Lake Roosevelt Fisheries Evaluation Program

Meadow Creek vs. Lake Whatcom Stock Kokanee Salmon Investigations in Lake Roosevelt

Annual Report 2000 - 2001

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Lake Roosevelt Fisheries Evaluation Program

Meadow Creek vs. Lake Whatcom Stock Kokanee Salmon Investigations in Lake Roosevelt

Annual Report 2000-2001

Contributions to Fisheries Management in Eastern Washington State Number 2

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Abstract

Lake Roosevelt has been stocked with Whatcom stock kokanee since 1989 to mitigate for anadromous salmon losses caused by the construction of Grand Coulee Dam. The primary objective of the hatchery plantings was to create a self-sustaining recreational fishery. Due to low return numbers, it was hypothesized a native stock of kokanee might perform better than the coastal Whatcom strain.

Therefore, kokanee from Meadow Creek, a tributary of Kootenay Lake, British Columbia were selected as an alternative stock. Matched pair releases of Whatcom stock and Meadow Creek kokanee were made from Sherman Creek in late June 2000. Stock performance between Lake Whatcom and Meadow Creek kokanee was evaluated through three performance measures 1) returns to Sherman Creek, the primary egg collection facility, 2) returns to other tributaries, indicating availability for angler harvest, and 3) returns to the creel. A secondary objective was to evaluate the numbers collected at downstream fish passage facilities.

Age 2 kokanee were collected during five passes through the reservoir, which included 89 tributaries between August 17th and November 7th, 2000. Sherman Creek was sampled once a week because it was the primary egg collection location. A total of 2,789 age 2 kokanee were collected, in which 2,658 (95%) were collected at Sherman Creek.

Chi-square analysis indicated the Meadow Creek kokanee returned to Sherman Creek in significantly higher numbers compared to the Whatcom stock ($\chi^2 = 734.4$; $P < 0.01$). Reservoir wide recoveries indicated similar results ($\chi^2 = 733.1$; $P < 0.01$). No age 2 kokanee were collected during creel surveys. Age 3 kokanee are expected to recruit to the creel in 2001. No age 2 kokanee were collected at the fish passage facilities due to a 170 mm size restriction at the fish passage centers. Age 3 kokanee are expected to be collected at the fish passage centers during 2001. Stock performance cannot be properly evaluated until 2001, when age 3 kokanee are expected to return to Sherman Creek.

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Table of Contents

ABSTRACT	1
LIST OF TABLES	5
LIST OF FIGURES	6
INTRODUCTION.....	7
METHODS	9
DESCRIPTION OF THE STUDY AREA.....	9
REARING, MARKING, RELEASE, AND LONG TERM TAG RETENTION	9
EXPERIMENTAL DESIGN FOR CODED WIRE TAG RELEASE GROUPS	14
<i>Hypothesis 1 - Returns to Sherman Creek.....</i>	<i>14</i>
<i>Hypothesis 2 - Returns to Tributaries throughout Lake Roosevelt.....</i>	<i>14</i>
<i>Hypothesis 3 - Returns to the creel.....</i>	<i>14</i>
<i>Hypothesis 4 - Recoveries below Grand Coulee Dam.....</i>	<i>14</i>
Decision Matrix	15
SAMPLING PROCEDURES	15
RESULTS	17
SUMMARY	17
HYPOTHESES RESULTS.....	25
<i>Hypothesis 1- Sherman Creek Returns</i>	<i>26</i>
<i>Hypothesis 2- Reservoir Wide Recoveries</i>	<i>26</i>
<i>Hypothesis 3- Recoveries from the Creel</i>	<i>26</i>
<i>Hypothesis 4- Recoveries below Grand Coulee Dam.....</i>	<i>27</i>
Decision Matrix	27
DISCUSSION	27
RETURNS-SHERMAN CREEK.....	27
RETURNS-RESERVOIR WIDE	28
CREEL SURVEYS	29
RECOVERIES BELOW GRAND COULEE	30
SUMMARY	30
RECOMMENDATIONS.....	32
KOKANEE MONITORING.....	32
CREEL AND TEST FISHERIES	32
ENTRAINMENT	32
LITERATURE CITED	33
APPENDIX A	35
APPENDIX B	36

List of Tables

Table 1. Coded wire tagged (CWT) kokanee released in Lake Roosevelt during 2000.....	13
Table 2. Summary information for kokanee collected during 2000. AD- = fin clipped only, AD+ = fin clipped + CWT, NO- = no clips or CWT (wild fish).....	19
Table 3. Number of CWT kokanee from each release group collected by EWU, STOI, CCT, and WDFW in Lake Roosevelt, fall 2000.	22
Table 4. Mean total length (TL; mm) and standard deviation (S.D.) of kokanee from each CWT number and stock.	23
Table 5. Number and catch-per-unit-effort (CPUE) of kokanee collected by EWU at Sherman Creek per date sampled, 2000.....	24
Table 6. Number and recovery percent at Sherman Creek of Lake Whatcom kokanee (WHAL), Meadow Creek kokanee (MEAD), and Whatcom returns (WHAL*) released from Sherman Creek, 2000.	24
Table 7. Age 2 kokanee collected per coded wire tag lot at Sherman Creek and at other tributaries throughout the reservoir, 2000.	25
Table 8. Returns to Sherman Creek of coded wire tagged age 2 Whatcom stock (62-03-34) vs. Meadow Creek stock (62-03-35) released from the Sherman Creek Hatchery.....	26
Table 9. Reservoir wide recoveries for coded wire tagged age 2 Whatcom (62-03-34) vs. Meadow Creek stock (62-03-35) released from the Sherman Creek Hatchery.....	26
Table 10. Summary of kokanee stocked into Lake Roosevelt from Sherman Creek, Kettle River net pens, and below Little Falls Dam, 2000.	35
Table 11. Summary of the total number of fish collected (n), relative abundance (R.A.), catch- per-unit-effort (CPUE), and size range (mm) of the fish collected by EWU via boat electrofishing at Lake Roosevelt between August 17 th – November 17 th , 2000 (effort = 71.2 hours).	36

List of Figures

Figure 1. Map of Lake Roosevelt, Spokane Tribal Hatchery and Sherman Creek hatchery.....	12
Figure 2. Map of Lake Roosevelt and 89 locations sampled for kokanee during 2000.	16
Figure 3. Total number kokanee collected at Sherman Creek by EWU via boat electrofishing and backpack electrofishing per sample date during 2000 (n= 2,565).	23
Figure 4. Meadow Creek stock and Whatcom stock kokanee collected per date at Sherman Creek, 2000. (Graph excludes 10/4/2000 backpack shocking day).....	25

Introduction

The construction of Grand Coulee Dam prevented anadromous salmon and steelhead from returning to their natal streams above the dam. To partially mitigate for the loss of anadromous fish, Lake Whatcom kokanee salmon (*Oncorhynchus nerka kennerlyi*) have been stocked in Lake Roosevelt since 1987. The primary purpose of the stocking was to develop a self-sustaining sport fishery and restore a migratory salmonid species to the Lake Roosevelt ecosystem. In 1990, kokanee were coded wire tagged to evaluate planting strategies (Scholz et al. 1992, Tilson et al. 1994, 1995, 1996, 1997, Tilson and Scholz 1998, McLellan et al. 2001).

Since 1996, residualized smolts were planted instead of fry because they returned to egg collection facilities in larger numbers (Tilson and Scholz 1998). In 1998 and 1999, a variety of matched pair releases were conducted in an attempt to improve returns (McLellan et al. 2000). In each year, a jack run composed primarily of precocious males was approximately 0.2-0.5% of the total fish stocked (McLellan et al. 2001). However, age 3 male and female spawners still failed to return the following year. For all Whatcom cohorts stocked, the number of age 3 spawners has been far less than the number of age 2 jacks that returned. For example, the 1996 cohort 2,441 age 2 kokanee were collected in 1998 and 28 age 3 kokanee in 1999. (McLellan et al. 2001).

Hatchery kokanee contributions to the fishery have been difficult to assess. Kokanee harvest in Lake Roosevelt increased from about 100-300 per year in 1980-1982 (Beckman, personal communication) to 1,265-32,353 per year after hatchery stocking began in 1997 (Cichosz et al. 1997). However only a portion of hatchery fish were marked during the first ten years of stocking, therefore it was not possible to determine if unmarked creel fish were of hatchery origin. In 1997 all hatchery kokanee were adipose fin clipped. In 1998, 36 kokanee were observed in the creel in which 12 were of hatchery origin (Cichosz et al. 1998). Therefore, hatchery kokanee appeared to be contributing at least 33% of the kokanee fishery in Lake Roosevelt (McLellan et al. 2001). In 1999 two kokanee, 1 wild and 1 hatchery were observed in the creel (K. Underwood, personal communication). Limited data collected in the creel has restricted our ability to determine the hatchery contribution to the fishery.

Evidence from the Lake Roosevelt Monitoring Program (LRMP) test fishery suggested the creel surveys underestimated the kokanee harvest. Employees from the STOI, Colville Confederated Tribe (CCT), Department of Fish and Wildlife (WDFW), and Eastern Washington

University (EWU) conducted 3-4 days of angling in the Spring Canyon/Swawilla Basin area in the middle of January 1999-2000. In 1999, 61 kokanee were collected of which 3 were of hatchery origin. In 2000, 46 kokanee were harvested of which 1 was of hatchery origin (STOI unpublished data). These results only have partial value because fish were collected during a short period of time in a small section of the reservoir.

Rock Island Dam and Rocky Reach Dam both operate fish passage facilities that count a percentage of the fish that pass through the dams. The facilities operate from April 1 to August 31st and during this time they have collected Lake Roosevelt hatchery kokanee that were moving downstream. The data they collected supported the idea that Whatcom stock kokanee entrain over Grand Coulee Dam. In 1998 the fish passage facilities returned 238 kokanee to EWU in which the majority (87%) were from the spring releases (McLellan et. al 2001). In 1999, the fish passage centers only collected kokanee over 170 mm, which limited the number of hatchery smolts they returned (n = 10). In 1999, the majority of the fish returned (76%) were age 2.5, and would have spawned in the fall (McLellan et. al 2001). Additionally, the dams only observe 5% of the fish passing the dams and more kokanee could have been entraining after August and before April that were missed. Therefore, Lake Whatcom kokanee appear to have a high propensity to entrain through Grand Coulee Dam.

It was concluded that Whatcom stock kokanee have responded poorly to conditions found in Lake Roosevelt and recommended that fisheries managers try and obtain a native stock of kokanee from the upper Columbia River system. It was hypothesized that a native kokanee might be better adapted to the conditions found in Lake Roosevelt. A native strain of kokanee also might have less of a downstream migration tendency that is evident in the currently used Whatcom stock kokanee. Additionally, a kokanee native to the upper Columbia River would be more favorable if mixed genetically with downriver sockeye salmon.

Kokanee stocks native to the upper Columbia River basin that were considered as possible egg sources for supplementing Lake Roosevelt included 1) Arrow Lakes, upper Columbia River, British Columbia, 2) Meadow Creek, a tributary to Kootenay Lake, British Columbia and 3) Chain Lakes, Little Spokane River drainage. The kokanee population in the Arrow Lakes system was decreasing and eggs were not available. The spawning population in the Chain Lakes was small, approximately 50 spawning pairs, therefore it was not considered. Consequently, Meadow Creek was chosen because the eggs were abundant and available.

The objective of the study was to test stock performance using three criteria. A significant difference in at least two of the three categories, with one stock consistently outperforming the other, would indicate greater performance. The criteria were to:

- Determine if there was a significant difference in the number of Meadow Creek and Lake Whatcom kokanee that returned to the appropriate release location.
- Determine if there was a significant difference in the number of Meadow Creek and Lake Whatcom kokanee that returned to other tributaries throughout the reservoir.
- Determine if there was a significant difference in the number of Meadow Creek and Lake Whatcom kokanee that recruited to the creel.

A secondary objective was to determine if there was a significant difference in the number of Meadow Creek and Lake Whatcom kokanee recovered below Grand Coulee Dam.

Methods

Description of the 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 430 m (1,290 ft) above mean sea level (MSL) and minimum operating pool is 403 m (1,208 ft.) above MSL. Grand Coulee Dam was constructed primarily for hydropower, 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 from the 1998 brood stock were obtained from the Lake Whatcom Hatchery in Bellingham, WA (WDFW). Kokanee were collected from Meadow Creek, a tributary of Kootenay Lake, British Columbia by WDFW and British Columbia personnel. The fertilized eggs were held at the Clearwater Hatchery in British Columbia until they eyed up, and then transported to the Spokane Tribal Hatchery for incubation and rearing (M. Combs, WDFW, personal communication).

All fish were reared at the Spokane Tribal Hatchery in Wellpinit, Washington. Fish were supplied with a combination of spring and well water ranging from 8-11°C. Fish were feed trained on Biodiet[®] feed from Bioproducts, Inc (Tilson and Scholz 1998). Once the fish were approximately 100 mm, they were 100% adipose fin clipped and a portion coded wire tagged (CWT). Unique tag numbers were given to each lot of fish based on their stock origin (Meadow Creek or Lake Whatcom) and release location (Sherman Creek or Little Falls). Coded wire tags were injected into the rostrum using a model MK4 CWT machine (Northwest Marine Technology, Inc.). After marking, fish were returned to the hatchery raceways via a quality control device, which ensured 100% of the fish were marked. Kokanee that were to be released from the Sherman Creek Hatchery in June 2000 were transferred there in March 2000. Kokanee released in July were transferred two weeks prior to release. Kokanee released at Little Falls were kept at the Tribal Hatchery.

Meadow Creek and Lake Whatcom CWT kokanee were released from the Sherman Creek Hatchery on June 28th, 2000 (Table 1). Whatcom adipose only clipped kokanee were released from the Colville River net pens and the hatchery. On July 25th, 2000 CWT Whatcom returns were released from the Sherman Creek Hatchery. Whatcom returns were progeny of age 2 and 3 Lake Whatcom kokanee that returned to egg collection sites and were spawned in 1998. There was no experiment conducted on the returning kokanee or the adipose only kokanee. Complete stocking records for Lake Roosevelt were summarized in Appendix A.

Kokanee released below Little Falls Dam consisted of Lake Whatcom and Meadow Creek fish. The coded wire tagged fish were released between June 20th and 29th, 2000 (Table 1). Adipose only fish were released between May 19th and June 12th, 2000. The coded wire tagged groups released at Little Falls experienced high mortality when released (Lake Whatcom 62-03-36; Meadow Creek 62-03-37). The fish were loaded into a fish holding facility located directly below Little Falls Dam. The holding facility was used as an acclimation pond, in an attempt to imprint fish to the Spokane River water that flows through it. The fish were held in the pond for several days prior to release. The fish holding facility water level was dependent on the amount of water Little Falls Dam released. The night before the fish were released, the dam did not refill to their typical water elevation, which caused the water level in the holding facility to drop and did not allow fresh water to filter through the holding facility. Upon release, approximately 50% mortality was observed (T. Peone, STOI Hatchery, personal

communication). Since Whatcom, Meadow Creek, and adipose only kokanee were mixed in the acclimation pond, it was not possible to determine if differential mortality occurred between the two groups. Consequently, statistical analysis was not performed on the Little Falls kokanee.

In previous Lake Roosevelt studies, tag retention could be determined from returning fish because all hatchery kokanee were coded wire tagged. In 1999 and 2000, all hatchery kokanee were not CWT, so tag retention could not be calculated for the year. Tag retention of returning age 2 smolts was estimated at 74% in 1996, 90% in 1997, and 73% in 1998 (Tilson et al. 1997, 1998). Therefore, the average long term CWT retention was estimated to be 79% for returning age 2 smolts. The number of CWT kokanee stocked was 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 of low numbers of returns. The number of CWT kokanee estimated after long-term retention was used for statistical analysis.

Figure 1. Map of Lake Roosevelt, Spokane Tribal Hatchery and Sherman Creek hatchery.

Table 1. Coded wire tagged (CWT) kokanee released in Lake Roosevelt during 2000.

Stock	CWT	Brood	Date	Release	No. Kokanee	Adjusted Long
	Code	Year	Released	Location	Released	Term
						Retention**
WHAL	62-23-34	1998	06/28/2000	Sherman Creek	94,518	74,669
MEAD	62-03-35	1998	06/28/2000	Sherman Creek	105,432	83,291
WHAL*	62-55-29	1998	07/25/2000	Sherman Creek	5,829	4,605
WHAL*	62-51-44	1998	07/25/2000	Sherman Creek	3,557	2,810
WHAL	62-03-36	1998	6/20-29/00	Little Falls	51,075	40,349
MEAD	62-03-37	1998	6/20-29/00	Little Falls	55,675	43,983

WHAL = Lake Whatcom stock kokanee

MEAD = Meadow Creek stock kokanee

WHAL* = Lake Whatcom kokanee that returned to Sherman Creek and were spawned in 1998.

**The number of kokanee released was multiplied by 0.79 to adjust 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[®]; $\alpha = 0.05$). For each trial, the null hypothesis was tested to determine if one group returned in significantly larger numbers compared to the other.

Hypothesis 1 - Returns to Sherman Creek

- 1-H₀: There was no significant difference in the number of Meadow Creek stock kokanee and Lake Whatcom stock kokanee that returned to Sherman Creek.
- 1-H₁: Meadow Creek stock kokanee returned to Sherman Creek in significantly greater numbers compared to Lake Whatcom stock kokanee.
- 1-H₂: Lake Whatcom stock kokanee returned to Sherman Creek in significantly greater numbers compared to Meadow Creek stock kokanee.

Hypothesis 2 - Returns to Tributaries throughout Lake Roosevelt

- 2-H₀: There was no significant difference in the number kokanee collected throughout the reservoir of each stock released from Sherman Creek.
- 2-H₁: Meadow Creek stock kokanee were collected throughout the reservoir at significantly higher rates compared to Whatcom kokanee.
- 2-H₂: Lake Whatcom stock kokanee were collected throughout the reservoir at significantly higher rates compared to Meadow Creek stock kokanee.

Hypothesis 3 - Returns to the creel

- 3-H₀: There was no significant difference between the numbers of Meadow Creek stock kokanee and Lake Whatcom stock kokanee that recruited to the creel.
- 3-H₁: Meadow Creek stock kokanee recruited to the creel in significantly larger numbers compared to Lake Whatcom stock kokanee.
- 3-H₂: Lake Whatcom stock kokanee recruited to the creel in significantly larger numbers compared to Meadow Creek stock kokanee.

Hypothesis 4 - Recoveries below Grand Coulee Dam

- 4-H₀: There was no significant difference in the number of Meadow Creek stock kokanee and Lake Whatcom stock kokanee recovered below Grand Coulee Dam.
- 4-H₁: Meadow Creek stock kokanee were collected in significantly higher numbers than Lake Whatcom kokanee.
- 4-H₂: Lake Whatcom stock kokanee were collected in significantly higher numbers compared to Lake Whatcom kokanee.

Decision Matrix

A decision matrix was used on hypotheses 1-3 to determine stock performance. A significant difference in at least 2 of the 3 categories, with one stock consistently outperforming the other, would indicate greater performance. Hypothesis 4 was used as a secondary objective to determine if one stock was entraining at higher rates compared to the other.

Sampling Procedures

Kokanee recovery during 2000 in Lake Roosevelt was conducted from August 17th to November 7th. Kokanee collection in Lake Roosevelt was two tiered:

1. Weekly electrofishing surveys at Sherman Creek to collect kokanee returning to the primary egg collection location. Backpack electrofishing in Sherman Creek was utilized when kokanee moved into the creek.
2. Five passes through the reservoir during the study period. A pass consisted of electrofishing for 10 minute transects at the primary embayments to Lake Roosevelt on 5 different occasions (embayments = 86). 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, measured to the nearest mm (total length), and a sub-sample weighed (grams). Kokanee with CWT were sacrificed, heads removed and placed in individually numbered bags for lab analysis.

Lake Roosevelt creel 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 sent to EWU for analysis.

Rock Island Dam and Rocky Reach Dam monitored the fish passage centers between April 1st and August 31st, 2000. During 2000, CWT studies were conducted on the Lake Wenatchee sockeye, therefore only coded wire tagged kokanee/sockeye greater than 150 mm were sacrificed and returned to EWU as Lake Roosevelt kokanee (L. Praye, WDFW personal communication). All CWT were extracted from the kokanee heads at the EWU Fisheries Research Center and examined with a dissecting microscope to determine the binary code. For quality control, 50% of the tags were re-read. Tag reading error was less than 1%.

Lake Roosevelt

Figure 2. Map of Lake Roosevelt and 89 locations sampled for kokanee during 2000.

Results

Summary

A total of 33 trips were made to Lake Roosevelt between August 17th and November 7th, 2000 during which 70.7 hours were spent boat electrofishing (Table 2). Most sites were sampled on 5 different occasions during the sampling period at approximately 2 week intervals. Additional backpack electrofishing surveys were conducted in Sherman Creek when the fish moved into the creek. EWU collected a total of 2,753 hatchery kokanee (1,066 AD- = adipose fin clipped/ no CWT; and 1,687 AD+ = adipose fin clipped/ CWT). An additional 31 wild kokanee were collected at sites throughout the reservoir (NO- = no adipose clip/no CWT). The wild kokanee were primarily captured at Hawk Creek (n=13), Sanpoil River (n=5), and the northern China Bend sites (n=6). During sampling, all fish species were collected to standardize catch data with previous surveys. Total number, catch-per-unit-effort (CPUE) and relative abundance of all fish species captured by EWU was summarized (Appendix C).

The STOI collected and provided heads of 7 AD- and 6 AD+ kokanee; 5 from Sherman Creek and 1 from Nez Perce Creek. The CCT provided 2 AD+ kokanee, 1 from the Sanpoil River and, 1 from Sherman Creek. The WDFW returned 1 AD+ fish, 1 AD-, and 4 NO-.

During the CWT analysis, 13 fish did not have tags and 12 tags were lost. Therefore, a total of 1,671 coded wire tags were used for statistical analysis (1,687 EWU; 6 STOI; 2 CCT; 1 WDFW; Table 3).

The majority of the returns (92%) were from the paired releases of Lake Whatcom and Meadow Creek stock kokanee at Sherman Creek (lots 62-03-34 and 62-03-35). The kokanee released at Little Falls dam were captured throughout the Spokane River, with a few at Sherman Creek (Table 3). The Whatcom returns released from the Colville River net pens were primarily collected at Sherman Creek.

The mean total length of age 2 Whatcom stock kokanee was 279 mm ($\pm$ 24 standard deviation, SD) and Meadow Creek stock was 271 mm ($\pm$ 23 SD; Table 4). The overall female to male ratio was 1:7 (364 females to 2,377 males), 2 immature fish were killed, and 2 hermaphrodites (male/female) were found. Each of the 2 hermaphrodites had one egg skein and one male gonad. Of the kokanee with CWT, the female to male ratio for Meadow Creek fish was 1:8 (117 females to 899 males) and the Whatcom fish were 1:44 (4 females to 174 males).

September 20th, was the largest kokanee collection day during 2000 with 620 fish collected and a catch-per-unit-effort (CPUE) of 1,240 fish/hour at Sherman Creek (Figure 3; Table 5). The number of kokanee collected decreased to only 2 and 3 on October 18th and 25th. The last day sampled was November 1st, when 38 kokanee were collected.

Meadow Creek and Whatcom kokanee started returning to the Sherman Creek Cove on August 22nd and September 5th, respectively (Table 6). The Meadow Creek run peaked during mid-September, while the Whatcom kokanee did not experience a peak, but were captured in low numbers throughout the sampling period (Figure 4). The Meadow Creek run ended by October 18th, while the Whatcom kokanee were still being captured on November 1st. We did not sample after November 1st due to boat motor problems. No kokanee were observed in Sherman Creek or the cove between November 1 and November 20, when the cove froze over (M. Combs, WDFW Sherman Creek Hatchery, personal communication).

Table 2. Summary information for kokanee collected during 2000. AD- = fin clipped only, AD+ = fin clipped + CWT, NO- = no clips or CWT (wild fish).

Location	Site Number	Days Fished	Effort (min)	AD-	AD+	NO-	Total
Grand Coulee							
Crescent Bay	E1	5	46				0
Eden Harbor	E2	5	40				0
Spring Canyon	E3	5	56				0
Qui Qui Creek	E4	5	39				0
Swawilla Basin	E5	5	41				0
Cayuse Bay	E6	5	50				0
Wynhoff Cove	E7	5	30				0
Coffman Canyon	E8	5	35				0
Keller Ferry							
Bay at RM 14 (Flats)	E11	1	10				0
Keller Boat Launch							
Bay	55	1	8				0
Covington Cove	E13	1	10				0
Hellgate Canyon	70	2	15				0
Penix Canyon	E14	5	43				0
Spiegel Canyon	E15	5	38				0
Whitestone Creek	E16	5	38				0
Burbot Creek	E17	5	43				0
Sanpoil							
Manila Creek	SP14	3	25				0
John Tom Creek	SPE3	3	23				0
Silver Creek	SPE4	1	10				0
Sanpoil River Mouth	SPE5	4	80		1	5	6
Hawk Creek/Seven Bays							
Lundstrom Bay	E18	4	30				0
Moonshine Bay	E19	4	33				0
Halverson Canyon	E20	4	33				0
Sterling Point Creek A	E21	4	28				0
Sterling Point Creek B	E22	4	33				0
Lincoln Creek Cove	E23	5	53		1		1
Hawk Creek	HE2	6	290	7	11	13	31
Sunday Bay	E24	5	43				0
George Creek	E25	5	45				0
Friday Bay	E26	4	30				0
Fort Spokane							
Spokane River	S2/S4	4	29				0
Columbia River	137	4	28				0
Louie Creek	E28	4	30				0
Abraham Creek	E29	4	31				0
Denison Canyon	E31	4	31				0

Continued. Location	Site Number	Days Fished	Effort (min)	AD-	AD+	NO-	Total
Three mile Creek	E30	4	48				0
Castle Rock Creek	E33	4	41				0
Six Mile Creek	E34	4	50				0
Nine Mile Creek	E35	4	40				0
Hunters							
Wilmont Cove	E36	4	60	1	1		2
Gerome Bay	E37	4	40		1	1	2
Alder Creek	E39	4	50	1			1
Managhan Creek	E40	4	22				0
Hunters Creek	E41	4	50	3		1	4
Falls Creek	E42	4	38				0
Nez Perce Creek	E43	4	58				0
Gifford							
Cloverleaf	E46	5	45				0
East Strange Creek	E47	5	50		1	1	2
West Stranger Creek	E44/E45	5	55				0
Hall Creek	E48	5	62	2		1	3
Bradbury Beach							
Cheweka Creek	281	5	32				0
Barnaby Creek	282	5	43				0
Quilisacut Creek	289	5	30				0
La Fleur Creek	294	5	26			1	1
Martin Creek	302	5	23				0
Roper Creek	E49	5	74		1		1
Rickey Creek	E50	5	43				0
Kettle Falls							
Colville River	E51	9	190	1	2		3
Sherman Creek Cove	E52	10	297	996	1,568	1	2,565
Sherman Creek (BP)	Creek	4	41	37	56		93
Kettle Marina	E53	5	45	1			1
Across Kettle Marina	E54	5	45				0
Fenders Creek	E55	5	50	2	3		5
Nancy Creek	E56	5	48		2		2
Napoleon Bridge	K16	5	65				0
Deadman Creek	K8	5	52				0
Kettle Bridge	K1/K3	5	55				0
Evans/China Bend							
15-mile Creek	E60	5	30			1	1
Flat Creek	E61	5	45				0
Crow Creek	406	5	45	2		5	7
Rattlesnake Creek	408	5	40				0
Porcupine Bay							
McCoy Springs	SE2	5	38.3	5	10		15
Continued. Location	Site	Days	Effort	AD-	AD+	NO-	Total

	Number	Fished	(min)				
Orazada Creek	SE3	4	38.3	1	3	1	5
Hollies Creeks	SE4	5	43				0
Sand Creek	SE5	5	40				0
Porcupine Creek	S37	5	32				0
Blue Creek	SE7	5	60	2	4		6
Pitney Creek	SE8	5	35				0
Springs	S57	5	46.7		1		1
Cayuse Cove	SE10	5	55				0
Harker Canyon	SE11	5	56.7				0
Mill Canyon	SE12	5	45				0
Little Falls							
Pumphouse	S80	5	45				0
Boat Launch	S82	5	50.5		1		1
Above Spring Creek	S93	1	20				0
Spring Creek	SE13	5	70				0
Powerhouse	S94	5	65	3	19		22
Spillway	SE14	5	100	6	6		12
Grand Total			4,316	1,066	1,692	31	2,789

BP = backpack shocked in Sherman Creek.

Numbers represent all fish collected by EWU.

Table 3. Number of CWT kokanee from each release group collected by EWU, STOI, CCT, and WDFW in Lake Roosevelt, fall 2000.

Release Location Stock of Fish Number released Lot Number	Sherman Creek		Little Falls		Sherman Creek		Grand Total
	WHAL ¹	MEAD ²	WHAL ¹	MEAD ²	WHAL* ³	WHAL* ³	
	74,669	83,291	40,349	43,983	2,810	4,605	
	62-03-34	62-03-35	62-03-36	62-03-37	62-51-44	62-55-29	
<i>Recovery Site</i>							
<i>Sanpoil River</i>		1		1			2
<i>Hawk Creek</i>		1	4	4			9
<i>Spokane River</i>							
McCoys Marina			4	6			10
Orazada Creek			2	1			3
Blue Creek			2	2			4
Springs				1			1
Little Falls B.L.			1				1
Little Falls (Dam)			11	14			25
<i>Hunters Area</i>							
Gerome Creek			1				1
<i>Gifford Area</i>							
Nez Perce Creek						1	1
Cloverleaf to Daisy ⁴		1					1
Colville River	1						1
<i>Kettle Falls Area</i>							
Sherman Creek	199	1,340	2	1	35	33	1,610
Fenders Creek	1						1
Nancy Creek		1					1
Grand Total	201	1,344	27	30	35	34	1,671

¹WHAL = Lake Whatcom stock.

²MEAD = Meadow Creek stock.

³WHAL* = Whatcom kokanee that returned to Sherman Creek in 1998.

⁴ Kokanee was collected by the WDFW in a vertical gill net set between Cloverleaf Campground and the Daisy boat launch.

Table 4. Mean total length (TL; mm) and standard deviation (S.D.) of kokanee from each CWT number and stock.

Year Class	Lot #	n	Average TL (mm)	S.D.(±)
Whatcom Stock (2 yrs.)	62-03-34	201	281	24
	62-03-36	27	265	19
	Mean	228	279	24
Meadow Creek Stock (2 yrs.)	62-03-35	1,342	271	23
	62-03-37	33	263	22
	Mean	1,375	271	23
Whatcom Returns (2 yrs.)	62-51-44	35	280	27
	62-55-29	34	293	28
	Mean	68	286	28
Grand Mean		1,687	273	25

Figure 3. Total number kokanee collected at Sherman Creek by EWU via boat electrofishing and backpack electrofishing per sample date during 2000 (n= 2,565).

Table 5. Number and catch-per-unit-effort (CPUE) of kokanee collected by EWU at Sherman Creek per date sampled, 2000.

Date	# Fish	Effort (hr.)	CPUE (Fish/hr)
08/23/00	33	0.25	132
09/05/00	390	0.50	780
09/06/00	290	0.62	470
09/12/00	514	0.87	593
09/19/00	620	0.50	1,240
09/27/00	512	0.72	714
10/11/00	163	0.33	489
10/18/00	2	0.33	6
10/25/00	3	0.42	7
11/01/00	38	0.42	91
Grand Total	2,565	4.95	518

* October 4th backpack electrofishing was not included in CPUE summary.

Table 6. Number and recovery percent at Sherman Creek of Lake Whatcom kokanee (WHAL), Meadow Creek kokanee (MEAD), and Whatcom returns (WHAL*) released from Sherman Creek, 2000.

Stock	WHAL	MEAD	WHAL*	WHAL*	
Number released	74,669	83,291	2,810	4,605	
Coded wire tag No.	62-03-34	62-03-35	62-51-44	62-55-29	Grand Total
Date					
08/23/2000	0	16	0	0	16
09/05/2000	6	258	3	0	267
09/06/2000	7	196	2	1	206
09/12/2000	40	287	6	4	338
09/19/2000	45	299	7	6	357
09/27/2000	42	239	7	7	297
10/04/2000 ¹	1	36	0	0	37
10/11/2000	36	5	5	12	59
10/18/2000	6	1	1	0	8
10/25/2000	2	0	0	0	2
11/01/2000	12	0	4	2	18
Grand Total	197	1,337	35	32	1,605
Recovery Percent	0.26	1.61	1.25	0.69	

¹Fish collected through backpack electrofishing.

Figure 4. Meadow Creek stock and Whatcom stock kokanee collected per date at Sherman Creek, 2000. (Graph excludes 10/4/2000 backpack shocking day).

Hypotheses Results

Results for hatchery kokanee collected at Sherman Creek and throughout the reservoir were summarized (Table 7). Age 3 kokanee were not available for collection, therefore results were for age 2 hatchery kokanee only.

Table 7. Age 2 kokanee collected per coded wire tag lot at Sherman Creek and at other tributaries throughout the reservoir, 2000.

Stock	CWT Code	Date Released	Release Location	Fish Released	Sherman Creek		Reservoir	
					Age 2	Age 3	Age 2	Age 3
WHAL	62-23-34	06/28/2000	Sherman Ck	74,669	199	--	2	--
MEAD	62-03-35	06/28/2000	Sherman Ck	83,291	1,340	--	3	--
WHAL*	62-55-29	07/25/2000	Sherman Ck	4,605	33	--	1	--
WHAL*	62-51-44	07/25/2000	Sherman Ck	2,810	35	--	0	--
WHAL	62-03-36	6/20-29/00	Little Falls	40,349	2	--	25	--
MEAD	62-03-37	6/20-29/00	Little Falls	43,983	1	--	28	--
Total				249,707	1,610	0	59	0

1. WHAL = Lake Whatcom,

2. MEAD = Meadow Creek kokanee

3. WHAL* = Whatcom kokanee that returned to Sherman Creek and were spawned in 1998.

Hypothesis 1- Sherman Creek Returns

Chi-square analysis indicated that the age 2 Meadow Creek kokanee returned to Sherman Creek in significantly higher numbers compared to the Whatcom stock ($P < 0.01$; Table 8).

Table 8. Returns to Sherman Creek of coded wire tagged age 2 Whatcom stock (62-03-34) vs. Meadow Creek stock (62-03-35) released from the Sherman Creek Hatchery.

CWT #	Age	# Stocked	# Recovered	Recovery %	χ^2	P-value
62-03-34	2	74,669	199	0.27	734.5	< 0.01
62-03-35	2	83,291	1,340	1.61		

Hypothesis 2- Reservoir Wide Recoveries

Four kokanee, 2 Meadow Creek and 2 Whatcom stock, released from Sherman Creek were collected at a different location in the reservoir. Lake Whatcom fish were collected in the Kettle Falls area. The Meadow Creek fish were collected in the Sanpoil River, Hawk Creek, Gifford area, and at Nancy Creek (Kettle Falls area). For reservoir wide recoveries, including those at Sherman Creek, there was a significant difference in the number of Meadow Creek kokanee recovered compared to the Whatcom stock ($P < 0.01$; Table 9).

Table 9. Reservoir wide recoveries for coded wire tagged age 2 Whatcom (62-03-34) vs. Meadow Creek stock (62-03-35) released from the Sherman Creek Hatchery.

CWT #	Age	# Stocked	# Recovered	Recovery %	χ^2	P-value
62-03-34	2	74,669	201	0.27	733.1	< 0.01
62-03-35	2	83,291	1,344	1.61		

Hypothesis 3- Recoveries from the Creel

No hatchery kokanee were collected in the creel during 2000 (STOI unpublished data). Age 3 kokanee released in 2000 are expected to recruit to the creel in 2001. An angler returned 2 age 3 hatchery kokanee to EWU. Both fish were captured on May 12th at Spring Canyon. One of the fish was released from the Colville River net pens on June 16th, 1999 (62-03-25). The

other fish was released from the Sherman Creek Hatchery on June 28th, 1999 (62-03-30). The fish from the net pen was 343 mm TL and the hatchery fish was 318 mm TL.

Hypothesis 4- Recoveries below Grand Coulee Dam

There were no Meadow Creek or Whatcom stock age 2 fish collected at the fish passage center. A total of 10 kokanee were collected at the Rock Island Dam fish passage center between April 1st and August 31st, 2000. Three of the fish were wild, while the other seven would have been age 3 Whatcom stock fish from Lake Roosevelt in the fall. 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.

Decision Matrix

The decision matrix was not performed in 2000. Two of the performance measures (Sherman Creek and reservoir wide recoveries) were analyzed, however fish were not available in creel until 2001. Recoveries in the creel and below the Grand Coulee Dam are expected during 2001, therefore stock performance will be completely analyzed in 2002.

Discussion

Returns-Sherman Creek

The majority of kokanee were collected at Sherman Creek (95%), of which 87% were Meadow Creek stock fish. There were significantly more Meadow Creek kokanee that returned to Sherman Creek compared to the Whatcom stock (1,339:199; $P < 0.01$) as well as throughout the reservoir (1,344:201; $P < 0.01$). Age two fish have little value (low angler harvest and poor egg production), so the decision on stock performance won't be made until the fall of 2001 when age 3 fish return.

The return rate of age 2 Meadow Creek and Whatcom stock kokanee was 1.61% and 0.26%. The return rate of Whatcom stock kokanee was similar to ranges reported in past years. In 1999 the return rate for Whatcom fish was 0.25% and in 1998 the return rate was 0.51% (McLellan et al. 2001). Higher return rates coupled with a healthier male to female sex ratio (Meadow Creek 8:1; Lake Whatcom 44:1) indicated that the Meadow Creek kokanee may perform better than the Lake Whatcom stock in the future.

The higher return rates of Meadow Creek kokanee could be the result of higher performance (stay in the reservoir better) or early maturity. Lewis (1970) found that Meadow Creek kokanee tended to mature at ages 1 and 2, while the Whatcom stock matured at ages 2 and 3. Meadow Creek kokanee from Canada have been known to mature at age 4, when they are 200 mm total length (G. Gale, Ministry of Fisheries, personal communication). Lewis (1970) also indicated that maturity was highly dependent on productivity, faster growing fish matured at younger ages. Lake Roosevelt kokanee were not limited in food and grew to large sizes when compared to other areas (Underwood et al. 1996). The average size of age 2 Meadow Creek kokanee collected in the fall was 271 mm.

Lewis (1970) observed the Meadow Creek kokanee entering traps during mid-September, and the Whatcom stock entering traps in October. The Meadow Creek fish were bright red in coloration, very distinct from the Whatcom fish. In this study, Meadow Creek kokanee returned to Sherman Creek earlier than Whatcom kokanee, and they were easily distinguishable. Meadow Creek kokanee were bright red in color, and the males had large green heads with prominent kypes. Stock performance between Meadow Creek kokanee and Lake Whatcom kokanee will be determined after age 3 fish have a chance to return to Sherman Creek in the fall of 2001.

Returns-Reservoir Wide

A total of 131 kokanee were collected at other locations in the reservoir. However, only 5 of those fish had CWT's (2 Lake Whatcom and 3 Meadow Creek). Chi-square analysis included kokanee collected at Sherman Creek to see if there was a significant difference in the number of kokanee from the two stocks that stayed in the reservoir. The results were similar to Sherman Creek returns. Meadow Creek kokanee returned in significantly higher numbers than Whatcom stock kokanee (1,342:201; $P < 0.01$).

Monitoring tributary mouths throughout the reservoir was initiated in 1998 to determine if kokanee released from certain areas experienced lower entrainment/mortality (stayed in the reservoir). The secondary objective was to determine if large numbers of kokanee were spawning at locations other than the egg collection sites and producing the wild fish observed in the reservoir. In 1998, 121 sites were sampled in the reservoir in which kokanee were collected at 45 sites. Sherman Creek, Little Falls, and Barnaby Creek were the predominant sites where kokanee were collected. The majority of the fish (71%) were collected at Sherman Creek

(2,449 out of 3,456 kokanee; McLellan et al. 2001). In 1999, the number of sites was reduced to 100 to eliminate unnecessary electrofishing. Kokanee were collected at 30 sites in which 85% of the kokanee were collected at Sherman Creek (1,250 out of 1,473 kokanee; McLellan et al. 2001). The total number of kokanee collected decreased, as did the number at the other primary collection sites. Hawk Creek and Barnaby decreased to only 70 and 2 kokanee respectively. During 2000, 89 sites were sampled in which 95% of the kokanee were collected at Sherman Creek (2,658 out of 2,789). Kokanee collection at Little Falls and Hawk Creek decreased perceptibly. No fish were collected at Barnaby and only 31 at Hawk Creek.

The data indicated that kokanee were not spawning in large numbers at other locations in the reservoir. The stream mouths should be sampled again in 2001 to determine if age 3 Meadow Creek kokanee stray to other streams in the reservoir.

Creel Surveys

STOI is responsible for coordinating the creel surveys at Lake Roosevelt and analyzing the data. In 1998, a total of 38 kokanee were observed in the creel of which 12 (33%) were of hatchery origin. The total kokanee harvest estimate was 9,980 (± 539), with 3,323 being hatchery kokanee (Cichosz et al. 1999). In 1999, 2 kokanee were observed in the creel in which one was of hatchery origin (K. Underwood, STOI, personal communication), but harvest estimates have not been calculated. No kokanee were observed in the creel during 2000 (K. Underwood, STOI, personal communication).

The annual kokanee test fishery was the only supplemental kokanee creel data available. During four days of fishing at Spring Canyon in January 1999, 58 wild and 3 hatchery kokanee were captured. In 2000, 45 wild and 1 hatchery kokanee were captured (K. Underwood, STOI, personal communication). The surveys might conflict with the annual creel surveys because they were limited to a localized area during a short period of time. Additionally, WDFW set gill nets on February 14th, 2000 from Spring Canyon to Swawilla Basin. They captured 2 wild kokanee in a floating horizontal net, and 1 wild kokanee in a vertical gill net (M. Polacek, WDFW, personnel communication).

Low numbers of kokanee were observed in the creel and high numbers during the test fishery. The conflicting data has prompted the STOI to perform supplemental creel surveys in

2001 to improve the accuracy of their estimates. During 2001, age 3 kokanee from the Meadow Creek stock will have the opportunity to recruit to the creel.

Recoveries Below Grand Coulee

Whatcom kokanee have been demonstrated to entrain over Grand Coulee (Tilson et al. 1996; Tilson and Scholz 1997, McLellan et al. 2000). Fish passage centers (Rock Island and Rocky Reach Dams) were monitored between April 1st and August 31st. In 1998, 238 kokanee were collected of which 93% were smolts released in the spring of 1998. The majority of those fish were released from net pens located at Seven Bays and Lincoln. In 1999, only 78 kokanee were collected and 76% were from the 1998 release. The number of smolts collected at the dams was lower because they could only sacrifice kokanee over 170 mm because sockeye smolts from the Wenatchee River were also bypassing the dams (L.Praye, WDFW, personal communication). Additionally, the lower reservoir net pens were not used in 1999. No Meadow Creek or Whatcom smolts released during 2000 were collected at the fish passage centers in 2000. The fish released into Lake Roosevelt ranged in size from 140 mm to 200 mm (M. Combs, personal communication), therefore some smolts might have been missed due to the size restriction.

Entrainment over Grand Coulee Dam has been suggested to increase when water retention times were less than 30 days (Cichosz et al. 1997, Spotts et al. 2000). In 1998, water retention times fluctuated between 26.7 and 39.0 from January through July, potentially increasing entrainment for over half the year. Therefore, the number and age of kokanee collected at the fish passage centers greatly depends on the release strategies conducted in Lake Roosevelt, water retention times, as well as other studies being conducted down stream.

Summary

The goal of testing new stocks of fish was to increase return rates of age 3 fish to Sherman Creek and increase harvest of hatchery fish by anglers. Parameters such as entrainment, precocity, and predation have potentially contributed to the low numbers of kokanee returns in the past. Previous entrainment studies conducted by the CCT have demonstrated that the majority of entrainment occurred around the third powerhouse (CCT, unpublished data). Batelle Northwest is currently studying the dynamic flows around the third

powerhouse of Grand Coulee Dam in an attempt to find a way to reduce entrainment. Precocity is currently being evaluated by the STOI (K. Underwood, STOI, personal communication).

Predation by walleye on kokanee is currently being studied by the WDFW (C. Baldwin, WDFW, personal communication). Preliminary results from the 2000 walleye predation study was conducted between Daisy to Snag Cove during June and July did not indicate a significant difference in predation rates on the two stocks of kokanee. In lavaged stomachs of walleye, 20 CWT from Whatcom kokanee and 24 CWT from Meadow Creek kokanee were found ($\chi^2 = 0.058$, $P = 0.81$).

Kokanee collected during the fall of 2001 will determine if the Meadow Creek kokanee perform better than Whatcom stock in Lake Roosevelt. It is important to maintain a migrating salmonid species in the Lake Roosevelt ecosystem. Bald eagles (a threatened species) and river otters have been feeding on the kokanee stocked in Lake Roosevelt (A. Scholz personal observation). Maintaining a balanced ecosystem will provide angler opportunities not only for kokanee, but other important game fish such as the walleye.

Recommendations

Few recommendations were made due to the need for data on age 3 kokanee.

Recommendations are as follows:

Kokanee Monitoring

1. Continue to monitor Sherman Creek in 2001 and 2002 to collect age 3 fish and to conduct a repeat of this experiment.
2. Continue to monitor major tributaries to Lake Roosevelt to determine if age 3 Meadow Creek stock kokanee stay in the reservoir and are available for harvest at higher rates compared to Whatcom kokanee.
3. Explore using sterile (triploid) kokanee to reduce possible mixing with downstream sockeye salmon.

Creel and Test Fisheries

1. Expand test fishery to incorporate the Keller Ferry area, and possibly up to Lincoln area. This may mimic the true angler harvest more accurately.
2. Encourage a late summer/fall fishery for age 2 fish. Determine, through angling, if the kokanee on the spawning run in the Sherman Creek area are harvestable. Age 2 kokanee in Lake Roosevelt are typically larger than most age 3 kokanee in other lakes.
3. Adjust creel surveys to target kokanee fishery. The current surveys do not allow for enough kokanee to be observed, which biases the estimate of kokanee harvested, as well as the precision of analysis. Enhancement of creel surveys would assist managers in determining percentages of wild and hatchery fish harvested.

Entrainment

1. Entrainment of hatchery kokanee occurs, however the fish passage center information is limited by timing and size restrictions. Kokanee may be entraining when the passages are not monitored (before April 1st and after August 31st). If Lake Roosevelt kokanee information is requested from the fish passage centers in the future, monetary assistance should be provided.

Literature Cited

- Cichosz, T.C., J.P. Shields, and K.D. Underwood. 1998. Lake Roosevelt monitoring/data collection program, 1996 Annual Report in T.A. Cichosz, J.P. Shields, K.D. Underwood, and M.B. Tilson. Lake Roosevelt Fisheries and Limnological Research, 1996 Annual Report. Prepared for Bonneville Power Administration. Portland, OR. Project No. 94-043.
- Lewis, Stephen L. 1970. An evaluation of 3 kokanee races in Oregon Lakes (1967-69). Research Division. Oregon State Game Commission. Federal Aid Completion Report 36-724.
- McLellan, H.J., J.G. McLellan, A.T. Scholz, and M.B. Tilson. 2001. Lake Whatcom kokanee salmon (*Oncorhynchus nerka kennerlyi*) investigations in Lake Roosevelt, 1998-2000. 1999 Annual Report. Prepared by Eastern Washington University Fisheries Center for Bonneville Power Administration, Portland Oregon. Project Number 96BP192246, Contract No. 97283-3621.
- Spotts, J.V., J.P. Shields, K.D. Underwood, and T.C. Cichosz. 2000. Annual report 1998, Part A. Lake Roosevelt fisheries evaluation program, Creel Survey, and Population Status Analysis. Spokane Tribe of Indians. Department of Natural Resources. Prepared for the Bonneville Power Administration. Division of Fish and Wildlife. Portland, OR. Project Number 199404300.
- Tilson, M.B. and A.T. Scholz. 1998. Artificial imprinting of juvenile kokanee salmon (*Oncorhynchus nerka*): Implications for operating Lake Roosevelt kokanee salmon hatcheries. 1996 Annual Report. Prepared by Eastern Washington University Fisheries Center for Bonneville Power Administration. Portland Oregon. In: Cichosz, T.A., J. Shields and K.D. Underwood. 1998. Lake Roosevelt Fisheries and Limnological Research. Annual Report 1996. Prepared by Department of Natural Resources, Spokane Tribe of Indians for Bonneville Power Administration, Portland, Oregon. 331 pp.
- Tilson, M.B., A.T. Scholz and J.L. Miller. 1997. Artificial imprinting and smoltification in juvenile kokanee salmon: Implications for operating Lake Roosevelt kokanee salmon hatcheries. 1995 Annual Report. Prepared by Upper Columbia United Tribes Fisheries Research Center. In: Underwood, K., and J. Shields. 1997. Lake Roosevelt Fisheries and Limnological Research. Annual Report 1995. Prepared by Department of Natural Resources, Spokane Tribe of Indians for Bonneville Power Administration, Portland, Oregon. 340 pp.
- Tilson, M.B., A.T. Scholz, R.J. White and H. Galloway. 1994. Thyroid-induced chemical imprinting in early life stages and assessment of smoltification in kokanee salmon hatcheries. 1993 Annual Report. Prepared by Upper Columbia United Tribes Fisheries Research Center for Bonneville Power Administration. Portland Oregon. 156 pp.

- Tilson, M.B., A.T. Scholz, R.J. White and J.L. Hendrickson. 1995. Artificial imprinting and smoltification in juvenile kokanee salmon: Implications for operating Lake Roosevelt kokanee salmon hatcheries. 1994 Annual Report. Prepared by Upper Columbia United Tribes Fisheries Research Center for Bonneville Power Administration. Portland Oregon. 127 pp.
- Tilson, M.B., A.T. Scholz and J.L. Miller. 1996. Artificial imprinting of juvenile kokanee salmon (*Oncorhynchus nerka*): Implications for operating Lake Roosevelt kokanee salmon hatcheries. Pages 281-340 in K.D. Underwood and J.P. Shields, Editors. 1996. Lake Roosevelt Fisheries and Limnological Research: 1995 Annual Report. Unites States Department of Energy, Bonneville Power Administration, Portland, OR. Report No. DOE/BP-91819-16. 340 pp.
- Underwood, K.D., J.P. Shields, and M.B. Tilson. 1996. Lake Roosevelt fisheries monitoring program , 1995 annual report. Lake Roosevelt Fisheries and Limnological Research: 1995 Annual Report. Unites States Department of Energy, Bonneville Power Administration, Portland, OR. Report No. DOE/BP-91819-16. 340 pp.

Appendix A

Table 10. Summary of kokanee stocked into Lake Roosevelt from Sherman Creek, Kettle River net pens, and below Little Falls Dam, 2000.

CWT Code	Brood Year	Date	Release Location	Stock	Run Time	Kokanee Released	CWT Released	Release fish/lb.
62-23-34	1998	06/28/2000	Sherman Creek	WHAL	early	94,518	74,669	9.63
62-03-35	1998	06/28/2000	Sherman Creek	MEAD	x	105,432	83,291	9.63
62-55-29	1998	07/25/2000	Sherman Creek	WHAL*	middle	5,829	4,605	8.9
62-51-44	1998	07/25/2000	Sherman Creek	WHAL*	middle	3,557	2,810	8.9
AD ONLY	1998	07/25/2000	Sherman Creek	WHAL	middle	72,602	72,602	8.9
AD ONLY	1998	06/14/2000	Kettle Falls NP	WHAL	middle	197,975	197,975	19.6
AD ONLY	1998	06/28/2000	Sherman Creek	WHAL	middle	95,680	95,680	9.63
62-03-36	1998	6/20-29/00	Spokane River	WHAL	early	51,075	40,349	10.0
62-03-37	1998	6/20-29/00	Spokane River	MEAD	x	55,675	43,983	10.0
AD ONLY	1998	06/12/2000	Spokane River	WHAL	middle	15,770	15,770	14.0
AD ONLY	1998	05/19/2000	Spokane River	WHAL	middle	41,600	41,600	18.0
AD ONLY	1998	05/30/2000	Spokane River	WHAL	middle	21,600	21,600	3.5
AD ONLY	1998	06/12/2000	Spokane River	WHAL	middle	30,000	30,000	15.0

WHAL = Whatcom stock

MEAD = Meadow Creek stock

WHAL* = Whatcom kokanee that returned to Sherman Creek in 1998 and were spawned.

Appendix B

Table 11. Summary of the total number of fish collected (n), relative abundance (R.A.), catch-per-unit-effort (CPUE), and size range (mm) of the fish collected by EWU via boat electrofishing at Lake Roosevelt between August 17th – November 17th, 2000 (effort = 71.2 hours).

Species	n	R.A. %	CPUE	Size range (mm)
Black crappie	41	0.79	0.58	36-206
Bull trout	2	0.04	0.03	417-800
Bridgelip sucker	7	0.14	0.10	191-360
Brown trout	31	0.60	0.44	113-567
Bull trout/E. Brook hybrid	1	0.02	0.01	383
Burbot	37	0.72	0.52	95-601
Chinook	6	0.12	0.08	425-752
Chiselmouth	1	0.02	0.01	113
Cottidae	107	2.07	1.50	18-143
Carp	35	0.68	0.49	42-747
Cutthroat	1	0.02	0.01	411
Eastern brook trout	47	0.91	0.66	73-409
Kokanee	2807	54.35	39.42	167-562
Largemouth bass	26	0.50	0.37	33-380
Longnose dace	1	0.02	0.01	35
Longnose sucker	8	0.15	0.11	80-437
Largescale sucker	397	7.69	5.58	43-682
Lake Whitefish	4	0.08	0.06	493-523
Northern pikeminnow	61	1.18	0.86	33-599
Peamouth	5	0.10	0.07	60-138
Pumpkinseed	3	0.06	0.04	93-103
Rainbow trout	502	9.72	7.05	30-588
Redside shiner	29	0.56	0.41	41-79
Smallmouth bass	187	3.62	2.63	24-297
Speckled dace	1	0.02	0.01	
Tench	7	0.14	0.10	148-470
Walleye	178	3.45	2.50	66-536
Mountain whitefish	27	0.52	0.38	109-418
Yellow bullhead	1	0.02	0.01	180
Yellow perch	478	9.25	6.71	49-210
Grand Total	5,165	100.00	72.54	