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) the name ‘Pacific salmon’ includes 6 species, *Oncorhynchus kisutch* (aka Coho, Medium Red or Silver salmon) and *Oncorhynchus tshawytscha* (aka Chinook, King or Spring salmon) being two species that are farmed in aquaculture systems. Both species will be detailed in this report. The UK market is dominated by farmed Atlantic salmon products, and supplies of farmed Pacific Coho and Chinook in the UK are thought to be limited.

The purpose of this guide is to give buyers background information on the responsible sourcing of farmed Pacific salmon. It is recommended that the Atlantic salmon Responsible Aquaculture Sourcing Guide is read in conjunction with this guide.

**Coho salmon – Sources and quantities**

Coho salmon is available both caught and farmed. Wild populations of Pacific salmons are generally in decline and capture of coho salmon has seen significant reductions (2). Culture of coho salmon was initiated around 1900 in Oregon, US, to improve fisheries and mitigate human activity, such as dam construction.

Seventy years later, the first cage-based farming of coho salmon took place in Puget Sound in Washington State. Over a 15-year period, from 1970 until the mid-80s, it farmed some 3,000 metric tonnes (mt) of Coho salmon per year (3).

In 1980 cage farms were established in Chile and Japan. By 1994, Japanese production was stable at 10,000 mt per year. Chile continued to increase (4) - now the major aquaculture producer of Coho salmon with 90% of global production (170,000 mt produced in 2012 (Fig 1) (2, 5). North America have some closed aquaculture facilities, but production is small (3).

Combined farmed salmonid (Atlantic and Pacific salmon, and
trout) supply in 2013 represented almost two million mt of head-on, gutted (HOG) fish. The contribution of Coho salmon to global farmed salmonid supplies is small (~1/10th) compared to Atlantic salmon which equated to 1.84 million mt HOG or 92% of total supply (6).

The Japanese market represents 40% of Chile’s total salmon exports and is the main destination for coho salmon (7). Although Japan ranks 2nd as a global coho producer, it is the leading coho market with a share of more than 90% of the total volume. Most of the Japanese consumption is based on imports from Chile. The production of coho is to a great extent determined by consumer preference in Japan which is 1.8 – 2.7 kg fish sold frozen in supermarkets (3). Subsequently, Chilean coho exports to Japan are mainly frozen, headless whole gutted (HG) fish (7). New Brazilian and Russia markets may be important to coho producers in the future (8).

**Chinook salmon – Sources and quantities**

Chinook salmon is available both caught and farmed. Wild populations of Pacific salmons are generally in decline and capture of Chinook salmon has seen significant reductions (9).

The majority of aquaculture production of Chinook salmon comes from New Zealand, where production reached 12,397 mt in 2012 (10). Chinook salmon are not native to New Zealand, they were introduced as a game fish in the mid-1800’s and became fully established in the early 1900’s. Chinook salmon were first farmed in New Zealand in 1983. The species is cultured in either marine net pens located in the inshore environment, or freshwater pens which are constructed in abandoned freshwater hydropower canals (11). Production is split between these two systems, circa 90% and 10% respectively (10).

New Zealand’s production makes up approximately 88% of the global production of Chinook salmon (14,000 mt in 2012 (9)) and is produced by a handful of companies / farms (10, 12). Remaining production comes mainly from Chile. Chinook is also farmed in Canada (10), but production is small. Combined farmed salmonid (Atlantic and Pacific salmon, and trout) supply in 2013 represented almost two
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million mt of head-on, gutted (HOG) fish. The contribution of Chinook salmon to global farmed salmonid supplies is extremely small when compared to Atlantic salmon (equated to 1.84 million mt HOG, or 92% of total 2013 supply (6).

Taking figures from New Zealand’s largest Chinook salmon producer gives a good indication of Chinook salmon markets. The majority of the farmed Chinook (60%) is consumed domestically in New Zealand. Australia and the US are the largest importers, each purchasing 13% of the product, whilst Japan follows with 6%, South East Asia with 6% and the rest of the world making up the remaining 2% (10).

Pacific salmon aquaculture is small compared to the dominance of the Atlantic salmon industry. Nevertheless Pacific 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.

Much research has, and continues to be conducted in all aspects of aquaculture science and salmon farming; the vast majority has unsurprisingly been for Atlantic salmon (13). However developments in this sector of the salmon aquaculture industry can, and has, been translated to Pacific salmon production.

Biology

All Pacific salmon species are anadromous, which means they spend some part of their juvenile life in fresh water before migrating to sea. There they feed and grow before maturing and moving inshore where they aggregate into ‘salmon runs’ to swim through estuaries into fresh water, usually their river of origin, where they spawn. All Pacific salmon spawn just once and then die (13).

Coho salmon (2)

Coho salmon, range from California to Canada and Alaska and on the eastern coast of Russia and northern Japan (Figure 3). The species spawn in nearly all accessible freshwater bodies, from large rivers to small tributaries, where the juveniles spend one to two years before migrating to sea. All coho spend just 18 months at sea and grow rapidly before returning to spawn at a weight of 2.5 – 5kg.

Chinook salmon (9, 15)

Chinook salmon is the least abundant but largest Pacific salmon, often exceeding 20kg. The species’ range extends along the American coast from central California to Alaska, and across the Bering Sea to Siberia.
and northern Japan. Juveniles spend 3 months to a year or more in freshwater before migrating to sea. The fish may mature at anything from 2 – 7 years.

Figure 3. Wild Pacific salmon geographical distribution (2, 9)

Figure 3 details the natural range (‘certain’ in the colour legend), of Coho and Chinook salmon, but also highlights ‘not certain’ distribution. This shows where the species have been introduced (e.g. in New Zealand for Chinook salmon), and where they are reared in aquaculture facilities (e.g. Coho in Chile, and Chinook in New Zealand). Both species are utilised for aquaculture production outside their natural range.

As salmon are cold-blooded animals (ectothermic), water temperature plays an important role in their growth rate, the optimal temperature range for coho salmon is within 9 - 15 °C (3). Chilean seawater temperatures compliment this species production. Coho salmon has a red colour, whereas Chinook flesh is dark pink, and has the highest natural oil content of all salmon giving it a rich flavour and delicate texture; perfect for sashimi, baking, frying, grilling and smoking (12).

Cultivation methods and systems

Usually, the production cycle and the technology applied in coho (and chinook) salmon farming are not very different from Atlantic salmon farming (3), stages include:

- Broodstock and freshwater hatchery techniques
- Smolt transfer to sea
- Grow-out on floating pens / cages (e.g. Coho salmon 10 - 12 months and harvested at 2.5 - 3.5 kg; Chinook 19 - 31 months to reach market size 3.5 - 4 kg) (16, 17)
- Harvesting and culling
Coho and Chinook salmon are hatched, raised and harvested under controlled conditions, utilising high-end technology (18, 19), such as computerised, automated feeding systems, with feedback mechanisms to reduce over feeding and feed wastage.

General cultivation methods and systems for Atlantic salmon are detailed in the Seafish guide for this species. See this document for further information.

**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 (20).

The use of FM and FO in all farmed fish feed is a contentious issue, 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 an example for Atlantic salmon feed (Figure 6).

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 (21). 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 (22).

**Flesh colour**

Several weeks before harvesting, a pigment is included in salmon feed to give the flesh its normal pink colour (the colour demanded by the market). In nature, fish such as salmon
get their pink colour from eating crustaceans (mainly small shrimps), which contain natural carotenoid pigments. Farmed salmon are fed carotenoid pigments (usually astaxanthin or canthaxanthin) to create the same flesh colour as found in wild fish. Organic salmon are fed only naturally derived pigments (such as a type of yeast extraction or shrimp shell). Other farmed salmon may be 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 it. Synthetic astaxanthin is considered safe for use in salmonids up to 100 mg/kg complete diet by the European Food Safety Authority (EFSA) (23).

**Licensing, management and health**

In all salmon producing regions, the relevant authorities have a licensing regime in place to operate salmon farming. Licenses constrain the maximum production for each company and the industry as a whole. Licensing regimes vary across jurisdictions (6).

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 (6).

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 (6). Still the industry does have serious issues in certain areas of health management.

The Chilean salmon industry was hit hard between 2007 - 2009 by ISA (Infectious Salmon Anemia) virus, and its main Atlantic salmon industry was hit hard (24, 25). Seemingly Pacific salmon finds ISA and also sea lice (one of the most serious problems the Atlantic salmon industry has to deal with (26, 27)) less problematic (3,10, 28).

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. High bio-security measures, resistances to parasites such as sea lice, as well as and low farming densities have contributed to an absence of disease outbreaks in New Zealand Chinook aquaculture. As such, antibiotics, pesticides and chemicals have not been used to a great extent (10, 29).
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 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. However, the inevitable rapid growth of the farmed salmon industry has raised some environmental and social concerns (10, 25, 30), including:

- Farms create reservoirs for disease, particularly sea lice, which could affect migrating wild salmon
- Escapees from fish farms could establish themselves in regions where they are a non-native species - as Coho is in Chile for example
- 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 marine mammals, 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.

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 (31), GLOBALG.A.P.(32) and the Aquaculture Stewardship Council (33). In January 2011 the FAO approved technical guidelines on the certification of aquaculture (34). For the responsible sourcing and production of FM and FO there is the Marine Ingredients Organisation (IFFO) (21) which offers their IFFO Global Standard for Responsible Supply (35).
All the major certification schemes mentioned above have standards for salmon, but to distinguish which species (Atlantic, Coho, Chinook) has been certified is difficult. As the vast majority of global production is Atlantic salmon, those farms currently certified are mostly for this species (more detail is given in the Atlantic salmon guide). It is assumed that farms certified in Chile for example will include Coho producers, as will ASC certified farms. The Global Aquaculture Alliance (GAA) database does list 8 New Zealand farms that have been certified, and these could be assumed to be Chinook producers.

- **The Global Salmon Initiative (GSI)** (36) began in 2012 following a meeting of salmon farming companies from Norway, Chile and Scotland, after realising that the 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)** (37). As seafood certification and labelling programs become the primary tool to address sustainability issues 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. The final version of the Global Benchmark Tool should be available in QIII 2015.

In addition there are various retailer-led schemes including: supermarket quality schemes; as well as niche market schemes such as organic salmon schemes. There are also supply chain standards. The British Retail Consortium (BRC) Global Standard & Safe & Local Supplier Approval (SALSA) certifications are designed to raise standards in the processing and wholesaling sectors.

### Product characteristics

Farmed salmon has a high oil content (38), 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, four times higher than the minimum daily intake, recommended by the UK’s Scientific Advisory Committee on Nutrition, and the World Health Organisation (39). It is a good source of thiamin, niacin, Vitamin B6 and phosphorus, and a very good source of protein, Vitamin B12 and selenium.

At the end of end 2014 new EU ‘Labelling of Fishery and Aquaculture products’ (FAPs) came into force. Now all wild fishery and farmed aquaculture products marketed within the EU (both the EU and non-EU products) will display mandatory and voluntary information about the product for final consumers and mass caterers (40, 41).
REFERENCES