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Atlantic Salmon Trust Position Paper on Salmon Aquaculture
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1. Context

Aquaculture currently provides about half of the world's seafood supply, and future growth in supply will come from the aquaculture industry. Global harvest from wild capture fisheries reached a plateau in the mid-1980s and is not likely to increase significantly even with the adoption of smarter fishing practices and fish habitat conservation. Rising global demand for seafood, along with technological and scientific innovations, may well allow the industry to realise its economic targets but this must be achieved alongside environmentally responsible aquaculture production. In this way, it should be possible to produce the desired quantities of sea food in a resource-efficient way, to create jobs, and to help maintain healthy oceans.

However, to achieve these goals in the North Atlantic, fin fish aquaculture must, as a matter of urgency, overcome persistent and serious problems relating to the impacts of salmon farming on wild migratory salmonids. These problems have been extant for over 30 years and, despite numerous initiatives and undertakings by industry and governments, they continue to severely impact individual populations of wild salmon and sea trout.

The Atlantic Salmon Trust (AST) is committed to the protection of wild migratory salmonids and the ecosystems that sustain them. We believe that any industry can only claim to be sustainable if it protects and safeguards the surrounding natural habitat. This is particularly true in the case of salmon farming, where the welfare of the industry itself is in the longer term totally dependent on the quality and integrity of the surrounding aquatic environment.

AST recognises the economic and social importance of fish farming in remote rural areas but it is our view that this must not be allowed to override the need to conserve natural ecosystems and maintain the high conservation status of wild salmonids. Implicit in the adoption by governments of the ecosystem approach to managing our natural aquatic resources is a requirement for the salmon farming industry to be sustainable both economically and environmentally, operating in harmony with its surrounding environment.

The AST also believes that reducing sea lice infestation levels, treating / eradicating diseases from fish farms and preventing the escape of fertile farmed salmon are goals shared by both the wild fish and fish farming sectors. For example in the case of sea lice, mutual concerns relate not only to the direct physical and physiological impacts of the lice themselves but also to their role as disease vectors.

The AST recognises that there will be significant financial costs involved in combating lice infestation, both to governments and industry. However, we believe that these are costs that must be met because if sea lice, disease and farmed escapes are not better controlled they will threaten the viability of both the salmon farming industry and the survival of wild migratory salmonid stocks.

2. Risks to Wild Migratory Salmonids

AST believes that there are three major sources of risk from the aquaculture industry to wild salmon and sea trout stocks:

1. Sea lice,
2. Farm escapes, and
3. Disease and Pollution Risks from Salmon Cages,

Advice presented to the recent NASCO meeting in Bad Neunenahr – Ahrweiler, Germany, by the International Council for the Exploration of the Seas (ICES) on the status of salmon stocks in the North Atlantic region showed there was continuing low, and in some areas, critically low abundance of salmon throughout the Atlantic salmon's range. In this context AST believes that urgent action is required to deal with current impacts and risks from the aquaculture industry.

2.1 Sea Lice Control and Management

There is compelling scientific evidence that sea lice emanating from salmon farms can pose a very dangerous risk to wild migratory salmonid populations. It is essential that urgent action is taken by the salmon farming industry, and by governments, to control levels of sea lice infestation on salmon farms.

Sea lice are the most significant parasitic pathogen in salmon farming in Europe and are estimated to cost the world industry over €300m a year. Despite this level of expenditure it is now clear that wild salmonids are impacted by excessive infestations of sea lice arising from local salmon farms. Moreover, given evidence of increasing resistance to chemical controls amongst the lice infecting certain farmed stocks and of changing environmental conditions in bays along the western rim of Europe due to climate change, efforts to control lice need to be redoubled if we are to significantly reduce the risks to wild migratory stocks.

Based on the current body of research and presentations delivered to the NASCO day-long Special Session on Aquaculture (June 2016), the Atlantic Salmon Trust firmly believes that ICES has provided convincing evidence of both direct impacts and major risks from open cage salmon aquaculture on wild salmon and sea trout stocks, in terms of both sea lice loadings and genetic introgression from escaped farmed fish.

Indeed Marine Scotland Science's recent publication: *'Summary of information relating to impacts of salmon lice from fish farms on wild Scottish sea trout and salmon'*, reviewed the current body of available peer reviewed published evidence to assess the likelihood and scale of impact of salmon lice from salmon farms on Scottish wild salmonids. In the closing summary it states that *'salmon aquaculture can result in elevated numbers of sea lice in open water and hence is likely to increase the infestation potential on wild salmonids. This in turn could have an adverse effect on populations of wild salmonids in some circumstances'.*

AST is convinced that a solution to the problem of sea lice can only be found by taking account of the latest understanding of how sea lice infect farmed and wild salmonids. Most salmon farms are located in bays and sea lochs. These have a finite limit in their capacity to accommodate fish farming activity. Each bay may well have a different capacity which will vary depending on environmental conditions in any

given year. The risk to salmonid year classes is equally variable and therefore the management of the problem requires a rigorous regime of surveillance both in terms of the lice levels on the farms and the health of the neighbouring wild stocks.

The examples provided by Norwegian scientists at the NASCO Special Session clearly showed the complex nature of the relationship between lice densities on farms, lice dispersion and infestation on wild salmonid migratory stocks. The presentations described innovative sea lice dispersion models which enabled the quantitative assessment of bays and their potential to generate high sea lice levels into neighbouring bays and estuaries. They also provide the basis for the practical management of lice levels in bays through the strategic locations of cages (including, where necessary, the relocation of cages to more appropriate farming sites) and managing fish densities in cages.

2.1.1 Action needed

- Governments should introduce effective **mandatory fallowing and treatment regimes.**
- These should include:
    - **single generation management areas**
    - **synchronised fallowing of these management areas**
    - **minimum fallowing periods**
    - **synchronous winter lice treatment**
    - **rotation of sea lice treatments**
    - **adoption of appropriate treatment triggers**

- Governments and industry should introduce **officially validated lice monitoring regimes, the results of which are publicly available.**
- As is the case with most European countries where salmon farming is taking place, **farm-specific sea-lice and sea-lice control data should be published in full and on a regular basis.**
- **Maximum sea lice densities of 0.3 or less, during the critical spring period of March to late May,** should be introduced.
- All **Voluntary Codes of Good Practice should be put on a statutory basis**, with the express purpose of protecting wild migratory salmonids.
- **An upper-tier sea lice threshold should be introduced**, above which an immediate cull or harvest of farmed fish is mandatory.
- Consideration should be given to **closing / relocating sites which, over the medium-term, consistently fail to reach the minimum statutory standards of sea lice control**.

- **All regulations and rules relating to salmon farming must be fully enforced.**

- Where there is a persistent problem with sea lice control in a given location, regulators should be empowered to enforce sanctions and take appropriate action including **such measures as mandatory treatments and harvesting.**

- Governments and industry must continue to **invest in research geared towards reducing the impact of sea lice on wild migratory salmonids**. Particular priorities should include: the refinement and application of sea lice dispersion models as practical management tools; a quantitative assessment of the migration patterns and health of sea trout stocks in selected areas of the coastline, including an ongoing assessment of sea lice infestation parameters.

2.2 Farm Escapes

As in the case of sea lice, the ICES advice at the NASCO Special Session clearly showed that escapes from marine and freshwater salmon farms can interbreed with wild salmon stocks, with a varying level of success. High levels of interbreeding pose serious risks, which can result in genetic introgession, a significant drop in overall fitness and poor survival of the wild salmon stocks. In Norway, for example, one third of the major salmon rivers have been seriously affected by interbreeding between wild and farmed stocks and only one third of wild stocks have shown little if any genetic introgresssion.

Recent research in Norway by Dr Sten Karlsson and his colleagues has shown that some fifty one rivers in Norway showed significant genetic introgression from farmed fish, when compared with historical reference samples. The team found a highly significant correlation between estimated farmed introgression and the average proportion of escaped farmed salmon. The team found a generally lower level of introgression in National Salmon Rivers and National Salmon Fjords subjected to formal protection from salmon farming by the Norwegian authorities. They concluded that farmed to wild genetic introgression is high in a large proportion of Norwegian salmon rivers, with the highest levels found in the most intensive areas of salmon farming. They further concluded that the extensive genetic introgression found from their study poses a serious challenge to the management of farmed and wild Atlantic salmon in Norway and, in all likelihood, in other regions where farmed-salmon escape events occur with regularity

2.2.1 Action needed

- **Efforts to reduce or eliminate escapes from marine salmon cages should be redoubled** and an appropriate penalty system put in place to ensure strict compliance with containment protocols.

- A **ban should be introduced on all open rearing systems for the young stages of salmon**, both raceways and freshwater cage culture and **Government support provided for salmon farmers to invest in modern closed containment rearing systems for juvenile salmon**. A strict timeline should be set for the introduction of a ban on all open rearing systems for juvenile salmon.

- **There should be confidential access to genetic profiles of farmed salmon strains used in freshwater and marine cages**, to help identify the source of escapees from individual sites.

- Incentives for fin fish farmers to move quickly towards the use of **sterile (triploid) stocks,** with an eventual **ban on the use of fertile stocks for rearing in open cage culture**, should be introduced

2.3 Disease and Pollution Risks from Salmon Cages

Since the expansion of salmon farming in the 1980's the industry has suffered serious and persistent problems from a range of virulent diseases and disease "syndromes". Research has shown that sea lice play a pivotal role in transferring disease between cages and cage sites. The presence of disease organisms poses a serious threat to farmed salmon and also to wild migratory salmonids within the vicinity of the cages. There is a real risk that mutations of disease organisms, infecting farmed fish, could occur and infect wild salmon. Wild salmon stocks may well have little if any immunity to such organisms and cannot be treated for the resulting infections.

Cage farming of fin fish, particularly in freshwater lochs, has the potential to generate significant amounts of organic waste from unconsumed fish feed and fecal matter. This can enrich sediments, alter maroinvertebrate community composition and fish population structure. In the case of brown trout, increased food availability risks lowering the physiological drive to migrate to the marine environment and may increase the proportion of resident trout, reduce the number of migratory sea trout and increase the incidence of predatory, ferox trout.

2.3.1 Action needed

- **Assessments should be made of bay holding capacity along each area of the coast** where salmon farming is taking place.

- **Farm / adult salmon densities in each bay should be reduced** to a level which minimizes risk from heavy sea lice infestation and the occurrence of chronic disease outbreaks.

- A **move towards off-shore sites containing low densities of sterile farmed salmon** should be encouraged.

- **A ban on all open rearing, freshwater cage culture should be phased in over a three to five year period** and **Government support provided for fish farmers to invest in modern, closed containment rearing systems for the freshwater phase of the salmon's life cycle.**

3. Closed Containment Systems.

Research is on-going in Scandinavia and North America to develop systems for growing Atlantic salmon right through the marine stage of production, to harvest. Such systems would result in the separation of farmed fish from wild salmonids (and from the environment) by a physical barrier. Both land-based recirculating (RAS) and floating, closed containment systems are being undergoing trials at present. They

are likely to offer many benefits to salmon farmers, as they would protect their fish from sea lice, disease, predators and other natural threats such as jellyfish swarms and algal blooms.

Ideally, in the longer term, the aim should be to move to **closed containment systems.** Such systems could resolve many of the other problems affecting caged farms (such as disease, escapes and faecal waste). The development of closed systems should be a priority for both governments and the industry. Major advances are also likely in the development of offshore, closed containment units for salmon farming and AST supports urgent investment in R&D to bring closed containment systems to commercial viability.

4. International Agreements and Obligations

Salmon farming has been subject to a series of international agreements and signatory parties have an obligation to strive towards the goals as outlined in these accords. These agreements have primarily been brokered through NASCO and are outlined in some detail on their website (http://www.nasco.int/aquaculture.html).

In 2009, the Liaison Group between NASCO and the International Salmon Farmers Association developed 'Guidance on Best Management Practices to Address Impacts of Sea Lice and Escaped Farmed Salmon on Wild Salmon Stocks' (http://www.nasco.int/pdf/aquaculture/BMP%20Guidance.pdf). The international goals of this BMP Guidance include:

- 100% of farms to have effective sea lice management such that there is no increase in sea lice loads or lice-induced mortality of wild salmonids attributable to the farms.
- 100% farmed fish to be retained in all production facilities.

5. Attaining Sustainable Aquaculture

The special session at NASCO, highlighted some very positive steps that could now be made towards the attainment of sustainable salmon farming. In addition to tighter regulations as outlined above, AST strongly recommends that these approaches be reviewed with a view to their application in improving the sustainability of salmon aquaculture. They include:

- Major advances in the development of closed containment RAS (Recirculation Aquaculture Systems) for the rearing / *head-starting* of so-called *super-smolts* (500g to 1kg in weight) and adult salmon. The larger smolts provide the benefit of a shorter period at sea, therefore reducing the time over which sea lice levels can build up on farms. This will enable farms to better manage the time at which salmon are put to sea cages. A shorter rearing cycle could also ensure that bays are fallow during the critical period, when wild salmon and sea trout smolts are heading seawards.
- The introduction of incentives to encourage experimental programmes to produce and rear sterile / triploid aquaculture stocks, as is currently taking place in both Norway and Canada. Such programmes could greatly reduce genetic impacts from fish farm escapes, both in fresh water and salt water.

- Acoustic tracking of wild salmon smolts to identify migration routes. Such an approach could advise the planning process regarding new or alternative fish farm sites, so that their location has the lowest possible impacts on neighbouring wild salmonid stocks.
- The development of quantitative methods, such as those currently in use in Norway, which could measure the level and impact of genetic introgression in wild salmon stocks.
- Monitoring and modelling of sea lice distribution patterns to advise on fish farm locations and locations of potentially greatest risk to wild salmonids.

6. Conclusion

AST urges all interested parties to take urgent action so as to cooperatively take forward these advances and to build a sustainable aquaculture industry, which will have a minimal impact on all the stocks of wild salmon and sea trout; also to cooperate and learn from the techniques and regulations being implemented by their colleagues in other wild salmon and fish farming nations.

AST believes that with strengthened legislation and regulation, statutory and enforceable codes of practice, and the application of new technological developments, it will be possible to make very significant progress in providing a suite of practical management options to ensure the future development of a sustainable fin fish aquaculture industry. As outlined previously, stocks of wild salmon are under increasing pressure from a variety of sources and some stocks in the southern range of the species may face extinction. We have long talked about the impacts from aquaculture on wild migratory salmonids and perhaps in the past believed that we had the luxury of time to deal with such issues. However there is increasing evidence that taking management action in areas such as aquaculture is no longer a choice - it is an imperative.

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Glossary

Area Management: An area based management approach designed to facilitate cooperation at a local level in order to achieve shared objectives including the maintenance of healthy stocks of farmed fish and the protection of the wild salmon stocks. Area management applies to all salmon farmers in the shared area.

Adaptive Management: Adjustment of management policies and actions in response to monitoring and scientific information.

Containment (physical): Prevention of escapes of farmed salmon into the freshwater and marine environments.

Code of Containment: A set of guidelines and/or regulations applying to the salmon farming industry with the intention of preventing escapes of farmed salmon into the freshwater and marine environments. Codes of Containment can be voluntary or mandatory. Annex 3 of NASCO's Williamsburg Resolution contains Guidelines on Containment of Farm Salmon that require each jurisdiction to draw up a national action plan for implementing the Guidelines through codes of practice, regulations or both:
http://www.nasco.int/pdf/agreements/williamsburg.pdf

Ecosystem: An ecosystem consists of all the organisms living in a particular area, as well as all the non-living, physical components of the environment with which the organisms interact. In other words, a biological community and its physical environment. Ecosystems can be permanent or temporary, and usually form a number of food webs.

Ecosystem management: An approach to natural resource management which aims to sustain ecosystems to meet both ecological and human needs in the future. In the case of Atlantic salmon and sea trout, we need to consider both the freshwater (river and loch) and marine (open ocean, inshore water and sea loch) ecosystems.

Environmentally responsible: The duty which a company has to society, to operate in a way that protects the environment.

Fallowing: After all the salmon have been harvested from a particular farm site, the cages will be left empty for a time. This helps break the cycle of disease, and also interrupts the breeding cycle of sea lice. The Scottish salmon farmers' Code of Good Practice specifies a minimum fallow period of 4 weeks, although many salmon farming companies choose to allow much longer fallow breaks. The process works most effectively if an entire sea loch/bay is fallowed at the same time, so it is an essential part of good single bay management.

Lice dispersion models: During the first stages of its life after hatching from the egg, the larval sea louse can be carried significant distances in the surface of the ocean by wind and tide. Because every bay/sea loch will have different hydrographical and morphological characteristics, tidal currents will also differ from one to another. In the same way, prevailing winds will vary in strength and direction. Recent scientific studies have shown that, taking these local characteristics and the behaviour of the sea lice larvae into account, it is possible to map the likely dispersion pattern of sea lice larvae emanating from salmon farm cages.

Salmon farms: At present, all Atlantic salmon raised commercially on marine farms are held in net pens (also known as cages), so that the fish are swimming in natural seawater.

Sea lice: Parasites which attach themselves to fish (usually on the fins, and around the head), and graze on their skin. The two types of sea louse which have the biggest impact on Atlantic salmon and sea trout are the salmon louse *Lepeophtheirus salmonis* and *Caligus elongatus*. By far the most troublesome for farmers within the British Isles is *L. salmonis*. Sea lice are found in the natural marine environment, and their presence is a way for anglers to identify a fish which has come into the river within the last few days. However, severe lice infestations can cause stress, and can even cause fish mortalities.

Single bay management/bay-by-bay management: When first established salmon farm sites operated by different companies were often sited close to one another within sea lochs, fjords and bays. These farm sites often held fish of more than one generation, and were at different stages of the production cycle. Over the last twenty years, experience has shown that sea lice control on farms within mixed-generation bays is extremely difficult. If all fish farms in a single bay or loch contain fish which are the same age, then the production cycle can be synchronised, so that all fish are put into cages at roughly the same time, and harvested at roughly the same time. All the farm sites in that bay can then be left fallow simultaneously. Equally importantly, all farms can be treated for sea lice at the same time, so that a farm which has been treated does not re-infect its untreated neighbour. The farms can also arrange to use anti-lice medicines in rotation, to reduce the build-up of resistant lice. This has been shown to be one of the most effective ways of keeping lice levels on salmon farms under best possible control.

Sustainability: Any form of development that meets the needs of present generations without compromising the ability of future generations to meet their own needs, from the earth's finite resources.

Treatment triggers: Salmon farmers treat their fish with anti-sea-louse medicines at various stages during the marine production cycle, to keep the infection levels down to an agreed number of adult female lice per fish. This agreed 'trigger level' normally varies according to the time of year; the levels are designed to minimise the number of breeding adult female lice on farmed fish at the time of salmonid smolt migration (normally April to early June).