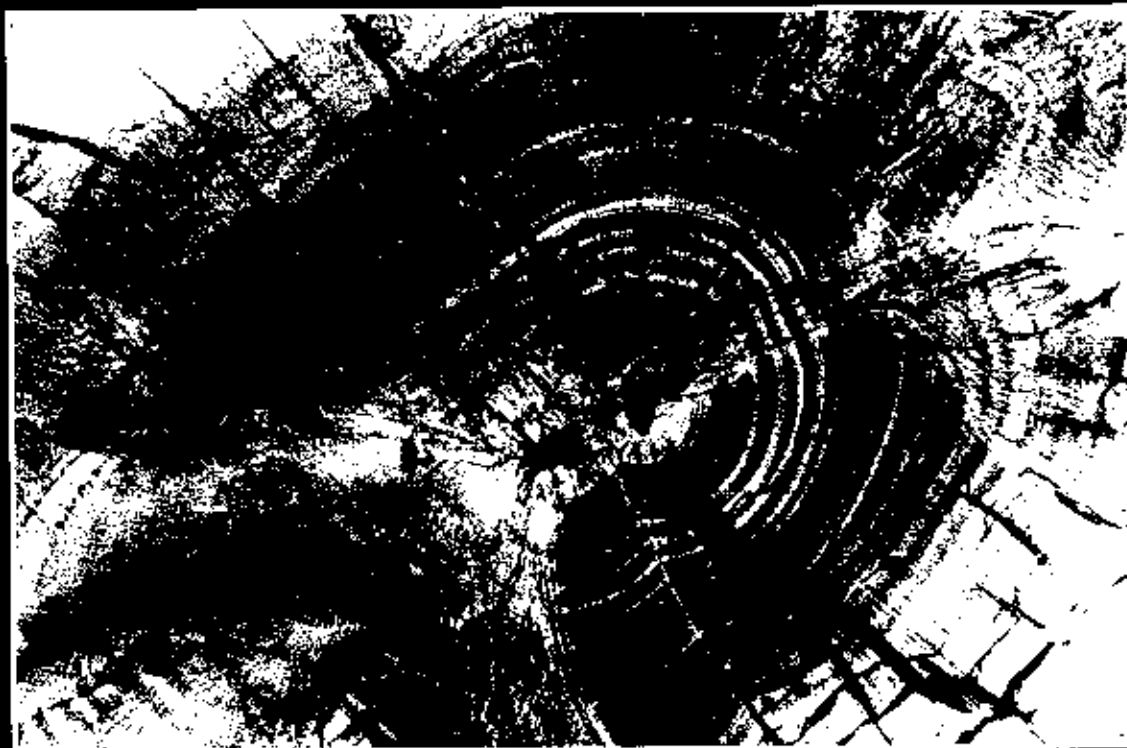


**MATERNAL ORIGIN OF SOCKEYE SALMON
(*ONCORHYNCHUS NERKA*) RETURNING TO THE PELTON
FISH TRAP, DESCHUTES RIVER, OREGON IN 1997**

PELTON ROUND BUTTE HYDROELECTRIC PROJECT

FERC NO. 2030



Prepared by

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and

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Corvallis, Oregon 97370

March 1999

Prepared for Portland General Electric Company

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The photo on the cover is a photomicrograph of a cross section of a sockeye salmon otolith magnified 100 times. The primordia are visible as small dots in the center of the otolith and the circuli surrounding the primordia represent daily growth in the same way that tree rings represent annual growth of a tree.

- Photo by Chris Zimmerman

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Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

INTRODUCTION

Sockeye salmon (*Oncorhynchus nerka*) are native to the upper Deschutes River Basin, historically spawning in the upper Metolius River basin and rearing in Suttle Lake (Nehlsen 1995). As early as 1942, the demise of this population of anadromous fish was noted by fisheries managers and assumed to be the result of dams at Suttle Lake and Lake Creek (Nehlsen 1995). By 1958, no run of sockeye salmon was present in the basin. Kokanee, the resident form of *O. nerka*, are still present in Suttle Lake, Lake Billy Chinook, and Lake Simtustus. Since 1956, returns of adult anadromous sockeye salmon to the Pelton Fish Trap have ranged from 0 to 340 each year with an annual average of 66 (Figure 1). The origin of these fish is unknown, but it has been suggested that kokanee from the upper basin could pass through or over the dams and maintain this small run of sockeye to the Pelton Fish Trap. All fish returning to the Pelton Fish Trap in 1997 were collected. The purpose of this study was to determine the maternal origin of these fish using microchemical analysis of otoliths with the assumption that fish of sockeye parentage are strays from other systems and those of kokanee parentage could result from passage of juvenile kokanee.

Otoliths are small calcium carbonate structures found in the inner ear of fish. Like scales, otoliths grow concentrically and can be used to age fish. Strontium (Sr), an element with binding characteristics similar to calcium (Ca), is substituted for calcium in the calcium carbonate matrix of the otolith at levels relative to the concentration in the environment (Kalish 1990). The concentration of strontium is greater in seawater compared to freshwater. Therefore, examination of strontium/calcium ratios across the otolith of a fish will describe the chemical life history of that fish and identify times spent in fresh and saltwater. Further, examination of Sr/Ca ratios in the primordia (the part of the otolith that forms first) can be used to determine maternal origin of juvenile salmonids (resident or anadromous) based on the assumption that primordia composition reflects the environment in which yolk precursors develop (in the ocean for anadromous forms)(Kalish 1990). Using these techniques, Rieman et al. (1994) were able to distinguish between anadromous sockeye salmon and their resident form, kokanee, in the Snake River, Idaho. Zimmerman and Reeves (1996,1997) were able to distinguish the maternal origin of steelhead and resident rainbow trout (*Oncorhynchus mykiss*) in the Deschutes River, Oregon.

Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

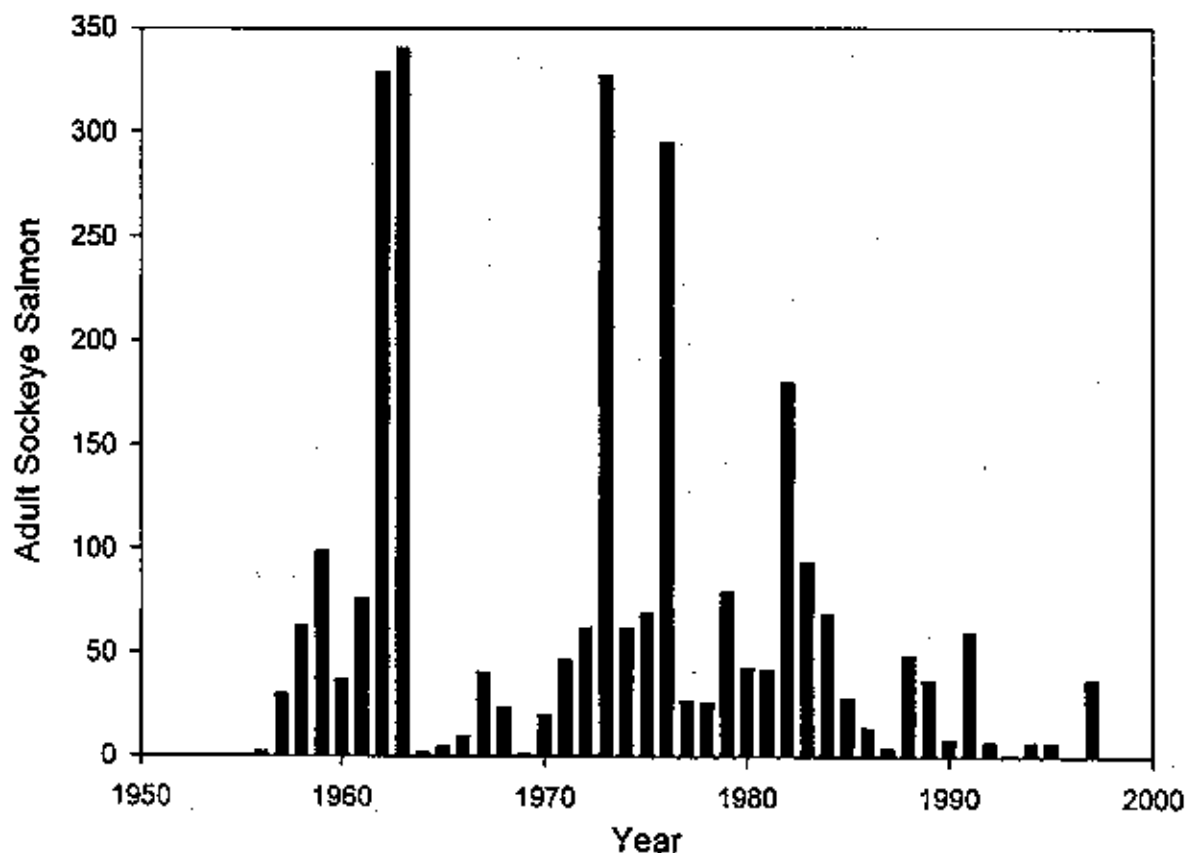


Figure 1. Number of adult sockeye salmon returning to the Pelton Fish Trap, Deschutes River, Oregon from 1956 to 1997.

METHODS

One otolith from each fish was mounted sulcus side down with crystal bond 509 on a microscope coverslip attached to a standard microscope slide. The otolith was then ground in the sagittal plane to the level of the nucleus with 600-grit and 1200-grit sandpaper. The mounting medium was heated and the otolith turned sulcus side up and the otolith ground in the sagittal plane to the level of the primordia with 1200-grit and 2000-grit sandpaper and polished with a slurry of 0.05 μm alumina paste. The coverslip was then cut with a scribe and so that several such otoliths could be mounted on a petrographic slide for microprobe analysis. The slide was rinsed with deionized water, air dried, and coated with a 200 Å carbon layer.

Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Elemental analysis was conducted with a Cameca SX-50 wavelength dispersive microprobe at Oregon State University School of Oceanography. A 15 kv, 50 nA, 7 μm diameter beam was used for all analyses. Strontiantite (SrCO_3 - USNM R10065) and calcite (CaCO_3 - USNM 136321) were used as standards for Sr and Ca, respectively. Each element was analyzed simultaneously and a counting time of 40s was used to maximize precision (Toole and Nielsen 1992).

Otolith regions were classified as primordia, freshwater growth region, and saltwater growth region. Freshwater and saltwater growth regions were identified based on growth rates inferred from banding patterns. Microprobe sample points included all primordia and a transect bisecting a primordium and continuing to the edge of the otolith (life history transect). Each transect of Sr/Ca was plotted and compared to expected transects for anadromous and resident *O. nerka*. Maternal origin was determined by comparing primordia measures with those taken in the freshwater growth region. A fish was determined to be of sockeye maternal origin if the Sr/Ca ratio in the primordia was significantly higher than in the freshwater growth region.

Thirty-seven adult sockeye salmon were collected at the Pelton Fish Trap in 1997 ranging in length from 477 mm to 613 mm (Table 1). Eight kokanee were collected from Lake Billy Chinook ranging in length from 150 mm to 167 mm (Table 2). All fish were aged by examining otolith banding patterns. Before microchemical analysis, the otolith was examined with a binocular microscope under reflected light on a black background to age the fish (Tables 1 and 2). An annulus was assumed to consist of one opaque and one dark ring. Thirty-five of the sockeye otoliths were examined and all eight kokanee otoliths were examined. Two sockeye otoliths were not examined due to preparation difficulties.

Table 1. Fork length (mm) and age (freshwater years.saltwater years) of sockeye salmon returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997.

Fish	Length (mm)	Age
1	572	1.2
2	605	1.2
3	574	3.1
4	547	1.2
5	610	1.2
6	554	1.2
7	590	1.2
8	477	1.2
9	612	2.1
10	602	1.2
11	586	1.2
12	613	1.2
13	601	1.2
14	563	1.2
15	603	1.2
16	605	1.2
17	552	1.2
18	495	1.2
19	603	1.2
20	583	1.2
21	492	1.2
22	569	1.2
23	565	1.2
24	524	1.2
25	594	1.2
26	601	1.2
27	494	1.2

Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Fish	Length (mm)	Age
28	534	1.2
29	583	1.2
30	565	1.2
31	563	1.2
32	572	1.2
33	592	1.2
34	560	1.2
35	554	1.2
36	562	1.2
37	547	1.2

Table 2. Fork length (mm) and age of kokanee collected from Lake Billy Chinook, Oregon.

Fish	Length (mm)	Age
1	165	1
2	167	1
3	165	1
4	145	1
5	150	1
6	155	1
7	178	1
8	152	1

RESULTS AND DISCUSSION

Of the 35 sockeye otoliths examined, all but two were of sockeye origin (Table 3). Mean Sr/Ca ratios in the otoliths of kokanee are presented in Table 4. Sr/Ca ratios in the primordia, freshwater growth regions, and saltwater growth regions were useful in determining the maternal origin of the sockeye returning to the Pelton Fish Trap (Figure 2). Elevated levels of Sr/Ca were observed in saltwater growth regions compared with freshwater growth regions. Sockeye of

Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

kokanee origin were distinguishable in both comparisons of primordia and freshwater growth regions and life history transects. Life history transects of all sockeye salmon returning to the Pelton Fish Trap are presented in Appendix 1. Life history transects for kokanee collected from Lake Billy Chinook are presented in Appendix 2.

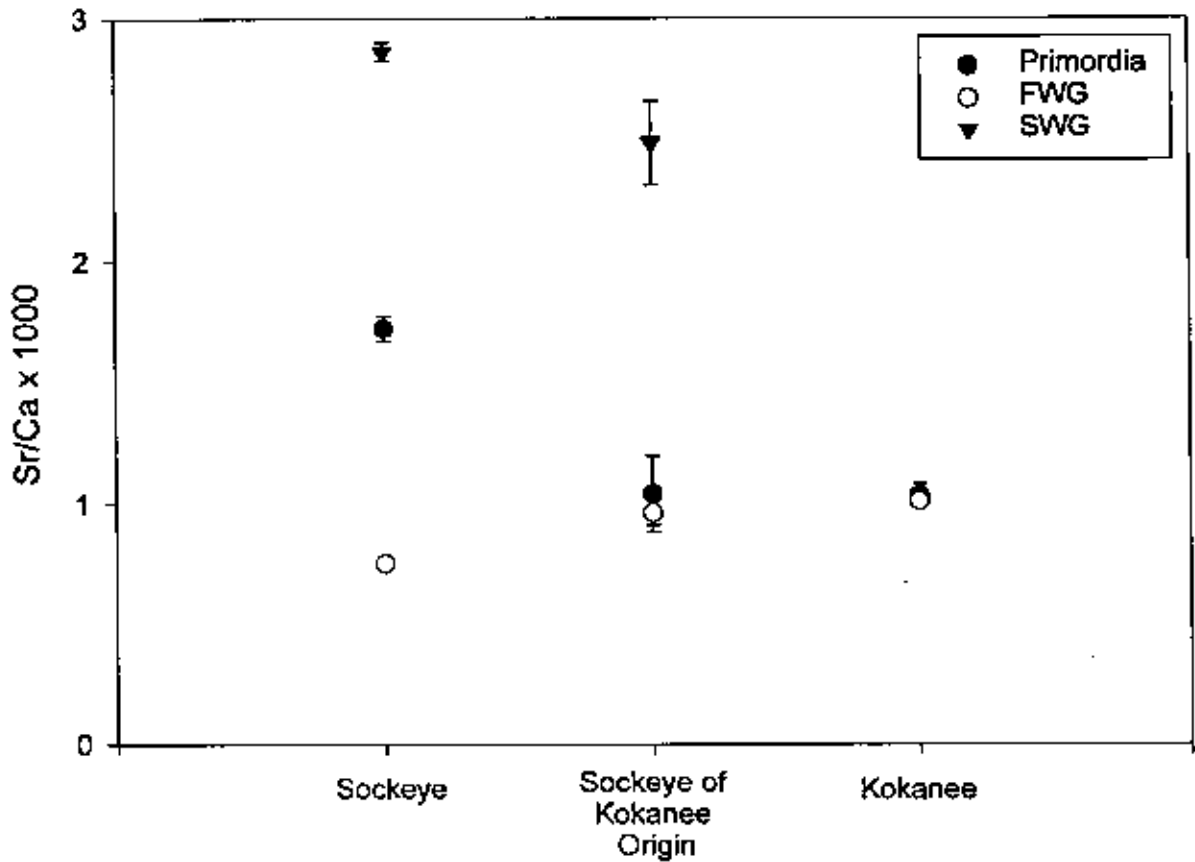


Figure 2. Mean and 95% confidence intervals of Sr/Ca ratios in primordia, freshwater growth region (FWG) and saltwater growth region (SWG) in otoliths of sockeye salmon returning to the Pelton Fish Trap and kokanee collected from Lake Billy Chinook.

Analysis of otolith microchemistry is useful in identifying the maternal origin of sockeye salmon returning to the Pelton Fish Trap. It cannot, however, identify the geographic origin of the fish. It is certain that the fish of sockeye origin are strays from another basin. The origin of the sockeye of kokanee origin can only be surmized. The Sr/Ca ratios in the primordia and freshwater growth regions of the sockeye of kokanee origin are similar to those found in the

Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

corresponding regions in kokanee collected from Lake Billy Chinook and slightly higher than those values observed in the stray fish of true sockeye origin. It is possible, but not certain, that the sockeye of kokanee origin originated from kokanee passing through the Pelton/Round Butte project.

Table 3. Maternal origin, mean Sr/Ca ratios (95% confidence interval) of primordia, freshwater growth region, and saltwater growth region in otoliths from sockeye salmon returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997.

Fish	Primordia	Freshwater Growth Region	Saltwater Growth Region	Maternal Origin
1	2.29 (0.32)	0.85 (0.12)	3.03 (0.20)	Sockeye
2	1.60 (0.43)	0.62 (0.08)	2.53 (0.18)	Sockeye
3	1.91 (0.33)	0.73 (0.24)	3.04 (0.33)	Sockeye
4	1.70 (0.31)	0.85 (0.31)	2.86 (0.29)	Sockeye
5	1.66 (0.17)	0.67 (0.08)	2.76 (0.26)	Sockeye
6	1.75 (0.19)	0.60 (0.09)	2.72 (0.20)	Sockeye
7	1.62 (0.39)	0.69 (0.10)	2.46 (0.26)	Sockeye
8	0.88 (0.63)	0.94 (0.06)	2.41 (0.31)	Kokanee
9	1.43 (0.35)	0.66 (0.13)	2.61 (0.20)	Sockeye
10	2.04 (0.07)	0.64 (0.07)	2.89 (0.27)	Sockeye
11	1.19 (0.51)	0.75 (0.22)	2.85 (0.46)	Sockeye
12	1.82 (0.54)	0.84 (0.15)	3.07 (0.36)	Sockeye
13	1.93 (0.33)	0.69 (0.11)	3.18 (0.30)	Sockeye

Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Fish	Primordia	Freshwater Growth Region	Saltwater Growth Region	Maternal Origin
14		0.79 (0.41)	2.59 (0.18)	
15	1.37 (0.25)	0.73 (0.12)	3.02 (0.34)	Sockeye
16	2.08 (0.18)	0.87 (0.38)	2.97 (0.19)	Sockeye
17	1.85 (0.34)	0.74 (0.11)	3.14 (0.29)	Sockeye
18	1.13 (0.10)	0.98 (0.09)	2.55 (0.26)	Kokanee
19	1.47 (0.42)	0.83 (0.14)	2.64 (0.17)	Sockeye
20	1.64 (0.29)	0.72 (0.19)	2.43 (0.23)	Sockeye
22	1.62 (0.34)	0.78 (0.08)	2.88 (0.32)	Sockeye
23	1.85 (0.53)	0.70 (0.13)	3.16 (0.27)	Sockeye
24	1.36 (0.47)	0.74 (0.09)	2.76 (0.17)	Sockeye
25	1.47 (0.71)	0.87 (0.25)	2.92 (0.23)	Sockeye
26	1.93 (0.25)	0.78 (0.09)	2.90 (0.18)	Sockeye
27	1.82 (0.31)	0.78 (0.13)	2.98 (0.23)	Sockeye
28	2.04 (0.20)	0.88 (0.20)	2.77 (0.18)	Sockeye
29	1.74 (0.17)	0.73 (0.06)	2.91 (0.18)	Sockeye
30	1.96 (0.32)	0.83 (0.16)	2.96 (0.20)	Sockeye
31	1.60 (0.32)	0.74 (0.06)	2.80 (0.18)	Sockeye

Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Fish	Primordia	Freshwater Growth Region	Saltwater Growth Region	Maternal Origin
32	1.48 (0.27)	0.64 (0.15)	2.66 (0.17)	Sockeye
33	1.76 (0.27)	0.79 (0.13)	2.96 (0.18)	Sockeye
34	1.82 (0.24)	0.77 (0.12)	2.79 (0.17)	Sockeye
35	1.67 (0.14)	0.70 (0.10)	2.95 (0.20)	Sockeye
36	1.61 (0.25)	0.87 (0.30)	2.96 (0.23)	Sockeye
37	1.86 (0.25)	0.74 (0.09)	3.10 (0.21)	Sockeye

Table 4. Mean Sr/Ca ratios (95% confidence interval) of primordia and freshwater growth region in otoliths from Kokanee collected from Lake Billy Chinook, Oregon in 1997.

Fish	Primordia	Freshwater Growth Region
1	0.93 (0.08)	0.98 (0.03)
2	1.07 (0.07)	1.04 (0.06)
3	1.02 (0.11)	1.01 (0.06)
4	0.85 (0.07)	0.94 (0.07)
5	0.98 (0.01)	0.93 (0.04)
6	1.08 (0.13)	1.01 (0.04)
7	0.94 (0.07)	1.05 (0.04)
8	1.47 (0.11)	1.32 (0.06)

Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

REFERENCES

- Kalish, J.M. 1990. Use of otolith microchemistry to distinguish progeny of sympatric anadromous and nonanadromous salmonids. *Fishery Bulletin*. 88:657-666.
- Nehlsen, W. 1995. Historical salmon and steelhead runs of the upper Deschutes River and their environments. Report prepared for Portland General Electric. 65 p.
- Rieman, B.E., D.L. Myers, and R.L. Nielsen. 1994. Use of otolith microchemistry to discriminate *Oncorhynchus nerka* of resident and anadromous origin. *Canadian Journal of Fisheries and Aquatic Sciences*. 51:68-77.
- Toole, C.L., and R.L. Nielsen. 1992. Effects of microprobe precision on hypotheses related to otolith Sr:Ca ratios. *Fishery Bulletin*. 90:421-427.
- Zimmerman, C.E., and G.H. Reeves. 1996. Steelhead and rainbow trout early life history and habitat use in the Deschutes River, Oregon: 1995 Annual Report. U.S. Forest Service, Pacific Northwest Research Station. Corvallis, Oregon.
- Zimmerman, C.E., and G.H. Reeves. 1997. Steelhead and rainbow trout early life history and habitat use in the Deschutes River, Oregon: 1996 Annual Report. U.S. Forest Service, Pacific Northwest Research Station. Corvallis, Oregon.

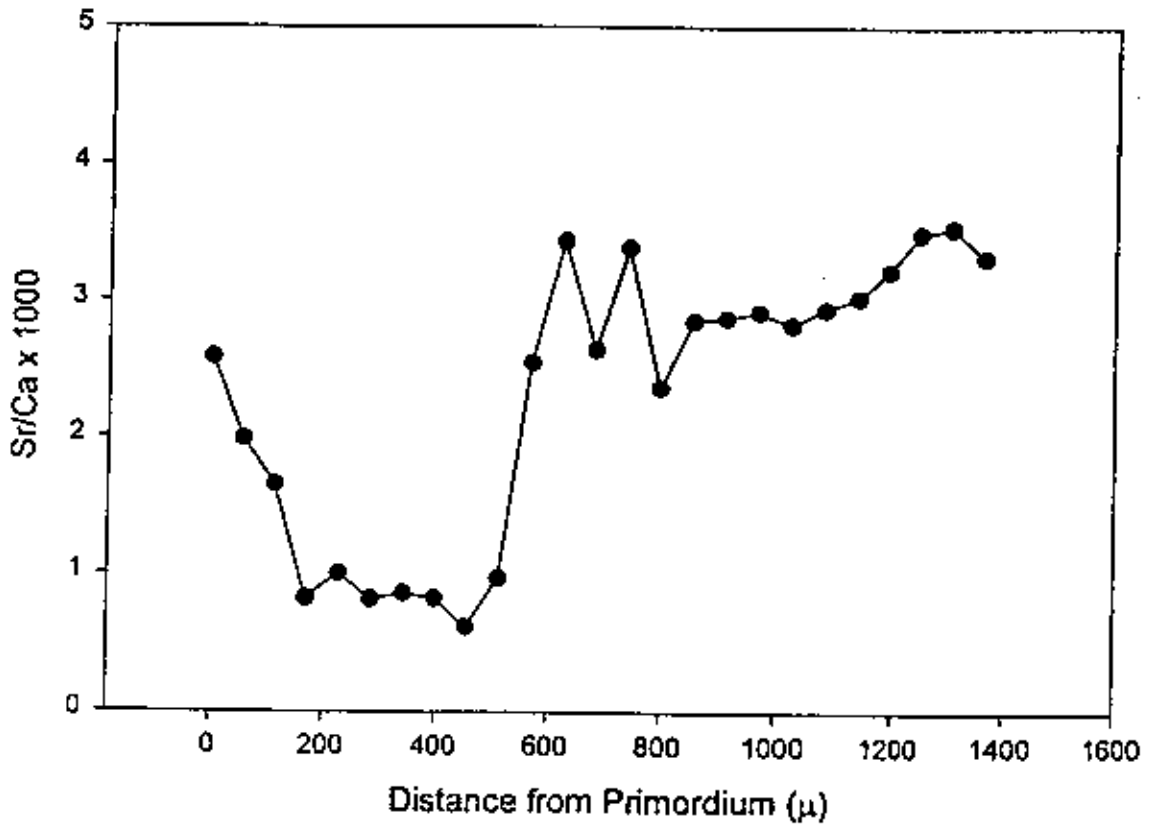
APPENDIX 1

Life History Transects of Sr/Ca Ratios In Sockeye Salmon Otoliths Collected From The Pelton Fish Trap, Deschutes River, Oregon.

*Maternal Origin of Sockeye Salmon (*Oncorhynchus nerka*) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997*

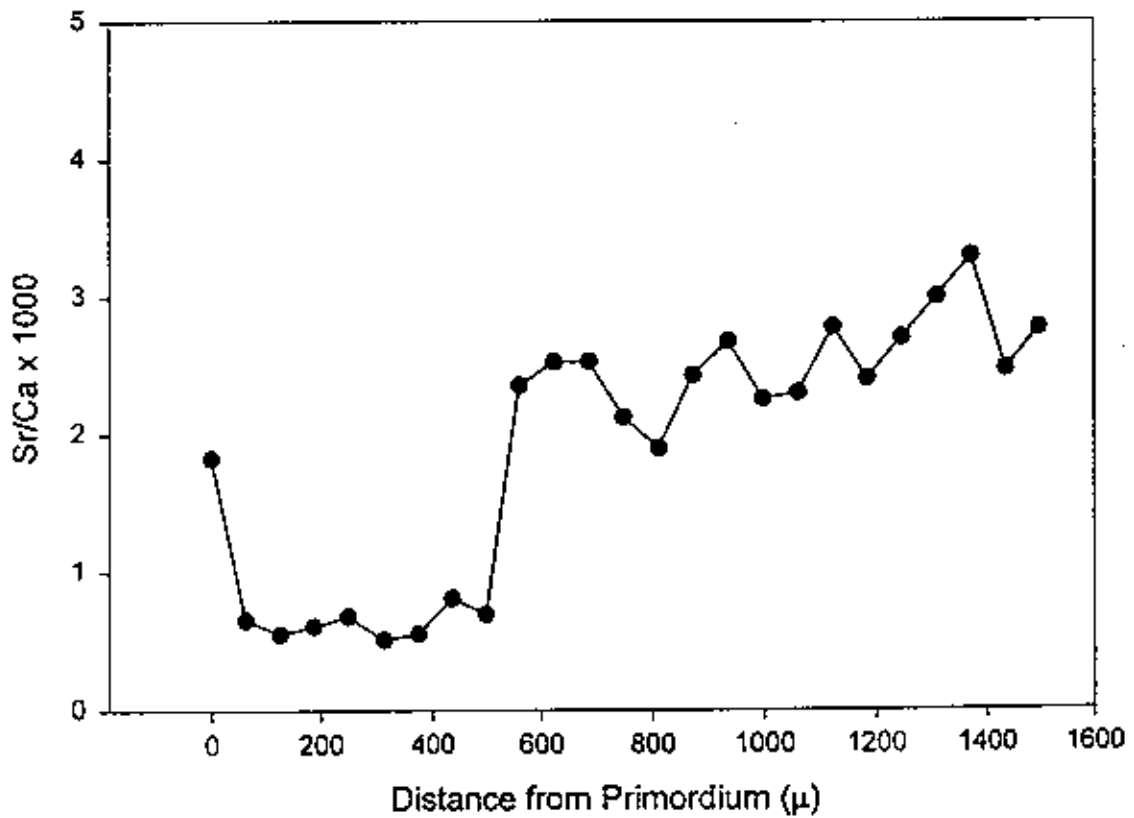
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Sockeye 1



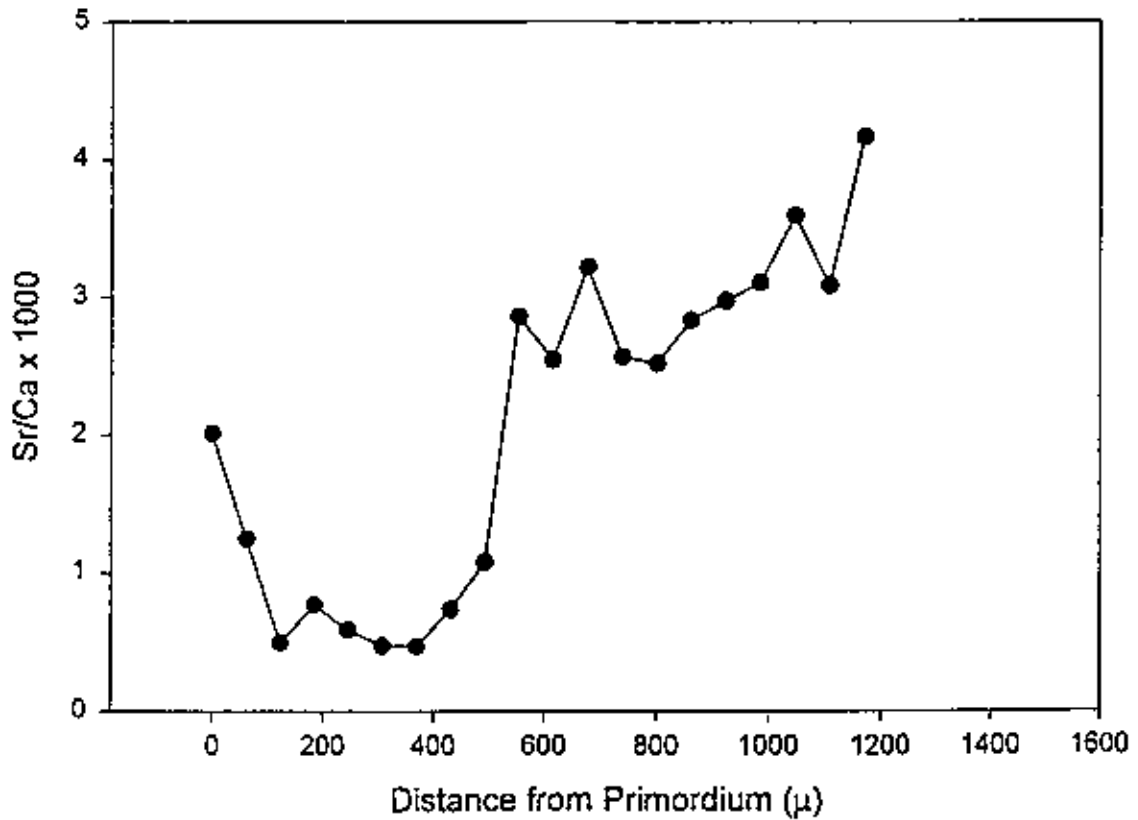
*Maternal Origin of Sockeye Salmon (*Oncorhynchus nerka*) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997*
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Sockeye 2



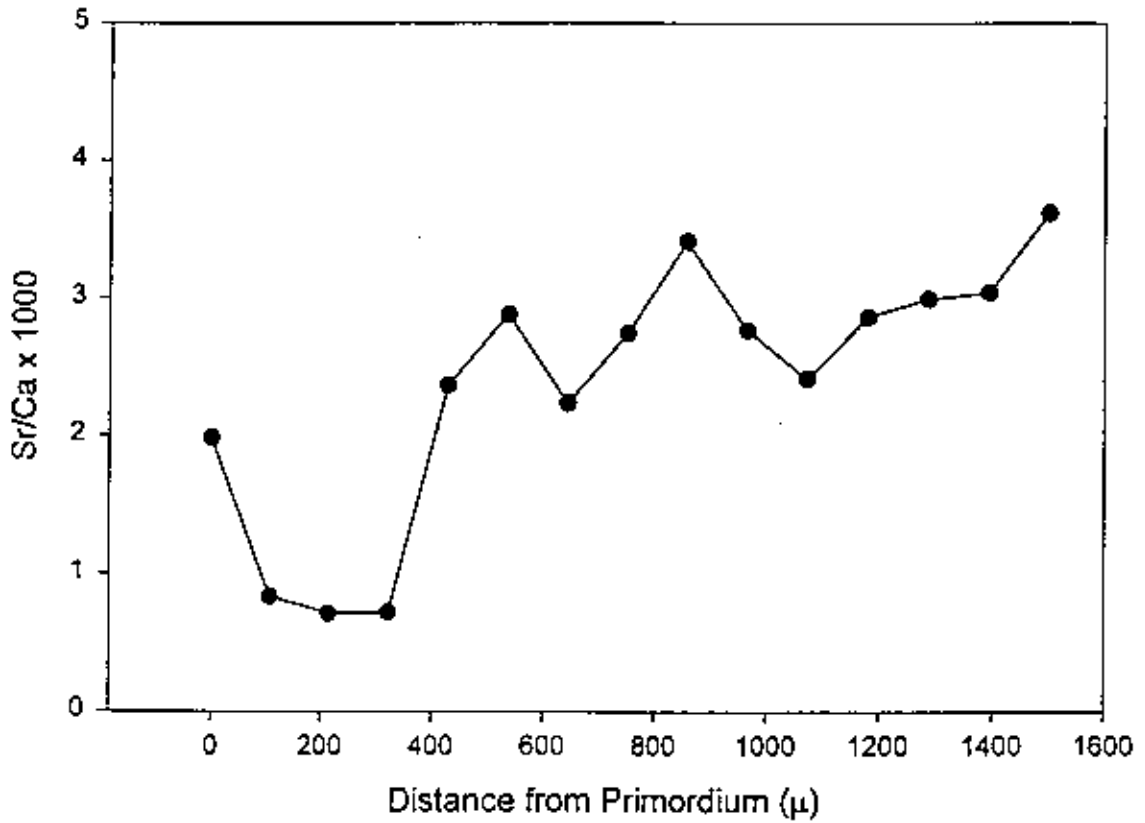
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 3



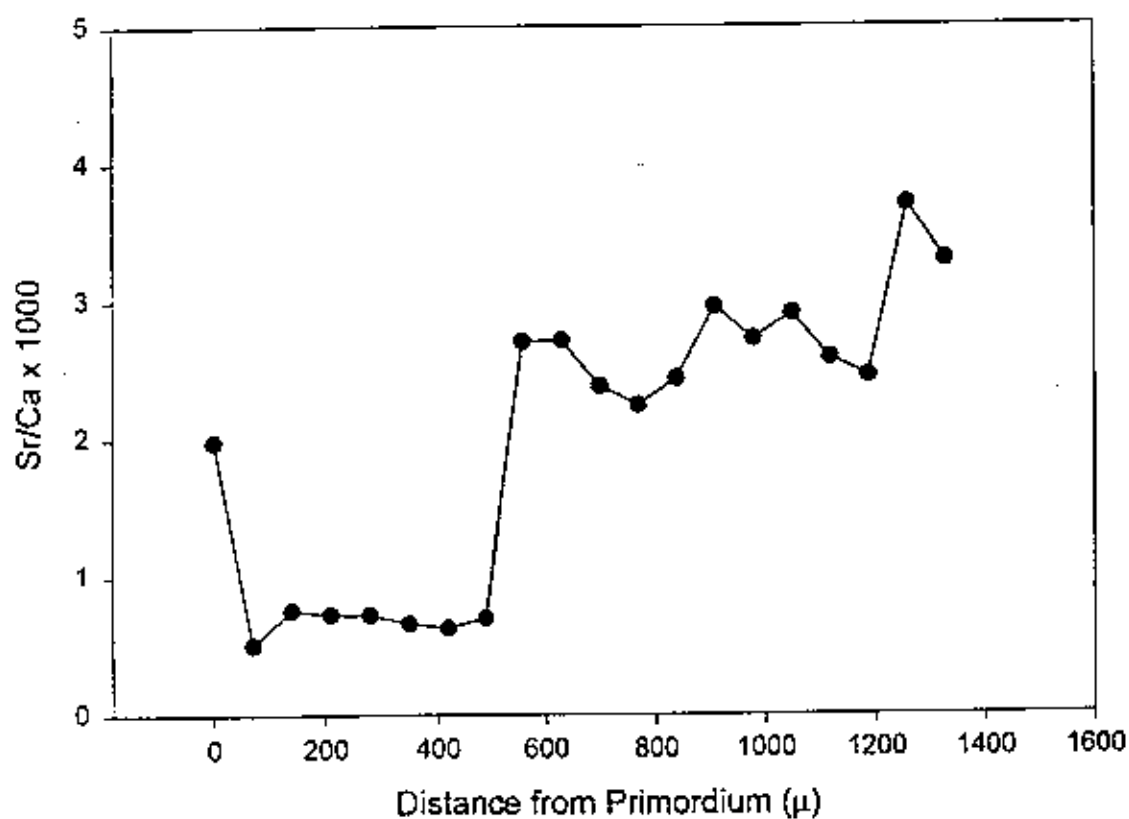
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 4



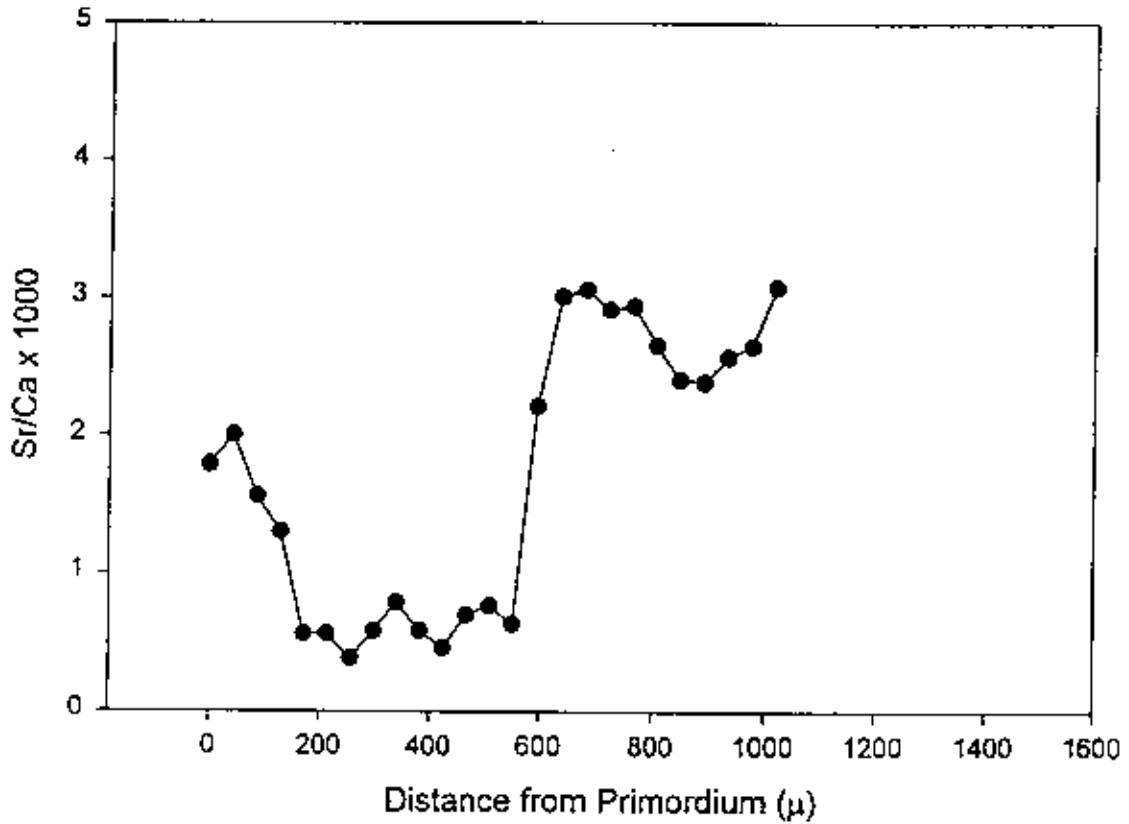
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997
Pelton Round Butte Hydroelectric Project/FERC No. 2030

Sockeye 5



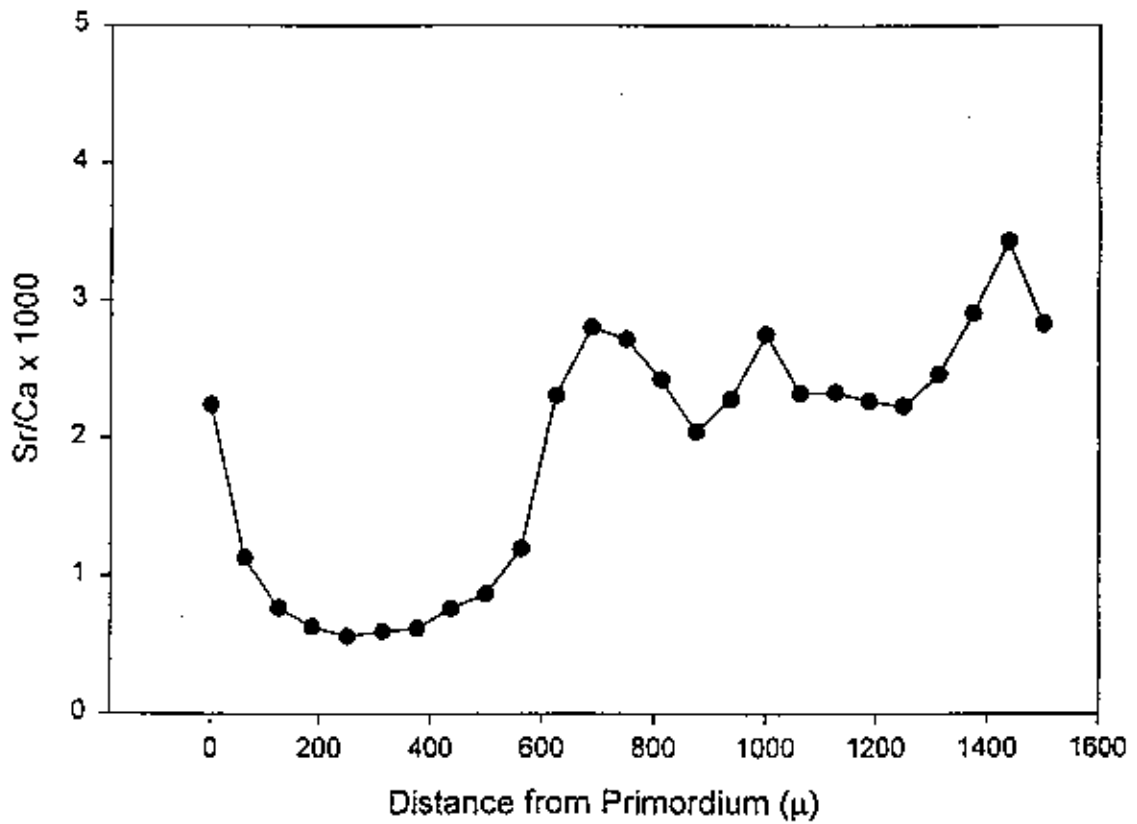
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Sockeye 6



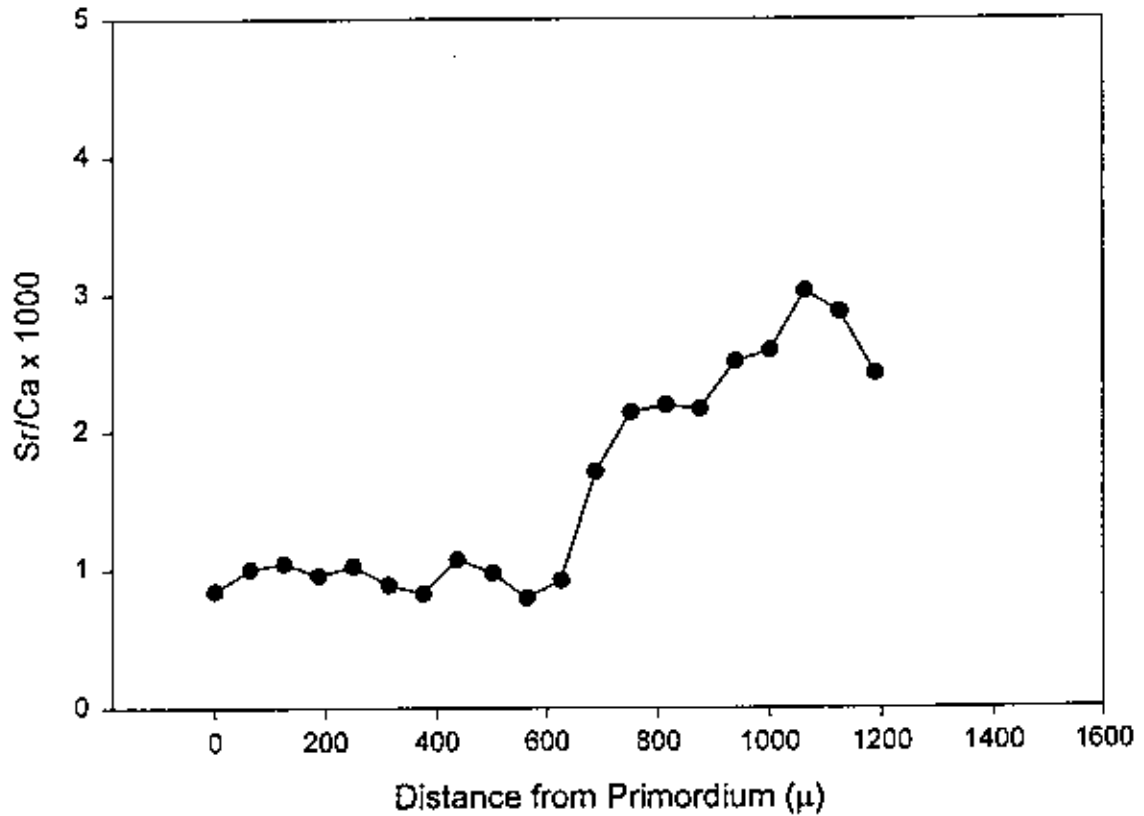
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 7



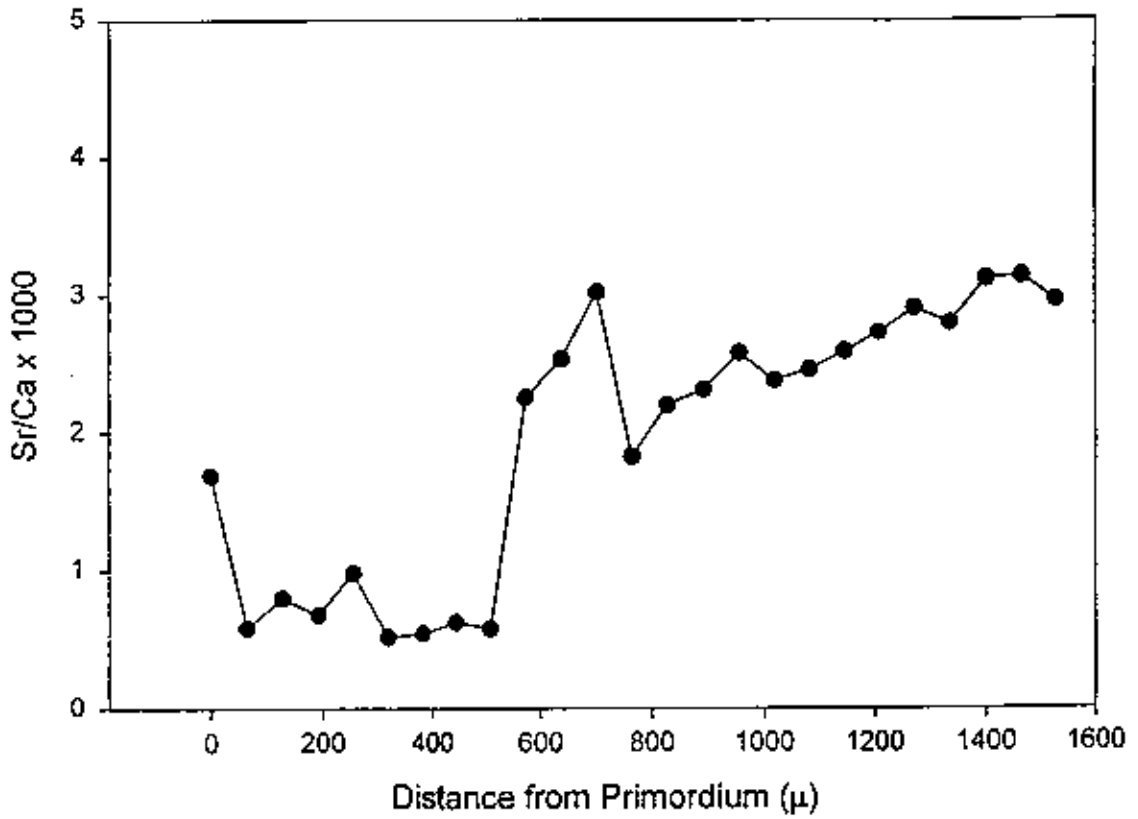
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 8



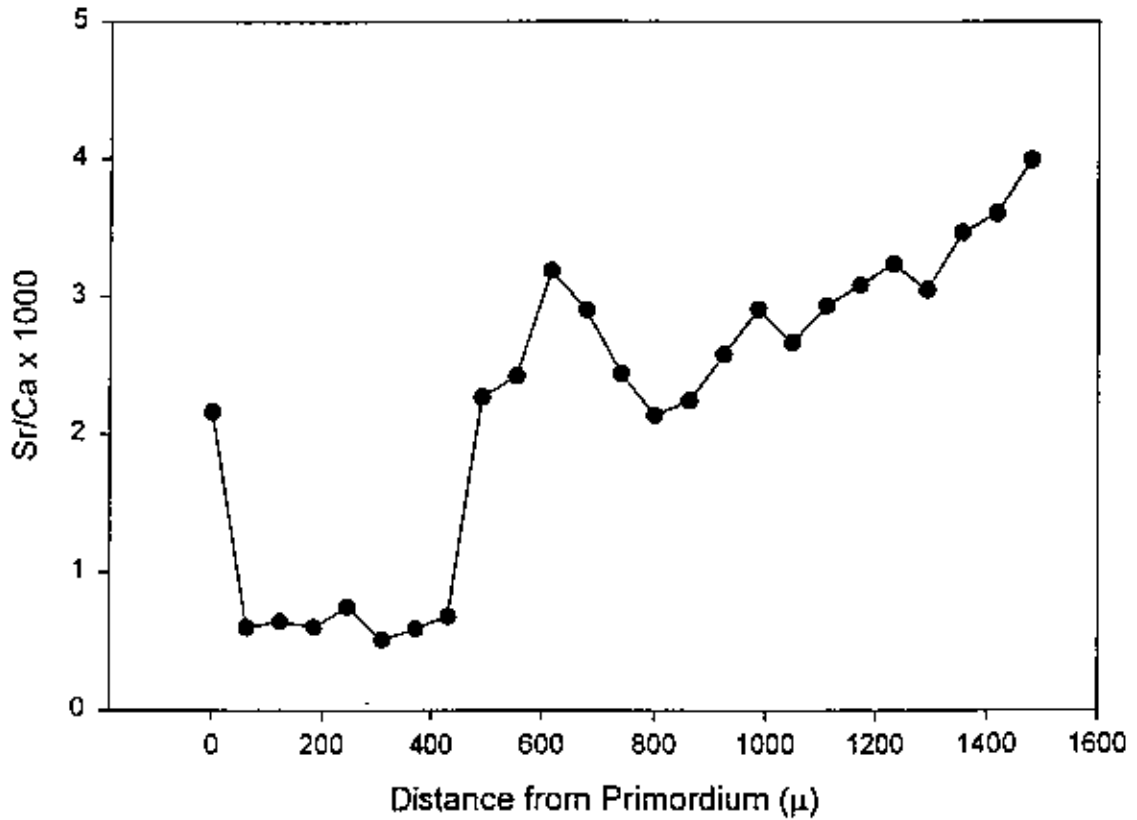
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Sockeye 9



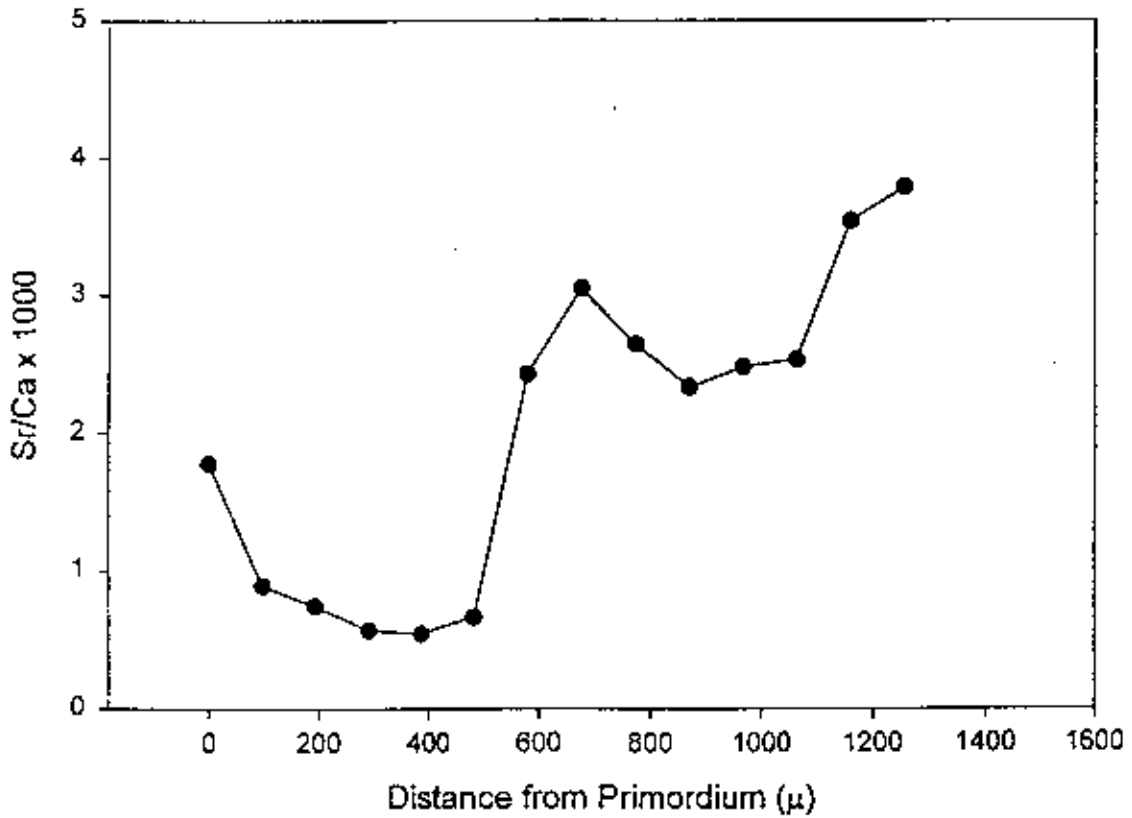
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 10



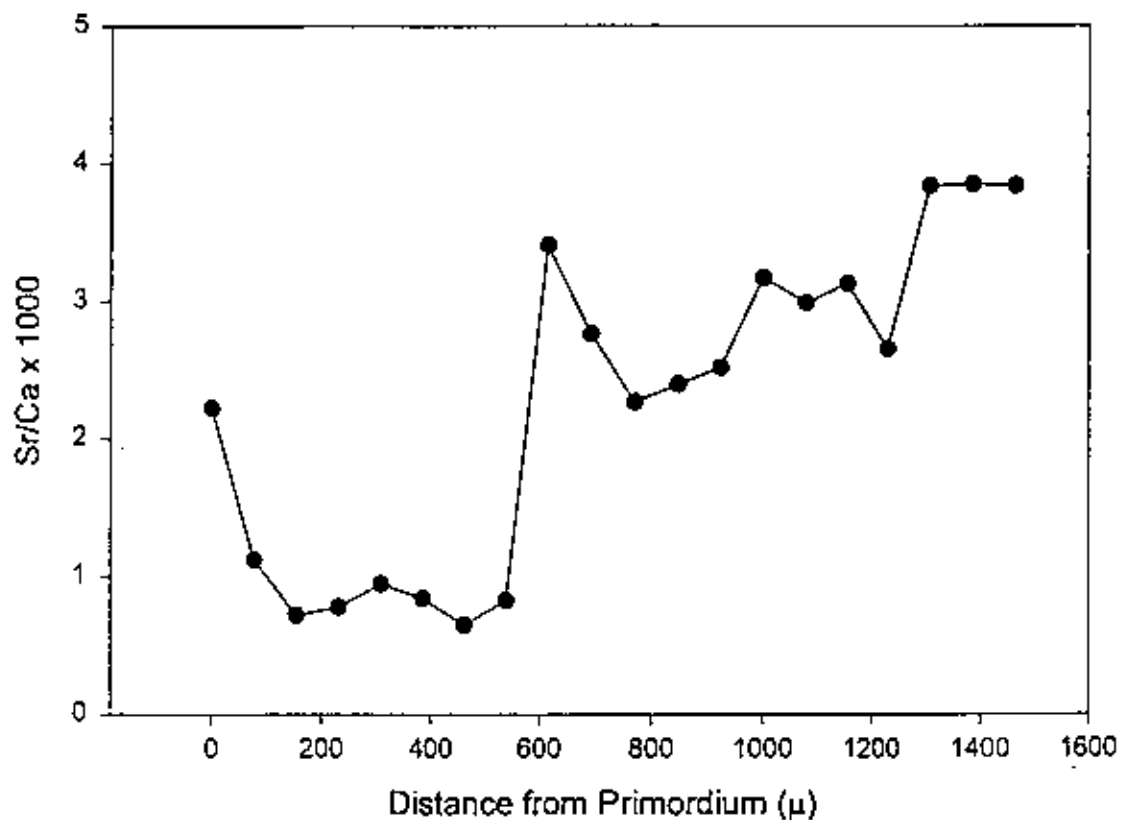
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Sockeye 11



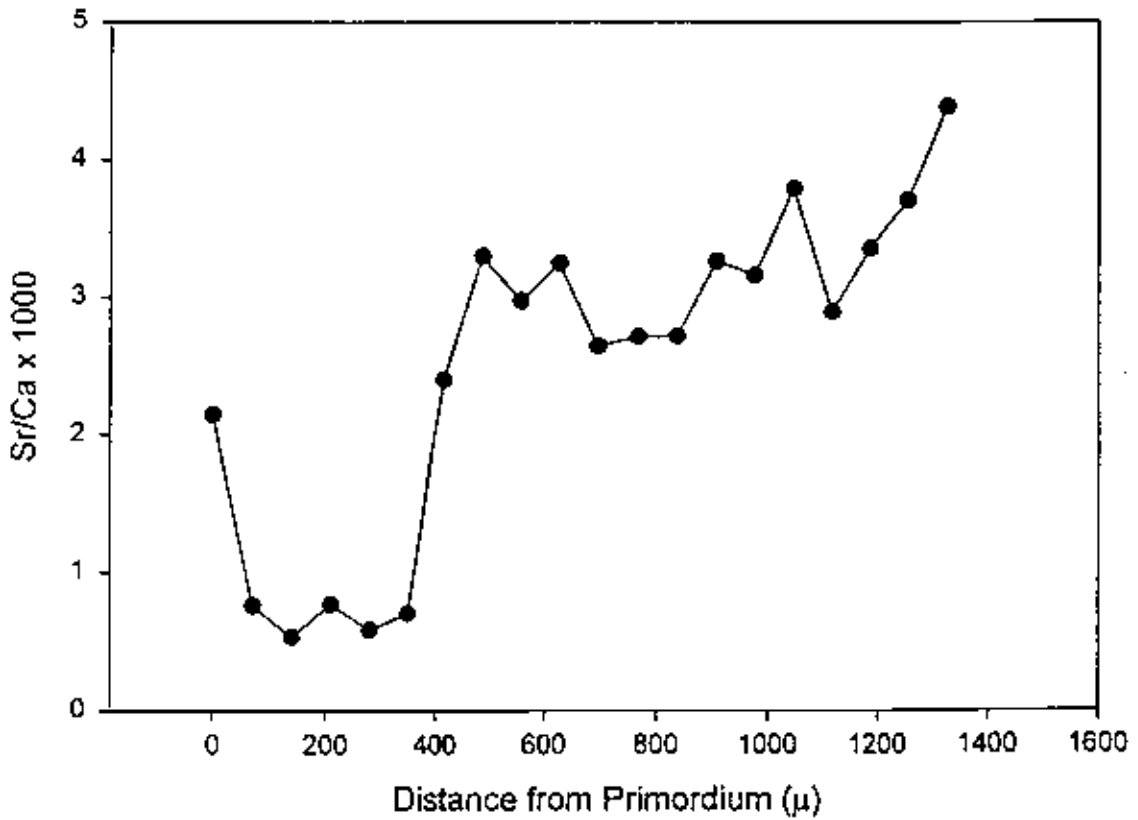
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 12



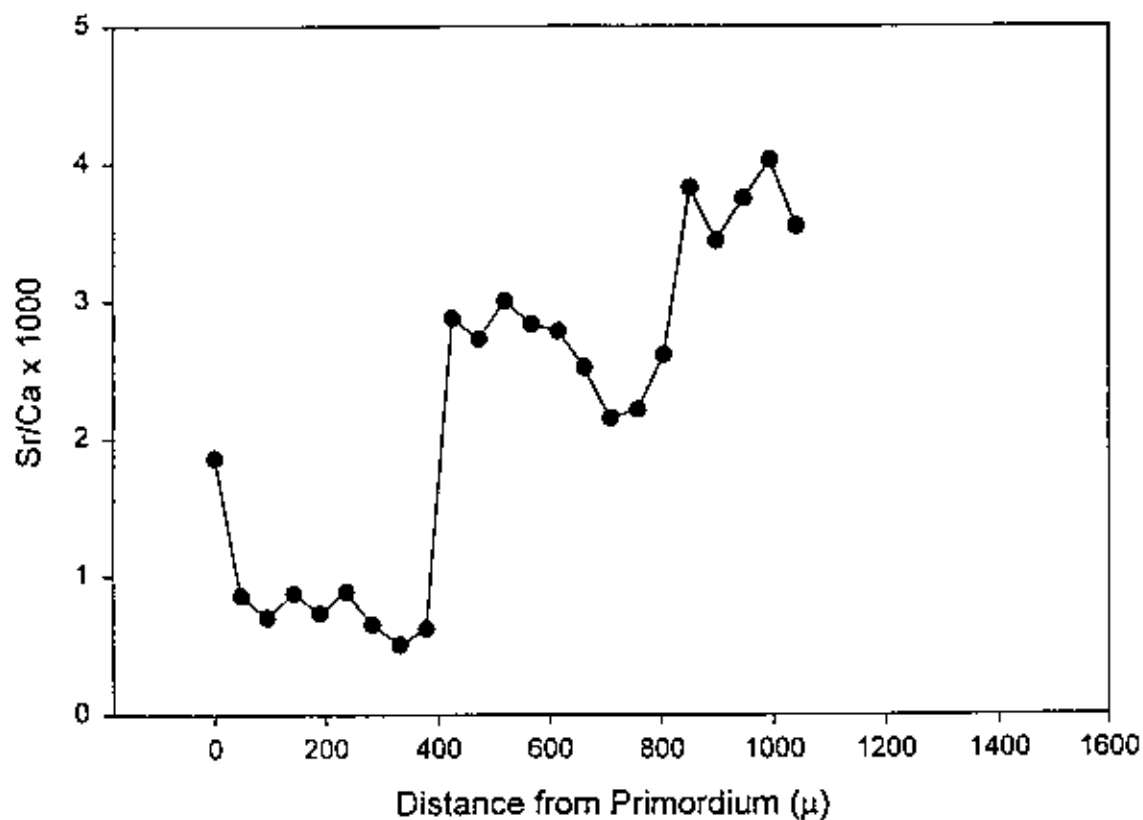
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 13



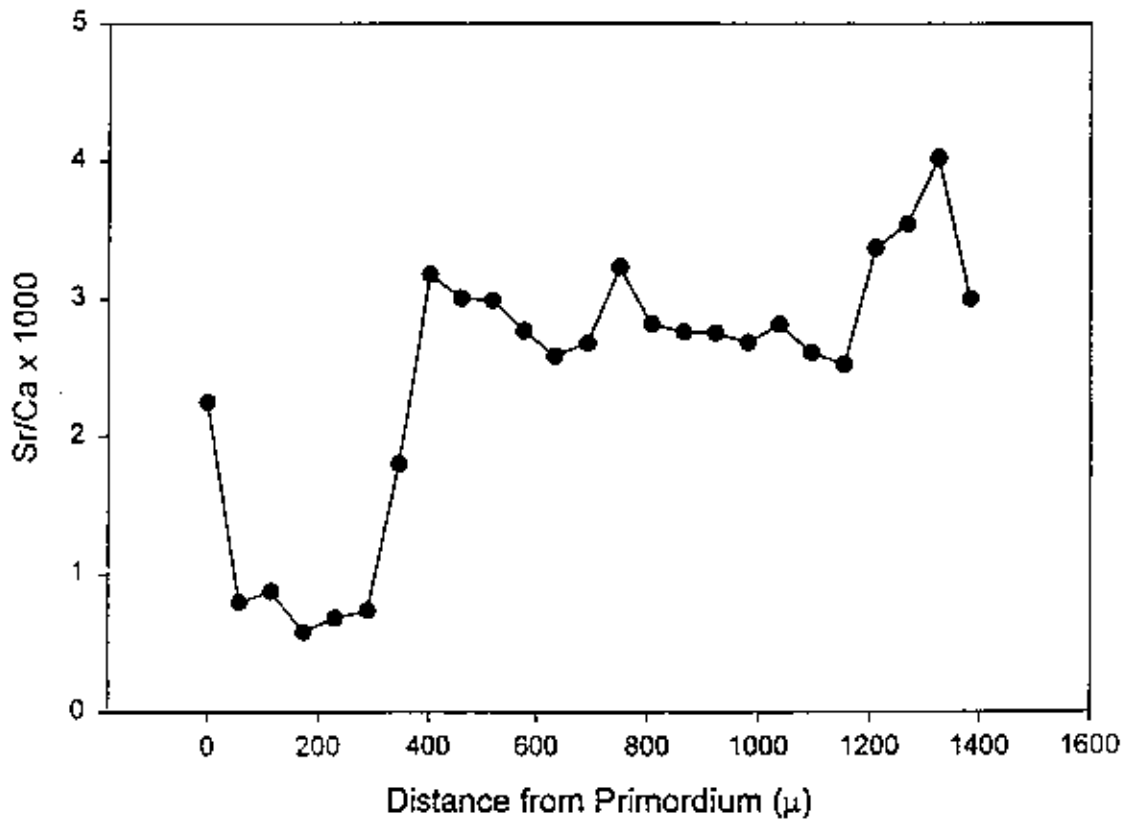
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 15



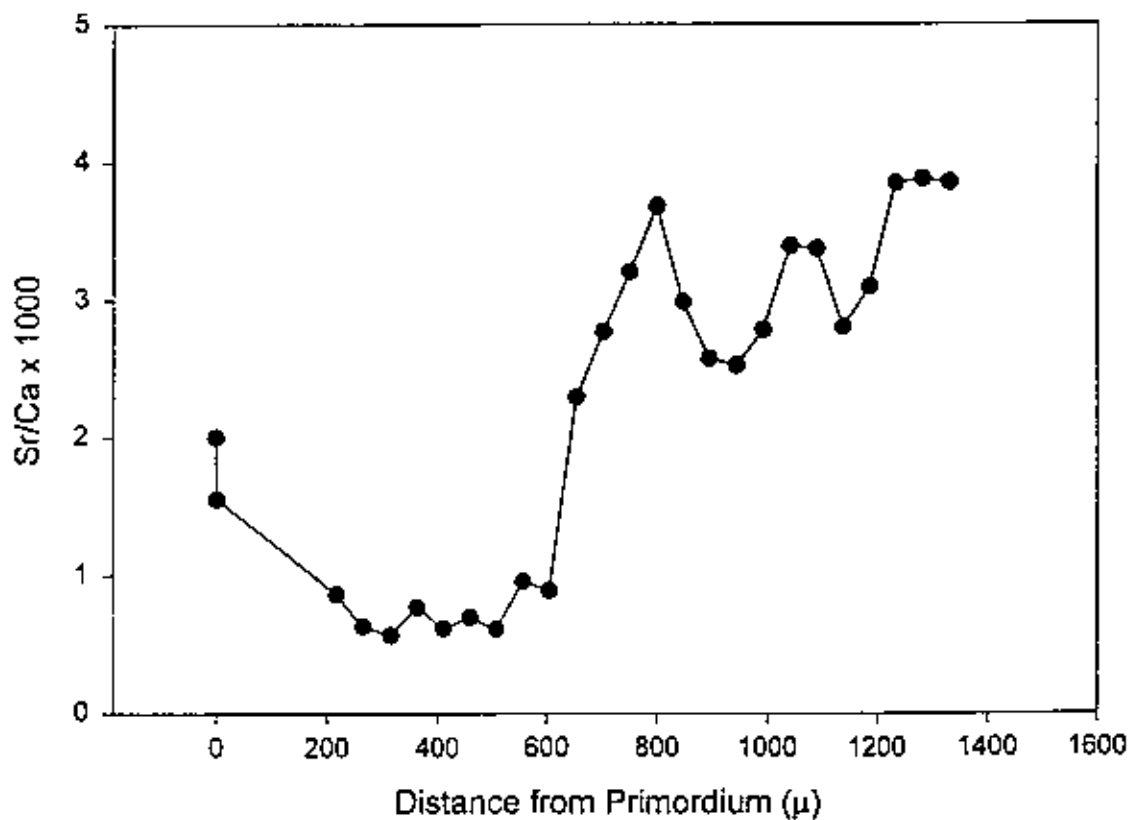
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 16



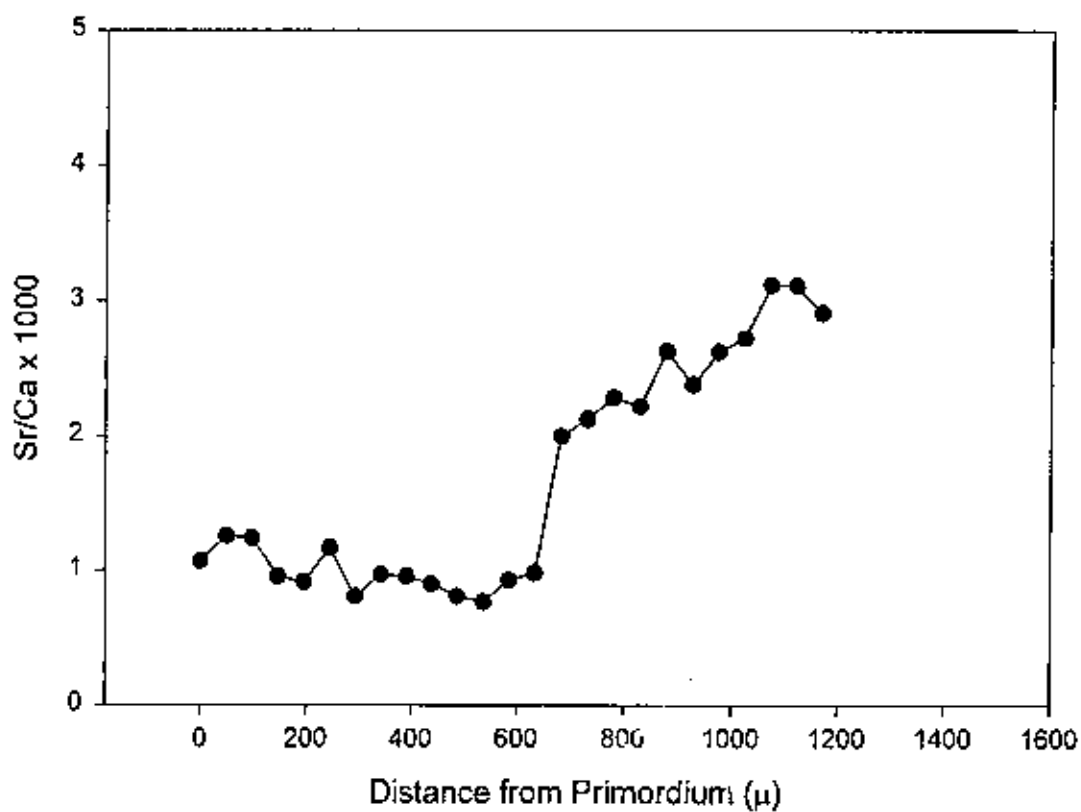
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 17



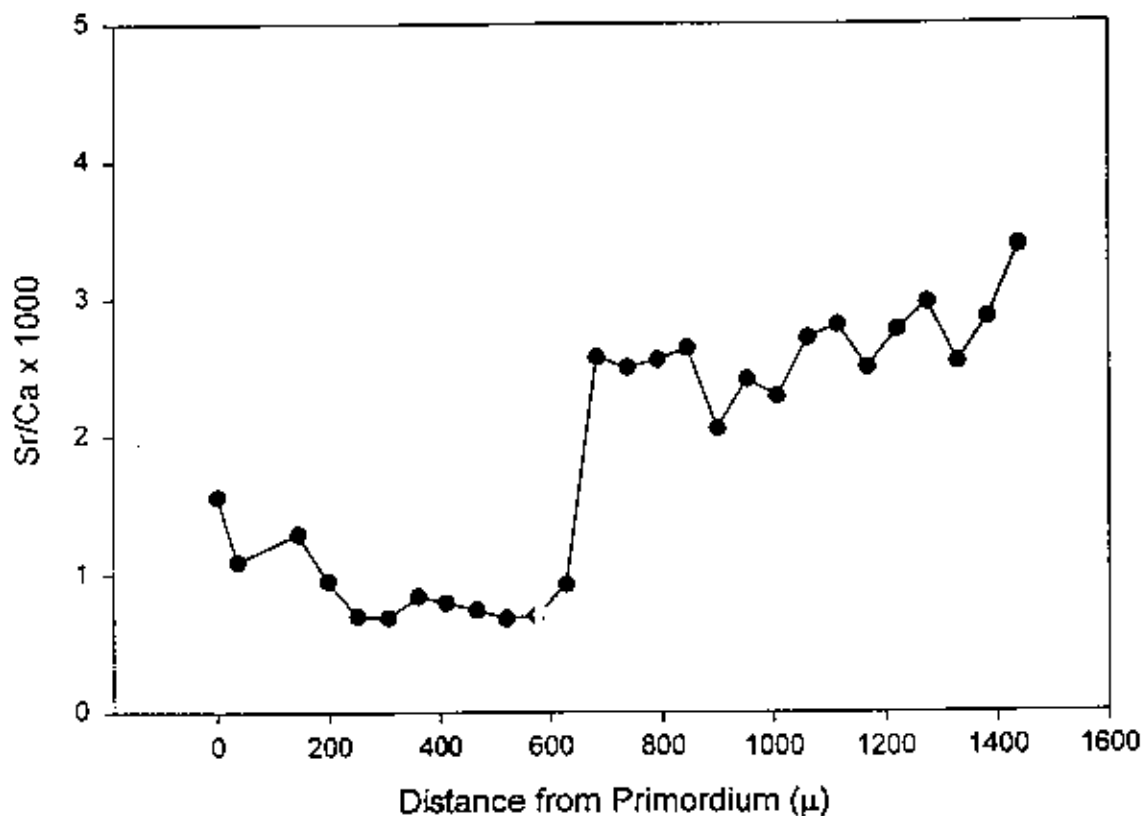
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 18



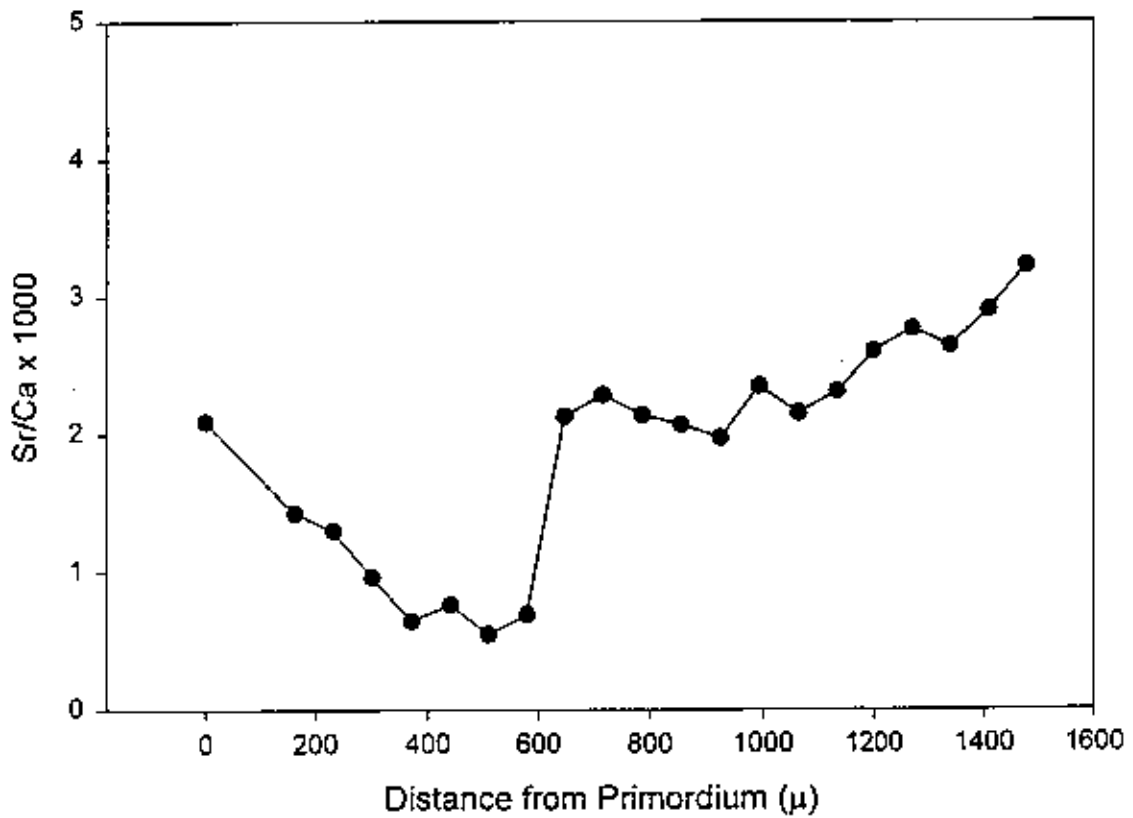
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 19



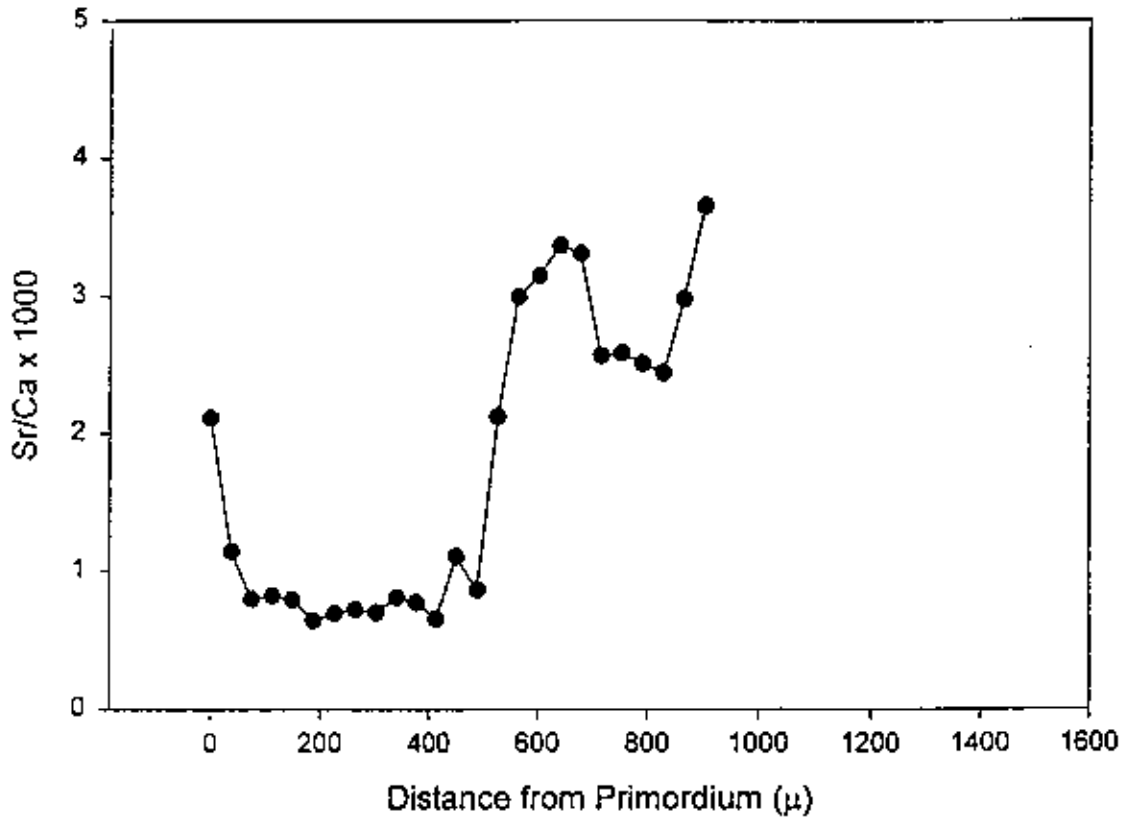
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 20



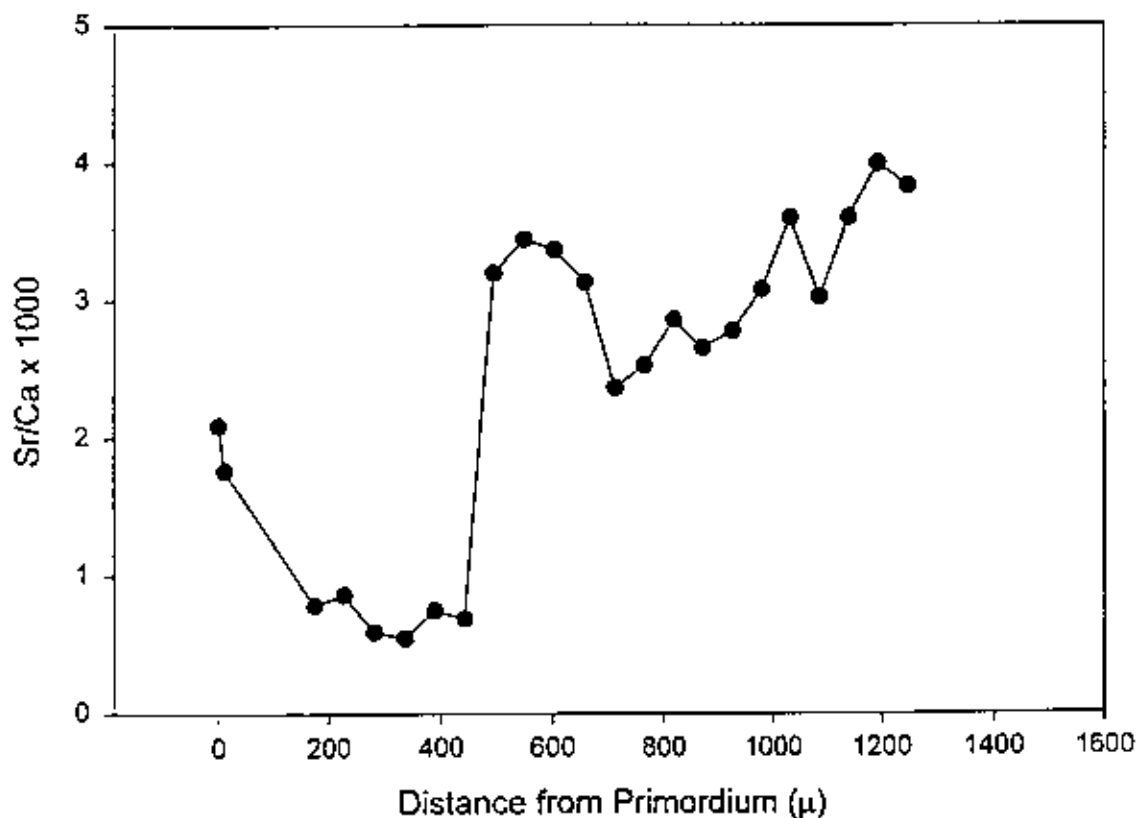
*Maternal Origin of Sockeye Salmon (*Oncorhynchus nerka*) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997*

Sockeye 22



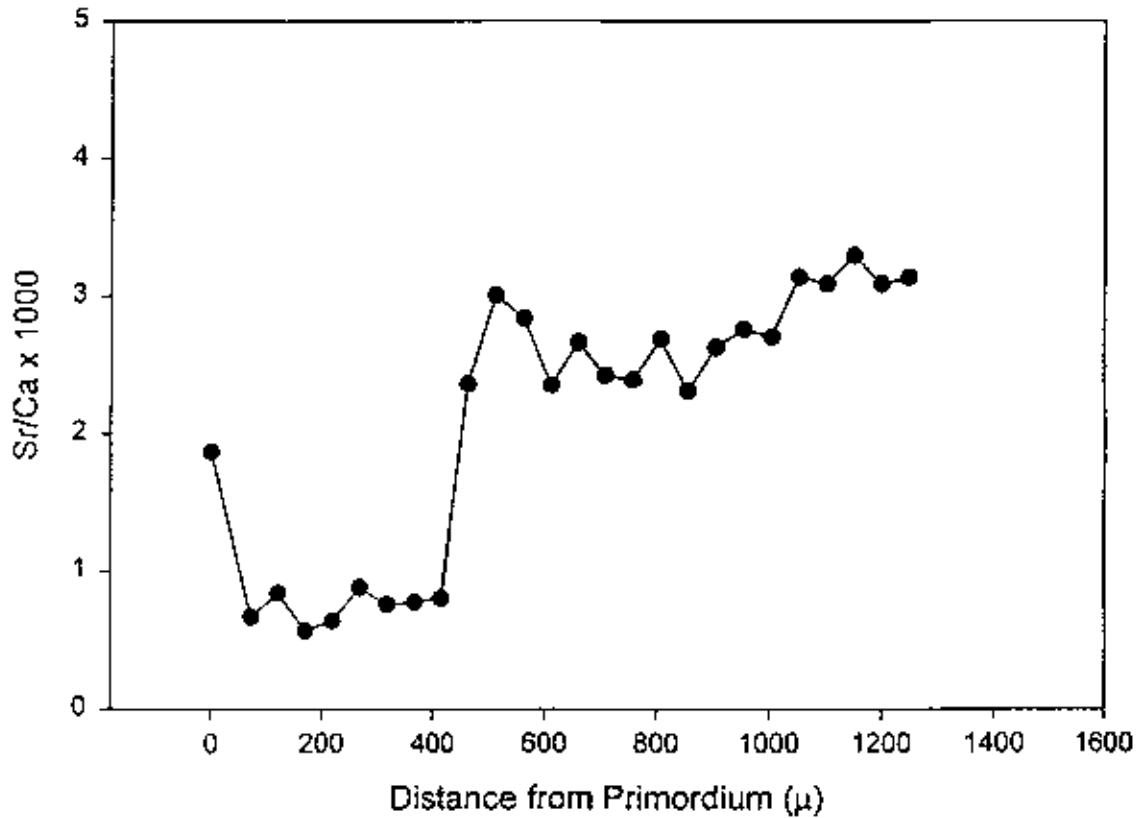
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 23



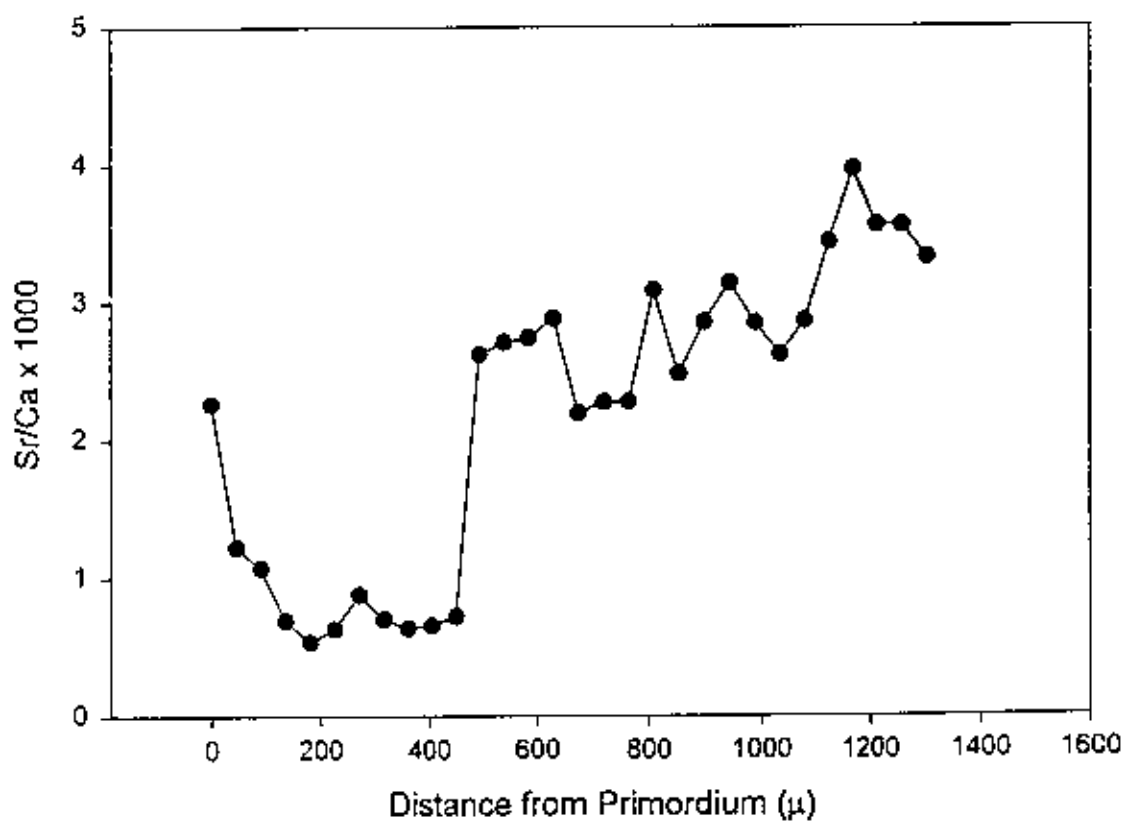
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 24



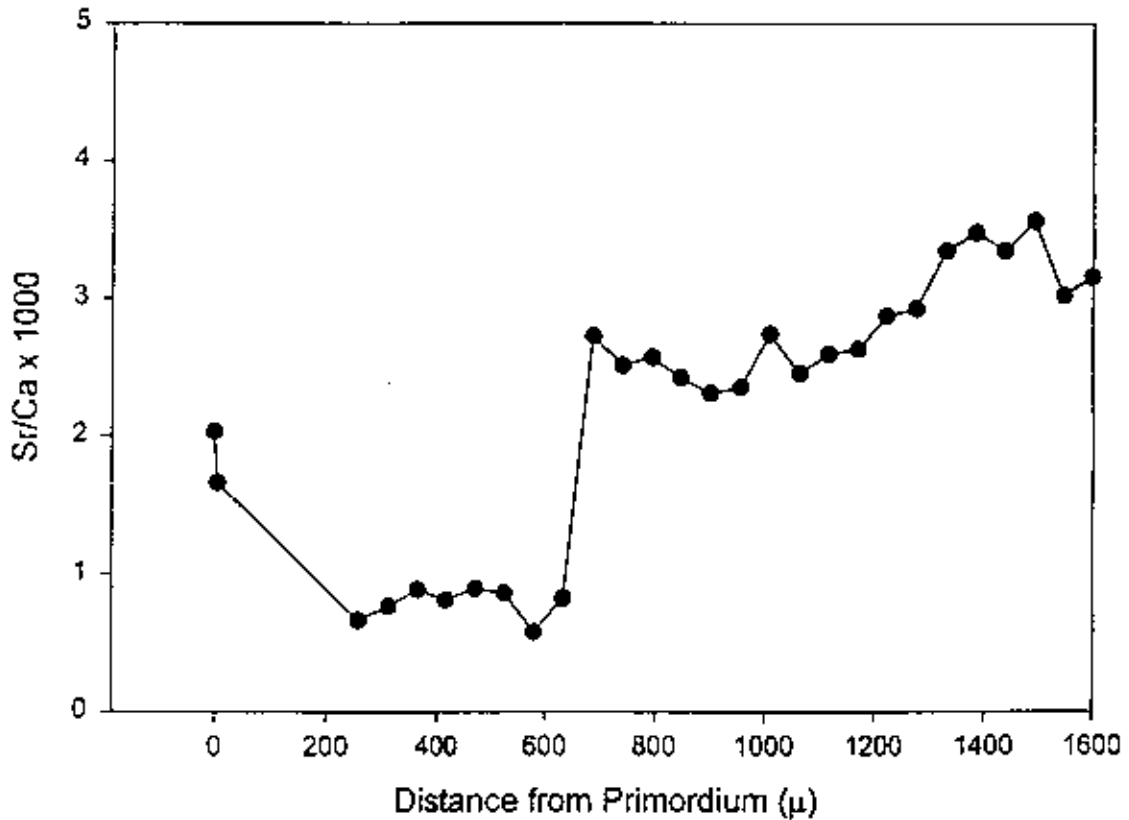
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 25



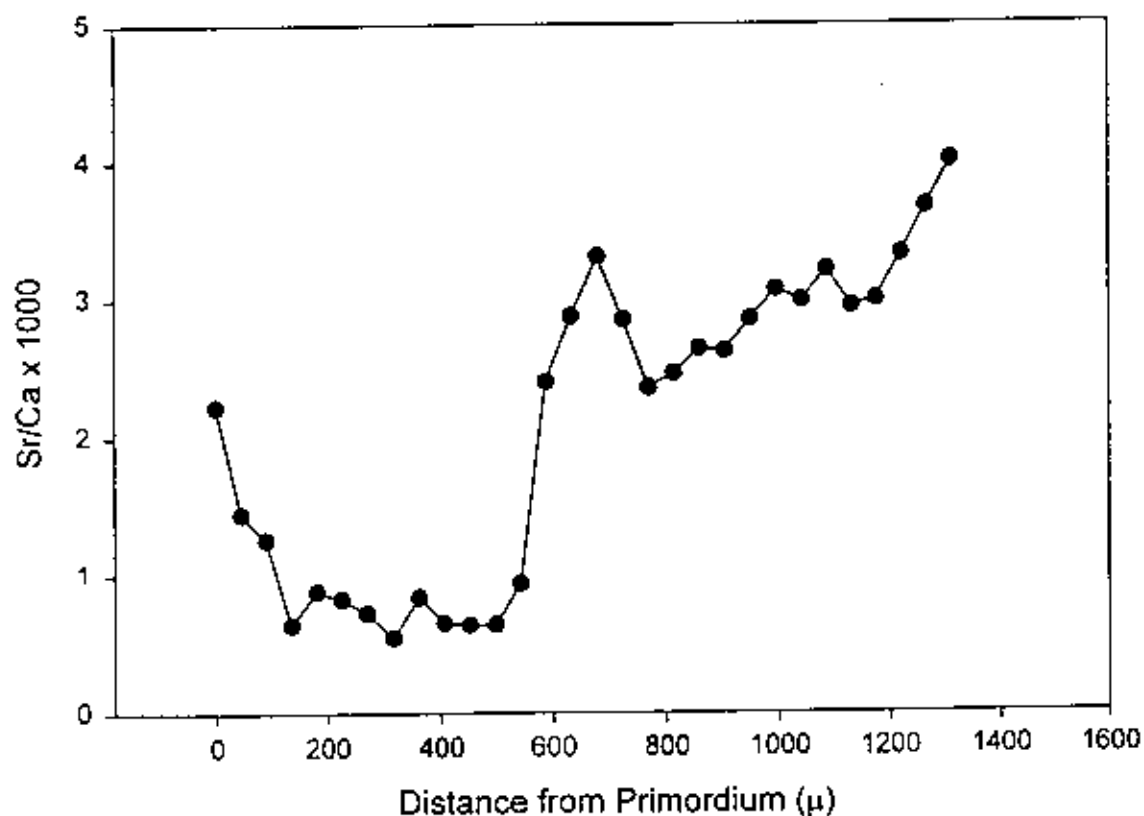
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 26



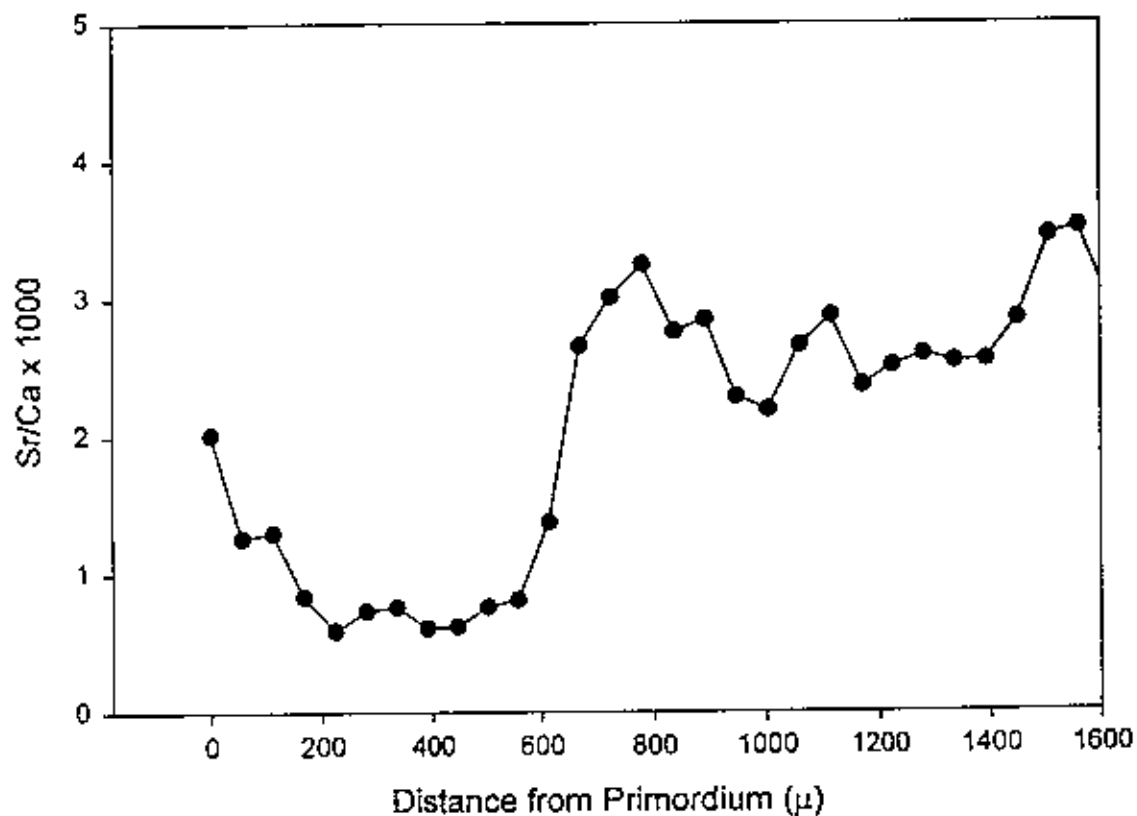
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 27



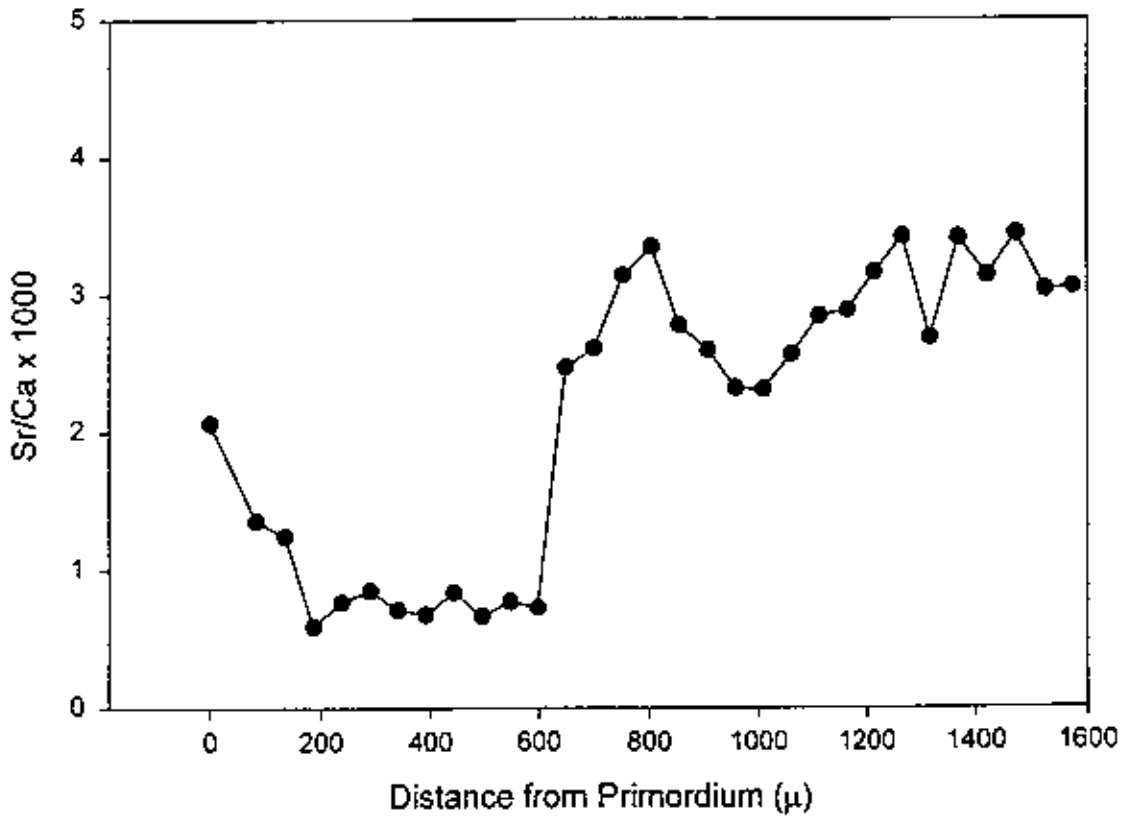
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 28



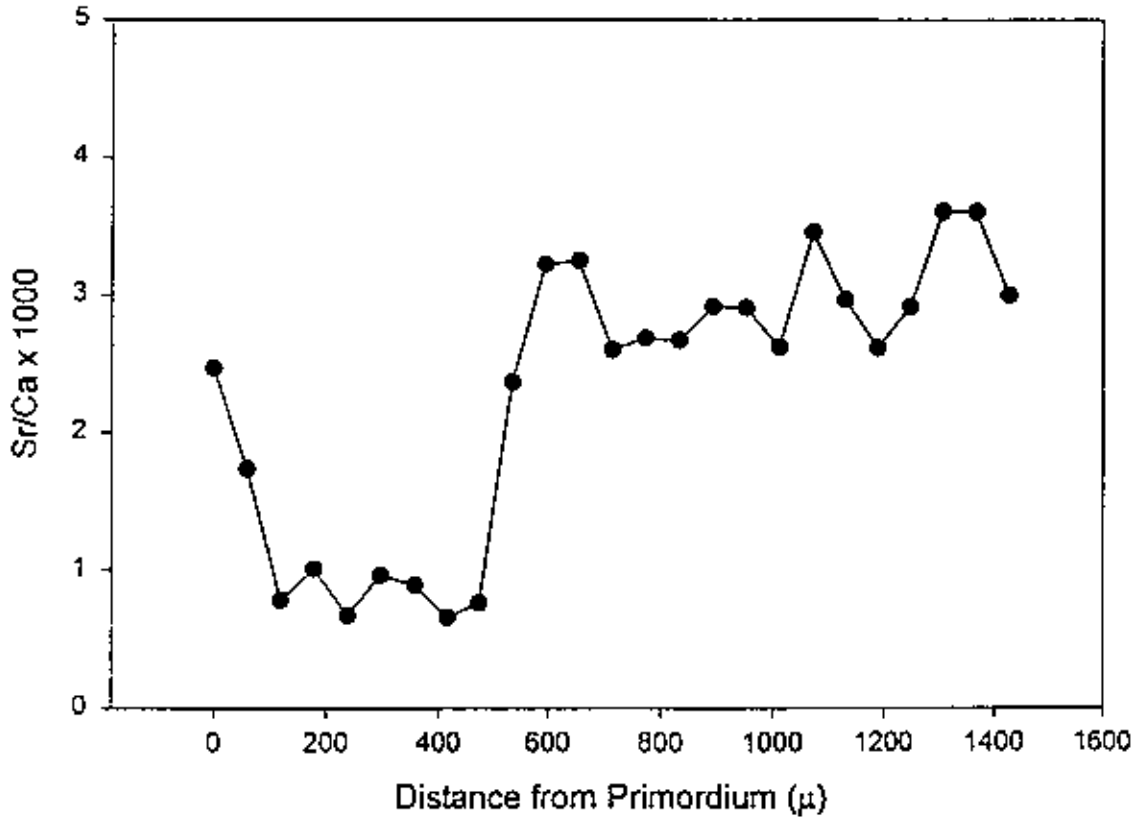
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 29



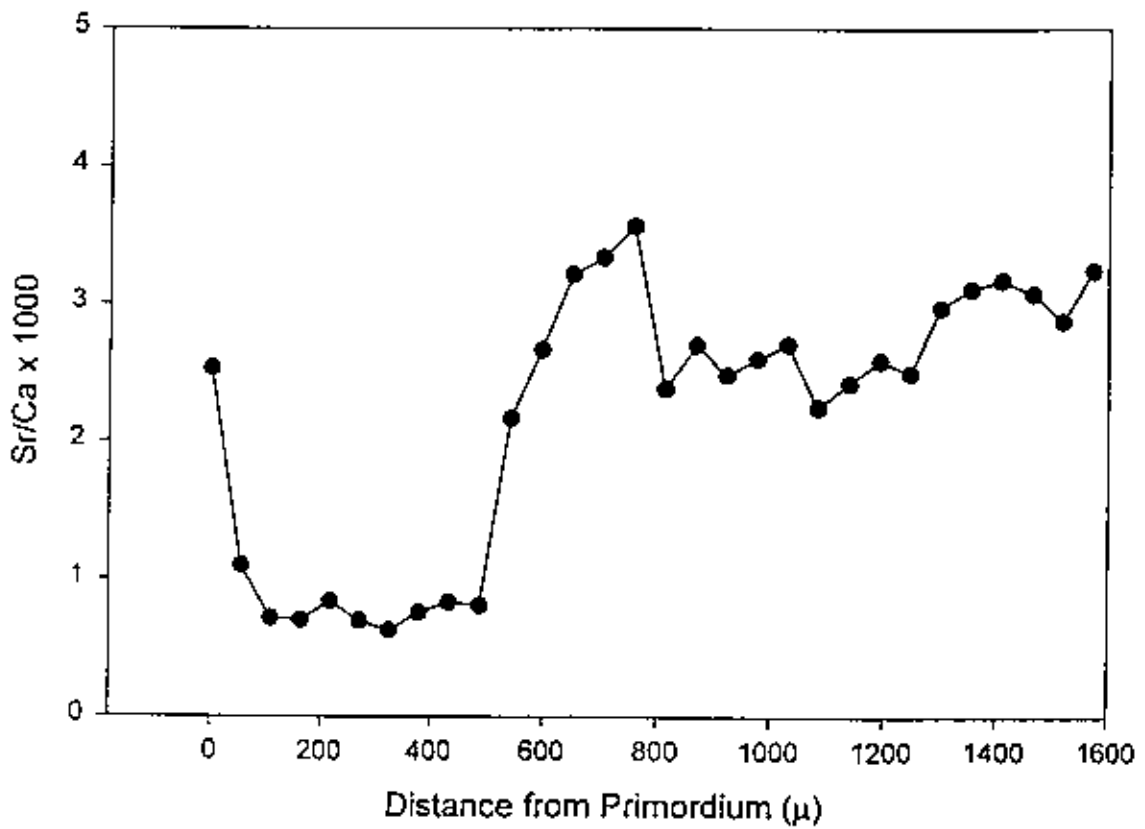
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 30



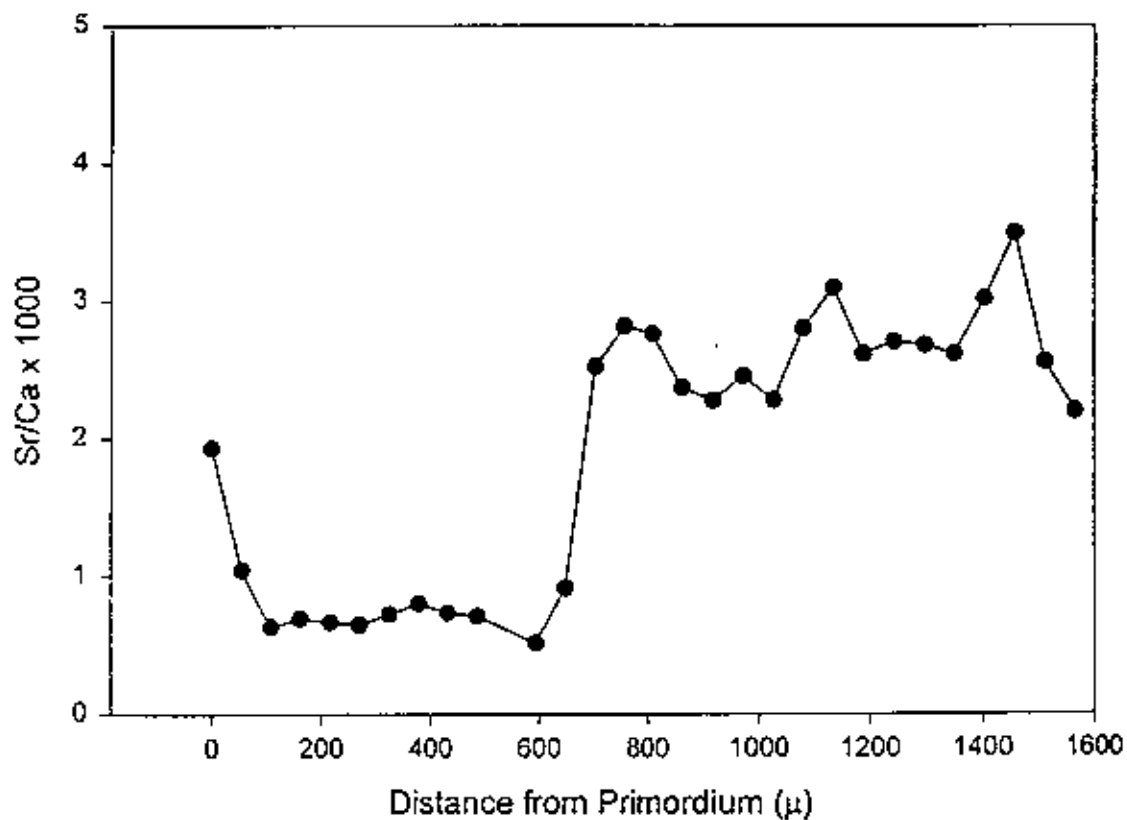
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 31



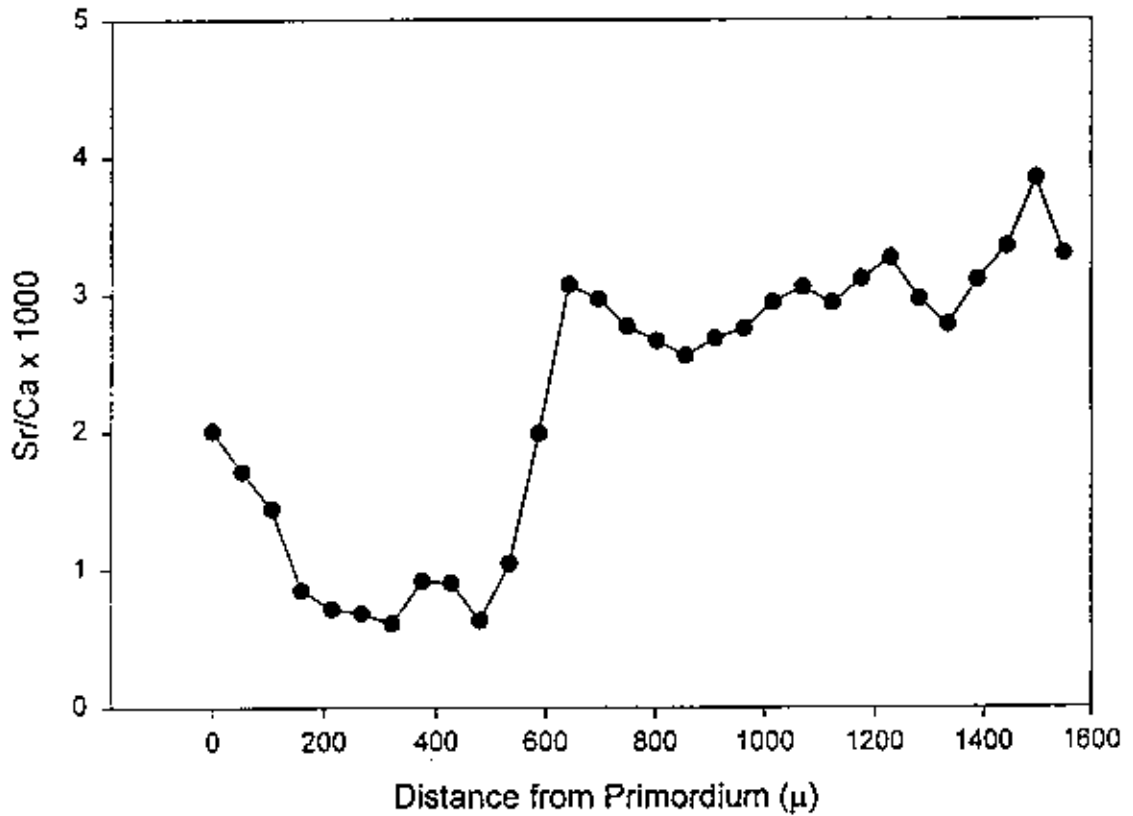
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 32



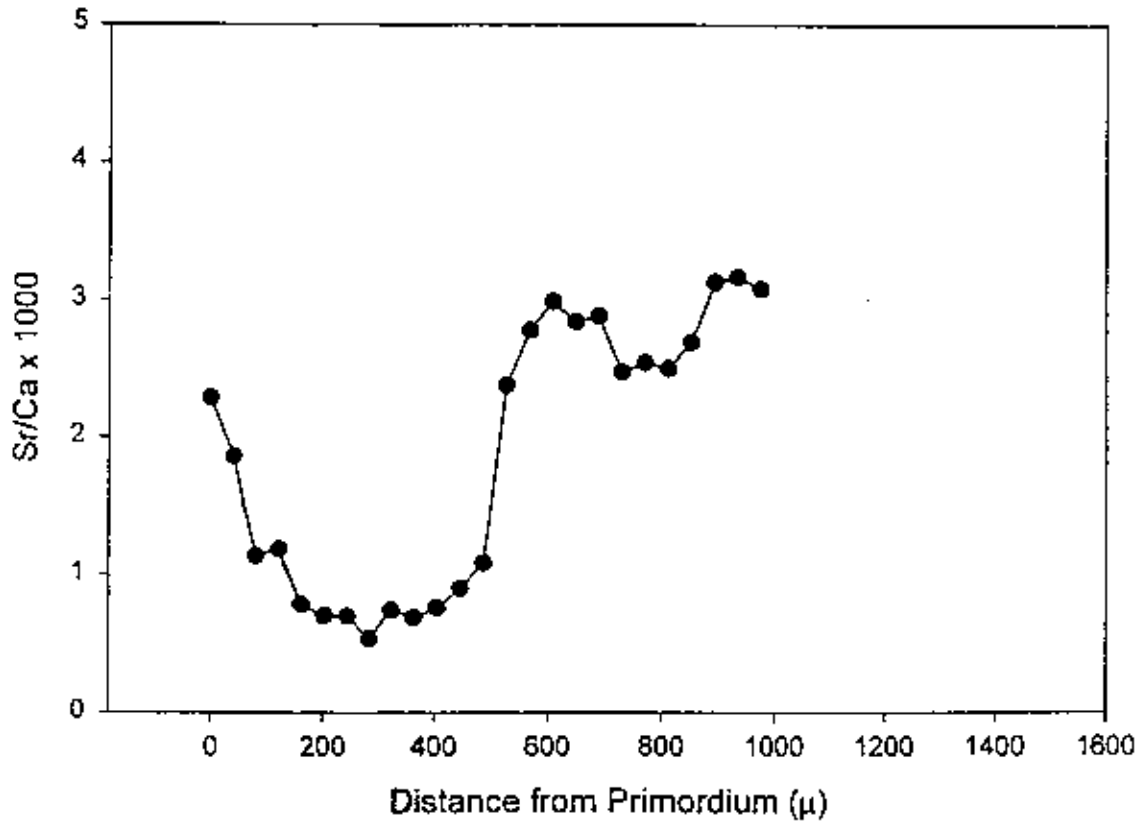
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 33



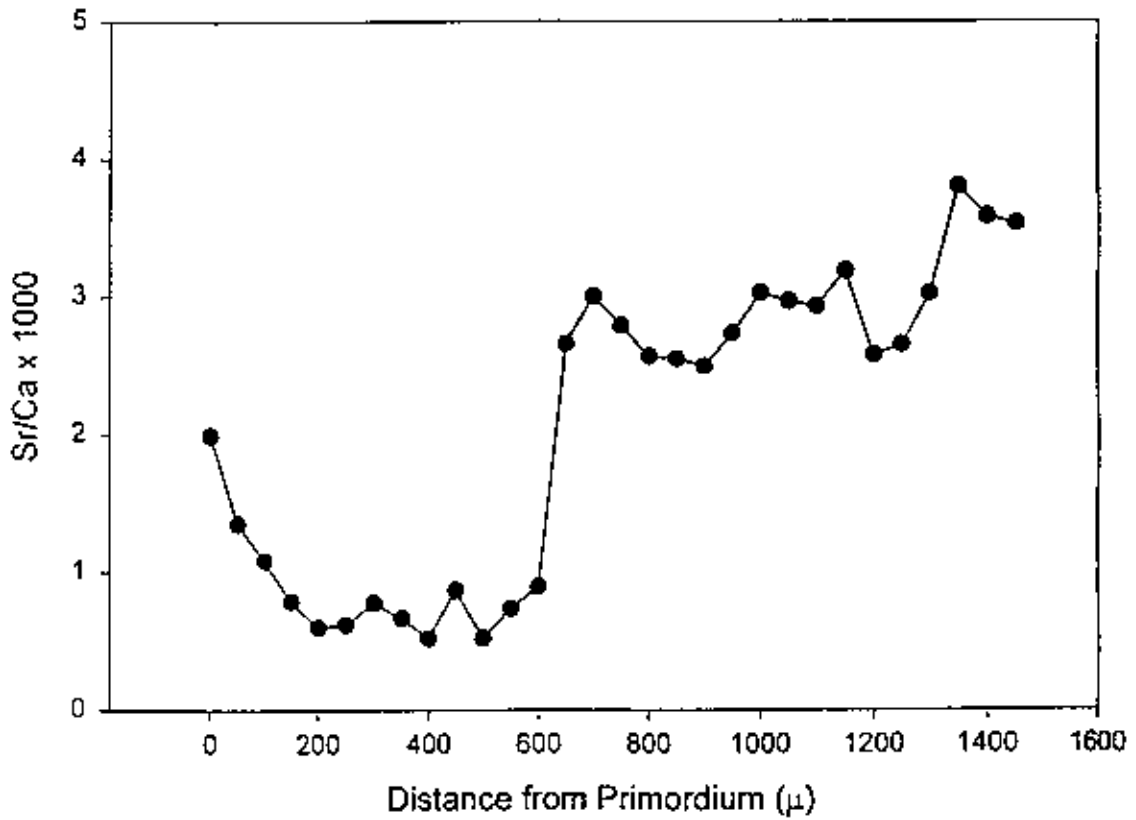
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 34



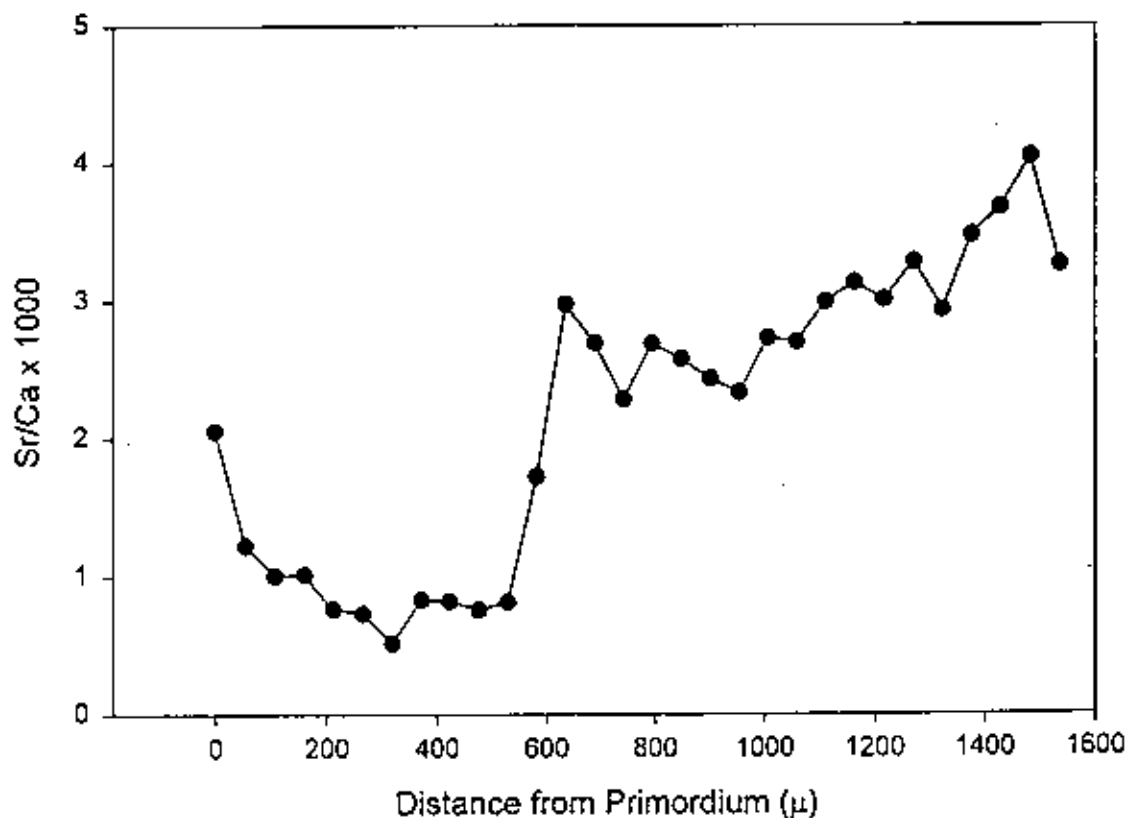
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 35



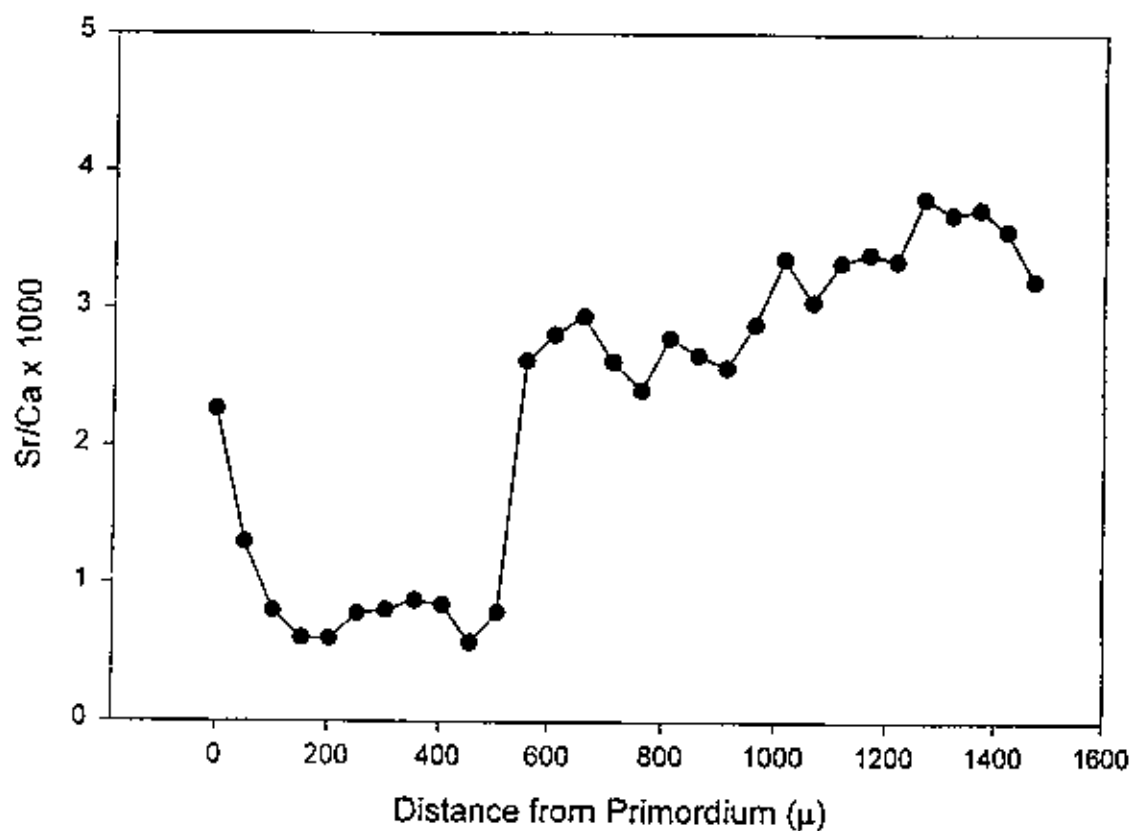
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 36



Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Sockeye 37



Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997



APPENDIX 2.

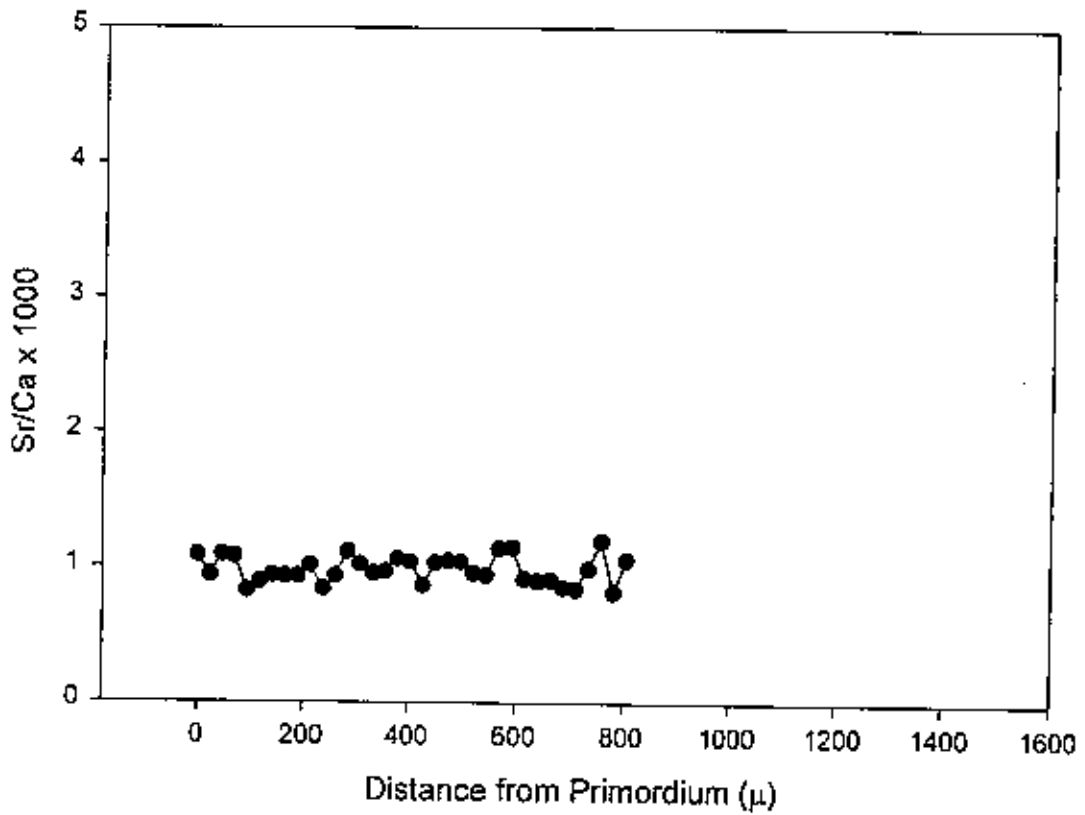
Life history transects of Sr/Ca ratios in kokanee otoliths
collected from Lake Billy Chinook, Oregon.

*Maternal Origin of Sockeye Salmon (Oncorhynchus
nerka) Returning to the Pelton Fish Trap, Deschutes
River, Oregon in 1997*

Pelton Round Butte Hydroelectric Project/FERC No. 2030

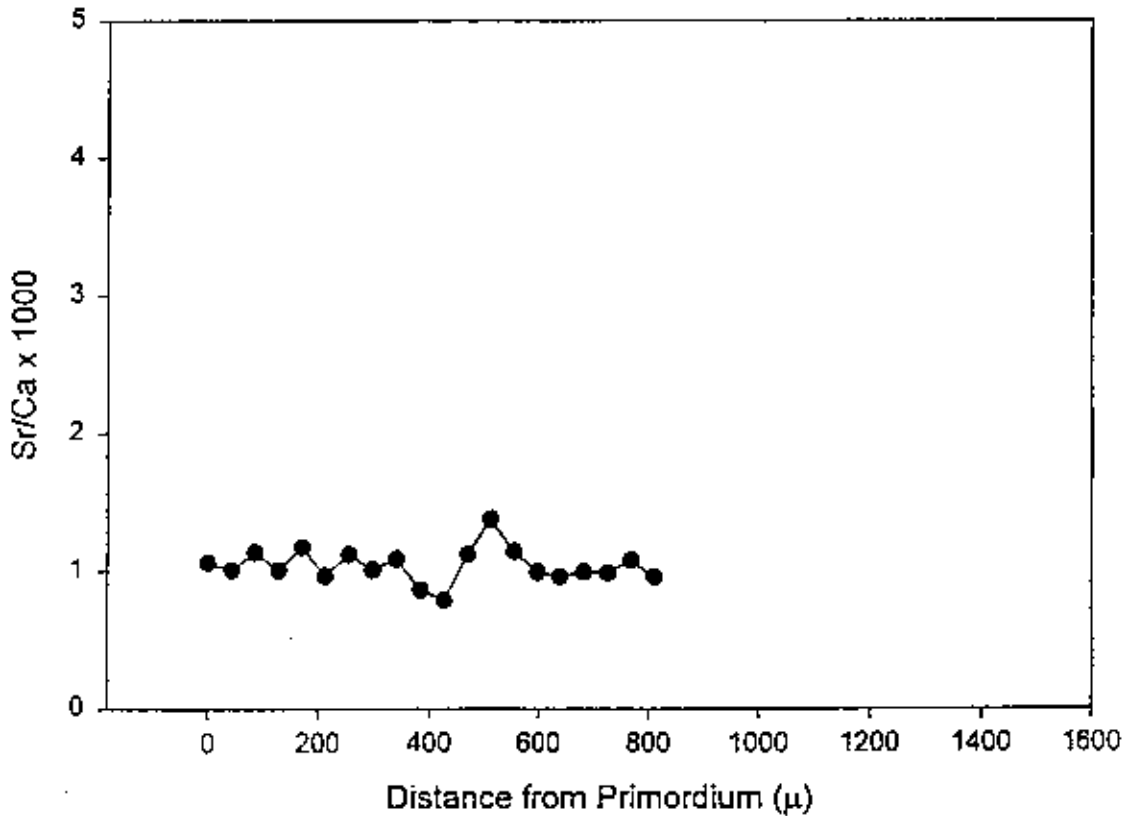


Kokanee 1



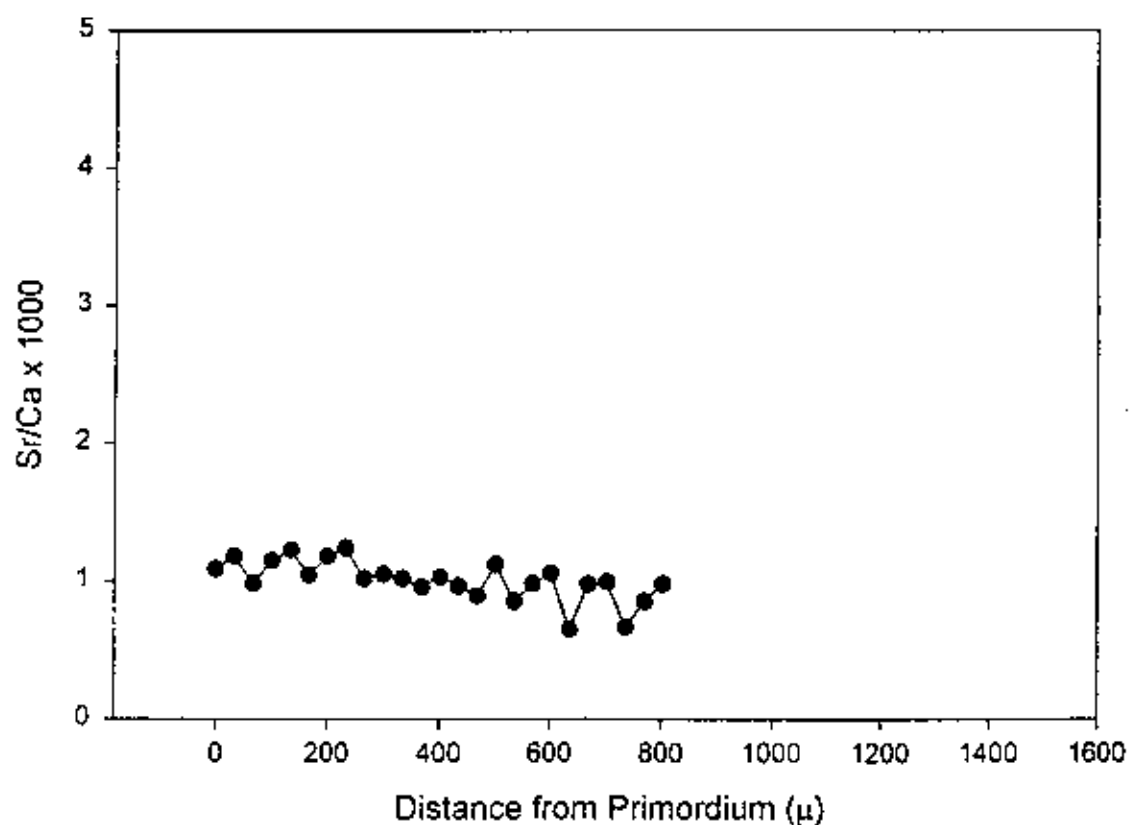
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Kokanee 2



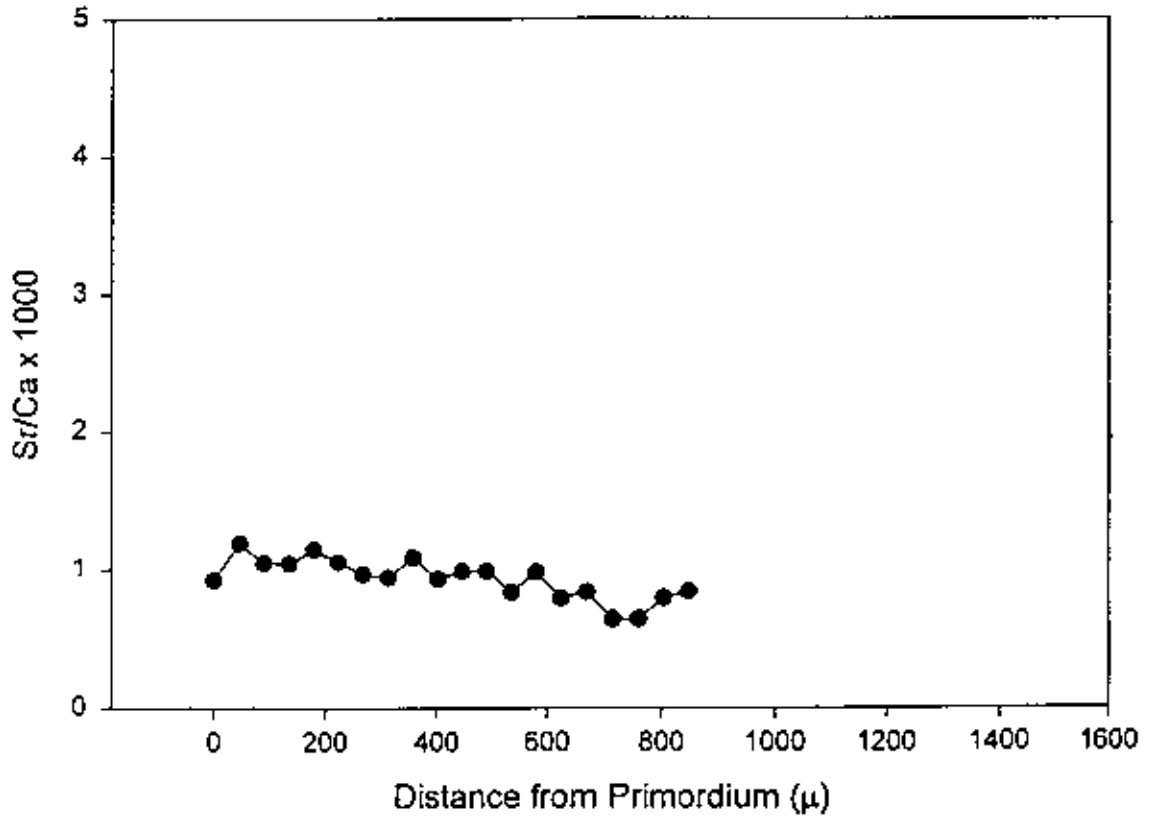
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Kokanee 3



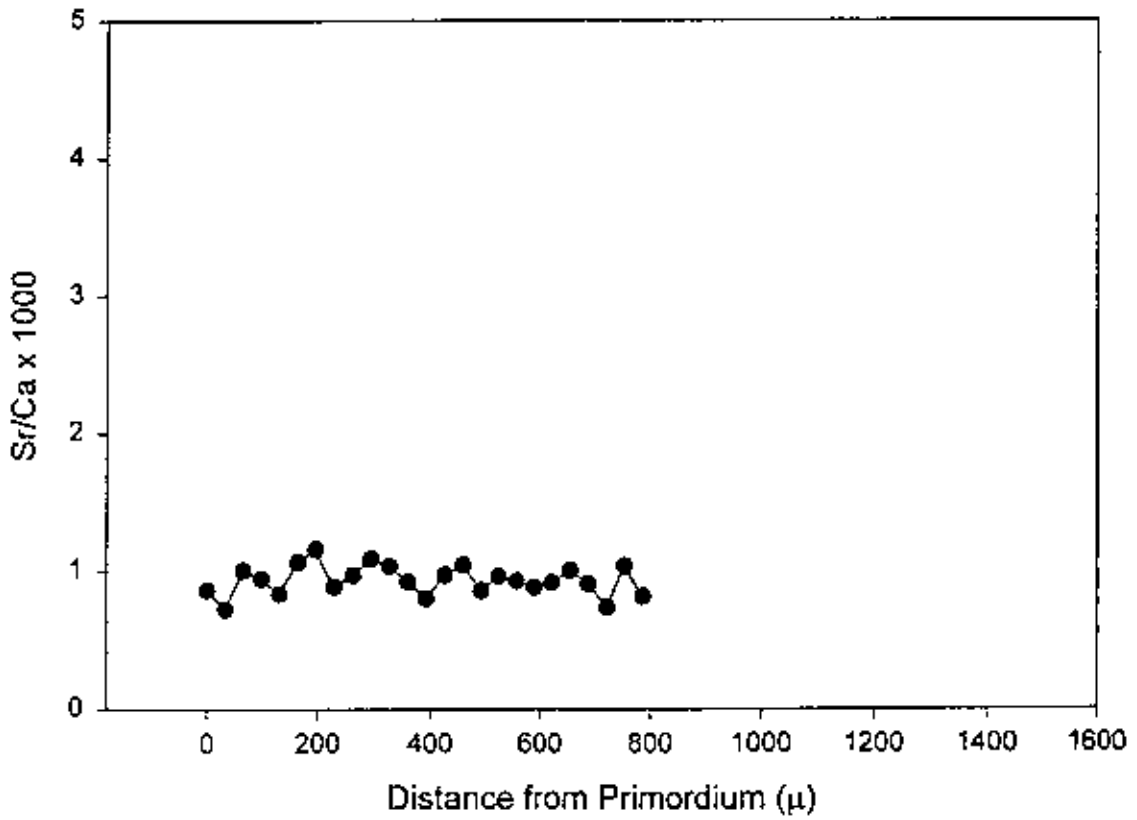
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Kokanee 4



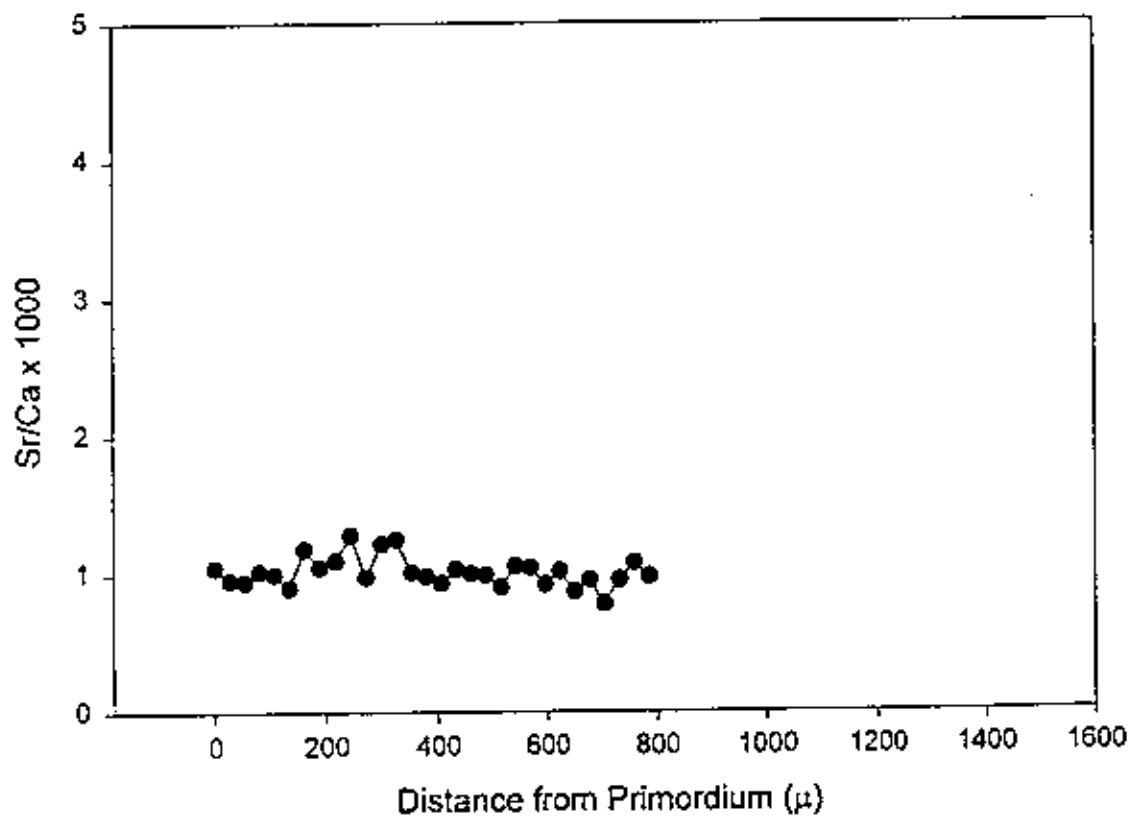
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Kokanee 5



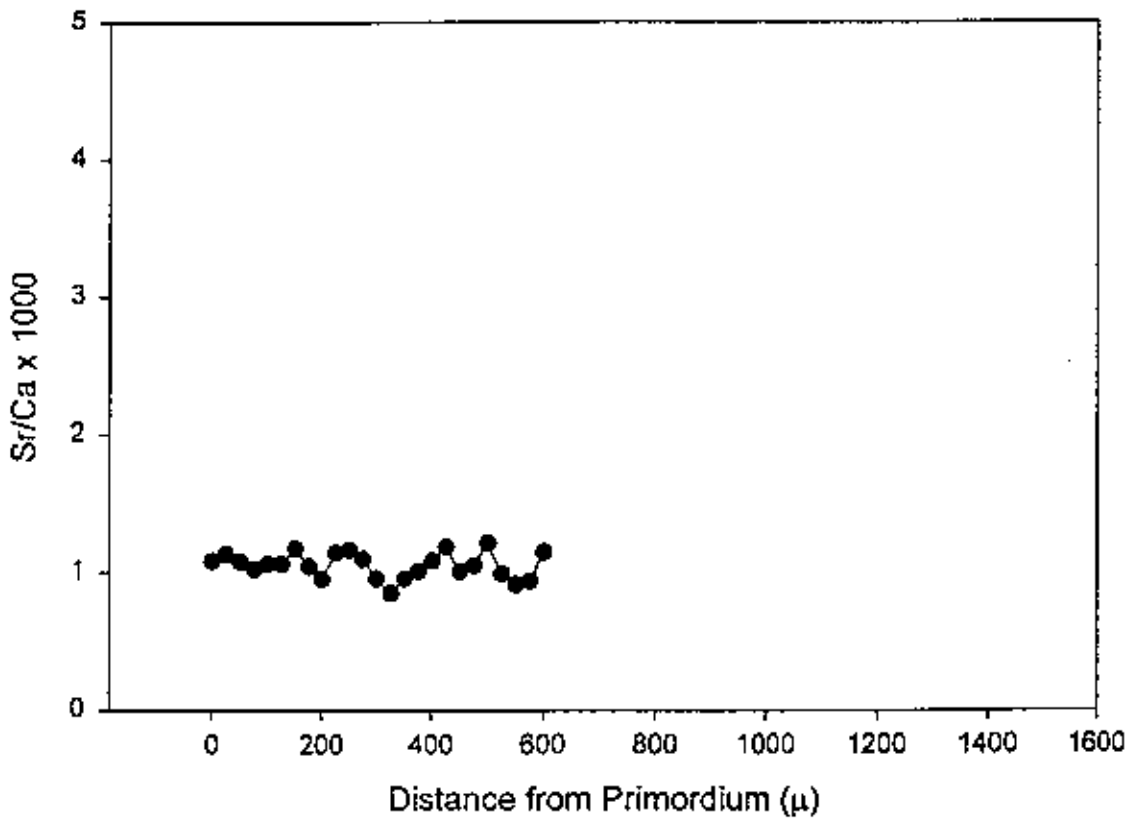
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Kokanee 6



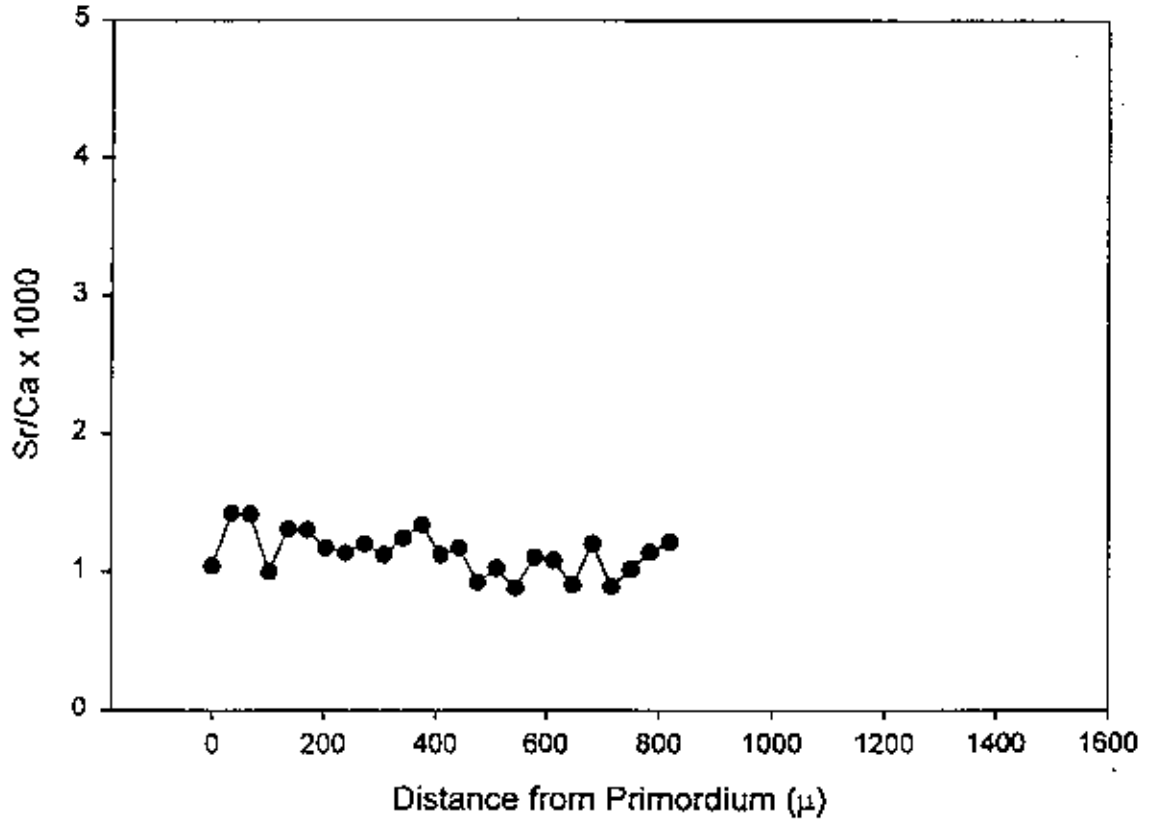
Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997

Kokanee 7



*Maternal Origin of Sockeye Salmon (*Oncorhynchus nerka*) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997*

Kokanee 8



Maternal Origin of Sockeye Salmon (Oncorhynchus nerka) Returning to the Pelton Fish Trap, Deschutes River, Oregon in 1997