# INTRODUCTION

British Columbia is home to vast tracts of wilderness, majestic inlets and island archipelagos that support a rich and diverse array of wildlife species, from sharks and crustaceans to seabirds and marine mammals. Salmon farmers acknowledge the significance of operating in these coastal waters, recognizing the deep cultural and public value attributed to the wildlife in their environments by First Nations and the public. We have developed effective infrastructure and processes to protect wildlife, with a primary focus on preventing harm. This chapter describes how salmon farmers minimize interactions with wildlife to keep both farmers and wildlife safe and provides important statistics on wildlife interactions at farms in British Columbia.

## WHAT IS CONSIDERED AN INTERACTION?

Salmon farms are located in wilderness areas of coastal BC. Interactions between wildlife and salmon farms occur in a variety of ways. The majority of these interactions are harmonious, consisting of viewing each other from a safe distance. On occasion, wildlife comes into close proximity to farms. Care must be taken to ensure wildlife and people are not harmed during these events. Infrastructure innovations, farm practices and regulatory frameworks have been successful at reducing both the frequency and consequences of close interactions.

# REGULATIONS TO PROTECT WILDLIFE

The conservation and protection of wildlife is regulated on global, federal, provincial, and municipal levels.

- Internationally, Canada regulates the international trade in animals and plants in adherence to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1975(2).
- Federally, the government's jurisdiction with respect to the conservation of wildlife, habitat and the recovery of species at risk is established by the Species at Risk Act (SARA), 2002, (3) the Fisheries Act, 1985, (4) and the Migratory Birds Convention Act, 1994 (5), including their associated Regulations and Orders.
- Through amendments to the Fisheries Act and associated regulations, Canada also adheres with the international requirements of the US Marine Mammal Protection Act, 1972, which prohibits the lethal removal of nuisance mammals for the protection of fishing equipment (6).
- Provincially, the Wildlife Act, 1996, (7) with associated regulations, protects wildlife from harm.
- Municipalities can incorporate wildlife protection objectives though several measures, including by enacting local bylaws.

In addition to these protections, there are specific requirements for wildlife interactions at farms prescribed in the Marine Finfish Aquaculture License under the Fisheries Act (4). License requirements are described in the following sections.

See "Chapter 6 – Caring for the Environment – Minimizing Incidental Catch" and "Chapter 8 – Caring for the Environment – Protecting Biodiversity", for more information on how incidental catch and biodiversity are protected near salmon farms.

## DFO REQUIREMENTS

Salmon farmers are required to provide information to DFO on how they will minimize interactions with megafauna at each site, as well as report any entanglements or entrapments (Figure 1). The term "megafauna" refers to marine mammals (whales, dolphins, porpoises, seals, sea lions, sea otters), turtles, and sharks. Considerations for basking sharks and turtles came into effect in 2020, in alignment with the Species at Risk Act.

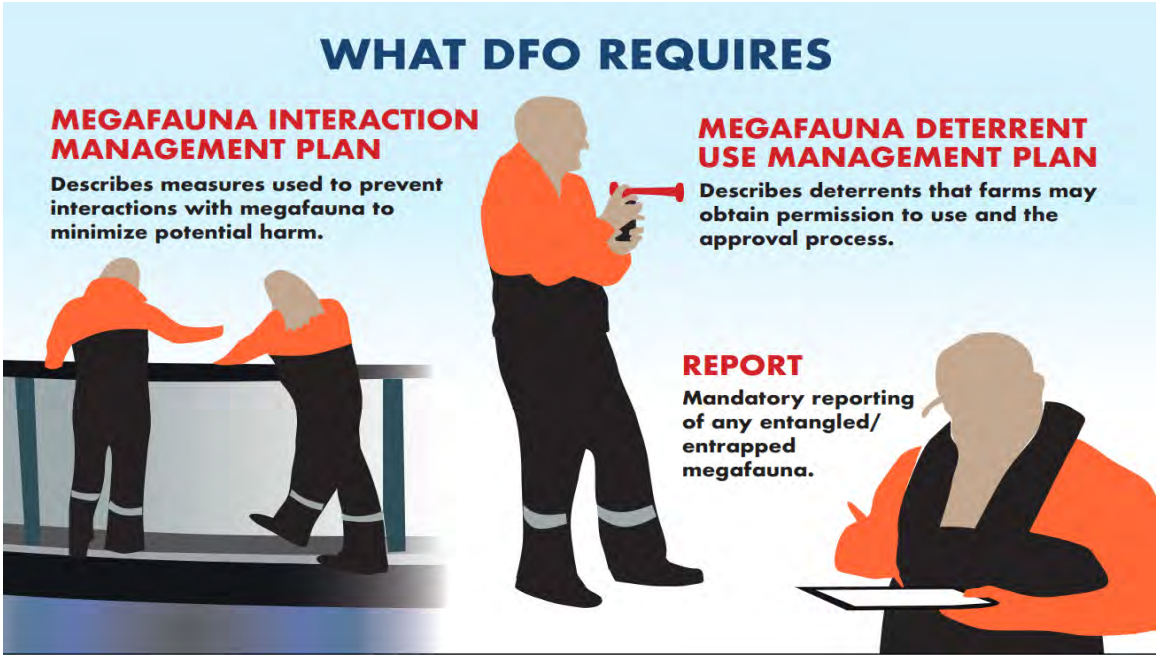


*Figure 1. The current requirements under the Marine Finfish Aquaculture License under the Fisheries Act.*
*Source DFO Marine finfish B.C. aquaculture licence and conditions of licence (8)*

Requirements include:

- Megafauna Interactions Management Plan - describes how the site will minimize conflicts with megafauna.
- Megafauna Deterrent Use Management Plan – describes non-harmful deterrents the site may need to use in the unlikely event there is a threat to human safety or to the integrity of the farm system. These measures can only be used if approved by DFO.
- Reporting – mandatory for any entangled or entrapped megafauna.

## MEGAFAUNA INTERACTIONS MANAGEMENT PLAN REQUIREMENTS

Salmon farmers are required to submit a Megafauna Interaction Management Plan (MIMP) each year to DFO. The plan must describe policies, procedures, infrastructure, and measures each site has implemented to minimize conflicts with megafauna (Figure 2). This must include procedures to address issues related to entanglements and entrapments.

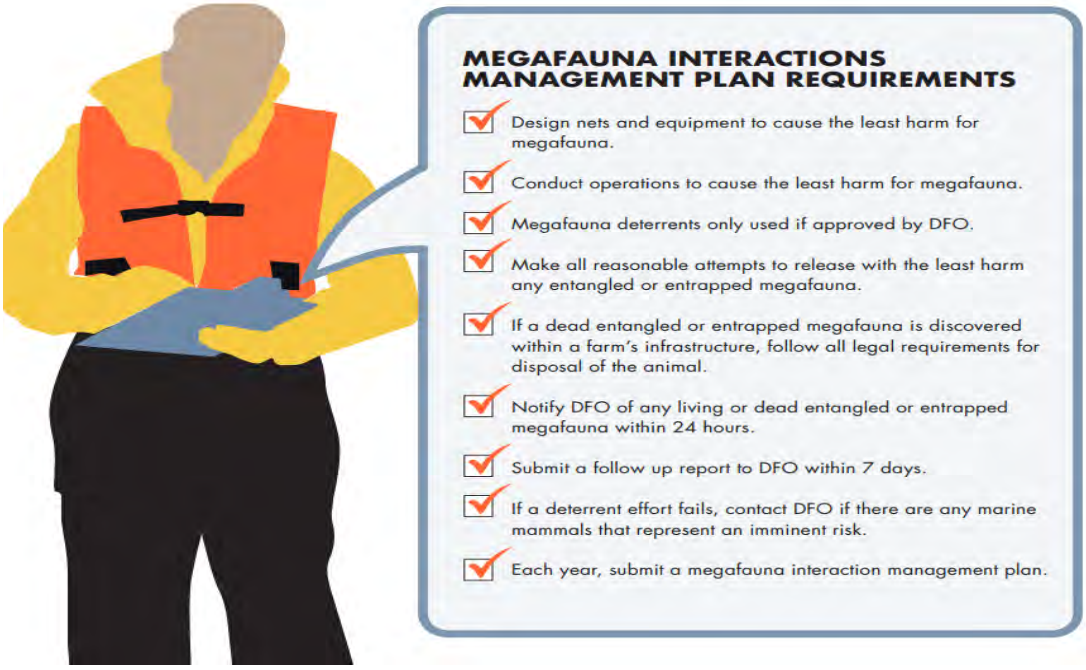


*Figure 2. List of requirements for Megafauna Interactions Management Plans, as a condition of licensing for salmon farms in BC.*
*Source DFO Marine finfish B.C. aquaculture licence and conditions of licence (8)*

## MEGAFAUNA DETERRENT USE MANAGEMENT PLAN REQUIREMENTS

As of March 2023, salmon farmers may provide a Megafauna Deterrent Use Management Plan (MDUMP) describing the non-harmful deterrents a farm site may use to manage challenging mammal interactions that threaten the safety of the salmon farmers and the integrity of the farm systems. The submission of an MDUMP is voluntary and will only be approved if the licence holder has demonstrated that all available exclusion devices and other preventative measures have been ineffective. This proactive approach aims to pre-authorize what can be used at a salmon farm, in order to maximize planning and safety for all.

## REPORTING

All reports related to entanglements and entrapments are made publicly available on the Government of Canada Open Data website (9). If a salmon farm is certified to the Aquaculture Stewardship Council (ASC) Salmon Standards, marine mammal and bird interaction information is publicly available on the company's website.


*Photo by Britan Kingzett*

## HOW MANY WILDLIFE INTERACTIONS ARE THERE AT SALMON FARMS?

Wildlife that interacts with salmon farms in BC typically consists of fish-eating animals. This includes the California sea lion (*Zalophus californianus*), the harbour seal (*Phoca vitulina*) and, less commonly, the Steller sea lion (*Eumatopias jubatus*). River otters (*Lutra canadiensis*) have also been known to directly interact with the farms. Birds may be attracted to the feed or the farm infrastructure as a resting space (10). The most common birds that interact with farms include crows (*Corvus* spp.) and seagulls (*Larus* spp.).

*Photo by Britan Kingzett*

*Photo by Bill Pennell*

## MEGAFAUNA INTERACTIONS

In total, there were 431 megafauna mortalities at salmon farms in British Columbia from 2011 to 2022 (Table 1). California sea lions accounted for 68% and seals accounted for 30% of the mortalities from 2011 to 2022. In 2012, BC salmon farmers implemented a sector-wide management policy for seals and sea lions that included the implementation of mandatory prevention measures and a "no-kill" policy. Innovations in infrastructure and staff training have significantly reduced mortalities at farms. From 2013 to 2022, there were, on average, 10 mortalities per year at salmon farms in BC, which is approximately one mortality per seven operating farms yearly.

There have been no reported mortalities of sharks, turtles, otters, porpoises or dolphin at BC salmon farming operations.

*Table 1. Megafauna interactions at BC salmon farms 2011 to 2022.*

*Source DFO Open Data (11).*

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **California Sea Lion** | **232** | **9** | **4*** | **6** | **25** | **5** | **0** | **2** | **0** | **2** | **2** | **6** |
| Accidental drowning | 4 | 7 | 0 | 6 | 10 | 4 | 0 | 2 | 0 | 2 | 2 | 4 |
| Permitted Euthanasia | 228 | 2 | 1 | 0 | 15 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Harbour Seal** | **70** | **18** | **3** | **9** | **17** | **1** | **2** | **1** | **0** | **3** | **4** | **0** |
| Accidental drowning | 4 | 13 | 1 | 7 | 14 | 1 | 2 | 1 | 0 | 3 | 4 | |
| Permitted Euthanasia | 66 | 5 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Northern Fur Seal** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1** | **0** |
| Accidental drowning | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **Steller Sea Lion** | **2** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1** |
| Permitted Euthanasia | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Under Investigation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **Humpback Whale** | **0** | **0** | **1*** | **0** | **0** | **3** | **0** | **1** | **0** | **0** | **1** | **0** |
| Accidental drowning | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Live release | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| **Porpoises, Dolphins, Other Whales** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **Species at Risk (Turtles, Sharks) **** | N/a | N/a | N/a | N/a | N/a | N/a | N/a | N/a | N/a | **0** | **0** | **0** |
| **Total mortalities** | **304** | **27** | **8** | **15** | **42** | **9** | **2** | **4** | **0** | **5** | **8** | **7** |

* Three California sea lions and one humpback whale were discovered deceased, cause unknown.

** *New reporting requirements to align with the Species at Risk Act.*

## SEA LIONS

There are two types of sea lions in BC: the California sea lion and the Steller sea lion.

Both have exhibited exponential population growth over the past 20 years (1, 12, 13). California sea lions, which breed in California, have stabilized, but the proportion that overwinter in BC has increased in recent years, raising concerns about impacts on local ecosystems, including competition for prey resources and local fisheries (1). The number of rookeries and year-round haul-out sites of Steller sea lions is also increasing (13).

Population increases in sea lions increase competition for resources in the sea. Sea lions eat a variety of fish and shellfish, including salmon. Sea lions are very effective predators with excellent abilities for sound detection, learning potential and memory (14). This has brought additional pressure to salmon farmers as some sea lions strive to enter pens to consume the farm-raised salmon.

The **California sea lion** population in BC **has grown to about 13,600, which is a three-fold increase since 2010 (1).**

Before 2012, salmon farmers retained qualified contractors to undertake DFO-authorized euthanasia as a management tool for sea lions that were hazardous or could not be deterred from the pens. Out of concern for wildlife, the sector collaborated and developed preventative measures to keep sea lions away from the pens and instituted a "no-kill" policy (Figure 3). In 2016, in response to the US Marine Mammal Protection Act, DFO also no longer permitted authorized euthanasia as a management tool (15).

Recognizing that populations are growing, salmon farmers have invested in infrastructure and staff training to stay one step ahead of the growing populations and keep sea lions safe. For most farms, exclusion devices effectively deter sea lions from accessing the farms. Unfortunately, there are instances where determined sea lions continue to pursue entry into farms aggressively. This can lead to accidental drowning if they are caught between the primary containment and predator nets.

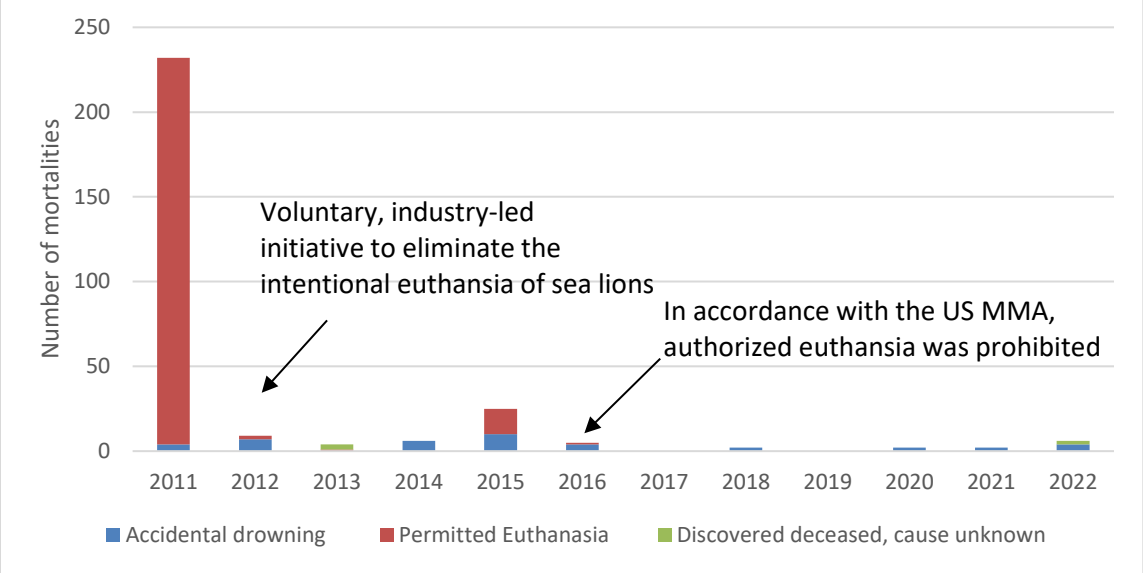


*Figure 3. California sea lion mortalities at BC salmon farms from 2011 to 2012.* Source DFO Open Data (11).

*Photo by Brian Kingzett*

Photo by Bill Pennell

## HARBOUR SEALS

Populations of harbour seals in BC have been slowly increasing since the 1960s when hunting ended. DFO now estimates that the population has fully recovered in BC, with the majority of the population residing in the Strait of Georgia (16).

BC harbour seal populations have increased from about 10,000 seals in the 1960s to over 100,000 seals in the early 2000s (DFO 2023).

Similar to sea lions, after the industry implemented a voluntary "no-kill" policy in 2012, the was a dramatic reduction in the authorized euthanasia of seals at salmon farms (Figure 4). Salmon farms have also entirely phased out the use of shark guards at the bottom of containment nets that had been a source of entanglement for seals and sea lions.

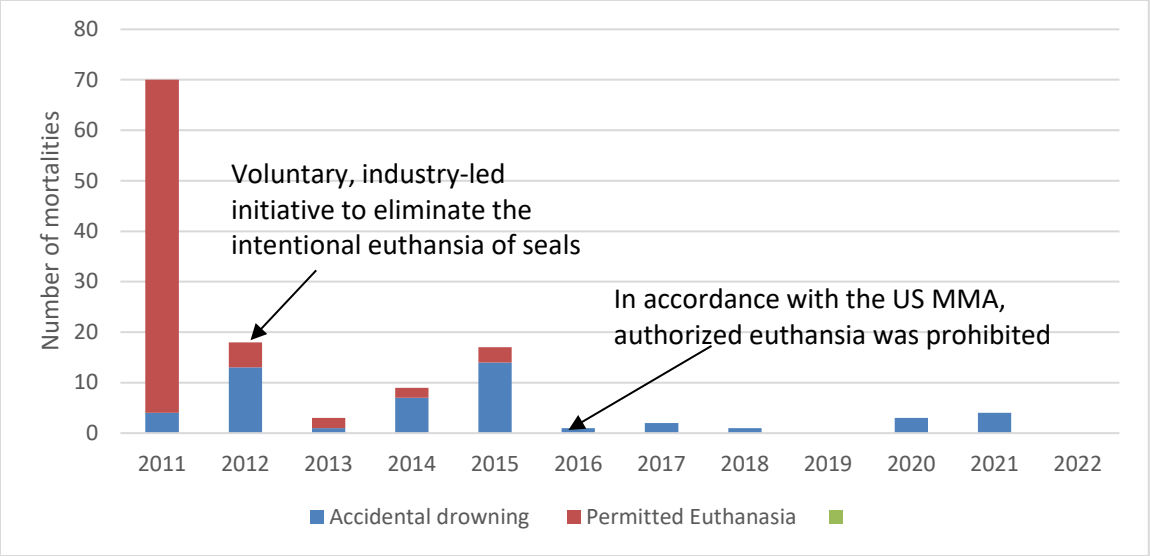


*Figure 4. Harbour seal reported mortalities from 2011 to 2012.*
*Source: DFO Open Data (11).*

## DOLPHINS, PORPOISES, ORCAS AND OTHER WHALES

From 2011 to 2022, there were no lethal interactions with orcas, dolphins or porpoises at BC salmon farms. Orca, grey, minke and humpback whales are seen in the vicinity of farms. Salmon farmers have participated in cetacean (whales, dolphins, and porpoises) sighting programs and specific research programs.

To date, there have been no mortalities of cetaceans at farms, with the exception of three humpback whales, as described below.

### *Humpback whales*

Humpback whale populations are increasing in BC. In the 1800's and early 1900's they were a targeted species for whaling and the population declined by 90% (17). In 1982, the North Pacific population of humpback whales was designated as "Threatened" by the Committee on the Status of Endangered Species in Canada (18). This was re-examined and reconfirmed in May 2003(19). In May 2011, reflecting increasing populations of humpback whales in the north Pacific Ocean, the designation was lowered to "Special Concern"(20). As of 2018, there were an estimated 12,460 humpback whales in BC waters, with an estimated annual population growth between 4 to 8% (21).

The increase in humpback whales in BC coastal waters has resulted in increasing interactions with human activities. Blunt force trauma and serious injury from ship strikes have been identified, on an international scale, as major causes of mortality for whales (22). As vessel traffic volume increases, whale strikes in high vessel traffic areas is on the rise. However, in BC the estimated probability of a ship strike is less than a 1%, even in the areas of highest predicted risk for whale-ship strikes (22).

Humpback whales may be more prone to becoming entangled in fishing gear than toothed whales because they do not use echolocation for navigation. A preliminary research study reported nearly 50% of sampled BC humpback whales had scarring that could be an indication of entanglement with commercial fishing gear (23).

Six humpback whales interacted with salmon farms in BC from 2011 to 2022. Prior to the development of the DFO database (Table 1), an additional two interactions occurred with farms: one in 2008 and another 2009. Of the eight entangled humpback whales over the thirteen year period (2008 to 2022), five were successfully released unharmed (24). Unfortunately, the other three did not survive.

These events were related to mooring lines or nets located under farms. Contributing factors to entanglement included facility design, anatomy and age: all whales entangled were young (24). The authors of the study concluded that this could be due to naivety and inexperience, as well as developing new feeding methods compared with adults. The entanglements accounted for less than six per cent of all entanglements in B.C.

Operational changes to mooring lines were made after 2018 to reduce these interactions. DFO whale experts and regulatory personnel provide guidance/instruction to farmers in the event of an entanglement.

*Photo by Brian Kingzett*

## BIRDS

Most wildlife interactions at salmon farms are with birds. Birds will perch on farm infrastructure for a reprieve from travelling at sea while other birds are in search of food. Bird nets and shade nets placed on pens deter most birds. Farm staff receive instruction on minimizing bird interactions, identifying bird species (especially any species at risk), and what to do if they encounter an entangled bird. On the rare occasion a bird finds its way through the mesh (typically a crow or gull), farmers will try to coax the bird outside the net.

Since companies started tracking bird interactions and mortalities, there has been, on average, zero to two bird mortalities on a farm in a 2-year period.

DFO does not request bird mortality data but, if a salmon farm is certified to the Aquaculture Stewardship Council (ASC) Salmon Standards, the information is publicly available on the company's website.

### SEA OTTERS AND RIVER OTTERS

River otters and sea otters are often seen near salmon farms. River otters try to slip through small openings in nets to eat fish. Electric fences and leap fences help deter river otters from getting onto farms and into sea pens. Sea otters are commonly seen floating past farms; however, they generally avoid interacting with farms.

Photo by Brian Kingzett

## HOW DO SALMON FARMERS MINIMIZE INTERACTIONS AT FARMS?

### STAFF TRAINING

All site staff are trained on how to inspect and maintain the equipment that is used to minimize wildlife interactions. Training incorporates regulatory requirements including reporting, safety considerations, boating distance buffers for marine mammals and wildlife identification guides.

### PREVENTION

Farmers focus on preventing interactions by minimizing both attractants and the ability for wildlife to access farm infrastructure. Over the past 20 years, farm infrastructure, including nets, anchoring, lighting, fencing, feed storage, fish mortality storage and disposal have been redesigned to minimize wildlife interactions.

## MINIMIZING ATTRACTANTS

### *Feed use and storage*

Salmon feed pellets contain ingredients and odors that can attract wildlife. To reduce the amount of uneaten feed that enters the environment, advanced feeding systems have been developed to optimize feed intake (see "Chapter 7 – Caring for the Environment – Feed Sustainability" and "Chapter 8 – Caring for the Environment – Protecting Biodiversity"). Feed is distributed to the farmed-raised salmon in the pens either by hand (for smaller fish) or by using a floating spreader on the surface of the water (Figure 5), or through a slightly submerged "snorkel feeder". Bird nets are attached to the top of pens to prevent birds from accessing feed as it spreads from the feeder in the center of the pen.

Feed is stored securely within the floating barges to prevent wildlife from accessing the feed (Figure 6).

Photo by Brian Kingzett

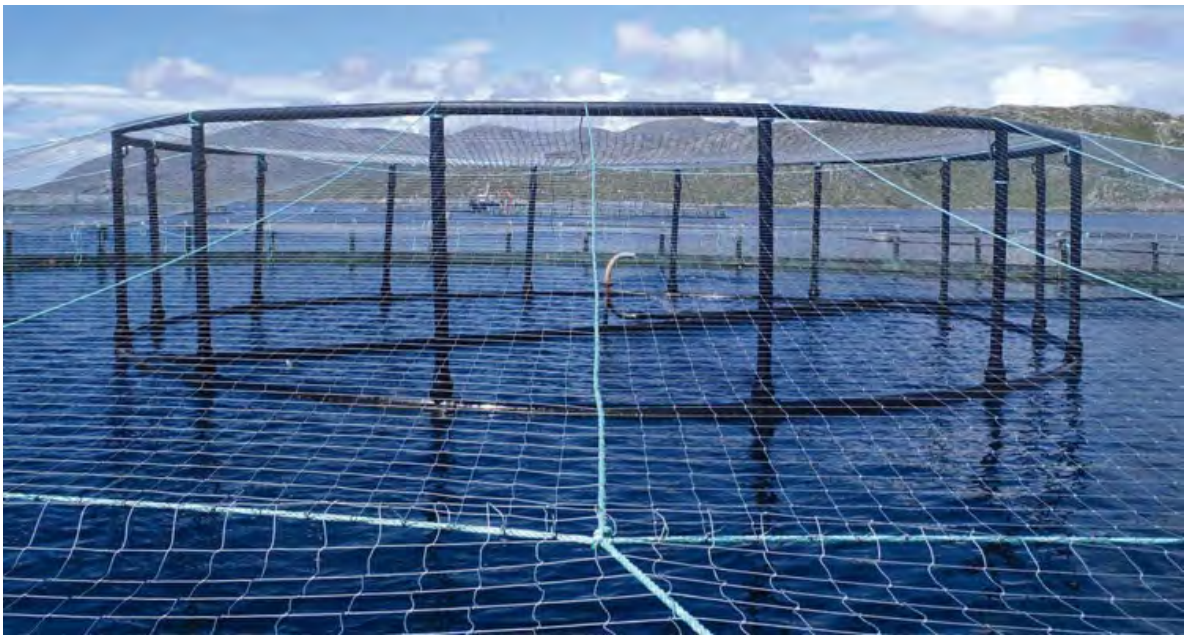

*Figure 5. A feed spreader is positioned at the center of the circular pen, equipped with protective netting to prevent bird interactions.*

*Figure 6. Feed being stored within a floating barge.*

### *Use of lights*

Atlantic salmon farms use lights during the night for a portion of the production cycle to control the salmon stock's early maturation (grilsification) during their first year at sea. The use of lights and the availability of refuge at the farms may draw wild fish to the area, and this, in turn, may attract marine mammals (25). Conversely, the structure and lights, as well as vessel traffic and other farm disturbances can also deter marine wildlife (26).

About ten years ago, salmon farmers began transitioning from high-powered incandescent or metal halide lights to high-efficiency-emitting diode (LED) lighting systems. This has resulted in about a 7-fold reduction of light penetration beyond the cages, which appears to have significantly reduced the potential of wild fish interaction (see "Chapter 6 Caring for the Environment - Minimizing Incidental Catch") (Figure 7).

*Figure 7. View of LED lights at night within a salmon pen. Note the minimal light penetration beyond the edge of the cage.*

### *Energy use and sound*

Energy is required to operate the feeding and environmental mitigation systems at farms, as well as the accommodations for staff. Given that hydro power is not currently accessible at any of the salmon farms operating on the BC coast, farmers rely on diesel powered generators and air compressors that produce noise. This noise can attract curious seals and sea lions (14). There are several trials underway to incorporate the use of alternate technologies to reduce dependence on diesel fuelled systems on the farms (see "Chapter 1 – Caring for Coastal British Columbia"). These alternatives include the use of hybrid battery systems that can

reduce generator run times on the feed and accommodation barges and the installation of efficient air compressors(27, 28).

### *Carcass handling*

Despite the sometimes challenging conditions of the marine environment, on average Atlantic salmon growing in ocean pens have an 80% survival rate, and Pacific salmon have an 87% survival rate (see "Chapter 11 – Caring for Fish Health"). Carcasses from farm-raised salmon that have not survived are routinely collected by in pen retrieval systems and are transferred into containers. These containers are generally stored on floats away from the cage arrays. The containers are secured to prevent wildlife access until they are transported to licensed facilities on land for disposal (Figure 8).

An ensilage system is an alternate way to store fish carcasses on the farms (Figure 9). An ensilage system uses a low concentration of formic acid to break down the fish carcasses. An inert, odorless, liquid results. The liquid is stored within a double walled tank, generally on floats alongside the accommodation barges in order to access the power required to operate the ensilage system.

*Figure 8. Sealed mortality totes shown on a smaller utility float.*

*Figure 9. Ensilage system.*
*Fish carcasses are put through a grinder before entering the steel mixing container. An automated system adds formic acid into container and thoroughly mixes the contents into a liquid slurry. The liquid is considered inert and is stored in a double walled container until it is transported to a licenced disposal facility on land.*

Photo by Brian Kingzett

## EXCLUDING ACCESS

Excluding wildlife from accessing the farm infrastructure is an effective way to minimize wildlife interactions. This includes the use of physical barriers, like nets and perimeter fences, and active deterrents like electric fences (Figure 10). Note that the type of exclusion devices used at each farm is site-specific and determined by the type of wildlife present in the vicinity. For example, sea lions do not interact with all farms.

### JUMP NETS AND PERIMETER FENCES

As part of the DFO Marine Finfish Aquaculture license for each site, all sea pens must have jump nets that rim the outside of the cage and extend at least one meter above the surface of the water to contain any salmon that may jump out of the water. These jump nets also help prevent small marine mammals such as seals and otters from accessing the fish; however, they are not effective to deter sea lions.

In areas with high sea lion populations, many farms are using taller perimeter fences to prevent access into the pens (Figure 11). As seals and sea lions have adapted over time, so have these nets; some are now taller than seven feet.

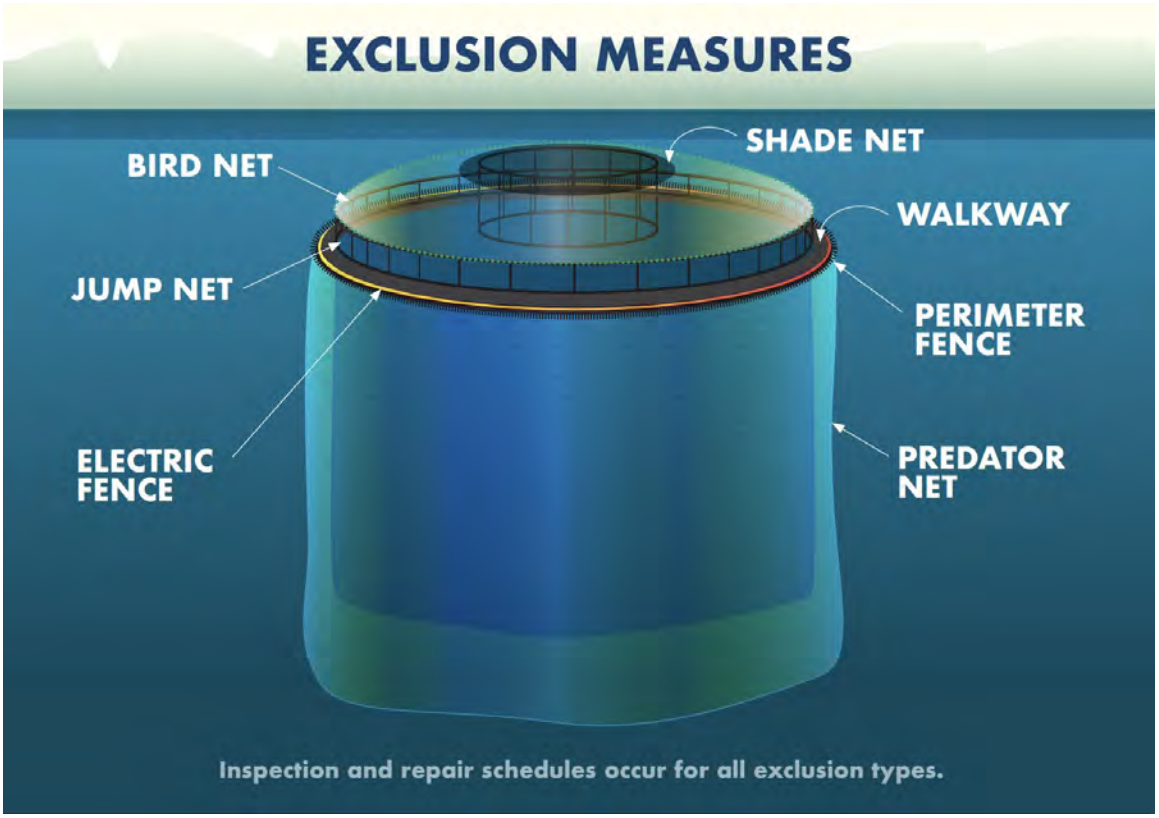


*Figure 10. Illustration of the potential exclusion devices to deter wildlife that may be used in any combination at farms, depending upon the wildlife in the vicinity.*

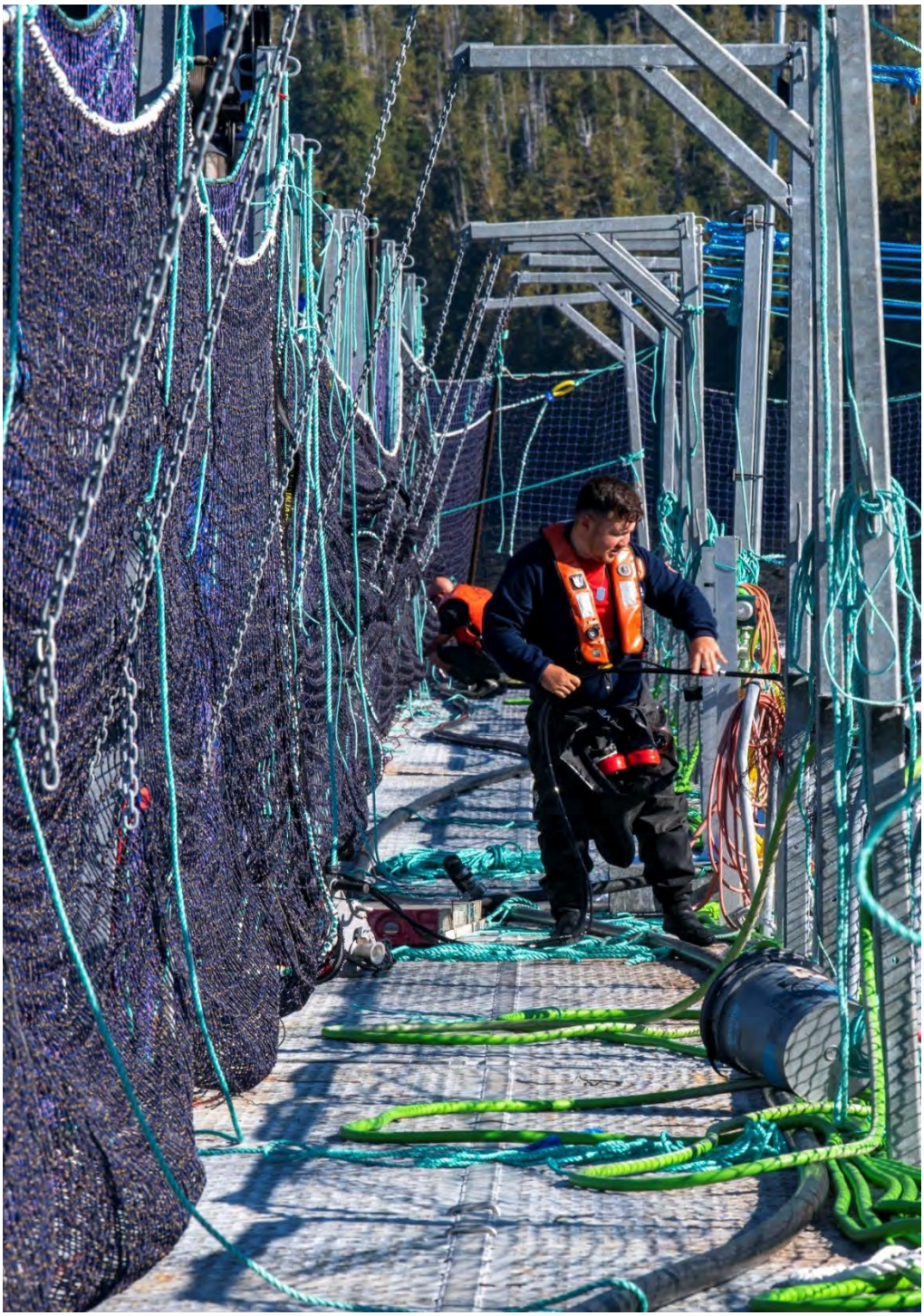

*Figure 11. View of perimeter fence on a farm in an area with a dense sea lion population.*

## ELECTRIC FENCES

Electric fences are exclusion devices that require electricity and are considered to be an "active deterrent". Electric fences are used along the perimeter of the farm structures and can be tied into perimeter fences (Figure 12). Electric fences can also be used on floats that mammals may rest on. This exclusion device is commonly found on farms and can be effective in preventing access to the containment nets.

Improvements to electrical fence systems include:

- Redesigning and increasing the size of the power boxes, suitable for the marine environment, to ensure the charge in the lines is powered consistently at a charge that deters wildlife.
- Double running lines or using larger wires with multiple disconnection points to isolate parts of the system where the fence must be shut off for operational activities, without compromising the entire line.

*Figure 12. Electric line along outside of perimeter fencing.*

## BIRD NETS AND SHADES

All farms use bird nets to prevent birds from entering the pens in search of food. Bird nets are secured to the top of the primary containment net and are held up by poles or large plastic structures in the middle of the pen (Figure 13). These structures prevent the net from draping down into the water. Bird nets have been effective for excluding birds.

Bird shades may also be used in combination with bird nets over top of the feed spreaders. They are similar to a tarp, but allow light to penetrate into the pen. Shades prevent birds from accessing feed directly above the spreaders.

*Figure 13. Jump net being lowered to allow diver to exist the primary containment net of the fish pen.*
*The bird net is visible above the diver. The perimeter fence is visible in the background behind the farm staff.*

## PREDATOR NETS

Salmon farmers commonly install underwater secondary predator nets around the outside of the primary containment nets that keep the salmon in the pens. Predator nets add an additional layer of underwater protection to exclude marine mammals from accessing the salmon in the pens. There have been continual improvements in the way these nets are secured and weighted to keep them taut to make it very difficult for sea lions to chew the netting material. Since 2008, there has been a shift to high density polyethylene (HDPE) netting which is more difficult for sea lions to tear. Some farms have added metal threading to make nets even more difficult to chew or tear.

### *Net and infrastructure inspections*

Sea cages and exclusion devices are inspected daily to ensure integrity. This includes:

- Electric fences are operational, and charge is being consistently delivered throughout the entire line as applicable to the schedule of use developed for each site,
- Above water perimeter fences, perimeter nets and bird nets are

taut and do not have any gaps or holes,

- Any damage to the system that would indicate that a mammal was attempting to access the system is reported to a supervisor and documented,
- Underwater net pen cages are visually inspected every 30 – 60 days subject to wildlife activity, and
- Underwater predator nets are inspected at minimum every 60 days unless there has been an increase in predator related fish mortality or a facility breach by a marine mammal.

Note that the type of exclusion devices used at each farm is site-specific and determined by the type of wildlife present in the vicinity. For example, sea lions do not interact with all farms.

*Photo by Brian Kingzett*

## USE OF AUTHORIZED DETERRENTS

For most farms, exclusion devices are effective in preventing wildlife from interacting with farms. Unfortunately, there are instances where determined sea lions continue to aggressively pursue entry into sea pens. This can create a dangerous situation for both the sea lions and farm staff, as well as risk damage to infrastructure. In situations where all feasible exclusion devices have failed, DFO may authorize the use of deterrents. Authorization is given through the approval of the Megafauna Deterrent Use Management Plan.

*Photo by Brian Kingzett*

## BEHAVIOURAL DETERRENTS

Farmers will try to encourage smaller marine mammals, like seals, to leave by banging pipes, shouting, or waving arms. If this is not effective or for larger marine mammals such as sea lions, startle devices like bear bangers may be approved for use. These devices are intended to change the behavior of the marine mammal and do not cause any physical harm.

## AGGRESSIVE DETERRENTS

Non-lethal aggressive deterrents may be used at a farm to deter California sea lions if authorized by DFO through the Megafauna Deterrent Use Management Plan (MDUMP) process. Deterrents can only be used from the farm infrastructure by qualified individuals approved in the MDUMP.

Aggressive deterrents that may be approved include:

- chemical irritants used for animal control (e.g., nontoxic pepper spray),
- projectiles (e.g., non-toxic, water-soluble paint ball or rubber pellets), and
- electrified implements (e.g., cattle prods).

If the aggressive deterrent includes a firearm to shoot projectiles (rubber bullets) the qualified individual must be licenced, use factory projectiles and be trained on were to target the area of least impact on the sea lion. Prior to using an aggressive deterrent, the salmon farmers must:

- provide a synopsis of the situation that warrants the use of the aggressive deterrent,
- proposed timing of deterrent use, and
- identify the qualified individual and their contact information.

Within seven days after the last use of the aggressive deterrent, the licence holder must provide DFO a detailed account of the deterrent usage.

### ACOUSTICAL DETERRENTS

Underwater acoustical deterrents are not permitted and are not used at any salmon farm in BC. DFO defines acoustical deterrents as "a device that is used underwater and is intended to generate an aversive response in marine mammals and could cause harm, which includes but is not limited to: explosives, incendiary devices, and electronic sound recordings" (8).

Photo by Brian Kingzett

## RESULTS ARE ENCOURAGING

We understand that farming within the wilderness of BC is both a privilege and a responsibility. Over the years, we have made significant investments to significantly reduce wildlife interactions at salmon farms. Our approach has been to minimize attractants at farms, prevent wildlife from accessing fish, and only, when necessary (and authorized by DFO), use deterrents to encourage wildlife to leave. The results are very encouraging – very few animals are harmed at farms.

We know many marine mammal populations are increasing in BC and there will be continued pressure to breach farm infrastructure. For this reason, we continue to support research and new technology. For example, bubble curtains used for sea lice (see "Chapter 10 – Caring for the Wild Salmon- Sea Lice Management") may be effective in reducing interactions as the fish will not be visible to the mammals from underwater. New cage systems that sit higher above the water surface to prevent access are being trialed in BC. We are confident that continued innovation will keep both wildlife and people safe at salmon farms.

# REFERENCES

1. Fisheries and Oceans Canada. California Sea Lion abundance estimation in Canada 2020-21. DFO Can Sci Advis Sec Sci Advis Rep2023.https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/40951753.pdf
2. Environment and Climate Change Canada. Convention on International Trade in Endangered Species Ottawa: Government of Canada; [Available from: https://www.canada.ca/en/environment-climate-change/corporate/international-affairs/partnerships-organizations/convention-trade-endangered-species-summary.html.
3. Species at Risk Act, (S.C. 2002, c. 29) (2002).
4. Fisheries Act, (R.S.C., 1985, c. F-14) (1985).
5. Migratory Birds Convention Act, 1994, S.C. 1994, c. 22 (1994).
6. The Marine Mammal Protection Act of 1972 as amended through 2018, 16 U.S.C. 1361 (1972).
7. Wildlife Act, [RSBC 1996] CHAPTER 488 (1996).
8. Fisheries and Oceans Canada. Marine finfish B.C. aquaculture licence and conditions of licence. In: Canada FaO, editor. Nanaimo: Government of Canada; 2023.https://www.pac.dfo-mpo.gc.ca/aquaculture/licence-permis/docs/licence-cond-permis-mar/index-eng.html
9. Open Government. 2024. Escapes of cultured finfish from BC aquaculture sites Ottawa: Government of Canada; [Available from: https://open.canada.ca/data/en/dataset/691dd994-4911-433d-b3b6-00349ba9f24e.
10. Forrest B, Keeley N, Gillespie P, Hopkins G, Knight B, Govier D. 2007. Review of the ecological effects of marine finfish

aquaculture: final report. Prepared for Ministry of Fisheries. Nelson, New Zealand: Cawthron Institute. Contract No.: 1285.https://www.mpi.govt.nz/dmsdocument/15865-Review-of-the-Ecological-Effects-of-Marine-Finfish-Aquaculture-Final-Report

11. Open Government. 2023. Marine mammal interactions at British Columbia marine finfish aquaculture sites Ottawa: Government of Canada; [Available from: https://open.canada.ca/data/en/dataset/a7b3fdfb-5917-4ca6-b29c-093e3f65d6ba.
12. Fisheries and Oceans Canada. Status of Steller Sea Lions (Eumetopias jubatus) in Canada. DFO Can Sci Advis Sec Sci Advis Rep2020.https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/40951753.pdf
13. Fisheries and Oceans Canada. Trends in abundance and distribution of Stellar Sea Lions (Eumetopias jubatus) in Canada. DFO Can Sci Advis Sec Sci Advis Rep2021. p. 8.https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/41003925.pdf
14. Schusterman RJ. 1981. Behavioral Capabilities of Seals and Sea Lions: A Review of Their Hearing, Visual, Learning and Diving Skills. The Psychological Record.31(2):125-143.10.1007/BF03394729
15. National Oceanic and Atmospheric Administration. Fish and Fish Product Import Provisions of the Marine Mammal Protection Act. In: National Marine Fisheries Service (NMFS)

NOaAAN, Commerce, editor.: Federal Register, US Government; 2016. p. 31.https://www.federalregister.gov/documents/2016/08/15/2016-19158/fish-and-fish-product-import-provisions-of-the-marine-mammal-protection-act

16. Fisheries and Oceans Canada. Stock Assessment of Pacific Harbour Seals (Phoca vitulina richardsi) in Canada 2019. In: Branch EaO, editor. Ottawa, Ont: Canadian Science Advisory Secretaria; 2022. p. 10.https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/41073654.pdf

17. Canada FaO. 2020. Special Projects - Structure of Populations Levels of Abundance, and Status of Humpbacks Ottawa: Government of Canada; [Available from: https://www.dfo-mpo.gc.ca/science/mammals-mammiferes/structure/index-eng.html.

18. COSEWIC. Canadian wildlife species at risk. Ottawa: Committee on the Status of Endangered Wildlife in Canad; 2022. p. 136.https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/species/CSAR%20EN%202022.pdf

19. Baird R. 2003. Update COSEWIC status report on the humpback whale Megaptera novaeangliae in Canada. COSEWIC Assessment and Update Status Report on the Humpback Whale Megaptera Novaeangliae in Canada, https://www.researchgate.net/profile/Robin-Baird/publication/288950602_Update_COSEWIC_status_report_on_the_humpback_whale_Megaptera_novaeangliae_in_Canada/links/631154c4acd814437ff7878d/Update-COSEWIC-status-report-on-the-humpback-whale-Megaptera-novaeangliae-in-Canada.pdf?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIn19

20. COSEWIC. 2003. COSEWIC assessment and status report on the Humpback Whale Megaptera novaeangliae , North Pacific population in Canada. Ottawa: Committee on the Status of Endangered Wildlife in Canada. Available from: https://publications.gc.ca/collections/collection_2012/ec/CW69-14-233-2011-eng.pdf.

21. COSEWIC. 2022. COSEWIC assessment and status report on the Humpback Whale Megaptera novaeangliae kuzira, North Pacific population in Canada. Ottawa: Committee on the Status of Endangered Wildlife in Canada. Available from: https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports/humpback-whale-2022.html.

22. Canadian Science Advisory Secretariat. 2017. Assessing the risk of lethal ship strikes to humpback (Megaptera novaeangliae) and fin (Balaenoptera physalus) whales off the west coast of Vancouver Island, Canada. Ottawa: Fisheries and Oceans Canada. 10 p.https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/40619709.pdf

23. Fisheries and Oceans Canada. 2020. Keeping whales free from fishing gear Ottawa: Government of Canada; [Available from: https://www.pac.dfo-mpo.gc.ca/fm-gp/mammals-mammiferes/whales-baleines/docs/entanglements-empetrements-pub-eng.html.

24. Storlund RL, Cottrell PE, Cottrell B, Roth M, Lehnhart T, Snyman H, et al. 2024. Aquaculture related humpback whale entanglements in coastal waters of British Columbia from 2008–2021. PLOS ONE.19(3):e0297768.10.1371/journal.pone.0297768

25. Callier MD, Byron CJ, Bengtson DA, Cranford PJ, Cross SF, Focken U, et al. 2018. Attraction and repulsion of mobile wild organisms to finfish and shellfish aquaculture: a review. Reviews in Aquaculture.10(4):924-949.https://doi.org/10.1111/raq.12208

26. Quinones R, Fuentes M, Montes R, Soto D, León-Muñoz J. 2019. Environmental issues in Chilean salmon farming: a review. Reviews in Aquaculture.11.10.1111/raq.12337

27. Fjord Maritime. 2023. Cermaq Canada with first hybrid in BC [Available from: https://fjordmaritime.co.uk/cermaq-canada-with-first-hybrid-in-bc/.

28. Poseidon Ocean Systems. 2024. Flowpressor Campbell River: Poseidon Ocean Systems,; [Available from: https://poseidonos.com/life-support/#flowpressor.

*Photo by Brian Kingzett*

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CHAPTER 10

# CARING FOR WILD SALMON

## SEA LICE MANAGEMENT






This document describes sea lice management at salmon farms and discusses important results from juvenile wild salmon feedback loops

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# CHAPTER HIGHLIGHTS – CARING FOR WILD SALMON – SEA LICE MANAGEMENT

## SEA LICE NATURALLY EVOLVED ALONGSIDE PACIFIC SALMON

Sea lice occur on all species of wild Pacific salmon and are called *ḵa̱ta̱'yat'si* by coastal Kwak'wala peoples, and *daaga* by Hlg̱aagilda X̱aayda Kil (Haida) peoples.

Two main species of sea lice are in BC: the "salmon louse" (*Lepeophtheirus salmonis oncorhynchi*), which mainly infests salmon; and the "herring louse" (*Caligus clemensi*), which infests at least 12 fish species besides Pacific herring. The salmon louse is the larger and more harmful species and the subject of regulatory management programs.

*Susceptibility to sea lice and the ability to reject sea lice vary considerably among species of salmon.*

Atlantic salmon appear to be the most susceptible salmon species to sea lice in BC. Chum and sockeye salmon are the next most susceptible to sea lice followed by Chinook, pink, and coho salmon. Coho salmon skin mucus can engulf and disintegrate sea lice.

In controlled laboratory experiments, sockeye salmon at 40 grams can host 19 attached "salmon lice" with no significant harm. By about 90 grams, sockeye salmon appear to become more vulnerable to the "salmon louse", similar to Atlantic salmon.

Pink salmon develop the ability to shed sea lice within a few weeks after entering seawater. Based on laboratory trials, it takes an average of seven or more "salmon lice" to kill a 0.7-gram pink salmon. All researchers have reported that rapid shedding of sea lice makes it challenging to study sea lice effects on pink salmon in controlled laboratory and field settings.

Newly emergent pink salmon can swim well above the typical cruising speed of one body length per second while infested with three pre-adult "salmon lice." It takes two or more pre-adult/adult louse to compromise maximum swimming speed in small pink salmon 0.5 – 0.7 grams in size.

## SEA LICE ON FARMS ARE MANAGED PRIMARILY AS A MEASURE TO PROTECT JUVENILE WILD PACIFIC SALMON

Farm-raised salmon are sea lice-free when they are stocked in ocean pens. Although Atlantic salmon are the salmon species most sensitive to sea lice, observations of significant harm to farm stock caused by sea lice have been extremely rare. Farm-raised Pacific salmon are robust against sea lice infestation and almost never require treatment. For example, there were no sea lice treatments for farm-raised Chinook salmon between 2016 and 2021.

Farmers have treated for sea lice infestations on farm-raised Atlantic salmon in British Columbia since at least 1991. In 2003, the BC government instituted a precautionary management threshold for sea lice that was twice as stringent as Norway at that time. The regulatory sea lice management threshold has been in place for 20 years.

Farmers have progressed to sophisticated and effective measures to minimize sea lice transmission from farm-raised salmon to wild salmon. These measures focus on integrated pest management using a suite of prevention and treatment tools as well as an industry agreement to cooperate, innovate, and improve.

Salmon farmers are successfully managing sea lice populations at Atlantic salmon farms during the juvenile wild salmon out-migration window, with very few exceptions. Sea lice levels at most farms have been below the regulated management threshold; all farms that exceeded the threshold initiated management measures to reduce sea lice.

## PUBLICLY AVAILABLE DATA FROM FIRST NATIONS, NGOS, DFO, RESEARCHERS AND INDEPENDENT THIRD-PARTY PROFESSIONAL BIOLOGISTS DOCUMENTS THAT MOST BC WILD JUVENILE SALMON HAVE NO OR FEW SEA LICE

Sea lice levels on juvenile wild salmon are monitored in every salmon farming region in BC as a condition of federal licensing for Atlantic salmon farms. Sea lice are also monitored by other organizations. We compiled a dataset from this monitoring that includes 320,177 juvenile wild salmon that were examined for sea lice (2001 – 2022). Pink and chum salmon comprised 96% of the fish examined; coho (2%), Chinook (1%) and sockeye salmon (<1%).

- Over a two-decade period, 86.0% of wild salmon had zero or one sea louse.
- Sockeye salmon were the most infested species; however, the majority of sea lice were "herring louse"; only 1% of sockeye salmon had pre-adult/adult "salmon lice".
- Among pink salmon larger than 0.7 grams, 99% had no adult "salmon lice".

Pink salmon grow rapidly, doubling their body size in 2 – 4 weeks. As they grow, so does their ability to shed sea lice. Most of the "salmon lice" that successfully infect a pink salmon are shed before the sea lice reach pre-adult and reproductive stages.

Comparing the dataset to published laboratory-derived thresholds of harm for juvenile pink salmon revealed:

- sea lice might have impeded the natural cruising speed of 0.17% of the wild salmon
- sea lice might have impeded the maximum swimming speed of 5.1% of the wild salmon

It is not known what proportion of sea lice originated from farms versus natural hosts. Also, it is not known if pink salmon that were harmed by sea lice would have otherwise survived to adulthood.

| Salmon species | Number of fish sampled | % juvenile wild salmon with sea lice (any species or life stage) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 lice | 1 louse | 2 lice | 3 lice | 4 lice | 5 lice | >5 lice |
| Chinook | 4,353 | 89.8 | 4.5 | 2.1 | 0.9 | 0.9 | 0.5 | 1.4 |
| Chum | 168,832 | 72.4 | 12.4 | 5.7 | 2.9 | 1.8 | 1.1 | 4.0 |
| Coho | 6,112 | 71.8 | 7.5 | 6.6 | 2.5 | 3.0 | 1.7 | 7.0 |
| Pink | 138,970 | 73.0 | 15.1 | 5.9 | 2.4 | 1.3 | 0.7 | 1.6 |
| Sockeye | 1,910 | 53.7 | 13.9 | 8.0 | 4.8 | 3.8 | 2.9 | 12.9 |
| **Total** | **320,177** | **72.6** | **13.4** | **5.8** | **2.7** | **1.6** | **0.9** | **3.0** |

## SEA LICE DO NOT IMPACT CHUM SALMON POPULATIONS

Chum salmon are common in all monitoring regions. They have consistent yearly out-migration patterns in all regions (as opposed to the strong odd-year pink spawning cycle), and the species is more vulnerable to sea lice than Chinook, pink and coho salmon.

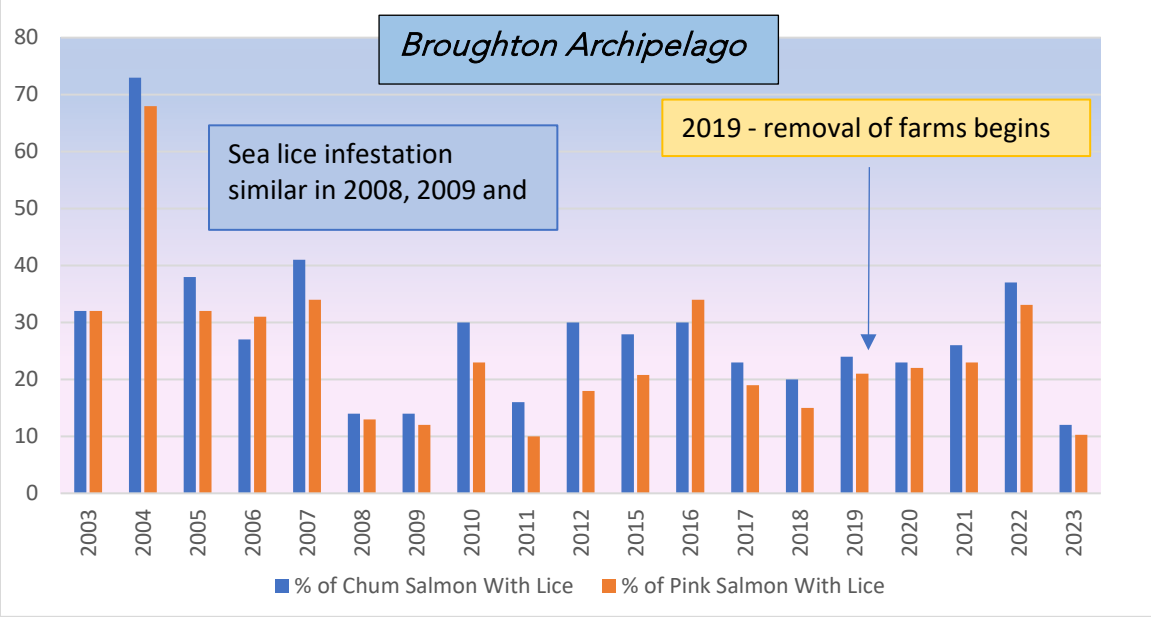
Most juvenile chum salmon do not have sea lice (any species or life stage). The highest prevalence of chum salmon with no sea lice on is in Muchalat Inlet (94.5%); the lowest is in the Broughton Archipelago (63.5%).

Researchers focusing on the Broughton Archipelago conclude that despite higher infestation rates in chum salmon compared to pink salmon, there is no evidence of reduced productivity on chum salmon populations with either the expansion of salmon farming in the 1990s or sea louse infestations on farm-raised salmon.

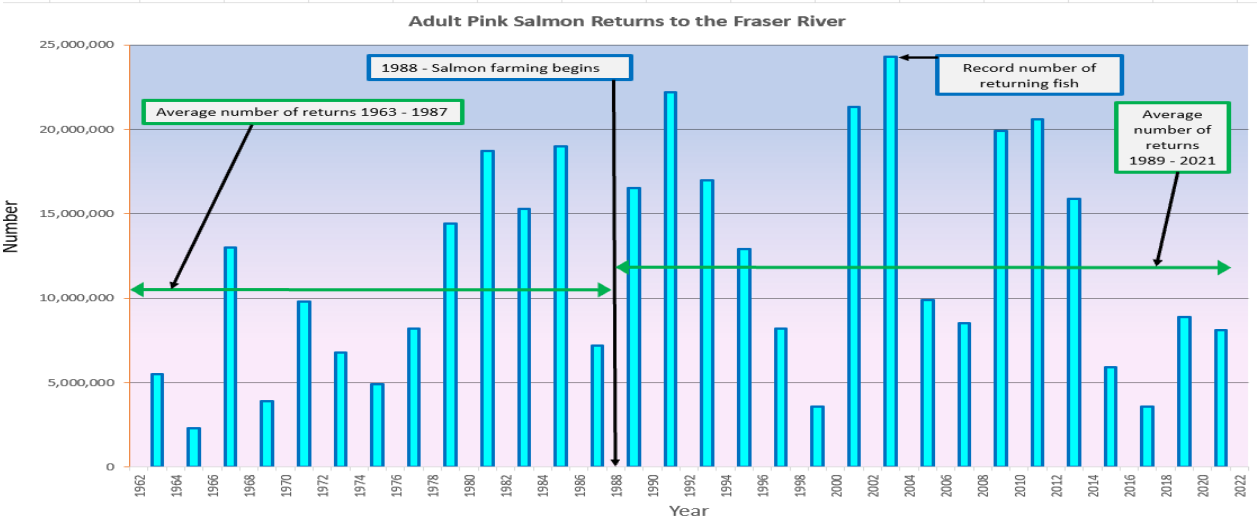
## ICONIC SALMON POPULATIONS DID NOT DECLINE DURING THE SALMON FARMING YEARS

Researchers from the Broughton Archipelago Monitoring Plan (BAMP), a collaboration between DFO, environmental groups, academic researchers and salmon farmers report that sea lice treatments at salmon farms prior to the out-migration of wild juvenile salmon successfully reduce infestations on juvenile pink salmon in the Broughton Archipelago.

*Sea lice infestations of pink and chum salmon in the Broughton Archipelago and Discovery Islands appear to be unchanged with the removal of salmon farms.*



The Fraser River supports the largest pink salmon population in the northeast Pacific basin south of Alaska. Large pink salmon returns have occurred more often during salmon farming years in the Broughton Archipelago and Discovery Islands than in years without salmon farming. Similar patterns also occurred with sockeye salmon in the Fraser River.




In conclusion, wild salmon returns were highly variable both before and after the introduction of salmon farms. Removal of salmon farms in one area had no immediate impact on salmon returns, suggesting an independence. Wild salmon returns will continue to fluctuate with or without salmon farms. Farm management measures are effective at controlling sea lice.

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