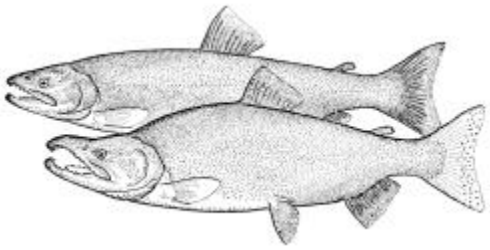
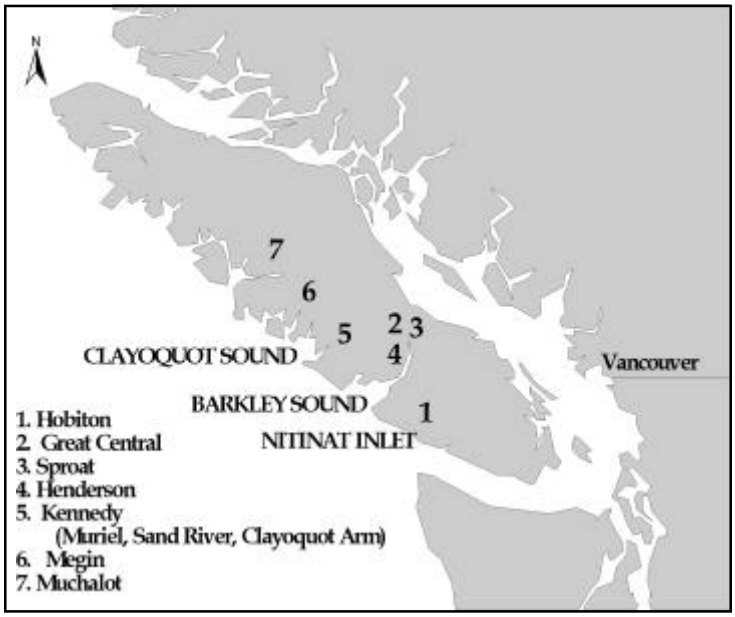


West Coast Vancouver Island Sockeye



Background

Anadromous sockeye salmon spend portions of their life cycle in freshwater and marine environments (rivers, lakes, ocean habitats) on both sides of the North Pacific. In the eastern Pacific, sockeye range from the Columbia River to the Bering Sea. Sockeye exhibit great life history variation but generally spend their first 1 to 3 years in freshwater lakes, after which they migrate seaward to spend another 1-3 years rearing in the North Pacific. Adult sockeye enter coastal fisheries and typically return to spawn in their rivers and lakes of origin between ages 3 and 6.

More than 20 distinctive stocks of sockeye originate from the west coast of Vancouver Island (WCVI). However, more than 80 % of all WCVI sockeye, taken as catch prior to the end of July, originates from stocks returning through Barkley Sound to Great Central, Sproat and Henderson lakes. Barkley Sound sockeye have been the subject of more than a century of management, research and enhancement activities. From 1890 to 1972, average returns were less than 100,000 fish. From 1972 to present, lake fertilization and management designed to increase spawner abundance have been used to increase production of Barkley Sound sockeye. Annual harvests now average more than 400,000 fish. Although other WCVI sockeye, such as the Hobiton, Kennedy, Megin, and Muchalot stocks, are too unproductive to support commercial harvests, they remain important to First Nations for food, ceremonial and cultural purposes.

The Fishery and Resource Status

Average WCVI Sockeye Catch
(in thousands of fish)

Barkley Sound

1911-30	1931-50	1951-70	1971-90	1991-98
27	46	29	418	383

Clayoquot Sound

1887-1910	1911-30	1951-70	1971-90	1991-98
89	60	36	1	0

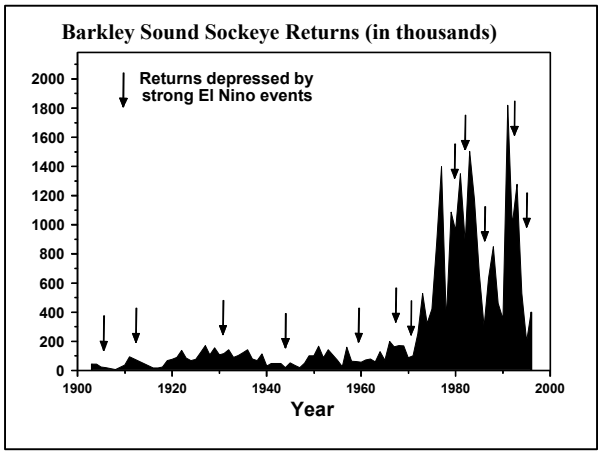
From the late 1800s to the mid-1900s, terminal net fisheries harvested small quantities of sockeye from several WCVI stocks to supply canneries at Nitinat Inlet, Barkley and Clayoquot Sounds. The two largest fisheries occurred in Clayoquot and Barkley Sounds, where average annual harvests ranged from 27,000 to 89,000 fish. Smaller quantities were harvested principally for subsistence purposes at other WCVI sites. Although Clayoquot Sound once supported the largest WCVI sockeye fishery, persistent stock declines since early in the century led to the collapse of the fishery in the mid to late 1970s.

Stock declines appear to have been related to over-exploitation and unfavourable environmental conditions in both freshwater and marine environments. In spite of 25 years of continuous closure to commercial fishing, these stocks have failed to recover.

The history of Barkley Sound sockeye stocks and fisheries contrasts sharply with that of Clayoquot Sound. The fishery has passed through several phases including a largely terminal subsistence fishery that probably harvested no more than 50,000 sockeye per year (pre-1900); a terminal beach seine and gillnet fishery that provided catches as high as 125,000 sockeye (1900-40); a more diffuse gillnet fishery that exploited mixtures of sockeye in Alberni Inlet and the outer waters of Barkley Sound yielding catches of 5,000 to 76,000 sockeye (1940-70); and finally, a mixed-gear, mixed-stock fishery in which gillnet, purse-seine, recreational and aboriginal fisheries harvest an average of more than 400,000 sockeye per year (1971-1998).

Barkley Sound sockeye are currently managed to: meet a target of no less than 200,000 adult spawners to ensure long-term sustainability of the stocks, provide for the food, ceremonial and cultural needs of aboriginal peoples, and create and identify opportunities for surplus sockeye to be taken by recreational and commercial fisheries.

Habitat protection measures have on at least three occasions prevented the almost certain destruction of one or more of the Barkley Sound sockeye stocks. Gear and area restrictions within the commercial fishery have been used with varying effectiveness throughout the past century to focus exploitation or stock rebuilding efforts alternately on Henderson, Great Central or Sproat Lake sockeye. Stock development and enhancement activities have included: removal of obstructions to fish passage (1901, 1903, 1912-16, 1936); construction and maintenance of fishways at Stamp Falls (1927, 1954), Sproat Falls (1951), and the outlet of Great Central Lake (1929, 1957); operation of a sockeye hatchery on Henderson Lake (1909-35, 1993-98); and fertilization of Great Central (1970-73, 1977-98), Henderson (1976-98) and Sproat Lakes. Lake fertilization in combination with management to increase spawner abundance has been used to increase the production of Barkley Sound sockeye to historically unprecedented levels and has made them the focus of major aboriginal, recreational and commercial fisheries since the early 1970s. However, it is doubtful that this would have been achieved in the absence of the other stock protection and enhancement activities that have contributed over the past century to the maintenance or development of the Barkley Sound stocks.



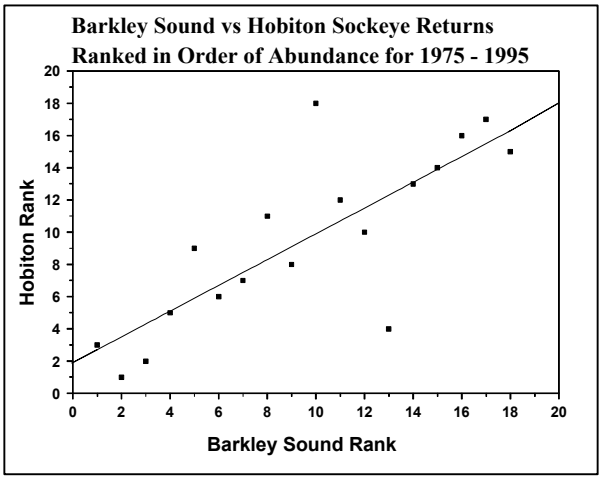
Climatic Factors and Stock Status

Recently, production and catches of Barkley Sound sockeye have declined dramatically. Research by Fisheries and Oceans Canada has shown that marine growth and survival of WCVI sockeye, including those from Barkley Sound, are sensitive to periodic variations in ocean climate that occur at intervals of 3 to 20 years.

Barkley Sound Catch (in thousands)

1991	1992	1993	1994	1995	1996	1997	1998
1,121	567	738	200	30	55	144	207

Recurring shifts in ocean climate result in changes in community structure and productivity of both coastal and offshore ecosystems where WCVI sockeye spend 1 to 3 years of their life. Consequently, returns of several WCVI sockeye stocks (Barkley Sound and Hobiton, for example,) fluctuate together.



Marine conditions are especially unfavourable for juvenile sockeye survival when coastal ocean temperatures are high and salinities are low because migratory predators, including Pacific hake and mackerel, arrive earlier and in greater abundance in such years. Pacific mackerel reached such high abundance during recent warm El Niño summers that ocean survival of sockeye that migrated seaward during these years are the lowest on record for WCVI stocks. Indeed, strong El Niño events accompanied by above-average temperatures in the nearshore marine environment have been followed 2 and 3 years later by declines in sockeye returns throughout the 100-year period of records for Barkley Sound sockeye. Research conducted over the past 15 years suggests that juvenile sockeye migrating seaward from WCVI nursery lakes experience survival rates 2 to 5 times higher during years when the coastal ocean exhibits cool, high-salinity waters compared with years when coastal waters are warm and less saline.

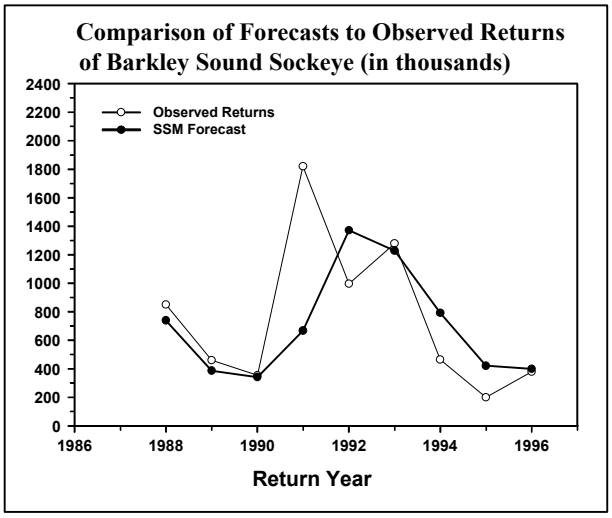
Rapid changes from one ocean climate state to another can lead to steep increases or dramatic "crashes" in WCVI sockeye returns. Prior to the 1992-94 El Niño event, for example, Barkley Sound sockeye returns peaked at almost 2 million fish in 1991 followed by a 10-fold decline to only 200,000 returning fish in 1995. Although Barkley Sound sockeye returns have remained high enough in most recent years to satisfy spawning requirements as well as to support aboriginal, sport and commercial harvest, stock declines associated with the recurrence of strong El Niño events have been severe enough to entirely eliminate commercial harvest there in 1989, 1990, 1995 and 1996. These same events have likely contributed to simultaneous declines from thousands of adults to record lows of fewer than 100 adults returning to each of several small WCVI stocks (e.g. the Muriel Lake and Clayoquot Arm stocks in the Kennedy Watershed) even in the absence of any exploitation.

Outlook and Forecasts

Barkley Sound and other WCVI sockeye stocks exhibit highly variable returns in response to a multitude of natural or man-induced changes in environmental conditions in both the freshwater and marine ecosystems they occupy throughout their life history. Future returns may be expected to exhibit even more extreme interannual to interdecadal variations because WCVI sockeye stocks reside at the southern end of the range for the species where they are likely to be especially sensitive to climate change (e.g. global warming or cooling) and the increasing influence of human populations on critical freshwater and coastal marine habitats.

Our understanding of the complex mechanisms that control both short and long term variations in salmon returns is still rudimentary. For example, we still can't explain the collapse of the Clayoquot Sound sockeye stock in the early 1970's or its failure to recover in the absence of any commercial exploitation for the past 25 years. However, research conducted by federal fisheries scientists over the past decade has provided a basis for new procedures to forecast annual return variations of WCVI sockeye. Recent forecasts of total returns of sockeye are based on models that account for annual variations in marine survival, as well as the abundance of juvenile sockeye migrating seaward from various nursery lakes. Marine survival predictions are based on direct observations of strong associations between coastal ocean climate indicators (salinity and temperature during ocean entry by juveniles) and

return rates. Pre-season forecasts generated annually since 1988 have been applied with excellent success by fisheries managers to anticipate when to plan for either strict stock conservation or progressive harvest measures for WCVI sockeye.



During 1997 to 1999, the coastal ocean exhibited a dramatic swing from the extremely warm, low salinity conditions associated with a strong El Niño to the extremely cold, high salinity conditions associated with a strong La Niña event. In addition, estimates of juvenile sockeye production were average to above average for these years. Consequently, Barkley Sound and WCVI sockeye returns between 1999 and the year 2001 are anticipated to exhibit extreme numeric fluctuations similar to those observed between 1990 and 1992 (i.e. lows of 400,000 to highs of approximately 2,000,000 sockeye).

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