LOUSY CHOICES III:

Why Salmon Farms have to come Out of the Water

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EXECUTIVE SUMMARY

As the Canadian government launched its public consultation process for the long-awaited Transition Plan that will make good on their promise to transition open netpen salmon farms from British Columbia waters by 2025, DFO aquaculture staff appeared to be aligned with industry in an effort to define 'transition' as the addition of some technological innovations to ocean-based farms. All of the questions in their tightly designed public input questionnaire lumped together the only proven solution, land-based recirculating aquaculture (RAS), with experimental concepts such as "semi-closed", "hybrid" and "offshore" production systems, all of which still employ open netpens for all or part of the production cycle.

In this report, we take a close look at semi-closed and hybrid netpen systems and consider their ability to control the two main impacts of the farms on wild salmon: the transmission of sea lice and effluent-borne pathogens to young salmon entering the ocean from their natal streams. We also look briefly at offshore systems—briefly, because there are few in existence worldwide that have raised a cohort of Atlantic salmon and little is known about where and how such a system might be implemented in B.C.


photo: Eric Kilby

The great variety of salmon production systems that the industry is experimenting with globally, falling under the general description of 'semi-closed', share two common traits: they are not closed; and they don't work to raise fish to market size at commercial density or scale. Instead, semi-closed systems are used to raise smolts to one or more kilograms, after which the fish are placed in an open netpen for approximately 12 months of growout to market size.

Moreover, nowhere in the world is the use of such systems mandated: even in progressive Norway, where research and development has been heavily subsidized, operators are not obliged to continue using the innovative technologies they develop. Once they succeed in converting their free development licences to ordinary production licences (at a heavily subsidized price), they can revert to using netpens if that is cheaper. After a decade of richly-incented research and development, the industry has failed to produce a semi-closed system that is commercially viable and capable of growing fish to market size.

Two factors appear to limit the commercial utility of semi-closed systems. First, the sea lice seem to keep outwitting the industry, invading technology specifically designed to keep them out. Second, the impermeable partial barrier that is supposed to stop the sea lice actually does stop water exchange, resulting in poor water quality and, in worst-case scenarios such as the recent Clayoquot Sound trial by Cermaq, the death of the fish being cultivated. For this latter reason, semi-closed systems have not been successfully used to grow out market-sized fish at commercial densities or scale.

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Netpen salmon aquaculture is, after all, premised on the ability of ocean currents to carry fish waste away from the growing fish. It seems that none of the innovations involving pumping seawater through semi-closed systems and oxygenating it has solved the problem of water exchange for the growout of market-sized fish. Operating pumps and oxygenators is costly; and without the benefit of reduced sea lice treatment costs, is unlikely to give satisfactory results for the industry.

From a farm fish welfare viewpoint, decreased oxygen and increased ammonia levels inside the semi-enclosure can result in damage to the nervous system, internal organs, gills, blood chemistry and in acute cases, "convulsions and bursts of panic-like swimming", followed by "a rapid onset of a mortality finally reaching 100%".[1]

From the viewpoint of wild salmon protection, semi-closed systems offer very little, if any, promise. Given that sea lice have managed to invade all of the different models under trial, the farm's liquid effluent (which is released directly to the ocean) will contain sea lice eggs, larvae and the infectious-stage copepodids that latch on to outmigrating juvenile salmon. Whether or not the sea lice pressure would be reduced by the operation of semi-closed systems would depend on the operator's diligence in controlling lice within the system—which, in British Columbia, would require a combination of drugs, chemicals and bath treatments. And of course, since final growout is achieved in an open netpen, for fully half of the growout cycle the transmission of sea lice to wild salmon would remain as problematic as it is today.

The industry has been increasingly challenged in recent years to deliver sufficient treatments to maintain lice levels below the treatment threshold set by DFO for the protection of wild salmon, due to the tolerance lice are building against the drug SLICE and the shortage of treatment vessels for servicing farms over the vast area of the Province where tenures are located. The best that can be hoped for from a semi-closed system is that the ingress of lice to the farm is slowed somewhat, giving the operators more time to try to meet their licence obligations for louse control. As we elaborate later in this report, it is unlikely that this hope will be realized using the 'technology' currently (publicly) proposed.

Semi-closed systems offer no hope at all for the reduction of pathogen transmission to wild salmon. While some such systems offer the option to collect solid waste, none provides treatment for liquid waste. In the liquid waste stream will be found toxic ammonia, decreased oxygen, parasites, viruses and bacteria, including *Piscene orthoreovirus* and *Tenacibaculum maritimum*, two pathogens that are clearly linked in the published literature to disease in wild Pacific salmon and, in the case of *T. maritimum*, further associated with poor body condition (skinny fish) and poor salmon returns.

So-called "hybrid" production systems involve the use of land-based recirculating aquaculture technology to raise smolts to the size of about 1 kilogram before they are placed in an open netpen to grow out to market size. There is nothing about hybrid systems that suggests they are a 'transition' from open netpens; they depend upon open netpens. Similarly to the semi-closed systems, they offer wild salmon no protection at all from parasites, pathogens and pollutants. Because the fish spend only 12 months at sea, rather than the 18-24 months spent in a conventional aquaculture facilility, the main advantage of such systems is to allow operators to increase production by a factor of 1.4-1.6 times from each ocean tenure. From an ecosystem perspective, hybrid production increases the biomass on each tenure and so, increases the ecological problems caused by its effluent.

Finally, this report looks at offshore aquaculture, a concept so vague that we don't even know where it might be proposed to take place. We imagine it must be intended for the continental shelf, if it is to be anchored; and the shelf is the home of all of the marine life that we harvest and value for its role in our coastal ecosystems. There are no regulations governing offshore aquaculture, so will the solution to its pollution be dilution, once again?

1. Knoph, M.B., "Gill Ventilation Frequency and Mortality of Atlantic Salmon (salmo salar) Exposed to High Ammonia Levels in Seawater" Water Research, vol. 30, issue 4 (Apr, 1996) Copyright 1996 Elsevier Science Ltd. accessed at https://www.sciencedirect.com/science/article/abs/pii/0043135495002332

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That hasn't worked out well for our coastal habitats. One offshore system known to have raised a cohort of Atlantic salmon cost NOK 1 billion (CAD $134 million for 5000MT capacity), an investment which puts land-based solutions (in a place like British Columbia, where suitable land is available) on an equal, if not better, footing.[2]

While science clearly points to land-based, recirculating aquaculture technology as the best possible solution to the issues facing us, the Department of Fisheries and Oceans' Science and Aquaculture staff maintain the position that salmon farming in conventional netpens poses less than minimal risk to wild salmon. They maintain this position even in the face of a large and growing body of peer-reviewed, published science that implicates lice, *Piscine orthoreovirus* and *Tenacibaculum maritimum* amplified on salmon farms in the poor returns of wild salmon. It is accordingly no surprise that their interpretation of the Fisheries Minister's mandate to "transition open netpen salmon farms from BC waters by 2025" is premised on the continued operation of netpen salmon farms with technological and regulatory tweaks.

If the technology existed that would permit industrial-scale salmon farming to take place safely in the same waters required to support wild salmon, the debate about salmon farming would be over. But that technology does not exist; and wild salmon survival depends on immediate and decisive action to eliminate the harm being done by industrial salmon farming. The current discussion framework for British Columbia's Transition Plan has no such ambition: its objectives go no further than 'reducing interactions' between wild and farmed salmon and its proposed pathways are unlikely to achieve even that modest goal.

In contrast to all of these experimental systems, land-based RAS salmon aquaculture is a proven technology that is being developed all over the world. It eliminates interactions with wild salmon and produces farmed salmon without the use of drugs and chemicals, earning the highest sustainability rating. If both wild and farmed salmon are to have a future in British Columbia, the salmon aquaculture industry must be confined to land-based RAS facilities and transitioned out of BC waters.

2. RAS Atlantic Salmon Industry on Vancouver Island: Financial Model and Economic Impact Analysis (Counterpoint, 2019) calculated that a 50,000MT land-based closed containment industry would cost approximately $1.1 billion CAD. Salmar's Ocean Farm I has produced about 5000MT per cohort and its cost in CAD was $134 million. Scaled to the same size, the projected cost of the land-based industry is about $24 million lower.

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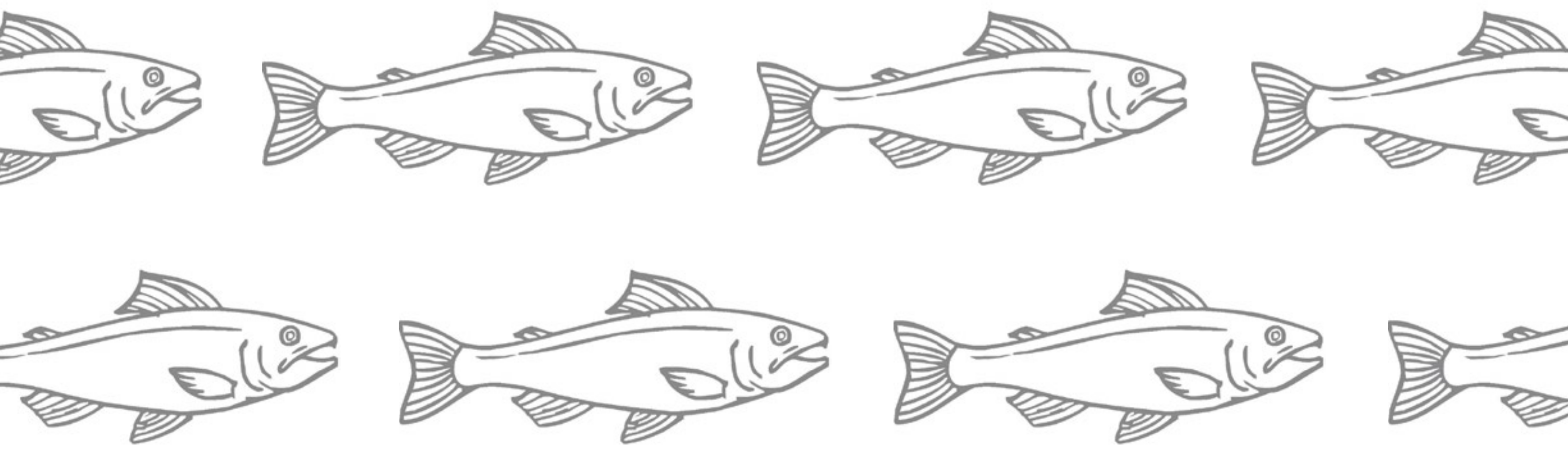


SEMI-CLOSED CONTAINMENT SYSTEMS

Drivers of Innovation

Since about 2015, the variety of semi-containment systems for salmon aquaculture has grown enormously. Driven largely by Norwegian policy, significant investments have been made in designing farms that continue to release pathogens and pollutants and so far, have failed to foil the industry's most significant parasite, the sea louse.

The motivation behind all this expenditure on the industry's part is expansion. Norway will not allow expansion unless sea lice, escapes and pollution are reduced. In order to achieve this, the government offered free development licences, awarded to projects involving significant technological innovation with an option to convert to regular production licences for a fraction of the market price. Unlike Canada, Norway charges heavily for the right to use public waters for salmon farming, so substantial investments in innovation made economic sense.

But there's a kicker: there is no requirement to continue to use the new technology once the licence is converted to regular production. All that is required is to demonstrate that the prototype is capable of improvement in louse control, escapes and/or pollution in order to convert the licence. Commercial viability is not required. With regular production licences selling at auction for about $30,000 CAD per metric tonne[3] (roughly $105 million CAD for an average-sized Canadian salmon farm) and conversion costs fixed at NOK 10 million ($1.3 million CAD), hundreds of millions of kroner could be devoted to the design, construction and operation of a prototype to meet the government's objectives and the industry still came out ahead. If the technology proved too expensive to operate competitively, it could be abandoned once the production licence was secured.[4]

The lure of those production licences is clearly evident in the fact that Norway now has over 80,000MT of production in development licences—more than the total production in British Columbia.[5] This is not to suggest that there are no earnest attempts in progress to solve the knotty problems of marine-based salmon farming; but to point out a consequence of Norway's policy that was no doubt unintended and may well be responsible for the fact that there are not yet any commercially viable semi-closed containment systems proven capable of growing fish to market size. It remains difficult to imagine how any of the costly designs that have been trialed could ever compete with the basic netpen, but that is exactly what they must do before there will be industry uptake—unless open netpen salmon farming is banned.

It should be pointed out here that Canada has very little leverage for incenting research and development spending through a similar 'development licence' approach. The fees charged for open netpen tenures and operating licences are so small by comparison to Norway that even waiving the fees altogether would not 'free up' sufficient capital to support investment in the order of the hundreds of millions of dollars that these same companies that farm our waters have already spent in Norway. Canada's approach to date has been to fund research and development with grants of tax dollars, such as the $5.4 million paid through The Fisheries and Aquaculture Clean Technologies Adoption Program (FACTAP) to Cermaq, MOWI and Cargill in 2021. Cermaq applied its share of the grant, $752 thousand, to its failed trial of the FiiZK floating bag system as a growout facility. MOWI installed solar panels on its Dalrymple hatchery; and Cargill put a wastewater treatment system into its Surrey facility.[6]

3. 2020 auction results as reported by IntraFish at https://www.intrafish.com/salmon/here-are-the-winners-in-norways-670-million-salmon-farming-license-auction/2-1-860253

4. Hersoug, Bjorn, et al, "Serving the industry or undermining the regulatory system? The use of special purpose licences in Norwegian salmon aquaculture" Aquaculture, vol. 543 (2021)

5. IBID

6. as reported by IntraFish at https://www.intrafish.com/aquaculture/mowi-cermaq-cargill-take-slice-of-5-4-million-government-grant-for-british-columbia-operations/2-1-993094

SEMI-CLOSED CONTAINMENT SYSTEMS

Types of Semi-closed Systems

Since 2015, when Norway introduced the development licences, the assortment of systems described as 'semi-closed' has increased dramatically. Prior to that, conventional netpens had tried installing 'skirts'—essentially tarps of various depths, designed to stop lice from entering the system. We look at lice skirts separately in this report, as they are now quite primitive compared with the technologies being trialed.

Other semi-closed systems fall into two broad categories: rigid and flexible structures. Some of the former are enormously expensive steel structures; while the latter are generally plastic bags supported on a floating structure. Either category may include optional solid waste recovery. None proposes liquid waste recovery. Some prototypes use pumps to draw in water, while others try to rely on ocean currents to exchange the water inside the structure. All attempt to defeat sea louse infestation by drawing water from a depth at which lice are not thought to survive and where temperature is optimal for salmon growth. Finding that sweet spot in the water column has proven challenging, as we elaborate below.

The Problems with Semi-closed Systems

It should be noted at the outset that most semi-closed salmon culture systems are not designed to raise fish to market size, so they rely on transferring the fish to open netpens for at least one year of the grow-out cycle. Attempts to date to use them to grow fish to market size have failed; so their main attraction is to grow large smolts for transfer to pens, enabling industry to put a greater volume of salmon biomass through its netpen tenures. Here, we elaborate some of the issues with semi-closed systems.

Liquid Effluent

The main problem with semi-containment is of course that which it doesn't contain: the liquid effluent. Water-bourne viruses and bacteria are introduced or amplified by salmon farms; and we now know that at least two of those, *Piscine orthoreovirus* (PRV)[7] and *Tenacibaculum maritimum* cause disease in wild Pacific salmon species. We also know that transmission to wild stocks is occurring; and that untreated, the diseases caused by both pathogens can be fatal. *T. maritimum* is further associated with poor body condition in coho and Chinook and reduced returns of coho, Chinook and sockeye salmon.[8] [9]

The published literature contains the strongest argument against semi-closed containment systems that could possibly exist. It couples empirical findings of infection of wild juvenile fish with statistically significantly depressed returns in their adult cohort. Short of actually tracking the infected fish to watch them die and conducting necropsies on them (an activity that is actually impossible), there could be no stronger argument that these two, water-borne pathogens are causing population-level impacts to wild salmon. For this reason alone, semi-closed containment systems cannot be viewed as viable 'transition' targets for open netpens.

But there is another reason that liquid effluent is a problem in semi-closed facilities. One of the things that has plagued all designs is that of inadequate flushing of the contaminated water. Salmon excrete ammonia and are sensitive to elevated levels of it in their environment, particularly when that environment is also oxygen-poor.[10] Where netpens rely on ocean tidal action to carry effluent out of the cages and bring in freshly oxygenated water, semi-closed systems must rely on pumps and oxygenation of the facility's water to maintain a healthy environment. Many of the prototype semi-closed systems fail to replace water adequately, especially as the fish grow larger.[11] In Norway, companies can afford to experiment with more powerful pumps to run the prototypes until they achieve licence conversion. To date (i.e., after a decade of innovation) semi-closed systems cannot exchange water efficiently enough to be physically and commercially viable grow-out facilities.

7. E Di Cicco, HW Ferguson, KH Kaukinen, et al., "The same strain of Piscine orthoreovirus (PRV-1) is involved in the development of different, but related, diseases in Atlantic and Pacific salmon in British Columbia," FACETS 3(2018) 599-641 ("Di Cicco (2018)"), https://doi.org/10.1139/facets-2018-0008

8. AL Bass, AW Bateman, BM Connors, BA Staton, EB Rondeaus, GJ Mordecai, et al. "Identification of infectious agents in early marine Chinook and Coho salmon associated with cohort survival," (2022, in press) GJ Mordecai, KM Miller, AL Bass, et al., "Aquaculture mediates global transmission of a viral pathogen to wild salmon," Sci. Adv. 7 (2021) eabe2592 ("Mordecai et al. (2021)"), https://doi.org/10.1126/sciadv.abe2592

9. https://psf.ca/wp-content/uploads/2022/09/PSF-Report_Risk-OpenNetAcquaculture_Sept2022.pdf

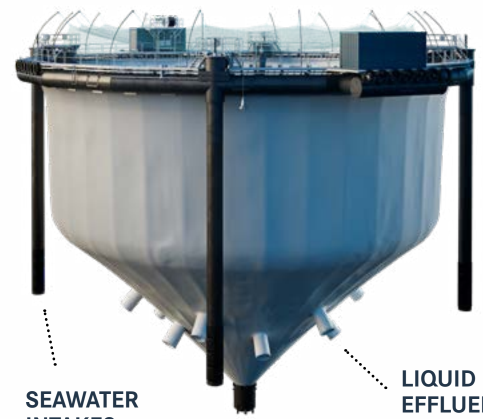
10. Knoph, M.B., "Gill Ventilation Frequency and Mortality of Atlantic Salmon (salmo salar) Exposed to High Ammonia Levels in Seawater" Water Research, vol. 30, issue 4 (Apr, 1996) Copyright 1996 Elsevier Science Ltd. accessed at https://www.sciencedirect.com/science/article/abs/pii/0043135495002332

11. https://www.fishfarmingexpert.com/aquatraz-midt-norsk-havbruk-norway/aquatraz-given-deeper-lice-skirt-and-better-water-flow/1156923

SEMI-CLOSED CONTAINMENT SYSTEMS

The Cermaq Clayoquot Trial

THE FIIZK SYSTEM TRIALED BY CERMAQ, COURTESY OF FIIZK



In 2020, Cermaq Canada was awarded a federal grant of over $742,000 to trial a semi-closed containment system at its Millar Channel tenure in Clayoquot Sound. Stocked in November, 2020, the farm was depopulated by October, 2021 as a result of "fish welfare concerns" following what appeared to be a massive die-off. Although no comprehensive report on the failure of the system appears to have been published, local conservation organization Clayoquot Action obtained a summary report under the Access to Information Act, which contains only the bald statement, "Fish removed due to fish welfare concerns resulting from chronic exposure to higher levels of ammonia".[11] The fish, in other words, were attempting to breathe in a soup of their own, toxic excrement.

Without far more information, it is impossible to say whether the pumps on the system were inadequate to the clean water needs of the farmed salmon; or whether those pumps were in fact drawing contaminated water due to the proximity of the intakes to both the liquid effluent and the mound of rotting fish, fish feed and feces that built up under the structure, since Cermaq chose not to include the optional solid waste recovery system in its trial. Where the solid waste from a netpen would have been cast over a large area around the netpen, the semi-closed system deposited it from a point source at the base of the unit, no doubt resulting in an abnormally large accumulation close to the water intake. Microbial decomposition of organic matter can also generate ammonia under anaerobic conditions.[12]

This was the first attempt globally to use the FiiZK system to grow fish to market size and it was unquestionably an expensive failure. Cermaq itself described the system on its website as "immature technology under development". It is noteworthy that the plan for this facility was, from inception of the project, to grow smolts from 100 grams to 600 grams and 1500 grams, transferring them to netpens for growout. A smaller cohort (numbers unknown) was to be left in the semi-closed system until spring of 2022, when it was expected that they would have grown to 5.5 kilos.[13] The news that the experiment had to be truncated in October, 2021 as a result of toxic ammonia buildup, indicates that this system is far from capable of producing commercial quantities of fish at market size. Its utility would be limited to serving a hybrid production system—in other words, continued use of netpens.

Rising levels of ammonia inside a salmon farm have potentially fatal consequences for the farmed stock. The first laboratory study of ammonia concentrations in seawater noted that salmonids are among the most sensitive of species to ammonia. During 48-hour LC50 trials with varying concentrations of ammonia, the researchers observed 100% mortality at ammonia concentrations above 0.6 mg/litre of seawater and described the effects:

> Moribund fish showed a characteristic behaviour indicating toxic effects on the nerve system, apparent from one to several hours before death. Coughing, twisting, loss of equilibrium, spiral swimming and convulsions were observed. Shortly before death, the fish often showed panic-like bursts of swimming. The fish collided violently with the walls or covers of the aquaria and then sank to the bottom in a coma-like state, in which there were no body movements except for weak and irregular opercular movements, and, occasionally, shivering fins. At death, the mouth was usually gaped open, and the fish often had wounds on the nose due to the mechanical trauma from collisions with the aquarium walls or covers.[14]

11. ATIP A0584689 dated 2021-10-14

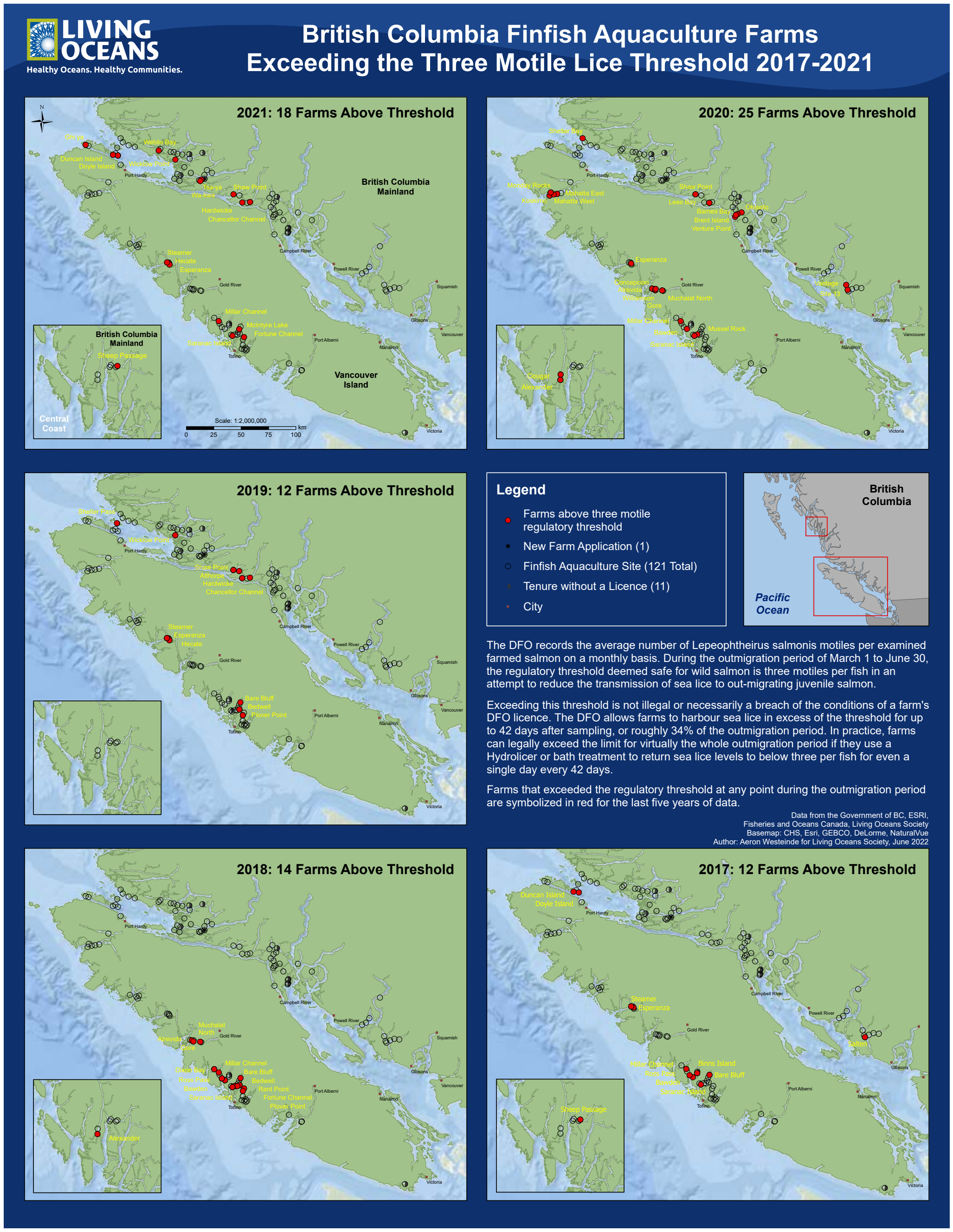
12. https://chempedia.info/info/anaerobic_decomposition_of_organic_matter/#:~:text=Ammonia%20and%20amines%20are%20produced%20by%20microbial%20decomposition,aerobic%20bacteria%20such%20as%20Nitrosomonas%20or%20Nitrobacter%20species.

13. https://www.fishfarmingexpert.com/british-columbia-cermaq-canada-clayoquot-sound/cermaq-prepares-to-trial-improved-and-optimised-semi-closed-cage-in-bc/1169170

14. Knoph, M.B., "Gill Ventilation Frequency and Mortality of Atlantic Salmon (salmo salar) Exposed to High Ammonia Levels in Seawater" Water Research, vol. 30, issue 4 (Apr, 1996) Copyright 1996 Elsevier Science Ltd. accessed at https://www.sciencedirect.com/science/article/abs/pii/0043135495002332

Sea Lice

The louse that specializes in salmon, *Lepeophtheirus salmonis*, is a remarkably adaptive creature that has evolved resistance to many of the drugs and chemicals used in salmon farming and remains by far the most expensive treatment challenge facing the industry in Norway and Canada alike. Because Norway recognizes (unlike Canada) that louse infections are amplified on the farms and spread to their endangered wild populations of Atlantic salmon, one of the objectives of the development licence innovations is the control of sea lice.



Earlier effort to create barriers to lice involved the use of tarps around the upper portion of the netpens, called 'lice skirts', partially enclosing the netpen. The first skirts were installed to depths of 5-6 metres, but that rather quickly proved ineffective: there were often more lice in the pens than outside them.[15] Subsequent designs have increased the enclosed portions to 18-20 metres, with one company saying it intends enclosing the next generation of its (rigid) experimental system to a depth of 25 metres.[16] Floating bag systems, which are enclosed except for their intake and outflow pipes, have been designed with deeper or telescoping intakes, all in an effort to prevent sea lice from entering the farm.

15. Jevne, LS, Reitan, KI. How are the salmon lice (Lepeophtheirus salmonis Krøyer, 1837) in Atlantic salmon farming affected by different control efforts: A case study of an intensive production area with coordinated production cycles and changing delousing practices in 2013–2018. J Fish Dis. 2019; 42: 1573-1586. https://doi.org/10.1111/jfd.13080

16. https://www.fishfarmingexpert.com/article/aquatraz-given-deeper-lice-skirt-and-better-water-flow/

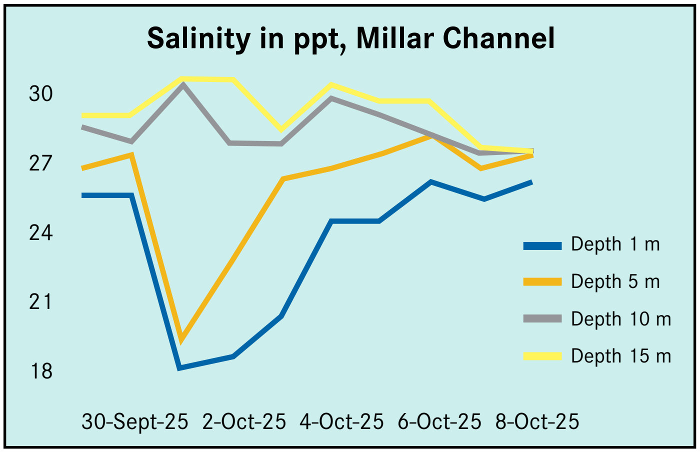
SEMI-CLOSED CONTAINMENT SYSTEMS

The Aquatraz 3 is one of four steel cage designs operated by Salmonor in Norway. Developed at a cost of EUR 35 million (CAD $46 million), the prototypes are steel cages with lice skirts of varying depths, up to 25 metres. Over a total of 8.5 operating years under development licences, the four systems have grown a total of 7000MT of salmon to market size, making this the only semi-closed prototype to have done so. Aquatraz 4 is said to have a design capacity of 3000MT, making it comparable to a small BC salmon farm; but the system is not yet capable of moving enough water fast enough to exploit the full design capacity.

Recent research shows this may continue to be a losing battle. Originally, sea lice were thought to aggregate only in the upper 12 or so metres of the ocean. A study in 2019 found that salinity, rather than depth, had more to do with the dispersal of larval- and infectious-stage lice. The larval stages (nauplii) tended to avoid any waters with salinity lower than 30 ppt, while infectious-stage lice could be found in water salinities from 34.7 to 16 ppt.[17]

The following chart, prepared using data from Cermaq Canada following a fish mortality event at its Millar Channel site in August, 2021, shows that salinity at depths of 15 metres varies day by day, with salinities lower than 30 ppt found at that depth on 80% of measurements taken over the 10-day period reported. This, of course, means that infectious-stage lice will be found at depths lower than 15 metres. The FiiZK system indicates on its website[18] that the Certus model (which we believe to be the unit trialed at Millar Channel) draws its water from a depth of ">20 metres", which still gives rise to the potential for it to pump juvenile sea lice into the farm.

There are no published lice counts from the Cermaq trial to tell us whether or not the system successfully avoided sea lice. Certainly, all of the reports from Norwegian trials of semi-contained systems continue to cite the presence of lice on the farms; and the evolution of ever-deeper enclosures on the systems under trial suggests that they have not yet discovered the depths to which sea lice will sink to feast on farmed salmon.



17. Crosbie, T. et al, "Effects of step salinity gradients on salmon lice larvae behaviour and dispersal", Aquaculture Environment Interactions, vol. 11, p. 181-190 (2019).

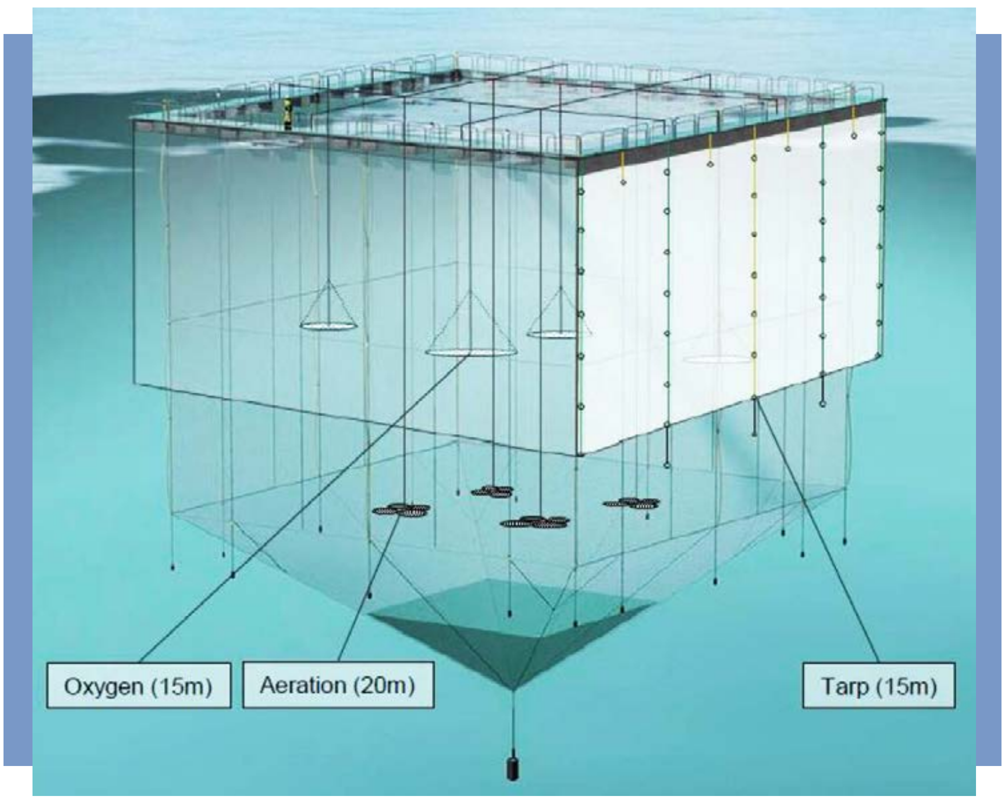
18. https://fiizk.com/en/product/semi-closed-cage/

Lice Skirts

This brings us back to Canada, where lice skirts were hailed by Grieg Seafood in recent news reports as “Cutting Edge Technology: Rocky Boschman, managing director, commented, “As a company, we are always looking for ways to improve our operations, and this includes transitioning from standard farming equipment, to new, cutting-edge technology aimed at reducing potential impacts from our operations.”[19]

The diagram provided by Grieg was at least honest that the “cutting edge” is provided by a “tarp” set at 15 metres below the surface, on a conventional netpen.

Seawater salinity will of course be site-specific. Grieg is installing tarps on its Esperanza (West Coast Vancouver Island) farms, where sea lice have been wildly out of control in recent years. The sites there share some basic characteristics with those in Millar Channel to the south, so it may well be that the 15 metre tarp proves an inadequate barrier to sea lice. The plan is otherwise unremarkable as to innovation—it has long been known that the deeper the enclosure on a netpen, the less dissolved oxygen in the water[20]. Additional oxygen and aeration have been used for some time on British Columbia’s farms. This is an open netpen with a removable tarp; hardly an innovation that meets the federal mandate to ‘transition open netpens from BC waters by 2025”. The pen remains open to the transmission of lice, pathogens and waste just as it did before installation of the tarp.



19. https://salmonbusiness.com/grieg-expanding-use-of-new-semi-closed-salmon-farm-system/

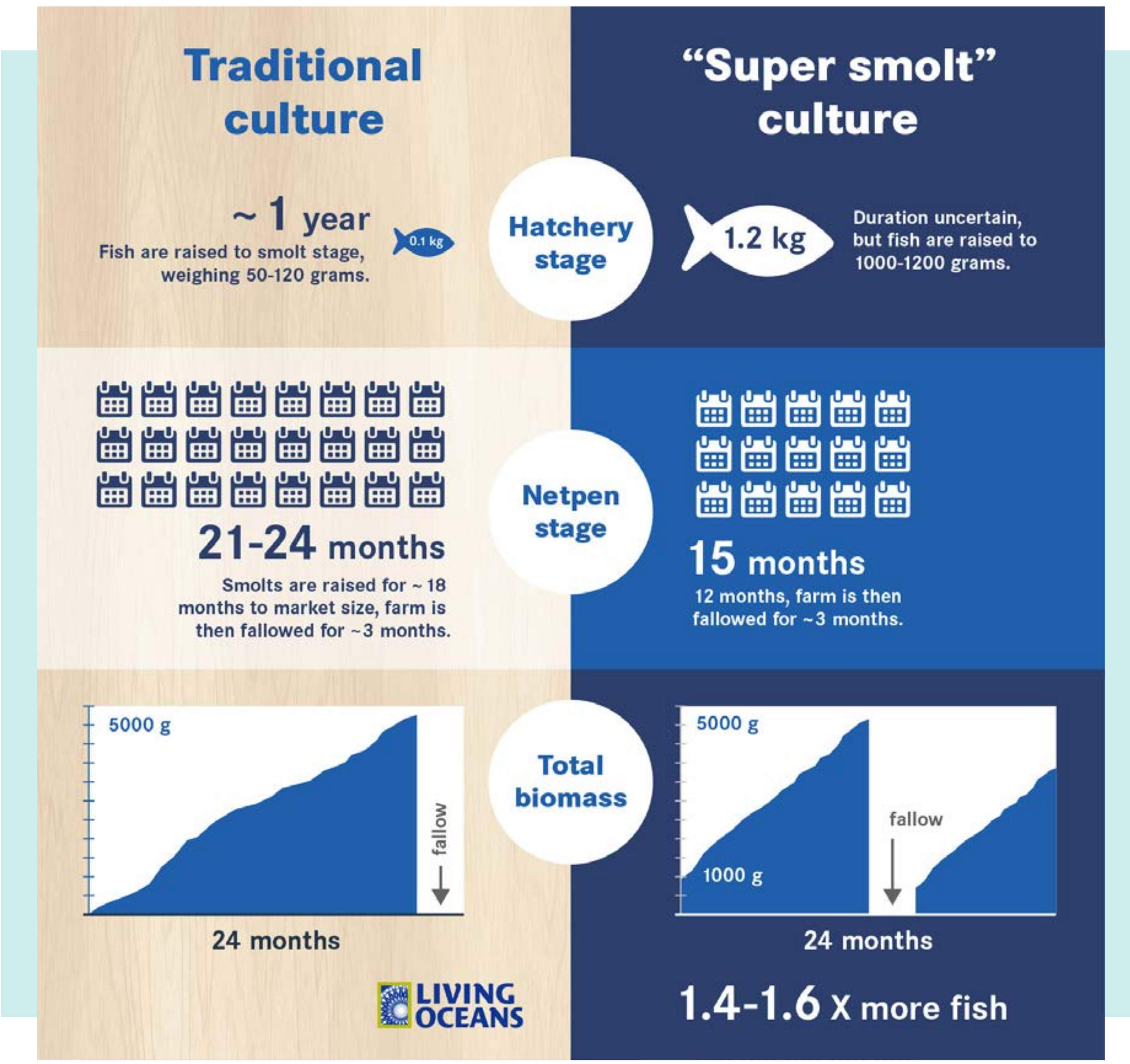
20. Kristbjörg Edda Jónsdóttir, Andreas Ugelvik Misund, Leif Magne Sunde, Merete Bjørgan Schrøder, Zsolt Volent,Lice shielding skirts through the decade: Efficiency, environmental interactions, and rearing challenges, Aquaculture, Volume 562, 2023, 738817, ISSN 0044-8486, https://doi.org/10.1016/j.aquaculture.2022.738817. (https://www.sciencedirect.com/science/article/pii/S0044848622009346) “Lower dissolved oxygen, poor water quality (plankton), increased particle accumulation and deterioration of gills, poor or no effect on salmon lice infestation, perceived increase in amoebic gill disease (AGD) infestation or perceived lower feed conversion ratio (FCR) are amongst the primary reasons that certain Norwegian and Scottish companies and production sites choose not to use lice skirts (Misund et al., 2020; A. Currie, personal communication, September 1, 2021).”

HYBRID CONTAINMENT SYSTEMS

The term "hybrid" has been used in the industry to describe a production method that involves raising large smolts (1-2 kilograms) in land-based RAS nurseries and then transferring them to open netpens for growout. Sold by the industry as a way of having the fish spend "less time in the ocean", this production method is really all about putting more biomass through existing tenures than is the case with conventional netpen farming. Each cohort requires only 12 months, rather than 18-24, to grow to market size. Allowing for fallowing time between cohorts, each tenure will produce about 1.5-1.75 cohorts every 24 months, where conventional production would see only 1-1.2 cohorts. And starting with larger fish means more biomass on site throughout the production cycle, actually exacerbating the problems associated with fish waste and its associated pathogens.

It will be apparent that hybrid systems are no different than semi-closed systems in terms of their impact on wild salmon. Both ultimately depend on open netpens to complete growout and so both offer the full suite of impacts to wild salmon that we seek to eliminate.

All 3 of the companies farming our waters have now invested in the technology to raise large smolts, meaning they are already using land-based RAS or have the capacity to do so. Moving from nursery-scale to growout-scale with their RAS systems on existing nursery sites would be one approach to transition clearly available to them, should they wish to continue producing salmon in British Columbia.



OFFSHORE OPEN NETPEN SALMON FARMS

Globally, there are only two offshore systems in commercial production of Atlantic salmon, operating in Norway; although three companies initially applied for development licences for offshore designs and many more, globally, are in planning and development stages of offshore farms.

Concepts include permanently anchored structures; mobile anchored structures that could be quickly de-coupled from their anchorage and moved to sheltered locations; and fully self-propelled vessels.

In Norway, there is even mention of “semi-offshore” designs, although little information about them is available online. Mobility or reasonably sheltered locations within 3-5 kilometres of shore appear to be key issues in the early stages of development. Location of the farms outside of Norway’s regulated salmon farming areas has also attracted opposition from fishermen.

Photo: Jørgen Fjeldvær

In 2020, Salmar was granted conversion of its development licences for “Ocean Farm I” to production licences. This is a steel structure measuring 38 metres deep by 110 metres diameter, fully anchored. Its production capacity is given at 1.5 million Atlantic salmon, or about 5000MT. In the fall of 2021, it was taken out of service after having grown out 2 cohorts of salmon totaling 10,000MT, reportedly because of two escape events.[21] The plan is to put it back into operation fall 2022.

Despite the farm’s offshore location, the company reported sea lice on the fish, although at levels that did not require treatment.

21. As reported by The Fishfarming Expert at https://www.fishfarmingexpert.com/atle-eide-ocean-farm-1-salmar/ocean-farm-1-taken-out-of-use-for-months-for-improvement-work/1323183

OFFSHORE OPEN NETPEN SALMON FARMS

In 2021, Nordlaks 'Havfarm I', a ship-based design, was refused conversion of its development licences on the grounds of poor fish welfare. The Norwegian Fisheries Directorate cited mortality rates of 25% in several of its cages, noting that the fish died primarily of wounding.[22]

A subsequent cohort was raised with mortality rates below 3% and Nordlaks achieved conversion of its development licence in March, 2022.[23]

Nordlaks Havfarm I has a capacity of 10,000MT and is presently raising a third cohort of Atlantic salmon[22].

A third applicant for offshore development permits was Gigante Offshore, a pioneer in the development of submersible salmon farms. This company has been testing offshore prototypes since 2008, trying to come up with a design that can be submersed to avoid rough sea-surface conditions. Its novel "Super Tank Cage" application was denied[24]; and parent company Gigante Salmon appears to be moving to land-based development.

Elsewhere in the world, submersible prototypes are being trialed: Ocean Aquaculture Chile reported favourable results in December, 2021 from one trial production cycle in a copper cage designed by Eco-Sea that can be submerged to 50 metres. In China, a small submersible farm in the Yellow Sea (Shenlan I) was launched in 2018 with a production target of 1500MT of Atlantic salmon, but no information is available about its current status other than that it had a 'successful trial'. Another, much larger semi-submersible completed construction in June, 2020 with plans to grow yellow croaker for the domestic Chinese market. Unlike most offshore trials, the "Spar Fish Farm" is in the open ocean, 45 miles off the Fujian Province coastline.

There are dozens of applications or announced plans for offshore facilities, but the price tags continue to be enormous and the prototypes are still so new that it is difficult to predict their useful lifespan in the ocean. Conflicts over the location of the farms are a common theme, as fishermen protest the occupation of fishing grounds and conflicts with shipping and military operations are also cited by some articles.

22. as reported by Fish Farmer Magazine at https://bit.ly/3KMs8CW

23. Personal communication, Lars Fredrik Martinussen, Nordlaks, September 23, 2022

24. as reported by Fish Farming Expert at https://www.fishfarmingexpert.com/development-licences/development-licence-decisions-made/1216246

OFFSHORE OPEN NETPEN SALMON FARMS

Offshore in Canada

In the absence of any information at all about the type of facility or its possible location, Canadians are being asked by DFO to evaluate offshore open netpen salmon farming as an option for transitioning open netpens from BC waters. Would it be 6 kilometres from shore or 60? The industry globally has yet to arrive at consensus on what constitutes an "offshore" environment.[25] Would it be a self-propelled, floating facility that would duck into the nearest inlet in the event of a storm? Would it be anchored on the continental shelf and if so, in whose fishing grounds? What would be the impact of introducing the equivalent of a small city's sewage into the rich feeding grounds of our continental shelf? Are our groundfish as susceptible to contracting disease from Piscine orthoreovirus as Chinook salmon are? Or as liable to develop tenacibaculosis?

These are just a few of the more salient questions that we would want to see answered before DFO asks our opinion about a transition plan that would set aquaculture operators on a path to make investments that are roughly equal in capital outlay to land-based salmon farming and merely move the pollution issue into waters about which we know far less than we do about coastal environments.

CONCLUSION

The past decade has seen a decided boom in research and development and yet no technology has emerged that can grow Atlantic salmon to market size in semi-containment at commercial scale. Most of this research has taken place in Norway, where the driving concerns are the reduction of escapes, pollution and sea lice. Note that protection of wild salmon from disease pathogens introduced by, or amplified on the salmon farms was not among the criteria for evaluation of Norwegian development licence applications and that accordingly, none of the designs being trialed seeks to treat liquid effluent.

While some of the fancier semi-closed systems claim to have reduced sea lice ingression to the point where treatment is not required, they have to date only done so in trials scaled at less than commercial volumes or densities. The fact that even the industry continues to experiment with deeper semi-containment, requiring more powerful pumps and more oxygenation, suggests that the technology remains experimental.

Canada's wild Pacific salmon don't have time for experiments: far too many populations are in steep decline, to levels never before measured. There is only one solution for them and that is complete separation of culture facilities from wild salmon habitat. Land-based recirculating aquaculture technology (RAS) is capable of growing Atlantic salmon to market size with no impact on wild salmon. There are companies in 20 countries either operating, constructing or planning over 100 such facilities right now, including the parents of companies presently farming B.C. waters in netpens. If salmon aquaculture in British Columbia is to co-exist with wild fish, it must be in such fully contained facilities.

25. Lauren Watson, Lynne Falconer, Trine Dale, Trevor C. Telfer, 'Offshore' salmon aquaculture and identifying the needs for environmental regulation, Aquaculture, Volume 546, 2022, 737342, ISSN 0044-8486, https://doi.org/10.1016/j.aquaculture.2021.737342. (https://www.sciencedirect.com/science/article/pii/S004484862101005X)

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