Responsible Sourcing Guide: Farmed Atlantic salmon

QII 2015

Salmo salar

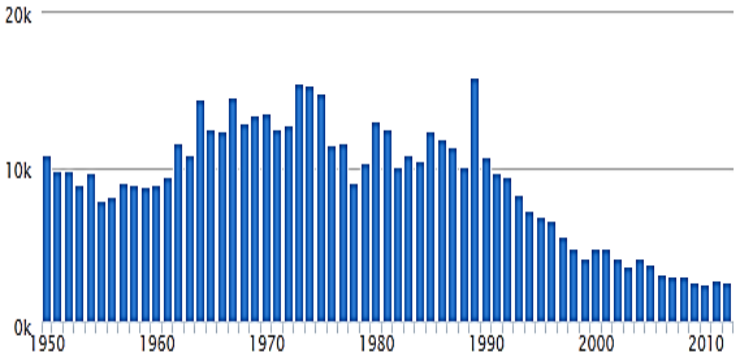
Salmon is a common name used for several species of fish of the family Salmonidae (e.g. Atlantic salmon, Pacific salmon) while other species in the family are trout (e.g. brown trout, sea trout). Under the UKs 'Commercial Designations of Fish' (1), *Salmo salar* can either be called Atlantic salmon or salmon. Atlantic salmon is available both wild and farmed. Wild populations are generally at very low levels, and capture has seen a significant decline (2) (Figure 1). Commercial wild harvest is now limited and almost all commercially available Atlantic salmon comes from aquaculture (3). Salmon ranked 1st in the top 35 UK retail species by value in the 52 weeks running up to August 2014, with 837,000 metric tonnes (mt) of retail sales (4).

The purpose of this guide is to give buyers background information on the responsible sourcing of farmed Atlantic salmon.

Introduction, sources and quantities

In terms of volume Atlantic salmon is the most important species of salmonid in the world. Atlantic salmon constituted 69% of all global salmon production (wild and farmed) in 2012 (5).

Figure 1. Wild Atlantic salmon global capture trend (2) (1k = 1 kilotonnes or 1,000 mt)



Norway and Chile dominate global aquaculture production of this species. In 2012 these two countries accounted for 78% (59% and 19% respectively) of farmed supplies (5).

Combined farmed salmonid (Atlantic and Pacific salmon, and trout) supply in 2013 was almost two mt of head-on, gutted (HOG) fish. The supply of Atlantic salmon (HOG) was 1.84 million mt or 92% of total farmed salmonid supply (3).

Atlantic salmon is farmed across the globe in suitable sites (3). Norway, Chile, Scotland and Canada are the four main producers (ranked in production importance) and represented 91% of the total harvest in 2012; and this dominance is set to continue in the coming years. Production also occurs in the Faroe Islands, Australia (Tasmania), Ireland and the US (again, ranked in importance). These nations accounted for ~8% of farmed Atlantic salmon in 2012. Other producers

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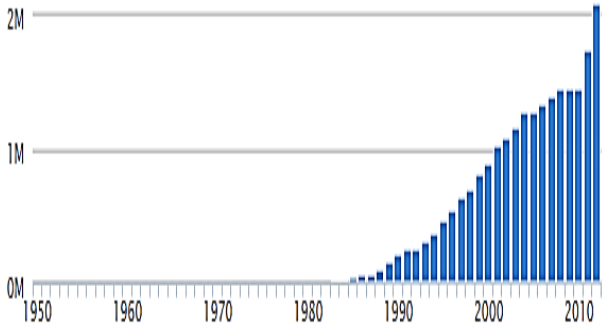
(e.g. New Zealand, France and Spain) accounted for minor production and the remainder of 2012 supplies, i.e. <1% (5).

In the EU in 2012, almost 70% of the Atlantic salmon supply went to retailers (40% went to the commercial sector i.e. restaurants etc.) and just over half of that was sold fresh (whole, steaks or fillets). Of the different products, fillets had the largest market share (47%) in 2012, followed by smoked salmon (28%). There has been much product diversification (besides smoked salmon) within the salmon industry and value-added products (VAPs) had a market share on par with whole fish, at ~12% in 2012 (3).

Atlantic salmon is an ideal species for aquaculture. It grows well in sea cages, commands a high market value and adapts well to being farmed away from its native range. Many research projects have, and continue to be conducted, into all aspects of aquaculture science and Atlantic salmon farming, to develop and better the industry (6).

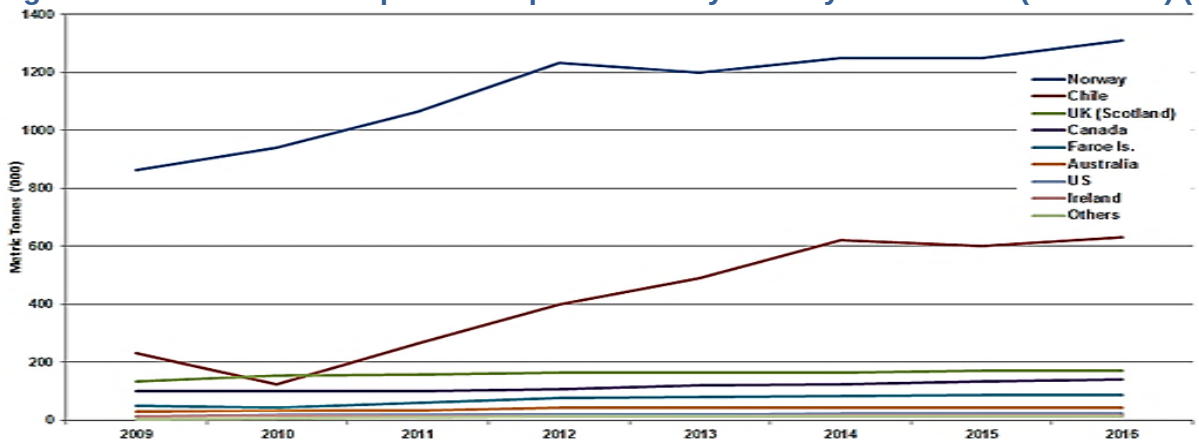
Figure 2. Global Atlantic salmon aquaculture production - 2.07 million mt 2012 (2)



Even with an increase in production of Atlantic salmon of more than 600% since 1990, total global supply of salmonids only equates to 4.2% of global seafood supply (3). Production of Atlantic salmon has increased almost exponentially over the last thirty years (Figure 2).

As Figure 3 clearly shows, Norway and Chile dominate the production of Atlantic salmon, and trend is set to continue (4).

Figure 3. Atlantic salmon aquaculture production by country 2009 – 2016 (estimates) (2)



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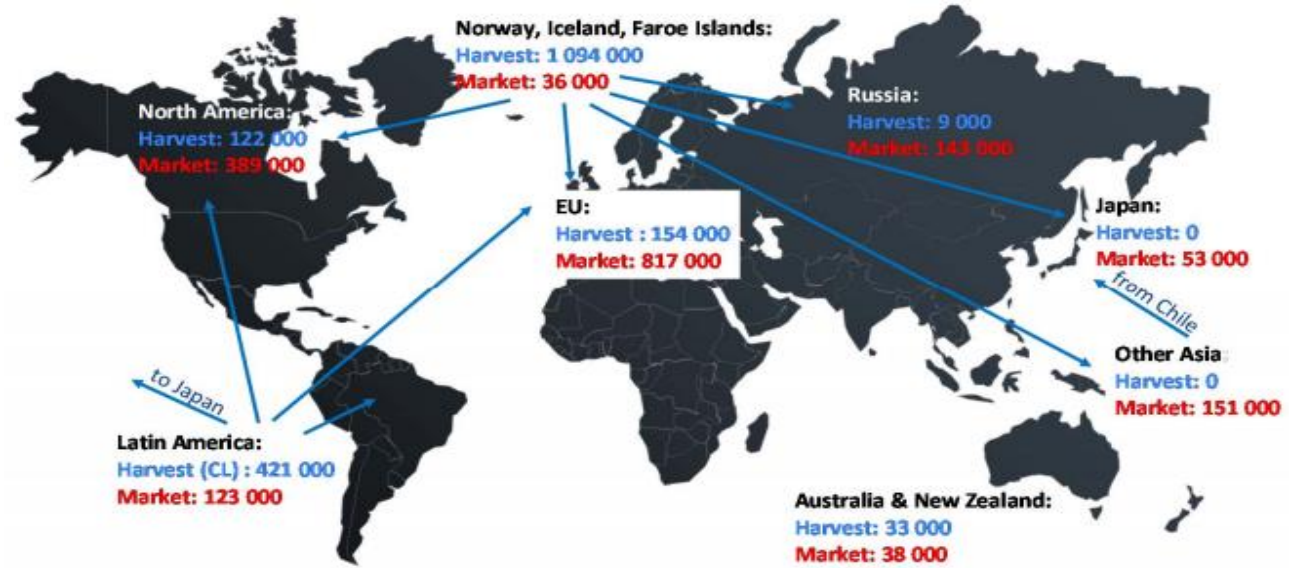
Salmon farming started on an experimental level in the 1960s, but became an industry in Norway in the 1980s and in Chile in the 1990s (7).

Farmed Atlantic salmon is now a global commodity (Figure 4), and often produced by multi-national aquaculture companies. Norwegian Atlantic salmon for instance is exported to 160 countries, and only 20% is sold in domestic or local markets (8). Europe (including Russia) and North America are by far the largest markets for Atlantic salmon. However, emerging markets are growing and are important to future sales (3).

Figure 4. Global trade flows of farmed Atlantic salmon (3) in metric tonnes



Scotland is by far the largest producer of farmed Atlantic salmon in the EU (and the third largest globally). In 2012,162,200 mt of Atlantic salmon was produced from Scottish farms with an estimated value of ~£520 million at farm gate prices (9).

Scottish salmon is the largest food export from Scotland, and accounted for around 40% of total value in 2014. UK exports of whole, fresh Atlantic salmon where shipped to 60 different countries. The US and France are the top importers of UK salmon (32.8% and 18.5% respectively in 2014), but the Far East and the Middle East are becoming increasingly important (5, 10).

In 2012 the Scottish salmon industry had 100 freshwater and 257 seawater sites, and directly employed 1,387 on these sites (9). The top five Atlantic salmon producers in Scotland account for ~137,000 mt (3) of production; equivalent to ~85% of 2012 Scottish production.

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Biology

Figure 5.
Wild Atlantic salmon geographical distribution (2)

Wild Atlantic salmon are native to North Atlantic on both the European (Portugal to Russia) and North American (Cape Cod to Labrador) sides. They also occur around North Atlantic islands (e.g. UK, Iceland, Greenland, etc.) (Figure 5). Atlantic salmon is farmed outside its native range in some production countries such as Chile, Australia, etc. (11).

Salmon are an anadromous fish, which means that they spend most of their adult life in the ocean but return to freshwater to reproduce. Wild Atlantic salmon spend up to four 4 years in deep-sea feeding grounds feeding on pelagic species. At the onset of maturation, fish stop feeding, and return to their rivers of origin to spawn. The subsequent juvenile fish remain in freshwater through their fry and parr stages for 2 - 5 years, until they undergo seawater adaptation and become smolts. They then migrate to the sea, where they head for deep water feeding grounds to grow and mature (2).

To farm an Atlantic salmon takes approximately 24 - 36 months (in Norway). Time spent in freshwater is 10 - 16 months, followed by 14 - 22 months in seawater. This is however dependent on water temperature.

As salmon are cold-blooded animals (ectothermic), water temperature plays an important role in their growth rate. The optimal temperature range for Atlantic salmon is 8 -14^{o} C which means that historically the production time in Chile is a few months shorter than elsewhere, because the seawater temperatures are more optimal, and because average harvest weight is lower, resulting in fewer months grow-out before harvesting

Farmed Atlantic salmon are hatched, raised and harvested under controlled conditions, utilising high-end technology (12, 13). FAO guidelines have been used to give an outline of the production systems used for farmed Atlantic salmon (14). However this should be treated as a guide only, as there will be inevitable differences in production methods used throughout the world.

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Cultivation methods and systems

Freshwater hatchery

Broodstock (parent fish) are selected from the best performing fish on a sea farm and are moved into freshwater tanks or cages, usually during the autumn. Broodstock salmon are bred to enhance desirable characteristics such as growth rate, disease resistance and colour (3). Much genetic research (as well as in other areas) has been performed and continues to be conducted enabling better breeding programmes and stock improvement in Atlantic salmon (6)

During late autumn the eggs are taken from the mature female salmon, and these are fertilized by mixing them with milt from mature male fish.

The fertilised eggs are stored in individual containers or trays supplied with high quality freshwater. This is done in purpose-built hatcheries which have to be maintained to the highest quality and bio-security standards. Within 2-3 months the eggs hatch to produce fry.

Freshwater production

During early spring, the fry start to feed and are transferred to small hatchery tanks. Feeding is partly by hand and partly automatic. As the fish grow during the summer period, they are moved outdoors into larger tanks, ponds or into net cages in freshwater lakes. By the second spring (at about 12 months), the fish will have reached a size of 40-100g and have undergone the process of ‘smoltification’, where they adapt to deal with life in seawater.

It is possible to speed up the growth of the juveniles with light manipulation to accelerate the smoltification process by up to 6 months. The light manipulated juveniles are called S0s and the normally grown juveniles are called S1s (3). They are now ready for transfer to the sea. It is at this stage that the fish are termed ‘smolts’.

Smolt Transfer

During late spring, the smolts are transferred to sea cages either by truck, well boat or helicopter, depending on a number of considerations including the location of the sea site(s) and the number of smolts to be transferred. A truck can carry up to 25,000 smolts and a helicopter can carry up to 4,000 smolts at a time. A well boat can transport over many thousands of smolts (depending on its capacity), in a specially-designed well in the hold of the boat. The water quality (temperature, pH, oxygen etc.) can be controlled, and underwater cameras monitor the fish (15).

In Norway, smolt is mainly released into seawater twice a year. S0s are released in autumn/spring within 12 months and S1s in the autumn at about 18 months, and a very small part of the production is produced as S1½, which are only put to sea after 2 years. This ensures the harvest is spread all year round (3).

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Recirculating Aquaculture Systems (RAS) and smolt production

Over the past decade there has been increasing investment in RAS farms for Atlantic salmon smolt production in Scotland, Norway and Chile. These systems are reputedly cost competitive with alternative cage-based systems.

One scenario is that juvenile salmon could be reared to a larger size in RAS before being moved to sea for final grow-out. The rationale for this is that the highest mortalities during the marine farming stage is from post-transfer smolts (up to 20%), post transfer smolts can have reduced feed intake and growth rates, sea lice problems are increased with longer grow-out periods, shorter grow-out at sea would enable farms to improve utilisation of sites and allowable biomass limits (16).

Rearing in the Sea

Smolts are reared in the sea in cages or pens made from netting, hung from a floating collar. The floating collar can be made of steel, plastic or rubber. The pens vary in size.

Farms in which fish are produced in marine waters typically consist of one or more groups of cages arranged in a grid pattern. These cages/pens are structures consisting of a floating circular or square ring on the surface of the sea supporting a large net bag hanging in the water. The floating rings are normally 90 - 110m in circumference with the net bags being 15 - 20m deep enclosing a volume of 10,000 – 15,000 m^3 of water. The cages are anchored securely to the seabed using ropes, chains and heavy specialised anchors (17).

Much interest is currently centred on the feasibility/research into moving salmon production out to more exposed, offshore locations (6, 18).

Salmon are usually harvested after growing for 14-18 months in the sea by which time they have reached a size of over 4 kg.

Feed

Salmon are carnivorous and are fed industrially produced, compound ‘aquafeeds’ in the form of pellets. Historically the two most important ingredients in aquafeeds have been fishmeal (FM) and fish oil (FO). The sustainability of aquaculture (particularly salmon farming) has frequently been questioned on the basis of its FM and FO usage, even though the industry has had very little impact on the overall quantity of capture fisheries utilised for FM and FO. Any increase in availability has come through greater use of fish processing co-products (18).

The use of FM and FO in all farmed fish feed is a contentious issue (catching wild fish to feed to farmed fish), and the feed industry is active in reducing FM and FO inclusion levels and finding materials and methods whereby it can replace both with alternative ingredients, without having detrimental effects to fish health, growth rate and ultimately the quality of the final product. A typical salmon diet in 1995 may have contained >50% FM and >25% FO, but levels today are considerably lower as shown in Figure 6.

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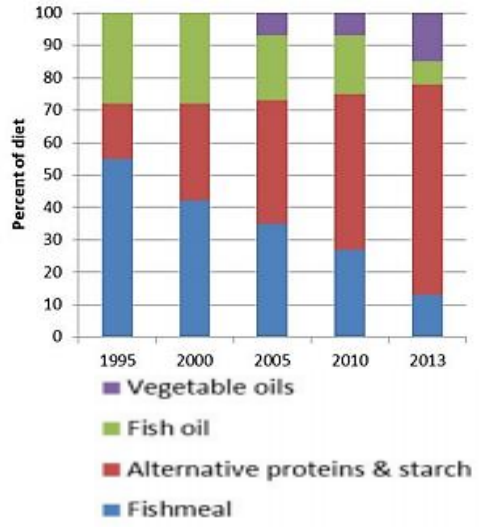
Figure 6. Atlantic salmon diets over time (18)



The International Fishmeal and Fish Oil Organisation (IFFO) (now the Marine Ingredients Organisation), estimates that on average producing 1 mt of farmed fish (excluding filter feeding species) takes 0.5 mt of whole wild fish. For salmon the FI:FO (Fish In: Fish Out) ratio is higher at around 1.7:1, but reduces to 1.4:1 for all salmonids (19).

In terms of protein production efficiency farmed salmon compares very favourably with other main sources of animal protein, i.e. cattle, poultry, sheep, and pork. There is a variation in the feed conversion ratio (FCR) of between 1.2 and 8.0, with farmed salmon scoring best and cattle worst. Wild salmon has an FCR of approximately 10.0 (20).

Many sea farms use computerised systems to drive automated feeding systems, with feedback mechanisms to detect when the fish have finished feeding. This allows fish to be fed to satiation without overfeeding and consequent feed wastage.

Flesh colour

Several weeks before harvesting, a pigment is included in the feed pellets to give the salmon flesh its normal pink colour (the colour demanded by the market). In nature, fish such as salmon, trout and Arctic charr get their pink colour from eating crustaceans (mainly small shrimps), which contain natural carotenoid pigments. These provide vitamin A and function as antioxidants, enhancing the animal's immune system, helping to prevent disease.

Farmed salmon are fed carotenoid pigments (usually astaxanthin or canthaxanthin) to create the same flesh colour as found in wild fish (a paler pink). Organic salmon are fed only naturally derived pigments (such as a type of yeast extraction or shrimp shell). Other farmed salmon maybe fed on a synthetically produced, but identical, pigment, or the natural extract, depending on the requirements of the particular retailer or brand that is selling the farmed fish. Synthetic astaxanthin is considered safe for use in salmonids up to 100 mg/kg complete diet by the European Food Safety Authority (EFSA) (21).

Carotenoid pigments are added to the diet during the seawater growing phase of the production cycle. The colour of farmed salmon can vary widely from red to orange-red, rose and pink and this depends mostly on the amount of pigment in the diet. Flesh colour is particularly important in some

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markets and buyers often use colour charts such as a 'Salmofan' (22) to compare different products.

Culling/harvesting methods

The whole process must be carried out with the aim of keeping stress to a minimum (this also maximises flesh quality). The fish are starved for 2-3 days (no more than 72 hours), and are transported to the slaughter plant alive, or are slaughtered at the farm. An efficiently applied percussive blow is currently used in the UK to stun the salmon (23). Once stunned the fish are bled and then immersed in iced water. Waste disposal of blood is strictly controlled in order to prevent disease transmission. The fish are then gutted, washed and chilled. Once the flesh temperature reaches approximately 3°C, the fish are graded and packed on ice. The next step depends on the market. Fish can be frozen for sale as whole frozen salmon or as fresh gutted salmon. However, most fish are filleted and either sold as fresh salmon fillets or set aside for smoking and other VAPs.

In the UK RSPCA welfare standards for farmed Atlantic salmon call for all fish to be 'killed humanely without any unnecessary distress or discomfort' (24).

Licensing, management and health

In all salmon producing regions, the relevant authorities have a licensing regime in place. In order to operate salmon farming. The licenses constrain the maximum production for each company and the industry as a whole. Licensing regimes vary across jurisdictions (3).

Scottish fish farming is amongst the most highly regulated food production systems in the world (25), both through statutory duties and voluntary codes.

Maximising survival and maintaining healthy fish stocks are primarily achieved through good husbandry and health management practices and policies. Such practices, in addition, reduce exposure to pathogens and the risk of health challenges.The industry is tightly controlled and uses plans to manage fish health, veterinary health, bio security, disease mitigation, contingency, disinfection procedures and surveillance schemes, as well as coordinated and synchronised zone/area management approaches to support healthy stocks with an emphasis on disease prevention (3).

For the majority of salmonid health conditions, prevention is achieved through vaccination at an early stage in production. Vaccines are widely used commercially to reduce the risk of health challenges (3). Still the idustry does have serious issues in certain areas of health management – the continued battle against sealice is just one example (26, 27).

In some situations medicinal treatment is still required to maximise survival and even the best managed farms may use medicines from time to time (3). If medicinal products are applied strict withdrawal times are followed so that any veterinary medicine residues do not remain when salmon are harvested.

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Management standards and certification

Both environmental and economic pressures support the need for management standards and certification of aquaculture production.

Environmental considerations

The cultivation of Atlantic salmon is one of the most commercially successful intensive aquaculture operations in the world. It demonstrates what can be achieved through targeted investment, innovative research, technological advances and creative marketing strategies.

But inevitably the rapid growth of the farmed salmon industry has raised some environmental and social concerns (11, 16)

- Farms could create reservoirs for disease, particularly sea lice, which could affect migrating wild salmon
- Escapees from fish farms could compete with wild salmon, especially for spawning habitat, breed with wild populations and dilute their genetic integrity, or establish themselves in regions where they are a non-native species
- Solid organic wastes from the farms cause degradation of the sea bed and local benthic habitats
- Dissolved nutrient wastes from the farms could contribute to eutrophication and increased risk of algal blooms
- Chemical and pharmaceutical use by farms could have adverse effects on other organisms and the local ecology
- Farms attract predatory animals (especially seals and sea birds) which can then be adversely impacted by anti-predator measures adopted by farmers (e.g. deaths due to entanglement in anti-predator nets)
- The visual amenity and utility of spaces for other recreational and commercial uses can be adversely affected by cage-farming
- The continued use of FM and FO in salmon feed

Certification schemes

Certification is a voluntary process that allows a supplier to demonstrate responsible sourcing practices by: minimising impact on the environment; making the best use of locally available resources; making informed choices regarding labour rights in the developing world; complying with national legislation and ensuring the best use of feed and therapeutic products.

In the UK

- Code of Good Practice for Scottish FinFish Aquaculture (CoGP) (28). Since its implementation in 2006, the CoGP has been widely adopted as an industry production standard in Scotland and has become recognised both nationally and internationally. The CoGP provides a framework to: help achieve balanced and proportionate regulation of the industry's activities, without overwhelming

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preoccupation with regulatory detail or bureaucracy; provide assurance to all stakeholders, consumers and the general public that Scottish finfish aquaculture is a responsible sector; and to maintain standards at a specified desirable level.

- RSPCA Freedom Food welfare standards for farmed Atlantic salmon (24). The standards embody the RSPCA five freedoms and take account of legislation, official codes of practice, scientific advice, practical experience and Farm Animal Welfare Council advice. AS of QI/II 2014 70% of Scottish Atlantic salmon was covered by Freedom Food standard (29).

International arena

Internationally the development of aquaculture standards has been underway for many years, and a variety of organisations now offer independent, 3rd party audited standards, including the Global Aquaculture Alliance, GLOBALG.A.P and the Aquaculture Stewardship Council . In January 2011 FAO approved technical guidelines on the certification of aquaculture (30).

For the responsible sourcing and production of FM and FO there is the Marine Ingredients Organisation (IFFO) (19) which offers their IFFO Global Standard for Responsible Supply Global Standard for Responsible Supply (31).

- GLOBALG.A.P (GG) - Good Agricultural Practice (32) is a private sector body that sets voluntary standards for the certification of production processes of agricultural (including aquaculture) products around the globe. The standard serves as a global reference system for other existing standards. It is a business to business (B2B) label and not directly visible to consumers. Standards for salmon farms were launched in 2005. Their website states at least 125 salmon producers worldwide had been GG certified by QI 2015.
- The Global Aquaculture Alliance (GAA) (33) is an international, non-profit trade association, registered in the USA that promotes advancement in environmentally and socially responsible aquaculture. The GAA has developed Best Aquaculture Practices (BAP) certification standards for aquaculture products and offers a consumer-facing logo. GAA BAP Standards for salmon were launched in June 2011. According to their website 140 salmon farms worldwide had been GAA certified by QI 2105.
- Aquaculture Stewardship Council (ASC) (34) engaged with many industry, government and non-governmental organisations to reach agreement on principles and standards for its certification scheme. ASC also offers a consumer-facing logo. The salmon standard was launched in June 2012. As of QI 2015, 31 farms had been certified, with a further 19 under assessment.
- The Global Salmon Initiative (GSI) (7) began in 2012 following a meeting of salmon farming companies from Norway, Chile and Scotland, after realising that the

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global potential of the farmed salmon industry will only be met with significant improvements in sustainability. The GSI is committed to minimising their environmental impact, sourcing sustainable feed and improving the social impact of their operations..

- The Global Sustainable Seafood Initiative (GSSI) (36). As seafood certification and labelling programs become the primary tool to address sustainability issues for many companies, buyers, and consumers, the number of such programs has led to confusion and inefficiencies. In 2013 the GSSI was created to develop a common, consistent and global benchmarking tool for these programs, in order to measure and compare their performance. It is envisaged that the final version of the GSSI Global Benchmark Tool will be available in QIII 2015.

In addition there are various retailer-led schemes including: UK supermarket quality schemes; the Label Rouge government-led scheme in France (35); as well as niche market schemes such as organic salmon.

There are also supply chain standards. The British Retail Consortium (BRC) Global Standard & Safe & Local Supplier Approval (SALSA) certification are designed to raise standards in the seafood processing and wholesaling sectors.

Product characteristics

Farmed Atlantic salmon has a high oil content (36), and is excellent source for the marine Omega-3 polyunsaturated fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). A standard portion of farmed Atlantic salmon fillet (200 g) provides approximately 2 g of EPA and DHA,which is four times higher than the minimum daily intakes recommended by the UK's Scientific Advisory Committee on Nutrition and the World Health Organisation (37). It is also a good source of thiamin, niacin, Vitamin B6 and phosphorus, and is a very good source of protein, Vitamin B12 and selenium. Farmed Atlantic salmon is available all year round. It has a medium flavour and flesh texture, with large flakes (36). It is sold fresh or frozen in slices, fillets or as whole fish. Salmon fillets can also be cured, cold-smoked and hot-smoked. Fresh salmon can be used raw in sashimi and sushi. It can be baked, poached, smoked, grilled, steamed, fried, etc

At the end of 2014 new EU 'Labelling of Fishery and Aquaculture products' (FAPs) came into force. Now all wild fishery and farmed aquaculture products marketed within EU (both the EU and non-EU products) will display mandatory and voluntary information about the product for final consumers and mass caterers (39, 40).

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This is one of a series of responsible sourcing guides for aquaculture. See: http://www.seafish.org/industry-support/aquaculture

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