

SR694 Aquaculture in England, Wales and Northern Ireland:

An Analysis of the Economic Contribution and Value of
the Major Sub-Sectors and the Most Important Farmed
Species

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Aquaculture in England, Wales and Northern Ireland:

An Analysis of the Economic Contribution and Value of the Major Sub-Sectors and the Most Important Farmed Species

Final Report to Seafish

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Acronyms and terms

AAC	Aquaculture Advisory Council	MSFD	Marine Strategy Framework Directive
BIM	Bord Iascaigh Mhara (Irish Sea Fisheries Board)	NAFC	North Atlantic Fisheries College
BBSRC	Biotechnology and Biological Sciences Research Council	NERC	Natural Environment Research Council
BTA	British Trout Association	NGO	Non-Government Organisation
Cefas	Centre for Environment, Fisheries and Aquaculture Science	NOSAP	Native Oyster Species Action Plan
CFP	Common Fisheries Policy	Parr	A young salmon between fry and smolt stages
CMO	Common Market Organisation	PML	Plymouth Marine Laboratory
CSAR	Centre for Sustainable Aquaculture Research, University of Swansea	RAS	Recirculation Aquaculture Systems
Cultch	Stones, old shells, etc., for the attachment of oyster spat	R&D	Research and Development
DAERA	Northern Ireland Department of Agriculture, Environment and Rural Affairs	SAGB	Shellfish Association of Great Britain
DARDNI	Department of Agriculture and Rural Development Northern Ireland	SAIC	Scottish Aquaculture Innovation Centre
DCF	European Data Collection Framework	SAMS	Scottish Association for Marine Science
DEFRA	UK Department of Environment Food and Rural Affairs	SARF	Scottish Aquaculture Research Forum
DETI	Northern Ireland Department of Enterprise, Trade and Investment	SEPA	Scottish Environment Protection Agency
DoE	Department of the Environment, Northern Ireland	SME	Small and Medium-Sized Enterprise
EMFF	European Maritime and Fishery Fund	Smolt	A young (silver) salmon ready to transition to seawater environment
EWNI	England Wales and Northern Ireland	Spat	A newly settled juvenile bivalve shellfish
FAO	Food and Agriculture Organisation of the United Nations	SPS measures	Sanitary and phytosanitary (food safety and animal and plant health measures)
FHI	Fish Health Inspectorate	SRO	Several or Regulating Order
FRS	Fishery Research Services, Scottish Government	SRUC	Scotland's Rural College
FTE	Full Time Equivalent jobs	SSMG	Scottish Shellfish Marketing Group
GM	Genetically Modified	SWOT	Strengths, weaknesses, opportunities and threats analysis
HIE	Highlands and Islands Enterprise	t	metric tonnes
IFCA	Inshore Fisheries and Conservation Authority	TSB	Technology Strategy Board
IMTA	Integrated multi-trophic aquaculture	ToR	Terms of reference
OATA	Ornamental Aquatic Trade Association	UHI	University of the Highlands and Islands
MANP	Multi-Annual National Plan	VHS	Viral haemorrhagic septicaemia
MIS	Marine Information System		
MMO	Marine Management Organisation		

Aquatic species mentioned in the text

SHELLFISH

Abalone (European)	<i>Haliotis tuberculata</i>
Cockle (Common)	<i>Cerastoderma edule</i>
Green lipped mussel	<i>Perna canaliculus</i>
Hard clam	<i>Mercenaria mercenaria</i>
King scallop	<i>Pecten maximus</i>
Lobster (European)	<i>Homarus gammarus</i>
Manila clam	<i>Ruditapes philippinarum</i>
Mussel (Blue)	<i>Mytilus edulis</i>
Native clam	<i>Ruditapes decussatus</i>
Native oyster	<i>Ostrea edulis</i>
Pacific oyster	<i>Crassostrea gigas</i>
Queen scallop	<i>Aequipecten opercularis</i>
Soft shell mussel	<i>Mytilus trossulus</i>
Spiny lobster	<i>Palinuridae spp.</i>
White leg shrimp	<i>Litopenaeus vannamei</i>

FINFISH

Arctic char	<i>Salvelinus alpinus</i>
Atlantic salmon	<i>Salmo salar</i>
Ballan wrasse	<i>Labrus bergylta</i>
Barramundi	<i>Lates calcarifer</i>
Bream	<i>Abramis brama</i>
Brown trout	<i>Salmo trutta</i>
Carp	<i>Cyprinidae spp.</i>
Eel (European)	<i>Anguilla anguilla</i>
European seabass	<i>Dicentrarchus labrax</i>
Golden orfe	<i>Leuciscus idus</i>
Goldfish	<i>Carassius auratus</i>
Goldsinny wrasse	<i>Ctenolabrus rupestris</i>
Gudgeon	<i>Gobio gobio</i>
Halibut	<i>Hippoglossus hippoglossus</i>
Lumpsucker	<i>Cyclopterus lumpus</i>
Pangasius	<i>Pangasius hypophthalmus</i>
Perch	<i>Perca fluviatilis</i>
Rainbow trout	<i>Oncorhynchus mykiss</i>
Sturgeon	<i>Acipenseridae spp.</i>
Tench	<i>Tinca tinca</i>
Tilapia	<i>Oreochromis spp.</i>
Turbot	<i>Psetta maxima</i>

The Report

This report has been prepared in order to demonstrate quantitatively and qualitatively how the economic performance of existing aquaculture businesses in England, Wales and Northern Ireland may be improved and capacity of the industry increased.

It explores the present status of the industry, its distribution and contribution of the industry, its competitive strengths and weaknesses, and the measures – applied via government, market structure or other group – that would lead to sectoral growth in England, Wales and Northern Ireland.

The report is broad in scope, covering all forms of aquaculture and associated activities, and a very wide range of markets. Limited resources have necessarily constrained the depth of analysis in some areas, and we have highlighted areas where there is substantial uncertainty, and/or where we believe further research and analysis would be cost effective.

It is important to note that the researching and drafting of this report was undertaken prior to the UK referendum on its EU membership, and before the announcement of 'Brexit'. Throughout the report, reference is made to European policy and funding streams relevant to UK aquaculture (such as the European Maritime and Fisheries Fund (EMFF)). Until the UK becomes fully independent from the EU, these references remain valid, and the messages presented throughout the report are considered just as pertinent.

Acknowledgements

Most of the insights in this report come from fish and shellfish farmers and their representatives. They are typically very dedicated and busy professionals dealing with sourcing, production, staff, marketing and regulatory issues. They also have to deal with researchers with clipboards and a great deal of paperwork. Nonetheless, many of them (listed in Annex 1) were prepared to spend a great deal of time talking with us. We greatly appreciated their engagement and input, and hope we have been able to do justice to their knowledge and perspective.

We also received a good deal of information and perspectives from researchers and staff in government agencies, and again appreciate the time and effort spent helping us.

Finally, we received many useful suggestions from the project steering group.

1 EXECUTIVE SUMMARY

1.1 Main findings

Overall economic contribution

1. **Total production** (finfish and shellfish) in England, Wales and Northern Ireland has declined in recent years from 34,394t in 2010 to 21,342t in 2014. The decline was common to both finfish and shellfish sectors and occurred in all three countries.
2. **Direct value.** Production in 2014 was associated with an estimated £54 million in farm gate sales, with roughly equal contributions from shellfish and finfish. This generated roughly £26 million direct value added, and around 1,000 jobs, most of which are full time.
3. **Total contribution.** Total benefit to the economy as whole is likely to be closer to £100 million in revenue and 1,700 FTE jobs (including indirect and induced). The industry also makes a substantial contribution to household (aquaria, ponds, etc.) and countryside education and recreation (lakes, rivers, fisheries, countryside destinations, etc.).
4. **Nature of businesses.** Most of the jobs in aquaculture in England, Wales and Northern Ireland are associated with small businesses serving relatively local demand, especially in recreational fisheries. Some producers are closely integrated with these fisheries and other service/retail activities, and it is difficult to separate the contribution of aquaculture from these other activities.
5. **Contribution to rural and coastal areas and quality of life.** The contribution of aquaculture to the economies of England Wales and Northern Ireland is modest; but it is diverse, spread widely across all three countries, closely associated with quality seafood and aquatic products important to the image of some regions, and locally important in rural areas. It also produces healthy seafood, with opportunities for growth that do not exist in capture fisheries. Indirectly aquaculture makes a substantial contribution to healthy recreation and leisure for millions of people through countryside visits, angling and ornamentals.
6. **Industry trends.** The aquaculture industry in England, Wales and Northern Ireland has been relatively stagnant over the last three decades with an apparent decline in recent years, despite impressive growth rates in many other countries - including Scotland. There have been some significant successes in the application of recirculation technology to hatchery fry and smolt production, and some major failures related to the application of indoor recirculation technology for the production of both freshwater and marine finfish for the table. There are some signs that shellfish farming may be entering a growth phase, but is highly constrained by a wide range of factors.

Regional economic contribution

7. Table 1 estimated the current regional contribution to employment by different types of aquaculture across England Wales and Northern Ireland. Figure 1 illustrates the distribution of aquaculture activity (including the estimated contribution to employment) across the three countries. Aquaculture makes the biggest contribution in North Yorkshire, Northern Ireland, the Welsh Borders and southern England.

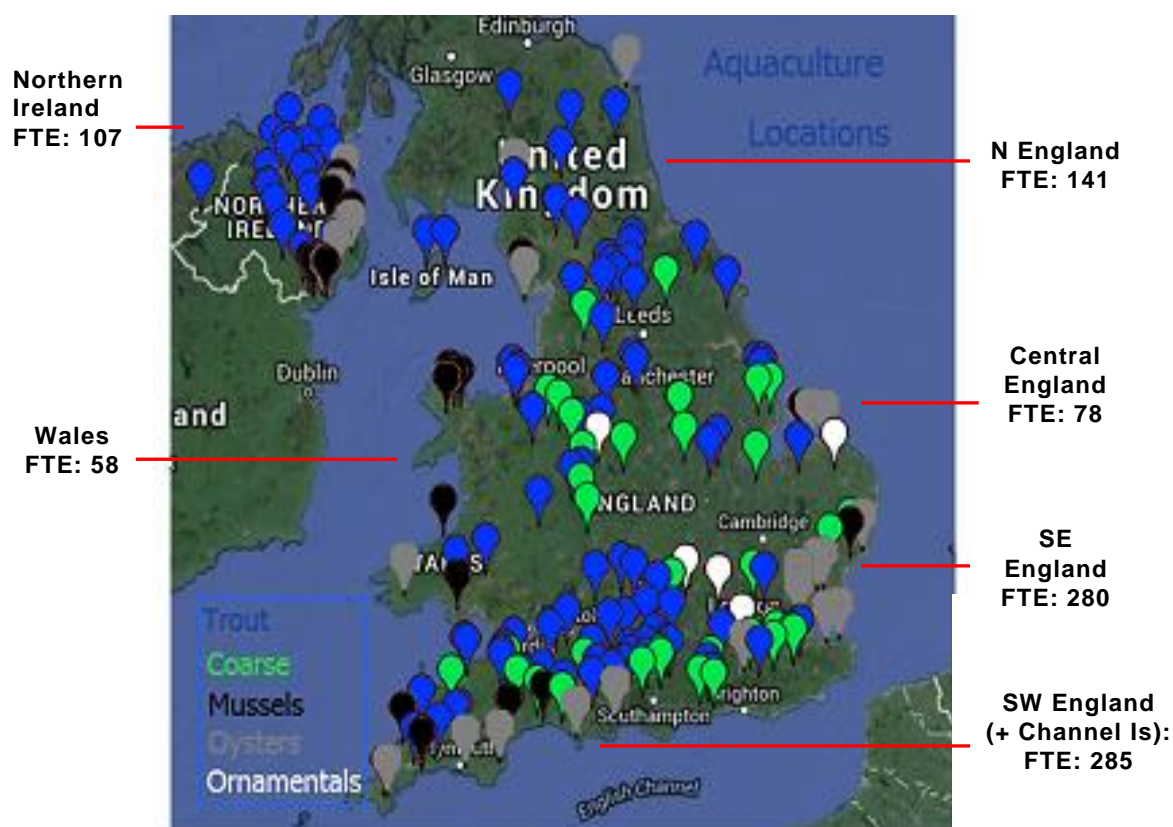
Table 1: Regional contribution of established commercial aquaculture production businesses to direct (on farm) employment (FTE)

	Northern England	Central England	SE England	SW England	Wales	Northern Ireland	Channel Islands	Grand Total
Trout or salmon egg and fry production	30	2	2	25	4	26		89
Table trout production	15	8	12	55	6	9		105
Trout or salmon for restocking and on-growing	54	29	35	89	12	20		239
Production of coarse fish for restocking	22	35	75	22				154
Ornamental fish production		4	37					41
Shellfish seed production	4		4				4	12
Oyster on-growing for the table market	12		113	37	4	18		184
Mussel growing for the table market	4		2	53	32	34		125
Grand Total	141	78	280	281	58	107	4	949

Note: there is no reliable published information at this level of disaggregation, and production categories are difficult to define or distinguish. These figures are rough estimates based on information from a variety of sources including government statistics, web sources, information from producers and other studies.

RAS is not included. It does not meet the criteria for the other entries – i.e. established commercial aquaculture. Employment in RAS is considered later in the report.

Figure 1: Distribution of aquaculture activity and estimated contribution to employment across England, Wales and Northern Ireland



Sub-sector contribution and potential

8. **Carp and coarse fish farming** makes a significant contribution to the economy of per-urban and rural areas, especially in southern England and the Welsh Borders. It not only supports recreational fisheries, but is an integral part of many multi-attraction rural recreational destinations. It is relatively well established with modest opportunities for growth, but is highly dependent on site opportunity.
9. **Production of salmonids for restocking** recreational fisheries is concentrated in southern England, with significant activity also in the north, the Welsh Borders and Northern Ireland. This sub-sector also makes a diverse contribution to rural economies, and may also be integrated with local food retailing. However, demand for trout for restocking fisheries is rather flat, and growth opportunities limited. This is due to a variety of factors including the increasing tendency to put fish back, the triploidy rule¹, the declining interest in fly fishing, and indeed the decline in angling more generally.
10. **Production of salmonid ova** is a specialist activity supplying an international market. There is no reason why the UK should not be a world leader in this sub-sector. While this in itself would not make a huge economic impact, downstream impacts could be substantial. It also crosses over with the animal genetics and biotechnology sectors and would strengthen the UK as a leader in these areas of activity.
11. **Trout for the table market.** Demand for trout (predominantly rainbow trout) is relatively flat, and producer margins slender. Demand for the traditional whole, plate sized trout in the UK is limited and easily met by existing suppliers. Internationally the UK is in competition with high quality production from Denmark, and volume supply from Iran, Turkey, and Chile. Growth in the trout market appears to be confined to the production of large seatrout in marine cages, which now takes place in Norway, Denmark, Scotland and Chile. There may be some growth potential for this sub-sector in Northern Ireland (perhaps in association with salmon production) but lack of competitive sites will significantly limit growth opportunities in other parts of England, Wales and Northern Ireland. Stimulating demand for trout through value added products may have more potential. Smoked trout fillets can be cold or hot smoked, are relatively popular, and are excellent products for high end supermarket or gourmet retail outlets, as well as more direct on farm/at the smokery sales. These various markets are already being exploited, but to date the product has not broken into a global mass market similar to that for smoked salmon. This may or may not be desirable as it would imply much higher volumes of production at lower prices, and the ratio of value added and employment to production would decline significantly.
12. **Production of salmon smolts** is locally important in the north England, using both through flow and recirculation technology. There may be some opportunity to both extend (to larger fishes for more strategic stocking in cages) and expand this business, but this will depend largely on the strategy of international salmon production companies. There are signs that further expansion will take place closer to production sites in Scotland.
13. **Salmon farming in Northern Ireland** has some potential for growth, though climate change may threaten the suitability of the rearing environment, and competition in

¹ In order to protect the genetic diversity of native brown trout populations, since January 2015, it has been illegal to stock rivers with fertile farmed fish. Stocked brown trout must be sterile female 'triploids' or from breeding programmes that use locally sourced brood-stock. <http://www.wildtrout.org/content/trout-stocking>

salmon farming is now so intense that enterprises must have very suitable sites, good logistics/market access, scale efficiencies, and/or a very clear niche market.

14. **Oyster farming** is difficult to separate from managed oyster fisheries, but there is currently some expansion and investment in the sub-sector. England, Wales and Northern Ireland appear to have comparative advantage in European, and possibly global markets, despite some disease issues. Seed is likely to become a significant constraint, and there is a pressing need for a coordinated strategic approach to address this problem. Clam farming also appears to have potential but also depends critically on hatchery seed production.
15. **Mussel farming** has significant potential, and there are important current initiatives both inshore and offshore. A major offshore venture in Lyme Bay, SW England is potentially a game changer for the sub-sector, and success or otherwise is likely to be determined in the next couple of years. Increased production may also lead to an added value sub-sector similar to that which has grown up in support of the Scottish mussel industry.
16. **Scallop farming** appears to have good potential, especially in southern England and South Wales. Temperatures are close to optimum for king scallop (*Pecten maximus*), and growth rates - which have always constrained Scottish initiatives - are far more commercially attractive further south. Various production models may be suitable, and some are being commercially tested at the present time. The main constraints are seed supply, gaining control over suitable areas of seabed, and protecting stock.
17. **Ornamentals production** is a small sub-sector in terms of direct employment and income, however there is significant “informal” or garage production taking place. There is an opportunity for modest expansion with significant downstream benefits as well as biosecurity advantages when compared with the importation of ornamentals.
18. **Farming in Recirculation Aquaculture Systems (RAS)**. Substantial investment (both public and private) has been made in RAS over the last two decades, for production of smolts for the Scottish salmon farming industry, and for production of warmwater tilapia, barramundi, seabass, and tropical prawn.

18.1. **RAS production for salmon smolts** is well established and has significant advantages over flow-through systems in terms of biosecurity and environmental control (which can be crucial for nurturing sensitive juveniles), as well as production scheduling to maximise the productivity of cage farm facilities. The higher costs associated with RAS can be accommodated for salmon smolts because they form a relatively small part of the final production cost. Indeed RAS systems are commonly used in hatcheries and early rearing throughout the world.

18.2. Most initiatives to use **RAS for table** ready fish have failed. The reasons are many and complex but the most important are:

- The long lead time before achieving significant production, and rarely reaching design capacity;
- High production costs (especially energy, capital and labour); and
- Unrealistic assumptions about price premia payable on locally produced RAS fish relative to prices paid for imported fish from countries where they can be produced more cheaply.

Two companies are currently developing RAS for tropical prawn production in England. RAS in Wales previously used for table fish are currently being used for research and semi-commercial production of cleaner fish for the Scottish salmon industry. The commercial viability of these companies remains to be established, but new investment in RAS for these purposes is likely to be located closer to demand.

19. **Other aquaculture (including enhanced fisheries) opportunities.** Lobster, abalone, seaweed, tropical prawn, etc. may have potential but need much more thorough and independent technical-economic appraisal, and need to be driven by realistic commercial interests rather than optimistic research interests.

1.2 Conclusions

20. **Unrealized potential.** Growth in aquaculture production has been impressive in many countries in recent years. Undertaken in the right place at the right time with the right skills it can make a significant contribution to national economies, and in particular coastal and rural economies. The UK has significant historic and current skills in this area, yet aquaculture in England, Wales and Northern Ireland has underperformed, in part due to a lack of understanding of its basic economic characteristics - as presented in the following paragraphs - on the part of both private sector and government.
21. **Aquaculture is hugely diverse technically and biologically.** From simple ponds to high-tech hatcheries; recirculation systems to robust offshore long-lines - each system is designed for a particular species or life stage, and production occurs in freshwater, estuarine, coastal and marine environments. The measures required to facilitate a healthy and dynamic aquaculture sector are therefore complex and diverse.
22. **Much aquaculture is relatively high risk.** Breeding can be erratic and unpredictable. Disease is a constant threat. Shellfish may be contaminated by pathogens or toxins as a result of events beyond the control of the farmer and may be closed down for an indeterminate period as a result. The product itself is usually highly degradable. Lead times and cash flow are major issues for many sub-sectors. A stable, predictable and high quality aquatic environment is essential and increasingly under threat. Global competition is severe and increasing leading to unpredictable prices. As is the case for all agricultural production, supply at local, national or global level is unpredictable due to weather, disease and other factors - leading to prices that can readily change by 50% or more from year to year, or even month to month. There is continuing upward pressure on feed input prices in the finfish sector, squeezing margins.
- These risks must be fully understood by would-be finfish and shellish farmers and those seeking to support them, and contingency planning (financial, procedural, etc.) must be in place if aquaculture businesses are to be sustained.
23. **Shellfish aquaculture has strong growth potential but is heavily constrained.** England, Wales and Northern Ireland appear to have comparative advantage (in terms of temperature regime and suitable sites) in the production of some shellfish species (in particular oysters, blue mussels and king scallops), and markets are buoyant. However, seed and (optimal) site availability are major constraints at the present time, followed closely by water quality issues. While the industry could show more initiative in terms of addressing the seed constraint, it would be extremely helpful if government played a pro-active role in facilitating and supporting shellfish aquaculture development; streamlining and reducing the time and cost of planning and regulatory procedures, and ensuring water quality in coastal waters suitable for high quality shellfish production.
24. **Freshwater finfish aquaculture has less growth potential but its valuable contribution needs to be maintained.** While freshwater finfish production currently makes the greatest economic contribution to the three countries (primarily through its association with recreational fisheries and rural destinations) opportunities for growth appear to be more limited. It is important nonetheless to create a supportive environment so that current levels of activity do not decline further.
25. **There is some limited potential for further expansion of salmon farming and marine trout** in Northern Ireland, but comparative advantage is less obvious for this sub-

sector, and future expansion may be market limited. Offshore production elsewhere in England, Wales and Northern Ireland is unlikely to succeed in current market conditions.

26. **There is limited potential, in the short and medium term, for large scale RAS production** of table fish and crustaceans due to high production costs (relative to simpler systems in other countries with comparative advantage) and relatively limited market premia for fish grown in this way. Similar arguments apply to hydroponic and integrated multi-trophic aquaculture systems, though the latter may evolve naturally at a more “water body” scale across different specialist producers. Feasibility studies for these systems need to be more informed, more rigorous, and more independent. The crucial questions must always be: *“Can we produce more cheaply than the competition?”* or *“Can we sustain a price premium that will more than cover the additional production costs?”* Put more simply: *“Do we have comparative advantage?”*
27. **Critical constraints.** Where England, Wales and Northern Ireland have comparative advantage, the key to growth will be to nurture technical skills, marketing skills and entrepreneurial ambition, and to facilitate secure long-term access to high quality production sites and input resources. The last of these represents a particular constraint on growth in shellfish aquaculture, the sub-sector identified as having the greatest potential for growth at the present time. This is a complex issue encompassing delays and uncertainties related to permitting procedures, site security, and water quality. Although the industry itself can address some of these issues, the primary need is for Government to take a lead in addressing these issues, most of which are within its scope.
28. **Sub-optimal investments.** Over the last decade, funding and support for the industry has been skewed in favour of major investments in high-risk, high-tech research driven projects, with inadequate attention to the basic needs and potential of the existing industry and well established technologies.
29. **Inefficient planning and regulation.** Shellfish farm development and other forms of aquaculture are hampered by regulation (or rather the manner of its implementation), leading to significant direct costs as well as delay, investment uncertainty and operational uncertainty. While it is universally agreed by the industry that regulation is necessary, the current system tends to constrain rather than facilitate sustainable development. There is also a widespread view in the industry that the seafood safety measures, water quality designations, and regulatory regimes are not fit for purpose. Furthermore there is currently some uncertainty surrounding opportunities to grow non-native shellfish species in different parts of England, Wales and Northern Ireland, and possibly some inconsistency in the application of decision criteria.
30. **Inefficient collection and analysis of industry performance data.** The data on the economic contribution of aquaculture is limited. Independent researchers cannot access it in its raw form because of confidentiality issues, and Government officers lack the resources to undertake exploratory analysis themselves. We are concerned that “outsourcing” this type of analysis is further distancing Government from industry, and undermining the capacity of government to support the industry more effectively. However, data collection and analysis by Cefas is in a state of revision and we anticipate significant improvement in the coming years.

1.3 The way forward

Facilitating development

31. **Strategic guidance.** While there have been significant efforts on the part of Government and agencies (and in particular the Centre for Environment, Fisheries and Aquaculture Science, Cefas) to clarify the nature of the regulatory regime for new entrants in to the English industry (i.e. the Aquaculture Regulatory “Toolbox” hosted on the Seafish website), it would be helpful if this were to be approached from the opposite direction: the various implementors of the regulations (planners, local planners, conservation and environment agencies, Inshore Fisheries and Conservation Authorities (IFCA’s), etc.) need guidance and standards relating to implementation. Initiatives currently underway in this regard (e.g. by Cefas) need to be taken forward pro-actively, and regulatory streamlining needs to be better balanced and coordinated with development facilitation. We recommend that this guidance includes at minimum:

- Guidance on strategic policy, and in particular the desire of Government to see sustainable growth in the aquaculture sector in areas best suited to its development
- The need for clarity on the decision criteria that will be used and the nature of any trade-off analysis
- Standards relating to response and decision times
- Clarification of policy and decision criteria relating to the culture of non-native species in different locations/circumstances

32. **More supportive marine planning.** The marine planning system, despite its goals and objectives, is more constraint than opportunity focused. If significant growth is to be achieved it needs to be less precautionary and conservative, and more pro-active in identifying opportunities for sustainable development. One possible way to achieve this would be to introduce targets for aquaculture development. While there are dangers of the industry/Government responding to targets rather than market signals, this would create a far more positive development environment. This might be reinforced through higher level targets set in the Multi-Annual National Plan for the Development of Sustainable Aquaculture.

33. **National piloting programme for shellfish farm development.** Taken together, the combination of natural uncertainty (seed, growth rate, fouling, etc.) and planning/regulatory uncertainty is sufficient to discourage significant investment in the shellfish sector despite market opportunity and comparative advantage. Government, working in partnership with industry could however reduce this uncertainty by developing a joint programme to monitor and test larval abundance and levels of spatfall at potential grow-out sites around English, Welsh and Northern Irish coasts. It could also trial grow-out, and monitor growth rate, fouling, predation and other issues such as local attitudes. Potential sites for such testing could be readily identified by a workshop of industry, scientists and experienced Government officers. This programme might then be linked to an “offer of licenses” or permits for development as suitable areas are identified.

In other words, Government itself could take on the cost of the trialling and regulatory regime so that entrepreneurs can then take up opportunities with far less risk, uncertainty and lead time. This is in some ways similar to – but goes beyond – the proposals recently made by the Shellfish Association of Great Britain (SAGB) which are described in the discussion section of this report (Section 9), and is also similar to the Norwegian government approach to both stimulating and managing growth in the salmon industry.

34. **National seed strategy for shellfish.** There is an immediate need to address the seed demand and supply conundrum constraining shellfish farm development, and possible assistance/intervention by Government would be considered a positive step forward. We suggest that a clear strategy is developed including a project to develop a major public or public-private hatchery facility to fill the demand gap and develop technologies

for new species – scallops, clams, mussels, etc. This facility would have to be sufficiently large to produce commercial quantities of seed, and would probably require twin management to undertake production and R&D. It is essential however that it does not take market share from the existing commercial oyster hatcheries, but rather works with them to address the existing structural supply weaknesses. There are initiatives under the Seafish Strategic Investment Fund² that may serve this purpose, but it is vital that any such initiative is made part of a national shellfish seed strategy, with input from the entire sub-sector, and does not become overly research focused. The strategy would also address *alternatives to hatchery production*, and in particular more strategic approaches to, or business models for, spat collection around the UK coast, based on the piloting work described in paragraph 33.

35. **A dedicated aquaculture development/loan package** Due to long, extended lead times typical of aquaculture development and the relatively short-term view taken by ‘high street’ lenders, financial backing for aquaculture is often hard to secure from the private sector, especially when starting a venture. It may be appropriate to develop a dedicated aquaculture development/loan package, offering low interest loans, or other financial incentives such as tax breaks, to help cover the extended lead times and allow production to be established. Grants are less desirable for obvious reasons – grantees are less rigorous in their financial planning than loan recipients. Grant aid, while sometimes justified, should be far more rigorously assessed. Development funding needs to be made more accessible to ordinary farmers by reducing time, complexity, jargon, etc., and through more direct facilitation services to support grant applications. It should also be linked to effective technical-economic mentoring.
36. **IFCA aquaculture development strategies.** It may be appropriate to build on the significant expertise within Inshore Fisheries and Conservation Authorities (IFCAs), and their influence on development decisions, to raise the profile of aquaculture development within their activities. This might involve funding of strategy development and implementation support, and possibly an aquaculture development facilitator for a period of (say) 5 years. There are particular opportunities here relating to the designation of Several or Regulating orders, and these should be integrated closely with suggestions under paragraphs 33 and 34.

Supporting operation

37. **Water quality.** The limited number of Category A shellfish waters in England, Wales and Northern Ireland is a constraint on shellfish farm development. Tougher regulation of water companies (in particular in relation to “exceptional events” i.e. Combined Sewer Overflows) would not only lead to more Class A shellfish waters and fewer shellfish production area closures, but increased water quality would greatly benefit many other coastal users, sectors, e.g. recreation and tourism, and ultimately the stability of many coastal economies.
38. **Fit for purpose Sanitary & Phytosanitary (SPS) regime.** There is an immediate need for a broad independent audit of the testing regime and closure protocols associated with bacterial contamination and toxins in shellfish, and the accuracy and comparability of the shellfish waters classifications relative to those of other countries in Europe. The audit should also consider opportunities for self-sampling/testing, and greater use of testing at depuration sites.

² <http://www.seafish.org/industry-support/funding-and-awards/funding/strategic-investment-fund>

39. **Biosecurity and disease response strategies.** The health status of UK aquaculture is a comparative advantage reinforced by our status as an island nation. It is imperative that measures to protect this status are effectively implemented and adequately resourced, infringements are effectively punished, and that the industry supports and facilitates implementation. It is also important that when disease outbreaks do occur Government response is timely and effective, but damage to aquaculture businesses is minimised. This will require full and effective consultation; both strategic and emergency.
40. **Measures to maintain or increase trout production.** The following may facilitate maintenance or modest expansion of existing trout production:
- Trout needs an 'image boost' – through major retailers, celebrity chefs, outdoor/leisure programmes, etc., with British Trout Association (BTA) leading this process, but with support from EMFF, Government, and/or other organizations and agencies
 - There is a need for increased consultation, more notice, and some flexibility in the implementation of disease response and other regulations (such as triploid rules). Where this is not possible, some form of compensation or mitigation fund may be appropriate, especially for small producers, helping them to remain financially viable over difficult periods, securing their role as local employers and local economy contributors
 - The supermarket protocol that requires no animal proteins in fish feeds deserves re-appraisal; this would improve margins whilst make production more sustainable by reducing the amount of wild fish required to produce farmed fish. The additional costs associated with using non-GM vegetable protein also needs attention
 - Thorough assessment and understanding of consequences of more rigorous or costly abstraction/discharge legislation
41. **Skills.** The critical shortage of skilled and motivated labour in the aquaculture industry needs to be addressed through better hands-on training and apprenticeship schemes.

Promoting innovation

42. **Aquaculture R&D strategy.** Research and development is important to ensure that England, Wales and Northern Ireland maintain or improve their technical capacity, and identify and develop new opportunities. However, much of the R & D in the past has been research driven by academia rather than commercially focused, and a rebalancing towards the latter is considered important. An aquaculture R&D strategy should be developed informed by industry, technical researchers and economists, and should be balanced between the short, medium and long term needs of the industry. There may be a possibility of developing such a strategy (or at least some prioritisation) under the new UK Aquaculture Initiative, but there needs to be greater strategic clarity which is more informed by industry. Specific current research needs include for example, vaccine development for finfish production, research/private sector partnerships to support breeding and stock quality programmes, development of improved viral neutralisation and screen techniques.
43. **Funding of major innovative projects such as RAS, Integrated Multi-Trophic Aquaculture (IMTA) and aquaponics** should be subject to much more rigorous and independent economic feasibility assessment prior to funding, and any such spending should be balanced against the need for more widespread support for practical innovation in the industry. It may also be appropriate to develop a *special collaboration programme* that specifically requires researchers to work with commercial farmers to explore technical, operational and species innovation.

Improving information and understanding of the industry

44. **Strengthening Government understanding and capacity.** Government/agency and Seafish staff with a longer term remit to support the industry, would be better placed than independent consultants to undertake strategic economic analysis of the kind presented here. This would ensure that existing Government information sources were fully utilised, data collection methodologies and sampling protocols refined/improved over time, and that officers themselves benefitted directly from the field learning and industry contacts required to undertake this type of study. This might be supplemented with some independent advice – perhaps brought in for “internal” steering committees related to particular work streams.
45. **Understanding economic performance.** In order to understand sector economic performance, it is not necessary to collect detailed financial and operational data from a high proportion of businesses. The key is to have a good representative sample informed by, and coupled with, practical understanding, and a few good case studies. The industry itself responds far better to a short informed interview than a complex questionnaire. Simple basic publicly available Government data related to operational licenses/registrations, combined with non-Government and informal web based sources, informal interviews and technical understanding of the industry can be combined to generate a good appraisal of sector performance and potential.

2 THE STUDY

2.1 Aim and objectives

The scope of this project was set down in the Terms of Reference, of which we have interpreted in terms of the following broad aim and more specific objectives.

The study **aim** was to demonstrate the possible extent and means by which the social and economic performance of the aquaculture industry in England, Wales, and Northern Ireland could be improved.

Specific study **objectives** where:

- Using available metrics and sub-regional case studies, assess the current economic value and contribution of aquaculture at regional level
- Identify key factors affecting economic performance of the main aquaculture sub-sectors in each of the three nations
- Identify demand side opportunities for increasing the volume and value of production
- Demonstrate quantitatively and qualitatively how the economic performance of existing aquaculture businesses could be improved
- Demonstrate quantitatively and qualitatively how the capacity and performance of the industry as a whole could be increased
- Define the measures, applied via government, market structure or other group that would lead to sectoral growth (e.g. in terms of increases in the number of aquaculture businesses; volumes of production; revenues generated; number of people employed, etc.) across the three nations and above levels seen in previous years

2.2 Methodology

2.2.1 Information and data sources

Literature Review

The project reviewed a wide range of relevant literature in the form of specialist studies on economic performance and development potential, relating primarily to the UK but also drawing on studies from elsewhere where relevant. Key references are footnotes throughout the text where appropriate, and a supplementary list is provided in Annex 2.

Government datasets and statistical publications

Information on UK aquaculture performance is collected by Government largely to comply with EC Regulations (The Aquaculture Statistics Regulation EC Reg 762/2008 and the EU Data Collection Framework (EC Reg 199/2008DCF). These regulations require submission of data in year N+2. Details are provided in Annex 4.

Basic data (nature of operation and production) is legally required and already collected for all 569 registered aquaculture producers in the UK. The Fish Health Inspectorate (FHI³) compiles an aquaculture business register⁴ which includes basic data on location (postcode)

³ <https://www.gov.uk/government/groups/fish-health-inspectorate#contact>

⁴ <https://www.Cefas.co.uk/eu-register/>

health status, system type (e.g. freshwater pond) and production type (e.g. for human consumption).

For Scotland, some of the required data, and additional non-financial data is collected by Marine Scotland in an annual census by Marine Scotland Science and analysed/presented by Marine Scotland Science in long standing annual publications. For England and Wales, Cefas takes the lead in conducting an annual industry census for production volumes and employment, and in Northern Ireland, the Department of Agriculture and Rural Development conducts a similar census. An additional annual survey of UK aquaculture enterprises was introduced in 2013 (for 2011 data) to fulfil DCF requirements which Cefas has recently (from 2015 for 2013 data) led. To date this has yielded very low (10%) response rates, and is regarded (by Cefas) as unreliable and probably unrepresentative.

Additional data relating to socio-economic performance by sub-sector, as required under the EU DCF, is solicited through an annual farm survey by Cefas⁵.

Co-incident with this EU data requirement has been the development of the FHIs STARFISH database. This is a bespoke cross-government database for farm data, inspection details, test results and movement requests for live aquatic animals. It will interface with tablets used on-site by Fish Health Inspectors and was due to go live (internally) in 2015, but this is still on going. This database is not available to the wider public.

The MMO database provides data on planning applications, coastal works and dredging, but has limited utility for assessing status and contribution of aquaculture.

For England and Wales Cefas takes the lead in survey and analysis, while in Northern Ireland, the Department of Agriculture and Rural Development is responsible⁶.

Data on production, values, and employment has been published annually in the Cefas publications Finfish News and Shellfish News. For the 2012 statistics a standalone report was produced by Cefas "Aquaculture Statistics for the UK with a Focus on England and Wales 2012"⁷, and provides information on 2012 production, value, employment and number of enterprises by species, and includes finfish, shellfish and cold-water ornamental fish. It covers all four UK countries, but with more detail for England and Wales. It does not provide a breakdown by region or for different sub-classes of production system. This report and more recent data provided directly by Cefas has been drawn upon to provide the initial appraisal of the nature and scale of the aquaculture industry in England, Wales and Northern Ireland as described in section 4.

On-line survey

An on-line survey was designed to source a range of qualitative information directly relevant to this study (primarily perspectives on future development, i.e. opportunities and constraints; business outlook; system/technology; role of government and other organisations, etc.). The survey was designed to avoid duplication of existing official surveys/censuses (such as those of Cefas and DARDNI) and included an optional confidential technical and financial supplement designed to provide quantitative insights into

⁵ <https://www.Cefas.co.uk/about-us/>

⁶ As of 9th May 2016 the new Department of Agriculture, Environment and Rural Affairs (DAERA) will encompass all the functions of DARD; environmental functions of the current DOE (including regulations), inland fisheries and policy responsibility for Sustainable Strategy.

⁷ Online 25/11/2015

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/405469/Aquaculture_Statistics_UK_2012.pdf

technical and economic performance and potential. Annex 5 provides a report on this on-line survey.

Participation in the survey was encouraged through producer/trade representative organisations and leading professionals. Although, as expected, the response rate was not particularly high, several key players provided substantial information, insights and perspectives.

Interviews

Semi-structured interviews were conducted with more than 30 key informants. All those talked to were extremely forthcoming and provided strong evidence in support of a basic appraisal of the technical and economic nature of the main aquaculture production sub-sectors. Interview focus was tailored to the nature of the respondent as much as to the needs of this study, and this resulted in a wealth of practical information. In all cases however, key information relating to strengths, weaknesses, opportunities, constraints, and needs in terms of industry or Government initiatives and support was sought.

Confidentiality

Confidentiality issues were approached in two ways:

- Where government sourced data was involved, aggregation of at least five businesses has been undertaken to meet standard confidentiality protocols
- Where information has been collected directly from the on-line survey, interviews, and case study “participants”, the level of disclosure in the final report was agreed with the providers of that information

2.2.2 Typology

Aquaculture is diverse and the performance of sub-sectors varied. It was therefore necessary to breakdown the industry into meaningful segments or sub-sectors. This is not an easy task as sub-sectors can be defined in various ways - by species, or species groups, life stage, production system, etc. The challenge was to classify them in terms meaningful to the industry and its economic performance, while at the same time maintaining consistency as far as possible with categories used by government. By considering all these factors, we arrived at the following aquaculture production sub-sectors:

- **Finfish**
 - Salmonid ova and juveniles
 - Table trout
 - Adult salmonids for restocking
 - Carp and coarse fish for restocking
- **Shellfish**
 - Shellfish seed
 - Oyster for the table
 - Mussel for the table
 - Scallop for the table
 - Other shellfish (clams, cockles, lobsters, prawns etc.)
- **Ornamental**
 - Coldwater fish
 - Tropical fish
 - Aquatic plants
- **Marine algae**
- **Recirculation Aquaculture Systems (RAS)**
- **Aquaponics**
- **Integrated Multi-Trophic Aquaculture (IMTA)**

These typologies have been used in the appraisal of status and potential throughout this report. In places, simpler broader groupings have been used according to data sources and analytical needs.

2.2.3 Scope

Given the range of aquaculture production systems, and project resource limitations, it has been challenging to analyse all these sub-sectors at the level of detail required to make statements about economic performance and potential. We have therefore sought to focus our resources in the areas of most importance for the future planning, support and facilitation of a dynamic and sustainable aquaculture industry in England, Wales and Northern Ireland.

2.2.4 Economic contribution

It was not possible to access and interrogate the Cefas or FHI databases directly for reasons of confidentiality. While it is possible to request specific datasets aggregated at levels where attribution to individual businesses was avoided, this does not allow for adaptive exploration of data as new ideas and hypotheses arise, or as new analytical needs emerge. Neither does it allow for any analysis focused on small areas with few businesses. Furthermore, it is unrealistic to expect government officers to be able to set aside significant amounts of time to rework data on request.

As a result, our analysis has been more constrained than it would have been for government or agency officers responding to the same ToR. We therefore used multiple sources to develop our own database of all the significant aquaculture enterprises in England, Wales and Northern Ireland. The starting point was the basic information available on-line in the register of aquaculture businesses. Additional data was then collected from on-line sources (i.e. business websites, directories and databases), from other studies, from the on-line survey, and from interviews or email contacts. The following fields were populated and used as far as possible:

- Business
- Proprietor
- Address and contact details
- Postcode
- Map area (sub-regions as specified in the ToR, assigned using postcodes and address data)
- Main production activity
- Secondary production activity
- Tertiary production activity
- Associated enterprises
- FTE employment category
- FTE estimate
- Turnover
- Business/organisation type (e.g. Ltd Company, sole trader, NGO, not for profit, etc.)
- Additional information (e.g. detailed information from websites; Google Maps satellite images, etc.)

Economic contribution by sub-sector at regional and sub-regional level was measured primarily in terms of employment, since this information was more reliable than that for turnover for example.

An employment category (e.g. single worker/manager; 1 plus family; 2 - 4; 4 - 9; 10 - 19) was assigned to each aquaculture enterprise on the basis of available information. Actual employment (FTE) was also assigned to a separate field where this data was available. Where this was lacking we assigned three FTE estimates (low, medium, high) standardised

for each employment category. These estimates were then collated to generate total direct employment for the sub-sectors and the sector as a whole using the high, medium and low employment estimates (or actual FTE where known) for each category. This generated three overall estimates of FTE. These estimates were compared with the most recent historic employment estimates from Cefas and it was found that the totals based on the “high” estimates (plus actual) corresponded most closely. These were then used to generate subsidiary totals for regions and sub-sectors.

For our employment estimates we have used only the category of production which was thought to be the primary source of revenue, although we included labour on non-production enterprises which supported the aquaculture business. Had we done otherwise we would have been double counting our employment estimates. For the other, structural, analyses we have looked at all the production categories and enterprises undertaken by each business.

2.2.5 The use of economic multipliers

Economic multipliers are used to extrapolate wider economic effects from those of individual businesses or groups of businesses.

There are various types of multiplier, including those that describe the effects of the output (production) of an industry. Employment multipliers are the ratio of change in direct employment within an industry to the magnitude of the ripple effect on employment elsewhere. This ripple effect is divided into two waves:

1) The indirect effect – the “Type I multiplier” - is the change in the number of other jobs upstream and downstream, within the industry but outside the individual business. This is known as “indirect employment” and the ratio of this to direct employment is a Type I multiplier. For a small industry with many production systems such as aquaculture, this is hard to estimate. As an example of how this multiplier might be affected, the mussel and oyster sector do not need to buy fish food, and the oyster sector in particular does very little processing. Their type I multiplier will therefore be relatively low in comparison with finfish, that need feeding and whose value can be much increased by processing.

2) The induced effect - the “Type II multiplier” - is the change in the number of jobs outside an industry caused by changes in household expenditure. More people in the industry – more household consumption, therefore more service sector jobs, and others. This is known as “induced employment” and the ratio of this to direct employment is a Type II multiplier. Wage levels, household spending patterns and the level of saving (if any) will affect this.

The multipliers used in this study have been deduced from a range of sources, as shown in Table 2. More information on multipliers and sources used are given in Annex 6.

Table 2: Multipliers for the aquaculture industry

Source	Type I multiplier	Type II multiplier	Comments
1) Scottish Government official statistics, 1998-2012 ⁸	1.4	1.5	From a small sample survey
2) Imani and SRSI for Marine Scotland, 2014 "An assessment of the benefits to Scotland of aquaculture"	1.78	2.96	Industry-focused, Shetland-based, dominated by salmon cage systems, long-distance transport and heavy engineering
3) Broughton, M and Quagrainie, K, 2013 "Economic Importance of the Aquaculture Industry in Indiana" Purdue University	1.38	1.66	Many similarities to our own inland aquaculture
4) Food and Agriculture Organization (FAO) of the United Nations (2013) ⁹ . A Canadian study. Quoted in "Economic Baseline Assessment of the South Coast"	2.5	Not quantified	This is derived from "other aquaculture studies", is unreferenced, and applied mainly to caged salmon farming, in Canada
5a) Washington State, for the Pacific shellfish Institute	1.21	1.43	Study on shellfish using specialist software
5b) California, for the Pacific shellfish Institute	1.15	1.40	Study on shellfish using specialist software

Based on the above sources and on previous studies the consultants have undertaken on aquaculture in the UK, the following multipliers have been selected:

	Type I Multiplier	Type II Multiplier
Finfish	1.5	1.8
Shellfish	1.2	1.5

2.2.6 Assessing growth opportunity and potential by sub-sector

Each of the sub-sectors were appraised using all available sources of information – statistics, previous studies, our economic performance indicators as generated above, and crucially the perspectives of key players with knowledge of that sub-sector.

For each sub-sector we reviewed location/distribution/siting; markets and competition; planning and regulation; current economic status and contribution; and summarized the assessment in the framework of strengths, weaknesses, opportunities and threats (SWOT) analysis.

⁸ Online at <http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Downloads/IO1998-2012L1>

Download the full tables as Excel files and look for Type 1 Multipliers and Type 2 employment multipliers on the second sheet

⁹ National Aquaculture Sector Overview - Canada. Available online at www.fao.org/fishery/countrysector/naso_canada/en

3 BACKGROUND AND CONTEXT

3.1 History

For four hundred years there was a skilled and organised commercial fish-keeping industry in England, mainly of carp for the London market¹⁰, and it is likely that many kinds of freshwater fish were in demand by the wealthy who sought the status eating such fish conferred¹¹.

In the 1860's Mrs Beaton was writing that carp, pike and trout were rarely bought, and by the end of the 19th century the UK market for freshwater fish had shrunk considerably. Retail fishmongers could offer marine fish derived from the booming marine fishing fleets, and delivered throughout the country by the rapidly developing rail network. By the 1950's the ponds and particularly their carp were all but gone. This contrasts with the situation in Germany and Eastern Europe where carp remains a significant table fish.

Trout farming for the table revived the UK freshwater industry in the 1950's and was followed by rapid growth of Atlantic salmon farming in Scotland in the late 1970s and early '80s. Trout farming quickly plateaued however, and there has been limited growth in other species in England, Wales and Northern Ireland. This contrasted with the growth in salmon farming in Scotland, and the very rapid growth of aquaculture throughout the world.

Bivalve shellfish have been collected for thousands of years. In the 17th century, Londoners ate so many that there were concerns that stocks would be over-fished, and Admiralty Boards and other designated authorities enforced close seasons¹² and other management measures. As recently as the 19th century oysters were considered so numerous as to be food for the poor.

Fish kept alive entirely for pleasure is a relatively recent phenomenon in the UK, beginning with the development of glass tanks in the 1840's, and encouraged by the availability of electric pumps and filters in the 1920's. The aquarium industry in the UK has blossomed, unassisted save for welfare¹³ and import¹⁴ regulations, into an industry estimated to be worth some £400m¹⁵. Aquaria have moved on considerably from the lonely fairground goldfish and are now a pastime for many¹⁶, with fish keeping having proven benefits¹⁷ to human health and well-being.

The UK industry now produces trout, salmon and shellfish for the table, ornamental fish and trout and coarse fish (particularly carp) for restocking for sport angling. The Scottish salmon industry (over 40 years old, dominant in terms of UK aquaculture production and value, and currently thriving), uses parr and smolts from England worth some £6 million; a relatively secure and valuable shared trade.

¹⁰ Currie, C.K. 1990. The Early History of the Carp and its Economic Significance in England. British Agricultural History Society. Online at <http://www.bahs.org.uk/AGHR/ARTICLES/39n2a1.pdf>

¹¹ P 245 Frantzen, A. J. 2014. Food, eating and identity in early medieval England. The Boydell Press.

¹² <http://www.camulos.com/oyster.htm>

¹³ Fish are covered by the Animal Welfare Act of 2006 and the meaning of the provisions of the Act are spelt out clearly by the Federation of British Aquatic societies. Online 24/11/2015 at <http://www.fbas.co.uk/FISH%20CARE%20and%20LAW.pdf>

¹⁴ See <http://www.seafish.org/industry-support/legislation/import-and-export/import-guidance>

¹⁵ From Ornamental Aquatic Trade Association <http://www.ornamentalfish.org/>

¹⁶ OATA estimate that >3 million homes in the UK have an aquarium or pond.

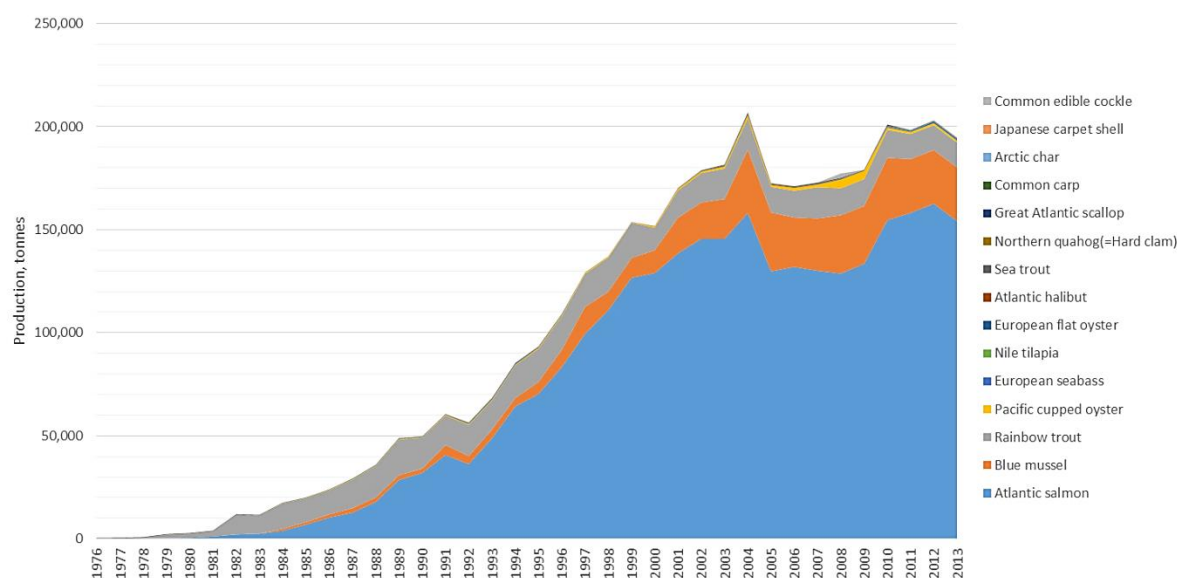
¹⁷ Cracknell D, et al. Aquariums Deliver Health and Wellbeing Benefits. ENVIRONMENT & BEHAVIOR. 2015, as reported in Medical Daily July 2015. Accessed online at <http://www.medicaldaily.com/health-benefits-aquarium-visits-viewing-fish-aquariums-can-lower-blood-pressure-heart-345144>

3.2 Recent developments

In terms of value, the UK is now the major aquaculture producer in the European Union, with Scottish Atlantic salmon by far the most important product. Production from England, Wales and Northern Ireland and is modest and dominated by production of mussels, oysters and rainbow trout, as well as ornamental and coarse fish.

Figure 2 shows the evolution of table aquaculture production in the UK over the last four decades. Note that these statistics exclude ornamentals and production for stocking.

Figure 2: Historic development of aquaculture in the UK (source FAO)



It is notable that Scottish salmon production grew rapidly over three decades to become a major industry in Scotland, making a significant contribution to GDP¹⁸ and export earnings. Its growth has become more limited/erratic in recent years; the dip in the mid-2000s was related to a combination of continuing low prices between 1995 - 2004 (due mainly to global supply outstripping demand) and production problems related to high sea lice infection rates. The history of salmon production (and many other species) neatly illustrates the main twin threats to aquaculture - disease and international competition.

UK rainbow trout farming took off very rapidly in the early 1980's, but has remained almost constant and at a relatively low level since.

Mussel farming based on re-laying of seed mussels in suitable locations (accessible/sheltered/good growth) has been a steady and significant industry in Wales and Scotland in recent decades. Although promoted by government and its agencies since the 1970s, off-bottom mussel farming on long-lines has only really become a significant industry since the late 1990s, in large part due to the expansion of mussel farming in Shetland. Farming of mussels is now the dominant form of shellfish aquaculture in the UK as a whole, with about 95% of the total shellfish tonnage in 2012, and at about £9 million harvest value, some 80% of the total income. Oysters, mainly cultivated Pacific oysters, are a distant second though increasing.

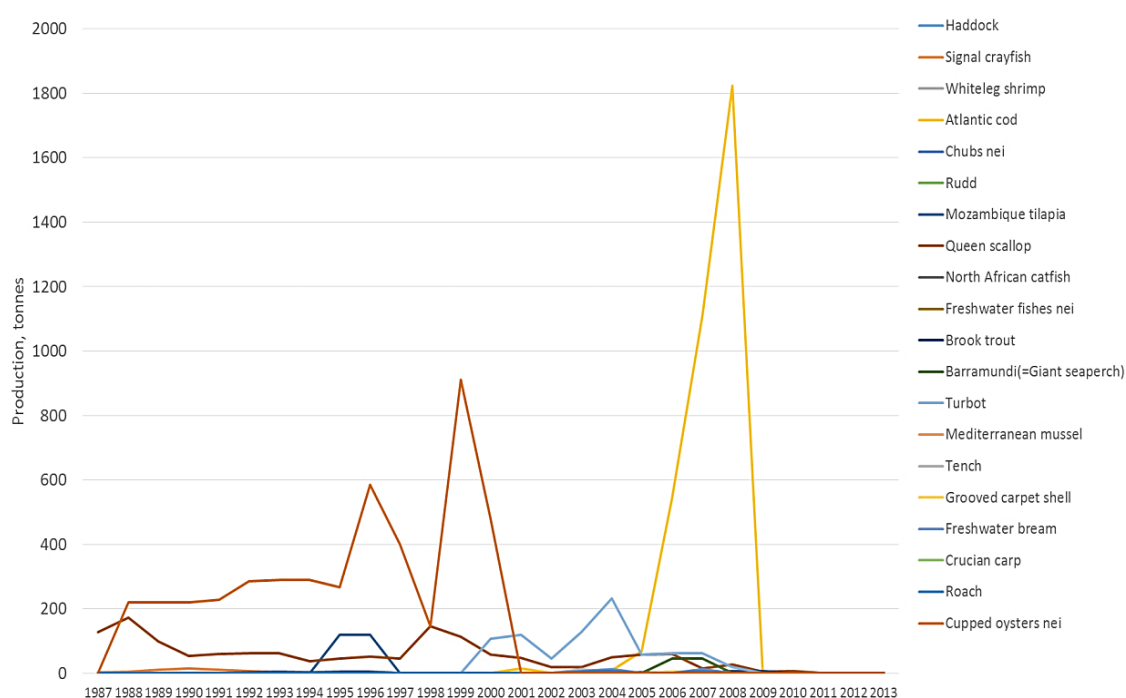
¹⁸ See recent report for the Scottish Government <http://www.gov.scot/Resource/0045/00450799.pdf>

In England, Wales and Northern Ireland aquaculture has shown only limited and erratic growth, although there are a significant number of smaller specialist enterprises experimenting with a wide variety of table and ornamental species, and the ratio of employment to production is much higher in England, Wales and Northern Ireland than in Scotland¹⁹. The difficulty and risks associated with diversification into new species is illustrated in Figure 3, which shows the erratic and often failed attempts to develop aquaculture of both native and exotic species in a variety of systems. Of particular note have been a series of trials, experiments and pilots using recirculation aquaculture systems (RAS). These have been largely successful for the production of trout and salmon fingerlings and smolts, but those designed to produce more exotic and particularly warmer water table species have mostly failed due to cash flow problems and competition with overseas producers.

Production of both salmonids and coarse fish for recreational fisheries is also a significant activity in England and Wales, with substantial downstream value added; but the industry sources suggest that this has peaked and may now be in decline.

The limited growth of aquaculture in England Wales and Northern Ireland contrasts with the tremendous growth and success of aquaculture in Scotland, Norway and many other parts of the world, where the industry has responded to substantial increased market demand that cannot be met from capture fisheries. While this demonstrates the economic potential of aquaculture, it also highlights the substantial international competition already in place, and the challenging context for future expansion in the UK, especially in England, Wales and Northern Ireland.

Figure 3: Erratic production of minor/experimental species in the UK (source FAO fishstat)



¹⁹ This may be interpreted as a good thing (more employment per unit production) and a higher contribution to value added; or as a bad thing, and may be associated with lower labour productivity. This all depends on context.

3.3 Market context, globalisation and comparative advantage

Aquaculture for restocking operates largely in a national context, and the potential for growth therefore depends mainly on the state of the national recreational fishery. This is widely regarded as in decline, though there are nonetheless modest business opportunities.

Aquaculture production for food, on the other hand, operates in a highly competitive international market (in both production and consumption), with global production and trade in commodity species:

- *Pangasius* (river cobbler and various other names, primarily from Vietnam and now increasingly Bangladesh) has now made major inroads into European frozen whitefish fillet markets
- Farmed seabass and seabream from the Mediterranean is common in our seafood outlets and restaurants
- Atlantic salmon comes, from not only Scotland but also Norway, Chile, and Canada, etc.
- Warm-water shrimp or prawn is produced throughout the tropics and sub-tropics in Asia and the Americas
- Mussels are exported globally in large quantities from New Zealand and Chile

Box 1: Globalisation of production, processing and marketing

The food from aquaculture industry is now of global strategic importance for food security. By way of example, the world's largest grain trader and the USA's largest private company, Cargill, has just bought EWOS, who have about one-third of the market for trout and salmon feed.

The Edinburgh Salmon Company - a major player in trout and salmon processing in the UK, was bought in 2012 by France-based Merinvest (parent of Meralliance), which was in turn bought by Thai Union Frozen Products in 2014.

Many seafood production and processing companies are now major international corporations (Box 1), sourcing globally and strategically to maximise returns, by exploiting variations in production and markets. Meanwhile European production (and market leverage) remains relatively weak. A study on European aquaculture competitiveness²⁰ found that most of the recent increase in EU aquatic food consumption has come from imports.

Nonetheless, even within Europe there is strong competition for England, Wales and Northern Ireland in some sub-sectors. France is a large producer and consumer of oysters and clams and has a highly sophisticated production and distribution system. In recent years however it has suffered badly from disease problems. Spain is a major producer of farmed mussels. The Czech Republic is now a major supplier of ornamentals.

Within the UK, Scotland can compete with England, Wales and Northern Ireland in the production of many species (most notably salmon, trout and native shellfish species) and the Scottish industry has a supportive Government committed to ambitious expansion targets.

²⁰ EU Committee of the Regions OPINION: The future of European aquaculture. 114th plenary session, 12, 13 and 14 October 2015 NAT-VI/002

Aquaculture is a sophisticated and efficient global enterprise, and many companies and countries have already developed significant economies of scale, irrespective of other comparative advantages or disadvantages. England, Wales and Northern Ireland can only succeed if they have, or can create, comparative advantage and/or scale efficiencies, and can ensure that they are competing on a level playing field.

Awareness of these issues is increasing, as evidenced by EU policy analysis (Box 2), and UK Government briefings.

Box 2: European aquaculture competitiveness - limitations and possible strategies

To substantially increase aquaculture production at competitive prices for mainstream EU markets will require larger entities capable of scale economies, although small and micro-enterprises can also provide niche products and help sustain rural and coastal livelihoods.

As spatial expansion is highly constrained by environmental regulation and conflicts with other resource users, productivity gains will be important in increasing output.

Technological solutions are emerging, but are costly, so under current conditions, investments are more likely to be made in lower-cost production systems in third countries that export to the EU.

2009. DG Internal Policies, Policy Department, EU IP/B/PECH/IC/2008_177

The Department for Business Innovation and Skills recently (July 2015) produced a report²¹ on the framework and indicators for mapping local comparative advantages in innovation. The intention was to assist partners to “*marshal their innovation assets to best effect using European Structural Funds and other funding streams*”.

3.4 Policy and planning

3.4.1 EU and the Common Fisheries Policy

Europe has had its own aquaculture strategy since 2002²². This strategy was revised and updated in 2009 after the European Commission recognised that EU aquaculture production had stagnated (in stark contrast to the high growth rate in the rest of the world) and that actions were needed to improve governance, competitiveness and encourage sustainable growth. This strategy is largely subsumed by the 2013 strategic guidelines discussed below.

Aquaculture activities form part of the new (2014) Common Fisheries Policy (CFP) and contribute to many of the same objectives as capture fisheries. Article 34 of CFP regulation offers an outline of some key requirements and generic actions for “promoting sustainability and contributing to food security and supplies, growth and employment”.

Coordination and delivery of these actions is to be achieved through European Commission level strategic guidelines²³, multi-annual strategic plans at national level (MANP)²⁴, the Aquaculture Advisory (stakeholder) Council (AAC), and industry producer organisations.

²¹ Accessed online 30/11/2015 at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/468179/bis-15-344-mapping-local-comparative-advantages-in-innovation-framework-and-indicators.pdf

²² Strategy for the Sustainable Development of European Aquaculture 2002, revised 2009: (COM(2009)0162).

²³ http://ec.europa.eu/fisheries/cfp/aquaculture/official_documents/com_2013_229_en.pdf

²⁴ https://consult.defra.gov.uk/fisheries/european-maritime-and-fisheries-fund-in-the-uk/supporting_documents/Multiannual%20National%20Plan%20for%20the%20Development%20of%20Sustainable%20Aquaculture.pdf

Article 34 of the CFP regulation is supported through the Common Market Organisation (CMO) and EMFF, consistent with MANPs as set down in the UK Operational Programme²⁵ and local spatial planning initiatives.

Aquaculture is an EU member state competence (i.e. UK) but with devolved responsibilities to each Devolved Administration (i.e. England, Wales, Northern Ireland and Scotland). Coordination between member states with respect to measures under the MANPs is facilitated through information sharing and the actions of the Commission.

The Strategic Guidelines for Aquaculture Development were published in 2013. In addition to the preparation of the MANP, these emphasise the need for promotion and coordination of best practice and research to address some of the environmental concerns. They also emphasise the need for spatial planning to promote sustainable development and reduce actual or potential conflict between different users.

3.4.2 UK policy, strategy and plans

In accordance with the CFP, in April 2014 Defra published the UK Multiannual National Plan for the Development of Sustainable Aquaculture (UK MANP)²⁶, which gives a concise guide as to the complexities of achieving simplification.

This work was largely based on two previous documents: the 2012 England Aquaculture Plan Consultation Group report, Planning for Sustainable Growth in the English Aquaculture Industry²⁷; and the Wales Marine and Fisheries Strategic Plan (published in 2013)²⁸. Most recently, the UK Operational Programme designed to support spending under the EMFF 2014 - 2020²⁹ (amounting to €243 million for the UK fisheries sector) was published.

These many documents have much in common. Taken together they emphasise (to a greater or lesser degree) the following:

- The significant potential for aquaculture to contribute to EU objectives
- The need to focus on competitiveness, and understand the global market context
- The need for better market intelligence, responsiveness to market demand and marketing strategy
- The need to reduce the burden of legislation that reduces opportunity and competitiveness³⁰
- The need for predictable, secure and appropriate access to/allocation of land and water resources – in part through integration of aquaculture development planning within the wider framework of coastal and marine spatial planning
- The need to ensure environmental sustainability, linked where appropriate with market strategy, labelling and branding initiatives
- Improved resource use efficiency (especially with regard to finfish feeds)
- Ensuring proper stakeholder participation and the provision of appropriate information to the public

²⁵ European Maritime and Fisheries Fund – Operational Programme for the United Kingdom - http://ec.europa.eu/fisheries/cfp/emff/doc/op-uk_en.pdf

²⁶ United Kingdom Multiannual National Plan for the Development of Sustainable Aquaculture. April 2014. DEFRA. Accessed 20/10/15 at https://consult.defra.gov.uk/fisheries/european-maritime-and-fisheries-fund-in-the-uk/supporting_documents/Multiannual%20National%20Plan%20for%20the%20Development%20of%20Sustainable%20Aquaculture.pdf

²⁷ Planning for sustainable growth in the English Aquaculture Industry. Produced by the England Aquaculture Plan Consultation Group. Published by DEFRA. January 2012. Accessed 20/10/15 at www.defra.gov.uk/consult/2012/01/12/aquaculture-1201/

²⁸ Accessed 20/10/15 at <http://gov.wales/docs/dra/p/publications/131127marine-and-fisheries-strategic-action-plan-en.pdf>

²⁹ European fund for 2014-2020 designed to help with implementation of the CFP and support the fisheries sector

³⁰ E.g.: STECF 2011. There is scope to reduce the delay in the licensing process and to reduce the complexity of implementing and applying the EU legislation at the national level. http://stecf.jrc.ec.europa.eu/documents/43805/218925/2012-03_STECF+EWG+11-14+-+EU+Aquaculture+Sector_JRC70424.pdf

- The need for research, innovation and knowledge sharing
- The opportunities and constraints associated with consumer health

The mechanism by which the administrative burden (repeatedly highlighted in these and other documents^{31,32}) can be reduced is unclear in the European guidance, but should be addressed in MANPs and other national strategic documents.

3.4.3 Marine planning

All of the above strategic needs should be taken into account when implementing the new marine planning regime as developed under the EU Marine Strategy Framework Directive (MSFD).

England

The Marine Management Organisation (MMO) recently published a document dealing specifically with aquaculture in marine plans³³, for which they are the responsible authority in England. The Marine Information System (MIS)³⁴ displays the appropriate marine policy documents for all of England's marine plan areas in an on-line format. How exactly this new planning regime will affect aquaculture developments will depend on the details of the marine plan for the area and the nature of the development. It is possible to check Marine Plan aquaculture statements for any area through the MIS.

Wales

The Welsh Government, whose ministers are responsible for marine planning, commissioned a study³⁵ to identify likely locations for marine aquaculture before developing their National Marine Plan. However, as the authors acknowledged, their model can only be used to indicate broad areas of potential; higher resolution data, consideration of un-modelled variables and more local study are needed for individual applications. The Welsh National Marine Plan is still in development.

Northern Ireland

Northern Ireland differs in that the Department of the Environment (DoE) is currently (as of April 2016) the Marine Plan authority but responsibility for regulating other aspects of the plan rest with DARD and with DETI.

As of May 2016 the new Department of Agriculture, Environment and Rural Affairs (DAERA), will encompass all the functions of DARD, the environmental functions of the current DoE (including regulations), inland fisheries, and policy responsibility for Sustainable Strategy³⁶. Northern Ireland is currently preparing to release the first draft of the Marine Plan for public consultation³⁷ in early 2016. No view can be taken yet in regards to the place of aquaculture within this.

³¹ Regulatory and legal constraints for European aquaculture 2009, DG for Internal Policies, Policy department. Online 30/11/2015 at [http://www.europarl.europa.eu/RegData/etudes/etudes/join/2009/431568/IPOL-PECH_ET\(2009\)431568_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/etudes/join/2009/431568/IPOL-PECH_ET(2009)431568_EN.pdf)

³² Hambrey et al 2008 Socio-economic Assessment of potential impacts of new and amended legislation on the cultivation of fish and shellfish species of current commercial importance. SARF Research Report 046; Poseidon 2009. <http://www.consult-poseidon.com/fishery-reports/509%20Poseidon%20Comparative%20Regulatory%20Costs%20in%20Salmon%20Farming.pdf>

³³ MMO April 2015 Marine Planning and Aquaculture. Author Stacey Clarke, Aquaculture lead for marine plans, Online 27/11/2015 at http://www.seafish.org/media/1391570/acig_april2015_mmo.pdf

³⁴ Marine Information System – England. Online 27/11/2015 at <http://mis.marinemanagement.org.uk/>

³⁵ A spatial assessment of the potential for aquaculture in welsh waters. R.2384. May 2015 MER for the Welsh government. Online 27/11/2015 at <http://gov.wales/docs/drah/publications/150702-a-spatial-assessment-of-the-potential-for-aquaculture-in-welsh-waters-en.pdf>

³⁶ <https://www.nidirect.gov.uk/articles/changes-government-departments>

³⁷ <https://www.daera-ni.gov.uk/articles/marine-plan-northern-ireland>

4 THE ECONOMIC CONTRIBUTION OF AQUACULTURE IN ENGLAND, WALES AND NORTHERN IRELAND

Section 4 focuses on the economic contribution of aquaculture and comprises three main parts. The first part briefly summarizes previous work on the economic contribution of aquaculture to the UK economy. The second part comprises a statistical overview derived primarily from Cefas and DARDNI publicly available data. The third part presents economic analysis based on our own database developed from publicly available government statistics, supplemented with website and other publicly available data. More information on various sub-sectors' technical and economic characteristics is presented in section 6.

4.1 Previous work

There have been social and economic aquaculture impact studies at a global³⁸, national³⁹ and EU⁴⁰ level using the concept of economic multipliers to assess the wider impact on society. These are useful at national level, but less helpful for regional work where local circumstances may differ markedly from national averages, and where differing social and economic circumstances may make the effective responses to development investment very variable. Socio-economic studies such as the one commissioned by Marine Scotland in 2014⁴¹ on the economic contribution of aquaculture to Scotland, and earlier work produced through SARF⁴² are perhaps of more immediate interest. The Marine Scotland study estimated that aquaculture contributed “as much as £1.4 billion turnover and 8,000 jobs to Scotland, and £1.8 billion turnover and 8,800 jobs to the whole UK”.

The focus provided by the advent of Marine Protected Areas (MPAs⁴³) has led to the production of targeted studies such as the 2014 MMO report on the social impacts of aquaculture in English MPAs⁴⁴. Regional baseline studies such as the MMO work on the South Coast⁴⁵ are particularly useful to examine the economic and social context in which potential development might operate. In terms of targeting EMFF funding this is crucial information to maximise societal gain from the limited public funding available.

Sector reports such as the Nautilus case study on trout farming⁴⁶ and a comparative study of commercial sea fishing and recreational sea angling⁴⁷ add to the ability of those in the

³⁸ <http://www.sciencedirect.com/science/article/pii/S0308597X13002169> A global synthesis of the economic multiplier effects of marine sectors.

³⁹ <http://www.sciencedirect.com/science/article/pii/S0964569114000350> Irish multipliers

⁴⁰ Scientific, Technical and Economic Committee for Fisheries (STECF) – The economic performance of the EU aquaculture sector (STECF14-18). 2014. Publications Office of the European Union, Luxembourg, EUR 27033 EN, JRC 93169, 451 https://stecf.jrc.ec.europa.eu/documents/43805/839433/2014-11_STECF+14-18+-+EU+Aquaculture+sector_JRCxxx.pdf

⁴¹ Marine Scotland 2014 An Assessment of the Benefits to Scotland of Aquaculture. Imani and SRSL for Marine Scotland. May 2014. Accessed 20/10/15 at <http://www.gov.scot/Topics/marine/Publications/publicationslatest/farmedfish/AqBenefits>

⁴² Hambrey, J., J. Westbrook, S. Southall, T. Robinson, R. (2008). Socio-economic Assessment of Potential Impacts of New and Amended Legislation on the Cultivation of Fish and Shellfish Species of Current Commercial Importance. SARF, Pitlochry. <http://jncc.defra.gov.uk/marineprotectedareas>

⁴⁴ MMO (2013). Social impacts of fisheries, aquaculture, recreation, tourism and marine protected areas (MPAs) in marine plan areas in England. A report produced for the Marine Management Organisation, pp 192. MMO Project No: 1035. ISBN: 978-1-909452-19-0. Accessed 20/10/15 <http://webarchive.nationalarchives.gov.uk/20140108121958/http://www.marinemangement.org.uk/evidence/documents/1035.pdf>

⁴⁵ MMO, “Economic baseline assessment of the South Coast” December 2013 <http://webarchive.nationalarchives.gov.uk/20140108121958/http://www.marinemangement.org.uk/evidence/documents/1050.pdf>

⁴⁶ Carleton pers. com.

⁴⁷ “Comparing Industry Sector Values, With a Case Study of Commercial Fishing and Recreational Sea Angling” 2015 http://www.seafish.org/media/Publications/eftec_comparing_industry_sector_values_FINAL_Aug_2015.pdf

industry to discuss wider effects, including socio-economic ramifications and multipliers, with greater confidence.

The ornamental fish sector is particularly interesting in terms of socio-economic effects. It was notable when drawing up our own database of contact details that many ornamental fish wholesalers and retailers operated out of semi-industrial areas, and employed a number of people in relatively high quality jobs. A report to DEFRA from Stirling University⁴⁸ examines the economics of the ornamental aquatic trade in the UK but this is not in the public domain.

It is noteworthy that although Scotland has the bulk of UK aquaculture production, the English, Welsh and Northern Irish industries have a far higher ratio of direct employment to production, a more species-diverse industry (much of which is still locally owned), a greater emphasis on freshwater production, and are often situated closer to markets⁴⁹.

The Marine Socio-Economic Project⁵⁰ datasheets offer a refreshing perspective on some of these issues. Intended as an information source for NGOs, the series of economics briefing papers and “facts and figures” provide excellent background reading for policy-makers and practitioners.

4.2 Total production and value

The contribution of aquaculture to the national economies of England, Wales and Northern Ireland is very modest, as shown in Table 3. England and Wales have both experienced decline in finfish and shellfish production since 2010. Northern Ireland has also experienced decline in shellfish farming but a small increase in finfish.

Overall, the picture is of a stagnant or declining industry. However, as described below there are significant current initiatives, especially in the shellfish farming sector that could lead to a resurgence of the industry.

4.3 Value added

There are no reliable published statistics on ‘value added’ in aquaculture in England, Wales and Northern Ireland⁵¹. However, by examining the cost structure of different aquaculture enterprises, and industry perspectives on profitability, we estimate value added on average to be roughly 50% of sales, though this varies significantly between sub-sectors⁵². This implies value added in production for England, Wales and Northern Ireland will be of the order of £26 million. Value added generally represents a greater proportion of sales value for shellfish because feed is not required, although more modern, offshore production systems will require significant energy inputs.

⁴⁸ Rana, K. J., Sturrock, H.T., Rooney, W., Young, J.A., & Bostock, J.C., 2006. Strategic economic analysis of the ornamental aquatic trade in the UK. Report Commissioned by Defra (Project FC0933) from the University of Stirling, 89pp.. Unpublished, commercial-in-confidence. Supplied to us by Seafish.

⁴⁹ Planning for sustainable growth in the English Aquaculture Industry. Produced by the England Aquaculture Plan Consultation Group. Published by DEFRA. January 2012. Accessed 20/10/15 at www.Defra.gov.uk/consult/2012/01/12/aquaculture-1201/

⁵⁰ Marine socio-Economics Project, online 30/11/2015 at <http://www.mseproject.net/>

⁵¹ Some assessment is made by STECF but based on very limited data

⁵² Simple financial models were developed for each aquaculture production system, based on interviews, and understanding of system inputs and outputs. Value added was estimated as profit + wages based on current farm gate prices. Depending on the system and assumptions used, value added ranged from around 35% to more than 60% with the former more typical of intensively fed finfish production systems and the latter of more extensive and labour intensive shellfish production systems

Table 3: Production, value and employment in UK aquaculture

	<i>Finfish</i>			<i>Shellfish</i>			<i>Total</i>		
Production (T)	2012	2013	2014	2012	2013	2014	2012	2013	2014
England	8,709	6,632	6,456	6,915	7,577	2,456	15,624	14,209	8,912
Wales	453	484	497	8,999	8,344	7,945	9,452	8,828	8,442
Northern Ireland *	600	605	750	4,920	3,463	3,238	5,520	4,068	3,988
Scotland	168,006	168,945	185,023	6,525	6,935	7,980	174,531	175,880	193,003
EWNI	9,762	7,721	7,703	20,834	19,384	13,639	30,596	27,105	21,342
UK	177,768	176,666	192,726	27,359	26,318	21,619	205,127	202,985	214,345
Imputed value (£m)	<i>Finfish</i>			<i>Shellfish</i>			<i>Total</i>		
England	21.53	16.66	23.73	10.06	17.19	5.17	31.59	33.85	28.90
Wales	1.44	1.63	2.13	9.01	15.86	15.10	10.45	17.49	17.22
Northern Ireland *	1	3	3	5.35	6.10	4.75	6.70	8.76	7.49
Scotland	532.95	690.83	733.64	8.77	8.95	10.55	541.72	699.78	744.18
EWNI	24.32	20.95	28.60	24.42	39.15	25.02	48.74	60.10	53.61
UK	557.27	711.78	762.23	33.19	48.10	35.57	590.46	759.88	797.80
Total employees	<i>Finfish</i>			<i>Shellfish</i>			<i>Total</i>		
England	665	655	na	258	265	na	923	920	na
Wales	96	89	na	34	33	na	130	122	na
Northern Ireland	63	69	na	55	46	na	118	115	na
Scotland	1,540	1,608	1,747	358	333	345	1,898	1,941	2,092
EWNI	824	813	na	347	344	na	1,171	1,157	na
UK	2,364	2,421	na	705	677	na	3,069	3,098	na
FTE employees	<i>Finfish</i>			<i>Shellfish</i>			<i>Total</i>		
England	530	531	na	240	211	na	838	742	na
Wales	68	61	na		32	na		93	na
Northern Ireland	43	57	na	30	36	na	73	93	na
Scotland	1,399	1,521	na	255	238	na	1,654	1,759	na
EWNI	641	649	na	270	279	na	911	928	na
UK	2,040	2,170	na	525	517	na	2,565	2,687	na

Notes

1. EWNI = England, Wales and Northern Ireland
2. All figures are from Cefas except for Scotland "total employees 2014". To enable presentation of comparable figures, those working in the ornamental fish industry are not included in this table (Thanks to Tim Ellis for Cefas figures)
3. The Cefas 2013 imputed farm gate values originally given in Euros: converted at 0.85 Euro/GBP.
4. Employees are by total, not by Full Time Equivalent (FTE). FTE figures are only available for finfish for 2013, making year-on year comparisons impossible in that format. Those working in the ornamental fish industry are not included in this table, although they are in the original 2013 figures. Again, this is to make year-on-year comparisons possible

* Consultant estimate

4.4 Contribution of different subsidiary sectors and activities

The aquaculture industry can be broken down into a large number of subsidiary production activities or segments, relating to different species, stages of production and markets. Many of the businesses in the industry undertake several activities, while others specialise. It is therefore no simple matter to disaggregate contribution or performance of different segments, and the publicly available analysis of Cefas reflects this difficulty.

This section explores in more detail the types of business involved in various activities, and provides basic data on the scale of major activities as aggregated in the Cefas report⁵³.

4.4.1 *Finfish: eggs, fry and fingerlings*

There are specialist finfish breeders in the UK – producing eggs, fry and fingerlings of a wide range of species. Many of these also produce larger fish for the table or restocking.

Eggs of several salmonid species are produced in the UK; these include Atlantic salmon, rainbow trout, brown/seatrout, and Arctic char. Reported rainbow trout egg production varied between 5 million eggs in 2010 to 25 million in 2011, before falling to 6 million eggs in 2012. Almost all rainbow trout eggs were either triploid or all female. Between 2 - 3 million Atlantic salmon eggs were produced in England and Wales, along with 1 - 2 million brown trout and with the occasional production of Arctic char eggs.

Juvenile fish are produced for on-growing on the source farm, for sale for on-growing on other farms, stocking waters for sport angling, and for the ornamental trade. In England around 15 million rainbow trout, 4 million Atlantic salmon, and 4 million brown trout juveniles were sold for on-growing in 2012. A further 0.7 million Atlantic salmon and 13,000 brown trout juveniles were produced for release stocking to the wild (a category which includes stocking into confined lake and pond recreational fisheries). However, it is possible that some of the “on-growing” fish were in fact stocked in recreational fisheries (confined lakes and ponds). Perhaps 2m of other native species were produced, primarily for release to the wild, including carp (by far the most important), chub, bream, barbel, orfe, tench, roach, rudd, grayling, stickleback, crucian carp, dace, Arctic char, gudgeon, perch and eel.

Various species are also sometimes sold for on-growing, including goldfish and koi carp, tilapia, golden orfe, and Siberian sturgeon.

Wales produced around 2 million rainbow trout for on-growing and around 0.5 million Atlantic salmon for restocking in the wild, as well as small numbers of brown trout and Arctic char primarily for release to the wild.

⁵³Online 25/11/2015

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/405469/Aquaculture_Statistics_UK_2012.pdf

4.4.2 Finfish – grow-out production

Production of larger finfish is a much more significant activity in terms of farm sales and employment. Larger fish are produced for both the table market, and for the restocking of commercially orientated leisure fisheries. Many farms that produce eggs or juveniles grow them on to generate more value added, depending on site constraints in terms of space and water resources.

English finfish production is dominated by rainbow trout with around 8,000t produced in recent years - mainly for the table, but with significant amounts for restocking and on-growing (>2,000t each). Insofar as on-growing will generate fish for both restocking and table in subsequent years, there may be some double counting here. The value of this production in 2012 was estimated at around £18 million. Wales produced roughly 250t of rainbow trout, worth around £0.5 million, of which around 60% went to the table market and the rest for stocking. Northern Ireland produced 563t of rainbow trout worth around £1.2million.

Brown trout production in England amounted to just over 300t, worth around £0.75 million, and modest amounts of Arctic char (7t) and Atlantic salmon (4t) were produced for restocking. Small amounts of brook trout were also produced in both England and Wales for stocking purposes. Northern Ireland produced some 44t of brown trout worth £0.1 million.

Around 130t of common carp were produced in England, primarily large fish for the angling sector. These fish are significantly more valuable per kg than table fish, generating roughly £1.7 million. There was also significant production of freshwater bream and tench (worth perhaps £0.4 million) and a range of other freshwater coarse fish species primarily for angling waters and ornamental ponds, worth around £0.2 million.

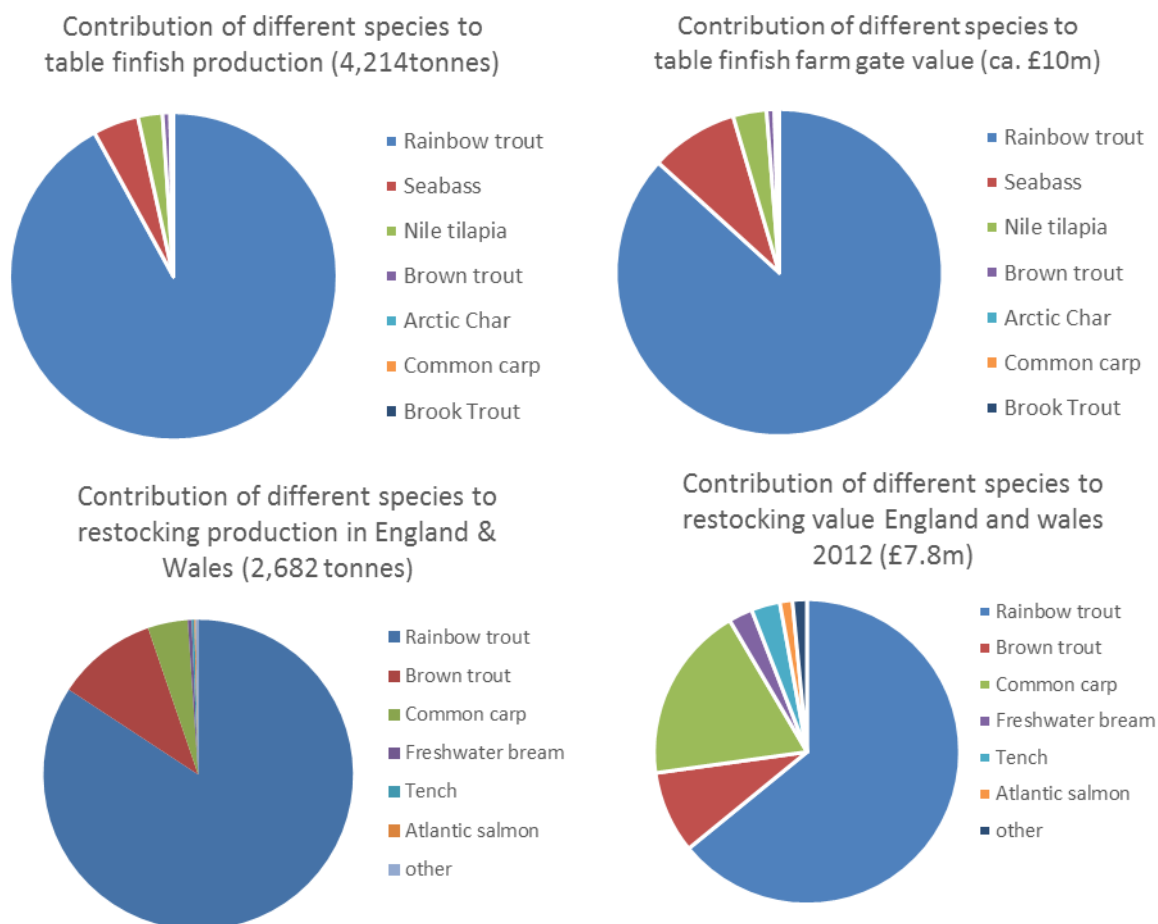
In 2012 several RAS systems were in operation producing roughly 100t of tilapia in England and around 190t of European seabass in Wales. Production of the latter (in a system originally developed for turbot and subsequently for 1,000t of European seabass) has now ceased and new opportunities are being explored, including the production of wrasse and lumpfish – used as cleaner fish (i.e. grazers of parasites, namely sea-lice) in salmon farming.

Total value of the finfish table trade in England may be estimated at around £8.8 million, and the restocking trade at £7.4 million – although given our discussions with producers on prices that are achieved, we consider this latter estimate to be very conservative. Sales for on-growing on other farms are around £5.3 million, but it should be noted this will not contribute to value added since this is an intermediate product whose value is encompassed in the table fish and restocking values.

Total value of finfish production in Wales is estimated by Cefas as £1.4 million in 2012 (of which more than half was represented by seabass production, however this has now ceased) with the balance made up primarily by rainbow trout for both stocking and table.

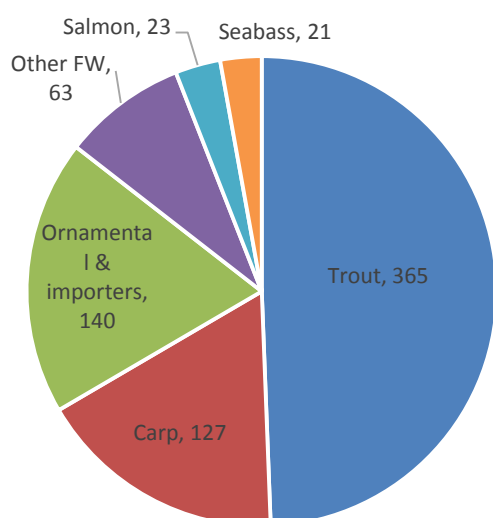
Figure 4 details Cefas 2012 data on the contribution of different finfish species to production and value in England and Wales.

Figure 4: Contribution of different species to production and value in England and Wales, 2012 (Cefas data)



Note: Figures for 2012 include some aquaculture production (e.g. seabass) that has now ceased

Figure 5: Employment (FTE) in finfish aquaculture England and Wales 2012 (Cefas data)



Note: Figures for 2012 include some aquaculture production (e.g. seabass) that has now ceased

Total employment in finfish production in 2012 is estimated by Cefas at around 667 FTE in England, 71 FTE in Wales, and 43 in Northern Ireland, corresponding around 800 jobs in total, with the majority (85%) being male. Note that the 20+ jobs in seabass production in N Wales are now mostly lost.

It is notable that at least 50% of employment in England and Wales is in the non-trout sector, and related primarily to coarse fish angling and ornamentals, despite the dominance of trout in terms of production (Figure 5).

The segment comprises primarily of small businesses. There are 142 registered trout and salmon farming businesses in England and Wales, of

which 130 employ less than five people. A further 22 enterprises produce trout (20) and salmon (in freshwater (1) and in marine cages (1)) in Northern Ireland.

One farm in Wales was producing seabass in 2012 (employing nearly 30 people at its height).

A significant number of businesses were also producing carp (68) and other freshwater fish (29) though many of the former would also be engaged in the latter; again, the vast majority of these employed fewer than five people. In 2012, some 38 businesses were registered to grow and/or hold, and trade ornamental fish species.

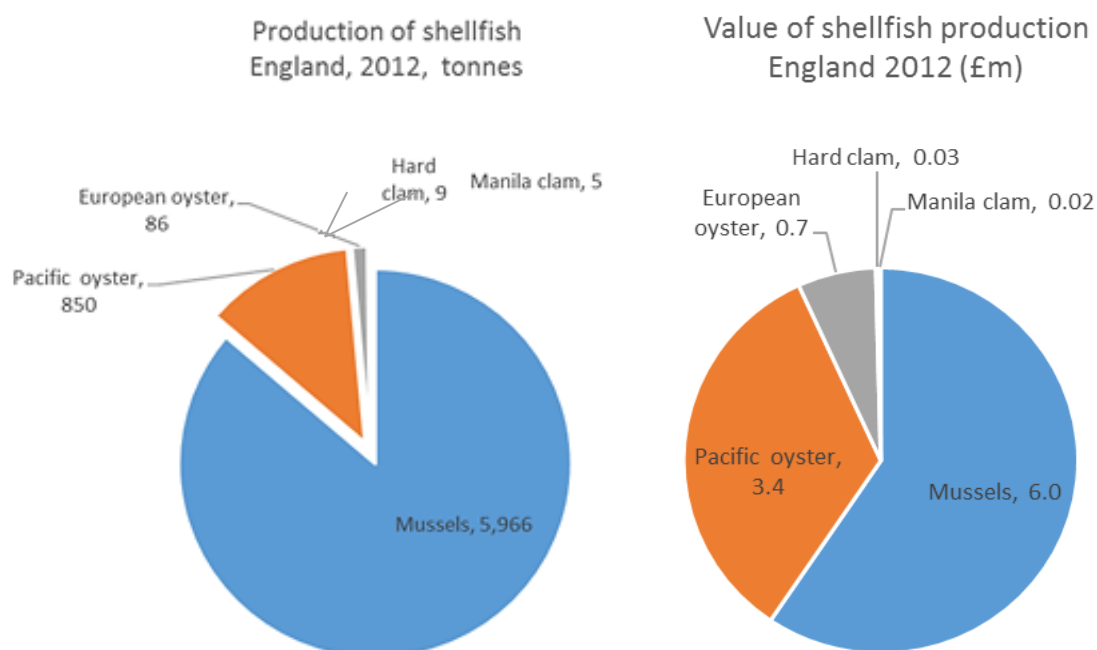
4.4.3 Shellfish production

Almost 8,000t of wild mussel seed was collected in 2012 (along with an estimated 200t of European oyster) primarily for relaying on the seabed, although some mussel long-lines are now in production in all three countries. In excess of 400 million seed of Pacific oyster were hatchery produced in England in 2012, and around 0.3 million Pacific and European oysters in Northern Ireland.

Total shellfish production in 2012 amounted to some 7,000t (worth £10million) in England, 9,000t in Wales (£9 million) and 5,000t in Northern Ireland (£5.3 million). Production was dominated by mussels in all three countries, however shellfish production is diverse, and with the greatest diversity being found in England (Figure 6). Pacific oyster is the second most important species, followed by European oyster, hard clam and Manila clam. No production of farmed scallops was recorded for England, Wales and Northern Ireland in 2012, but some production is now underway.

Cefas estimated employment in shellfish production at around 258 in England, 34 in Wales, and 55 in Northern Ireland. As with finfish production, shellfish production is a very male dominated profession.

Figure 6: Production and value of shellfish 2012 (Cefas data)

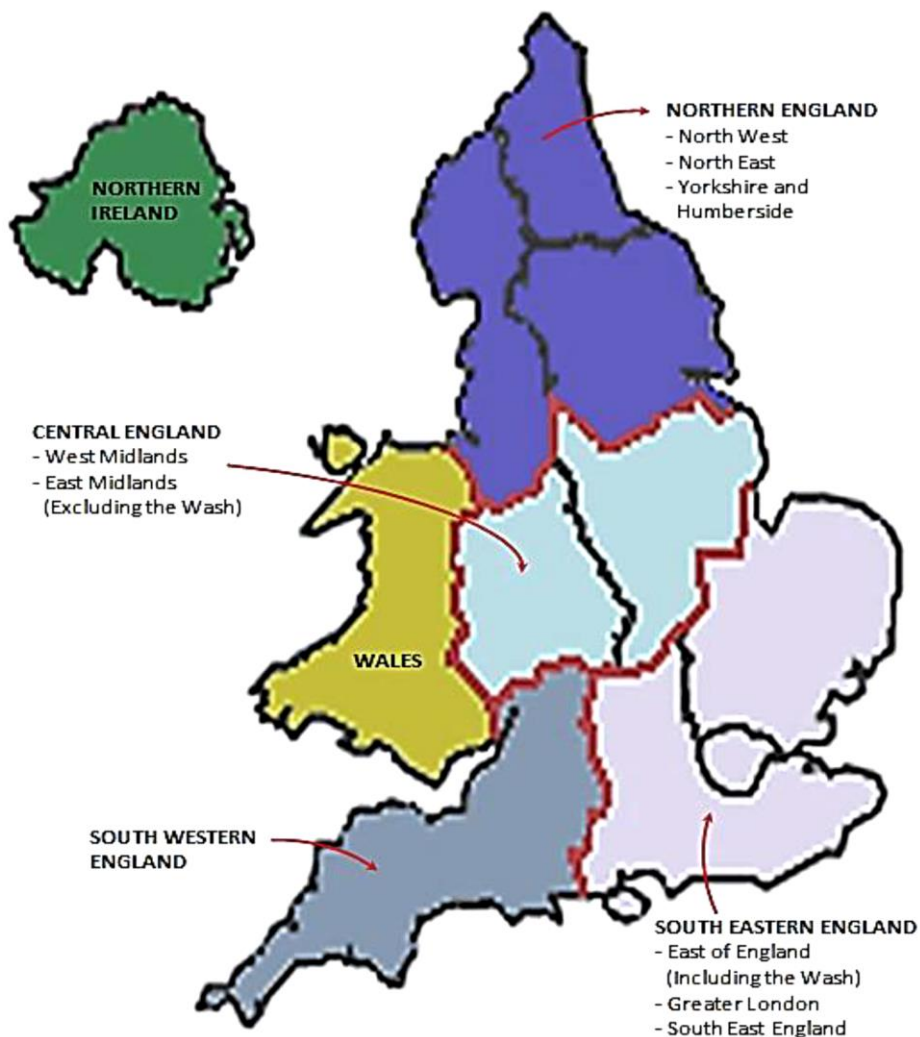


5 DISTRIBUTION OF ACTIVITIES AND BENEFITS

5.1 Business activity, distribution and regional employment

Our remit includes assessing the current economic value and contribution of aquaculture at regional level. The report focuses on the following regions: northern England, central England, south eastern England, south western England, Wales and Northern Ireland (Figure 7). The latter two encompass entire devolved administrations, whilst the others are either euro-constituencies⁵⁴ in themselves (i.e. SW England) or combinations of them.

Figure 7: Regional analysis



This section offers a geographic overview of aquaculture business activity and estimated contribution to employment, derived from both government and other sources (i.e. web based data, personal contacts, etc.), as described in the methodology section (Section 2).

It should be emphasised that while estimates for direct employment are reasonably accurate, those for indirect and induced employment are considerably less reliable, although

⁵⁴ <http://www.europarl.org.uk/en/your-meps.html>

more accurate for locally focused industries (such as carp or trout for angling/recreation) than for example table trout, where substantial downstream employment is generated in other regions or in Scotland.

Table 4 provides estimates of direct employment in aquaculture businesses in England, Wales, and Northern Ireland. The high–end of our estimated range is the closest to official Cefas estimates in all except Northern Ireland, where our mid-range estimate is used. We have slightly under-estimated Wales.

These estimates suggest that aquaculture employment is distributed fairly evenly across the three countries (relative to land area).

Table 4: Estimated direct employment in aquaculture production businesses by country and region

	Total employees (not FTE) from CEFAS data, 2012.	Estimated direct FTE employees from our database, 2015 LOW	Estimated direct FTE employees from our database, 2015 MEDIUM	Estimated direct FTE employees from our database, 2015 HIGH
Northern Ireland	118	70	102	134
Wales	130	30	44	58
England – North	Not available	90	129	167
England – Central	Not available	42	62	82
England – SW	Not available	154	220	286
England – SE	Not available	144	208	271
England - all	923	430	619	806

The following Figures (Figures 8 – 13) detail the types and distribution of aquaculture business activity across each of the six regions described in Figure 7.

The following Tables (Tables 5 – 10) detail FTE employment estimates for each of six regions described in Figure 7, and includes direct, indirect and induced FTE using the multipliers detailed in sub-Section 2.2.5.

Estimates suggest that all direct, indirect and induced employment across the three countries equates to at least 1,630 full time jobs.

5.1.1 NORTHERN ENGLAND

Figure 8



Table 5: Employment estimates for Northern England

NORTHERN ENGLAND		Multipliers		Direct			Indirect			Induced			Total		
Sector	No. of producers	Type 1	Type 2	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Coarse	6	1.5	1.8	11	17	22	6	8	11	3	5	7	20	30	40
Table	2	1.5	1.8	10	14	18	5	7	9	3	4	5	18	25	32
Restocking	11	1.5	1.8	36	51	65	18	25	33	11	15	20	65	91	117
Hatchery	6	1.5	1.8	23	33	42	12	16	21	7	10	13	41	59	76
Oysters	3	1.2	1.5	6	9	12	1	2	2	2	3	4	9	14	18
Mussels	1	1.2	1.5	2	3	4	0	1	1	1	1	1	3	5	6
Other shellfish	1	1.2	1.5	2	3	4	0	1	1	1	1	1	3	5	6
TOTAL	30			90	129	167	42	60	78	27	39	50	159	227	295

Note: The high-end direct estimate is closest to official government estimates

Aquaculture production in northern England is economically more important than other regions, with significant trout restocking production, coarse fish and hatchery production taking place.

There is a notable concentration of salmon smolt production in north Cumbria (supplying the Scottish salmon industry), trout production for both restocking and the table in the limestone Yorkshire Dales, and a strategically important oyster hatchery (plus some mussel spat) on the north coast of Morecambe Bay. Coarse fish production/fisheries are generally located on the rural fringes of major urban environments.

5.1.2 CENTRAL ENGLAND

Figure 9

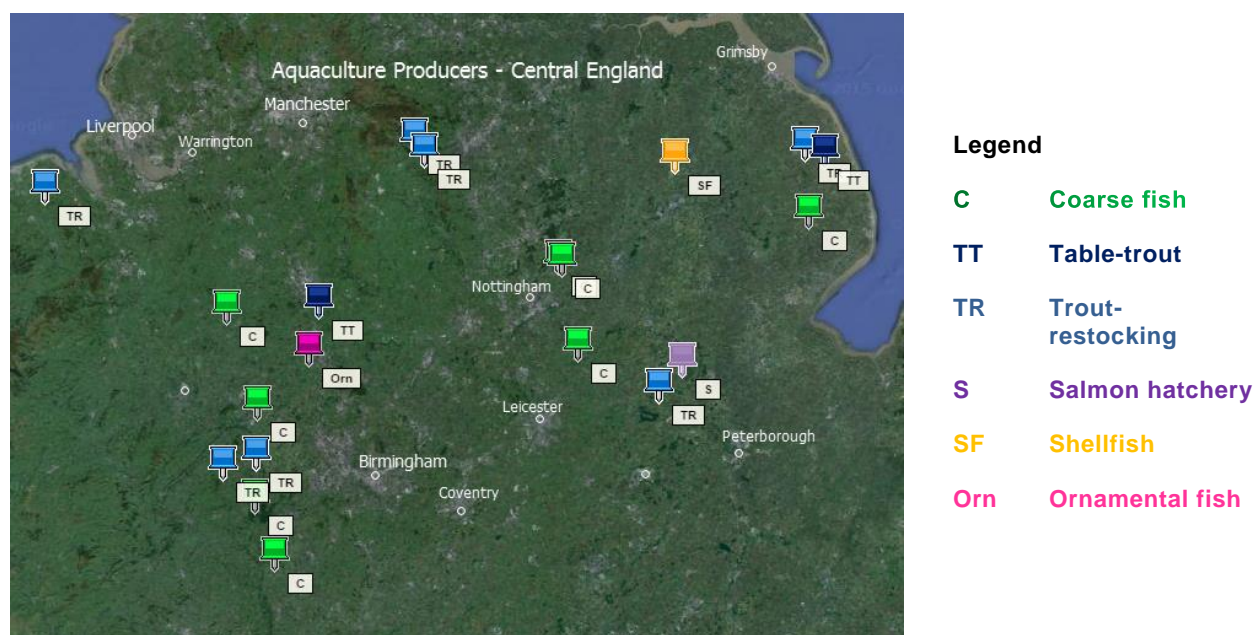


Table 6: Central England employment estimates

CENTRAL ENGLAND		Multipliers		Direct			Indirect			Induced			Total		
Sector	Number of producers	Type 1	Type 2	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Coarse	8	1.5	1.8	18	27	35	9	13	18	5	8	11	32	48	63
Table	2	1.5	1.8	4	6	8	2	3	4	1	2	2	7	11	14
Restocking	7	1.5	1.8	15	22	29	8	11	15	5	7	9	27	40	52
Hatchery	1	1.5	1.8	1	2	2	1	1	1	0	0	1	2	3	4
Other shellfish	1	1.2	1.5	2	3	4	0	1	1	1	1	1	3	5	6
Ornamentals	1	1.5	1.8	2	3	4	1	2	2	1	1	1	4	5	7
TOTAL	20			42	62	82	20	30	40	13	19	25	75	111	146

Note: The high-end direct estimate is closest to official government estimates

Aquaculture makes a rather limited contribution (relative to population and economic activity) to the regional economy of central England. This relates to several factors:

- Limited and generally unsuitable coastline for marine and coastal aquaculture
- Inappropriate water quality for salmonid production
- Heavy urbanisation

There is modest trout and carp production primarily for restocking and local fisheries, mainly on rural/urban fringes, and surprisingly a small, specialist salmon smolt producer in Lincolnshire.

This area is also of substantial importance for ornamental fish trade and retailing. Most of this activity is related to imports rather than production, so is not strictly speaking aquaculture. There is also significant “informal” breeding and sale (e.g. “Facebook” sales) of ornamental fish in non-registered small-scale “garage” systems.

5.1.3 SOUTH EASTERN ENGLAND

Figure 10

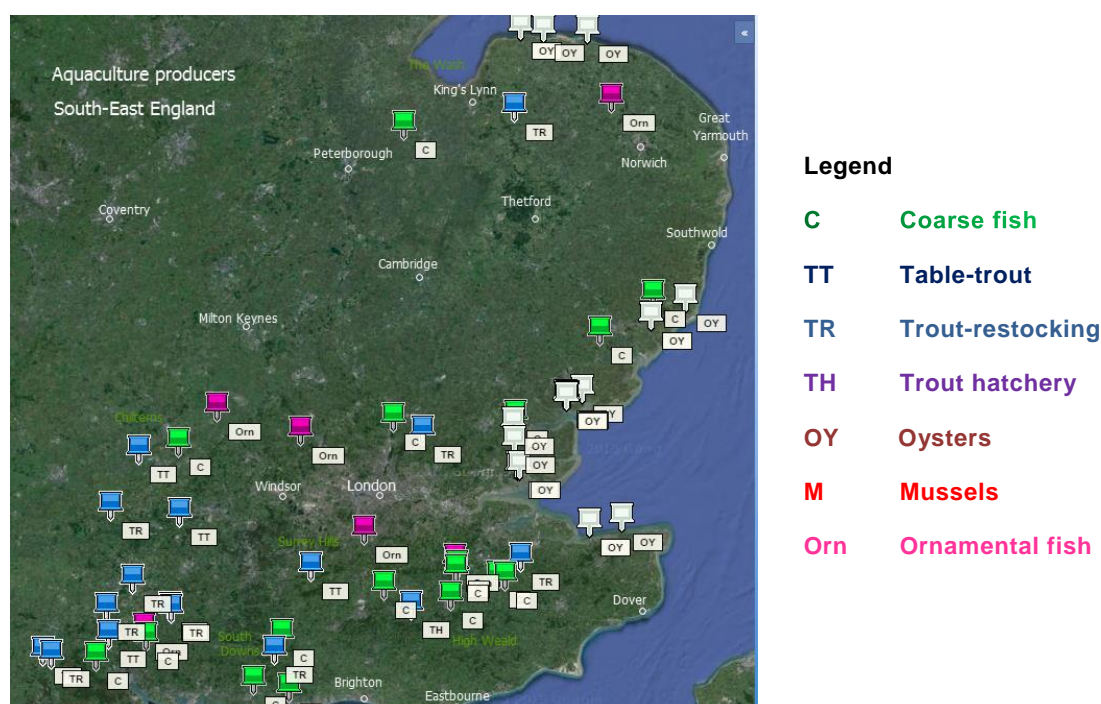


Table 7: Employment estimates for South Eastern England

SOUTH EAST ENGLAND		Multipliers		Direct			Indirect			Induced			Total		
Sector	No. of producers	Type 1	Type 2	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Coarse	18	1.5	1.8	39	57	75	20	29	38	12	17	23	70	103	135
Table	5	1.5	1.8	7	10	12	4	5	6	2	3	4	13	17	22
Restocking	10	1.5	1.8	20	30	39	10	15	20	6	9	12	36	53	70
Hatchery	1	1.5	1.8	1	2	2	1	1	1	0	0	1	2	3	4
Oysters	19	1.2	1.5	57	82	106	11	16	21	17	24	32	86	122	159
Ornamentals	6	1.5	1.8	20	29	37	10	14	19	6	9	11	36	51	67
TOTAL	59			144	208	271	55	79	104	43	62	81	242	349	456

Note: The high-end direct estimate is closest to official government estimates

South Eastern England has a significant aquaculture industry, including trout and coarse fish production (primarily for local recreational fisheries, especially to the south of London), as well as oyster production on the estuaries of Suffolk, Essex and the north Kent coast.

There are also several ornamental fish producers, located within easy access of London.

5.1.4 SOUTH WESTERN ENGLAND

Figure 11

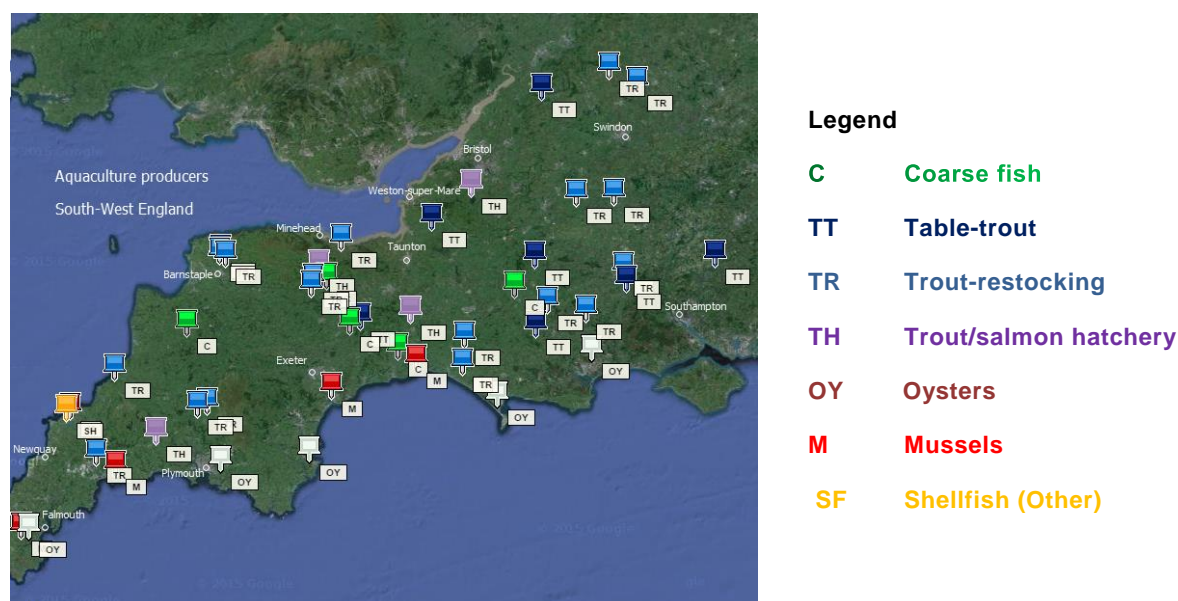


Table 8: Employment estimates for South Western England

SOUTH-WEST ENGLAND		Multipliers		Direct			Indirect			Induced			Total		
Sector	No. of producers	Type 1	Type 2	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Coarse	7	1.5	1.8	12	17	22	6	9	11	4	5	7	22	31	40
Table	8	1.5	1.8	29	42	55	15	21	28	9	13	17	52	76	99
Restocking	20	1.5	1.8	46	66	85	23	33	43	14	20	26	83	118	153
Hatchery	4	1.5	1.8	13	13	25	7	7	13	4	4	8	23	23	45
Oysters	6	1.2	1.5	20	29	37	4	6	7	6	9	11	30	43	56
Mussels	7	1.2	1.5	29	41	53	6	8	11	9	12	16	44	62	80
Other shellfish	1	1.2	1.5	5	7	3	1	1	1	2	2	1	8	11	5
TOTAL	53			154	214	280	61	84	112	46	64	84	261	362	476

Note: The high-end direct estimate is closest to official government estimates

Like the south eastern region of England, south western England is also important for aquaculture and here it is particularly diverse, with trout production for restocking, recreational fisheries and the table (with particular concentrations in Hampshire, Wiltshire, and around Dartmoor and Exmoor); and some coarse fish production primarily for local recreational fisheries.

There is also significant shellfish production activity in the Solent, Lyme Bay and Poole, St Austell Bay, the Fal and Helford estuaries. This includes oysters (native and Pacific), mussels and scallops, with several new and ambitious initiatives underway.

5.1.5 WALES

Figure 12



Table 9: Employment estimates for Wales

WALES employment		Multipliers		Direct			Indirect			Induced			Total		
Sector	No. of producers	Type 1	Type 2	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Table	2	1.5	1.8	3	5	6	2	2	3	1	1	2	5	8	11
Restocking	3	1.5	1.8	6	9	12	3	5	6	2	3	4	11	16	22
Hatchery	1	1.5	1.8	2	3	4	1	2	2	1	1	1	4	5	7
Oysters	1	1.2	1.5	2	3	4	0	1	1	1	1	1	3	5	6
Mussels	6	1.2	1.5	17	25	32	3	5	6	5	7	10	26	37	48
TOTAL	13			30	44	58	9	14	18	9	13	17	48	71	94

Note: The high-end direct estimate is closest to official government estimates for Wales

The extent and diversity of aquaculture production in Wales is rather less than most other regions, and consists primarily of significant concentration of bottom-laid mussels in the Menai Straits, and some mussel rope culture in south Wales. There is now some oyster restoration and production in south Wales, along with plans to develop more shellfish farming in Milford Haven and the Cleddau Ddu.

There is some relatively small-scale trout production mainly for restocking (but with a small volume (around 100t) of table fish) from two farms in the Welsh borders. Whilst there has been substantial RAS R&D and commercial activity over the last 15 years, this is not reflected in any significant current commercial aquaculture production. One indoor RAS system is now utilised for cleaner fish research and production (i.e. wrasse, lumpfish), whilst the other is seeking new opportunities following closure of its European seabass production operations in summer 2015.

5.1.6 NORTHERN IRELAND

Figure 13

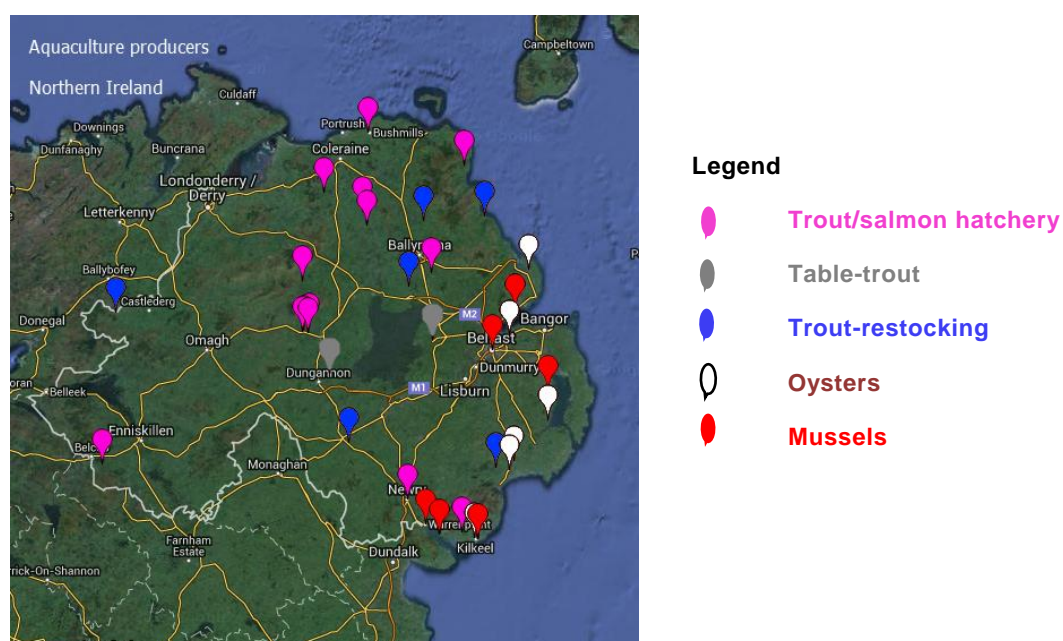


Table 10: Employment estimates for Northern Ireland

NORTHERN IRELAND		Multipliers		Direct			Indirect			Induced			Total		
Sector	No. of producers	Type 1	Type 2	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Coarse	0	1.5	1.8	0	0	0	0	0	0	0	0	0	0	0	0
Table	2	1.5	1.8	6	9	11	3	4	6	2	3	3	11	15	20
Restocking	6	1.5	1.8	13	19	24	7	9	12	4	6	7	23	33	43
Hatchery	13	1.5	1.8	16	23	30	8	12	15	5	7	9	29	41	54
Oysters	7	1.2	1.5	12	18	24	2	4	5	4	5	7	18	27	36
Mussels	10	1.2	1.5	23	34	45	5	7	9	7	10	14	35	51	68
TOTAL	38			70	102	134	25	35	46	21	31	40	116	168	221

Note: The mid-range direct estimate is closest to government estimates for Northern Ireland

Northern Ireland has a reasonably diverse aquaculture industry, though it lacks significant coarse fish or freshwater table fish production. However, there is a balance of trout hatcheries and restocking enterprises, mussel and oyster production.

County Antrim also hosts a significant producer of organic salmon (600t) with sites in Red Bay and Glenarm Bay.

6 PROFILE OF AQUACULTURE SUB-SECTORS IN THE UK

This section summarizes a much more detailed profiling of the industry presented in Annex 8, which offers detailed information and expansive analysis for each of the aquaculture sub-sectors, covering:

- A mainly descriptive overview (i.e. what it is, where it fits in to the bigger picture, important technical characteristics, etc.) and the geographic distribution of activity (illustrated with a small subsidiary map)
- Business structures and economic contribution
- Major sub-sector trends (e.g. growth, technology, business models, etc.)
- Markets, comparative advantage, scale issues and growth potential
- Risks, constraints and summary SWOT table
- Strategic needs for growth where appropriate
- Case studies and/or producer perspectives as gathered from the on-line survey or individual interviews

Analysis is based on a wide range of published, unpublished and industry sources, including the on-line survey and in depth interviews. The “strategic needs” section in particular draws heavily on interviews and the on-line survey, rather than detailed technical analysis of all relevant issues.

The tabulated estimates of economic contribution by each sub-sector in England, Wales and Northern Ireland are based on appraisal of published data (and in particular the 2012 Cefas analysis and report reviewed in Section 4), supplemented and modified according to more recent unpublished government data from:

- Cefas
- Other databases as listed in Table A3.1 in Annex 3
- Other recent economic studies as reviewed in sections 3 and 4
- Industry and academic sources
- Data on current input and product market prices
- Estimates of cost structure and profitability based on micro-economic modelling informed by our knowledge of fish farming systems, discussions with fish farmers, and the on-line survey

More specifically, employment data and information on the number/nature of businesses has been generated from our own database (as described in the methodology section, Section 2). This included - total revenue (value of first hand sale) from combination of Cefas production statistics and market price derived from FAO Fishstat; Cefas and/or industry sources; and value added based on assumption of between 40% and 60% of value of first hand sales, depending on the cost structure of the business as explored in financial models.

Estimates in the summary tables are for direct value, employment and value added only, and supplemented in the text with data on downstream/upstream value where available. More detail on the down/upstream value chain is presented in Section 7.

The scope of the analysis, and the changing nature of the industry meant that many assumptions had to be made, and the estimates provided in this section should be considered indicative only. Nonetheless, we have been able to triangulate between the various sources and are confident that the figures provide a useful indication of current contribution.

6.1 Finfish farming

6.1.1 Salmonid egg and juvenile production

The distribution and economic parameters of salmonid egg and juvenile production are given in Figures 14 and 15, and Table 11.

Figure 14: Distribution of trout hatcheries in England, Wales and Northern Ireland



Figure 15: Distribution of salmon breeders, fry, parr and smolt producers



Table 11: Economic parameter estimates: Salmonid eggs and juveniles from England, Wales and Northern Ireland

No of eggs	50 - 65 million
No of juvenile fish	20 - 30 million ⁵⁵
Revenue	£7.5 million + ⁵⁶
Number of businesses	27
Employment (Direct FTE)	89
Value added	£5 million
Main inputs	Skills, capital
Regional concentration	N England, SW England, N Ireland

Markets, comparative advantage, scale issues and growth potential

There is a global market for high quality salmon and trout eggs. For salmon the main markets are Scotland, Norway, Chile and Canada; for trout there has been a rapid increase in demand from Iran, Chile, Turkey and Norway in recent years. The market for

⁵⁵ Cefas 2012

⁵⁶ Eggs at £15/1000; trout fry @ £0.1/pc; salmon parr/smolt at £1/pc. Cefas (2011) estimated sales of salmon smolt to Scotland worth £6m. It is not possible to distinguish clearly this sub-sector from that for restocking presented below

fingerlings/parr is primarily limited to the UK. The UK imports most of its salmonid eggs, suggesting there may be an opportunity for both import substitution and reduction of disease risk associated with the import of live eggs.

Fish genetics and breeding is an area where the UK has global strengths, and there is no reason why the UK should not be globally competitive - generating exports of eggs and providing genetic services, and underpinning production of high performing fish for restocking and the table market.

As an island, the UK is well placed in terms of managing its disease status, and is free of many aquaculture diseases that plague the industry worldwide. This together with significant technical expertise means that the UK has significant comparative advantage with respect to most northern, temperate species.

Risks and constraints

The egg production business is relatively low risk insofar as it is small, relatively immune to the uncertainties of climate, markets, and indeed disease. It is risky in that success takes substantial time and research, and ultimately a competitor may generate a better product. There are also risks that disease becomes significant in the wider environment irrespective of an individual biosecurity measures and regulations related to the movement of seed from an infected area.

The small-scale fry and fingerling producers are at significant risk from climate, market and disease, and lower margins related to their economies of scale. Space and time is required, and most farms have too few broodstock and suffer from inbreeding and introgression⁵⁷.

The main constraint to success is the cost of R&D required to reach the forefront of this sub-sector. Given the size of the market, payback is likely to be too far in the future to make relatively long-term investment worthwhile. Further development of the sub-sector will therefore be highly dependent on industry support through joint research grants, working with specialist research institutions, and strategic use of intellectual property rights.

SWOT - Salmonid breeding and hatcheries

Strengths/Opportunities	Weaknesses/Threats
<ul style="list-style-type: none"> Significant global market and opportunities for market substitution UK as an island nation has greater opportunity to establish and maintain disease free status UK has a long history breeding salmonids and significant research capacity England Wales and Northern Ireland have favourable temperature regime for holding broodstock and breeding Excellent logistics for international air freight Synergy with R&D in animal and plant breeding more generally Significant downstream benefits leading to potentially more competitive grow-out sub-sector 	<ul style="list-style-type: none"> Inbreeding and introgression (limited space for/numbers of broodstock) Disease, including threat from imported eggs Concentration of expertise in a few global corporations that can operate in the most suitable locations (climatic, logistics, skills) Rising temperatures in southern England Actual and potential competition from US and Scandinavian countries Long lead times, and high R&D costs of maintaining technical lead globally, coupled with uncertain success

⁵⁷ **Introgression**, also known as **introgressive** hybridization, in genetics is the movement of a gene (gene flow) from one species into the gene pool of another by the repeated backcrossing of an interspecific hybrid with one of its parent species.

Strategic needs

Success will depend on determination and the capacity to raise medium/long-term investment to underpin a high-tech R&D based sub-sector:

- A more strategic approach to technical research, market analysis, and longer term investment
- Private sector/research institute/University partnerships to secure national and EU research funding to underpin more efficient selective breeding and/or genetic modification (GM)
- Business development mentoring – technical, economic, business management and marketing expertise

6.1.2 Table trout production

The distribution and economic parameters of table trout production are given in Figures 17 and Table 12.

Figure 17: Distribution of table trout producers in England, Wales and Northern Ireland

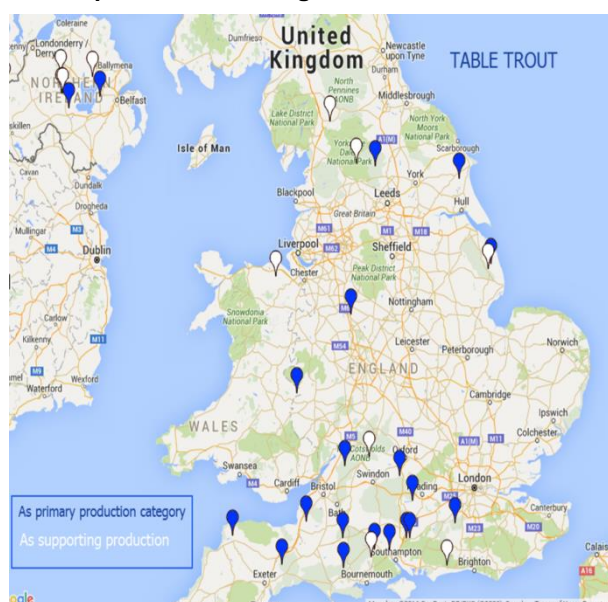


Table 12: Economic parameter estimates: Trout for the table

Production	4,500t
Number of businesses	21
Revenue	£13.8 million ⁵⁸
Employment (Direct FTE)	105
Value added	£6 million
Main inputs	Capital, feed

Comparative advantage and market opportunity

The UK is a small player in a large global trout market (global production of rainbow trout is around 800,000t; England, Wales and Northern Ireland contributes less than 1%), with production spread across Europe, the near East and the Americas. Top producers in recent years have been Iran, Chile and Turkey. In Europe, the major producer is Norway. European production of rainbow trout amounted to 284,000t in 2012. Sea cage production has allowed recent increases in Chilean and Norwegian production. Scotland has also begun to adopt this method (around 1,000t). The price of marine grown rainbow trout is generally higher than freshwater farmed fish.

Although trout is in partial competition with salmon, it suffers some significant disadvantages. Trout grown in ponds may have relatively poor flavour, and have a lower fillet yield

⁵⁸ Based on farm gate price of £3/kg

compared with salmon. While large sea-grown rainbow trout may be better on both counts, it is unclear what the advantage is over salmon, other than diversity of product. Marine grown brown trout may have some market potential, but the requirement for any trout stocked in open waters to be triploid may undermine the opportunity.

Table trout from England, Wales and Northern Ireland faces intense global competition. High quality freshwater trout from Denmark and Norway feed into higher value UK and European markets; there is increasing competition from marine cage grown trout and salmon; and mass pond production in countries such as Iran, Chile and Turkey. Most British grown trout supplies UK markets. Price peaked around the millennium but has since declined to levels seen in the early 1980s.

The combination of falling production and falling prices suggests significant market weakness. This will result in further consolidation to achieve economies of scale in production and marketing.

Some in the industry believe that freshwater trout production in England, Wales and Northern Ireland still has a bright future - it is simply a matter of being innovative and technically advanced, with investment in water systems and recirculation. This occurred in the Danish trout sector, but investment took place at a time when the market price, in real terms was higher than it is at present. Danish production also appears to be in slow decline, suggesting that this business model is no better. However, currently freshwater trout producers in England, Wales and Northern Ireland may have a small advantage over their Scottish counterparts, as Scottish charges for water abstraction and wastewater discharge have tripled recently (as much as £7,500 per annum in Scotland). These rates are double those found in England and Wales.

Possible diversification of the English, Welsh and Northern Irish industry into offshore cage farming of trout would be highly risky given the relatively slim margins, the scale and substantial investments required, the increased risk associated with offshore production, and the strong competition from Norway, Denmark and increasingly Scotland. However, there may be opportunity to build on Northern Irish salmon cage farming.

There may be more opportunity in product differentiation, e.g. ready meals or smoked trout. Smoked trout products sell reasonably well; amounting to a 3 - 4 fold added value relative to fresh fillets. Smoked salmon has become almost commonplace and has suffered quality complaints in recent years. There is a possibility of breaking into this very substantial higher value market.

Both small and large-scale producers undertake modest scale trout smoking across England, Wales and Northern Ireland. A step change in smoked trout production may be an opportunity for the industry, e.g. investing in larger smokeries to supply domestic and international markets. Careful financial analysis would be required to assess the level of competition in this market from foreign producers.

There are also opportunities related to the local food movement. Rising numbers of high street fishmongers, together with farmer's markets and farm gate sales, offer a significant opportunity for relatively small-scale "local" trout farmers.

Advances in genetic selection for growth, food conversion and flesh quality traits may also increase competitiveness in both production and marketing (see 6.1.1).

Risks and constraints

Currently the trout industry, not only in England, Wales and Northern Ireland but across the UK is facing many significant risks and constraints, and it is struggling.

Continuing downward pressure on market price is the main risk, with margins having been squeezed to a minimum in the table trade. Few wholesalers remain, and supermarkets have near monopolistic power and very demanding product requirements. There also appears to be a lack of interest by large retailers in trout product promotion and innovation.

Disease is an ever present risk, and while vaccines have been produced for some of the more serious trout diseases this remains an issue. Vaccines and drugs now represent a major cost. Furthermore, there is inadequate development of new treatments.

There is a feeling within industry that inadequate consultation and/or notice is given to farmers in relation to both emergency and conservation measures such as the triploid rule (recently extended to Scotland). These risks favour the larger producer who may have several sites, better cash flow, and can 'weather the storm'. A disease incident followed by restrictions can finish a small farm, and this is likely to continue to reinforce rationalisation across this sub-sector.

A key need in addressing all of these risks and constraints is skilled labour; the shortage of which was raised as a major problem by almost all those in industry we talked to.

A significant constraint is also access to sites and/or increased use of high quality water, which is often found in areas such as national parks and other specially designated areas.

Feed represents the greatest proportion of production costs. Feed specification is a significant problem for UK trout producers. Despite the relaxation of EU legislation banning LAPs (land animal proteins) in aquafeeds, the main retail chains do not accept the use of LAPs as a substitute for fish protein. Fishmeal is roughly double the cost of LAP, resulting in much higher feed costs. Compounding this problem is the difficulty and cost of sourcing non-GM feed ingredients – especially soya.

SWOT analysis - Table trout

Strengths/Opportunities	Weaknesses/Threats
<ul style="list-style-type: none"> • England, Wales and Northern Ireland has a very long tradition of trout farming • Temperature regimes and water quality are suitable for freshwater trout production in the North of England and parts of the south, though the latter may be becoming a little warm • Production in freshwater could be increased substantially through greater use of recirculation • Production of larger trout (rainbow and brown) in marine cages appears to be more profitable than production of "plate" sized trout and offers more value added opportunities • Smoked trout is a reasonably high value product that could take market share from smoked salmon • Trout has the potential to fit well in the "local food" revival • Genetic improvements can result in better food conversion, growth and flesh quality increasing competitiveness • Water abstraction charges are lower in England, Wales and Northern Ireland than in Scotland 	<ul style="list-style-type: none"> • Intense global competition/downward pressure on price • Semi/skilled labour is difficult to access and retain • Existing operations may be subject to increasingly stringent water abstraction and discharge regulations • Significant new development (freshwater flow through) is unlikely to be permitted in favourable areas, which are typically also areas of high environmental quality • Investment in recirculation as a means of expansion on existing sites will require substantial investment – difficult to justify given current market conditions • England and Wales have relatively few suitable marine sites that could be developed competitively. Northern Ireland has more potential in this regard • Other mass producers of trout are likely to enter cage farming on a substantial scale, e.g. Denmark • It will be difficult to match the labour productivity of large scale marine cage fish farming • Disease outbreaks, coupled with the regulatory response and lack of compensation schemes, may be sufficient to "finish off" smaller scale (especially single site) producers already struggling • High cost of vaccines and other drugs • High costs of feed relative to competitors (non-use of LAPs and/or GM soya) • Possible imposition of increased abstraction and discharge charges similar to increases that have already occurred in Scotland

Strategic needs

While rationalisation of the industry seems inevitable, the growth potential for the table trout industry appears limited. However, there is no reason why production should not continue at many existing facilities, and expand modestly given a supportive environment. There may be potential for significant expansion into smoked trout and other value added and “easy cook/eat” products.

The following may facilitate maintenance or modest expansion of existing production:

- Trout needs an ‘image boost’ – The British Trout Association (BTA) should lead this process, but support from EMFF, government, and/or other organizations and agencies would help
- There is a need for increased consultation, more notice, and some flexibility in the implementation of disease response and other regulations (such as triploid rules). Where this is not possible, some form of compensation or mitigation fund may be required, especially for small producers
- A more positive attitude to aquaculture development is needed on the part of planning authorities and their advisors, especially in national parks, which are often the most suitable areas for trout farming
- There is a need for national investment in vaccine development. An aquaculture sector wide R&D strategy would underpin a more resilient national industry and possibly stimulate health service exports in the longer term
- There is a critical shortage of skilled and motivated labour and need for better training and apprenticeship schemes
- A national initiative may be needed to change supermarket protocol that requires no animal proteins in fish feeds. This would improve margins whilst making production more sustainable by reducing the amount of fishmeal. The cost of non-GM feed ingredients also needs to be addressed
- Development funding is not easily accessible to most trout farmers because of the time, complexity, jargon, etc. There is need for support and facilitation to aid grant application
- Bureaucracy needs to be reduced, e.g. much time spent on official forms and surveys that are unnecessary/over-complex, or that do not apply to most fish farming businesses
- There is a need to rebalance funding of and support to established aquaculture methods

6.1.3 Production of trout and salmon for restocking/on-growing

The distribution and economic parameters of salmonid restocking and on-growing production are given in Figure 18 and Table 13.

Figure 18: Distribution of businesses whose primary activity is trout for restocking/on-growing

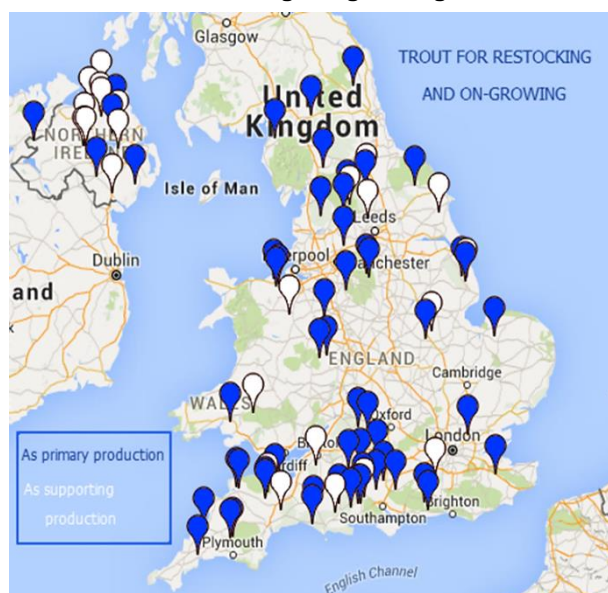


Table 13: Economic parameter estimates: trout restocking

Production	5,000t
Number of businesses	58
Revenue	£25 million ⁵⁹
Employment (Direct FTE)	239
Value added	£15 million
Main inputs	Labour, capital, feed

Markets, comparative advantage and growth potential

Production for restocking is primarily a national activity and there is little competition from overseas due to transport costs and disease regulations. This is therefore a captive market.

There is continuing strong demand for small rainbow trout and salmon smolts for stocking in marine cages in Scotland, and some parts of Ireland, and is supplied from farms in north Cumbria and one in Lincolnshire. There may be opportunities for further modest expansion. However, such investment will be almost entirely dependent on the major salmon and trout producers in Scotland, who may prefer to develop this activity closer to Scottish grow-out sites, perhaps using RAS technology.

Suitable temperatures for inland restocking trout production are found across the UK. England probably has the temperature advantage over Scotland, and with northern England increasingly have the advantage over the south if temperatures continue to rise.

Risks and constraints

There is substantial risk related to disease, and to the regulations that are implemented following disease outbreaks. A serious outbreak could easily force a small farm out of business. Such disease risks may be mitigated by having several farms in different locations, implying further rationalisation of the sub-sector.

⁵⁹ Farm gate price estimated at £5/kg

A significant constraint is also access to sites and/or increased use of high quality water, which is often found in areas such as national parks and other specially designated areas. RAS is more likely to be cost effective for producing restocking fish (compared with table trout production) under present market conditions, but if these further deteriorate such investment is unlikely.

While LAPs (land animal proteins) can be used in feed for rearing fish for stocking, the bulk of feed production in the UK is for table fish and is typically free of LAP. It makes little commercial sense to make specialist feeds for restocking in the UK, and the bulk of feed is purchased from abroad (Europe), increasing production costs and reducing indirect economic benefit.

SWOT analysis - Trout restocking

Strengths/opportunities	Weaknesses/threats
<ul style="list-style-type: none"> • Small hatcheries/salmonid farms add significant interest to countryside visitor destinations • There are many species/varieties options for more specialist restocking producers that may allow them to increase margins or increase market share • Supply of smolts or larger trout for stocking in marine cages is an expanding market 	<ul style="list-style-type: none"> • <i>See those relating to table trout production</i> • Disease and response to disease • Interest in angling – especially for trout – appears to be in decline • Scotland may have comparative advantage in terms of logistics and management • Lack of UK produced LAP inclusion feed

Strategic needs

While opportunities for expansion may be limited, this sub-sector is nonetheless a significant employer for some of the smaller rural population centres in England and Wales, and it is desirable that it should survive if not prosper.

Strategic needs are broadly similar to those as described for table trout.

In particular there is the need for greater efficiency, predictability and flexibility in the regulatory system; support for genetic improvements in terms of quality (for angling) and growth traits, food conversion etc.; more proactive incorporation in planning systems; and measures/initiatives to reduce feed costs and increase the proportion of suitable feed manufactured in the UK.

6.1.4 Production of carp and coarse fish for restocking

The distribution and economic parameters of carp and coarse fish restocking and on-growing production are given in Figure 19 and Table 14.

Markets comparative advantage, scale issues and growth potential

Southern England has the strongest comparative advantage in terms of water temperature for carp and coarse fish, coupled with attractive countryside accessible to major cities. Whilst recreational fisheries are mainly local (evening and weekend destinations) there is a more specialist market for serious angling enthusiasts who are prepared to travel (e.g. to Europe) for the best angling. There is no reason why this should not work both ways – with English waters attracting continental anglers. Although angling generally appears to be in decline, there is a strong band of passionate anglers prepared to spend significant time and money to access quality fish. An English carp lake is an attractive recreational destination, especially when combined with other “country attractions” (e.g. cafes, shops, walking, etc.). There is no reason why there should not be some modest growth in this sub-sector on the back of appropriate packaging of attractions and promotion.

Figure 19: Distribution of coarse fish producers in England and Wales



Table 14: Economic parameter estimates: carp and coarse fish

Production (traded)	100 – 300t
Number of businesses	39
Revenue	£5 million+
Employment (direct FTE)	154
Value added	£3 million +
Main inputs	Capital, wages, feed

Risk and constraints

Carp and coarse fish production and fisheries have suffered on occasion from serious disease, and this remains a risk. However, this sub-sector tends not to be an intensive activity, and thereby risk of disease reduces.

Regulatory constraints also tend to be less onerous - coarse fish can be grown extensively in more enclosed waters with little impact on the quality of river systems.

SWOT analysis - Carp and coarse fish

Strengths/opportunities	Weaknesses/threats
<ul style="list-style-type: none"> This is a diverse sub-sector that can adapt to changing demand Strong association with countryside recreation, for which demand is buoyant Large fish are in high demand, and the best (appearance, angling qualities) can be extremely valuable 	<ul style="list-style-type: none"> Disease International trade in high performing strains and large valuable live fish takes place illegally and threatens UK biosecurity Some decline in the popularity of angling in all its forms Limited opportunity for development of new “lakes”

Strategic needs

Existing data collection protocols are inadequate to provide a good understanding of this sub-sector. A sample interview survey addressing business structure, trends and perspectives would be of more value than standard returns.

Many producers will require support for business development if they decide to diversify into countryside attractions rather than continue to rely purely on angling revenue.

6.2 Shellfish farming

6.2.1 Seed production

The economic parameters associated with oyster hatchery production in England, Wales and Northern Ireland are given in Table 15.

Table 15: Economic parameter estimates: Oyster hatcheries

Production (millions)	~500 million spat / Highly variable
Number of businesses	3
Revenue	£0.5 - £0.75 million
Employment (direct FTE)	12
Value added	£0.35 - £0.5 million
Main inputs	Capital, skills

Markets, comparative advantage, scale issues and growth potential

There are currently three fully commercial oyster hatcheries in England, Wales and Northern Ireland. Current seed supply of oysters (and scallops and clams) is inadequate to meet demand, or underpin significant expansion of production.

The UK has suitable temperatures for the production of oyster (native and Pacific), scallop and clam, all of which are in high demand in national and international markets. Furthermore, the UK arguably has significant historic comparative advantage in shellfish hatchery technology, although the French and perhaps the Norwegians have overtaken the UK in recent years. Given current actual and potential demand, and the opportunity for significant R&D under funding streams such as EMFF, there is no reason why the UK should not restore its position at the forefront of shellfish hatchery R&D.

The UK also has comparative advantage as an island nation in terms of disease control, and significant parts of the UK remain clear of shellfish diseases such as *Bonamia* and OsHV-1 μ var (oyster herpesvirus virus). Effective import controls should allow this status to be maintained. There is an in-built comparative advantage for any domestic producer operating in a disease-free zone in supplying the domestic market⁶⁰. Still, production and distribution of oyster seed is heavily constrained by disease issues.

There is also some seed demand for shellfish restocking. The native oyster is a European Biodiversity Action Plan species and the UK has a responsibility to enhance natural stocks, and it is a commercially important species supporting especially in southern England.

Notwithstanding the broadly positive outlook, hatchery production in the UK is constrained by a lack of significant and consistent demand, whereas on-growing is constrained by a lack of a consistent and reliable supply of seed - a frustrating “chicken and egg” scenario.

⁶⁰ However, this is less than simple. For example, some British oyster growers in diseased areas may be happy to source seed from French hatcheries also in disease zones – and indeed these seed may be cheaper precisely because they come from a diseased zone

A key issue also relates to the production of the introduced Pacific oyster and the lack of clear policy on farming these “invasive species” in locations where they are not already well established. This is not only having a significant influence on demand for Pacific oyster seed, but is an issue for on-growing, and must be addressed with a clear strategy and protocols.

Wild mussel seed is not usually limiting, and the case for hatchery production is less strong. However, the requirements for shellfish eating coastal birds have to be assessed before consents for the removal of seed for aquaculture are issued, and erratic mussel seed supply in Shetland has led to strong support for hatchery research in Scotland. There may also be opportunities to establish one or more mussel seed collection companies in the UK to ensure more consistent and predictable seed supplies, helping to simplify on-growing procedures.

Although lobster fishery enhancement faces major challenges there have been some encouraging results in recent years. A 25-year stocking programme might result in a 100-year impact if combined with effective management and “ownership” institutions. However, this would need very long-term investment and strong, consistent industry support.

SWOT analysis - Shellfish hatcheries

Strengths/opportunities	Weaknesses/constraints
<ul style="list-style-type: none"> • The British Isles have natural comparative advantage in terms of biosecurity, so long as prevention and management measures are fully and effectively implemented • Temperatures are very suitable for oysters, mussels, scallops and clams in most parts of England, Wales and Northern Ireland and there is significant current demand in the market place and from existing/prospective on-growing enterprises • The UK has a long history of leading/cutting edge hatchery technology. Current examples include the work at the National Lobster Hatchery and e.g. Shellplant⁶¹ project at Swansea • More professional specialist collection of seed, sourcing from many sites around the UK to even out seasonal and annual variations in settlement could result in more reliable supply of mussel and scallop seed 	<ul style="list-style-type: none"> • Supply of seed from collection from the wild is often unreliable and inconsistent • There are too few existing hatcheries to guarantee consistent production across and between years and for a range of species • Despite the relatively good disease status in the UK (e.g. relative to France) there are problems that restrict movement of seed and constrain commercial operations • Establishing a hatchery and developing the necessary skills and protocols – according to species and location - requires many years of dedication and substantial long-term investment

Strategic needs

- A seed supply and quality improvement strategy (possibly government led) which addresses both wild collection and hatchery production
- A clear policy on farming Pacific oysters
- Modest and focused investments made or supported and based on strategic needs
- Research on effective viral neutralisation/screening and hatchery certification

⁶¹ <http://www.swansea.ac.uk/csar/projects/shellplant/>

6.2.2 Oyster on-growing for the table market

The distribution and economic parameters of oyster producers are given in Figure 19 and Table 16.

Figure 19: Distribution of oyster producers in England, Wales and Northern Ireland



Table 16: Economic contribution of Oyster farming

Production	1200t ⁶²
Number of businesses	36
Revenue (value of first hand sales)	£4.6 million ⁶³
Employment (Direct FTE)	184
Value added (direct)	£2.3 million ⁶⁴
Main inputs	Capital, skills, seed

Markets and comparative advantage, scale issues and growth potential

The market for oysters is now strong and prices are rising. This is due to a combination of steadily increasing demand in the UK, France, China and SE Asia, coupled with falling production in Europe. Recent Valentine's Day sales have demonstrated significant growth potential.

France is Europe's biggest producer of Pacific oysters but suffers from disease issues. While it is likely that French oyster production will eventually recover, there is now an opportunity for the UK to establish itself as a significant producer of both native and Pacific oysters, especially if it can maintain large disease free areas, and establish itself as the pre-eminent supplier to China and SE Asia.

Southern England and South Wales have a significant temperature advantage for oyster culture. This translates into a much shorter grow-out cycle than that in northern England, Northern Ireland and Scotland, and these two regions also have a relatively large number of potentially suitable sites (i.e. sheltered, relatively nutrient rich, shallow, estuarine), whereas Scotland is more constrained in this regard.

On the other hand, disease is more widespread in the southern parts of the UK, possibly associated with higher temperatures, and this may favour Scotland over England, and possibly England over France - although there is always the trade-off with higher growth

⁶² Variable from year to year. This the figure used by Humphries (2014) as a sensible estimate in recent years. FAO statistics suggest no great change since.

⁶³ Based on value as estimated by Cefas 2012. This is almost double the value as estimated by Humphries (2014)

⁶⁴ Assuming value added at 0.5 of first hand sales. Note that Humphries (2014) uses 0.55 based on industry level published multipliers.

rates as noted above. High salinity may also favour some pathogens, suggesting a possible advantage in the brackish water estuaries of the UK.

The market for the native oyster is smaller and could be flooded relatively easily, but there is an opportunity nonetheless for niche high-value “genuine native” production. Again it is arguable the UK, and especially England, Wales and Northern Ireland, have comparative advantage in the production of this species.

Risks and constraints

Disease from imported stock or from the local aquatic environment is a main threat to successful oyster production. Disease is both a risk and opportunity; there is always the danger that it will strike, but as an island the UK has some comparative advantage in terms more effective biosecurity opportunities.

There is a lack of clear policy on farming the introduced Pacific oyster in locations where they are not already well established, and where they may be regarded as “invasive species”. This is not only an issue for on-growing, it also has a significant impact on demand for seed and must be addressed with very clear strategy and protocols.

Food contamination/safety issues (e.g. faecal coliforms, norovirus and algal toxins) and associated closures are significant problems. There is widespread feeling in shellfish on-growing and harvesting that it is their industry who pays the price for the poor regulation and management of sewage, particularly during exceptional precipitation events/periods. The recent downgrading of some shellfishery classifications is of significant concern to the industry.

Inadequacies in the testing regime may also have devastating effects on the industry where closures follow. There is widespread concern in the industry about the accuracy and representativeness of the sampling and subsequent closures. Given the strict protocols associated with depuration, it seems likely that a more cost effective and safe system could be developed.

Those in industry also regard planning and permitting procedures as significant constraints. This issue is discussed in more detail in relation to mussel farming, as well as in Section 9.

SWOT analysis - Oyster production

Strengths/Opportunities	Weaknesses/Constraints
<ul style="list-style-type: none"> Oyster prices are at historic high with strong demand from France and increasing demand in the UK and Asia, Larger seafood companies are beginning to invest in oyster production, confirming market potential England, Wales and Northern Ireland have suitable water temperatures, and sites for increased and competitive production of native and Pacific Oysters England, Wales and Northern Ireland and the Channel Islands are home to 3 well established oyster hatcheries with many years' experience England, Wales and Northern Ireland has the potential for better biosecurity than continental producers There is an immediate opportunity for a more cost effective regulatory regime, taking full account of the potential/role of depuration, and opportunities for self-testing/regulation/reporting 	<ul style="list-style-type: none"> Seed production is inadequate to meet demand; and is unpredictable Disease status of surrounding waters is constraining the sales of one hatchery Oysters prefer estuarine conditions, and these areas are vulnerable to closures England, Wales and Northern Ireland has surprisingly few Category A shellfish waters - related in part to poor regulation and management of land based sources of pollution The SPS testing/closure regime appears to be inadequate and inefficient

Strategic needs

- A clear policy on farming Pacific oysters
- A more cost effective food safety testing regime
- Better regulation of sewage outfall/overspill during exceptional precipitation periods
- More positive and pro-active planning for sustainable shellfish aquaculture development through the various planning and economic development procedures
- Careful maintenance and market exploitation of biosecurity advantages of island status and strong regulatory regime

6.2.3 Mussel growing for the table market

The distribution and economic parameters of mussel production are given in Figure 20 and Table 17.

Figure 20: Distribution of mussel producers in England, Wales and Northern Ireland

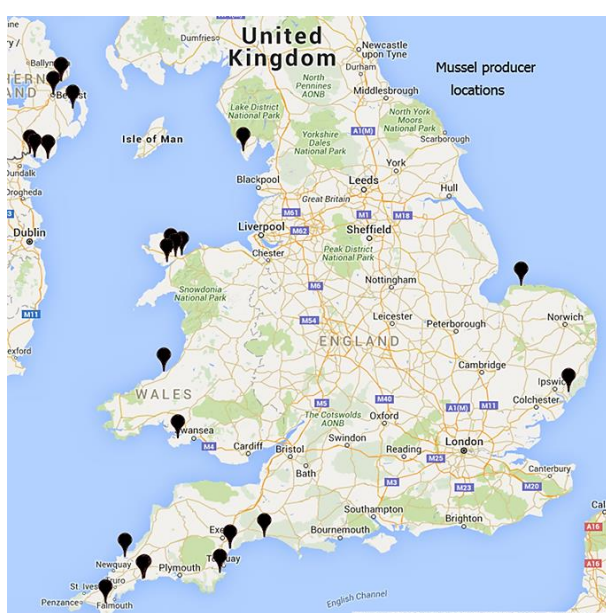


Table 17: Economic contribution of mussel farming

Production	20,000t
Number of businesses	25
Revenue	£10 - £20 million (prices and production variable)
Direct employment	125
Value added	£6 - £12 million
Main inputs	Capital, skills

Markets, comparative advantage, scale issues and growth potential

Mussel farming is a well-established business in Europe. Perhaps surprisingly, and despite relatively strong prices, European production has declined since a peak in 1999, due mainly to natural declines in the Netherlands and some production problems in Spain.

Mussel production is a global industry, led by New Zealand and Chile, both with large-scale production, highly mechanised, and accessing global markets.

Shetland has been successful at developing medium-scale rope mussel production, with investment in part coming on the back of the salmon industry.

Mussel supply and price are highly variable from year to year although a clear relationship between supply and price within Europe is not evident. There was a substantial strengthening of price in the late 1990s as the variety of products increased (in particular vacuum packed); and mussels are undoubtedly more popular in the UK than they were. Demand has strengthened for both whole, live mussels for the restaurant trade, and convenience products for the home consumer (such as those produced by the Scottish Shellfish Marketing Group) sold through the supermarket chains.

Comparative advantage and growth potential

The market for mussels is strong in Europe, Asia and the US. Mussels are well suited to a variety of fresh and convenience products and as additives to seafood dishes more generally.

The potential for growth of high quality bottom and rope grown mussels is well demonstrated in other countries, and in parts of the UK. The climate of England, Wales and Northern Ireland is well suited to growing mussels. However, given the significant global competition, it is likely that success will only come with scale.

Risk

Despite the potential, this is a risky business. Large-scale production still depends on natural spat fall that is often variable and has caused some problems for the Scottish industry. Even when spat fall is good, retention after settlement is not guaranteed. Fouling can also threaten growth and operations of grow-out stages. Problems with invasive species can also be very damaging. Larger scale offshore systems must also make large investment if they are to withstand high-energy offshore environments.

Constraints

The difficulties in getting licences and permits to use significant areas of water can be very time consuming and costly, and is related to fishing, navigational and environmental concerns, as well as the sheer complexity and uncertainty of the regulatory process. This creates particular difficulties for mussel farming (and shellfish farming generally) because however suitable a site may appear, piloting must be undertaken. If piloting itself becomes associated with a significant regulatory burden, then the whole development process becomes too costly and uncertain to justify the time and investment needed. This is arguably one of the main constraints to increased mussel production in England, Wales and Northern Ireland.

SWOT analysis - Mussel production

Strengths/opportunities	Weaknesses/threats
<ul style="list-style-type: none">• Large global market, fair national market, and relatively buoyant demand• Relatively short grow-out time compared with other shellfish• Opportunities for both fresh and value added processed products• Suitable climatic regime• Significant offshore areas that might be developed with sufficient investment	<ul style="list-style-type: none">• Strong competition from Europe, New Zealand, Chile• Difficult to predict site suitability because of variations including: spat fall, fouling, tubeworm, predation• Threat of shellfish poisoning, norovirus, and bacterial contamination – especially at inshore sites• Relatively few Class A shellfish waters• Relatively few sheltered sites for SME scale start up• Permitting complexity, uncertainty and delay – for both piloting and scale up• Regulatory regime onerous/arguably “not fit for purpose”

Strategic needs

- A strategic policy and regulatory environment premised on the assumption that there will be sustainable development of shellfish aquaculture in suitable locations
- A role for government itself to facilitate and help start-ups navigate the regulatory obstacles and uncertainties
- More effective regulation of land-based pollution sources and more Class A shellfish areas
- Independent review of the shellfish and shellfish waters testing regime

6.2.4 Scallops for the table market

Markets, comparative advantage scale issues and growth potential

European aquaculture production of scallops is very limited. Spain was the major European producer of farmed scallops but this industry has since collapsed and main suppliers are now Ireland and Norway, with a small contribution from the UK and France. High quality, sustainably produced scallop (such as hand dived) command a substantial premium over wild scallops, especially since the damage caused by scallop dredgers has been highlighted in recent years and raised public awareness.

Research suggests that at many sites around southern coasts (i.e. the English south coast and parts of Wales) provide good conditions for scallop aquaculture, and may be optimal for this species by providing a longer growing season than Scotland. Recent experience on the south coast of England suggests time to market may be as little as 2 - 3 years; Southern England is arguably one of the best places in Europe to grow King scallops.

Risks

Suspended containment nets (e.g. lantern nets) are commonly used to reduce predation of farmed scallops, but are high cost and high maintenance, and therefore increase financial risk. Investment may be reduced by transferring the stock to the seabed but this increases the risk of natural predation on the young stages, and poaching for the larger stages. There are also risks associated with contamination and production water closure as described for the other shellfish. Price is also very variable - related to the unpredictability of the capture fisheries production.

Strategic needs

- Strategic needs are similar to those for other shellfish species. However, there is a more pressing issue in terms of the need for consistent levels of hatchery production, since there are no existing commercial hatcheries, and natural spat settlement is erratic
- This reinforces the need for a clear national shellfish seed strategy that addresses the varied but overlapping needs for seed of many different species, supported by national or European R&D and commercial enterprise start-up support

SWOT analysis - Scallop production

Strengths/Opportunities	Weaknesses/Threats
<ul style="list-style-type: none">• Good market value• Near optimum temperatures for King scallop and Queen scallop. 2 - 3 years grow-out has been demonstrated in England compared with 4+ in Scotland and Norway• Prefers marine conditions which are less susceptible to contamination issues than estuarine/brackish water suited to other shellfish species• Not susceptible to major known shellfish diseases• Laid/ranched scallops can be diver collected with associated market premium• There is natural spat fall around UK coasts that might be exploited by specialist spat collection company• Hatchery technology is well established and there is some UK expertise. There may be an opportunity to combine scallop seed with other shellfish hatcheries• There may be opportunities for offshore scallop production in collaboration with fishermen under various "ranching" arrangements	<ul style="list-style-type: none">• Variable price related to capture fisheries supply• Security/poaching likely to be more serious in England, Wales and Northern Ireland compared to Scotland/Norway particularly at larger scale extensive sites using bottom culture• Need either or both expensive cages and lots of space. The latter may interfere with fishing/navigation interests.• Suitable sites are few, depending on access; shelter; limited alternative use/designation• The lack of seed prevents viable start-up; the lack of demand for seed (i.e. established farms) undermines the financial rationale for hatchery start-up• Long grow-out in lantern nets increases susceptibility to bio-fouling and/or high labour costs• More sensitive than mussels and oysters, and live sales more difficult. Shells do not fully close; they do not do survive out of water; they do not like regular handling• Recent experience in commercial scale hatchery production is limited.

6.2.5 Other shellfish

Markets, comparative advantage scale issues and growth potential

Clams, cockles, lobsters and prawns

There is a large global market for clams. Italy has been the biggest producer (with more than 40,000t) but has suffered disease problems, creating an opportunity for increased UK production. Many of the English and Welsh estuaries could be developed for clam farming (preferably the native clam), but there are likely to be objections in some areas, e.g. from conservation interests concerned at the loss of feeding habitat for wading birds.

There is current commercial interest in developing cockle management systems in high-density re-laid beds.

To date there have been several trials on seeding lobster capture fisheries in the UK – in Shetland and in SW England, but the economic viability of this approach remains questionable.

Sea-based nursery and on-growing rearing systems, as well as land based RAS, have been developed for the European Lobster and tropical prawns but are some way from commercial success. Global competition to supply these animals (produced in very large quantities in SE Asia and South and Central America) is huge, commodity prices are close to lowest current production costs, and a substantial premium will be required to make European and/or UK farming of these species economic.

6.3 Ornamental fish and plants

The distribution and economic parameters of ornamentals are given in Figure 20 and Table 18.

Figure 20: Distribution of ornamental fish and plant growers

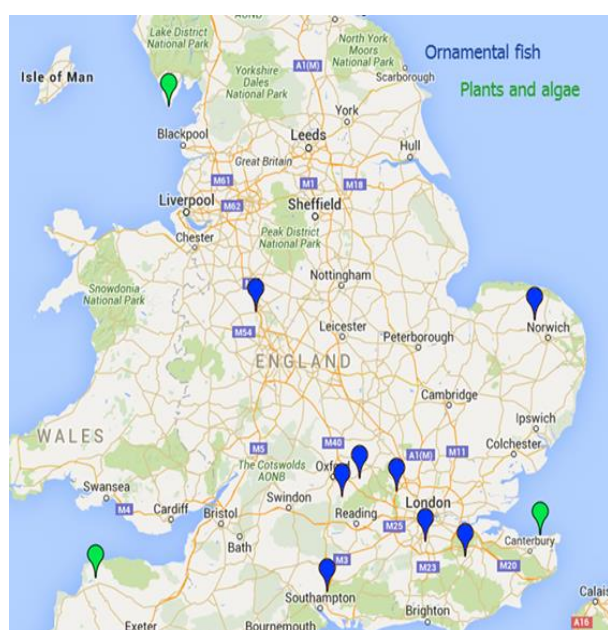


Table 18: Economic parameter estimates: ornamental fish

Production	1.34million juveniles; 1t larger fish ⁶⁵
Number of businesses	7
Revenue	£1.5 million + ⁶⁶
Employment (direct FTE)	41 ⁶⁷ (formal); (165+ informal, part time)
Main inputs	Capital, wages

⁶⁵ Cefas 2012 for number of juveniles. They estimate 0.8t for larger fish which is likely an underestimate

⁶⁶ Estimate based on 50FTE (formal and informal) with sales per employee of £30,000

⁶⁷ Rana et al 2006 estimated 30-40 jobs in ornamental fish production in the UK

Markets, comparative advantage, scale issues and growth potential

The UK and Germany are by far the most important importers of ornamental fish in Europe. Many tropical marine fish species are collected from the wild, but most cold freshwater species are artificially reared, and an increasing proportion of tropical freshwater species are also farmed. There are around 80 ornamental importers in the UK importing £16m of freshwater and marine ornamental fish.

Freshwater ornamentals still represent the largest market segment, and a significant proportion of these fish could be UK produced. However, there has only been modest growth in registered UK ornamental production over the last 20 years, although there is significant informal “garage” production.

There is a strong argument for more UK production of ornamentals: suitable climate in southern England for growing goldfish, etc., coupled with the high cost of importing and transporting live fish, and increasingly rigorous biosecurity. UK based production would have the additional advantage of reducing risks of importing disease with imported fish.

However, the market for temperate species could be supplied by relatively few farms, so the economic impact would be relatively limited, and the downstream impact will occur irrespective of sourcing (domestic or imported).

There is also an opportunity to produce a much wider range of species (freshwater and marine, fish, plants and others) in temperature controlled RAS; and given the high value/weight ratio and rapid turnover of many ornamental species and the great advantage of producing live fish close to holding and retail outlets, the investment may be justified.

There is already significant international competition in ornamental fish production (especially from Czechoslovakia) and UK investors would need to study this competition carefully before identifying the best market “niche”. The industry is struggling with some regulations, for instance the impact of biocides regulations on using barley straw for pond cleaning, and constraints on invasive species (e.g. aquatic plants⁶⁸).

SWOT analysis – Ornamental fish and plant production

Strengths/Opportunities	Weaknesses/threats
<ul style="list-style-type: none">• The production sector generates substantial downstream impacts• Gardening remains very popular and stocking garden ponds with fish could certainly be increased with positive publicity. 3 million UK households have ponds, only a small fraction of which stock fish• There are substantial opportunities for the production of a much wider range of aquarium species in recirculation aquaculture systems• UK is SVC⁶⁹ free, unlike Ireland and parts of continent (Denmark)	<ul style="list-style-type: none">• Most downstream impacts would be realised irrespective of origin• Average garden size is in decline; this reduces the likelihood of significant ponds in gardens• In the past many advocates of “wildlife ponds” advised against stocking with fish• Unregulated producers not subject to FHI/Animal Plant and Health Agency (APHA) regulations and protocols can undermine formal producers following the appropriate codes and regulations• Anti-pet trade campaigns⁷⁰ e.g. Eurogroup for Animals exotic pet campaign• Inconsistent/incoherent approach to pet shop licensing may undermine good animal welfare practices and bring the industry into disrepute

⁶⁸ <http://www.nonnativespecies.org/beplantwise/>

⁶⁹ Spring Viraemia of Carp

⁷⁰ <http://www.ornamentalfish.org/hands-off-my-hobby>

Strategic needs

- The sub-sector needs to be formalised and properly regulated. The present structure disadvantages the few formal operations, and exposes the wider industry to risk
- This is an area where basic support for entrepreneurial activity (e.g. breeding valuable tropical species in RAS) such as partial grants or low interest loans linked with technical advice could make a significant difference

6.4 Marine Algae

There has been significant interest in recent years in seaweed cultivation for biomass (e.g. for use in anaerobic digesters) but this is unlikely to be economic in the near future, and other alternative energy sources are more cost effective at the present time. There is some potential for the production of high value human food products from seaweeds, as well as production of animal feed additives.

Strategic needs

- In depth feasibility studies (technical, economic, market) on promising seaweed products as identified in previous research
- Graduated start-up grants and loans to entrepreneurs tied in with R&D funding and periodic economic review and assessment

6.5 Recirculation Aquaculture Systems (RAS), aquaponics and Integrated Multi-trophic Aquaculture (IMTA)

6.5.1 RAS

RAS technology has been widely applied in hatcheries and for early stage growth (e.g. for salmon smolts), and for table fish, e.g. trout production in Denmark where effluent regulations are stringent. Globally there have been numerous trials, pilots and business ventures using RAS for a wide variety of species, e.g. one of the most recent is a commercial enterprise in Denmark to grow table salmon in RAS. In the UK there have been several pilots and commercial initiatives for table fish production in both freshwater (e.g. tilapia, barramundi) and seawater (e.g. turbot, European seabass), but success has been limited and significant investment has been lost on many of these ventures. There are currently two initiatives to grow tropical shrimp in RAS (in Lincolnshire⁷¹ and northern England), and plans for new systems around England and Wales.

Salmon smolts are high-value and in high demand in a sub-sector with substantial capital availability, technical expertise, and where there is no serious competition. RAS culture is particularly suited because salmon smolts, weight for weight, are three times the value of table-fish, and full control and timing of production is the key to success. There may be some opportunities for RAS in extending the production of salmon smolts into early stage grow-out in order to maximize the use of limited inshore cage capacity, and there is little doubt that the major players in the industry are now seriously exploring these options. This may not benefit England, Wales and Northern Ireland (investment may be directed closer to salmon grow-out sites in Scotland as is happening for smolt production), although expansion at existing sites in Cumbria in northern England may make commercial sense.

⁷¹ <http://www.flogrosystems.com/>

The same rationale applies to early stage production of other fish and shellfish species; of particular note is the production of wrasse and lumpfish (cleaner fish for the salmon industry) in recirculation systems in Wales.

Some British trout farmers are of the view that the UK should invest in trout recirculation systems; but others say current price levels simply could not justify such investment. Given the increasing competition from marine cage production and bulk production in other countries, such investment would appear to be unwise at the present time.

A great deal of public as well as private money has been used to support RAS projects directed at table fish production (e.g. seabass production in North Wales⁷²), but there has been a lack of commercial success. The limited success and high failure rate of RAS systems for grow-out (i.e. table fish) is due to a combination of technical, economic, management and marketing issues, including in particular:

- Long lead time before achieving significant production; rarely reaching design capacity
- High production costs (especially energy, capital and labour)
- Unrealistic assumptions about price premia payable on locally produced RAS fish relative to prices paid for imported fish from countries where production is cheaper

Some of these disadvantages may be countered through, for example, the use of higher stocking densities to reduce the costs per kg of production and improved temperature control through insulation and smart technologies, but the key issue for the success of RAS is comparative advantage. More robust, transparent and fully independent technical, economic and market analysis is needed in the future before major investments are made.

It is clear that England, Wales and Northern Ireland have not had comparative advantage in the production of a number of species farmed in RAS. It is difficult to see how new RAS projects will compete, given competition from countries better suited to production, and with lower wage costs. It is also unclear that UK consumers will pay a premium for a UK grown exotic fish and shellfish products.

SWOT analysis - RAS

Strengths/Opportunities	Weaknesses/Threats
<ul style="list-style-type: none"> • Controlled temperature environment allowing for optimal growth, strategic seasonal production, improved feed conversion ratio, etc. • Siting close to processing and/or markets • Easier waste management/recycling of wastes to other productive activities • Potential improved biosecurity • In some locations (especially peri-urban) it may be easier to gain planning permission and environmental permits for the establishment of RAS compared with pond/cage systems in attractive rural/coastal locations • Fail-safe monitoring, response, and backup systems • Utilization of written-off historic investment for more commercially viable options • Strategic production of optimal economic sized salmon for on-growing in limited optimal (accessible, sheltered, high water quality) marine cage sites • Growing high value spp. – cleaner fish, ornamentals 	<ul style="list-style-type: none"> • High capital costs relative to cage fish and open circulation pond systems • High energy costs and carbon footprint – but trade off here with “food miles” • Higher production risks related to technical failure or human error • Potential difficulties treating/eliminating pathogens • ‘Plug and play’ RAS systems have been oversold. There is a lack of awareness of the importance of a combination of good design and skilled operators/management • Lower cost production in alternative systems in suitable climatic regimes • Competition from countries with less constraint on optimal inshore sites • Competition from Scotland with sites closer to salmon grow-out operations • Scotland for cleaner fish

⁷² The Anglesey operations have received more than £5m in European and Welsh Government funding and more than £10m in private finance

6.5.2 Aquaponics

Aquaponics has a rather similar history to RAS, although these are generally rather different enterprises, usually with a strong educational or community development focus. There are very few examples, globally, where these have been viable businesses in their own right (i.e. in terms of the production and sale of fish and plants). Some of the most successful examples are in Hawaii where there has been very substantial research support, but the “near” commercial operators all admit that their products are significantly more expensive than normal market rates and that they struggle to maintain financial viability⁷³ unless combined with visitor attractions, research, education, etc.

In the UK there has been significant research and development interest over the last two decades. None are significant fish producers, but are rather more herb producers or training/multiple interest organisations.

The constraints associated with RAS production of table fish apply to aquaponics but with several additional problems:

- Water quality has to be maintained to suit both fish and plants, and this may be sub-optimal for both
- Balanced, low waste aquaponic systems produce a fixed ratio of plants to fish, irrespective of market demand. If significant economic production of fish is to be achieved (through high density fish culture) a much greater volume of vegetable production will be required to keep the system in balance (i.e. use a large proportion of the fish waste), and the enterprise effectively becomes vegetable production using fish - fed with pelleted feeds - as the source of fertilizer
- Pest or disease problems in the plant or fish sub-systems may lead to an imbalance between the two, and pest or disease treatment for one sub-system may compromise production in the other
- Skills are required in both fish and plant husbandry

In conclusion, aquaponics is not a significant food producing system at the present time, and is unlikely to be so for some time, if at all given the substantial constraints on economic viability.

6.5.3 Integrated Multi-trophic Aquaculture (IMTA)

IMTA may be regarded as “an open water version of aquaponics”. There have been many trials of these systems throughout the world, but we are not aware of any fully commercial IMTA ventures.

More generally (and as with RAS and aquaponics), IMTA is a complex business, involving radically different markets. While it is perfectly conceivable that a successful finfish farm may seek to exploit “free” nutrients and diversify its business, it makes little commercial sense to seek to establish a complex integrated system from the outset, unless there are very clear marginal economic advantages to the core business – which is not normally the case. It is nonetheless arguable that IMTA on a “bay wide” or “zonal scale”, with a balance of intensive input and extractive aquaculture businesses complementing each other within a relatively enclosed water body, may represent an opportunity, and should be encouraged.

⁷³ Hambrey Consulting 2013 The relevance of aquaponics to the New Zealand aid program. Commissioned report for the New Zealand Ministry of Foreign Affairs and Trade

7 THE VALUE CHAIN

The aquaculture value chain in England, Wales and Northern Ireland was not a major focus of this study but we have gleaned significant information from existing resources and primary producers themselves. Value chain information has been derived from a number of sources including: public and non-public government datasets and statistical publications; non-governmental publicly available data; literature reviews; on-line survey results; interviews, etc.

The key elements of the aquaculture value chain not addressed in the previous sections (i.e. excluding seed input) include:

- Feed suppliers
- Specialist equipment suppliers
- Drugs and pharmaceuticals
- Trainers/researchers/advisors
- Recreational Fisheries
- Fish and shellfish depurators, wholesalers and processors
- Specialist distribution/logistics companies
- Aquaculture product exporters
- Farmed aquatic food retailers
- Garden centres and pet shops

7.1 Upstream/supplies

7.1.1 *Finfish feed*

Skretting⁷⁴ is the UK and Ireland's largest aquaculture feed producer and dominates supply to the finfish production sub-sector in England, Wales and Northern Ireland. Skretting began in Norway (where most of Skretting's R&D still takes place) but ownership is now with the Nutreco⁷⁵, The Netherlands, who have a global network of feed mills supplying 2 million t of aquaculture feeds.

Skretting has plants in Northwich (Cheshire) and Longbridge (Lancashire) as well as Invergordon in Scotland, and supplies direct/in bulk to major trout producers in England, Wales and Northern Ireland, as well as distributing to smaller scale (stocking/restocking) hatchery and fish farm enterprises through a dealership network based primarily on agricultural input suppliers.

Feed suppliers also come from Coppens⁷⁶ (owned by Alltech and Irish Company) and Biomar⁷⁷, (owned by Aktieselskabet Schouw & Co.) who although they have a plant in Scotland, their supply trout feed to the UK from production sites in Denmark.

There is also a small feed mill, Voda Feeds⁷⁸ (producing trout and carp pellets) in South Wales producing around 350t per year. Voda employs three people and supply smaller trout producers in England and Wales who are unable to buy bulk, discounted feed from the larger companies.

⁷⁴ <http://www.skretting.com/>

⁷⁵ <http://nutreco.com/>

⁷⁶ <http://www.coppens.eu/en>

⁷⁷ <http://www.biomar.com/>

⁷⁸ <http://www.vodafeedsltd.co.uk/>

Assuming an average delivered cost of feed at around £1,000/t⁷⁹, a total finfish production of 10,000t⁸⁰, and an average feed conversion rate of 1.5⁸¹, this equates to a total value of some £15 million for the finfish feed industry in England, Wales and Northern Ireland.

Employment at Skretting and other UK plants probably amounts to around 0.6 FTE/1000t, or around nine at the larger companies⁸², plus those in the smaller companies as well as in the feed distribution, wholesale and retail. Employment probably amounts to around 30 in actual feed production, with an additional 30 in distribution (transport, wholesale/retail).

7.1.2 Specialist equipment suppliers (including aquarium equipment)

Equipment suppliers are of four main types:

- Conventional agricultural/rural suppliers providing basic everyday items used in aquaculture
- Specialist marine suppliers and chandleries supplying a range of nets, rope, tackle and other equipment designed for use with boats and marine platforms more generally, as well as specially designed boats
- Standard fish farm suppliers e.g. tanks, filters, pipes, monitoring equipment, etc.
- Specialist high-tech hatchery and RAS plant and equipment suppliers

We identified at least 15 specialist fish farm suppliers to the aquaculture industry England, Wales and Northern Ireland (see list in Annex 9), although seven of these are based in Scotland and one in Denmark. These are all more or less family businesses employing between 3 - 10 persons, thus generating around 70 FTE jobs UK wide, of which perhaps 20 could be allocated to the England, Wales and Northern Ireland industry.

The significant research interest in shellfish hatchery technology has also led to several technology spin-off companies, including Northbay Shellfish⁸³/Aquahive in Orkney, Todd Fisheries⁸⁴, Dumfermline, and Aquaculture Equipment Ltd⁸⁵, Manchester.

7.1.3 Vets, drugs and pharmaceuticals

US based Merck dominates the supply of drugs and vaccines to the fish farming industry in England, Wales and Northern Ireland. Europharma⁸⁶ acts as distributor for these products and also provides veterinary advice through Fishguard⁸⁷ (with five vets).

The Fishvet Group⁸⁸ is becoming a significant player in providing veterinary services to the aquaculture industry, (not only in UK and Europe but also in Asia and the Americas), along with a range of independent vets/small businesses. The Fishvet Group employs around 25 people in the UK, but the majority of their business will be associated with the Scottish salmon industry.

⁷⁹ Typical current price of trout feed

⁸⁰ Average production in recent years

⁸¹ Above best practice, but accounts for general wastage in the industry as a whole.

⁸² Industry source

⁸³ <http://www.northbayshellfish.co.uk/index.html>

⁸⁴ <http://www.toddfish.co.uk/>

⁸⁵ <http://aquacultureequipment.co.uk/>

⁸⁶ <http://www.europharma-uk.com/>

⁸⁷ <http://fishguard-uk.com/om-fishguard/>

⁸⁸ <http://fishvetgroup.com/>

7.1.4 Research, development and consultancy

The UK has been at the forefront of aquaculture development historically and has maintained a strong influence globally.

The UK developed some of the first trout and salmon hatcheries at the end of the 19th century, and the various organisations with responsibility for inland water and waterways management have maintained expertise in this area ever since. Research on aquaculture in the UK was boosted not only by the establishment of the White Fish Authority in 1951 (now Seafish), which established a small marine research facility and hatchery at Ardtoe on Scotland's west coast, but by the work of the various government funded precursors of Fish Research Services (FRS) in Scotland and Cefas in England and Wales.

The shellfish laboratory at Conwy was highly active in the 1960s and '70s and made a significant contribution to development of shellfish hatcheries in the UK and throughout the world. In the 1970s the commercial interest of Unilever, BOC and other companies in salmonid farming further boosted research activity by several universities (especially Stirling; Bangor; Hull; Plymouth; Portsmouth) and marine research stations (i.e. Plymouth Marine Laboratory (PML⁸⁹), Scottish Association of Marine Science (SAMS⁹⁰)) and Cefas; helping the rapid development of salmonid farming in the 1970s and '80s.

Research establishments in England, Wales and Northern Ireland now also include the Centre for Sustainable Aquatic Research in Swansea (CSAR⁹¹), the University of Liverpool, PML, The National Lobster Hatchery, and Cefas. In Scotland, most universities have some research interest in aquaculture, although the main providers are University of Stirling (Institute of Aquaculture), SAMS at Dunstaffnage, and University of the Highlands and Islands NAFC Marine Centre⁹² at Scalloway, Shetland. Many other universities have marine and aquatic resource research interests and occasionally undertake aquaculture related research. The Scottish Fish Immunology Research Centre brings together expertise from several Scottish Universities.

These various organisations attract many millions in research funding from European and national sources. One current funding example is the recently launched UK Aquaculture Initiative⁹³ – a joint BBSRC and NERC initiative to “support high-quality, innovative research and research translation” to support a sustainable UK aquaculture system. In Scotland research funding is also available through Scottish Aquaculture Research Forum (SARF⁹⁴), which draws on UK and European wide scientific expertise. A new focal point for the coordination and facilitation of aquaculture research in Scotland has been established as the Scottish Aquaculture Innovation Centre (SAIC⁹⁵).

Recent and current aquaculture research in England, Wales and Northern Ireland includes work on lobster culture (e.g. National Lobster Hatchery, University of Exeter, West Country Mussels of Fowey, Cefas and Falmouth University), integrating aquaculture with offshore wind generation, RAS, lumpfish and wrasse production for Scottish salmon farming industry, environmental capacity modelling (e.g. PML).

Many universities across the UK now offer graduate and post-graduate courses in aquaculture, most notably Stirling, Plymouth, Swansea, St Andrews, Highlands and Islands

⁸⁹ <http://www.pml.ac.uk/>

⁹⁰ <http://www.sams.ac.uk/>

⁹¹ <http://www.swansea.ac.uk/csar/>

⁹² <https://www.nafc.uhi.ac.uk/>

⁹³ <http://www.bbsrc.ac.uk/innovation/collaboration/collaborative-programmes/uk-aquaculture-initiative/>

⁹⁴ <http://www.sarf.org.uk/>

⁹⁵ <http://scottishaquaculture.com/>

(UHI). More practical fish husbandry, fisheries management and aquaculture training in England is offered by Sparsholt Hadlow, and Plymouth University; in Scotland it is provided mainly by SRUC's Barony College, and UHI in collaboration with both SAMS and NAFC (see list in Annex 9). Lantra also has a 'National Occupational Standard'⁹⁶ in Aquaculture', which underpins vocational qualifications and modern apprenticeships, but these only seem to be available in Scotland.

The various research organisations listed above overlap with more commercial provision of R&D, advisory and consultancy services. These in turn overlap with some of the hatchery operators and producers that also provide advisory services. Indeed, training, research and consultancy in aquaculture is now a significant global business in its own right generating significant export earnings. We identified a significant number of companies (at least 15) offering training and consultancy services in aquaculture in the UK, though many other more general economic and marketing consultants operate in this area (see list in Annex 9). Some 60 to 80 high skilled, FT jobs are supported by these enterprises.

7.2 Downstream

7.2.1 Table Trout – national sales

The table trout business in the UK is highly centralised and controlled by a handful of production and processing companies. Over 75% of production ends up in major supermarkets.

The biggest trout producer in England, Wales and Northern Ireland is Trafalgar, who process their own fish and sell direct to Waitrose. Test Valley transports the bulk of its trout production whole, un-gutted, and on ice to central Scotland for processing by Dawnfresh, who typically sell on to M&S, Tesco and Sainsbury. Glasshouses undertakes mainly primary processing and sells direct to Morrisons. Perhaps only 2% of Glasshouses production is smoked, and primarily for local markets.

Smaller farms producing table trout either sell locally, or supply the likes of Dawnfresh, or the Edinburgh Salmon Company. Clearly a good deal of value added to English and Welsh trout takes place in Scotland.

7.2.2 Table trout – local value added and sales

The balance of table fish production, though limited in volume, generates substantially more value per unit production locally – through local smokeries, on farm/fishery sales and high-end local outlets, on-line sales, etc. While the volume is much lower, the value added and impact on local economies is far greater. We found 17 smokeries (Figure 21), 41 retail shops (Figure 22), and 11 on-line sales associated with aquaculture enterprises.

⁹⁶ Lantra work with organisations to produce flexible sets of qualifications and Apprenticeships using their National Occupational Standards (NOS). The Aquaculture NOS was approved and has been available since August 2015 <https://www.lantra.co.uk/research-standards/standards-and-qualifications>.

Figure 21: Distribution of smokeries associated with aquaculture in England, Wales and Northern Ireland



Figure 22: Distribution of local retail shops associated with aquaculture in England, Wales and Northern Ireland



7.2.3 Trout and carp: recreational fisheries and visitor attractions

There are two types of recreational fishery:

- Integrated businesses that include aquaculture production to stock and maintain their own fishery (some of which may also engage in some processing and retailing of their aquaculture products)
- Those that rely on external aquaculture production to stock their independent fisheries

In practice, there are a very large number of recreational fisheries associated with fish farms, and indeed this is the biggest aquaculture sub-sector in terms of employment and probably of value.

Increasingly however, these fisheries are evolving and developing as more general multi-activity visitor attractions, including a wide range of outdoor/leisure facilities and activities such as cafes, shops, etc. We found a total of 62 recreational fisheries, 2 general visitor attractions, 14 cafes and 11 self-catering businesses directly associated with fish farms (Figures 23 and 24).

Figure 23: Distribution of recreational fisheries associated with aquaculture production businesses in England, Wales and Northern Ireland

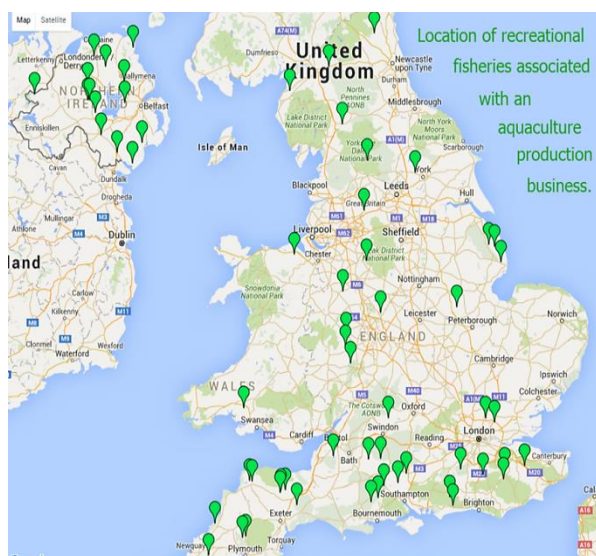


Figure 24: Distribution of visitor attractions associated with aquaculture in England, Wales and Northern Ireland



7.2.4 Mussels

The bulk of mussel production from England, Wales and Northern Ireland is from the Menai Strait, North Wales, and the bulk of this production is sold live and direct (usually in 1t bags) to Dutch, French, Spanish and other European markets.

A significant part of Scottish production on the other hand is cooked, vacuum packed and sold as high-end, luxury convenience food. This market has grown substantially in recent years and is the main growth area in the UK mussel market, but increasingly penetrating overseas markets. A plant in Bellshill, central Scotland run by the SSMG is the current focus for this type of processing.

7.2.5 Oysters

Most large-scale oyster production is sold live and direct to the French markets, although an increasing proportion is transported to central Scotland for distribution to Asian markets. An increasing proportion is also going to high-end restaurants and oyster bars, both within oyster growing areas and in London. There have also been highly effective campaigns resulting in greatly increased sales leading up to Valentine's Day.

Many of the oyster production companies (managed fisheries and aquaculture) are also wholesalers (see 7.2.6), and this is reflected in figure 32.

7.2.6 Depuration

Shellfish that is not produced in category A shellfish waters (i.e. most shellfish) will require depuration. This typically undertaken by existing producers, but may be an emerging area for sub-contracting as the industry expands and rationalises.

7.2.7 Wholesalers

We found 31 aquaculture producers who are also engaged in wholesale business (Figure 25). This applies in particular to oyster and mussel, but also the larger table trout and some ornamentals producers. In most cases aquaculture production feeds into its own wholesale

and distribution systems rather than entering major capture fishery seafood markets and distribution systems.

Figure 25: Distribution of wholesalers associated with aquaculture production businesses in England, Wales and Northern Ireland



For these companies there would be typically 1 - 2 staff specifically engaged in sales and organisation of logistics, probably amounting to some 30 - 40 FT jobs.

7.2.7 Specialist distribution/logistics companies

The most significant farmed seafood routes are:

- Table trout production from the south of England transported to major seafood hubs in central Scotland (e.g. Motherwell, Lanark, etc.)
- Oyster production in the south of England exported to Paris / other continental markets
- Oyster production in southern England transported to the major seafood hubs in central Scotland for onward distribution to both the continent and East and SE Asia
- Mussel production from North Wales exported to continental markets and in particular Belgium, Holland and France

Two of the main businesses engaged in fish transport include Solway Transport Ltd.⁹⁷ (14 wagons) with about 15 FTE, Migdale Smolts (with 7 trailers, and around 15 FTE), plus various small, independent contractors. We estimate around 40 FTE in this sub-sector.

7.2.8 Garden centres and pet shops

While aquaculture production of ornamental species in England, Wales and Northern Ireland is relatively limited, and largely confined to temperate species such as goldfish, koi, orfe, etc., it is part of, and contributes to a major economic activity in the ornamentals trade. The ornamentals trade supports 10,000 - 12,000 jobs in pet shop retailing, generating £400m in turnover at 2,000 pet shops, many garden centres, etc.⁹⁸. We are not able to allocate the proportion of this to UK ornamentals aquaculture but it is likely to be modest; the downstream impact is nonetheless highly significant.

⁹⁷ <http://solwaytransport.co.uk/>

⁹⁸ See newsletter of the Ornamental Aquatic Trade Association (OATA); also more detailed background in unpublished report by Rana *et al* 2006.

8 OVERALL INDUSTRY STRUCTURE AND CONTRIBUTION

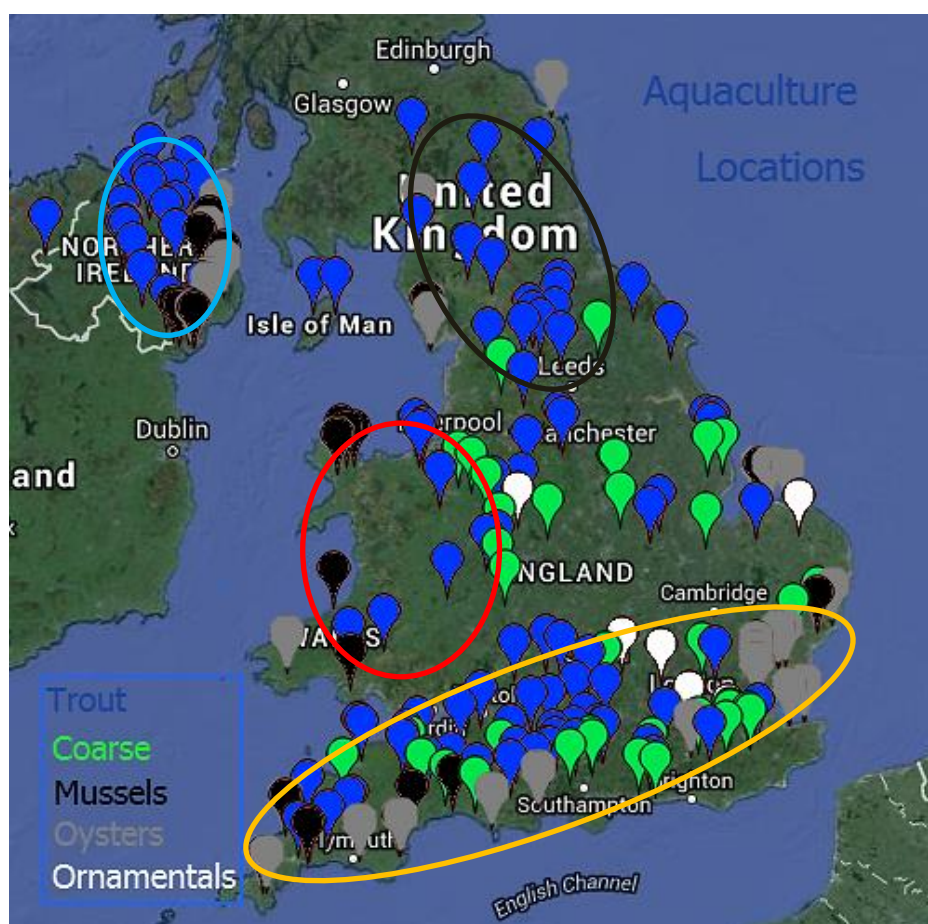
The following briefly summarizes the geographic distribution and economic contribution of aquaculture in England, Wales and Northern Ireland.

8.1 Distribution and nature of activity

Aquaculture production is concentrated primarily in northern and southern England, the Welsh borders, and Northern Ireland (Figure 26).

- **Northern England** is important for trout production for restocking, and modest production of table fish. It is also a major supplier of smolts to the Scottish salmon farming industry
- **Southern England** is important for table trout production for the national market (though this contributes rather limited economic benefit), table trout production for local sales and smokeries. Both trout and carp production in southern England supports recreational fisheries and countryside destinations. It also has a significant oyster production sub-sector and emerging mussel farming
- The **Welsh borders** have a range of small aquaculture businesses mainly associated with recreational fisheries. They also have significant re-laid mussel bed production from the Menai Strait, and a strong R&D sub-sector related to marine recirculation systems. To date the latter has not resulted in significant commercial production
- **Northern Ireland** has the only marine cage farm salmon producer, and a fair density of trout farms along with oysters and mussels in the loughs and estuaries

Figure 26: Concentrations of aquaculture activity in England, Wales and Northern Ireland



8.2 Direct and indirect economic contribution

The following summarizes the data and analysis presented in previous sections. Total direct employment is estimated at almost (possibly in excess) of 1,000 FTE broken down per sub-sector as presented in Table 19.

Table 19: Summary of direct economic contribution by sub-sector

Sub-sector	Businesses	Income (£ million)	Direct employment estimate	Growth potential
Salmonid breeding (eggs, fingerlings, smolts)	27	7.5	89	Modest
Trout on-growing for table	21	13.8	105	Limited
Trout on-growing for restocking	58	25	239	Limited
Carp and coarse fish breeding (eggs, fingerlings, restocking)	39	5m+	154	Limited
Ornamental fish production	7	1.5	41	Modest
Shellfish hatcheries and seed collection	3	0.5	12	High
Oyster grow-out	36	2.6	184	High
Mussel grow-out	25	10-20	125	High
Totals	221	70-80	949	

Note: To this should be added some modest employment (perhaps 10- 20) in several RAS and aquaponics systems most of which are not yet operating commercially and/or are dependent on research/training or visitor revenues rather than sales of fish or shellfish.

Up and downstream indirect employment estimates are given in Tables 20 and 21.

Table 20: Upstream indirect employment within England, Wales and Northern Ireland
(Note that a significant proportion of total jobs are based in Scotland)

Feed suppliers (including transport/distribution and storage)	60
Specialist equipment manufacturers and suppliers	20
Drugs, pharmaceuticals, vets	10
Teachers, trainers, researchers, advisers	70
Misc.	15
Total	175

Table 21: Downstream indirect employment within England, Wales and Northern Ireland

	Businesses	Employment
Trout processing	3	15
Total number of recreational fisheries	62	30
Total number of general visitor attractions.	2	1
Total number of cafes	14	7
Total number of wholesalers/packaging	31	31
Logistics/distribution	5	40
Total number of retail shops	41	41
Total number of smokeries	17	20
Total number with online sales	11	5
Total number with self-catering accommodation	11	2
Misc.	-	33
Total	197	225

These rough estimates suggest a multiplier of the order of 1.5, similar to that used in our initial assessments of indirect employment multipliers. If a greater proportion of trout processing were to be undertaken in England, Wales and Northern Ireland this employment figure would increase significantly as basic processing requires roughly one person/100t of product.

8.3 Indirect contribution to the economy and wellbeing

Indirect employment from English, Welsh and Northern Irish aquaculture is generated in numerous ways, as illustrated in the previous sections. It is likely that the upstream and downstream contribution to employment is over 400 (Tables 20 and 21) and probably more. It is notable that the overall contribution is widely spread across the three nations (apart from central England and parts of Wales) and of particular importance to rural areas and tourist destinations.

The contribution of aquaculture is not just economic. Aquaculture (and fisheries) contributes to the structure and attraction of the countryside. Fisheries and associated countryside attractions are popular, restorative destinations, and enhance the countryside experience for many - they are of substantial additional value.

8.4 Structural trends

In the UK aquaculture food production sub-sector there is a long-term tendency towards rationalisation/centralisation.

- Dawnfresh is a vertically integrated seafood producer with interests in freshwater trout production, marine grown trout, scallop production, and seafood processing, i.e. now processes the bulk of English table trout production.
- Loch Fyne Oysters⁹⁹ are major wholesalers and restaurateurs with an interest in both oyster and mussel production, and now own Morecambe Bay Oysters hatchery, Loch Roag Mussels and other small companies
- Edinburgh Salmon Company is now owned by Thai-American seafood giants
- On the R&D side, Benchmark Holdings PLC¹⁰⁰ (an international animal health, sustainable science and technical publishing corporation) now own INVE¹⁰¹ and FAI Ardtoe
- The fish feed sector is now highly concentrated in the hands of Skretting and to a lesser extent Coppins and Biomar

There are some less extreme parallels in the production sector. For instance, Northern Trout is probably the largest trout restocking farm, having taken over 8 sites from other smaller companies, and Trafalgar, Glasshouses and Test Valley Trout dominate table trout production.

However, there are important exceptions to this centralisation/scale trend. Ben Green's salmon parr facility in Lincolnshire (Supreme Salmon) demonstrates what technically competent enthusiasts can achieve in sustaining a small business. Voda feeds in Wales can compete with multi-national feed producers by offering relatively small volumes of feed to relatively local customers.

⁹⁹ <http://www.lochfyne.com/>

¹⁰⁰ <http://www.benchmarkplc.com/>

¹⁰¹ <http://www.inveaquaculture.com/>

SMEs also dominate the many multi-function carp and trout farms/fisheries/smokeries/visitor centres and make a substantial contribution to local economies in rural areas.

Along the English, Welsh and Northern Irish coastline there have always been a number of significant companies engaged in oyster fisheries and their management, and this is likely to continue. The Menai Straits host several significant mussel businesses, which, operating as a group, amount to a substantial commercial organisation.

A range of new small businesses is also emerging to exploit the opportunities in shellfish culture – in oysters, clams, mussels and scallops. The future looks relatively bright for these SMEs so long as they can access seed and jump the various site access and regulatory hurdles. Mussel farming however is now recognised as an area where economies of scale are important; current large-scale offshore activity in Lyme Bay reinforces this view. In any case, it is likely that economies of scale will eventually develop throughout this shellfish production sector, as they have in Scotland, and a substantial export sector is likely to be premised on large-scale production.

There is also the range of high-tech businesses, mainly focused on RAS, which have been founded on research and economic development grants from Europe and the UK, and

strongly backed by scientists and technical specialists. It remains to be seen whether successful and sustainable RAS production businesses will arise from these high-risk investments.

Box 3: Organisational structures for longer term support in fisheries and aquaculture innovation and development

Orkney Sustainable Fisheries was established as a Ltd company in 2006 with the aim of taking over the running of the Orkney Lobster hatchery. In 2013 the company was recognised by Marine Scotland as the local Inshore Fisheries Group.

OSF are involved in a number of sustainable fisheries & fisheries ecology research projects working in partnership with both national and international organisations.

OSF is industry led with the company board made up of local fishermen, merchants and a processor working together with the common aim of taking forward various initiatives relating to the sustainability of the local shellfisheries.

<http://www.orkneysustainablefisheries.co.uk/>

There have also been attempts to engage the fishing industry with aquaculture production with a view to enhance fisheries for lobsters or scallops (e.g. Orkney Sustainable Fisheries Ltd, Box 3). To date fishing industry interests have been difficult to sustain in the absence of substantial R&D funding, but initiatives are continuing and it may be that successful models can be developed.

There are also interesting academic offshoots – such as Scalpro Norway, and its productive relationship Scothatch and Scallop Ranch to commercialize seed and grow-out production of scallops.

9 DISCUSSION

9.1 Opportunities and potential

9.1.1 *Market potential and comparative advantage*

Many of the key market opportunity issues have been addressed in the sub-sector profiles in section 6 and to a greater degree in Annex 8. These are summarized here along with discussion of other analyses.

In general terms the outlook for exporting aquaculture products from the UK, and more specifically England, Wales and Northern Ireland is high. Apart from Europe being the world's largest seafood market and importing more than it produces, East Asian markets for seafood have been strong for many years, and buyers are prepared to pay very high prices for premium products.

UK markets are also significant and have substantial growth potential. A recent Scottish report¹⁰² highlights the fact that expenditure on seafood in the UK has increased faster than other foods, but that spending and consumption remains below average European levels. This implies significant market potential. It also notes a trend to buy chilled rather than frozen product in recent years, reflecting a desire for freshness and quality – a distinct advantage for home-grown aquaculture products.

Trout

The table market for trout is relatively flat. British trout is in competition with producers such as Denmark who produce high quality trout in high-tech systems, as well as and many other countries already producing at low cost and in high volume.

Interest in whole, “plate size” trout as a medium value product is limited. UK consumers generally regard whole trout (and whole fish in general) as “messy” and unappealing. Without some kind of product differentiation and promotional boost, it is hard to see this trend changing despite the opportunities for cooking a whole fish in a variety of ways.

Smoked trout fillets have potential. Trout fillets can be cold or hot smoked, are relatively popular and are excellent products for high-end supermarket or more gourmet retail outlets, as well as on farm/at smokery sales. These various markets are exploited at local and gourmet foods levels, but to date the product has not broken into a volume commodity market as exemplified by smoked salmon. This may or may not be desirable as it would imply much higher volumes of production at lower prices (and possibly significant exports), but the ratio of value added and employment to production would decline significantly.

The stocking market for trout is also rather flat, exacerbated by a variety of factors including the increasing tendency to put fish back, the triploidy rule, and the declining interest in fly-fishing and angling more generally.

Perhaps the best potential is in quality egg production for the international market. The UK has a strong technical history and some technically advanced producers able to produce eggs with traits suited to particular growing conditions or markets, or having (for example) exceptional growth or feed conversion traits. Although the existing UK trout egg market is dominated by US Troutlodge on the Isle of Man, there is nonetheless opportunity for more

¹⁰² Levercliff. (2011). To Review the UK Market for Fish and Identify Potential Opportunities for Scottish Aquaculture Products in UK Multiple Retailers and the Foodservice Sector.

advanced activity in this area. There is, however a need for research funding to underpin technical advances and maintain skills at the leading edge. Insofar as this activity would strengthen genetic skills and capacity and have far wider applications in animal genetics, it would probably be highly cost effective research.

This activity overlaps with the production of salmon parr and smolts, which is a huge global business.

Marine trout

There has been rapid growth in recent years in the production of trout in sea cages – especially in Norway, Denmark and Chile, but also in Scotland. These offer the prospect of cheaper production of larger fish with higher yields which can be sold as steaks and/or fillets, or processed in a variety of food dishes. To date cage culture is with rainbow trout, and this could be extended to brown trout (which is our true native sea trout), though it is possible that infertile triploids would be required for stocking unless these were from local stock.

England, Wales and Northern Ireland has rather few sites where such cage production could be competitively located – although Northern Ireland offers some opportunities. Thorough feasibility studies would be required, taking into account volume, logistics issues, and competition, but it may be possible to develop something of a premium product – especially if the native brown trout were to be used.

Salmon parr and smolts

The market for parr and smolts is relatively strong and northern England is already a significant supplier to the Scottish industry. It is important that this role is maintained, and that the attractions of growing smolts closer to production sites in Scotland is countered through facilitating expansion or new developments south of the border in locations with favourable water supply and temperature regimes. Growing larger fish for strategic stocking at cage sites increasingly limited by environmental capacity may also offer an interesting opportunity, and restrictions on water abstraction and discharge may favour RAS for this type of production. See RAS below.

Carp and coarse fish

Despite the declining interest in salmonid fishing, carp angling appears to be slightly more robust at the present time with a core of highly enthusiastic anglers. However, opportunities for expansion are limited, primarily by the availability of suitable lakes and ponds, most of which are already in use. Creation of new waters may be possible when associated with other major land works, but is unlikely to be attractive as a dedicated new investment.

There are European markets for carp and perch for the table in Germany, Austria, Switzerland and Eastern Europe, but these are modest, prices unexceptional and competition from producers closer to these markets is significant. The UK's increasingly ethnically diverse population also suggests a possible increased demand for carp and other freshwater fish from Chinese and European communities. Some of these opportunities have been explored in more detail in a report from Northern Ireland on diversification opportunities for the land-based aquaculture sector¹⁰³. While this report concludes that perch has high development potential, it fails to make a strong case for Northern Ireland (or the rest of the UK) having comparative advantage in the production of these species.

¹⁰³ Potential diversification opportunities for the land-based aquaculture sector in Northern Ireland” funded by DARDNI and by the European Fisheries Fund. AM Consultancy. Feb. 2011. Accessed 20/10/15 at <http://www.aquacultureinitiative.eu/diversification%20report.pdf>

Mussels

A report from the Institute of Aquaculture, Stirling¹⁰⁴, identified opportunities for growth in Scottish shellfish, and highlights significant potential for mussels. Per capita consumption of mussels in the UK is a mere 0.3kg/person/year compared with 2kg in France and 4 - 5kg in Belgium, but the popularity of mussels is increasing in the UK. At present 80% of mussels produced in the UK are destined for retail sales of which roughly half are pre-prepared, cooked vacuum-packed products, and these have seen rapid increases in sales in recent years.

The prospect of England, Wales and Northern Ireland producing more mussels seems to be positive due to:

- Rising domestic popularity in mussel consumption
- Reduced competition from Europe's largest producer (Spanish mussel aquaculture has reduced in recent years because of disease and other problems)
- A European mussel market that demands considerable volumes (greater than 500,000t)

Subsequently there seems to be potential in the bulk, the high-value, and/or the convenience food end of this market.

Despite higher temperatures and faster growth rates in England, Wales and Northern Ireland which places them in a better situation for mussel production than Scotland, all three suffer from very few Class A shellfish waters, implying extra cost for depuration¹⁰⁵. To be competitive it is essential that the Government improves its record on dealing with land-based sources of pollution, especially during extreme weather events, and develops targets for more Class A shellfish waters.

Oysters and clams

Many parts of England, Wales and Northern Ireland have suitable sites and temperature regimes for growing oysters (Pacific and native) and clams, the former on laid beds or possibly in bags on trestles or hanging baskets; the latter under plastic mesh. There are also opportunities for enhanced natural production of native oysters.

Box 4: Oyster producer perspective

"The price of oysters is good at the moment, and young people need to be encouraged to join. Grants to get started would help."

The main competition is from France (oysters) and Italy (clams). In terms of suitable temperature, South Wales and the South Coast of England are particularly well suited for oyster cultivation, and disease is currently less prevalent in the British oyster industry compared with continental producers. There seems high confidence in the industry at present (Box 4) and some producers are currently making significant investment.

Scallops

Scallops represent a major high-value European and global market, and the UK is seemingly well placed to cultivate them. To date the main efforts to do so have taken place in Scotland and Norway but both have suffered from both inconsistent spat fall or limited hatchery seed supply and slow growth rates. Southern England and South Wales have a substantial advantage in terms of the temperature regime, and recent trials suggest that grow-out may be achieved in 2 - 3 years compared with 4 - 5 in Scotland. However, scallops are more challenging to grow than oysters or clams because of their ability to swim, and therefore

¹⁰⁴ Scott, D. McLeod, D. Young, J. Brown, J. Immink, A. Bostock, J. (2010). Prospects and Opportunities for Growth in Scottish Shellfish. Institute of Aquaculture, Stirling University, Stirling;

¹⁰⁵ There are on-going discussions on opportunities to reduce depuration time from the standard 42 hours

need containment leading to higher costs. A variety of models are currently being tested, and it seems likely that a cost effective way forward can be developed.

However, it is considerably cheaper to fish for scallops than to grow them, and a market premium will be required for farmed scallops. There is currently a premium on “dive” caught scallops and this premium, or something equivalent, would need to be secured for large-scale aquaculture through effective marketing of farmed scallops. Given the size of the capture fisheries production, the concerns over the sustainability of scallop dredging, and the luxury image of scallops it seems likely that a significant premium on a small proportion of this market could be achieved.

It is worth noting that scallops have been identified as having a strong market potential, exemplifying a seafood considered an “affordable convenient luxury” (Levercliff, 2011¹⁰⁶).

Turbot and halibut

Opportunities for the production of these species in England, Wales and Northern Ireland appear to be limited. Most of England, Wales and Northern Ireland is too warm for halibut and too cold for turbot. Any initiatives would be in direct competition with turbot producers in southern Europe and halibut producers in Scotland, Norway and Nova Scotia. The option of growing these in controlled environment RAS systems is dealt with below.

Seabass

Seabass production has boomed in recent years in southern Europe and the Mediterranean and prices have fallen accordingly. The UK does not have natural comparative advantage in terms of temperature regime, and access to markets, and would be in direct competition with countries that have substantial and existing infrastructure in terms of hatcheries, cage sites, processing and logistics. Growing these fish in RAS for a premium domestic market is dealt with below.

RAS

Use of RAS allows for highly controlled environment for the production of juveniles stages, or for the production of other species outside their optimal temperature/water quality range. It also allows for the production of fish closer to major markets with potential reduction in food miles. However, this comes at a significant cost i.e. in capital investment, in energy consumption, in complexity and risk, and in highly experienced and skilled labour.

Whilst these additional costs will depend greatly on the species, the quality of the farm design, the sophistication of the monitoring equipment, and the skills of the staff, analysis to date suggests that costs are likely to be something between 30 - 100% greater than those for production in, for example, through flow or cage systems sited in favourable climatic regimes. Practical experience to date suggests costs may be even higher.

Capital and operational costs (excluding labour) are broadly proportional to the weight of fish held in the system, though some of these costs (e.g. growing tanks and floor area) can be reduced by high-density production. While the advantages of environmental control and intensive management are very high for RAS production of juvenile fish and may outweigh the additional costs (since fingerling cost is usually a relatively small proportion of final table fish cost) these costs can be prohibitive for RAS production of larger fish.

¹⁰⁶ Levercliff. (2011). To Review the UK Market for Fish and Identify Potential Opportunities for Scottish Aquaculture Products in UK Multiple Retailers and the Foodservice Sector. <http://www.gov.scot/Resource/Doc/295194/0120277.pdf>

It is clear that any investment in RAS for producing species that are already being grown outside the UK in relatively high volumes and in cheaper production systems should be undertaken with the greatest care. The authors of this report are of the view that public money should not be invested in such projects in the absence of a successful, independently funded pilot phase, followed by thorough independent feasibility analysis. UK RAS for several species of table fish (tilapia, barramundi and seabass) have all failed at substantial cost to the private and public purse.

To date RAS has been and will continue to be successful for the production of salmon juveniles, high-value ornamentals and other medium to high-value species such as cleaner fish. There may be opportunities for further investment in RAS salmon smolt production in the northern parts of England, but this will depend very much on the strategy of the major salmon production companies, who may prefer to locate RAS closer to their grow-out sites, and indeed are already investing in new smolt facilities closer to these sites.

There are two current initiatives to produce tropical whiteleg shrimp in RAS in Lincolnshire and the north of England, and it will be interesting to follow their progress. They will need a great deal of determination and a substantial price premium to succeed.

RAS facilities require substantial long-term investment in both equipment and people, and a sufficient time to development system related experience. They are well suited to hatchery and early life stage production, as well as for ornamental fish, where the relative value of environmental control is often high or essential. They are far less suited to the production of table fish, for which the costs of close containment may be prohibitive relative to simpler outdoor systems. There may be opportunities for other high value species, and the experience and expertise developed in the UK, particularly Wales, is well placed to investigate these. Nonetheless, thorough and realistic feasibility studies should be undertaken by technically informed but independent analysts before further investment of public money is considered.

Aquaculture as part of rural recreational business

The substantial contribution that aquaculture makes to recreational fisheries and rural recreation more generally has been highlighted in previous sections. The demand for rural outdoor recreation remains strong, but it needs to compete increasingly with home-based recreational activities. A fish farm adds a unique, interesting and educational dimension to any visitor attraction.

There is significant potential to maintain existing and/or struggling facilities through stronger emphasis on recreation and education. This could also be applied to the development of new aquaculture ventures partly premised on their recreational and educational roles (e.g. already being exploited by the National Lobster Hatchery; other small-scale lobster hatcheries; by some aquaponics initiatives) – although this may be partly constrained by health and safety and biosecurity issues. Aquaponics is particularly interesting from an educational perspective since they exemplify in practical terms the interdependency of animals and plants, and the delicacy of the balance between the two.

9.1.2 Potential economic contribution

The foregoing analysis suggests that for most English, Welsh and Northern Irish aquaculture sub-sectors, except perhaps shellfish, growth opportunities are rather limited. The UK and particularly England, Wales and Northern Ireland are not ahead of the game, and we are at a temperature disadvantage for many species. However, we consider that there is significant potential in the following areas:

Mussel farming in both nearshore and offshore areas. Growth of nearshore mussel production is constrained by the existence of, and access to potential sites allowing sufficient

scale, but increased production may be possible for local and/or premium supplies where marketing is a central focus of the business. Offshore offers the potential for the scale required to be competitive in European markets, and at least partially compete with more extensive production systems. There are current initiatives for both types of production and these will serve as important testing grounds for the business models themselves and the support and commitment of Government to aquaculture development. It is arguable that mussel production could be increased by at least 100% over the next 10 years, generating around 50 full time jobs with the potential for a significant processing/distribution hub, similar to that south of Glasgow and which supports the Scottish industry. Mussels represent a relatively high value added activity, since no feed inputs are required, and depending on the site, energy use may be modest.

Oysters are in demand and there is a current opportunity related to disease problems in the French industry as well as strong Asian markets. The UK is rediscovering its taste for oysters, especially on Valentine's Day and in emerging oyster bars and restaurants. Current aquaculture production at a little over 1,000t is very low by historic fishery standards and could be increased significantly if sites could be accessed. There is also a substantial opportunity to produce clams, and in particular native clams. Oyster and clam production (like mussel production) can be linked to coastal tourism and substantial value added in the restaurant sector. Oyster and clam farming are also a relatively high value added activities with no feed inputs and modest energy requirements.

Scallops. England and Wales probably have comparative advantage in production of king scallops, and there is emerging expertise in this area. There is potential for significant production to supply the top end of this market, locally, across the UK and globally. There is also potential for convenience cooked value added products similar those that have been developed for mussels.

Table trout value added. Expansion of trout farming to compete in high volume low price markets will be difficult – even at the quality end of the range, given competition from Denmark. The main opportunity lies in high quality smoked and marinated products, and in the face of declining demand for whole trout and the likelihood of excess capacity, this might be usefully directed at companies specialising in smoked trout fillet production. This may arise either from existing smokeries making significant investment to produce more product, or farms investing in their own smoking facilities either for on-site sales or possibly for larger scale supply on-line, and/or to high-end retailers throughout the country.

Sea trout (sea-grown rainbow or brown trout). There is expanding production of this product in Norway, Denmark and Scotland. While there may be opportunities in Northern Ireland, England and Wales lack suitable sites for competitive production, and would be better to concentrate on supply of parr and/or fingerlings.

Recreational fisheries. Some parts of this sub-sector remain buoyant and there are many opportunities for recreational activities serving a wide range of users (Box 5).

Hatchery/farm/seafood visitor destinations. Fish and shellfish are visitor attractions in their own right, and opportunities to observe breeding and juvenile production is interesting and educational. There is some potential to develop more such attractions, potentially associated with research and training work.

Box 5: Recreational fisheries producer perspective

"We are almost embarrassed that in a sport which is considered the largest participant of any sport in the UK, we are but a handful of thousands of commercial fisheries and angling centres within the UK that can support people with disabilities that would like to access angling."

In general there are many other opportunities, but it is important to emphasise that aquaculture is a relatively high risk enterprise – especially when undertaken at high intensity

– and that any further investment should be founded on thorough, independent technical economic appraisal and feasibility analysis. Such analysis should pay particular attention to the likelihood of production shortfalls during start-up, competition and comparative advantage.

Targets. Setting targets has strengths and weaknesses, however if target setting was undertaken it may have significant advantages, in that:

- It would be psychologically beneficial for the industry
- Demonstrate political will to see increased aquaculture production
- Send out a message to regulators that their job is to promote sustainable development rather than constrain activity

Taking into account the opportunities in offshore mussel farming a feasible target might be for a doubling of aquaculture production England, Wales and Northern Ireland within 10 years. Whether this is achievable is debatable, but it would likely have a generally positive impact on the industry (as appears to have been the case in Scotland where targets have been introduced), and would have negligible environmental effects – arguably positive in some cases. Target setting must be done in parallel with more specific initiatives to reduce development constraints.

9.2 Constraints

Constraints to aquaculture development may be summarized as:

- Market
- Site
- Regulatory
- Technical/skills

‘Markets’ have been detailed in sections 6 and 9.1.1.

9.2.1 Sites and water quality

Basic site criteria for farming various species are well established and available in technical literature, and have been explored in wider planning perspectives in other reports and studies¹⁰⁷. There have also been multi-criteria GIS mapping initiatives to identify suitable aquaculture sites, as well as environmental capacity studies to address the capacity of estuaries, bays or lochs to accommodate aquaculture. These initiatives may develop further using multi-criteria selection analysis, but we suggest simpler, more pragmatic approaches based on practical experience are likely to be more cost effective.

Identifying a possible site on a map or chart is relatively straightforward for the various species discussed; they have different requirements in terms of water quality, sediment quality, depth or location in the tidal range, need for shelter, water currents, etc. A rough assessment by map/chart would lead to a long list, and site visits with an experienced grower would lead to short lists. The latter would allow for consideration not just of the environmental qualities but also issues of access, navigation and other existing use/interests, logistics, prevalence of disease and so forth.

Shellfish

On paper there appears to be relatively large areas suitable for shellfish farming around the coastlines of England, Wales and Northern Ireland. The reality is far more constrained, not

¹⁰⁷ Welsh Study on Shellfish sites; SARF 005 Hambrey Consulting 2006. Site optimisation for aquaculture.

just by the factors noted above, but also because suitability will be dependent on the availability of spat and food, and the susceptibility to fouling and to predation. This means that in most cases productivity from a particular site cannot be readily predicted (though there are some models that may help). Trialling or piloting is essential before any site is readied for significant investment. This takes time and money, and may be constrained by regulation or resisted by other stakeholders. Subsequently significant uncertainty is introduced into investment decisions, and this has probably been a major factor in holding back shellfish aquaculture development over the last several decades.

In many cases, would-be shellfish farmers will require a Several or Regulating order to allow control access to and management of the seabed, and to assure full ownership and control over the stock. Gaining such a right can be costly, uncertain and time consuming, and there is a strong feeling in the industry that the process needs to be supported and facilitated. Two of the main factors that hinder the granting of a Several Order are:

- Prior use of the area by fishermen or more general for navigation (typically sub-tidal areas e.g. for rope/long-line cultivation of mussels)
- Value of the area for seabirds and waders (typically intertidal or shallow sub-tidal areas e.g. for oyster or clam cultivation)

There is also the issue of Marine Protected Areas (MPAs). Although MPAs do not specifically inhibit shellfish production, gaining access to protected waters once they have been designated can be difficult and/or uncertain. If shellfish production is already established an MPA designation is more likely to compromise with existing interests.

For all these reasons, the Shellfish Association of Great Britain (SAGB) has proposed an approach to facilitate site selection and acquisition as described in the regulation section below.

Finfish

For freshwater aquaculture there is no great demand for new sites, and given the strict regulatory regime the expansion of existing sites may depend on water recirculation. It is likely that business expansion will continue to depend on rationalisation of site ownership and operations.

In marine waters there are very few suitable sheltered inshore sites, other than some of the loughs of Northern Ireland, and offshore production other than in Northern Ireland is unlikely to be competitive when compared with well-established producers that already have substantial existing infrastructure and more favourable siting options.

Recreational

There are occasional opportunities to develop new fisheries – related to major infrastructure developments or rehabilitation of older aquatic systems. These offer promise to develop into fisheries and/or visitor attractions, though this requires substantial long-term investment. We do not consider the modest growth potential in this sector to be especially constrained by siting issues.

9.2.2 Regulation

In almost all our discussions with industry, regulation has come up as a major problem and constraint. This is usual in any sector, but the level of frustration encountered amongst aquaculture producers was nonetheless exceptional (Box 6). The utility and value of the new

“Aquaculture Regulatory Toolbox for England¹⁰⁸” has been recognised as helping to clarify the issue of what licences, permits, etc. are needed by a new aquaculture business in England.

Frustrations with regulation relates to several different regulatory issues:

- Permitting/consent/licensing
- Shellfish waters categorisation
- Animal disease testing and monitoring
- SPS testing – bacteria, neurotoxins, viruses

Compounding these issues are the demanding operational protocols required by retail chains.

An in-depth discussion on regulation details and the particular bottlenecks due to them is beyond the scope of this report, but there are three main aspects associated with the regulatory problem:

- **Cost:** Satisfying regulatory requirements takes substantial senior management time
- **Delay:** Delays in gaining permits or licenses can undermine business plans and cash flow, increase the total up-front investment, and lengthen payback time
- **Investment uncertainty:** substantial investment may be required without clarity or predictability of planning/regulatory outcome
- **Operational uncertainty:** In terms of potential closures or quarantine (e.g. due to disease, contamination etc.) for indefinite periods of time

Box 6: Shellfish producer perspectives

“We have been prevented from expanding due to the objections of one person who wants the whole of the coast to be a marine park”.

“We have issues associated with the property rights that we require and how these are interpreted and we have issues in respect of how we are seen within the wider marine planning process.”

“It can’t work within the current legislation, too many government bodies obstructing aquaculture development”.

“The testing programme (of Cefas and FSA) should be designed to reflect the management needs of the industry as well as legislative/ enforcement requirements and the results should be reliable.”

There is no question that good regulation is required, and all producers agree strongly on the need to manage disease and ensure food safety – indeed, these may be regarded as strengths of the UK industry. It is also the case that the regulators have no desire to constrain development, but the costs have increased substantially over the last two decades, and there is a widespread feeling that delays are excessive, some sampling regimes are not fit for purpose, and that conservation interests are considered absolute, while development interests and innovation are considered expendable.

For shellfish farming these problems are compounded by the need for piloting, which itself is subject to regulatory delay and constraint, which in turn further undermines robust investment planning.

While it is beyond the scope of this report to explore in any detail where regulatory procedures may be streamlined and rationalised, it is clear that regulatory activity needs to be more collaborative, better focused and more risk-based (e.g. more intensive sampling during periods of high runoff).

One of the key objectives of effective marine planning is to facilitate sustainable development in best locations, from the point of view of the developers themselves, and other stakeholders. This has not happened, and the whole tenor of most marine planning is conservative and precautionary - development in coastal areas is generally something to be concerned about rather than something to be encouraged.

¹⁰⁸ <http://www.seafish.org/industry-support/aquaculture/aquaculture-regulatory-toolbox-for-england>

There has already been significant discussion as to how to facilitate rather than constrain aquaculture development, particularly for shellfish. The SAGB has produced a position paper on this that seeks to:

- Put a structure in place to secure a realistic strategic aquaculture plan
- Speed up and reduce the uncertainty of a Several Order application, turning it from a passive to an active process
- Provide DEFRA and the Crown Estate with information to enable them to plan levels of support required from their staff for the duration of a strategic plan

To achieve this, they propose the following outline process; one that could be further developed and refined by consultation with industry and relevant parties:

- A comprehensive review and SWOT analysis of existing sites and operations
- A comprehensive coastal survey to identify sites where new or expanded operations are feasible, taking into account the SWOT analysis
- Determination of potential priorities for implementation at the most favourable sites
- Several and Regulating Order application - linked pre-planning and focused guidelines for the consent process to allow a faster-track completion of a full application
- Creation of a publicly available “library of sites” to allow a prospective shellfish producer/Order grantee to identify, select, and commence the completion of the Several Order application

9.2.3 Seed

As noted elsewhere in this report that there is a classic development step problem with aquaculture in England, Wales and Northern Ireland, constrained by:

- Lack of demand for seed to stimulate hatchery development
- Lack of supply of seed to facilitate grow-out development

As witnessed in other countries, it is often the case that producers import seed from neighbouring countries in the early stages of development to “kick start” the industry.

In the case of oysters, England, Wales and Northern Ireland do have three hatcheries, but one is constrained by disease in surrounding waters, the other by lack of space for algal (feed) production. Compounding the issue is that a Scottish company now owns one of these two hatcheries, and its future focused will no doubt be northwards towards Scotland.

There is an option of facilitating increased natural breeding and settlement, but overall it is probable that development of the industry will be constrained by the lack of available hatchery oyster seed. Shortages could be reduced by importing more seed, however importing oyster seed e.g. from disease-plagued France for re-laying in UK waters already designated as “diseased” is arguably not good practice, and undoubtedly increases the risks of importing other diseases as they emerge. There is an argument therefore for some kind of concerted effort to increase or stabilize the supply of oyster seed in the UK.

Scallop seed is being imported in to the UK from Norway (using UK broodstock) for various pilots, and there are initiatives emerging to establish a scallop hatchery in Scotland. If successful, this hatchery may overcome Scottish seed constraints, but will it for the whole of the UK? Again, there is an argument for a serious strategic initiative to ensure adequate and consistent UK scallop seed supply.

Mussel farming relies up on wild mussel spat collection, and this generally works well. However there is unpredictability with this reliance on a wild resource (e.g. the Shetland industry has suffered lack of wild seed supply in some years). There are initiatives to pilot mussel seed from hatchery production, but there could be other alternatives; for instance, a national wild spat collection network that would source from different areas and help even out erratic supply. There are also opportunities to be better informed and prepared in terms

of detecting larvae and setting spat collectors to maximize success. Again, there is a need for some kind of national seed strategy to address this issue.

Shellfish production in the UK has always suffered from demand and supply mismatch that routinely occurs in an undeveloped industry:

- The lack of substantial and reliable supply of seed is a significant disincentive to investment in grow-out
- The limited number of grow-out farmers, and demand for seed, makes investment in a hatchery highly risky
- The unpredictability of success rates and production in both hatchery and seed collection systems

Compounding these problems are technical and economic risks; seed production requires experience and dedication, a long lead-time, consistent environmental conditions, and high biosecurity to be successful.

It is our opinion that the most effective method to counter these difficulties would be for Government to support both hatchery and grow-out operations, with a clear strategy for balanced growth and consistent supply. England, Wales and Northern Ireland do not need numerous hatcheries they need a clear strategy to ensure that there is adequate seed to meet the needs of a growing sector, and/or a clear seed export strategy. Counteracting this lack of seed availability could involve:

- An expansion of existing hatcheries
- More consistent, effective and strategic wild seed collection
- Seed imports
- New hatchery development

All the above options would need to take in to account both disease and comparative advantage issues.

The increased demand for oysters, as well as growing interest in production in several parts of England, Wales and Northern Ireland suggests that this may be an auspicious time for significant investment in new or existing hatcheries.

Many in the industry regard permitting procedures, regulations, etc. as onerous. In the case of shellfish, a key issue relates to Pacific oyster and Manila clam, and the lack of clear policy on farming these species in locations where they are not already well established. This is not only an issue for on-growing, it has a significant influence on demand for seed and must be addressed with very clear strategy and protocols.

While the technology for lobster production from hatcheries is relatively well advanced, the costs are high (relative to short/medium returns from the fishery), restocking must be coupled with rigorous fishing management, and to date a successful commercial model has not been demonstrated. Maintaining interest and dynamism over the necessary timeframe represents a significant commercial, governance and institutional challenge. Clear and effective long-term financing through some form of levy, coupled with user rights and effective management is required. There is a possible significant role for IFCA's in this process.

Taking this forward a seed strategy will take both time and commitment, from both public and private sector, and relating to both wild collection and hatchery production. Developing and ensuring more consistent supply from wild resources will require UK-wide initiatives to monitor larval abundance and alert actual or would be collectors. The ability to produce large quantities of seed in hatcheries, and nurse them successfully to a size suitable for on-growers depends on complex technical and management skills together with learning and adaptation to local water quality and productivity issues. Operators must also be able to

survive periodic setbacks related to, e.g. disease or weather. Success will depend on years of experience coupled with government support at all stages.

9.2.1 Disease and invasive species

Disease is the major global aquaculture constraint, and enormous losses due to disease outbreaks have been recorded in many parts of the world, e.g. shrimp farming in Asia and South America has suffered multi-billion dollar losses over the last decade¹⁰⁹.

In Europe, the *Bonamia* parasite wreaked havoc on French production of native oysters, which declined from 20,000t per year in the early 1970s to a mere 1,400t in 1982. Production subsequently recovered largely due to the introduction of the more resistant Pacific oyster. However, OsHV-1 μ var (oyster herpesvirus) to which Pacific oyster is susceptible led to a fall in French production from 120,000t in 2008 to 80,000t in 2012. Bonamiasis also decimated the English native oyster fishery in 1982, and the oyster herpesvirus is now present at several locations in southern England and in the Republic of Ireland.

Trout and carp farming in England and Wales have suffered serious outbreaks of disease, possibly imported with ornamental fish such as goldfish.

Some Scottish mussel production has been ruined by the introduction of the highly competitive soft shelled mussel that is of no use in mussel culture because of its fragile shell.

It is clear therefore that both industry and Government must be alert to this threat and set in place measures that are cost effective. Prevention of disease will protect the industry from crashes, but over-zealous and inappropriate controls can equally cripple the industry. It is unclear at present that the procedure for developing regulations and protocols is sufficiently inclusive or practical and more needs to be done to address the concerns of the industry.

9.2.2 Hygiene and food safety

It is universally acknowledged that food safety for consumers is of paramount importance to the future of UK aquaculture, and particularly in the shellfish industry. However, the current regulatory regime for testing shellfish for bacteria and toxins is regarded as unsatisfactory by the industry.

The current random testing system needs to be modified to a risk-based regime, where sampling is increased at times of greatest risk (typically heavy rain and runoff or when toxic blooms have been identified). Furthermore, the extent to which depuration or enhanced depuration, coupled with appropriate sample testing, possibly self-testing (according to standard protocols), which could provide adequate levels of food safety needs to be further explored.

9.2.3 Research and technology

It is unclear that lack of research is a constraint, though some would argue that current aquaculture research is of limited value to the bulk of industry. It may be appropriate to develop a research strategy that is informed and influenced by industry to ensure it is grounded and effective in addressing key needs and constraints both industry-wide and in specific sub-sectors. The LINK and CARD aquaculture schemes¹¹⁰ addressed industry

¹⁰⁹ Stentiford *et al*, 2012. Disease will limit future food supply from the global crustacean fishery and aquaculture sectors. Journal of Invertebrate Pathology. Volume 110, Issue 2, June 2012. Diseases in Aquatic Crustaceans: Problems and Solutions for Global Food Security

¹¹⁰ p 31 in <https://www.Cefas.co.uk/publications/troutnews/tnews36.pdf>

priorities for R&D in the past and something similar might be developed now. In Scotland the Scottish Aquaculture Research Forum fulfils this role. There was substantial and consistent criticism from practicing farmers about past research money that they perceive has been wasted on “fish in the sky” projects. It is clear that there needs to be some rebalancing of emphasis, and a hefty injection of realism.

9.3 Historic and on-going support to the industry

9.3.1 Financial support and infrastructure

Aquaculture in the UK has received public support in terms of research, finance, etc. for many years (see Section 7). Over the last two decades the main source of financial support has been European funds; the EFF and currently the new EMFF. The previous EFF was criticised by a European Court of Auditors Special Report¹¹¹, concluding that the measures to support aquaculture up to 2013 had not been well designed or implemented at EU Member State level, and had failed to provide value for money or to support the sustainable growth of aquaculture. The total UK allocation under the EMFF has recently been set at €243 million¹¹² and it is hoped this funding round will be better implemented and the money put to more effective use across the UK (see Annex 7).

Over the last decade other European money has also been available, (e.g. the EU Leader programme), and enterprise companies and local councils have continued to provide some modest support for the aquaculture industry. There have also been substantial aquaculture research programmes on environmental assessment, new technology such as IMTA, seaweed farming and much else, funded under major EU research programmes, sometimes with additional support from Crown Estate and private companies.

In Scotland, where aquaculture is of far greater economic significance, there is a dedicated multi-stakeholder research programme (SARF) now supplemented by the activities of the SAIC. In Wales the Centre for Sustainable Aquatic Research was established in 2003, and has benefitted from significant industry and European funding.

Funding for aquaculture is/will be available under a range of other research funds including the new NERC and BBSRC UK Aquaculture Initiative (which has recently for example, provided substantial research funding to the National Lobster Hatchery and several research partners). It is important that this fund does not just focus on research driven issues, but reaches out to the industry to address the many practical problems and constraints that they face.

The Seafish website includes a set of datasheets¹¹³ giving details of all seventeen potential sources of funding for aquaculture in the UK. Further information on actual/potential subsidy to UK aquaculture can be found in the Marine Socio-Economics Project (MSEP) ‘Facts and Figures’, Series 5: Subsidies to UK Aquaculture¹¹⁴.

There is also increasing interest from venture capital in innovative and sustainable seafood production; funds such as the Virgin Business Fund for Aquaculture and Aquaspark (a \$10 million fund with focus on feed, antibiotics and transparency that funded for example Sogn Aqua (halibut) in Norway; smart feeding systems; single cell protein). Linnaeus Capital Partners also funded the more recent phase of the Anglesey RAS seabass initiative.

¹¹¹ http://www.eca.europa.eu/Lists/ECADocuments/SR14_10/QJAB14010ENC.pdf

¹¹² http://ec.europa.eu/fisheries/cfp/emff/index_en.htm

¹¹³ Online 23/11/2015 at <http://www.seafish.org/industry-support/aquaculture/aquaculture-funding-guides>

¹¹⁴ Online 30/11/2015 at www.msep.net

Overall there has been significant private and public sector funding for aquaculture in England, Wales and Northern Ireland. Despite this the sector is, if anything, in decline – though there are some possible “green shoots”. Given the foregoing analysis of opportunity (and in particular the analysis presented in Annex 8) it is arguable that funding should be more strategically directed at aquaculture initiative with demonstrated comparative advantage and market opportunity, rather than unproven high-tech systems. Either way, any financial support to the industry should be underpinned by far more thorough and independent economic feasibility studies.

9.3.2 Education, training, research and innovation for aquaculture development

Without knowledgeable practitioners, research cannot be well focused or implemented, and without practical innovation, the industry is less able to compete in wider markets and to profit in the local one. While aquaculture education and training in the UK is significant (see Section 7 and Annex 10), and the UK has a reputation for excellence in aquaculture worldwide, industry did voice its concerns to us.

Aquaculture requires skilled and dedicated husbandry before all else. Despite the existence of academic and practical aquaculture courses (as well as the Lantra Aquaculture National Occupational Standard), many farms have trouble recruiting and retaining staff with good practical skills and dedication.

There was a common feeling with those in industry we spoke with that spending on high-tech R&D was both expensive and unrealistic. Many were of the view that we need a facilitating environment for innovation and development, not more ‘blue sky’ R&D.

9.4 Lessons learned

Many countries have experienced spectacular growth in aquaculture over the last two decades: in East and Southeast Asia, South America, and closer to home, in Norway and Scotland. Europe generally however, is the under-performer despite strong historic R&D and development.

The reasons for rapid growth in regions such as South East Asia relate mainly to the strong aquaculture traditions in those countries coupled with the rapid emergence of major urban seafood markets, and increasing access to global markets. The rate of development in the wider economies has also made investment capital readily available (even at the family household level through remittances from city dwelling relatives) and constraints in terms of planning and regulation have been very limited. However, many of these countries are now suffering from the lack of planning and regulation in terms of chronic disease, over-use of chemicals and antibiotics, environmental degradation, etc. Nonetheless these countries retain a major comparative advantage in terms of ability to produce commodity products such as tropical shrimp and *pangasius* in highly favourable temperature regimes allowing for short and efficient production cycles, e.g. as little as 2 - 3 months for shrimp.

In Latin America where both shrimp farming and tilapia production have taken off the development model has usually been different. Large-scale landowners have been able to establish extensive and semi-intensive production systems for both species, coupled with a ready access to US markets, and its diverse immigrant communities. There have also been initiatives in terms of “aquaculture parks” (comprising well-designed water and pond systems; ready access to inputs and advice, etc.). These have had mixed success e.g. there are disease transmission risks in concentrating fish farmers together in one area, and such ventures do not allow a flexible private sector response to particular production, market and

logistical opportunities. Similar initiatives have also been tried (again with mixed success) in Indonesia and Thailand.

In Europe the success stories may be regarded as Norway and Scotland for Atlantic salmon and Denmark for trout. Governments in both Norway and Denmark have been highly proactive in their support for aquaculture development whilst demanding high environmental standards. A study for the Scottish Government¹¹⁵ suggested that the regulatory regime in Norway was more predictable and cost effective than that in Scotland. A particular feature of the system in Norway is the periodic issue by Government of production licenses; apart from the fact that being assigned a licence ensures a farmer can produce, the process also sends a clear message to the industry that Government wishes expansion in an orderly and strategic manner. This greatly increases the predictability of development and while there remain hurdles to jump, a licensee is likely to be producing a known amount of product relatively quickly.

Danish Government imposed very strict environmental regulations, but counteracted with investment finance to encourage a shift to recirculation technology. There is also a strong producers' organisation staffed with a range of advisors and facilitators that help farmers navigate the economic, market and regulatory minefields.

The Czech Republic has become a major exporter of ornamental fish, in large measure building on cooperative networks established during the communist era. The Scottish mussel farming industry has also demonstrated that cooperatives (or commercial groupings) of smaller farms can be highly effective if well managed. There may be opportunities here for government authorities and agencies to facilitate designation of Several or Regulating orders that might then be leased or licensed to individuals or groups of would be fish farmers.

Box 7: Aquaculture producer perspectives

"All businesses in our context face similar challenges in respect of almost complete lack of Government support"

"We have issues associated with the property rights that we require and how these are interpreted and we have issues in respect of how we are seen within the wider marine planning process."

"It [the situation in 10-20 years] depends on whether the administrations in England /Wales/Ni look at what has occurred in Scotland and try to mirror the positive approaches to the development of the sector seen there."

"International marketing of premium seafood products from NI is currently limited primarily owing to the size of the sector and the lack of will/effort from producers as unfortunately there is still a reliance on Government financial support."

Successful examples of aquaculture development can either be attributed to lack of regulation (i.e. as in Asia), or facilitated regulation (i.e. in parts of Europe). In addition, commercial collaboration to address scale issues can be important, especially in the earlier stages of development.

In England, Wales and Northern Ireland there has not been the support or active facilitation for well-regulated aquaculture. In general there has been failings to address the basic regulatory constraints restricting aquaculture development in relatively well-established technologies (both for the expansion of existing businesses, and the creation new start-ups), whilst focusing on major R&D projects. Producer perspectives given in Box 7 reflect these sentiments.

Table 22 summarises the opportunities, constraints and comparative advantages for the major aquaculture sub-sectors found across England, Wales and Northern Ireland.

¹¹⁵ <http://www.consult-poseidon.com/fishery-reports/509%20Poseidon%20Comparative%20Regulatory%20Costs%20in%20Salmon%20Farming.pdf>

Table 22: Summary of opportunity, constraints and comparative advantage

Key					
High potential for significant growth		Potential for some growth	Possible modest growth	Constrained by market and other factors	
Sub-Sector	Main Geographic Area of Opportunity	Comparative Advantage	Level and Type of Opportunity	Most important Constraints	Way Forward
Salmonid breeding (eggs, fingerlings, smolts)	All, but building on existing enterprises	<i>High</i>	<i>Fair</i> Important synergies with animal and plant breeding and bioscience more generally	Relatively few – disease and markets	Research partnerships
Trout on-growing for table	Northern England, Southern England, Wales, NI	<i>Low-Medium</i>	<i>Limited</i> Some opportunity in added value processing and marketing.	Market/global competition; regulation	Industry marketing initiative coordinated with investment in value added production, perhaps with some government support
Trout on-growing for restocking	Northern England, Southern England, Wales, NI	<i>Medium</i>	<i>Limited</i> Declining demand for salmonid recreational fishery	Market; regulation	Industry initiatives
Carp and coarse fish breeding (eggs, fingerlings, restocking)	Southern England, Welsh borders	<i>Medium-high</i>	<i>Limited</i> Demand largely met	Suitable sites	Industry initiatives
Ornamental fish production	Southern England (ponds); RAS all other areas	<i>Medium</i>	<i>Fair</i> Opportunity to substitute imports and reduce disease risks (coldwater (pond) species and warm water species produced in RAS)	Market/global competition	Support for well researched small business start-ups
Shellfish hatcheries and seed collection	All coastal	<i>High</i>	<i>Good</i> Strong market for final product	Demand from grow-out, disease	Joint government-industry strategic initiative
Oyster grow-out	South and East of England, Wales, possibly NI	<i>Medium-High</i>	<i>Good</i> Increasing national and international demand	Availability of sites /water quality, seed	Pro-active marine planning and facilitation; Pacific oyster policy
Scallop grow-out	South and East of England, Wales	<i>Medium-High</i>	<i>Good</i> Increasing national and international demand	Sites/water quality, seed, security/theft	Pro-active marine planning and facilitation
Mussel grow-out	All coastal	<i>High</i>	<i>Good</i> Increasing national and international demand; value added opportunities	Sites/water quality, seed	Pro-active marine planning and facilitation
Hard clam grow-out	South and East of England, Wales, possibly NI	<i>Medium-High</i>	<i>Fair</i> Increasing national and international demand	Sites/water quality, seed	Pro-active marine planning and facilitation

ANNEX 1: PERSONS CONSULTED

- John Bayes, Seasalter Shellfish (Whitstable) Ltd, Reculver, Kent
- Dominic Boothroyd, National Lobster Hatchery, Padstow, Cornwall
- Alan Bradshaw, Voda Feeds, Llandovery, Carmarthenshire, S Wales
- Craig Burton, Seafish Scotland
- Greg Clifford, Scallop Ranch Ltd, Hampshire
- Keith Davenport OATA, Westbury, Wiltshire
- David Fletcher, RAS Aquaculture Research Ltd, Caernarfon, N Wales
- Colette Connor, Department of Agriculture, Environment & Rural Affairs (DAERA), Northern Ireland
- Tim Ellis, Cefas Weymouth
- Dave Gotto, Glasshouses Trout Farm Ltd., Blazefield, North Yorkshire
- Richard Haward, Richard Haward Oysters, West Mercea, Essex
- Hans Hof, Houghton Springs Fish Farm, Dorset
- Jonathan Jowett, Northern Trout, Skipton, N Yorkshire
- John Holmyard, Offshore Shellfish Ltd., S Devon
- Paul Howes, CSAR, University of Swansea
- John Humphries, researcher
- Stella Hooper, Milford Haven, S Wales
- Mark Mercer, Duchy Oster farm, Falmouth, Cornwall
- David Jarrad, Director, Shellfish Association of Great Britain
- Adrian Love and George Hide, Sparsholt College, Hampshire
- Eleni Papathanasopoulou, Plymouth Marine Laboratory
- Daniel Phillips, Anglesey Aquaculture, N Wales
- Mick Roach, retired Trout farmer
- Oliver Robinson, British Trout Association Vice-Chair/Test Valley Trout Ltd., Test Valley Trout Ltd, Fish Farms & Hatcheries, Romsey, Hampshire
- Chris Seagrave, Hampshire Carp Hatcheries Ltd., Bowlake Fish Farm, Hampshire
- Kelsey Thomson, Morecambe Bay Oysters, Barrow-in-Furness, Cumbria
- Andy Woolmer, Mumbles Oysters/Salacia Marine, Swansea, S Wales
- Garry Wordsworth, Othniel Oysters, Poole Harbour, Dorset

ANNEX 2: MAIN INFORMATION SOURCES

Many information sources are listed as footnotes in the main text. The following is a list of some of the more important and/or general sources.

Literature

- A.M Consultancy 2011. Potential diversification opportunities for the land-based aquaculture sector in Northern Ireland. Funded by DARDNI and by the European Fisheries Fund. Accessed 20/10/15 at <http://www.aquacultureinitiative.eu/diversification%20report.pdf>
- Black, K. (2012). Aquaculture: Food and Energy from the Sea. SARF, Pitlochry.
- Broughton, M and Quagrainie, K, 2013. Economic Importance of the Aquaculture Industry in Indiana. Purdue University. Online 26/04/2016 at <https://www.extension.purdue.edu/extmedia/EC/EC-770-W.pdf>
- Cefas 2014. Aquaculture statistics for the UK, with a focus on England and Wales 2012. Tim Ellis, Richard Gardiner, Mike Gubbins, Allan Reese and David Smith
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/405469/Aquaculture_Statistics_UK_2012.pdf
- Cheshuk et al 2003. Integrated open-water mussel (*Mytilus planulatus*) and Atlantic salmon (*Salmo salar*) culture in Tasmania, Australia. Aquaculture Volume 218, Issues 1–4, 27 March 2003, Pages 357–378
- Clarke, Stacey. 2015. Presentation on marine planning and aquaculture.
- Cracknell D, et al. 2015. Aquariums Deliver Health and Wellbeing Benefits. Environment & Behavior. as reported in Medical Daily July 2015. Accessed online at <http://www.medicaldaily.com/health-benefits-aquarium-visits-viewing-fish-aquariums-can-lower-blood-pressure-heart-345144>
- Currie, C.K. 1990. The Early history of the Carp and its Economic Significance in England. British Agricultural History Society. Online at <http://www.bahs.org.uk/AGHR/ARTICLES/39n2a1.pdf>
- Department for Business Innovation and Skills 2015. Mapping Local Comparative Advantages in Innovation. Framework and Indicators.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/468179/bis-15-344-mapping-local-comparative-advantages-in-innovation-framework-and-indicators.pdf
- DEFRA 2014. United Kingdom Multiannual National Plan for the Development of Sustainable Aquaculture. April 2014 (https://consult.defra.gov.uk/fisheries/european-maritime-and-fisheries-fund-in-theuk/supporting_documents/Multiannual%20National%20Plan%20for%20the%20Development%20of%20Sustainable%20Aquaculture.pdf)
- DEFRA 2012. Planning for sustainable growth in the English Aquaculture Industry 2012 (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/82402/120112-aquacultureconsult-doc.pdf) . An Aquaculture Consultation: Response Summary was produced by Defra in May 2012.
- Eftcc/UKFEN 2015. Comparing Industry Sector Values, With a Case Study of Commercial Fishing and Recreational Sea Angling. For UKFEN, supported by Seafish, Defra and Marine Scotland.
- European Commission 2002, revised 2009. Strategy for the Sustainable Development of European Aquaculture. COM(2009)0162
- European Commission 2013. Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions. Strategic Guidelines for the Sustainable Development of EU aquaculture. Brussels, 29.4.2013. COM(2013) 229 final

- Eftec 2014. Comparing Industry Sector Values, With a Case Study of Commercial Fishing and Recreational Sea Angling. For UKFEN, supported by Seafish, Defra and Marine Scotland. http://www.seafish.org/media/publications/eftec_comparing_industry_sector_values_FINAL_Aug_2015.pdf
- European Commission (DG Internal Policies) 2009. Regulatory and legal constraints for European Aquaculture. Online 30/11/2015 at [http://www.europarl.europa.eu/RegData/etudes/etudes/join/2009/431568/IPOL-PECH_ET\(2009\)431568_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/etudes/join/2009/431568/IPOL-PECH_ET(2009)431568_EN.pdf)
- European Commission 2012. Guidance on Aquaculture and Natura 2000. Sustainable aquaculture activities in the context of the Natura 2000 Network
- Europe 2020 Growth Strategy. Smart, sustainable, inclusive growth http://ec.europa.eu/europe2020/index_en.htm
- European Commission 2012. Blue Growth: opportunities for marine and maritime sustainable growth. COM(2012) 494 final. Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions Brussels, 13.9.2012
- European Commission 2013. Strategic Guidelines for the sustainable development of EU aquaculture. Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions Brussels, 29.4.2013 COM(2013) 229 final http://ec.europa.eu/fisheries/cfp/aquaculture/official_documents/com_2013_229_en.pdf
- European Commission 2015. European maritime and Fisheries Fund (EMFF) Operational Programme 2014-2023.
- European Court of Auditors Special Report 2014. The effectiveness of European Fisheries Fund support for aquaculture. http://www.eca.europa.eu/Lists/ECADocuments/SR14_10/QJAB14010ENC.pdf
- Eunomia Research & Consulting Ltd 2013. Economic baseline assessment of the South Coast. MMO Project No: 1050 <http://webarchive.nationalarchives.gov.uk/20140108121958/http://www.marinemanagement.org.uk/evidence/documents/1050.pdf>
- FAO 2003. A guide to the seaweed industry. FAO Fisheries Technical Paper 441
- FAO 2012. National Aquaculture Sector Overview - Canada. Available online at www.fao.org/fishery/countrysector/naso_canada/en
- Frantzen, A. J. 2014. Food, eating and identity in early medieval England. The Boydell Press.
- Frontline & Poseidon 2015. Pilot Study into Collection of Economic Data on the Marine Aquaculture Sector (in the context of EU - Data Collection Framework) Final Report for the Seafish Industry Authority.
- Jacobsen, K.I., Lester, S.E., Halpern, B.S. 2014. A global synthesis of the economic multiplier effects of marine sectors. Marine Policy Vol 44 273-278.
- Hambrey, J. 1981. Technical and economic consequences of increasing fish growth through the use of waste heat in aquaculture. PhD thesis, University of Stirling 1981.
- Hambrey Consulting 2006. Site optimisation for aquaculture. SARF report 005. Hambrey, J., J. Westbrook, S. Southall, T. Robinson, R. (2008). Socio-economic Assessment of Potential Impacts of New and Amended Legislation on the Cultivation of Fish and Shellfish Species of Current Commercial Importance. SARF, Pitlochry.
- Hambrey Consulting 2008. Economies of scale in the Scottish Salmon Farming Industry. Confidential report to Scottish Salmon Growers Association
- Hambrey Consulting/Nautilus Consultants 2011. The economic development potential of seaweed harvesting and cultivation in Scotland. Feasibility study: rationale and opportunities to facilitate and support innovation and commercialisation in seaweed cultivation. Confidential report to Scottish Enterprise

- Hambrey Consulting 2013 The relevance of aquaponics to the New Zealand aid program. Commissioned report for the New Zealand Ministry of Foreign Affairs and Trade
- Herbert R.J.H et al 2012. The pacific Oyster (*Crassostrea gigas*) in the UK: economic, legal and environmental issues associated with its cultivation. Wild establishment and exploitation. Report for the Shellfish Association of Great Britain.
- Homarus 2012. New Approaches to Mussel Seedstock Acquisition. SARF Research Report 96.
- Hughes, A.D and Kelly, M. Integrated multi-trophic aquaculture. Briefing paper for SARF Board. <http://www.sarf.org.uk/cms-assets/documents/28926-823833.current-state-of-integrated-aquacultur>
- Humphreys, J., Herbert, R., Roberts, C., and Fletcher S. 2014. A Reappraisal of the History and Economics of the Pacific Oyster in Britain. *Aquaculture* 428–429 (2014) 117–124
- Imani Development and SRSI 2014. An assessment of the benefits of aquaculture to Scotland. For Marine Scotland. <http://www.gov.scot/Resource/0045/00450799.pdf>
- James, M.A., (2010) A review of initiatives and related R&D being undertaken in the UK and internationally regarding the use of macroalgae as a basis for biofuel production and other non-food uses relevant to Scotland. Report commissioned by the Marine Scotland, 79pp
- Levercliff. (2011). To Review the UK Market for Fish and Identify Potential Opportunities for Scottish Aquaculture Products in UK Multiple Retailers and the Foodservice Sector. <http://www.gov.scot/Resource/Doc/295194/0120277.pdf>
- Lewis, M.R. (1979). Fish farming in Great Britain: an economic survey with special reference to rainbow trout. University of Reading, Department of Agricultural Economics and Management, Miscellaneous Study No 67,74pp.
- Marine Planning Consultants Ltd. 2013. Spatial trends in aquaculture potential in the South and East inshore and offshore marine plan areas. MMO Project No: 1040 <http://webarchive.nationalarchives.gov.uk/20140108121958/http://www.marinemanagement.org.uk/evidence/documents/1040.pdf>
- Mayhoff Fry, J. (2012). Carbon Footprint of Scottish Suspended Mussels and Intertidal Oysters. SARF, Pitlochry
- MEP 2012. North Menai Strait Mussel (*Mytilus Edulis*) Fishery (Certificate Mep-F-002) Public Certification Report For Unit Of Certification Extension To Include River Dee As Seed Collection Site
- MMO 2013. Social impacts of fisheries, aquaculture, recreation, tourism and marine protected areas (MPAs) in marine plan areas in England. A report produced for the Marine Management Organisation, pp 192. MMO Project No: 1035. ISBN: 978-1-909452-19-0. Accessed 20/10/15
- MMO 2013. Economic baseline assessment of the South Coast. <http://webarchive.nationalarchives.gov.uk/20140108121958/http://www.marinemanagement.org.uk/evidence/documents/1050.pdf>
- Morrissey, K. 2014. Producing regional production multipliers for Irish marine sector policy: A location quotient approach. *Ocean and Coastal Management* Vol. 91. 58-64.
- Murray, F., Bostock, J., and Fletcher, D. 2014. Review of recirculation aquaculture system technologies and their commercial application. Prepared for Highlands and Islands Enterprise by Stirling Aquaculture.
- Nautilus Consultants 2001. Socio-economic study of the UK trout industry. Report and industry economic model prepared for the British Trout Association.
- Nimmo, F. Cappell, R. (2011). Assessment of evidence that fish farming impacts on tourism. SARF, Pitlochry
- PACEC. (1999). The Economic Impact of Scottish Salmon Farming. PACEC and HIE, Cambridge
- Peker, K., and Ertekin, H. 2011. Economic analysis and development strategies of seabass enterprises in the mediterranean region of Turkey. *Bulletin UASVM Horticulture*. 68(2)/2011.

- Pacific Shellfish Institute. 2013. The Economic Impact of Shellfish Aquaculture in Washington, Oregon and California. Online at <http://www.pacshell.org/economic-impacts.asp>
- Poseidon and Hambrey Consulting (2008). Detailed investigation of a range of issues to assess the cost structure and competitiveness of the salmon growing industry in Scotland. <http://www.consult-poseidon.com/fishery-reports/509%20Poseidon%20Comparative%20Regulatory%20Costs%20in%20Salmon%20Farming.pdf>
- Rana, K. J., Sturrock, H.T., Rooney, W., Young, J.A., & Bostock, J.C., 2006. Strategic economic analysis of the ornamental aquatic trade in the UK. Report Commissioned by Defra (Project FC0933) from the University of Stirling, 89pp. Unpublished, commercial-in-confidence. Supplied to us by Seafish.
- SEAFISH 2013. The Seafish Guide to Aquaculture. http://www.seafish.org/media/publications/SeafishGuidetoAquaculture_201309.pdf
- Seafish. Aquaculture Funding Guides. Online 23/11/2015 at <http://www.seafish.org/industry-support/aquaculture/aquaculture-funding-guides>
- Scientific, Technical and Economic Committee for Fisheries (STECF) – The economic performance of the EU aquaculture sector (STECF14-18). 2014. Publications Office of the European Union, Luxembourg, EUR 27033 EN, JRC 93169, 451 pp.
- Scientific, Technical and Economic Committee for Fisheries (STECF) 2011. There is scope to reduce the delay in the licensing process and to reduce the complexity of implementing and applying the EU legislation at the national level.
- Scientific, Technical and Economic Committee for Fisheries (STECF) 2012. Economic Performance of the EU Aquaculture Sector (STECF-OWP-12- 03) JRC Technical and Research Reports. JRC/IPSC http://stecf.jrc.ec.europa.eu/documents/43805/218925/2012-03_STECF+EWG+11-14+-+EU+Aquaculture+Sector_JRC70424.pdf
- Scientific, Technical and Economic Committee for Fisheries (STECF) 2014. The Economic Performance of the EU Aquaculture Sector (STECF 14-18)
- Scott, D. McLeod, D. Young, J. Brown, J. Immink, A. Bostock, J. (2010). Prospects and Opportunities for Growth in Scottish Shellfish. Institute of Aquaculture, Stirling University, Stirling;
- Scottish Government Input-output tables. <http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Downloads/IO1998-2012L1>
- Scottish Government. Multipliers. <http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Multipliers>
- Scott, D. McLeod, D. Young, J. Brown, J. Immink, A. Bostock, J. (2010). Prospects and Opportunities for Growth in Scottish Shellfish. Institute of Aquaculture, Stirling University, Stirling;
- Seafish 2015. Understanding the Welsh Seafood Supply Chain. http://www.seafish.org/media/1635910/welsh_seafood_supply_chain.pdf
- Stentiford *et al*, 2012. Disease will limit future food supply from the global crustacean fishery and aquaculture sectors. Journal of Invertebrate Pathology. Volume 110, Issue 2, June 2012. Diseases in Aquatic Crustaceans: Problems and Solutions for Global Food Security
- Syvret, M., Bayes, J., and Utting, S Sustainable Production Of Native Oyster Spat For On-Growing – Final Report, Fife Project No: 06/Eng/46/05. For: Seasalter Shellfish (Whitstable) Ltd.
- The Welsh Government 2013. Wales Marine and Fisheries Strategic Action Plan. The Welsh Government 2015. A spatial assessment of the potential for aquaculture in Welsh waters. Welsh Government Report R.2384. <http://gov.wales/docs/dra/publications/131127marine-and-fisheries-strategic-action-plan-en.pdf>

The Welsh Government. 2015. A spatial assessment of the potential for aquaculture in welsh waters. R.2384. MER/MESL/MPC for the Welsh government. Online 27/11/2015 at <http://gov.wales/docs/drah/publications/150702-a-spatial-assessment-of-the-potential-for-aquaculture-in-welsh-waters-en.pdf>
<http://gov.wales/docs/drah/publications/150702-a-spatial-assessment-of-the-potential-for-aquaculture-in-welshwaters-en.pdf>

Key organisation websites

- British Trout Association (BTA) - <http://britishtrout.co.uk/>
- Cefas - <https://www.Cefas.co.uk/sectors/aquaculture-and-food-security/>
- DAERA - <https://www.daera-ni.gov.uk/about-daera>
- DARDNI - <http://www.dardni.gov.uk/index/fisheries/aquaculture.htm>
- DEFRA - <https://www.gov.uk/government/organisations/departement-for-environment-food-rural-affairs>
- EC - Aquaculture - http://ec.europa.eu/fisheries/cfp/aquaculture/index_en.htm
- Association of IFCA's - <http://www.association-ifca.org.uk/>
- MMO - <https://www.gov.uk/government/organisations/marine-management-organisation>
- Ornamental Aquatic Trade Association - <http://www.ornamentalfish.org/>
- Ornamental Fish International - <http://www.ofish.org/>
- Welsh Government - <http://gov.wales/?view=Search+results&lang=en>
- <http://gov.wales/topics/environmentcountryside/marineandfisheries/aquaculture/?lang=en>
- Seafish - <http://www.seafish.org/> / Market analysis: Insight Division / Economics: Economics Division
- Shellfish Association of Great Britain (SAGB) - <http://www.shellfish.org.uk/index.html>

(Note: "The Seafish Guide to Who's Who in UK Aquaculture" is available at http://www.seafish.org/media/1650669/3lc_amended_whos_who_aqua_lc_august_2016_2.pdf)

Data, databases and online tools

- EC - Register of aquaculture production businesses and authorised processing establishments - http://ec.europa.eu/food/animal/liveanimals/aquaculture/register_aquaculture_establishments_en.htm / <https://www.Cefas.co.uk/eu-register/>
- EC - Aquaculture - http://ec.europa.eu/fisheries/cfp/aquaculture/index_en.htm
- UK Government - Information on the UK's implementation of the EU Data Collection Framework <https://www.gov.uk/datacollection-framework>
- Cefas - <https://www.Cefas.co.uk/publications-data/food-safety/classification-and-microbiologicalmonitoring/england-and-wales-classification-and-monitoring/shellfish-monitoring-results/>
- FAO Fishstat - <http://www.fao.org/fishery/statistics/software/fishstat/en>
- Northern Ireland - Authorisation of Aquaculture Production Business - <http://www.dardni.gov.uk/index/fisheries/fishhealth/authorisation-and-registration.htm> / <http://www.dardni.gov.uk/regofauhprodbusiness>
- MMO - Data Knowledge Management - dkm@marinemanagement.org.uk
- Marine Information System – England. Online 27/11/2015 at <http://mis.marinemanagement.org.uk> / accesstoinformation@marinemanagement.org.uk Aquaculture data held by the MMO is all publically accessible via the Environment Agency's Geostore (<http://www.geostore.com/environmentagency/WebStore?xml=environment-agency/xml/ogcDataDownload.xml> : use 'ctrl+f' to search for 'Aquaculture' to bring up the data sets which reference aquaculture). The MMO's 'Master Data Register' (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/448518/20150727_MDR.pdf) identifies other organisations which are listed as holding data relevant to aquaculture.
- Seafish - Regulatory Toolbox for England. <http://www.seafish.org/industry-support/aquaculture/aquaculture-regulatory-toolbox-for-england>

ANNEX 3: APPRAISAL OF SOURCES

Information on aquaculture sector performance is currently collected by government largely to comply with EC Regulations (The Aquaculture Statistics Regulation EC Reg 762/2008 and with the EU Data Collection Framework (EC Reg 199/2008DCF). These regulations require submission of data in year N+2.

For Scotland, some of the required data, and additional non-financial data is collected by Marine Scotland in an annual census by Marine Scotland Science and analysed/presented by Marine Scotland Science in long standing annual publications.

For England and Wales Cefas conduct an annual industry census for production volumes and employment, and in Northern Ireland, DARD conducts a similar census¹¹⁶. An additional annual survey of UK aquaculture enterprises was introduced in 2013 (for 2011 data) to fulfil DCF requirements which Cefas has recently (from 2015 for 2013 data) led.

In England and Wales, the Fish Health Inspectorate (FHI) also compiles an aquaculture business register¹¹⁷. It is noted in the ToR that data for England, Wales and Northern Ireland is less comprehensive than that collected for Scotland, and information on value and distribution of all aquaculture production is not fully broken down at a regional level.

Data on production, values, and employment have been published annually in the Cefas publications *Finfish News* and *Shellfish News*. These statistical analyses are periodically supplemented with specialist studies. "Aquaculture Statistics for the UK with a Focus on England and Wales 2012", was published by Cefas in 2015¹¹⁸. This report is a clear presentation of production and price figures by species for 2010, 2011 and 2012. It also provides an industry-wide breakdown of employment and number of enterprises by species, and does all this for finfish, shellfish and cold-water ornamental fish. This report is at national, i.e. England, Wales and NI level and is adequate to provide a straightforward picture of the industry (excluding tropical fish), although without any regional breakdown.

In Scotland a report on the benefits of aquaculture to Scotland¹¹⁹ was recently produced, and Scotland has a major research programme (SARF) which generates in depth analysis on major issues affecting the industry. Seafish undertakes and commissions a range of relevant studies and produces leaflets and guidance related to both production and marketing. At the European level STECF and JRC are becoming increasingly active in analyses and monitoring of economic performance of aquaculture using data collated under the Data Collection Framework Regulation. Historically there have also been many other more specific studies of the UK trout industry, and the shellfish industry in Scotland, as well as England and Wales. Historically there have also been many other more specific studies of the UK trout industry, and the shellfish industry in Scotland, England and Wales.

Other sources include:

- Research, technical and market publications, economic development analyses and coastal and marine plans (literature review)
- Official government and EU aquaculture authorisations, registers and datasets (as listed in the ToR), and some data related to leases from the Crown Estate
- Business datasets available at both national and case study area (local government) level
- Pilot datasets related to the development of the EU data collection framework
- Trade and producer representative organisations

¹¹⁶ As of 9th May 2016 the new Department of Agriculture, Environment and Rural Affairs (DAERA) will encompass all the functions of DARD, environmental functions of the current DOE (including regulations), inland fisheries and policy responsibility for Sustainable Strategy.

¹¹⁷ <https://www.Cefas.co.uk/eu-register/>

¹¹⁸ Online 25/11/2015 at

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/405469/Aquaculture_Statistics_UK_2012.pdf

¹¹⁹ Marine Scotland 2014 An Assessment of the Benefits to Scotland of Aquaculture. Imani and SRSL for Marine Scotland. May 2014. Accessed 20/10/15 at <http://www.gov.scot/Topics/marine/Publications/publicationslatest/farmedfish/AqBenefits>

Formal data on aquaculture production and performance in England, Wales and Northern Ireland

The collection and presentation of aquaculture data is in a state of uncertain development. Seeing potential in European aquaculture development and wishing to standardise data collection across the region, the EU implemented a compulsory Data Collection Framework (DCF) beginning in 2008¹²⁰. Complying with this EU requirement is not straightforward. In 2013 the combined resources of the MMO, the Agri-Food and Biosciences Institute of Northern Ireland, Marine Scotland and Cefas prepared a 300 page paper¹²¹, a detailed revision, explaining how they were going to achieve this. The indicative costs of the data collection and management, together with scientific advice on the CFP for 2011, 2012 and 2013 combined were over €28m, of which about half was eligible for an EU contribution. Given that the EU contribution includes UK funding, and that all EU member states have to do this, the total European resource commitment is considerable. A study by consultants in 2013¹²² made recommendations as to how to minimise the inevitable difficulty associated with collecting the required data, but the relevance of most of the “required” data to the implementation of practical development measures remains questionable¹²³.

Details of the data collected under the two EU regulations is presented in Table A3.1. Basic data (nature of operation and production) is legally required and already collected for all 569 registered aquaculture producers in the UK. Additional data relating to socio-economic performance by sub-sector, as required under the EU DCF, is solicited through an annual farm business survey: by consultants in 2013 and 2014 (for 2011 and 2012 data) and by Cefas from 2015 (for 2013 data onwards). The surveys for 2011 and 2012 data yielded very low (10%) response rates, and due to errors introduced by the consultant during collation, the available collated data is regarded (by Cefas) as unreliable. Cefas expects the quality of published DCF data to improve: the errors in the 2012 data are being corrected; the questionnaire has been greatly simplified and the targeted surveys for 2013 and 2014 data have achieved much higher response rates (>40%); more expert input is now being put into data collation.

The Cefas FHI's STARFISH database is a bespoke cross-government database developed for aquatic animal health management within England and Wales. It has entries for business and farm data, inspection details, test results and movement requests for live aquatic animals, and is additionally used to store collected data on production, facilities and employment.

The MMO database also provides data on planning applications, coastal works and dredging, but has limited utility for assessing status and contribution of aquaculture.

Access to and analysis of much of this data by third parties is problematic. Flexible exploratory analysis is simply not possible. With government staff assistance, questions can be submitted for specific database interrogation but answers must be aggregated to a level that assures confidentiality, which may be too high for regional studies relating to sub-sectors. Accessing useful financial data on aquaculture businesses at anything smaller than national level by external parties (such as consultants) is therefore difficult at least in the short term, and the lack of opportunity to explore the data means that sensible “freedom of access” questions cannot be developed. Consultants may be allowed access to databases on-site with strict confidentiality protocols, but this increases costs and time, limits the flexibility of access, and reduces the quality of analysis.

Other publicly available datasets and information resources

¹²⁰ Regulations 762/2008 and 199/2008

¹²¹ UK National Data Collection Programmes for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the CFP in 2011, 2012 and 2013, Revision for year 2013, Compiled by: MMO, NIML, MS, Online 26/11/2015 at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/341475/2011-2013national.pdf

¹²² Hamilton and Capell, 2015, EU Data Collection Framework – Pilot Study into Collection of Economic Data on the Marine Aquaculture Sector. Poseidon and Frontline for Seafish

¹²³ Definition of Data collection needs for aquaculture. Reference No. FISH/2006/15 – Lot 6 final report may 2009. Review of the EU Aquaculture Sector and Results of Costs and earnings survey. In Dropbox EU aquadata part one, economic studies.

The key datasets available are the register of aquaculture production businesses (APBs) in England Wales and Northern Ireland, publicly available on-line. These datasets contain names and locations and some limited species and production system information. From this information, with some detective work, we built our own database. We used business information available on company websites and other online resources such as telephone directories, Google Earth and links to local newspaper websites. For wider purposes such as marine planning, grant assessment and local economic planning there are many other useful online resources available.

Table A3.1 contains a summary table of all relevant datasets, with a description of the data held, availability, accessibility and links.

Conclusions

- Formal government data systems have been developed primarily for aquatic animal health management, with fields for data required under EC aquaculture statistics regulations being an adjunct. The most recent financial performance data that is publicly available is considered unreliable by both Government and industry
- It is not necessary to collect detailed financial and operational data from a high proportion of businesses – they key is to have a good representative sample informed by and coupled with practical understanding and a few good case studies. The industry responds far better to a short informed interview than a complex questionnaire. Financial performance data is fundamentally difficult to collect and is associated with major confidentiality issues that make analysis by non-government parties almost impossible.
- The current situation is unsatisfactory. Those who collect and understand the strengths and weaknesses of the data lack to resources to undertake policy relevant analysis. Meanwhile resources are available for consultants to undertake such analysis, but they in are in turn significantly constrained by confidentiality issues and limited understanding of the strengths and weaknesses of some of the data
- Despite these limitations, simple basic publicly available government data related to operational licenses/registrations, combined with non-government and informal web based sources, informal interviews, and technical understanding of the industry can be combined to generate a good appraisal of sector performance and potential. This begs the question however as to the value of much of the confidential information that is collected by government

Table A3.1 Summary of all relevant datasets

DATA SOURCE COMPARISON TABLE	Online at:	Accessibility	Aggregation level	Confidence level.	Business locations	Production category for individual businesses	Financial data for individual businesses	Employment data for individual businesses.	Practical use.
List of CEFAS (England, Wales & Scotland) registered aquaculture businesses.	https://www.cefas.co.uk/eu-register/ .	Public. Free. Online. Easy to use.	By individual business.	High, but does include some businesses no longer trading.	Yes, but not always clear - perhaps deliberately for security reasons.	Incomplete. No clear species information.	No	No	For building a basic database of aquaculture businesses, and for checking on registrations.
Public Register of Northern Ireland aquaculture businesses.	https://www.dardni.gov.uk/publications/public-register-aquaculture-production-businesses	Public. Free. Online. Easy to use.	By individual business.	High, but does include some businesses no longer trading.	Yes	Incomplete. No clear species information.	No	No	For building a basic database of aquaculture businesses, and for checking on registrations.
STARFISH	Not available. Bespoke confidential database for CEFAS only. Stores and manages all data collected by FHI inspectors in the field. Designed to be primarily for fish health protection.	Confidential. On request only. Fully accessible on-site by FHI inspectors only (to be completed 2016).	Unless FHI staff, country level only due to confidentiality issues.	Unknown to us, but probably high.	Yes but only for FHI staff.	Yes but only for FHI staff.	Yes but partial and only for FHI staff.	Yes but partial and only for FHI staff.	For FHI. Essential for recording of health status and compliance with health regulations.
Eurostat	http://ec.europa.eu/eurostat/web/fisheries/data	Public. Free. Online.	By EU member state.	Unknown. Last UK entry for aquaculture is 2012 production.	No	No	No	No	EC policy purposes.
European Data Collection Framework	https://datacollection.jrc.ec.europa.eu/da/aqua	Public. Free. Online. But empty. Aquaculture data tables available via https://stecf.jrc.ec.europa.eu/ewg1410 but appear empty as at 27/03/16	Appears to be insufficient to aggregate yet, so unknown, but probably by Member State.	Low. The UK financial information is derived from a small sample.	No	No	No	No	In compliance with Commission Regulation (EC) No. 665/2008 of 14/07/2008. Collection of data relating to inland fisheries is not compulsory under DCF, so may end up as marine only.
UK ONS Annual Business Enquiry (ABI)	http://www.ons.gov.uk/search?q=aquaculture .	Public. Free. Online.	For aquaculture, UK. Bespoke analysis is possible, but confidence would be unknown.	Unknown. Sample of 62,000 out of 2 million businesses, all industries.	No	Standard Industrial Classification. Aquaculture Saltwater or Freshwater.	No	No	General UK policy and input-output tables.
Scotland's aquaculture database	http://aquaculture.scotland.gov.uk/	Public. Free. Online. Straightforward.	Individual farm sites.	High. Excellent response rate and verifiable data.	Yes.	Yes.	No	No	For all locational, environmental and production figures on aquaculture businesses in Scotland.
Companies House Data	www.duedil.com , and others	Public. Online. Small charge or subscription required. Careful interpretation needed.	Individual UK limited liability businesses and partnerships.	High, although these are tax accounts and may be obfuscatory. Trading names may not be obvious.	Yes	Not always clear from companies house categories.	Yes, but only balance sheet, not always a P/L account, so hardly any turnover figures.	Generally not.	For a discreet look at individual limited company financial information.
Marine Information System	http://mis.marinemanagement.org.uk/	Public. Free. Online. Straightforward.	By marine plan area.	High.	No	No	No	No	Essential study for any marine aquaculture development eg shellfish beds.
Marine charts	https://sites.google.com/site/nauticalfree/ .	Public. Digital copies almost free. Online or on paper.	Depends on scale of chart.	Fairly high. Some doubt as to depths in remoter areas but generally very reliable.	Working areas can be identified for individual shellfish beds.	No	No	No	Essential study for any marine aquaculture development eg shellfish beds.
Marine Recorder database	http://ncc.defra.gov.uk/page-1599	Public. Free. Online. Requires some familiarity with database management and mapping.	Various, depending on the nature of the data provided. Generally habitat sample surveys.	With vary with the nature of each set of data.	Working areas can be identified for individual shellfish beds, and relevant surveys accessed.	No	No	No	Essential study for any marine aquaculture development eg shellfish beds.
Business telephone directory	www.yell.com	Public. Free. Online. Straightforward.	Individual UK businesses.	High, although some businesses no longer trading.	Yes	Not in sufficient detail	No	No	For building a basic database of aquaculture businesses.
UK map of multiple deprivation	http://dclgapps.communities.gov.uk/imd/idmap.html	Public. Free. Online. Straightforward.	By individual datazones - area of about 500 people.	High, although common sense interpretation required. Derived from census data and various sample surveys.	Can be mapped as an overlay.	No	No	No	Essential pre-development study, particularly for EMFF grant applications.
Google Earth	http://www.google.co.uk/intl/en_uk/earth/	Public. Free. Online. Straightforward.	By individual property.	High, if sometimes a little out-of-date.	Yes, and working areas can be identified for individual shellfish beds.	No	No	No	Essential pre-development study, particularly for EMFF grant applications.
Aquaculture business websites	various	Public. Free. Online. Straightforward.	Usually by individual business, sometimes a group of businesses.	Variable. Sometimes a website still exists where the associated business does not, and vice-versa.	Yes, generally contact details are provided.	Yes. Usually very clear.	No	Sometimes given, or can be estimated from information provided.	For background on an individual business, and links to eg. relevant technical videos explaining production methods.

ANNEX 4: EC DATA COLLECTION FRAMEWORK (DCF)

The European Commission's Data Collection Framework (DCF) establishes a European Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy (CFP).

The UK is required to collect, collate and report statistics on UK aquaculture under EC Regulations:

- (EC) No 762/2008 requires submission of data on aquaculture production (tonnages of fish harvested; egg and juvenile output from hatcheries and nurseries and destination; eggs for human consumption, e.g. caviar; inputs to aquaculture from the wild; aquaculture systems used).
- (EC) No 199/2008 requires submission of data on employment, numbers of enterprises and various indicators of economic performance

EC Reg. 762/2008: Cefas and DARD collect data (by farm) and collate data for England and Wales, and NI respectively on:

- Production (tonnage) by species, FW or SW, production system type
- Unit value of production tonnage (i.e. £/tonne)
- Production (number) of eggs / juveniles from hatcheries and nurseries, and whether these are on-grown on farms or released into the wild
- Input (tonnage) from the wild by species

EC Reg. 199/2008: Cefas collect data (by enterprise) and collate data for the UK on:

- Aquaculture production sales (output) (tonnes & £)
- Subsidies (£)
- Other income (£)
- Livestock purchased (input) (tonnes & £)
- Feed purchased (input) (tonnes & £)
- Employees: numbers of M&F & FTE M&F
- Personnel costs - wages and salaries (£)
- Value of unpaid labour (£)
- Energy costs (£)
- Repair & maintenance costs (£)
- Other operational costs (£)
- Net extraordinary costs (£)
- Debt (£)
- Net financial costs (£)
- Total value of assets (£)
- Depreciation of capital assets (£)
- Net investment in capital assets (£)

ANNEX 5: REPORT ON THE ON-LINE SURVEY

This short report provides an overview of the survey reports obtained, followed by a de-identified selection of quotes in the respondents own words.

Design and distribution of the web survey

This survey was designed to elicit honest replies from aquaculture practitioners and specifically avoided asking for so much financial information as to put respondents off answering anything at all. Respondents could choose the level of confidentiality of their replies, and encouraged by this some did give detailed information. We have no record of the IP addresses of our respondents and know whom they are only if they chose to tell us. We deliberately avoided a preponderance of “tick-box” answers and asked open-ended questions. We were hoping for quality before quantity - an intelligent consideration of the issues by experienced and articulate practitioners - and that is exactly what we got. We used Survey Monkey, having previously found this to be extremely fast, versatile, reliable and cost-effective. The mailing list was developed from the list of registered aquaculture business, web-based research and personal contacts. This was a found population survey, excluding only those businesses with no discoverable email address. The responses were a self-selecting sample.

A covering email included the link to the survey and a brief explanation of the purpose of the research, the identity of the client and the confidential nature of the replies. The questionnaire was piloted to a relevant small (Scottish) business before the final version was decided, the answers being fulsome, considered and most illuminating. The timing (December 2015 – January 2016) might not be thought ideal, covering the busy run-up to Christmas and subsequent recovery time, but in reality there is never an ideal time. The survey was sent out in small email batches to avoid the type of mass mailing that can be rejected as spam, and was first distributed on 14 December 2015, with a “thank you” and reminder being sent in January 2016.

Of the 135 survey invitations sent out, 14 responses were received.

The questions asked...

1. Do please describe your business, your main activities, what products you sell and/or services you provide, listed in order of importance.
2. Do give us a brief history of your business.
3. How do you hope your business will develop in the future, and how secure does it feel right now?
4. What are the main inputs and costs for your business?
5. Where do you buy your main inputs?
6. How many people work in your business altogether, including you?
7. How and where do you sell to? Include fish and shellfish sales, consultancy services and fishing days/café sales etc.
8. What are your most important day-to-day difficulties and constraints, in order of importance?
9. What are your longer-term constraints and difficulties?
10. Look forward 10-20 years. What situation do you think English/Welsh/N Irish aquaculture will be in?
11. What are the most important factors in the smooth running of your business?
12. What are the main opportunities for your business, and similar businesses in your county and region?
13. So, working within existing legislation as you understand it, and thinking of the constraints and opportunities you have identified for your own business, what needs to be done, by whom, and how?
14. Is there anything else you would like to tell us about the industry?
15. Where, very roughly, are you? If you work in more than one area, please tick all that apply.
16. If you feel able to tell us, what is your approximate annual turnover? Combined with the same figure from other similar businesses this helps us to estimate the economic effect of your industry.
17. If you are happy for us to contact you, or just to know who you are, please do fill in the [contact] details below.

The responses

A brief summary of each respondent follows, identified by number. We show how long they took to complete the survey and paint a brief pen-picture of their business.

#1 Trout for restocking

Time taken 14 mins. Central England. No contact details given.

"I am about to retire but hoping to either let or sell"

This used to be a table trout farm but changed to growing trout for restocking about 30 years ago. Important factors are water quality and constant sales, weather is a constraint and cash flow over the winter months is a problem. Two people work here, dividing their time each between office and site. Fingerlings are bought in from elsewhere in England, feed from Holland. Sales are to fishing clubs, syndicates and day waters. The owner is about to retire, and is hoping to either let or sell the business as a going concern.

Annual expenditure: Feed £40k, wages £40 k, fuel/lorry £35K, fingerlings £10k, power £5k.

Annual turnover £100-200k.

#2. Mussels

Time taken 1 hour. Wales and Northern Ireland. Full contact details provided

"We have issues associated with the property rights that we require and how these are interpreted and we have issues in respect of how we are seen within the wider marine planning process."

"All businesses in our context face similar challenges in respect of almost complete lack of Government support"

"A lack of wider societal appreciation of the need for property right protection to undertake any activity that involves investments in time"

"Horizon issues - Oceanic acidification / climate change / marine pollution (especially micro plastics and pathogenic viruses)"

It [the situation in 10-20 years] depends on whether the administrations in England /Wales/Ni look at what has occurred in Scotland and try to mirror the positive approaches to development of the sector seen there. It is my single biggest concern, that Government will remain in its detached almost disinterested state, doing as little as possible to not just develop but also defend the legitimacy of aquaculture as a viable and highly sustainable economic undertaking, not just for today but one that could be nurtured into something many times more substantial for the future. The Blue growth agenda and the reformed CFP with its objectives for smart green aquaculture are great opportunities".

"There is nothing wrong with the legislative framework per se - it all goes Pete Tong when you have a poor interpretation applied due to a) poor levels of understanding by Civil servants or Lawyers or b) more malicious intent. For example, N2K is often cited as being a block to development - not necessarily the case - it can be when zealots dictate interpretations - it should be seen as intended which is as described in the first recital of the directive - as playing an important role in the sustainable development of the environment. However saying that - any emerging legislative framework, be that domestic, national or at the EU level, needs to fully engage with industry at earlier stages to avoid unintended contradictions."

This is a large concern with at least ten people at work. The major expenditure is running large vessels, there being no need to feed mussels. About 75% of expenditure is within the local area (about 30 miles). Sales are export, mainly direct to processors, and to the domestic market, wholesale and commercial. Their longer-term constraints were summed up as space, the government, pollution and the challenge of increasing the domestic market. We later interviewed this respondent in person.

Produces 2,000-3,000 tonnes/yr.

Annual turnover >£1 million.

#3. Trout for restocking

Time taken 40 mins. South West England. Full contact details provided.

"It would be a shame if trout farming was to become a single-generation industry"

"Table trout became an unprofitable nightmare"

"It is possible that in 20 years' time that it is vital that we are producing more food within the UK and aquaculture is a perfect way to do this."

"This [aquaculture] will have to be done within current and future environmental constraints and using diets other than those available now."

This is a four-person business stocking their two own trout lakes, offering day tickets and corporate

fishing days. Since 2000 all the fish (60 tons/ha) have been for their own re-stocking – prior to that they were producing and processing 160 tons of table trout annually. Now the problem is falling customer numbers (down 50% in the last 5 years) and getting a properly skilled and devoted workforce (from Sparsholt). Longer-term difficulties include consumer demand, environmental legislation and the difficulty of financing existing bank loans with a falling turnover. Main opportunities are seen as being in corporate hospitality and tourist-related visits. Feels the trout sector in general is barely breaking even and that this is limiting investment in new technology e.g. on the lines of the Danish model. Needs financial incentives for new technology to enable more efficient water use, better promotion of the product and help with freshwater lice and weed control, for which there are currently no effective solutions.

Annual expenditure: Feed £60k, staff £60k, electricity £20k.

Feed is from Skretting in Lancashire.

Annual production 60 tonnes.

Annual turnover: £300,000-£500,000

#4. Trout and salmon hatchery (mainly salmon), with some salmon grown to full size for fishing and consumption.

Time taken 23 mins. Central England. Full contact details given.

“It can’t work within the current legislation, too many government bodies obstructing aquaculture development”.

“Poor administration resulted in aquaculture grants being returned to the EU, a really bad failure”

“Public perception of aquaculture is very poor”

The main constraint on this business is felt to be “red tape”. They are hoping to go onto a new site, and a bigger lake, and feel that there is a lack of opportunity for new aquaculture developments due to planning constraints. *The current hatchery site employs extremely basic technology yet (from consultant’s personal experience) this owner is capable of producing salmon parr of high quality. He has never enjoyed paperwork.*

Feed is from Preston, Lancashire. Two people employed, owner full time on site, partner part time in the office.

Annual expenditure- Wages £35k, electricity £10k, feed £10k, oxygen £6k, other £5k.

Annual turnover £50,000 - £100,000

#5. College – Aquaculture training courses

Time taken 28 mins. South East England. Full contact details given.

“If aquaculture changes and adapts then it has a future”

“The UK has to increase its food security and capacity”

This college runs short courses, FE level 1-3, apprenticeships and undergraduate/post-graduate courses. They also run commercial trails and conduct research. They are finding it increasingly difficult to compete with larger, more commercial universities, in spite of being perhaps the best-known aquaculture-training provider. They have 11 staff, plus executive managers, and train both UK and international students.

No cost breakdown for in-house production.

Annual turnover >£1million.

#6. Rope-grown mussel producer

Time taken 25 mins. Wales. Contact details given.

*“We have been prevented from expanding due to the objections of one person who wants the whole of the *****¹²⁴ coast to be a marine park”.*

¹²⁴ This is a geographical area that would identify our respondent, not an expletive.

"[in 10-20 years aquaculture will be in] the same place that it is now if the government continue to allow the environmentalists to hijack any expansion of the industry. They never seem to look at the bigger picture of food security, jobs etc. "

A well-established family business hoping to increase their number of sites, diversify into oysters and expand their UK market with different products/packaging. Main overheads are marine diesel for the boat (local supplier), staff costs and insurance. The ropes come from New Zealand, the packaging from the UK. Five people work here. They sell to UK food service companies, restaurants and pubs. It is important to this company that they maintain quality throughout the season and avoid any breakdowns of the boat or the packaging equipment. They do see an opportunity to expand the business with more sites, different species and new types of packaging but the first two need planning permission and the third needs finance, both serious constraints.

No specified cost breakdown.

No annual turnover given.

#7 Oyster growers, wholesalers and retailers.

Time taken 1hr 16mins. Essex. Full contact details provided.

"The government needs to ensure that a MCZ means what it says and enables oyster cultivation to continue as it has for hundreds of years in conserving the existing oyster beds and encouraging their area to increase. The testing programme (of Cefas and FSA) should be designed to reflect the management needs of the industry as well as legislative/enforcement requirements and the results should be reliable."

This is a very long-established family business employing about ten people. They sell primarily for UK wholesale and retail, with a little trade to export and a small amount to restaurants. Local labour is their biggest single cost. Transport is by a national company with local branches. Packaging comes from France. Their most important day-to-day issues are disease, water quality and competing for space with "projects of national importance"; in their case a proposed nuclear power station in a Marine Conservation Zone that was so designated because of the native oyster. Their main opportunity is seen as being the encouragement of wild-spawned oysters, both native and pacific. They need a reliable testing method (Cefas/FSA) that reflects the management needs of the industry. Annual inputs - Labour £175,000, transport £15,000, packaging £20,000, rent £20,000. Annual sales – wholesale £300,000, retail £300,000, export £40,000, restaurants £20,000. Annual turnover £500,000 - £1million

#8 full contact details given, but nothing else.

Time taken – over a week. Northern Ireland. Full contact details provided.
No other information.

#9 Community Interest Company

Time taken 30 mins. Northern England. Full contact details provided.

"We are almost embarrassed that in a sport which is considered the largest participant of any sport in the UK, we are but a handful of thousands of commercial fisheries and angling centres within the UK that can support people with disabilities that would like to access angling."

An access for all fishing and education lake. The company provides training courses based around angling skills, fishery management and land-based education to schools and special needs groups. They have twelve staff. Their biggest day-to-day issue is the general administration and management of government contracts – Ofsted regulations, HSE appraisals, safeguarding etc. This is not, strictly speaking, an aquaculture production business, it is a put and take fishery. However, this response highlighted an opportunity to support those such fisheries who are offering good access for the less than agile (some private fisheries advertise this) and the use of angling and fish keeping for rehabilitation. The fishery is used as a meeting point for various marginalised social groups, provides considerable training and employment opportunities and has a good turnover.

Annual inputs. Staff £200,000. Contract holders £30-40,000. Vehicles £20-25,000. Feed £5,000.

Annual sales. Not given. Supported by EU Agricultural Fund for rural Development and eight other bodies.

Turnover. £500,000 - £1million.

#10. Cyprinid breeder – restocking and cold-water ornamentals

Time taken 20 mins. South East England. No contact details given.

“Indications are that demand is falling both in the recreational angling industry and the cold water ornamental industry. This downward trend has been ongoing for 6 years and looks set to continue.”

This is a family business selling cyprinids (e.g. carp/tech/roach) to freshwater angling ponds and as ornamental fish. About 90% of the fish are delivered to the customer in oxygenated bags, mostly by overnight courier. Six people work in the business, which is surviving a 6-year downturn because of a low cost base, no debt and a strong customer base. They cite problems including a decreasing availability of treatments and the increasing cost of various compliance requirements (H & S, pensions, environmental). The feed comes from Coppens in Denmark – other expenditure is local.

Annual inputs. Labour £160,000, power £10,000, feed £10,000, deliveries £20,000, and rent £10,000, other £10,000

Annual sales/production approximately 600,000 fish

Annual turnover £300,000 - £500,000

#11 Producer of organic Atlantic salmon

Time taken 35 mins. Northern Ireland. Full contact details given.

“International marketing of premium seafood products from NI is currently limited primarily owing to the size of the sector and the lack of will/effort from producers as unfortunately there is still a reliance on Government financial support.”

“The aquaculture/seafood sector in NI is in a way becoming if not already stagnant owing to the legislation on allowable catch, limitations on accessing suitable new aquaculture licenses and a general apathy amongst many producers.”

The only Atlantic salmon farmers in the Irish Sea, and very proud of this. They export weekly to fifteen countries, employ ten people and all their smolts come from Northern Ireland. Weather is the biggest problem for day-to day operations, and the major longer-term constraint is limitations/restrictions on expansion. Compared with Scottish salmon producers (who commonly have 2,000 tons from a single site) this is an extremely small operation but clearly very market orientated and looking to the future.

Annual inputs: No figures given

Annual sales: 600 tonnes salmon

Annual turnover: >£3m

#12 Oyster Farm. Owner in the south of England, farm actually in Scotland but comments valid.

Time taken: 10 mins. South of England/Scotland: Full contact details given.

“The price of oysters is good at the moment, and young people need to be encouraged to join. Grants to get started would help.”

This is an oyster farm growing native oysters for sale in London restaurants. Their site is actually in Scotland, but the comments are nonetheless valid. The right to the oyster bed is by Royal Charter dating from 1701. Inputs are purely local labour and diesel from a local supplier. There is a skipper and a deckhand at the site and the owner at the office. They could double production and find a market for it but they are tricky to breed. They need a source of shell for cultch to help the young oysters develop.

Annual costs: Labour (2) £40,000. Boats (2) £20,000

Annual production: 20-30 tonnes.

Annual turnover: Not given.

#13 Table trout producer

Time spent – over a day. South west England. Full contact details given.

“Our production, due to decreased demand has gone down by around 40% in the last 5 years”

“Not entirely secure! Cannot understand why really what with decreasing sea stocks and salmon booming...surely trout should be as well???? This country does not like fish as much as the rest of Europe I guess” “Our industry needs to grow the market for trout.”

This is a third generation three-person family table trout farm, currently diversifying into carp. They grow portion-sized trout to an average of 650g, with a few sold to fisheries. 95% of the fish go to a factory ten minutes away, feed comes from Skretting and fingerlings from Yorkshire. Disease is a difficulty as is labour supply, with not many young people coming into the industry. Production has declined by 40% in the last 5 years due to decreased demand.

Annual costs: Feed £270,000. Labour £36,000. Stock £27,000. Oxygen £21,000. Electricity £18,000. Veterinary £10,000.

Annual production: Not known.

Annual turnover: £450k last financial year. In 2010, it was £750k.

#14 Eel smoker.

Time taken five mins. Central England.

Sole owner of a “very secure” business with two people working. Sells to commercial and wholesale buyers. The business has been trading for over 20 years and the owner hopes to sell this year.

Annual turnover £100-200k.

ANNEX 6: MULTIPLIERS

Multipliers are estimated by taking the sum of direct, indirect, and induced amounts for each category (e.g. employment) and dividing that amount by the direct amount for the given category.

Example. Direct Employment = 169
 Indirect = 64 (up and down supply chain in same industry)
 Induced = 47 (outside industry – extra consumption)

Type I employment multiplier, (direct and indirect effects)

$$= (169+64) / 169$$

$$= 1.38$$

Type II employment multiplier (direct, indirect and induced effects)

$$= (169+64+47)/169$$

$$= 1.66$$

See SG website at <http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Multipliers> for more detail.

Derivations

1) From Scotland (official statistics)

Type I and II multipliers, 1998-2012, based on SIC [aquaculture] 2007. Online at <http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Downloads> , on the Leontief pages.

Employment multipliers

Type 1 1.4

Type 2 1.5

2) From Marine Scotland (SG).

Imani and SRSL for Marine Scotland, 2014. An assessment of the benefits to Scotland of aquaculture. Online at <http://www.gov.scot/Topics/marine/Publications/publicationslatest/farmedfish/AqBenefits>

Aquaculture is described as an “anchor activity”, with “considerable (likely a majority of) value is found in provision of inputs and further down the value chain, not in the actual farming itself”.

Annex table 6.1 Derivation of multipliers

	Direct (Scotland)	Indirect	Induced	Total (Scotland)	Type 1 Multiplier	Type II Multiplier
Employment	2,700	2,100	3,200	8,000	1.78	2.96

Section 5.4.3 in the “Induced Multipliers for Shetland” report discusses the “significant” type II multiplier in Shetland but does not actually quantify it. Again in Section 8.5.3 of this report this effect is again discussed anecdotally, but not quantified.

3) From Indiana

Broughton, M and Quagraine, K, 2013. Economic Importance of the Aquaculture Industry in Indiana. Purdue University. Online 26/04/2016 at <https://www.extension.purdue.edu/extmedia/EC/EC-770-W.pdf>

Annex table 6.2 Derivation of multipliers

	Direct	Indirect	Induced	Type 1 Multiplier	Type II Multiplier
Employment	169	64	47	1.38	1.66

4) From Canada/FAO

National Aquaculture Sector Overview. Canada. National Aquaculture Sector Overview Fact Sheets. Text by Olin, P. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 1 January 2012. [Cited 28 April 2016]. Online at http://www.fao.org/fishery/countrysector/naso_canada/en

Salaries and wages paid in the aquaculture sector in 2010 totalled USD 103 million and employer paid benefits amounted to USD 15.7 million (Statistics Canada, 2011). A study carried out in 2004 estimates that aquaculture employed 5 565 people (Mathews, 2004). One-third of these employees earned a yearly income between USD 25 000 and 35 000 and received other benefits. The survey also found that 80 percent of the jobs were full-time and most of them were on salmon farms in rural British Columbia (53 percent) and New Brunswick (25 percent). This direct employment creates indirect employment further downstream in supply and service industries. Using an employment multiplier of 2.5, as reported in other aquaculture studies, the estimated total direct and indirect employment created by the aquaculture industry would be 14 000 jobs.

5) From Washington, Oregon and California, for the Pacific shellfish Institute.

Northern Economics, Inc. *The Economic Impact of Shellfish Aquaculture in Washington, Oregon and California*. Prepared for Pacific Shellfish Institute. April 2013. Online at <http://www.pacshell.org/economic-impacts.asp> The following numbers were sourced directly from this report:

Annex table 6.3 employment figures, PSI report.

Employment (actual employment figures)

	Direct	Indirect	Induced	total
Washington	1900	390	420	2710
Oregon	n/a	n/a	n/a	n/a
California	200	30	50	280

Annex table 6.4 Derivation of multipliers.

	Type 1 (direct and indirect)	Type II (direct, indirect and induced)
Washington	1.21	1.43
Oregon	n/a	n/a
California	1.15	1.4

ANNEX 7: SUMMARY OF THE OPERATIONAL PROGRAMME FOR SUPPORT FROM THE EMFF IN THE UK

Main objectives

The Operational Programme (OP) "Fisheries and Maritime 2014-2020" for support from the European Maritime and Fisheries Fund (EMFF) in the UK aims at achieving key national development priorities along with the "Europe 2020" objectives. The OP addresses the general reform of the Common Fisheries Policy (CFP) and the development of the Integrated Maritime Policy (IMP). The UK objectives are defined under 4 main policy goals:

1. Adapting the fisheries sector to the requirements of the reformed CFP – focused on the transition of the fleet to sustainably managed and discard-free fisheries, innovation
2. Fostering growth potential across the fisheries, aquaculture and processing supply chains - through support for innovation, onshore and offshore investments in infrastructure
3. Supporting the increased economic, environmental and social sustainability of the sector – through efficient use of natural resources, support policies that will attract and maintain people in coastal areas, improve local governance etc.
4. Fulfilling the UK's enforcement and data collection obligations – by developing IT tools and technologies to support control and enforcement, improving the traceability of fisheries products, adapting data collection to respond to the new requirements of the reformed CFP

Funding priorities

The UK OP is organised around the following priorities:

- **Union Priority 1 (UP1):** €67,487,315 (28%) will aim at striking the right balance between fisheries activities, environmental protection and thus contributing to the sustainable development of the fisheries sector. The accent is put on innovative research projects whose outcomes will add value to the sector, energy savings and scientific knowledge.
- **Union Priority 2 (UP2):** €19,327,305 (8%) is focused on supporting innovative projects to help expand production while improving sustainability of the sector. Funding will also support greater profitability in the sector through improvements in predator control, the potential of new species being cultured, opening up of new aquaculture locations and diversification in income through complementary activities.
- **Union Priority 3 (UP3):** €97,633,875 (40%) will go towards the implementation of control, inspection and enforcement system as required by the CFP as well as the collection, management and use of data required by the CFP
- **Union Priority 4 (UP4):** €13,583,840 (6%) for fisheries and aquaculture dependent communities to diversify their economies and bring added value to their fishing activities through improved local marketing and supply chain logistics.
- **Union Priority 5 (UP5):** €27,243,978 (11%) will focus on investments in the development of new or improved products, as well as marketing and promotional campaigns. The Producer Organisations will be supported to take a greater role in production and marketing.
- **Union Priority 6 (UP6):** €5,334,672 (3%) will support the Marine Strategy Framework Directive and an effective marine planning process. Funding will be used to establish baselines and monitoring to tackle more complex issues such as cumulative impacts, future analysis and filling knowledge gaps.

€12,528,452 (4%) is allocated to technical assistance in order to reinforce the implementation system, ensure efficient administration of the EU funding, including support to reducing burden on beneficiaries, improving e-administration and publicity and information measures.

Financial information

- Total OP budget: €309,993,982
- Total EU contribution: €243,139,437 (co-funding of 78.43%)
- Total national contribution: €66,854,545

Managing Authority

Marine Management Organisation (MMO), Lancaster House, Hampshire Court, Newcastle upon Tyne NE4 7YH

Website: <https://www.gov.uk/government/organisations/marine-management-organisation>

ANNEX 8: PROFILE OF AQUACULTURE SUB-SECTORS AND BUSINESSES IN THE UK

The aquaculture sub-sector profiles presented in this Annex are explored in terms of:

- A mainly descriptive overview (i.e. what it is, where it fits in to the bigger picture, important technical characteristics, etc.) and the geographic distribution of activity (illustrated with a small subsidiary map)
- Business structures and economic contribution
- Major sub-sector trends (e.g. growth, technology, business models, etc.)
- Markets, comparative advantage, scale issues and growth potential
- Risks, constraints and summary SWOT table
- Strategic needs for growth where appropriate
- Case studies and/or producer perspectives as gathered from the on-line survey or individual interviews

8.1 Finfish farming

Although there are several different types of economic activity (in terms of species, stage of production, and market) many salmonid fish farmers combine different production stages, or target several markets, though there is a tendency toward greater specialisation and/or vertical integration. Most farms growing for restocking also have a hatchery.

8.1.1 Salmonid egg and juvenile production

Overview

The UK has been involved in salmonid ova production and rearing of juveniles since the late 19th century in order to supplement or enhance wild stocks or introduce them to new areas. The basic procedure is relatively straightforward and now largely routine and predictable, but genetic selection technology to develop desirable traits has become far more sophisticated over the last two decades.

Distribution

The distribution of both salmonid egg and juvenile production/hatchery activities across England, Wales and Northern Ireland are shown in Figures 8.1.1a and b.

Figure 8.1.1a: Distribution of trout hatcheries in England, Wales and



Figure 8.1.1b: Distribution of salmon breeders, fry, parr and smolt producers



A relatively small hatchery can produce a very large number of eggs, and these can be shipped internationally (given appropriate disease free certification) so it is unsurprising that the industry is increasingly centralised with relatively few major hatcheries underpinning the bulk of table fish production of both salmon and trout throughout the world. Some of the most significant businesses supplying eggs and juveniles for UK production for trout and salmon include:

- Troutlodge¹²⁵, USA. Isle of Man subsidiary (trout)
- Aquasearch ova Aps¹²⁶, Troutex, Denmark (trout)
- AquaGen¹²⁷, Norway (salmon and trout)

¹²⁵ <http://www.troutlodge.com/>

¹²⁶ <http://aquasearch.dk/home/>

¹²⁷ <http://aquagen.no/en/>

- Landcatch/Hendrix Genetics (mainly salmon)
- Northern Trout¹²⁸, North Yorkshire, England (trout)
- Houghton Springs, Dorset, England (trout and Arctic char)
- Lakeland Smolts, Cumbria, England (salmon)
- Supreme Salmon¹²⁹, Lincolnshire, England (salmon)

The salmon industry has its own supply chain, largely vertically integrated, and with hatcheries in Norway, Scotland and the north of England. There remains only one independent supplier of salmon parr – Supreme Salmon, based in Lincolnshire.

The existing UK trout egg market is dominated by a US company with a subsidiary in the Isle of Man (i.e. Trout Lodge¹³⁰), however according to Cefas data, approximately 50% of English, Welsh and Northern Irish trout egg production is from small hatcheries Northern Ireland. In some cases hatcheries may be supported by research scientists from universities (e.g. Bangor, Stirling, St Andrews) or the private sector (e.g. Xelect¹³¹).

Specialist egg production is not big business. England and Wales together have produced between 10 - 30 million eggs in recent years, worth something in the region of £100,000 - £500,000 (although prices are highly seasonal and quality dependent). A single company (for example Troutlodge, Isle of Man) can produce up to 70 million eggs.

Business structure and economic contribution

Key characteristics of larger international hatchery facilities supplying the large-scale salmonid table trade include:

- Substantial capital investment (e.g. in ponds, tanks, buildings, temperature and water quality control systems, etc.)
- Significant energy costs (e.g. pumping, temperature control, lighting, etc.)
- 10 - 20 employees comprising management, highly/technically skilled personnel, and reliable, semi-skilled labour
- Significant research overhead costs
- Variability in the price of eyed ova according to quality and season (£8 - £20 per 1000)
- Value added (e.g. wages, profit, etc.) compromising a relatively high proportion of income

Smaller operations (of which there are more than 20 across the three countries) are generally characterized by:

- Sales of fry or fingerlings rather than eggs
- Sales mainly to local restocking/recreational fisheries
- Substantial “sunk capital costs” (most investment was in late 1970s/80s)
- A motivated technical manager/owner
- A small workforce of 1 - 4 individuals whose wages dominate operational costs
- Highly variable but significant energy costs (mainly for pumping)
- Value added comprises a relatively large proportion of income; these are highly skilled, labour intensive operations

There are currently 27 registered businesses engaged in salmonid breeding as their primary activity employing an estimated 89 FTE and generating revenues in excess of £7.5m and value added of around £5 million. Production is concentrated in northern England, South West England, and Northern Ireland (Table 11).

¹²⁸ <http://northerntrout.co.uk/>

¹²⁹ <http://www.supremesalmon.co.uk/>

¹³⁰ <http://www.troutlodge.com/?pageID=781EE0B4-3048-7A03-3934BCDCCF5E7473>

¹³¹ <http://xelect.co.uk/>

Trends

There is significant inter-annual variation in egg production, while parr/fry production is more stable. The former variation relates to the ease with which buyers can switch between UK and foreign produced eggs.

Table 8.1.1a: Economic parameter estimates: Salmonid eggs and juveniles from England, Wales and Northern Ireland

No of eggs	50 - 65 million
No of juvenile fish	20 - 30 million
Revenue	£7.5 million + ¹³²
Number of businesses	27
Employment (Direct FTE)	89
Value added	£5 million
Main inputs	Skills, capital
Regional concentration	N England, SW England, N Ireland

Note: Estimates for number of egg and juvenile fish production based on Cefas data, 2010 - 2014

Many of the smaller hatcheries with juvenile operations have been closing or taken over by larger companies over the last two decades, and this process is likely to continue as the existing technical managers retire. It is anticipated there will be an overall shift from small-scale egg and fry production to specialist, large-scale egg production on the one hand, and larger grow-out farms that hatch bought in eggs and rear them through the fry, fingerling and grow-out stages.

There may be some niche grow-out farms with sufficient scale that continue to breed their own high performing strains, though it seems likely that these in turn may be bought out by either specialist genetic companies on the one hand, or large-scale producers on the other.

However, there will remain significant opportunities for small businesses that combine a hatchery with recreational fishery/visitor attraction and these will continue to contribute a significant proportion of employment to the sub-sector.

Markets, comparative advantage, scale issues and growth potential

There is a global market for high quality salmon and trout eggs. For salmon the main markets are Scotland, Norway, Chile and Canada; for trout there has been a rapid increase in production in Iran, Chile, Turkey and Norway in recent years. The market for fingerlings/parr is primarily limited to the UK.

Fish genetics and breeding (and more generally animal breeding and genetics) is an area where the UK has global strengths, and an industry any country looking to underpin a competitive animal production sector might seek to reinforce. While there is global competition (especially from the US, Scandinavia, as well as emerging expertise in East and SE Asia), there is no reason why the UK should not be globally competitive; generating exports of eggs and providing genetic services, and underpinning production of high performing fish for restocking and the table market.

As an island nation the UK is well placed in terms of managing its disease status, and is free of many aquaculture diseases that plague the industry throughout the world. This together with significant technical expertise means that the UK has significant comparative advantage with respect to most

¹³² Cefas (2011) estimated sales of salmon smolt to Scotland worth £6m. It is not possible to distinguish clearly this sub-sector from that for restocking presented below

northern, temperate species. For example, the biggest global producer, Troutlodge USA has Red Mark Disease in its North American operations.

Risks and constraints

The egg production business is relatively low risk insofar as it is small, relatively immune to the uncertainties of climate, markets, and indeed disease (most production systems are specifically built to be biosecure, and breeding programmes are often specifically aimed at disease resistance). It is risky in that success takes substantial time and research, and ultimately a competitor may generate a better product. There are also risks that disease becomes significant in the wider environment and that irrespective of an individual hatchery's biosecurity measures, the movement of seed from an infected area is not permitted.

The UK is highly dependent on imported eggs – a possible threat in terms of biosecurity, and an opportunity for import substitution

The small-scale fry and fingerling producers are at significant risk from climate, market and disease, and lower margins related to their limited economies of scale. Space and time is required, and most farms have too few broodstock and suffer from inbreeding.

The main constraint to success is the cost of R&D required to reach the forefront of this sub-sector, and therefore establish an international reputation. Given the size of the market, payback is likely to be too far in the future to make relatively long-term investment worthwhile. Further development of the sub-sector will therefore be highly dependent on industry support through joint research grants, working with specialist research institutions, and strategic use of intellectual property rights.

SWOT - Salmonid breeding and hatcheries

Strengths/Opportunities	Weaknesses/Threats
<ul style="list-style-type: none"> • Significant global market and opportunities for import substitution • UK as an island nation has greater opportunity to establish and maintain disease free status • UK has a long history breeding salmonids and significant research capacity • England Wales and Northern Ireland have favourable temperature regime for holding broodstock and breeding • Excellent logistics for international air freight • Synergy with R&D in animal and plant breeding more generally • Significant downstream benefits leading to potentially more competitive grow-out sub-sector 	<ul style="list-style-type: none"> • inbreeding and introgression (limited space for/numbers of broodstock) • Disease (including introduction through imports) • Concentration of expertise in a few global corporations that can operate in the most suitable locations (climatic, logistics, skills) • Rising temperatures in southern England • Actual and potential competition from US and Scandinavian countries • Long lead times, and high R&D costs of maintaining technical lead globally, coupled with uncertain success

Strategic needs

Success will depend on motivation, determination and the capacity to raise medium to long-term investment to underpin a high-tech R&D based sub-sector:

- National strategic plan for aquaculture seed
- Private sector/research institute/University partnerships to secure national and EU research funding to underpin more efficient selective breeding and/or genetic modification (GM)
- Business development mentoring – bringing together technical, economic, business management and marketing expertise

Growth potential

Possible scenarios – in one of the existing (probably more northerly) locations:

- One major global salmonid breeding business with 10 - 20 employees and drawing in/linking with 5 - 10 researchers
- 10 small rural visitor attractions/fisheries enhanced by working hatcheries

8.1.2 Table trout production

Overview

Somewhat less than a third of trout production in the UK goes to the table market, although the proportion is much higher in England as this is where main supplies of table trout are generated. Table trout production can be divided into the following main market categories:

- Production to supply major supermarket/retailers with whole fish
- Production to supply large seafood processing companies, mainly for processing into smoked product and some fillet
- Production to supply on farm and/or local smokeries, and other specialist food outlets; destined primarily for local farmer's markets, delicatessens and similar high end outlets

This sub-sector is suffering from flat or declining demand, and very slim margins, especially in the whole fish to processor or supermarket sector, and the last major investment in a new trout farm was in 1984.

The ideal temperature for trout growth is 16 - 17°C. The North Yorkshire moors are probably the ideal location for land-based production in the UK. Scotland is slightly too cold, but has excellent grow-out sites on the West coast for marine cage production. Land based systems in the south of England may be a little too warm in summer, particularly if temperatures continue rise due to climate change.

Business structure and economic contribution

There has been significant rationalisation in recent years, with just five medium-sized companies dominating production:

- Trafalgar Fisheries¹³³, Wiltshire: The largest trout farmer in England with two large farms, and may also buy in from other producers. Undertakes some primary processing and sells direct to Waitrose, the wholesale trade, and food service industry. Trafalgar also produce trout for restocking. Production is around 1000t annually, with some spare capacity
- Test Valley Trout Ltd¹³⁴, Hampshire: Focuses on table fish production, and most goes to Dawnfresh (Scotland). Production about 1000t annually, with spare capacity
- Glasshouses, North Yorkshire: Produces trout exclusively for the table, and undertakes primary processing. Supplies Morrisons
- Northern Trout, North Yorkshire: A diverse business; includes the production of trout eggs, fry, table and restocking fish. They have steadily expanded to eight sites in three clusters in North of England and Dumfries, Scotland

These main businesses are supplemented by a few SME table/restocking businesses, and a scattering of smaller more diverse businesses often associated with a small fishery or rural attraction, mainly based in southern England. Other key players in the trout sector are:

- Dawnfresh¹³⁵: The largest trout producer in the UK based near Glasgow, Scotland. Dawnfresh not only farms but buys in trout from England (e.g. from Test Valley). It sells to Tesco, Sainsbury, M&S. Dawnfresh also grow trout in marine cages in Scotland
- Edinburgh Smoked Company, Dingwall, Scotland: Seafood processor who buys trout from many of the smaller producers. It supplies UK supermarkets. Owned by a large Thai-American seafood company

Feed is the dominant cost of trout production, comprising up to 50% of costs. Labour is the second most significant, with a minimum requirement of 3 - 4 staff per 100t of production. It is notable that labour productivity in Scottish salmon farming is at least three times higher than English trout production, related primarily to economies of scale as well as lower costs associated with cage operations. This highlights the challenge faced by trout producers seeking to compete in national and international markets for salmonid products. Fuel costs are also substantial, dependent on the farm site and system (e.g. bore hole or river water used, local topography, farm design, etc.). Capital

¹³³ <http://www.trafish.com/>

¹³⁴ <https://www.facebook.com/testvalleytrout/>

¹³⁵ <http://www.dawnfresh.co.uk/>

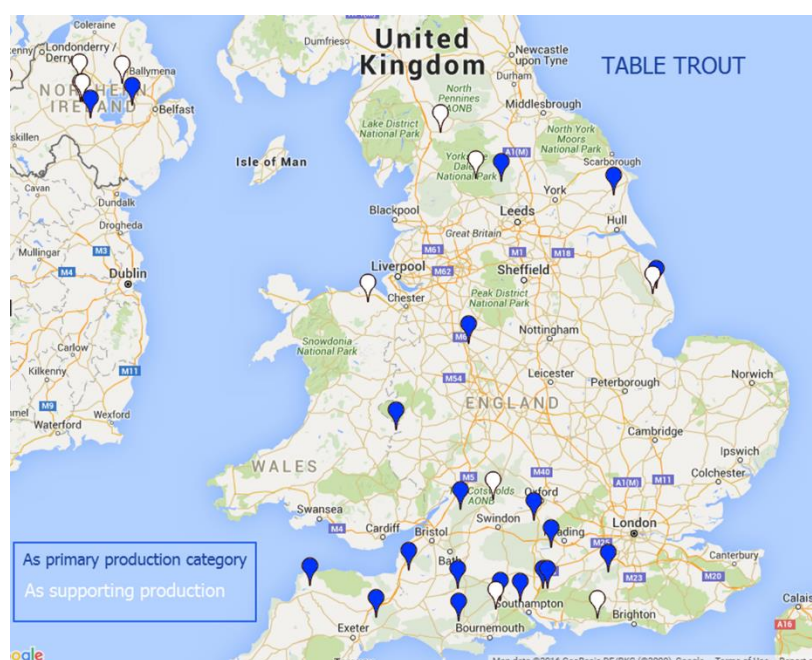
investment costs have largely been written off for most trout farms in the UK; a new farm however would require substantial investment, especially to meet current effluent standards, and is unlikely to be financially attractive.

The main trout producers are dependent on the chalk rivers of southern England or the limestone areas in North Yorkshire, with a small amount of production also from Northern Ireland. There are 21 businesses in England, Wales and Northern Ireland (Figure 8.1.2a) whose primary activity is trout production for the table, producing between 4,000t - 5,000t, valued at around £12 - £15 million, of which a little under half will be value added. They employ an estimated 105 FTE (Table 8.1.2a).

Table 8.1.2a: Economic parameter estimates: Trout for the table in England, Wales and Northern Ireland

Production	4,500t
Number of businesses	21
Revenue	£13.8 million
Employment (Direct FTE)	105
Value added	£6 million
Main inputs	Capital, feed

Figure 8.1.2a: Distribution of table trout producers in England, Wales and Northern Ireland



Comparative advantage and market opportunity

The UK is a very small player in a large global trout market. Global production of rainbow trout stands at around 800,000t, with production widely spread across Europe, the near East and the Americas. Perhaps surprisingly, the top producers in recent years have been Iran, Chile and Turkey – each producing over 100,000t of rainbow trout. In Europe, the major producer is Norway, followed by Italy, Denmark, France, Russia, Spain, Finland, and the UK (Figure 8.1.2b). European production of rainbow trout amounted to 284,000t in 2012.

Figure 8.1.2b: Global development of trout (rainbow, brook, sea) farming

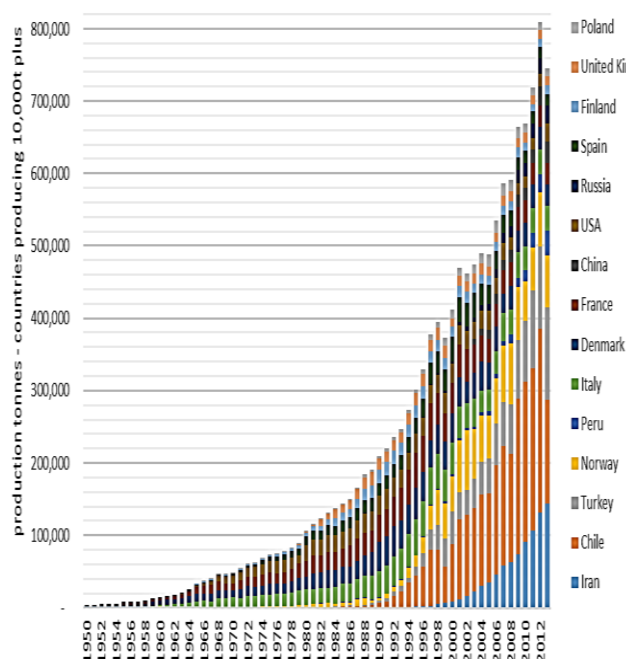
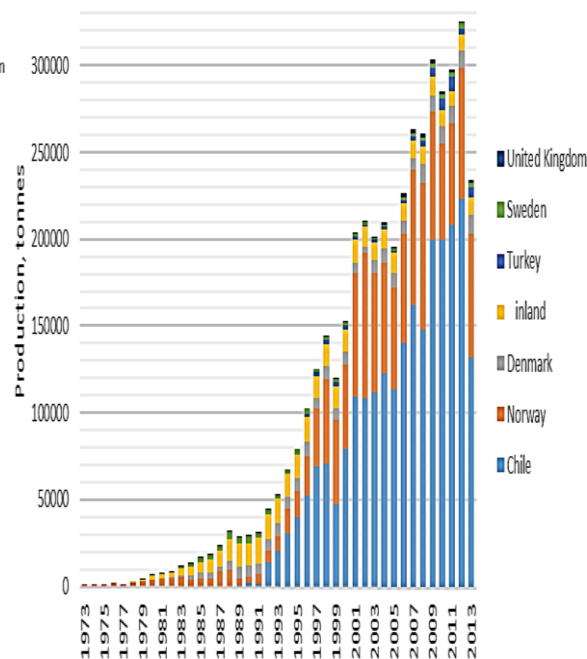


Figure 8.1.2c: Global development of marine trout farming (source FAO)



The rapid increase in production in Chile and Norway in recent years has come from production in sea cages (Figure 8.1.2c). Dawnfresh in Scotland has also begun to adopt this method (around 1,000t is produced in Scotland). There are several advantages to cage farming trout:

- Investment costs and overall cost of production is lower
- Economies of scale are easier to realize
- Rates of production are less constrained by water supply
- Off-flavour is less likely
- Larger fish can easily be produced – for which there is more demand (i.e. giving a wider range of processing options/products rather than just a whole fish) and which give a better flesh yield

Furthermore, the price of marine grown rainbow trout is generally higher at around \$4/kg (although prices in Chile appear to be exceptionally high, perhaps due to strong demand in North America).

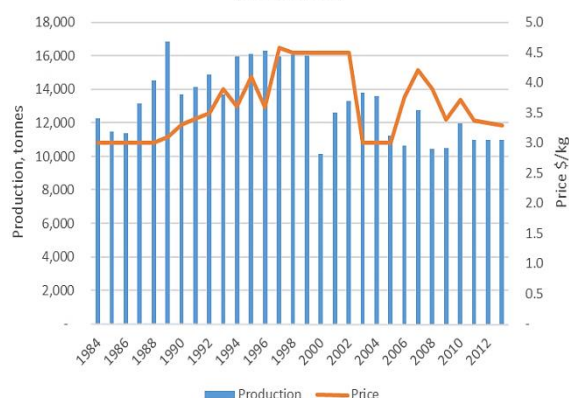
Although trout is in partial competition with salmon, it suffers some significant disadvantages. Freshwater grown trout in ponds may have relatively poor flavour, and has a 30 - 35% fillet yield compared with 48% for salmon. While large sea-grown rainbow trout may be better on both counts, it is unclear what the advantage is over salmon, other than diversity of product. Marine grown brown trout (genuine seatrout) may have some market potential, but the requirement for any trout stocked in open waters to be triploid may undermine both the opportunity and the market potential of this fish.

Table trout from England, Wales and Northern Ireland faces intense global competition. High quality freshwater trout from Denmark and Norway feed into higher value UK and European markets; there is increasing competition from marine cage grown trout and salmon; and mass production in countries such as Iran, Chile and Turkey supply the global commodity market.

Most British grown trout feeds in to UK markets. UK trout price peaked around the millennium but has since declined back to levels similar to those in the early 1980s (Figure 8.1.2d). The current price for whole fish stands at around £3/kg and £6/kg for fillets.

The combination of falling production and falling prices suggests significant market weakness, confirmed by all those with whom we talked. This will inevitably result in further consolidation to achieve economies of scale in production and marketing.

Figure 8.1.2d: Production and price trend for UK freshwater Rainbow trout (source FAO FISHSTAT)



New opportunities

While ideal in terms of temperature regime, siting marine trout production in SW England would suffer from high exposure environments; increasing capital, maintenance and labour costs, and ultimately the risk of loss. Planning and permitting procedures are also likely to be demanding in these areas and the scale and infrastructure needed to support a competitive business would be substantial. It remains unclear whether England is particularly well placed to compete with either Scottish marine trout at the higher end of the market, or overseas producers in the commodity market.

Some in industry believe that freshwater trout production in England, Wales and Northern Ireland

still has a bright future - it is simply a matter of being innovative and technically advanced, possibly emulating the example of Denmark; here there has been far greater investment in water systems and recirculation, allowing for significant expansion at existing sites, greater environmental control, etc. However, it is important to understand that the modern industry in Denmark arose from a 'carrot and stick' approach by the authorities; very strict discharge regulations coupled with strong support for investment in recirculation and water treatment systems. This also took place at a time when the market price, in real terms was higher than it is at present, therefore it is likely to be tough to emulate the well-established Danish example. In any case, Danish production also appears to be in slow decline, suggesting that this business model is no better.

Advances in genetic selection for growth, food conversion and flesh quality traits may also increase competitiveness in both production and marketing.

There may be more opportunity for different varieties of smoked trout fillet; such smoked trout products sell reasonably well and at retail prices of £27/kg, amounting to a 3 - 4 fold value added relative to fresh fillets. Smoked salmon has become almost commonplace and has suffered significant quality complaints in recent years. There is a possibility of breaking into this very substantial higher value market.

Smoking trout is undertaken widely across England, Wales and Northern Ireland and by both small and large-scale producers, but at modest scales. A step change in smoked trout production may be an opportunity for the industry, e.g. major investment in larger smokeries could then supply product to domestic and international markets. Careful financial analysis would be required to assess the level of competition in this market from Denmark and the large-scale foreign producers.

There is also opportunity related to the local food movement. There has been a modest upturn in the number of high street fishmongers after years of decline, and this – together with farmer's markets and farm gate sales, offers a significant opportunity for relatively small-scale "local" trout farmers.

Currently freshwater trout producers in England, Wales and Northern Ireland may have a small advantage over their Scottish counterparts, as Scottish Environment Protection Agency (SEPA)¹³⁶ charges for water abstraction and wastewater discharge have tripled in recent years. These can amount to as much as £7,500 water charges for a Scottish farm site. These rates are now double those found in England and Wales.

Possible diversification of the English, Welsh and Northern Irish industry into offshore cage farming would be highly risky given the relatively slim margins, the scale and substantial investments required, the increased risk associated with offshore production, and the strong competition from Norway,

¹³⁶ <https://www.sepa.org.uk/regulations/water/aquaculture/>

Denmark and increasingly, Scotland – countries that all have natural or industry level comparative advantage.

Risks and constraints

Currently the trout industry not only in England, Wales and Northern Ireland, but across the UK is facing many significant risks and constraints, and it is struggling (Box 8.1.2a). Continuing *downward pressure on market price* is the main risk since margins have been squeezed to the minimum in the table trade. There remain very few wholesalers, and supermarkets have near monopolistic power as well as very demanding requirements, and there appears to be a general lack of interest by large retailers in trout product promotion and innovation.

Box 8.1.2a: Trout producer perspectives

"Table trout became an unprofitable nightmare"

"Our production, due to decreased demand, has gone down by around 40% in the last 5 years. Our industry needs to grow the market for trout."

Disease is an ever present risk, and while vaccines have been produced for some of the more serious trout diseases this remains an issue. This is not simply a question of stock mortalities; farms may be shut down and/or quarantined for significant periods which totally disrupts production. The implementation of VHS (Viral Haemorrhagic Septicaemia) legislation was very strict, and there is a feeling within

industry that inadequate consultation and/or notice is given to farmers in relation to both emergency measures such as these, and conservation measures such as the triploid rule (recently extended to Scotland). These risks favour the larger producer who may have several sites, more cash flow, and can 'weather the storm'. A disease incident followed by restrictions can finish a small farm, and this is likely to continue to reinforce the rationalisation process.

Vaccines and other treatments now represent a major cost for fish farms, in part because of near monopolies in vaccine and drug supply by companies (e.g. MERCK¹³⁷) that have benefited from substantial publicly funded R&D. Furthermore, there is inadequate development of new vaccines; the private sector is "not interested" (development is too long and costly), whereas public sector spending is inadequate to meet the emerging challenges.

A key need in addressing all of these risks and constraints is *skilled labour*; the shortage of which was raised as a major problem by almost all those in industry we talked to.

Feed specification is also a significant problem for UK producers. Despite the relaxation of EU legislation banning use of LAPs (land animal proteins) in 2011/13, the main retail chains do not accept the use of animal protein as a substitute for fish protein. Since fishmeal is roughly double the cost of LAP, this results in much higher feed costs (e.g. 20% more expensive than that used by farmers abroad), which in turn represents the greatest proportion of production costs.

This problem is compounded by the difficulty and cost of sourcing non-GM feed ingredients – especially soya. Taken together this adds substantially to the costs of table trout production.

¹³⁷ <http://aqua.merck-animal-health.com/>

SWOT analysis - Table trout

Strengths/Opportunities	Weaknesses/Threats
<ul style="list-style-type: none"> • England, Wales and Northern Ireland has a very long tradition of trout farming • Temperature regimes and water quality are suitable for freshwater trout production in the North of England and parts of the south, though the latter may be becoming a little warm • Production in freshwater could be increased substantially through greater use of recirculation • Production of larger trout (rainbow and brown) in marine cages appears to be more profitable than production of portion sized trout and offers more value added opportunities • Smoked trout is a reasonably high value product that could take market share from smoked salmon • Trout has the potential to fit well in the “local food” revival • Genetic improvements can result in better food conversion, growth and flesh quality increasing competitiveness • Water abstraction charges are lower in England, Wales and Northern Ireland than in Scotland 	<ul style="list-style-type: none"> • Intense global competition/downward pressure on price • Semi/skilled labour is difficult to access and retain • Existing operations may be subject to increasingly stringent water abstraction and discharge regulations • Significant new development (freshwater flow through) is unlikely to be permitted in favourable areas, which are typically also areas of high environmental quality • Investment in recirculation as a means of expansion on existing sites will require substantial investment – difficult to justify given current market conditions • England and Wales have relatively few suitable marine sites that could be developed competitively. Northern Ireland has more potential in this regard • Other mass producers of trout are likely to enter cage farming on a substantial scale, e.g. Denmark • It will be difficult to match the labour productivity of large scale marine cage fish farming • Disease outbreaks, coupled with the regulatory response and lack of compensation schemes, may be sufficient to “finish off” smaller scale (especially single site) producers already struggling • High cost of vaccines and other treatments • High costs of feed relative to competitors (non-use of LAPs and/or GM soya) • Possible imposition of increased abstraction and discharge charges similar to increases that have already occurred in Scotland

Strategic needs

While growth potential for the table trout industry appears limited, there is no reason why production should not continue at existing facilities, and expand modestly given a supportive environment. There may even be potential for significant expansion into smoked trout and other value added and “easy cook/eat” products.

The following may facilitate maintenance or modest expansion of existing production:

- Trout needs an ‘image boost’ – through major retailers, celebrity chefs, outdoor/leisure programmes, etc. The British Trout Association (BTA) should lead this process, but support from EMFF, government, and/or other organizations and agencies would help
- There is a need for increased consultation, more notice, and some flexibility in the implementation of disease response and other regulations (such as triploid rules). Where this is not possible, some form of compensation or mitigation fund may be required, especially for small producers
- A more positive attitude to aquaculture development is needed on the part of planning authorities and their advisors, especially in national parks, which are often the most suitable areas for trout farming
- There is a need for national (or international) investment in vaccine development. An aquaculture sector wide R&D strategy would underpin a more resilient national industry and possibly stimulate health service exports in the longer term
- There is a critical shortage of skilled and motivated labour and need for better training and apprenticeship schemes
- There should be a national initiative to change the supermarket protocol that requires no animal proteins in fish feeds. This would improve margins whilst making production more sustainable by reducing the amount of wild fish required to produce farmed fish. The cost of non-GM feed ingredients also needs to be addressed
- Development funding is not accessible to most trout farmers because of the time, complexity, jargon, etc. There is need for support and facilitation to aid grant application
- Bureaucracy needs to be reduced. Farmers spend too much time filling in survey forms that are unnecessary/over-complex, or that do not apply to most fish farming businesses

- There is a need to rebalance public funding of and support to aquaculture. In the last couple of decades far more money has gone to supporting highly speculative new ventures rather than supporting and facilitating practical established fish farming

8.1.3 Production of trout and salmon for restocking/on-growing

Overview

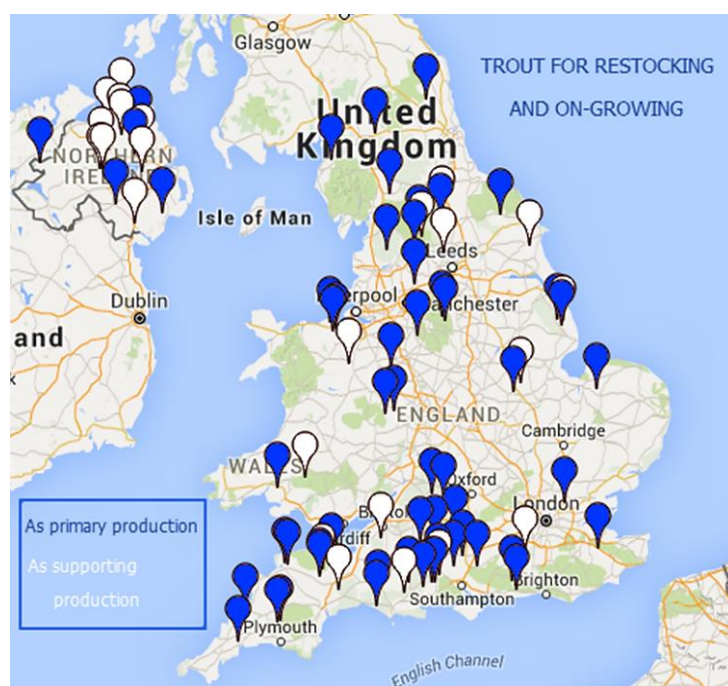
Production of trout for restocking in closed lakes or open waters, or for grow-out farms producing bigger fish for restocking or the table, is now the most important form of trout production, and generates the greatest economic impact both directly and indirectly. This is particularly important, as many of the economic benefits are local and in terms of both direct and indirect employment, and value added. Some restocking farms may also produce table fish or smoked trout as a secondary activity, often adding diversity and interest to their facility/countryside destination.

Farms range from small 1 - 2 person businesses through to the larger producers that also produce table fish. Some of the River Trusts and Water Companies (e.g. Northumbrian Water) also continue to operate hatcheries and fry/parr rearing facilities for restocking purposes – increasingly in support of recreational activities at reservoirs and other water bodies they may control. Some angling clubs and syndicates also support small hatcheries/restocking farms. The Environment Agency itself operates a hatchery at Kielder in Northumberland. In other words, the separation of business types (table, restocking, hatchery, fishery, etc.) used here is somewhat artificial, and many farms may change over time according to market conditions and opportunity.

While margins are currently higher for this sub-sector than for table trout, there is nonetheless downward pressure on price; exacerbated by the low table trout prices leading to more table trout producers switching to sale for restocking.

These businesses are more widely spread than those producing table trout, reflecting an emphasis on proximity to stocking markets rather than optimal water quality conditions. There is nonetheless a concentration of activity in southern (particularly SW England), northern England, the Welsh Borders and Northern Ireland (Figure 8.1.3a).

Figure 8.1.3a: Distribution of businesses whose primary activity is trout for restocking/on-growing



Business structure and economic contribution

Insofar as many producers of fish for restocking are also engaged in other activities, it is very difficult to define a typical business structure or separate out the economic contribution of this sub-sector. However our research suggests that an estimated 58 businesses focus on sales for restocking as their primary business activity. Some of these are one person business; most (31) employ 2 - 4 people including family members; 10 employ 5 – 9 people, and one employs close to 20; generating around 239 FTE in total. Revenue is extremely difficult to estimate because the value of the product depends critically on size, but like for like, fish for restocking are probably worth double the value of table fish.

Value added as a proportion of income is significantly higher for the restocking market since unit value is roughly double and the main input cost of feed, is actually less because a less highly specified feed can be used, and much more labour is required to handle and distribute fish. Indirect economic benefit can also be high where restocking is associated with valuable recreational fisheries and other recreational attractions (Table 8.1.3a).

Table 8.1.3a: Economic parameter estimates: trout restocking

Production	5,000t
Number of businesses	58
Revenue	£25 million
Employment (Direct FTE)	239
Value added	£15 million
Main inputs	Labour, capital, feed

Trends

Many in the industry see angling, and especially salmonid angling as being in decline and the new rules on triploidy, as well as the growing tendency to return fish to the water rather than cook-and-eat, are compounding the problem. Furthermore, specialist restocking producers are operating in a highly competitive market wherein many table trout producers have shifted because of higher margins. It is therefore likely that there will be further concentration and rationalisation of restocking production as a specialist activity with limited prospects for growth.

However, this is unlikely to affect the many smaller integrated production/recreational fishery/visitor attraction type enterprises, so long as they can make a shift from pure angling to more generic rural recreation.

Markets, comparative advantage and growth potential

Production for restocking is primarily a national activity and there is little competition from overseas because of transport costs and disease regulations. This is therefore a captive, if declining market.

Suitable temperatures for inland restocking trout production are found across the UK. England probably has the temperature advantage over Scotland, and with northern England increasingly having the advantage over the south if temperatures continue to rise.

There is continuing strong demand for small rainbow trout and salmon smolts for stocking in marine cages in Scotland, and perhaps some parts of Ireland. This market is currently supplied with fish from farms in north Cumbria and one in Lincolnshire, and there may be opportunities for further modest expansion. However, such investment will be almost entirely dependent on the major salmon and trout producers in Scotland, and they may prefer to develop this activity closer to their Scottish grow-out sites, perhaps using RAS technology.

Risks and constraints

There is substantial risk related to disease, and to the regulations that are implemented following disease outbreaks. A serious outbreak could easily force a small farm out of business. Such disease risks may be managed by having several farms in different locations, implying further rationalisation of the sub-sector.

Significant constraints include access to and/or increased use of high quality water, especially in national park and other specially designated areas – the type of environment in which trout thrive. RAS is more likely to be cost effective for restocking fish (compared with table trout production) under present market conditions, but if these further deteriorate such investment is unlikely.

While LAPs can be used for rearing fish for stocking, the bulk of feed production in the UK is for table fish and is typically free of LAP. It makes little commercial sense to make specialist feeds for restocking in the UK, so the bulk of feed must be purchased from abroad (Denmark, France, Holland) again increasing production costs and reducing benefits to the national economy.

SWOT analysis - Trout restocking

Strengths/opportunities	Weaknesses/threats
<ul style="list-style-type: none">• Small hatcheries/salmonid farms add significant interest to countryside visitor destinations• There are many species/varieties options for more specialist restocking producers that may allow them to increase margins or increase market share• Supply of smolts or larger trout for stocking in marine cages is an expanding market	<ul style="list-style-type: none">• <i>See those relating to table trout production</i>• Disease and response to disease• Interest in angling – especially for trout – appears to be in decline• Scotland may have comparative advantage in terms of logistics and management• Lack of UK produced LAP inclusion feed

Strategic needs

While opportunities for expansion may be limited, this sub-sector is nonetheless a significant employer for some of the smaller rural villages and towns of England and Wales, and it is desirable that it should survive if not prosper.

Strategic needs are broadly similar to those as described for table trout. In particular there is the need for greater efficiency, predictability and flexibility in the regulatory system; support for genetic improvements in terms of quality (for angling) and growth traits, food conversion etc.; more proactive incorporation in planning systems; measures/initiatives to reduce feed costs and increase the proportion of suitable feed manufactured in the UK.

8.1.4 Production of carp and coarse fish for restocking

Overview

Carp and coarse fish represent the bulk of wild fish living in the freshwater of England, and carp in particular has been cultured for centuries. There are a surprising number of small carp and coarse fish breeders in southern England and the Welsh Borders, and more widely scattered around urban fringes in England, Wales and Northern Ireland (Figure 8.1.4a).

The current trend appears to be the production of very large fish for on-growing or restocking. Size is one of the most desirable traits for carp anglers. Specialist producers sell their various strains based on size/growth rate, fighting ability, and appearance.

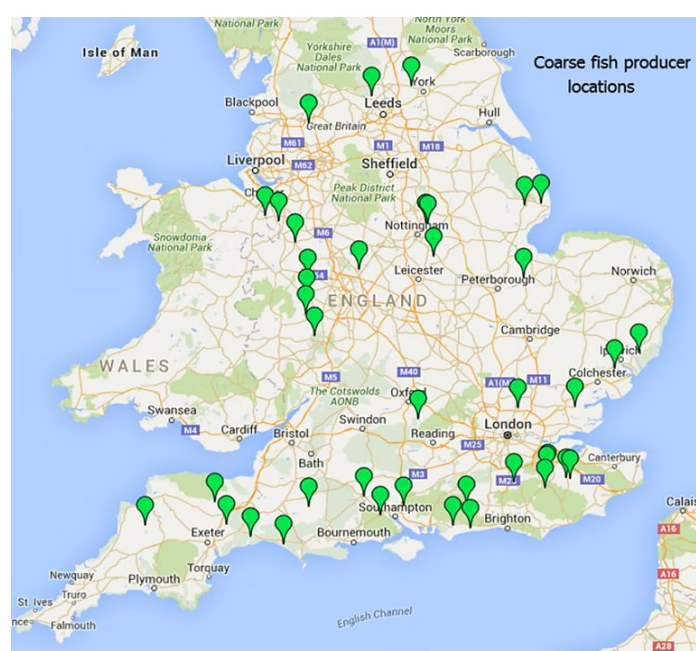
Business structure and economic contribution

As in other production sub-sectors, there is a spectrum of carp and coarse fish enterprise types. These range from specialist breeders (where the emphasis is on genetic selection of the fastest growing fish or those with the finest angling characteristics), through to more extensive production and fishery enterprises, and/or visitor attractions that may stock bought-in fish and/or breed some of their own. It is not possible to separate these out in the statistics.

Specialist breeding enterprises are typically operated by a fishing enthusiast/s, supported in many cases by family, and cater primarily for local angling needs. A few are run by angling associations or consortia. There are some exceptions e.g. where a relatively large farm is producing significant numbers of fish for several significant fisheries, but these are still not large businesses (90% employ less than 4 people) and do not appear to be anticipating significant expansion.

Cefas collects data on production (defined as sales under EC Reg 762/2008) of both juvenile fish (by number) and larger fish (by weight). It is probable that these figures misrepresent the industry for several reasons: production categories are non-discrete; juvenile fish may be produced but not sold; larger fish may be grown for angling within extensive systems where numbers are uncertain; no value data is imputed for juvenile fish. Such uncertainties are compounded when trying to assess the sub-sectors economic contribution. Prices of fish sold for restocking are very variable and dependent upon size and reputation, many fish produced are not traded (they are an angling resource), and angling receipts bear no relation to fishery production. The following estimates are based primarily on the number of enterprises and estimates of associated employment, and should be treated with caution.

Figure 8.1.4a: Distribution of coarse fish producers in England and Wales



Our research suggests there are 39 businesses in England, Wales and Northern Ireland whose primary activity is carp and/or coarse fish production. These have sold between 100 - 300t of fish in recent years, but production for local fisheries or fisheries based around the breeding enterprise suggests that real production is much higher. Revenue is likely to be more than £5 million, and these businesses employ an estimated 154 FTE. It should be emphasised however that these businesses overlap with fishery businesses and their real contribution will be significantly greater (Table 8.1.4a).

Table 8.1.4a: Economic parameter estimates: carp and coarse fish

Production (traded)	100 – 300t
Number of businesses	39
Revenue	£5 million+
Employment (FTE)	154
Value added	£3 million +
Main inputs	Capital, wages, feed

Trends

Unlike the trout sector there appears to be no clear trend in terms of business rationalisation. Most of those in the industry are more optimistic as regards the future of their sub-sector as opposed to those in trout production. However, coarse fishing and associated recreational activities appear to be in decline (Box 8.1.4a), but less so than trout restocking/fisheries, and the demand for multiple attraction rural recreational destinations is buoyant.

Box 8.1.4a: Carp and ornamental producer perspective

"Indications are that demand is falling both in the recreational angling industry and the cold water ornamental industry. This downward trend has been ongoing for 6 years and looks set to continue."

Markets comparative advantage, scale issues and growth potential

Within England, Wales and Northern Ireland it is southern England that has strong comparative advantage in terms of water temperature for carp and coarse fish, coupled with attractive countryside accessible from London and other major cities. Whilst recreational fisheries are mainly local (evening and weekend destinations) there is nonetheless a more specialist market for serious angling enthusiasts who are prepared to travel (especially to areas such as northern France) in search of the best angling. However, there is no reason why this should not work both ways – with English waters attracting continental anglers.

Although angling generally appears to be in decline, there is a strong band of passionate anglers prepared to travel and pay significant amounts of money for access to quality fish. Equally an English carp lake will always be an attractive recreational destination, especially when combined with other "country attractions" (e.g. cafes, shops, walking and riding, conference/corporate event centres, etc.). There is no reason why there should not be some modest growth in this sub-sector on the back of appropriate packaging of attractions and promotion.

Risk and constraints

Carp and coarse fish production and fisheries have suffered on occasion from serious disease, and this remains a risk. However, this sub-sector tends not to be an intensive activity, and the risk of disease is thereby reduced.

Regulatory constraints also tend to be less, since coarse fish can be grown extensively in more enclosed waters with little impact on the quality of river systems.

SWOT analysis - Carp and coarse fish

Strengths/opportunities	Weaknesses/threats
<ul style="list-style-type: none">• This is a diverse sub-sector that can adapt to changing demand• Strong association with countryside recreation, for which demand is buoyant• Large fish are in high demand, and the best (appearance, angling qualities) can be extremely valuable	<ul style="list-style-type: none">• Disease• International trade in high performing strains and large valuable live fish takes place illegally and threatens UK biosecurity• Some decline in the popularity of angling in all its forms• Limited opportunity for development of new "lakes"

Strategic needs

Existing data collection protocols are inadequate to provide a good understanding of this sub-sector. A sample interview survey addressing business structure, trends and perspectives would be of more value than standard returns.

Many producers will require support for business development if they decide to diversify in to countryside attractions rather than continue to rely on the angling.

8.2 Shellfish farming

8.2.1 Seed production

Overview

Shellfish seed (or “spat”) can be sourced from the wild or produced in hatcheries. Hatchery production is relatively poorly developed in the UK, and indeed in Europe more widely, although France is more advanced than the UK with strong local government support, modern large-scale oyster hatcheries and supporting scientific institutions. This is despite the fact that one of the first large-scale experimental oyster hatcheries was started in Conwy, Wales in the 1930’s and was very active and influential through until the 1980s. Substantial shellfish hatchery production research was undertaken at Ardtoe in Scotland. Some of the technology and techniques developed in these hatcheries are still in use worldwide.

Collection from the wild

For both mussels and oysters there are natural beds where juvenile shellfish can be found, and these can be transferred to suitable on-growing grounds – though subject to restrictions if the source area is designated as hosting a disease. Major seed collection grounds for mussels include the Irish Sea and Morecambe Bay and various locations in Scotland. Juvenile and under-sized oysters are routinely dredged in many parts of southern England and re-layed in more suitable areas for on-growing.

Mussel seed can be collected on hanging ropes, and scallop seed on/in suspended mesh bag collectors, hung in strategic locations with a good tidal current and when and where larvae are known to be present. The method is only effective if the collectors can be set for days when peak settlement is imminent. If they are in the water too long fouling by other organisms will prevent effective settlement. A good current is essential to encourage firm attachment of the spat, especially for scallops. Planktonic shellfish larvae can be identified in the water column and collectors set to maximise settlement of target species and minimise fouling which would otherwise greatly reduce collection efficiency. While the approach has many advantages (especially for mussels which readily adhere to the ropes) the unpredictability and inconsistency of settlement and attachment (especially for scallops) makes for an unreliable supply. An emerging problem with mussel seed collection appears to be an increase in “trickle spawning”, i.e. short bursts of spawning and settlement rather than one major seasonal (and harvestable) event. This has stimulated renewed interest in mussel hatcheries in recent years. A recent review on these issues has been published by SARF¹³⁸.

Most mussel producers collect their own spat, although they may also buy in from other shellfish farmers if their own settlement is poor. At the present time there are no dedicated commercial mussel spat collectors. There are however some commercial scallop spat producers around the Isle of Skye and in North-west Ireland, where conditions for settlement are favourable, but these are small operations and do not offer a substantial and consistent source of seed. These producers usually hold the spat for the first year after settlement before selling them for on-growing at a size of 20 - 30 mm shell height. Annual variation is a big problem.

Enhanced and restored fisheries

Oysters may be encouraged to spawn and settle through the use of broodstock beds coupled with settling cultch, and taken a stage further by establishing “spatting ponds” where oysters are laid at strategic locations for the specific purpose of spawning, with settling cultch laid downstream to encourage settlement¹³⁹. This may be done for restoration or harvesting purposes, and recent experience in Swansea bay suggests this may be effective.

¹³⁸ Homarus 2014. New Approaches to Mussel Seedstock Acquisition. Prepared for SARF (SARF report 096)

¹³⁹ Syvret, M., Bayes, J., and Utting, S Sustainable Production Of Native Oyster Spat For On-Growing – Final Report, Ffg Project No: 06/Eng/46/05. For: Seasalter Shellfish (Whitstable) Ltd.

Hatchery production

The technology for shellfish spat production, while more complex than that for salmonids or coarse fish, is nonetheless well established. The normal procedure is to stimulate spawning of broodstock (e.g. by temperature shock), maintain the larvae in suspension in high quality water, and feed with algal cultures. The challenge is to maintain the quality and purity of algal cultures, as well as producing sufficient volumes of algae to feed commercial numbers of spat. Algal feed can be produced very small scale or in significant open tanks, ponds or lagoons in which the seed can be nursed once they have settled. Commercial hatcheries therefore have substantial areas of ponds and tanks (Figure 8.2.1a). Those hatcheries whose main income is derived from research and education can operate with much smaller facilities

Figure 8.2.1a: Commercial oyster hatcheries

Google Earth images of the oyster hatcheries at Walney Island in Cumbria (left) and Reculver in Kent (right) provide a clear indication of the space required to grow algal feed for a commercial scale shellfish hatchery



Other technical issues relate to the desirability of producing triploid oysters for both nature conservation (triploids are infertile) and market reasons (i.e. far better/higher meat content throughout the year). The intellectual rights relating to the techniques used in producing triploid oysters are currently the subject of a legal battle between French and US producers.

Hatchery production of scallop is similar to that for oysters, mussels and other shellfish. The technical procedures are well established, skilled operators are likely to be successful, although rates of production are always difficult to anticipate, and larval survival/successful settlement depends on a wide range of factors. In the UK the currently main source of scallop seed is from Scalpro Norway. Scothatch is commercially associated with Scalpro, and there may be a new initiative to develop a hatchery at Aultbea in Scotland. Some scallop seed may also be sourced from e.g. Tralee Bay hatchery in south west Ireland, but the presence of diseases, and in particular Bonamiasis in Irish waters, constrains movement of any shellfish seed from infected areas to clean areas. Scallop seed is more difficult and costly to transport than oyster or mussel seed because, as it is sub-tidal by nature, the shell does not seal, and transportation out of water is risky for more than 4 - 6 hours at 8°C

It is arguable that other existing shellfish hatcheries specialising in oyster seed or other species might produce scallop seed (and indeed have done so occasionally in the past). However at present hatchery production is constrained by lack of significant and consistent demand; whereas on-growing is constrained by a lack of a consistent and reliable supply of seed.

There are also several small lobster and mixed shellfish hatcheries in the UK, which may be described as semi-commercial (i.e. some seed sales but supported mainly through research, education and/or visitor attractions). Lobster hatchery technology is not as complex and difficult as some, but cannibalism remains an issue, however this is manageable in well-designed systems. There is now a small but significant technology supply and service industry with two British companies trading in the UK, one of which has exported/supported lobster hatchery development in Norway.

There has been substantial progress in recent years developing small “off the shelf” shellfish hatchery systems. These can greatly reduce the required capital investment and lead-time to seed production,

but do not however address the need for significant investment in nursery systems (i.e. space, biosecure water systems, substantial supply of good planktonic food, etc.) in order to take the newly settled spat up to a size that most on-growing farms require.

Disease

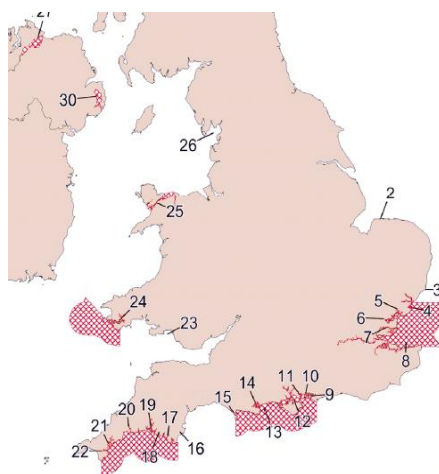
Production and distribution of oyster seed is now heavily constrained by disease. Waters around the UK have defined zones where notifiable shellfish diseases have been recorded. Aquaculturists may not move stock from areas with disease to those without¹⁴⁰. Notifiable diseases of molluscs reported in the UK include *Bonamia exitiosa*, *Bonamia ostreae* and *Marteilia refringens*.

Significant parts of the south coast of England have either *Bonamia* (a parasitic disease) or oyster herpesvirus (OsHV-1 μ var). *Marteilia* has been reported in mussels from the Tamar estuary in Cornwall.

Regulations do not preclude shellfish production, but restrict movement, for example of seed, half-grown shellfish, or live shellfish moved from a grow-out site to a depuration site. Restrictions apply to hatcheries in disease-defined zones irrespective of whether they have or have not recorded the diseases in their systems. While totally enclosed and biosecure systems are feasible, especially on a small-scale, this becomes challenging in larger, more open nursery systems.

- The Seasalter hatchery at Whitstable is in an oyster herpesvirus and *Bonamia* zone, and this significantly restricts sales opportunities. While it may be possible to develop a disease free and biosecure system, this is extremely difficult to demonstrate, e.g. it is very difficult to tell the difference between active and inactive viral DNA. In any case, with a relatively large facility, maintaining biosecurity becomes a major challenge.
- The hatchery at Walney Island, Barrow in Furness, is in a disease free zone. The hatchery is not only owned by and supplies Loch Fyne Oysters in Scotland, it is situated on an important oyster grow-out site with plans for expansion, and subsequently there may or may not be a surplus of seed for sale to other parts of England and Wales.
- The Guernsey hatchery is in a disease free zone (but rather close to France where both oyster herpesvirus and *Bonamia* are widespread and chronic) and has limited nursery space.

Figure 8.2.1b: Confirmed designations for *Bonamia ostreae* (*B. exitiosa* has also been found in area 21) (Laing *et al*, 2014)



At the present time it is likely that anyone wishing to grow oysters in a disease free zone on a substantial scale would have problems sourcing sufficient disease free seed (unless Seasalter can develop a biosecure disease free system, but here remain both regulatory and technical constraints to achieving this).

Oyster seed can also be sourced from France, but is not guaranteed disease free and therefore can only be imported into designated disease affected areas. However, French production is on a large-scale and highly efficient, making this seed relatively cheap to purchase. The French are also heavily engaged with the Irish Industry. Arguably the current situation encourages the regular import of potentially diseased seed.

Bonamiasis, a serious parasitic disease that decimated the French and British oyster industries, has occurred in all the main fishery areas listed above since 1982, and seven other areas in England, Scotland, Wales and Northern Ireland since 2005. It is most prevalent in the south east of

England – and especially in the farmed sites in the Essex creeks (Figure 8.2.1b).

¹⁴⁰ Council Directive 2006/88/EC and Commission Regulation [EC] No 1251/2008

Regulations prohibit the movement of stock out of disease-designated areas for relaying or depuration into any area free of *Bonamia* or other specified pathogen. Another species of *Bonamia*, *B. exitiosa* was found in a single oyster from the Helford in 2011, although not found since. *Bonamia* is also found in France, Ireland (since 2002) and Norway (2008), and indeed more widely in Europe.

Bonamiasis effectively wiped out the oyster industry in on the south coast of England in the 1980s, with a ten-fold decrease in landings in some areas (though tributyl tin antifouling was probably also a contributory factor). Since then there has been a partial recovery.

However, bonamiasis was detected in Northern Ireland for the first time in 2005 and in Scotland and Wales for the first time in 2006. Since then bonamiasis has been detected in native oyster in seven new areas in England, Scotland, Wales and Northern Ireland¹⁴¹. Possible causes of spread include movement of shellfish to depuration facilities, movements of oyster dredgers between fishing grounds, oyster seed on boat hulls, or larvae released with ballast water. Various invertebrate species may also act as carriers. Measures have been put in place to prevent further spread of the disease from these areas. Regulations prohibit the movement of stock out of a re-laying area or depuration facility in a confirmed, designated disease area into any area free of *Bonamia* or other specified pathogen.

A more recent disease, Oyster herpesvirus or OshV-1 μ var, has been a major problem with Pacific oyster in France, and is now present in Ireland (where production businesses are closely associated with the French Industry) and a first outbreak occurred in south east England in 2010. France is also suffering from an outbreak of the bacteria *Vibrio aestuarianus* that appears to affect older oysters and may be exacerbated by hot weather.

Again, shellfish cannot be moved from areas designated with disease to those without, and this includes movement to a centralised depuration facility. In turn this means that any shellfish grower in a disease-designated zone must have access to depuration facilities within their own or some other diseased zone.

Depuration

In accordance with the requirements in EC Regulation 854/2004, Annex II, Chapter II, bivalve mollusc production areas are classified A, B or C according to bacteriological criteria (levels of *E.coli* found in samples from the site)^{142, 143}. Shellfish cultivated in harvesting areas with a 'B' classification must be purified of any faecal bacterial content before sale for consumption. Depuration is undertaken in tanks and normally for at least 42 hours in UV-treated re-circulated seawater. Shellfish harvested in Class C areas must be re-layed for at least 2 months, followed by depuration, although this may be avoided if the product is to be subject to approved heat treatment. Most sites in England and Wales are classified B, some C (with a shorter class B season).

Only the following locations meet Class A standards:

- Horseshoe Point, Humber
- Kentish flats, North Kent Coast
- Porlock, Somerset
- Carrigananean and Ballyedmond, Carlingford Lough (provisional) and Skate Rock, Strangford Lough

Business structure and economic contribution

There are currently three fully commercial oyster hatcheries in England, Wales and Northern Ireland - in Cumbria¹⁴⁴, Kent¹⁴⁵ and Guernsey¹⁴⁶. These are all relatively small businesses, typically employing

¹⁴¹ Laing, I. *et al*, 2014. Epidemiology of *Bonamia* in the UK, 1982 to 2012. Diseases of Aquatic Organisms. Vol. 110: 101–111, 2014

¹⁴² <https://www.food.gov.uk/enforcement/monitoring/shellfish/shellharvestareas>

¹⁴³ <https://www.Cefas.co.uk/media/52553/201504-classification-protocol-revised-version-12-final.pdf>

¹⁴⁴ <http://www.morecambebayoysters.co.uk/>

¹⁴⁵ <http://www.oysterhatchery.co.uk/>

3 - 5 people (plus technical management), and each turning over perhaps £150,000 - £250,000. The main inputs are capital investment (largely written off by the current commercial operations) and skilled labour. Feed is grown rather than brought in, and the hatcheries may maintain their own algal stocks for significant periods. Energy consumption is also a significant cost. Value added is relatively high and downstream value added in grow-out trade and retailing is substantial.

Most mussel producers collect their own spat, although they may also buy in from other shellfish farmers if their own settlement is poor. Currently there are no dedicated commercial mussel spat collectors. In previous years there was a substantial Dutch market for mussel seed, supplied in large part from North Wales and Ireland. However, this has greatly diminished in recent years due to increased accessibility of local supplies from the Wadden Sea.

The North Atlantic Fisheries College (University of the Highlands and Islands) is currently developing a research hatchery with a particular focus on mussel seed supply aimed at the substantial mussel farming industry in Shetland. This is a 30-month multi-partner collaborative project involving key aquaculture stakeholders, including Scottish Government, academia, and private enterprise¹⁴⁷.

There are some commercial scallop spat producers around the Isle of Skye and in northwest Ireland, where conditions for settlement are favourable, but these are small operations and do not offer a substantial and consistent source of seed. These producers usually hold the spat for the first year after settlement before selling them for on-growing.

Scalpro¹⁴⁸, Norway have supplied both oyster and scallop seed to UK growers in the past, but are largely research funded and have not become a major commercial source. Scothatch¹⁴⁹, based on the West Coast of Scotland is currently collaborating with Scalpro, and has aspirations to develop a fully commercial scallop hatchery that might supply the whole UK.

In Scotland small amounts of oyster seed are available from FAI Ardtoe¹⁵⁰, and in the past this facility has also produced seed of scallop and other species. While biosecurity is excellent here, there is limited space, and it is unlikely that this hatchery could meet any significant increase in demand. However, we understand some £2 million of joint private and EMFF funding is being invested in this facility.

There are several small lobster and mixed shellfish hatcheries in England, Wales and Northern Ireland, which may be described as semi-commercial, including lobster hatcheries in Padstow (National Lobster Hatchery¹⁵¹) and at Anglesey Sea Zoo¹⁵². These are primarily funded through research, education and visitors, rather than sales of seed although the National Lobster Hatchery does have some support from local fishermen. Elsewhere in the UK Orkney Sustainable Fisheries¹⁵³, in association with Northbay shellfish, have operated a lobster hatchery for many years with support from local fishermen's associations.

The three main commercial oyster hatcheries in England, Wales and Northern Ireland probably generate £0.5 - £0.75 million in revenue, of which a substantial proportion (probably 2/3) is value added. These three hatcheries also support 12 - 15 FTE (Table 8.2.1a). This does not include lobster, shrimp or any other hatcheries that are not yet evidently commercial from an aquaculture production perspective, nor employment relating to the trade in seed mussels or small oysters for relaying.

¹⁴⁶ <http://www.guernseyseafarms.com/index.html>

¹⁴⁷ <http://scottishaquaculture.com/trial-could-lead-to-scotlands-first-commercial-shellfish-hatchery/>

¹⁴⁸ <http://settleproject.com/consortium/scalpro>

¹⁴⁹ <http://www.scothatch.com/>

¹⁵⁰ <http://www.fairfarms.com/our-locations/scotland/>

¹⁵¹ <http://www.nationallobsterhatchery.co.uk/>

¹⁵² <https://www.angleseyseazoo.co.uk/>

¹⁵³ <http://www.orkneysustainablefisheries.co.uk/>

Table 8.2.1a: Economic parameter estimates: Oyster hatcheries

Production (millions)	~500 million / Highly variable
Number of businesses	3
Revenue	£0.5 - £0.75 million
Employment	12
Value added	£0.35 - £0.5 million
Main inputs	Capital, skills

Markets, comparative advantage, scale issues and growth potential

Current seed supply of oysters, scallops and clams is inadequate to meet demand, or underpin significant expansion of production. The UK has comparative advantage as an island nation in terms of disease control, and significant parts of the UK remain clear of shellfish diseases such as *Bonamia* and oyster herpesvirus, and effective import controls should allow this status to be maintained to some degree. There is an in-built comparative advantage for any domestic producer operating in a disease-free zone in supplying the domestic market¹⁵⁴.

There is also seed demand for shellfish restocking. The native oyster is a European Biodiversity Action Plan species and the UK has a responsibility to enhance natural stocks (under the Native Oyster Species Action Plan, NOSAP). The native oyster is also a commercially important species supporting many fishermen especially in SW England, the Solent and in Essex.

The UK has suitable temperatures for the production of oyster, scallop and clam, all of which are in high demand in national and international markets. Furthermore, the UK arguably has significant historic comparative advantage in shellfish hatchery technology, although the French and perhaps the Norwegians have overtaken the UK in recent years. Given current actual and potential demand, and the opportunity for significant R&D under the new EMFF, there is no reason why the UK should not restore its forefront position in shellfish R&D.

Notwithstanding the broadly positive outlook, hatchery production in the UK is constrained by lack of significant and consistent demand, whereas on-growing is constrained by a lack of a consistent and reliable supply of seed; a frustrating “chicken and egg” scenario. Production and distribution of oyster seed is also heavily constrained by disease.

Mussel seed is not usually limiting, and the case for hatchery production is less strong. However erratic supply in Shetland has led to strong support for mussel hatchery research in Scotland, and the requirements for shellfish eating coastal birds have to be assessed before consents for removal of seed for aquaculture are issued. There may be opportunities for one or more specialist mussel seed collection companies to establish sites around the UK to ensure more consistent and predictable seed supplies, and therefore simplify on-growing procedures.

Although lobster fishery enhancement faces some major challenges there have been some encouraging results in recent years. Survival rates at sea of up to 20 - 40% have been achieved, and contribution to fishing can be high. A 25 year stocking programme might result in a 100 year impact if combined with effective management and “ownership” institutions. However, this would need very long-term investment and strong, consistent industry support.

¹⁵⁴ However, this is less than simple. For example, some British oyster growers in diseased areas may be happy to source seed from French hatcheries also in disease zones – and indeed these seed may be cheaper precisely because they come from a diseased zone

SWOT analysis - Shellfish hatcheries

Strengths/opportunities	Weaknesses/constraints
<ul style="list-style-type: none"> • More professional specialist collection of seed, sourcing from many sites around the UK to even out seasonal and annual variations in settlement could result in more reliable supply of mussel and scallop seed • The British Isles have natural comparative advantage in terms of biosecurity, so long as prevention and management measures are fully and effectively implemented • The UK has a long history of leading/cutting edge hatchery technology. Current examples include the work at the National Lobster Hatchery and ShellPlant¹⁵⁵ project at Swansea • Temperatures are very suitable for oysters, mussels, scallops and clams in most parts of England, Wales and Northern Ireland and there is significant current demand from existing/prospective on-growing enterprises 	<ul style="list-style-type: none"> • Supply of seed from collection from the wild is often unreliable and inconsistent • There are too few existing hatcheries to guarantee consistent production across and between years and for a range of species • Despite the relatively good disease status in the UK (e.g. relative to France) there are problems that restrict movement of seed and constrain commercial operations • Establishing a hatchery and developing the necessary skills and protocols – according to species and location - requires many years of dedication and substantial long term investment

Strategic needs

- A Government-industry seed supply and quality improvement strategy which addresses both wild collection and hatchery production
- Modest and focused investments made or supported and based on strategic needs
- Research on effective viral neutralisation/screening and hatchery certification

8.2.2 Oyster on-growing for the table market

Overview

Native oysters have been managed for hundreds of years around the UK coastline¹⁵⁶. Major fisheries in England are the Solent (17,500ha of beds) and the Fal (where no mechanically propelled vessels are allowed). The south coast harbours of Portsmouth, Langstone and Chichester are public fisheries, although they are covered by local fishery byelaws. Essex creeks (especially the River Blackwater and Walton Backwaters) are commonly stocked with oysters from the Solent and harvested at the end of each growing season.

Oyster culture is highly varied. It ranges from “managed” fisheries (e.g. where oyster beds are raked or dredged and smaller animals returned for on-growing), through to relaying systems where small oysters are fished or collected in one area and relayed in another, and highly controlled production systems where seed from hatcheries or the wild are reared and cultivated under relatively controlled conditions.

Pacific oyster have been introduced in to the UK intermittently since 1890 in response to a crash in native oyster stocks, and disease free stocks were officially introduced in 1967 through the Conwy shellfish laboratory. Pacific oysters have become naturalised in most of southern England, and are now of much greater commercial significance than native oysters¹⁵⁷. This relates to the abundance of the stock and the higher growth rate (natives take 4 – 5 years grow-out, compared to 3 years or less for Pacifics), and better market characteristics (though there is probably regional variation and

¹⁵⁵ <http://www.swansea.ac.uk/csar/projects/shellplant/>

¹⁵⁶ Humphreys, J., Herbert, R., Roberts, C., and Fletcher S. 2014. A Reappraisal of the History and Economics of the Pacific Oyster in Britain. *Aquaculture* 428–429 (2014) 117–124

¹⁵⁷ See Humphreys op cit for thorough appraisal of history and economics

opportunity for both in this regard). Pacific oyster seed can be purchased from hatcheries or small oysters are sourced from wild oyster fisheries and re-laid at designated growing sites¹⁵⁸

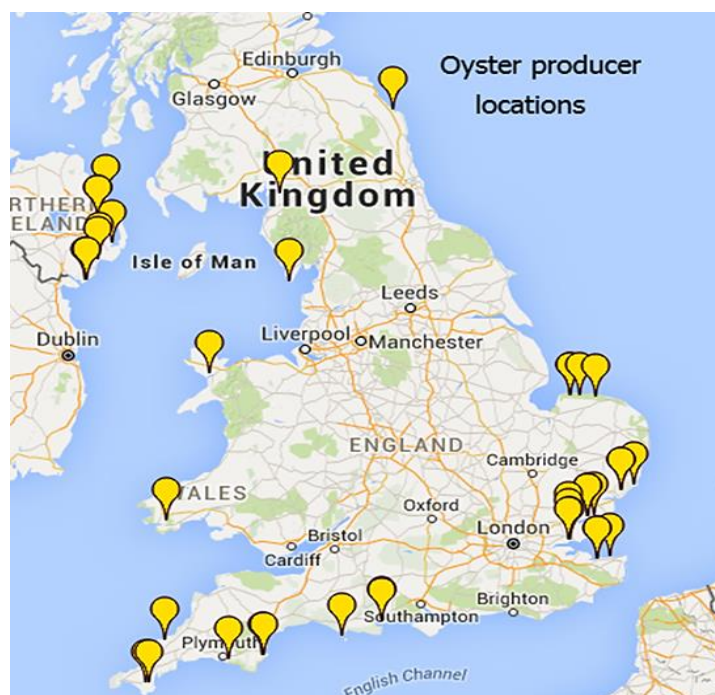
Most oyster production is mainly from laid beds in southern England and from oyster bags on trestles in Morecambe Bay. While the latter are more expensive, there is less predation and growth rates may be higher (although relative performance of different grow-out systems depends critically of local conditions). Some production also takes place in Strangford Lough, Northern Ireland.

Business distribution, structure and economic contribution

Significant oyster aquaculture businesses include Morecambe Bay Oysters¹⁵⁹ (also a hatchery); Duchy oysters¹⁶⁰ (Fal), Othniel oysters¹⁶¹ (Poole); Limosa Oysters (near Plymouth); Lindisfarne oysters¹⁶² (Northumberland); Seasalter Whitstable¹⁶³ (also a hatchery); Cuan Oysters in Strangford Lough and Killough Oysters in County Down. In addition, a new community interest company (CIC) has recently established to grow oysters in Porlock Bay¹⁶⁴, Somerset.

Most of the oyster fisheries are managed (oysters are turned and small oysters may be re-layed), and therefore regarded by some as aquaculture, and these are included in the distribution map (Figure 8.2.2a).

Figure 8.2.2a: Distribution of oyster producers in England, Wales and Northern Ireland



In Scotland production is limited and dispersed, with the largest operators being Loch Fyne Oysters, Cumbrae oysters, West Kilbride, and Kyle of Tongue oysters (on the north coast). There is also a managed (selective fishing/partial re-laying) oyster fishery in Loch Ryan.

An estimated 36 businesses are engaged in oyster grow-out, employing an estimated 184 FTE. They produce approximately 1,200t of annually, with first hand sales value of £4.6 million. (Table 8.2.2a).

¹⁵⁸ Designated Pacific oyster relaying areas include West Mersea (Old Hall Creek); Poole (South Deep); Percuil; Lower Fal (St Just) Helford (Calamansack)

¹⁵⁹ <http://www.morecambebayoysters.co.uk/>

¹⁶⁰ <http://www.thewrightbrothers.co.uk/wholesale.html>

¹⁶¹ <http://www.othniel.com/>

¹⁶² <http://www.lindisfarneoysters.co.uk/>

¹⁶³ <http://www.oysterhatchery.co.uk/>

¹⁶⁴ <http://www.porlockbayoysters.co.uk/>

Table 8.2.2a: Economic contribution of Oyster farming

Production	1200t ¹⁶⁵
Number of businesses	36
Revenue (value of first hand sales)	£4.6 million ¹⁶⁶
Employment (Direct FTE)	184
Value added (direct)	£2.3 million ¹⁶⁷
Main inputs	Capital, skills, seed

Humphries (2014 op cit), using a shell value of 20p estimates gross output for pacific oyster (>90% of production) at the lesser figure of £2.66m. However, by considering all stages of production through to export he estimates total gross output (i.e. based on export and retail prices) at £13.4m and GVA for the sub-sector at £10.1m. While this gives some idea of the kind of downstream benefit that may be associated with relatively modest levels of production, it should be noted that the GVA multipliers used are highly uncertain.

Markets and comparative advantage, scale issues and growth potential

The markets for both native and Pacific oysters are now strong and prices are rising. (Figures 8.2.2b and 8.2.2c),

Figure 8.2.2b: Production and price trend for Pacific oyster in Europe (source FAO FISHSTAT)

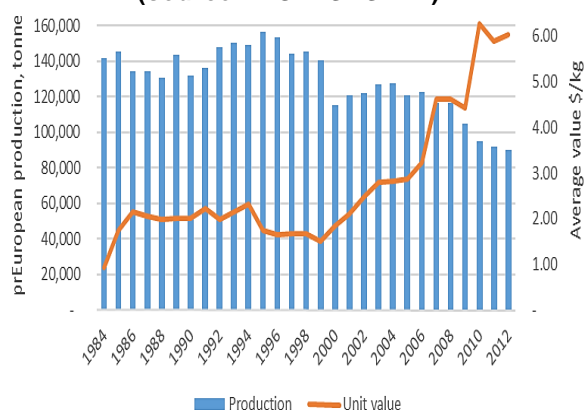
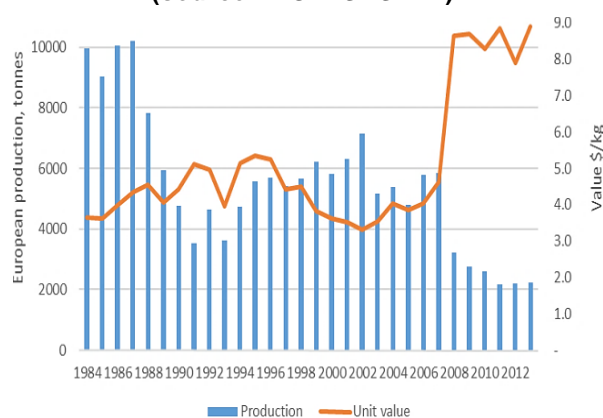


Figure 8.2.2c : Production and price trend for native oyster (source FAO FISHSTAT)



This is due to a combination of steadily increasing demand in the UK market (especially in London and southern England more generally, primarily in the high-end restaurant market), plus falling production in Europe (Figures 8.2.2d and 8.2.2e), strong demand in France, as well as increasing demand from China and SE Asia.

Whilst France is by far the biggest producer of Pacific oyster in Europe, they suffered a massive reduction in production in 1973 due primarily to bonamiasis and have suffered a more chronic decline

¹⁶⁵ Variable from year to year. This the figure used by Humphries (2014) as a sensible estimate in recent years. FAO statistics suggest no great change since.

¹⁶⁶ Based on value as estimated by Cefas 2012. This is almost double the value as estimated by Humphries (2014)

¹⁶⁷ Assuming value added at 0.5 of first hand sales. Note that Humphries (2014) uses 0.55 based on industry level published multipliers.

since 1995 probably due to oyster OsHV-1 μ var (oyster herpesvirus) and more recently the bacterium *Vibrio aesturianus*. This has had a dramatic impact on price - which has jumped in recent years from \$2 to \$6/kg.

While it is likely that French oyster production will recover eventually, there is a window of opportunity for the UK to establish itself as a significant producer, especially if it can maintain large disease free areas, and establish itself as the pre-eminent supplier to China and SE Asia. Currently 67% of UK oyster production is exported across the globe; from France to SE Asia¹⁶⁸.

Figure 8.2.2d: Production of Pacific oyster in Europe (source FAO)

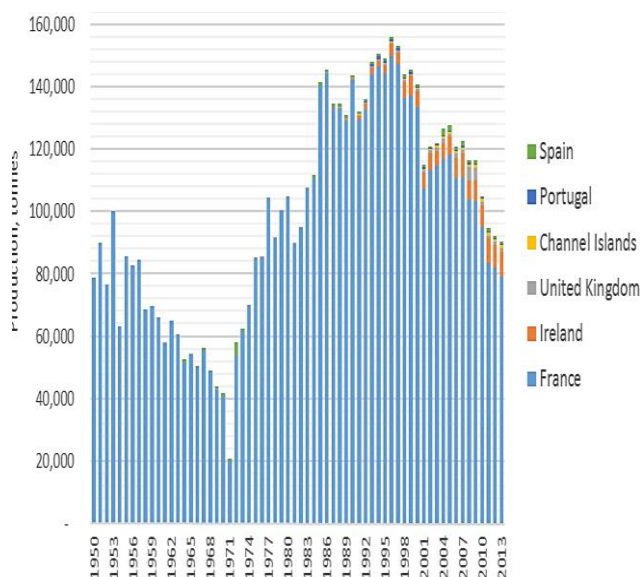
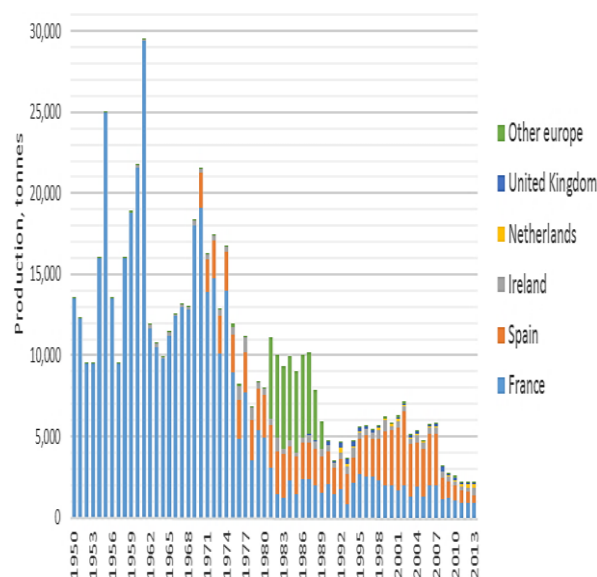


Figure 8.2.2e: Production of Native oyster in Europe (source FAO)



Southern England and South Wales have a significant temperature advantage for oyster culture. This translates into a much shorter grow-out cycle than that in northern England, Northern Ireland and Scotland, and these two regions have a relatively large number of potentially suitable sites (i.e. sheltered, relatively nutrient rich, shallow, estuarine), whereas Scotland is more constrained in this regard. On the other hand, disease is more widespread in the southern parts of the UK. Several producers however suggest that disease is not a major issue so long as production density is maintained at sensible levels.

Warmer temperatures in southern parts of the UK possibly favour bonamiasis and *Vibrio aesturianus*, and this may favour Scotland over England and possibly England over France (although there is always the trade-off with higher growth rates). High salinity may also favour some pathogens, suggesting a possible advantage in the brackish water estuaries of the UK. It is also suggested by some in the industry that recent wet summers may have favoured a decline in the incidence, or at least the impact, of *Bonamia*.

The market for the native oyster is smaller and could be flooded relatively easily, but there is an opportunity nonetheless for niche high-value “genuine native” production. Again it is arguable that the UK, and especially England, Wales and Northern Ireland, have comparative advantage in the production of this species.

¹⁶⁸ Humphreys et al 2014 op cit

Risks and constraints

Disease from imported stock or from the local aquatic environment is the main threat to successful oyster production, closely followed by food safety issues. Disease is both a risk and opportunity; there is always the danger that it will strike, but the UK has some comparative advantage in terms more effective biosecurity opportunities.

Food contamination/safety issues (mainly faecal coliforms, norovirus and algal toxins) and associated closures are significant problems. There is a strong and widespread feeling in the industry that they are effectively paying the price for poor regulation and management of sewage during exceptional precipitation events or periods. The recent downgrading of some shellfishery classifications is of significant concern to the industry.

Inadequacies in the testing regime may also have devastating effects on the industry where closures follow. In the summer of 2013 England's SW region was closed for four months. There was widespread concern in the industry about the accuracy and representativeness of the sampling and the need for the closure. Given the strict protocols associated with depuration, it seems likely that a more cost effective and safe system could be developed.

SWOT analysis - Oyster production

Strengths/Opportunities	Weaknesses/Constraints
<ul style="list-style-type: none">Oyster prices are at historic high with strong demand from France and increasing demand in the UK and Asia, e.g. recent Valentine's Day sales have demonstrated significant growth potentialLarger seafood companies are beginning to invest in oyster production confirming market potentialEngland, Wales and Northern Ireland have suitable water temperatures, and sites for increased and competitive production of native and Pacific oystersEngland, Wales and Northern Ireland and the Channel Islands are home to 3 well established oyster hatcheries with many years' experienceEngland, Wales and Northern Ireland has the potential for better biosecurity than continental producersA more cost effective regulatory regime, taking full account of the potential/role of depuration, and opportunities for self-testing/regulation/reporting	<ul style="list-style-type: none">Seed production is inadequate to meet demand; and is unpredictableDisease status of surrounding waters is constraining the sales of one hatcheryOysters prefer estuarine conditions that are vulnerable to closuresEngland, Wales and Northern Ireland has surprisingly few Category A shellfish waters - related in part to poor regulation and management of land based sources of pollutionThe Sanitary and Phytosanitary (SPS) testing/closure regime appears to be inadequate and inefficient

Strategic needs

- A more cost effective food safety testing regime
- Better regulation of sewage outfall/overspill during exceptional precipitation periods
- More positive and pro-active planning for sustainable shellfish aquaculture development through the various planning and economic development procedures
- Careful maintenance and market exploitation of biosecurity advantages of island status and strong regulatory regime

8.2.3 Mussel growing for the table market

Overview

Mussels can be dredged or raked from natural and/or laid beds, also grown on long-lines. In recent years Shetland has become an important producer of rope grown mussels (generally regarded as of higher quality than bottom grown mussels though this is not necessarily the case), and has demonstrated that long-line production of mussels on a significant scale is economic. The concentration of activity in Shetland allows for substantial volumes of product to be transported down to distribution centres in central Scotland.

England, Wales and Northern Ireland have significant mussel (blue mussel) production, mostly bottom-cultured, however rope-grown mussels are produced in several locations and volumes may well increase significantly in the future, particularly in SW England.

There is a perception that natural settlement of mussel spat has been decreasing in recent years, and this is creating problems for the rope-growing industry in Scotland, which relies wholly on this source for seed stock. This is thought to be the main factor behind recent production declines¹⁶⁹. In addition, some strategically important production areas, such as Loch Etive, in Scotland have been severely impacted by the occurrence of a damaging invasive species of soft shelled mussel.

Business structure, distribution and economic contribution

By far the largest producer of mussels in England, Wales and Northern Ireland is Bangor Mussel Producers Ltd, North Wales¹⁷⁰ (an association of four independent businesses, including Deepdock, Extramussel, Myti Mussels and Ogwen Mussel).

Production is based on mussel seed collected in Morecambe Bay, Caernarfon Bay, and the River Dee Estuary, which is then re-laid in the productive, sheltered and accessible waters of the Menai Strait. The association also uses spatting rope seed from Morecambe Bay Oysters and other sources. These bottom cultured Menai mussels are dredged, graded and re-laid, or marketed as appropriate, and the production is MSC certified¹⁷¹. Other mussel producers in this area include Conwy Mussels¹⁷² (based on hand raking rather than dredging). Production from the Menai Strait varies between 6,000 and 9,000t per year.

In addition, rope-grown mussels (i.e. mussels collected on or attached to a series of ropes suspended from a moored and buoyed long-line) are now being produced in Swansea Bay, in St Austell Bay and in Lyme Bay. The latter Offshore Shellfish Ltd.¹⁷³ is a major initiative with large offshore permits and promises to be the largest rope-grown mussel producer in Europe producing up to 5,000t, possibly 10,000t annually.

In England, Wales and Northern Ireland a total of 25 registered businesses (Figure 8.2.3a) produce mussels as their primary activity, generating £10 - £20 million in farm gate revenues (of which around 2/3 will be value added). These businesses support 125 FTE in employment (Table 8.2.3a).

¹⁶⁹ Homarus 2012. New Approaches to Mussel Seedstock Acquisition. SARF Research Report 96.

¹⁷⁰ <http://menaimussels.com/home-1.aspx>

¹⁷¹ MEP 2012. North Menai Strait Mussel (*Mytilus edulis*) Fishery (Certificate Mep-F-002) Public Certification Report For Unit Of Certification Extension To Include River Dee As Seed Collection Site

¹⁷² <http://www.conwymussels.com/>

¹⁷³ <http://www.offshoreshellfish.com/>

Figure 8.2.3a: Distribution of mussel producers in England, Wales and Northern Ireland

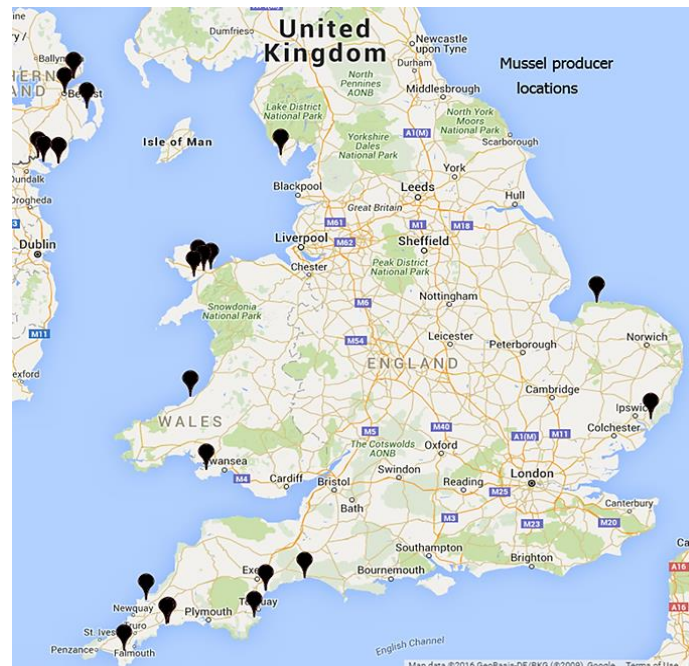


Table 8.2.3a: Economic contribution of mussel farming

Production	20,000t
Number of businesses	25
Revenue	£15 - £30 million (prices and production variable)
Direct employment	125
Value added	£6 - £12 million
Main inputs	Capital, skills

Markets, comparative advantage, scale issues and growth potential

Mussel farming is a well-established business in Europe with substantial production from rafts and ropes in Spain, rafts and poles in Italy and France, and managed beds in the Netherlands and the UK. Perhaps surprisingly, and despite relatively strong prices, European production has declined since a peak in 1999, due mainly to natural declines in the Netherlands and some production problems in Spain (Figure 8.2.3b).

Mussel supply and price are highly variable from year to year, although a clear relationship between supply and price within Europe is not evident. There was a substantial strengthening of price in the late 1990s as the variety of products increased (in particular vacuum packed), and mussels are undoubtedly more popular in the UK than they were.

Figure 8.2.3b: Production of mussels in Europe (source FAO)

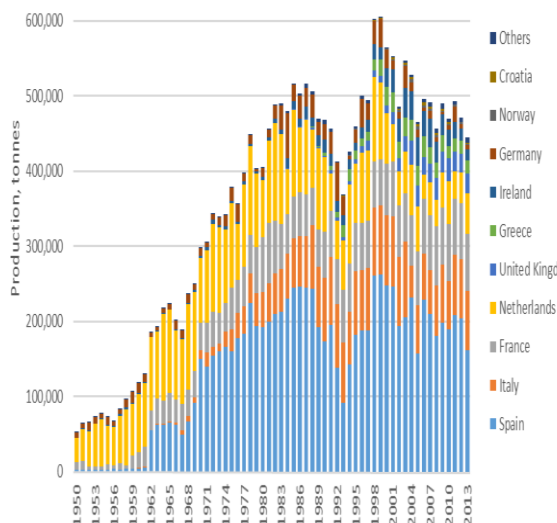
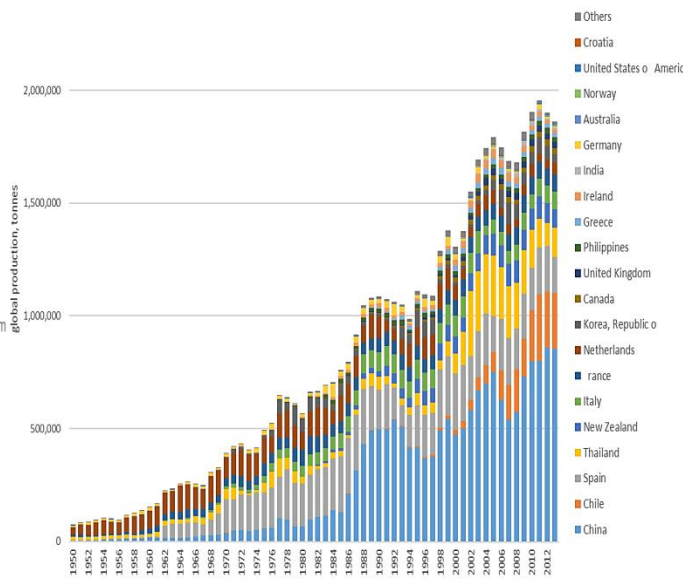


Figure 8.2.3c: Global production of mussels (Source FAO)



There are two examples of mussel farming development worthy of note here. New Zealand has demonstrated that large-scale rope-grown mussel production can develop as a global business, generating a wide variety of fresh and processed products (in this case using the Green lipped mussel). New Zealand production expanded from around 1,000t in 1979 to 83,000t in 2013. It is now a major industry - large-scale production, highly mechanised, and accessing global markets. Production from Chile has also increased rapidly in recent years and has been highly effective at penetrating the bulk whole/frozen mussel meat markets (Figure 8.2.3c).

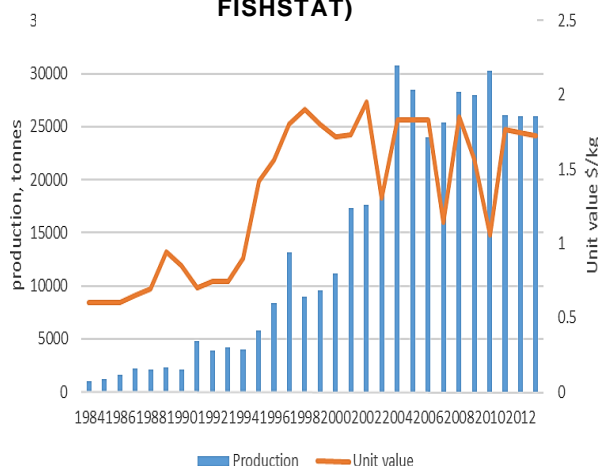
Closer to home, Shetland has been successful at developing medium-scale rope mussel production and now produces around 6,000t. Investment was forthcoming in part on the back of the successful salmon industry, and effective sales were achieved largely through the Scottish Shellfish Marketing Group (SSMG¹⁷⁴), which distributes fresh mussels and produces a variety of convenience/ready meal packs.

Growth potential

The market for mussels is strong in Europe, Asia and the US. Mussels are well suited to a variety of fresh and convenience products and as additives to seafood dishes more generally. The potential for growth of high quality bottom and rope grown mussels is well demonstrated in other countries, and in parts of the UK. The climate of England, Wales and Northern Ireland is well suited to the growth and health of blue mussel. However, given the significant global competition, it is likely that success will only come with scale – for both bottom and rope grown mussels. England, Wales and Northern Ireland must be able to compete with a very wide range of producers in the UK, Europe and globally, and though prices are good relative in comparison to past prices (Figure 8.2.3d), £1/kg is not a high price for a fresh shellfish product.

¹⁷⁴ <http://www.scottishshellfish.co.uk/>

Figure 8.2.3d: Production and price trend for UK mussels (source FAO FISHSTAT)



Risk

Despite the potential this is a risky business. Large-scale production still depends on natural spat fall that is often variable and has caused some problems for the Scottish industry. Even when spat fall is good, retention after settlement may be compromised by high levels of fouling by other marine creatures or by severe weather at critical times. Fouling can also threaten growth and operations of grow-out stages. Problems with invasive species such as soft shelled mussel can be very damaging. Larger scale offshore systems must also make large investment if they are to withstand high-energy offshore environments – implying a trade-off between investment risk and payback period, and the risk of loss.

Constraints

Offshore Shellfish Ltd in Lyme Bay took 10 years to get off the ground (or into the water), largely because of the difficulties in getting permits to use significant areas of water. This related to fishing, navigational and environmental concerns as well as the sheer complexity and uncertainty of the regulatory process. This creates particular difficulties for shellfish farming because however suitable the site may appear, piloting must be undertaken to assess spat fall, growth rate, fouling issues etc. If piloting itself becomes associated with a heavy regulatory burden, then the whole development process becomes too costly and uncertain to justify the time and investment needed. This is arguably the main constraint to increased mussel production in England, Wales and Northern Ireland.

SWOT analysis - Mussel production

Strengths/opportunities	Weaknesses/threats
<ul style="list-style-type: none"> Large global market, fair national market, and relatively buoyant demand Relatively short grow-out time compared with other shellfish Opportunities for both fresh and value added processed products Suitable climatic regime Significant offshore areas that might be developed with sufficient investment 	<ul style="list-style-type: none"> Strong competition from Europe, New Zealand, Chile Difficult to predict site suitability because of variations including; Spat fall, Fouling, Tubeworm, Predation Threat of shellfish poisoning, norovirus, and bacterial contamination – especially at inshore sites Relatively few Class A shellfish waters Relatively few sheltered sites for SME scale start up Permitting complexity, uncertainty and delay – for both piloting and scale up Regulatory regime onerous and from some perspectives “not fit for purpose”

Strategic needs

- A strategic policy and regulatory environment premised on the assumption that there will be sustainable development of shellfish aquaculture in suitable locations
- A role for Government itself to facilitate and help start-ups navigate the regulatory obstacles and uncertainties
- More effective regulation of land-based pollution sources and more Class A shellfish areas
- A testing regime fit for purpose

8.2.4 Scallops for the table market

Overview

Great Atlantic or King scallops are fairly demanding in terms of site suitability, requiring high salinity (30 - 35ppt), and, if bottom grown, clean, firm sand, fine gravel or sandy gravel sometimes with a mixture of mud, and an optimal depth of 15 - 30 metres.

There has been much research on scallop culture - historically by the White Fish Authority (now Seafish), particularly at Ardtoe in Scotland, and by a range of small and large companies (notably “King Scallop” in Scotland). Still, scallop farming has never established itself in England, Wales and Northern Ireland. The main constraint in Scotland for instance, has undoubtedly been the long grow-out cycle, coupled with the high cost of containment, and in some instances with fouling and associated high labour costs. Inconsistent seed supply from collectors has also been an issue for some initiatives, although in some cases Queen scallops (*Aequipecten opercularis*) have been collected and reared as an alternative.

Lantern nets and various types of basket can be used to contain scallops (which are capable of swimming short distances by flapping their shells) and to protect them from predators. Containment is costly due to the large number of nets or cages needed to avoid crowding (which can lead to mortality), and maintenance and labour costs over a long grow-out period, usually about 4 years. One method of significantly reducing these costs, but exposing the scallops to “unofficial fishing” and other risks, is to start culture in lantern nets and after 12 - 18 months release the scallops on to the seabed for the final 1 - 2 years growth.

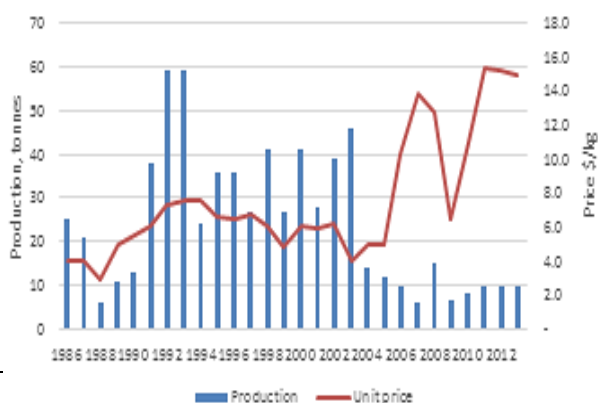
This “ranching” approach is feasible because although mobile, most scallops remain within 30 metres of the point of their release, generally spreading out until they achieve a density of less than one scallop per square metre, although higher densities may be achievable at particularly favourable sites. Survival at this stage can be high, as much as 80%. This method requires the granting of a Several Fishery Order¹⁷⁵, or a lease on an existing Several Order. At least three companies in the UK are exploring this “ranching” approach, however gaining support and permission for ranching may be difficult if it involves the “displacement” of existing inshore fishing activities.

Business structure and economic contribution

Three companies are currently involved in scallop aquaculture in the UK, along with several smaller initiatives. Scothatch, based in Scotland has sourced seed from Scalpro, Norway, (using locally sourced broodstock) and aim to keep the young scallops in nets for the minimum period before deploying them on the seabed and rearing for hand-dive harvesting. Scothatch is commercially associated with Scalpro, and there may be a new initiative to develop a hatchery at Aultbea in Scotland. Results so far suggest good growth and viability. Dawnfresh in Scotland has also trialled scallop spat collection and grow-out, but to date have only had significant settlement and growth of Queen scallops.

Scallop Ranch¹⁷⁶, Torbay, has been partly funded by a Philanthropic Trust and aims to produce market size scallops either exclusively from long-lines, or from long-lines followed by a sea ranching phase, which would include using local fishing boats to harvest in the conventional way. To date they have also obtained seed from Scalpro, Norway (using locally sourced Lyme Bay broodstock). Trials on “seeding” commercial scallop beds off the Isle of Man were also undertaken but did not continue.

Figure 8.2.4a : Production and price trend for UK King scallop (source FAO FISHSTAT)



Markets, comparative advantage scale issues and growth potential

The major European producer of farmed scallops was Spain in the 1990s, but this industry has since collapsed (due mainly to temperature stress and disease), and main suppliers are now Ireland and Norway, with a small contribution from the UK and France. European aquaculture production is now very limited at less than 100t and prices are high (£10/kg) (Figure 8.2.4a). High quality

¹⁷⁵ <https://www.gov.uk/guidance/shellfisheries-several-orders-and-regulating-orders>

¹⁷⁶ <http://drcompany.co.uk/wp-content/uploads/2014/02/Scallop-Ranch.pdf>

sustainably produced scallop (such as hand dived) command a substantial premium over wild scallops, especially since awareness of the damage caused by scallop dredgers has been highlighted in recent years.

Many sites around southern coasts (i.e. the English south coast and parts of Wales) provide good conditions for scallop aquaculture. Food (plankton and detritus) would not be a limiting factor, and as growth rates are primarily influenced by temperature (optimum growth rate and condition achieved between 12 – 16°C), these waters may be optimal by providing a long (8 – 9 month) growing season. Some recent commercial experience suggests that time to market as little as 2 - 3 years may be achieved, though full grow-out has not yet been achieved and some research suggests that as scallops approach market size, growth becomes less temperature sensitive. Nevertheless, southern England is arguably one of the best places in Europe to grow King scallops. By contrast, suitable sites in Scotland are likely to be limited to a 5 - 6 month growing season, corresponding to up to 5 years to reach minimum market size of 100 - 110mm (25g meat yield (adductor plus gonad)).

Risks

Lantern nets are commonly used to reduce predation, but are high cost and high maintenance, and therefore increase financial risk. Investment may be reduced by transferring the stock to the seabed as quickly as possible, but this increases the risk of natural predation on the young stages, and poaching for the larger stages.

There are also risks associated with contamination and production water closure as described for the other shellfish. Price is also very variable - related to the unpredictability of the capture fisheries production.

SWOT analysis - Scallop production

Strengths/Opportunities	Weaknesses/Threats
<ul style="list-style-type: none"> • Good market value • Near optimum temperatures for King scallop and Queen scallop. 2 - 3 years grow-out has been demonstrated in England compared with 4+ in Scotland and Norway • Prefers marine conditions which are less susceptible to contamination issues than estuarine/brackish water suited for other shellfish species • Not susceptible to major known shellfish diseases • Laid/ranched scallops can be diver collected with associated market premium • There is natural spat fall around UK coasts that might be exploited by specialist spat collection company • Hatchery technology is well established and there is some UK expertise. There may be an opportunity to combine scallop seed with other shellfish hatcheries • There may be opportunities for offshore scallop production in collaboration with fishermen under various "ranching" arrangements 	<ul style="list-style-type: none"> • Variable price related to capture fisheries supply • Security/poaching likely to be more serious in England, Wales and Northern Ireland compared to Scotland/Norway particularly at larger scale extensive sites using bottom culture • Need either or both expensive cages and lots of space. The latter may interfere with fishing/navigation interests. • Suitable sites are few, depending on access; shelter; limited alternative use/designation • The lack of seed prevents viable start-up; the lack of demand for seed undermines the financial rationale for hatchery start-up • Long grow-out in lantern nets increases susceptibility to bio-fouling and/or high labour costs • More sensitive than mussels and oysters, live sales more difficult. Shells do not fully close; they do not do survive out of water; do not like regular handling • Recent experience in commercial scale hatchery production is limited

Strategic needs

- Strategic needs are similar to those for other shellfish species. However, there is a more pressing issue in terms of the need for consistent levels of hatchery production, since there are no existing commercial hatcheries, and natural spat settlement is erratic
- This reinforces the need for a clear national shellfish seed strategy that addresses the varied but overlapping needs for seed of many different species, supported by national or European R&D and commercial enterprise start-up support

8.2.5 Other shellfish

Clams

Small quantities of the naturalised hard clam and Manila clam are produced from time to time in southern England. The hard clam was introduced accidentally in to English waters and is now naturalised in Southampton Water. The Manila clam was introduced intentionally in 1980. It has been produced in significant quantities in the past but has suffered periodic setbacks due to disease; nonetheless it has culture potential. There is also potential to produce the native clam (*Ruditapes decussatus*, also known as palourde or carpet shell).

Cefas record 9t of hard clam and 5t of Manila clam production in 2012; most likely from the harvest of naturally recruited animals from Several Order areas. This compares with tens of thousands of tonnes produced in the US. Production is normally dependent on hatchery produced seed (using techniques similar to those used for oyster and scallop. See Annex 9). Grow-out is usually in muddy estuarine beds in far low tide/sub-tide areas, and protected from predation by sheets of plastic mesh. Harvesting can be mechanized using modified potato harvesters.

There is a large global market for clams. Italy has been the biggest producer (with more than 40,000t) but has suffered disease problems, subsequently the market outlook for increased UK production is generally good. Many of the English and Welsh estuaries could be developed for clam farming (preferably the native clam), but there are likely to be objections in some areas, e.g. from conservation interests concerned at the loss of feeding habitat for wading birds.

Cockles

There are opportunities to harvest small cockles from very dense beds, re-lay at lower densities for better growth, before harvesting using techniques such as suction dredges or similar. Large cockles may sell for as much as £4/kg. This production may be regarded as aquaculture, or managed fishery depending on perspective. There is current commercial interest in developing this management system.

Lobsters and prawns

Tropical lobster (*Panulirus* spp) farming, based on stocking wild caught juveniles in marine cages is a substantial business in other parts of the world (e.g. Vietnam and parts of China to supply the Chinese and Thai markets), but to date has not been developed in Europe despite some success in hatchery production as described in previous sections. It should be noted that these Asian systems are highly dependent on “trash fish”¹⁷⁷, and achieve very poor feed conversion rates.

To date there have been several trials on seeding European lobster (*Homarus gammarus*) capture fisheries in the UK – in Shetland and in SW England, but the economic viability of this approach remains questionable.

There is also a current research initiative funded by InnovateUK¹⁷⁸ and the Biotechnology and Biological Sciences Research Council (BBSRC¹⁷⁹) to develop a sea-based nursery and on-growing rearing systems for the European Lobster - led by The National Lobster Hatchery, partnered with Exeter and Falmouth Universities, Cefas, Fusion Marine¹⁸⁰ and Westcountry Mussels of Fowey¹⁸¹. There has also been recent research in Wales on the spiny lobster (*Palinurus elephas*), but both are some way from commercial culture.

Globally the most important shellfish aquaculture species is the hardy Whiteleg shrimp (*Litopenaeus vannamei*), that can be cultured in brackish water. There are various initiatives in Europe (including in

¹⁷⁷ Small fish species, damaged catch and juvenile fish are sometimes referred to as 'trash fish' because of its low market value. Usually part of a (shrimp) trawler's bycatch. Often it is discarded at sea although an increasing proportion is used as human food or as feed in aquaculture and livestock feed. <http://www.fao.org/faoterm/en/?defaultCollId=14>

¹⁷⁸ <https://www.gov.uk/government/organisations/innovate-uk>

¹⁷⁹ <http://www.bbsrc.ac.uk/>

¹⁸⁰ <http://fusionmarine.com/>

¹⁸¹ <http://www.westcountrymussels.co.uk/>

the UK) to grow these crustacea in RAS systems. However, global competition to supply these animals (produced in very large quantities in SE Asia and South and Central America) is huge, commodity prices are close to lowest current production costs, and a substantial premium will be required to make European and/or UK farming of this species economic.

8.3 Ornamental fish and plants

There are a handful of farms, located mainly in southern England, producing freshwater ornamental fish – for the home aquaria and garden pond market. The most important species are goldfish, koi carp, orfe, and varieties of tench.

In addition to government statistics on this sub-sector there are other sources of information, in particular the Ornamental and Aquatics Trade Association (OATA), which is the representative body for the UK ornamentals industry.

While this appears at first sight to be a very small sub-sector, the ornamental fish trade as a whole is economically significant, and its downstream impact is highly significant. An unpublished report prepared in 2006¹⁸² suggested that the UK imports over £16 million of freshwater and marine ornamental fish, and is the largest importer of ornamental fish in the EU. This study estimated retail turnover at between £273 million and £474 million, and is probably closer to the latter. Recent figures from the OATA suggest that the value of ornamental fish imports peaked at around £19 million in 2009, but has since fallen to around £16.5 million. Freshwater fish represent at least 75% of this trade.

More than 30% of this trade are imports from Singapore, although most of this will be sourced from elsewhere in SE Asia. Israel, Indonesia, Japan, Thailand and Sri Lanka are also major sources. There is also a substantial industry closer to home in the Czech Republic. Live imported ornamental fish are typically worth in the region of £10-12/kg, and there are somewhere between 60 and 100 UK importers.

Production in the UK, mainly of coldwater freshwater fish (such as goldfish, koi carp, orfe, etc.) represents a small proportion of this trade, estimated by Rana *et al* (2006) at 4.6% of the total value (or 11% of numbers).

Business structure and economic contribution

National statistics provide very limited insight into the value of this industry, numbers and weight of fish are largely irrelevant, but value is highly dependent on species, quality, etc.

There are seven significant registered production businesses currently operating in England, Wales and Northern Ireland (Figure 8.3a); four relatively small family businesses, three more substantial businesses employing between 5 - 9 persons. Employment is around 41 FTE.

The main producers of ornamental fish and plants in England, Wales and Northern Ireland include; Hampshire Carp Fisheries¹⁸³, Green Line Ornamental Fish¹⁸⁴, Cuttlebrook Koi¹⁸⁵, Neil Hardy Aquatica¹⁸⁶, The Carp Company¹⁸⁷, and Anglo-Aquatic Plants¹⁸⁸. Some other operators may also produce aquatic plants as a secondary activity.

¹⁸² Rana, K. J., Sturrock, H.T., Rooney, W., Young, J.A., & Bostock, J.C., 2006. *Strategic economic analysis of the ornamental aquatic trade in the UK*. Report Commissioned by Defra (Project FC0933) from the University of Stirling, 89pp.

¹⁸³ <http://www.hampshirecarp.co.uk/>

¹⁸⁴ <http://www.berryring.com/greenlinefish.asp>

¹⁸⁵ <http://www.cuttlebrookkoifarm.co.uk/>

¹⁸⁶ <http://neilhardyaquatica.com/>

¹⁸⁷ <http://www.carpco.co.uk/index.php>

¹⁸⁸ <http://www.angloaquatic.co.uk/>

Figure 8.3a: Distribution of ornamental fish and plant growers



In addition there are significant numbers (more than 165¹⁸⁹) of “garage aquarium” or “Facebook” operators. While these may be regarded as innovative entrepreneurs, they are not subject to effective regulation and may undercut the formal sub-sector, and more worryingly, undermine wider biosecurity protocols.

Total production at present is around 11,000 juveniles and perhaps 1t of larger pond fish. Although no good data is available, farm gate value is probably of the order of £1.5 million, of which 2/3 or more will be value added (Table 8.3a).

Table 8.3a: Economic parameter estimates: ornamental fish

Production	1.34million juveniles; 1t larger fish
Number of businesses	7
Revenue	£1.5 million + ¹⁹⁰
Employment (direct)	41 ¹⁹¹ (formal); 165+ (informal)
Main inputs	Capital, wages

Markets, comparative advantage, scale issues and growth potential

The UK and Germany are by far the most important importers of ornamental fish in Europe. Many tropical marine fish are still sourced from the wild, but most cold freshwater species are artificially bred and reared, and an increasing proportion of tropical freshwater species are also farmed. There are around 80 ornamental importers in the UK importing £16m of freshwater and marine ornamental fish.

Freshwater fish, for both indoor aquaria and outdoor ponds, still represent the largest market segment, and a significant proportion of these fish could be produced in the UK. There has been

¹⁸⁹ Industry source

¹⁹⁰ Estimate based on 50FTE (formal and informal) with sales per employee of £30,000

¹⁹¹ Note that Rana et al 2006 estimated 30-40 jobs in ornamental fish production in the UK

some modest growth in ornamental production over the last 20 years, but the industry is still dominated by imports.

It has been estimated that 15% or more of UK households keep aquatic pets. Retail sales of ornamental fish in the UK have been estimated at £400m associated with perhaps 10,000 jobs. The income and employment multipliers for this sub-sector are exceptionally high; £1m in production or imports may generate as many as 500 retail jobs.

There is a strong argument for more UK production of ornamentals; suitable climate in southern England for growing goldfish, etc., coupled with the high cost of importing and transporting live fish, and increasingly rigorous biosecurity. However, the market for temperate species could be supplied by relatively few farms, so the economic impact would be relatively limited (at most £5 million in farm gate sales and 50 farm jobs), and the downstream impact will occur irrespective of sourcing (domestic or imported). However, it would have the additional advantage of reducing the risk of importing disease with imported fish.

There is also an opportunity to produce a much wider range of species (freshwater and marine, fish, plants and other organisms) in temperature controlled RAS; and given the high value/weight ratio and rapid turnover of most small aquarium species and the great advantage of producing live fish close to holding and retail outlets, the investment may be justified. However, the possible impact of this production on developing country suppliers needs to be taken into account.

In any case there is already significant international competition - production of aquarium fish is a substantial business in the Czech Republic, where there are efficient networks of small-scale producers exporting roughly \$18 million worth of ornamental fish including both coldwater species and tropical aquarium species. UK investors would need to study this competition carefully before identifying the best market "niche".

The industry is struggling with some regulations, for instance the impact of biocides regulations on use of barley straw for pond cleaning, and the constraints of invasive species regulations (e.g. on aquatic plants¹⁹²).

SWOT analysis – Ornamental fish and plant production

Strengths/Opportunities	Weaknesses/threats
<ul style="list-style-type: none"> The production sector generates substantial downstream impacts Gardening remains very popular and stocking garden ponds with fish could certainly be increased with positive publicity. 3 million UK households have ponds, only a small fraction of which stock fish There are substantial opportunities for the production of a much wider range of aquarium species in recirculation aquaculture systems UK is SVC¹⁹³ free, unlike Ireland and parts of continent (Denmark) 	<ul style="list-style-type: none"> Most downstream impacts would be realised irrespective of origin Average garden size is in decline; reduces the likelihood of significant ponds in gardens In the past many advocates of "wildlife ponds" advised against stocking with fish Unregulated producers not subject to FHI/Animal Plant and Health Agency (APHA) regulations and protocols can undermine formal producers following the appropriate codes and regulations Anti-pet trade campaigns¹⁹⁴ e.g. Eurogroup for Animals exotic pet campaign Inconsistent/incoherent approach to pet shop licensing may undermine good animal welfare practices and bring the industry into disrepute

Strategic needs

- The sub-sector needs to be formalised and properly regulated. The present structure disadvantages the few formal operations, and exposes the wider industry to risk

¹⁹² <http://www.nonnativespecies.org/beplantwise/>

¹⁹³ Spring Viraemia of Carp

¹⁹⁴ <http://www.ornamentalfish.org/hands-off-my-hobby>

- This is an area where basic support for entrepreneurial activity (e.g. breeding valuable tropical species in RAS) such as partial grants or low interest loans linked with technical advice could make a significant difference

8.4 Marine Algae

There has been significant interest in recent years on seaweed cultivation for biomass, including a major EU funded research programme, and significant research by Bord Iascaigh Mhara (Irish Sea Fisheries Board, BIM) and various universities. Marine research institutions in France (especially Brittany) have also been active in this area.

The FAO Guide to the Seaweed Industry¹⁹⁵ offers a useful overview of the use of seaweed worldwide though this is now rather dated. A review of seaweed cultivation for biomass was undertaken for the Marine Scotland in 2010¹⁹⁶, and a commercial/economic feasibility study was undertaken for Scottish Enterprise in 2011¹⁹⁷. The latter concluded that mass production of seaweed for biomass (e.g. for use in anaerobic digesters) was unlikely to be economic in the near future, and that other alternative energy sources were more cost effective.

However, there is some potential for the production of high value food products from seaweeds - sophisticated structural organic compounds, nutraceuticals and food supplements/additives including low calorie sweeteners. Some seaweeds also contain valuable sterols, which have antibacterial, antifungal, and cytotoxic properties. There might also be some potential for production of animal feed additives. Further development of innovative high-value algae-based products would require substantial and committed long term R&D and this will need to be grounded in comprehensive market and economic feasibility studies.

It must also be acknowledged that there are major global food product corporations engaged in seaweed collection and culture, and if mass production of seaweeds appeared to be promising in England, Wales and Northern Ireland investment would probably be visible already. The future, if any, for seaweed culture in England, Wales and Northern Ireland, will be in innovative high-value niche products developed by determined entrepreneurs working closely with research institutions. To date, the emphasis has been on the research, and work has been driven by research funding. There needs to be a shift in favour of joint product R&D with entrepreneurs with a strong commercial instinct.

By way of example, Selwyn Seafood has recently begun to market seaweed snacks made from wild *Porphyra*. They are now working with Swansea University and other parties (e.g. Swansea Bay Tidal lagoon project¹⁹⁸) with a view to culturing their own seaweed.

Strategic needs

- In depth feasibility studies (technical, economic, market) on promising seaweed products as identified in previous research
- Graduated start-up grants and loans to entrepreneurs tied in with R&D funding and periodic economic review and assessment

¹⁹⁵ FAO 2003. A Guide to the Seaweed Industry. FAO Fisheries Technical Paper 441

¹⁹⁶ James, M.A., (2010) A review of initiatives and related R&D being undertaken in the UK and internationally regarding the use of macroalgae as a basis for biofuel production and other non-food uses relevant to Scotland. Report commissioned by the Marine Scotland, 79pp

¹⁹⁷ Hambrey Consulting/Nautilus Consultants 2011. The economic development potential of seaweed harvesting and cultivation in Scotland. Feasibility study: rationale and opportunities to facilitate and support innovation and commercialisation in seaweed cultivation. Confidential report to Scottish Enterprise.

¹⁹⁸ <http://www.tidallagoonpower.com/>

9.5 Recirculation Aquaculture Systems (RAS), aquaponics and Integrated Multi-trophic Aquaculture (IMTA)

Recirculation aquaculture systems (RAS) remove solid wastes and nutrients¹⁹⁹ from the effluent of a fish production unit and recirculate a proportion of the water back into the system. The higher the proportion of water recirculated, the more sophisticated the treatments systems must be, and may include some or all of any of the following treatments:

- Settling of wastes
- Aeration/oxygenation
- Biological filtration (aerobic and anaerobic)
- Physical filtration
- Chemical filtration or treatment
- Treatments such as ozonation and/or UV

RAS can be used for both freshwater and marine production, although water quality management is more challenging in the latter.

RAS is an intensive form of livestock production and generates substantial amounts of relatively concentrated waste (both metabolic and e.g. uneaten feed) in the form of suspended solids, and nitrogen and carbon in a variety of forms. Attempts have been made to integrate RAS with heated effluent streams, with a view to reducing heating costs for aquatic species requiring higher than ambient temperatures, though this may also be achieved with high recirculation rates in well-insulated buildings.

Aquaponics takes the recycling concept one-step further by utilizing a proportion of these wastes for the production of plants - usually relatively high quality, high-value vegetables and herbs, and build on the very substantial expertise that has developed in the commercially successful field of hydroponics. Comprehensive reviews have recently been undertaken on both RAS²⁰⁰ and aquaponics²⁰¹.

Integrated Multi-trophic Aquaculture (IMTA) is similar in conception to aquaponics, but applies to more 'open systems' and does not usually involve any recycling. By way of example, seaweeds and/or shellfish may be grown in close proximity to marine finfish reared in cages. In theory the nutrients and/or waste particles from the intensive finfish farming can be exploited by the seaweeds and shellfish; boosting growth of the latter while reducing the waste entering the wider environment from the former.

There has been substantial public investment in particularly in RAS in recent years, and for this reason a relatively detailed appraisal of its potential is presented.

9.5.1 RAS

The rationale for RAS is strong:

- Increased control of water temperature and other water quality parameters in line with optimum requirements of the cultured species, potentially resulting in better growth and feed conversion efficiency
- Potential for year round production
- More flexible siting, with potential for more localised production and/or siting close to major markets, therefore reduced "food miles"
- Co-location with processing facilities and improved traceability

¹⁹⁹ Using a varied combination of one or more of settling tanks, biofilters, physical filters, chemical filters, aeration/oxygenation, ozone treatments, UV treatment.

²⁰⁰ Murray, F., Bostock, J., and Fletcher, D. 2014. Review of recirculation aquaculture system technologies and their commercial application. Prepared for Highlands and Islands Enterprise by Stirling Aquaculture.

²⁰¹ Hambrey Consulting 2013 The relevance of aquaponics to the New Zealand aid program. Commissioned report for the New Zealand Ministry of Foreign Affairs and Trade
http://www.spc.int/aquaculture/index.php?searchword=aquaponics+hambrey&ordering=&searchphrase=all&option=com_search

- Reduced water demand
- Easier control, management and utilization of feed and metabolic waste
- Potential for improved biosecurity

RAS has been around since the 1950s and evolved in parallel with more generic wastewater treatment systems. There was much research and commercial interest in these systems in the 1970s, initially in salmonid culture in the USA, carp culture in Germany, and subsequently with a variety of species, including trout, carp, eels and tilapia in Europe. Several of these were associated with industrial heated effluents – from power stations, textile manufacturers, chemicals companies and others²⁰². These enterprises faded away once grant or research funding ended, or because of difficulties reconciling the needs of fish culture and the priorities of parent companies.

Since that time RAS technology has been widely applied in hatcheries and for early stage growth (e.g. for salmon smolts), and for trout production in Denmark where effluent regulations are stringent. Globally there have been numerous trials, pilots and business ventures using RAS for numerous species, e.g. one of the most recent is a commercial enterprise in Denmark to grow table salmon in RAS (Langsund Laks²⁰³). In the UK there have been several pilots and commercial initiatives for table fish production in both freshwater (e.g. tilapia, barramundi) and seawater (e.g. turbot, European seabass), but success has been limited and significant investment has been lost on many of these ventures.

There are currently two initiatives to grow tropical shrimp in RAS (in Lincolnshire²⁰⁴ and northern England), and plans for a turbot RAS system in Portland, southern England²⁰⁵, as well as a site in Wales for an integrated food production facility including tropical prawns and vegetables/herbs²⁰⁶.

The limited success and high failure rate of RAS systems for grow-out (i.e. table fish) is due to a combination of technical, economic, management and marketing issues that can be summarized as follows:

- Production of table fish/shellfish usually requires large volumes of high quality water; effective wastewater treatment to a level suitable for recirculation requires high levels of capital investment. There has to be substantial growth rate/feed conversion rate advantage to offset these costs. Estimates by various authors (reviewed in Murray *et al*, 2014²⁰⁷) suggest that capital investment is likely to be roughly double that for equivalent marine cage systems. Lead-time to full production may be higher because of technical complexity and the need to develop a wide range of skills, monitoring and management systems. Operational costs are then likely to be at least 20 - 30% higher than equivalent cage culture systems²⁰⁸
- Aquaculture production and trade is global, and tropical and sub-tropical countries are now highly efficient aquaculture producers operating under generally favourable temperature regimes and able to produce a very wide range of species. With relatively low international air-freight charges, it is extremely difficult for RAS to compete with these producers in anything other than relatively small, high-value niche markets
- Managing water quality in RAS systems requires well designed systems coupled with high levels of skill and experience. Poor water quality will rapidly undermine any other growth or health advantage related to optimal temperatures
- RAS systems are relatively complex, and failure of any part may lead to rapid system collapse and loss of stock. This can be addressed in part through better design, more sophisticated monitoring and backup systems, and skilled staff, but this further increases capital costs
- RAS systems may be operated as highly bio-secure units and this is arguably a significant advantage. Properly designed RAS farms have the capability to reduce disease outbreaks and

²⁰² Hambrey, J. 1981. Technical and economic consequences of increasing fish growth through the use of waste heat in aquaculture. PhD thesis, University of Stirling 1981.

²⁰³ <http://langsundlaks.dk/technology/>

²⁰⁴ <http://www.flogrosystems.com/>

²⁰⁵ http://www.seafish.org/media/1391567/acig_april2015_landfish.pdf

²⁰⁶ <http://www.ukconstructionmedia.co.uk/news/green-investment-for-anglesey/>

²⁰⁷ Murray, F., Bostock, J., and Fletcher, D. 2014. Review of recirculation aquaculture system technologies and their commercial application. Prepared for Highlands and Islands Enterprise by Stirling Aquaculture.

²⁰⁸ Note that every system and every comparison will be different and these estimates should only be taken as examples

deal more rapidly and effectively with pathogenic parasites than flow through or cage farms. This has been demonstrated several times at a commercial level in a marine RAS farms. However, if bacterial, fungal or viral diseases do enter the system (e.g. with stock, in make-up water, etc.), total system disinfection (requiring re-establishment of biological treatment systems) may be required, with serious implications for production

- While RAS may be regarded as environmentally friendly, energy costs are nonetheless significant, and intensive indoor production of fish does not chime well with premium and organic markets (though most such systems have sought such accreditations)
- While waste management should be easier than it is for cages i.e. where solid and dissolved wastes enter the wider environment directly, RAS wastes nonetheless have to be utilised or disposed. This is easier for freshwater systems (wastes can be applied directly as fertilizer for vegetable or crop production) but more difficult for marine systems where salt content reduces its value as a generic fertilizer/soil conditioner

There are many potential trade-offs with RAS including:

- Higher stocking densities will reduce the costs per kg of production, but high densities of stock increases risks and management needs (e.g. water quality parameters can change more rapidly), and possibly increases stress in some species, and may compromise animal welfare standards
- RAS located closer to markets can reduce transport miles, but RAS typically use more energy than flow through or cage systems (although a great deal depends on location and logistics)
- Temperature control can be greatly enhanced through insulation and smart technologies, but these will require more upfront investment

The key issue for the success of RAS is comparative advantage. Can the product be produced more cheaply (or sold at a higher price) than that of actual or potential competitors? The following sections explore some of the current opportunities and initiatives.

RAS and salmon smolts

The main success with RAS in the UK and Europe so far has been for growing salmon smolts (Box 8.5a). Smolts are high-value and in high demand in a sub-sector with substantial capital availability, technical expertise, and where there is no serious competition. RAS is particularly suited because

Box 8.5a: Commercially successful RAS

"In the UK, juvenile rather than table-fish production provides the most sustained example of commercial adoption, specifically for the production of juveniles in hatcheries and salmon smolts for cage/pond on-growing. Smolts constitute up to 20% of table-fish whole live farm-gate price, making them a high-value commodity; over three times the value of table-fish in weight terms. At the same time their production in RAS incurs a relatively small proportion of total salmon production costs. Consequently RAS have made a considerable contribution to increased smolt yields".

Murray, F., Bostock, J., and Fletcher, D. 2014. Review of recirculation aquaculture system technologies and their commercial application. Prepared for Highlands and Islands Enterprise by Stirling Aquaculture

salmon smolts, weight for weight, are three times the value of table-fish, and full control and timing of production is the key to success.

There may be some opportunities for extending the production of smolts into early stage grow-out in order to maximize the use of limited inshore cage capacity, and there is little doubt that the major players in the industry are now seriously exploring these options. This may not benefit England, Wales and Northern Ireland; investment may be directed closer to grow-out sites in Scotland (as is

happening for smolt production²⁰⁹), although expansion at existing sites in Cumbria may make commercial sense.

The same rationale applies to early stage production of other fish and shellfish species. Most hatcheries employ RAS technology; allowing for better monitoring of feeding and health of vulnerable early stages, biosecurity, temperature and photoperiod manipulation for breeding purposes or strategic seasonal timing of production, etc. These benefits outweigh the higher costs, which in any case form a smaller part of full life cycle production costs. Of particular note is the current, successful production of wrasse and lumpfish (cleaner fish for the salmon industry) in recirculation systems²¹⁰.

RAS and table salmon

Langsand Laks, based in Denmark and seeking to produce 1,000t of premium salmon per annum from a RAS, and are seeking a 30% premium on their production, to compensate the estimated 20 - 30% higher operating costs compared with marine cage salmon aquaculture systems. While this may be achievable for 1,000t production to highly niche markets, it is unlikely to be sustained should the industry expand significantly, especially as the sustainability and welfare credentials could be seen as somewhat ambiguous.

RAS and table trout

Freshwater recirculation technology (which is somewhat simpler than marine) has been applied successfully to trout production in Denmark and the USA. In Denmark, investment was driven by what were regarded as draconian environmental regulations introduced in the late 1990's. Many at the time thought these would put an end to trout farming in Denmark which had grown steadily to over 40,000t production. However, the Government responded by offering generous grants and technical support to develop and install waste treatment and recirculation systems. Investments were made and the Danish industry survived, although production has slowly declined to around 30,000t, and an increasing proportion of that is now produced in marine cages, where it is typically securing a 10% price premium/kg. Some British trout farmers are of the view that the UK should invest in trout recirculation systems; but others say that Danish investments were made at a time when prices were higher, and that current price levels simply could not justify such investment.

It has been estimated that the minimum cost for RAS produced trout would be around £3.8/kg²¹¹. This would be loss making under present market conditions and in the absence of a hefty "sustainability" premium. Economies of scale might make this a more attractive proposition, but these are modest, and the financial risk would increase substantially. Given the increasing competition from marine cage production and bulk production in other countries, such investment would appear to be unwise at the present time.

²⁰⁹ Marine Harvest has recently made a £20 million investment at Inchmore, Scotland in a RAS smolt production system capable of holding 14 million fish in an 18,000 cubic metre system²⁰⁹. <http://www.fishupdate.com/work-starts-on-20m-highlands-hatchery/>

²¹⁰ There has recently been interest and investment across the UK in breeding wrasse and more recently lumpfish to act as cleaner fish and to support the sea lice eradication programme in the Scottish salmon sector.

- During August and September 2013 6,000 Scottish bred Ballan wrasse and 3,000 Goldsinny wrasse were transferred to Scottish salmon farms - a £2 million joint research project based at Machrihanish involving Scottish Sea Farms and Marine Harvest
- A similar 2012 project with Scottish Salmon Company and Meridian Salmon Group was undertaken by Otter Ferry Seafish to farm Ballan wrasse with the objective of deploying more than 250,000 farmed wrasse at the companies sites. Lumpfish could perhaps be seen as a more favourable species to use as cleaner fish than wrasse as they can be stocked in greater density in cages (at 10% as opposed to the 4%), they feed all year, and are less susceptible to the vibrio infection. They are also easier to farm, robust, hardy and are faster growing than wrasse.
- In Shetland a joint project between salmon farming company Hjaltsland, Shetland Aquaculture and NAFC Marine Centre is looking at lumpfish as an alternative cleaner fish to wrasse
- Marine Harvest Ltd is currently supporting a combined production and research programme into the lumpfish, at Swansea University. RAS Aquaculture Research Ltd. introduced the contract opportunity to the University. The University is currently identifying techniques for large-scale production of the species. Swansea University was identified as a suitable location for this work because of its technically advanced marine RAS technology facility

²¹¹ Industry source

RAS and European Seabass

A RAS facility in Anglesey, North Wales was initially set up in 2002 with a £840,000 Welsh Government grant²¹². In 2012 Anglesey Aquaculture Ltd. was purchased by Tethys Ocean (the aquaculture division of Linnaeus Capital Partners²¹³) and aimed to produce 800 - 1,000t of European seabass in its sophisticated recirculation system. Anglesey Aquaculture secured supply contacts with the retailer Waitrose, and seafood suppliers M&J Seafood²¹⁴ and Sealord²¹⁵.

In July 2015 production ceased. According to John Watters, MD at the time, this was due to “challenging market conditions” related to large volumes of low priced seabass imported from Mediterranean. Others have suggested that the Greek financial crisis contributed to dumping of seabass onto the markets at near cost prices²¹⁶. However, Anita Hamilton, Partner and MD of Linnaeus, said “buyers are not ready to pay a premium for UK grown fish”. There were also production issues that compounded the problem - “growth rates are still much lower than expected from growing fish at these temperatures; and the expense and volume of the power supply”²¹⁷.

The economic assumption behind the investment was that high quality sustainably and locally grown fish could be sold for £8-9/kg; but seabass can be grown more cheaply in cages in the Mediterranean. The rapidly increasing production from Turkey and Greece was fair warning that there would be a price squeeze at some point, at which time industry prices would fall to around the cost of production of the most efficient producers (around £3 - £3.5/kg²¹⁸). While a premium could undoubtedly be maintained, the absolute price was bound to fall and squeeze out more costly indoor RAS production.

Some have argued that when prices fall to close to production cost of the most efficient systems, more committed and strategic producers could switch to alternative species. This may be, but to re-enter the production and marketing learning curve when a company is already under financial pressure will in itself be costly and uncertain, and the same competitive problems are likely to be encountered again – unless RAS is clearly the most sustainable and cost-effective technology. This is yet to be demonstrated for any species in the UK other than smaller high value fish, and the assumption that this could be part of a commercial investment strategy (i.e. “we could always switch to something better”) is economically naive. Investment must be predicated on clearly identified opportunity and comparative advantage. It is also worth noting that the salmon production industry in Scotland requires around 5 - 6 staff to produce 800t of table fish; Anglesey aquaculture employed 22 people to produce this amount of fish. In other words, high capital and operating costs are compounded by high labour costs.

It may be concluded that a great deal of public as well as private money²¹⁹ has been wasted on this and similar ventures directed at table fish production - through lack of understanding of production and markets on the one hand, and lack of realistic and impartial appraisal of RAS costs and benefits on the other. While North Wales has undoubtedly benefitted in many ways from the substantial R&D investment and the inflow of European funds (Box 8.5b), the lack of commercial success highlights the need for more robust, transparent and fully independent technical, economic and market analysis.

²¹² <http://www.bbc.co.uk/news/uk-wales-north-west-wales-20839439>

²¹³ <http://linnaeuscpl.com/index.html>

²¹⁴ <http://www.mjseafood.com/>

²¹⁵ <http://www.sealord.com/our-story/> <http://gtfsgroup.co.uk/sealord-caistor-ltd/>

²¹⁶ Industry source

²¹⁷ <http://www.intrafish.com/news/article1415285.ece>

²¹⁸ Peker, K., and Ertekin, H. 2011. Economic analysis and development strategies of seabass enterprises in the Mediterranean region of Turkey. Bulletin UASVM Horticulture. 68(2)/2011.

²¹⁹ The Anglesey operations have received more than £5m in European and Welsh Government funding and more than £10m in private finance

Box 8.5b: RAS and Wales

“The interest in RAS in Wales has generated significant employment in research and development. Through RAS Aquaculture Research Ltd. the two Wales RAS farms have generated some 20 - 25 EU Framework 6 & 7 research programmes related specifically to RAS technology development. These have benefitted Wales and England Research, Technology Developments (RTDs) plus SMEs. Some projects have actually resulted in creation of new technologies now nearing commercialisation to support both RAS and cage operation. North Wales now has the most in-depth knowledge of marine RAS operation and design more than comparable with anywhere in Europe and the US and is generating significant business in Europe, Gulf and SE Asia”.

Dr David Fletcher, RAS Aquaculture Research Ltd.

RAS and turbot and halibut

Since the late 1970s there has been significant interest in growing both halibut (a high value northern finfish species) and turbot (a medium value temperate/sub-tropical finfish species) in RAS. Globally there are five enterprises now growing halibut in partial recirculation systems – one in Scotland, three in Norway and one in Nova Scotia. These are relatively small-scale, niche market producers. The Scottish farm (Gigha Halibut²²⁰) produces around 75t per annum and hopes to expand to 150t. It has been in production since 2007. This is a premium product selling to top restaurants and nice retailers at £12/kg. This farm uses a high volume of pumped seawater with effluent treatment but only limited recirculation.

Turbot has been farmed for many years, and the UK was originally at the forefront of technical development in turbot culture, some of which took place in RAS. This species is more suited to higher temperatures and the bulk of production now takes place in Spain in outdoor land-based systems with open-circuit pumped seawater, or marine cages. There is some limited production in RAS, but these fish are less amenable to the high densities required to make RAS economic.

It is unclear whether England, Wales and Northern Ireland have comparative advantage in the production of either of these species: halibut prefer temperatures in the range 10 - 14°C depending on size; turbot prefer temperatures in the range 15 - 22°C, which explains the distribution of current aquaculture activity.

RAS production of exotic freshwater species

There have been RAS initiatives using exotic species in freshwater in northern Europe, including tilapia and barramundi (Asian seabass). Freshwater RAS systems are somewhat easier to manage, and species such as tilapia are relatively hardier and are easier to grow in sub-optimal water quality. Unfortunately, their demand is limited, their market value is lower, and these enterprises have failed to meet expectations to date. This was probably in large part due to relatively poor RAS technology resulting in poor water quality and poor tasting (tainted) product²²¹. It is very difficult to see how these projects will compete, given rapidly increasing tilapia in many countries far better suited to its production, and with very low wage costs. It is also unclear that people will pay a premium for a UK grown exotic fish.

²²⁰ <http://www.gighahalibut.co.uk/gigha/>

²²¹ Fletcher pers. com

SWOT analysis - RAS

Strengths/Opportunities	Weaknesses/Threats
<ul style="list-style-type: none"> Controlled temperature environment allowing for optimal growth, strategic seasonal production, improved feed conversion ratio Siting close to processing and/or markets Easier waste management/recycling of wastes to other productive activities Potential improved biosecurity In some locations (especially peri-urban) it may be easier to gain planning permission and environmental permits for the establishment of RAS compared with pond/cage systems in attractive rural/coastal locations Fail-safe monitoring, response, and backup systems Utilization of written-off historic investment for more commercially viable options Strategic production of optimal economic sized salmon for on-growing in limited optimal (accessible, sheltered, high water quality) marine cage sites Production of other small high value species – cleaner fish, ornamentals 	<ul style="list-style-type: none"> High capital costs relative to cage fish and open circulation pond systems High energy costs and carbon footprint – but trade off here with “food miles” Higher production risks related to technical failure or human error Potential difficulties treating/eliminating pathogens ‘Plug and play’ RAS systems have been oversold. There is a lack of awareness of the importance of a combination of good design and skilled operators/management Lower cost production in alternative systems in suitable climatic regimes Competition from countries with less constraint on optimal inshore sites Competition from Scotland with sites closer to salmon grow-out operations Scotland for cleaner fish

9.5.2 Aquaponics

Aquaponics has a rather similar history to RAS, although these are generally rather different enterprises, usually with a strong educational or community development focus. There are very few examples, globally, where these have become viable businesses in their own right (i.e. in terms of the production and sale of fish and plants). Some of the most successful examples are in Hawaii where there has been very substantial research support, but the “near” commercial operators all admit that their products are significantly more expensive than normal market rates, and they struggle to maintain financial viability²²² unless combined with visitor attractions, research, education, etc.

In the UK there has been significant research and development interest over the last two decades, driven in part by the enthusiasm of the British Aquaponics Association (BAQUA²²³) and associated enterprises. There are three main enterprises - Herbs from Wales²²⁴, Bioaqua²²⁵, and Humble by Nature²²⁶. None are significant fish producers, but are rather more herb producers or training/multiple interest organisations.

The constraints associated with RAS production of table fish apply to aquaponics but with several additional problems:

- Water quality has to be maintained to suit both fish and plants. This may be sub-optimal for both
- Balanced, low waste aquaponic systems produce a fixed ratio of plants to fish, irrespective of market demand. If significant economic production of fish is to be achieved (through high density fish culture) a much greater volume of vegetable production will be required to keep the system in balance (i.e. use a large proportion of the fish waste), and the enterprise effectively becomes vegetable production using pellet fed fish as the source of fertilizer
- Pest or disease problems in the plant or fish sub-systems may lead to an imbalance between the two, and pest or disease treatment for one sub-system may compromise production in the other
- Skills are required in both fish and plant husbandry

²²² Hambrey Consulting 2013 The relevance of aquaponics to the New Zealand aid program. Commissioned report for the New Zealand Ministry of Foreign Affairs and Trade

²²³ <http://www.bagua.org.uk/>

²²⁴ <http://herbsfromwales.co.uk/joomla/>

²²⁵ <http://bioaquafarm.co.uk/>

²²⁶ <http://www.humblebynature.com/>

In conclusion, aquaponics is not a significant food producing system at the present time, and is unlikely to be so for some time to come, if at all given the substantial constraints on economic viability.

9.5.3 Integrated Multi-trophic Aquaculture (IMTA)

IMTA may be regarded as “an open water version of aquaponics” (or aquaponics a sub-set of IMTA). For instance, seaweed and shellfish may be sited and grown in the vicinity of high input finfish farms, with the fish farm benefiting from some level of waste treatment, whilst the algae or shellfish benefit from nutrients and other wastes from the fish farm²²⁷.

There have been many trials of these systems throughout the world, including for example trials on seaweed and salmon production in Scotland²²⁸, salmon and mussels in Tasmania²²⁹, salmon, seaweed and mussels in New Brunswick (Canada)²³⁰ and various configurations in Israel²³¹. We are not aware of any fully commercial IMTA ventures, and the historic seaweed and salmon trials conducted in Scotland were not pursued by the salmon company involved.

The reasons for the limited success are again multiple, but include the following:

- The very large quantity of algae required to extract a significant proportion of the nutrients produced by e.g. intensive salmonid cage culture
- The low value of such seaweed production, effectively compromising the higher value generating activities of the salmon farm (if within the same business)
- The fact that most intensive cage fish farms produce barely detectable increases in nutrients 100 metres or more from the site, and that these are readily taken up by existing planktonic and macroalgal communities
- The possible impact of large seaweed farms around cages on water flow/exchange
- Where mussels or other bivalves are used:
 - The time/distance required for nutrients to be converted to quality planktonic food
 - The conversion of a significant proportion of absorbed nutrients and enhanced plankton production into ammonia in the water column and pseudofaeces beneath the rafts, compounding the seabed impacts of salmon production, and undermining the whole objective

More generally (and as with RAS and aquaponics), IMTA is a complex business, involving radically different markets. While it is perfectly conceivable that a successful finfish farm may seek to exploit “free” nutrients and diversify its business, it makes little commercial sense to seek to establish a complex integrated system from the outset, unless there are very clear marginal economic advantages to the core business – which is not normally the case. It is nonetheless arguable that IMTA on a “bay wide” or “zonal scale”, with a balance of intensive input and extractive aquaculture businesses complementing each other within a relatively enclosed water body, may represent an opportunity, and should undoubtedly be encouraged.

²²⁷ Current overview available at <http://www.sarf.org.uk/cms-assets/documents/28926-823833.current-state-of-integrated-aquaculture>

²²⁸ E.g. historic trials on seaweed and salmon farming at Loch Duart Salmon in association with Scottish Association for Marine Sciences; more recent trials in Loch Fyne by the Scottish Salmon Company and the Loch Fyne Oyster Company in association with the Scottish Association for Marine Sciences

²²⁹ E.g. Cheshuk et al 2003. Integrated open-water mussel (*Mytilus planulatus*) and Atlantic salmon (*Salmo salar*) culture in Tasmania, Australia. Aquaculture Volume 218, Issues 1–4, 27 March 2003, Pages 357–378

²³⁰ See for example ongoing research by Thierry Chopin and his team. e.g. <http://www2.unb.ca/chopinlab/articles/files/Chopin%202015%20Fisheries%20Marine%20aquaculture%20in%20Canada.pdf>

²³¹ Various projects - Israel Oceanographic and Limnological Research Ltd. National Centre for Mariculture Eilat, Israel

ANNEX 9: AQUACULTURE SUPPLIERS

There are numerous independent and/or private businesses servicing the UK aquaculture industry: from veterinary services to offshore equipment suppliers, research consultancies through to specialist hauliers.

Many of the aquaculture and fisheries trade websites and publications detail aquaculture service providers, but a simple web search will lead those seeking assistance to a number of relevant sources.

Some of the main specialist equipment, training and consultancy service providers are listed below. Please note that these lists are not definitive.

Some of the main specialist fish farming equipment suppliers (not definitive)

- Aquaculture Equipment Ltd., Greater Manchester, England <http://aquacultureequipment.co.uk/>
- Aquahive Shellfish Hatchery Systems Ltd <http://www.aquahive.co.uk/>
- Aquatec Solutions Ltd., Denmark <http://aquatec-solutions.com/>
- Aquatico, South Yorkshire, England <http://www.aquatico.co.uk/>
- Fishkit, Suffolk, England <http://www.fishkit.co.uk/>
- Fusion Marine, Argyll, Scotland <http://fusionmarine.com/>
- Kames Fish Farming Ltd., Argyll, Scotland <http://www.kames.co.uk/>
- Llyn Aquaculture, North Wales <http://www.llyn-aquaculture.co.uk/>
- Norfab Aquaculture Equipment, Fort William, Scotland <http://www.norfab.co.uk/>
- Northbay Shellfish Ltd., Orkney, Scotland <http://www.northbayshellfish.co.uk/>
- Purewell Fish Farming Equipment, Hampshire, England <http://www.purewellfishfarming.co.uk/>
- Seawinch, Dorset, England <http://seawinch.com/>
- Spirex Aquatec Ltd., Redditch, England <http://www.spirexaquatec.com/>
- Sterner Aquatech UK, Inverness, Scotland <http://www.sterner.co.uk/>
- Todd Fish Tech, Dumfermline, Scotland <http://www.toddfish.co.uk/>

Some of the independent aquaculture training and consultancy services in England, Wales and Northern Ireland (not definitive)

- Aquatic Consultancy/Sunset Koi Farm, Worcestershire, England <http://www.aquaconsultant.co.uk/>
- Aquafish Solutions Ltd., Devon, England <http://www.aquafishsolutions.com/>
- Aqueous Consultants, Wiltshire, England <http://www.aqueousconsultants.co.uk/index.html>
- Homarus Ltd, Hampshire, England <http://www.homarusaquafish.co.uk/?id=home>
- Integrated Marine Management Ltd., (IMM), Devon
- Invicta Trout, Dumfries and Galloway, Scotland <http://www.invictatrout.co.uk/>
- Landell Mills, Wiltshire, England <http://www.landell-mills.com/>
- Longline Environment, London <http://www.longline.co.uk/>
- Llyn Aquaculture, North Wales <http://www.llyn-aquaculture.co.uk/>
- McAlister Elliot & Partners, Hampshire, England <http://www.macalister-elliott.com/index.php>
- MRAG Ltd., London <https://www.mrag.co.uk/>
- Pontus Aqua, South Wales <http://www.pontusaqua.com/>
- Poseidon Aquatic Resource Management Ltd, Hampshire, England <http://consult-poseidon.com/>
- RAS Aquaculture Research Ltd, North Wales
- Salacia Marine, South Wales <http://salacia-marine.co.uk/>

Many UK universities and colleges also provide direct (or related) academic aquaculture training (from vocational courses to higher degrees)

Academic aquaculture training providers - Universities and colleges (not definitive)

- Aberdeen University, north east Scotland <http://www.abdn.ac.uk/>
- Bangor University, Gwynedd, North Wales <https://www.bangor.ac.uk/>
- Bridgewater College, Somerset, England <http://www.bridgewater.ac.uk/>
- Glasgow University, Lanarkshire, Scotland <http://www.gla.ac.uk/>
- Hadlow College, Kent, England <http://hadlow.ac.uk/>
- Harper Adams University, Shropshire, England <http://www.harper-adams.ac.uk/>

- Heriot-Watt University, Edinburgh, Scotland <https://www.hw.ac.uk/>
- Hull University, East Yorkshire, England <http://www2.hull.ac.uk/>
- Liverpool University, north west England <https://www.liverpool.ac.uk/>
- Newcastle University, Tyne and Wear, England <http://www.ncl.ac.uk/>
- Napier University, Edinburgh, Scotland <http://www.napier.ac.uk/>
- Plymouth University, Devon, England <https://www.plymouth.ac.uk/>
- Queens University, Belfast, Northern Ireland <https://www.qub.ac.uk/>
- Sparsholt College, Hampshire, England <https://www.sparsholt.ac.uk/>
- Southampton University, Hampshire, England <http://www.southampton.ac.uk/>
- SRUC, Barony Campus, Dumfries, Scotland <https://www.sruc.ac.uk/>
- St Andrews University, Fife, Scotland <https://www.st-andrews.ac.uk/>
- Stirling University, Stirlingshire, Scotland <http://www.stir.ac.uk/>
- Swansea University, South Wales <http://www.swansea.ac.uk/>
- University of the Highlands and Islands, Inverness, Scotland <https://www.uhi.ac.uk/en>
- York University, North Yorkshire, England <https://www.york.ac.uk/>

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