BACKGROUNDER
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Technical Report Project 4 – Marine ecology

Project description: The researcher will review the marine ecology of Fraser River sockeye salmon to determine whether there are oceanographic factors that can explain the reduction in short-term and long-term Fraser sockeye productivity.

Researcher: The North Pacific Marine Science Organization (PICES) is an intergovernmental scientific organization, established in 1992, whose present members are Canada, Japan, People's Republic of China, Republic of Korea, the Russian Federation, and the United States. The purposes of PICES are to promote and coordinate marine research in the northern North Pacific and adjacent seas; to advance scientific knowledge about the ocean environment, global weather and climate change, living resources and their ecosystems, and the impacts of human activities and to promote the collection and rapid exchange of scientific information on these issues.

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This report reviewed studies of North Pacific Marine ecology and carried out new analyses to understand the conditions in the North Pacific Ocean that may have affected Fraser River sockeye. The researchers aimed to answer:

- *Can the decline in Fraser sockeye in 2009 be explained by the conditions the fish experienced in the marine environment?*

- *Is there evidence for declines in marine productivity or changes in Fraser sockeye distribution that can be associated with the 15 year gradual decrease in Fraser sockeye productivity?*

2009 Returns

The research identified the times and locations where extreme conditions in the ocean could potentially have caused extremely low survival of Fraser River sockeye salmon, yet allowed other sockeye populations to have average to good survival. Most of the Fraser River sockeye that did not return in 2009 entered the ocean in 2007, so the researchers analyzed the marine environment from 2007 looking for answers to explain the low 2009 return.

They found that an El Niño during the winter of 2006/07 combined with an unusual spring/summer climate in 2007 conspired to generate an atypical coastal ocean that year – one that was likely detrimental to Fraser River sockeye salmon growth and survival.

- El Niños tend to intensify Northeast Pacific storms and cause an eastward shift in their path. By late winter, parts of Central BC had extreme snowpacks. A cool spring in 2007 delayed the melt and allowed more snow to accumulate. Rapid warming in late May and an intense spring storm in early June brought heavy rain on top of the deep snow. The end result was extremely high discharge by Central and North Coast rivers in the summer of 2007 that set the stage for a very unusual ocean in Queen Charlotte Strait and Queen Charlotte Sound, the migration route of most juvenile Fraser River sockeye salmon.

- Record high river discharge in the summer of 2007 created a thick surface layer of relatively fresh water to develop along the Central Coast. Being lighter than the saltier
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water below, it didn't mix into the cooler deeper water, so the warmer surface layer that summer likely acted like a cap that restricted nutrients and impaired plankton growth, and created an atypical environment through which the Fraser River sockeye smolts had to pass.

- In addition to these oceanic extremes, a very unusual wind pattern developed in the spring and summer of 2007, which coincided with a very late spring plankton bloom. The delayed bloom could have made less food available for migrating sockeye smolts.

- Oceanic conditions were less extreme in the Strait of Georgia and different on the West coast of Vancouver Island, and the U.S. west coast, suggesting that Queen Charlotte Sound is a location where extremes in climate, oceanography and biology could have affected Fraser River sockeye salmon growth and survival.

The delayed spring in Queen Charlotte Sound in 2007, when added to the incremental energetic cost of migrating through a warm surface layer with a potentially reduced food supply in 2007, could have combined to reduce Fraser River sockeye growth and survival leading to much lower returns of Fraser River sockeye in 2009.

Long Term Decline

Identifying the cause of the long term decline begins with understanding the nature of the change in productivity over 15 years. Persistent periods of high and low productivity of Pacific salmon have been reported by scientists since the 1950s. When the median productivity of 16 Fraser River sockeye stocks was examined, there was an abrupt shift to lower productivity (rather than a trend) beginning with the 1992 ocean entry year.

The 1992 ocean entry year for smolts appears to divide a period of high productivity from the beginning of a period of low productivity. This same year saw abrupt declines in sockeye populations in other watersheds such as Rivers Inlet, but the persistence and magnitude of the declines has been variable. While there was a large El Niño that winter, 1992 is not recognized as a year of large-scale climatic change in the North Pacific. On the other hand, the summer of 1992 marked the reappearance of sardines in BC after a 47-year absence, perhaps indicating a fundamental oceanic change that is not yet understood. Marine factors, therefore, may not fully explain this shift to lower productivity.

The timing of this study of Fraser River sockeye salmon abundance in relation to marine ecology allowed an opportunity to make a contrast between the low returns in 2009 and the high returns in 2010. As in 2007, Fraser River sockeye salmon smolts migrated through a relatively warm surface layer in the Strait of Georgia in 2008, but arrived at a coastal ocean that was significantly colder and more Subarctic in character than had been seen on the BC coast in decades. It has been demonstrated that colder ocean temperatures on the B.C. coast are associated with more nutritious forms of zooplankton, which had the potential in 2008 to provide better growth and survival for migrating sockeye smolts.

The favourable ocean combined with a potentially large abundance of sockeye juveniles in 2008 could explain a large return of Fraser River sockeye in 2010, providing that other factors did not affect their growth and survival. If only average marine survival was achieved by Chilko Lake sockeye, for example, it would have produced a return of more than five million adult sockeye to that one lake alone in 2010.