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The consultation document *Aquaculture Growth to 2030* highlights three issues from a comprehensive literature review led by the Scottish Association for Marine Science.

1. The environmental impacts of salmon farming in Scotland;
2. The scale of these impacts, and;
3. Approaches to mitigating impact.

Impacts:

As with all intensive farming methods, when the wider environment is directly involved, responses from many impacted organisms often manifest themselves as problems to the Industry itself, with transferring back to the natural environment, enhanced. With its current structure and methodology, the salmon farming Industry is a prime example.

SEA LICE & DISEASE.

Sea lice exist naturally and healthy wild fish are often host to a very small number, with which they cope. However, when up to a million captive fish are exposed to the same parasitic threat they are unable to escape, being confined in open-mesh nets. Sea lice multiply uncontrollably, and hosts are plentiful and readily accessible in open-net fish farm cages. The effect of such parasitism is that the affected fish are eaten alive, hence the intervention with large doses of therapeutic chemicals. Sea lice are increasingly becoming resistant to the conventional treatments, which eventually require wholesale culling of fish followed by road transportation to incineration sites many hundreds of miles away, which in itself is resulting in controversy. See the evidence as reported on BBC's The One Show on 12th December 2017¹

The Scottish Government's intention to allow doubling of intensive open-net salmon farming will vastly increase sea lice larvae, to disperse on tidal currents to infest migratory salmonids. This would simply exacerbate an existing problem, predictably leading to local extinctions of already vulnerable salmonid species. In addition an unintended consequence would be to impact fresh water pearl mussel populations, which are wholly dependent on salmonid species as hosts to their larvae in a symbiotic relationship.

Compounding the issue of sea lice, amoebic gill disease (AGD), *Pasteurella skyensis* and other piscine diseases are becoming an increasing threat with – until research has been completed – additional unknown wider environmental impacts. Multiple movements of dead salmon ('Morts') by sea and road from many local farm sites have been witnessed in recent times and act as a reminder of the seriousness of the problems facing an industry and Government in denial of these massive problems.

Additional problems impacting our Scottish west coast marine biodiversity associated with the salmon farming industry:

¹ <https://www.bbc.co.uk/iplayer/episode/b09hzdh7/the-one-show-11122017>

MARINE POLLUTION

Solid organic waste released by a single modern fish farm (12 x 120 m cages) directly into the sea is untreated and is approximately 1,000 tonnes *per annum*.² In 2015 there were 250 fish farms active in Scotland.³ Therefore, total waste from Scotland's salmon farms is currently of the order of 250,000 tonnes per annum. Every salmon farm creates a dense, anoxic bacterial mat on the seabed beneath the cages causing local extinctions of species and habitats, a situation which, apparently on scientific grounds, is condoned by the Scottish Environment Protection Agency (SEPA). **Dissolved inorganic waste**, consisting mainly of dissolved nitrogen (N) as ammonia and urea, and phosphorus (P) as phosphates, is liberated from Scotland's fish farms, estimated to be equivalent to the entire human sewage of Scotland.⁴ But that was eighteen years ago, since when the aquaculture industry has expanded significantly.⁵ Today, dissolved N & P released from Scotland's more numerous and larger fish farms greatly exceed the equivalent in Scotland's untreated sewage. **Chemical residues** – potentially and also proven harmful – in the form of therapeutants have been a source of public concern, yet little is known of the effects, other than that they are toxic. The most frequently applied anti-sea lice pesticide, emamectin benzoate is known to be toxic to birds, mammals, fishes and other aquatic organisms (particularly sea bed crustaceans!).

Seals and cetaceans:

Because seals naturally predate fish they are attracted to industrial sized fish farms by all of the distress signals emitted by the fish when they register a predator is nearby. This has the effect of stimulating hungry seals. This is no fault of the seals, yet they are condemned to die, albeit under a government licence. Similarly when inshore **cetaceans**, typically porpoise, become distressed when acoustic deterrent devices (ADDs) are deployed. To an animal relying on sonar, ADD emissions will be at least painful and possibly disorientating or worse, but certainly deprive them of large areas of sea in which to hunt. “*Modelling of the exposure time to exceed injury criteria for seals and porpoises at given ranges from active ADDs suggest that there is a credible risk of exceeding injury criteria for both seals and porpoises. Thus the risk that ADDs at Scottish aquaculture site is causing permanent hearing damage to marine mammals cannot be discounted*”.⁶ There should be a moratorium on the deployment of ADDs while deleterious impacts on seals and cetaceans are studied properly.

Here the precautionary principle⁷ needs to be implemented to avoid detrimental impacts on such species as, bottlenose, white-beaked, Risso's and common dolphins, orca, minke whale and harbour porpoise, which are now specifically protected under the Harbour Porpoise Special Area of Conservation (HPSAC).

Grey seals *Halichoerus grypus* and Common seals *Phoca vitulina* are listed under the:

- Bern Convention Appendix III Protected fauna species⁸
- EU Habitats Directive Annex II and V species

All species of cetaceans are listed under the:

- EU Habitats Directive Annex II and V species⁹

This legislation needs to be fully implemented, monitored and respected.

² Data: e.g. ES DOC 6 APP 7.5.1a AUTODEP MODELLING REPORT (page 7)

<http://wam.highland.gov.uk/wam/applicationDetails.do?activeTab=documents&keyVal=ORYFDYIH0FN00>

³ Munro, L.A., & Wallace, I.S. (2016). Scottish Fish Farm Production Survey 2015. Marine Scotland Science.

<http://www.gov.scot/Resource/0050/00505162.pdf>

⁴ Mcgarvin M. (2000). *Scotland's Secret? Aquaculture, nutrient pollution, eutrophication and toxic blooms*. WWF Scotland.

<http://www.wwf.org.uk/filelibrary/pdf/secret.pdf>

⁵ Total salmon production (Scotland, 2000) = 128,830 tonnes. Data: Stagg, R.M & Allan, C.E.T. (2001). Scottish Fish Farms Annual Production Survey 2001. Marine Scotland Science.

<http://www.gov.scot/Uploads/Documents/survey2001.pdf>.

Total salmon production (Scotland, 2015) = 171,722 tonnes. Data: Munro & Wallace, 2016 (note 3).

⁶ http://www.snh.org.uk/pdfs/publications/commissioned_reports/517.pdf (Establishing the sensitivity of cetaceans and seals to acoustic deterrent devices in Scotland)

⁷ Principle 15 resolved by the United Nations, in Rio de Janeiro, 1992.

⁸ <https://rm.coe.int/1680304356>

⁹ <http://jncc.defra.gov.uk/page-4063>

MITIGATION

Closed containment:

Truly ecologically sustainable aquaculture cannot be guaranteed until salmon farming in open nets at sea is replaced by closed containment – aquaculture in tanks rather than nets. Closed containment systems would eliminate all of the deleterious impacts on our marine ecosystems of salmon farming as currently conducted. Closed containment should be the overriding aim of the Scottish Government for the development of salmon aquaculture in Scotland key additional concern is that of feed containing a high proportion of wild fish products, which needs to be urgently addressed. Consideration should be given to alternatives such as farmed insects, suitable marine worms and high omega-3 vegetable products currently under investigation. Land based Recirculating Aquaculture Systems (RAS) are in production and being developed globally to address these concerns fully. Therefore, it is incumbent on Scottish Government to prioritise an Innovation Centre which specifically investigates RAS methodologies, ensuring that Scotland maintains its spirit of innovation and entrepreneurship associated with previous generations of imaginative and creative Scots. It is no longer acceptable to dismiss this RAS innovation as being not commercially viable simply due to cost. The marine environment has been paying the cost for far too long. Out of sight should no longer mean out of mind. Given the accrued benefits of innovative development there will be parity with the costs of current open-net fish farming. A genuine cost-benefit analysis with all aspects included should be undertaken.

RAS designs are scalable, enabling large industrial sized units producing high outputs of quality clean fish, which because they are able to pump water in a stream, fish naturally swim against the current and their flesh confirmation becomes similar to that of wild fish (not so with current marine farmed fish). The land-based closed design eliminates all (see Table 1.) of the problems already highlighted and if combined with small-scale hydro and solar panel energy further benefits will accrue. Environmental responsibility is built into the systems allowing ecological principles to develop aquaculture where by-products and waste can be integrated into energy production, fertilisers or algae farming.

Aquaponics

To compliment large scale closed containment, the design can be extrapolated to incorporate aquaponics (aquaculture combined with hydroponics) with additional benefits. Recirculated water is pumped from fish tanks via filters to a series of containers, which can produce fruit and vegetables by utilising fish waste as a source of nutrients before the same water is recirculated in the system¹⁰. Because these systems are scalable they can be tailored to suit spatial conditions in remote and fragile coastal communities, producing sustainable jobs and where it would be true to say produce could be delivered with food yards not food miles.

With the *Aquaculture Growth to 2030* report¹¹ having recognised that there are significant problems with the industry it would be a rational conservation measure for the Government to instigate a moratorium on any further marine aquaculture development until a consensus is reached on the way forward. Then, instigation of a programme phasing-in closed containment facilities to start redressing the damage to our sensitive marine ecology should be instigated. Brown field sites could be targeted for new facilities and eventually even more jobs could be created in an ecologically sustainable way, especially when combined produce, fish, fruit and vegetables is enabled from a correctly designed installation.

Aspirations:

- Closed containment facilities developed as innovation and demonstration sites.
- Aquaponics centres developed, especially in western Scotland as demonstration sites.

¹⁰ <https://www.youtube.com/watch?v=HcDnCaexSvU> (From 38mins 30secs.)

¹¹ <http://scottishsalmon.co.uk/wp-content/uploads/2016/10/aquaculture-growth-to-2030.pdf>

- Significantly, the Norwegian government is taxing polluting cars to promote development into sustainable electric vehicles. It is therefore logical, when the mounting evidence of pollution and undeniable impacts on marine biodiversity are clear that the same principle should operate to remove the all of the ecological problems by taxing the aquaculture industry to promote development of the alternative strategy of Closed Containment (RAS).

The Scottish Salmon Think-Tank¹² is a member of Salmon Aquaculture Reform Network Scotland (SARNS).¹³ Other SARNS members have responded to the ECCLR's call for information and as SST-T agrees entirely with these other submissions by members of SARNS, please record us as supporting their comments in full.

Table 1.

Comparing the two systems, open-net and closed containment previously discussed under Mitigation.

NET-CAGE	CLOSED CONTAINMENT
Full of holes, open to the sea ✗	No holes, fully contained ✓
Waste disposed of in the sea ✗	Waste contained ✓
Marine environment polluter ✗	Marine environment polluter ✓
Waste treatment non-existent, therefore completely free ✗	Waste treatment costs ✓ money, but see next two:
Waste is thrown away ✗	Waste can be reused ✓
Waste is not recycled ✗	Waste can be recycled ✓
Pests & Diseases affect farmed fishes ✗	Pests & Diseases almost eliminated ✓
Pests & Disease affect wild fishes ✗	Pests & Diseases do not affect wild fishes ✓
Pesticides & Medicines required ✗	Pesticides & Medicines much reduced ✓
Pesticides & Medicines pollute ✗	Pesticides & Medicines do not pollute ✓
Fishes escape ✗	Fishes do not escape ✓
Genetic contamination of wild fishes ✗	Genetic contamination of wild fishes ✓
Invasion by carnivorous mammals and birds ✗	Carnivorous mammals and birds excluded ✓
Carnivorous mammals and birds 'culled' ✗	Carnivorous mammals and birds excluded ✓
Cages damaged or destroyed by rough seas ✗	Cages not damaged by rough seas ✓
Creates a few new jobs =	Creates a few new jobs =
Contribution to local economy? =	Contribution to local economy? =
Fish feed contains wild caught fish as meal =	Fish feed contains wild caught fish as meal =

¹² <http://www.scottishsalmonthinktank.net>

¹³ <https://salmonaquaculturescotland.wordpress.com/clean-up-scotlands-unsustainable-fish-farming-industry>