ASSESSMENT OF FACTORS AFFECTING SOCKEYE SALMON (ONCORHYNCHUS NERKA) PRODUCTION IN OZETTE LAKE, WA

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Assessment of Factors Affecting Sockeye Salmon
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in Ozette Lake, WA

by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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1.0 INTRODUCTION

Ozette Lake, situated on the northwest corner of the Olympic Peninsula in Washington (Figure 1), supported harvests of more than 17,000 sockeye in the 1940's (Figure 2). By the 1980's total returns had declined to between 350 and 2,200 sockeye, with the only spawning activity observed in the lake. Furthermore, this population has not increased in spite of the cessation of terminal area fishing in 1973. The reasons for the initial decline and the inability for the stream spawners to become re-established were suggested to be unregulated logging and fishing practices (Dlugokenski et al. 1981, Blum 1984). Foerster (1968) suggests that sockeye runs are comprised of three discrete groups that spawn in tributary, lake-shore, and river habitat. Brannon (1972) shows that such groups can be genetically determined which suggests that they are not interchangeable. This offers one explanation why the existing lake-spawners have not expanded into the streams and re-established the runs to historical levels. However, the logging of the watershed was so extensive that stream spawning and rearing conditions are still questionable, despite having 35 years to recover from the major logging activity.

Most of the timber in the Ozette Lake watershed was burned off in the 1880's to make clearings for settlements (Russell 1971). Commercial railroad logging of the watershed began in the 1930's, while truck logging and road construction began in the 1940's. Over 90% of the watershed has been clear-cut (McVey 1979; Blum 1984).

Timber harvests have been demonstrated to have negative effects on fish habitat. Peak winter flows increase and can result in flood

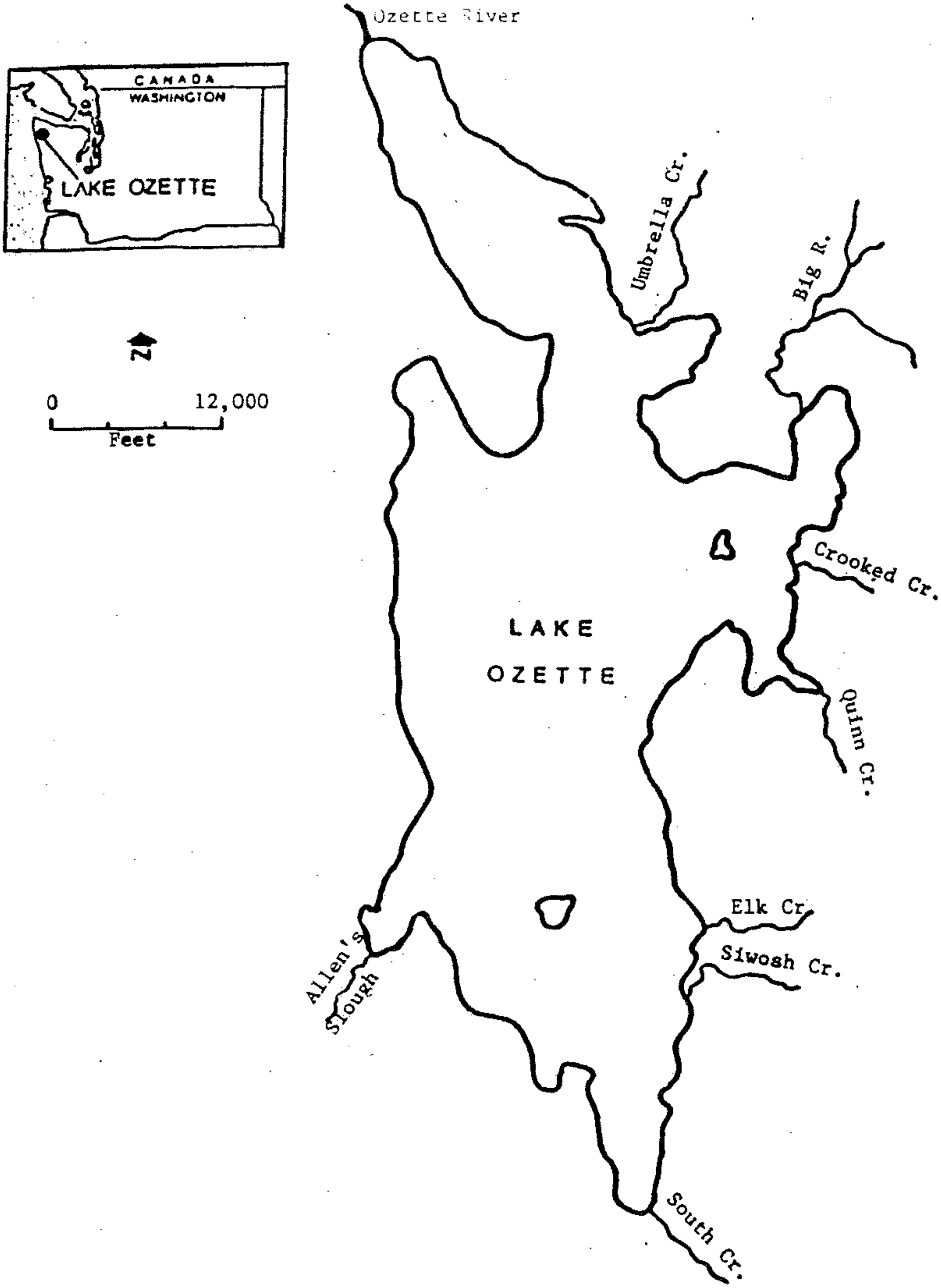

Figure 1. Location of Ozette River and Ozette Lake drainage basin, northwestern Olympic Peninsula.

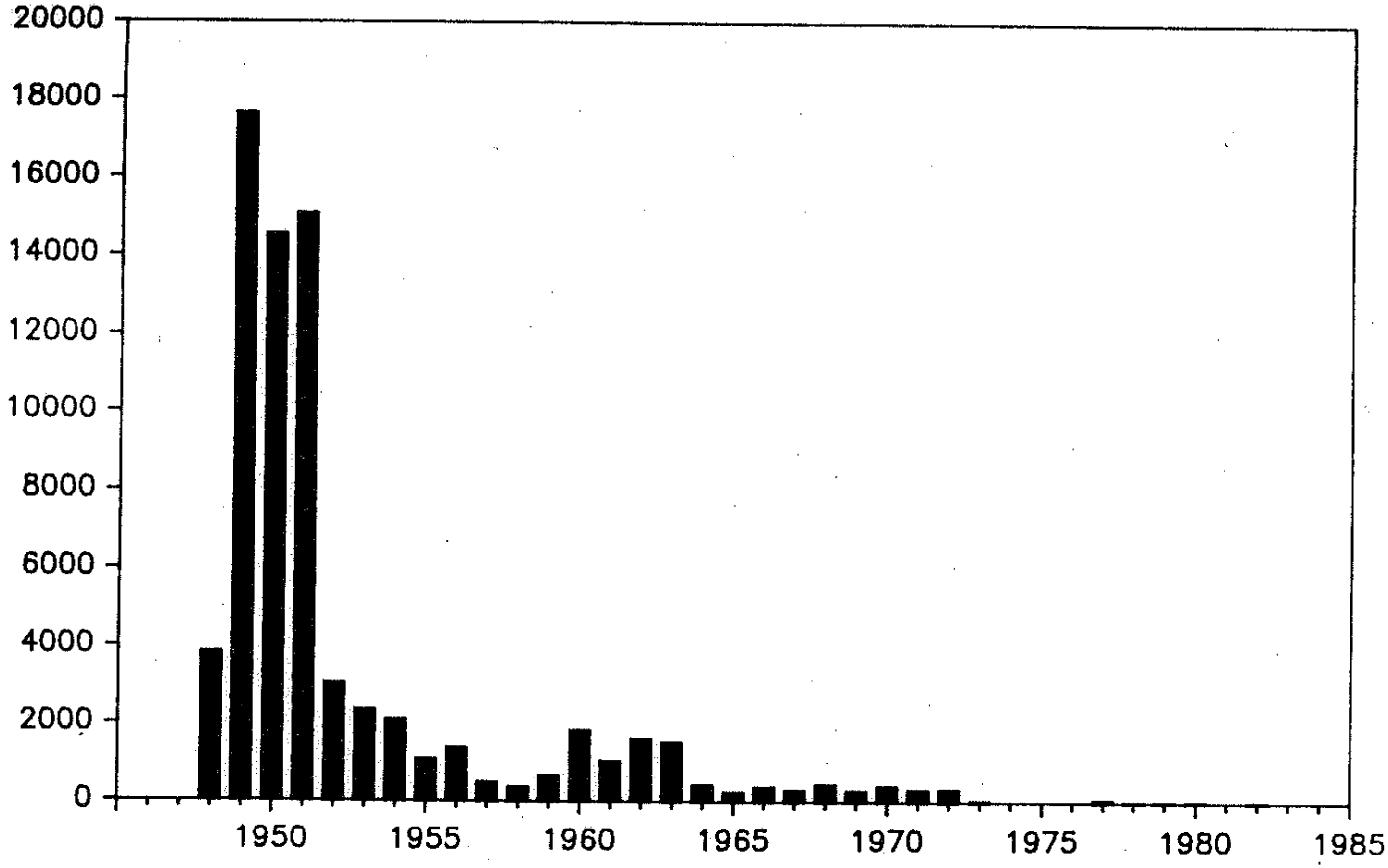

Figure 2. Sockeye salmon catches by the Makah Tribe from the Ozette River, 1948-1985.

conditions which: scour the gravel (i.e. the incubation habitat for salmonid eggs), flush the within-bank river zone (i.e. the rearing habitat for juvenile salmonids) and subject both habitats to poor water quality. Logging, by removing the trees, increases storm run off by eliminating interception (Rothacher 1963), greatly reducing evapotranspiration, and decreasing system storage capacity while increasing surface run-off through soil compaction and road building (Kovner 1957; Rothacher 1965).

Road building has exacerbated the effects of deforestation by intercepting sub-surface flow through road cuts, backfills and ditches which allow for large run-offs with high content of organic and inorganic substances (Anderson et al. 1976). In the old growth forests the forest floor prevented excess leeching of inorganic and organic matter before their entry into tributaries (Peters 1974). Studies in Central Idaho suggest that some watersheds never recover from road construction (Megahan 1975). Other studies reveal that poor logging practices, such as locating roads adjacent to streams, caused increased sediment concentrations for years <u>after</u> floods and in one case history, this added 10 years to the recovery time for a logged California watershed (Anderson 1970, 1972). All these factors have been demonstrated to have pronounced effects on fish production (Dahl 1927; Brown 1957; Hasler et al 1951; Waters 1956; Neess 1949; Pease 1973; Doudoroff and Katz 1950).

Thorne and Ames (1987) demonstrated that in Lake Washington, flooding during the time of egg incubation is a major factor affecting spawning productivity. At Lake Quinault, the instability of the upper river spawning grounds attributable to past logging and road and property protection practices have decreased egg to fry survival (Gilbertson 1981). Wustenber (1954), Calhoun (1962) and Campbell (1970) pointed out that unremoved logging slash left in tributaries has caused extensive scouring during floods and sometimes prevented access to spawning grounds. Pease (1973) and Peters (1974) show organic compounds and pH levels during winter freshets in Western Olympic streams that are lethal to salmonid eggs and alevins. In central Alaska severe winters that cause subgravel freezing are believed to lower incubation survival during years of large escapement (Rogers, unpublished manuscript). Thus, throughout the geographical range of the sockeye, the survival of incubating eggs compounded with winter flooding in the south and winter freezing in the north appears to be an important determinant for survival.

Other scientists support the theory that density-dependent factors such as species interactions and the inherent productivity of the system limit sockeye populations. Narver (1966) suggested that in British Columbia lakes, reduced escapements so altered the ecological niche once occupied by sockeye that the relationships determining the capacity of the lake had changed and that niche was filled by other species. He postulated that long-term escapement increases could raise sockeye population levels while suppressing and replacing competitive species. Stockner (1981) described low elevation lakes with marine climates along the British Columbia coast as typical low-nutrient systems that require fertilization to enhance sockeye populations. Koenigs et al. (1985a,b) showed that low phosphorus levels limited production in Alaskan sockeye lakes and recommended carrying out lake fertilization programs to increase productivity. Today several lake enrichment programs are active throughout the Pacific Northwest and Alaska with the goal of enhancing sockeye production. Some of these programs have been successful, such as Great Central Lake (Hyatt and Stockner 1985).

Higher stream discharges can further reduce lake productivity in that the water retention period decreases and nutrients are flushed from the system more rapidly (Welch XX). Johnson (1965) showed that in lakes with high flushing rates, water residency period had a more important effect on zooplankton standing crops than sockeye grazing, thereby reducing even further the amount of forage available for juveniles.

In other sockeye salmon-producing systems, it has been shown that a reduction in spawner carcasses has effected the productive capacity of the nursery lake (Juday et al. 1932; Nelson and Edmondson 1955; Krokhin 1967; LeBrasseur et al. 1978). Mathisen (1972) and Richey et al. (1978) have demonstrated that the amount of phosphorus and nitrogen released from the decaying carcasses can be directly related to the fertility of the lake at the time the brood-year fry rear. Therefore, Ozette Lake, already classified as a low-productivity, marine-climate coastal lake, potentially could have even further reduced productivity due to the lack of nutrient input from spawned-out carcasses.

The objectives of this investigation were to: 1) determine the limiting factors to Ozette Lake sockeye production; and 2) estimate the potential of the lake to produce sockeye. I intend to demonstrate that logging and road development are responsible for destabilizing the flood control mechanisms in Ozette tributaries, reducing the sockeye production potential of the spawning and incubation habitats and resulting in the lake being below its productive potential. I will show that the spawning and incubation habitats currently limit sockeye production at Ozette Lake, and if these habitat restrictions were removed, the lake could support sockeye runs at least two orders of magnitude larger than it does presently.

2.0 METHODS

The potential limitations to sockeye production at Ozette Lake were divided into two categories, habitat and trophic status. The potential habitat limitations were the availability and quality of spawning, incubation and rearing habitat. I assess the maximum (peak) monthly discharges in Ozette Lake and its major tributaries and the effects of these peak flood events on sockeye egg and fry survival. I feel that Ozette Lake, a low-elevation, marine climate lake, is also a system with low productivity, which raised questions about its carrying capacity for juvenile sockeye. I assess the current status of habitat and trophic production in Ozette Lake and use the Plankton-Acre Index (PAI) model to determine the potential sockeye carrying capacity.

2.1 Habitat Measurement and Analysis

I obtained flow data from U.S. Geological Survey (USGS) stage recorders located in the Ozette River between 1976-79 and on Big River and Umbrella Creek, the largest lake tributaries, from 1976-77. Lake levels were recorded daily between 1976-79 and since 1983. I developed simple regression models (Bovee 1982) from Ozette River, Umbrella Creek and Big River from 1976-77 discharge data to estimate tributary discharges through 1987. These data were used to determine the frequency that stream flow conditions were within the range preferred for sockeye spawning and incubation as obtained from Swift (1978).

Washington Department of Natural Resource (WDNR) planimetric maps (1983) and a curvimetre map measurer were used to determine logging road densities (km/km^2) in Big River and Umbrella Creek watersheds. These data were used to estimate the percent of fines (sediments <0.85

mm) in the spawning gravels with the regression advanced by Rittmueller (1986). I used the relationship between percent of fines and egg and fry survival that was determined by Cederholm et al. (1980) on the Clearwater River to estimate egg and fry mortality in the Ozette tributaries.

Adult sockeye and spawning and incubation habitat surveys were conducted from 1971 to present by the USGS, U.S. Fish and Wildlife Service (USFWS), Washington Department of Fisheries (WDF), and Makah Fisheries Management (MFM). USFWS conducted surveys from 1971-79 to count spawners in the lake and tributaries (USFWS, unpublished). USGS conducted habitat surveys on the tributaries to determine the potential spawning area for sockeye at preferred flows (Bortleson and Dion, 1979). WDF conducted habitat surveys in 1979 on the tributaries and extensive spawning surveys in the lake and tributaries in 1980-81 (as reported in Dlugokenski et al. 1981, and WDF, unpublished). MFM conducted spawning surveys from 1981 to present on the lake and tributaries (MFM, unpublished).

2.2 Productivity Measurement and Analysis

Ozette Lake primary and secondary production data were obtained from Bortleson and Dion (1978,1979) and Dlugokenski et al. (1981). Primary productivity measurements included chlorophyll _a_, growth nutrients (P and N) and physical state (conductivity, dissolved oxygen, and temperature). The primary production data were used as input to the PAI model to estimate potential sockeye production in Ozette Lake (Appendix 1). Secondary productivity measurements were restricted to zooplankton sampling which provided information on distribution, composition and abundance to compare to other systems (Appendix 2).

Sockeye production data were obtained from fry, smolt (Appendix 3) and adult (Appendix 4) surveys in the lake, river and tributaries. Hydroacoustic surveys were conducted to determine abundance and distribution of sockeye fry and other limnetic fishes in the lake (Thorne and Thomas 1984). Smolt numbers, length, weight, age, and outmigration timing were determined in 1979, 1982 and 1984 using methods described in Dlugokenski et al. (1981). Pelagic fish densities and smolt characteristics were compared to values from other systems to evaluate the status of Ozette Lake sockeye production.

Adult sockeye escapement was measured below the lake outlet by stretching a beach seine across the river and counting fish that passed through a restricted opening in the middle of the seine from 1977 - 81. A white counting board was installed at the opening to simplify this visual counting procedure developed by Dlugokenski et al. (1981). In 1982 and 1984, the beach seine was replaced with an aluminum picket weir in the same location and daytime sampling was added to improve the accuracy of the technique. Catch data on Ozette salmon from 1948-76 was obtained from Ward et al. (1976) and 1977-present from the Makah Tribe.

2.3 PAI Predictions

Several models were investigated to predict potential sockeye productivity in Lake Ozette. The PAI was chosen as the most appropriate model because of its use in estimating sockeye rearing capacities in other Northwest lakes (IPSFC 1972). Other models that I examined were the Morpho-Edaphic Index (Ryder et al. 1974), Mean-Depth Index (Rawson 1952), the Bio-Index (Northcote and Larkin 1956), Lake-Area Index (Youngs and Heimbuch 1982), Chlorophyll a Index (Oglesby 1977) and Total-Dissolved-Solids Index (TDS), (Hanson and Leggett 1982). The comparison of these models can be found in Appendix 5.

The PAI was developed by the International Pacific Salmon Fisheries Commission (IPSFC 1972) to estimate the potential sockeye rearing capacity of Fraser River system lakes. Briefly, the PAI estimates the number of sockeye fry that can be supported per surface acre of lake. The PAI uses as input the relative volume of zooplankton (cm^3) per haul and compares this estimate to two standardized lakes in the Fraser system that are assumed to be at carrying capacity (Shuswap and Chilko). The relative PAI value of 1 is equivalent to the ability of the lake to support the progeny of 10 female spawners per acre in the dominant cycle, and on natural spawning grounds (IPSFC 1970). This index is responsive to variations in climate, female sockeye fecundity and inter- and intra-specific competition.

I substituted primary production information to estimate the PAI because the zooplankton samples were not available when I conducted this analysis. PAI values for all Fraser River system lakes were obtained from the IPSFC (1972, Table 1). Stepwise multiple regression (Snedecor and Cochran 1980) was used to determine the relationship between primary production data and the PAI for Fraser River lakes (Goodlad et al. 1974, Stockner and Shortreed 1983). This regression model was then applied to Ozette Lake primary production data to estimate escapements that would fully use the carrying capacity of the

Table 1. Salient limnological and morphometric variables for Fraser River Lakes, British Columbia, Canada (from Stockner and Shortreed 1983; Goodlad et al. 1974).

Lake	Area (km^2)	Mean Depth (Z-m)	Chlorophyll (ug/l)	TDS (mg/l)	Total Phos. (ug/l)	pH
Adams	138	169	1.70	31	2.3	7.6
Anderson	28	140	0.89	61	3.5	8.0
Bowron	10	16	1.51	49	3.8	7.4
Chilko	200	108	0.93	53	2.9	7.6
Cultus	6	30	-	167	-	-
Francois	260	87	1.88	76	4.5	7.4
Fraser	55	13	4.47	95	10.7	7.6
Harrison	218	151	78.00	40	3.3	7.3
Kamloops	56	74	-	-	-	-
Lillooet	35	62	83.00	29	21.1	7.4
L.Shuswap	18	14	2.46	52	3.5	7.6
Mabel	589	-	-	-	-	-
Mara	19	18	1.78	69	5.0	7.6
Momich	2	32	2.13	32	3.5	7.2
N.Barrier	5	-	-	-	-	-
Pitt	54	46	0.25	26	3.0	6.8
Quesnel	270	158	1.23	62	2.0	7.8
Seton	24	85	1.40	45	8.0	7.6
Shuswap	310	62	1.63	87	3.7	7.5
Stuart	360	20	2.03	78	3.5	7.3
Takla	260	107	1.68	48	3.5	7.4
Taseko	31	46	0.35	29	17.8	-
Trembleur	117	40	1.72	58	3.5	7.2

Table 1. Cont'd. Salient limnological and morphometric variables for Fraser River Lakes, British Columbia, Canada.

Lake	Algal Volume (cm^3)	Alkalinity (mg/l)	Secchi Depth (m)	MEI[1/] (TDS/Z)	MEI25[2/] (TDS/Z25)
Adams	6.8	18.7	8.3	0.18	1.24
Anderson	34.5	31.8	11	0.44	2.44
Bowron	12.2	32.9	5.3	3.06	3.06
Chilko	5.6	18.9	4.8	0.49	2.12
Cultus	-	8.0	10.5	5.57	6.68
Francois	19.9	-	-	0.87	3.04
Fraser	32.8	41.9	4.0	7.31	7.31
Harrison	7.8	12.8	4.1	0.26	1.60
Kamloops	-	-	-	-	-
Lillooet	5.2	14.4	0.3	0.47	1.16
L.Shuswap	16.0	29.9	8.0	3.71	3.71
Mabel	-	-	-	-	-
Mara	11.1	41.0	7.0	3.83	3.83
Momich	6.5	13.0	7.0	1.00	1.28
N.Barrier	-	-	-	-	-
Pitt	1.3	5.2	2.6	0.57	1.04
Quesnel	7.5	44.1	10.9	0.39	2.48
Seton	22.0	28.0	2	0.53	1.80
Shuswap	13.5	31.7	9.4	1.40	3.48
Stuart	34.2	41.4	7.2	3.90	3.90
Takla	13.0	28.7	5.9	0.45	1.92
Taseko	0.3	-	0.3	0.63	1.16
Trembleur	16.6	33.7	6.3	1.45	2.32

1/ Morpho-edaphic Index.

2/ Morpho-edaphic Index, adjusted for maximum depth of 25 m.

system. I also analyzed total run size, catch and escapement data from the IPSFC annual reports and unpublished data for years 1969-80 (Appendix 6) to determine catch/spawner and recruits/spawner relationships (Table 2). I then estimated the total run size and catch of sockeye for Ozette Lake from these relationships.

Table 2. Sockeye salmon predictive variables and mean run size components of Fraser River System sockeye lakes, British Columbia, Canada, 1969-1980 (from Int. Pacific Salmon Fish Comm. Annual Reports, E. Vernon 1982).

Lake	Plankton Acre Index	Potential Female Spawners	Mean Escapement	Mean Catch	Mean Total Run
Adams	0.87	296,000	2,326	9,764	12,090
Anderson	1.90	133,000	14,387	66,198	80,586
Bowron	1.20	53,000	30,065	133,983	164,049
Chilko	0.44	218,000	484,253	1,567,101	2,051,354
Cultus	2.18	34,000	17,556	79,298	96,854
Francois	1.19	758,000	31,094	152,635	183,733
Fraser	1.76	238,000	169,257	755,717	924,974
Harrison	0.41	221,000	68,611	282,791	351,392
Kamloops	0.76	105,000	5,522	65,730	71,252
Lillooet	0.20	17,000	115,360	486,308	601,668
L.Shuswap	1.01	45,000	-	-	-
Mabel	0.93	135,000	6,171	17,067	23,238
Mara	0.85	41,000	100,879	288,246	389,125
Momich	-	-	-	-	-
N.Barrier	1.00	13,000	7,006	26,156	33,162
Pitt	0.20	27,000	31,633	82,423	114,056
Quesnel	0.76	511,000	357,477	1,453,689	1,811,166
Seton	0.81	49,000	5,301	24,389	29,689
Shuswap	1.20	918,000	1,402,880	3,838,517	5,241,404
Stuart	1.50	1,350,000	91,894	465,544	557,438
Takla	0.80	448,000	176,189	826,219	1,002,408
Taseko	0.05	4,000	1,200	8,161	9,361
Trembleur	1.16	336,000	96,200	494,481	590,681

3.0 RESULTS AND DISCUSSION

3.1 Analysis of Spawning Habitat

Surveys of spawning habitat indicate the potential for 13,000 (± 3,700), 10,000 (± 2,800) and 2,000 (±560) redds on Big River, Umbrella Creek, and other Lake Ozette tributaries, (Bortleson and Dion 1979; Dlugokenski et al 1981), for a total estimate of 25,000 ±7,060 redds, or potential escapements of 50,000 ± 14,120 adult sockeye.

Tributary spawners, once present in the Ozette system, are now absent. Spawning ground surveys conducted since 1971 show that only lake shore spawners are present, although a small river-spawning population was observed in 1982. The only consistent spawning activity occurs on the lake shore in waters 2 - 4 m deep, where flood events do not affect spawning success. Sockeye did spawn at the mouths of major tributaries in the mid-1970's. I suspect that these spawning fish were unsuccessful because of the high silt levels in these areas. All the documented lake shoreline spawning occurs on the southeast and southwest borders of the lake, away from any major tributary inflow.

Tribal records of estimated catch show that fishing effort was greatest on the early part of the run which would impact the tributary spawners the most since stream spawners generally enter the system before the lake spawners (Killick 1955; Foerster 1968). Sockeye were also harvested directly from the spawning grounds in the late 1940's (P. Ward and T. Parker, pers. comm. 1983). However, the tributary spawners have not become re-established despite the cessation of fishing in 1973 which suggests that overfishing does not fully account for the disappearance of stream spawners.

I suggest that uncontrolled logging activities in the Ozette watershed immediately following World War II (Bortleson and Dion 1979) caused major perturbations to the sockeye habitat which has retarded the successful recolonization of the tributaries by the sockeye. In support of this hypothesis, Peters (1974) pointed out a striking correlation between the decline in the Raft and Moclips commercial fisheries on the Quinault Reservation and the simultaneous increase in logging in these watersheds. Similar sockeye declines have also been observed in Vancouver Island sockeye stocks (Hyatt et al. 1985). In the following analysis I have examined present conditions and estimated their impact on sockeye production.

3.1.1 Tributary Flow

At Coweeta Hydrologic Laboratory in North Carolina, peak flows were shown to increase by an average of 9% and total run-off increased by an average of 11 percent after a 108-acre mature hardwood forest was clear-cut (Hewlett and Helvey 1970). Anderson (1952) studied the effects of deforestation on streamflow in large Oregon watersheds and shows when watersheds were logged and poorly reforested, peak flows increased by more than 30%. Anderson and Hobba's (1959) analysis of forest cutting and peak flows in 54 Northwest watersheds suggested that, even if sustained yield management were properly applied (i.e. 1% of the watershed were cut over each year) and the logged area were quickly reforested, a 6% increase in the peak flood and 20% increase in the mean annual flood would occur. The Ozette watershed was clear-cut at a much higher rate and in an unregulated fashion; moreover, timber removal from smaller watersheds (such as the Ozette tributaries) has a greater influence on peak flows than from large watersheds (Hoyt and Langbein 1955). I perceived that logging of old growth forest has increased instability of flow regimes in the Ozette tributaries which are important habitat for sockeye spawning and incubation. Thus, I have examined the flow regimes of the tributaries to assess their present status to support sockeye production.

Simple regression models were developed to determine flows in the Ozette River and major lake tributaries. The relationship of lake level (X, in m) to Ozette river discharge (Y, in m^3/s) is defined by the equation:

$$Y = 19.22\,X - 184.663\ (r^2 = 0.99,\ P < 0.01) \qquad \text{(Eq. 1)}$$

(n=18, Y ranged from 0.57-42.48 m^3/sec, X ranged from 9.5-11.7 m).

Discharges in Big River (Y) from Ozette River flows (X) are defined by the equation:

$$Y = 0.422\,X - 1.613\ (r^2 = 0.73,\ P<0.05) \qquad \text{(Eq. 2)}$$

(n=13, measured Y flows ranging from 0.31-19.3 m^3/sec and measured X flows ranging from 2.8-32.6 m^3/sec).

Discharges in Umbrella Creek (X) based on Ozette River flows (Y) were defined by:

$$Y = 0.223\,X - 1.02\ (r^2 = 0.59;\ P<0.05) \qquad \text{(Eq. 3)}$$

(n=12, measured Y flows ranging from 0.05-10.8 m^3/sec).

The observed variation in the tributary-river regressions can be attributed to frequent and highly localized winter storms at Ozette Lake. One tributary drainage may experience a flash freshet while adjacent watersheds may only have moderate precipitation. Since the lake acts as a buffer for storms in the upper watershed and tributary discharges are based on lower river flow, estimates of frequency and amplitude of tributary storm events may be underestimated, and so are the effects on spawning and incubating sockeye.

The extent and success of sockeye spawning in the tributaries of Ozette Lake are dependent not only upon suitable habitat, but the availability of preferred water velocities and depths. Preferred discharge ranges for sockeye salmon spawning and incubation were calculated per Swift (1978) at 4.86 $\pm$ 2.59, 2.42 $\pm$ 1.17, and 2.27 $\pm$ 1.00 (in m^3/sec) for the Ozette and Big rivers and Umbrella Creek (Bortleson and Dion 1979). The flows calculated for Ozette River (Table 3), Umbrella Creek (Table 4) and Big River (Table 5) between 1976-87 and the upper 95% confidence interval for preferred spawning and incubation flows are shown in Figures 3, 4, and 5.

Nine hundred thirty-five flow measurements were made of the Ozette River from 1976-87 during the sockeye spawning and incubation period. Daily flows in the Ozette River exceeded the upper range preferred by sockeye on 827 occasions, or 88% of the time, during that period. In Big River, favorable flows were exceeded 78% of the time (in all but three months), and 62% (all but five months) in Umbrella Creek. Maximum peak discharges exceeding 9, 6, and 4 times the upper range of the preferred flows for incubation and spawning have been recorded in Ozette River, Big River and Umbrella Creek, respectively.

Before being harvested, I believe that the old growth forest not only had a limited capacity to store water, but served to actively recirculate excess water in the soil through evapotranspiration. In a

Table 3. Estimated flows (m^3/sec) in the Ozette River during the spawning and incubation period (preferred spawning and incubation flows: 2.27 - 7.45 m^3/sec).

Month	Flow Levels	1976	1977	1978	1979	1983	1984	1985	1986	1987
October	Minimum	-	-	3.4	5.3	-	4.0	0.6	0.7	0.7
	Mean	-	2.8	5.4	6.7	-	5.4	13.1	8.3	0.9
	Maximum	-	-	13.1	9.7	-	9.2	19.2	22.7	4.8
November	Minimum	-	4.6	15.3	5.2	-	9.2	15.7	14.5	4.5
	Mean	-	6.4	24.2	8.8	-	33.2	23.3	23.8	9.8
	Maximum	-	8.4	31.7	11.0	-	50.3	30.3	30.0	29.1
December	Minimum	-	6.3	20.1	10.2	-	17.4	29.7	13.9	21.5
	Mean	-	11.6	32.5	13.2	-	28.6	30.7	15.4	25.0
	Maximum	-	18.1	42.2	15.6	-	42.4	29.0	16.8	28.0
January	Minimum	-	10.8	13.6	6.7	4.0	19.8	10.7	10.4	22.7
	Mean	-	14.1	18.5	8.0	30.3	32.1	16.7	22.5	27.7
	Maximum	34.0	19.0	23.1	11.1	42.6	39.7	30.0	30.3	32.7
February	Minimum	-	11.6	11.2	6.1	18.0	23.3	9.2	20.9	20.4
	Mean	28.3	15.5	15.2	20.0	31.5	29.7	12.4	26.4	24.5
	Maximum	-	20.5	19.1	35.4	44.4	35.6	16.3	39.1	26.8
March	Minimum	-	17.6	8.5	11.5	22.8	21.5	12.2	23.9	19.2
	Mean	31.2	21.7	10.7	25.1	31.9	25.3	15.1	27.9	25.3
	Maximum	-	29.2	13.7	39.4	39.7	31.5	19.8	34.1	31.5

Table 4. Estimated flows (m^3/sec) in Big River, during the spawning and incubation period (preferred spawning and incubation flows: 1.25 - 3.59 m^3/s).

Month	Flow Levels	1976	1977	1978	1979	1983	1984	1985	1986	1987
October	Minimum	-	-	0.1	0.5	-	0.1	0.1	0.7	0.7
	Mean	-	-	0.5	1.1	-	0.5	3.9	2.3	0.9
	Maximum	-	-	3.8	2.4	-	2.2	6.4	9.2	4.8
November	Minimum	-	0.2	4.8	0.4	-	2.2	4.9	5.2	0.4
	Mean	-	1.0	8.6	2.0	-	12.5	8.2	9.7	3.0
	Maximum	-	1.8	11.8	3.0	-	19.8	11.2	12.7	12.3
December	Minimum	-	0.9	6.8	2.6	-	5.7	11.0	4.9	8.6
	Mean	-	3.2	12.2	3.9	-	10.5	11.4	5.7	10.3
	Maximum	-	6.0	16.3	4.9	-	16.4	10.7	6.4	11.7
January	Minimum	-	2.9	4.0	1.1	0.1	6.7	2.8	3.2	9.2
	Mean	15.6	4.3	6.2	1.6	11.2	12.0	5.4	9.1	11.6
	Maximum	-	6.4	8.1	3.0	16.5	15.2	11.1	12.9	14.0
February	Minimum	-	3.2	3.0	0.8	5.9	8.2	2.2	8.3	8.1
	Mean	10.8	4.9	4.7	6.8	11.7	11.0	3.5	11.0	10.0
	Maximum	-	7.0	6.4	13.4	17.2	13.5	5.2	17.1	11.2
March	Minimum	-	5.8	1.9	3.1	8.0	7.4	3.4	8.5	6.4
	Mean	5.1	7.5	2.8	9.0	11.9	9.1	4.7	10.2	9.1
	Maximum	-	10.7	4.1	15.1	15.2	11.7	6.7	12.8	11.7

Table 5. Estimated Flows (m^3/sec) in Umbrella Creek during the spawning and incubation periods (preferred spawning and incubation flows: 1.27 - 3.27 m^3/sec).

Month	Flow Levels	1976	1977	1978	1979	1983	1984	1985	1986	1987
October	Minimum	-	-	0.0	0.2	-	0.1	0.0	0.1	0.0
	Mean	-	-	0.2	0.5	-	0.2	2.0	0.9	0.0
	Maximum	-	-	2.0	1.2	-	1.1	3.5	4.3	0.1
November	Minimum	-	0.1	2.5	0.2	-	1.1	2.6	2.4	0.0
	Mean	-	0.5	4.6	1.0	-	6.7	4.4	4.5	1.3
	Maximum	-	0.9	6.4	1.6	-	10.7	6.0	6.0	5.8
December	Minimum	-	0.5	3.7	1.4	-	3.0	5.9	2.2	4.0
	Mean	-	1.7	6.6	2.1	-	5.6	6.1	2.6	4.8
	Maximum	-	3.2	8.8	2.6	-	8.9	5.7	2.9	5.5
January	Minimum	-	1.5	2.1	0.5	0.1	3.6	1.5	1.4	4.3
	Mean	6.2	2.3	3.3	0.8	6.0	6.5	2.9	4.2	5.4
	Maximum	-	3.4	4.4	1.6	8.9	8.2	6.0	6.0	6.6
February	Minimum	-	1.7	1.6	0.4	3.2	4.4	1.1	3.9	3.7
	Mean	11.3	2.6	2.5	3.6	6.3	5.9	1.9	5.1	4.7
	Maximum	-	3.8	3.4	7.2	9.3	7.3	2.8	8.1	5.2
March	Minimum	-	3.1	1.0	1.7	4.3	4.0	1.8	4.5	3.5
	Mean	0.1	4.0	1.5	4.8	6.4	4.9	2.5	5.5	4.9
	Maximum	-	5.8	2.2	8.2	8.2	6.3	3.6	6.9	6.3

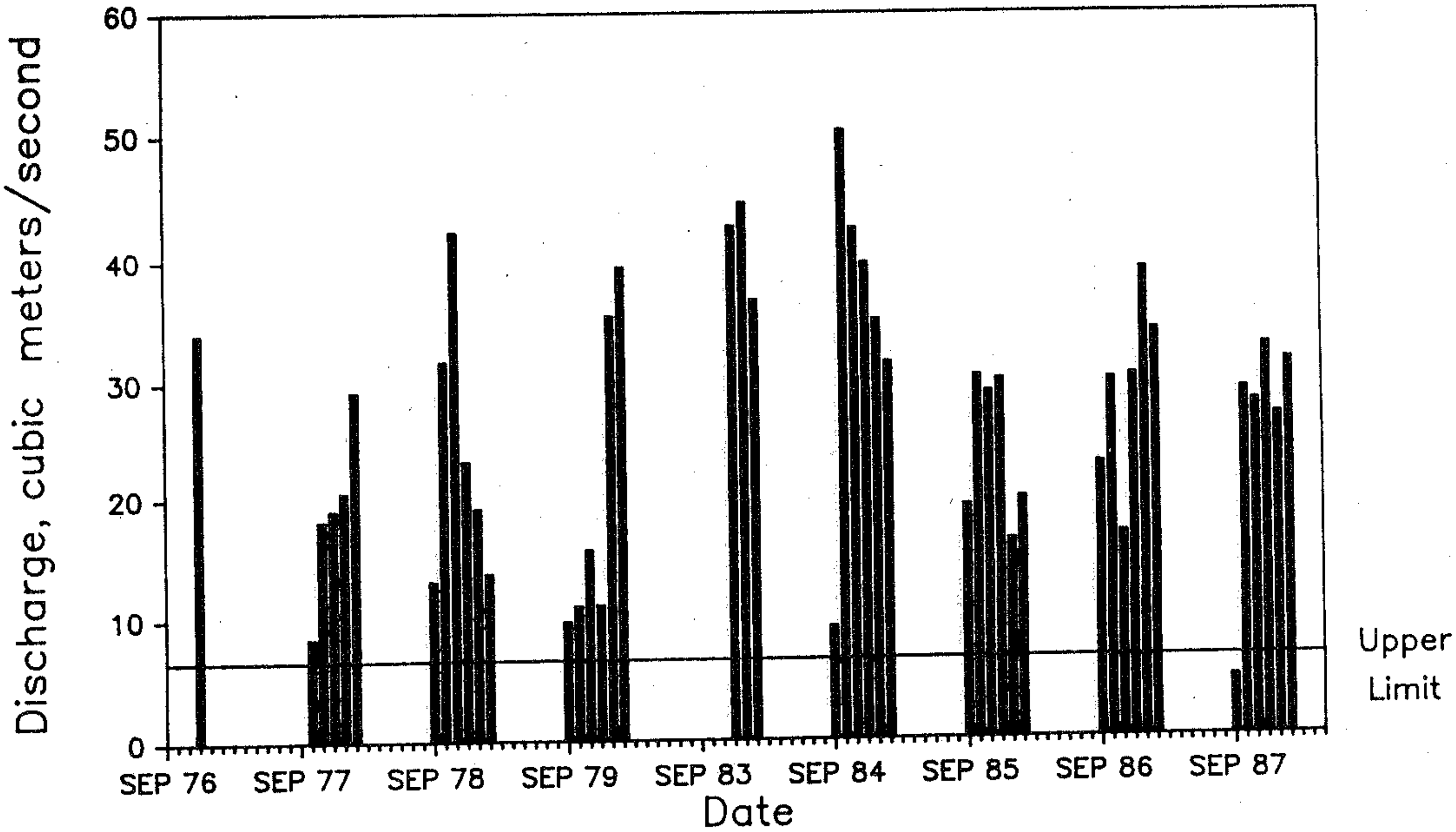

Figure 3. Peak Ozette River monthly flows and upper limit of sockeye spawning and incubation preferences (7.45 m^3/sec).

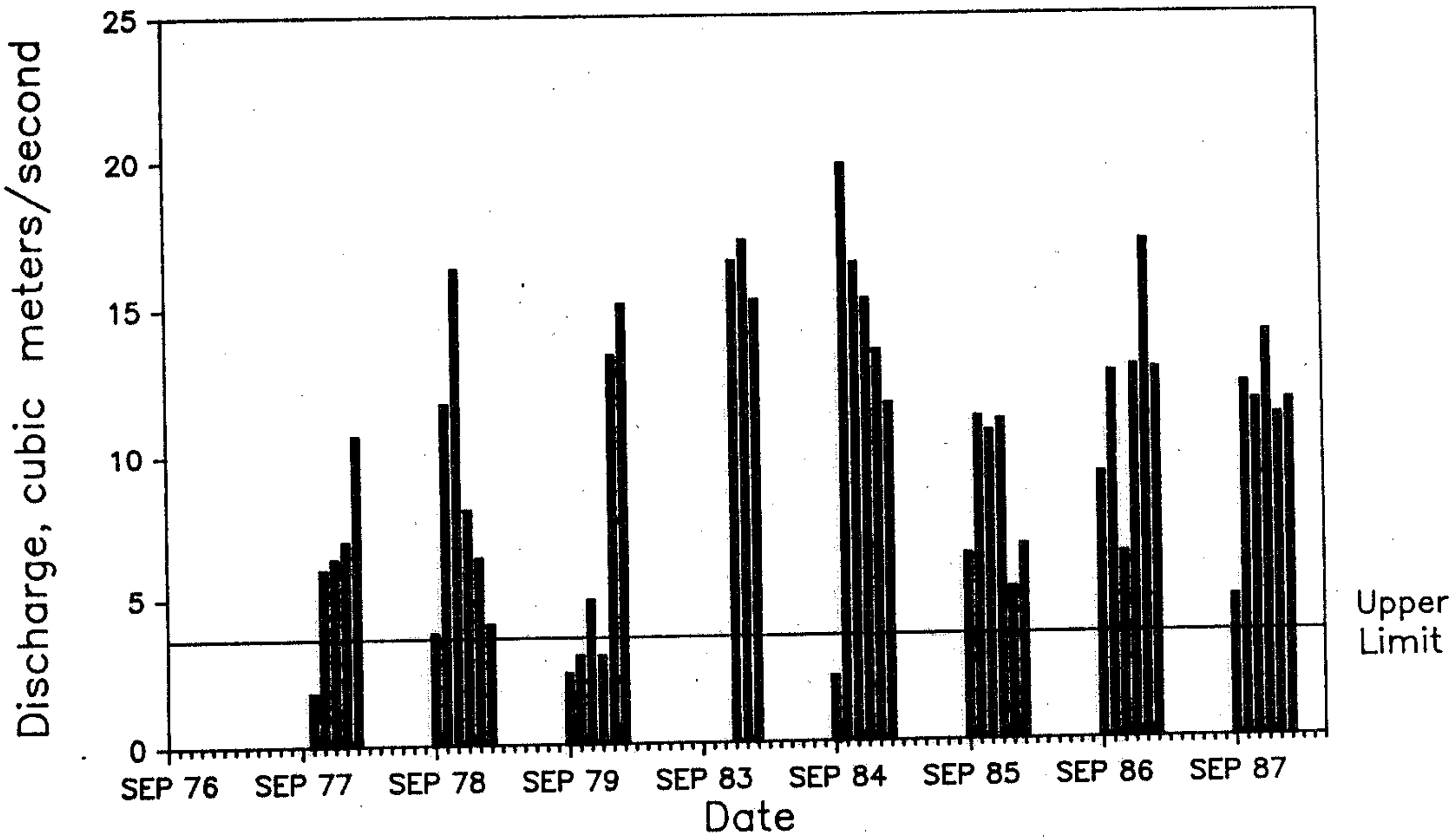

Figure 4. Peak Big River monthly flows and upper limit of sockeye spawning and incubation preferences ($3.59\ m^3/sec$).

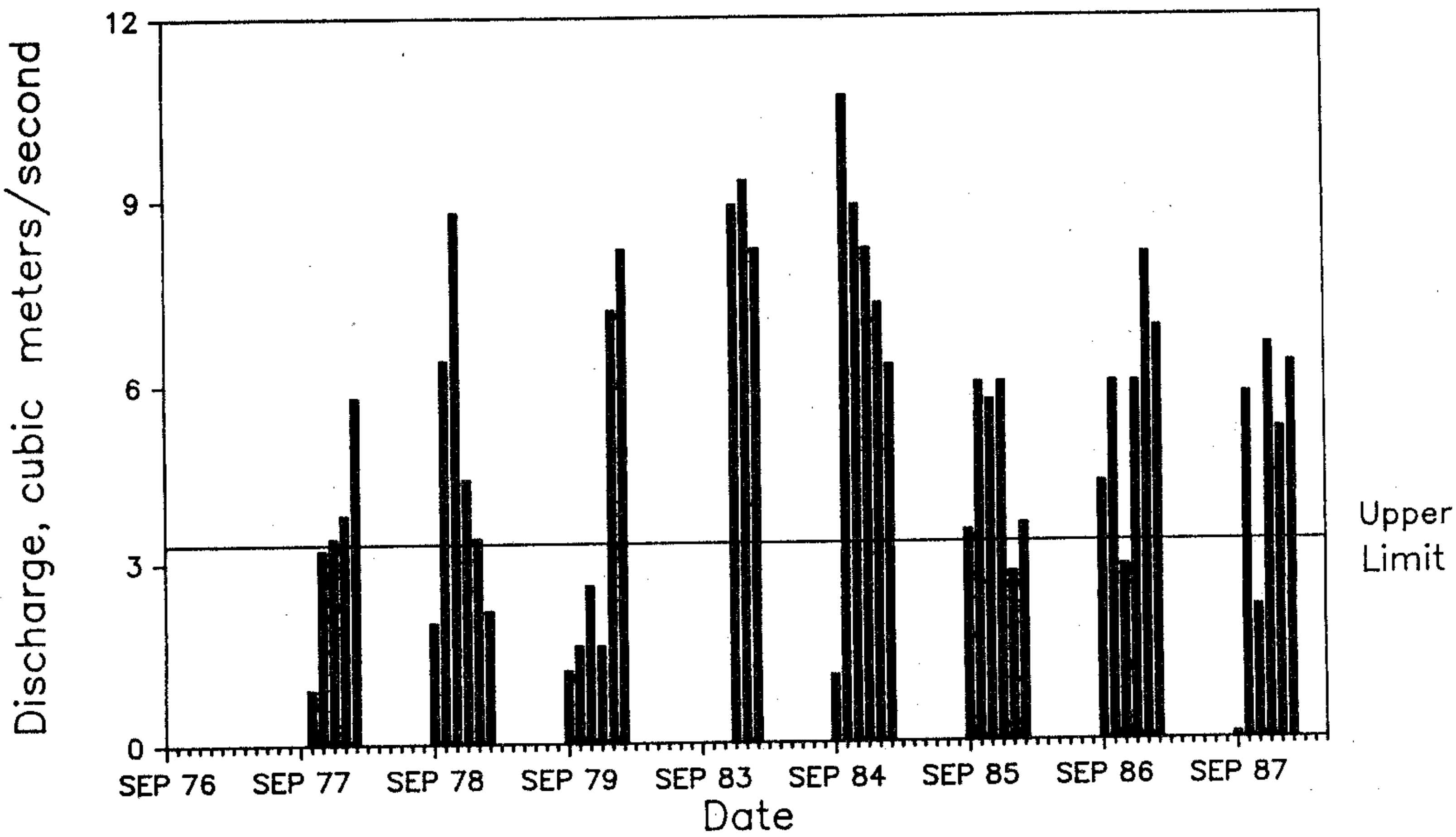

Figure 5. Peak Umbrella Creek monthly flows and upper limit of sockeye spawning and incubation preferences (3.27 m^3/sec).

Douglas Fir forest in Canary, Oregon, fully one-third of the area's mean annual precipitation was recycled through evapotranspiration (Thornthwaite and Mather 1957). Through interception, the old growth stems, branches and leaves also decrease the amount of rainfall reaching the soil by as much as 14% during winter months (Rothacher 1963).

Indirectly, the undisturbed forests prevent overland flow by building up a large, organic soil and litter base that increases soil storage and infiltration (Rothacher 1965). Tsukamoto (1975) showed the importance of forest floor litter in reducing flood volumes by demonstrating the removal of litter increased peak flows from storms of <10 cm by 168%. Therefore, logging, by removing the trees, increased storm run off by eliminating interception, greatly reducing evapotranspiration, and decreasing storage capacity while increasing surface run-off through soil compaction and road building (Kovner 1957).

Egg mortality after flood flows is not uncommon on salmon spawning grounds. McNiel (1966, 1969) found the disappearance of eggs from spawning beds often exceeded 50% following storm freshets and over 90% on one occasion in Alaska. Logging a watershed has been shown to increase stream run-off, resulting in floods which can cause gravel displacement and streambed scouring (Chapman 1962; Hsieh 1970). Scouring and gravel displacement are believed to be the causative mechanisms for mortality of incubating sockeye eggs and alevins in Lake Washington (Stober et al. 1978) and Lake Quinault (Gilbertson 1981).

Floods are considered to be a major cause of sockeye egg-fry

Floods are considered to be a major cause of sockeye egg-fry mortality at Lake Washington (Thorne and Ames 1987). A major flood in December, 1975 in the Cedar River, reduced sockeye egg and fry densities in two reaches by 50.6 and 96.6% (Narita 1978; Stober et al. 1978). Peak floods in Ozette have been about the same magnitude as this event, suggesting the potential to cause significant incubation mortality.

3.1.2 Tributary Substrate

Over 85% of the Ozette Lake watershed has been clear-cut since the 1940's (McVey 1979; Blum 1984) and logging road development has been extensive. In the Big River watershed, average logging road densities were 2.56 km/km^2. Road densities ranged from 1.24 km/km^2 near the river mouth to 3.88 km/km^2 in the stream reaches where sockeye would be most likely to spawn. Similar densities were found in the Umbrella Creek watershed, averaging 2.24 km/km^2 and ranging from 0.31 km/km^2 at the mouth to 3.73 km/km^2 on the East Fork (Table 6).

Logging roads have been found to be a major source of fine sediment input into streams (Cederholm et al. 1980). Figure 6 shows the relationship between the level of fines and egg to fry survival (Rittmueller, 1986). Umbrella Creek and Big River would be expected to have a level of fines in the gravel nearly three times that of unlogged watersheds, with an approximate 70% decrease in survival to emergence compared with natural survival in unlogged watersheds. Thus, when flooding has been shown to cause a minimum of 50% egg-fry mortality and the densities of road building similar to that found in the Ozette watersheds have been shown to cause 83% mortality, the total impact of

Table 6. Logging road densities in Big River and Umbrella Creek, major spawning areas in the Ozette Lake Watershed.

Location Township/ Range	Section	Big River Km roads	Big River Km/Km^2	Umbrella Creek Km roads	Umbrella Creek Km/Km^2
T. 30 N.	6	-	-	9.65	3.73
R. 14 W.					
Total				9.65	3.73
T. 30 N.	1	-	-	8.05	3.11
R. 15 W.	2	-	-	4.83	1.86
	3	1.61	1.24	2.61	2.02
	11	-	-	0.80	0.31
	12	-	-	4.02	1.55
Total		1.61	1.24	20.31	1.74
T. 31 N.	7	6.44	2.48	-	-
R. 14 W.	18	6.44	2.48	-	-
	3	-	-	6.03	2.33
	10	-	-	6.84	2.64
	15	-	-	7.24	2.80
	16	-	-	6.44	2.48
	20	-	-	1.61	1.24
	21	-	-	3.62	1.40
	22	-	-	3.02	1.16
	29	-	-	3.62	1.40
	30	-	-	3.62	1.40
	31	-	-	5.63	2.17
	32	-	-	6.84	2.64
Total		12.872	2.48	54.50	2.00
T. 31 N.	1	6.03	2.33	-	-
R. 15 W.	11	7.24	2.80	-	-
	12	6.44	2.48	-	-
	13	9.65	3.73	-	-
	14	10.06	3.88	-	-
	15	6.03	2.33	-	-
	16	4.83	1.86	-	-
	21	6.84	2.64	-	-
	22	8.45	3.26	-	-
	23	8.45	3.26	-	-
	24	4.02	2.07	2.41	3.73
	25			5.63	2.17
	26			4.83	1.86
	27	3.62	1.40	-	-
	34	4.83	1.86	-	-
	35	-	-	2.82	1.09
	36	-	-	7.64	2.95
Total		86.48	2.62	23.33	2.12
Grand Total		100.96	2.56	117.46	2.24

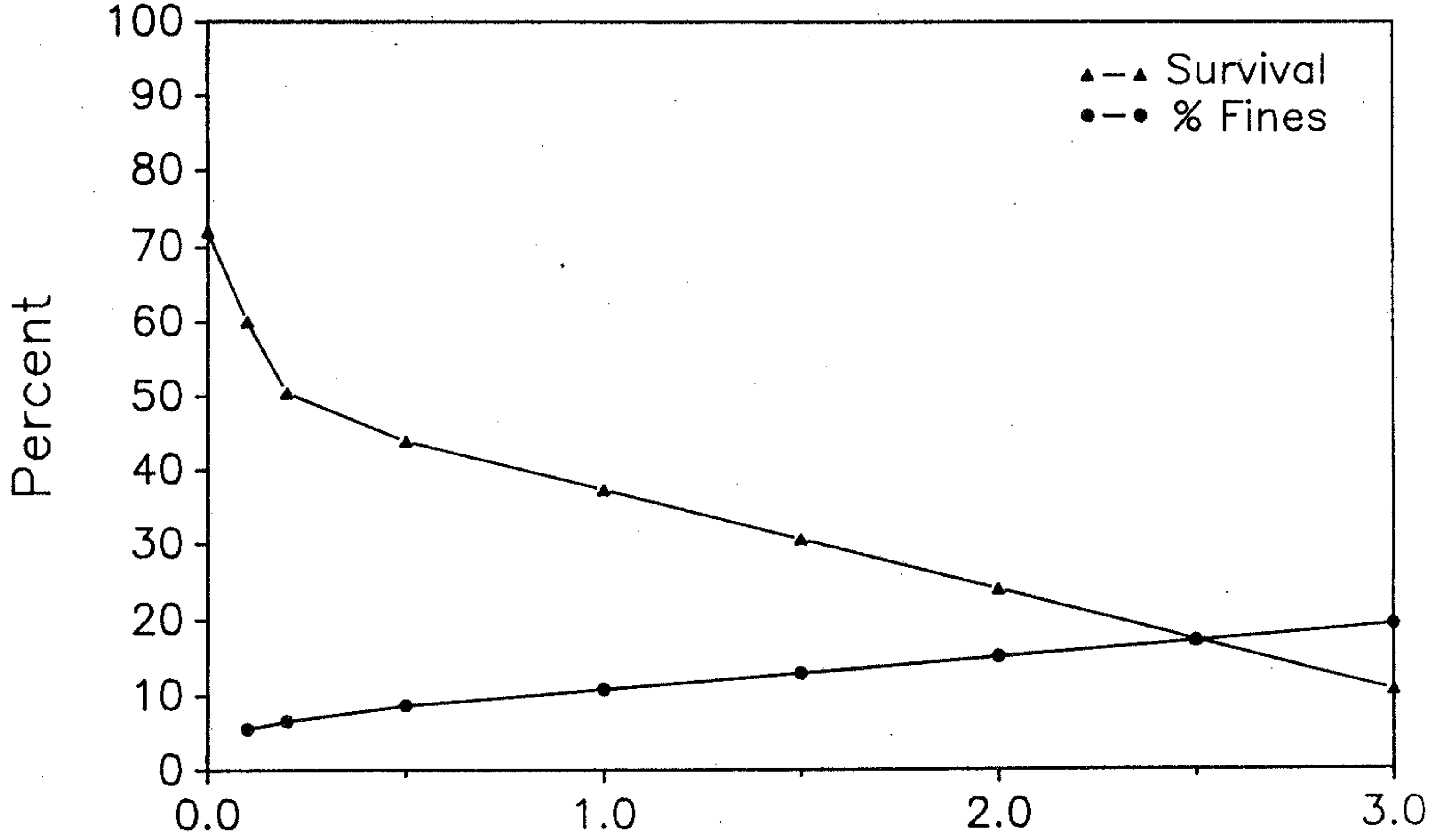

Figure 6. Salmon egg-emergence survival and percent fines in gravel as a function of road densities (km/km^2) per Rittmueller (1986).

both perturbations could result in over a 90% loss of tributary sockeye production in Ozette Lake.

Although habitat degradation is the probable reason for the inability of tributary spawners to become re-established at Ozette Lake without fishing pressure, other problems may confront this sockeye stock. Measurements indicate that primary productivity in Ozette Lake is low, typical of Pacific Northwest coastal, marine lakes (Stockner 1981; Stockner and Shortreed 1985).

3.2 Productivity Estimates

Morphometric and limnological data collected from Fraser River system lakes were analyzed to determine those factors best predicting the PAI (Y). Those variables explaining the most variance in the PAI were TDS, chlorophyll a and the Morpho-edaphic Index (MEI, Ryder et al. 1974), adjusted for a maximum depth of 25 m (Oglesby 1977).

The univariate model which explained the most variance utilized TDS as a surrogate for the PAI (Y):

$$Y = 0.0165\ TDS - 0.00286\ (r^2 = 0.465,\ P < 0.05) \qquad \text{(Eq. 4)}$$

(n=21, TDS ranged from 31-167 mg/l, PAI values from 0.2 - 2.18; Figure 7).

Equation 4 predicts a PAI value of 0.4 for Ozette Lake, showing each surface acre could support the progeny of 4 effective female spawners. Although the MEI, calculated as TDS/Mean Depth, was not significantly correlated to PAI (Y), the MEI adjusted to 25 m maximum depth (X) was, resulting in the relationship:

$$Y = 0.2196 + 0.267\ X\ (r^2 = 0.617;\ P<0.01) \qquad \text{(Eq. 5)}$$

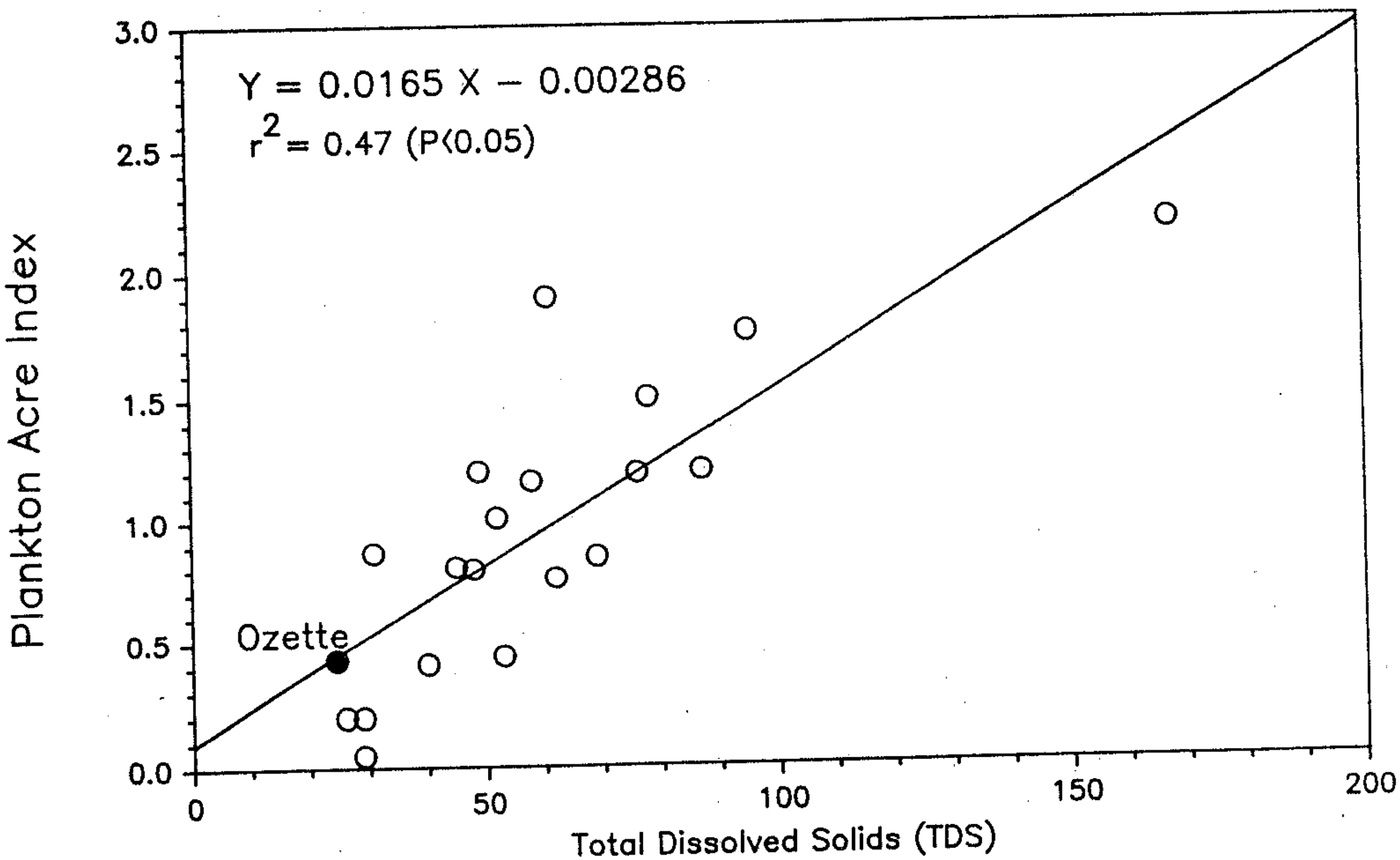

Figure 7. Relation between the Plankton Acre Index (PAI) and Total Dissolved Solids (TDS, mg/l) for 19 Fraser River system sockeye salmon lakes.

(n=21, MEI25 ranged from 1.0-7.31), predicting a PAI value of 0.5 (Figure 8).

The multivariate model that explained the most variability in the PAI included TDS (X_1) and chlorophyll a (ug/l) (X_2), where:

$$Y = 0.0118\ X_1 + 0.1569\ X_2 + 0.2247\ (r^2=0.506, P<0.01) \qquad \text{(Eq. 6)}$$

(n=21, X_2 ranging from 2.5 - 44.7 ug/l, predicting a PAI of 0.9, but the X_1 and X_2 coefficients were not significant at $P<0.05$).

The estimates of PAI from this analysis indicate a range from 0.4 - 0.9, suggesting that Ozette Lake could support the progeny of 27,000 - 60,750 effective female spawners, with potential escapements ranging from 54,000 - 121,500 adult sockeye under present conditions. Escapement estimates are based on the assumption that: 1) 1:1 female/male ratio (IPSFC 1972); 2) effective spawn-out of 3,000 eggs/female (Dlugokenski, 1981); and 3) lake rearing capacity limits production where density independent factors are not limiting (Stockner 1981). Although these carrying capacity estimates exceed any recorded catch in the system, the historical catch record is sketchy, is most certainly an underestimate (accurate records were not kept until 1974) and only extends back until the mid-1940's when the stock had already declined. It is known that the run was of sufficient size (more than 50,000 fish) before 1940 that consideration was given to constructing a cannery at the lake (T. Parker, pers. comm.1983). Also, pre-1940 run data on Lake Quinault shows that runs in excess of 1 million fish were observed whereas today runs range from 7 to 60 thousand.

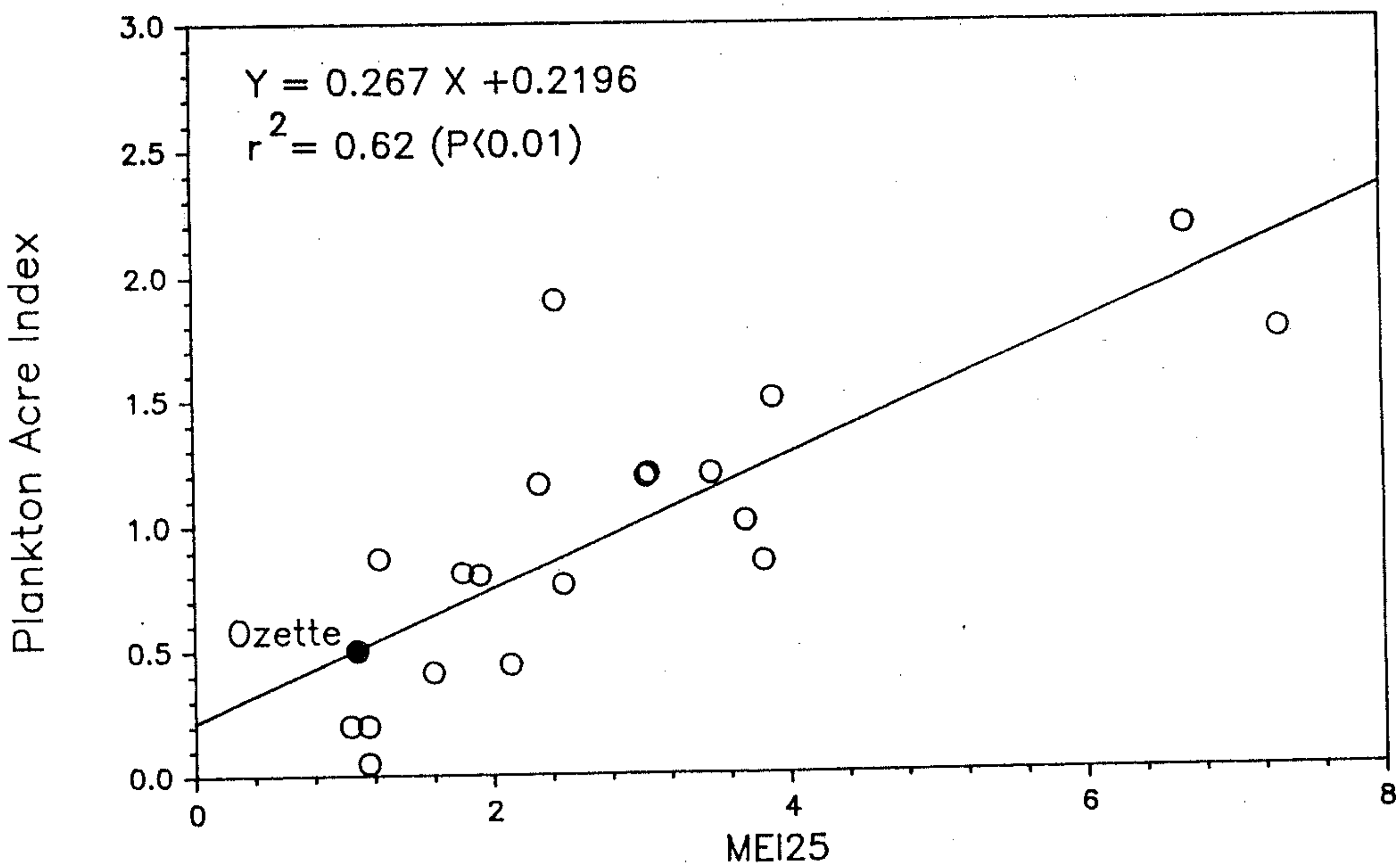

Figure 8. Relation between the Plankton Acre Index (PAI) and the Morpho-Edaphic Index adjusted for a maximum depth of 25m (MEI25) for 19 Fraser River System sockeye salmon lakes.

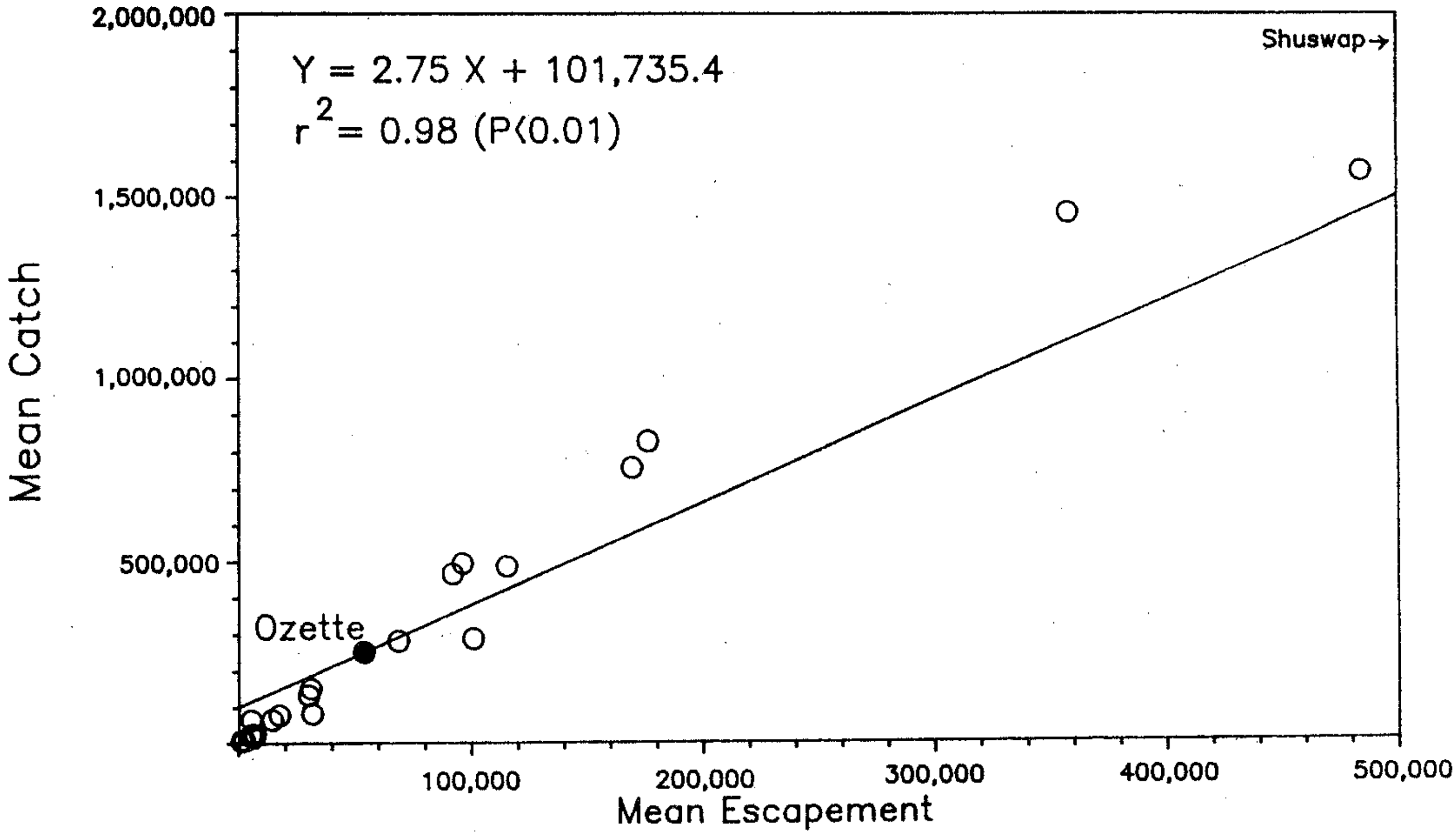

Figure 9. Relation between mean escapement and catch for 21 Fraser River System sockeye salmon lakes (1969 - 1980 average).

Predictions of mean catch (Y), based on set escapement levels (X), were made using Fraser River system data (Figure 9). Expected yields were estimated as a function of:

$$Y = 2.795\ X + 101735.4 \qquad (r^2=0.976,\ P<0.01) \qquad \text{(Eq. 7)}$$

(n=21, Fraser System mean catches range from 8,100-3,838,000 and mean escapements from 2,300-1,402,880). Predicted yields of Ozette sockeye using carrying capacity estimates range from 252,700 ($\pm$79,300) - 441,400 ($\pm$92,800).

When mean total run sizes (Y) of Fraser River sockeye are regressed against mean escapements (X), total run size (Y) can be predicted:

$$Y = 3.79\ X + 101734.77 \qquad (r^2=0.741,P<0.01) \qquad \text{(Eq. 8)}$$

(N=21, Fraser System mean total run sizes from 12,000 to 5,241,000), indicating that, on average, nearly 4 recruits are produced per each spawner (Figure 10). The model predicts that Ozette Lake could produce total runs of 306,700 ($\pm$73,300) to 562,900 ($\pm$92,900).

Estimates of total run size and yield are made on the assumption that escapements equivalent to carrying capacity are realized, which often is not the case for a variety of habitat and management reasons. Table 7 shows lakes in the Fraser system with similar rearing capacities as Ozette Lake. Only Mara Lake has been managed so that actual escapements meet estimated capacity. Pitt Lake, similar to Ozette Lake in potential female spawners, TDS level and Mean depth, produces runs averaging 114,000 while mean escapements are only 59% of

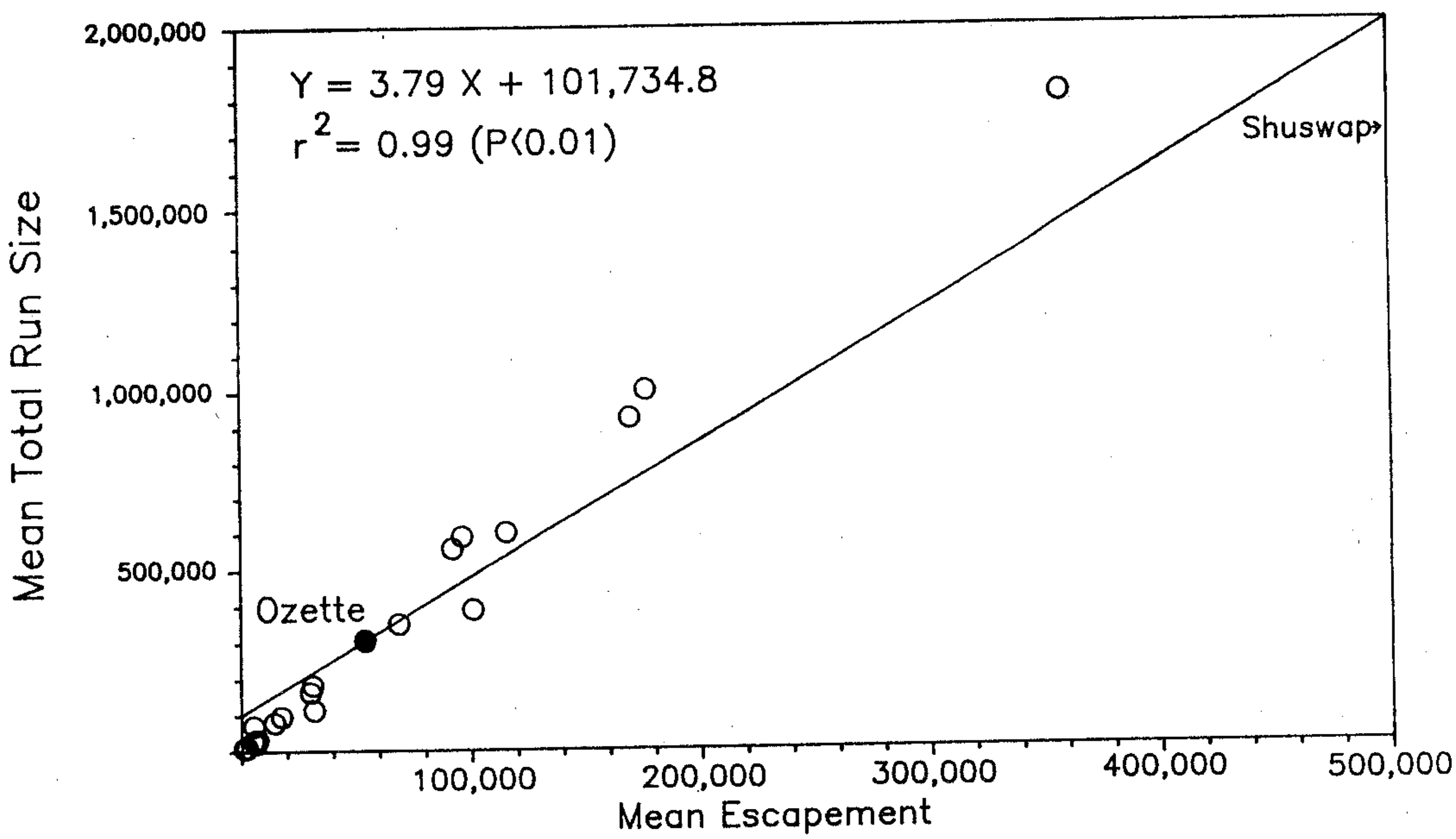

Figure 10. Relation between escapement and total run size for 21 Fraser River System sockeye salmon lakes (1969 - 1980 average).

Table 7. Fraser River System sockeye salmon lakes with comparable seeding capacities as Ozette Lake, WA (mean 1969-1980 values).

Lake	Potential Female Spawners	Mean Escapement	Mean Catch	Mean Total Run	Mean R/Spawner
Pitt	27,000	32,000	82,000	114,000	3.56
Mara	41,000	101,000	288,000	389,000	3.85
Bowron	53,000	30,000	134,000	164,000	5.47
Cultus	34,000	17,000	79,000	96,000	5.65
Seton	49,000	5,000	24,000	29,000	5.80

predicted carrying capacity. Recruits/spawner (R/S) values range from 3.56 - 5.80, so predictions of 3.79 R/S for Ozette Lake seem reasonable.

Zooplankton surveys conducted during the growing season (April through September) show zooplankton densities ranging from 5,200 - 14,000 organisms/m^3. Most of the zooplankters present were calanoid and cyclopoid copepods; however the cladocerans and rotifers, the preferred prey of sockeye (Eggers 1978) were found at relatively high percentages (greater than 25%). The expected PAI value of 0.5, the observed mean summer standing crops of ca. 10,000 organisms/m^3, and the high relative abundance of preferred zooplankters support my contention that at the current sockeye production levels, prey resources are not limiting (Table 8).

3.3 Smolt Production Potential

Smolt population estimates from 1977 - 1984 range from 5,600 to 11,000 fish but may be underestimated because of sampling difficulties. Based on scale examination, over 99% of the smolts sampled spent one winter in fresh water. Mean length varied between years, with smolts averaging 11.3 cm, 11.8 cm and 12.1 cm in 1979, 1982 and 1984. Length/weight regressions based on 1979 data (modified from Dlugokenski et al. 1981) showed smolts averaged about 14.2 g, 15.5 g and 16.1 g for the three years sampled. Literature review suggested these smolts are large, exceeded only by Lake Washington (Dlugokenski et al 1981; Eggers 1978; Table 9). Since large smolt size has been correlated with higher marine survival rates in sockeye salmon populations (Foerster), Ozette

Table 8. Summer growing season (April - September) zooplankton densities in Ozette Lake, WA, 1976-1979 (mean of four stations).

Category	Year	Mean	Range	% Total
Total Zooplankton	1976-1979	9,481	5,232 - 13,911	-
	1976	9,657	7,838 - 11,421	-
	1977	9,824	8,932 - 11,281	-
	1979	9,142	7,180 - 13,931	-
Rotifers	1976-1979	2,480	349 - 4,863	26.2
	1976	2,599	349 - 4,863	26.9
	1977	2,185	628 - 4,592	22.9
	1979	2,453	309 - 4,034	26.7
Total Cladocerans	1976-1979	1,349	164 - 2,152	14.2
	1976	1,510	1,120 - 1,756	15.6
	1977	692	164 - 956	7.3
	1979	1,394	816 - 2,152	15.2
Daphnia	1976-1979	541	218 - 909	5.7
	1976	609	429 - 909	6.3
	1977	483	137 - 738	5.1
	1979	310	218 - 586	3.4
Bosmina	1976-1979	840	27 - 1,933	8.9
	1976	902	528 - 1,328	9.3
	1977	209	27 - 382	2.2
	1979	1,546	385 - 1,933	16.8
Leptodora	1976-1979	-	-	Trace
Holopodium	1976-1979	-	-	Trace
Total Calanoid Copepods	1976-1979	3,523	1,752 - 7,498	37.2
	1976	2,553	1,752 - 3,486	26.4
	1977	2,713	1,803 - 3,851	28.5
	1979	4,750	2,552 - 7,498	51.6
Diaptomus	1976-1979	1,835	1,420 - 2,568	20.4
	1976	1,923	1,466 - 2,393	19.9
	1977	2,131	1,450 - 2,568	22.4
	1979	689	-	-
Epischura	1976-1979	1,217	82 - 6,203	12.8
	1976	630	286 - 1,093	6.5
	1977	583	82 - 1,284	6.1
	1979	6,203	-	67.4
Cyclops Copepods	1976-1979	2,129	0 - 5,419	22.5
	1976	2,994	2,295 - 5,419	31.0
	1977	4,234	3,278 - 4,807	44.5
	1979	599	0 - 1,720	6.5

Table 9. Comparative size data for age 1 sockeye smolts from various systems producing sockeye (Eggers 1978).

System	Years	Number Years' Data	-Length (mm)- Mean	Range	-Weight (gm)- Mean	Range	Source
Wood R.	1949-70	22	83.7	77-91	4.8	3.5-5.8	ADF&G
Kvichak	1953-72	10	88.4	80-96	5.7	4.2-7.4	ADF&G
Naknet	1955-73	19	101.6	91-113	9.3	6.9-13.1	ADF&G
Ugaskik	1956-72	16	91.6	81-97	6.6	5.0-7.7	ADF&G
Babine	1955-58	3	82.0	-	-	-	Ricker (1962)
Owikeno	1913-15 1951	4	59.7	59-61	-	-	Foskett (1958)
Great Central	1969-76	6	69.0	64-78	-	-	LeBras- seur
Chilko	1950-70	20	81.7	73-101	4.6	3.1-8.4	IPSFC
Shuswap	-	7	74.0	-	4	-	Goodlad (1974)
Cultus	1925-71	21	81.6	68-94	6.2	3.0-8.6	IPSFC
Dalnee	1933-41	7	116.0	106-133	16.4	12.5- 23.0	Krogius (1948)
Wash- ington	1965-69	5	126.5	120-133	18.5	16.7- 20.5	J.Woodey J.Traynor
Ozette	1979,82 1984	3	117.0	41-164	15.3	-	Dlugokenski (1981) MFM 1982 1984

Lake sockeye smolts should prove to be successful. Although smolts are large in Ozette Lake, which corroborates my contention that food is not limiting, Eggers (1978) points out that the longer growing season and low intraspecific competition may confound the use of smolt size as an indicator of prey availability and lake productivity. Goodlad et al (1974), Burgner (1958), and Mathisen (1955) have shown-density dependent growth for sockeye juveniles. However, the presence of at least moderate numbers of rearing sockeye in Ozette suggests the potential for prey resource competition is not absent, even though sockeye densities average only 3 smolts/hectare under present conditions.

Low smolt numbers are consistent with total fish densities found in Ozette Lake. Hydroacoustic surveys, conducted from 1979-82 to determine abundance, distribution and densities of limnetic fishes within the lake, showed that densities were uniform, with slightly higher densities in the southern portion. Fish numbers varied from a low of 347,000 in 1981 to a high of 541,000 in 1979, with significant decreases in fish population of 17% and 14% between 1979/80 and 1980/81 surveys. (Thomas 1979a,b; 1980 a,b; 1981, 1982). Mean densities (25.5-40 fish/ha) are low when compared with densities of 173-740 and 122-837 fish/ha in Lake Quinault (Lemberg 1975) and Lake Washington (Thorne and Ames 1987). A limited amount of data on the species composition of pelagic fish in the lake suggest that the assemblage is primarily kokanee, land-locked sockeye salmon (Thomas, 1982). Smolt to adult survival rates range from 3.6% - 12.8%, averaging about 8% (Table 10), within the range of expected survival for sockeye smolts

Table 10. Ozette Lake presmolt population estimates and associated run characteristics for 1977-84 brood years.

Brood Year	Pelagic Fish (1000's)	Adult Escapement	Smolt Estimate	Marine Survival (Percent)	Smolts/ Female	Presmolts /Spawner
1977	N/A	920	9600	3.65	20.9	N/A
1978	546	920	N/A	N/A	N/A	593.5
1979	441	540	N/A	N/A	N/A	816.7
1980	379	402	5400	12.80	26.9	942.8
1981	395	350	N/A	N/A	N/A	1128.6
1982	N/A	2170	11400	N/A	10.5	N/A
1983	N/A	N/A	N/A	N/A	N/A	N/A
1984	N/A	691	N/A	N/A	N/A	N/A

(Foerster 1968). Adult escapements may be underestimated because early spring discharges often prevent counts at the beginning of the run. However, juvenile survival is expected to be higher, about 50%, suggesting that with current natural production, sockeye fry account for only 18,000, or roughly 4-6% of the fish assemblage present. Evidently, lake productivity processes support other fish species and this productivity might be available to sockeye if present in greater numbers.

In 1987, over 6,000 kokanee were observed spawning in Siwash and Elk Creeks. The progeny from such escapements would account for roughly 360,000 - 480,000 of the acoustic targets observed in Ozette Lake. The kokanee in the Ozette system spawn early and are only found in short (less than 4 km), small drainage, low-flow, low-gradient streams where the effects of logging may have been less severe and recovery more rapid. The kokanee appear to be using only that habitat suitable for incubation where floods and silt are not major influences. Flow conditions in these streams are such that sockeye cannot use these tributaries, and therefore the species of major fish using the lake is probably kokanee.

In Ozette lake the kokanee may represent a early successional stage for the re-establishment of natural sockeye salmon production after the logging perturbations. Many investigations on the upper Columbia River reservoirs that no longer allow for passage of anadromous sockeye show that kokanee are the dominant species occupying the pelagic habitat (Thomas 1978, Jeppson 1955, Earnest and Spence 1983). Foerster (1968) showed that given the proper circumstances, kokanee could produce an anadromous run. With regard to the absence of sockeye spawners in tributaries of Ozette Lake, kokanee represent the gene pool on which the rehabilitation of sockeye could take place. Female kokanee could be crossed with Ozette Lake male sockeye, and eggs could be translanted to tributaries for imprinting.

4.0 CONCLUSIONS

A review of the factors that are limiting the sockeye production at Ozette Lake suggest that the absence of tributary spawners is the paramount problem, which in part explains why the sockeye runs in Ozette Lake have not increased even though terminal area fishing ceased in 1973. Without tributary spawning the sockeye cannot adequately seed the lake to use its present carrying capacity. Kokanee have filled the pelagic niche once occupied by sockeye fry. Given that sockeye could completely replace the kokanee rearing in the lake that number of fry could produce smolt runs of 120,000 to over 250,000, which in turn could produce total runs of 5,000 to 75,000 adults (Thorne and Ames, 1987).

As a result of the extensive logging operations in the 1940's, the increased surface run off during winter freshets has destabilized tributary incubation and rearing habitats. I believe that the removal of old growth forest and the building of roads have reduced the capacity for tributary sockeye production by increasing magnitude and frequency of peak flows (Anderson and Hobba 1959; Hibbert 1967; Harper 1969), stream-bed scouring (McNiel 1966; 1969; Zach 1950), flushing the within-river bank zone and the input of excessive amounts of inorganic and organic materials, degrading water quality (Hsieh 1970; Rittmueller 1986). The evidence suggests that extensive deforestation has removed the natural flood control and water recirculation mechanisms that were inherent to the old growth forests (Reinhart 1972). Even after 35 years to recover, the winter flows and percent of fines in the gravel of Ozette Lake tributaries still exceed conditions preferred for sockeye spawning, incubation and rearing and that present conditions could reduce the expected egg-to-fry survival to less than 2%.

Ozette Lake is classified as a low elevation, marine climate lake with low productivity. I used the Plankton Acre Index model to estimate the productive potential of the lake. My estimates of the present carrying capacity of Ozette suggest the lake can support runs of at least 54,000 adults. This points out that even if the tributaries are completely rehabilitated so the sockeye could use the maximum natural spawning area, it is doubtful that they could overseed the lake because the maximum redd area would only support 60,000 fish. Thus, spawning area limitation possibly represents the natural constraint to Ozette sockeye production. In contrast, the watershed of Lake Quinault, also on the Olympic Peninsula, offers over four times the potential spawning area of Ozette and conveniently displays records of run sizes of about the same magnitude. Thus, all analysis suggest that Ozette sockeye could prosper with the addition of artificial spawning habitat, possibly a spawning channel or a hatchery facility.

In spite of these limitations, Ozette Lake has the potential to produce many more sockeye salmon than it does now. Owing the similarities geographically and morphometrically between Ozette Lake and Lake Quinault, it is not unreasonable to assume Ozette Lake could support a sockeye salmon run as large as those found in Lake Quinault, particularly with twice the rearing area. Success will depend on 1) how much natural spawning tributary stock can be re-established and 2) what size sockeye population the lake can support.

Estimates of spawning potential in the tributaries are 30,000 redds or 60,000 adult sockeye, which coincide with predictions of existing lake rearing potential. After selection of a tributary-spawning stock compatible with environmental conditions in Ozette Lake, measures could be taken to increase spawning and incubation survival. A hatchery would increase survival of eggs and fry by eliminating the effects of flooding, gravel shifting and egg perturbation. A hatchery has proven successful at enhancing the runs of sockeye salmon on Lake Tustumena, Alaska. Construction of spawning channels, much like the one at Weaver Creek, British Columbia, has proven successful in increasing sockeye production (Cooper 1977) and has been suggested by the Makah Tribe for Big River. Net pens, situated in Umbrella Bay, have been employed to eliminate competition and predation during the first few months of lake residence and increase survival. The restoration plans for Ozette Lake are discussed in Blum (1984).

Analysis of limnological and morphometric parameters at Ozette Lake shows that at current sockeye population levels, lake processes do not limit production. However, with increased output of sockeye fry density- dependent growth may occur in the lake. The PAI indicates that the lake could support spawning populations of 54,000 - 121,000, with total runs ranging from 306,000-563,000 sockeye. If, as Stockner (1981) suggests, coastal lowland lakes are limited by low productivity, Ozette Lake may be a prime candidate for fertilization. LeBrasseur et al. (1978) concluded that primary and secondary productivity limited sockeye numbers at Great Central Lake, located on Vancouver Island. By inputting nutrients artificially, mean summer primary productivity increased 5 times, zooplankton standing crop increased nine times, percent survival for estimated potential egg deposit to juvenile increased 2.6 times, and adult sockeye returns increased from <50,000 to >350,000, a seven-fold increase.

Although these increases in standing crop, survival and total returns observed in Great Central Lake may be exceptional, I believe similar results could occur at Ozette Lake if spawning area were not limiting. By estimating chlorophyll a increases based on results at Great Central lake, I used the PAI to predict an increase in carrying capacity to such a level that the lake could support the progeny from between 77,000 and 217,000 adult spawners. The use of the PAI and the integration of enhancement measures that remove habitat restrictions (spawning channel and hatchery) with measures to reduce production limitations (lake fertilization and net pen-rearing), could result in predicted sockeye returns ranging from 400,000 - 925,000. Run sizes larger than this have occurred at Lake Quinault, which has less that half the rearing area of Ozette but more that 4 times the spawning area.

5.0 LITERATURE CITED

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Appendix 1. Ozette Lake Primary Production Data, 1976-1979

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Year	Month	Day	Station	Survey	Secc. Dep.	Chlor-a	Spec. Cond.	Surf. Temp.	Mean Temp
76	2	19	1	1	274	9	39	45	432
76	4	1	1	2	229	12	38	44	432
76	4	27	1	3	305	16	39	49	454
76	5	27	1	4	259	41	38	54	485
76	6	22	1	5	274	27	36	59	512
76	7	21	1	6	213	50	37	63	543
76	8	26	1	7	290	26	34	63	533
76	9	28	1	8	287	36	38	64	533
76	11	9	1	9	244	22	35	53	519
77	2	8	1	10	-	-	-	-	-
76	2	19	2	1	229	12	40	44	436
76	4	1	2	2	229	8	38	44	429
76	6	22	2	5	244	29	36	60	515
76	7	21	2	6	213	49	38	64	521
76	8	26	2	7	335	26	34	62	523
76	9	28	2	8	290	32	39	65	508
76	11	9	2	9	381	25	33	53	488
77	2	8	2	10	-	-	-	-	-
77	5	16	2	11	305	55	54	502	99
77	7	12	2	12	274	66	540	91	-
77	9	20	2	13	305	28	60	526	88
76	2	19	3	1	296	8	39	44	437
76	3	31	3	2	229	10	37	44	430
76	5	25	3	4	244	35	38	53	478
76	6	22	3	5	305	3	36	60	520
76	7	20	3	6	229	38	64	529	94
76	8	26	3	7	320	23	36	63	524
76	9	28	3	8	290	22	40	64	510
76	11	10	3	9	335	35	37	53	488
77	2	8	3	10	-	-	-	-	-
77	5	16	3	11	305	59	54	499	99
77	7	12	3	12	274	63	533	91	-
77	9	20	3	13	305	25	62	527	90
76	2	20	4	1	223	5	40	44	435
76	3	31	4	2	229	12	39	44	429
76	4	27	4	3	305	14	39	47	442
76	5	25	4	4	229	38	37	54	475
76	6	22	4	5	274	36	37	61	519
76	7	20	4	6	213	48	37	64	529
76	8	26	4	7	320	3	36	63	525
76	9	28	4	8	293	34	39	63	512
76	11	10	4	9	351	4	37	53	487
77	2	8	4	10	-	-	-	-	-
79	1	8	1	14	-	-	-	-	-
79	1	22	1	15	-	-	-	-	-
79	2	21	1	16	-	-	-	-	-
79	3	10	1	17	-	-	-	-	-

Appendix 1. Cont'd. Ozette Lake primary production data, 1976 -1979.

Year	Month	Day	Station	Survey	Secc. Dep.	Chlor-a	Spec. Cond.	Surf. Temp.	Mean Temp
79	3	12	1	18	-	-	-	-	-
79	3	15	1	19	-	-	-	-	-
79	3	18	1	20	-	-	-	-	-
79	3	19	1	21	-	-	-	-	-
79	3	21	1	22	-	-	-	-	-
79	4	16	1	23	-	-	-	-	-
79	4	20	1	24	-	-	-	-	-
79	4	25	1	25	-	-	-	-	-
79	5	25	1	26	-	-	-	-	-
79	6	23	1	27	-	-	-	-	-
79	7	25	1	28	-	-	-	-	-
79	8	23	1	29	-	-	-	-	-
79	9	18	1	30	-	-	-	-	-
79	1	9	2	14	-	-	-	-	-
79	2	21	2	16	-	-	-	-	-
79	3	8	2	17	-	-	-	-	-
79	3	12	2	18	-	-	-	-	-
79	3	21	2	22	-	-	-	-	-
79	4	20	2	24	-	-	-	-	-
79	4	25	2	25	-	-	-	-	-
79	5	25	2	26	-	-	-	-	-
79	7	25	2	28	-	-	-	-	-
79	8	23	2	29	-	-	-	-	-
79	9	18	2	30	-	-	-	-	-
79	1	9	3	14	-	-	-	-	-
79	2	21	3	16	-	-	-	-	-
79	3	12	3	18	-	-	-	-	-
79	3	15	3	19	-	-	-	-	-
79	3	18	3	20	-	-	-	-	-
79	3	19	3	21	-	-	-	-	-
79	4	20	3	24	-	-	-	-	-
79	4	25	3	25	-	-	-	-	-
79	5	25	3	26	-	-	-	-	-
79	6	23	3	27	-	-	-	-	-
79	7	25	3	28	-	-	-	-	-
79	8	23	3	29	-	-	-	-	-
79	9	18	3	30	-	-	-	-	-
79	1	9	4	14	-	-	-	-	-
79	2	21	4	16	-	-	-	-	-
79	3	12	4	18	-	-	-	-	-
79	4	2	4	24	-	-	-	-	-
79	4	25	4	25	-	-	-	-	-
79	5	25	4	26	-	-	-	-	-
79	6	23	4	27	-	-	-	-	-
79	7	25	4	28	-	-	-	-	-
79	8	23	4	29	-	-	-	-	-
79	9	18	4	30	-	-	-	-	-

Appendix 1. Cont'd. Ozette Lake primary production data, 1976 -1979.

Year	Month	Day	Sta-tion	Sur-vey	Dis. Oxygn	Color	Algal Gro.Pot	Nitrat	Nitrit
76	2	19	1	1	117	25	6	10	3
76	4	1	1	2	123	20	3	10	4
76	4	27	1	3	112	25	4	6	1
76	5	27	1	4	98	30	7	3	4
76	6	22	1	5	101	30	3	6	0
76	7	21	1	6	93	35	4	2	5
76	8	26	1	7	90	35	5	4	4
76	9	28	1	8	87	3	2	6	8
76	11	9	1	9	89	4	4	4	10
77	2	8	1	10	-	-	-	-	-
76	2	19	2	1	116	30	6	10	3
76	4	1	2	2	120	25	3	9	5
76	6	22	2	5	100	30	3	7	0
76	7	21	2	6	94	35	4	2	5
76	8	26	2	7	92	35	5	4	4
76	9	28	2	8	93	3	2	6	6
76	11	9	2	9	89	3	5	3	4
77	2	8	2	10	-	-	-	-	-
77	5	16	2	11	-	-	-	-	-
77	7	12	2	12	-	-	-	-	-
77	9	20	2	13	-	-	-	-	-
76	2	19	3	1	118	30	7	10	3
76	3	31	3	2	118	20	4	9	4
76	5	25	3	4	101	25	11	3	5
76	6	22	3	5	101	35	3	7	0
76	7	20	3	6	25	4	2	5	15
76	8	26	3	7	93	35	3	6	5
76	9	28	3	8	89	3	2	7	8
76	11	10	3	9	92	25	3	6	4
77	2	8	3	10	-	-	-	-	-
77	5	16	3	11	-	-	-	-	-
77	7	12	3	12	-	-	-	-	-
77	9	20	3	13	-	-	-	-	-
76	2	20	4	1	115	30	7	14	3
76	3	31	4	2	119	20	3	8	5
76	4	27	4	3	111	20	4	7	1
76	5	25	4	4	101	30	8	3	4
76	6	22	4	5	98	30	3	7	0
76	7	20	4	6	96	25	5	2	6
76	8	26	4	7	94	35	3	6	5
76	9	28	4	8	92	3	3	8	10
76	11	10	4	9	94	25	4	6	4
77	2	8	4	10	-	-	-	-	-
79	1	8	1	14	-	-	-	-	-
79	1	22	1	15	-	-	-	-	-
79	2	21	1	16	-	-	-	-	-
79	3	10	1	17	-	-	-	-	-

Appendix 1. Cont'd. Ozette Lake primary production data, 1976 -1979.

Year	Month	Day	Station	Survey	Dis. Oxy	Color	Algal Gro.Pot	Nitrat	Nitrit
79	3	12	1	18	-	-	-	-	-
79	3	15	1	19	-	-	-	-	-
79	3	18	1	20	-	-	-	-	-
79	3	19	1	21	-	-	-	-	-
79	3	21	1	22	-	-	-	-	-
79	4	16	1	23	-	-	-	-	-
79	4	20	1	24	-	-	-	-	-
79	4	25	1	25	-	-	-	-	-
79	5	25	1	26	-	-	-	-	-
79	6	23	1	27	-	-	-	-	-
79	7	25	1	28	-	-	-	-	-
79	8	23	1	29	-	-	-	-	-
79	9	18	1	30	-	-	-	-	-
79	1	9	2	14	-	-	-	-	-
79	2	21	2	16	-	-	-	-	-
79	3	8	2	17	-	-	-	-	-
79	3	12	2	18	-	-	-	-	-
79	3	21	2	22	-	-	-	-	-
79	4	20	2	24	-	-	-	-	-
79	4	25	2	25	-	-	-	-	-
79	5	25	2	26	-	-	-	-	-
79	7	25	2	28	-	-	-	-	-
79	8	23	2	29	-	-	-	-	-
79	9	18	2	30	-	-	-	-	-
79	1	9	3	14	-	-	-	-	-
79	2	21	3	16	-	-	-	-	-
79	3	12	3	18	-	-	-	-	-
79	3	15	3	19	-	-	-	-	-
79	3	18	3	20	-	-	-	-	-
79	3	19	3	21	-	-	-	-	-
79	4	20	3	24	-	-	-	-	-
79	4	25	3	25	-	-	-	-	-
79	5	25	3	26	-	-	-	-	-
79	6	23	3	27	-	-	-	-	-
79	7	25	3	28	-	-	-	-	-
79	8	23	3	29	-	-	-	-	-
79	9	18	3	30	-	-	-	-	-
79	1	9	4	14	-	-	-	-	-
79	2	21	4	16	-	-	-	-	-
79	3	12	4	18	-	-	-	-	-
79	4	2	4	24	-	-	-	-	-
79	4	25	4	25	-	-	-	-	-
79	5	25	4	26	-	-	-	-	-
79	6	23	4	27	-	-	-	-	-
79	7	25	4	28	-	-	-	-	-
79	8	23	4	29	-	-	-	-	-
79	9	18	4	30	-	-	-	-	-

Appendix 1. Cont'd. Ozette Lake primary production data, 1976 -1979.

Year	Month	Day	Sta- tion	Sur- vey	Ammon	Organ. N	Phos.	Orphos.	PH
76	2	19	1	1	5	13	9	4	71
76	4	1	1	2	5	10	6	4	73
76	4	27	1	3	6	10	7	3	71
76	5	27	1	4	15	6	3	69	-
76	6	22	1	5	3	17	10	3	66
76	7	21	1	6	11	7	3	71	-
76	8	26	1	7	15	12	3	59	-
76	9	28	1	8	7	4	-	-	-
76	11	9	1	9	6	2	-	-	-
77	2	8	1	10	-	-	-	-	-
76	2	19	2	1	5	13	9	4	65
76	4	1	2	2	5	11	7	3	68
76	6	22	2	5	3	16	10	0	67
76	7	21	2	6	12	6	2	71	-
76	8	26	2	7	10	8	4	59	-
76	9	28	2	8	6	5	-	-	-
76	11	9	2	9	10	6	3	-	-
77	2	8	2	10	-	-	-	-	-
77	5	16	2	11	-	-	-	-	-
77	7	12	2	12	-	-	-	-	-
77	9	20	2	13	-	-	-	-	-
76	2	19	3	1	5	14	7	3	68
76	3	31	3	2	6	9	7	4	64
76	5	25	3	4	12	7	3	68	-
76	6	22	3	5	4	20	10	0	67
76	7	20	3	6	9	2	72	-	-
76	8	26	3	7	4	14	11	4	59
76	9	28	3	8	5	5	-	-	-
76	11	10	3	9	4	9	6	6	-
77	2	8	3	10	-	-	-	-	-
77	5	16	3	11	-	-	-	-	-
77	7	12	3	12	-	-	-	-	-
77	9	20	3	13	-	-	-	-	-
76	2	20	4	1	5	14	10	3	70
76	3	31	4	2	6	8	5	3	68
76	4	27	4	3	6	10	7	4	71
76	5	25	4	4	23	9	3	67	-
76	6	22	4	5	3	15	10	3	67
76	7	20	4	6	17	5	3	70	-
76	8	26	4	7	4	12	7	3	59
76	9	28	4	8	6	5	-	-	-
76	11	10	4	9	5	12	3	6	-
77	2	8	4	10	-	-	-	-	-
79	1	8	1	14	-	-	-	-	-
79	1	22	1	15	-	-	-	-	-
79	2	21	1	16	-	-	-	-	-
79	3	10	1	17	-	-	-	-	-

Appendix 1. Cont'd. Ozette Lake primary production data, 1976 -1979.

Year	Month	Day	Station	Survey	Ammon	Organ. N	Phos.	Orphos.	PH
79	3	12	1	18	-	-	-	-	-
79	3	15	1	19	-	-	-	-	-
79	3	18	1	20	-	-	-	-	-
79	3	19	1	21	-	-	-	-	-
79	3	21	1	22	-	-	-	-	-
79	4	16	1	23	-	-	-	-	-
79	4	20	1	24	-	-	-	-	-
79	4	25	1	25	-	-	-	-	-
79	5	25	1	26	-	-	-	-	-
79	6	23	1	27	-	-	-	-	-
79	7	25	1	28	-	-	-	-	-
79	8	23	1	29	-	-	-	-	-
79	9	18	1	30	-	-	-	-	-
79	1	9	2	14	-	-	-	-	-
79	2	21	2	16	-	-	-	-	-
79	3	8	2	17	-	-	-	-	-
79	3	12	2	18	-	-	-	-	-
79	3	21	2	22	-	-	-	-	-
79	4	20	2	24	-	-	-	-	-
79	4	25	2	25	-	-	-	-	-
79	5	25	2	26	-	-	-	-	-
79	7	25	2	28	-	-	-	-	-
79	8	23	2	29	-	-	-	-	-
79	9	18	2	30	-	-	-	-	-
79	1	9	3	14	-	-	-	-	-
79	2	21	3	16	-	-	-	-	-
79	3	12	3	18	-	-	-	-	-
79	3	15	3	19	-	-	-	-	-
79	3	18	3	20	-	-	-	-	-
79	3	19	3	21	-	-	-	-	-
79	4	20	3	24	-	-	-	-	-
79	4	25	3	25	-	-	-	-	-
79	5	25	3	26	-	-	-	-	-
79	6	23	3	27	-	-	-	-	-
79	7	25	3	28	-	-	-	-	-
79	8	23	3	29	-	-	-	-	-
79	9	18	3	30	-	-	-	-	-
79	1	9	4	14	-	-	-	-	-
79	2	21	4	16	-	-	-	-	-
79	3	12	4	18	-	-	-	-	-
79	4	2	4	24	-	-	-	-	-
79	4	25	4	25	-	-	-	-	-
79	5	25	4	26	-	-	-	-	-
79	6	23	4	27	-	-	-	-	-
79	7	25	4	28	-	-	-	-	-
79	8	23	4	29	-	-	-	-	-
79	9	18	4	30	-	-	-	-	-

Appendix 2. Ozette Lake zooplankton data, 1976-79

Appendix 2. Ozette Lake zooplankton data, 1976-79.

Year	Month	Day	Stat.	Survey	Corr. Fact.	Agency	Net Diam	Depth	Vol. Samp.	Samp. Vol.
76	2	19	1	1	100	1	300	274	1922	120
76	4	1	1	2	100	1	300	274	1922	120
76	4	27	1	3	100	1	300	274	1922	210
76	5	27	1	4	100	1	300	274	1922	210
76	6	22	1	5	105	1	300	290	2029	210
76	7	21	1	6	100	1	300	274	1922	210
76	8	26	1	7	100	1	300	274	1922	210
76	9	28	1	8	100	1	300	274	1922	210
76	11	9	1	9	100	1	300	274	1922	210
77	2	8	1	10	100	1	300	274	1922	210
76	2	19	2	1	253	1	300	762	5340	120
76	4	1	2	2	254	1	300	762	5340	120
76	6	22	2	5	261	1	300	786	5511	210
76	7	21	2	6	253	1	300	762	5340	210
76	8	26	2	7	258	1	300	777	5447	210
76	9	28	2	8	253	1	300	762	5340	259
76	11	9	2	9	100	1	300	274	1922	210
77	2	8	2	10	253	1	300	762	5340	210
77	5	16	2	11	100	1	300	274	1922	210
77	7	12	2	12	100	1	300	274	1922	210
77	9	20	2	13	100	1	300	274	1922	210
76	2	19	3	1	233	1	300	701	4913	120
76	3	31	3	2	242	1	300	732	5126	120
76	5	25	3	4	233	1	300	701	4913	210
76	6	22	3	5	233	1	300	701	4913	210
76	7	20	3	6	243	1	300	732	5126	210
76	8	26	3	7	238	1	300	716	5020	210
76	9	28	3	8	243	1	300	732	5126	259
76	11	10	3	9	100	1	300	274	1922	210
77	2	8	3	10	231	1	300	579	4058	210
77	5	16	3	11	100	1	300	274	1922	210
77	7	12	3	12	100	1	300	274	1922	210
77	9	20	3	13	100	1	300	274	1922	210
76	2	20	4	1	258	1	300	762	5340	120
76	3	31	4	2	253	1	300	762	5340	120
76	4	27	4	3	252	1	300	762	5340	210
76	5	25	4	4	253	1	300	762	5340	210
76	6	22	4	5	253	1	300	762	5340	210
76	7	20	4	6	243	1	300	732	5126	210
76	8	26	4	7	253	1	300	762	5340	210
76	9	28	4	8	253	1	300	762	5340	210
76	11	10	4	9	100	1	300	274	1922	210
77	2	8	4	10	100	1	300	274	1922	210
79	1	8	1	14	-	-	200	200	628	300
79	1	22	1	15	-	-	254	250	1267	300
79	2	21	1	16	-	-	254	200	1013	300
79	3	10	1	17	46	-	200	210	660	300

Appendix 2. Cont'd. Ozette Lake zooplankton data, 1976-79.

Year	Month	Day	Stat.	Survey	Corr. Fact.	Agency	Net Diam	Depth	Vol. Samp.	Samp. Vol.
79	3	15	1	19	100	2	200	270	848	300
79	3	18	1	20	36	-	200	200	628	300
79	3	19	1	21	100	2	200	200	628	300
79	3	21	1	22	61	-	303	274	1911	300
79	4	16	1	23	100	2	303	250	1803	300
79	4	20	1	24	100	2	303	250	1803	300
79	4	25	1	25	100	2	303	250	1803	300
79	5	25	1	26	-	-	303	250	1803	300
79	6	23	1	27	100	2	303	250	1802	300
79	7	25	1	28	-	-	303	250	1803	300
79	8	23	1	29	-	-	303	200	1442	300
79	9	18	1	30	-	-	303	250	1803	300
79	1	9	2	14	-	-	200	450	1414	300
79	2	21	2	16	100	2	254	250	1267	300
79	3	8	2	17	-	-	254	245	1241	300
79	3	12	2	18	100	2	200	250	785	300
79	3	21	2	22	100	2	303	250	1803	300
79	4	20	2	24	100	2	303	270	1947	300
79	4	25	2	25	840	-	303	270	1947	300
79	5	25	2	26	494	-	303	270	1947	326
79	7	25	2	28	-	-	303	270	1947	300
79	8	23	2	29	-	-	303	270	1947	300
79	9	18	2	30	-	-	303	270	1947	300
79	1	9	3	14	-	-	200	400	1257	300
79	2	21	3	16	340	-	254	250	1267	300
79	3	12	3	18	100	2	200	250	785	300
79	3	15	3	19	144	-	200	270	848	300
79	3	18	3	20	190	-	200	270	848	300
79	3	19	3	21	100	2	200	270	848	300
79	4	20	3	24	100	2	303	270	1947	300
79	4	25	3	25	396	-	303	270	1947	300
79	5	25	3	26	-	-	303	270	1947	300
79	6	23	3	27	100	2	303	270	1947	300
79	7	25	3	28	-	-	303	270	1947	300
79	8	23	3	29	-	-	303	270	1947	300
79	9	18	3	30	-	-	303	270	1947	300
79	1	9	4	14	-	-	200	400	1257	300
79	2	21	4	16	-	-	254	250	1267	300
79	3	12	4	18	182	-	200	250	785	300
79	4	2	4	24	100	2	303	270	1947	300
79	4	25	4	25	660	-	303	270	1947	300
79	5	25	4	26	-	-	303	270	1947	300
79	6	23	4	27	100	2	303	270	1947	300
79	7	25	4	28	-	-	303	270	1947	300
79	8	23	4	29	-	-	303	270	1947	300
79	9	18	4	30	-	-	303	270	1947	300

Appendix 2. Cont'd. Ozette Lake zooplankton data, 1976-79.

Year	Month	Day	Stat.	Survey	Roti-fer	Clado-cera	Daphnia	Bosmina
76	2	19	1	1	5	10	0	10
76	4	1	1	2	0	15	15	0
76	4	27	1	3	0	10	5	5
76	5	27	1	4	10	85	40	45
76	6	22	1	5	55	65	25	40
76	7	21	1	6	405	120	90	30
76	8	26	1	7	280	105	70	35
76	9	28	1	8	530	90	60	30
76	11	9	1	9	175	105	50	55
77	2	8	1	10	20	10	0	10
76	2	19	2	1	0	25	5	20
76	4	1	2	2	0	15	15	0
76	6	22	2	5	140	195	55	140
76	7	21	2	6	480	160	60	100
76	8	26	2	7	235	80	40	40
76	9	28	2	8	495	190	95	95
76	11	9	2	9	95	60	30	30
77	2	8	2	10	5	5	0	5
77	5	16	2	11	60	20	15	5
77	7	12	2	12	375	120	80	40
77	9	20	2	13	100	65	40	25
76	2	19	3	1	0	30	10	20
76	3	31	3	2	5	15	10	5
76	5	25	3	4	75	130	70	60
76	6	22	3	5	45	135	25	110
76	7	20	3	6	370	170	35	135
76	8	26	3	7	140	115	35	80
76	9	28	3	8	225	150	75	75
76	11	10	3	9	160	65	50	15
77	2	8	3	10	0	5	0	5
77	5	16	3	11	55	10	10	0
77	7	12	3	12	460	55	25	30
77	9	20	3	13	150	110	95	15
76	2	20	4	1	5	50	10	40
76	3	31	4	2	0	25	15	10
76	4	27	4	3	5	10	10	0
76	5	25	4	4	25	120	70	50
76	6	22	4	5	75	305	65	240
76	7	20	4	6	285	225	40	185
76	8	26	4	7	315	140	55	85
76	9	28	4	8	485	180	90	90
76	11	10	4	9	100	65	55	10
77	2	8	4	10	0	5	5	0
79	1	8	1	14	1	4	10	0
79	1	22	1	15	7	0	21	0
79	2	21	1	16	23	14	50	27
79	3	10	1	17	2	2	2	0

Appendix 2. Cont'd. Ozette Lake zooplankton data, 1976-79.

Year	Month	Day	Stat.	Survey	Roti-fer	Clado-cera	Daphnia	Bosmina
79	3	15	1	19	0	1	1	0
79	3	18	1	20	0	1	5	5
79	3	19	1	21	1	4	4	0
79	3	21	1	22	1	8	9	9
79	4	16	1	23	2	50	25	25
79	4	20	1	24	2	16	16	0
79	4	25	1	25	6	36	27	9
79	5	25	1	26	5	48	87	131
79	6	23	1	27	155	173	18	155
79	7	25	1	28	154	45	246	0
79	8	23	1	29	215	81	281	0
79	9	18	1	30	25	4	20	0
79	1	9	2	14	9	5	96	0
79	2	21	2	16	6	2	2	0
79	3	8	2	17	4	2	16	0
79	3	12	2	18	1	5	3	2
79	3	21	2	22	0	5	3	2
79	4	20	2	24	4	35	28	7
79	4	25	2	25	6	44	495	371
79	5	25	2	26	32	58	35	23
79	7	25	2	28	118	39	159	0
79	8	23	2	29	276	94	452	0
79	9	18	2	30	163	70	295	0
79	1	9	3	14	2	1	40	0
79	2	21	3	16	4	5	115	115
79	3	12	3	18	1	3	3	0
79	3	15	3	19	0	2	43	43
79	3	18	3	20	1	3	45	45
79	3	19	3	21	1	12	7	5
79	4	20	3	24	3	30	18	12
79	4	25	3	25	0	37	220	165
79	5	25	3	26	21	54	217	0
79	6	23	3	27	121	80	8	72
79	7	25	3	28	230	106	378	0
79	8	23	3	29	225	185	733	0
79	9	18	3	30	151	104	351	0
79	1	9	4	14	2	4	44	0
79	2	21	4	16	4	2	31	0
79	3	12	4	18	1	3	39	39
79	4	2	4	24	6	36	18	18
79	4	25	4	25	0	47	382	286
79	5	25	4	26	19	43	195	195
79	6	23	4	27	324	152	15	137
79	7	25	4	28	134	106	164	0
79	8	23	4	29	256	113	382	0
79	9	18	4	30	296	109	272	0

Appendix 2. Cont'd. Ozette Lake zooplankton data, 1976-79.

Year	Month	Day	Stat.	Survey	Cal. Cop.	Diap-tomus	Epish.	Cycl. Cop.	Zoop/ Liter
76	2	19	1	1	20	10	10	750	-
76	4	1	1	2	45	45	0	460	-
76	4	27	1	3	10	5	5	215	-
76	5	27	1	4	305	190	115	545	-
76	6	22	1	5	140	85	55	125	-
76	7	21	1	6	420	275	145	230	-
76	8	26	1	7	155	140	15	210	-
76	9	28	1	8	145	100	45	270	-
76	11	9	1	9	15	10	5	460	-
77	2	8	1	10	35	0	35	37	-
76	2	19	2	1	90	80	10	745	-
76	4	1	2	2	35	30	5	535	-
76	6	22	2	5	300	235	65	325	-
76	7	21	2	6	385	285	100	265	-
76	8	26	2	7	195	150	45	190	-
76	9	28	2	8	235	200	35	220	-
76	11	9	2	9	105	105	0	480	-
77	2	8	2	10	65	60	5	145	-
77	5	16	2	11	270	125	145	485	-
77	7	12	2	12	235	225	10	315	-
77	9	20	2	13	180	135	45	440	-
76	2	19	3	1	60	55	5	650	-
76	3	31	3	2	25	25	0	660	-
76	5	25	3	4	385	310	75	455	-
76	6	22	3	5	345	270	75	350	-
76	7	20	3	6	405	265	140	205	-
76	8	26	3	7	230	190	40	225	-
76	9	28	3	8	65	55	10	215	-
76	11	10	3	9	65	55	10	415	-
77	2	8	3	10	140	135	5	245	-
77	5	16	3	11	435	345	90	360	-
77	7	12	3	12	220	215	5	285	-
77	9	20	3	13	150	125	25	440	-
76	2	20	4	1	70	65	5	1115	-
76	3	31	4	2	40	35	5	720	-
76	4	27	4	3	5	5	0	735	-
76	5	25	4	4	265	195	70	580	-
76	6	22	4	5	230	180	50	285	-
76	7	20	4	6	150	110	40	200	-
76	8	26	4	7	160	135	25	310	-
76	9	28	4	8	175	165	10	275	-
76	11	10	4	9	70	65	5	335	-
77	2	8	4	10	100	100	0	255	-
79	1	8	1	14	100	2	74	-	-
79	1	22	1	15	100	2	40	-	-
79	2	21	1	16	100	2	307	-	-
79	3	10	1	17	6	0	100	2	-

Appendix 2. Cont'd. Ozette Lake zooplankton data, 1976-79.

Year	Month	Day	Stat.	Survey	Cal. Cop.	Diaptomus	Epish.	Cycl. Cop.	Zoop/ Liter
79	3	15	1	19	21	21	0	0	-
79	3	18	1	20	0	2	100	2	-
79	3	19	1	21	55	55	0	6	-
79	3	21	1	22	0	21	100	2	-
79	4	16	1	23	550	385	165	0	80
79	4	20	1	24	209	209	0	11	314
79	4	25	1	25	600	450	150	0	1068
79	5	25	1	26	100	2	447	-	-
79	6	23	1	27	398	40	358	99	1373
79	7	25	1	28	100	2	741	-	-
79	8	23	1	29	100	2	1200	-	-
79	9	18	1	30	100	2	495	-	-
79	1	9	2	14	100	2	231	-	-
79	2	21	2	16	18	18	0	3	67
79	3	8	2	17	100	2	49	-	-
79	3	12	2	18	72	72	0	8	329
79	3	21	2	22	279	167	112	0	471
79	4	20	2	24	453	272	181	0	758
79	4	25	2	25	124	0	100	2	-
79	5	25	2	26	144	62	100	2	-
79	7	25	2	28	100	2	487	-	-
79	8	23	2	29	100	2	1265	-	-
79	9	18	2	30	100	2	804	-	-
79	1	9	3	14	100	2	105	-	-
79	2	21	3	16	0	20	100	2	-
79	3	12	3	18	36	36	0	4	169
79	3	15	3	19	0	4	100	2	-
79	3	18	3	20	0	5	100	2	-
79	3	19	3	21	197	197	0	22	817
79	4	20	3	24	316	190	126	0	537
79	4	25	3	25	55	0	100	2	-
79	5	25	3	26	100	2	480	-	-
79	6	23	3	27	279	28	251	70	848
79	7	25	3	28	100	2	1100	-	-
79	8	23	3	29	100	2	1762	-	-
79	9	18	3	30	100	2	935	-	-
79	1	9	4	14	100	2	137	-	-
79	2	21	4	16	100	2	85	-	-
79	3	12	4	18	0	4	100	2	-
79	4	2	4	24	777	660	117	0	1260
79	4	25	4	25	96	0	100	2	-
79	5	25	4	26	100	2	697	-	-
79	6	23	4	27	633	63	570	158	1954
79	7	25	4	28	100	2	623	-	-
79	8	23	4	29	100	2	1157	-	-
79	9	18	4	30	100	2	1048	-	-

Appendix 3. Sockeye salmon smolt enumeration data in the Ozette River, WA, 1982 and 1984

Appendix 3. Sockeye salmon smolt enumeration data in the Ozette River, 1982.

Month	Date	Time	No.	Length (mm)
May	11	2115	1	12.0
May	11	2115	1	11.8
May	11	2115	1	13.1
May	11	2245	1	13.3
May	11	30	1	12.6
May	12	443	1	12.8
May	12	443	1	14.1
May	12	446	1	11.9
May	12	443	1	12.8
May	12	2110	1	12.2
May	12	2110	1	11.3
May	12	25	1	12.3
May	12	25	1	11.1
May	12	25	1	12.0
May	13	45	1	12.6
May	13	45	1	14.1
May	13	45	1	12.6
May	13	45	1	10.7
May	13	45	1	12.8
May	13	45	1	12.4
May	13	45	1	12.6
May	13	45	1	11.7
May	14	415	1	11.9
May	14	2315	1	11.8
May	14	2315	1	13.1
May	14	915	1	13.8
May	14	915	1	11.5
May	14	915	1	13.2
May	14	915	1	13.7
May	14	915	1	11.5
May	14	915	1	7.2
May	15	215	1	12.0
May	15	215	1	14.2
May	15	215	1	11.3
May	15	215	1	11.7
May	15	215	1	13.0
May	15	215	1	14.1
May	16	515	1	11.9
May	16	515	1	12.1
May	16	215	1	12.0
May	16	515	1	11.8
May	16	215	1	14.5
May	17	2245	1	11.5
May	17	2245	1	11.5
May	17	2245	1	12.5
May	18	2345	1	15.6
May	18	230	1	10.6
May	19	2345	1	11.5
May	19	2345	1	12.3
May	19	2345	1	13.4
May	19	2345	1	11.0
May	19	2345	1	11.4
May	19	2345	1	10.8
May	19	2345	1	4.1
May	20	2345	1	11.4
May	20	245	1	13.1
May	20	245	1	12.3
May	20	245	1	11.7
May	21	545	1	11.7
May	21	2345	1	11.6
May	21	2345	1	11.2
May	21	2345	1	10.2
May	21	2345	1	13.5
May	21	545	1	11.7
May	21	545	1	10.6
May	22	2115	1	11.4
May	23	545	1	14.5
May	24	145	1	13.0
May	25	1615	1	14.6
May	25	1615	1	12.7
May	25	2345	1	13.2
May	25	2345	1	12.4
May	25	2345	1	11.8
May	25	2345	1	6.6
May	25	215	1	12.0
May	25	215	1	13.2
May	26	500	1	12.2
May	26	500	1	12.0
May	26	2115	1	11.7
May	26	2115	1	12.3
May	26	2344	1	11.4
May	27	245	1	10.1
May	28	245	1	11.0
May	29	245	1	10.0
May	30	545	1	10.2
June	1	430	1	11.5
June	1	1	1	6.2
June	2	415	1	6.5
June	2	415	1	8.5
June	3	-	-	-
June	4	-	-	-
June	5	-	-	-
June	6	-	-	-
June	7	-	-	-

Appendix 3. Sockeye salmon smolt enumeration data in the Ozette River, 1984.

Month	Date	Time	No.	Length (mm)
April	10	-	1	-
April	11	2225	1	15.9
April	11	2225	1	11.9
April	11	2225	1	12.3
April	11	2225	1	12.3
April	12	27	1	12.2
April	12	27	1	11.8
April	12	27	1	11.7
April	12	27	1	11.7
April	12	27	1	12.2
April	12	27	1	12.6
April	12	27	1	12.1
April	12	27	1	13.6
April	12	215	1	11.2
April	12	215	1	11.6
April	12	430	1	12
April	12	430	1	12.2
April	12	430	1	11.5
April	12	635	1	11.6
April	12	2210	1	12.9
April	13	10	1	10.8
April	13	210	1	11.6
April	13	210	1	12.5
April	13	415	1	8.1
April	13	415	1	10.5
April	13	415	1	9.6
April	13	415	1	9.1
April	13	415	1	10.5
April	13	415	1	8.6
April	13	615	1	12.3
April	14	-	-	-
April	15	-	-	-
April	16	2230	1	13.4
April	17	219	1	13.2
April	17	219	1	12
April	17	417	1	11.3
April	17	417	1	12.7
April	17	417	1	13
April	17	417	1	11.6
April	17	417	1	11.5
April	17	417	1	12
April	17	417	1	12
April	17	417	1	-
April	17	608	1	12.2
April	17	2205	1	11.8
April	17	2205	1	12.5
April	18	600	1	11.9

Month	Date	Time	No.	Length (mm)
April	18	600	1	12.2
April	18	600	1	13
April	18	600	1	12.3
April	18	600	1	11.7
April	18	600	1	12.5
April	18	600	1	10.4
April	18	600	1	12.7
April	18	600	2	-
April	18	22	1	12.3
April	18	22	1	10.5
April	18	22	1	12.8
April	18	22	1	11.6
April	18	22	1	12.5
April	18	22	1	12.8
April	18	22	1	13
April	18	22	1	10.9
April	18	22	2	-
April	18	400	1	12.9
April	18	400	1	13.4
April	18	400	1	12.6
April	18	400	1	13
April	18	400	1	13.6
April	18	400	1	11.8
April	18	400	1	10.7
April	18	400	1	11.5
April	18	400	1	12.4
April	18	400	1	11.6
April	18	400	1	-
April	18	600	1	11.4
April	18	600	1	12.2
April	18	600	1	12
April	18	600	1	11.6
April	18	600	1	12.7
April	18	600	1	12
April	18	600	1	12.4
April	18	600	1	16.2
April	18	600	1	15.7
April	18	600	1	-
April	18	2200	1	12.6
April	18	2200	1	12.1
April	18	2200	1	12.9
April	18	2200	1	12.2
April	19	10	1	12.9
April	19	10	1	12.3
April	19	10	1	12.4
April	19	10	1	12.8
April	19	10	1	10.3

Appendix 3. Cont'd. Sockeye salmon smolt enumeration data in the Ozette River, 1984.

Month	Date	Time	No.	Length (mm)
April	19	230	1	12.4
April	19	230	1	13.6
April	19	230	1	12.3
April	19	230	1	11.7
April	19	230	1	12.1
April	19	230	1	12.3
April	19	230	1	11.9
April	19	230	1	11.8
April	19	230	1	11.1
April	19	230	1	11.3
April	19	230	1	11.6
April	19	230	1	11.8
April	19	230	1	11.7
April	19	230	1	11.1
April	19	230	1	13.1
April	19	230	1	12.2
April	19	430	1	11.1
April	19	430	1	11
April	19	430	1	12.5
April	19	430	1	13.1
April	19	430	1	12.6
April	19	615	1	11.7
April	19	2214	1	12.5
April	19	2214	1	11.2
April	19	2214	1	13
April	19	2214	1	12.7
April	19	2214	1	12.6
April	19	2214	1	12.3
April	19	2214	1	12.9
April	19	2214	1	13.4
April	20	15	1	12.4
April	20	15	1	12.5
April	20	15	1	11.6
April	20	15	1	10.9
April	20	210	1	10.6
April	20	210	1	11.2
April	20	210	1	12.9
April	20	210	1	11.7
April	20	210	1	12.8
April	20	210	1	13.8
April	20	210	1	-
April	20	355	1	11.6
April	20	355	1	12.3
April	20	355	1	12.2
April	20	355	1	12
April	20	355	1	11.4

Month	Date	Time	No.	Length (mm)
April	21	-	-	-
April	22	2210	1	11.4
April	22	2210	1	13
April	23	10	1	10.8
April	23	10	1	11.2
April	23	10	1	14
April	23	210	1	12.4
April	23	410	1	12.1
April	23	410	1	11.5
April	23	410	1	11.5
April	23	2200	1	13
April	23	2200	1	14.5
April	23	2200	1	11.9
April	23	2200	1	12.3
April	23	2200	1	11.7
April	23	2200	1	11.8
April	23	2200	1	12.3
April	23	2200	1	12.3
April	23	2200	1	12.2
April	23	2200	1	12.4
April	23	2200	1	12.4
April	23	2200	1	-
April	24	1	1	12.5
April	24	1	1	15
April	24	1	1	12.4
April	24	1	1	12.1
April	24	1	1	12.8
April	24	1	1	12
April	24	1	1	-
April	24	200	1	12.5
April	24	200	1	12.5
April	24	200	1	12.8
April	24	200	1	12
April	24	200	1	12
April	24	400	1	11.9
April	24	1	1	11.2
April	24	400	1	12
April	24	400	1	12.6
April	24	400	1	12.1
April	24	400	1	12
April	24	400	1	11.9
April	24	400	1	12.2
April	24	400	1	12.8
April	24	400	1	-
April	24	600	1	10.8
April	24	600	1	11.6

Appendix 3. Cont'd. Sockeye salmon smolt enumeration data in the Ozette River, 1984.

Month	Date	Time	No.	Length (mm)	Month	Date	Time	No.	Length (mm)
April	20	605	1	12.9	April	24	600	1	12.0
April	24	600	1	12.5	April	27	420	1	12.1
April	24	600	1	12.6	April	27	420	1	11.9
April	24	600	1	-	April	27	420	1	12.7
April	24	2226	1	11.7	April	27	420	1	12.4
April	24	2226	1	10.8	April	27	420	1	12.2
April	24	2226	1	12	April	27	420	1	13.8
April	25	9	1	11.4	April	27	420	1	13.3
April	25	214	1	12	April	27	420	1	-
April	25	214	1	10.4	April	27	555	1	11.2
April	25	214	1	11.6	April	27	555	1	12.2
April	25	409	1	11.5	April	27	555	1	11.3
April	25	409	1	12.9	April	27	555	1	12.8
April	26	615	1	12.3	April	28	346	1	12.8
April	25	2215	1	11.2	April	28	346	1	12.5
April	25	2215	1	12.3	April	28	346	1	12.2
April	25	2215	1	12.2	April	28	346	1	12.5
April	25	2215	1	12	April	28	346	1	12.4
April	25	2215	1	12.5	April	28	346	1	12.8
April	26	15	1	12.6	April	28	346	1	12.9
April	26	15	1	12.3	April	28	346	1	10
April	26	220	1	12.1	April	28	614	1	12.5
April	26	220	1	13.6	April	28	614	1	14
April	26	220	1	11.8	April	28	614	1	12.5
April	26	220	1	-	April	28	614	1	-
April	26	410	1	12.5	April	28	2030	1	11.2
April	26	110	1.	12.4	April	28	2251	1	12
April	26	610	1	12.2	April	28	2251	1	13
April	26	610	1	12	April	29	55	1	12
April	26	610	1	13.7	April	29	55	1	12
April	26	2220	1	12.6	April	29	55	1	12
April	26	2220	1	12.3	April	29	55	1	11
April	26	2220	1	11.5	April	29	55	1	12.2
April	26	2220	1	12	April	29	55	1	13.2
April	26	2220	1	13.8	April	29	55	1	11
April	26	2220	1	12.2	April	29	55	1	12
April	26	2220	1	11.2	April	29	55	1	12
April	26	2220	1	11.8	April	29	55	1	12
April	26	2220	1	12	April	29	55	1	12
April	26	2220	1	11.8	April	29	55	1	11
April	26	2220	1	13.9	April	29	55	1	11.1
April	26	2220	3	-	April	29	55	1	12
April	27	10	1	14.5	April	29	55	1	11
April	27	210	1	13.3	April	29	55	1	12
April	27	210	1	12.2	April	29	55	1	11.8
April	27	210	1	11.5	April	29	55	1	10.8

Appendix 3. Cont'd. Sockeye salmon smolt enumeration data in the Ozette River, 1984.

Month	Date	Time	No.	Length (mm)
April	27	210	1	12.2
April	27	420	1	12.5
April	29	255	1	11.5
April	29	225	1	11
April	29	255	1	11.5
April	29	255	1	12
April	29	255	1	13
April	29	255	1	12.2
April	29	255	1	12.5
April	29	255	1	12
April	29	255	1	12
April	29	255	1	12.5
April	29	255	1	12.8
April	29	255	1	12.5
April	29	255	1	11
April	29	255	1	12.5
April	29	255	1	11.5
April	29	255	1	13.5
April	29	255	3	-
April	29	705	1	12.5
April	29	705	1	11.5
April	29	705	1	10.5
April	29	705	1	11.8
April	29	705	1	13
April	29	705	1	12.5
April	29	705	1	11
April	29	705	1	12.5
April	29	705	1	12.5
April	29	705	1	11
April	29	705	1	-
April	30	2345	1	12.4
April	30	2345	1	12
April	30	2345	1	12.2
April	30	2345	1	13
April	30	2345	1	12.7
April	30	2345	1	13
April	30	2345	1	12.5
April	30	2345	1	11.4
April	30	2345	1	12
April	30	2345	1	13
April	30	2345	1	12.4
April	30	2345	1	12.5
April	30	2345	4	-
May	1	235	1	12.6
May	1	235	1	11.3
May	1	235	1	13
April	29	55	1	13.5
April	29	55	3	-
May	1	600	1	12.8
May	1	600	1	13
May	1	600	1	12.5
May	1	600	1	12.7
May	1	600	1	11.7
May	1	600	13	10.5
May	1	600	2	-
May	1	2315	1	12.4
May	1	2315	1	12.2
May	1	2315	1	12.3
May	1	2315	1	13
May	1	2315	1	13
May	1	2315	1	12.9
May	1	2315	1	11.7
May	1	2315	1	12.2
May	1	2315	1	12.3
May	1	2315	1	-
May	2	130	1	12.4
May	2	130	1	12.3
May	2	130	1	11.8
May	2	130	1	12.4
May	2	130	1	13
May	2	130	1	13
May	2	130	1	12.2
May	2	130	1	12.3
May	2	130	1	-
May	2	530	1	12.1
May	2	530	1	12.3
May	2	530	1	13
May	2	530	1	12.6
May	2	715	1	12.1
May	2	715	1	11.8
May	2	2330	1	11.9
May	2	2330	1	8.4
May	2	2330	1	12.6
May	2	2330	1	11.5
May	2	2330	1	13.6
May	2	2330	1	12.5
May	2	2330	1	11
May	2	2330	1	11.9
May	2	2330	1	12.3
May	2	2330	1	10.5
May	2	2330	1	12.2
May	2	2330	1	12.5

Appendix 3. Cont'd. Sockeye salmon smolt enumeration data in the Ozette River, 1984.

Month	Date	Time	No.	Length (mm)
May	1	600	1	11.5
May	1	600	1	12
May	3	300	1	13
May	3	300	1	10.9
May	3	300	1	12.8
May	3	300	1	12.4
May	3	500	1	11
May	3	500	1	11.9
May	3	500	1	11.4
May	3	500	1	12.5
May	3	2310	1	11.5
May	3	2310	1	11.8
May	3	2310	1	12
May	3	2310	1	12.1
May	3	2310	1	12.1
May	3	2310	1	12.5
May	3	2310	1	9.8
May	3	2310	1	12.1
May	3	2310	1	12.5
May	3	2310	1	12.2
May	3	2310	1	-
May	4	105	1	11.9
May	4	105	1	11.5
May	4	105	1	10.5
May	4	315	1	12.7
May	4	315	1	11.2
May	4	530	1	12.5
May	4	530	1	12.3
May	4	530	1	11.9
May	4	2330	1	11.6
May	4	2330	1	12.2
May	4	2330	1	11.4
May	4	2330	1	13.1
May	4	2330	1	11.3
May	4	2330	1	11.5
May	4	2330	1	12.4
May	4	2330	1	11.7
May	4	2330	1	11
May	4	2330	1	11.9
May	4	2330	1	12.1
May	4	2330	1	-
May	5	100	1	11.8
May	5	100	1	11.7
May	5	100	1	11.9
May	5	100	1	10.1
May	5	100	1	12.3

Month	Date	Time	No.	Length (mm)
May	3	100	1	13.6
May	3	100	1	11.4
May	5	100	1	13.5
May	5	100	1	12
May	5	100	1	-
May	6	300	1	12.3
May	6	300	1	12.4
May	6	300	1	13.8
May	6	300	1	11.5
May	6	300	1	12.1
May	7	2045	1	13
May	7	2045	1	12
May	7	2045	1	12.5
May	8	130	1	15.5
May	8	130	1	12
May	8	130	1	12
May	8	130	1	13
May	8	130	1	12
May	8	430	1	11
May	8	2212	1	10.6
May	8	2212	1	10.4
May	8	2212	1	11.3
May	8	2212	1	12.8
May	8	2212	1	12.4
May	8	2212	1	11.6
May	8	2212	1	12.3
May	8	2212	1	11.2
May	8	2212	1	10.9
May	8	2212	1	10.8
May	8	2212	1	10.6
May	8	2212	1	13.5
May	8	2212	1	11.8
May	8	2212	1	-
May	9	8	1	8.8
May	9	8	1	10.4
May	9	8	1	12.2
May	9	245	1	11.2
May	9	245	1	12.7
May	9	245	1	10.6
May	9	600	1	12.8
May	9	600	1	12.4
May	9	600	1	12
May	9	600	1	11.2
May	9	2230	1	14.1
May	9	2230	1	12.6
May	9	2230	1	12.4

Appendix 3. Cont'd. Sockeye salmon smolt enumeration data in the Ozette River, 1984.

Month	Date	Time	No.	Length (mm)
May	5	100	1	10.9
May	5	100	1	12.5
May	5	100	1	12.2
May	10	30	1	12.4
May	10	30	1	12.4
May	10	2230	1	12.2
May	10	2230	1	12.8
May	10	2230	1	11.3
May	10	2230	1	12.9
May	10	2230	1	11.4
May	10	2230	1	13.2
May	10	2230	1	-
May	11	30	1	12.6
May	11	30	1	11.9
May	11	30	1	12.3
May	11	30	1	12.4
May	11	30	1	13
May	11	30	1	10.9
May	10	30	1	11.9
May	10	30	1	12.9
May	10	30	1	12.6
May	11	30	1	11.3
May	11	30	1	-
May	11	230	1	11.3
May	11	230	1	12.4
May	11	530	1	12.4
May	11	530	1	11.8
May	11	2230	1	12.6
May	11	2230	1	11.2
May	12	530	1	11.6
May	13	-	-	-
May	14	5	1	10
May	14	245	1	13
May	14	245	1	11.4
May	14	521	1	12.6
May	14	521	1	11.5

Appendix 4. Adult sockeye salmon enumeration in the Ozette River, WA, 1982 and 1984

Appendix 4. Adult sockeye salmon enumeration in the Ozette River, WA, 1982.

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
May	21	-	-	-	-
May	22	-	-	-	-
May	23	-	-	-	-
May	24	430	4	-	-
May	25	215	1	-	-
May	25	445	1	-	-
May	26	-	-	-	-
May	27	2330	1	-	-
May	27	230	1	-	-
May	27	530	1	-	-
May	28	2330	1	-	-
May	28	230	1	-	-
May	29	230	2	-	-
May	30	-	-	-	-
May	31	-	-	-	-
June	1	-	-	-	-
June	2	-	-	-	-
June	3	-	-	-	-
June	4	-	-	-	-
June	5	230	1	-	-
June	6	-	-	-	-
June	7	-	-	-	-
June	8	30	1	-	-
June	8	200	4	-	-
June	8	410	2	-	-
June	8	600	4	-	-
June	9	2100	1	53	1.9
June	9	2100	1	51	1.3
June	9	2100	1	57	2.6
June	9	2100	1	52	1.6
June	9	2100	1	50	1.6
June	9	2100	1	52	1.7
June	9	2300	1	52	2.0
June	9	2300	1	53	2.0
June	9	2300	1	52	1.8
June	9	2300	1	51	1.7
June	9	2300	1	51	1.6
June	9	2300	1	50	2.0
June	9	2300	1	52	1.8
June	9	2300	1	51	1.7
June	9	2300	1	51	1.6
June	9	2300	1	50	2.0
June	9	2300	1	51	1.8
June	9	2300	1	51	1.7
June	9	2300	1	52	2.0
June	9	2300	1	49	1.4
June	9	200	1	49	1.5
June	9	200	1	50	1.7
June	9	200	1	49	1.8
June	9	200	1	48	1.3
June	9	200	1	52	1.4
June	9	500	1	58	2.9
June	9	500	1	49	1.5
June	9	500	1	59	2.8
June	9	500	1	49	1.6
June	9	500	1	54	2.1
June	9	500	1	57	2.6
June	10	900	1	47	-
June	10	900	1	48	-
June	10	900	1	49	-
June	10	1400	2	-	-
June	10	2000	19	-	-
June	10	2100	1	51	1.8
June	10	2100	1	56	2.4
June	10	2100	1	51	1.5
June	10	2100	1	51	1.6
June	10	2330	1	51	1.7
June	10	2330	1	51	1.7
June	10	2330	1	50	1.6
June	10	2330	1	49	1.4
June	10	2330	1	52	1.9
June	10	200	1	53	2.0
June	10	200	1	51	1.7
June	10	200	1	52	2.0
June	10	200	1	52	2.4
June	10	200	1	50	1.6
June	10	200	1	52	1.8
June	10	200	1	49	1.6
June	10	200	1	60	2.8
June	10	200	1	48	1.4
June	10	200	1	52	1.7
June	10	500	1	51	2.0
June	10	500	1	49	1.6
June	10	500	1	54	2.3
June	10	500	1	53	1.9
June	10	500	1	53	1.8
June	10	500	1	55	2.3
June	11	930	1	-	-
June	11	1530	1	57	2.4
June	11	1530	1	52	1.7
June	11	1530	1	55	2.4
June	11	1530	1	54	2.6

Appendix 4. Cont'd. Adult sockeye salmon enumeration in the Ozette River, WA, 1982.

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
June	9	2300	1	54	2.1
June	9	2300	1	54	2.0
June	9	2300	1	47	1.0
June	9	200	1	55	2.5
June	11	2300	1	53	2.0
June	11	2300	1	51	1.8
June	11	200	1	53	2.0
June	11	200	1	49	1.5
June	11	200	1	50	1.6
June	11	200	1	53	1.9
June	11	200	1	52	1.9
June	11	500	1	57	2.5
June	11	500	1	50	1.6
June	11	500	1	53	1.9
June	11	500	1	53	2.0
June	12	1000	3	-	-
June	12	2100	1	51	1.7
June	12	2100	1	50	1.5
June	12	2100	1	41	0.9
June	12	2300	1	53	1.9
June	12	2300	1	55	1.8
June	12	2300	1	48	1.1
June	12	2300	1	49	1.6
June	12	2300	1	-	-
June	12	200	1	53	1.9
June	12	200	1	52	1.7
June	12	200	2	-	-
June	12	500	1	53	1.8
June	12	500	1	50	1.6
June	12	500	1	52	1.9
June	12	500	1	57	2.5
June	12	500	1	54	2.3
June	12	500	1	50	1.7
June	12	500	1	49	0.9
June	13	1100	1	-	-
June	13	1500	1	53	1.7
June	13	1500	1	54	1.9
June	13	1500	1	52	2.0
June	13	1500	1	48	1.2
June	13	1500	1	50	1.5
June	13	1500	9	-	-
June	13	2100	1	51	1.8
June	13	2100	1	56	2.5
June	13	2100	1	53	1.8
June	13	2100	1	52	1.8
June	13	2100	1	56	2.6

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
June	11	2300	1	56	2.2
June	11	2300	1	54	2.0
June	11	2300	1	53	2.0
June	11	2300	1	43	1.0
June	13	200	1	54	2.0
June	13	200	1	53	2.0
June	13	200	1	54	2.4
June	13	200	1	52	1.7
June	13	200	3	-	-
June	13	500	1	53	1.9
June	13	500	1	50	1.7
June	13	500	1	50	1.6
June	13	500	1	51	1.7
June	13	500	1	51	1.9
June	14	1900	1	52	2.0
June	14	1900	1	56	2.4
June	14	1900	1	56	2.4
June	14	1900	1	55	2.2
June	14	1900	1	52	1.7
June	14	1900	1	38	2.8
June	14	1900	1	55	2.5
June	14	1900	1	54	2.1
June	14	1900	1	48	1.6
June	14	1900	1	52	2.0
June	14	1900	15	-	-
June	14	1500	1	-	-
June	14	2100	1	-	-
June	14	2200	5	-	-
June	14	2230	6	-	-
June	14	2330	10	-	-
June	14	30	8	-	-
June	14	200	1	51	1.7
June	14	200	1	51	1.8
June	14	200	1	55	2.4
June	14	200	1	50	1.7
June	14	200	1	52	1.8
June	14	200	12	-	-
June	14	400	1	56	2.2
June	14	400	1	55	2.4
June	14	400	1	51	1.8
June	14	400	1	51	1.7
June	14	400	1	57	2.7
June	14	400	14	-	-
June	15	1200	1	59	2.9
June	15	1500	2	-	-
June	15	1700	1	54	2.0

Appendix 4. Cont'd. Adult sockeye salmon enumeration in the Ozette River, WA, 1982.

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
June	13	2100	1	40	0.8
June	13	2100	1	55	2.4
June	13	2300	1	51	1.6
June	13	2300	1	50	1.7
June	13	2300	1	49	1.4
June	13	2300	1	47	1.3
June	13	2300	1	53	1.8
June	13	200	1	51	1.7
June	15	2200	1	59	3.0
June	15	2200	1	51	1.7
June	15	2200	1	42	0.9
June	15	2200	1	55	2.2
June	15	2200	1	52	1.5
June	15	1	20	-	-
June	15	200	9	-	-
June	15	400	10	-	-
June	15	530	11	-	-
June	15	730	2	-	-
June	16	1200	2	-	-
June	16	1400	3	-	-
June	16	1530	1	-	-
June	16	1	1	50	1.6
June	16	1	1	53	2.0
June	16	1	1	56	2.0
June	16	1	1	52	1.9
June	16	1	1	50	1.8
June	16	1	1	53	1.8
June	16	1	1	52	2.0
June	16	1	1	49	1.6
June	16	1	1	51	1.6
June	16	1	1	55	1.8
June	16	1	31	-	-
June	16	200	7	-	-
June	16	400	1	48	1.6
June	16	400	1	54	2.0
June	16	400	1	57	2.4
June	16	400	1	58	2.3
June	16	400	1	48	1.5
June	16	400	1	52	1.8
June	16	400	1	47	1.6
June	16	400	1	54	2.1
June	16	400	1	51	1.9
June	16	400	1	49	1.7
June	16	600	3	-	-
June	17	800	6	-	-
June	17	1800	8	-	-
June	15	1830	1	50	1.6
June	15	1830	1	54	2.2
June	15	1830	1	51	1.9
June	15	1830	1	50	1.7
June	15	1930	1	48	1.4
June	15	2030	1	64	3.5
June	15	2200	1	54	2.4
June	15	2200	1	48	1.4
June	17	400	1	49	1.5
June	17	400	1	49	1.5
June	17	400	1	51	1.7
June	17	400	1	57	2.1
June	17	400	1	51	1.7
June	17	400	1	51	1.8
June	17	400	1	53	2.0
June	17	400	1	49	1.6
June	17	400	1	58	2.6
June	17	400	1	53	2.2
June	17	400	8	-	-
June	17	600	1	-	-
June	18	1000	1	-	-
June	18	2000	1	50	1.7
June	18	2000	1	49	1.4
June	18	2000	1	51	1.5
June	18	1	1	53	2.0
June	18	1	1	51	1.7
June	18	1	1	56	2.2
June	18	1	1	41	0.8
June	18	1	1	56	2.1
June	18	1	1	53	1.8
June	18	1	1	51	1.7
June	18	1	15	-	-
June	18	200	3	-	-
June	18	400	1	55	2.4
June	18	400	1	56	2.4
June	18	400	1	54	2.2
June	18	400	1	49	1.4
June	18	400	1	51	1.6
June	18	400	1	54	2.0
June	18	400	1	52	1.8
June	18	400	1	53	1.7
June	18	400	1	48	1.6
June	19	700	1	52	1.6
June	19	1100	1	-	-
June	19	1	1	51	1.6
June	19	1	1	56	2.2

Appendix 4. Cont'd. Adult sockeye salmon enumeration in the Ozette River, WA, 1982.

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
June	17	2000	1	56	2.6
June	17	2000	1	51	1.7
June	17	2000	1	-	-
June	17	2200	1	56	2.3
June	17	2200	1	57	2.5
June	17	1	1	58	2.6
June	17	1	1	53	2.1
June	17	1	1	58	2.7
June	17	1	1	57	2.6
June	17	1	1	57	2.6
June	17	1	19	-	-
June	17	200	11	-	-
June	19	400	1	49	1.4
June	19	400	1	54	1.9
June	20	1230	2	-	-
June	20	1530	4	-	-
June	20	1800	4	-	-
June	20	1	2	-	-
June	20	200	1	50	2.1
June	20	200	1	52	1.9
June	20	200	1	53	2.0
June	20	200	1	53	2.3
June	2	200	1	51	1.9
June	20	200	1	55	2.1
June	20	200	1	52	2.0
June	20	200	1	58	2.5
June	20	200	1	54	2.0
June	20	200	1	47	1.4
June	20	200	3	-	-
June	20	400	1	51	1.8
June	20	400	1	55	2.2
June	20	400	1	52	2.0
June	20	400	1	52	1.9
June	20	400	1	53	2.2
June	20	400	1	52	1.8
June	20	600	1	50	1.7
June	21	800	1	-	-
June	21	900	10	-	-
June	21	1100	1	52	2.0
June	21	1100	1	54	2.3
June	21	1400	1	-	-
June	21	1600	4	-	-
June	21	1800	5	-	-
June	21	2000	1	54	1.9
June	21	2100	1	54	2.0
June	21	2100	1	52	2.0

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
June	19	1	1	49	1.4
June	19	1	1	53	1.7
June	19	1	1	52	1.7
June	19	1	1	55	2.3
June	19	1	1	52	1.6
June	19	1	1	53	1.8
June	19	1	1	50	1.5
June	19	1	4	-	-
June	19	200	8	-	-
June	19	400	1	58	2.7
June	19	400	1	56	2.6
June	19	400	1	51	1.6
June	21	200	1	50	1.6
June	21	200	1	53	2.0
June	21	200	5	-	-
June	21	400	11	-	-
June	21	600	6	-	-
June	21	1200	2	-	-
June	22	1200	2	-	-
June	22	1400	14	-	-
June	22	1600	6	-	-
June	22	1800	1	58	2.8
June	22	1800	1	58	2.7
June	22	1800	1	58	2.5
June	22	2000	1	56	2.2
June	22	2000	1	55	2.1
June	22	2000	1	53	1.8
June	22	2000	1	55	2.2
June	22	2000	1	51	1.7
June	22	2000	1	53	2.0
June	22	2000	1	54	2.0
June	22	2000	1	53	1.7
June	22	2200	1	50	1.6
June	22	2200	1	57	2.7
June	22	2200	1	57	2.0
June	22	2200	1	54	2.0
June	22	2200	1	59	2.7
June	22	2200	1	52	1.8
June	22	2200	1	53	2.0
June	22	2200	1	64	3.4
June	22	2200	1	54	2.0
June	22	2200	3	-	-
June	22	1	6	-	-
June	22	1	12	-	-
June	22	400	14	-	-
June	22	600	10	-	-

Appendix 4. Cont'd. Adult sockeye salmon enumeration in the Ozette River, WA, 1982.

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
June	21	300	1	53	2.2
June	21	2300	1	53	2.2
June	21	2300	1	50	1.8
June	21	2300	1	54	2.1
June	21	2300	1	55	2.2
June	21	2300	1	54	1.9
June	21	2300	1	50	1.4
June	21	2300	1	49	1.5
June	21	2300	1	-	-
June	21	2300	6	-	-
June	21	200	1	53	2.0
June	21	2300	1	53	2.0
June	21	200	1	52	1.9
June	21	200	1	52	1.8
June	21	200	1	48	1.4
June	21	200	1	51	1.8
June	23	600	1	50	1.6
June	23	600	1	52	1.9
June	23	600	1	53	1.8
June	23	600	1	52	1.8
June	23	600	1	54	2.1
June	23	600	1	52	1.8
June	23	600	1	53	2.1
June	23	800	1	-	-
June	24	2000	1	51	1.6
June	24	2200	1	53	1.9
June	24	1	1	53	2.0
June	24	1	1	56	2.3
June	24	1	1	52	1.6
June	24	1	1	55	2.2
June	24	1	1	50	1.4
June	24	1	1	51	1.6
June	24	1	1	54	1.8
June	24	1	1	52	1.6
June	24	1	11	-	-
June	24	200	14	-	-
June	24	400	1	56	2.6
June	24	400	1	54	2.1
June	24	400	1	50	1.5
June	24	400	1	53	2.0
June	24	400	1	51	1.7
June	24	400	1	54	2.1
June	24	400	1	55	2.2
June	24	400	1	49	1.4
June	24	400	1	52	1.5
June	24	400	1	53	1.8

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
June	23	1800	2	-	-
June	23	2100	1	53	1.9
June	23	2100	1	54	2.0
June	23	2200	1	59	2.8
June	23	2200	1	53	2.0
June	23	2200	1	55	2.2
June	23	1	12	-	-
June	23	200	14	-	-
June	23	600	1	55	2.2
June	23	600	1	62	3.1
June	23	600	1	59	2.8
June	23	600	1	51	1.5
June	23	600	1	54	1.9
June	23	600	1	51	1.8
June	23	600	1	47	1.3
June	23	600	1	53	1.9
June	25	400	1	58	2.6
June	25	400	1	58	2.6
June	25	400	1	48	1.4
June	25	400	1	49	1.6
June	25	400	1	52	1.6
June	26	1800	1	-	-
June	26	2000	1	52	2.3
June	26	1	1	55	2.2
June	26	1	1	52	0.7
June	26	1	1	50	1.7
June	26	1	1	59	2.6
June	26	1	1	54	2.2
June	26	1	1	49	1.6
June	26	1	1	50	1.5
June	26	1	1	43	1.1
June	26	1	1	53	1.9
June	26	200	7	-	-
June	27	2000	1	53	1.9
June	27	2000	1	51	1.7
June	27	2000	1	55	2.1
June	27	2000	1	47	1.4
June	27	2000	1	55	2.8
June	27	2000	1	52	1.9
June	27	2000	1	52	1.7
June	27	2200	1	56	2.2
June	27	1	1	55	1.9
June	27	1	1	50	1.6
June	27	1	1	-	-
June	27	200	1	55	2.3
June	27	400	1	32	1.8

Appendix 4. Cont'd. Adult sockeye salmon enumeration in the Ozette River, WA, 1982.

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
June	25	1400	1	-	-
June	25	1600	1	-	-
June	25	1800	3	-	-
June	25	2000	1	52	1.8
June	25	2000	1	52	1.8
June	25	2000	1	53	2.2
June	25	1	1	53	1.9
June	25	1	1	53	2.0
June	25	1	1	51	1.9
June	25	1	1	43	1.1
June	25	1	1	59	2.8
June	25	1	1	52	1.9
June	25	1	1	51	1.7
June	25	1	1	60	3.0
June	25	1	8	-	-
June	25	200	7	-	-
June	25	400	1	53	2.0
June	25	400	1	52	2.0
June	25	400	1	57	2.6
June	25	400	1	51	1.8
June	29	2000	1	52	2.2
June	29	2000	1	54	2.1
June	29	2300	1	53	1.9
June	29	2300	1	50	1.6
June	29	2300	1	51	1.7
June	29	2300	1	54	2.0
June	29	2300	1	51	1.8
June	29	2300	1	49	1.5
June	29	2300	1	52	1.8
June	29	2300	1	56	2.6
June	29	2300	1	58	1.4
June	29	2300	1	51	1.7
June	29	200	26	-	-
June	29	400	13	-	-
June	29	600	6	-	-
June	30	800	2	-	-
June	30	1200	1	-	-
June	30	1400	1	-	-
June	30	1600	1	-	-
June	30	1800	1	49	1.4
June	30	1800	1	54	1.8
June	30	1800	1	51	1.8
June	30	2000	1	59	2.8
June	30	2000	1	55	2.2
June	30	2000	1	45	1.2
June	30	2000	1	59	2.5

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
June	28	1200	1	54	1.9
June	28	1600	1	54	2.3
June	28	1800	1	52	1.7
June	28	1800	1	54	2.0
June	28	2000	1	42	1.0
June	28	2000	1	56	2.3
June	28	2000	1	50	1.7
June	28	2000	1	56	2.0
June	28	2000	1	56	2.4
June	28	2200	21	-	-
June	28	1	16	-	-
June	28	200	11	-	-
June	28	400	6	-	-
June	28	600	4	-	-
June	29	800	16	-	-
June	29	1000	3	-	-
June	29	1200	4	-	-
June	29	1400	3	-	-
June	29	1600	5	-	-
June	29	1800	6	-	-
June	30	400	1	58	2.5
June	30	600	1	-	-
July	1	800	1	-	-
July	1	1400	1	-	-
July	1	1600	1	50	1.6
July	1	1600	1	55	2.2
July	1	1600	1	50	1.7
July	1	1600	1	51	1.7
July	1	1600	1	55	2.6
July	1	1600	1	47	1.3
July	1	1600	1	50	1.4
July	1	1600	1	52	1.5
July	1	1600	1	54	1.9
July	1	1600	1	47	1.0
July	1	1600	3	-	-
July	1	1800	2	-	-
July	1	2000	5	-	-
July	1	2200	2	-	-
July	1	1	20	-	-
July	1	200	24	-	-
July	1	400	1	60	2.8
July	1	400	1	56	2.1
July	1	400	1	55	2.2
July	1	400	1	50	1.4
July	1	400	1	51	1.8
July	1	400	1	55	2.1

Appendix 4. Cont'd. Adult sockeye salmon enumeration in the Ozette River, WA, 1982.

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
June	30	2000	1	51	1.9
June	30	2200	1	55	2.0
June	30	2200	1	50	1.4
June	30	2200	1	54	2.5
June	30	2200	1	44	1.1
June	30	2200	1	53	2.0
June	30	2200	1	49	3.0
June	30	2200	1	52	1.7
June	30	1	1	52	1.7
June	30	1	1	51	1.7
June	30	1	36	-	-
June	30	200	9	-	-
June	30	400	1	55	2.0
June	30	400	1	53	2.0
June	30	400	1	58	2.8
June	30	400	1	51	1.8
June	30	400	1	52	1.9
June	30	400	1	53	1.8
July	2	400	1	48	1.2
July	3	80	1	-	-
July	3	1600	7	-	-
July	3	2000	1	51	2.2
July	3	2000	1	43	0.9
July	3	1	1	51	1.8
July	3	1	1	42	0.9
July	3	1	1	56	2.4
July	3	1	1	50	1.6
July	3	1	1	53	1.9
July	3	1	1	53	2.1
July	1	1	1	50	1.6
July	3	1	1	55	2.0
July	3	1	9	-	-
July	3	200	1	49	1.6
July	3	200	1	50	1.7
July	3	200	1	58	2.6
July	3	200	1	47	1.1
July	3	200	1	54	2.1
July	3	200	1	47	1.4
July	3	400	1	53	1.9
July	3	400	1	58	2.6
July	3	400	1	51	1.7
July	3	400	1	50	1.7
July	3	400	2	-	-
July	3	600	1	-	-
July	4	800	1	-	-
July	4	1200	1	-	-

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
July	1	400	1	51	1.7
July	2	1400	10	-	-
July	2	1600	4	-	-
July	2	1	1	53	2.0
July	2	1	1	50	1.5
July	2	1	1	50	1.6
July	2	1	1	54	1.9
July	2	1	1	55	2.0
July	2	1	1	53	1.9
July	2	1	1	61	3.0
July	2	1	1	53	2.1
July	2	1	1	50	1.7
July	2	1	1	48	1.3
July	2	1	27	-	-
July	2	200	13	-	-
July	2	400	1	51	1.5
July	2	400	1	55	2.1
July	2	400	1	52	1.5
July	5	1	1	59	3.0
July	5	1	1	47	1.1
July	5	1	1	52	1.9
July	5	1	1	55	2.0
July	5	1	1	52	1.5
July	5	1	1	51	1.7
July	5	1	1	55	2.1
July	5	1	1	57	2.5
July	5	1	1	58	2.7
July	5	1	1	43	0.9
July	5	1	19	-	-
July	5	200	1	49	1.6
July	5	200	1	50	1.7
July	5	200	1	51	1.6
July	5	200	1	54	2.4
July	5	200	1	57	2.5
July	5	200	1	55	2.1
July	5	200	1	50	1.7
July	5	200	1	55	2.3
July	5	200	1	50	1.6
July	5	200	1	54	2.5
July	5	400	6	-	-
July	5	600	3	-	-
July	6	1400	2	-	-
July	6	1600	9	-	-
July	6	1800	6	-	-
July	6	2200	9	-	-
July	6	2300	16	-	-

Appendix 4. Cont'd. Adult sockeye salmon enumeration in the Ozette River, WA, 1982.

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
July	4	1600	2	-	-
July	4	1	1	52	1.8
July	4	1	1	51	1.7
July	4	1	1	58	2.4
July	4	1	1	57	2.4
July	4	1	1	56	2.0
July	4	1	1	55	2.2
July	4	1	1	43	1.0
July	4	1	1	52	1.7
July	4	1	1	61	3.0
July	4	1	1	50	1.6
July	4	1	16	-	-
July	4	200	6	-	-
July	4	400	1	55	2.1
July	4	400	1	52	1.7
July	4	400	1	47	1.2
July	5	800	1	-	-
July	5	1400	1	-	-
July	5	1600	1	-	-
July	5	1800	3	-	-
July	5	2000	1	-	-
July	5	2200	12	-	-
July	8	1	1	54	2.0
July	8	1	1	51	1.4
July	8	1	1	53	1.6
July	8	1	1	58	2.4
July	8	1	14	-	-
July	8	400	1	54	2.0
July	8	400	1	43	0.9
July	8	400	1	53	1.9
July	8	400	1	56	2.5
July	9	1	1	50	1.3
July	9	1	1	42	0.7
July	9	1	1	54	2.0
July	9	1	1	52	1.5
July	9	1	1	57	2.1
July	9	1	1	55	2.1
July	9	1	1	53	2.1
July	9	1	1	51	1.5
July	9	1	1	52	1.5
July	9	1	1	51	1.6
July	9	1	1	-	-
July	9	200	1	44	1.3
July	9	200	1	54	2.2
July	9	200	1	56	2.8
July	9	200	1	53	2.0
July	7	1800	1	50	1.6
July	7	1800	1	56	2.0
July	7	1800	1	54	2.1
July	7	1800	1	50	1.7
July	7	1	16	-	-
July	7	200	4	-	-
July	7	400	1	60	2.9
July	7	400	1	57	2.4
July	7	400	1	53	1.9
July	7	400	1	51	1.8
July	7	400	1	44	1.1
July	7	400	1	52	1.9
July	7	400	1	49	1.4
July	7	400	1	50	1.6
July	7	600	1	53	2.2
July	8	1400	5	-	-
July	8	1800	1	52	1.7
July	8	1800	1	55	2.3
July	8	1800	1	54	2.1
July	8	1800	1	55	2.2
July	8	1800	1	42	1.0
July	8	1800	1	55	2.0
July	12	400	3	-	-
July	12	600	1	-	-
July	13	800	1	-	-
July	13	1600	1	58	2.6
July	13	2200	1	52	1.7
July	13	1	4	-	-
July	13	200	13	-	-
July	13	400	6	-	-
July	13	600	2	-	-
July	14	10	1	-	-
July	14	1600	1	54	2.0
July	14	1800	1	52	1.6
July	14	1800	1	53	1.8
July	14	2000	1	56	2.3
July	14	2200	1	60	3.1
July	14	1	1	55	2.1
July	14	200	1	51	1.6
July	14	200	1	55	2.3
July	14	200	1	54	1.9
July	14	200	1	52	1.9
July	14	400	7	-	-
July	14	600	3	-	-
July	15	1600	1	56	2.3
July	15	1800	1	56	2.4

Appendix 4. Cont'd. Adult sockeye salmon enumeration in the Ozette River, WA, 1982.

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
July	9	400	1	51	1.4
July	9	400	1	52	1.7
July	9	400	1	53	2.0
July	9	600	1	51	1.6
July	10	1	1	53	1.8
July	10	1	1	51	1.5
July	10	1	1	45	0.9
July	10	400	2	-	-
July	11	1200	2	-	-
July	11	2000	1	-	-
July	11	1	1	53	1.8
July	11	1	1	51	1.4
July	11	200	1	50	1.2
July	11	200	1	54	2.0
July	11	200	1	51	1.0
July	11	200	1	53	1.6
July	11	400	1	52	1.6
July	11	600	1	55	2.3
July	12	1600	1	42	0.8
July	12	1600	1	57	2.5
July	12	1800	1	52	1.9
July	12	2200	1	41	0.9
July	12	2200	1	55	2.1
July	12	2200	1	55	2.1
July	12	1	6	-	-
July	12	200	12	-	-
July	16	400	6	-	-
July	16	600	2	-	-
July	17	1200	1	52	1.5
July	17	1200	1	50	1.4
July	17	1400	1	54	2.0
July	17	1600	1	53	1.8
July	17	1	1	61	2.8
July	17	1	1	51	1.8
July	17	1	1	57	2.7
July	17	1	1	56	2.0
July	17	1	1	56	2.4
July	17	1	1	56	2.2
July	17	1	11	-	-
July	17	200	1	55	1.9
July	17	200	1	45	1.3
July	17	200	1	52	2.2
July	17	200	1	52	1.8
July	17	400	1	42	1.0
July	17	400	1	52	1.8
July	18	1200	1	52	1.5

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
July	15	1800	1	-	-
July	15	2000	1	50	1.5
July	15	1	15	-	-
July	15	200	1	53	1.9
July	15	200	1	51	1.5
July	15	200	1	54	2.1
July	15	200	1	54	1.9
July	15	200	1	58	2.5
July	15	200	1	54	2.2
July	15	200	1	51	1.6
July	15	200	1	53	2.3
July	15	200	1	57	2.6
July	15	200	1	59	2.5
July	15	200	1	43	1.0
July	15	400	1	49	1.5
July	15	400	1	55	2.7
July	15	400	1	50	1.8
July	15	400	1	58	2.7
July	15	400	1	49	1.6
July	15	400	5	-	-
July	16	1200	2	-	-
July	16	1800	1	53	2.0
July	16	1800	1	51	1.8
July	16	2200	1	50	1.6
July	16	1	16	-	-
July	16	200	2	-	-
July	21	600	1	51	1.7
July	21	600	1	51	1.5
July	22	1100	1	50	1.7
July	22	1100	1	54	2.2
July	22	1100	1	41	1.3
July	22	1100	1	53	2.1
July	22	1100	1	51	1.6
July	22	1100	1	41	1.1
July	22	1100	1	60	2.8
July	22	1800	1	58	2.6
July	22	2000	1	51	1.5
July	22	2200	1	58	2.6
July	22	1	1	56	2.7
July	22	1	1	52	1.8
July	22	1	1	55	2.1
July	22	1	1	58	2.7
July	22	1	1	53	2.0
July	22	1	1	54	2.0
July	22	1000	1	58	2.8
July	22	1000	1	55	2.0

Appendix 4. Cont'd. Adult sockeye salmon enumeration in the Ozette River, WA, 1982.

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)	Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
July	18	1	1	51	1.6	July	22	1000	1	58	2.6
July	18	200	1	57	2.6	July	22	1000	1	61	2.9
July	18	400	1	51	1.8	July	22	1000	1	61	2.9
July	19	1600	1	50	1.6	July	22	1000	1	53	1.9
July	19	1600	1	59	2.6	July	22	1000	1	50	1.6
July	19	2200	5	-	-	July	22	1000	1	51	1.6
July	19	1	2	-	-	July	22	1000	22	-	-
July	19	200	3	-	-	July	23	1600	2	-	-
July	19	400	1	-	-	July	23	2100	1	52	2.0
July	20	1000	2	-	-	July	23	2300	1	57	2.7
July	20	1200	1	-	-	July	23	2300	1	52	1.8
July	20	1400	1	-	-	July	23	2300	1	54	2.4
July	20	1800	2	-	-	July	23	2300	1	48	1.5
July	20	2000	4	-	-	July	23	2300	1	51	1.8
July	20	2200	6	-	-	July	23	2300	1	52	1.7
July	20	1	6	-	-	July	23	2300	1	43	1.3
July	20	200	4	-	-	July	23	2300	1	55	2.0
July	20	400	3	-	-	July	23	2300	1	59	2.7
July	20	600	2	-	-	July	23	2300	8	-	-
July	21	1400	1	54	2.0	July	23	600	1	49	1.6
July	21	1600	1	62	3.3	July	23	600	1	52	1.9
July	21	1800	1	55	2.0	July	23	600	1	53	2.0
July	21	2000	1	51	1.6	July	23	600	1	52	1.9
July	21	2200	1	52	1.7	July	23	600	1	51	1.6
July	21	2200	1	-	-	July	23	600	1	57	2.6
July	21	1	11	-	-	July	23	600	1	51	1.9
July	21	600	1	53	1.9	July	23	600	1	53	2.0
July	21	600	1	55	2.1	July	23	600	1	53	1.8
July	21	600	1	61	3.1	July	23	600	1	53	1.5
July	21	600	1	52	1.6	July	23	600	15	-	-
July	24	1600	1	-	-	July	27	1	2	-	-
July	24	1	18	-	-	July	27	600	10	-	-
July	24	700	1	49	1.4	July	28	800	1	-	-
July	24	700	1	51	1.8	July	28	800	1	55	2.2
July	24	700	1	58	2.8	July	29	800	1	51	1.8
July	24	700	1	55	2.3	July	29	800	1	57	2.4
July	24	700	1	55	2.3	July	30	630	1	51	1.5
July	24	700	1	51	1.8	July	30	630	1	52	1.7
July	24	700	1	53	1.9	July	30	630	1	53	2.0
July	24	700	1	58	2.5	July	30	630	1	56	2.3
July	24	700	1	58	2.4	July	30	630	1	51	1.6
July	24	700	1	59	2.7	July	31	800	1	56	1.9
July	24	700	1	52	1.9	July	31	800	1	56	2.0
July	24	700	1	52	1.9	July	31	800	1	53	1.8
July	24	700	1	57	2.4	July	31	800	1	54	1.6
July	24	700	1	56	2.2	July	31	800	1	41	0.8

Appendix 4. Cont'd. Adult sockeye salmon enumeration in the Ozette River, WA, 1982.

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
July	24	700	1	55	2.2
July	24	700	1	-	-
July	25	1600	1	-	-
July	25	2300	1	51	1.6
July	25	2300	1	55	2.4
July	25	2300	1	52	1.8
July	25	2300	1	53	2.1
July	25	2300	1	58	2.7
July	25	700	1	51	1.4
July	25	700	1	53	1.5
July	25	700	1	53	1.8
July	25	700	1	58	2.6
July	25	700	1	54	1.9
July	25	700	1	53	1.6
July	25	700	1	59	2.8
July	25	700	1	51	1.4
July	25	700	1	52	1.5
July	26	1000	1	-	-
July	26	2000	1	-	-
July	26	800	17	-	-
July	27	2000	1	-	-

Month	Day	Time	No.	Len. (cm)	Wt. (Kg)
July	31	800	1	51	1.6
July	31	800	1	55	2.1
July	31	800	1	53	1.9
July	31	800	1	57	2.2
July	31	800	1	-	-
Aug.	1	530	12	-	-
Aug.	2	600	4	-	-
Aug.	3	2200	1	-	-
Aug.	4	1	7	-	-
Aug.	5	600	6	-	-
Aug.	6	2230	1	-	-
Aug.	6	600	2	-	-
Aug.	8	600	6	-	-
Aug.	9	-	0	-	-
Aug.	10	-	0	-	-
Aug.	11	-	0	-	-
Aug.	12	600	1	-	-
Aug.	13	600	1	-	-
Aug.	14	-	0	-	-
Aug.	15	-	0	-	-
Aug.	16	-	0	-	-

Appendix 4. Adult sockeye salmon enumeration in the Ozette River, WA, 1984

Month	Day	Time	Number	Month	Day	Time	Number
June	19	2200	1	June	30	500	6
June	19	1	6	July	1	1	5
June	19	200	4	July	1	200	7
June	19	400	4	July	1	500	7
June	19	600	3	July	2	1100	5
June	20	2000	1	July	2	1	2
June	20	200	5	July	2	200	4
June	20	400	6	July	3	2000	5
June	21	2000	4	July	3	2200	4
June	21	2200	3	July	3	1	8
June	21	1	3	July	3	200	10
June	21	200	6	July	3	400	2
June	21	400	7	July	3	600	3
June	21	600	7	July	4	2000	4
June	22	1	3	July	4	200	2
June	22	200	4	July	4	400	2
June	22	600	2	July	5	1	1
June	23	-	-	July	5	200	5
June	24	2000	1	July	5	500	1
June	24	1	2	July	5	1000	3
June	24	200	3	July	6	1	8
June	24	400	2	July	6	200	5
June	25	200	3	July	6	500	1
June	25	600	1	July	7	1	7
June	26	2000	1	July	7	200	6
June	26	1	6	July	7	500	1
June	26	200	6	July	7	1100	1
June	26	400	5	July	8	1	6
June	26	2000	2	July	8	200	4
June	26	1	7	July	8	500	2
June	26	200	7	July	8	1000	3
June	26	400	4	July	9	1	7
June	26	600	4	July	9	200	6
June	27	1	5	July	9	500	2
June	27	200	4	July	10	1	3
June	27	400	6	July	10	400	6
June	27	600	3	July	10	600	5
June	28	2200	1	July	11	1	4
June	28	1	9	July	11	200	10
June	28	200	1	July	11	400	9
June	28	400	3	July	11	600	2
June	29	1300	1	July	12	1	5
June	29	1600	2	July	12	200	6
June	29	1	10	July	12	400	5
June	29	200	7	July	13	1	2
June	29	400	6	July	13	200	2
June	29	600	2	July	13	400	4

Appendix 4. Adult sockeye salmon enumeration in the Ozette River, WA, 1984

Month	Day	Time	Number
June	30	1	3
June	30	200	9
July	14	400	3
July	14	600	1
July	15	1	2
July	15	400	4
July	16	1	3
July	16	200	1
July	17	1	1
July	17	200	2
July	18	1	1
July	19	1	6
July	19	200	3
July	19	400	1
July	20	200	4
July	20	400	1
July	21	1	6
July	21	200	2
July	21	400	1
July	22	1	4
July	22	200	1
July	23	1	2
July	23	200	1
July	23	600	1
July	24	200	2
July	24	400	1
July	24	600	1

Month	Day	Time	Number
July	14	1	8
July	14	200	2
July	25	200	3
July	25	400	2
July	25	600	1
July	26	1	2
July	26	200	1
July	26	1200	1
July	27	1	1
July	27	200	1
July	28	1	1
July	28	400	1
July	29	400	1
July	30	-	-
July	31	2000	4
Aug.	1	2000	1
Aug.	1	2200	1
Aug.	1	1	2
Aug.	1	200	3
Aug.	1	400	2
Aug.	2	600	1
Aug.	3	2200	1
Aug.	4	-	-
Aug.	5	1	1
Aug.	5	200	1
Aug.	5	400	1
Aug.	6	1	1

Appendix 5. Predictive models for potential Ozette Lake sockeye escapement, catch and total run size

Appendix 5. Table 1. Predicted Yield from the Morpho-Edaphic Index (MEI) and the MEI Adjusted for a Maximum Depth of 25 m (MEI25) from Selected Fraser River Sockeye Salmon-Producing Lakes.

Lake	Mean Depth (m)	TDS	MEI	YIELD (kg/ha)	MEI25	YIELD25 (kg/ha)
Pitt	46	26	0.57	0.7	1.04	1.0
Cultus	30	167	5.57	2.3	6.68	2.5
Lillooet	62	29	0.47	0.7	1.16	1.0
Harrison	151	40	0.26	0.5	1.60	1.2
Adams	169	31	0.18	0.4	1.24	1.2
Mara	18	69	3.83	1.9	3.83	1.9
Seton	85	45	0.53	0.7	1.80	1.3
Anderson	140	61	0.44	0.6	2.44	1.5
Chilko	108	53	0.49	0.7	2.12	1.4
Taseko	46	29	0.63	0.8	1.16	1.0
Quesnel	158	62	0.39	0.6	2.48	1.5
Bowron	16	49	3.06	1.7	1.96	1.3
Stuart	20	78	3.90	1.9	3.90	1.9
Trembleur	40	58	1.45	1.2	2.32	1.5
Takla	107	48	0.45	0.6	1.92	1.3
Fraser	13	95	7.31	2.6	7.31	2.6
Francois	87	76	0.87	0.9	3.04	1.7
Shuswap	62	87	1.40	1.1	3.48	1.8
Little Shuswap	14	52	3.71	1.9	2.08	1.4

Appendix 5. Table 2. Comparison of Predicted Fish Yield (kg/ha) of Ozette Lake Using Various Indices of Productivity.

Variable	Predicted Productivity
Mean Depth (m)	1.7 - 2.0 kg/ha
TDS (mg/l)	0.7 - 1.1 kg/ha
MEI (TDS/Z; Z_{18}; Z_{25})	0.8 - 1.1 kg/ha
Area (km^2)	1.1 - 6.2 kg/ha
Primary Productivity	0.9 kg/ha
(Chlorophyll a in mg/l)	
Total Phosphorus (ug/l)	0.6 - 1.3 kg/ha
Bio-Index	1.5 kg/ha

Appendix 5. Table 3. Regression equations for Plankton Index.

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PI = Plankton Index
TDS = Total Dissolved Solids
CHLORA = Chlorophyll *a*
SEC = Secchi Disk Depth
MEI = Morpho-edaphic Index

Regressions

(1) PI = 0.01655 TDS - 0.00286
(r^2 = 0.465; P $\leq$ 0.01, N = 21)

(2) PI = 0.01178 TDS + 0.1559 CHLORA + 0.2214
(r^2 = 0.506; P < 0.001; N = 21)

(3) PI = 0.32582 CHLORA + 0.42687
(r^2 = 0.375; P < 0.05; N = 21)

(4) PI = 0.2674 MEI25 + 0.2196
(r^2 = 0.617; P $\leq$ 0.001)

Calculations of Plankton Index for Ozette Lake:

(1) 0.4
(2) 0.9
(3) 1.2
(4) 0.5

Appendix 5. Table 4. Regression Equations and Calculations for Potential Female Spawners in Fraser River Lakes.

S = Potential Female Spawners/km^2
PI= Plankton Index
TDS = Total Dissolved Solids
C = Chlorophyll a
MEI25 = MEI with a maximum depth of 25m

Equation	Ozette Lake Predicted Potential Female Spawners
(1) $S = 2379.3297\ PI - 27.89$ ($r^2 = 0.89$; $P < 0.001$; $N = 21$)	26,888 - 53,757 1/
(2) $S = 42.6671\ TDS - 246.76$ ($r^2 = 0.48$; $P < 0.01$; $N = 21$)	23,054
(3) $S = 837.672\ C + 927.396$ ($r^2 = 0.37$; $P < 0.05$; $N = 21$)	86,947
(4) $S = 1066.678\ MEI25 - 246.7593$ ($r^2 = 0.48$; $P \leq 0.01$)	23,338

1/ Based on Plankton Index Values Ranging from 0.399 - 0.786.

Appendix 5. Table 5. Regression equations for Mean Escapement, Fraser River Lake Systems (Mean 1969-1980 Data).

E = Mean Escapement/km^2 lake surface area
E_1 = Mean Escapement per lake system
MNDP = Mean Depth (m)
MEI = Morpho-edaphic Index
MEI25 = MEI with maximum depth of 25 m
T = Total Run/km^2 lake surface area
C = Catch/km^2 lake surface area
A = Lake area in km^2

PFS = Potential Female Spawners per lake system

Regressions	Predicted Mean
Ozette Escapements	
(1) $E = -12.36\ MNDP + 2592.380$ ($r^2 = 0.165$; $P > 0.05$; $N = 21$)	61,974
(2) $E = 314.85\ MEI + 1082.41$ ($r^2 = 0.14$; $P < 0.169$; $N = 21$)	37,625
(3) $E = 793.223\ MEI25 - 213.7516$ ($r^2 = 0.158$; $P \leq 0.142$)	23,657
(4) $E_1 = 1568.699\ A - 12765.322$ ($r^2 = 0.2699$; $P \leq 0.041$)	33,574
(5) $E = 2 \times PFS$	54,000-121,500*
(6) $E = 0.227\ T - 107.734$ ($r^2 = 0.94$; $P < 0.001$; $N = 21$)	
(7) $E = 0.999\ T - 0.999\ C + .00196$ ($r^2 = 0.99$; $P < 0.001$; $N = 21$)	

* based on a Plankton Index of 0.4 - 0.9

Appendix 5. Table 6. Regression equations for Mean Catch from Fraser River System Lakes (1969-1980).

C = Mean catch/km^2 lake surface area
T = Total run/km^2 lake surface area
TDS = Total Dissolved Solids
EP = Epilimnetic Phosphorus in ug/l
MEI = Morpho-edaphic Index
MEI25 = MEI with maximum depth of 25m
A = Lake area in km^2
E = Total Escapement C_1 = Mean total catch per lake system

Regression Equations	Predicted Ozette Lake Mean Catches
(1) $C = 614.97\ EP + 2526.65$ ($r^2 = 0.31$; $P < 0.05$; $N = 21$)	216,866
(2) $C = 689.95\ EP + 124.144\ TDS - 4996.04$ ($r^2 = 0.555$; $P < 0.01$; $N=21$)	94,389
(3) $C = 1231.537\ MEI + 3728.123$ ($r^2 = 0.213$; $P > 0.05$; $N = 21$)	102,254
(4) $C = 2541.397\ MEI25 - 53.107$ ($r^2 = 0.162$; $P \leq 0.137$; $N = 21$)	71,402
(5) $C_1 = 4386.009\ A + 10186.598$ ($r^2 = 0.326$; $P < 0.009$)	139,749
(6) $C = 2.75\ E + 101735.4$ ($r^2 = 0.98$; $P < 0.01$; $N = 21$)	252,700-441,400
(7) $C = 0.77298\ T + 107.736$ ($r^2 = 0.995$; $P < 0.001$; $N = 21$)	
(8) $C = 1.000\ T - 1.000\ E + 0.00192$ ($r^2 = 0.1.00$; $P < 0.001$; $N = 21$)	

* Assuming escapement = (2)X(potential female spawners) Potential female spawners range = 27,000 - 60,750 per Table 9.

Appendix 5. Table 7. Regression Equations for Mean Total Sockeye Runs in Fraser River lakes.

T = Mean total sockeye run per km^2 lake surface area
T_1 = Mean total sockeye run per lake system
E = Mean escapement
C = Mean total catch
P = Phosphorus
TDS = Total Dissolved Solids
AL = Algal Volume
MEI = Morpho-edaphic Index
MEI25= MEI with Maximum mean depth of 25 m
A = Lake area in km

MNDP = Mean Depth

	Regression Equations Sockeye Returns	Tot.Ozette Lake
(1)	$T = 748.33304\ P + 3428.2523$ ($r^2 = 0.277$; $P < 0.05$; $N = 21$)	267,064
(2)	$T = 875.52850\ P + 160.94382\ TDS - 6324.4109$ ($r^2 = 0.510$; $P < 0.05$; $n = 21$)	122,679
(3)	$T = 947.55984\ P + 288.92643\ TDS - 39.55940\ AL - 8300.4716$ ($r^2 = 0.746$; $P \leq 0.001$; $N = 21$)	116,579
(4)	$T = 1546.39\ MEI + 4810.53$ ($r^2 = 0.197$; $P = 0.097$, $N= 21$)	169,877
(5)	$T = 1875.609\ MEI25 + 887.1953$ ($r^2 = 0.33$; $P > 0.05$; $N = 21$)	80,062
(6)	$T = 658.34638\ P + 1265.6200\ MEI + 1793.9252$ ($r^2 = 0.406$; $P < 0.05$; $N = 21$)	221,561
(7)	$T = -42.76\ MNDP\ 96.195\ TDS + 5251.79$ ($r^2 = 0.26$; $P \leq = 0.158$; $M = 21$)	173,664
(8)	$T_1 = 5780.24\ A - 2667.8139$ ($r^2 = 0.310$; $P \leq 0.011$; $N = 21$)	168,080
(9)	$T = 1.35029\ C - 34083.727$ ($r^2 = .998$; $P < 0.001$; $N = 21$)	195,533* 424,251
(10)	$T = 0.99999\ C + 1.00000\ E - 0.2597$ ($r^2 = 1.000$; $P < 0.001$; $N = 21$)	224,032* 447,399
(11)	$T = 3.79\ E + 101734.77$ ($r^2 = .99$; $P < 0.01$; $N = 21$)	306,700* 562,900

* based on plankton index values of 0.4 - 0.9, escapement estimates of 54,000 - 121,500 and catches of 252,000 - 441,400.

Appendix 6. Fraser River System sockeye catch, escapement, and total run sizes, 1969-1980

Appendix 6. Fraser River System sockeye catch, escapement, and total run sizes, 1969-1980.

Lake		1969	1970	1971	1972
Cultus	Tot. Run	39,504	136,335	134,476	64,714
	Escape.	6,739	15,149	9,145	10,660
	Catch	32,765	121,186	125,331	54,054
Pitt	Tot. Run	161,090	50,914	82,038	82,858
	Escape.	25,799	7,021	15,863	13,714
	Catch	135,291	43,893	66,175	69,144
Lillooet	Tot. Run	260,082	238,684	491,488	359,800
	Escape.	64,527	72,760	32,672	113,097
	Catch	195,555	165,924	458,816	246,703
Harrison	Tot. Run	256,203	159,951	149,900	169,304
	Escape.	74,037	24,032	9,413	30,499
	Catch	182,166	135,919	140,487	138,805
Seton-Anderson	Tot. Run	7,067	32,784	13,283	84,675
	Escape.	1,921	4,704	2,580	10,029
	Catch	5,146	28,080	10,703	74,646
Adams	Tot. Run	-	2,267	22	7,247
	Escape.	-	-	-	1,034
	Catch	-	-	-	-
Mara	Tot. Run	6,270	72,560	63,267	1,096
	Escape.	1,703	29,074	6,117	-
	Catch	4,567	43,486	57,150	-
Mabel	Tot. Run	-	15,222	2,940	-
	Escape.	-	4,559	-	-
	Catch	-	-	-	-
Quesnel	Tot. Run	1,652,135	7,953	2,146	6,910
	Escape.	278,966	1,373	171	3,488
	Catch	1,373,169	6,580	1,975	3,422
Taseko	Tot. Run	-	-	75,385	21,938
	Escape.	-	-	10,500	2,287
	Catch	-	-	64,885	19,651
Chilko	Tot. Run	380,201	791,502	2,102,377	2,390,073
	Escape.	76,518	145,049	174,266	566,465
	Catch	303,683	646,453	1,928,111	1,823,608
Bowron	Tot. Run	18,861	22,349	194,910	49,906
	Escape.	3,872	1,341	25,497	4,138
	Catch	14,989	21,008	169,413	45,768

Appendix 6. Cont'd. Fraser River System sockeye catch, escapement and run size, 1969 - 1980.

Lake		1973	1974	1975	1976
Cultus	Tot. Run	7,427	46,215	46,631	37,186
	Escape.	858	9,814	11,478	4,450
	Catch	6,569	36,401	35,153	32,736
Pitt	Tot. Run	79,866	84,504	129,295	192,422
	Escape.	12,355	22,435	40,878	37,921
	Catch	67,511	62,069	88,417	154,501
Lillooet	Tot. Run	617,014	880,277	354,299	511,435
	Escape.	139,295	173,463	92,928	108,121
	Catch	477,719	706,814	261,371	403,314
Harrison	Tot. Run	415,592	536,892	175,283	303,334
	Escape.	53,503	84,564	38,029	57,850
	Catch	362,089	452,328	137,254	245,484
Seton-Anderson	Tot. Run	36,307	64,049	29,840	159,807
	Escape.	5,171	10,777	8,385	21,544
	Catch	31,136	53,272	21,455	138,263
Adams	Tot. Run	-	867	148	17,532
	Escape.	-	-	-	2,038
	Catch	-	-	-	-
Mara	Tot. Run	39,959	405,788	51,831	1,680
	Escape.	7,452	86,396	11,652	-
	Catch	32,507	319,392	40,179	-
Mabel	Tot. Run	-	14,401	972	-
	Escape.	-	3,064	-	-
	Catch	-	11,337	-	-
Quesnel	Tot. Run	1,626,582	28,104	756	7,397
	Escape.	278,061	4,459	201	2,197
	Catch	1,348,521	23,645	555	5,200
Taseko	Tot. Run	-	-	16,739	3,882
	Escape.	-	-	4,394	634
	Catch	-	-	12,345	3,248
Chilko	Tot. Run	464,529	742,216	838,396	2,059,300
	Escape.	61,707	142,595	275,698	387,467
	Catch	402,822	599,621	562,698	1,671,833
Bowron	Tot. Run	23,628	17,034	124,337	25,671
	Escape.	4,700	1,850	29,700	2,250
	Catch	18,928	15,184	94,637	23,421

Appendix 6. Cont'd. Fraser River System sockeye catch, escapement, and total run sizes, 1969-1980.

Lake		1977	1978	1979	1980
Cultus	Tot. Run	1,350	28,492	109,445	6,237
	Escape.	353	7,265	32,045	1,687
	Catch	997	21,227	77,400	4,550
Pitt	Tot. Run	78,849	66,671	130,836	52,668
	Escape.	14,314	26,435	38,157	17,524
	Catch	64,535	40,236	92,679	35,144
Lillooet	Tot. Run	328,243	686,044	371,194	483,713
	Escape.	43,139	99,857	78,088	9,022
	Catch	285,104	586,187	293,106	474,691
Harrison	Tot. Run	359,499	357,332	247,144	294,256
	Escape.	57,740	97,237	97,228	80,541
	Catch	301,759	260,095	149,916	213,715
Seton-Anderson	Tot. Run	72,585	45,712	35,102	86,342
	Escape.	10,863	12,800	8,668	27,492
	Catch	61,722	32,912	26,434	58,850
Adams	Tot. Run	214	5,010	14	11,491
	Escape.	-	-	-	3,905
	Catch	-	-	-	7,586
Mara	Tot. Run	62,606	689,028	34,909	217
	Escape.	14,695	187,167	10,092	-
	Catch	47,911	501,861	24,817	-
Mabel	Tot. Run	-	40,091	1,993	-
	Escape.	-	10,890	-	-
	Catch	-	29,201	-	-
Quesnel	Tot. Run	2,154,780	27,365	2,970	6,507
	Escape.	515,404	8,524	0	3,176
	Catch	1,639,376	18,841	2,970	3,331
Taseko	Tot. Run	-	-	-	323
	Escape.	-	-	-	697
	Catch	-	-	-	(374)
Chilko	Tot. Run	251,417	609,976	1,590,501	1,704,689
	Escape.	54,322	159,174	272,694	498,826
	Catch	197,095	450,802	1,317,807	1,205,863
Bowron	Tot. Run	11,230	10,659	172,899	8,516
	Escape.	2,500	3,150	35,000	2,894
	Catch	8,730	7,509	137,899	5,622

Appendix 6. Cont'd. Fraser River System sockeye catch, escapement, and total run sizes, 1969-1980.

Lake		1969	1970	1971	1972
Stuart	Tot. Run	509,468	17,821	3,302	35,612
	Escape.	94,801	2,866	360	7,527
	Catch	414,667	14,955	2,942	28,085
Trembleur	Tot. Run	623,152	85,240	20,001	4,789
	Escape.	111,500	12,189	913	957
	Catch	511,652	73,051	19,088	3,832
Takla	Tot. Run	404,256	74,130	310,995	23,974
	Escape.	109,890	32,747	95,942	5,086
	Catch	294,366	41,383	215,053	18,888
Fraser	Tot. Run	238,902	348,979	557,195	145,211
	Escape.	49,341	45,876	40,010	36,852
	Catch	189,561	303,103	517,185	108,359
Francois	Tot. Run	126,758	33,902	156,846	73,180
	Escape.	36,579	4,017	17,543	3,587
	Catch	90,179	29,885	139,303	69,593
Shuswap	Tot. Run	171,697	4,050,049	3,298,276	57,628
	Escape.	64,338	148,535	303,234	7,342
	Catch	107,359	3,901,514	2,995,042	50,286
Kamloops	Tot. Run	27,744	23,560	21,565	111,032
	Escape.	5,633	4,744	1,733	1,710
	Catch	22,111	18,816	19,832	109,322
N.Barriere	Tot. Run	255	45	15,215	14,846
	Escape.	52	9	1,300	1,931
	Catch	203	36	13,915	12,915

Appendix 6. Cont'd. Fraser River System sockeye catch, escapement, and total run sizes, 1969-1980.

Lake		1973	1974	1975	1976
Stuart	Tot. Run	894,539	33,500	34,657	43,596
	Escape.	117,569	5,398	7,525	2,637
	Catch	776,970	28,102	27,132	40,959
Trembleur	Tot. Run	772,282	83,088	74,285	6,663
	Escape.	95,503	9,229	6,704	363
	Catch	676,779	73,859	67,581	6,300
Takla	Tot. Run	1,307,818	162,296	382,812	63,568
	Escape.	300,653	39,644	65,767	12,648
	Catch	1,007,165	122,652	317,045	50,920
Fraser	Tot. Run	240,736	246,838	513,928	751,457
	Escape.	30,755	41,473	176,271	150,811
	Catch	209,981	205,365	337,657	600,646
Francois	Tot. Run	121,593	30,746	76,310	12,875
	Escape.	19,496	3,825	16,944	1,774
	Catch	102,097	26,921	59,366	11,101
Shuswap	Tot. Run	212,194	5,222,389	798,248	74,487
	Escape.	49,637	1,072,733	193,897	13,718
	Catch	162,557	4,149,656	604,351	60,769
Kamloops	Tot. Run	15,849	13,771	10,622	80,022
	Escape.	2,751	2,739	2,787	9,269
	Catch	13,098	11,032	7,835	70,753
N.Barriere	Tot. Run	1,058	1,003	15,603	35,375
	Escape.	205	243	4,127	4,090
	Catch	853	760	11,476	31,285

Appendix 6. Cont'd. Fraser River System sockeye catch, escapement, and total run sizes, 1969-1980.

Lake		1977	1978	1979	1980
Stuart	Tot. Run	268,306	27,856	84,736	3,172
	Escape.	63,313	8,770	10,940	756
	Catch	204,993	19,086	73,796	2,416
Trembleur	Tot. Run	376,608	35,103	137,757	1,164
	Escape.	81,597	4,183	18,211	198
	Catch	295,011	30,920	119,546	966
Takla	Tot. Run	1,295,150	119,470	197,647	29,288
	Escape.	118,017	50,097	92,763	17,026
	Catch	1,177,133	69,373	104,884	12,262
Fraser	Tot. Run	122,179	254,369	1,703,799	292,785
	Escape.	23,452	60,421	291,490	72,098
	Catch	98,727	193,948	1,412,309	220,687
Francois	Tot. Run	87,476	13,215	318,042	13,808
	Escape.	18,499	2,782	58,795	3,338
	Catch	68,977	10,433	259,247	10,470
Shuswap	Tot. Run	255,823	6,451,775	1,213,040	39,264
	Escape.	86,577	1,650,574	338,942	11,187
	Catch	169,246	4,801,201	874,098	28,077
Kamloops	Tot. Run	8,379	6,982	12,301	22,701
	Escape.	2,036	2,500	2,717	5,587
	Catch	6,343	4,482	9,584	17,114
N.Barriere	Tot. Run	1,514	1,372	68,669	24,827
	Escape.	355	675	15,590	8,437
	Catch	1,159	697	53,079	16,390