CLOSED SYSTEM AQUACULTURE: the future of sustainable salmon farms

EXECUTIVE SUMMARY

As global demand for seafood products increase, so does the pressure on aquaculture to meet demands. Escape of farmed Atlantic salmon from open net-pens pose great biological, ecological, and genetic risks to wild salmon populations and ecosystems. By switching to closed system aquaculture (CSA), the possibility of escape is eliminated, along with disease transmission, interbreeding, and marine pollution. Closed system aquaculture is the future of sustainable salmon farming.

Farm Atlantic salmon is escaping open net-pens and having major adverse consequences on already dwindling wild salmon populations and the marine environment. Public policy has not provided satisfactory incentives to improve farming practices in several salmon-farming countries, and scientists suggest the lack of strong policy reflects uncertainty associated with the magnitude and impact of escapes[1]. Researchers used empirical evidence to assess the ecological and genetic impacts of escapes using a risk-assessment framework, and it was found that farming large populations of salmon posed a great biological, ecological, and genetic risk to wild salmon populations and ecosystems[1]. Another group of researchers agree and state the ecological, cultural, and legal implications resultant from escaped Atlantic salmon are sufficient to consider these salmon pollutants, and "biological pollution" from farm fish escapes can cause irreversible ecological impact[2]. The most important management issue that needs to be resolved immediately is reducing the number of escaped farmed salmon in nature.

Given the increasing global demand for seafood products, the Canadian aquaculture industry has grown substantially and is presently a major supplier of fish and shellfish to markets around the world. Worldwide, 40% of human-consumed fish are farmed[2], and of farmed salmon in Canada, 81% are Atlantic salmon. Escape of Atlantic salmon from open net-pens occurs periodically because of damage to nets in storms, and at a slow but constant rate through unreported "leakage." Between 1989 and 1996 20-40% of Atlantic salmon caught off the Faroes was of farmed origin[3].

Sea lice and disease transmission

In BC alone there are 80 active salmon farms[1], and many are located in sheltered bays and inlets near rivers or along salmon migratory routes. Pathogens and diseases can be easily transmitted from farm salmon to their wild counterparts – sea lice being one of the major threats. High-density fish farms are ideal breeding grounds for sea lice, and because open net-pens are not able to confine sea lice, the number in surrounding waters increases. Juvenile salmon en route to the ocean have a high probability of encountering sea lice, and as few as one or two sea lice may be enough to kill a wild juvenile pink salmon newly arrived in salt water[1]. In 2001, sea lice originating in salmon farms were thought to cause a huge collapse of pink salmon in the Broughton Archipelago (See Box 1).

Genetics and interbreeding

Wild salmon populations have genetic variation reflecting adaptations to local environments, while farmed salmon have very limited genetic variation. Escaped farm Atlantic salmon can successfully interbreed with wild salmon, but hybrids often exhibit decreased fitness and offspring are less fit than their parents[1]. A study found one-way gene flow could half the genetic difference between escaped and wild Atlantic salmon every 3.3 generations, and at this rate the amount of genetic variability that could be maintained could depend on that of just the farmed fish – very limited![4] Neither ocean cages nor open net-pens can contain fish eggs if by chance a farm salmon lays eggs, and interbreeding is likely to occur if eggs hatch and survive to maturity.

Marine waste and pollution

Open net-pens cannot prevent waste feed and feces from falling through the net pores and entering the marine environment. This style of aquaculture relies on ocean currents to dissipate any waste. In 2006, 78,000 metric tonnes of farmed BC salmon was produced for market.[5] Waste accumulates beneath fish pens and causes localized pollution, or gets carried by ocean currents and causes localized pollution elsewhere. **The solution to pollution is *not* dilution.** Much of this waste is nitrogen-rich, and can cause harmful algal blooms and create hypoxic or anoxic environments.

Recommendations

Stronger net materials or covers on boat propellers to avoid net tears have been proposed to reduce escape and mitigate these harmful effects of marine aquaculture in open net-pens, but these solutions do not address the major threat of disease transmission! The use of chemicals has been proposed to control sea lice, but then there lies the risk of contaminating surrounding waters and impacting other marine organisms. The solution lies in **closed system aquaculture (CSA)** – isolating farm salmon completely from their wild counterparts. CSA eliminates any possibility of disease transmission, breeding with wild salmon, water column pollution, and allows control such that optimal growing conditions for Atlantic salmon can be achieved. CSA has many configurations. It can be land-based or set in the ocean as a floating tank; and can re-circulate if water is limited or have a unidirectional flow if water is plentiful. This is the future of **sustainable salmon aquaculture**.

Box 1. Collapse of the Broughton Archipelago pink salmon[6]

In 2002, fisheries biologists expected 3,600,000 pink salmon to return. There were only 147,000. The Department of Fisheries and Oceans Canada (DFO) and the Pacific Fisheries Resource Conservation Council (PFRCC) showed this to be an unnatural event, not just a regular fluctuation. First Nations, commercial fishers, conservationists, and residents believed sea lice were the cause. The Broughton Archipelago has BC's highest concentration of fish farms, and most are on salmon migration routes. Evidence suggests sea lice origination in local salmon farms killed outward migrating juvenile pink salmon in 2001, resulting in an unexpected small return in 2002.

References

1 Naylor, R., Hindar, K., Fleming, I.A., Goldburg, R., Williams, S., Volpe, J., Whoriskey, F., … Mangel, M. (2005). Fugitive salmon: Assessing the risks of escaped fish from net-pen aquaculture. *BioScience, 55*(**5**), 427-437
2 Firestone, J., Barber, R. (2003). Fish as pollutants: Limitations of and crosscurrents in law, science, management, and policy. *Washington Law Review, 78,* 693-756
3 Hansen, L.P., Jacobsen, J.A., Lund, R.A. (1999). The incidence of escaped farmed Atlantic salmon, *Salmo salar* L., in the Faroese fishery and estimates of catches of wild salmon. ICES Journal of Marine Science. 56: 200-206
4 Tufto, J. & Hindar, K. (2003). Effective size in management and conservation of subdivided populations. *Journal of Theoretical Biology, 222,* 273-281
5 Coastal Alliance for Aquaculture reform. Retrieved from http://www.farmedanddangerous.org/ (accessed 26 November 2013).
6 Watershed Watch Salmon Society (2004) report *Sea lice and salmon: Elevating the dialogue on the farmed-wild salmon story,* CAAR report. Obtained from http://www.farmedanddangerous.org/