



SST-T: www.scottishsalmonthinktank.net



A concise gathering of facts (with refs.), questions and discussion. Opinions are left to the reader.

NET-CAGE SALMON AQUACULTURE AT SEA

Problem 1. POLLUTION

- **DATA:** According to predictions provided by SEPA, published by Marine Harvest Ltd. in recent applications to occupy sea loch sites in Skye & Lochalsh a single modern salmon farm annually deposits in excess of 1,000 tonnes of organic waste directly into the sea untreated.¹
- **DATA:** At the last available count there were 250 fish farms active in Scotland.²
- **CALCULATION: Therefore, total (Scotland) fish farm solid waste released *per annum* into the sea untreated exceeds 250,000 tonnes (1,000 x 250).**
 - **OBSERVATION:** Even if this back-of-an-envelope estimate exaggerates the situation, it still represents a shocking and dangerously significant potential for pollution, eutrophication, extinctions and marine habitat degradation.
- **QUESTION:** Does all of that solid waste become dispersed or diluted until its environmental impacts are negligible?
 - **ANSWER:** Most of the solid waste sinks to the seabed below the farm where a dense, anoxic bacterial mat builds up. This is known to SEPA as the ‘Allowable Zone of Effect’ (AZE) where all natural biodiversity is smothered and killed (*allowably*). [Satirically renamed by the SST-T as the ‘SEPA-Allowed Zone of Extinction’.]
- **QUESTION:** Does that solid waste cause any detrimental environmental impacts, and if so, how severe and how widespread?
 - **ANSWER:** Sediments wipe out most seabed life beneath the farm by smothering, while therapeutic chemicals remaining undegraded in uneaten feed pellets and fish faeces tend to be toxic to most seabed life. Fish farm generated sediments have been shown to be detrimental (fatal) to nearby maerl up to a minimum of 100 m beyond the AZE.³
- **DATA:** In 2000, concentrations of dissolved nitrogen as ammonia (N) and phosphorus as phosphates (P) liberated from Scotland’s fish farms were estimated to be equivalent to more than the entire sewage of Scotland (were it to be released into the sea untreated).⁴
- **DATA:** By 2015, farmed salmon production had increased significantly.⁵
- **CONCLUSION: Today, dissolved N & P compounds released from Scotland’s now more numerous and larger fish farms greatly exceed Scotland’s untreated human sewage.**
- **QUESTION:** Does all that dissolved N & P get flushed away, diluted to extinction, so that any environmental impacts may be presumed negligible?

¹ 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=ORYFYDIH0FN00>

² Munro, L.A., & Wallace, I.S. (2016). Scottish Fish Farm Production Survey 2015. Marine Scotland Science.

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

³ Hall-Spencer, J. *et al.* (2006). Impact of fish farms on maerl beds in strongly tidal areas. *Marine Ecology-Progress*. 326: 1-9. Grall J, Hall-Spencer JM (2003). Problems facing maerl conservation in Brittany. *Aquatic Conservation: Marine Freshwater Ecosystems*. 13:55-64.

⁴ Megarvin 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: see footnote 2.

- **ANSWER #1:** Increases in dissolved N & P on land, in water courses and lakes or in the sea cause nutrient enrichment (eutrophication) and consequent simplification of biodiversity (extinctions), in water promoting the growth of blanket weed and algal blooms. Eutrophication is becoming increasingly detrimental to marine ecosystems worldwide. Even the sea has limited capacity to remain stable if persistently loaded with pollutants, just like the atmosphere where pollution catastrophes include climate change, acid rain and the hole in the ozone layer. Will we ever learn?
- **ANSWER #2:** Even slight, to humans barely perceptible, increases in dissolved N lead to epiphytic organisms settling on and smothering sea grass (eel grass) leaves, preventing efficient photosynthesis and causing colonies to draw back into shallower water and eventual extinction: “Even at low enrichment levels, chronic exposure to nitrate enriched waters is directly lethal to *Zostera marina*.”⁶
- **QUESTION:** Is there a link between dissolved N & P in fish farm waste and the recent West Highland cyanobacterial bloom (second week in June 2016) noticed and questioned by many observers?
 - **ANSWER:** Likely to be a cause for concern. Local fact-finding in progress.
- **QUESTION:** Has there been a link between dissolved N & P in fish farm waste and numerous past West Highland cyanobacterial and/or algal blooms?
 - **ANSWER:** Likely to be a cause for concern. Local fact-finding in progress.

Problem 2. SEA LICE

- **FACT:** Sea lice (*Lepeophtheirus salmonis*), a natural inhabitant of marine ecosystems, attach to migrating salmon and sea trout, feeding on skin, surface mucus and superficial flesh. ‘Punctured’ fishes become ‘leaky’, cannot maintain their internal water relations, weaken and may die. In the absence of fish farms, sea lice do not usually attack fishes in numbers likely to kill them and wild stocks remain sustainable.
- **FACT:** Captive, locally concentrated salmon – e.g. in fish farm cages – routinely become super infested with sea lice, often so severely that whole farmsworths have to be slaughtered. Pesticides are used, but those that are permitted tend to be of limited efficacy (unless in used at concentrations toxic to most animal life including fish) or sea lice develop immunity, rendering treatments useless.
- **FACTS:** Young salmon and sea trout migrate south-north along the west coast of Scotland, obliged to pass close to many fish farms and even through the cages as they head for the North Atlantic where they feed and grow before returning as adults. *En route*, they become infested with sea lice in numbers that greatly exceed natural levels becoming severely weakened, potentially fatally. Infested young sea trout have been observed to hurry back to their natal rivers early in life in order to swim in fresh water where the marine sea lice are forced to ‘jump ship’.
- **FACT:** In all parts of the world where fish farms are installed adjacent to salmon rivers (e.g. Norway, Canada, Scotland, Ireland), wild populations of salmon and sea trout have declined to below sustainable levels during the past few decades, coincidentally with the expansion of intensive net-cage salmon aquaculture.
- **QUESTION:** Is there a link between fish farms, sea lice and wild fish population declines?
 - **ANSWER:** A rich library of peer reviewed research has many times demonstrated a direct causal link.⁷ This inconvenient truth is routinely denied by representatives of the salmon aquaculture

⁶ Burkholder J. M. *et al.* (1992). Water-column nitrate enrichment promotes decline of eelgrass *Zostera marina*: evidence from seasonal mesocosm experiments. *Marine Ecology Progress Series*, 81: 163-178.

⁷ Four examples from among many: Rosenberg, A.A. (2008). The price of lice. *Nature*, 451: 23–24. Costello, M.J. (2009). How sea lice from salmon farms may cause wild salmonid declines in Europe and North America and be a threat to fishes elsewhere. *Proceedings of the Royal Society Biological Sciences*, 276(1672): 3385-3394. Krkošek, M. *et al.* (2012). Impact of parasites on salmon recruitment in the Northeast Atlantic Ocean. *Proceedings of the Royal Society Biological Sciences*, 280(1750): 20122359. Thorstad, E.B. *et al.* 2014. Effects of salmon lice on sea trout - a literature review. *NINA Report 1044*, 1-162.

industry, who when contradicted assert either that the research was ‘flawed’ (it isn’t) or that it was not carried out in Scotland and is, ‘therefore’, irrelevant here (it isn’t). Such assertions are demonstrably obfuscatory.

- **FACT:** When you ask industry spokespersons about the sea lice problem you will be confidently assured that a new biological control method is proving successful: wrasse or lumpsuckers (lumpfish), ‘cleaner fishes’ introduced to salmon nets to feed on sea lice.
- **QUESTIONS:** (rhetorical) If cleaner fishes are efficacious, why do fish farmers continue to use dangerous, often ineffective chemical treatments? If cleaner fishes are as efficacious as they say, why are fish farm companies trialling expensive freshwater bath ships as a claimed safe alternative?
- **QUESTION:** Are these ‘cleaner fish’ effective at sea louse control?
 - **ANSWER:** Industry spokespersons say yes. Investigation suggests no (or perhaps *not yet*).
- **FACT:** At present, cleaner fishes used in fish farm cages are harvested, unregulated, in thousands from wild populations. At the end of each salmon production cycle they are not re-allocated or released. They are slaughtered.⁸
- **QUESTION:** What are the ecological consequences of removing large numbers of wrasse from the wild?
 - **ANSWER:** Nobody knows, though it is reasonable to predict that it will be detrimental, if not now, very soon if the practice continues. Research is required *before* fish populations and marine ecosystems are irreparably harmed by this practice.
- **QUESTION:** To protect wild stocks, can cleaner fishes be farmed for fish farm use?
 - **ANSWER:** Industry spokespersons usually confidently say yes, but investigation suggests no, well *not yet*.

THE ABOVE ARE JUST TWO OF THE MOST WORRYING PROBLEMS ASSOCIATED WITH NET-CAGE SALMON FARMING

There are others to consider:

- Noise – from feed pipes, frequent boat traffic (service boats, well boats etc.), bird scarer explosions.
- Visual – detracts from scenic views that, particularly in this region, attract tourists (local economy).
- Light pollution – navigation marker lights and underwater lighting.
- Pollution – as well as fish faeces, waste food and excess therapeutic chemicals discussed above, litter in the sea and on beaches includes empty feed bags, plastic barrels, black plastic piping (sometimes up to 100 m long), floats, pontoons and many small items ‘lost at sea’.
- Amenity Value – potential for undesirable effects on clean water and safe beaches used for swimming, snorkelling, diving and other visitor activities.
- Obstruction – of fishing grounds (particularly creeling), kayaking, yachting.
- Employment – loss of creel fishing grounds and undesirable impacts on wild, beautiful places, the reason tourists visit (income for existing local economies: accommodation, food & drink, tours etc.).
- Impact on seals and cetaceans by Audible Acoustic Devices (ADDs) and seal deaths due to culling.
- Impacts on seabird populations – little known, rarely acknowledged.
- Appalling quality of Environmental Impact Assessments (EIAs) pretending to support fish farm planning applications, overlooked by regulatory authorities required not to obstruct government salmon production targets. See: www.scottishsalmonthinktank.net click on Environment (EIA).

All of the disadvantages of net-cage salmon farming are listed in the table below, which shows that ALL of them can be solved by doing away with the old-fashioned net-cages (pens) and replacing them with tank systems: closed-containment aquaculture, which is already in use around the world, using salt or fresh water, at any scale, back yard to industrial, even in deserts and even producing salmon.

⁸ Wester Ross Salmon company employee (2014). Pers. Comm.

Industry spokespersons routinely deny that closed containment works. Reality disagrees. Judge for yourself from the table below and careful use of the Internet. As well as a wealth of informative websites, YouTube provides us with numerous instructive videos. Here are just a few suggestions:

<https://www.youtube.com/watch?v=qYCEGtMdORU>

https://www.youtube.com/watch?v=yS9WF_vrkLQ

<http://www.humblebynature.com/about-us/projects-at-humble-by-nature/aquaponics-solar-greenhouse>

<https://www.youtube.com/watch?v=oIBvXMwwwzY>

<https://www.youtube.com/watch?v=Umt79IXnNuY>

N.B. Marine Harvest (MH) and Hauge Aqua are currently trialling closed containment systems in Norway where – perhaps significantly for Scotland – the government is increasing regulation of net-cage salmon farming. That government crackdown might be why the Norwegian-owned aquaculture business, which dominates the industry worldwide, has recently bombarded the Highland Council with planning applications for numerous new and expanded farms in Scottish waters. Would it be unnecessarily cynical to wonder: if they may no longer pollute Norway for profit, why not Scotland? Meanwhile, MH are preparing a large container ship or tanker that will become an enclosed fish farm. If the biggest in the business is beginning to change methodology, will the rest follow?

CLOSED-CONTAINMENT AQUACULTURE (in tanks)

The practical alternative that eliminates ALL objections to farming salmon in nets

COMPARISON

✓ advantageous
✗ disadvantageous
= equally good or bad

Big Nets

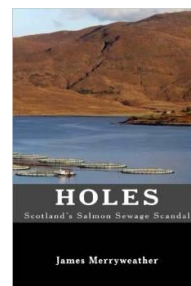
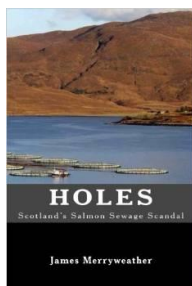
NET-CAGES (PENS)

- Full of holes, open to the sea ✗
- Waste disposed of in the sea ✗
- Marine environment polluter ✗
- Waste treatment non-existent, therefore completely free ✗
- Waste is thrown away ✗
- Waste is not recycled ✗
- Pests & Diseases affect farmed fishes ✗
- Pests & Disease affect wild fishes ✗
- Pesticides & Medicines required ✗
- Pesticides & Medicines pollute ✗
- Fishes escape ✗
- Genetic exchange with wild fishes ✗
- Invasion by carnivorous mammals and birds ✗
- Carnivorous mammals and birds 'culled' ✗
- Cages damaged or destroyed by rough seas ✗
- Creates a few new jobs =
- Contribution to local economy? =
- Fish feed contains wild caught fish as meal =

Big Tanks

CLOSED CONTAINMENT

- No holes, fully contained ✓
- Waste contained ✓
- Marine environment non-polluter ✓
- Waste treatment costs ✓ money, but see next two:
- Waste can be reused ✓
- Waste can be recycled ✓
- Pests & Diseases almost eliminated ✓
- Pests & Diseases do not affect wild fishes ✓
- Pesticides & Medicines much reduced ✓
- Pesticides & Medicines do not pollute ✓
- Fishes do not escape ✓
- No genetic exchange with wild fishes ✓
- Carnivorous mammals and birds excluded ✓
- Carnivorous mammals and birds no culling ✓
- Cages not damaged by rough seas ✓
- Creates a few new jobs =
- Contribution to local economy? =
- Fish feed contains wild caught fish as meal =



You can learn more about the pros and cons of net-cage salmon farming by visiting www.scottishsalmonthinktank.net or by reading James Merryweather's no-profit book *HOLES: Scotland's Salmon Sewage Scandal* – Amazon pbk £3. Buy four and delivery is free.