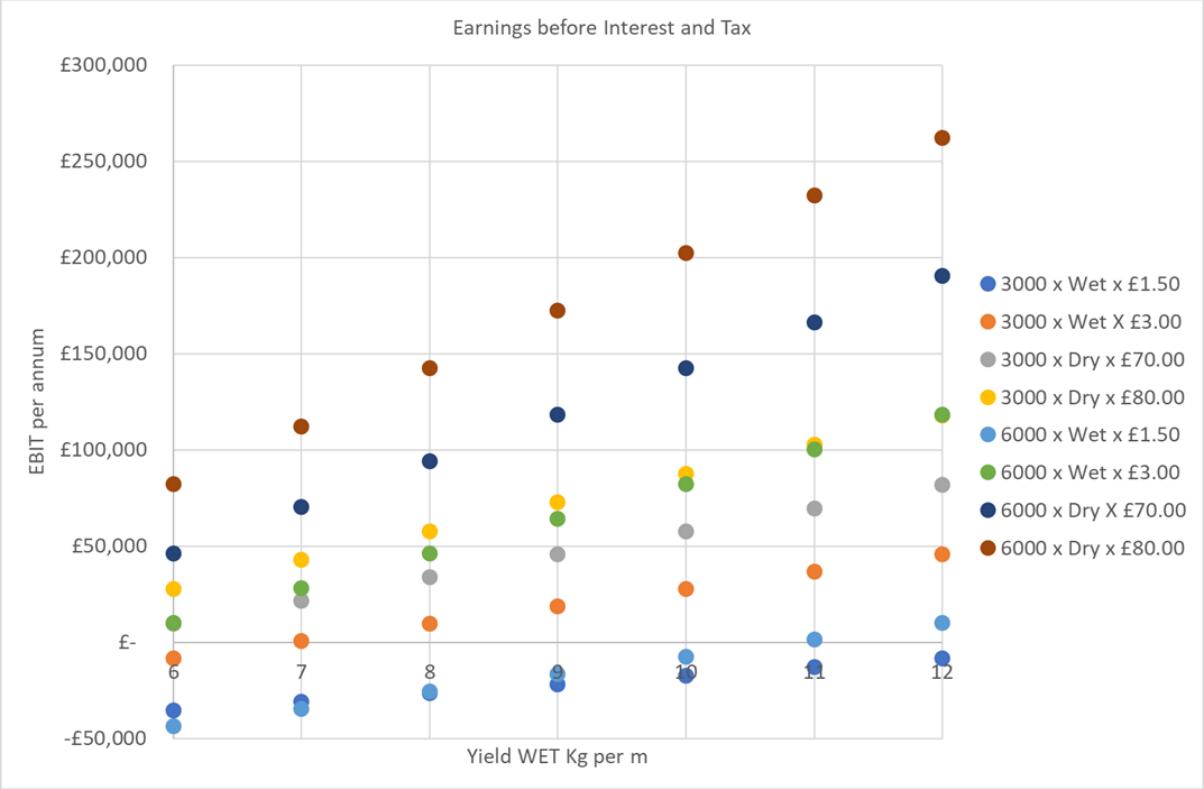


Figure 8.3 – Projected earnings before interest and tax for alternate scenarios

Cost benefit analysis

The annual operating cost for alternate product types are:

- 3000m farm, £62,300 per annum, revised investment £46,196
- 6000m farm, £97,700 per annum, revised investment £68,774
- Drying £3.00 per wet kg assuming 18T wet loads

Table below estimates the payback period in years for alternate scenarios.

Payback less than 3 years	Payback greater than 3 years	No breakeven

			Yield (wet) kg per metre						
Farm	Product	Price per kg	6.0	7.0	8.0	9.0	10.0	11.0	12.0
3000	Wet	£1.50	-	-	-	-	-	-	-
		£3.00	-	66.0	4.8	2.5	1.7	1.3	1.0
	Dry	£70.00	4.8	2.1	1.4	1.0	0.8	0.7	0.6
		£80.00	1.7	1.1	0.8	0.6	0.5	0.4	0.4

6000	Wet	£1.50	-	-	-	-	-	52.9	6.7
		£3.00	6.7	2.4	1.5	1.1	0.8	0.7	0.6
	Dry	£70.00	1.5	1.0	0.7	06	0.5	0.4	0.4
		£80.00	0.8	0.6	0.5	0.4	0.3	0.3	0.3

The analysis indicates that a 3,000m farm supplying wet material faces challenges – it must supply food grade material with payback projected to be circa 5 years at a yield of 8kg per m. The lower risk model is to construct a 6000m farm - this scale of farm could breakeven in circa 7 years even if only supplying lower grade non-food material. It should breakeven at circa 2 years supplying higher quality food grade wet seaweed at 8kg per m.

Scenario 1 Non-food grade wet material to food grade wet material

The table below shows the change in income, EBIT, payback, NPV and IRR as a farm moves from the supply of non-food grade to food grade seaweed.

Assumptions

- 6,000m farm
- Yield non-food grade 12kg per m, food grade 8kg per m
- Revised capital investment, £68,774
- Cost of capital £3.5%
- Sales price, non-food grade wet £1.50 per kg
- Sales price, food grade wet £3.00 per kg
- Operating cost per annum £97,700

Non-food (%)	100	75	50	25	-
Food (%)	-	25	50	75	100
Income (£)					
Non-food	108,000	81,000	54,000	27,000	-
Food	-	36,000	72,000	108,000	144,000
Total	**108,000**	**117,000**	**126,000**	**135,000**	**144,000**
Effective income per kg	£1.50	£1.77	£2.10	£2.50	£3.00
Cost of operations (£)	97,700	97,700	97,700	97,700	97,700
EBIT (£)	10,300	19,300	28,300	37,300	46,300
Payback	6.7	3.6	2.4	1.8	1.5
NPV at year 3	-39,917	-14,702	10,512	35,727	60,942
IRR at year 3	-31.4%	-8.1%	11.3%	28.9%	45.4%

To achieve a payback of less than three years and a positive NPV and IRR a crop should have a minimum effective price of circa £2.00 per kg.

Scenario 2 Food grade wet material to food grade dry material

The table below shows the change in income, EBIT, payback, NPV and IRR as a farm moves from the supply of food grade wet to food grade dry seaweed.

Assumptions

- 6,000m farm
- Yield food grade 8kg per m
- Revised capital investment, £68,774
- Cost of capital £3.5%
- Sales price, food grade wet £3.00 per kg
- Sales price, food grade dry £70.00 per kg
- Operating cost per annum £97,700
- Cost of drying £3.00 per kg (wet)

Food wet (%)	100	75	50	25	-
Food dry (%)	-	25	50	75	100
Income (£)					
Food wet	144,000	108,000	72,000	36,000	-
Food dry	-	84,000	168,000	252,000	336,000
Total	144,000	192,000	240,000	288,000	336,000
Effective income per kg	£3.00	£4.00	£5.00	£6.00	£7.00
Cost of operations (£)	97,700	133,700	169,700	205,700	241,700
EBIT	46,300	58,300	70,300	82,300	94,300
Payback	1.5	1.2	1.0	0.8	0.7
NPV at year 3	60,942	94,561	128,181	161,801	195,420
IRR at year 3	45.4%	66.4%	86.4%	106.0%	125.1%

In all cases payback is less than two years with positive NPV and IRR.

Economic Impact

Research published by BIGGAR Economic (Estimation of the wider Economic Impacts of the Aquaculture Sector in Scotland) in 2020 estimated the gross value-added contribution of the sector at £885M with 11,700 jobs associated with production, processing, and services provided in the wider economy.

This analysis estimated the multipliers associated with Type 1 (direct and indirect effects) and Type 2 (direct, indirect, and induced effects). These metrics included contributions from both production and processing activities. The table below shows the Type 1 and Type 2 multipliers calculated by BIGGAR Economics and a modified set assuming no processing. These figures take a conservative position due to the nascent position of the cultivated seaweed industry.

	Scottish Government		BIGGAR Economics		Revised metrics	
	GVA	Employment	GVA	Employment	GVA	Employment
Type 1	2.19	1.94	1.77	1.68	1.24	1.18
Type 2	2.57	2.23	1.89	1.87	1.32	1.31

Note - GVA = Operating profit (before tax) + employment costs + depreciation

Note - Direct impacts represent employment and earning generated by activities that directly deal with an activity or sector. Indirect impacts accrue from three different factors: Capital Investment, Government Spending and Supply Chain Effects. Induced impacts represent the wider contribution through the expenditures of those who are directly or indirectly employed by project.

Impacts from 6000m farm

The table below summarises the gross benefits associated with operation of a 6000m farm based on the shown multipliers.

per annum £'000		Direct	Indirect	Induced	Total
Earnings	Wet (no processing)	60.0	10.8	18.6	89.4
GVA 1	Non-food grade wet 12kg per m £1.50 per kg	70.3	16.9	22.5	109.7
GVA 2	Food grade wet 8kg per m £4.00 per kg	106.3	25.5	34.0	165.8
Earnings	Dry (with processing)	60.0	40.8	52.2	153.0
GVA 3	Food grade dry 8kg per m £70.00 per kg	154.3	46.2	53.4	253.9

Deadweight and Displacement

The net economic benefit of a development can differ from gross impacts dure to Deadweight and Displacement.

Deadweight – outcomes which would have occurred without the decision to proceed. This could be because the same or a similar development could have been accommodated on another site in the local authority area which has been identified as suitable for that type of development. The characteristics of different sites are therefore likely to be a key consideration when assessing deadweight.

Displacement - measures the extent to which the benefits of a development are offset because the development also leads to reductions of output or employment elsewhere.

Deadweight is considered zero as no alternate development is planned on the proposed sites or is likely. Displacement is considered low due to the projected growth in the market and the limited number of locations that can supply emerging demand. Displacement is projected to be between 0% and 25%. Taking a conservative position, the net impacts associated with the establishment of a 6000m farm are:

per annum £'000		Direct	Indirect	Induced	Total
Earnings	Wet	45.0	8.1	13.9	67.1
GVA 1	Non-food grade wet 12kg per m £1.50 per kg	52.7	12.7	16.9	82.3
GVA 2	Food grade wet 8kg per m £4.00 per kg	79.7	19.1	25.5	124.4

Earnings	Dry	45.0	10.8	14.4	70.2
GVA 3	Food grade dry 8kg per m £70.00 per kg	115.7	27.8	37.0	180.5

The analysis indicates that the net benefits to the wider economy of a 6,000m farm could be between £83K per annum and £181K per annum depending on the selling price of the goods and the levels of post-harvesting processing.

Community benefits

Analysis has found little or no risk to the local communities or supply chain from the establishment of seaweed farms. Potential issues focus on good site management and good neighbourliness and ensuring that there are no increases in environmental contamination through effective waste management and control. There are potential benefits to the community during both the construction and operational phases.

Construction phase

There is no statutory requirement to include a Community Benefits in any project specification, however when included, these requirements have the potential to provide enhanced positive outcomes. There is no standard methodology for calculating the fiscal impacts of this activity therefore bespoke methods must be employed.

Intangible and community benefits from construction activity can be focussed in five areas: employment, skills, and training, environmental, SME and third sector and community. The table below summarises where opportunities exist:

Employment	Skills and training	Environmental	SME and 3rd Sector Involvement	Community
Requiring apprentices, new entrants and returners to the industry to be included in the delivery of work	Running open days with schools, FE and HE can promote the benefits of a career in construction, engineering, and aquaculture	Utilising environmentally friendly construction methods	Delivering supplier development programmes – providing guidance to SME and 3rd Sector on a range of relevant topics: tendering, risk management, value management, etc	Arranging open days to discuss the project and allow the community to highlight any concerns.

	Providing pre-employment work placements	Minimising volume of material to landfill	Running meet the buyer days for local contractors to highlight where opportunities lie for local contractors and how the engage	Supporting local 3rd sector groups to deliver a specific element of work
		Minimising site pollution and travel	Promptly paying sub-contractors	Enhancing local habitats

Supply Chain

The global development of seaweed farming has provided benefits to multiple remote and rural communities including boosting local incomes and improving food security. At a local level, this project has the potential to create employment, increase levels of innovation and entrepreneurism, facilitate diversification and improve the sustainability of existing operations. Identified opportunities include:

- Marine contractors – supply, placement and maintenance of moorings, buoys and ancillary equipment,
- Inshore fisheries – utilising workboats to support planting, husbandry, and harvesting,
- Logistics – increased demand for haulage of material to end users,
- Fish meal producers – new product lines requiring drying,
- Construction – increased demand for shoreside facilities.

9. Case Studies

KelpCrofting: South Pabay, Isle of Skye

KelpCrofting is a seaweed start-up company based in Skye and Lochalsh. Over the past 12 months they have been working to develop a small to medium sized kelp farm in the area to produce kelp for all markets – specifically food grade product. Their cultivation site is 13.12 ha with 3.5 ha growing area, and the farm comprises of 2# grids of 20 longlines each, resulting in a maximum of 40 longlines in total. Each longline is 150 metres in length and spaced 5-8 meters apart, giving a total maximum growing length of 6000m linear meters (150m x 40 lines). The 2 grids are cross-tensioned, with spade embedment anchors and ground chain, making the system high strength and durable. The site included 26 anchors, 1 boat mooring and 2 marked buoys.

The development fits within the Scottish Governments definition of a small-medium scale algal farm (0-50 x 200m lines).

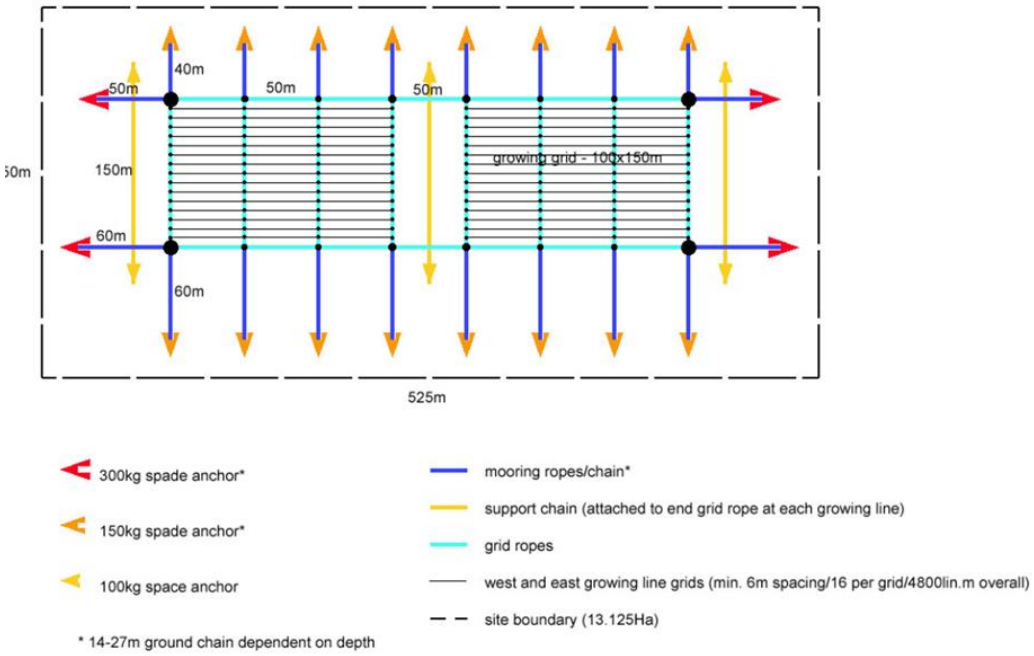


Figure 9.1 – Farm design/ surface plan, showing two grids of longlines, held in place with a network of anchors and ground chains.

Unlike many other potential seaweed start-ups KelpCrofting have their own hatchery, and the necessary expertise to naturally self-seed some of their growing rope creating the brand's own completely organic product - a market they intend to enter after 2-3 growing seasons.

KelpCrofting's core activity will be the production and supply of raw material, in the form of both fresh (food grade) and eventually dried kelp. The seaweed species cultivated will include:

- *Saccharina latissima* - sugar kelp
- *Laminaria digitata* – oarweed, tangle or 'kombu'
- *Alaria esculenta* – dabberlocks, or 'wakame'

In years 1 - 3 of production they will focus on sale of fresh kelp, while developing their own drying and processing facilities, so that by years 3 or 4 they can start supplying dry material. In the meantime, they are also looking into 'contract' drying for surplus production (over and above fresh sales). Over the next 2 years KelpCrofting will also work towards obtaining Organic Certification for their seaweed.

Potential end users of the product may include current established companies (using wild harvested seaweed) that may want to go down the route of using cultivated products, these companies in Scotland include, Shore Seaweed based in Caithness, Hebridean Seaweed based in Stornoway, Mara Seaweed in Fife to name but a few. Another route may be for the company to use another organisation's primary processing facilities to dry their product and then send that product onto an end user to create the final product.

KelpCrofting are currently in their first production cycle, and have completed their first harvest, which is still in progress. As of the end of May 2021, 12 tonnes of food-grade Saccharina Lattisima had been successfully harvested, with a yield of 8kg per metre of seeded rope achieved in the later stages. The harvest volume was slightly limited due to bio-fouling by another seaweed species growing on the long lines and there were some delays due to bad weather, but the operation has been deemed successful with notable lessons learned.

KelpCrofting has a research partner in place to supply large quantities of their first food-grade harvest to, a company producing biodegradable packaging, nutritional products and nutraceuticals. The surplus (after May 2021 harvest) will be retained for further RD&I into growth rates and biofouling. In addition to their new seaweed farm at Pabay, KelpCrofting currently have access to a second site, near the isle of Scalpay (Skye), which has a full license for seaweed, scallops and oysters. These two sites combined provide them with around 20 hectares of marine area to grow kelp, with a capacity of producing circa 150 tonnes of fresh kelp per year.

NAFC Seaweed Growers Project 2014-2016: Shetland

The Shetland Seaweed Growers project was undertaken by NAFC Marine Centre in Scalloway, Shetland from June 2014 to December 2016, funded by the Coastal Communities Fund. The aim of the project was to explore whether growing seaweed on a commercial scale was a feasible option for Shetland. Key attention was made to job creation, economic gain for the community and new business opportunities for existing companies. The Seaweed growers project looked to support local businesses to incorporate seaweed into their existing products.

Commercial partner in the project, Scottish Sea Farms Ltd, provided a six-hectare licensed sea-site for growing seaweed at Sandsound, South Shetland. They also provided use of a work-boat, skipper and crew to help set up the necessary longlines; sea-deploy the hatchery-grown seedlings, and harvest and sample the resulting seaweed crop.

East Voe Shellfish Ltd. were industry associates of the project who were contracted to carry out the same tasks listed above on a second seaweed sea-site at Lea of Trondra, Shetland that is owned by the NAFC Marine Centre. Grieg Seafoods Ltd. donated several drying/smoking racks to the project to allow the NAFC Marine Centre to dry bulk quantities of seaweed.

The project is deemed by the concluding report and their website materials as "very successful" and by producing their Seaweed Cultivation Manual they conclude that they have been able to transfer knowledge of seaweed-related opportunities to interested parties by giving details of the background to the project, seaweed life-cycles and biology, hatchery cultivation of seaweed seedlings, sea-site

selection and permissions, farming seaweed at sea and the preliminary conclusions from the project trials.

Papers and presentations resulting from the project included: *The potential for kelp production in Shetland* and *Regrowth and biofouling in two species of cultivated kelp in the Shetland Islands.*

As noted on their website the project has encouraged nine local Shetland businesses to diversify by incorporating seaweed (both cultivated and wild-harvested) into their products. Companies noted are as diverse as the following:

- Artisan Cheese
- The Shetland Fudge Company
- COPE Ltd - Shetland Soap Company
- COPE Ltd - Shetland Garden Co
- Mirrie Dancers Chocolatier
- Shetland reel Gin
- Orkney Soap
- Shetland Sea Salt
- Saxa Vord Restaurant

Ocean Rainforest 'Sustainable Nordic Seaweed': Faroe Islands

Ocean Rainforest was established in 2010 based in the Faroe Islands. Ocean Rainforest focuses on research and innovation within seaweed cultivation. In 2017, Ocean Rainforest purchased a 620 m2 processing plant in Kaldbak. The building has a capacity for cleaning, packaging, freezing, drying, and ensiling. There is also capacity for cold and dry storage and a hatchery for seaweed seedlings and laboratory. In the Faroe Islands they maintain over 42,000m of seeded lines from which their seaweed is harvested. This line is deployed on approximately 6 hectares in Funningsfjørður, where there is continuous current and stable sea temperature. Ocean Rainforest carry out growing in both a 'nearshore exposed site' and 'nearshore sheltered site'.

In January 2020, Ocean Rainforest opened its first pilot offshore farm in Santa Barbara, California. They are in the process of engaging with stakeholders and potential partners in the local community to launch the initial phase.

The company has a vision of "a local ocean rainforest around the world" aiming to produce a million tonnes of seaweed a year by the end of the decade.

Turning kelp into fuel is a serious operation, which is why companies are working hard to level-up seaweed production technology. Off the coast of California, Marine BioEnergy is using drone submarines to lift its kelp near the surface during the day to absorb the sun's rays, then lower it down at night to benefit from the nutrient-rich deeper waters.

Atlantic Seafarms: Portland, Maine, USA

Established in 2009 in Maine, United States with the goal of establishing another sustainable source of income for lobster fishermen – diversifying existing farmers. Atlantic farming's model ensures that lobster fishing is not the areas only significant income with seaweed providing diversification for these workers.

The company has its own processing facility, with 20,000 tonnes kelp harvested in 2019, growing year on year with 35,000 tonnes harvested in 2020.

One of the company's main incomes include *Saccharina latissimi* (Sugar kelp), which is processed for food grade products such as - on salad/ wrap/ or garnish with chicken/fish and predominately purchased by local chefs/restaurants. The seaweed is carefully removed from the farm, blanched until it turns bright green, then vacuum packed and sold on as a high end product.

Lessonia variagata (strap kelp), following harvesting is put through a shredder to create a finer product, then blanched through their mechanical blancher OR put for fermentation OR for ready cut kelp (defrost and eat product they produce).

The companies farming operations last for the growth period of 90 days, they then harvest long days from April through to June. The company is currently producing 13.6 tonnes per acre.

https://www.youtube.com/watch?v=eTTj1Wo6_yU

https://www.youtube.com/watch?v=Q JgwZxAAU_4

Hebridean Seaweed; Arnish Point near Stornoway, Isle of Lewis.

Hebridean Seaweed, based on the Isle of Lewis, is the only large industrial processor of wild seaweeds in the UK. Established in 2006, the company provides seaweed products for use in animal feed supplements, soil enhancement, alginate, and nutraceutical sectors. They only harvests wild seaweeds with an agreement in place to harvest *Ascophyllum nodosum* throughout the Western Isles. The company has a fleet of specially designed harvesting workboats that ensures they can harvest all year round, with circa 40 tonnes of fresh seaweed harvested per day, equating to 10 tonnes of processed product. The boats work close to the shore and cut the seaweed. As the stalks float above the seabed, they are then filled into sacks and towed by a small boat to a sheltered area for loading onto a lorry.

Hebridean Seaweed in recent years has expanded production by the design and construction of a £7million processing seaweed factory. The project was supported by the European and Scottish Government, with 3,250 square metres of covered facility and a further 17,000 square metres of yard space.

Hebridean Seaweed work on the model that once the product is harvested it is transported to the factory where the seaweed is dried and milled into the product requested by the customer e.g., 300 microns (fine powder) to 5mm (rough granules). Products can be supplied in bulk or in small quantities with packaging sizes ranging from 2Kg buckets to 10Kg, 20Kg, 25Kg and 1 Tonne bags.

Figure 9.2: Image © Hebridean Seaweed, harvesting product.

In terms of processing, following arrival at the facilities, the raw material is dried in a tunnel drier and then milled to the customers' requirements. The drying machinery used ensures the product remains in the optimum condition.

Figure 9.3 Image © Hebridean Seaweed, Factory Interiors

10. Identify Local Businesses/ Investigate Opportunities for Diversification

In order to identify existing businesses that would be interested in the opportunity to diversify into seaweed cultivation, at each level of the value chain, various stakeholders were identified and consulted. Seaweed has such a broad range of end uses; the potential options for processing and routes to market could be unique dependent on the requirement from buyers. That said, regardless of the end use of product the farming and initial primary processing element will remain relatively similar.

Potential Farmers

The most obvious industry sector that could diversify into farming of seaweed would be inshore fishermen. Local fishermen know the area, have relevant skills, they know the sea conditions and have access to infrastructure (vessel, safety equipment, berthing etc) necessary to check and maintain the seeded rope and farm infrastructure throughout growing seasons. The other attractive benefit of seaweed cultivation to local fishermen is that the growing season for seaweed is the off-season for creel, mackerel and squid fishing. Seaweed is typically placed in the sea in October and harvested in May/June.

For the purposes of this study, we have carried out initial engagement with a number of local operators, mostly for the purposes of site selection. This included Charlie Hill (Portknockie creel fisherman), David Whyte (Rosehearty creel fisherman) and Robert Soutar (Scottish Whitefish Producers Association/Squid fisher). For each of the respondents the main theme was clear – in order to carry out seaweed cultivation successfully in the area without conflict with other marine users there must be further engagement carried out for micro-siting farm locations with all local stakeholders. There was also potential interest in seaweed farming as a business opportunity that could be viable for inshore fishermen.

Local inshore fisheries representatives including the Scottish Whitefish Producers Association and North & East Coast Regional Inshore Fisheries Group will be invited to attend the end-of-study presentation, and some limited further engagement will be carried out, in conjunction with consultation on social licence.

There are a few cases where Seaweed Farming is used as a diversified business opportunity for local fisherman such as Ocean Rainforest (further info available in Case Studies). Fishermen's skillsets and knowledge can be intrinsically and beneficially linked to that of seaweed farming and so a natural alignment exists.

Throughout our engagement it should be noted that there has been keen interest from respondents. At these early stages it is very positive that they are keen to find out more information on the opportunities available.

Potential Processors

As discussed earlier the main bottle neck for the Scottish Seaweed cultivation industry is in processing/ drying capabilities. Following initial engagement with a number of companies in the area (Mapco, Frontier Agriculture) - there are a number of options available for the drying and processing of the product in the area - specifically close to the coast ensuring that perishable goods are transported in a timely manner.

Several fish processors in the area (NORSeafood, Whitelink) may be interested in the potential opportunity for diversification.

Potential processors are explored in more detail in Section 8. Note that the industry will need to be operating at scale with significant volumes for processing to be viable for some, although with Aberdeenshire having much better links to market than many West coast operations there could be an opportunity to create a processing hub.

Potential End Markets

As discussed in detail in Section 8, there are wide-ranging uses for algae products, and encouragingly a number of businesses in the region which may have a use for seaweed products. This should be Initially focussed on food grade products for human consumption until sufficient scale can be produced to enter markets such as animal feed and cosmetics.

Third Sector/Social Enterprises

There is an opportunity for third sector organisations and/or social enterprises to establish and operate a seaweed farm, based on the equipment, start-up and operational costs detailed in Section 5, and the Cost Benefit Analysis in Section 9 – assuming that grant funding is available to cover the investment required.

An inshore fisherman's association, running as a co-operative, would be an appropriate model. As cultivation increases and volumes grows the coop would be in a position to provide processing and logistics by pooling existing equipment, infrastructure and access to existing partners in their value chain. As such, the business model which would apply to a third sector/social enterprise entrant to the sector would be broadly the same as for a commercial coop entity.

Grant Funding Options

There are a number of funding options that may be available to businesses or community organisations to develop a trial seaweed farm. These are outlined below:

NESFLAG Coastal Communities Challenge Fund 2021 :

NESFLAG has been allocated £196,159 from Aberdeenshire Council to distribute to projects in coastal communities for 2020-21. This funding is drawn from revenue generated by the Crown Estate Scotland's inshore waters and is intended to support and develop coastal communities.

Marine Fund Scotland :

Marine Fund Scotland (MFS) replaces the European Maritime and Fisheries Fund (EMFF), following the UK's exit from the EU. The EMFF supported the sustainable growth of the marine economy in coastal communities, in sectors such as fishing, aquaculture and seafood processing.

The MFS is currently open to applications, and has a one-year budget of £14 million, meaning all projects must be completed by 31st March 2022. This fund is expected to be open to applications in 2022 for the next round.

Crown Estate Scotland :

Community Capacity Grants: This programme looks to provide early-stage financial support for community enterprise projects that contribute to local regeneration and sustainable development.

In the first year (2020/2021), a total of £150,000 of funding is available for grants of between £10,000 and £50,000.

Currently closed for new applications.

Environment Grants: This programme will provide funding to Crown Estate Scotland tenants for projects on the Scottish Crown Estate which can deliver demonstrable environmental benefits within 18 months of award of funds. Typical projects could include:

- Initiatives to increase local biodiversity;
- Making the local environment more attractive through, for example, planting and landscaping etc.
- Facilitating a change to greener ways of operating e.g., measures to support recycling or waste reduction; enabling green travel; activities that reduce flood risk, pollution, or carbon emissions; and
- Materials providing information e.g., display boards about the local environment.

Projects which can demonstrate wider community benefits as well as environmental benefits are encouraged.

In the first year £100,000 of funding is available, with individual grants of £5,000 - £20,000. The programme is open to Crown Estate Scotland tenants and applicants must have an agreement with us at the point of application and when monies are awarded (February 2021).

Seafood Innovation Fund :

Applications to the UK Seafood Innovation Fund are currently closed. Updates in due course for the next funding call will be dependent on whether all funding has been expended in the first two years.

Applications can be made for up to £50,000 for a feasibility study. These are projects funded for up to three months, to develop an idea for a new technology or process, and to undertake the initial testing to assess whether progressing further is beneficial.

Applications can be made for up to £250,000 for a full research and development (R&D) project. These projects can be up to 18 months long and should aim to further develop a technology or process that is already through the initial feasibility stage.

The total funding pool for the UK Seafood Innovation Fund is £10 million across the 3-year programme.

11. Consultation on Social License

For the purposes of this project, we have used the definition of social license as:

"social licence requires any business to ensure its activities respect the rights of all of those in any community." (Ethical Leadership, 2021)

And by extension not to impact in a negative way on existing communities, groups or businesses.

The original intention for the study was to map stakeholders throughout the value chain, including organisations of different sizes and industry sectors, the local community, third sector organisations, and other stakeholders who could be impacted by seaweed cultivation, including marine tourism operators.

Having undertaken some engagement with local businesses and organisations whilst working on Sections 4 and 8 it was realised that in order to gauge support for the project and validate its social licence it would be preferable to delay consultation with these groups until after the presentation of the final report from the study. This ensures that stakeholders consulted are equipped with an understanding of the potential of seaweed cultivation as a viable opportunity with many benefits, and to be in a position to comment on the findings.

A list of stakeholders was prepared in conjunction with the Coastal Regeneration Team and these parties invited to the final report presentation on 24th June. Following the presentation, a selection of attendees will be contacted and invited to participate in further consultation.

The stakeholders consulted include:

- Inshore fishermen/fisheries groups – both as potential operators and conflicting marine users
- Marine and coastal tourism operators.
- Community groups e.g. community councils

Following the event, through discussion with Aberdeenshire Council the identified consultees were as follows:

- Moray Firth Partnership
- Scottish White Fish Producers Association Limited
- Regional Inshore Fisheries Group
- Banff Sailing Club (not in attendance)
- Portsoy Enterprise Hub (not in attendance)
- King Edward & Gamrie Community Council (not in attendance)

Unfortunately, due to a small number of community groups and marine and coastal tourism operators attending the event, some of the identified contacts did not attend the live event. In order to ensure they were briefed prior to follow-up engagement, an introduction to the project, presentation slides and a zoom recording of the event was sent on to them all with sufficient time to review prior to engagement.

Moray Firth Partnership

Moray Firth Partnership were identified as an organisation who should be further engaged with. The Moray Firth Coastal Partnership plays a unique role as a neutral, independent charity in promoting and facilitating sustainable solutions to the marine and coastal challenges faced by the Moray Firth and its communities. As the local coastal partnership for the Moray Firth and its 800kms of coastline,

they are involved with a wide variety of issues, projects, and stakeholders. Natalie Palmer, Partnership Manager for the organisation attended the event and was happy to provide take a call to share her initial feedback on the opportunity.

Feedback post-event:

The presentation was educational specifically learnings regarding a similar initiative underway in Caithness. Specifically, sections on potential sites, how the process would work and financial feasible of the project were of particular interest. Suggestion that MFP could provide support through their network in terms of more consultation / survey on the initial views of local communities – currently over 500 subscribers from locations along the coastline. It was noted that there is moves being made towards a Regional Planning Model. This is currently at very early stages with current assessments being made by Marine Scotland to assess whether there is an appetite in the area for a regional plan. Working concurrently with the idea of a Regional Marine Plan, MFP are currently in discussions to formulate a forum. Through this they hope projects such as Seaweed Cultivation could be discussed and as a result play a part in the consultation aspect of planning considerations of these sorts of projects.

Initial thoughts on Seaweed Cultivation opportunity:

MFP would not be the correct body to provide an opinion on whether they support the project as they cover such a massive area they wouldn't comment on specific locations. But they are always looking for diversification opportunities specifically following Covid-19 and the impact of Brexit. – She would be interested to know what the appetite is from other stakeholders such as fishermen. Nothing discussed in the event presentation highlights as a key concern. Yet, it is always difficult to add new infrastructure to the coast, often met with concerns regarding the aesthetic impact on the coastline.

Scottish White Fish Producers Association Limited

Formed in 1943, SWFPA is the largest fishing association in Scotland – and in Europe. Representing around 220 vessels and 1,400 fishermen who contribute a collective £158 million to Scotland's economy. SWFPA act as the political voice of their members. This means continually speaking to their fishermen – hearing their experiences, concerns, and insights – and then relay those messages to policymakers and other relevant industry figures. Kenny Coull, Fisheries Policy Manager for the organisation attended the event and was happy to take a call to share initial feedback on the opportunity.

Feedback post-event:

SWFPA has not been involved in this project at all. Only became aware and brought to his attention following recent discussions with the squid fisheries – specifically Robert Soutar who has been engaged with at an earlier point in this study. Site selection is a key concern, working hard to protect the opportunities of squid fisheries at present following BREXIT. Squid is a valuable area/important fishery with 6/7million per year along the Moray Firth. So far feedback he has received from fishermen is that they would like to be engaged early in this process.

Initial thoughts on Seaweed Cultivation opportunity:

Not opposed to the opportunity, yet there is understandably concerns about the shared marine environment. Fishermen in the area expect to be treated with fairness in a transparent manner with regards to decisions relating to the marine matters in line with marine planning policies in particular marine fisheries 1 and 2.

SWFPA are keen to be engaged if this project develops – emphasising they want to be involved early and ensure the best sites are chosen. Currently there has been problems with the wind farm developments, not taking into account fishing practices and so they have to protect their members interests. Key theme throughout the discussion was that associations/ industry such as SWFPA, RIFG and SFF should be involved in the planning stages and can assist with further micro siting of the coastline, representing each fisheries interests.

Encouragingly, it was noted, that throughout the presentation event it was clear that this is very much feasibility stage of the project exploring potential options and opportunities available which is welcomed. No concerns to note at this stage, but important to stress that it is important for fisheries to be involved from an early stage in order to mitigate any potential issues later down the line, although they do recognise it is shared seas and the bigger policy may intervene with projects.

Noted there may be support, the last year has brought significant challenges with Brexit and is causing large worries so diversification may be welcomed, although it is unclear how many opportunities may be there at the early stages. Providing support is something that may be considered, often one of two skippers may provide support for offshore wind farms such as liaison work or guardship duties which is always well received.

Can envisage short term work being incorporated into the plan for the year but if its longer term it may be 1 or 2 who are interested in converting to something different. An opportunity for supplementary work may be of interest.

If associations such as SWFPA or SFF could be involved at this early stage it could be discussed with the industry as it progresses but at this point it's quite vague and the scale is yet unknown.

Regional Inshore Fisheries Group

Regional Inshore Fisheries Groups (RIFGs) are non-statutory bodies that aim to improve the management of Scotland's inshore fisheries, giving commercial inshore fishermen a strong voice in wider marine planning initiatives. The current Regional Inshore Fisheries Groups (RIFGs) in Scotland were established in April 2016 when they replaced the previous Inshore Fish Groups (IFGs) structure. The RIFG network includes: North & East Coast RIFG, Outer Hebrides RIFG and West Coast RIFG

Jennifer Mouat, Chair, for the organisation attended the event and was happy to take a call to share her initial feedback on the opportunity.

Feedback post-event:

The presentation was informative and clearly laid out possibilities in terms of feasibility of seaweed farming. Key point was that, feedback from inshore fishermen has so far been questioning why this study was commissioned without informing the Inshore sector via early discussions. The feeling is it would have been beneficial to have consulted them for their views on this opportunity prior to tendering of the contract. Questions have been asked regarding the rationale behind this diversification opportunity. Noted that in reference to the areas identified for site selection it is unfortunate that more up-to-date data on vessel movements/fishing grounds was not utilised or sought. More accurate data can be identified via fishermen's plotter data and if engaged with earlier this could have been sought. NLC stated that via other feedback consultation this idea of a steering group has been discussed and Jennifer agreed this is a good option going forward.

Initial thoughts on Seaweed Cultivation opportunity:

Site selection and how this progresses remains the key concern, the benefits of creating a steering group to work under the remit of assessing and selecting the most suitable sites going forward.

In terms of support for the opportunity, diversification options following Brexit are welcomed. If this Is a viable option there is confidence some entrepreneurial fishermen may be interested to take this further. None have expressed interest as of yet.

Emphasised the key is to ensure everyone is involved at this early stage - bring the coastal industry with them and make them a part of the decision making process.

A busy coastline does present challenge for them already to maintain their business, so seaweed must be a positive opportunity for the industry and not have a negative impact.

Banff Sailing Club

Unfortunately there was very few attendees at the event from marine tourism or leisure groups and so as a result a number of non-attendees were identified for this follow up engagement piece, one of these were representatives from Banff sailing club. Peter Scott-Wilson sent via email – his own personal views – not those of the Sailing Club in general. His views are as follows;

This year is not typical as harbour works in Banff are ongoing and boats are prevented from going to sea. However, in a typical year, yachts in the marinas at Banff and Whitehills engage in day sailing of a type that allows return to harbour taking advantage of the twice daily change in longshore tidal currents. Many of the small bays are anchorages and some boats may anchor up in bays including Sandend and other smaller bays along the coast, allowing weekend cruising. Mostly yachts' keels draw <2m and they cruise in the nearshore, i.e. from very close to the shore where the depth, rocks and weather allow to several miles offshore. The focus of sailing activity is from Portknockie (Bowfiddle rock) to Penan, with few boats venturing further across Aberdour Bay.

Most sailing skippers rely on visual navigation. In this sailing area, there are already a great many temporary hazards in the form of inadequately marked fishing gears. Any addition to this would be unwelcome, particularly in poor visibility and at night. At very least, it should be a requirement that any seaweed farm be equipped with lighted buoys.

Consider what would happen if a yacht suffering a mishap that compromises its ability to manoeuvre (loss of rigging, engine failure or what have you) were to be carried into a seaweed farm by the combined effect of wind and tide. What harm might be done to crew, yacht, seaweed lines etc.?

Of the three locations indicated in the slide show, it is my view that:

a) The one in Aberdour bay poses low risk for local yachts, because they seldom pass through that area.

b) Not so the Gamrie Bay location. Boats from Banff and Whitehills often sail towards Gamrie using Crovie as a visual reference point until they pick up the transit into Gardenstown Harbour from the north behind Craigandargity Rock. If the seaweed farm were located further inshore, in the side of the bay between Craigandargity Rock and Pecking Craig, it would present less obstruction.

c) The Boyne Bay location is an area where yachts routinely make passage between Banff/Whitehills and Portsoy (and already have many lobster pots to avoid).

Aberdeenshire may be a suitable location for seaweed farming and bio-polymer production in the future. In the past it has been a good cruising coast for yachting, and will be again when Banff harbour is restored to us. The slides say that an application for a Social Licence will not 'impact in a negative

way on existing communities, groups or businesses'. In considering the location of any seaweed farm, I hope you will therefore consider the way that yachtsmen navigate this coast.

Other members of the sailing club, Commodore - Helen Robbins and Graham Osler, echoed the points made above by Peter Scott Wilson. Adding the following:

The Aberdour Bay site does seem the least impactful. The Gamrie Bay and Portsoy sites are right in navigable water for leisure boats and will impact on safety and navigation particularly for Gardenstown harbour. We would object to the current positions for Gamrie and Boyne Bay.

We are also concerned about increased vessels around Troup Head and the impact on the fantastic bird colony that is there. We wonder if the RSPB is aware of this?

Harvesting seems to be within peak sailing months and so wonder about increased vessels and restrictions. We are also not clear how much clearance vessels are obliged to give the farms?

Portsoy Enterprise Hub

Portsoy Community Enterprise (PCE) is a social enterprise, driven by the enthusiasm and passion of volunteers who bring together an array of assets, events and offerings, which keep alive the ingrained heritage and cultures of the north east of Scotland. Richard Thorne, Development Manager for the organisation did not attend the event but reviewed all materials prior to taking a call to share initial feedback on the opportunity.

Feedback:

Interesting possible opportunity and is keen to learn more and explore further the opportunities for Portsoy. Felt there was little detail on the risks of seaweed cultivation covered, yet agreed this would potentially come at the next stage. Richard explained how currently Portsoy is at an in-between stage - it is no longer solely a fishing port. In recent times, a lot of people of working age would go offshore for employment but unfortunately some of that is coming to an end. Tourism is starting to pick up but the infrastructure is not quite ready yet.

The new opportunity for Seaweed Cultivation is certainly interesting and something he has looked at on and off for years, mainly through his previously employment in Mull. New ideas and opportunities is always welcome for consideration.

The main concerns noted by Richard, was on the drying side of production. Believes that the drying process must be right and understood and the lowest cost possible. Harvesting is one stage but processing is far more than just growing the product.

Also noted on the specific site identified at Portsoy - on the assumption this identified site works out, concerns are how the product will be taken onshore AND what will then be done with it. Also as mentioned above Richard believes there was a lack of risks covered in the presentation, an example he gave for this reasoning was as follows; currently France is growing a lot of seaweed and they are starting to squeeze prices. What happens if they half the prices and then it no longer becomes viable in Aberdeenshire after a lot of money is invested? Agrees this is a long way down the line and believes these risks could be mitigated.

Another point noted by Richard was quayside access not being an issue at Portsoy. A local transport company near the harbour has sufficient access to this section so no problems should be foreseen.

Initial thoughts on Seaweed Cultivation opportunity:

Richard was supportive of the proposed opportunity and was definitely keen to find out more. When suggested to him the opportunity of being involved in a steering group in relation to a trial farm, this is something he would be keen to find out more information on – assuming his board gave approval.

King Edward and Gamrie Community Council

Unfortunately there was very few attendees at the event from community councils or community groups and so as a result a number of non-attendees were identified for this follow up engagement piece, the community council identified was King Edward and Gamrie Community Council. The community council was asked to share their initial views on the opportunity from the information provided. This included a recording of the presentation and the presentation slides. Secretary Andy Sturdy sent a letter (via email) outlining the below.

The council stated that: *The King Edward and Gamrie Community Council support in principle any new economic activity which brings employment benefits to our community, conditional that it does not conflict with existing activities and interests.* Followed by: *The village's existing mainstays are tourism and fishing, the first dependent on unspoiled views and the second on unrestricted access for fishing.*

The council noted that they believe the next steps for this project would be a public presentation and discussion opportunity in the Dreel Hall, Gardenstown *promoted by the circulation of information to the widest possible cross section of the community, but especially the fishing and tourist interests, to ensure sound consultation outcome.* The community council concluded their note by adding: *We would like to see early provision of more detailed information on the proposer's thoughts on prospects for local employment, development and revenue streams to the community of any such activity regardless of whether or not the processing activity were to be based in the village. We look forward to hearing further on the progress of this interesting opportunity.*

Summary

In conclusion, from engagement with the parties as identified above it is clear that there is support for further research into this opportunity. There is a keen interest in diversification opportunities in the region at present, but it is clear dialogue must be carried out at the earliest possible stage to ensure all parties are supportive of the project and not impacted in a negative way. A steering group has been identified as a sufficient way for all stakeholders to be involved throughout.

12. Summary and Recommendations

The aim of this study was to analyse and determine if seaweed cultivation is a viable and acceptable proposition for the North Aberdeenshire Coast.

In recent years there has been greater interest in seaweed cultivation with the global seaweed market size valued at $4,097.93 million in 2017, and projected to reach $9,075.65 million by 2024, registering a CAGR of 12% from 2018 to 2024.

Currently within the UK market the majority of active companies identified are harvesting wild seaweeds, with only a very small number cultivating their own algae. The Scottish market - although not a new industry - has seen significant growth in recent years. There is considerable opportunity for small farmers to establish their presence yet - there are significant barriers within the supply chain, specifically in terms of processing capabilities, licensing and regulation.

The major bottle neck in the industry is commonly identified as the lack of processing capability; but along the Aberdeenshire coast there are a large number of industrial food grade and animal feed

processing factories, and so the role of the intermediary may be easier to fill than on the West Coast where this style of industrial processing is less common.

The environmental benefit of seaweed cultivation is extensive, and the commercial benefits may provide a successful opportunity for the region.

Sugar Kelp should be considered as the primary target species for cultivation, with Dabberlocks as a secondary option.

Research has been carried out to identify potential sites in the area. Physical characteristics, water quality, biological diversity, protected species and habitats, existing commercial operations, and existing infrastructure were considered when establishing 3 potential sites for the farming to take place. These sites are proposed as they meet the various suitability criteria but are subject to verification and micro-siting dependent on:

- Accurate seabed geology and depth of water from ROV and bathymetric surveys
- Metocean data for wave height direction etc obtained from deployment of monitoring devices such as Waverider buoys
- Further detailed consultation with multiple stakeholders to minimise impact on existing inshore fishing activities

The specific locations proposed as potential sites are as follows:

- Boyne Bay, Portsoy
- Gamrie Bay, Gardenstown
- Aberdour Bay

Macduff Harbour has also been identified as having the key parameters and the most appropriate location required to act as a hub for initial seaweed cultivation in the northeast. Through further engagement it has been established that further input from various groups

Capital equipment costs and start-up costs have been detailed with a grid-based system identified as the most suitable for the small/medium farm systems, that is more than 3,000m of longline. Seaweed farm design consists of two main components – moorings and long lines – supported by floatation buoys. Variables such as volume of seaweed, intended end-use of the biomass and harvesting method may impact on the most appropriate farm design.

Detailed in section 5 are the costs for both a small (3,000m growing line) farm and a medium (6,000m growing line) farm. Set up costs for a small farm would be approx. £46,196 and medium farm £68,774. The analysis indicates that the lowest risk model is to construct a 6000m farm and initially supply wet material. To achieve a similar breakeven position for a 6,000m farm supplying dry product, a sales price of circa £85 per kg is required. Subject to price and yield, for a 6000m farm supplying wet material at between £1.50 per kg to £3.00 per kg, it is estimated that the payback on the initial investment will be around three years.

Section 6 outlines the requirements for the required marine licenses and pre-application consultations, application to Crown Estate Scotland and Marine license itself.

Section 7 outlines the process from selecting a suitable site to completing installation. The infrastructure set-up is estimated to take in the region of 285 days (Mon-Fri) or 57 weeks, assuming no delays during the Marine Scotland consenting process.

It is recommended that the human food grade product is the core target market with animal feed ingredient trade a secondary option, further down the line when significant scales can be produced. It is essential for any trial to ensure there is a confirmed processing partner or other customer in place. Further investigations must be carried out to ensure there is capability for the scale required.

It is recommended that the best way to build on this study is to carry out further engagement with potential partners across the value chain, and seek grant funding, with a view to carrying out a small-scale trial in order to validate the study outcomes. It would also be advisable to ensure a steering group of some kind is set-up at the earliest possible stage with interested parties/stakeholders to ensure that relevant bodies are consulted throughout. This would assist with micro siting of specified sites using associations like the SWFPA and RIFG and its members can be included from the earliest possible stage. Aligning with this the input from community groups and associations is a key factor from the earliest stage to garner support for the project.

In summary, this study concludes that there is a socially beneficial, technically feasible and commercially viable opportunity for seaweed cultivation to be carried out in the Aberdeenshire area.

In order to confirm this further micro-siting and further engagement with end users must be carried ensure there is the necessary supply chain is firmly in place. It is recommended that the next steps would be to establish a small-scale trial with industry and farming partners in place.

Disclaimer

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