The Collapse of the Rivers Inlet Sockeye Fishery: The Case Against a Freshwater Cause

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Owikeno Lake is a large, oligotrophic, glacially turbid coastal lake that drains into Rivers Inlet via the Wannock River. Throughout much of the 20th century, Owikeno Lake vied with the Skeena River to produce the second largest catch of sockeye in British Columbia (Fig. 1). Several years of low escapements during the late 1950s and early 1960s and widely fluctuating catches beginning in the late 1960s led to five years of severe fishery restrictions (1979-1984). These years of higher escapements did not result in higher catches. Logging in the Owikeno watershed began during the 1960s and this became one of the popular hypotheses for the decline of the stock. If Owikeno Lake had become less productive after the 1960s because of habitat damage or other factors, the data should indicate that fewer fry were produced for a given number of spawners.

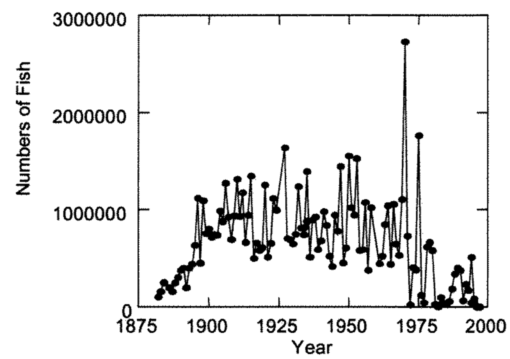

Fig. 1. Rivers Inlet sockeye catch.

Very few sockeye juveniles spend a second year rearing in Owikeno Lake so samples of fry collected during the summer are almost exclusively the product of a single cohort. Trawl survey estimates of juvenile abundance in Owikeno Lake have been collected intermittently since 1960. The most intensive surveys occurred from 1960 to 1968. These data indicate that there is density-dependent growth in juvenile sockeye in Owikeno Lake (R^2=81%; Fig. 2). When sockeye fry were abundant in the lake during the summer (July-August), their body size as pre-smolts was smaller. Samples collected for the 1994 and 1995 brood years indicate that this relationship still holds (Fig. 2). The good relationship between pre-smolt weight and juvenile abundance allowed us to use pre-smolt weights as a proxy for fry abundance. In years when neither trawl surveys nor pre-smolt weights were available, we used freshwater scale growth measured from returning adults to infer juvenile abundance. Our measure of freshwater scale growth was the principal component of the correlation between age 1.2 and age 1.3 freshwater growth from adult sockeye of the same brood year (Fig. 3).

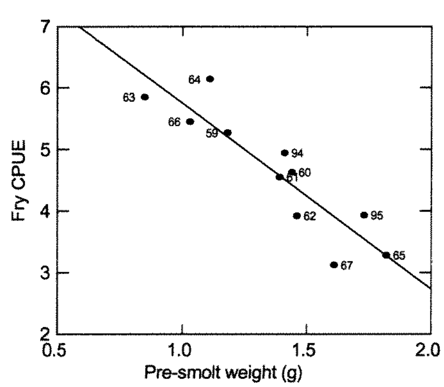

Fig. 3. Sockeye fry catch per unit effort (CPUE) index (log scale) in summer versus mean annual pre-smolt weight (g) by brood year.

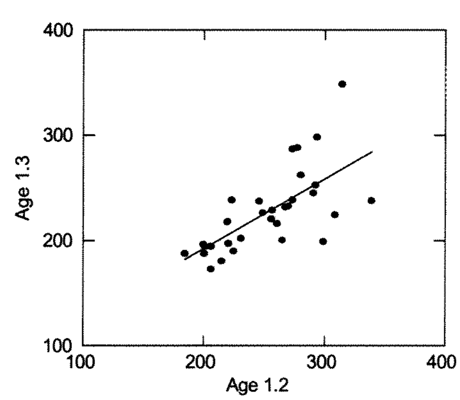

Fig. 2. Freshwater scale growth (microns) taken from returning adults, by brood year.

A 46-year index of juvenile sockeye abundance in Owikeno Lake was reconstructed by combining archival data from trawl surveys, pre-smolt sizes, and freshwater scale growth (Fig. 4). These data suggest that fry abundance was generally lower during the 1950s than during subsequent decades. There is no evidence of a long-term decline in fry abundance. Years of low fry abundance include 1954-1957, 1965, 1967, 1989, 1992, and 1996. These years generally coincide with years of lower than average escapements; 1992 was the notable exception (Fig. 5). Our index of escapement does not include unreliable estimates of spawner abundance in turbid rivers or streams. Spawner abundance declined to very low levels from 1994 to 1996. Total closures of the Rivers Inlet sockeye fishery occurred in 1996 and 1997. A low escapement in 1994 resulted in an above average fry recruitment index.

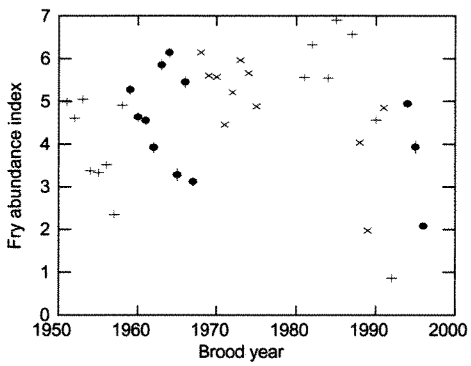

Fig. 4. Estimated abundance (± 1 standard error (s.e.) for trawl data) of juvenile sockeye in Owikeno Lake. The source of the estimates are indicated by the plot symbols (•) trawl, (x) pre-smolt weight, (+) freshwater scale growth.

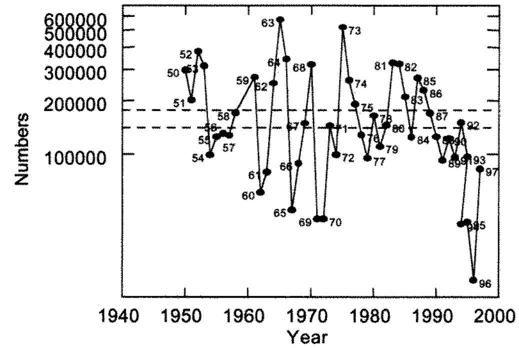

Fig. 5. Escapement (numbers) to clear (non-glacial) streams. Arithmetic (above) and geometric (below) means are indicated by the dashed lines.

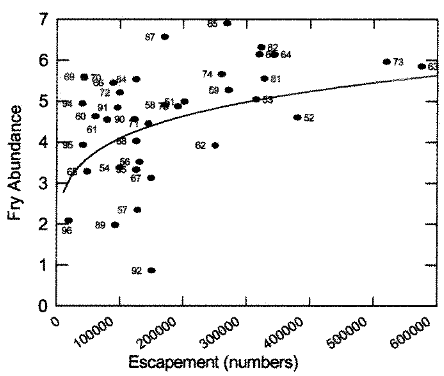

Fig. 6. Sockeye fry abundance versus clear stream escapement index by brood year.

Clear stream escapements exceeding about 175,000 spawners have not resulted in low fry recruitment (Fig. 6). Fry recruitment from clear stream escapements below 175,000 has been variable, but was typically adequate even from lower escapements. Note that the brood years 1963 and 1968 that produced two years of phenomenal catches were not the peak years of fry abundance. This suggests that good marine survival coupled with good fry recruitment can produce very good catches, but this combination has not been observed since the early 1970s.

Although the total escapement estimates are suspect, if one assumes that the total escapement estimates are correlated with the true escapement, a marine survival index can be computed as the log(total returns/fry CPUE) by brood year. The marine survival index has decreased over the last 50 years (Fig. 7). As has been demonstrated for other sockeye populations and other salmon species, marine survival is correlated with smolt size (Fig. 8).

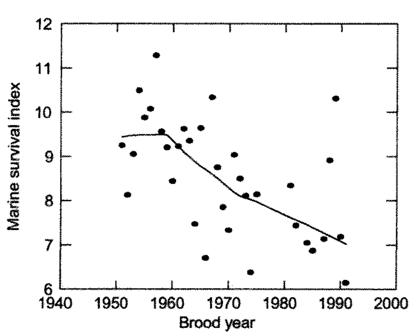

Fig. 7. Marine survival index for Rivers Inlet sockeye.

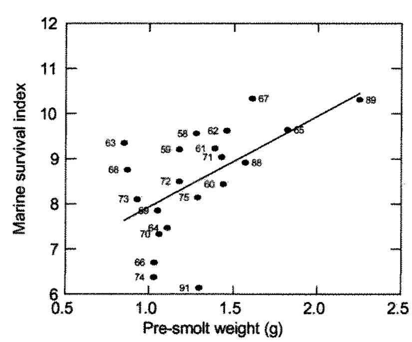

Fig. 8. Marine survival of Owikeno Lake sockeye versus mean pre-smolt weight. Brood years are indicated.

There is a clear signal of the 1976/77 climate change in the Wannock River discharge data and in the adjacent Queen Charlotte Sound sea surface temperatures (SSTs). Discharge from the Wannock River was significantly lower after 1976 than before (Fig. 9). Both winter and spring SSTs were significantly warmer after 1976 than before (ANOVA: $P<0.001$, Fig. 10). There is no evidence of physical, chemical, or biological changes within Owikeno Lake. Recent secchi depth and zooplankton biomass measurements are within the levels of variation seen from 1960-1968.

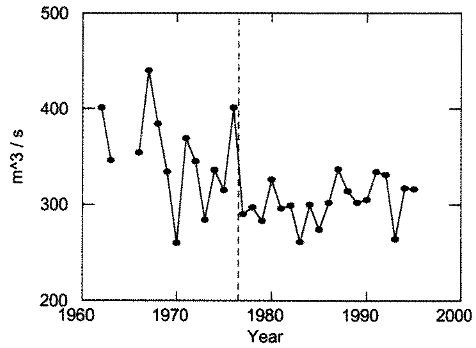

Fig. 9. Wannock River annual mean discharge. The vertical line indicates the 1976/77 climate change.

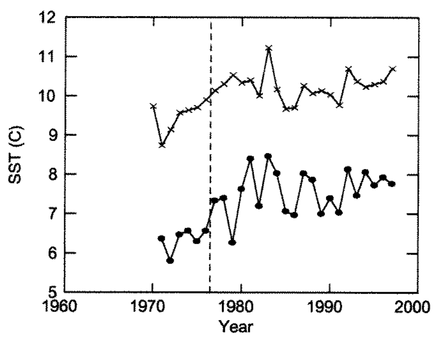

Fig. 10. Winter (below) and spring (above) sea surface temperatures sea surface temperatures (SSTs) at Egg Island, Queen Charlotte Sound.

Owikeno Lake sockeye smolts have the smallest mean size of any on the B.C. coast, and as such, they may have unique physiological or environmental constraints on marine survival. Reduced freshwater discharge in Rivers Inlet may have changed some aspect of the marine environment in the inlet that is critical to the survival of sockeye smolts. Very small smolts may have difficulty during the transition to salt water. Reduced estuarine circulation may result in less primary and secondary biological production in the inlet. Reducing the freshwater lens may reduce feeding opportunities. Migration timing may be affected if currents are reduced. The warmer ocean they now encounter may be bringing new predators to the region, or placing additional physiological or behaviour demands on the fish.

The returns in 1998 will result from age 1.3 fish produced from the 1993 brood year and age 1.2 fish produced from the 1994 brood year. There were no summer trawl surveys in Owikeno Lake during 1994 (1993 brood) and no juvenile weights were measured. Freshwater scale growth measured on returning age 1.2 adults in 1997 suggests that fry abundance for the 1993 brood year was low. Low fry densities tend to produce adults that mature as age 1.2 rather than age 1.3 adults. The apparent low fry abundance and its probable effect on age at maturity suggests that most of the production from the 1993 brood year has already returned. Although the 1994 escapement index was one of the lowest, the juvenile abundance that resulted from this spawning was very good. This suggests that most of the 1994 brood year will return in 1999 as age 1.3. Despite higher fry abundance, there is no evidence in coastal ocean climate data to suggest that marine survival will improve returns in the next few years.