

*Salmo salar*

**Atlantic salmon (*Salmo salar*) is a species of fish of the family *Salmonidae* (1). Other species in the family are Pacific salmon and trout. While Atlantic salmon is both wild and farmed, wild populations are generally at very low levels, and their commercial harvest is limited, so the great majority of Atlantic salmon is farmed.**

In volume terms Atlantic salmon is the most important species of salmonid in the world and is mainly farmed in Norway, Chile, Scotland and Canada. These countries represent approximately 95% of the total harvest. Production also occurs in Ireland, the Faroe Islands, USA and Australia (Tasmania), with minor production in New Zealand, France and Spain.

Farmed Atlantic salmon constitute >90% of the farmed salmon market, and >50% of the total global salmon market (farmed and wild). Global production of Atlantic salmon was 1,475,780 tonnes in 2010 (2). The major markets for farmed Atlantic salmon are Russia, the EU and North America. The major products are fresh (whole, as steaks or filleted), frozen, and smoked (mainly for the European market). A small, but increasing percentage, is processed to supply value-added products into the market (3). Scotland is by far the largest producer of farmed Atlantic salmon in the EU (the third largest globally), producing 154,164 tonnes in 2010 with an estimated value of £539.6 million at farm gate prices. It accounts for over one-third of Scotland's food exports by value (4).

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. The vast majority of Atlantic salmon currently in production is hybrid stock, derived originally from native crossed with Norwegian stock. Some selective breeding programmes are now in place, in order to attempt to identify family lines with increased production potential and/or disease resistance.

### BUYERS' TOP TIPS

Know your source of supply and only purchase salmon which is traceable throughout its entire production chain.

Ensure product complies with the appropriate farming, processing and production standards.

Buyers should ensure the salmon flank is silvery in colour, with bright eyes, pale pink gills, little or no smell and cold and firm flesh (5)

Be aware of the social and environmental impacts.

**Responsible Sourcing Services** This guide is one of a series of Responsible Sourcing Guides.

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**The purpose of this guide is to help seafood buyers by outlining important features of the cultivation of Atlantic salmon and detail the standards available, and in development, to control environmental effects.**

## Sources and quantities

Norway, Chile and Scotland dominate the production of Atlantic salmon (Figure 1). Production (Figure 2) has steadily increased over the last twenty years (6).

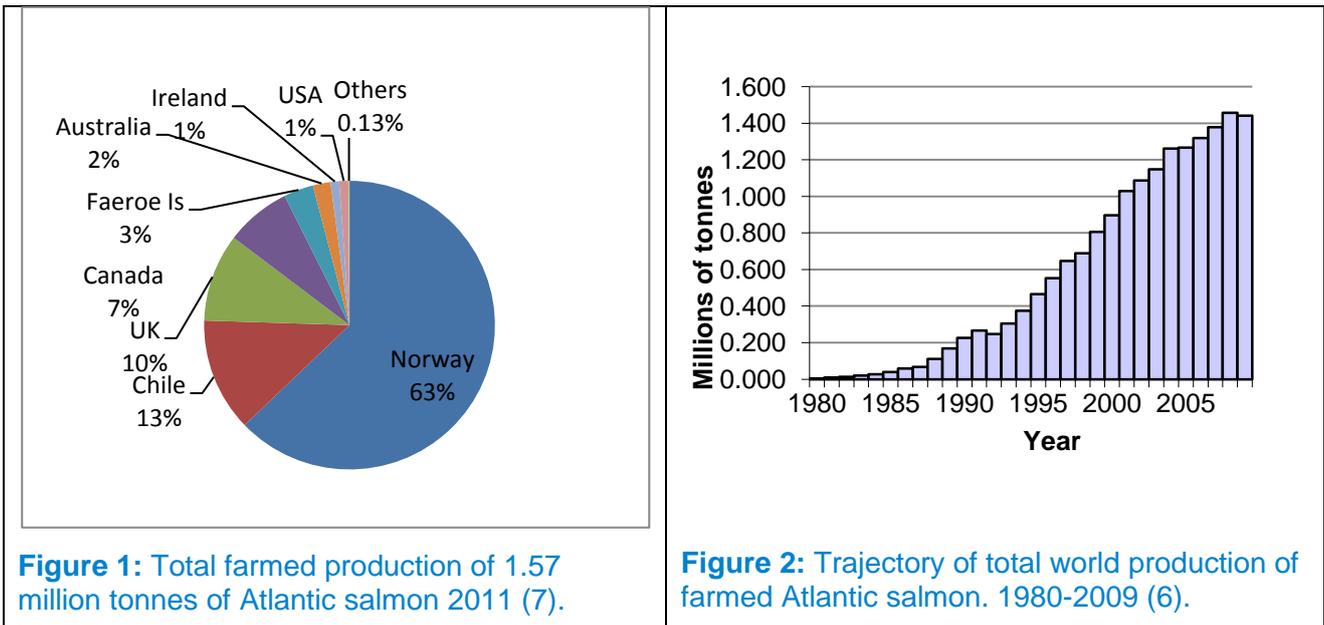


Figure 3: Global trade in farmed salmon and trout (5).



## Biology<sup>(8,9)</sup>

Salmon are an anadromous fish, which means that they spend most their adult life in the ocean but return to freshwater to reproduce. The total farmed Atlantic salmon life cycle takes approximately 24 to 36 months, with 10 to 16 months in freshwater, followed by 14 to 22 months in sea water. This is however dependent on water temperature. As salmon are cold-blooded animals (ectotherm), water temperature plays an important role in their growth rate. The optimal temperature range for Atlantic salmon is 8-14° C. This means that historically the production time in Chile is a few months shorter than elsewhere, because the sea water temperatures are more optimal, and because average harvest weight is lower, resulting in fewer months needed in sea water before harvesting.

### Feed

Salmon are carnivorous and are generally fed compound fish feeds (as specially formulated pellets). Historically the two most important ingredients in fish feed have been fishmeal and fish oil. The use of these two marine raw materials in feed production has been reduced and partly replaced by vegetable ingredients, such as soya beans, sunflower meal, poultry by products (Chile and Canada) and rape seed oil. Fishmeal and other raw materials of animal origin have a more complete amino acid profile than protein of vegetable origin. It is therefore difficult to replace fishmeal 100%. Due to market demands, legislation and different availability of raw materials, the ingredients used in fish

feed today are different from country to country, giving higher raw material flexibility in certain regions such as Chile and Canada.

Typical salmon diets contain 45-50% protein and up to 25% fat. There are various calculations to determine the fish in-fish out ratio for farmed salmon (comparing the amount of whole wild fish used in fish feed with the amount of whole fish produced by the fish farm).

The International Fishmeal and Fish Oil Organisation (IFFO) estimates that on average producing one tonne of farmed fish (excluding filter feeding species) takes 0.5 tonnes of whole wild fish. For salmon the FIFO ratio is slightly higher at around 1.7:1 (when combined with shrimp production) but comes down to 1.2:1 when also combined with carp production. It is technically possible to grow high quality salmon using a feed that delivers a 1:1 fish in – fish out ratio, by substituting vegetable proteins and oils for fish ingredients, however this does not deliver the same high levels of essential Omega-3 fatty acids in the final product (10, 11).

In terms of protein production efficiency farmed salmon compares very favourably with beef, poultry, sheep, and pork. There is a variation in the feed conversion ratio (FCR) - a measure of efficiency in converting feed mass into increased body mass - of between 1.2 - 8.0. Farmed salmon scores best and cattle worst. Wild salmon has an FCR of approximately 10.0 (9). 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.

## Cultivation methods and systems (8, 9)



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

### 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. 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 standards. Within two to three months the eggs have hatched to produce fry.

### Freshwater production

During early spring, the fry start to feed and they are transferred to small tanks in the hatchery. Feeding is partly by hand and partly automatic. As the fish grow during the

summer period, they are moved outdoors into bigger 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. 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 100,000 smolts depending on its well capacity.

### Rearing in the Sea

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

It has been illustrated that each 100g smolt has a space in a cage equivalent to 1,000 times its own volume and a salmon ready for harvest has a space equivalent to 50 times its own volume. In other words, the salmon in the cages only takes up between 0.1% and 2% of the available space. Also, with a tidal current of 1 mile per hour, 24 miles of sea water passes through the cages every day. By extrapolation, the fish must swim up to 24 miles in one day just to stay in the same position. However, they actually swim around

the cage at about 4 miles per hour which is the equivalent of a good walking pace (12).

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.

### 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) and to mirror the diet of wild fish. 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, and to aid fish health. 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.

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 markets and buyers often use colour charts to ensure the flesh colour can be consistently graded (13).

### 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. 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. In the UK RSPCA welfare standards call for all fish to be 'killed humanely without any unnecessary distress or discomfort' (14).

The next step will depend on the market. Whole 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.

### Fish health management

The industry is tightly controlled and uses fish health management plans, veterinary health plans, bio security plans, disease mitigation plans, contingency plans, 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.

If medicinal products are applied strict withdrawal times are followed so that any veterinary medicine residues do not remain when salmon are harvested.

## 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. FAO has highlighted the need to minimise any potentially negative impacts that aquaculture could have on the environment and society (7), and there are programmes in place to address all of these issues (9):

- General legal issues surrounding construction and operation;
- How farms affect land and water use, siting and their benthic impact;
- Water pollution and waste management;
- Effective containment to minimise the potential of farmed fish escaping;
- The efficient use of fishmeal and fish oil to aid the effective management of a finite resource;
- Issues surrounding health management, veterinary medicines and chemicals;
- Social responsibility regarding labour practices and conflicts among users of the shared resources.

### 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 available resources; making informed choices regarding labour rights in the third 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)** (15). Since its implementation in 2006, the independently-audited 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: embrace new science and developments so that it remains a robust reflection of sustainable finfish aquaculture; it comprehensively sets out the standards that farmers must demonstrate, comprising consumer reassurance, fish health, protecting the environment, welfare and husbandry, feed and feeding; and to provide assurance to all stakeholders, consumers and the general public that Scottish finfish aquaculture is a responsible sector.
- **RSPCA Freedom Food welfare standards for farmed Atlantic salmon** (14). Launched in 2002 the standards from the UK's leading

animal charity embody the RSPCA five freedoms and take account of legislation, official codes of practice, scientific advice, practical experience and Farm Animal Welfare Council advice. Scottish farmed salmon tops the RSPCA's Freedom Food chart, with an impressive 70% of marine production participating in the stringent animal welfare scheme.

### International arena

Internationally the development of aquaculture standards is underway through a variety of organisations (below). In January 2011 FAO approved technical guidelines on the certification of aquaculture (16).

Benchmarking studies are in the pipeline but a review of Fish Sustainability Information Schemes including aquaculture, was completed by MRAG in January 2010 (17).

- **GLOBALG.A.P Good Agricultural Practice** (18) is a private sector body that sets voluntary standards for the certification of production processes of agricultural (including aquaculture) products. 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. The first Chilean salmon producer achieved Integrated Farm Assurance Standard 4.0 in June 2011.
- **The Global Aquaculture Alliance (GAA)** (19) 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 completed BAP Standards for salmon in June 2011 - first salmon farm was certified in December 2011 (British Columbia), first processing facility in Jan 2012 (Chile).

- **WWF initiated the Salmon Aquaculture Dialogue** process (20) which engaged with many industry, government and non governmental organisations to reach agreement on principles and standards for the **Aquaculture Stewardship Council (ASC)** certification scheme. ASC offers a consumer-facing logo. Global standards for salmon aquaculture were handed over to the ASC on 13 June 2012. The ASC will oversee certification of salmon farms that are in compliance with the standards.
- IFFO has introduced **IFFO RS**, a Global Standard and Certification Programme for the Responsible Supply of Fishmeal and Fish Oil (11).
- **The Sustainable Fisheries Partnership (SFP)** (21) operates Aquaculture Improvement Partnerships (AIPs), which are alliances of producers, suppliers and buyers working together to address relevant issues in specific areas. SFP does not offer a certification scheme.

In addition there are other schemes including: UK supermarket quality schemes; the Label Rouge quality scheme in France; as well as niche market schemes such as organic salmon schemes.

## Product characteristics and seasonal cycles

Farmed Atlantic salmon is an excellent source for the marine Omega-3 polyunsaturated fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). A 200 g farmed Atlantic salmon fillet provides approximately 200 mg of EPA and DHA (22). The Scientific Advisory Committee on Nutrition (SACN) recommendation is to consume at least two portions of fish per week, of which one should be oily, which provides 450 mg of EPA and DHA/day (SACN 2004) (23).

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.

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, microwaved or barbecued. Smoked salmon can be served as a sandwich filling or in salads, with pasta and in many other combinations.

## Supply chain standards

Responsible practice in the chilled and frozen supply chain depends on correct catching, gutting, washing, chilling or freezing, processing and handling practices throughout the chain. There are standards which cover these aspects from capture to retailer:

- **British Retail Consortium (BRC) Global Standard & Safe & Local Supplier Approval (SALSA) certification.** Designed to raise standards in the seafood processing and wholesaling sectors.

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**For further guides see:** <http://tinyurl.com/seafishrsg>

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