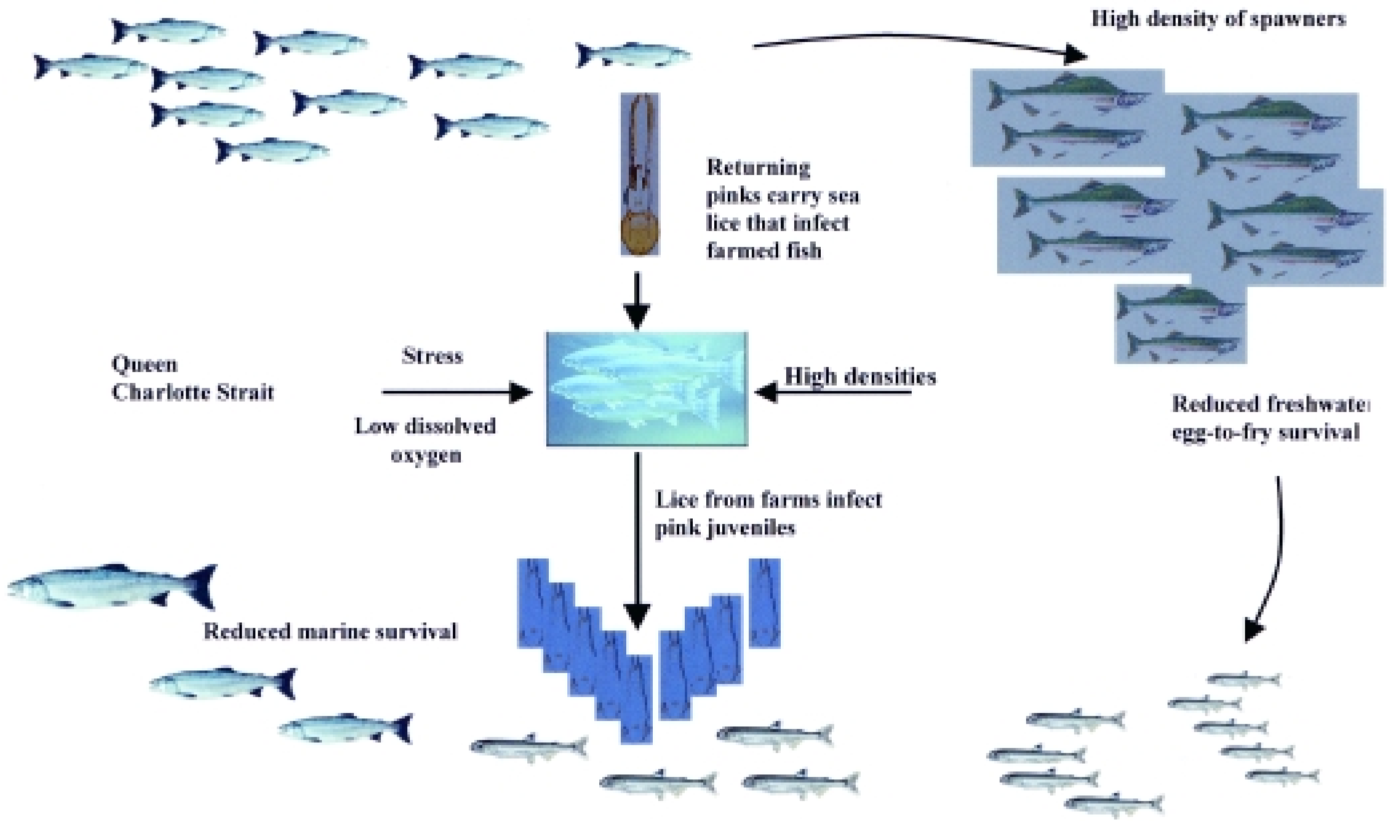
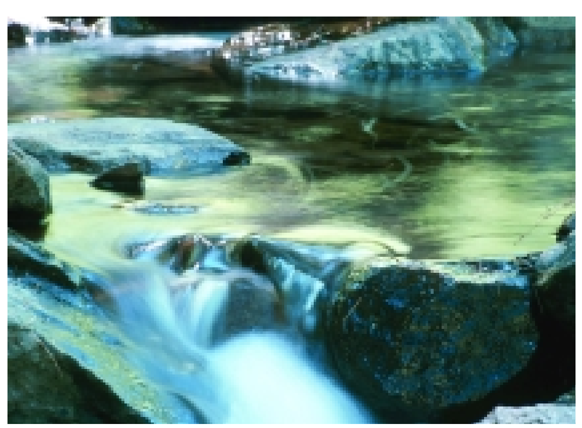
Broughton study area, July-October 2000



Possible scenario describing the impacts on production of the 2000 brood year pink salmon migrating through the Broughton Archipelago.

Financial support for this report has been generously contributed by the Park Foundation.



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Possible Factors Contributing to the Low Productivity of the 2000 Brood Year Pink Salmon *(Oncorhynchus gorbuscha)*

that migrate through the Broughton Archipelago, BC, Canada

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Summary

Pink salmon *(Oncorhynchus gorbuscha)* that migrate through the Broughton Archipelago of British Columbia, both as adults and juveniles, had a very poor return in 2002. Fewer than two fish returned for every 100 spawners counted in 2000. This triggered concern regarding the status of wild populations within the region.

The objective of this report is to review the possible factors contributing to the low productivity of the 2000 brood year pink salmon in the Broughton Archipelago. We conclude that this low productivity is a result of cumulative impacts from marine adult migration, through freshwater spawning and incubation, to early marine residence.

We know the following:

- The observed returns of pink salmon to 11 watersheds in the study area in 2000 were the highest on record.
- The return per spawner for 2000 brood year pink salmon in the study area was the lowest on record.
- The return per spawner of 2000 brood year pink salmon in adjacent areas was significantly higher.

These data lead us to believe that the low survivals of the 2000 brood year pink salmon that migrate through the Broughton area were the result of impacts occurring

Aerial Photo: Otto Langer
Fish Photo: Alexandra Morton

sometime between spawning and the emigration of juveniles from the near-shore marine rearing to the open ocean. Within this time period, there are many possibilities that could have affected survival in both the riverine and marine environments.

Possible impacts in the freshwater spawning and incubation to fry emigration phase include temperature and discharge effects. Unfortunately, there were no environmental data from the key study streams that could help us, so we used Port Hardy, BC weather data as a surrogate. We believe that these data give a general indication of weather-related events in the study area.

Very high water temperatures during adult migration and spawning can cause prespawn mortalities, and very cold water temperatures prior to blastopore closure will kill salmon eggs. Weather records from Port Hardy and Pine Island, British Columbia, indicated that air temperature, sea surface temperature, and salinity were all within the normal range for late summer to spring during the 2000 brood year spawning and incubation period, suggesting no temperature impacts.

Extremes in river discharge have prevented access to the streams, restricted spawning areas, scoured spawning beds, and caused major siltation in the study area streams over the past 50 years. Precipitation records from Port Hardy indicate lower than normal total precipitation from late summer through the winter of 2000-2001. Low precipitation could have resulted in low discharge in non-glaciated streams during adult migration, which in turn could have caused access problems. However, the Department of Fisheries and Oceans (DFO) has modified the streams with a number of salmonid enhancement projects that improve access through trouble spots, and DFO officers did not report any blockages in 2000. Due to ice melt, lower than normal discharge would probably not occur in glaciated systems during summer.

High rainfall can cause high stream discharge, which can reduce the survival of salmon eggs through siltation and scouring. This is believed to have occurred in 1980, when a record 153.8 mm of rain fell on December 10. The highest daily rainfall during the 2000 brood incubation period was 52.6 mm on October 17. This was not considered problematic, as this level of rainfall is common in this area, with 48 out of 62 years having daily precipitation exceeding 50 mm during the spawning and incubation period.

These data lead us to believe that the low survivals of the 2000 brood year pink salmon that migrate through the Broughton area were not the result of temperature or discharge impacts during the freshwater life history phase.

Pink salmon spawner density was considered to be a possible impact on freshwater survival, given the record escapements. A measure of spawning habitat carrying capacity is necessary in order to assess the impact of density. Ground-based habitat assessments were completed for three streams in the study area. In order to assess the others, we used a habitat model that was based on Terrain Resource Information Management (TRIM) map data. The model assessment was slightly higher than the ground-based estimates in all three streams.

The next question was how exceeding the spawning ground capacity influences survival. The best method is to have a time series of accurate escapement estimates based on fence counts or mark-and-recapture programs combined with a mark-and-recapture program to assess fry production. No data of this type were available for the pink salmon in the study area. We therefore used data from sockeye studies in the Adams River and pink studies in Cayoosh Creek. Although both systems were in the Fraser River watershed, we believe that these data are reasonable given the benign environmental influences on spawning and incubation during 2000-2001.

These data lead us to believe that high spawner densities contributed to the low survival of the 2000 brood year pink salmon that migrate through the Broughton area. We conclude that fry production was less than half that expected from the previous two brood years. The total spawning populations of the previous two broods were less than half that of 2000. That is, the 2000 brood, with over twice the spawners of the previous two broods, produced less than half the fry.

While this is a significant reduction, it does not explain all of the reduced survival for the pink salmon returning in 2002. We therefore believe that impacts in the early marine phase of the life cycle must have contributed significantly to the low pink salmon production from the 2000 brood spawning.

Regarding the early marine residence of pink salmon juveniles, we know that:

- The complexity and extent of shoreline throughout the islands in the Broughton area, combined with extensive shallow near-shore bathymetry within the study area, create a high-quality nursery area for pink juveniles migrating from the study streams to the ocean.
- There was no evidence of an unusual distribution of large populations of predators in Queen Charlotte Strait that would selectively prey on pinks exiting the study area in 2001.
- Several local residents in the study area observed high numbers of dead and moribund pink juveniles carrying lethal levels of sea lice in the spring of 2001. Consequently, sampling of pink juveniles was carried out from June through early August in near-shore areas where pinks would be expected to rear.
- Experimental evidence indicates that a sea lice burden of over 1.6 lice per gram of fish is always lethal and burdens as low as 0.75 sea lice per gram of fish can be lethal.
- Biologist Alexandra Morton reported that the infection rate of the sea louse, Lepeophtheirus salmonis, ranged from 68% to 99% based on samples captured by dip net. She also reported that sea lice burdens ranged from 13% to 81% of juvenile pink salmon infected with lethal levels.
- Based on studies in the Gulf Islands and Alaska, we expect pink salmon juveniles to remain in the nursery area until lack of food forced dispersion, usually when fry are larger than 65-70 mm.
- A large number of fish farms occupy areas in or close to the pink salmon nursery area. These farms are raising Atlantic salmon, a species that, in high densities, is vulnerable to sea lice infestation. Although no direct evidence of a causal link between L. salmonis on farmed salmon in this area and mortality of wild juvenile salmon has been found to date, these data indicated that a closer look was warranted.
- A relatively low infestation rate of sea lice on fish in farms will produce very high levels of the infectious stage in nearby waters due to the large numbers of host fish.

Unfortunately, we were denied access to sea lice and environmental data collected by Stolt Sea Farm in 2000-2001. We therefore used Port Hardy weather records and Pine Island Lighthouse data from DFO to enhance our understanding of events in 2000-2001.

The low rainfall that occurred when the 2000 brood pink salmon were migrating through the study area, combined with salinities greater than 30 ppt, would have created environmental conditions conducive to the transfer of sea lice from returning feral fish to farmed Atlantic salmon. The low rainfall in the late winter and early spring could have resulted in salinities remaining above the threshold of 30 ppt in the area of fish farms. This would have provided environmental conditions favourable to the proliferation of the infectious stage of L. salmonis, setting the stage for very high levels of the infectious stage overlapping with the juvenile pink salmon migration, which leads to the high levels of infestation.

We have observed that when compromised fish are easily seen in these kinds of numbers, the impact on fish populations is serious. We do not see compromised or moribund fish in situations where their numbers are low due to rapid removal by predation and the difficulty of spotting them in the field.

The sample size was several times larger than that required to establish with 95% confidence that L. salmonis was distributed throughout the juvenile population rearing in near-shore nursery areas if the samples are random. The debate on whether the samples taken in 2001 were random will not be resolved until parallel studies are conducted using a suite of sampling techniques, including dip netting.

We conclude that serious mortality occurred in the early marine residence of pink salmon juveniles in the Broughton nursery area. Although we have not seen any direct evidence to date linking transmission of sea lice from sea farms in the study area to wild pinks, these data strongly suggest that sea lice from farms had a serious impact on the survival of the 2000 brood pinks under environmental conditions that prevailed in 2000-2001. However, there is no evidence to indicate whether L. salmonis was the primary invader (the root cause of mortality) or a secondary invader (an opportunistic parasite taking advantage of an already weakened immune system). This question of whether sea lice were the root of the problem or a secondary invader will probably never be answered for the 2000 brood year pinks without the cooperation of the sea farm industry.

If the sea lice were secondary invaders, then there had to have been another serious problem regarding the health of the fry. Primary invaders could have been bacterial, such as furunculosis or vibrio, or viral in nature. These are not unusual epizootics in the sea farm industry, and given the overlap between farm sites and juvenile pink habitat, it is feasible that lateral transmission could have taken place.

The diagram on the back page summarizes a possible scenario describing the impacts on production of the 2000 brood year pink salmon migrating through the Broughton Archipelago.