

The Seafish Guide To Aquaculture



This is one of a series of guides in which Seafish explores topical issues affecting the UK seafood industry. Here we look at the UK and European aquaculture markets, the global picture, opportunities and challenges and how the sector is moving forward.

A Definition

The United Nations Food and Agriculture Organisation (FAO) defines aquaculture¹ as:

“The farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated, the planning, development and operation of aquaculture systems, sites, facilities and practices, and the production and transport¹.”

Globally some 580 species of aquatic plants and animals are farmed². Farmed aquatic animals can be omnivores, herbivores or carnivores. Aquaculture species and how they are produced can be categorised in various ways:

- Species themselves can be freshwater, marine or diadromous (i.e. those that live in both fresh and marine waters)
- Depending on the species being farmed, they can be fed (i.e. most finfish species) or non-fed (e.g. seaweeds and filter-feeding shellfish, and some fish species such as carps)
- The density of stock (i.e. how many fish or shellfish in a given area or volume of water) defines a production system as either extensive (low density), semi-intensive and intensive (high density)

The type and intensity of farming depends on the species and on market demand. Generally fish and shellfish are farmed in ponds, tanks, suspended on supporting structures or confined in nets or cages in lakes or coastal waters. As shellfish, generally stay in one place, they can also be farmed on the seabed.

- Mussels and oysters, which feed on plankton and organic particles in the surrounding water, are grown on the bottom or on suspended ropes or racks
- Warm water prawns are farmed in large, coastal ponds predominantly in the Asia-Pacific region. When fed, artificial feeds come in the form of pelleted, granulated feeds containing a range of ingredients including fishmeal (FM) and fish oil (FO)
- Most marine fish are raised in net pens in coastal waters and are fed on pellets containing a range of ingredients including FM and FO

In developing countries, where aquaculture production is aimed at food for survival or to support the local economy, this can mean a family-owned operation where several species are cultured at the same time. In developed and developing countries market demand has led to increased intensification of aquaculture production methods to produce moderate to high-value species.

Key Facts

In the UK, the total value of shellfish aquaculture production in 2014 was

£35.6 million

In the UK, the total value of finfish aquaculture production in 2014 was

£762.2 million

Aquaculture remains the fastest growing food supply sector in the world



The Global Picture

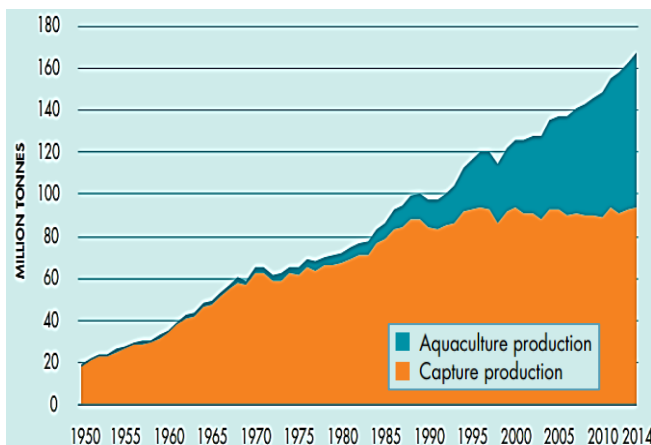
Almost all *fish* produced from aquaculture are destined for human consumption (the term '*fish*' refers to finfish and all other animals, e.g. shellfish (crustaceans, mollusc), etc.).

According to the FAO 'State of World Fisheries and Aquaculture 2016' (SOFIA²) report, total world aquaculture production of fish in 2014 was 73.8 million tonnes, with an estimated total value of US\$160.2 billion. 2014 figures are up by almost 11% compared to 2012 production figures (i.e. 66.5 million tonnes).

Farmed <i>Fish</i> * Harvested from Global Aquaculture in 2014			
Category	Number of Farmed Species	Production (million tonnes)	Value (US\$ billion)
Finfish	362	49.8	99.2
Molluscs	104	16.1	19
Crustaceans	62	6.9	36.2
Others**	15	7.3	3.7
Total	580	73.8	160.2

* *fish* refers to finfish and all other animals
 ** Including amphibians (frogs), aquatic reptiles (except crocodiles) and other aquatic animals (such as sea cucumbers, sea urchins, sea squirts and jellyfishes)

Aquatic food production has transformed from being primarily based on capture of wild fish to culture of increasing numbers of farmed species. A significant milestone was reached in 2014 when aquaculture's contribution to global fish supply for human consumption overtook that of wild-caught fish for the first time.



World Capture Fisheries and Aquaculture Production²

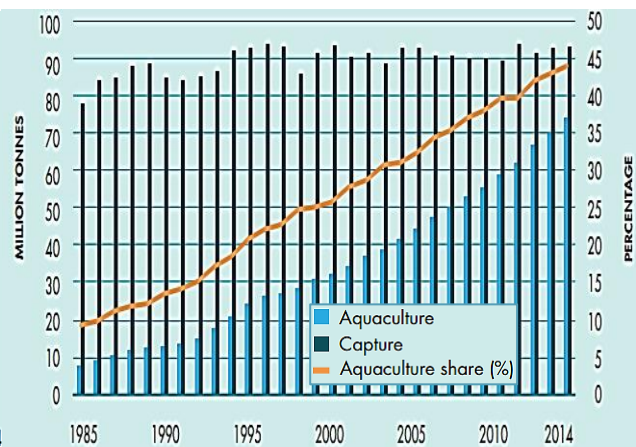
When farmed aquatic plants and non-food products are included, this aquaculture production figure increases to 101 million tonnes, with a value of US\$165.8 billion. In terms of global production volume, farmed fish and aquatic plants combined surpassed that of capture fisheries in 2013.

Growth in supplies of seafood for human consumption (from capture fisheries and farming) has outpaced population growth in the past five decades. Seafood supplies increased at an average rate of 3.2% in the period 1961 to 2013.

One major factor in increased supplies has been aquaculture. In the decade 2005 – 2014, fish culture production grew at healthy 5.8% annually (but down from 7.2% in the previous decade). This far outpaces world population growth, which was 1.2% per annum between 2010 and 2014³.

Increased seafood supplies have resulted in average world per capita fish consumption estimated at over 20kg in 2014 (in the 1960s it was only 9.9kg). However, considerably lower averages are still found in many low-income food deficit countries (LIFDCs).

For global fish availability to meet projected demand, it has been estimated that aquaculture production will need to more than double by mid-century, rising to roughly 140 million tonnes in 2050⁴.



Share of Aquaculture in Total Production of Aquatic Animals²



The UK Aquaculture Sector

UK aquaculture is diverse however Scottish Atlantic salmon dominates harvest tonnage and value. Five companies are responsible for 92% of the industrialised Scottish salmon industry⁵. Scotland also produces significant amounts of farmed shellfish, particularly from Shetland. Scottish aquaculture has been estimated to contribute as much as £1.8 billion turnover and 8,800 jobs to the whole UK⁶.

Aquaculture elsewhere in the UK differs significantly from Scotland both in terms of scale and species cultivated. Collectively the industries in England, Wales and Northern Ireland place emphasis on shellfish (particularly mussels and oysters) and trout production for the table and restocking. England also supplies salmon smolts to the Scottish industry and boasts a significant coarse fish and ornamental sector. Many of these aquaculture businesses are small to medium-sized enterprises (SMEs)⁷.

Production from England, Wales and Northern Ireland has declined in recent years from 34,394 tonnes in 2010, to 21,342 tonnes in 2014, but it continues to support over 220 businesses and directly creates almost 1,000 full time jobs⁷.

UK Aquaculture Production and Value in 2014				
Country	Finfish Production (tonnes)	Shellfish Production (tonnes)	Finfish Value (£ million)	Shellfish Value (£ million)
England	6,456	2,456	23.7	5.2
Wales	497	7,945	2.13	15.1
Northern Ireland	~750	3,238	~3	4.7
Scotland	185,023	7,980	733.6	10.5
Total	192,726	21,619	762.2	35.7

Farmed UK finfish production

UK aquaculture production is primarily Atlantic salmon; grown in sea cages mostly on the Scottish west coast, Orkney, and Shetland, with small volumes from Northern Ireland. Total Scottish production during 2014 was 179,022, with estimates of 186,508 tonnes in 2015. The total number of direct, full time staff in Scottish marine salmon production in 2014 was almost 1,200⁸.

There is significant UK production of rainbow trout with concentrations in southern England, North Yorkshire and Scotland. According to CEFAS the total UK value of aquaculture finfish production in 2014 was £762.2 million, not only from salmon and trout, but from other species including coarse and ornamental species, dominated by carp species⁷. The UK has considerable expertise in Recirculating Aquaculture Systems (RAS). The salmon industry is increasingly using this technology to produce smolts and also wrasse and lumpfish which act as cleaner fish in salmon cages (i.e. eating sea lice off salmon). Commercial success to produce other species using RAS in the UK (e.g. seabass, tilapia, barramundi) has been inconsistent⁹.

Farmed UK shellfish production

Shellfish cultivation is spread relatively evenly across the UK. Blue mussel is by far the most important farmed species, with Scotland and Wales both producing around 8,000 tonnes in 2014. Wild caught seed (called spat) underpins UK mussel production and is either collected for rope-growing or dredged and relayed on the seabed. The majority of Welsh mussel production is bottom culture, whilst rope-growing in Shetland constitutes the majority from Scotland. The prospect for large-scale rope-growing mussels in England looks positive. Mussels are increasingly popular in the UK, especially pre-cooked and vacuum packed.

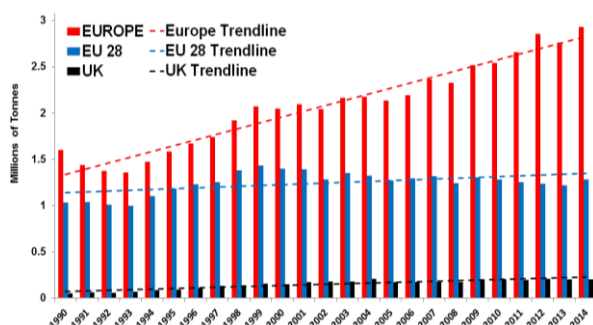
The market for UK oysters is strong due to decreased French production and increasing domestic and overseas demand. The UK grows both Native and Pacific oysters, generally using hatchery reared seed. Oyster production in 2014 was over 1000 tonnes, but is limited by seed availability, disease (e.g. Oyster Herpes Virus), suitable growing sites, and long-standing issues with farming the introduced Pacific oyster in UK waters.

UK scallop farming (as well as other shellfish, e.g. clams, lobsters) is considered as having potential, but has yet to establish itself widely. There are a number of UK initiatives looking to expand the cultivation of various shellfish species, not just scallop^{7,10}.



The European Aquaculture Sector

European aquaculture produced 2.9 million tonnes in 2014. It shows a healthy upward trend compared to the EU and UK, mainly due to the inclusion of Norwegian Atlantic salmon farming. EU aquaculture production was 1.28 million tonnes in 2014¹¹; with an almost equal split between finfish and shellfish production¹².



European, EU 28, and UK Aquaculture Production 1990 - 2014¹¹

In the EU, aquaculture accounts for nearly 20% of fish production and directly employs some 85,000 people. The sector is mainly composed of SMEs or micro-enterprises in coastal and rural areas¹³. Whereas global aquaculture production has been growing, EU output has been more or less constant in volume since 2000. Despite the EU only producing 2% of all fish farmed worldwide, its product quality is high, as is its research, and environmental standards¹⁴.

The European Commission is aiding EU members to increase aquaculture; it is a key component of both the Common Fisheries Policy¹⁵ and the Blue Growth agenda¹⁶, and supported through EU funding instruments e.g. European Maritime and Fisheries Fund (EMFF¹⁷) and Horizon 2020¹⁸.

European finfish production

There are three key European finfish aquaculture production sectors; marine cold water (71% of total production), marine Mediterranean (12.8%), and freshwater (15.7%). The main species produced are Atlantic salmon, rainbow trout, European seabream and seabass, and carps¹⁹. These five species represented 94% of the 2.34 million tonnes of European finfish production in 2014, with an ex-farm value of over €8 billion^{19,20}.

- Marine cold water production (1.67 million tonnes): Atlantic salmon are diadromous; juveniles are reared in freshwater and grown-out in marine cages. Trout are also grown in cages. Marine cold water production of salmonids is primarily Norwegian (82%) (Scottish 10%; Faroese 5%)
- Marine Mediterranean (0.29 million tonnes): seabass and seabream. 73% is grown in Greek and Turkish sea cages, and these two species represent 96% this production sector
- Freshwater (0.36 million tonnes): 95% of European FW finfish farming is trout (79%) and carps (19%)

2014 EU finfish production was 0.64 million tonnes.

EU shellfish production

Production of shellfish (predominately molluscs) is around half of EU aquaculture¹². In 2014 over 0.63 million tonnes of bivalve molluscs were produced (3.7% of the world total of 16.1 million tonnes²). Major producers were Spain (223,000 tonnes), France (155,000 tonnes), and Italy (111,000 tonnes)¹¹. With a value of US\$1.21 billion it is just over 8.5% of the world total. Crustacean production in Europe is small on a world scale; 315 tonnes in 2014.

Mussels are the main group cultivated in the EU, with almost 493,000 tonnes (all species) produced in 2014. Pacific oysters are next in importance, with just over 92,600 tonnes produced in 2014. EU shellfish production has been exhibiting a decreasing trend over the last decade but this may be changing, e.g. 2014 mussel production was up 12.3% on 2013¹¹.

EU imports

Europe is the largest seafood market and importer in the world. Even excluding intra-EU trade, Europe accounts for some 20 - 25% of the global seafood market²¹. The EU relies on imports for 68% of the seafood it consumes²². This includes salmon from Norway, warm water prawns and FW fish (e.g. pangasius and tilapia) from SE Asia and S America.



Opportunities and Challenges

Fish in aquaculture systems are very efficient converters of feed in to protein - more efficient than most terrestrial livestock systems. Aquatic animal production systems also have a lower carbon footprint per kg of output compared with terrestrial animal production systems^{23, 24}.

Aquaculture can produce traceable, high quality, healthy seafood in large volumes. It continues to help bridge the gap between supply and demand, and reduce pressure on wild fisheries.

Health benefits

Fish and shellfish are excellent sources of Omega-3 fatty acids and are recognised as important components of a healthy diet. Many experts recommend that we eat at least two portions of seafood every week. This recommendation has been made by the Scientific Advisory Committee on Nutrition (SACN) who advise the Food Standards Agency (FSA), also suggests that at least one weekly portion of seafood should be oil-rich, such as trout, mackerel or herring. One portion of seafood is generally considered to be 140g²⁵.

Some sources claim UK home consumption of fish has declined from around 170 g per person per week in 2006 to 144 g per person per week in 2012, and consumption is falling, particularly with the younger generation²⁶. If seafood consumption levels are to increase then the continued sustainable development of aquaculture will be needed to help meet demand. However it is important that more innovative ways to market and sell both farmed and caught seafood are developed.

Key Facts

Aquaculture production of non-fed animal species in 2014 was

22.7 million tonnes

Over 30% of farmed fish produced are non-fed species

Economic benefits

Aquaculture is of huge economic importance. In Scotland for example, it is a nationally important industry, particularly for coastal and island communities, and is often a mainstay of the local economy. Scottish salmon is exported to more than 60 countries. Exports of whole, fresh salmon rose in 2014 with a value of £494 million. The US was the top export destination with sales worth £213 million. In France and Germany 40% and 105% increases in sales value was reported, and sales to China also grew by 28%²⁷.

Challenges

Aquaculture is a relatively young industry, and its rapid growth has raised environmental, societal, and animal welfare concerns²⁸. The pressures exerted by aquaculture are not uniform. The level of impact will vary according to production scale, techniques and the species farmed. However, aquaculture is generally a highly regulated industry, and measures are taken to manage these pressures and help reduce their impact.

Standards and certification

Aquaculture standards have been developing for many years. Certification is a voluntary process that demonstrates responsible practices by: minimising environmental impact; making the best use of locally available resources; helping to ensure labour rights in the developing world; complying with national legislation; and ensuring the best use of feed and therapeutic products.

Examples of Standard Setting and Initiatives	
Feed Standards	<ul style="list-style-type: none"> • IFFO Global Standard for Responsible Supply • Organic standards such as Soil Association
Farming Standards and Initiatives	<ul style="list-style-type: none"> • Global Aquaculture Alliance (GAA) • GlobalG.A.P. - Good Agricultural Practice • Aquaculture Stewardship Council (ASC) • Friend of the Sea • Code of Good Practice for Scottish FinFish Aquaculture (CoGP) • RSPCA Freedom Food welfare standards • The Global Salmon Initiative (GSI) • The Global Sustainable Seafood Initiative (GSSI) • EU rules for organic aquaculture - sets legal minimum criteria
Farmer and Retail Schemes	<ul style="list-style-type: none"> • Farming companies and most retailers have Codes of Practice and/or standards which add specific criteria to those prescribed by the organisations above • UK supermarket quality schemes • Label Rouge quality scheme • Niche market schemes such as organic salmon The British Retail Consortium (BRC) Global Standard & Safe & Local Supplier Approval (SALSA) certification standards in processing and wholesaling sectors



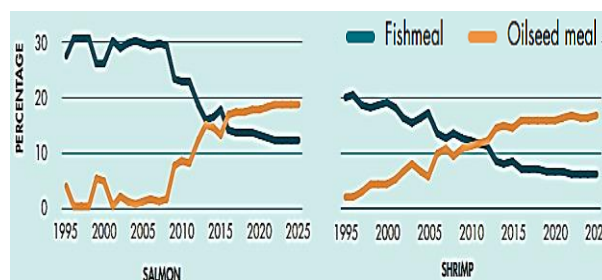
Aquaculture Feeds

Historically the two most important ingredients in aquafeeds have been fishmeal (FM) and fish oil (FO), and the use of both in fish feed is a contentious issue (catching wild fish to feed to farmed fish) and a challenge to the growth of the aquaculture sector. Traditionally FM and FO usage in aquaculture diets competes with feed for livestock, and dietary supplements for direct human consumption for (e.g. FO). This competition will remain, but it will be constrained given that the amount of wild fish that can be caught annually is finite.

Low-trophic level species use fewer supplementary feeds and FM, whilst for higher trophic level species such as salmonids and shrimp, FM and FO remain an essential ingredient in aquafeed, even if it is only used at specific production stages. Much of today's aquaculture is still dependent on FM and FO from wild fish, however increases in the availability of FM has also come through much greater use of fish processing by-products.

Critics of using FM and FO for aquaculture or land animal feed insist that is simply not acceptable in terms of resource use and should be banned or curtailed²⁹. There has been much research focused on finding replacements for FM and FO in aquafeeds for farmed carnivorous fish. It is crucial that any ingredient used to replace FM and FO does not have detrimental effects on fish health, growth rate, and ultimately the quality of the product. Replacements have been identified from vegetable products and other sources. There is a growing need for aquaculture to demonstrate that all the raw materials in aquafeeds are being responsibly sourced, and this is often achieved by using internationally recognised certification standards³⁰.

Aquafeeds have seriously improved in terms of technology, formulation, and ingredient sourcing. A typical salmon diet in 1995 may have contained >50% FM and >25% FO, but levels today are considerably lower and the use of FM and FO in trout and salmon diets has decreased to below 20%³¹. It is expected that the inclusion of FM and FO in aquaculture feeds will continue its downward trend.



Share of Fishmeal Used in Salmon and Shrimp Feed in Aquaculture²

Fish In: Fish Out

Fish In: Fish Out (FIFO) is a calculation of the weight of wild fish in kg needed to produce one kg of farmed fish. An incorrect and misleading 5:1 ratio is often quoted for salmon, but the correct FIFO for the conversion of wild feed fish to farmed salmon is 1.4:1*. For all fed aquaculture, the FIFO is 0.3:1* (*2010 ratio)²⁹.

Non-fed aquaculture production

An important point to highlight is that by volume, half of world aquaculture production in 2014 was realized without feeding. The culture of non-fed animal species (including aquatic plants and filter-feeding animals (e.g. silver and bighead carp, bivalve molluscs, plus others such as sea squirts) produced 22.7 million tonnes in 2014, and represented 30.8% of world production of all farmed fish species².

Growth in the production of species which are fed has been faster than those which are not, although production of non-fed species can be more beneficial to food security and the environment.

Key Facts

In 2014, global production of farmed fish was 73.8 million tonnes – an all-time high

The Global Sustainable Seafood Initiative (GSSI) aims to benchmark fisheries and aquaculture standards, in order to measure and compare their performance against internationally recognised metrics

It is expected that future growth in fish production and consumption will mainly originate from aquaculture

Other Seafish guides

There are a number of other Seafish Guides in this series, covering different aspects of responsible seafood sourcing, fisheries management and aquaculture. For more details and the most up to date information consult our website at www.seafish.org

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Further information

- Aquaculture Stewardship Council (ASC) - <http://www.asc-aqua.org/>
- Association of Scottish Shellfish Growers (ASSG) - <http://assg.org.uk/>
- British Retail Consortium (BRC) - <http://www.brcglobalstandards.com/Home.aspx>
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- Seafish - <http://www.seafish.org/>
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- The Fish Site - <http://www.thefishsite.com/>
- Welsh Government - <http://gov.wales/topics/environmentcountryside/marineandfisheries/aquaculture/?lang=en>
- WorldFish - <https://www.worldfishcenter.org/>

About Seafish

Seafish was founded in 1981 by an Act of Parliament and aims to support all sectors of the seafood industry for a profitable, sustainable, and socially responsible future. It is the only pan-industry body offering services to all parts of the industry, from the start of the supply chain at catching and aquaculture; through processing, importers, exporters and distributors of seafood right through to restaurants and retailers.

Contact Seafish:

Origin Way, Europarc, Grimsby DN37 9TZ
t: 01472 252300 | f: 01472 268792
e: seafish@seafish.co.uk | w: www.seafish.org

To support a profitable, sustainable and socially responsible future for the seafood industry



the authority on seafood