Environment, Climate Change and Land Reform Committee

Environmental impacts of salmon farming

Written submission from Dr Sally Campbell, Marine Ecologist, Board Member of Scottish Creel Fishermen's Federation

In commenting on the review paper by SAMS "*Review of The Environmental Impacts of Salmon Farming In Scotland*", I aim to follow 4 of the main headings of this document, and I wish to focus on cumulative impacts, primarily using the Firth of Clyde, as an example: It is clear cumulative impacts around the west coast of Scotland must be considered more widely, and reported on in the future rather than simply confining data to individual salmon farms.

2. Sea lice & disease impacts on wild and farmed stocks and 4. Effect of the discharge of medicines and chemicals from salmon farming

EMAMECTIN BENZOATE (EMB). It is a complex organic compound, a solid, with a significant level of solubility in seawater of around 5milligrams/litre but with a great affinity for attachment to other organic material such as food and faeces. In application it is supplied as a coating on food granules and is absorbed into fish tissue, being excreted gradually over a long period of weeks largely unaltered in the fish metabolic process. Its efficacy in terms of its toxicity to parasitic lice is therefore maintained over that same period as is of course its constant release into the environment. Although it is degraded in sunlight it is stable in seawater of slight acidity or alkalinity and is only very slowly broken down in association with seabed sediment. Its affinity for other organic substances means essentially that it remains associated with food sources for largely seabed organisms such as crustaceans and shellfish. EMB is toxic in organisms due to its reaction with muscle and nerve systems disrupting salt balance, which is vital for organisms surviving in marine environments. The Water Research Centre (WRc) Ecotox review commissioned by SEPA does draw attention to the extent of use on Scottish fish farms with 26ug/kg stocked fish biomass in 2002 peaking at 67ug/kg in 2015. Application rates also increased from 1.4 applications in 2002 to 2.7 applications in 2016. Total loading to the marine environment also increased between 2002 and 2015 with salmon output doubling whereas total mass of EMB increased 6 fold. This is disturbing as it is now understood that this affects the other arthropods (including prawns, lobsters, crabs), which are important economic contributors to the viability of marine coastal communities on the west of Scotland.

The long-term effects of neurotoxin pesticides on scallops and mussels remain ill-defined. There has been concern about scallops last year, as stocks appear to be declining in areas hosting Atlantic salmon farms. These shellfish are the economic drivers of small communities on the west coast, too long neglected in favour of aquaculture.

However the most damning of evidence published in July 2017 in Chemosphere 185 (2017) 1019-1029. Gerbauer *et.al* (2017) addressed the lethal and sub-lethal effects

of commonly used anti-sea lice formulations on non-target crab *Metacarcinus edwardsii* larvae.
This study clearly shows:

- Cypermethrin, deltamethrin, and azamethiphos affected 100% crab larvae at concentrations lower than used against sea-lice.
- Hydrogen peroxide at the concentration used as an anti-sea lice treatment had lethal and sub-lethal effects on M. edwardsii zoea I.
- Repeated exposure to azamethiphos (0.0625e0.5 mg L ^{1}) increased mortality, but did not affect zoea developmental time.
- Chronic exposure to hydrogen peroxide (187.5e1500 mg L ^{1}) had a lethal effect on larvae.

This paper raises serious issues about these neurotoxins, and what else they may be affecting in zooplankton and in settlement. Recent research published 30 January 2018 by Veronica Nagelsen (Institute of Marine Research) showed similar results with prawns over 98 days. Mortality was 50% and for those not receiving the treated feed it was 2.5%. The salmon industry has been permitted to expand in unsuitable sites, over industrialise by increasing stocked biomass and use of chemical to control disease whilst too little independent research has been conducted on bioaccumulation and longer-term effects on inshore waters ecosystems. With both in-feed pesticides and bath treatments in salmon farms, association of pesticide residues to organic substrates remains a totally inadequate area of marine science understanding.
The value of the static fishery, creeling and local diving, to the economic, environmental sustainability and social community values should carry a greater weight in decisions. 88% of fishermen in Scotland are part of the inshore fleet. Creel boats make up 80% of the 1452 10m and under fishing vessels in Scotland's inshore commercial fishing fleet and generated £40.98 million for the Scottish Economy in 2015. (Marine Scotland Analytical Unit figures). Fergus Ewing has recently stated that the rural economy is fished by almost 1400 creel vessels around Scotland, most of them on the west coast lochs and inshore waters, most often in remote communities. For every boat it is estimated 3-4 permanent jobs are created in the supply chain. Fish farm expansion takes more creeling grounds and hand diving areas away from local communities and the financial value is transferred to mostly foreign owned multinationals. Expansion of biomass or new salmon farms is a policy that inevitably is creating strategic difficulties for the creeling and diving communities. It is well known that neurotoxins affect the other arthropods (including prawns, lobsters, crabs), which are important economic contributors into marine coastal communities on the west of Scotland. There has been concern about scallops this year, as the stocks appear to be declining in areas with Atlantic salmon farms. These shellfish are the economic drivers of small communities on the west coast. Too long neglected in favour of aquaculture. I fear it is only when neurotoxins deployed in aquaculture are found in the products of supermarket shelves, be they crabs, lobsters, prawns, mussels, scallops or line caught mackerel that that the Government will cry stop! Too little and too late. Reputational risk to Scotland is clear.

3. The discharge of waste nutrients and their interaction in the wider marine environment

The cumulative impact from several salmon farms in one inshore area has not been addressed in official reports. To give examples of the total emissions:
In Wester Ross between Little Loch Broom, Loch Broom and the Summer Isles, there are 7 salmon farms with a total licenced biomass of 4,372 tonnes. Discharges from these farms between 2010-2016 were as follows:

- 8.24 tonnes of total copper from feed and nets
- 3.62 tonnes of zinc from feed
- 128.09 tonnes of nitrogen
- 176.89 tonnes of phosphorus
- 410.96 tonnes of total organic carbon

Whilst the Loch Duart brand claims, rightly, that they have low maximum biomass in each farm, there are no less than 12 farms/holding pens in Eddrachillis Bay in northwest Sutherland . So the potential is for 5170 tonnes, although "fallow" periods between stocking will vary between farms, nevertheless that is a large potential biomass in a small marine locality. Emissions of food waste and faeces there are considerable (www.aquaculture.scotland.gov.uk); and there are losses due to disease, judging by the use of chemicals coinciding with fish lice and salmon mortalities. In Loch Laxford just north of Loch Duart, the company has 4 farms Laxford 1, 2, 3, and 4, with maximum biomass of 480, 480, 480 and 120 tonnes, a total of 1560 tonnes. It is not just the biomass of single licenced farms but the accumulation of waste from several farms in one locality that poses increased risk of disease and parasites and damage to ecosystems. Cumulative impact has yet to be accepted as a wider threat to Scottish sea loch and coastal waters requiring practical investigation.

The Firth of Clyde "hosted" 17 farms in 2016, the last reported number, with a total of 23,780 tonnes of maximum biomass licenced. Of these farms 15 are owned and operated by The Scottish Salmon Company (SSC), in Loch Fyne, Loch Striven, Kyles of Bute and Lamlash Bay; two, in North and South Carradale in Kilbrannan Sound by Marine Harvest licenced for 2500 tonnes each, so a total of 5000 tonnes biomass.

Whilst individual farms vary in licenced biomass the total content from the present 17 farms of discharges into the Firth of Clyde and its sea lochs for the years 2014, 2015, and 2016 approximate to the following:

- 38 tonnes of total copper from feed and nets
- 4 tonnes of zinc from feed
- 1539 tonnes of nitrogen as ammonia and urea
- 212 tonnes of phosphorus as phosphate
- 4939 tonnes of total organic carbon

It is surely time to look carefully at bioaccumulation of wastes and effects of treatment chemicals used in aquaculture on the ecosystem. But it is just not the number of farms but also the hydrodynamics of the area, Tidal flow, and also the complexity of disease control.

The maximum velocity of the tidal currents in the Firth of Clyde is generally less than 0.5 m/sec and within the sea lochs of the Clyde estuary they are even weaker

attaining about 0.2m/sec. The bathymetry controls the balance of processes at any particular depth. At the surface there is free connection throughout and movement is dominated by pressure gradients set up by tide, wind and freshwater outflows. However in more confined waters like Loch Fyne, which has two sills, and denser saline waters are trapped at depth. Flows are obstructed and are dominated by oscillatory internal movements. Deep-water stagnation, some oxygen depletion and nutrient build-up can occur within the lower levels of these sea lochs. However the importance of the deep water is sometimes overemphasised, by area only 20% lies below 70 m and 6% below 100 m. Results from the most recent sediment tracking model developed at the University of Strathclyde to represent passive material clearly indicates just how long these particles remain and accumulate in the sea lochs.

Although there have been numerous individual studies of aspects of the food web in the Clyde, no one quantitative overall assessment of the post-industrial ecosystem productivity is available (particularly after cessation of dumping of untreated sewage and temperature effects of climate change). What is needed is to integrate the physics, chemistry and biology driving the Clyde marine ecosystem in a quantifiable way to show a fully functioning ecosystem model.

Oxygen is critical to the health of the planet. It affects the cycles of carbon, nitrogen and other key elements, and is a fundamental requirement for marine life from the seashore to the greatest depths of the ocean. Nevertheless, deoxygenation is worsening in the coastal and open ocean, including around Scottish waters. (UNESCO 2017). This is mainly the result of human activities that are increasing global temperatures (CO_2-induced warming) and increasing loads of nutrients from agriculture, sewage, and industrial waste. The Clyde has warmed 1 degree C in 10 years. Increasing temperatures will reduce the capacity of the ocean and inshore waters to retain dissolved oxygen in the future; Oxygen deficiency is predicted to worsen in estuaries, coastal areas and oxygen deficient zones in the open ocean. Habitat loss is expected to also worsen, leading to vertical and horizontal migration of species. This oxygen deficiency will alter biogeochemical cycles and food webs. Lower oxygen concentrations are projected to result in a decrease in reproductive capacity and biodiversity loss. Attention must be paid to global affects of climate change. It is not business as usual.

While there is still no conclusive evidence, a number of marine biologists believe there is a strong link between the tonnage of protein waste dumped into the sea in the form of dead salmon, salmon faeces and uneaten salmon food, and the increased outbreaks in Chile of deadly Red Tide, a highly toxic algae that kills marine mammals, molluscs and fish, including salmon. "There is a proven relationship between Red Tide formation and ammonia, which is the result of the decomposition of organic matter," said Professor Tarsicio Antezana, a marine biologist and oceanographer.

There is little longitudinal (over time, year on year) research into the complexity cycle of fish farms; how they affect spawning grounds of demersal and pelagic fish for example? Do we even know where these grounds are in the sea lochs and inshore waters and how are they protected? We know the sea is warming due to climate change so how is this warming together with so much fish farm waste driving phytoplankton blooms, and zooplankton populations? What effect over time have pesticides had on inshore species? This could in turn be affecting the iconic marine bird species of the west of Scotland.

Over the past 10 years, at least, many individuals in Scotland and elsewhere, especially in British Columbia, Norway and Chile faced with scientific and video evidence of anoxic mats beneath farms, harms to the ecosystems, especially to wild salmon runs, called for a reduction in biomass on salmon aquaculture farms, and drastic reduction or outright exclusion of neurotoxins and antibiotics. Here the veterinary chemical producers and salmon farmers powerful lobbying influence and economic clout have held sway. SEPA has been almost mute, and the Scottish government talks only in GDP gain. What is being witnessed is serious harm to the inshore lochs and waters of Scotland. Anoxic mats, serious harm to the ecosystems, and much more worryingly, denial there are long-term effects of neurotoxins on arthropods and others, which are also the economic and important mainstay of many small communities around western Scotland. These small communities do not have the money or lobbying power of fish farmers yet are vital in supporting equally important contributors to the Scottish GDP The Precautionary Principle has as one of its main tenets, “including public participants in decision making”. This has been singularly absent in recent times in decisions over permitting new salmon farms and increased biomass stocking approvals.

7.Emerging Environmental Impacts

7.1 Effects on Marine Mammals

Historically Loch Fyne teemed with porpoise and now there is a lower density of mammals in the loch compared to the rest of the Clyde. Data under FOI shows ADDs are used “occasionally” in Loch Fyne. It really needs a full study but this is difficult unless the companies, by law, inform the community and record when ADDs are on. They always appear to be switched on at the farm just south of Tarbert and occasionally they are picked up in Rothesay Bay.

7.2 The use of Wrasse as Cleaner Fish

It is now clear that overfishing with wrasse creel pots for the salmon aquaculture industry is leading to depletion in certain inshore waters. This wild species important for the health of reefs, controlling sea urchins, which damage kelp forests, the very areas where many marine species are reared, eg. Cod. They are not a protected species. Research shows the overall health, size, and even diversity of fishes is greater in the reefs where cleaner wrasses are found versus those without their services. Ecosystem services need wrasse! Wrasse are protogynous hermaphrodites, meaning they have a very unusual life cycle. All wrasse are born female and remain female for the first part of their lives. Being a relatively slow growing species they take around two years to reach ten centimetres in length and will not reach sexual maturity until they are around six years old. At this point around half of the wrasse will transform into males and be able to breed with the wrasse which have remained female. There are long term implications for wild populations. A number of scientific studies and research attest to the important role these fish play in the health of the reefs. There is no convincing evidence to suggest they control lice infestation and the industry should be stopped from exploiting the natural resource.