Restoration of Cook Inlet Herring Fishery

by

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Abstract

The Pacific herring (*Clupea pallasii*) population in the Lower Cook Inlet and its related fishery have been severely affected by over harvesting and other factors. Pacific herring have a pelagic lifestyle. This means they spend most of their time at sea and not near the shoreline. When a predator catches a herring, it gets a large boost of energy. This high energy output causes herring to be preyed upon by many different species making it a vital part of the oceanic food web. Thus, when the herring population in Cook Inlet dropped due to over harvesting by local fisheries, it was of considerable interest. In the following pages, insight as to why and how this happened is described. Past influences on the herring population, as well as current influences were gathered and reviewed. The factors of the herring decline were over harvesting, changes in environment, humpback whale predation, and diseases. The management plan that seemed the most effective was the construction of an open pound hatchery, while cleaning and improving the conditions of the surrounding environment. The goals for this project are to aid the recovery of herring and reinstate a successful herring fishery in the Lower Cook Inlet.
Problem

In Cook Inlet, the herring population decreased so dramatically that the herring fishery was shut down. Hypotheses as to the cause of this are as follows: over harvesting, changes in their environment, predation by whales, and diseases that are killing the herring have brought the population so low that its recovery is threatened.

Over harvesting is thought to be one of the major causes for the herring population’s decrease. In Cook Inlet, this over harvesting was the main cause of the fishery’s closure from 1980-1984 (Welch, 2011). At that time, fishermen started to use seine netting instead of gill netting. Unlike the gill nets of before, which caught only the larger herring for processing, the seine netting caught everything that was within its area. The seine nets were catching juvenile herring and causing the population to be unable to sustain itself, whereas the gill nets only caught larger herring that, for the most part, had already reproduced. This created an unsustainable environment for the herring which was reflected by the decrease in biomass of herring during these years. The fishery reopened in 1985, and consequently, harvests peaked in 1986 with 4,842 tons (Klein, 1981). By 1995 the herring population was so diminished that such a harvest would be impossible.

In Cook Inlet, changes in the environment may also have contributed to the herring population’s decrease. At many small herring processing factories in Halibut Cove Lagoon, waste was being dumped directly into the water (Springer, 1997). The abundance of waste, lack of ocean currents, or water stratification caused anaerobic environments in which the herring were unable to live. This waste was numerous enough that fish were rarely, if ever seen alive near the shoreline. This was likely a factor in the herring population’s decrease.
Other factors towards the decline in the herring population are diseases such as ichthyophoniasis (also known as ichthyophonus), viral erythrocytic necrosis, and viral hemorrhagic septicemia. These diseases are killing the herring before they are able to reproduce, and in some cases before they are able to be contained and studied. Ichthyophoniasis is a pathogen that causes ulcers that kill herring (Meyers, 1999). This pathogen was found to be most prevalent in fish in 1994, with 8% of caught herring having symptoms. Following 1994 was a decrease in the prevalence of this disease. However, in 1998, the prevalence of this pathogen in the herring reached a similar height as to that of the 1994 outbreak. Viral hemorrhagic septicemia has also affected the herring. In 1994 and 1995 the percent of fish with this disease was below 5%, and in 1996 it was thought that the disease had gone entirely. A drastic leap in 1997, however, shattered that theory. Viral hemorrhagic septicemia was seen at rates of greater than 14% (Meyers, 1999). This was another factor in the herring population decrease.

Humpback whale predation is a relatively new development in the understanding of the herring’s ecology. Humpback whales have the ability to eat herring in large quantities. In the example of the herring fisheries in Prince William Sound, whales have been passing through schools of herring, taking in large amounts. In some cases, the whales have responded to the sound made by opening hatchery doors, and thus have removed large parts of the exiting population of herring. This may have been a substantial factor in the decline of the herring population.

**History of Herring in Cook Inlet**

The Cook Inlet herring fishery started as a subsistence fishery for both native and non-native peoples on a small scale and didn’t become a commercial fishery until after 1914 when a
new curing method was invented and introduced. The Cook Inlet herring fishery consists of two primary fisheries; the fisheries of Kachemak Bay and Kamishak Bay (Fig. 1). Today there is little to no large scale herring fishing in Cook Inlet. Only a small run of herring return to Seldovia Bay. Their numbers are too few for commercial fishing and the herring is only gill netted for personal use by individuals.

Figure 1. Lower Cook Inlet salmon and herring management areas (Hammarstrom et. al., 2007).

Seldovia was named for its abundance of herring by the Russians and is named from the Russian word “Seldevoy” meaning “bay of herring.” This name first appeared on Tebenkov’s 1852 atlas of the Northwest Coast of America. In 1910, Seldovia’s human population exploded. For the most part, the herring fishing in Seldovia lasted from 1910 to 1940. As reported in Pacific Fisherman’s Yearbook in 1919, there was only one herring processor in Seldovia and the
processor packed 900 barrel of herring that year. By 1926, there were 19 packing companies plus
individuals processing herring with some companies packing as many as 3,599 barrels of herring
per year. By 1935 there was only one processor left in Seldovia producing only 89.5 barrels. By
1940 there was only one company and they were taking herring from Seldovia to be packed in
Kodiak (Springer, 1997).

The Halibut Cove settlement was born in 1911 due to the development of the herring
fishery in Kachemak Bay parallel to the Seldovia fishery. The Halibut Cove fishery ended in
1928.

Historically herring were gill netted and harvested for roe, which is a delicacy in oriental
communities. Gill netting was the main fishing technique used in Halibut Cove in 1926 as
described by George A. Rounsefell (1930), “Those gillnets used at Halibut Cove were 50
fathoms and 100 meshes (about three fathoms) in depth and are anchored in one stop while
fishing. The mesh used is supposed to be three inches across (stretched measured). Since herring
seldom gill in daylight, the nets are usually let down at night. The gillnets, or set nets, as used at
Halibut cove, are anchored at both ends and kept up with buoy kegs.” (page 232). Herring was
also harvested for bait and fertilizer and was commonly packed in barrels with salt for
preservation. Another less common way of preserving herring was pickling it for human
consumption. Herring was also reduced to oil and meal.

The herring fishery collapse was due to many variables: one was over fishing, another
was destruction of habitat by the dumping of offal into the bay, and the third was less demand for
the fish. There were no regulations to prevent the collapse. The herring fishery was short lived
due to many factors including quality and quantity of fish, availability of markets and
competition from both American and foreign fisheries.
More recent fisheries in the Lower Cook Inlet area have provided recent harvest numbers (Otis and Cope, 2004). Harvests happened during 1978-1979 and 1985-1999 (Table 1).

Table 1. Commercial herring harvest abundance (x1,000) by harvest year, Kamishak Bay District, Lower Cook Inlet, 1978-2003 (Otis and Cope 2004).

| Harvest Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total Harvest |
|--------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|-------------|
| 1978         | 0 | 55| 400|1,333|913 |93 |88 |131|110|110 |44  |11 |0  |0  |0  |0  |3,310        |
| 1979         | 0 | 0 | 0 | 618 |531 |1,012|725 |31 |31 |40  |21 |21 |21 |0  |0  |0  |3,079        |
| 1980         | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest |
| 1981         | 0 | 0 | 0 | 2,342|3,088|476 |5,113|3,612|3,666|2,454|3,182|1,335|579 |476 |112 |9  |36,504       |
| 1982         | 0 | 0 | 0 | 120 |5,590|5,338|592 |5,140|5,187|2,743|1,231|1,485|481 |82 |103 |14 |25,735       |
| 1983         | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest |
| 1984         | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest | No Commercial Harvest |
| 1985         | 0 | 0 | 0 | 10 |569 |700 |1,114|739 |1,177|413 |253 |204|49 |0  |0  |0  |5,258        |
| 1986         | 0 | 0 | 0 | 1,095|227 |1,028|889 |1,336|1,190|1,609|647 |25 |196 |28 |8  |0  |8,556        |
| 1987         | 0 | 0 | 0 | 2,342|3,088|476 |5,113|3,612|3,666|2,454|3,182|1,335|579 |476 |112 |9  |36,504       |
| 1988         | 0 | 0 | 0 | 120 |5,590|5,338|592 |5,140|5,187|2,743|1,231|1,485|481 |82 |103 |14 |25,735       |
| 1989         | 0 | 0 | 0 | 12 |388 |7,599|4,764|823 |2,765|1,615|1,158|918 |662 |234 |51 |37 |21,086       |
| 1990         | 0 | 0 | 0 | 154 |364 |603 |4,337|2,333|647 |789 |444 |211 |94 |34 |26 |2  |15,043       |
| 1991         | 0 | 0 | 0 | 1,102|697 |787 |941 |3,690|1,462|45  |270 |112 |22 |22 |0  |0  |9,154        |
| 1992         | 0 | 0 | 0 | 87 |3,443|1,848|520 |491 |1,415|491 |115 |173 |29 |39 |58 |0  |13,600       |
| 1993         | 0 | 0 | 0 | 26 |367 |10,077|2,842|945 |945 |1,916|600 |105 |52 |26 |26 |0  |17,477       |
| 1994         | 0 | 0 | 0 | 187 |343 |4,589|949 |654 |488 |971 |507 |77 |33 |53 |22 |20 |8,913        |
| 1995         | 0 | 0 | 0 | 49 |346 |673 |1,015|6,919|1,356|736 |724 |756 |312 |66 |0  |0  |13,040       |
| 1996         | 0 | 0 | 0 | 49 |687 |1,017|1,006|1,227|5,691|1,006|383 |245 |196 |148 |0  |0  |11,727       |
| 1997         | 0 | 0 | 0 | 543 |1,911|1,006|564 |1,016|941 |2,004|259 |98 |66 |21 |0  |0  |8,490        |
| 1998         | 0 | 0 | 0 | 71 |220 |694 |281 |93 |129 |89 |94 |9  |7  |0  |0  |1,693        |
| 1999         | 0 | 0 | 0 | 52 |37 |121 |181 |77 |26 |23 |9  |7  |1  |0  |0  |534          |

The success of any fishery is dependent upon its market; the Japanese market impacts the herring fishery. The delicacy of herring roe was very popular among the older generations. Recent national disasters have impacted the market, leaving it unstable and not leaving much room for delicacies.

Herring are a great source of nutrients for many animals above it on the food chain including Stellar sea lions, seals, porpoises, belugas and many species of birds. These predators feast on the fish as well as the sticky eggs deposited by females. Herring deposit their roe on
vegetation in intertidal areas. Herring in Kachemak Bay were unusually large, around 12 to 14 inches long compared to the Baltic herring which can be as small as 14cm.

For a herring population to be successful it needs the proper habitat for the herrings’ different life stages. The readiness to spawn seems to be related to surface temperatures and ocean currents. Weak currents lessen the chance of eggs washing away (Brown and Carls, 1998). Herring lay their eggs in shallow waters on eelgrass, rockweed and other seaweeds. After the adults have spawned they return to deeper waters. The incubation time for the herring roe is determined by the temperature. The roe is food for birds and fish along with several species of marine mammals.

When larvae emerge from eggs they are very vulnerable. Strong ocean currents can sweep them away along with predations from invertebrates and fish. The larvae have a yolk sack that will last for about one week. When the yolk sack is gone they begin to feed on zooplankton. Juveniles stay in the shallow waters for 1-2 years. These shallow waters serve as sanctuaries where they can feed and grow. The juvenile herring fall prey to seabirds and marine mammals because they can be easily found on surface waters and are packed full of energy. After two years herring journey out to deeper waters with older adults to begin feeding. When these herring hit the 3-year mark they will start spawning themselves.

The herring population of some areas of Lower Cook Inlet have not recovered from the commercial herring fisheries in this area. Reasons why the herring have not recovered in Lower Cook Inlet are: predation on the juveniles and adults, habitat loss and change, and disease. By looking at the life cycle of herring and the ecosystem in which they live we can find the factors affecting their recovery.
Many animals predate on herring. This includes whales, seals, fish, and sea birds. It’s hard being a herring. Herring eggs are eaten by seabirds and sea lions. Herring larvae are eaten by jellyfish. Herring juveniles are eaten by more seabirds and marine mammals. When finally an adult, humans, seals, and fish are all trying to catch them. In Prince William Sound it is suspected that humpback whales are slowing down the herrings recovery. Although anecdotal accounts suggest that whale predation is also affecting the recovery of herring in the lower Cook Inlet, there is no scientific proof.

Alaska has many glaciers that empty into the sea. This addition of fresh water lowers the salinity of waters along with adding more sediment and minerals from the erosion of creek and rivers. Multiple glaciers empty into Kachemak Bay. The Bay in general, but especially the south shore, has quite low salinity because of glacial run off. From available information, eggs have a tolerance for a large range of salinity, though at a very high salinity herring larvae showed signs of deformation and developmental problems (Alderdice, 1971). When the sediments washed down the rivers from glacial melting settle they can cause many different problems for herring eggs. The sediments can smother herring eggs to where they don’t hatch. Even very thin layers can cause a large loss of eggs (Speight, 2010).

The Kachemak Bay herring stock is isolated from other herring stocks in Cook Inlet because of the water circulation patterns. These patterns keep the fish in the Bay. This also limits the chance of diseases like ichthyophonous from getting a foot hold in a population. Other stocks however are not so lucky. Populations left straggling because of overfishing or past disease are more susceptible to new disease in the area. Kamishak with more open areas to the inlet, along with its current low population make it quite open for disease. The disease mentioned earlier, ichthyophonus, is a fungus-like organism that is chronic, it decreases the lifespan of affected
fish, but probably does not play a major role in unexpected population fluctuations. Ichthyophonus can contribute to population decrease when the population is old (Marty, 1999).

The herring population of the lower Cook Inlet is monitored by aerial surveys and seining boats. The herring population numbers from the past (i.e. early 1900’s) is comprised of hard data from herring fisheries catch. The data on the current populations of herring however are estimates based from the aerial surveys. “Aerial surveys are conducted annually throughout the herring spawning season in the Kamishak Bay and Southern Districts, from late April through early June, to determine relative abundance and distribution of herring.” (Hammarstrom, et. al, 2007) “Due to invariably poor weather and water clarity, aerial surveys rarely provide reliable estimates of total herring biomass returning to Kamishak District Bay waters. As a result, an age-structured-assessment (ASA) Model has been used for the past 14 years to forecast herring abundance for Kamishak Bay, as well as to “hindcast” previous years’ total abundance.” (Hammarstrom, 2007) It needs to be remembered that the aerial surveys also can’t see all the groups of fish. This means that there is still the variable that fish from past and current surveys could have been missed.

Solution

There is no easy fix to solve the problem of the decline in the herring population in the Cook Inlet area. The most effective solution, however, which could also be done in a timely manner, would be a herring hatchery for Cook Inlet. Based on the history, ecosystem factors, economic value we propose the following management plan to restore the population.

The Pacific herring hatchery could be established in Kachemak Bay, Alaska. From data collected in 1926 by NOAA (http://fishbull.noaa.gov/45-1/rounsefell.pdf), it has been found that
herring do well in Halibut Cove Lagoon, Halibut Cove, McDonald Spit, and Homer Spit Lagoon. These four places could be stocked with Kachemak Herring in the months of April-May of every year, and the areas where they are released would become marine protected areas. This would restrict human activity in the interest of conserving the natural environment, its surrounding waters and the occupant ecosystems, and any cultural or historical resources. Restrictions in the marine protected areas include absolutely no fishing in halibut cove lagoon, and in the other three places, fishing would be off limits from shore extending out a mile and a half. This gives the herring, as well as the phytoplankton and zooplankton which are eaten by herring, shelter and the many nutrients they need to flourish. In the hatchery the eggs will be able to live off of silt, which would kill them, and around the much needed vegetation.

There are still some concerns, the most critical being disease. Governmental agencies in the Northeast and elsewhere in the United States and other countries have established fish health management programs that mandate periodic testing of aquaculture populations and certification that these populations are free of specific exotic or high risk pathogens. It is important to note that such fish must be "free of the pathogen,” not simply without overt disease symptoms. Our natural hatchery in Kachemak Bay would have frequent samples taken to determine if any diseases or parasites attack the fish.

**Management Plan**

There is no easy fix to solve the problem of the decline in the herring population in the Cook Inlet area. The most effective solution, however, which could also be done in a timely manner, would be a herring hatchery for Cook Inlet. Based on the history, ecosystem factors, and
economic value, we propose the following management plan to address the restoration of the herring fishery.

The tool to bring back the Kachemak herring population would be a hatchery. The Kachemak herring hatchery will be established in Kachemak Bay, Alaska. From data collected in 1926 by NOAA (http://fishbull.noaa.gov/45-1/rounsefell.pdf), it has been found that herring do well in Halibut Cove Lagoon, Halibut Cove, McDonald Spit, and Homer Spit Lagoon, and Seldovia.

We have considered the Kachemak herring hatchery to be the most efficient way of bringing the herring back but due to disease issues and cost, a cheaper and more sustainable solution would be habitat enhancement and an open pound hatchery. We propose that the open pound hatchery be owned and managed by the state. Alaska Department of Fish & Game would be the agency to carefully watch over the comeback of the herring population. ADF&G currently has regulations in place for the management of hatcheries and fisheries (Ted Otis, pers comm.).

An open pound fishery is a floating cage that is open on top, has net around the sides and bottom and has kelp hanging in it. The net would be a mesh that is small enough to keep the adult herring in but large enough that water could easily flow through the open pound, supplying the herring with plenty of oxygen. Once the eggs have been deposited and the adult fish releases, the mesh net would then be switched out with a fine mesh small enough to keep the hatched herring in and potential predators out. The net would be monitored daily to ensure that there is no buildup of algae or any other object or organisms that could potentially stop the flow of water through the pound. To fill the open pound, we would get a contract with a seine boat to retrieve some herring from the Kachemak Bay population and dump them into the pound. Being unable to leave until they spawn, the eggs they produce would fall on the kelp. The adults would then be
released and free to live their lives while the eggs would then be kept inside the pound for the first few months of their life until they can effectively swim on their own. A facility would be created to grow food for these newly hatched herring and we would fertilize the water with the necessary plankton herring need. The pound would be placed near the closest juvenile habitat and where research shows that they do best, in Halibut Cove Lagoon, Halibut Cove, McDonald Spit, and Homer Spit Lagoon, and/or Seldovia. Further research would be done to check the temperature, salinity, and substrate of these locations to ensure they truly are the best locations for the fish to be placed.

The main goal of the hatchery is to bring the herring population back. Currently, the herring population is not coming back naturally, but with our help, once we bring it back, it will be able to sustain itself. We intend to monitor these populations with cast nets four times a year for juveniles, herring aged 0-1. However, during the time of spawning, which takes place from April-May, monitoring would be done every two weeks to closely look at the herring. Also an annual survey would be done both by aerial surveys and by test seining. All monitoring would be to look at the numbers of the herring and the size and the overall health.

Currently the minimum number of herring needed for the Kamishak Bay fishery to be open is 6,000 tons, however, after the open pound has been established further research could be done to find the optimal number of herring needed in Kachemak Bay. Once the appropriate number of herring has been met, a fishery can be created once again. Fishing could occur in the Cook Inlet area however Kachemak Bay would be off limits completely to bottom trawling, due to the fish spawning in this area.

The areas where they are released would become highly protected critical habitat areas. This would restrict human activity in the interest of conserving the natural environment, its
surrounding waters and the occupant ecosystems, and any cultural or historical resources.

Restrictions in the highly critical habitat areas include absolutely no commercial herring fishing in Halibut Cove Lagoon, and in the other four places. This gives the herring, as well as the phytoplankton and zooplankton which are eaten by herring, shelter and the many nutrients needed to flourish.

A potential roadblock would be the storms negatively affecting the open pound’s anchor. During rough storms, the open pound could possibly break loose from its anchor and float out to the ocean. With further research, the best anchors could be found to keep the pound in place during the roughest of storms.

Another concern to this solution would be whales that have been known to wait outside of salmon hatcheries, for the salmon to be released. The whales could also wait outside of where the herring are released. However a way to address this problem would be to put some low frequency sonobuoys near where the Kachemak herring are released each year. The sonobuoys, which emit low frequency bursts of sound would act as a deterrent. This would address this situation and allow the herring to safely go out into the bay.

Finally, something that would need to be considered would be the impact that bringing the herring fishery back would have. Not only would this further develop a herring fishery but also other fisheries such as the halibut fishery. Being a main food source for halibut, once the herring population grows, it will increase the amount of food available to the halibut. This would bring more halibut into the picture, creating more stable fisheries.
Conclusion

The population of the Kachemak herring has declined dramatically in the past 30 years. The problem of the lack of herring in Cook Inlet can be fixed. It will, however, take time, money and the combined effort on the part of many people and agencies. Being a vital part of the oceanic food chain, it is imperative that an open pound be established in the Halibut Cove Lagoon, Halibut Cove, McDonald Spit, and Homer Spit Lagoon areas. With habitat enhancement, Kachemak herring can live a live full of the much needed nutrients and shelter they require.
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