

Aquaculture or Salmon feedlots?

Over time and unanticipated, a suite of problems began to attach themselves to the salmon aquaculture industry, fouling the once clear waters and sucking blood, and money, from the enterprise.

Excrement



Salmon excrete. Wild salmon swim in small schools ranging over large areas of the ocean and this droppings vanish into the water column, often consumed by small invertebrates, or else is otherwise dissipated. Salmon in open pens are kept in close confinement in enormous numbers. Large sea cages can house up to 90,000 fish, and one farm now planned for St. Mary's Bay in Nova Scotia is licensed for 1.4 million fish. Such quantities of fish produce colossal amounts of waste that sinks to the bottom (along with uneaten food and dead fish) completely destroying all life below the cages and in their immediate vicinity. A black anoxic sludge covered by white bacterial mats is created.



Since open pens are sited in sheltered bays to protect them from storms, currents are typically insufficient to dissipate these putrefying sediments, or else limited water circulation simply succeeds in spreading the mess more widely, destroying even larger areas of the sea bottom. Given that many coastal sites are also home to other forms of aquaculture (oysters, mussels, etc.) or existing shellfish, lobster, or fin-fish fisheries, such a spreading toxic sewage deposit is of understandable concern to both fisher folk and marine ecologists.

Heavy metal pollution

A significant problem in open net cages is "fouling" in other words the growth of marine algae, hydroids, tunicates, barnacles, mussels, and other marine organisms all over the cages themselves. This not only restricts the circulation of water through the cages but also complicates all kinds of work that needs to be done. Consequently, various anti-fouling (i.e., toxic) substances such as copper-based paints are often applied to equipment. Furthermore, zinc is added to the feed of salmon as a nutritional supplement. Both of these heavy metals end up in the waste and excrement sludge below the enclosures, and they can subsequently leach into surrounding waters. Both can be toxic of other marine animals such as lobsters.

Parasites



Sea lice are small copepods in the family Caligidae. They are ectoparasites that feed on the mucus, skin, and blood of host fish, to which they attach themselves. Some sea lice (notably *Lepeophtheirus salmonis* and several species of *Caligus*) are parasitism of salmon. Under normal circumstances, these parasites are of minor concern with respect to wild salmon, since a whole host of biological conditions (the biology of host and parasite, the timing of salmon breeding and subsequent migration of smolt to the sea, the relatively dispersed schools of wild fish, etc.) keep parasite numbers to a minimum.

However, as biologist Alexandra Morton and others have demonstrated on the Canadian Pacific coast, in salmon farms, the density of fish, and the fact that they stay in one location for their entire lives, creates a hothouse environment for sea lice in which they can increase their populations geometrically, and move readily from fish to fish. Sea lice can weaken, injure, disfigure, and kill fish and so a whole cornucopia of treatment options -- organophosphates, pyrethroids, avermectins, topical treatments with hydrogen peroxide, growth regulators, etc. -- have been developed in response. One problem is that these chemicals can then enter the environment, affecting various non-target organisms, such as lobsters and crabs, which are also crustaceans. Of equal concern is the fact that these open pen salmon feedlots can become parasite-generating factories spewing vast quantities of larval sea lice into the surrounding waters where they can readily affect wild salmon populations, particularly the juvenile smolt salmon that are unequipped to fend off such attacks. Alexandra Morton and her colleagues on the west coast have identified this as a major contributing factor to the decline of wild salmon populations, and there are similar concerns with salmon farms on the Atlantic coast where Atlantic Salmon populations are only slowly recovering.

Disease



Ditto. In the same way that open-pen salmon feedlots can become parasite-generating factories, they can also become disease generating centers. Diseases such as Salmon Leukemia Virus (SLV), Piscine Rheovirus (PRV), and Infectious Salmon Anemia (ISA) are serious notifiable diseases of salmonid (salmon, trout, char) fishes. The latter was first detected in Norway in 1984 and has subsequently spread to New Brunswick (1996), Scotland (1998), Chile (1990's), British Columbia (2011), and Newfoundland and Labrador (2012). An outbreak in Chile in 2007 caused \$2 billion of damage to the salmon farming industry. Beyond the economic impact of such diseases to aquaculture concerns, is the fact that the farms become epicenters for viral production -- in the case of one British Columbia salmon farm, producing on the order of 650 billion viral particles per hour -- that can then infect native populations of wild salmon.

Genetic Pollution

There are inevitably escapes of farmed salmon into the wild. The impact of these can be varied. Atlantic Salmon are, as their name suggests, native to the north Atlantic. They are now being farmed extensively in British Columbia and Chile in the Pacific Ocean. What happens when such fish escape? Can they establish themselves? Will they compete with native salmon species? Hybridize with them? Will they have other ecological impacts?

And in the Atlantic Ocean, such escaped fish can and do hybridize with native wild Atlantic Salmon, leading to concerns that genetic diversity, disease resistance, behavioral adaptability, and biological fitness may be reduced. At one time in the Faeroe Islands, some 20-40% of all supposedly "wild" salmon being caught by fishers were, in fact, escaped farmed salmon.

Furthermore, companies such as the Prince Edward Island-based **Aqua Bounty Farms** have developed a genetically modified Atlantic Salmon that grows faster, is more disease resistant, and more cold tolerant. It was created using a Chinook salmon (*Oncorhynchus tshawytscha*) gene sequence and promotor sequence from an ocean pout (*Zoarces americanus*), the former in a different genus from Atlantic Salmon, the latter in a different family. What might happen if such genetically modified fish were to escape and interbreed with native salmon? It's a complex issue,

but one that should not be avoided. What are our responsibilities to ensure that the genetic makeup of wild animals and plants is not forever adulterated?



In the case of losses of salmon to disease (when they are detected in farmed salmon the destruction of all the infected stock is generally required in order to halt the disease) this can then trigger compensation processes. As Silver Donald Cameron reported in his superb documentary, **Salmon Wars**, in New Brunswick federal and provincial governments have paid in excess of \$75 million in compensation to salmon aquaculture companies for losses due to ISA infection.

Fish Farming and Food Chains

Atlantic Salmon are carnivores. To raise them in captivity they require diets that are high in animal protein, and much of what they are fed is fishmeal, in other words pellets composed of processed fish. In 1986 only 8 per cent of the world's fishmeal production was going to aquaculture production; by 2005 it was 42 per cent with over 50 per cent of the world's fish oil production going to feed salmonids. This extensive harvesting of fish only to feed other fish is of great concern from the standpoint of ocean ecology and conservation, and it highlights the enormous dependence of the farmed salmon industry on the exploitation of other fish stocks. The energetic efficiency of farmed salmon ranges between 20 and 40 percent i.e., it takes between two and four kilograms of fishmeal to produce one kilogram of salmon. Critics have pointed out that in terms of creating a sustainable aquaculture fishery that does not drain other ocean resources, and which can create food to feed a growing world population, we should be concentrating our efforts on farming herbivorous fish such as tilapia that feed on algae. Being lower on the food chain as herbivores, allows for a much greater conversion of energy into protein than is the case with predaceous fish. As such, farming salmon may be a luxury that the world call ill afford in the future.

Not swallowing the bait



Given the above, people are unhappy. Citizens of coastal communities and those concerned with ocean conservation have been growing increasingly alarmed at the threats that open-pen salmon aquaculture poses. For the last twenty years in British Columbia, biologist and activist **Alexandra**

Morton has spearheaded research into the impacts of open-pen salmon farming. She has joined with many environmentalists in a series of campaigns to draw attention to the problems, and to encourage federal and provincial governments to take appropriate action. Speaking at this year's **Ransom A. Myers Lecture in Science and Society** at Dalhousie University, Morton said: *"The problem is that salmon farms break natural laws. That instead of allowing salmon to move, (they) hold them stationary. In the wild, salmon move into the rivers and the sea lice die in the fresh water. The juveniles come out in the spring and there are no adult fish to speak of in the area, they go to sea and grow, and by the time they meet other adult fish they are robust and clad in armored scales and they can take a few lice. But in the situation with the salmon farms, the wild fish come in, they affect the farms, the wild fish go into the rivers, and they die, but the lice breed on the farms."*



In the past two years in Nova Scotia there has been considerable concern by groups such as the Association for the Preservation of the Eastern Shore (APES), Atlantic Coalition for Aquaculture Reform, Mayday Shelburne County, St. Mary's Bay Coastal Alliance, and Friends of Port Mouton Bay to applications by the New Brunswick-based **Cook Aquaculture** for permits to operate open-net salmon farms in Port Mouton, Shelburne, Jordan Bay, and St. Mary's Bay, and **Snow Island Salmon** a New Brunswick-based group (majority owned by the Scottish **Loch Duart**) that has proposed sites in Spry Harbour and Shoal Bay on the Eastern Shore. Many of the members of these groups are concerned about the impact of salmon feedlots on the existing lobster fishery in these areas, as well as on wild salmon populations. A **recent study** by Gardner Pinfold Economic Consultants valued the wild salmon industry of Eastern Canada at \$255 million a year, and found it supported 3,872 full-time equivalent jobs in the region. In terms of the lobster fishery, in 2009 the value of exports alone from the region was \$805 million, and the fishery employs over 10,000 fishers. Consequently, perceived threats to either fishery are of great concern, particularly in rural communities in Atlantic Canada that are very dependent on resource industries.



The groups are calling for a moratorium on all new open-pen salmon feedlot licenses, "until community-based inquiries can determine that no harm will come to our environment, quality of life, and existing industries such as the lobster fishery and tourism." They are also calling for a more robust level of Environmental Assessment that would require an independent inquiry. The dispute has been documented by writer **Silver Donald Cameron** in his powerful and hard-hitting documentary, **Salmon Wars**. Says Cameron:

"The net cage salmon farming industry ... is seen as grasping, reckless, sly, and sometimes criminal. How has this salmon expansion gone so incredibly wrong? The underlying failure, as with so many environmental issues, is a failure of counting and of critical thinking. Governments assume that any increase in GDP is growing the economy, and that is a good thing. But GDP is a bankrupt indicator. What isn't counted, doesn't count. And what isn't counted is most of what makes life worthwhile. Like clean air and water. A healthy population in a healthy environment. None of this shows up in GDP."

Seeking solutions

Are there solutions for the problems outlined above? Most certainly. The most obvious one that eliminates almost all the problems of open-net fin-fish aquaculture, are closed-containment systems, sited either on land or on the water. Farming salmon in closed tanks eliminates issues of parasites, disease, and genetic pollution since farmed fish have no contact with the marine environment or with native wild fish. Anti-fouling measures are not needed and filtration systems remove excrement, and typically in excess of 97 per cent of the water is recycled. Presto, problems solved!



Proponents of open-net fin-fish aquaculture argue that the additional costs make the closed-containment approach uneconomical; however, these are belied by enterprises that are actually operating -- economically. In British Columbia a closed containment salmon farm, the **Middle Bay Project**, is operating in Campbell River, a collaborative project between the Middle Bay Sustainable Aquaculture Institute and **Agrimarine Inc.** In Nova Scotia **Sustainable Blue** is farming European

sea bream and sea bass and managing a facility that farms arctic char in closed containment enclosures on land. It may well be the case that the containment and filtration systems required in a closed containment system do add to the cost of production, but we should view the necessity of conducting aquaculture in this way as we do the importance of installing sewage treatment systems for human waste. It's true we can dump it into rivers or the ocean for free, but the consequent environmental costs are considerable. Furthermore, is this the kind of stewardship of the environment that we want to exemplify?

In Scotland, a company called **Loch Duart** has developed what it believes is a lesser impact approach to farming salmon that involves a three- or four-year "crop rotation" model where aquaculture sites are left "fallow" (i.e., un-stocked) for periods of one to one and a half years to allow natural processes of cleansing and regeneration to help restore the sea bottom. The approach also involves significantly lower stocking densities (no more than 500,000 fish per farm), a minimum distance between sites and production classes, and a more natural feeding regimen to reduce waste. They use no growth promoters, antibiotics, or anti-fouling agents. This is the system that has been proposed for the Snow Island project in Nova Scotia with sites in Spry Harbour and Shoal Bay. Not everyone agrees that this is a better approach. The Association for the Preservation of the Eastern Shore (APES) **claims** "... that Loch Duart is in no way better than any other salmon farms although they always claim to be." However, on the face of it, this approach would mitigate (although not eliminate) many of the problems discussed earlier. In the context of AEP's call for a moratorium on the granting of open-pen salmon farming licenses, such a move would allow for the pros and cons of the Loch Duart approach to be evaluated more fully.

Wider political perspectives



Technical issues aside, there are larger political questions that need adjudication. For example, the significant compensation payments noted above result in what amounts to significant taxpayer subsidy to private industry. This has then to be factored into the larger economic "worth" of enterprises like open-pen salmon farms to society. Ecological concerns aside, is the value of the industry in terms of jobs, taxation, lease payments, etc. significantly greater than its public subsidy? If not, why not? And if not why then is the public purse involved?

One also needs to take into account contending uses. If other fisheries or aquaculture activities are impacted, if tourism is affected or diminished, is the loss on the one hand worth the gain on the other? As Silver Donald Cameron says, "(GDP) only counts what may be generated, not existing jobs that may be lost. Meanwhile, the public pays the cost of corporate failure, while the environment pays the long-term non-cash costs.



In her twenty-year campaign on behalf of wild salmon conservation, Alexandra Morton has documented some shocking conduct on the part of the Department of Fisheries and Oceans (DFO). "DFO is a criminal organization," Morton was told by the late **Ransom Myers** when he came to visit. Says Morton:

"I learned a lot about why DFO was doing this (its policy on open-pen salmon farming). It came down to trade laws. Failure to provide permission (for a salmon farm) could trigger a challenge under World Trade Organization regulations. DFO has become irrelevant to the guardianship of salmon populations. Not perhaps the individuals within (DFO), but the institution itself. DFO is protecting trade, not wild fish. If we want wild fish, it's up to us."

There is an intrinsic conflict of interest in DFO being, on the one hand, entrusted with conservation and management of fisheries, and on the other hand being promoters for its use by commercial interests. What Morton and others have found, is that the latter mandate is increasingly trumping the former, as DFO becomes ever more an unapologetic cheerleader for industrial exploitation of fisheries. Says Morton, whose non-profit **Raincoast Research Society** eschews all government and industry funding and survives by handouts, donations, and contributions, "If you want to fight something really big, you have to remain really small so that no one can find your power lines." Even larger questions are touched on by Morton, ones that pertain to how corporations function in relation to the utilization of any natural resource. Says Morton:

*"On the last night that I was in Norway I was invited by a director of **Marine Harvest**, one of the largest salmon aquaculture firms in the world, and she asked me, 'Morton, what do you want?' And I said, 'You've got to get (the open-net salmon farms) off the migration routes.' And she said, 'I can't do that. I have to make the share price of this company go up four times a year. I cannot control the price, but I can control the number of farms and the number of fish. And that's what I'm doing.' At that moment the thought came to me, this is like cancer. They are going to grow, and grow, and grow, and they're never going to be content at any one size. And that is a dangerous thing. It's a phase mismatch with the biological world."*



For decades ecologists have drawn attention to the natural limits of growth, and to the finite capacity of natural resources. The productive capacity of oceans, vast as it may be, is not infinite and their exploitation cannot be endlessly ramped up. Attempts to do so will increasingly produce collateral ecological damage. Beyond a certain point they become an exercise in robbing Peter to pay Paul. There is ample evidence that we are reaching such a point, if we have not already passed it. Corporate models with their unceasing focus on growth, shareholder profit, and ballooning executive compensation are indeed in a phase mismatch with the realities of biological systems and ecological processes. Open-net fin-fish aquaculture is a prime illustration of the lack of full-cost ecological accounting, wherein real costs of the process (pollution, parasitism, disease) are dumped into the ocean and the remediation costs are borne by the environment and/or other stakeholders. As such, the resolution of the dilemmas posed by open-net salmon farming parallel the resolution of corporate exploitation of the environment, human and natural. We need to find models of economic activity that are not in phase mismatch with either the biological world or the human one. The failure to do so will have critical consequences for both.

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