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NBBC DISCUSSION PAPER

OCEAN RANCHING: AN UNREALIZED OPPORTUNITY FOR BRITISH COLUMBIA'S COASTAL COMMUNITY DEVELOPMENT?

Ocean Ranching: Environmental Frequently Asked Questions (FAQ's)

Prepared for:

The Native Brotherhood of British Columbia

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Established in 1931 the Native Brotherhood of British Columbia (NBBC) is recognized as Canada's oldest active Native organization, and a senior BC commercial fishing organization. Over the years, the Brotherhood has been a very powerful voice on fisheries issues, and on many other concerns affecting the well being of BC's native coastal communities. The management and development of coastal renewable resources was and continues to be an integral component of this equation. The NBBC has a history spanning a period of seventy years. It was formed by a group of coastal villages solely for the betterment of Native people. As the organization grew so did its achievements. A better education system, the right to vote for Native people, improved medical care, better jobs and better living conditions at the canneries. Moving into the 21st Century, the NBBC has been directed by Coastal First Nations to go back to its broad based 'roots'. With this in mind, and as a current high priority initiative, the NBBC has received a strong mandate from many coastal First Nations to facilitate the implementation of a coastal zone management and development strategy that will include but not be restricted to fisheries and all marine resources, tourism, eco-tourism, forestry and other resources with economic potential and opportunities.

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1 Background – The NBBC Ocean Ranching Mandate

Over 50 First Nations and organizations gathered for the 71st Native Brotherhood of British Columbia (NBBC) Convention held on November 24th through 26th, 2002 in Vancouver. Overwhelmingly, they mandated the NBBC to facilitate the review and assessment of ocean ranching as a potential economic generator for coastal community development, and as a promising alternative to fish farms in coastal British Columbia waters. Included in this mandate was direction to the NBBC Executive to facilitate a coastal workshop on the issue, and to develop a strategy and follow-up action plan.

Given the mandate from the Convention, and informal conversations with senior First Nation leaders and other potential partners, there is every initial indication that the NBBC could and should play a strategic facilitation role in pursuing ocean ranching as a viable alternative in the British Columbia coastal zone.

This mandate was based in part upon an NBBC overview assessment of the results to date of the Alaskan ocean ranching model, and its potential applicability to British Columbia. The Alaska initiative has resulted in millions more fish for the troll, gillnet, seine and recreational fishing sectors. The program now contributes one-third of the total salmon harvest, and about two-thirds of those ocean-ranched salmon are designated as common property. The initiative is specifically tailored to provide direct economic and social benefits to the Alaskan coastal communities and peoples, and is managed through non-profit societies that have broadly representative Boards of Directors. The non-profit initiative is private sector/business based, and is intended to be financially self-sustaining. Perhaps most important, the Alaska ocean ranching initiative is solidly grounded upon a mutually beneficial partnership developed between the State and all the vested interests.

The NBBC Executive is convinced that ocean ranching is an opportunity that should not be ignored. They are also convinced that it is time to move on this opportunity; to do the homework needed in order to determine if it would be worthwhile for BC to undertake ocean ranching. Our initial review of the Alaskan ocean ranching model has led the NBBC to conclude that ocean ranching has the potential to make a significant contribution to the long term viability of our coastal communities. It is important to understand, however, that ocean ranching cannot be considered as *'THE ONLY'* solution to the BC fishery woes, but that it could become a very important part of the solution.

1.1 Two Unanswered Strategic Questions

With respect to ocean ranching, the NBBC had two initial strategic questions. Why has there never been a comprehensive economic and social benefit/cost assessment of the potential of ocean ranching for all British Columbians? Second, why have ocean ranching and salmon farming not been rigorously

compared in terms of their respective impacts on wild fish, clean waters, a viable commercial fishery and healthy coastal communities, all of which are key priorities of the NBBC?

It is particularly disturbing that these questions have not yet been addressed when one realizes that Dr. Peter Pearse, in his 1982 Commission on Pacific Fisheries Policy, stated that: *"the proposals for ocean ranching are most attractive: particularly, the opportunities to harness private initiative and ingenuity in producing fish, linking those who would incur the costs directly with those who would benefit. Policy should encourage cautious developments in ocean ranching along these lines and enable opportunities in this new field to be pursued'.*

1.2 NBBC Ocean Ranching 'First Steps'

With our mandate and these questions in mind the NBBC has taken four small but important 'first steps' to begin to put ocean ranching into a British Columbia context: initiation of dialogue with potential interested/concerned partners; the development of an ocean ranching discussion paper; facilitation of an ocean ranching 'mini Conference'; and the drafting of this draft 'Ocean Ranching Frequently Asked Questions (FAQ's).

Partnership Dialogue

To help gain a preliminary understanding of the possible benefits, costs, issues and concerns regarding ocean ranching in a British Columbia context, the NBBC had considerable informal dialogue with potential partners. These included: the BC Aboriginal Fisheries Commission (BCAFC), the Sport Fishing Institute of BC (SFI), the Coastal Community Network (CCN), the United Fishermen and Allied Workers Union (UFAWU), the University of British Columbia Faculty of Law (UBC Law), and the Forestry Continuing Studies Network (FCNS). Dialogue was also held with the Fisheries and Oceans Canada (DFO), Indian and Northern Affairs Canada (INAC), Western Economic Diversification Canada (WD), Human Resources Development Canada (HRDC) and the Ministries of Sustainable Resource Management (MSRM) and Agriculture, Food and Fisheries (MAFF).

NBBC Ocean Ranching Discussion Paper

Based upon this dialogue, and to help set the context for the Conference, the NBBC utilized their draft Discussion Paper 'Ocean Ranching: An Unrealized Opportunity for British Columbia's Coastal Community Development?' This NBBC Paper initiated an exploration of the ocean ranching by reviewing the Alaska experience, identified the key issues, and then discussed the possible applicability the 'Alaskan model' to the British Columbia coastal zone.

Some of the key specific issues of possible concern to British Columbians were briefly discussed. These included, for example: Common Property versus Private Ownership of Salmon Resources; Ocean Ranching and First Nations; Impact of Ocean Ranching on Wild Fish Genetics; Fisheries Management Costs; Interception of BC Ocean Ranched Fish; International Cooperation and Leverage; Marketing; Benefit Stream; Ocean Carrying Capacity, Environmental Organizations, and SEP and Hatcheries.

NBBC Facilitated Ocean Ranching Conference

Included in the 2002 Convention mandate was direction to the NBBC Executive to facilitate a coastal workshop on the issue, and to develop a strategy and follow-up action plan. Given this mandate, the NBBC facilitated an Ocean Ranching 'min-conference' on February 16th and 17th, 2003 at the Dorchester Hotel, Nanaimo, B.C. Funded by Western Diversification, the Conference was directly linked to a major Phase I Partnership Project: 'To Negotiate Natural Resource Based Partnerships Between the Native Brotherhood of British Columbia and Government, the Private Sector and Non-Government Organizations'.

The Conference was well attended. Pete Esquiro, General Manager of the Northern Southeast Regional Aquaculture Association (NSRAA), in Alaska was in attendance to provide information specific to their ocean ranching program

The basic purpose of the Conference was:

1. To initially determine if a broad based partnership or coalition can be established that is willing to consider ocean ranching as a potential economic opportunity for British Columbia coastal communities; and

2. To define the elements of an action plan that will systematically advance the examination of ocean ranching as a promising strategy capable of contributing to the economic and social development of British Columbia coastal communities

At the Conference the NBBC posed the question as to whether in fact ocean ranching represented an unrealized opportunity for the development of BC coastal communities. From the perspective of the Conference participants the answer was a clear affirmative. There was a consensus that the next phase should be undertaken with the aim of examining the application of ocean ranching as a strategic tool for B. C. coastal community development.

1.3 Vision and Principles

There was strong agreement by Conference participants that a common vision and associated set of principles would be required to establish a viable ocean ranching partnership. With this in mind the following draft ocean ranching vision and principles were developed for review and comment, and they help set the context for a basic requirement to identify and deal with a wide range of Frequently Asked Questions (FAQ's) regarding ocean ranching.

Vision

'The revitalization, maintenance and the long term sustainability and diversity of west coast salmon stocks is essential to the socio-economic and environmental well being of British Columbia coastal communities.'

Principles

A 'made-in-B.C.' ocean ranching strategy:

1. Should be a key component of an integrated approach to B.C. salmon management and enhancement leading to sustainability;

2. Needs to be a partnership initiative between First Nations, government, industry, labour, fishers and the environmental movement - *for the benefit of the resource;*

3. Is a long term investment spanning at least one or two generations of salmon stocks, and needs to be viewed as such;

4. Must be managed to reduce risks using the best science and management techniques available - *but this does not mean NO risk;*

5. Must have as its basic mission the task of enhancing the BC salmon stocks and their utilization as a common property resource;

6. Must create a financially self-sustaining management regime through a range of investments by the beneficiaries of the strategy;

7. Must be 'embedded' within a larger federal and provincial socio-economic policy framework;

8. Must recognize the 'pre-treaty' situation, and that First Nations and commercial and recreational fishers and coastal communities must benefit from the partnership in a substantial way;

9. Must recognize that because it is based upon a mutually beneficial partnership, new arrangements will be required between all the partners that will reach beyond just producing more fish; and

10. Must be built upon transparency, and open communication between all the partners.

With this in mind the NBBC has also taken a fourth small but important 'first step' to begin to put ocean ranching into a British Columbia context: initiation of dialogue with potential interested/concerned partners; the development of this Discussion Paper **'Ocean Ranching: Environmental FAQ's (Frequently Asked Questions)'.** A first draft was prepared for the Conference, and has been revised based upon Conference results and further research.

2 Key Points

Please note that the NBBC Executive view this Discussion Paper as an evolving document under an NBBC 'work in progress' initiative. Considerable dialogue with and input from a wide range of potential partners will be required as this initiative proceeds.

Key Points

Ocean ranching is a system of enhancing salmon production and harvesting that is designed, located, and operated:

- by a partnership of interests, rather than just government;
- to increase common property salmon production;
- to provide for selective common property harvest;
- to avoid or reduce harvesting and fisheries management problems;
- to help meet conservation requirements;
- to minimise risk to wild stocks;
- to achieve production that is economically viable and ensures harvest levels support fishers

The proposed ocean-ranching strategy would address or avoid problems of current strategies:

- The draft Wild Salmon Policy discussion paper is focused on sustaining at-risk stocks, which is essential, but doesn't go far enough to build populations.
- Fisheries management must also focus on increasing overall catch rather than just lowering the catch on problem stocks.
- Funding for salmon enhancement (SEP) has been cut back, has not increased production of harvestable stocks, and has been funded by government programs, rather than by a partnership that includes the public.
- Licensing in the salmon fishery has been focused on improving economics and has ignored impacts on employment and on rural coastal communities.
- Unlike salmon farming, ocean ranching is not dependent on practices that degrade ecosystems (such as elevated levels of use of drugs and fishmeal), or on practices that can cause local pollution, the introduction of alien species, or concentrated predation.
- Knowledge would build on the long-term, widespread success of the Alaskan ocean-ranching program and on local knowledge from SEP.

This Draft report was prepared by Nick Phillips, Research Consultant, and presented at the Ocean Ranching Mini-Conference hosted by the Native Brotherhood of BC on February 16-17, 2003 in Nanaimo, BC. Revised and re-organized by Michael Lewis and Maggie Paquet, Centre for Community Enterprise, 24 March 2003, with input from Thor Peterson and Dr. Doug Gordon. Last updated 30 July, 2004. Feedback and suggestions welcome at: oceanranching@njp.ca.

3 Frequently Asked Questions (FAQs)

3.1 What is Ocean Ranching? How does it differ from fish farming as practised in BC?

Ocean ranching is enhanced production of salmon done by a partnership of commercial, First Nations, and community interests. Its objectives are to produce more salmon for common property fisheries and meet conservation requirements.

Fishing for wild salmon is similar to hunting and gathering on land. On the other end of the spectrum, salmon farming is similar to large-scale farming on land. Ocean ranching is similar to ranching on land where an animal is reared in a domesticated, or controlled, environment, released to "graze" in the wild for most of its life, then caught for commercial use. Any activity that enhances fish stocks can be considered ocean ranching, but the term is more likely to be used when the people who perform the enhancement are closely associated with the people who derive the benefits. The methods already used in parts of BC's Salmonid Enhancement Program (SEP) are somewhat similar to the methods used in the ocean ranching program in Alaska; however, there are important differences.

While the government of Alaska retains regulatory and management authority over fisheries, ocean ranching operations are owned and operated on a non-profit basis by regional fisher cooperatives. Board members are drawn from community and user groups in the region, such as Fisher gear groups, First Nations, and conservation groups. This links fishery resources directly with the people living in coastal communities.

Alaskan hatcheries benefit from economies of scale and, unlike in BC, most are located away from sensitive wild salmon river habitat to reduce the likelihood of ocean-ranched salmon mixing with wild salmon. They are located on fresh water sources that are not used by wild salmon. Ocean ranchers imprint the salmon to return to these remote locations where they are then harvested with minimal interference with wild salmon.

Ocean ranching in Alaska benefited from the experience of other countries, such as Japan. It has evolved since it began in 1974, so the methods and levels of success are not uniform across Alaska. The more recent operations incorporate greatly improved science and management practices.

If some form of ocean ranching were to be implemented in BC, it would be possible to avoid the errors of some operations, learn from the best of the ocean ranching operations in Alaska, and adapt ocean ranching to the unique institutional and environmental conditions in BC. From now on, when the term ocean ranching is used, it refers to a community-based stakeholder system of enhancing fish stocks with the best available scientific knowledge and management practices.

3.2 What are the economic and conservation benefits of ocean ranching?

An ocean ranching system could improve the incentives and finances of fishery and habitat management in ways that could benefit wild salmon and their habitats, and increase economic sustainability of coastal communities.

1. Ocean ranching offers a more manageable alternative to salmon farming for communities and the environment. Because an ocean ranching operation can be owned by a partnership of local people, more economic benefits stay in coastal communities.
2. Ocean ranching changes the conservation incentives of local communities. As it is now, many coastal communities get few benefits from the fish resources in their area. Communities have little or no say in the development and management of local fish stocks, so have little opportunity to protect them. While they want to conserve local stocks, many are desperate for jobs. Ocean ranching could provide local jobs, a stake in local resources, and an incentive for conservation.
3. Increased ocean ranching production could reduce pressure on wild mixed-stock fisheries by providing fishers with alternatives.
4. Ocean ranching provides vital information, such as finding out about stock behaviour in an area, where stocks are intercepted, and at what rate. It also allows determining survival rates at each life stage.
5. Ocean ranching that involves egg takes provides a lot of basic population information that is not otherwise collected, including fecundity, age structure, size, disease profiles, and parasite profiles.
6. Ocean ranching should be done co-operatively with fishermen. This leads to reduced costs and facilitates selective harvesting. When fisheries are not managed co-operatively, management can become controversial, confrontational, and costly. Co-operative arrangements for selective and controlled harvesting would be beneficial in all wild stock fisheries, but when government does the enhancement, fishers only have an incentive to push for more catch. When they are partners in management, their interests change.
7. Successful ocean ranching should put money back into the fisheries. This increases discretionary spending for ocean ranching and rebuilding wild stocks and habitat. Ocean ranching spending isn' t limited to just fish production. It also is spent on understanding the enhanced populations.
8. For many years it has been the position of the BC government that if the fish stocks in a watershed are not being enhanced through some sort of fisheries-related investment, then those stocks are not important and extractive activities that affect fish habitat can go ahead unimpeded. However, if there is an enhancement facility in a watershed, then it acquires a different status that warrants more protection with limitations on industrial activities. The presence of ocean ranching will elevate an area's level of protection.
9. Ocean ranching could overcome the current impediment to rebuilding at-risk populations. At present DFO lacks the resources to deal with anything besides the largest at-risk stocks. The rest are left to chance. Ocean ranching could result in cost savings for DFO that could be redirected to the stocks on the next levels of priority.
10. Ocean ranching would provide more local eyes and ears to prevent or report poaching and habitat abuse.

3.3 How does ocean ranching avoid over-exploitation of wild salmon in mixed-stock fisheries?

Wild salmon would be given priority by law. Ocean ranching would be conducted in areas where mixed-stock fisheries are not a problem or can be avoided, and there would be limits on how many ocean-ranched salmon could be grown. Mixed-stock fisheries would be avoided by time and area of harvesting or production, or by selective harvest of marked species.

The concern is that when fishermen harvest hatchery and wild salmon in the same place, the wild salmon are inadvertently harvested at an unsustainable rate and cause a decline in wild stocks. Mixed-stock fisheries have been a factor in the decline of some wild stocks, but ocean ranching practices, such as terminal fisheries, can be used to avoid mixed-stock fisheries.

- First, an ocean ranching operation should not be licensed for an area where biologists judge that a mixed-stock fishery is unavoidable and that the risks cannot be sufficiently minimised. If harmful effects are discovered after a license is granted, then the license could be revoked or altered (such enforcement actions have been taken in Alaska), or harvest management could be changed.
- Second, if a mixed-stock fishery is judged to be acceptable in a particular locality, wild salmon are given priority. In order to ensure that a sufficient number of wild salmon will be available to spawn, fishermen would only be permitted to harvest at a rate that would protect the wild salmon. For instance, if biologists decide that only 30 percent of the wild fish can be harvested, but ocean ranchers want to harvest 50 percent of the enhanced fish, fishers will only be allowed to harvest 30 percent of both wild and enhanced salmon. Each hatchery permit would specify a limit on how many ocean-ranched salmon could be produced, taking into account the presence and size of possible mixed stock fisheries.
- Third, ocean ranchers have many tools to help prevent mixed-stock fisheries from occurring. Wild stocks can often be kept fairly separate from hatchery stocks by such methods as (a) raising salmon that migrate at different times of the year than local wild salmon, (b) releasing them away from wild stocks, and (c) imprinting them to return to a terminal harvest site away from the migration route of wild fish.
- Fourth, enhanced salmon can be marked so that biologists can quickly determine the portion of wild and hatchery fish in a mixed fishery. Almost all hatcheries in Alaska use otolith marking to distinguish their fish, so when a rapid assessment team of fishery officials examines the fishery they can quickly figure out the appropriate harvest rate. This can be updated periodically to prevent over-fishing of wild stocks. Coded wire tags and DNA testing are also used in some BC salmon enhancement programs to tell salmon apart, even salmon from the same watershed. BC is beginning to adopt otolith marking, also known as a thermal marking, which is an inexpensive and effective monitoring tool that was pioneered by an Alaskan ocean ranching operation. Otolith marking, also known as thermal marking, works by adjusting the water temperature in hatcheries to leave a pattern in the bone growth that can be viewed through a microscope to identify the hatchery of origin.

How thermal/otolith marking aids fishery management

- It is easy and inexpensive to mark 100% of ocean-ranched salmon
- Rapid assessment teams can take an in-season sample of a priority salmon run and determine within 2-3 days the portion that is ocean-ranched and wild
- Scientists can use the markings to distinguish wild from ocean-ranched salmon with accuracy ranching from 96% to 99.7%
- Both fishery managers and commercial fishers have trust and confidence in the resulting estimates
- Results can determine whether the portion of ocean-ranched salmon is higher or lower at the beginning or end of the run, so the timing of fishing effort can be adjusted
- Thermal marking also allows scientists to study and monitor other aspects of salmon behaviour, such as straying, spawning, and differences in coastal migration patterns of wild and ocean-ranched salmon that can assist fishery managers
- It is also possible to sample thermal-marked salmon in the high-seas to identify stocks, their abundance, and migration timing, before the commercial harvest begins, further aiding fishery management.

Source: Various papers in NPAFC Technical Report No. 3

References:

Alaska Board of Fisheries Mixed Stock Policy.
http://www.boards.adfg.state.ak.us/fishinfo/regs/mixedsal.php

Conversations with hatchery managers.

North Pacific Anadromous Fish Commission (NPAFC). 2001. *Technical Report No. 3: Workshop on Salmonid Otolith Marking*. Order free copy http://www.npafc.org/publication/publication.htm.

Most relevant papers contained within publication:

- Alaska Department of Fish and Game Otolith Marking and Recovery Program
- Application of Otolith Thermal Mass Marking in British Columbia, Canada
- High-Seas Ocean Distribution of Alaskan Hatchery Pink Salmon Estimated by Otolith Marks
- Using Thermally-Marked Otoliths to Aid the Management of of Prince William Sound Salmon

NPAFC *Working Group on Salmon Marking*. http://npafc.taglab.org/

Till, J. 2003. *Proposed thermal marks for salmon from British Columbia for brood year 2003*. (NPAFC Doc. 711). Fisheries and Oceans Canada. http://www.npafc.org/restricted_doc/2003%20Documents_PDF/711(Canada).pdf

3.4 What can cause wild stocks to decline?

There are a number of factors that can cause the decline of wild stocks. Enhancement program impacts and their minimization are discussed elsewhere in this document.

- Because salmon require a certain range of temperatures and food sources, climate change and changing ocean conditions, including temperature, can affect wild stocks.
- Over-fishing (a sufficient number of returning fish must be allowed to escape fishermen to spawn or else the stock will decline)
- Parasites and diseases (e.g., sea lice, Infectious Hematopoietic Necrosis [IHN])
- Loss of spawning or rearing habitat (human activity can harm sections of streams, estuaries, and the ocean that salmon need to reproduce and rear in). Human activities may damage habitat by altering its physical characteristics, such as with hydroelectric installations (dams), urban development, mining, and logging, or they may damage water quality through pollution, such as with oil and other chemical spills, effluents from sewage treatment plants and pulp mills, or from mining and agricultural runoff. Some of these activities can also affect water levels and temperatures in salmon rearing streams. Natural disasters, such as landslides, can also harm habitat.
- A negative change in the genetics of the stock (such as a change that reduces competitive behaviour or adaptability to environmental changes).
- Other sections of this document discuss the theoretical and proven impacts and risks that enhanced salmon can have on wild salmon, how these impacts and risks need to be acknowledged and either minimized or avoided depending on the particular situation, and what Alaska has done to preserve their wild stocks.

References:

DFO: *Aquaculture Fact Sheet: Keeping Fish Healthy—Facts About Disease.* http://www-comm.pac.dfo-mpo.gc.ca/pages/aquaculture/default_e.htm

Environment and Natural Resources Institute, University of Alaska. October 2001. *Evaluating Alaska's Ocean-Ranching Salmon Hatcheries: Biologic and Management Issues.* http://www.watershed-watch.org/ww/publications/hatchery/AKhatcheries.pdf

3.5 Can ocean-ranched salmon spread disease to wild salmon?

Ocean-ranched salmon would not spread disease any more than wild salmon do.

Diseases and parasites occur naturally in the wild, so it is theoretically possible for an ocean-ranched salmon to become infected and come into contact with other fish. Since ocean-ranched salmon will be isolated from wild salmon as much as possible, there is a low risk of spreading disease. Any disease outbreak will be contained and dealt with rapidly. How does ocean ranching prevent or reduce the risk?

- Ocean-ranched salmon incubating in a hatchery would not be exposed to wild salmon because they would be located on land and would use fresh water.
- Net pens in brackish water (where fresh water mixes with salty ocean water) may be used before releasing the salmon into the ocean. Site selection of net pens would be chosen to avoid the migration routes of wild salmon and to prevent or minimise interactions with wild salmon and other fish (such as herring) that could infect the ocean-ranched salmon with sea lice or disease.
- Ocean-ranched salmon would spend only a weeks or months in net pens depending on the species. In comparison, salmon farm net pens may be occupied year-round until fish are sent to market; this could be up to 3 years at the same site.
- As a precaution, certain species of ocean-ranched salmon would receive small vaccine doses before entering salt water in the wild. (More information has been requested on the type of vaccines that would be used, as well as the frequency or likelihood of their use based on Alaskan experience)
- Disease in Pink and Chum ocean-ranching hatcheries is very rare. It is more common for other species, especially Sockeye. Coho and Chinook are less prone to disease than Sockeye, and they are more commercially valuable than Pink and Chum so they would be more likely to be ocean-ranched. Salmon from ocean-ranching hatcheries are tested before being released, just to be safe. If a disease is found at any stage of hatchery growth or release, the salmon are either restored to health or destroyed. So the risk is not zero, but it is low.
- Once released into the ocean, ocean-ranched salmon would be segregated as much as possible from wild salmon, through several mechanisms. The ocean-ranched salmon would be imprinted so they would return to an area where fishers would harvest them separately from wild salmon when possible, and some would be imprinted to return to an area where they would be captured separately for broodstock purposes to raise future generations. The timing and location of the release can be chosen to lessen interaction between ocean-ranched and wild salmon during the early phase of their life that they spend along the Pacific Coast. Eventually the ocean-ranched salmon would migrate to the open ocean along with wild salmon, until the ocean ranched salmon return to their release site and the wild salmon return to the stream where they were born.

References:

Conversations with hatchery managers.

DFO: *Aquaculture Fact Sheet: Environmental Assessment*. http://www-comm.pac.dfo-mpo.gc.ca/publications/factsheets/aquaculture/e-assessment_e.htm

DFO: *Aquaculture Fact Sheet: Keeping Fish Healthy—Facts About Disease*. http://www-comm.pac.dfo-mpo.gc.ca/pages/aquaculture/default_e.htm

3.6 Will ocean ranching introduce alien species, such as Atlantic salmon, to coastal BC habitats?

No. Ocean ranching would only enhance local Pacific BC salmon species and stocks.

- Ocean ranching would use no alien (non-native) species. Ocean-ranching hatcheries in BC would only raise salmon species that are native to BC, just as Alaskan ocean-ranchers raise salmon species that are native to Alaska. Wherever possible, salmon for broodstock are not even transported from one watershed to another.

- BC's Salmonid Enhancement Program (SEP) also used no alien species. Ocean ranching would share this similarity.
- Salmon farming, on the other hand, largely uses Atlantic salmon, which is an alien species that may have the potential, because of its size and other characteristics, to out-compete wild Pacific salmon, especially in freshwater rearing habitats used by steelhead and other Pacific salmonids.

3.7 Will ocean-ranched salmon replace and compete with wild salmon? What about carrying capacity and density-dependence?

A properly managed and located ocean ranching operation should not harm wild salmon stocks, so the Precautionary Approach must be used. Most research in Alaska suggests that competition is not density-dependent and that ocean carrying capacity is not a reason to limit enhancement, however there are concerns in particular locations, so BC would need to take this issue quite seriously during site selection and monitoring and when deciding how many of which species to release each year.

Biologists would need to study the issue very carefully in order to calculate the risk before approving or rejecting a proposed location for the release of a certain quantity and species of ocean-ranched salmon. Even if a risk analysis led to the granting of a permit and ocean ranching began, if a later re-evaluation of the risk with updated information discovered that the level of risk was unacceptable, then the operation should be altered or shut down. The Precautionary Approach is an appropriate guide.

Here are some general comments on the issue of displacement and competition:

- Salmon compete for many types of food with many types of fish. "In the case of salmon ranching, carrying capacity denotes the ability of local receiving waters to accommodate additional consumers without adverse or other major changes in ecosystem dynamics" (Cooney).
- Long term cycles in ocean and climate conditions can affect the capacity of salmon habitat in oceans, migration routes, coastlines and rivers to support large salmon populations. Hare et al believe that the current ocean regime began in 1977 to the benefit of Alaskan salmon, and since the Pacific Decadal Oscillation as it is called appears to reverses every 20 to 30 years, a reversal should be expected, to the likely benefit of the West Coast of the United States and with a more ambiguous impact on BC salmon.
- Ocean-ranched salmon would be released into the ocean along the coast, not into a wild salmon stream or river. This means that ocean ranching cannot cause competition between wild and hatchery salmon in the river or stream environment in the early stage of the salmon life cycle.
- In the event that some ocean-ranched salmon stray away from their intended destination during the last stage of their life cycle, it is possible for ocean-ranched salmon to compete in a river or stream with wild salmon for breeding space (but not for food, since salmon generally stop feeding during the last stage of their life). See the question on straying for a discussion of the probability, consequences, and minimization of straying. This section focuses on the potential and consequences of competition along the coast and in the open ocean during the middle of the salmon life cycle.
- It is impossible to state categorically in advance that there is room for more salmon, or the opposite, that adding ocean-ranched salmon would significantly reduce the number of wild salmon.
- Whether or not salmon growth and survival is affected by the number of salmon released depends on many factors including the period in time, the species, and the region. If in a particular case and point in time the productivity of wild salmon (their numbers and sizes) is unaffected by the amount of hatchery releases, then salmon productivity is termed 'density *in*dependent'. Otherwise it is termed 'density dependent'. It is helpful to think in terms of whether or not there exists 'underused or unused capacity' to support larger salmon populations in a particular case.

- It is possible that a particular ocean area and coastline has the capacity to support more salmon than it currently does, but that the number of salmon is limited by a bottleneck elsewhere. For instance, there could have been natural or man-made damage or elimination of stream beds suitable for salmon spawning (e.g. due to earthquakes, dams, development, oil spills, pollution, etc), resulting in far fewer wild salmon being born each year than could be sustained by their ocean and coastal habitat. Or, a wild salmon stock may have been severely reduced by over-fishing in the past, and its size may be expected to rebound slowly over the long term, and in the meanwhile it might (or might not, depending on the circumstances) be possible to take advantage of underused capacity by ocean-ranching until wild stocks recover, without harming the ability of the wild stock to recover. Or there may never have been adequate breeding opportunities in a region to fully use up coastal and ocean capacity, in which case there may be room for ocean ranching in that region (again, only if ocean-ranched salmon in that region were deemed to be manageable within bounds that are safe for wild stocks in the region).

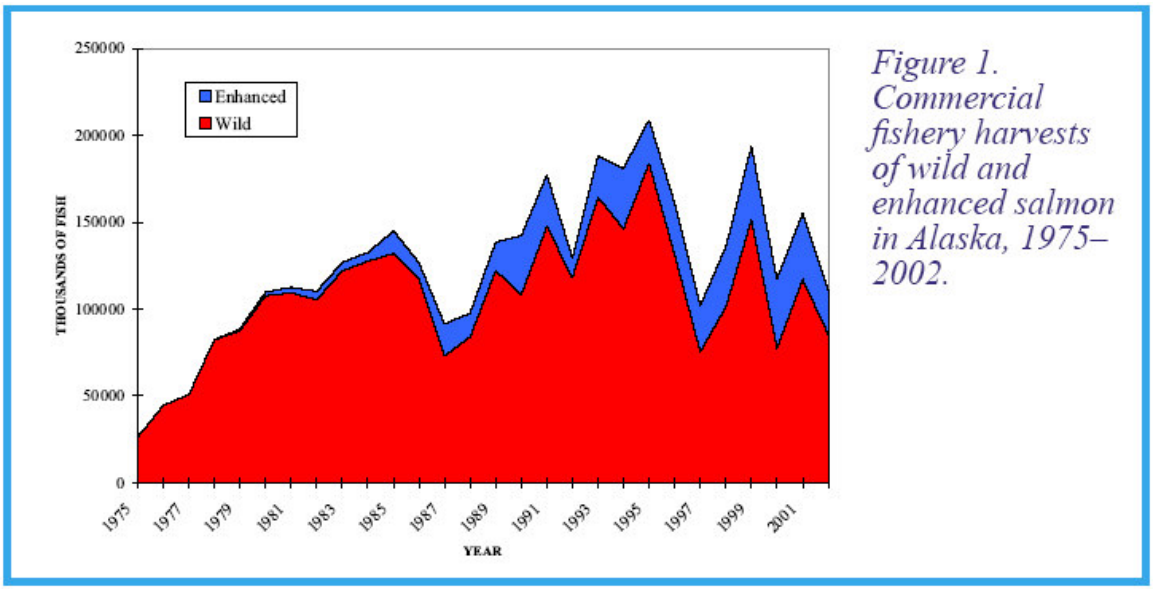
Table 1 BC Commercial salmon catch (round weight, tons)

Source: Irvine et al

Year	Chinook	Sockeye	Coho	Pink	Chum	Total
1952	7,104	15,208	10,829	25,281	15,738	74,160
1962	4,471	9,931	13,157	46,231	8,918	82,708
1972	8,870	10,324	10,958	19,453	32,595	82,200
1982	7,723	32,780	10,073	4,330	16,429	71,335
1992	5,786	22,655	7,955	16,239	19,560	72,195
2002	1,675	10,067	460	8,610	12,343	33,155

- Historically, wild salmon production has been much higher in almost all areas of the BC coast than it currently is (Table 1). It would be simplistic and hasty to take this information by itself as proof that ocean ranched salmon could be added without causing any significant reduction in the number or size of wild salmon, but it is positive enough to suggest the possibility that there may exist unused or underused capacity in BC that could support larger salmon populations, which could be investigated more closely.
- In some areas of BC, the decline in wild salmon stocks from historic highs can be traced to the loss of freshwater and estuarine habitat, in which case there could be underused capacity.

Figure 1. Source: McGee



- In a fishery where there are both wild and hatchery salmon, the hatchery salmon are marked and counted. With this tool scientist know the total number of hatchery salmon that are released, estimate or count the total number of wild and hatchery salmon that return to be captured or to breed, and calculate the portion that are hatchery salmon. Does the hatchery portion of the harvest represent a net gain (*augmentation hypothesis, or density independence*) for the fishery, or would the total number of wild salmon increase to fully compensate in the absence of hatchery salmon (*replacement hypothesis, or density dependence*)?
- To scientists it is not an absolute matter of determining whether the portion of ocean-ranched salmon in a given fishery represents 100% augmentation versus 100% replacement. Instead, it is a matter of degree. In any given case there may be zero or a trivial level of replacement, or there may be too much replacement. 'Too much replacement' can be judged from a biological perspective and an economic perspective.
    - Biological perspective: The Precautionary Approach, and the values of many Alaskans and British Columbians, calls for the fishery to be managed with a bias in favour of wild stocks. Of course, so long as we accept the principle that fishing for wild salmon is acceptable for healthy stocks, then we are accepting a certain range of reduction in the total number of wild salmon. From a biological perspective, it isn't whether or not there is a reduction in wild salmon that matters *per se*; what does matter is whether or not the reduction in wild salmon is *sustainable*. The connection to ocean ranching is that a small amount of replacement *might* be biologically acceptable, *so long* as that amount does not threaten the sustainability, recovery, or viability of the affected wild salmon stock.
    - Economic perspective: For fishers who invest in ocean ranching and harvest both hatchery and wild salmon, replacement is definitely *un*desirable, because it reduces their return on investment (ROI). Many fishers also know they depend economically upon wild salmon in the long term, and do not want to threaten the viability of that resource. A given amount of replacement may or may not be economically acceptable in a certain case, depending on whether the net gain in salmon harvested creates adequate economic returns, and depending on whether or not there is a long term impact on wild salmon in the region. There appears to be some overlap between economic incentives and the biological perspective on this issue. The possible exception is that a certain user group or gear type might benefit from the different allocation of benefits due to hatcheries, regardless of whether or not it is a net benefit. So economic incentives may be mixed. However the incentives of hatcheries face checks and balances from the state fishery managers and the public review process.

Table 2: Alaska - portion of hatchery fish in common property and total harvest

Sources: Farrington, and ENRI

Region	Percentage of Hatchery-Produced Fish in Common Property Harvest by Species in 2003					Percent of Total Harvest in 2000
	Chinook	Sockeye	Coho	Pink	Chum	
Southeast	12.2	7.7	23.6	1.0	93.2	27
Prince William Sound	0	49.5	15.0	93.3	83.0	88
Cook Inlet	4.3	26.7	6.3	1.4	0	10
Kodiak	0	19.8	39.8	40.1	40.1	32
Chignik/ Alaska Peninsula	0	0	0	0	0	0
Bristol Bay	0	0	0	0	0	0
Arctic-Yukon-Kuskokwim	0	0	0	0	0	0
Statewide	8.0	10.5	18.8	37.4	66.6	34

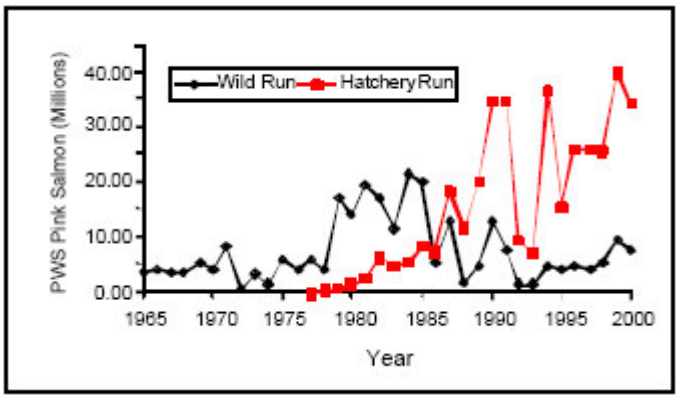
In Alaska at the state level, both wild stocks and ocean-ranched stocks have grown substantially since ocean ranching began in 1974 (Figure 1). This is largely attributable to a period of favourable ocean conditions, but it also suggests that ocean ranching may not have damaged wild salmon in Alaska overall, and may have been a net benefit for Alaska. Ocean ranching takes place in

several regions of Alaska, with several species, some in large numbers, and not all of these programs have been free of debate over whether or not there is too much replacement.

Controversy over the impact of ocean-ranched salmon on wild salmon in Alaska has focused mainly on Pink salmon in the Prince William Sound (PWS) region, and to a lesser extent on Chum salmon in Southeast Alaska. PWS hatcheries have very high production – they release a combined total of about 600 million Pink salmon fry each year (comparable to the total annual hatchery releases for all of BC), a small portion of which survive and return. On average in the past decade about 27 million PWS Pink are harvested each year. Most returning Pink salmon in PWS are ocean-ranched, compared to an Alaska-wide average of 34% for all ocean ranched species (Table 2).

Two researchers among the most critical of hatcheries, Hilborn and Eggers, believe that there would be many millions more wild Pink returning each year in PWS if there were no hatchery production, so that the net increase in returning salmon caused by PWS ocean ranching is only about 2 million, in which case PWS Pink hatcheries are counterproductive and should be shut down. Central to their argument is their observation that wild Pink salmon in PWS happened to decline at the same time as hatchery production rose (Figure 2), unlike many other areas of Alaska where both wild and hatchery

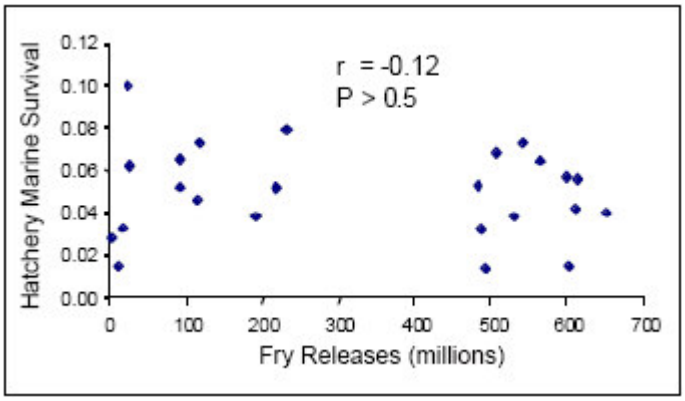
Figure 2 PWS Pink salmon trends. Source: Wertheimer et al 2002



production rose at the same time (Figure 1). Is what happened in Prince William Sound an example of correlation or causation? Coincidence, or cause and effect? Hilborn and Eggers argue for cause and effect.

A more recent analysis of the same data, by researchers Wertheimer et al in 2002, refutes Hilborn and Eggers' conclusions. They say that a quick glance at the data does indeed suggest hatcheries as a possible partial explanation for a reduction in wild salmon in PWS, but they say a deeper and broader statistical analysis finds several factors other than hatcheries that are much stronger explanations (so hatcheries either likely had no effect on the decline of wild salmon stocks, or just a small effect). As an example of some of Wertheimer et al's evidence, PWS saw a large reduction (not caused by salmon) in the level of zooplankton over the same time period, and Figure 3 shows that fluctuations in PWS Pink hatchery survival rates are not meaningfully related to the number of hatchery releases (contrary to what would be expected under density dependence).

Figure 3 Lack of relationship between releases and survival rates. Source: Wertheimer et al 2002



But the case is not closed in PWS. The issues are complex, there is not yet a consensus among scientists about PWS salmon, and hatcheries can arouse strong feelings and opinions on both sides.

Fagen and Smoker recommend that "to avoid concentrations of young salmon in estuarine habitats, hatcheries might: (1) coordinate temporal separation of releases; (2) release large individuals that would use limited nursery environments for a short period of time; (3) release young salmon at unused localities."

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Note the above report contains more optimistic figures than used in this discussion

Wertheimer, A., and Haverland, T. 2001. *Southeast Alaska Salmon: An Example of Sustainability, or Just Lucky?* Pacific Rim Wild Salmon and Steelhead Conference, Nov 2001, Porland, Oregon. http://www.wildsalmoncenter.org/presentations.php

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3.8 Do enhanced salmon have different behaviours than wild salmon?

Enhanced salmon can learn or evolve somewhat different behavioural or other characteristics. Changes would be minimised by hatchery management practises, discussed in the questions on genetics.

Table 3 Relative Differences Between Wild and Hatchery Salmonids

Adapted from: ENRI

Wild Salmonid		Hatchery Salmonid
Lower survival egg to smolt Higher survival smolt to adult Lower survival egg-adult	Survival	Higher survival egg to smolt Lower survival smolt to adult Higher survival egg-adult
Efficient forager Lower aggression Lower social density Higher territorial fidelity Disperse in migration Bottom habitat preference Flee from predators	Behaviour	Inefficient forager Higher aggression Higher social density Lower territorial fidelity Congregate in migration Surface habitat preference Approach predators
More variable shape Brighter colour Larger kype	Morph-ology	Less variable shape Duller colour Smaller kype
Smaller eggs Fewer eggs Higher breeding success	Repro-duction	Larger eggs More eggs Lower breeding success

Over time, and in extreme cases, the behaviour differences in the following chart may appear in enhanced fish. This would apply less to salmon species that spend little time in a hatchery and net pen before release. Some of these differences seem to result from conditioning in the hatchery environment rather than from genetics, so not all of these traits would necessarily be passed on to wild fish in the event of hybridization. Hatchery management practices and mating protocols can lessen these effects.

Reference:

Environment and Natural Resources Institute (ENRI), University of Alaska. October 2001. *Evaluating Alaska's Ocean-Ranching Salmon Hatcheries: Biologic and Management Issues*. http://www.watershed-watch.org/ww/publications/hatchery/AKhatcheries.pdf

3.9 Why are genetics important?

Salmon are genetically adapted to their local environments and to survival in the wild. Loss of this genetic adaptation would result in poorer survival rates, especially under adverse conditions.

Wild salmon adapt to their environments over many generations; local salmon stocks (populations) from each stream and region are often slightly different because of this. Since there is some limited interbreeding between wild populations, stocks are always evolving and exchanging genes.

If there is enough genetic diversity within and between stocks, then wild salmon will be able to adapt to most changes in their environments, such as a change in ocean temperature or a new disease. In the short term, factors such as habitat loss and over-fishing have a much larger impact on the survival of wild salmon. In the long run, genetics also plays a large role.

Unfortunately, BC is not a clean slate; ENRI points out that "Stock or fish transfers among hatcheries or watersheds are well documented . . . artificial gene flow and mixing of previously isolated gene pools have historically been standard practices" for salmon in the Pacific Northwest.

Conservationists and biologists agree that minimising the potential impact of hatcheries is important if genetic diversity is to be protected. Because of this, genetics policies and protocols for hatcheries have been developed, and implemented and enforced in Alaska.

Alaskan style ocean ranching differs greatly from BC's Salmon Enhancement Program (SEP) in this important way: Many SEP hatcheries are designed intentionally to mix hatchery and wild salmon and for the hatchery salmon to breed in the wild, whereas ocean ranching hatcheries in Alaska are designed to increase harvests while avoiding or minimizing the interaction between hatchery and wild salmon.

Reference:

Environment and Natural Resources Institute (ENRI), University of Alaska. October 2001. *Evaluating Alaska's Ocean-Ranching Salmon Hatcheries: Biologic and Management Issues*. http://www.watershed-watch.org/ww/publications/hatchery/AKhatcheries.pdf

3.10 What are genetics-related concerns have been raised about enhanced vs wild salmon? How are they dealt with?

A well-managed and properly located ocean-ranching operation would in many ways have less of an impact on the genetics of wild stock than some of BC's current Salmonid Enhancement Program (SEP) hatcheries. Many genetics concerns can be addressed through management practices and genetics policies, such as those developed in Alaska.

Ocean ranching in Alaska is governed by numerous regulations and guidelines, including a genetics policy to protect wild salmon. The same types of regulations and guidelines could be instituted in BC.

The following subsections deal with commonly raised and overlapping concerns. Raising questions about the risks is easy. Predicting the actual costs and degree of risk is much harder, so it is important to commit to use the best science available, to learn from best practices elsewhere, to continually monitor, and to apply the Precautionary Approach.

References:

Alaska Department of Fish and Game (ADF&G). *State of Alaska Finfish Genetics Policy*. http://www.cf.adfg.state.ak.us/geninfo/research/genetics/policy/finfish.htm

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Coast Range Association, & the Native Fish Society. Salmon & Survival: *Why Native and Hatchery Salmon are Different*. http://www.coastrange.org/salmon&survivalpg0.html

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Hard, J.J. June 2002. *Genetic Risks of Hatchery Salmon Production to Wild Salmon*. p. 72-83 in Hatcheries and the Protection of Wild Salmon, edited by Craig Orr. http://www.sfu.ca/cstudies/science/salmon/hatcheries_proceedings.pdf

3.10.1 Hybridization / Outbreeding Depression

Ocean ranching avoids the high degree of mixing of stocks caused by some of BC's current salmon enhancement initiatives. Ocean ranching addresses the hybridisation concern by segregating stocks, by minimising the chance of straying, and by using methods to minimise the impact if straying does occur (such as by rearing salmon that are almost genetically identical to wild salmon in the region).

Hybridisation or introgression occurs when two individual fish with somewhat different genetics mate and produce hybrid offspring, enabling those genes to spread into the wild stock. Hybridisation occurs naturally when salmon from one population stray from their ordinary migration route and enter the spawning grounds of a different salmon population. Sometimes hybridisation is done intentionally in a conservation program to boost the size of a population of wild salmon.

Some BC Salmonid Enhancement Program hatchery practises frequently lead to hybridisation because the hatchery salmon are not segregated from wild salmon. The SEP hatchery salmon and wild salmon often return to the same river of origin at the same time of year and mix together.

In contrast to SEP sites, ideal ocean-ranching sites are located away from wild salmon streams and rivers. Although the hatchery would be located by a stream or river to benefit from the fresh water, streams and rivers occupied by wild salmon would not be chosen. In addition, the ocean-ranched salmon would be imprinted to return to a salt water coastal location separate from wild salmon, where they would be captured and would not be able to enter wild salmon spawning grounds in fresh water. Some straying is a possibility, but many methods would be used to minimise this risk (see the discussion on Straying).

In theory, hybridisation can lead to one or more of the following consequences, so it must be taken very seriously: more genetic similarity between the wild and hatchery populations, less genetic diversity within the wild population, a decrease in the fitness of the wild population, and an increase of genetic diversity in the hatchery population.

Again, ocean ranchers address this concern by minimising the chance that it will occur (such as by releasing salmon in a way that imprints them to return to areas without wild salmon), and by minimising the impact if it does occur (such as by rearing salmon that are almost genetically identical to wild salmon in nearby watersheds). In Alaska, most ocean-ranching hatcheries use broodstock from nearby wild salmon populations. In some cases, broodstock is taken from a different region in Alaska, with a consideration of the risks involved, but broodstock is forbidden from being taken from outside the state. Biologists agree that it is best to take broodstock from a nearby wild source whenever possible.

Alaskan hatcheries use over 20 different sources of chum broodstock, and all of them originate from the same region or watershed as the hatchery. Over 30 sources are used for coho broodstock in Southeast Alaska alone. Pink broodstock in the Southeast comes from about 10 sources, most of which are near the hatchery. Sockeye broodstock is often taken from an area remote from the hatchery, but

they are released back into the remote area. This shows a concerted effort to maintain healthy genetic diversity.

Reference:

Environment and Natural Resources Institute, University of Alaska. October 2001. *Evaluating Alaska's Ocean-Ranching Salmon Hatcheries: Biologic and Management Issues*. http://www.watershed-watch.org/ww/publications/hatchery/AKhatcheries.pdf

3.10.2 Domestication

Domestication is minimised by adjusting mating protocols and imitating natural conditions during the rearing of enhanced salmon.

Domestication refers to the different evolutionary process that occurs in the presence of interaction with a human environment instead of entirely natural conditions. Ocean-ranched chum or pink salmon spend several months in a freshwater hatchery before being released into the ocean to live as wild salmon for 2 or more years. Coho and Chinook salmon would spend 1-2 years in freshwater before being released into the ocean.

Natural selection occurs in the hatchery just like in the wild. But the hatchery is an artificial environment, so the advantageous genetic characteristics for survival and reproduction are somewhat different. This effect can be minimised by adjusting mating protocols and imitating natural conditions in the hatchery as much as possible. Historically, some domestication in hatcheries has been intentional; hatcheries are more successful when they manage to increase the survival rate and market value of their fish, so hatchery operators sometimes selected fish with certain characteristics to reproduce, such as larger or pinker fish. Modern guidelines forbid such intentional selection.

Reference:

Environment and Natural Resources Institute, University of Alaska. October 2001. *Evaluating Alaska's Ocean-Ranching Salmon Hatcheries: Biologic and Management Issues.* http://www.watershed-watch.org/ww/publications/hatchery/AKhatcheries.pdf

3.10.3 Genetic Diversity

Using large numbers of broodstock, renewing them periodically, and implementing certain mating practices can help to prevent the inbreeding of salmon.

Loss of diversity within populations - Level of scientific understanding:

- Theory:
  Well-developed theoretical foundation
- Empirical evidence that hazard exists:
  Considerable evidence
- Methods of risk reduction:
  Large, representative broodstocks
  Low variance mating protocols
  Limit natural spawning of hatchery fish
- Major scientific uncertainties or analytical problems:
  Meta-population structure and its effects on within population diversity
- Adaptive management potential:
  Moderate (biologically)

Source: Hard

Inbreeding refers to the reproduction of very closely related hatchery fish. It is mainly caused when a relatively small number of parent fish (broodstock) is used to start the hatchery, instead of a larger broodstock with more genetic diversity. Inbreeding can lower the genetic diversity and the level of fitness in the hatchery population.

Trout hatcheries that use a small number of broodstock have suffered from inbreeding. But salmon hatcheries use a large number of broodstock, which avoids much of the risk of inbreeding. Generally, the effects of inbreeding have not been observed in salmon hatcheries. As the quote below shows, biologists agree that "hatchery best practices" are desirable to lessen the risk of inbreeding and causing a decline in fitness.

"A consensus of biologists is that the goal of hatcheries involved in fishery enhancement should

be to make every effort to avoid inbreeding and maintain high fitness of the hatchery stock. However, many believe it is not possible to adequately mimic the successful reproductive strategies fish use in nature to maintain their genetic viability. Fish culturists, thus, have been encouraged to compensate for inadvertent loss of genetic variability by avoiding mating practices that foster loss of variability and by following certain procedures to minimise inbreeding. Best hatchery practices use a large founder or effective population size, provide crosses between wild and hatchery fish every season, use random mating, mate fish from all parts and age classes of a run, and avoid intentional selection of any given trait (e.g., large size, brightness) to help conserve genetic variability." (ENRI)

References:

Environment and Natural Resources Institute, University of Alaska. October 2001. *Evaluating Alaska's Ocean-Ranching Salmon Hatcheries: Biologic and Management Issues*. http://www.watershed-watch.org/ww/publications/hatchery/AKhatcheries.pdf

Hard, J.J. June 2002. *Genetic Risks of Hatchery Salmon Production to Wild Salmon*. p. 72-83 in Hatcheries and the Protection of Wild Salmon, edited by Craig Orr. http://www.sfu.ca/cstudies/science/salmon/hatcheries_proceedings.pdf

3.10.4 Extinction

Ocean ranching would not cause the extinction of wild salmon in BC. To protect wild salmon, the Precautionary Principle should serve as a guide, as well as the best practices pioneered in Alaska

Since the beginning of ocean ranching began in Alaska in 1974, both wild and hatchery salmon stocks have increased in most regions of the state (see Figure 1 page 14).

Throughout history in North America, new salmon stocks have sometimes appeared, and some populations have gone extinct naturally, for instance as the result of climate change, or a landslide blocking spawning grounds. Other populations have gone extinct for man-made reasons, such as dams or over-fishing. The status of salmon stocks is discussed in the reports referenced below.

Ocean ranching, if it were to proceed in BC, would have 134 years of hatchery experience in North America to learn from, would benefit from knowledge developed under BC's Salmon Enhancement Program, and would selectively adopt the best practices that have been developed by the more responsible and modern of the many ocean ranching organizations operating under Alaska's 30 year old program.

Of course, it must be acknowledged that even the best science and the best intentions cannot provide complete certainty or completely eliminate all risks, so the Precautionary Approach must be respected (see question 3.16 page 31).

Each proposal for an ocean ranching site would have to undergo a stringent license approval process. It would be standard policy to locate and design an ocean ranching operation where it would have minimal impact on wild stocks, as discussed elsewhere. Even stricter regulations, if a license could be obtained at all, would apply if a nearby wild stock were particularly vulnerable. The license should be adjusted (for instance, reduce the limit on how many hatchery fish can be released), or revoked (so that the hatchery is shut down), if a serious problem occurs or is anticipated. For information on the kinds of regulations that would be required and that have been enforced in Alaska, see question 0 page 28.

References:

Baker, T.T. et al. 1996. *Status of Pacific Salmon and Steelhead Escapements in Southeastern Alaska*. Fisheries. 21(10):6–18.

Eggers, D.M., J. Irvine, M. Fukuwaka, and V. Karpenko. 2003. *Catch trends and status of North Pacific Salmon*. (NPAFC Doc. 723). http://www.npafc.org/restricted_doc/2003%20Documents_PDF/723(StockAssWG).pdf

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North Pacific Anadromous Fish Commission (NPAFC). 1998. *Bulletin Number 1: Assessment and Status of Pacific Rim Salmonid Stocks*. Order free copy http://www.npafc.org/publication/publication.htm.

Slaney, T.L. et al. 1996. *Status of Anadromous Salmon and Trout in British Columbia and Yukon.* Fisheries. 21(10)20–35.

3.10.5 Imprinting, straying and homing

Harvest methods, locations, and rearing practices are chosen to avoid interaction with wild salmon and minimise straying.

Definitions

Homing: Wild salmon who reach maturity have the innate ability to return to their home (natal) stream, where they incubated, hatched, and entered salt water. After some years at sea, almost all wild salmon migrate to their natal streams when they are ready to spawn, but some naturally stray to other areas.

Imprinting: The process where young salmon learn to return to the fresh water source where they were born or reared. This can be a wild salmon stream or another stream used for fresh water in a hatchery. Imprinting is central to the ability of ocean ranching to segregate wild and enhanced salmon.

Straying: "During straying, a small portion of salmon return to spawn in a stream different from their natal stream, maintaining genetic communication among local populations and, in turn, genetic diversity." (ENRI)

Where will hatchery salmon return? What is their home?

"For hatchery fish released at a remote location, the hatchery where they are reared and the release site could both be considered homes. While there is some tendency to return to the ancestral area, hatchery-reared salmon generally return to the site where they were released." (ENRI)

How much do salmon stray?

Straying is not yet well understood since it is difficult to study, but the growing prevalence of otolith marking of enhanced salmon (see question 3.3) is giving scientists a good tool to study straying. Scientists are unsure if wild fish stray more or less frequently. The amount of straying differs significantly by salmon species, river, year, and the age of the salmon when it spawns. It is widely thought that Pink salmon stray the most.

As an example of the magnitude of straying, an 8 year study by Hard and Heard of the straying of hatchery Chinook at Little Port Walter found that 98.8% of the 22,198 maturing Chinook that were recovered had successfully homed to their natal release site, implying a straying rate of 1.2%. Most (64%) of the straying hatchery Chinook were found in non-Chinook rivers within 25 km of the natal release site. Only 9 hatchery Chinook were found in wild Chinook rivers. Heard speculates that the release of hatchery salmon directly into the ocean, rather than upstream, might affect the imprinting process.

What are the concerns about straying?

The straying of hatchery fish into a wild stream: "There is concern that gene flow from hatchery strays may dilute the gene pool in populations of locally adapted wild fish. If a hatchery produces a large number of salmon, straying by even a small percentage of them has the potential to compromise the genetic makeup of *nearby small* wild populations." (ENRI)

The straying of wild fish into a hatchery: This would lead to genetic mixing, and if the straying were substantial, it might result in a decrease in the wild population. "…inclusion of wild salmon in hatchery broodstocks has often been practised as it theoretically slows domestication and thus the potential effects of outbreeding depression…" (ENRI). Alaskan fishery managers report that in the terminal harvests where ranched salmon are taken for broodstock, wild salmon make up far less than 1% of the salmon.

Is straying really a concern?

'Studies of small chum salmon populations on Vancouver Island indicate that degrees of genetic exchange between strays was lower than that inferred by the number of strays in the spawning area. [see study by Tallman and Healey] Simply counting stray hatchery fish on spawning grounds may not provide a reliable estimate of the genetic interaction between hatchery and wild populations. It is not known whether straying hatchery salmon spawn successfully with wild salmon or if any loss of fitness and productivity occurs, but the potential risk is a strong concern within Alaska's ocean-ranching program." (ENRI)

How do ocean ranchers prevent or minimise straying?

- First of all, if straying were judged to be too big a concern when an ocean ranching site was proposed, then that hatchery and release site would not be licensed. If the problem arose later it could be shut down, altered, or moved. Some areas are appropriate for ocean ranching and some are not. Typically, dozens or hundreds of sites are analyzed to find one ideal site. The regulatory limit on how many salmon a particular hatchery can release also takes into consideration the size, proximity and vulnerability of wild stocks in the region.
- Straying can be drastically reduced by effectively imprinting the salmon. Salmon are imprinted by keeping them in net pens in brackish water (where fresh water meets the ocean) away from wild salmon migration routes for a couple weeks or months before release.
- Straying can be further reduced by raising salmon from a broodstock that is native to the local region.
- The homing ability of salmon can be maximized by correctly timing their growth cycle in the hatchery.
- The harvest method also affects straying. When salmon return to the location where they were imprinted, fishery managers ensure that those salmon are fished quickly and steadily. With this harvest method the salmon do not have the inclination or opportunity to stray.
- The location of the imprinting/release site(s) is chosen to enable the harvest method described above, and to minimise the availability of creeks and rivers for the salmon to stray into. Nets can also be used to guide returning fish into the preferred location.

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3.10.6 Colonization and translocation

Only Pacific salmon species that are native to BC would be ocean-ranched, and this would occur away from vulnerable wild salmon rivers.

Salmon enhancement and ocean ranching do not raise the same concerns about colonisation as does the farming of Atlantic salmon. Colonisation is the establishment of a successful breeding population by a salmon species that is not native to the area. Non-native species of many creatures have been introduced around the world. Without natural predators, some of those introduced species have had devastating impacts on local ecology.

No one really knows if there is a serious risk of Atlantic salmon colonizing BC rivers. Thousands of Atlantics escape from net pens every year and they have been observed in more than 80 rivers in BC. Young Atlantic salmon that are assumed to have been born in the wild have already been observed in three BC rivers that also contain wild salmon. But the salmon farm industry points out that this does not mean colonisation has occurred and that past attempts to intentionally create sustainable runs of Atlantic salmon in BC rivers have failed. So far, hybridization—the crossbreeding of Atlantic salmon and wild Pacific salmon—is also believed to be impossible.

Colonisation is not really an issue for salmon enhancement and ocean ranching, since only Pacific salmon species that are native to BC are used. On the other hand, hybridization and straying are concerns. It is worth noting that colonisation occurs naturally among wild salmon. When there is a dramatic change in habitat, such as a landslide, a receding glacier, or a dam, straying wild salmon may colonize a new river.

Translocation is a similar concept to colonisation, and it occurs when humans take a BC salmon and move it from one region of BC to another, often through salmon enhancement programs. This has taken place numerous times in the history of BC, such as the introduction of sockeye to the upper Fraser River.

The BC Wildlife Foundation points out that, just in the period ‘between 1884 and 1941, a total of 3.4 billion salmon eggs were collected, hatched and transplanted or simply transplanted to 187 various streams in this province and to systems outside the province. These eggs came from 28 different Sockeye sources (not all from BC), 18 Pink sources, 11 Chum sources, 15 Coho sources and 5 Chinook sources. . . . In the 60 years since, many additional transplants have taken place.”

While translocation is not as radical as colonisation it can alter the gene pool of nearby wild fish. This is why, as much as possible, ocean ranchers in Alaska are obliged to take their first broodstock from a wild source that is relatively very near their hatchery, so that if any straying and interbreeding does occur between wild and ocean-ranched fish then the genetic impact will be far less than if the broodstock came from another region or state.

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3.11 Would ocean ranching use genetically modified salmon?

No.

3.12 Would ocean ranching pollute?

The impact would be small, similar to the impact of SEP hatcheries.

Ocean ranching operations deal with salmon for a much shorter period of time than salmon farming operations, and only while the salmon are very young and small. Enhanced salmon would be released when their weight is measured in grams not pounds, so the enhanced salmon grows to its adult size in the wild and over a period of one or more years (see . Salmon farms keep salmon in pens in the ocean until they weigh several pounds, up to about 20 pounds over three years.

Table 4 Incubation and rearing times for Pacific salmon species

Species	Life stage at release	Weight at release, grams	Age at release, years	Years spent in wild
Pink	Fry	0.5g–1g	1	1
Chum	Fry	2-4g	1	2-5
Coho	Smolt	15-30g	2	1
Chinook	Smolt	25-50g	2	2-5

Ocean ranching hatcheries would be located on land, just as BC salmonid enhancement hatcheries are. These treat most of their wastewater on land. Ocean-ranched pink and chum salmon only spend a couple of weeks or months in a net pen in the ocean. Overall, due to the small size of the salmon and the fact that they are reared on land, ocean ranching has far less impact from the deposition of sewage and other chemicals into the ocean. Ocean-ranching operations would be obliged to follow waste management regulations and use adequate waste management practices to deal with this concern.

References:

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3.13 Are ocean ranched salmon given drugs?

No hormones or pesticides would be used in the rearing of the salmon. Minor levels of antibiotics or vaccines are given to enhanced salmon depending on the species and enhancement method.

Some salmon enhancement methods that could fall within the scope of ocean ranching would not use any drugs, such as improving natural spawning and rearing grounds. However the method used in Alaska involves releasing young enhanced salmon into the wild soon after they are born in hatcheries. These salmon are tested at several stages in their life beforehand to prevent contacting or spreading a disease or parasite. Antibiotics are used only infrequently and in very small quantities in fresh water, since (a) young salmon weigh only a few grams, (b) the chance of acquiring a disease in the controlled fresh water hatchery environment is low, (c) the young salmon spend only a couple months

concentrated in a net pen in the ocean before release, (d) net pen locations are chosen to minimise contact with other fish, and (e) only local salmon eggs are used. If any ocean ranched salmon in a hatchery were medicated, the waste water could be treated on land as is currently the case in BC salmon enhancement hatcheries.

Hormones

No hormones would be used for any species during their time in the hatchery or netpen awaiting release. There is a possible exception for the small portion of the harvest that is set aside to provide eggs for the next year's releases; depending on how broodstock are collected in the ocean (rather than in streams), artificial means may be used to induce reproductive maturity.

Pesticides

No pesticides would be used for any species.

Antibiotics

A small amount would be used in the event that a problem occurs and is treatable.

Vaccines

Some species, such as chum, require no vaccines. Others, such as chinook and coho, would require small amounts, but only during the fresh water stage. Bacterial kidney disease occurs naturally in the wild among chinook and coho, so they would be treated once in their life for a 21-day period. On rare occasions they would also treated for Vibrio or Furunculosis.

Comparison with salmon farms

Salmon farmers feed Atlantic salmon comparatively large quantities of medications. First, farmed Atlantic salmon are kept concentrated in ocean net pens for years, increasing their exposure to diseases and parasites from the wild and from each other. Second, farmed Atlantic salmon grow in size until they weigh many pounds, requiring much larger quantities if drugs are used. Third, Atlantic salmon eggs are imported from other countries to establish local broodstocks. Salmon farmers use drugs, such as ivermectin and emamectin benzoate to treat sea lice. Some antibiotics are prescribed by veterinarians, but farmed salmon that contact the IHN virus are isolated and are not given antibiotics since antibiotics do not work on viruses. About 2.5% of the milled feed given to farmed salmon is medicated. Some salmon farms with infections are quarantined, including the employees. No hormones or pesticides are used, and regulations do not allow farmed salmon to be processed until the medications (also known as therapeutants) in their system have dissipated over a 2-week period.

References:

Conversations with hatchery managers.

Fish health on the DFO web site: http://www.agf.gov.bc.ca/fisheries/health/fish_health.htm

3.14 Are ocean ranched salmon as nutritious as wild salmon? Are they toxic?

The overall life cycle and level of nutrition of ocean ranched salmon are similar to wild salmon.

Is the nutrition and health of ocean-ranched salmon more similar to wild or farmed salmon? It is useful to compare life cycles. Farmed salmon spend their entire life in a hatchery or net pen. Ocean ranched salmon only spend the early period of their lifecycle in a hatchery and net pen. They spend the rest of their life migrating and consuming natural foods just like wild salmon do.

Wild and ocean-ranched salmon both contain Omega-3 fatty acids, which make them beneficial for health (interestingly, contrary to media perceptions, farmed salmon servings are actually higher in Omega-3 fatty acids, partly due to the fishmeal they are raised on, although sources of fishmeal are being depleted globally). Wild and ocean-ranched salmon eat the same foods out in the ocean, so there should be no difference in the amount of Omega-3 fatty acids available from eating them.

Regarding toxins, it is important to note that some toxins are present throughout the ecosystem, not just in fish bred by people. One example is dioxins. Dioxins are a known human carcinogen and among the most toxic chemicals known. These persistent chemicals accumulate in the food chain and, over time, in human and animal tissues. Dioxins are present in both wild and farmed salmon, but they seem to be found in relatively larger quantities in farmed salmon, probably because farmed salmon are given so much artificial feed. This feed includes fishmeal produced from other fish where dioxins have already accumulated. So far, government health authorities judge that both farmed salmon and wild salmon are safe for human consumption. More thorough investigations of this are underway.

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3.15 How can we regulate and monitor ocean ranching in a credible way?

British Columbians would demand on-going monitoring and strict enforcement of regulations affecting wild salmon, with transparent decision-making, and input from the public including conservationist stakeholders. The corresponding regulatory regime in Alaska has shown effectiveness and BC can learn from it.

"In total there are about 33 hatcheries. Unlike a lot of other areas, there are 14 hatcheries in Alaska that have been started up and then closed. Alaska is not afraid to close hatcheries if they do not work." (Wertheimer et al)

If the reader agrees that the Alaskan model offers encouragement about the possibility of safely managing ocean ranching, it is still reasonable to consider the possibility that economic needs and lobbies might trump cautious science, either in the selection and design of an ocean ranching location, or in the decision about whether or not to close or alter a hatchery that began for all the right reasons but later turned out to pose an inappropriate risk.

If ocean ranching proceeds in BC, then conservationists should be involved in the design of regulations that have a clear bias for the protection of wild salmon, they should be members of the boards that make management decisions such as which species to ranch and how many, and they should demand transparency in all decision-making.

In Alaska, the Commissioner of the Department of Fish and Game has the authority to penalize ocean ranching operations that violate the terms of their permit, and the regulations have had teeth. For example, the Commissioner has exercised his or her right to alter, suspend, or even revoke a hatchery permit on several occasions. 28% of Alaskan hatcheries have closed in the history of the program for various reasons; 6 (about half) of those had their permits revoked for failing to live up to the terms of their permit.

Alaska definitely has room to strengthen its ongoing monitoring program, however the existing program has shown some effectiveness. Several Alaskan hatcheries have had their permits altered in response to new information. For instance some were told to reduce the amount of eggs they may use in order to diminish the risk of over-fishing a local wild stock in a mixed stock fishery. Some hatcheries have had their request to increase their production rejected (each hatchery is assigned a limit on how many salmon it may release).

Effective monitoring mechanisms must be built into the system from the start, as Winton and Hilborn (1994) note: "*although effective techniques to evaluate both natural and hatchery-reared stock performance obviously must be developed and installed at the beginning of a program, of equal importance is the need to design some system of continuing program monitoring and feedback to ensure that program goals are being met and that corrective action is taken if required. Otherwise, program evaluations may not occur*."

Here is an example of thorough and ongoing monitoring: Sockeye salmon are the most vulnerable to disease, so there is an inspection regime in Alaska that detects sick hatchery Sockeye and destroys the infected salmon. Strict fish health protocols are enforced.

McGee describes the Alaskan hatchery permitting process:

The Alaskan hatchery permitting process is rigorous and thorough and usually takes two years

• Hatchery must fit into Regional Salmon Plan
• Application reviewed for impact to wild stocks

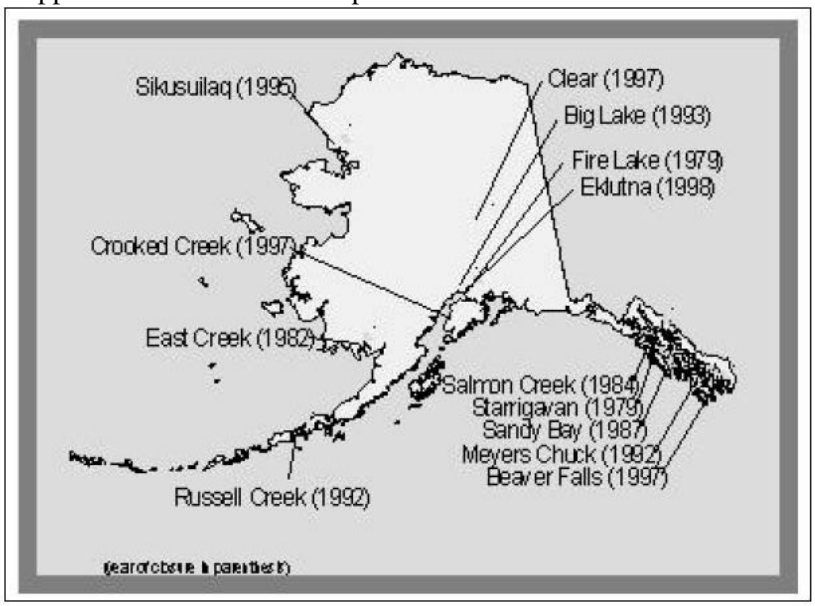


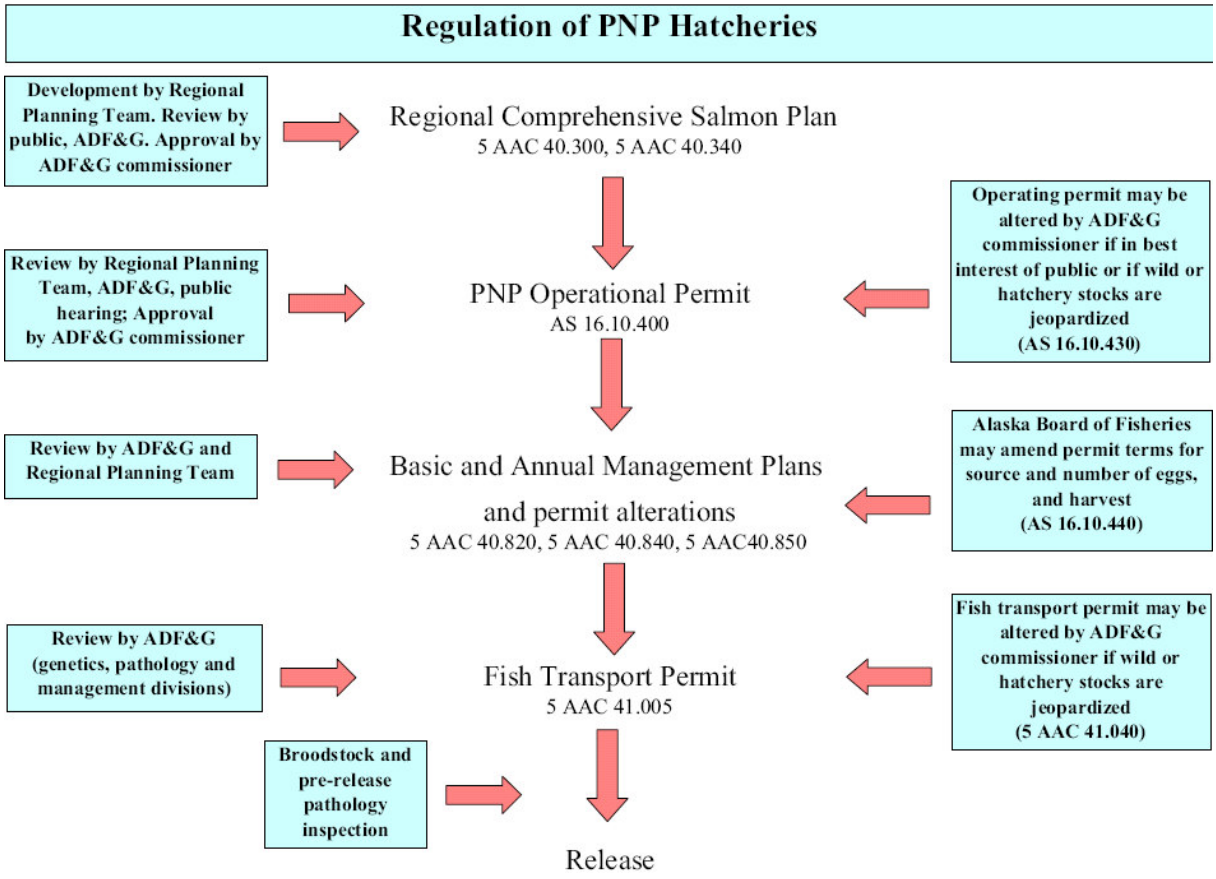
Figure 4 Location and names of the Alaska hatcheries that have closed since salmon ranching began in 1974. Source: Heard

• Public opinion solicited through formal hearing
• Multi-agency review involving state and federal agencies
• Use of specific brood stocks requires additional permits
• Approval of Annual Plan required for each year of operation
• Hatchery permits are non-transferable
• Tight regulatory oversight of hatcheries continues after operating permits have been issued
• Each facility is inspected at least every other year
• Each brood stock is examined for disease prior to its use in a hatchery
• The disease history of each stock must be kept current

• Samples of fish must be sent to the department's Pathology Laboratory for analysis whenever there is an incidence of disease
• An annual report containing information on hatchery returns, numbers of eggs taken, and numbers of fry or smolt released, by species and stock, must be filed.

Figure 5 depicts the entire permitting process, from hatchery permits to broodstock permits, that Alaska has chosen to adopt.

Figure 5 Alaskan regulation process for Private Non-Profit hatcheries. Source: McGee



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3.16 Will ocean ranching prioritize wild salmon and use the Precautionary Approach?

Ocean ranching would only proceed in areas and with methods that enable both wild stocks and common property fisheries to flourish in BC. Information gathered from ocean ranching can sometimes aid the management of wild stocks.

There is no inherent conflict between the goals of ocean ranching and the protection of wild salmon. If ocean ranching is managed with integrity and appropriate levels of humility and caution, with first priority going to wild salmon preservation, both goals are possible. In some circumstances, ocean ranching is inappropriate; in others, it is safe, and in some situations the information gathered from ocean ranching can even aid in the management of wild stocks (see otolith marking in question 3.3).

If ocean ranching were to proceed, British Columbians would justly expect that nothing short of the best available science and practices would be used, with regular monitoring and updating. Of course not even the best science can completely eliminate uncertainty, which is why the Precautionary Principle must be applied. The Box to the right provides an example of the kinds of principles that could guide ocean ranching in BC. Other questions in this report address specific measures that are taken in Alaska to protect wild stocks.

The Precautionary Approach has many definitions, but in essence it comes down to this. The Precautionary approach does *not* mean zero risk tolerance, but it *does* mean that incomplete information is not an excuse for inaction – some precautions need to be taken, especially when the hypothetical negative consequences are serious or irreversible.

Ultimately, it would be up to biologists to determine whether ocean ranching would be too risky in one area, and relatively harmless or beneficial in another area. If wild and ocean-ranched salmon could not be adequately segregated at a proposed new ocean ranching site, that site would not be approved. Another important decision that biologists and regulators need to make is to set an appropriate limit on the number of salmon that an ocean ranching association can release each year.

Principles for sustainable salmon management

Proposed in an extensive consultation process in Alaska. Principles are detailed at length in the report.

Principle I	Protect wild salmon and its habitat in order to maintain resource productivity
Principle II	Maintain escapements within ranges necessary to conserve and protect potential salmon production and to maintain normal ecosystem functioning
Principle III	Harvest salmon in a manner consistent with the degree of uncertainty regarding the status and biology of the resource
Principle IV	Establish and apply an effective management system to control human activities that affect salmon
Principle V	Maintain public support and involvement for sustainable use and protection of salmon resources

Source: Mundy

Wild salmon go through natural cycles, but fishers would prefer to have the opportunity to fish for more than just a couple of days or weeks each year. Ocean ranching can sometimes enable fishers to harvest while helping to alleviate the pressure on wild salmon fisheries. For instance, the government in Southeast Alaska absolutely refuses to permit fishers to begin the early salmon harvest until there is confirmation that ocean-ranched salmon are also returning. This ensures that most fishing vessels will be drawn towards the abundant ocean-ranched salmon, lessening the burden on wild salmon.

Since the ocean ranching association in the Northern-Southeast Region of Alaska is community-based and run by a broad spectrum of stakeholders and fishers, there are strong pro-wild salmon sentiments guiding the association. Members sometimes choose to take measures that protect wild salmon even when it costs them more. There are also ongoing instances of cost-sharing for wild salmon monitoring and habitat protection initiatives between the Alaska government and the ocean ranching association.

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4 Next Steps

The NBBC Executive have no doubt that the development and acceptance of a 'made in British Columbia' ocean ranching initiative will be a lengthy, complex, challenging and likely controversial task. It will also require considerable funding and capacity that the NBBC does not currently have. With this in mind, a well thought through and coordinated strategy based upon partnerships will be required to move forward on the task.

As one key initial part of this strategy the NBBC has taken a 'first step' to begin to put ocean ranching into a British Columbia context through the development of this Discussion Paper 'Ocean Ranching: Environmental Frequently Asked Questions (FAQ's)'.

The NBBC Executive views this Discussion Paper as an evolving document under a long term NBBC 'work in progress' initiative. The Paper is designed 'to be for discussion purposes only.' It is recognized that some agencies and organizations will consider that important questions have not been identified or addressed in the Paper. It is recognized that some of the statements in the FAQ material are very much subject to interpretation, and there will be differing and strongly held points of view on a number of key points. It is also recognized there is a great deal of information in some areas, and that considerably more research is required. That said, the NBBC Discussion Paper provides a much

needed basis to begin to enter into a rationale dialogue with parties interested in or concerned about ocean ranching.

With regard to the FAQ Discussion Paper, a core 'next step' is to undertake considerable dialogue with and input from a wide range of potential partners.

Subject to securing adequate funding support, key elements of this NBBC facilitated 'next step' FAQ dialogue process will take into consideration:

1. Positioning ocean ranching requires understanding the larger policy context. It also requires clearly demonstrating its value as a tool that can enhance the viability and sustainability of salmon, livelihoods and coastal communities. In addition, there is specific policy analysis required to design the minimal regulatory framework needed to advance a partnership based 'made in BC' ocean ranching strategy.

2. The critical issues of science related to protecting the genetic diversity and health of wild stocks are seen as a key reason for some scientific and environmental organizations fearing the idea of ocean ranching. These concerns have been and continue to be a critical priority in the Alaska program.

3. Exchanges between the scientific communities and promoting a better understanding of the management practices in Alaska that mitigate these important issues are important.

4. Building a strategy for entering into discussions with the Environmental Non-Government Organizations (ENGO's) is an important issue. Working pro-actively to link ENGO's in Alaska that have had long involvement in the ocean ranching with ENGO leaders in BC could be an important part of fostering greater understanding and productive dialogue.

5. Ocean Ranching is not well understood, indeed, it is misunderstood. Several decades ago when ocean ranching was first seriously discussed in B.C., it was strongly opposed by a number of parties with considerable justification. The core of the opposition was that the proposals of the day were based upon the principle of corporate ownership of the resource. The private sector would produce fish, and they would benefit from the fish they produced. Given principles such as non-profit societies and common property fish, the NBBC approach is fundamentally different. Critical work is required to elevate awareness and foster understanding at several levels ranging from fishers and coastal community leadership to senior politicians.

6. It is crucial to articulate a vision that demonstrates how fishers, First Nations and other coastal communities can share in the investment and the benefits from ocean ranching. Ocean Ranching must have a focus on enhancing BC salmon stocks and their utilization as a common property resource managed by all stakeholders, as opposed to pure corporate or pure government management and ownership of salmon resources.