Our Recommendations for the Diversification and Development of Responsible UK Aquaculture

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MCS Asks:

- **Develop robust regulation to guide the development of responsible UK aquaculture** across all sectors.
- **Invest and incentivise diversification of species and production practices** in UK aquaculture.
- **Implement and deliver research into environmental and cumulative impacts** of UK aquaculture production.
- **Improve understanding the role of aquaculture to mitigate aspects of climate change,** including rewilding and carbon capture.
- **Commercial trials developed to drive innovation** and improve environmental performance.

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Executive summary

Globally aquaculture provides around 50% of the fish required for human consumption, amounting to around 82 million tonnes in 2018. It remains the fastest growing food sector, with an average annual growth rate of around 5%. It is anticipated that 62% of global fish will be produced from aquaculture by 2030. In the face of climate change pressure, and the desire to reach Net Zero, changes to fisheries, aquaculture and shifting people to less carbon intensive diets could reduce emissions by between 0.3 and 0.94 billion tonnes of CO2e by 2030 and between 0.48 and 1.24 billion tonnes of CO2e by 2050[1].

There is an opportunity for responsible aquaculture to deliver a number of the Sustainable Development Goals. This could be achieved if the sector was underpinned by comprehensive planning, securing the right investment and utilising the best technology to overcome existing environmental challenges, including those induced by climate change.

For growth in aquaculture production to occur sustainably, it will require active support and encouragement. Finfish growth, will continue to be dominated by salmon farming in the UK. But it must adopt new technology and be embedded in a revised planning and regulatory regime before growth can be considered. Climate change will present emerging challenges that will need to be met and planned for, necessitating any growth to be cautious.

UK seaweed aquaculture could provide an opportunity for aquaculture growth. However, to unlock the potential of this sector there are a number of barriers to be overcome. An enabling regulatory framework, licensing and a planning system is required to support growth, whilst at the same time ensuring surrounding biodiversity is protected and safeguarded. Additional key issues that must be addressed to enable growth are related to infrastructure, allowing access to market, and market development.

UK shellfish aquaculture could also increase production, but this sector will need to adapt to the impacts of climate change, certainly in the medium term. Ocean acidification and spat availability are likely to impact growth, but hatchery development and offshore production may present mechanisms to overcome these constraints.

The development of restorative aquaculture could provide additional opportunities for growth. Shellfish species, such as native oyster, and seaweed, such as kelp, are both successfully in use, in Dornoch Firth, Scotland and Sussex respectively. Offshore aquaculture, within the right planning and regulatory framework, offers space for growth, and could be located alongside offshore structures such as windfarms. However, Integrated Multi-Trophic Aquaculture (IMTA), a concept that has been trialed successfully in Scotland, may become more viable in a changing climate. IMTA utilizes nutrients in the water column and dampens wave energy, which could prove to be useful services for finfish production. Land based aquaculture can offer further opportunities for species such as warmwater prawn, however growth in this sector is highly dependent on market demand and juvenile availability.

While in the short to medium term, it is likely all finfish growth in open net pens will be located in Scotland, centered on Atlantic salmon. There is opportunity for Scotland to also support shellfish and seaweed growth, particularly in IMTA systems.

Wales and England are best placed to support shellfish growth, with some opportunity for land-based finfish aquaculture dependent on market demand. Hatchery development is key to providing a sustainable supply of spat, particularly as the climate changes, this will be reliant on funding to support it.

This paper presents a clear overview of the current state of the UK aquaculture industry, and the different policy commitments across the different nations of the UK. We consider the current barriers to growth within the different aquaculture sectors, and present recommendations to address these barriers. If adopted, and provided with the right level of political and financial support, UK aquaculture can deliver a sustainable source of protein to the market, whilst also providing additional ecosystems goods and services.

Global aquaculture

Globally aquaculture provides around 50% of the fish required for human consumption, amounting to around 82 million tonnes in 2018. It remains the fastest growing food sector, with an average annual growth rate of around 5%[2], driven by human population growth and increasing fish consumption. Aquaculture will play an increasingly important role as wild capture fisheries reach their maximum production potential and land available for terrestrial protein production decreases. It is anticipated that 62% of global fish will be produced from aquaculture by 2030[3].

There is potential capacity for further expansion of aquaculture production, although not necessarily using current technology; however, it is imperative that any future development is underpinned by sustainable development strategies. Recent technological advancements within the aquaculture sector must be used to address continued environmental and emerging climate challenges for responsible production to be achieved. Not only will this better future-proof the industry, making it more resilient, it will also result in aquaculture products contributing to increasing global food security.

Sustainable development goals applied to aquaculture

The Sustainable Development Goals arose from the United Nations 2030 Agenda for Sustainable Development. The goals are based around the three pillars of sustainable development – economic; social and environmental and have a five-point focus. These in summary are:

People – An end to poverty and hunger, dignity and equality for all.

Planet – Protecting the planet from degradation, including sustainable consumption and production, sustainable management of natural resources and urgent action on climate change.

Prosperity – All can enjoy prosperous and fulfilling lives, all progress occurs in harmony with nature

Peace – Fostering peaceful, just and inclusive societies.

Partnership – Working to achieve goals through a Global Partnership for Sustainable Development, focusing on the poorest and most vulnerable with participation of all countries.

SUSTAINABLE DEVELOPMENT GOALS

2 ZERO HUNGER

Goal 2 - End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Achieving food security and promoting sustainable agriculture are the most salient aspects of this goal in relation to aquaculture. Sustainable agriculture will contribute to food security, as more of the fishmeal and fish oil content of aquafeeds are being replaced with terrestrial proteins and oils such as soya and rapeseed oil.

6 CLEAN WATER AND SANITATION

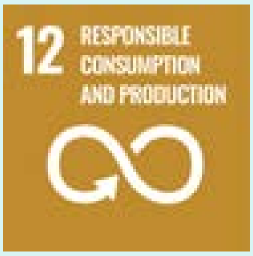
Goal 6 - Ensure availability and sustainable management of water and sanitation for all

Sustainable management of water is a key aspect of responsible aquaculture, in particular within pond culture systems such as those used to grow warmwater prawns. Brackish water is pumped into lined ponds within which the prawns grow. If the ponds are not lined, or the lining in not adequate, brackish water can seep out and contaminate the underlying freshwater aquifers, rending the freshwater undrinkable for other users. Seepage can also occur if the pond sludge is also not disposed of correctly.

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

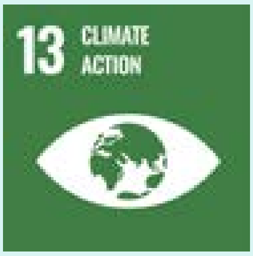
Goal 9 - Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Fostering innovation is essential if aquaculture is to reach its potential to contribute to food security within a changing climate. Innovation in feed ingredient development, offshore technology, integrated multi-trophic aquaculture, containment, species diversification and market development for novel products, such as seaweed, should be key areas of focus.



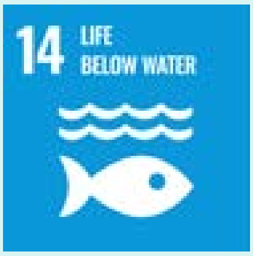
Goal 12 - Ensure sustainable consumption and production patterns

Ensuring sustainable consumption can only be achieved by encouraging and informing consumers about the sustainable choices they can make. For seafood this is the purpose of the Marine Conservation Society Good Fish Guide.



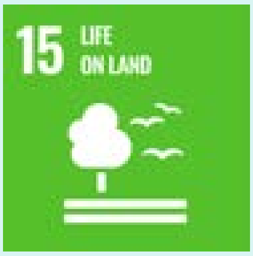
Goal 13 - Take urgent action to combat climate change and its impacts

Tackling climate change and its impacts is going to be one of the predominant challenges. Issues such as increasing water temperature leading to increased sea lice numbers and increasing disease outbreaks; increases in harmful algal blooms and jellyfish swarms; increasing storm events and magnitudes and ocean acidification are all issues that are /or will be happening in the short to long term. However, there will be opportunities for aquaculture, as shellfish and seaweed aquaculture can contribute to climate change mitigation by carbon sequestration, wave damage mitigation and nutrient uptake.



Goal 14 - Conserve and sustainably use the oceans, seas and marine resources for sustainable development

The most pertinent and relevant of the SDG's for aquaculture. The objective of conserving and sustainable use is the underlying principle that should be the basis for all aquaculture development. Conservation has to apply to all habitats and species that may be impacted by aquaculture and this translates into actions such as: comprehensive spatial mapping and planning of all marine activities, including areas of sensitive habitats; allocating aquaculture free zones where development is unsuitable; fully understanding the impact of aquaculture organic and non-organic pollution on surrounding habitats and species, including deposition areas, and a full understanding of cumulative carrying capacity of a receiving water body. Sustainable development has to ensure that all inputs, such as feed, going into the system are also sustainable, this would therefore include all fed ingredients, both marine and terrestrial. This is where innovation (goal 9) and diversification (goal 13) will come into play as new ingredients are sought and low carbon options are explored.



Goal 15 - Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably mange forests, combat desertification and haul and reverse land degradation and haul biodiversity loss

This goal is of increasing importance for aquaculture as more and more of the fishmeal and fish oil content of the feed is replaced by terrestrial proteins and oils. The use of soy, wheat and its derivatives for example have increased significantly as the aquaculture industry continues to grow, driven by the finite supply of fishmeal and fish oil. It is therefore essential that these protein sources are also managed sustainably if the aquaculture industry wants to produce sustainable products. Certified sustainable products are currently the only way that this can achieved and demonstrated.

UK's progress in achieving these goals has been reported here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/816887/UK-Voluntary-National-Review-2019.pdf

Opportunities for aquaculture growth

There are opportunities for aquaculture to contribute to food security and achieve the Sustainable Development Goals within a changing climate. For this to be achieved there needs to be a UK wide Government level commitment, including incentives to encourage and support the diversity of this important industry. Of particular interest for development are the seaweed and shellfish sectors. Within finfish farming innovative technology will play an increasing role to combat climate challenges and mitigate direct environmental impacts of production. Fisheries, aquaculture and shifting people to less carbon intensive diets could reduce emissions by between 0.3 and 0.94 billion tonnes of CO_2e by 2030 and between 0.48 and 1.24 billion tonnes of CO_2e by 2050[4].

Finfish aquaculture

Finfish aquaculture in the UK is dominated by Atlantic salmon production, as such it likely that any growth will occur with this species. The current salmon farming industry target for growth is 5% per annum[5], with a waiting market this is predicted to be achieved. However, given the challenges still faced by the industry in terms of sea lice management, escapes and disease, all of which is likely to be exacerbated by climate change, the current farming, regulatory and planning system is unsuitable to support any growth. For immediate production growth to be achieved within the current system, the issues of escapes and mortalities need to be further addressed. A revised regulatory framework that underpins a comprehensive planning process is required before future growth can be considered. A widespread use of technology, such as a recirculating aquaculture systems (RAS) for longer phase smolt production, semi-enclosed marine systems for grow out, and the use of waste capture technology in open marine pen systems has to underpin the future of open net pen production. Increasing storminess will present challenges, which will have to be met by technological advances in equipment design. It is essential that all farms be sited in the right location, which minimises impacts on sensitive habitats, Priority Marine Features and surrounding species such as wild salmonids.

Other species that are predicted to increase in production volumes are cleanerfish – ballan wrasse and lumpfish. These species are being farmed to be used as a biological control of sea lice in salmon farming. A large number are being farmed in a land-based system in Anglesey, Wales. The site has the potential to increase production, and the use of farmed cleanerfish is increasing as the industry endeavours to shift reliance away from wild caught species. However, the farming of cleanerfish is not without its own challenges – disease, welfare and post-harvest use of these fish are issues that have yet to be resolved.

Seaweed aquaculture

Global cumulative annual seaweed production (tonnes) from wild harvest has remained relatively consistent (2000-2013) both by the type of plants sourced and production levels (ranging between 1-1.3 million tonnes). Conversely, the global cumulative annual seaweed production (tonnes) from aquaculture rocketed in the same period, increasing from ~9.5 million to ~27 million tonnes, with the aquaculture of red seaweeds increasing significantly. The FAO also recorded 87,000 tonnes of farmed microalgae from 11 countries in 2018, 86 600 tonnes of which were reported from China alone[6].

In recent years, there has been a growth in kelp harvesting, with the alginates they contain used in food production, pharmaceuticals, textiles, paper and biotechnology. While there are no comprehensive estimates of seaweed production in the UK, seaweed production from wild harvest in the UK (2013), was estimated at around 2,000-3,000 dry tonnes (equivalent to 20,000-30,000 wet tonnes[7]). It is estimated that the kelp growing around the coast of Scotland alone covers 2,155 km2 and stores 1.73 million tonnes of carbon in its biomass, making it another, potentially significant, blue carbon store[8].

Expansion of seaweed farming could have positive impacts on food security goals, social economics, ecosystem management and climate change mitigation. Seaweed farming is gaining increasing attention to be promoted and monitored for climate and environmentally friendly bio economy development.

Seaweed absorbs carbon dioxide from the atmosphere, which in turn can help mitigate ocean acidification. It is also a net producer of oxygen, uptakes nutrients and can help dampen wave energy, reducing the impact of storm events and coastal erosion in inshore waters.

A recent study carried out for Crown Estate Scotland[9] included two scenarios for seaweed aquaculture in Scotland– one for business as usual, the other for high growth in the seaweed sector. The high growth scenario illustrated a seaweed cultivation industry worth £4 million by 2040 with associated employment opportunities in remote areas. There are a number of markets for seaweed production: animal feeds; human consumption; aquaculture diets; biochemical use and bio-energy, these markets need to be further developed to encourage growth in this sector.

However, there are various issues and barriers limiting or affecting the development of seaweed production and markets. In Europe and the UK, there is a perceived bottleneck in the seaweed supply chain in terms of production capacity (a result of high costs for seaweed biomass production and/or shortage of seaweed biomass due to seasonality). Factors such as large investment set-up costs; low value products with uncertain markets; lack of information on operational costs; potential biomass yields and ecological effects of seaweed farms; infrastructure and unclear (particularly for marine licensing) or lack of specific seaweed regulatory framework, are perceived to limit the development of the seaweed industry. The cost of transporting a wet and therefore heavy product, within a short window before degradation occurs, is another issue. This could be resolved by having small drying plants at site or at local community level, however this requires investment. These are the key issues that must be addressed within the UK to support growth of this sector. If delivered, an increase in seaweed aquaculture could play an increasing role in mitigating the effects of a changing climate. stratification of the water column and increased water temperature.

Shellfish aquaculture

One of the vulnerabilities of the future of shellfish aquaculture within the UK is the low diversity of species farmed. To ensure resilience in a changing climate a diversity of shellfish species, native to the UK, will need to be farmed, particularly as mussels and oysters, the UK's current favoured shellfish are the considered to be amongst the most vulnerable species to climatic changes[10].

Space for expansion of the shellfish farming industry may also be a limiting factor. Moving into offshore waters, such as seen in rope grown mussels in Lyme Bay, may be necessary to facilitate substantial sector growth, however improved marine spatial planning will be required to underpin any industry expansion. Regulation, in particular relating to water quality classification, of the shellfish aquaculture industry will also need to be reviewed. Finally, spat availability may prove to be a limiting factor due to climate induced stratification of the water column and increased water temperature.

A resilient and diverse shellfish industry of the future is dependant on plentiful spat; however, as noted above, the species farmed will need to be native to the UK, which may prove another limiting factor. This is currently being overcome in Devon, with the successful development of a scallop hatchery, producing spat for scallop aquaculture, it has the ability to increase production to supply similar scallop farming businesses.

In the short term, the biggest limiting factor is loss of the export market. With the UK, exiting from the EU a large percentage of the shellfish market has been lost. Whilst in the EU, the UK was able to export shellfish from Grade B shellfish waters; these were then depurated abroad before being sold within Europe. Now the UK is classed as a third country, as such EU countries cannot import shellfish from Grade B waters outside of the Union. Until the regulation is reviewed and changed, or a derogation facilities are in place to circumvent this restriction, the export market has been lost.

Rewilding/restorative aquaculture

Rewilding or restorative aquaculture refers to the practice of farming species, typically shellfish, for purpose of providing ecosystem services rather than as an economic venture. An example of this would be the restoration of the Native oyster population at the Dornoch Firth in Scotland (https://nativeoysternetwork.org/portfolio/deep/) and the restoration of the kelp forests in Sussex (https://sussexwildlifetrust.org.uk/helpourkelp).

A study carried out by The Nature Conservancy in collaboration with its partners at the Universities of Melbourne, Adelaide and New England, assessed the biodiversity benefits of mussel, oyster, clam and seaweed farming[11]. The study found that a great number of fish and invertebrates were found at mussel, oyster, clam and seaweed farm sites when compared to similar nearby locations without farms. The highest density found a mussel farms, that showed 3.6 time more fish and invertebrates than other locations.

These farms are able to provide ecosystem services such as improved water quality, excess nutrient removal, carbon sequestration and increasing biodiversity. Not only this, but the sites provide foraging ground for other species, protection from predators and reproduction from spawning farmed adults, which spill over into the surrounding environment.

Integrated multi-trophic aquaculture (IMTA)

Integrated Multi-Trophic Aquaculture (IMTA) refers to a system of aquaculture where the waste nutrients of one species, for example salmon, can be utilised for growth for one or more commercial species, for example macro algae and mussels. The nitrogen, phosphorus and carbon waste generated by finfish production can be utilised as a nutrient source by macro algae and shellfish, which may in turn help to mitigate the development of Harmful Algal Blooms (HAB's)[12] as excess nutrients leading to their formation are removed. This provides additional commercial species as well as mitigating the discharge load from the finfish farm.

IMTA has been commercially trialed in Scotland, but due to lack of market demand for the seaweed product, it did not continue as a commercially viable enterprise. However, this could be overcome if market development for seaweed products were to be developed and infrastructure were in place to support market access.

Offshore development

Suitable space for aquaculture expansion in inshore waters is limited; therefore, offshore production is being explored. Offshore can be defined as >3 km from shore but definitions vary in practice and higher energy sites are more likely to define an offshore delineation. Development of more exposed, offshore aquaculture may avoid the extremes in temperature, salinity, pH and oxygenation experienced closer to the coast.

Seaweed production in offshore sites has been developed in America and Europe in the last 15 years[13]; with most of developments at a pilot scale. While commercial production took place in Germany, Norway and the Netherlands, it is uncertain if these are still in operation.

Offshore bivalve production provides another development opportunity, particularly as warmer waters can adversely affect shellfish food availability. There are already existing UK offshore farming sites in commercial operation, for example mussel production in Lyme Bay[14]. The regulatory process in developing this farm was both lengthy and costly, thus discouraging similar future developments. Overcoming the regulatory burden is a key area for review if low carbon aquaculture solutions are to be encouraged in UK waters.

Offshore production of salmon is already underway in Norway, with SalMar being the first company to develop the world's first offshore fish farm ,"Ocean 1", in 2017[15]. Development plans for a similar structure in Scotland have been discussed. If progressed to deployment, it would be located at least 2 miles from Scottish shores and encompass new technologies to deal with the more exposed conditions. Scotland's coastline differs from Norway's, so using environmental performance data from Norway as a proxy from Scotland may not be appropriate. It is hoped that the new modelling programme used under the new (2019) Aquaculture Sector Plan developed by SEPA would be appropriate to inform and guide this development.

Colocation

The 2050 target for the UK is to achieve net zero emissions. In an October 2020 press release[16], the UK Government confirmed offshore wind would produce more than enough electricity to power every home in the country by 2030, based on current electricity usage. This would boost the government's previous 30GW target to 40GW. This will contribute to a reduction in carbon emissions, combating climate change and helping to secure the UK energy supply. One of the opportunities for offshore aquaculture is the colocation with existing structures such as offshore wind turbines, as this could ease the competition for space experienced in coastal waters.

In 2014, a study was undertaken in Wales for the Shellfish Association of Great Britain, to look at the potential for colocating aquaculture with offshore windfarms[17]. The study found there are a number of benefits colocation, including access to deeper, cleaner water; more dispersive sites; free from viral health threats and harmful algal blooms. However, there are also disadvantages, in particular the risks associated with working in higher energy and therefore more risky locations. While a number of shellfish species were considered, the report recommended that blue mussel was the most suitable species to trial. However, there are a significant number of technologies, licensing and operating issues to be addressed before this can be seen as a viable option in the near future.

Land based recirculating aquaculture systems (RAS)

Land based closed containment aquaculture systems avoid many of problems created by a changing climate: water temperature, oxygen levels and pH can be maintained at a constant level; harmful algal blooms are avoided; there is no exposure to parasites and diseases and containment is not compromised by environmental conditions. However, the carbon footprint of land based recirculating systems is a disadvantage when compared to open net pens, due to the electricity demand for the lighting, pumps and filters required, unless this is supplied by renewable energy.

As with all production systems, there are other considerations to be factored in when calculating

GHG emissions – energy source and transport costs being the most significant. A study was carried out comparing the production of Atlantic salmon in open net pens in Norway and land based closed containment systems in the US. It concluded that when comparing the carbon footprint of production only, not considering transport to market or energy sources, the land based closed containment system has a carbon footprint double that of the open net pen systems for the same tonnage of salmon produced[18]. This could be mitigated by the use of a renewable energy source and by locating land based systems closer to markets/supply chain infrastructure.

Barriers for responsible expansion

As Atlantic salmon is the primary focus for growth, space within the marine environment is one of the largest barriers, particularly using current technology. Sea lice management, escapes and disease control are also limiting factors to the expansion of Atlantic salmon production. Only when these factors can be controlled in such a way as to mitigate their impacts on wild salmonids, and the wider environment, could expanding the production Atlantic salmon be considered to be responsible. A sustainable feed supply also needs to be secured to support responsible growth. A diet based on by-products, trimmings, alternative ingredients and certified sustainable marine and terrestrial primary ingredients is essential.

Marine spatial planning, incorporating all users within a water body, and taking into consideration cumulative effects, is essential before growth in the salmon farming sector can be considered. An effective planning system can identify areas where growth can occur using current technology as well as areas that would be suitable for closed/semi-closed production only.

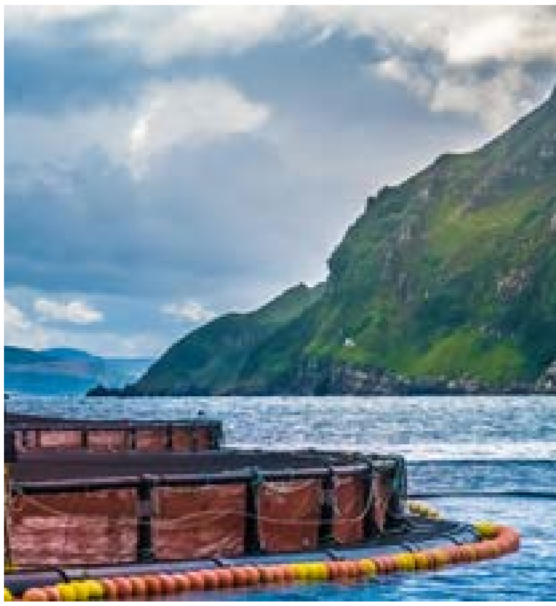
Competition for space in all of UK seas is a barrier to industry growth, particularly as the seas are heavily utilised. Lack of significant market demand for UK farmed species outside of Atlantic salmon; particularly shellfish is a significant barrier to further development.

UK aquaculture

UK aquaculture makes a substantial contribution to both the UK economy and UK food supply. In 2018 the aquaculture sector — dominated by salmon farming — contributed £885 million to the Scottish economy and supported 11,700 jobs, according to research commissioned by Marine Scotland[19]. Aquaculture in the UK is primarily focused in Scotland with the farming of Atlantic salmon. Other ther finfish species are also produced, but in much smaller volumes. The UK also produces shellfish, dominated by blue mussels and oysters. Other shellfish species are also produced, such as clams and scallops, again in lower volumes. Overall UK aquaculture production across all species is in the region of 250,000 tonnes, over 207,000 tonnes of which is Atlantic salmon.

Aquaculture production in Scotland

The predominant species farmed in Scotland is Atlantic salmon, farmed in the inshore waters along the West coast and in the Highlands and Islands. Salmon farming started in Scotland in the 1970's, and rapidly expanded in the 1990's. Production increased from 32,391 tonnes in 1990 to 207,630t in 2020, a 541% increase, the highest volume recorded. To date, there are 12 companies producing Atlantic salmon in 221 active sites.[20]



Rainbow Trout production in Scotland occurs in low volumes. In 2018 6,413 tonnes were produced, a decline from 2017 figures of 7,637 tonnes. There are 23 companies farming 53 active sites.

Other species farmed include brown trout, predominantly for angling restocking (9 companies, 25 tonnes), Atlantic halibut (1 company, tonnage unknown), lumpsucker (2 companies. 12 tonnes) and several wrasse species (3 companies, 5 tonnes), both of which are used as cleaner fish in the salmon farming industry.

The predominant shellfish species farmed in Scotland is the blue mussel, with a 2018 production of 6,874 tonnes, with Shetland accounting for 75% of this total. This was followed in tonnage by Pacific oysters at 322 tonnes, half of which is farmed in the Strathclyde region. Other minor farmed species include Native oyster (11 tonnes), King scallop (4 tonnes) and Queen scallop (1 tonne) a 93% decrease since 2017.

Potential and barriers for expansion in Scotland

In 2016, a group of aquaculture industry leaders developed an industry-led plan for growth in the entire aquaculture supply chain. This resulted in the development of **Aquaculture Growth to 2030: A Strategic Plan for Farming Scotland's Seas**[21]. Whilst not able to set precise targets for growth, the group did make projections of what the sector could deliver in the 14-year timeframe to 2030. A median production figure of 350,000 t of Atlantic salmon was estimated, representing a double in economic value to £3.6 billion, achieved by a year-on-year production growth of around 5%. The growth of the shellfish sector could also deliver 21,000t within this time. It is estimated this growth would generate over 9,000 new jobs, and establish Scotland as a global leader in the aquaculture sector.

However, before growth in Scottish salmon can be considered there are a number of issues to be resolved. The regulation of the Scottish aquaculture sector is undergoing review (October 2021), following recommendations stemming from the review carried out by the Rural Economy and Climate Change Committee's (RECC)in 2018. Many of RECC committee recommendations are yet to be actioned, such as implementing the recommendations of the Salmon Interactions Working Group, and implementing the Sea Lice Risk Assessment Framework. The Marine Conservation Society believes that these and subsequent regulations should be implemented before growth, using current production practices, is considered.

Aquaculture production in England

Despite the potential for growth within in the sector, the English aquaculture industry has seen a 5.6% decline in overall volume (although a 1% increase in value was observed) over the last 10 years[22]. According to the available information in 2019, the English aquaculture industry, small to medium size enterprises (SME's), produced 8,000MT with a value of £26Million, with 2/3 being freshwater finfish (predominantly Rainbow trout) and 1/3 shellfish (predominantly mussels). For comparison, wild capture fisheries landings were valued at around £209 million.[23]

Other species thought to still be farmed are Sea/Brown trout, Arctic char, Common carp and Brook trout. Mussels dominate English shellfish production; both rope grown and bottom culture. Other species include Pacific and Native oysters and clam species.

Capture fisheries in England are currently mostly overfished or fished at/near to their maximum capacity. It is therefore unlikely we will see significant expansion within the capture industry in the long-term.

Potential and barriers for expansion in England

In 2015, an industry task force was established to explore the challenges and opportunities facing the English seafood industry and to create a 2040 vision to enable it reach its full potential. It has an aspirational target of a 75% increase in seafood consumption by 2040. Contributing to achieving this target is the **English Aquaculture Strategy**[24], whose objective is to:

> *" .....building the industry and to support a realistic, ten-fold increase goal in production volume to approximately 90,000 tonnes by 2040. This can be achieved through a combination of expansion, innovation, integration and proportionate regulation."*

It is hoped that English aquaculture will provide at least 15% of overall English seafood consumption by 2040. Growth is planned across a number of species, including macro algae, shellfish, crustacea and freshwater and marine finfish. Production will be in a diversity of systems, including land based Recirculating Aquaculture Systems (RAS), bottom, trestle and rope culture of shellfish, flow through tanks and open pens. English Marine Plans will be the mechanism by which areas for growth will be identified. Increased production will need to contribute to the UK Government Carbon Net Zero targets and provide opportunities for carbon mitigation, including sequestration. This is the only country level strategy that addresses carbon mitigation.

We believe it unlikely that production will occur in open marine net pens. It is hard to imagine what species would be farmed in such systems.

Aquaculture production in Wales

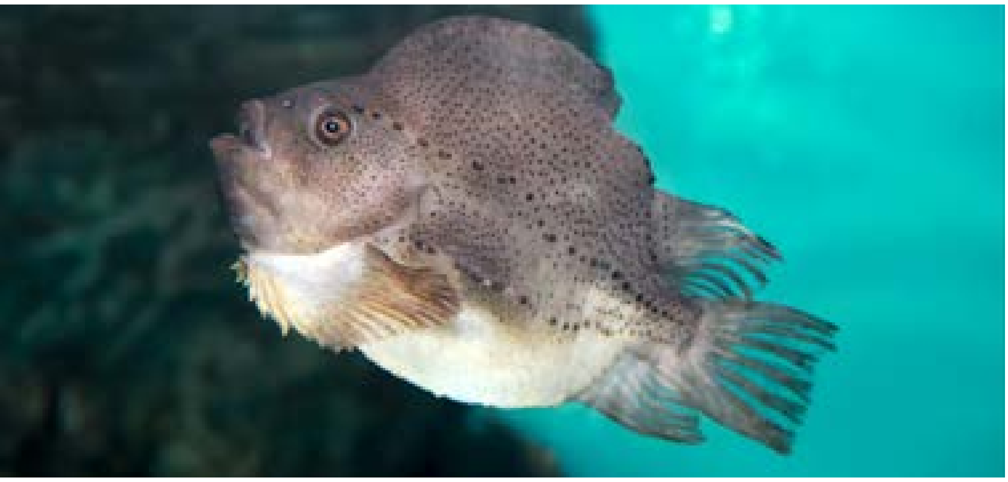
Welsh shellfish production, the same as English, is dominated by blue mussel culture, with an average of 7,000 tonnes produced per year, both as rope grown and bottom culture. Other species include Pacific and Native oysters and clam species[7].

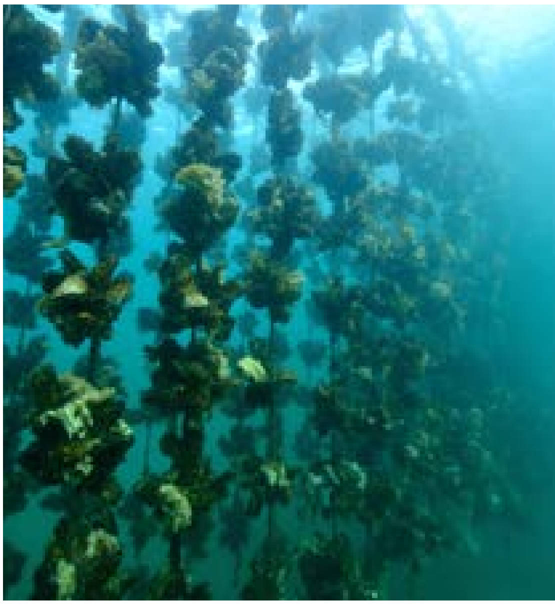
A relatively new species to be farmed is lumpfish, used as a cleaner fish in the salmon farming industry to remove sea lice. In 2019, in the land-based facility in Anglesey, over 2 million fish were produced[25]. Sea bass was previously farmed in Wales, but ceased in 2018. Rainbow trout was also produced; however, it is uncertain if this species is still farmed[26].

Potential and barriers for expansion in Wales

In 2016, the first iteration of the Welsh Seafood Strategy[27] was launched. Its original target of doubling aquaculture by 2020 has not been met and accurate figures on percentage increase are not available. This latest iteration of this strategy, aims for a 30% sustainable growth of the Welsh seafood industry by 2025, in alignment with the principles of the Well-being of Future Generations (Wales) Act 2015. The strategy hopes to achieve this growth whilst "maintaining and enhancing a biodiverse natural environment with healthy functioning ecosystems". It also hopes to progress "an adaptive, ecosystem-based approach to fisheries and aquaculture."

As with English aquaculture, it is likely that any growth will occur within the shellfish and seaweed sectors, providing markets for products can be found.





Changes and innovations: recommendations for responsible growth

Aquaculture of the future will face some serious challenges as the climate changes. Issues such as temperature rise, ocean acidification, increased storm events, nutrient run-off will affect how, and where the aquaculture industry operates. With these changes also comes opportunities – innovation in equipment design, feeds and market development will be essential for a successful future. Of most importance will be working with the ecosystem and not against it. Opportunities to use aquaculture to mitigate some of the effects of these climatic changes, such as seaweed aquaculture should be maximized; however, this can only be achieved if underpinned by fully integrated marine spatial planning. Science, innovation and pre competitive collaboration are key to ensure a resilient, responsible and climate smart UK wide aquaculture industry.

Below are our recommendations to overcome the barriers faced by each sector and what we view as the next steps to ensure responsible growth in UK aquaculture production:

Finfish

- For a system of fully integrated marine spatial planning to be fully developed, informed by the latest robust science and used to inform suitable locations for finfish aquaculture. This planning system should be adaptive and adaptable to account for climatic changes and emerging data.
- For innovation to be supported, via Government and finance and encouraged to address issues such as equipment design, pathogen and disease management and waste capture.
- For a revised technical standard for pen design to be developed to ensure all equipment is over specification in anticipation of increased storm events.
- Land based aquaculture to be adopted widely by industry, for longer smolt production for Atlantic salmon.
- Hatchery development to be supported and financially encouraged to support the development of new species, and those affected by juvenile supply such as warmwater prawns.
- Investment into research for offshore aquaculture, that considers and trials new equipment design, reducing environmental impacts and provides opportunities for environmental enhancement to be explored. It is anticipated that finfish aquaculture, in particular Atlantic salmon, may have to move further offshore in order to seek optimal water temperatures for on-growing.
- Greater support and investment to enable renewable energy to be deployed on farm sites.

Shellfish

- UK Government and devolved administrations to undertake a regulatory review, with regard to shellfish production including species farmed, to ensure that the process is streamlined, enabling and ensuring the industry is managed using an integrated ecosystem based approach in accordance with achieving Good Environmental Status under the Marine Strategy Regulation 2010 and objectives of the Fisheries Act 2020.
- For shellfish aquaculture to be fully integrated into marine spatial planning, with the objective of identifying opportunities for integrated multi trophic aquaculture (IMTA), offshore development and colocation.
- For the development of a shellfish hatcheries to be incentivised and encouraged to aid diversification of species and secure spat supply to support both an expanding shellfish aquaculture industry and restorative aquaculture.
- For restorative aquaculture to be seen as a viable mitigation tool for species and habitats, such as native oyster and kelp, and to be supported and promoted via policy and finance.

Seaweed

- Seaweed specific regulation to be developed, to ensure ecological footprint is understood, and development of this sector is consistent with an ecosystem based approach.
- Research the potential for seaweed farming to be used as climate change mitigation method. For example dampening wave energy in coastal waters, absorbing nutrients in areas of high run off and in conjunction with fin fish farms.
- Research into the potential yields/markets/economics of seaweed farming to be carried out.
- Research the potential of seaweed to produce human and animal feeds, including fish, to be explored and barriers identified.

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