Development of a New Stock Discrimination Tool for Naturally Spawning Sockeye Salmon (*Oncorhynchus nerka*) within Alberni Inlet from Stable Isotopic Composition of Otoliths

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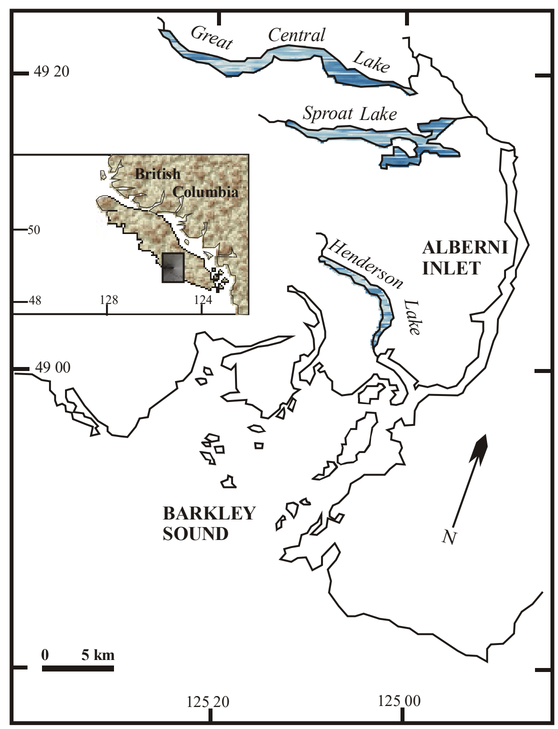
Great Central Lake, Sproat Lake, and Henderson Lake are tributaries to Alberni Inlet on the west coast of the Vancouver Island, British Columbia (Fig. 1). Two of these lakes, the Great Central and Sproat lakes support sockeye salmon (*Oncorhynchus nerka*) populations of magnitudes that support considerable commercial, recreational, and First Nations' harvest. The third lake, Henderson Lake, has a much smaller population of sockeye salmon which has not been able to support fisheries other than limited First Nations' harvest for food. With limited information on which to base decisions, managers attempt to limit harvest of Henderson Lake stock, during fisheries targeting Great Central and Sproat Lake sockeye stocks, through time and area restrictions. In this study we evaluate the use of stable isotopic composition of otoliths as a stock discrimination tool for improved management of Alberni Inlet sockeye fisheries.

Fig. 1. The location of the three neighbouring lakes in the Alberni Inlet of the Western Vancouver Island, British Columbia.



Stable isotope ratio analysis ($^{18}O/^{16}O$ or $\delta^{18}O$, and $^{13}C/^{12}C$ or $\delta^{13}C$) of otoliths provides a new chemical tool for stock discrimination of sockeye salmon populations from different lakes. This is based on the hypothesis that otoliths are deposited in, or very close to oxygen isotopic equilibrium between the mineral aragonite and the ambient water where a fish lived, and that the isotopic fractionation of $^{18}O/^{16}O$ is temperature dependent (e.g., Urey 1947; Epstein et al. 1953; Devereux 1967; Grossman and Ku 1986; Kalish 1991). Carbon isotope ratios are generally precipitated in isotopic disequilibrium with the ambient water, but are influenced by metabolic sources of the fish and dietary shifts (e.g., Mulcahy et al. 1979; Schwarcz et al. 1998). Sockeye salmon life history usually includes spending the first one to two years in a nursery lake before smoltification. If the nursery lakes have different $\delta^{18}O$ and $\delta^{13}C$ values, these isotope signatures would constitute a natural otolith mark that can be used to identify the natal sources of different tributary stocks of the fish (Nelson et al. 1989; Gao 1997; Gao and Beamish 1999). Consequently, otoliths of sockeye salmon appear to be ideal as a proxy for isotope analysis.

For the first phase of a project in April–May 2000, we collected 77 otolith samples of smolts from the three neighbouring lakes (Great Central, Sproat, and Henderson) draining Alberni Inlet (Fig. 1). Microsampling was conducted by using the Dremel method (Gao 1999). The aragonite powder samples were taken from the surface of sockeye smolt otoliths from annual increments, and were analysed for their oxygen and carbon isotope ratios. The powder samples were then reacted with 100% phosphoric acid to release CO_2 gas into a "Kiel" carbonate preparation system that coupled directly with a Finnigan MAT 251 mass spectrometer. All the measurements were reported in the standard δ notation (‰): $\delta^{18}O = \{[(^{18}O/^{16}O)_X / (^{18}O/^{16}O)_S] - 1\} \times 1000$, for instance, where X is sample and S is standard (VPDB via NBS-19). Precision of the analysis is better than 0.1 ‰ for both $\delta^{18}O$ and $\delta^{13}C$ values.

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Among the three lakes studied, the data showed there were significant isotopic differences between Henderson Lake (-10.0 to -9.2 ‰ VPDB in $\delta^{18}O$ and -16.1 to -14.5 ‰ VPDB in $\delta^{13}C$) and either Great Central Lake or Sproat Lake (Fig. 2 and Table 1). There were no significant differences in the isotopic composition between Great Central Lake (-13.6 to -9.5 ‰ VPDB in $\delta^{18}O$ and -18.4 to -15.9 ‰ VPDB in $\delta^{13}C$) and Sproat Lake (-11.0 to -9.6 ‰ VPDB in $\delta^{18}O$ and -18.0 to -16.3 ‰ VPDB in $\delta^{13}C$). The maximum 3.5 ‰ VPDB differences in $\delta^{18}O$ of otoliths among the three lakes might be related to water temperature that could be in turn related to fish growth (Gao 1997). Henderson Lake may be cooler than other two lakes, which would cause the slower growth rate of smolts. Based on these results, the isotopic technique will provide a new tool for sockeye stock discrimination to meet management requirements for the Henderson Lake sockeye stock.

The benefits of the isotopic technique include the ability to identify the origin and life history of individual fish, the relatively high precision and accuracy compared to either DNA analysis or parasite analysis, and the relatively low cost. The next phase of our project will examine the interannual variability of isotopic composition from otoliths of spawning adults from the mixed stocks or areas to verify and complete the development of this stock discrimination tool.

Fig. 2. The oxygen and carbon isotopic composition of sockeye salmon smolt otoliths from the three lakes, showing the isotopic differences for Henderson Lake and the two northern lakes.

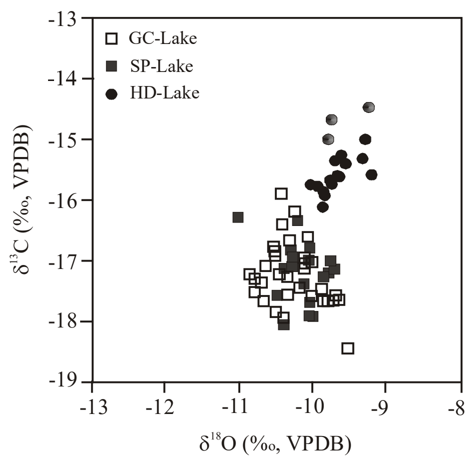

Table 1. ANOVA (one-way) of sockeye salmon smolt otoliths from three lakes in Alberni Inlet.

Isotope	Source	*DF	SS	MS	Fs	$F_{.05[2, 74]}$
$\delta^{13}C$	Factor	2	46.847	23.423	95.11	**3.15**
	Error	74	18.225	0.246		
	Total	76	65.072			
$\delta^{18}O$	Factor	2	5.430	2.715	11.06	**3.15**
	Error	74	18.173	0.246		
	Total	76	23.604			

*Column headings: DF -degrees of freedom, SS -sums of squares, MS -mean squares, Fs -sample variance ratio, and $F_{.05[2,74]}$ -critical F-values.

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