BONNEVILLE POWER ADMINISTRATION

Lake Roosevelt Fisheries Evaluation Program

Lake Whatcom Kokanee Salmon (Oncorhynchus nerka kennerlyi) Investigations in Lake Roosevelt

Annual Report 1999 - 2000 July 2001 DOE/BP-32148-11

This Document should be cited as follows:

McLellan, Holly, Allan Scholz, Jason McLellan, Mary Beth Tilson, "Lake Roosevelt Fisheries Evaluation Program; Lake Whatcom Kokanee Salmon (Oncorhynchus nerka kennerlyi) Investigations in Lake Roosevelt", 1999-2000 Annual Report, Project No. 199404300, 70 electronic pages, (BPA Report DOE/BP-32148-11)

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P.O. Box 3621
Portland, OR 97208

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

Lake Roosevelt Fisheries Evaluation Program

Lake Whatcom Kokanee Salmon (*Oncorhynchus nerka kennerlyi*) Investigations in Lake Roosevelt

Annual Report 1999-2000

Contributions to Fisheries Management in Eastern Washington State Number 1

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Annual Report Submitted to:

U.S. Department of Energy
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Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97283-3621

Project No. 1994-043-00
Contract No. 94BI32148

July 2001

Abstract

Lake Whatcom stock kokanee have been planted in Lake Roosevelt since 1988 with the primary goal of establishing a self-sustaining fishery. Returns of hatchery kokanee to egg collection facilities and recruitment to the creel have been minimal. Therefore, four experiments were conducted to determine the most appropriate release strategy that would increase kokanee returns. The first experiment compared morpholine and non-morpholine imprinted kokanee return rates, the second experiment compared early and middle run Whatcom kokanee, the third experiment compared early and late release dates, and the fourth experiment compared three net pen release strategies: Sherman Creek hatchery vs. Sherman Creek net pens, Colville River net pens vs. Sherman Creek net pens, and upper vs. lower reservoir net pen releases. Each experiment was tested in three ways: 1) returns to Sherman Creek, 2) returns to other tributaries throughout the reservoir, and 3) returns to the creel.

Chi-square analysis of hatchery and tributary returns indicated no significant difference between morpholine imprinted and non-imprinted fish, early run fish outperformed middle run fish, early release date outperformed late release fish, and the hatchery outperformed all net pen releases. Hatchery kokanee harvest was estimated at 3,323 fish, which was 33% of the total harvest. Return rates (1998 = 0.52%) of Whatcom kokanee were low indicating an overall low performance that could be caused by high entrainment, predation, and precocity. A kokanee stock native to the upper Columbia, as opposed to the coastal Whatcom stock, may perform better in Lake Roosevelt.

Acknowledgements

We thank the Spokane Tribe of Indians (STOI) Lake Roosevelt Monitoring Program (Keith Underwood), Washington Department of Fish and Wildlife (WDFW) Sherman Creek Hatchery (Mitch Combs), and STOI Spokane Tribal Hatchery personnel (Tim Peone) and Colville Tribe personnel (Richard LeCaire) for advice and coordination in all aspects of this project.

We thank the Spokane Tribal Hatchery personnel Del Brown, James Andrews, and Jayne Abrahamson who assisted with the rearing and tagging of the kokanee for this project. Additionally, Troy Arlee, Julie Abrahamson, Janet Brown, and JoAnn Wynne for code wire tagging and fin clipping kokanee. We also thank the Spokane Tribal Lake Roosevelt Monitoring Program crew: Bill Matt Sr. (Spokane Tribe), Leroy Williams (Colville Tribe), and Jim Meskin (WDFW), for recovering hatchery kokanee heads. We would also like to thank Jason McLellan for assisting in field collection. We would also like to thank Jason McLellan (WDFW), Casey Baldwin (WDFW), Curt Vail (WDFW), Mitch Combs (WDFW), Keith Underwood (STOI), and Monte Miller (CCT) for editing the final drafts of this report.

We would also like to thank Eastern Washington University students for assisting in field collection: Chuck Lee, Heather Woller, Kamia Knuttgen, Hoyet Taylor, and Fritz Nichols. We gratefully thank Jennifer Miller, who extracted the coded wire tags and entered the data into the computer.

We also thank Laura Prey (WDFW, Rock Island Dam) for collecting and sending coded wire tagged kokanee to us. We also thank John Hoskins, Tom Steen, Buster Hill, and Chuck Keys for repair and maintenance of our electrofishing boat and truck.

The project was supported by a contract from the U.S. Department of Energy, Bonneville Power Administration (BPA), Division of Fish and Wildlife, Project Number 00000118-00001, and Contract Number 96BP192246.

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Introduction

Lake Whatcom kokanee salmon (*Oncorhynchus nerka kennerlyi*) have been stocked into Lake Roosevelt since 1988 as partial mitigation for anadromous salmon and steelhead blocked by Grand Coulee Dam. Two hatcheries were constructed as resident fish substitution measures, under the Columbia River Basin Fish and Wildlife Program to mitigate for losses of salmon and steelhead that formerly spawned in the Columbia, Spokane, and Sanpoil Rivers above Grand Coulee Dam. The primary purpose of the hatcheries was to provide a substitute sport fishery and restore a migratory salmonid species to the Lake Roosevelt ecosystem. Additionally, the hatcheries produced rainbow trout for net pens located throughout the reservoir.

The kokanee stocking program was considered inadequate as indicated by limited numbers of kokanee that returned to egg collection sites and poor recruitment to the creel. Coded wire tagging investigations began in 1990 by Eastern Washington University (EWU) to evaluate the stocking regimes and provide feedback information to the managers on hatchery improvements (Scholz et al. 1992, 1993; Tilson et al. 1994, 1995, 1996, 1997, 1998). Investigations revealed kokanee were undergoing smoltification in the reservoir and entraining over Grand Coulee Dam. These results prompted the hatcheries to switch from fry plants to smolt plants in 1995 (Tilson et al. 1994, 1995). The new goal was to produce 1 million residualized smolts to be released into the reservoir.

Typically, fish bound for release at Sherman Creek were imprinted to morpholine and fish bound for the Spokane River at Little Falls Dam were imprinted with phenethyl alcohol (Tilson et al. 1994, 1995). Subsequently, morpholine was metered into Sherman Creek and phenethyl alcohol was metered at Little Falls Dam. However, some kokanee from the 1993 and 1995 brood years were not exposed to synthetic chemicals and returned to their release sites. Therefore, it was hypothesized that kokanee did not need to be imprinted with synthetic chemicals and they would imprint to the water where they were released during the smolt stage. This would be advantageous because it would save time, money, and eliminate the need to add a synthetic chemical to the river system.

Kokanee eggs have been provided from the mid-late portion of the Lake Whatcom spawning run. In Lake Roosevelt, the spawning run was typically from mid-September to early December with a peak from late October to mid-November (Tilson et al. 1996,1997,1998). The Sherman Creek Hatchery was initially designed with a fish ladder to collected returning

spawning fish. However, kokanee do not enter the ladder, therefore, boat electrofishing has been utilized. Sherman Creek had the tendency to freeze by mid-November making it difficult to collect spawners via electrofishing. Therefore, it was suggested that early run Whatcom kokanee be used in Lake Roosevelt in hopes the run would peak before the cove at Sherman Creek froze over.

Due to their relatively large size in comparison to fry, smolts had a greater demand for space in the hatcheries. The smolts also had to be held for a longer period of time (18 months) compared to the fry (6 months). One of the problems with achieving this goal was that the Sherman Creek Hatchery could only hold about 240,000 smolts at one time. Therefore, one group of 240,000 pre-smolts, were transferred to Sherman Creek Hatchery from the Spokane Tribal Hatchery in March and released in late May- early June (early release). Once the first group was released, a second group of fish would be transferred and released in July (late release). Kokanee undergo two critical periods for imprinting, one during the alevin stage and a second at the smolt stage (Scholz et al. 1992; Tilson et al. 1994). It was hypothesized that the fish being transferred in July were not imprinting to the water at Sherman Creek.

A second approach to solving the space problem at the Sherman Creek Hatchery was to hold kokanee in net pens at the mouth of Sherman Creek Cove. Kokanee could be placed in net pens prior to smoltification (November) and released after they residualized (June). Thus, they would experience the Sherman Creek water during smoltification. The primary problem with using net pens is that fish are potentially subjected to early release in the event of a large spring drawdown or if high total dissolved gas pressure develops in high runoff years. The Sherman Creek cove is also relatively shallow, and the net pens must be moved out of the cove if the reservoir drops more than 20 feet. Due to these problems, net pens were also held at the Colville River mouth and the Kettle Falls Marina.

Additionally, net pen operators in the lower reservoir at Seven Bays and Lincoln expressed interest in rearing kokanee. The primary kokanee angler harvest also occurred in the lower reservoir. Therefore, kokanee net pens were set up at the Seven Bays Marina and in the Lincoln Cove.

The switch to smolt plants increased age 2 return rates to egg collection facilities; however, angler harvest and age 3 returns remained low (Tilson et al 1996, 1997). Therefore, in 1998 and 1999 a variety of matched pair release experiments were conducted in an attempt to

determine the best release strategies to increase hatchery kokanee returns to egg collection sites and the creel. The results of this study include hypotheses tested on Lake Whatcom kokanee from 1998 through 2000. The objectives of the Lake Roosevelt kokanee coded wire tagging investigations in 1998-2000 were to evaluate the Lake Whatcom stocking protocols using matched paired releases. The specific objectives were:

1. Determine if there was a significant difference in the number of kokanee collected that were imprinted with morpholine vs. non-imprinted.
2. Determine if there was a significant difference in the number of kokanee collected between the early vs. middle run Lake Whatcom stock. This objective was evaluated with Sherman Creek Hatchery releases in 1998 and 1999, as well as the Colville River net pens in 1999.
3. Determine if there was a significant difference in the number of kokanee collected from the early vs. late release dates.
4. Determine if there was a significant difference in the number of kokanee collected from three net pen release strategies. (Sherman Creek vs. Sherman Creek net pens; Sherman Creek net pens vs. Colville River net pens; and upper net pen releases vs. lower net pen releases).

A set of hypotheses were developed and tested using the objectives and three performance measures; (1) kokanee returning to Sherman Creek, the primary egg collection facility, (2) kokanee collected from tributaries throughout the reservoir, to determine if one group of kokanee stayed in the reservoir and were available for harvest, and 3) kokanee collected in the creel, the primary objective of the hatchery kokanee program. A secondary objective was to evaluate the kokanee collected below Grand Coulee Dam at fish passage centers (Rock Island and Rocky Reach).

Methods

Study Area

Lake Roosevelt was formed when Grand Coulee Dam impounded the waters of the Columbia River in 1939 (Figure 1). At full pool the reservoir is 243 kilometers long, inundates 334.9 square kilometers, and has a maximum depth of 122 meters (Stober et al. 1981). At full pool the lake's surface elevation is 1,290 feet above sea level (430 m) and minimum operating pool is 1,208 feet above sea level (403 m). Grand Coulee Dam was constructed primarily for power production, flood control, and irrigation with secondary operations for recreation, fish and wildlife.

Rearing, Marking, Release, and Long Term Tag Retention

Lake Whatcom stock kokanee (LKW) eyed eggs were obtained from the 1996 and 1997 broods from the Lake Whatcom Hatchery in Bellingham, WA, (Washington Department of Fish and Wildlife; WDFW). Fish were raised at the Spokane Tribal Hatchery in Wellpinit, WA. Fish were supplied with a combination of spring and well water 8-11ºC. Fish were feed trained on Biodiet feed from Bioproducts, Inc. Detailed methods for rearing and feeding have been summarized in previous reports (Tilson and Scholz 1998).

All test groups of fish were exposed to morpholine during the swimup phase of development, except the non-morpholine test. Once the fish reached an adequate size (~ 100 mm), all kokanee were adipose fin clipped and a portion of each lot were coded wire tagged. Unique tag numbers were given to each lot of fish based on their origin, release site, release date, and morpholine exposure. Coded wire tags (CWT) were injected into the rostrum using a model MK4 CWT machine (Northwest Marine Technology, Inc.). Fish were released back into the hatchery raceways via a quality control device, which ensured 100% of the fish were marked. Coded wire tagging techniques and quality control have been summarized in detail in previous reports (Tilson and Scholz 1998).

In 1998, residualized smolts were released from the Sherman Creek Hatchery, Sherman Creek net pens, Colville River net pens, Kettle Falls Marina net pens, Seven Bays net pens, Lincoln net pens, and the Spokane River below Little Falls dam (Table 1). Dates of release varied between May 16th and July 12th, 1998.

In 1999, smolts were released from the Sherman Creek Hatchery, Colville River net pens, and the Spokane River below Little Falls Dam (Table 1). Dates released varied between March 22 and July 29th, 1999. Additional kokanee, with just adipose fin clips, were stocked during 1999. A complete stocking history was summarized in Appendix A.

In previous Lake Roosevelt studies, tag retention could be determined from returning fish because all kokanee were coded wire tagged and adipose fin clipped. In 1999 and 2000, a portion of the fish were only adipose fin clipped, so tag retention could not be calculated for the year. In 1996 tag retention of returning age 2 smolts was estimated at 74%, in 1997 it was 0.90%, and in 1998 it was estimated at 73% (Tilson et al. 1997, 1998). Therefore the average long term CWT retention was estimated to be 79% for returning age 2 smolts. The total numbers of CWT kokanee stocked were adjusted for long term tag retention by multiplying the total number stocked by 79%. Long-term tag retention was never established for age 3 fish because returns were low. The number of kokanee estimated after long term retention was used for statistical analysis.

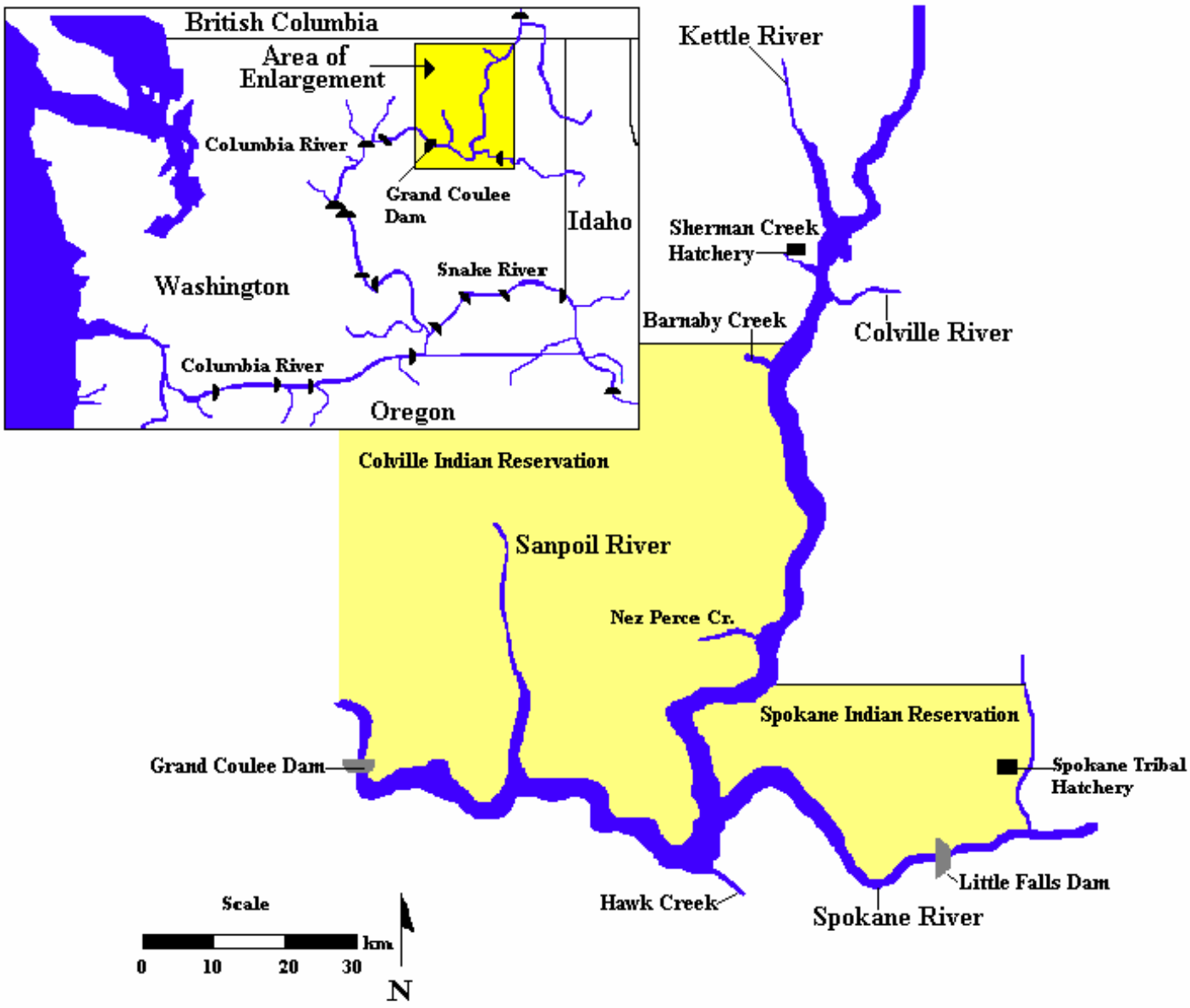

Figure 1. Map of Lake Roosevelt including kokanee hatcheries, rivers, and large tributaries.

Table 1. Coded wire tagged (CWT) kokanee released in Lake Roosevelt during 1998 and 1999.

CWT Code	Brood Year	Date Release	Release Location	Run Time	Expos Odor[1]	Expos Stage [2]	KOK Released	Adjusted Kokanee[3]
			1998 Releases					
62-08-25	1996	5-19-1998	Lincoln Net Pen	middle	MOR	h-su	49,492	39,099
62-08-24	1996	5-20-1998	Seven Bays Net Pen	middle	MOR	h-su	49,187	38,858
62-08-19	1996	5-23-1998	Kettle Falls Net Pen	late	MOR	h-su	67,622	53,421
62-08-20	1996	5-16-1998	Colville River Net Pen	middle	MOR	h-su	95,638	75,554
62-08-26	1996	5-29-1998	Sherman Cr. Net Pen	middle	MOR	h-su	56,328	44,499
62-08-23	1996	10-5-97	Colville River	middle	MOR	h-su	57,442	45,379
62-08-22	1996	5-28-1998	Sherman Creek	middle	MOR	h-su	73,575	58,124
62-08-21	1996	5-28-1998	Sherman Creek	early	NONE	-	72,394	57191
62-08-28	1996	5-28-1998	Sherman Creek	early	MOR	h-su	86,327	68,198
62-08-27	1996	7-12-1998	Sherman Creek	early	MOR	h-su	38,703	30,757
62-08-30	1996	5-25-1998	Little Falls Dam	early	MOR	h-su	35,000	27,650
62-08-31	1996	6-3-1998	Little Falls Dam	middle	MOR	h-su	10,046	5,794
62-08-31	1996	6-28-1998	Little Falls Dam	middle	MOR	h-su	24,270	14,112
			1999 Releases					
62-03-25	1997	06/16/1999	Colville River Net Pens	early	MOR	h-su	41,771	32,999
62-03-26	1997	06/16/1999	Colville River Net Pens	middle	MOR	h-su	40,982	32,376
62-03-32	1997	06/28/1999	Sherman Creek	middle	MOR	h-su	95,736	75,631
62-03-29	1997	06/28/1999	Sherman Creek	early	MOR	h-su	96,600	76,314
62-03-30	1997	06/28/1999	Sherman Creek	early	NONE	h-su	87,511	69,134
62-03-27	1997	05/11/1999	Spokane River	early	MOR	h-su	41,195	32,544
62-03-28	1997	06/07/1999	Spokane River	middle	MOR	h-su	41,482	32,771

[1]MOR: morpholine

[2]h-su: swim up

[3] Adjusted kokanee: 0.79 correction factor for long term tag retention

Experimental Design for Coded Wire Tag Release Groups

Chi-square tests for independence were used in all statistical analysis (Minitab®; α = 0.05). For each experiment, three tests were conducted; 1) returns to Sherman Creek, 2) kokanee collected at other tributaries in the reservoir, and 3) kokanee collected in the creel. The upper reservoir net pens vs. lower reservoir net pens were only analyzed for returns to tributaries reservoir wide and returns to the creel. The lower reservoir net pen fish were never exposed to Sherman Creek water, therefore they would not be expected to return there.

Morpholine was dripped from Sherman Creek during 1998 (Experiment 1, part I) and not dripped in 1999 (Experiment 1, part II). Experiment 2, part I was conducted during 1998 and 1999, however part II was only conducted during 1998. Experiments 3 and 4 were only conducted in 1999.

Experiment 1: Morpholine vs. Non-morpholine

I. With morpholine drip (1998 release)

Hypothesis 1- (Returns to Sherman Creek)

1-H_o: There was no significant difference in return rates of morpholine exposed and un-exposed kokanee to Sherman Creek.

1-H_1: Morpholine exposed kokanee return at a significantly higher rate than non-exposed kokanee to Sherman Creek.

1-H_2: Un-exposed kokanee return at a significantly higher rate than morpholine exposed kokanee to Sherman Creek.

Hypothesis 2 - (Returns to tributaries throughout the reservoir)

2-H_o: There was no significant difference in the return rates of morpholine exposed and un-exposed kokanee throughout Lake Roosevelt.

2-H_1: Morpholine exposed kokanee returned at a significantly higher rate compared to un-exposed kokanee throughout Lake Roosevelt.

2-H_2: Un-exposed kokanee returned at a significantly higher rate compared to morpholine exposed kokanee throughout Lake Roosevelt.

Hypothesis 3 - (Returns to the creel)

3-H_o: There was no significant difference in the return rates of morpholine exposed and un-exposed kokanee in the creel.

3-H_1: Morpholine exposed kokanee returned at a significantly higher rate compared to un-exposed kokanee in the creel.

3-H_2: Un-exposed kokanee returned at a significantly higher rate compared to morpholine exposed kokanee in the creel.

II. Without morpholine drip (1999 release)

Hypothesis 1- (Returns to Sherman Creek)

1-H_o: There was no significant difference in return rates of morpholine exposed and un-exposed kokanee to Sherman Creek.

1-H_1: Morpholine exposed kokanee return at a significantly higher rate than non-exposed kokanee to Sherman Creek.

1-H_2: Un-exposed kokanee return at a significantly higher rate than morpholine exposed kokanee to Sherman Creek.

Hypothesis 2 - (Returns to tributaries throughout the reservoir)

2-H_o: There was no significant difference in the return rates of morpholine exposed and un-exposed kokanee throughout Lake Roosevelt.

2-H_1: Morpholine exposed kokanee returned at a significantly higher rate compared to un-exposed kokanee throughout Lake Roosevelt.

2-H_2: Un-exposed kokanee returned at a significantly higher rate compared to morpholine exposed kokanee throughout Lake Roosevelt.

Hypothesis 3 - (Returns to the creel)

3-H_o: There was no significant difference in the return rates of morpholine exposed and un-exposed kokanee in the creel.

3-H_1: Morpholine exposed kokanee returned at a significantly higher rate compared to un-exposed kokanee in the creel.

3-H_2: Un-exposed kokanee returned at a significantly higher rate compared to morpholine exposed kokanee in the creel.

Experiment 2: Early vs. Middle Run

I. Sherman Creek Hatchery Releases (1998 and 1999)

Hypothesis 1- (Returns to Sherman Creek)

1-H_o: There was no significant difference in the return rates of early and middle run kokanee to Sherman Creek.

1-H_1: Early run kokanee returned at a significantly higher rate than middle run kokanee to Sherman Creek.

1-H_2: Middle run kokanee returned at a significantly higher rate than early run kokanee to Sherman Creek.

Hypothesis 2 - (Returns to tributaries throughout the reservoir)

2-H_o: There was no significant difference in return rates of early and middle run kokanee throughout the reservoir.

2-H_1: Early run kokanee returned at a significantly higher rate compared to middle run kokanee throughout the reservoir.

2-H_2: Middle run kokanee returned at a significantly higher rate compared to early run kokanee throughout the reservoir.

Hypothesis 3 - (Returns to the creel)

3-H_o: There was no significant difference in return rates of early and middle run kokanee to the creel.

3-H_1: Early run kokanee returned at a significantly higher rate compared to middle run kokanee in the creel.

3-H_2: Middle run kokanee returned at a significantly higher rate compared to early run kokanee in the creel.

II. Colville River Net pen Release (1999)

Hypothesis 1- (Returns to Sherman Creek)

1-H_o: There was no significant difference in the return rates of early run and middle run kokanee that returned to Sherman Creek released from the Colville River net pens.

1-H_1: Early run kokanee, released from the Colville River net pens, returned at a significantly higher rate than middle run kokanee to Sherman Creek.

1-H_2: Middle run kokanee, released from the Colville River net pens, returned at a significantly higher rate than early run kokanee to Sherman Creek.

Hypothesis 2- (Returns to tributaries throughout the reservoir)

2-H_o: There was no significant difference in the return rates of early and middle run kokanee, released from the Colville River net pens, that were collected throughout the reservoir.

2-H_1: Early run kokanee, released from the Colville River net pens, returned at a significantly higher rate than middle run kokanee throughout the reservoir.

2-H_2: Middle run kokanee, released from the Colville River net pens, returned at a significantly higher rate than early run kokanee throughout the reservoir.

Hypothesis 3- (Returns to the creel)

3-H_o: There was no significant difference in the return rate of early and middle run kokanee, released from the Colville River net pens, in the creel.

3-H_1: Early run kokanee, released from the Colville River net pens, returned at a significantly higher rate than middle run kokanee in the creel.

3-H_2: Middle run kokanee, released from the Colville River net pens, returned at a significantly higher rate than early run kokanee in the creel.

Experiment 3: Early vs. Late Release Dates (1998)

Hypothesis 1- (Returns to Sherman Creek)

1-H_o: There was no significant difference in the return rate of early and late release date kokanee to Sherman Creek.

1-H_1: Early released kokanee returned at a significantly higher rate compared to late released kokanee to Sherman Creek.

1-H_2: Late released kokanee returned at a significantly higher rate compared to late released kokanee to Sherman Creek.

Hypothesis 2- (Returns to tributaries throughout the reservoir)

2-H_o: There was no significant difference in the return rates of early and late release date kokanee throughout the reservoir.

2-H_1: Early date released kokanee returned at a significantly higher rate compared to late date released kokanee throughout the reservoir.

2-H_2: Late date released kokanee returned at a significantly higher rate compared to early date released kokanee throughout the reservoir.

Hypothesis 3- (Returns to the creel)

3-H_o: There was no significant difference in the return rate of early and late date released kokanee in the creel.

3-H_1: Early date released kokanee returned at a significantly higher rate compared to late date released kokanee in the creel.

3-H_2: Late date released kokanee returned at a significantly higher rate compared to early date released kokanee in the creel.

Experiment 4: Net pen Releases (1998)

I- Sherman Creek Hatchery vs. Sherman Creek net pens

Hypothesis 1- (Returns to Sherman Creek)

1-H_o: There was no significant difference in the return rate of Sherman Creek Hatchery and Sherman Creek net pen released kokanee to Sherman Creek.

1-H_1: Sherman Creek Hatchery released kokanee returned at significantly higher rate compared to Sherman Creek net pen released kokanee to Sherman Creek.

1-H_2: Sherman Creek net pen released kokanee retuned at a significantly higher rate compared to Sherman Creek Hatchery released kokanee to Sherman Creek.

Hypothesis 2- (Returns to tributaries throughout the reservoir)

2-H_o: There was no significant difference in the return rate of Sherman Creek Hatchery and Sherman Creek net pen kokanee throughout the reservoir.

2-H_1: Sherman Creek Hatchery kokanee returned at a significantly higher rate compared to Sherman Creek net pen kokanee throughout the reservoir.

2-H_2: Sherman Creek net pen kokanee returned at a significantly higher rate compared to Sherman Creek Hatchery kokanee throughout the reservoir.

Hypothesis 3- (Returns to the creel)

3-H_o: There was no significant difference in the return rate of Sherman Creek Hatchery and Sherman Creek net pen released kokanee in the creel.

3-H_1: Sherman Creek Hatchery kokanee returned at a significantly higher rate compared to Sherman Creek net pen kokanee in the creel.

3-H_2: Sherman Creek net pen kokanee returned at a significantly higher rate compared to Sherman Creek Hatchery kokanee in the creel.

II. Sherman Creek net pens vs. Colville River net pens

Hypothesis 1- (Returns to Sherman Creek)

1-H_o: There was no significant difference in the return rate of Sherman Creek net pen and Colville River net pen kokanee to Sherman Creek.

1-H_1: Sherman Creek net pen kokanee returned at a significantly higher rate compared to Colville River net pen kokanee to Sherman Creek.

1-H_2: Colville River net pen kokanee return at a significantly higher rate compared to Sherman Creek net pen kokanee to Sherman Creek.

Hypothesis 2- (Returns to tributaries throughout the reservoir)

2-H_o: There was no significant difference in the return rate of Sherman Creek net pen kokanee and Colville River net pen kokanee throughout the reservoir.

2-H_1: Sherman Creek net pen kokanee returned at a significantly higher rate than Colville River net pen kokanee throughout the reservoir.

2-H_2: Colville River net pen kokanee returned at a significantly higher rate than Sherman Creek net pen kokanee throughout the reservoir.

Hypothesis 3- (Returns to the creel)

3-H_o: There was no significant difference in the return rate of Sherman Creek net pen kokanee and Colville River net pen kokanee in the creel.

3-H_1: Sherman Creek net pen kokanee returned at a significantly higher rate than Colville River net pen kokanee in the creel.

3-H_2: Colville River net pen kokanee returned at a significantly higher rate than Sherman Creek net pen kokanee in the creel.

III. Upper reservoir net pens vs. Lower reservoir net pens

Hypothesis 1- (Returns to tributaries throughout the reservoir)

1-H_o: There was no significant difference in the return rate of upper reservoir net pen kokanee and lower reservoir net pen kokanee throughout the reservoir.

1-H_1: Upper reservoir net pen kokanee returned at a significantly higher rate compared to lower reservoir net pen kokanee throughout the reservoir.

1-H_2: Lower reservoir net pen kokanee returned at a significantly higher rate compared to upper reservoir net pen kokanee throughout the reservoir.

Hypothesis 2- (Returns to the creel)

2-H_o: There was no significant difference in the return rate of upper and lower reservoir net pen kokanee in the creel.

2-H_1: Upper reservoir net pen kokanee returned at a significantly higher rate compared to lower reservoir net pen kokanee in the creel.

2-H_2: Lower reservoir net pen kokanee returned at a significantly higher rate compared to upper reservoir net pen kokanee in the creel.

Sampling Procedures

Kokanee recovery during 1998-2000 in Lake Roosevelt was conducted between August 15th and December 1st (weather permitting). Kokanee collection in Lake Roosevelt was two tiered:

1. Weekly electrofishing surveys were conducted at Sherman Creek to collect kokanee returning to the primary egg collection location. Backpack electrofishing in Sherman Creek was also utilized when the kokanee moved into the creek.
2. Five passes through the reservoir were conducted during the study period. A pass consisted of electrofishing for 10 minute transects at the primary embayments to Lake Roosevelt. In 1998, 268 embayments were sampled, but only the primary embayments were sampled 5 times (121). In 1999, the primary 121 embayments were sampled approximately 5 times, and in 2000, 86 embayments were sampled five times. These including areas of the Sanpoil River, Hawk Creek, Spokane River, and the Kettle River. Sites were sampled at approximately 2 week intervals (Figure 2).

All kokanee collected were checked with a coded wire tag detector to determine if a CWT was present, measured to the nearest mm (TL), and a sub-sample was weighed. Kokanee with CWT were sacrificed and the heads placed in individually numbered bags for later analysis.

WDFW personnel dripped morpholine into Sherman Creek between August and December of 1998 to attract the morpholine-exposed kokanee. However, in 1999 the proper

permits were not obtained in time to drip during the fall spawning run. The Lake Roosevelt Monitoring Team decided not to drip morpholine at Sherman Creek in 1999 because they felt the 1998 results were adequate (M. Combs, WDFW and K. Underwood, STOI, personal communication).

Lake Roosevelt creel clerks conducted surveys throughout Lake Roosevelt between 1998 and 2000. Surveys were a cooperative effort between the Spokane Tribe of Indians (STOI), the Colville Confederated Tribe (CCT), and the WDFW. Creel clerks took heads of hatchery kokanee captured by anglers. Heads were then sent to EWU for analysis.

Supplemental creel information was obtained through a test fishery. The test fishery is a cooperation between employees that work on Lake Roosevelt from the STOI, CCT, WDFW, and EWU. During 4 days in the middle of January, the participants angle in the Spring Canyon area for kokanee. Total lengths, weights, and origin (hatchery/wild) were noted for all fish captured.

Rock Island Dam and Rocky Reach Dam monitored their fish passage centers from April 1st to August 31st during 1998, 1999, and 2000. During 1998, all hatchery kokanee with adipose fin clips and coded wire tags were collected and sent to EWU. During 1999 and 2000 coded wire tagging studies on the Lake Wenatchee sockeye took place, therefore only coded wire tagged kokanee/sockeye greater than 170 mm were sacrificed and returned to EWU as Lake Roosevelt kokanee (L. Praye, WDFW personal communication).

All coded wire tags were extracted from kokanee heads at the EWU fisheries research center and examined with a dissecting microscope to determine the binary code. For quality control 100% of the tags were re-read.

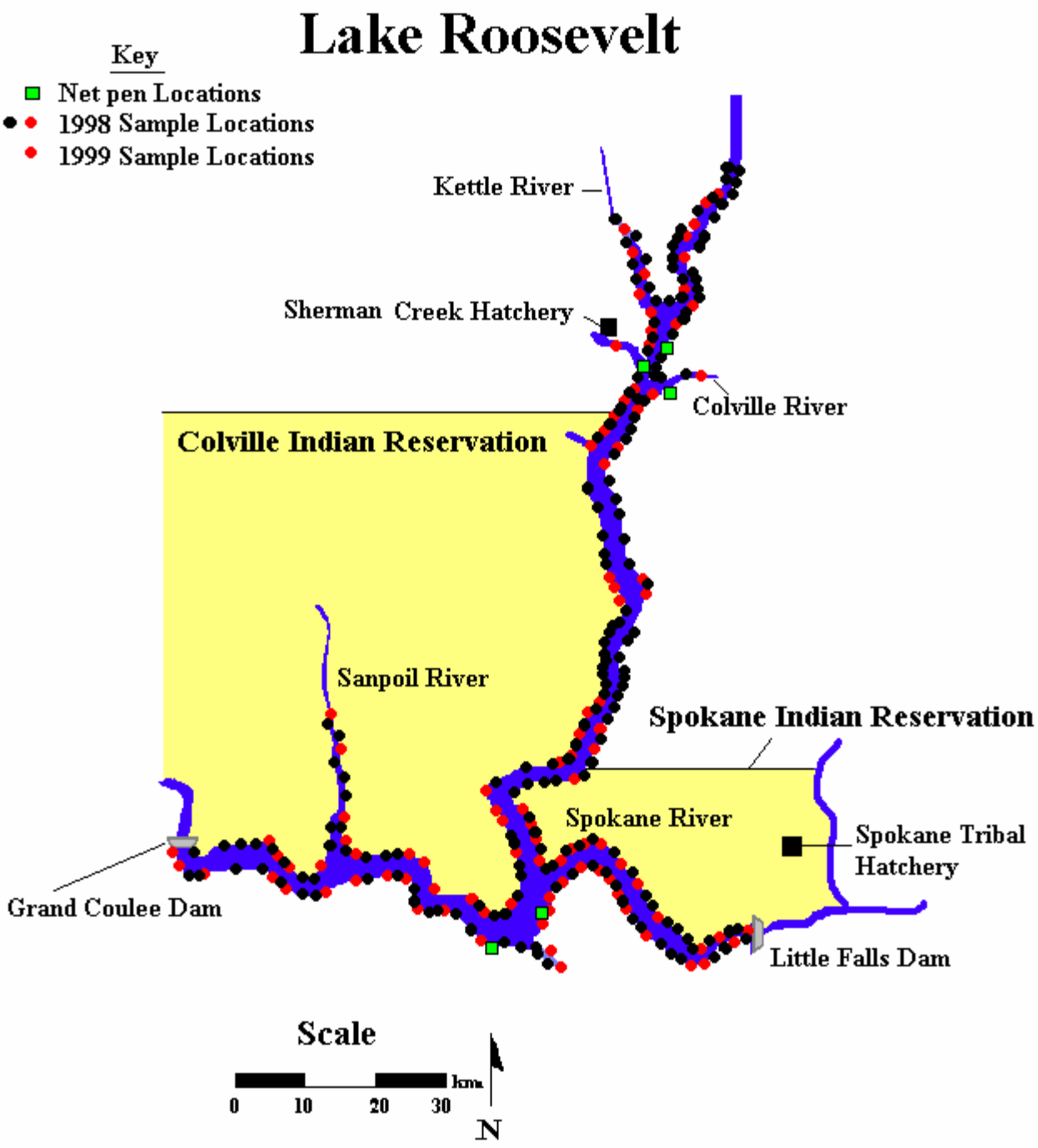

Figure 2. Map of sites sampled during 1998 and 1999 for kokanee collection and net pen release locations during 1998 in Lake Roosevelt.

Results

General Results

1998 Summary

Kokanee sampling occurred between August 17th, and December 10th, 1998. A total of 286 sites were sampled over 50 different days, for 117.8 hours (7,066 min.). An additional 4.9 hours of backpack electrofishing was conducted in Sherman Creek. Two seine hauls were conducted in the plunge pool at Hawk Creek.

A total of 3,453 kokanee were collected by EWU in Lake Roosevelt (Table 2). Of those, 2,460 were adipose fin clipped and had CWTs (AD+), 701 were adipose fin clipped with no CWT (AD-), 126 were adipose fin clipped and not checked for CWT (AD), 42 had a CWT but no adipose clips (NO+), and 124 kokanee had no adipose clip or CWT (NO-; wild kokanee).

The majority of fish were captured at Sherman Creek (71%; n = 2,449), followed by Hawk Creek (10%; n = 353), Barnaby Creek (4%; n = 152), Little Falls (3%; n = 94), and the Colville River (2%; n = 61). Kokanee collected at each sample site was summarized in Appendix B. Catch-per-unit effort (fish/hr) and relative abundance (%) of each species of fish captured was summarized in Appendix C.

November 4th, 1998 was the largest kokanee collection day at Sherman Creek (n = 498; Figure 3). The number of kokanee collected on October 14th was artificially low due to heavy rain and thunderstorms that ended sampling at 5:00 p.m. Catch-per-unit-effort (CPUE) was also highest on November 4th with 461 fish/hour (Table 3).

The overall female to male ratio was 1:8 (355 females: 3,014 males). The hatchery kokanee collected at Hawk Creek had a female to male ration of 1:5 (49 females: 260 males), and the wild kokanee collected at Hawk Creek had a 1:1.3 female to male ratio (18 females: 24 males).

A total of 3,785 kokanee heads were analyzed for coded wire tags; EWU collected 3,345 heads, CCT 36 heads, STOI 326 heads, and WDFW 42 heads. Of those, 1,073 did not have coded wire tags and 27 were lost, for a total of 2,685 CWT analyzed.

A total of 271 kokanee heads were analyzed for CWTs from fish collected below Grand Coulee Dam in 1998. The majority of fish were collected by WDFW at the Rock Island Dam bypass facility (n=246). Two fish were collected in an adult trap on the Nespelem River (Rufus

Woods Reservoir), and 23 CWT kokanee were collected by Chelan County PUD at the Rocky Reach Dam.

Age composition of spawning hatchery kokanee collected during the fall of 1998 in Lake Roosevelt was 92% (n = 2,423) age 2 fish, and 8% (n = 206) age 3 fish. Mean total length at maturity of age 2 kokanee was 299 mm TL (± 25; standard deviation, S.D.) and age 3 kokanee averaged 428 mm TL (± 33 S.D; Table 4). The age 3 kokanee were from fish planted in 1997, and not directly a part of these experiments.

Table 2. Effort and number of kokanee collected per section of Lake Roosevelt during 1998.

Location	Effort (min)	AD	AD-	AD+	NO-	NO+	Grand Total
Grand Coulee/Spring Canyon	431	0	9	24	6	2	41
Keller Ferry	362	0	10	50	3	2	65
Sanpoil River	179	0	0	0	0	0	0
Hawk Creek-Seven Bays	1,020	46	58	215	44	2	365
Fort Spokane	349	0	5	30	2	2	39
Hunters	725	0	7	36	4	2	49
Gifford	268	0	1	3	1	0	5
Bradbury Beach	444	1	33	120	3	1	158
Kettle Falls/Sherman Ck	1,730	71	554	1,866	20	23	2,534
Evans/China Bend	226	0	10	23	18	0	51
Porcupine Bay	716	6	3	16	6	0	31
Little Falls	616	2	11	77	17	8	115
Grand Total	7,066	126	701	2,460	124	42	3,453

AD = adipose fin clipped (did not check for coded wire tag, CWT).
AD- = adipose fin clip, without CWT.
AD+ = adipose fin clip, with CWT.
NO- = No adipose fin clip, no CWT.
NO+ = No adipose fin clip, with CWT.

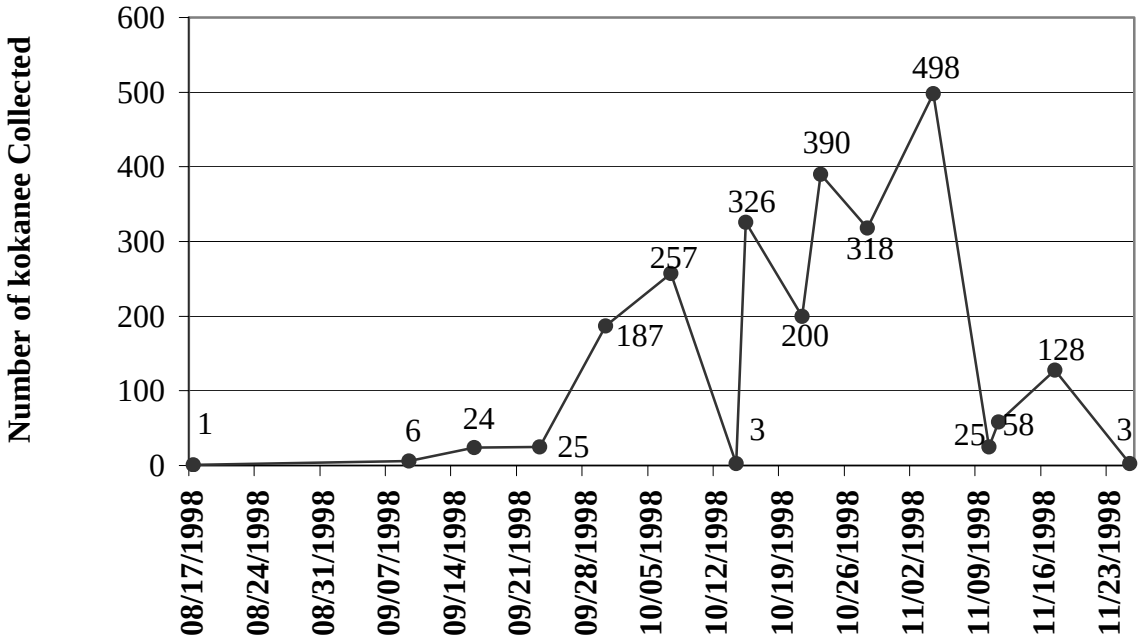

Figure 3. Total number of kokanee collected per date at Sherman Creek, 1998 (n = 2,449).

Table 3. Number of fish (n), total effort (boat and backpack electrofishing), and catch-per-unit-effort (CPUE) of kokanee collected at Sherman Creek, 1998.

Date	n	Effort (min)	Effort (hr)	CPUE (fish/hr)
08/17/98	1	20	0.33	3
09/09/98	6	20	0.33	18
09/16/98	24	10	0.17	144
09/23/98	25	57	0.95	26
09/30/98	187	35	0.58	321
10/07/98	257	127	2.12	121
10/14/98	3	25	0.42	7
10/15/98	326	90	1.50	217
10/21/98	200	45	0.75	267
10/23/98	390	100	1.67	234
10/28/98	318	70	1.17	273
11/04/98	498	65	1.08	461
11/10/98	25	35	0.58	43
11/11/98	58	25	0.42	137
11/17/98	128	42	0.71	181
11/25/98	3	38	0.63	5
12/10/98	0	28	0.47	0
Grand Total	**2,449**	**833**	**13.88**	**176**

Table 4. Mean total length (TL), standard deviation (S.D.), minimum length (Min TL) and maximum length (Max TL) of Whatcom stock kokanee collected from each lot number and age, 1998.

Lot # and Age	n	Average TL (mm)	S.D.	Min TL (mm)	Max TL (mm)
		Age 2 kokanee			
62-08-19	65	296	27	200	350
62-08-20	115	297	25	212	356
62-08-21	633	301	25	205	396
62-08-22	458	300	25	225	395
62-08-23	8	333	20	300	357
62-08-24	19	315	29	244	346
62-08-25	10	331	25	286	365
62-08-26	171	293	24	192	358
62-08-27	123	291	27	205	376
62-08-28	722	300	22	194	399
62-08-30	28	298	29	235	363
62-08-31	68	284	35	210	369
Total	**2,420**	**299**	**25**	**192**	**399**
		Age 3 kokanee			
62-52-20	11	442	27	410	497
62-55-29	1	480	0	480	480
62-55-32	144	426	34	250	491
62-55-33	4	458	23	433	485
62-55-34	6	449	38	385	481
62-55-35	4	432	16	410	446
62-55-36	5	445	10	431	455
62-55-38	1	409	0	409	409
62-55-39	2	448	21	433	463
62-55-40	8	419	22	374	443
62-55-41	4	415	52	340	458
62-55-42	6	410	12	397	430
62-56-44	8	428	25	399	455
62-56-45	2	415	11	407	423
Total	**206**	**428**	**33**	**250**	**497**

*Age 3 fish were from fish released during 1997, which were not a part of these experiment.

1999 Summary

Kokanee sampling was conducted between August 16th and December 1st, 1999. A total of 121 different sites were sampled during 74.9 hours (4,493 min) on 38 different days (Table 5). An additional 2.3 hours (140.7 min) of backpack electrofishing was conducted in Sherman Creek. The number of sites was reduced from 1998 because no fish were captured at a majority of the sites sampled.

A total of 1,473 kokanee were collected through out the reservoir by EWU. Of those, 554 were AD-, 892 kokanee were AD+, 25 were NO-, and 2 kokanee were NO+. The majority of fish were captured at Sherman Creek (85%; n = 1,250). The second highest collection site was Little Falls, in which 81 AD-, 21 AD+, and 1 NO- were collected (n = 103), followed by Hawk Creek, with 27 AD-, 29 AD+, and 11 NO- (n = 67). Kokanee collected at each site sampled were summarized in Appendix B. Catch-per-unit effort (fish/hr) and relative abundance (%) of each species of fish captured was summarized in Appendix C. Kokanee with blue floy tags (n = 18) and orange photonic tags (n = 3) at Sherman Creek, as well as one blue floy tag recapture at Hawk Creek (Appendix D).

September 29th and October 27th were the two largest kokanee collection days at Sherman Creek during the season, 366 and 382 respectively (Figure 4). September 29th had the highest CPUE (549 fish/hour; Table 6).

A total of 1,012 kokanee heads were analyzed for coded wire tags; EWU collected 892 heads, STOI collected 116 heads, and the CCT collected 4 heads. Of those, 69 did not have CWTs, therefore 943 CWTs were analyzed for the binary code. Rock Island and Rocky Reach Dams sent us 106 kokanee in which 78 heads had CWTs. Of the 778 kokanee that had CWTs, 97% (751) of them were the three experimental releases from Sherman Creek; (62-03-29,30,32; Table 8). The three lots of kokanee were released from Sherman Creek. The kokanee from each of these three release strategies returned at similar rates during the sampling period (Figure 5).

The female to male ratio of fish collected throughout the reservoir was 1:22 (64 females: 1,465 males). All of the kokanee collected in the Sanpoil River were wild, and 4 were females and 3 were males.

Age composition of spawning kokanee in 1999 was 91% (n = 929) age 2 kokanee, 8% (n = 80) age 3, and 1% (n = 12) age 4. The majority of age 3 kokanee (75%; n = 60) were collected below Grand Coulee Dam.

Mean TL (mm) at maturity of kokanee collected during the fall were summarized for each tag lot # and age (Table 7). Age 2 kokanee averaged 303 (± 28 S.D.), age 3 fish averaged 352 (± 69 S.D.), and age 4 fish averaged 477 (± 22 S.D.).

Table 5. Effort and number of kokanee collected per section of Lake Roosevelt during 1999.

Location Name	Effort (min)	AD-	AD+	NO-	NO+	Total
Grand Coulee/Spring Canyon	267	0	0	0	0	0
Keller Ferry	213	0	1	0	0	1
Sanpoil River	112	0	0	7	0	7
Hawk Creek- Seven Bays	778	27	32	11	0	70
Fort Spokane	286	0	2	0	0	2
Hunters	300	0	3	0	0	3
Gifford	125	2	1	0	0	3
Bradbury Beach	283	0	3	0	0	3
Kettle Falls/Sherman Ck	1085	441	820	4	2	1,267
Evans/China Bend	165	1	1	1	0	3
Porcupine Bay	604	1	5	0	0	6
Little Falls	415	81	23	1	0	105
Grand Total	**4,633**	**554**	**892**	**25**	**2**	**1,473**

AD = adipose fin clipped (did not check for coded wire tag, CWT).
AD- = adipose fin clip, without CWT.
AD+ = adipose fin clip, with CWT.
NO- = No adipose fin clip, no CWT.
NO+ = No adipose fin clip, with CWT.

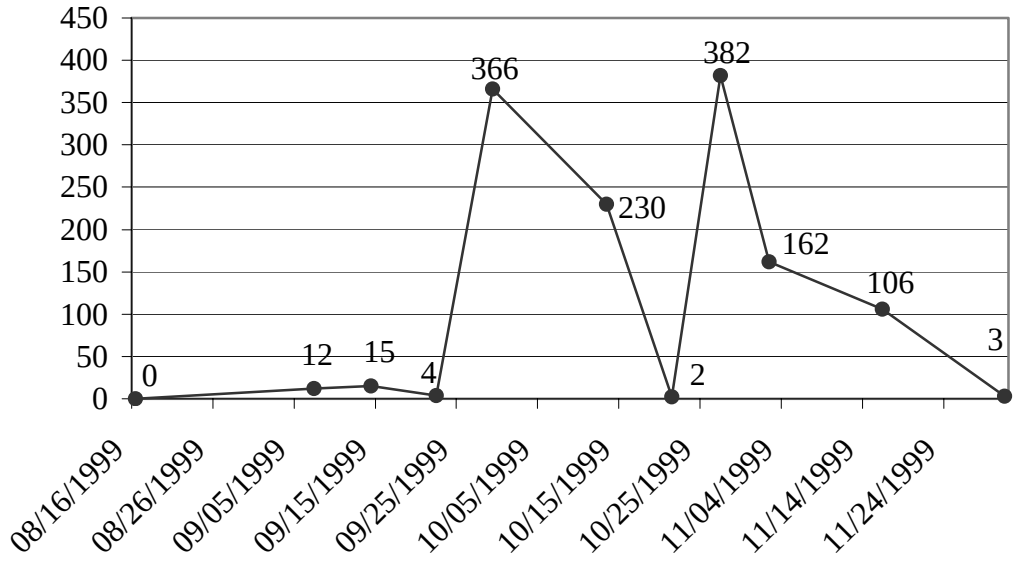

Figure 4. Number of kokanee collected per date at Sherman Creek via boat and backpack electrofishing, 1999 (n = 1,282).

Table 6. Number, effort, and catch-per-unit-effort (CPUE) of kokanee collected at Sherman Creek per date, 1999.

Date	# Fish	Effort (min)	Effort (hr)	CPUE (fish/hour)
08/16/99	0	25	0.42	0.0
09/07/99	12	15	0.25	48.0
09/14/99	15	50	0.83	18.0
09/22/99	4	12	0.20	20.3
09/29/99	366	40	0.67	549.0
10/13/99	230	60	1.00	230.0
10/21/99	2	47	0.78	2.6
10/27/99	382	89	1.48	257.8
11/02/99	162	29	0.48	337.9
11/16/99	106	57	0.94	112.6
12/01/99	3	44	0.74	4.0
Grand Total	**1,282**	**467.45**	**7.79**	**164.6**

Table 7. Number of kokanee collected by EWU at Sherman Creek per lot number per date, 1999. NP = net pens; E,M = early run and morpholine exposed; E,NM = early run non-morpholine exposed; and M,M = mid run and morpholine exposed.

Release Location	Binary #	09/07/99	09/14/99	09/22/99	09/29/99	10/13/99	10/21/99	10/27/99	11/02/99	11/16/99	12/01/99	Grand Total
					Age 2 Kokanee							
Colville River NP	62-03-25				2	2		3	1	2		10
Colville River NP	62-03-26				1	3		5	2	2		13
Little Falls	62-03-27							1				1
Sherman Ck (E,M)	62-03-29	4	5	1	73	48	1	61	32	14		239
Sherman Ck (E,NM)	62-03-30	2	6	1	75	42	1	82	33	18		260
Sherman Ck (M,M)	62-03-32	1		1	65	43		86	33	22	1	252
					Age 3 Kokanee							
Sherman Ck	62-08-21[2]									1		1
Sherman Ck	62-55-32[2]								1	1		2
Grand Total		**7**	**11**	**3**	**216**	**138**	**2**	**238**	**102**	**60**	**1**	**778**

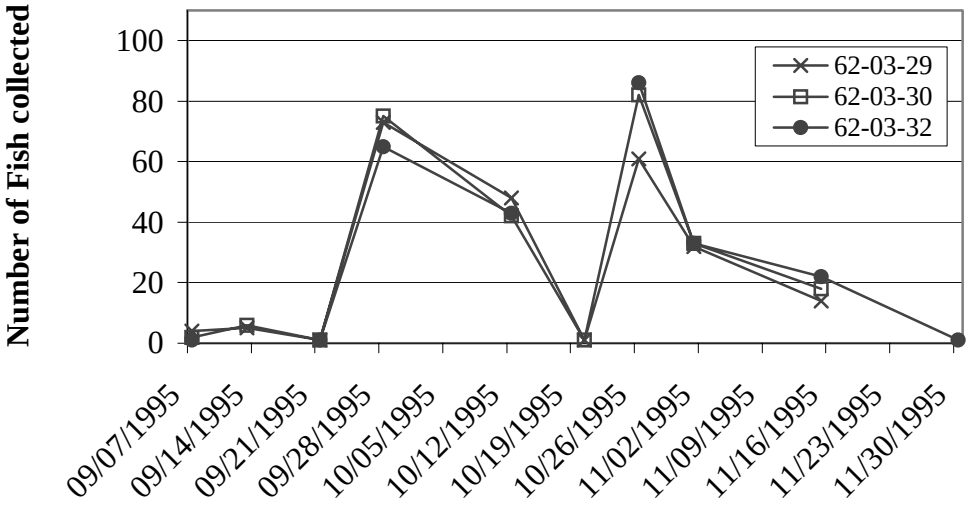

Figure 5. The number of kokanee from each coded wire tagged group collected per date at Sherman Creek (62-03-29,30,32).

Table 8. Mean total length (TL), standard deviation (S.D.), minimum length (Min TL) and maximum length (Max TL) of Whatcom stock kokanee collected from each lot number and age, 1999.

Lot # and Age	n	Mean TL (mm)	S.D.	Min TL (mm)	Max TL (mm)
		Age 2 kokanee			
62-03-25	27	309	26	251	351
62-03-26	23	304	43	196	369
62-03-27	15	299	36	242	350
62-03-28	5	284	6	279	293
62-03-29	267	300	26	203	390
62-03-30	296	307	28	215	432
62-03-32	275	302	28	251	382
Total	**907**	**303**	**27**	**180**	**432**
		Age 3 kokanee			
62-08-20	1	286	0	286	286
62-08-21	1	407	0	407	407
62-08-22	4	374	74	294	451
62-08-24	1	340	0	340	340
62-08-26	1	310	0	310	310
62-08-27	1	309	0	309	309
62-08-28	7	350	76	279	458
62-08-30	1	449	0	449	449
62-08-31	3	334	88	260	432
Total	**20**	**352**	**69**	**260**	**458**
		****Age 4 kokanee***			
62-52-20	2	471	13	461	480
62-55-32	5	473	24	440	503
62-56-44	1	496	0	496	496
Total	**8**	**475**	**21**	**440**	**503**

*Age 4 fish were stocked into Lake Roosevelt in 1996 and were not a part of this experiment.

2000 Summary

Sampling was conducted between August 17th and November 7th, 2000. A total of 89 sites were sampled for 70.7 hours (4,242 min.) on 33 different days (Table 9). A total of six age 3 fish were collected. Five fish were collected at Sherman Creek and one at Hawk Creek. Of the kokanee that returned to Sherman Creek, one was from the 1998 Colville River net pen release (early run; 62-03-25), two from the Sherman Creek release (62-03-29), and one from the Sherman Creek release (middle run; 62-03-32). The one age 3 fish collected in Hawk Creek was from the Colville River net pen release (62-03-25). The age 3 kokanee collected during the fall spawning period averaged 401 mm TL (± 52, S.D.). Catch-per-unit effort and relative abundance of all fish species captured was summarized in Appendix C.

Table 9. Effort and number of kokanee collected per section of Lake Roosevelt during 2000.

Location	Effort (min)	AD-	AD+	NO-	Total
Grand Coulee/Spring Canyon	337	0	0	0	0
Keller Ferry	205	0	0	0	0
Sanpoil	138	0	0	0	0
Hawk Creek/Seven Bays	618	0	1	0	1
Fort Spokane	328	0	0	0	0
Hunters	318	0	0	0	0
Gifford	212	0	0	0	0
Bradbury Beach	271	0	0	0	0
Kettle Falls/Sherman Ck	888	0	5	0	5
Evans/China Bend	160	0	0	0	0
Porcupine Bay	490	0	0	0	0
Little Falls	351	0	0	0	0
Grand Total	**4,316**	**0**	**5**	**0**	**6**

* This table includes age 3 fish only. Additional age 2 fish were collected, but were not a part of these experiments.
AD- = adipose fin clip, without CWT.
AD+ = adipose fin clip, with CWT.
NO- = No adipose fin clip, no CWT.

Sherman Creek and Other Tributary Results

Values used for statistical analysis of returning kokanee were summarized (Table 10). Age 3 kokanee did not return to Sherman Creek or to other tributaries throughout the reservoir in large enough numbers to perform statistical tests. Chi-square tests were only conducted on age 2 fish that returned to Sherman Creek and other tributaries to the reservoir. Reservoir wide tests included kokanee that returned to Sherman Creek.

Table 10. Age 2 and 3 kokanee collected per coded wire tag lot at Sherman Creek and at other tributaries throughout the reservoir between 1998 and 2000.

CWT	Date	Release	Run	Expos	Fish	Sherman Creek		Reservoir	
Code	Release	Location	Time	Odor	Released	Age 2	Age 3	Age 2	Age 3
1998-1999 Experiment Returns									
62-08-25	5-19-1998	Lincoln NP	middle	MOR	39,099	2	0	8	0
62-08-24	5-20-1998	Seven Bays NP	middle	MOR	38,858	3	0	16	1
62-08-19	5-23-1998	Kettle Falls NP	late	MOR	53,421	32	0	33	0
62-08-20	5-16-1998	Colville River NP	middle	MOR	75,554	69	0	46	1
62-08-26	5-29-1998	Sherman Cr. NP	middle	MOR	44,499	123	0	48	1
62-08-22	5-28-1998	Sherman Creek	middle	MOR	58,124	365	1	93	3
62-08-21	5-28-1998	Sherman Creek	early	NONE	57,191	483	1	151	0
62-08-28	5-28-1998	Sherman Creek	early	MOR	68,198	528	1	194	6
62-08-27	7-12-1998	Sherman Creek	early	MOR	30,575	97	0	26	1
62-08-30	5-25-1998	Little Falls Dam	early	MOR	27,650	4	0	22	1
62-08-31	6-3 & 28-1998	Little Falls Dam	middle	MOR	27,111	0	0	57	3
1999-2000 Experiment Returns									
62-03-25	06/16/1999	Colville River NP	early	MOR	32,999	11	1	16	1
62-03-26	06/16/1999	Colville River NP	middle	MOR	32,376	14	0	9	0
62-03-32	06/28/1999	Sherman Creek	middle	MOR	75,631	259	1	15	0
62-03-29	06/28/1999	Sherman Creek	early	MOR	76,314	247	2	23	0
62-03-30	06/28/1999	Sherman Creek	early	NONE	69,134	270	0	29	0
62-03-27	05/11/1999	Spokane River	early	MOR	32,544	1	0	15	0
62-03-28	06/07/1999	Spokane River	middle	MOR	32,771	0	0	8	0

NP: net pens

Experiment 1: Morpholine vs. Non-morpholine

I. Morpholine drip: 1998 Experiment

There was no significant difference in the number of age 2 kokanee that returned to Sherman Creek between morpholine exposed and non-exposed fish in 1998 ($P = 0.17$). There was no significant difference in the number of age 2 kokanee that were collected throughout the reservoir between morpholine exposed and non-exposed kokanee released from Sherman Creek ($P = 0.40$; Table 11).

Table 11. Returns to Sherman Creek and tributaries of coded wire tagged age 2 and 3 kokanee salmon exposed to morpholine (62-08-28) and not exposed to morpholine (62-08-21) in 1998 when morpholine was dripped.

CWT #	Year	Age	# Released	No. Recovered	Recovery %	χ^2	P-value
				Sherman Creek			
62-08-28	1998	2	68,198	528	0.77		
62-08-21	1998	2	57,191	483	0.84	1.92	0.17
62-08-28	1999	3		1	0.00		
62-08-21	1999	3		1	0.00	X	X
				Tributaries			
62-08-28	1998	2	68,198	722	1.06		
62-08-21	1998	2	57,191	634	1.11	0.72	0.40
62-08-28	1999	3		7	0.00		
62-08-21	1999	3		1	0.00	X	X

X = Sample size to small, statistical test not performed.

II. No morpholine drip: 1999 Experiment

In 1999, match pair releases were made of morpholine and non-morpholine exposed kokanee from Sherman Creek Hatchery. There were significantly more unexposed kokanee collected at Sherman Creek (P = 0.03) and in the reservoir (P = 0.02; Table 12).

Table 12. Returns to Sherman Creek and tributaries of coded wire tagged age 2 and 3 kokanee salmon exposed to morpholine (62-08-29) and not exposed to morpholine (62-08-30) in 1999 when morpholine was not dripped.

CWT #	Year	Age	# Released	No. Recovered	Recovery %	χ^2	P-value
				Sherman Creek			
62-03-29	1999	2	76,314	247	0.32		
62-03-30	1999	2	69,134	270	0.39	4.58	0.03
62-03-29	2000	3		2	0.00		
62-03-30	2000	3		0	0.00	X	X
				Tributaries			
62-03-29	1999	2	76,314	270	0.35		
62-03-30	1999	2	69,134	299	0.43	5.76	0.02
62-03-29	2000	3		2	0.00		
62-03-30	2000	3		0	0.00	X	X

X = Sample size to small, statistical test not performed.

Experiment 2: Early vs. Middle run

I. Hatchery releases: 1998 and 1999 Experiments

In 1998, there were significantly more early run age 2 kokanee that returned to Sherman Creek compared to middle run kokanee ($P < 0.01$). In 1999, there was no significant difference in the number of age 2 early run and middle run kokanee that were collected at Sherman Creek ($P = 0.53$; Table 13)

In 1998, there were significantly more age 2 early run kokanee collected in the reservoir compared to middle run kokanee ($P < 0.01$). In 1999, there was no significant difference in the number of age 2 early run and middle run kokanee that were collected in the reservoir ($P = 0.78$; Table 14).

Table 13. Returns to Sherman Creek of coded wire tagged kokanee from early run (62-08-28, 62-03-29) and middle run (62-08-22, 62-03-32) age 2 and 3 Lake Whatcom stock released from Sherman Creek hatchery, 1998 and 1999.

CWT #	Age	# Released	Sherman Creek	Recovery %	χ^2	P-value
			1998-1999 Experiment			
62-08-28	2	68,198	528	0.77	9.56	<0.01
62-08-22	2	58,124	365	0.63		
62-08-28	3		1	0.00	X	X
62-08-22	3		1	0.00		
			1999-2000 Experiment			
62-03-29	2	76,314	247	0.32		
62-03-32	2	75,631	259	0.34	0.40	0.53
62-03-29	3		2	0.00		
62-03-32	3		1	0.00	X	X

X = Sample size to small, statistical test not performed.

Table 14. Reservoir wide recoveries of coded wire tagged, early (62-08-28, 62-03-29) and middle run (62-08-22, 62-03-32) age 2 and 3 Lake Whatcom stock kokanee salmon that were released from Sherman Creek hatchery, 1998 and 1999.

CWT #	Age	# Released	Reservoir	Recovery %	χ^2	P-value
			1998-1999 Experiment			
62-08-22	2	58,124	458	0.79		
62-08-28	2	68,198	722	1.06	24.85	<0.01
62-08-22	3		4	0.00		
62-08-28	3		7	0.00	X	X
			1999-2000 Experiment			
62-03-29	2	76,314	270	0.35		
62-03-32	2	75,631	274	0.36	0.08	0.78
62-03-29	3		2	0.00		
62-03-32	3		1	0.00	X	X

X = Sample size to small, statistical test not performed.

II. Colville River net pens: 1999 Experiment

In 1999, early and middle run Whatcom stock kokanee were released from the Colville River net pens. There was no significant difference in the number of age 2 kokanee that returned to Sherman Creek (P = 0.52; Table 15) or were collected throughout the reservoir (P = 0.62; Table 16) from the early and middle runs in 1999.

Table 15. Recoveries of coded wire tagged kokanee at Sherman Creek and other tributaries of age 2 and 3 kokanee salmon released from the Colville River net pens from the early run (62-03-25) and the late run (62-03-26).

CWT #	Year	Age	# Released	No. Recovered	Recovery %	χ^2	P-value
				Sherman Creek			
62-03-25	1999	2	32,999	11	0.03		
62-03-26	1999	2	44,499	14	0.04	0.420	0.52
62-03-25	2000	3		1	0.00		
62-03-26	2000	3		0	0.00		
				Tributaries			
62-03-25	1999	2	39,099	27	0.08		
62-03-26	1999	2	44,499	23	0.07	0.249	0.62
62-03-25	2000	3		2	0.00		
62-03-26	2000	3		0	0.00		

Experiment 3: Sherman Creek Hatchery (Early vs. Late release)

1998 Experiment

There were significantly more age 2 early release (May 29th, 1998) kokanee collected at Sherman Creek ($P < 0.01$) and throughout the reservoir ($P < 0.01$; Table 16) compared to late release fish (July 13th, 1998) in 1998.

Table 16. Returns to Sherman Creek and other tributaries of coded wire tagged age 2 and 3 kokanee salmon released from Sherman Creek Hatchery on early (May 29th, 1998; 62-08-28) and late (July 13th, 1998; 62-08-27) dates.

CWT #	Year	Age	# Released	No. Recovered	Recovery %	χ^2	P-value
				Sherman Creek			
62-08-28	1998	2	68,198	528	0.77		
62-08-27	1998	2	30,575	97	0.32	37.33	<0.01
62-08-28	1999	3		1	0.00		
62-08-27	1999	3		0	0.00	X	X
				Tributaries			
62-08-28	1998	2	68,198	722	1.06		
62-08-27	1998	2	30,575	123	0.40	149.78	<0.01
62-08-28	1999	3		8	0.00		
62-08-27	1999	3		1	0.00	X	X

X = Sample size to small, statistical test not performed.

Experiment 4: Net pen (1998)

I-Sherman Creek hatchery vs. Sherman Creek net pens

During 1998, there were significantly more age 2 kokanee from the hatchery release that returned to Sherman Creek ($P < 0.01$) and were collected throughout the reservoir ($P < 0.01$; Table 17) compared to the Sherman Creek net pen release.

Table 17. Returns to Sherman Creek and tributaries throughout the reservoir of coded wire tagged age 2 and 3 kokanee salmon released from Sherman Creek hatchery (62-08-22) and the Sherman Creek net pens (62-08-26) in 1998.

CWT #	Year	Age	# Released	No. Recovered	Recovery %	χ^2	P-value
				Sherman Creek			
62-08-22	1998	2	58,124	365	0.63		
62-08-26	1998	2	44,499	123	0.28	65.82	<0.01
62-08-22	1999	3		1	0.00		
62-08-26	1999	3		0	0.00	X	X
				Tributaries			
62-08-22	1998	2	58,124	458	0.79		
62-08-26	1998	2	44,499	171	0.38	67.43	<0.01
62-08-22	1999	3		4	0.00		
62-08-26	1999	3		1	0.00	X	X

X = Sample size to small, statistical test not performed.

II-Sherman Creek net pens vs. Colville River net pens

In 1998, significantly more kokanee returned to Sherman Creek ($P < 0.01$) and were collected throughout the reservoir ($P < 0.01$) from the Sherman Creek net pen releases compared to the Colville River net pens (Table 18).

Table 18. Sherman Creek and tributary returns of coded wire tagged age 2 and 3 kokanee salmon released from Sherman Creek net pens (62-08-26), and the Colville River net pens (62-08-20) in 1998.

CWT #	Year	Age	# Released	No. Recovered	Recovery %	χ^2	P-value
				Sherman Creek			
62-08-26	1998	2	44,499	123	0.28		
62-08-20	1998	2	75,554	69	0.09	60.08	<0.01
62-08-26	1999	3		0			
62-08-20	1999	3		0		X	X
				Tributaries			
62-08-26	1998	2	44,499	171	0.38		
62-08-20	1998	2	75,554	115	0.15	63.46	<0.01
62-08-26	1999	3		1	0.00		
62-08-20	1999	3		1	0.00	X	X

X = Sample size to small, statistical test not performed.

III-Upper Reservoir vs. Lower Reservoir net pens

During 1998, there were significantly more age 2 kokanee recovered in the reservoir from the upper reservoir net pen releases (Kettle Falls marina, Sherman Creek, and Colville River) when compared to the lower reservoir net pen releases (Lincoln and Seven Bays; $P < 0.01$; Table 19).

Table 19. Reservoir wide recoveries of coded wire tagged age 2 and 3-year-old kokanee salmon released from net pen sites in the upper reservoir (Kettle Falls Marina, Colville River and Sherman Creek; 62-0819,20,26) and fish from net pens in the lower reservoir (Sevens Bay and Lincoln; 62-08-24,25), 1998.

CWT #	Year	Age	# Released	Reservoir	Recovery %	χ^2	P-value
62-08-19,20,26	1998	2	173,475	351	0.20		
62-08-24,25	1998	2	77,956	29	0.04	97.20	<0.01
62-08-19,20,26	1999	3		1	0.00		
62-08-24,25	1999	3		1	0.00	X	X

X = Sample size to small, statistical test not performed.

Creel Survey Recoveries 1998-2000

In 1998, a total of 36 kokanee were observed in the creel. Of those, 12 were of hatchery origin (STOI, unpublished data). During 1998, STOI estimated that 10,188 kokanee were captured and 9,980 were harvested (Spotts et al. 2000). Since 33% of the kokanee were of hatchery origin, the estimated harvest of hatchery kokanee in 1998 was 3,323 fish.

Eight of the hatchery kokanee had CWTs and adipose fin clips, while the other 4 were only adipose fin clipped. Two of those fish were from releases in 1998, one from Sherman Creek (62-08-21) and one from Little Falls (62-08-31). The other 6 were 3-year-olds from the 1997 releases (Table 20).

The 1999 results from the creel have not been analyzed by STOI. However, creel clerks observed only 2 kokanee during their surveys, 1 was wild and 1 was hatchery. The hatchery fish did not have a CWT, therefore we could not determine which release it came from (K. Underwood, STOI, personal communication).

In 2000, creel clerks did not observe any kokanee. However, two kokanee with coded wire tags were returned to EWU by anglers. Both kokanee were captured at Spring Canyon on

May 12th and were from the 1999 releases. One kokanee was released from the Colville River net pens (62-03-25), and the other was released from Sherman Creek Hatchery (62-03-30).

The test fishery conducted during 1999 and 2000 indicated that the majority of kokanee being harvested were of wild origin. There were 61 kokanee collected in 1999, and only 3 were of hatchery origin (K. Underwood, STOI, personal communication). There were 46 kokanee collected in 2000 and only 1 was of hatchery origin (K. Underwood, STOI, personal communication). The test fishery was only conducted during 1 week of the year at one location on the reservoir.

Table 20. Number and recovery location of kokanee collected in the creel during 1998.

Binary Number	Release Location	Release Year	Number Recovered	Location Recovered
62-08-21	Sherman Creek	1998	1	Hawk Creek
62-08-30	Little Falls	1998	1	Lake Roosevelt
62-55-32	Sherman Creek	1997	4	Hawk Creek/Lake Roosevelt/Qui Qui Creek/Swawilla Basin
62-55-35	Kettle Falls NP	1997	1	Spring Canyon
62-55-40	Sherman Creek	1997	1	Seven Bays
Ad only	Unknown	NA	4	Hawk Creek/ 2 Lake Roosevelt/Qui Qui Creek

Fish Passage Center Recoveries 1998-2000

In 1998, Rock Island Dam and Rocky Reach Dam returned 253 hatchery kokanee to EWU. The majority of them (n = 221; 87%) were from the 1998 releases. The net pens located in the southern part of the reservoir contributed 53% of the fish, Seven Bays (n = 111; 44%) and Lincoln (n = 22; 9%). A fry plant in the Colville River took place during October of 1997, which also experienced high entrainment (n = 62; 25%). An additional 17 (7%) kokanee were from 1997 spring releases. The 17 kokanee from the spring 1997 releases, would have been age 3 spawners in the fall. An additional 15 kokanee did not have CWTs (Table 21).

In 1999, the fish passage centers returned 105 hatchery kokanee to EWU. The majority of these fish were from the 1998 release (n = 59; 56%). Only 13% (n = 14) were from the 1999 releases, and 5% (n = 5) from 1997 releases. An additional 27 (26%) kokanee did not have CWTs (Table 21).

In 2000, a total of 10 kokanee were returned to EWU from the fish passage centers. Three of the fish were wild, while the other seven were from the 1999 releases. Two of the kokanee were released from the Colville River net pens on June 19th 1999 (62-03-25&26). The other five fish were released from the Sherman Creek Hatchery on June 28th, 1999 (Table 25).

Table 21. Number of kokanee per lot recovered below Grand Coulee Dam from Rock Island and Rocky Reach Dams, 1998-2000.

Binary Number	Release Location	Number Recovered 1998	Number Recovered 1999	Number Recovered 2000
		1999 Releases		
62-03-25	Colville River NP		0	2
62-03-26	Colville River NP		2	1
62-03-27	Little Falls		8	0
62-03-29	Sherman Creek		1	2
62-03-30	Sherman Creek		0	3
62-03-32	Sherman Creek		3	1
		1998 Releases		
62-08-19	Kettle Falls NP	0	5	0
62-08-20	Colville River NP	2	6	0
62-08-21	Sherman Creek	5	9	0
62-08-22	Sherman Creek	2	6	0
62-08-23	Colville River (fry)	62	4	0
62-08-24	Seven Bays NP	111	2	0
62-08-25	Lincoln NP	22	2	0
62-08-26	Sherman Creek NP	0	8	0
62-08-27	Sherman Creek	1	1	0
62-08-28	Sherman Creek	11	12	0
62-08-30	Little Falls	2	3	0
62-08-31	Little Falls	3	1	0
		1997 Releases		
62-52-20	Two Rivers NP	1	0	0
62-55-32	Sherman Creek	12	3	0
62-55-34	Kettle Falls NP	0	1	0
62-55-36	Kettle Falls NP	1	0	0
62-55-38	Sherman Creek	0	1	0
62-55-42	Sherman Creek	2	0	0
62-56-45	Little Falls	1	0	0
No Tag	Unknown	15	27	3
Total		**253**	**105**	**12**

Discussion

Coded Wire Tagging Experiments

The morpholine vs. non-morpholine experiment conducted during 1998 indicated that there was no significant difference between the two groups ($P = 0.28$), and morpholine imprinting was not necessary. Consequently, dripping morpholine at Sherman Creek was abandoned during 1999. However, fish released during 1999 had already been imprinted to morpholine prior to the 1998 results. Therefore, the 1999 morpholine-imprinted fish did not have the chemical smell to return to, which could explain why the non-imprinted fish seemed to out perform the imprinted kokanee in 1999 ($P = 0.03$). Not imprinting and dripping morpholine is still recommended, which saves time and money.

One experiment was repeated during the study, early run vs. middle run Whatcom kokanee. In 1998, there was significantly more kokanee that returned from the early run when compared to the middle run kokanee ($P < 0.01$). However in 1999, there was no significant difference in the return rates between early and middle run kokanee ($P = 0.53$). The 1998 data indicated the early run performed better, despite the non-significant 1999 data. If fish return too late in the season, the bay freezes and collection of eggs from returning adults becomes impossible. Using the early run Whatcom stock kokanee is recommended when eggs are available.

In 1998, the kokanee released early (May 29th) returned at significantly higher rates compared to kokanee released later in the summer (July 13th; $P < 0.01$). Kokanee transferred late in the summer were probably not imprinting to the Sherman Creek water because they missed the imprinting that occurred during the spring. Therefore it is recommended that kokanee be released at the end of May or early June.

Significantly more kokanee returned from the Sherman Creek hatchery release compared to the Sherman Creek net pens ($P < 0.01$). Therefore, it is recommended that kokanee be released from the hatchery when possible. Sherman Creek net pens out performed the Colville River net pens ($P < 0.01$). Net pens are necessary for kokanee rearing because of their large release size. It is recommended that fish be kept at the Sherman Creek net pens when possible. During large drawdowns, Sherman Creek bay dewaters and the net pens must be moved to the Colville River.

The upper reservoir net pens had significantly higher returns ($P < 0.01$) when compared to the lower reservoir net pens. The lower reservoir net pens also experienced the highest entrainment compared to the other groups released. In 1998 and 1999, only 30 kokanee (0 in the creel) out of the 71,847 fish released into the reservoir were recovered. At the current time, it is not recommended that kokanee be released from the lower reservoir net pen sites. However, additional experiments to verify the data are recommended.

The majority of kokanee returning to egg collection sites were age 2, which was a year earlier than what has been reported for most other reservoirs and lakes that support kokanee fisheries. Kokanee in Flaming Gorge Reservoir matured at age 3 (40%) and age 4 (60%; Gibson and Hubert 1993). Kokanee in Lake Ozette, Washington matured at age 4 (Beauchamp 1995). Kokanee in the Flathead River system matured at age 3 (92%; Fraley 1984). Kokanee spawning in Granite Creek and Sullivan Springs, Idaho matured at age 3 (58%) and age 4 (42%; Cochnauer 1984).

Mature kokanee from Lake Roosevelt were larger in size at maturity compared to other systems. Mature age 2 kokanee in Lake Roosevelt averaged 299 mm (TL) and age 3 kokanee averaged 428 mm in 1998. Mean TL of spawning kokanee in Dowrshak reservoir averaged 243 mm for males and 239 mm for females (Fredericks et al. 1995). Age 3 spawners in Coeur d'Alene Lake averaged 225 mm TL in 1985. In 1988, kokanee averaged 242 mm TL in Pend Oreille Lake, and averaged 263 mm TL in Priest Lake in 1986 (Reiman and Myers 1992). Age 3 spawners in Lake Granby, Colorado averaged 406 mm TL (Martinez and Wiltzius 1995).

Whatcom kokanee in Lake Roosevelt appear to be growing fast and maturing early, but were not returning to the egg collection facilities in large enough quantities to sustain a fishery. The return rate (# CWT kokanee collected/# CWT collected in the reservoir) of CWT kokanee was 0.51 in 1998 and 0.25 in 1999. Values ranged from 0.02-1.10 in 1998 and 0.07-0.43 in 1999 for individual experiments. The overall return rate included age 3 fish, however 90% of the fish collected were age 2. The overall recovery rates in 1998 and 1999 was similar to the recovery rates in 1995 (0.30%), 1996 (0.20%), and 1997 (0.55%), (Tilson et al. 1997, 1998), which were primarily age 2 fish also. Return rates of age 3 kokanee in Sullivan Springs, Idaho have been as high as 10-12% in 1979 (Cochnauer 1984), but remained between 1.9 and 5.0% during the early 1980's (Bowles et al. 1989). Unfortunately the majority of our results were from age 2 jacks.

Age 2 kokanee do not provide a good brood stock, which is one of the primary goals of the hatchery kokanee program.

Creel Survey

The creel survey conducted during 1998 indicated that 33% of the kokanee fishery was comprised of hatchery fish (Spotts et al. 2000). These numbers were based on a total of 36 kokanee of which 12 were hatchery. STOI has not evaluated the 1999 or 2000 creel data, however only 2 kokanee were observed in the creel during 1999 and none in 2000. The lack of kokanee observed by the creel clerks has prompted managers to evaluate the creel survey methods. The results from the test fishery suggest the hatchery contribution to the creel is less than 33%. However, the test fishery is limited because it is only conducted once a year, in one location of the reservoir.

Due to the conflicting results, between the test fishery and the creel surveys, minimal conclusions can be made from the data. Regardless, it appears that the majority of the kokanee harvested are of wild origin (at least 66%). Recruitment of Whatcom stock of kokanee appeared to be very low, in relation to the numbers planted.

Recoveries Below Grand Coulee

The data collected during 1998 was the most complete. The fish passage centers were able to collect all coded wire tagged and adipose fin clipped kokanee because other sockeye salmon smolt experiments were not being conducted that year. However, sockeye experiments resumed in 1999, limiting the number of kokanee collected. The 1998 entrainment results indicated that net pens in the lower reservoir (Seven Bays or Lincoln) should not be used. The majority of the fish observed below Grand Coulee Dam came from the lower reservoir. The fish were released from the lower reservoir net pens on May 21st, 1998 and were collected as early as June 9th, 1998 at Rock Island Dam. The Colville River fry released fish were also collected in high numbers below Grand Coulee. Historically, fry plants in Lake Roosevelt have rarely recruited to the creel or returned to egg collection facilities. The 1998 data indicated that the Colville River fry plant experienced high entrainment, did not recruit to the creel, or return to Sherman Creek. Returns to the Colville River were not evaluated due to shallow fast moving

water that would require a drift boat. The 1998 and 1999 data indicated the fry plants should not continue, however, sampling using an electrofishing drift boat could evaluate future plants.

The lower reservoir net pen releases were not repeated during 1999, so the number of smolts collected in 1999 decreased. Additionally, the dams did not collect fish smaller than 170 mm, because they could have been sockeye smolts from Lake Wenatchee. Sockeye smolts were also marked with adipose fin clips and CWT. Due to the overlap in marking strategies, the passage centers may have mistakenly identified Lake Roosevelt kokanee smolts as Lake Wenatchee sockeye, resulting in an underestimate of the entrainment of Lake Roosevelt kokanee.

In 2000, a total of 10 kokanee were returned from Rock Island Dam and 0 from Rocky Reach Dam. Three of the fish were wild, while the other seven were 2.5 years old, and would have been 3 the following fall. The numbers of smolts observed in 2000 could have also been artificially low due to the size limitations. It is recommended that the fish passage centers continue to return coded wire tagged and adipose fin clipped kokanee to EWU. Despite the numbers potentially being low, it provides a good indicator as to which release strategies might entrain at higher rates. Future efforts to coordinate with downstream sockeye studies needs to occur to reduce overlap in marking techniques.

Future Experiments

The Whatcom stock of kokanee have not adapted to the conditions in Lake Roosevelt. The kokanee recruit to the creel is unsatisfactory and few kokanee return as three year olds to egg collection facilities. Therefore, we recommend that a new stock of kokanee be used. Kokanee populations native to the upper Columbia River might be better suited for the conditions found in Lake Roosevelt.

Wild stocks of kokanee exist in Arrow Lakes, Kootenay Lakes, and Chain Lakes. The Arrow Lakes and Chain Lakes populations are optimal because the high flow conditions exist in both lakes. However, the Arrow Lakes kokanee are currently on the decline and eggs could not be obtained. It is currently unknown if the Chain Lakes population is native or introduced. Regardless, the current population is small owing to recent over harvesting by anglers. The population does not have more than 50 spawning pairs, therefore disrupting the population was not recommended. The Meadow Creek stock of kokanee found in Kootenay Lake, British Columbia was then selected as an alternative stock.

Paired release experiments will be conducted in 2000 and 2001 to determine if Meadow Creek stock kokanee return to egg collection facilities, and recruit to the creel at significantly higher rates than Whatcom stock kokanee. Age 2 kokanee that return to the egg collection sites do not recruit to the creel and do not provide good brood stock, so the success of the Meadow Creek stock will depend on the returns of age 3 fish in the fall of 2001.

Recommendations

The Whatcom stock of kokanee do not appear to be suitable for the conditions in Lake Roosevelt. Based on our results, we recommend the following:

1. Release matched pairs of Meadow Creek kokanee and Whatcom stock kokanee to compare performance in 2000 and 2001.
2. Monitor returns to the creel, egg collection sites, and major tributaries to Lake Roosevelt during 2001-2002 using similar methods applied in 1998-2000.
3. Continue to collect kokanee from fish passage centers downstream of Grand Coulee Dam during 2001-2002.
4. Explore obtaining the wild stock of kokanee identified by microsatellite DNA analysis as the source for supplementing the Lake Roosevelt kokanee population.

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Appendix A. Kokanee stocked in Lake Roosevelt 1995-1999.

Table 22. Summary of Whatcom stock kokanee salmon released into Lake Roosevelt from 1995 to 1999.

CWT Code	Brood Year	Release Date	Release Location	Kokanee Stock[1]	Run Time	Expos Odor[2]	Expos Stage1	Kokanee Released	Adjusted Kokanee[3,4]	Release (mm)	Release fish/lb.
1995									**0.74**		
62-54-37	1994	07/11/1995	Sherman Creek	LKW	n/a	MOR	h-su	10,855	8,033	73	138
62-54-38	1994	07/11/1995	Sherman Creek	LKW	n/a	MOR	h-su	11,152	8,252	73	138
62-54-39	1994	07/11/1995	Sherman Creek	LKW	n/a	MOR	h-su	11,397	8,434	73	138
62-54-40	1994	07/11/1995	Sherman Creek	LKW	n/a	MOR	h-su	10,772	7,971	73	138
62-54-48	1994	07/17/1995	Chamokane Creek	LKW	n/a	MOR	h-su	11,329	8,383	78	110
Total								**55,505**	**41,073**	**74**	
1996									**0.90**		
62-54-44	1994	06/14/1996	Kettle Falls Net Pen	LKW	n/a	MOR	h-su	11,290	8,355	135	22.5
62-54-45	1994	06/14/1996	Kettle Falls Net Pen	LKW	n/a	MOR	h-su	11,273	8,342	135	22.5
62-54-46	1994	06/14/1996	Kettle Falls Net Pen	LKW	n/a	MOR	h-su	11,305	8,366	135	22.5
62-54-47	1994	06/14/1996	Kettle Falls Net Pen	LKW	n/a	MOR	h-su	8,946	6,620	135	22.5
62-54-62	1994	06/14/1996	Kettle Falls Net Pen	LKW	n/a	MOR	h-su	11,007	8,145	135	22.5
62-54-63	1994	06/14/1996	Kettle Falls Net Pen	LKW	n/a	MOR	h-su	10,961	8,111	135	22.5
62-55-30	1994	06/10/1996	Barnaby Creek	LKW	n/a	PEA	h-su/smolt	15,048	11,136	185	8
62-54-31	1994	06/23/1996	Two Rivers Net Pen	FDR	n/a	NONE	-	11,085	8,203	177	8.5
62-54-32	1994	06/23/1996	Two Rivers Net Pen	FDR	n/a	NONE	-	11,600	8,584	177	8.5
62-54-33	1994	06/23/1996	Two Rivers Net Pen	FDR	n/a	NONE	-	11,656	8,625	177	8.5
62-54-34	1994	06/23/1996	Two Rivers Net Pen	FDR	n/a	NONE	-	9,982	7,387	177	8.5
62-54-35	1994	06/23/1996	Two Rivers Net Pen	FDR	n/a	NONE	-	8,648	6,400	177	8.5
62-54-36	1994	06/23/1996	Two Rivers Net Pen	FDR	n/a	NONE	-	5,181	3,834	177	8.5
62-55-31	1994	06/23/1996	Spokane River	LKW	n/a	PEA	h-su/smolt	40,137	29,701	177	8.5
62-54-50	1994	06/30/1996	Sherman Creek	LKW	n/a	MOR	h-su/smolt	10,711	7,926	170	10.5
62-54-51	1994	06/30/1996	Sherman Creek	LKW	n/a	MOR	h-su/smolt	10,654	7,884	170	10.5
62-54-52	1994	06/30/1996	Sherman Creek	LKW	n/a	PEA	h-su/smolt	10,823	8,009	170	10.5
62-54-53	1994	06/30/1996	Sherman Creek	LKW	n/a	PEA	h-su/smolt	10,780	7,977	170	10.5
62-54-54	1994	06/30/1996	Sherman Creek	LKW	n/a	PEA	h-su/smolt	10,762	7,964	170	10.5

Table 22 Continued

CWT Code	Brood Year	Release Date	Release Location	Kokanee Stock[1]	Run Time	Expos Odor[2]	Expos Stage1	Kokanee Released	Adjusted Kokanee[3,4]	Release (mm)	Release fish/lb.
62-54-55	1994	06/30/1996	Sherman Creek	LKW	n/a	PEA	h-su/smolt	10,980	8,125	170	10.5
62-54-56	1994	06/30/1996	Sherman Creek	LKW	n/a	MOR	h-su/smolt	10,864	8,039	170	10.5
62-54-57	1994	06/30/1996	Sherman Creek	LKW	n/a	MOR	h-su/smolt	10,721	7,934	170	10.5
62-54-58	1994	06/30/1996	Sherman Creek	LKW	n/a	MOR	h-su/smolt	10,572	7,823	170	10.5
62-54-59	1994	06/30/1996	Sherman Creek	LKW	n/a	MOR	h-su/smolt	10,536	7,797	170	10.5
62-54-60	1994	06/30/1996	Sherman Creek	LKW	n/a	MOR	h-su/smolt	10,438	7,724	170	10.5
62-54-61	1994	06/30/1996	Sherman Creek	LKW	n/a	MOR	h-su/smolt	10,577	7,827	170	10.5
62-55-05	1994	06/30/1996	Sherman Creek	LKW	n/a	MOR	h-su/smolt	10,749	7,954	170	10.5
62-55-06	1994	06/30/1996	Sherman Creek	LKW	n/a	MOR	h-su/smolt	10,722	7,934	170	10.5
62-55-07	1994	06/30/1996	Sherman Creek	LKW	n/a	MOR	h-su/smolt	10,848	8,028	170	10.5
62-55-09	1994	06/30/1996	Sherman Creek	LKW	n/a	MOR	h-su/smolt	7,816	5,784	170	10.5
62-55-29	1994	07/02/1996	Sherman Creek	LKW	n/a	PEA	h-su/smolt	31,170	23,066	175	9.6
Total								**377,842**	**279,604**	**165**	
1997									**0.73**		
62-55-33	1995	05/31/1997	Kettle Falls Net Pen	LKW	n/a	MOR	h-su	9,842	8,838	144	20.6
62-55-34	1995	05/31/1997	Kettle Falls Net Pen	LKW	n/a	MOR	h-su	9,466	8,500	144	20.6
62-55-35	1995	05/31/1997	Kettle Falls Net Pen	LKW	n/a	MOR	h-su	9,427	8,465	144	20.6
62-55-36	1995	05/31/1997	Kettle Falls Net Pen	LKW	n/a	MOR	h-su	9,820	8,818	144	20.6
62-55-37	1995	05/31/1997	Kettle Falls Net Pen	LKW	n/a	MOR	h-su	9,852	8,847	144	20.6
62-55-32	1995	06/30/1997	Sherman Creek	LKW	n/a	MOR	h-su	165,751	148,844	166	10.1
62-55-38	1995	06/30/1997	Sherman Creek	LKW	n/a	MOR	h-su	8,454	7,492	170	10.2
62-55-39	1995	06/30/1997	Sherman Creek	LKW	n/a	MOR	h-su	8,454	7,492	170	10.2
62-55-40	1995	06/30/1997	Sherman Creek	LKW	n/a	MOR	h-su	11,413	10,249	170	10.2
62-55-41	1995	06/30/1997	Sherman Creek	LKW	n/a	MOR	h-su	11,412	10,248	170	10.2
62-55-42	1995	06/30/1997	Sherman Creek	LKW	n/a	MOR	h-su	11,412	10,248	170	10.2
62-52-20	1995	06/16/1997	Two Rivers (Spokane R)	LKW	n/a	MOR	h-su	6,608	6,178	188	8.2
62-56-44	1995	06/21/1997	Little Falls Boat Launch	LKW	n/a	NONE	-	9,978	8,960	188	8.2
62-56-45	1995	07/06/1997	Little Falls Dam	FDR	n/a	NONE	-	11,975	10,754	197	7
62-56-46	1995	07/06/1997	Little Falls Dam	FDR	n/a	NONE	-	11,975	10,754	197	7

Table 22 Continued

CWT Code	Brood Year	Release Date	Release Location	Kokanee Stock[1]	Run Time	Expos Odor[2]	Expos Stage1	Kokanee Released	Adjusted Kokanee[3,4]	Release (mm)	Release fish/lb.
62-08-23	1996	10/05/1997	Colville River	LKW	mid	MOR	h-su	57,442	41,685	100	54
Total								**363,281**	**316,372**	**163**	
1998									**0.79**		
62-08-25	1996	05/19/1998	Lincoln Net Pen	LKW	mid	MOR	h-su	49,492	36,040	158	13.8
62-08-24	1996	05/20/1998	Seven Bays Net Pen	LKW	mid	MOR	h-su	49,187	35,836	159	13.7
62-08-19	1996	05/23/1998	Kettle Falls Net Pen	LKW	late	MOR	h-su	67,622	49,212	152	15.4
62-08-20	1996	05/16/1998	Colville R. Net Pen	LKW	mid	MOR	h-su	95,638	66,258	156	14.4
62-08-26	1996	05/29/1998	Sherman Cr. Net Pen	LKW	mid	MOR	h-su	56,328	39,443	151	13.9
62-08-22	1996	05/28/1998	Sherman Creek	LKW	mid	MOR	h-su	73,575	53,710	158	11.9
62-08-21	1996	05/28/1998	Sherman Creek	LKW	early	NONE	-	72,394	52,848	158	11.9
62-08-28	1996	05/28/1998	Sherman Creek	LKW	early	MOR	h-su	86,327	61,784	158	13.8
62-08-27	1996	07/12/1998	Sherman Creek	LKW	early	MOR	h-su	38,703	27,455	181	7.7
62-08-31	1996	05/17/1998	Little Falls Boat Launch	LKW	mid	MOR	h-su	15,000	10,950	188	8
62-08-30	1996	05/25/1998	Little Falls Dam	LKW	early	MOR	h-su	35,000	25,550	176	10
62-08-31	1996	06/03/1998	Little Falls Dam	LKW	mid	MOR	h-su	10,046	7,334	166	12
62-08-31	1996	06/28/1998	Little Falls Dam	LKW	mid	MOR	h-su	24,470	17,863	176	10
Total								**673,782**	**484,283**	**164**	
1999									**0.79**		
62-03-25	1997	06/16/1999	Colville R. Net Pens	LKW	early	MOR	h-su	41,771	32,999	152	13.3
62-03-26	1997	06/16/1999	Colville R. Net Pens	LKW	mid	MOR	h-su	40,982	32,376	157	12
62-03-32	1997	06/28/1999	Sherman Creek	LKW	mid	MOR	h-su	95,736	75,631	167	10.1
62-03-29	1997	06/28/1999	Sherman Creek	LKW	early	MOR	h-su	96,600	76,314	167	10.1
62-03-30	1997	06/28/1999	Sherman Creek	LKW	early	NONE	h-su	87,511	69,134	165	10.5
AD ONLY	1997	3/22-31-99	Sherman Creek	LKW	early	MOR	h-su	25,000	19,750	137	18.2
AD ONLY	1997	07/29/1999	Sherman Creek	LKW	early	MOR	h-su	88,775	70,132	167	10
AD ONLY	1997	06/16/1999	Sherman Creek	LKW	early	MOR	h-su	74,013	58,470	141	16.7
62-03-27	1997	05/11/1999	Spokane River	LKW	early	MOR	h-su	41,195	32,544	140	17
62-03-28	1997	06/07/1999	Spokane River	LKW	early	MOR	h-su	41,482	32,771	167	10
AD ONLY	1997	06/21/1999	Spokane River	LKW	early	MOR	h-su	22,370	17,672	177	8

Table 22 Continued

CWT Code	Brood Year	Release Date	Release Location	Kokanee Stock[1]	Run Time	Expos Odor[2]	Expos Stage1	Kokanee Released	Adjusted Kokanee[3,4]	Release (mm)	Release fish/lb.
AD ONLY	1997	06/22/1999	Spokane River	LKW	early	MOR	h-su	22,413	17,706	177	8
AD ONLY	1997	07/01/1999	Spokane River	LKW	early	MOR	h-su	11,250	8,888	188	7
Total								**689,098**	**544,387**	**162**	

[1]LKW = Lake Whatcom stock, and FDR = Whatcom stock kokanee that returned to egg collection facilities.

[2]MOR= morpholine exposed, PEA = phenethyl alcohol, NONE = unexposed.

[3]Adjusted kokanee represented long term tag retention

[4]Kokanee stocked from 1998-1999 were adjusted by the average of previous years (0.79)

Appendix B. Summary of kokanee collected per site in Lake Roosevelt, 1998.

Table 23. Kokanee data collected by EWU during the 1998 spawning season. Effort summarized by number of days fished and total minutes electrofished. Key: AD+ = fin clip + CWT, AD- = fin clip only, NO+ = No fin clip but CWT present, NO- = No clip or CWT.

Site	Location	Days Fished	Effort (min)	AD	AD-	AD+	NO-	NO+	Grand Total
	Grand Coulee/Spring Canyon								
E 1	Crescent Bay	3	27						0
2	Across from E1	1	10						0
3	Outside of Eden Harbor	1	10						0
E 2	Eden Harbor	3	25						0
5	North side of Eden Harbor	1	5						0
E 3	Spring Canyon BL	3	38		1	3	1		5
10	Bay across from Spring Canyon	3	35						0
12	1 km. Up from site 10	1	10						0
17	Bay south of Plum Pt.	2	10			1			1
20	Bay 2 km. South of Qui Qui Ck	1	10						0
E 4	Qui Qui Creek	3	46		7	19	4	2	32
23	3 km. South of Cayuse Cove	1	10						0
24	Flats by Swawilla Basin	1	10						0
E 5	Swawilla Basin	3	35.5			1			1
E 6	Cayuse Bay	3	77				1		1
30	1 km. Up from Cayuse Cove	1	10						0
E 7	Wynoff Cove	3	25						0
33	2 km. South of Coffman Canyon	1	10						0
E 8	Coffman Creek	3	27		1				1
	Keller Ferry								
E 9	Bay near Devils Pasture	1	7						0
45	Across from Devils Pasture	1	10						0
56	Devils Pasture	1	10						0
E 10	Moonbeam Bay	2	15						0
52	N. of Moonbeam Bay	1	10						0
E 11	Sandy bay south of boat launch	2	10						0
55	Keller boat launch	1	10						0
E 12	Bay at RM 14 (Flats)	2	27						0
61	1 k. north of Clark Pt.	1	10						0
66	3 km. South of Sterling Pt.	2	20						0
70	Hellgate Canyon	3	19.5						0
72	1 km up from Hellgate	1	10						0
E13	Covington Cove	3	20						0
73	Outside of Penix Canyon	1	5						0
E 14	Penix Canyon	4	35			1			1
E15	Spiegal Canyon	3	22						0
79	Outside of Spiegel Canyon	1	10						0
E 16	Whitestone Creek	5	47		2	8	1		11

	Table 23 Continued								
E 17	Burbot Creek	5	64		8	41	2	2	53
	Sanpoil River								
SP 1/3	1 km. North of Covington Cove	1	17						0
SPE 1	Cove 2 km. North of Covington Cove	3	17						0
SP 7	1 km. South of SPE 2	1	10						0
SPE 2	Creek 2 mi. up Sanpoil (East)	3	15						0
SP 9	1 km. North of SPE 2	1	10						0
SP 11	Across from Manila Creek	1	10						0
SP 14	Manila Creek	2	10						0
SP 15	Bay on East shore north of Manila Ck	1	5						0
SP 18	3 km. North of Manila Ck	1	10						0
SPE 3	John Tom Creek	1	5						0
SP 21	1 km. North of John Tom Ck	1	10						0
SP 23/24	1 km. South of the mouth	1	20						0
SPE 4/5	Sanpoil River Mouth	1	40						0
	Hawk Creek-Seven Bays								
E 18	Lundstrom Bay	4	40						0
83	Bay across from Lundstrom	1	10						0
87	Waterfall 1 km. South of Whitestone	1	5						0
E 19	Moonshine Bay	3	30						0
93	2 km. North of Moonshine Bay	1	10						0
E 20	Halverson Canyon	4	40						0
97	1 km. North of Halverson Canyon	1	10						0
E 21	Ck across from Sterling Pt 1	4	35						0
104	North side of E22	2	15						0
E 22	Ck across from Sterling Pt 2	3	28						0
E 23	Lincoln Creek	5	85		3	7	1		11
111	2 km. South of E23	1	10						0
114/116	Across from Welsh Ck. Cove	1	20						0
119	Outside of Hawk Ck bay	1	10						0
H1	South side of Hawk Creek bay	1	7						0
H 2	North side of Hawk Creek bay	1	10						0
H3	Hawk Creek Cove 1	2	17						0
H 7	Narrows before Hawk Creek Cove	1	10						0
HE 1	Hawk Creek Cove 2	1	10						0
HE 2	Hawk Creek	18	485	46	55	208	42	2	353
E 24	Sunday Bay	4	45				1		1
124	Outside of George Ck	1	10						0
E 25	George Creek	4	32						0
E 26	Friday Bay	1	7						0
E 27	Seven Bays (East)	2	17						0
132/134	Lamb Draw	1	22						0
	Fort Spokane								
136	1 km north of Louie Ck	1	10						0
138	2 km north of Louie Ck	1	10						0
E 28	Louie Creek	3	20						0
E 29	Abraham Creek	3	35						0
141	1 km. North of Abraham Ck	1	15						0
143/145	Ck 0.5 mi. up from Abraham	2	40						0

	Table 23 Continued							
E 30	Three-Mile Creek	3	30					0
E 31	Denison Creek	4	26					0
E 32	Cottonwood Creek	2	16			1		1
E 33	Castle Rock Creek	2	20					0
E 34	Six Mile Creek	3	37		3	1		4
155	Ck across from 6-mi creek							0
E 35	Nine Mile Creek	4	50	5	27		2	34
168	4 km. North of E 35	1	10					0
169	4 km. North of E 35 (east)	1	10					0
173	Islands 5 km soutth Wilmont	2	20					0
	Hunters							0
E 36	Wilmont Cove	4	89					0
179/181	Across from Wilmont Cove	2	30					0
184	Bay outside Wilmont	2	20					0
E 37	Gerome Bay	5	60	5	27			32
187	Outside Gerome Bay	1	10					0
188	3 km. North of Wilmont	1	10					0
192	1 km. South of Roger's Bay	1	8					0
E 38	Roger's Bay	2	15					0
E 39	Alder Creek	4	53		3	1		4
194	Across from Alder Creek	1	10					0
195	1 km. South of Alder Creek	1	10					0
E 40	Managhan Creek	3	19					0
198/200	Cove 1 km. North of Managhan	1	20					0
201/203	2 km. South of Hunters Cove	1	21					0
E 41	Hunters Creek	4	58	2	6	2	1	11
207	1 km. South of Boat launch	1	10					0
208	Coyote Falls	1	10					0
E 42	Falls Creek	4	57					0
E 43	Nez Perce Creek	3	66			1		1
212	1 km. North of Nez Perce Ck	1	10					0
213/215	1 km. North of Boat launch	1	10					0
217/219	1 km. South of Harvey Ck	1	15					0
218	Across of Harvey Ck	1	10				1	1
222	1 km. North of 219	1	10					0
228/230	8 km. North of Nez Perce Ck	1	20					0
234/236/238/240	2 km north of 230	2	54					0
235	Across from 234	1	10					0
239	3 km south of Bissell Flats	1	10					0
	Gifford							
241	2 km south of Bissell Flats	1	10					0
250	1 km south of E 44	2	13					0
E 44	Gifford (CCT)	4	29					0
E 45	West Stranger Creek	4	28	1	2	1		4
E 46	Cloverleaf Bay	2	10					0
255	1 km north of E 46	1	10					0
E 47	East Stranger Creek	4	33		1			1
E 48	Hall Creek	4	75					0
256/258	1 km north of Hall Ck	3	30					0

	Table 23 Continued								
259	2 km north of E 47	1	10						0
266	Mission Point	1	20						0
	Bradbury Beach								
267/269	Daisy	2	20						0
271	2 km south of Daisy Boat Launch	2	20						0
274	Across from Daisy BL	1	10						0
280	Across from Cheweka Ck	2	20						0
281	Cheweka Creek	2	8			3			3
282	Barnaby Creek	6	82		33	116	2	1	152
284	1 km north of Barnaby Ck	1	10						0
287	Bay S. of Quilisacut Ck.	1	10	1		1			2
289	Quilisacut Creek	4	22						0
290	3 km. North of Barnaby Ck	1	10						0
294	La Fleur Creek	2	10						0
298	French Pt. Rocks	1	15						0
301	Across from French Pt. Rocks	1	10						0
302/304	Martin Creek	2	10						0
306	2 km north of Martin Ck	1	10						0
E 49	Roper Creek	5	77						0
307/309	1 km south of E 50	1	20						0
310	2 km north of E 49	1	10						0
E 50	Rickey Creek	4	40						0
311	1 km north of E 50	1	10						0
314	Hagg Cove	1	10				1		1
315	Across from Hagg Cove	1	10						0
	Kettle Falls								
317	2 km south of Colville River mouth	2	25						0
318	Game Range Cove	1	10						0
321	Colville River Mouth (north)	2	20						0
E 51	Colville River	20	383		9	48	3	1	61
E 52	Sherman Creek	29	577	71	542	1797	16	22	2448
324	2 km north of Sherman Ck	1	10						0
E 53	Kettle Falls Marina	6	75						0
325/327	1 km north of marina	3	23						0
E 54	Bay across from Marina	4	45			1	1		2
326	1 km south of E 54	1	10						0
328	1 km north of E 54	1	15						0
329	Across from E 54	1	8						0
330	1 km north of bridge (west)	1	10						0
333	1 km north of bridge (east)	1	10						0
335/337	1 km after 333	2	18						0
E 55	Fenders Creek	5	41						0
339	1 km north of E 55	1	8						0
E 56	Nancy Creek	5	55		3	20			23
342/344	1 km north of Kettle River mouth	2	20						0
345	4 km north of E 55	1	10						0
351	2 km north of Pingston Ck	1	10						0
K 1/K2	Kettle River mouth	3	32						0
K 4	2 km up stream	2	25						0

	Table 23 Continued						
K 6	3 km up stream	1	15				0
K 7	Across from Deadman Ck	2	30				0
K 8	Deadman Creek	1	15				0
K 10	1 km north of Deadman Ck	2	20				0
K 11/13	Below Napoleon Bridge	2	20				0
K 15/19/20	Above Napoleon Bridge	2	30				0
E 57	Marcus	2	20				0
354	1 km south of E 58	1	15				0
357	1 km north of E 57	1	8				0
E 58	Across from Marcus	1	10				0
E 59	Evans	2	10				0
362/364/366	Across from China Ck	1	23				0
363/365/367	1 km north of Evans	1	24				0
371	1 km north of China Ck	1	10				0
372	1 km north of Snag Cove	1	15				0
376	4 km north of Snag Cove	1	5				0
379	Mile Marker 96	1	10				0
381	1 km north of Mile Marker 96	1	10				0
	Evans/China Bend						
388	2 km south of E 60	1	10				0
E 60	15-Mile Creek	3	20		1	3	4
E 61	Flat Creek	3	28	5	5	6	16
394	Across from China Bend BL	1	10				0
396	1 km north of 394	2	20				0
401	1 km north of BL	1	10				0
405	2 km north of BL	1	10				0
406	Crown Creek	3	25	5	17	9	31
407	1 km north of 405	1	18				0
408	Rattlesnake Creek	3	25				0
411	Across from 408	3	25				0
414/415	2 km north of 411	1	25				0
	Porcupine Bay						
S 1	Mouth of Spokane River (South)	1	15				0
S 2	Mouth of Spokane River (North)	2	10				0
S 4	South side of bridge	1	4				0
SE 1	Cove south of swimming beach	3	29				0
S 11	1 km north of Ft. Spokane BL	1	5				0
S 12	Cove on west shore north of Rocks	1	8				0
S 13	1 km north of S 11	1	10				0
S 14/16	Across from Mile Marker	1	20				0
S 19	Inside of Mile marker cove	1	10				0
S 21	2 km north of mile marker	2	15				0
SE 2	McCoys Springs	3	19			1	1
SE 3	Orazada Creek	4	40			1	1
S 27	Across from Orazada Ck	1	10				0
SE 4	Hollie's Creek	3	25				0
S 33	Between Hollies Cks	1	10				0
SE 5	Sand Creek	5	57.5			1	1
S 36	1 km west of SE 5	1	10				0

	Table 23 Continued								
SE 6	Bay 2 km west of SE 5	3	20						0
S 37/S 39	3 km east of Porcupine BL	2	22						0
S 40	1 km east of SE 6	1	10						0
SE 7	Blue Creek	5	92		3	11	1		15
SE 8	Pitney Creek	5	55			1			1
S 46	2 km east of SE 7	1	10						0
S 47/51/53	North side of narrows	1	30						0
S 48/50	South side of narrows	1	20						0
SE 9	Creek in narrows	3	20						0
S 57	Springs	1	5						0
S 60	Corner before SE 10	1	10						0
SE 10	Cayuse Cove	4	35						0
SE 11	Harker Canyon	4	38						0
SE 12	Mill Canyon	5	41	6		4	2		12
S 70	Across from SE 12	1	10						0
S 80	Pumphouse south of Tribal BL	1	15						0
S 82	Tribal Boat Launch	6	80			2			2
S 84	1 km north of BL	1	15						0
S 86	Across from pumphouse (north)	1	10						0
S 87	Pumphouse north	1	10						0
S 89	1 km north of pumphouse north	1	10						0
S 90/92	Across from Spring Creek	2	15						0
SE 13	Spring Creek	7	108	1	4	7	6		18
S 91	1 km south of Spring Ck	2	20						0
S 93	1 km north of Spring Ck	3	55		1				1
S 94	Spillway	7	108		2	10	4		16
SE 14	Little Falls Dam	7	170	1	4	58	7	8	78
Grand Total			**7,064.5**	**126**	**701**	**2460**	**124**	**42**	**3,453**

Table 24. Kokanee data collected by EWU during the 1999 spawning season. Effort summarized by number of days fished and total minutes electrofished. Key: AD+ = fin clip + CWT, AD- = fin clip only, NO+ = No fin clip but CWT present, NO- = No clip or CWT.

Code	Location Name	Days Fished	Effort (min)	AD-	AD+	NO-	NO+	Total
	Grand Coulee/ Spring Canyon							
E 1	Crescent Bay	5	50					0
E 2	Eden Harbor	5	50					0
E 3	Spring Canyon	3	28					0
E 4	Qui Qui Creek	3	25					0
E 5	Swawilla Basin	2	21					0
E 6	Cayuse Bay	5	50	1	1	1		3
E 7	Wynoff Cove	3	25	2				2
E 8	Coffman Canyon	3	18					0
	Keller Ferry							
E 10	Moonbeam Bay	1	10					0
E 11	Bay at RM 14 (Flats)	2	20					0
E 12	Clark Point Bay	2	18					0
E 13	Covington Cove	2	19					0
E 14	Penix Canyon	4	33					0
E 15	Spiegel Canyon	4	23					0
E 16	Whitestone Creek	5	43		1			1
E 17	Burbot Creek	5	47					0
	Sanpoil River							
SPE 1	Sanpoil-Columbia Confluence	1	8					0
SPE 2	Creek 2 mi. up Sanpoil (East)	3	20					0
SPE 3	John Tom Creek	2	10					0
SPE 4	Silver Creek	1	10					0
SPE 5	Sanpoil River Mouth	3	64			7		7
	Hawk Creek- Seven Bays							
E 18	Lundstrom Bay	5	49		1			1
E 19	Moonshine Bay	5	37					0
E 20	Halverson Canyon	5	40					0
E 21	Ck across from Sterling Pt	4	26					0
E 22	Ck 2 across from Sterling Point	4	35					0
E 23	Lincoln Creek	5	60		2			2
H 3	Hawk Creek Cove 1	1	10					0
HE 1	Hawk Creek Cove 2	3	40					0
HE 2	Hawk Creek	15	349	27	29	11		67
E 24	Sunday Bay	5	45					0
E 25	George Creek	4	30					0
E 26	Friday Bay	4	32					0
E 27	Seven Bays (East)	3	25					0
	Fort Spokane							
137	Columbia River	1	5					0
E 28	Louie Creek	4	25					0
E 29	Abraham Creek	3	30					0
143	Ck 0.5 mi. up from Abraham	1	10					0
E 30	Three mile Creek	4	50		1			1

Table 24 Continued

E 31	Denison Creek	3	21				0
E 32	Cottonwood Creek	2	15				0
E 33	Castle Rock Creek	4	40				0
E 34	Six Mile Creek	4	40		1		1
155	Creek across from 6-mile Ck	1	5				0
E 35	Nine Mile Creek	4	45				0
	Hunters						
E 36	Wilmont Cove	2	35				0
E 37	Gerome Bay	3	35				0
E 38	Roger's Bar	2	20				0
E 39	Alder Creek	3	50		1		1
E 40	Managhan Creek	2	15		1		1
E 41	Hunters Creek	3	60				0
E 42	Falls Creek	1	5				0
E 43	Nez Perce Creek	3	40		1		1
208	Coyote Falls	2	15				0
E 44	Gifford (CCT)	3	25				0
	Gifford						
E 45	West Stranger Creek	3	35	1			1
E 46	Cloverleaf Bay	2	10				0
E 47	East Stranger Creek	3	25				0
E 48	Hall Creek	3	55	1	1		2
	Bradbury Beach						
281	Cheweka Creek	3	20				0
282	Barnaby Creek	3	35		2		2
289	Quilisacut Creek	4	30				0
294	La Fleur Creek	3	25				0
302/304	Martin Creek	4	25				0
E 49	Roper Creek	5	80				0
E 50	Rickey Creek	5	48		1		1
318	Game Range Cove	2	20				0
	Kettle Falls						
E 51	Colville River	17	255	2	5	1	8
319	Colville River Mouth	1	15				0
E 52	Sherman Creek	23	326.8	362	636	1	999
	Sherman Creek (BP)	7	140.65	73	177	1	251
E 53	Kettle Net Pens	6	63				0
E 54	Bay across from Marina	5	50				0
E 55	Fenders Creek	6	55		1		1
E 56	Nancy Creek	5	45	4	2	2	8
340	Log Boom at K.R. Mouth	1	10				0
K 1	Kettle River Bridge	3	45				0
K 11	K.R. above RR bridge	1	10				0
K 13	KR below Napoleon Br.	1	10				0
K 15/ K 20	K.R. above Napoleon Br.	3	30				0
K 8	K.R. Deadman Creek	3	30				0
	Evans/China Bend						
390	South of 15-Mile Creek	2	20				0
406	Crown Creek	4	35	1	1	1	3

	Table 24 Continued							
408	Rattlesnake Creek	4	35					0
E 60	15-Mile Creek	4	35					0
E 61	Flat Creek	4	40					0
	Porcupine Bay							
SE 1	Cove at S.P.R Mouth (South)	5	40					0
S 10	Island	1	10					0
S 14	Spokane River 7 mi. up	1	15	1				1
S 15	Spokane River 8 mi. up	1	10					0
S 27	Detillion Campground	1	5					0
SE 2	McCoys Springs	5	45					0
SE 3	Orazada Creek	4	35					0
S 37/S 39	Porcupine Bay	3	30					0
SE 4	Hollies Creek	4	35					0
SE 5	Sand Creek	4	45					0
SE 6	Cove 0.5 mi. East Sand Ck.	2	12					0
SE 7	Blue Creek	5	87		3			3
SE 8	Pitney Creek	3	25					0
S 57	Springs	1	10		1			1
SE 9	Narrows Bay	2	15					0
SE 10	Cayuse Cove	3	35					0
SE 11	Harker Canyon	3	35					0
SE 12	Mill Canyon	3	30					0
S 74	Eagle Nest	3	25					0
S 82	Tribal Boat Launch	3	60		1			1
	Little Falls							
SE 13	Spring Creek	7	100		2			2
S 90/ S93	Above Spring Creek	3	25					0
SE 14	Little Falls Dam	16	290	81	21	1		103
	Grand Total	**398**	**4,633.45**	**554**	**892**	**25**	**2**	**1,473**

Appendix C. Total Relative Abundance and Catch-per-Unit Effort

1998

Table 25. Summary of fish collected, relative abundance (R.A.), and catch-per-unit-effort (CPUE), and size range (mm) via boat electrofishing at Lake Roosevelt between August 17th, and December 10th, 1998 (effort = 118 hours).

Species	n	R.A.%	CPUE(fish/hr)	Size Range
Brown bullhead	5	0.10	0.04	36-235
Black crappie	9	0.17	0.08	75-107
Bridgelip sucker	5	0.10	0.04	205-234
Brown trout	31	0.60	0.26	159-698
Burbot	116	2.25	0.98	382-716
Chinook	3	0.06	0.03	372-522
Cottidae	25	0.48	0.21	57-142
Carp	73	1.41	0.62	84-647
Cutthroat trout	1	0.02	0.01	321
Eastern brook trout	54	1.05	0.46	132-318
Kokanee	2846	55.08	24.12	80-569
Largemouth bass	150	2.90	1.27	65-569
Longnose sucker	55	1.06	0.47	45-480
Largescale sucker	850	16.45	7.20	56-654
Lake Whitefish	27	0.52	0.23	362-595
Northern pikeminnow	41	0.79	0.35	37-590
Peamouth	8	0.15	0.07	145-224
Pumpkinseed	9	0.17	0.08	75-115
Rainbow trout	365	7.06	3.09	72-558
Smallmouth bass	133	2.57	1.13	60-372
Tench	13	0.25	0.11	125-541
Walleye	242	4.68	2.05	95-561
Mountain whitefish	32	0.62	0.27	122-545
Yellow perch	74	1.43	0.63	55-230
Total	**5,167**	**100.00**	**43.79**	

Table 26. Summary of fish collected, relative abundance (R.A.), and catch-per-unit-effort (CPUE), and size range (mm) via backpack electrofishing at Lake Roosevelt between August 17th, and December 10th, 1998 (effort = 4.9 hours).

Backpack	n	R.A. (%)	CPUE (fish/hr)	Size Range
Burbot	1	0.14	0.20	381
Chiselmouth	1	0.14	0.20	--
Cottidae	10	1.41	2.04	46-110
Eastern brook trout	22	3.10	4.49	132-260
Kokanee	597	84.08	121.84	82-540
Largemouth bass	2	0.28	0.41	88-147
Longnose sucker	16	2.25	3.27	70-101
Largescale sucker	1	0.14	0.20	84
Northern pikeminnow	1	0.14	0.20	52
Peamouth	1	0.14	0.20	--
Rainbow trout	48	6.76	9.80	70-185
Mountain whitefish	10	1.41	2.04	115-135
Total	**710**	**100.00**	**144.90**	

1999

Table 27. Summary of fish collected, relative abundance (R.A.), and catch-per-unit-effort (CPUE), and size range (mm) via boat electrofishing at Lake Roosevelt between August 16th, and December 1st, 1999 (effort = 74.88 hours).

Species	n	R.A. (%)	CPUE (fish/hour)	Size Range (mm)
Bull trout	1	0.03	0.01	510
Brown trout	12	0.31	0.16	150-509
Chinook	12	0.31	0.16	156-730
Cutthroat trout	1	0.03	0.01	215
Eastern brook trout	61	1.59	0.81	159-476
Kokanee	1,337	34.81	17.86	141-595
Rainbow trout	131	3.41	1.75	33-535
Lake Whitefish	11	0.29	0.15	412-580
Mountain Whitefish	13	0.34	0.17	91-405
Chiselmouth	2	0.05	0.03	80-103
Carp	68	1.77	0.91	45-855
Northern pikeminnow	54	1.41	0.72	22-635
Peamouth	30	0.78	0.40	29-230
Redside shiner	13	0.34	0.17	57-115
Tench	12	0.31	0.16	120-470
Longnose sucker	4	0.10	0.05	43-400
Largescale sucker	544	14.16	7.26	20-620
Bridgelip sucker	5	0.13	0.07	115-242
Burbot	34	0.89	0.45	374-658
Black crappie	254	6.61	3.39	23-324
Largemouth bass	74	1.93	0.99	20-370
Smallmouth bass	284	7.39	3.79	34-351
Pumpkinseed	1	0.03	0.01	157
Yellow perch	501	13.04	6.69	9-272
Walleye	352	9.16	4.70	42-654
Cottidae	30	0.78	0.40	23-118
Grand Total	**3,841**	**100.00**	**51.30**	

Table 28. Summary of fish collected, relative abundance (R.A.), and catch-per-unit-effort (CPUE), and size range (mm) via backpack electrofishing at Lake Roosevelt between August 16th, and December 1st, 1999 (effort = 2.34 hours).

Species	n	RA (%)	CPUE (fish/hour)	Size Range (mm)
Eastern brook trout	1	0.30	0.43	135
Rainbow trout	19	5.64	8.12	74-230
Kokanee	311	92.28	132.91	202-566
Lake whitefish	2	0.59	0.85	445-475
Largescale sucker	1	0.30	0.43	62
Cottidae	3	0.89	1.28	36-105
Grand Total	**337**	**100.00**	**144.02**	

2000

Table 29. Summary of fish collected, relative abundance (R.A.), and catch-per-unit-effort (CPUE), and size range (mm) via boat electrofishing at Lake Roosevelt between August 15th, and November 1st, 2000 (effort = 71.20 hours).

Species	n	R.A. (%)	CPUE (fish/hr)	Size Range
Black crappie	40	0.85	0.56	36-206
Bull trout	2	0.04	0.03	417-800
Bridgelip sucker	6	0.13	0.08	191-360
Brown trout	31	0.66	0.44	133-567
Bull trout-brook hybrid	1	0.02	0.01	383
Burbot	37	0.79	0.52	95-601
Chinook	6	0.13	0.08	425-752
Chiselmouth	1	0.02	0.01	113
Cottidae	50	1.06	0.70	18-143
Carp	35	0.75	0.49	42-747
Cutthroat trout	1	0.02	0.01	411
Eastern brook trout	46	0.98	0.65	73-409
Kokanee	2711	57.72	38.08	167-562
Largemouth bass	26	0.55	0.37	33-380
Longnose dace	1	0.02	0.01	35
Longnose sucker	7	0.15	0.10	80-437
Largescale sucker	395	8.41	5.55	43-682
Lake whitefish	4	0.09	0.06	493-523
Northern pikeminnow	61	1.30	0.86	33-599
Peamouth	3	0.06	0.04	60-138
Pumpkinseed	3	0.06	0.04	93-103
Rainbow trout	385	8.20	5.41	30-588
Redside shiner	29	0.62	0.41	41-79
Smallmouth bass	174	3.70	2.44	24-297
Tench	7	0.15	0.10	148-470
Walleye	138	2.94	1.94	66-536
Mountain whitefish	27	0.57	0.38	109-418
Yellow bullhead	1	0.02	0.01	180
Yellow perch	469	9.99	6.59	49-210
Grand Total	**4697**	**100.00**	**65.97**	**--**

* Kokanee numbers include Whatcom and Kootenay stock kokanee that were not apart of the 1998-2000 experiments.

Table 30. Summary of fish collected, relative abundance (R.A.), and catch-per-unit-effort (CPUE), and size range (mm) via backpack electrofishing at Lake Roosevelt between August 15th, and November 1st, 2000 (effort = 0.68 hours).

Species	n	R.A. (%)	CPUE (fish/hr)	Size Range
Cottidae	12	7.32	17.65	13-126
Eastern brook trout	1	0.61	1.47	223
Kokanee	73	44.51	107.35	247-342
Longnose sucker	1	0.61	1.47	161
Rainbow trout	77	46.95	113.24	85-195
Total	**164**	**100.00**	**241.18**	**--**

* Kokanee numbers include Whatcom and Kootenay stock kokanee that were not apart of the 1998-2000 experiments.

Appendix D. Recaptured Floy and Photonic Tagged Kokanee

Table 31. Recaptured floy and photonic tagged kokanee in Lake Roosevelt, 1999.

Date	Site #	Tag color/#	M/R	TL (mm)	WT (g)	Sex	Mat	Fin Clip	H/W	Sample #	R.C.	Time	Effort (min)	Gear
09/29/1999	E 52	BL 27117	R	283		M	M	AD-	H		G	21:30	15	EB
10/13/1999	E 52	BL 22182	R	274		M	R	AD-	H	099	K	19:45	10	EB
10/13/1999	E 52	BL 22278	R	340		M	R	AD+	H	034	K	16:30	15	EF
10/13/1999	E 52	BL 23727	R	280		M	R	AD+	H	001	K	15:10	15	EB
10/13/1999	E 52	BL 24684	R	302		M	R	AD+	H	002	K	15:10	15	EB
10/13/1999	E 52	BL 29257	R	303		M	R	AD+	H	045	K	16:30	15	EF
10/13/1999	E 52	O-Photonic	R	332		M	R	AD+	H	036	K	16:30	15	EF
10/13/1999	E 52	O-Photonic	R	322		M	R	AD+	H	035	K	16:30	15	EF
10/27/1999	E 52	BL 24805	R	280		M	R	AD+	H	016	K	11:00	48.9	EF
10/27/1999	E 52	BL 25129	R	340		M	R	AD+	H	024	K	11:00	48.9	EF
10/27/1999	E 52	BL 26771	R	NL		M	R	AD+	H	037	K	11:00	48.9	EF
10/27/1999	E 52	BL 21247	R	331		M	R	AD-	H		G	18:30	10	EB
10/27/1999	E 52	O-Photonic	R	320		M	R	AD-	H		G	11:00	48.9	EF
11/02/1999	E 52	BL 21199	R	298		M	R	AD+	H	033	K	15:00	18.77	EF
11/02/1999	E 52	BL 21621	R	318		M	R	AD+	H	032	K	15:00	18.77	EF
11/02/1999	E 52	BL 23334	R	321		M	R	AD+	H	010	K	15:00	18.77	EF
11/02/1999	E 52	BL 23456	R	317		M	R	AD-	H		G	15:00	18.77	EF
11/02/1999	E 52	BL 28108	R	272		M	R	AD+	H	035	K	18:30	10	EB
11/02/1999	E 52	BL 29313	R	281		M	R	AD-	H		G	15:00	18.77	EF
11/16/1999	E 52	BL 26042	R	322		M	R	AD+	H	007	K	14:15	21.5	EF
11/16/1999	E 52	BL 26410	R	310		M	R	AD+	H	008	K	14:15	21.5	EF
09/16/1999	HE 2	BL 29521	R	320	415	F	M	AD+	H	005	K	20:30	40	EB

Site # = E52 = Sherman Creek; HE 2 = Hawk Creek
Fin Clip = AD+, adipose and coded wire tag; AD-, adipose no coded wire tag
R.C. = Release Condition. G = good and K = kill
Gear = EB = boat electrofishing; EF = backpack electrofishing