Lake Roosevelt Fisheries Evaluation Program, Part D

Assessment of the Lake Roosevelt Walleye Population

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**1998 Annual Report, Part D.
Lake Roosevelt Fisheries Evaluation Program,
Assessment of the Lake Roosevelt Walleye Population.**

Annual Report 1998

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Abstract

A walleye mark-recapture experiment was initiated on Lake Roosevelt in 1997, with the primary objective of estimating the size of the walleye population. The project was continued in 1998 with a revised sampling regime. The primary goals during 1998 were to estimate the size of the walleye population in Lake Roosevelt, estimate the size of the spawning run in the Spokane River Arm, and describe the age structure of the population for use in managing the population and developing a kokanee bioenergetics model. Secondary objectives included: determining walleye movements, back-calculating growth rates, estimating mortality rates, determining walleye condition, and estimating walleye young-of-the-year (YOY) production in the Spokane River Arm. All walleye, ≥ 150 mm TL, were marked with individually numbered Floy® tags, during five passes through the reservoir. The passes occurred between April 1st and September 16th, 1998. The most unbiased estimate of walleye abundance in Lake Roosevelt, 186,482 ($40,113 \leq N \leq 943,213$), was obtained using the M_{tb} model of the CAPTURE program. The most unbiased estimate of the size of the walleye spawning run in the Spokane River Arm, 27,345 ($1,535 \leq N \leq 57,519$), was calculated using the Jolly-Seber model. The abundance estimates appeared reasonable, but they had wide 95 % confidence intervals. Wide confidence intervals were attributed to low capture probabilities. Coefficient of variation (CV) values for both estimates indicated that they were not acceptable for general management, not to mention research. Despite the CV value, we felt that the reservoir estimate was reasonable and that it was the best possible, without a large increase in effort and money. The spawning run estimate could have been improved by a small increase in effort. Ages of walleye in Lake Roosevelt ranged from 0 to 13 years. Growth, mortality, and condition were all average when compared to other walleye producing waters. We recommended that there be no changes in the management of the Lake Roosevelt walleye population and that three separate values of walleye abundance be used in the calculation of the kokanee bioenergetics model.

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Introduction

A walleye (*Stizostedion vitreum vitreum*) mark-recapture study was initiated on Lake Roosevelt, Washington in 1997, with the primary objective of determining the size and age structure of the population (McLellan et al. 1998; McLellan 1998). The study was repeated in 1998 with a more intensive, extensive, and randomized sampling regime due to problems associated with sampling bias in the 1997 study. The 1997 and 1998 results were to be used to determine the status of the walleye population in Lake Roosevelt, as well as be used as the predator component of a kokanee (*Oncorhynchus nerka*) bioenergetics model that is currently being developed by the Washington Department of Fish and Wildlife (WDFW) and the Lake Roosevelt Monitoring Program (LRMP) (a cooperative investigation of the Lake Roosevelt ecosystem by the Spokane Tribe of Indians (STI), Colville Confederated Tribe of Indians (CCT), and WDFW).

Initial concern about the status of the walleye population in Lake Roosevelt was raised by the U.S. Fish and Wildlife Service (USFWS) in 1985. They concluded that the size and age structure of the population was changing to smaller, younger fish and warned that the population was at risk for collapse (Beckman et al. 1985). Several angling regulations were initiated after 1985, to protect Lake Roosevelt walleye (Washington Department of Fish and Wildlife 1995; McLellan et al. 1998; McLellan 1998). Despite the regulation changes, angler harvest estimates (from LRMP creel surveys) had wide fluctuations from 1988 through 1995, with estimates stabilizing in 1996 and 1997 (Cichosz et al. 1997; Cichosz et al. 1999a). The 1997 walleye assessment was originally designed to determine the status of the Lake Roosevelt population.

Abundance data collected during the 1997 study was generally inconclusive. Estimates of walleye abundance ($\pm$ 95% confidence interval) ranged from 51,849 ($\pm$ 111,620) to 64,641 ($\pm$ 18,739) using Jolly-Seber and Schnabel estimators, respectively (McLellan et al. 1998; McLellan 1998). The estimates were considered underestimates due to a 1997 angler harvest estimate of 115,696 walleye (McLellan et al. 1998; McLellan 1998, Cichosz et al. 1999a). The low values were probably due to sampling bias, as a result of a non-random sampling regime and evidence that the walleye were not moving randomly during the study period (McLellan et al. 1998; McLellan 1998).

Walleye age data compiled in 1997 was also considered inconclusive. Walleye age analysis in 1997 indicated that the population was comprised mostly of small, young fish, when compared to the USFWS data that had elicited a warning of a potential walleye population collapse. During 1997 there were no walleye collected that were older than 8 years of age, while the USFWS collected 87 walleye between 1980 and 1983 that were between 9 and 13 years of age (Beckman et al. 1985; McLellan et al. 1998; McLellan 1998). However, the comparison of the 1997 and 1980-83 age data was limited, due to the fact that the USFWS data was collected from the walleye spawning run while the EWU data was not (Beckman et al. 1985; McLellan et al. 1998; McLellan 1998). The Lake Roosevelt walleye project was repeated in 1998, in an attempt to remove the sampling related biases of the 1997 analysis.

Determining the abundance and age composition of the Lake Roosevelt walleye population had management implications beyond that of the walleye population itself. In 1991, with the construction of the Spokane Tribal Fish Hatchery and the Sherman Creek Fish Hatchery (WDFW), the LRMP began stocking kokanee into Lake Roosevelt, with the initial objective of developing a kokanee fishery in Lake Roosevelt, as mitigation to the Spokane Indian Tribe for salmon losses due to the construction of Grand Coulee Dam (Northwest Power Planning Council 1986). In order to maximize kokanee production, the LRMP and WDFW are developing a whole reservoir bioenergetics model for Lake Roosevelt (Underwood 1998, STI, personal communication). Predator abundance and kokanee consumption rates are important model inputs. Walleye were the primary predator of kokanee in the reservoir, due to the fact that they were the most abundant piscivore in Lake Roosevelt, based on CPUE (2.60 fish/hour) and relative abundance (19%), and salmonids were the most relatively important (index of relative importance (IRI) = 28.31) food item in walleye stomachs (Cichosz et al. 1997). CPUE's and relative abundances of the other main piscivores in Lake Roosevelt, smallmouth bass (*Micropterus dolomieu*) (0.78 fish/hour and 6 %), burbot (*Lota lota*) (0.58 fish/hour and 4 %), and northern pikeminnow (*Ptychocheilus oregonensis*) (0.25 fish/hour and 2 %), were much lower than those of the walleye (Cichosz et al. 1997). Based on the previous diet and relative abundance data, the bioenergetics model needs a walleye abundance estimate.

During 1998, we conducted a mark-recapture experiment on the Lake Roosevelt walleye population, with the primary objectives of estimating abundance in the entire reservoir, spawning run size in the Spokane River Arm, and describing its age structure, for use in managing the walleye population and developing a kokanee bioenergetics model. Secondary objectives included: 1) determining walleye movements, 2) back-calculating growth rates, 3) estimating mortality rates, 4) determining walleye condition, and 5) estimating walleye young-of-the-year (YOY) abundance in the Spokane River Arm.

Materials and Methods

Fish Sampling and Marking

Reservoir

The primary means of fish collection was boat electrofishing, which was completed with a Smith-Root® SR-18 boat electrofisher (Smith-Root, Vancouver, WA) with the DC voltage adjusted to produce 3-5 amps, and with a pulse frequency of 120 pulses per second. Sampling was conducted during five passes through the reservoir. A pass consisted of sampling at each of 16 reservoir sections (Figure 1). Pass dates were:

1. April 1st through June 11th,
2. June 12th through July 12th,
3. July 13th through August 2nd,
4. August 3rd through August 24th, and
5. August 25th through September 16th.

A stratified, random sampling design was used for fish collection. The mainstem reservoir was divided into ten sections, with the first section beginning at the forebay of Grand Coulee Dam and the last section ending at the downstream end of the Little Dalles (just north of China Bend). Each section was 20 kilometers long except the tenth section, which was 27 kilometers long. The Spokane River Arm was divided into two, 20 kilometer sections and one, seven kilometer section. The Sanpoil River Arm was treated as one, 13 kilometer section. The Kettle River Arm was treated as one, ten kilometer section. The Hawk Creek embayment was treated as one seven kilometer section (Figure 1). Within each section both shorelines were divided into one kilometer transects (40 transects per 20 km reservoir section), which were each assigned a number, with odd numbers on the south and east sides of the reservoir and even numbers on the north and west sides. Each major embayment in the reservoir was numbered consecutively as we moved up the reservoir. Major embayments were considered any deviation from a straight shoreline that had surface water inflow at some point during the year. Decisions as to those embayments that met the criteria were made based on previous observation and/or a nautical chart (U.S. Geologic Survey; scale 1:50,000).

Figure 1. Map of 1998 Lake Roosevelt sampling sections. Section NP/BC includes the Columbia River from the upstream boundary of section 10 to Hugh Keenleyside Dam, British Columbia.

During the first pass through the reservoir, four randomly selected river transects and four randomly selected embayments were sampled per river section, except at Hawk Creek where we sampled at two randomly selected shorelines and two randomly selected embayments. During the subsequent four passes, we sampled eight randomly selected river transects and all the embayments in each river section, except Hawk Creek and the Kettle River Arm, where we sampled 4 and 6 randomly selected shoreline sites. The division of sampling effort between the shoreline and embayment strata was not proportional, due to the necessity to facilitate marking more fish. White et al. (1982) recommended designing the study to allow for marking as many animals as possible during a mark-recapture project if there was indication that the animals might exhibit behavioral responses to marking. Previous estimates of walleye abundance in Lake Roosevelt resulted in the selection of CAPTURE models that indicated walleye had a behavioral response to collection and marking (McLellan et al. 1998; McLellan 1998). McLellan et al. (1998) reported that the highest densities of walleye occurred in the embayments.

Electrofishing surveys were supplemented with angling on April 4th, May 2nd and 30th, June 21st and 22nd, and August 3rd, 6th, and 12th. Angling on April 4th and May 2nd and 30th were conducted in the Spokane Arm, with the assistance of the Spokane Walleye Club. Walleye angling on June 21st and 22nd was in conjunction with the Governor's Cup Walleye Tournament in Kettle Falls, Washington. EWU personnel and Spokane Walleye Club volunteers completed the additional angling in the Keller Ferry, Sanpoil River, Hawk Creek, and Kettle Falls sections, as well as the area between Hawk Creek and Hunters. Personnel from the STI, CCT, and WDFW aided EWU with the walleye tagging during the Spokane River angling days and the Governor's Cup Walleye Tournament.

During the walleye spawning run in the Spokane River Arm, we conducted sampling in addition to the randomly selected Pass 1 sites, in order to mark large numbers of walleye while they were easily accessible. We determined the walleye spawning run in the Spokane Arm occurred between April 1st and May 22nd, which were the dates when we collected ripe fish in the spawning area below Little Falls Dam. The additional sampling consisted of electrofishing the entire accessible shoreline from Little Falls Dam

downstream to Harker Canyon. Walleye tagging during the spawning congregation was justified, due to the fact that those fish marked during the spawn randomly disperse following spawning (Beckman et al. 1985).

Spawning Run

In order to estimate the size of the walleye spawning run above Harker Canyon, we divided the spawning sampling period into six passes and estimates were calculated only using mark-recapture data collected upstream of Harker Canyon, during the spawning run. The passes were as follows:

1. April 4th,
2. April 12th through April 18th,
3. April 19th through April 25th,
4. April 26th through May 2nd,
5. May 10th through May 16th, and
6. May 17th through May 22nd.

Data Collection and Fish Marking

During electrofishing surveys, all species of fish were collected to standardize catch and effort data to allow for comparisons with previous studies. Total lengths (TL) (mm) were obtained from all fish collected. Weights (g) were measured with an Acculab® (Newton, PA) V-4Kg electric balance. The balance was calibrated, approximately once every three weeks, according to the instructions provided by the manufacturer. Scale samples were also collected and placed in coin envelopes with the length, weight, location, date, tag number, and sex of the fish written on the outside of the envelope. All walleye ≥ 150 mm TL were affixed with an individually numbered FD 94 $\frac{3}{4}$ monofilament long “T”- anchor Floy® (Floy Tag and Mfg., Inc., Seattle, WA) tag and released. Each tag also possessed the address “EWU CHENEY” so anglers would know where to return them. Tags were inserted into the dorsal musculature of the walleye at the posterior base of the first dorsal fin. Posters informing anglers about fisheries projects on Lake Roosevelt and where to report tag information were placed at major boat launches around the reservoir. Tag return data requested included the tag

number, length, location and date of capture, and weight (if possible). All anglers who returned walleye tags were sent a letter with information about the when and where their fish was tagged, as well as its length.

Electrofishing catch-per-unit-effort (CPUE) was calculated by dividing the number of fish captured by the amount of electrofishing effort (hours). CPUE was determined for each sampling section, as well as the entire reservoir. would

Abundance Estimates

Animal populations are generally considered either closed or open. In a closed population there is no change in animal abundance during the course of the study, so there is no death, emigration, birth, and/or immigration occurring in the population. Conversely, an open population experiences some or all of the previous factors, causing its size to change during the course of the study. We determined that the walleye population in Lake Roosevelt was open, due to angler harvest (tag returns) and emigrating fish, in 1997 (McLellan 1998; McLellan et al. 1998).

Using closed and open models, we calculated four estimates of the size of the walleye population in Lake Roosevelt and three estimates of the size of the Spokane River spawning run. The first two models, for estimating the size of closed populations, were the Chapman version of the Schnabel estimate (Seber 1982) and the “most appropriate” model chosen by the IBM computer program CAPTURE (Otis et al. 1978; White et al. 1982). The third model used was the Jolly-Seber model for an open population (Seber 1982). Only recaptures by EWU and STI were used to generate the population estimates. Captured walleye previously tagged by another agency or tagged in 1997 by EWU or STI were treated as first captures, using the original tag. Recaptures of fish tagged during the same pass were ignored.

Closed Population Estimators

A closed population estimator can be used to estimate the size of an open population, when the assumption of closure are relaxed, which would only affect the timing of the estimate (Pollock et al. 1990). If mortality and emigration had equal effects on the marked and unmarked portions of the population and neither recruitment nor immigration occurred, the estimate would be for the size of the population at the

beginning of the study (Otis et al. 1978). However, if recruitment (immigration) and mortality (emigration) were both occurring, the size of the population would be overestimated (Otis et al. 1978). Estimates for the open walleye population were calculated using closed estimators, by correcting for recruitment.

Beginning June 1, 1998, we adjusted for recruitment by increasing the minimum TL for tagging by 10 mm every two weeks, which was the approximate growth of Lake Roosevelt walleye in 1997, based on 98 recaptures with adequate length data provided at each sighting (McLellan et al. 1998; McLellan 1998). By initiating the recruitment adjustment on June 1st, we made the assumption that age 1 walleye were ≥ 150 mm TL prior to the beginning of the study and that YOY walleye would not reach 150 mm TL by June 1st (Beckman et al. 1985; Peone et al. 1990; Griffith and Scholz 1991; McLellan et al. 1998; McLellan 1998). We assumed no immigration, because previous movement data suggested that walleye would have been migrating out of the study area during the study period rather than into it (Hildebrandt, personal communication, 1998).

The Chapman version of the Schnabel model, corrected for small sample bias, was used to estimate walleye abundance (Seber 1982). For comparison, two estimates of abundance were calculated via the Schnabel model. The first estimate was not adjusted for recruitment and the second was. The Schnabel estimate equation was:

$$N = \frac{\sum C_t M_t}{\sum R + 1}$$

where:

- N = estimated population size,
- C_t = total number of fish captured at time t ,
- M_t = total number of marked fish available for capture at time t , and
- $\sum R$ = total number of recaptures up to time t .

The 95 % confidence intervals were calculated using the Poisson distribution table in Ricker (1975). Both Schnabel estimates were compared statistically ($\alpha = 0.05$) with the test proposed by Chapman and Overton (1966), in order to determine if tagging walleye ≥ 150 mm TL in Lake Roosevelt between April 1 and September 16, resulted in negligible recruitment as suggested by McLellan et al. (1998) and McLellan (1998).

The computer program CAPTURE was used to estimate the size of the reservoir walleye population, with the recruitment adjustment, as well as the estimate of the size of the spawning run. The USFWS developed the computer program, CAPTURE, to calculate closed population estimates using a Petersen-type model, arranged to compensate for heterogeneity in capture probabilities (all animals not having equal probability of capture) (Otis et al. 1978; White et al. 1982). CAPTURE had the ability to select the most “appropriate” of 11 different models, based on the data set. The 11 models were as follows: M_o , the null model, which assumes no differences in capture probability among all animals; M_b , which accounts for differences in capture behavior of the organism; M_t , which deals with differences in capture methods or environmental conditions (day vs. night); M_h , which accounts for individual differences in capture probability (trap accessibility influenced by sex, territory, age, dominance, etc.); and all the possible combinations of models M_b , M_t , and M_h (Otis et al. 1978; White et al. 1982). All the models, excluding M_o , were designed to relax the assumption of equal catchability, because biological populations rarely follow mathematical rules (Otis et al. 1978; White et al. 1982).

Open Population Estimator

The Jolly-Seber model was the open population estimator used to estimate walleye abundance for the entire reservoir, as well as the spawning run (Seber 1982). The Jolly-Seber model, corrected for small sample bias, was:

$$N_i^* = \frac{M_i^*(n_i + 1)}{m_i + 1}$$

where:

- N_i^* = total number in the population just before sample i ,
- M_i^* = the number of marked fish in the population just before sample i ,
- n_i = the number of captured at sample i , and
- m_i = total number of marked fish caught in sample i .

Before solving for N_i^* , we calculated M_i^* using the formula:

$$M_i^* = \left(\frac{R_i + 1}{r_i + 1} \right) z_i + m_i$$

where:

- M_i^* = the number of marked fish in the population just before sample i ,
- R_i = the number of marked fish released at sample i ,
- z_i = the sum of all recaptures made later than sample i and of fish marked before sample i ,
- r_i = the total number of recaptures that were first marked at sample i , and
- m_i = total number of marked fish caught in sample i .

The variance and standard error (S.E.) of the population estimate (N_i^*) were calculated with the following formula (Seber 1982):

$$V[N_i^* | N_i] = N_i^* (N_i^* - n_i) \left\{ \frac{M_i^* - m_i + R_i}{M_i^*} \left(\frac{1}{r_i} - \frac{1}{R_i} \right) + \frac{1 - \rho_i}{m_i} \right\}$$

where:

- $V[N_i^* | N_i]$ = the variance of the population estimate (N_i^*),
- N_i = actual size of the population just before sample i , and
- ρ_i = m_i/n_i .

$$S.E. = \sqrt{V[N_i^* | N_i]}$$

The 95 % confidence interval was calculated assuming a normal distribution.

Precision of the estimates was measured by calculating a coefficient of variance (CV), which was defined as the ratio of the standard error of the estimate to the estimate (Hightower and Gilbert 1984).

In order to verify the reservoir walleye abundance estimate, walleye density was extrapolated from the following equation (Beard et al. 1997): angler catch/hour = 0.018(number of walleye/acre). The angler catch rate (0.098 fish/hour) was determined from the LRMP creel surveys (Cichosz et al. 1999b). Walleye abundance was estimated by multiplying the walleye density estimate by the surface area of Lake Roosevelt (82,720 acres; Beckman et al. 1985).

In order to determine if a walleye population the size of which we estimated could support an angler harvest of approximately 100,000 fish, the potential recruitment to age four was calculated. Age four was selected because that was the age that most female walleye matured in Lake Roosevelt (Beckman et al. 1985). The mean fecundity of the female walleye collected during the spawning run was estimated using the regression equation (Forney 1976): $\text{fecundity} = -7,900 + 70,600(\text{weight in grams})$. Total number of female spawners was estimated by applying the percentage of female spawners collected during electrofishing surveys, to the mean estimated size of the spawning run. Egg production was calculated by multiplying the total number of female spawners by the mean fecundity. The potential recruitment to age four was calculated by applying survival rates to the estimated egg production. Egg to age one survival was assumed to be 0.0026 (0.26 %), which was the lowest value we could find in the literature (Carlander 1997). Survival of Lake Roosevelt walleye was previously shown to be 52 % between each age until age four (McLellan et al. 1998; McLellan 1998).

Model Assumptions

Models designed to estimate animal abundance via mark-recapture have a variety of mathematical and biological assumptions associated with them. Assumptions of the closed models were (Ricker 1975; Otis et al. 1978; White et al. 1982):

1. The population was closed.
2. Animals did not lose their tags during the study.
3. All animals in the population have an equal probability of being captured on each sampling occasion.

The assumptions of the Jolly-Seber model were (Seber 1982):

1. All animals alive and in the population had the same probability of capture at each sampling occasion.
2. All animals have the same probability of surviving or remaining in the population from sample i to sample $i+1$, if it was alive immediately after sample i .
3. Animals do not lose their tags.
4. All samples are instantaneous, so sampling time is negligible, and each release is made immediately after the sample.

In order to assure the validity of the abundance estimates, we had to insure the model assumptions had been met or could be relaxed.

The assumption of closure was relaxed by adjusting for recruitment for calculation of the CAPTURE estimate and one of the Schnabel estimates. An alternative estimate of abundance was calculated using the Schnabel method to determine whether or not tag loss was negligible in 1998. The alternative estimate was made by adding the number of recaptures per pass at the approximate observed rate of tag loss in 1998, similar to the method of Beamesderfer and Rieman (1991). The Schnabel estimate corrected for tag loss was compared statistically with the estimate assuming no tag loss, using the test for differences between Schnabel estimates (Chapman and Overton 1966).

The assumption of equal catchability was tested using the CAPTURE programs model selection procedure (Otis et al. 1978; White et al. 1982) and by comparing recapture rates of marked walleye collected via electrofishing with those collected via angling. The comparison of recapture rates was made using the chi-square Test for Independence ($\alpha = 0.05$, 1 degree of freedom (d.f.)) (Johnson and Bhattacharyya 1996). Angler catch ratios were determined from the Spokane River Angling Days, Governor's Cup Walleye Tournament, and data provided by anglers with tag returns. Several anglers provided catch data, with their voluntary tag returns, that included the numbers of marked and unmarked walleye captured on their outing.

The validity of the Jolly-Seber model was tested using Goodness of Fit Tests ($\alpha = 0.05$) proposed by Pollock et al. (1990).

Movements

Walleye movement from release location to subsequent recapture location was estimated from biologist and angler reported recaptures. Only returns with specific recapture locations and dates were included in the analysis. Walleye recaptured within 7 days of release were ignored for movement analysis. Minimum distance traveled between release and recapture location was estimated by measuring the shortest distance from the point of release to the location of recapture on a U.S. Geologic Survey Nautical Chart (scale = 1:50,000). Distance between the release and recapture location of walleye that were recaptured on more than one occasion was calculated from the most recent

release to the subsequent recapture. Recaptures of walleye recaptured more than once were treated individually during analysis. Distances between release and subsequent recapture location were calculated for walleye tagged in 1997 and recaptured in 1998, walleye tagged and recaptured in 1998, walleye tagged during the 1998 spawning run in the Spokane Arm and recaptured following the spawning run, and walleye tagged in 1998 after the spawning run.

Mean minimum distance traveled between release and recapture location by walleye tagged on the spawning run were compared statistically with those tagged following the spawning run, to determine if spawning walleye were recaptured farther from their release location, on average, than those marked following the spawning run. The comparison was made using a one-sided t-Test, assuming unequal variances ($\alpha = 0.05$) (Johnson and Bhattacharyya 1996).

Age and Growth

Scale samples were obtained from 4,614 walleye for scale analysis. For equal representation of all size classes, scales from five walleye per 1 cm length class were randomly selected for analysis. If fewer than five fish were collected in a length class, all the scale samples from fish in that specific length-class were analyzed. Scales were placed between two microscope slides and magnified (24X) with an Eyecom 3000® (Eye Communication Systems, Hartland, WI) microfiche reader. Ages were determined by counting the number of annuli formed on each scale (Devries and Frie 1996).

Measurements for back-calculations were obtained by measuring the distance, to the nearest mm, from the focus of the scale to outermost edge of each annulus and to the edge of the scale. Measurements were made along the longest axis, from the focus to the scale edge, using a transparent ruler. Two individuals read all scales. If there was a disagreement about the age of a fish, the researchers discussed the scale until a consensus was reached.

The Fraser-Lee method was used to back-calculate the total length at each annulus formation. The equation for Fraser-Lee Method was (Devries and Frie 1996):

$$L_i = \left(\frac{L_c - a}{S_c} \right) S_i + a$$

where:

- L_i = back-calculated TL of the fish at the formation of the i^{th} annulus,
- L_c = TL of the fish at capture,
- S_c = length from the focus to the outermost edge of the scale at capture,
- S_i = length from focus of the scale to the outer edge of the i^{th} annulus, and
- a = the Y-intercept of the body length vs. scale length regression line.

An age-length key was created to assign ages to fish from which scales were not obtained or analyzed (Anderson and Neuman 1996). The key was constructed by determining the total number of fish collected in each length-group. Length-groups were created by rounding the TL (mm) to the nearest centimeter (cm). Ages were determined for a subsample of fish in each length-group via scale analysis. Using the proportions of fish of each age in the subsample of a length-group, the total numbers of fish of each age in the length-group were estimated.

Mortality

Age frequency information derived from the age-length key was used to develop a simple catch-curve, according to the method in Ricker (1975). Instantaneous mortality (Z) was calculated via the Baranov method (Ricker 1975), where the absolute value of the slope of the regression line that described the descending limb of the catch-curve was multiplied by 2.3026. The age class at the peak of the curve and age classes represented by fewer than 10 individuals were ignored for the calculation of the regression equation. Mean annual survival was calculated with the following formula (Ricker 1975):

$$S = e^{-Z}$$

where:

- S = mean annual survival,
- e = natural log constant (≈ 2.718), and
- Z = instantaneous rate of mortality.

Mean annual mortality (A) was calculated with the formula $A = 1 - S$, where A and S were previously defined (Ricker 1975).

Assuming equal numbers at birth and equal mortality between each age class, for all cohorts, mean annual mortality between age classes was estimated with the formula $A = 1 - S$ (Ricker 1975). Before calculating the annual mortality (A) between age classes, annual survival (S) between age classes was estimated using the formula:

$$S = \frac{N_{t+1}}{N_t}$$

where:

- S = annual survival,
- N_t = number of age t fish collected, and
- N_{t+1} = number of age $t+1$ fish collected.

Condition

The length to weight relationship of walleye was determined by calculating a regression equation. Both variables were log-transformed in order to obtain the best-fit regression equation (Anderson and Neuman 1996).

Condition factors (K_{TL}) were calculated as an index of how Lake Roosevelt walleye add weight in relation to increasing length (Anderson and Neuman 1996). Mean condition factor was calculated for the entire walleye population and for each age class using the following formula:

$$K_{TL} = \left(\frac{WT}{TL^3} \right) \times 10^5$$

where:

- K_{TL} = condition factor based on total length,
- WT = weight, and
- TL = total length.

Walleye Young-of-the-Year Abundance

We attempted to estimate the abundance of YOY walleye in the Spokane River Arm, via a mark-recapture experiment. YOY walleye were collected via electrofishing on August 3rd, 4th, and 6th, 1998. Transects in the Spokane River Arm were randomly selected using the protocol scheme described for the adult estimates. All walleye < 150 mm TL were assumed to be YOY, based on scale analysis (McLellan et al. 1998; McLellan 1998) and were marked with yellow and green elastomere on August 3rd and 4th, and August 6th, respectively. Due to low numbers of YOY walleye captured and no recaptures, the estimate was determined to be unfeasible and was abandoned after August 6th, 1998.

Results

Fish Collection and Marking

Between April 1st, 1998 and September 16th, 1998, EWU biologists, with the aid of anglers, collected 5,025 walleye. Of those fish collected, 4,747 were marked with “Floy” tags (Table 1). In an attempt to increase the precision of the entire reservoir walleye abundance estimate, STI walleye marking data was combined with the EWU data (Table 1) (Cichosz et al. 1999b). There were 453 recapture events during 1998 (Table 2; Appendix A).

Twenty-four walleye recaptured in 1998 had been recaptured on at least one other occasion in either 1997 or 1998. Twenty-two of the multiple recaptures were fish recaptured on two occasions and 2 were fish recaptured on three occasions. Of the multiple recaptures, 17 occurred in the Spokane Arm, 3 occurred in the Kettle Falls area, and 1 occurred at Hunters. A walleye tagged near Sherman Creek in 1997 was subsequently recaptured on three occasions in the Spokane Arm in 1998. A walleye tagged at Hawk Creek in 1997 was later recaptured at Hawk Creek in 1998. The same fish was recaptured a second time in 1998, but an angler left the tag in a tag return box at the Fort Spokane Boat Launch with no other information. A walleye tagged at the Colville River in 1997 was recaptured on two occasions in 1998, both times at Flat Creek, near China Bend. One hundred-sixty seven of the recapture events were of walleye marked during the 1997 project and 286 of the recaptures were of fish marked during 1998. The recapture rate of walleye marked and recaptured in 1998 was 5.6 %.

Mean number of days between release and recapture for fish marked in 1998 was 43 days (standard deviation = 30), with a range of 8 to 186 days (n = 197). The mean number of days between previous release and subsequent recapture of walleye tagged in 1997 and recaptured in 1998 was 293 days (SD = 78), and ranged from 24 to 419 days (n = 146).

EWU biologists collected 4,071 walleye via electrofishing surveys during the study. Total electrofishing effort was 242.88 hours and total CPUE was 16.76 fish per hour. Sections H (Hawk Creek) and section 10 (China Bend) had the highest and lowest CPUE's at 59.55 and 0.19 fish per hour (Table 4).

Table 1. Summary of walleye tagged by Eastern Washington University (EWU), with the aid of anglers and Lake Roosevelt Monitoring Program (STI), arranged by pass and reservoir section. Section NP (Northport) was not a regular sampling section, but anglers tagged walleye for EWU in that area on one day.

Section	Pass					Total
	1	2	3	4	5	
1	1	11	15	1	3	31
2	2	27	66	2	1	98
SP	46	101	155	5	12	319
3	0	5	15	1	0	21
H	50	295	133	24	26	528
4	29	90	144	25	14	302
S 1	126	78	25	24	3	256
S 2	157	133	102	85	0	477
S 3	1,441	45	78	23	0	1,587
5	25	72	42	81	1	148
6	44	113	95	2	7	261
7	18	61	32	0	0	111
8	62	386	48	8	9	513
9	24	321	7	5	0	357
K	0	8	0	10	0	18
10	1	47	0	0	1	49
NP	0	0	0	5	0	5
Total	2,026	1,793	957	228	77	5,081

Abundance Estimates

Reservoir

The number of walleye ≥ 150 mm TL (95 % confidence interval (C.I.)), in Lake Roosevelt in 1998, was estimated to be 198,137 ($151,400 \leq N \leq 277,875$) via the Schnabel model without the correction for recruitment, and 191,433 ($146,278 \leq N \leq 268,473$) via the Schnabel model adjusted for recruitment (Table 4). Using the data set that was corrected for recruitment, CAPTURE selected the M_{tb} model as most appropriate and calculated an estimate of 186,482 ($40,113 \leq N \leq 943,213$) (Table 4). Selection of model M_{tb} , by CAPTURE, indicated time and behavioral effects which resulted in unequal capture probabilities between marked and unmarked fish that varied

Table 2. Walleye recaptures and tag returns during 1998. Tagged walleye were recaptured by anglers, Eastern Washington University (EWU), the Spokane Tribe (STI), the Colville Tribe (CCT), the Washington Department of Fish and Wildlife (WDFW), at the Governor's Cup Walleye Tournament (GCWT), and at the three Spokane River Arm Angling Days (SRAD).

Agency/Group	Walleye Tagged in ...		Total	Percent (%)
	1997	1998		
Anglers	89	140	229	50.6
EWU	41	121	162	35.8
STI	14	10	24	5.3
WDFW	0	1	1	0.2
CCT	0	1	1	0.2
GCWT	20	8	28	6.2
SRAD	3	5	8	1.8
Total	167	286	453	

Table 3. Catch-per-unit-effort (CPUE) of walleye collected in Lake Roosevelt (1998) via electrofishing surveys conducted by Eastern Washington University (EWU).

Section	n	Effort (hours)	CPUE (fish/hour)
1	33	16.88	1.95
2	99	15.78	6.27
SP	273	14.78	18.47
3	21	13.38	1.57
H	530	8.90	59.55
4	313	18.78	16.67
S 1	183	17.93	10.21
S 2	338	20.83	16.23
S 3	1,578	28.22	55.92
5	135	14.35	9.41
6	240	13.82	17.37
7	75	14.40	5.21
8	160	16.26	9.84
9	73	12.42	5.88
K	18	5.71	3.15
10	2	10.44	0.19
Total	4,071	242.88	16.76

with time. The size of the walleye population ≥ 150 mm TL (95 % C.I.) was estimated via the Jolly-Seber model was 213,213 ($5,081 \leq N \leq 464,215$) (Table 4). The CV provided by CAPTURE for the M_{tb} estimate was 98%. The probabilities of capture, calculated by CAPTURE, for passes one through five were as follows: 0.011, 0.010, 0.005, 0.001, 0.000. Walleye density in Lake Roosevelt was 5.44 fish/acre and the estimated size of the walleye population, extrapolated from Beard et al.'s (1997) equation and the surface area, was 450,364.

When the Schnabel estimate without the recruitment adjustment was compared to the corrected Schnabel estimate, the null hypothesis that the two estimates were not significantly different was not rejected ($\alpha = 0.05$, $z = -0.01$, $p \geq 0.50$).

Spawning Run

The size of the walleye spawning run (95 % C.I.) in the Spokane River Arm was estimated to be 15,222 ($12,018 \leq N \leq 19,855$) via the Schnabel model, 15,178 ($12,093 \leq N \leq 19,164$) using the M_t model of the CAPTURE program, and 27,345 ($1,535 \leq N \leq 57,519$) via the Jolly-Seber model (Table 5). The model selected as the most appropriate by the CAPTURE program was M_t , indicating time effects, or changing capture probabilities over time. The CV for the Jolly-Seber estimate was 57%. Raw data used to generate all of the estimates was provided in Appendix B.

During the walleye spawning run there were 96 females (6.3 %), 1,118 males (73.7 %), and 304 (20.0 %) fish of undetermined sex collected. The mean fecundity of the female spawners was 186,134 eggs/female (SD = 112,078). There were an estimated 1,723 female walleye that spawned in the Spokane Arm, when we applied the 6.3 % to the Jolly-Seber estimate for the size of the run. The estimated egg production was 3.21×10^8 eggs. After applying the survival rates, the Spokane Arm walleye spawning run had the potential to produce 117,245 recruits to age four, sexual maturity.

Table 4. Estimates of walleye abundance for the entire reservoir, and 95 % confidence intervals (95 % C.I.), calculated using various models.

Model	N	Lower 95 % C.I.	Upper 95 % C.I.
Schnabel ^a	198,137	151,400	277,875
Schnabel ^b	191,433	146,278	268,473
Schnabel ^c	183,364	146,204	268,338
CAPTURE (M_{tb}) ^b	186,482	40,113	943,213
Jolly-Seber	213,213	5,081	464,215

^a Not adjusted for recruitment.

^b Adjusted for recruitment.

^c Adjusted for 5% tag loss and recruitment.

Table 5. Estimates of the size of the walleye spawning run in the Spokane River Arm, and 95 % confidence intervals (95 % C.I.), calculated using various models.

Model	N	Lower 95 % C.I.	Upper 95 % C.I.
Schnabel	15,222	12,018	19,855
CAPTURE (M_t)	15,178	12,093	19,164
Jolly-Seber	27,345	1,535	57,519

Model Assumptions

The Lake Roosevelt walleye population was determined to be “open” during the 1998 study, due to evidence of mortalities (angler tag returns) and emigration (angler tag returns from British Columbia, Canada). The spawning run was determined to be open because fish were immigrating into and emigrating from the spawning area during the study period, according to recapture data.

EWU and STI biologists examined 193 recaptures in 1998, of which 7 had obvious tag scars, indicating a tag loss rate of 3.6 %. Because we could only see obvious tag scars, we estimated total tag loss at 5 %. Estimated abundance of walleye ($\pm$ 95 % C.I.) calculated with the assumption of 5 % tag loss was 183,364 ($146,204 \leq N \leq 268,338$) (Table 5). The walleye abundance estimate that was calculated with the data corrected for 5% tag loss was not significantly different than the estimate without the tag loss correction ($\alpha = 0.05$, $z = -0.13$, $p > 0.50$). There was no evidence of tag loss during the spawning run.

The CAPTURE program indicated that there were time and behavioral effects in the reservoir population, which caused differences in capture probabilities between the marked and unmarked groups of fish that varied with time. CAPTURE did not indicate differences in capture probability between individual fish. Approximately 1 out of 25 walleye captured by anglers had a tag compared to 1 out of 20 captured via electrofishing (Table 7). The recapture ratios of walleye marked and recaptured in 1998 did not differ significantly between electrofishing and angling ($X^2=1.99$, 1 d.f, $p > 0.10$).

Pollock et al.'s (1990) Jolly-Seber Goodness of Fit Tests indicated that the Jolly-Seber estimate was valid ($X^2 = 0.90$, 1 d.f., $p > 0.10$). However, due to low expected values, only the Goodness of Fit Test #2 was calculated for the third sampling period.

Capture probabilities varied only with time during the spawning run estimate, according to the CAPTURE model selection procedure. The Jolly-Seber Goodness-of-Fit Tests (Pollock et al. 1990) suggested that the Jolly-Seber estimate for the size of the spawning run was valid ($X^2 = 0.13$, 1 d.f., $p \geq 0.50$). The only test calculated was the Goodness-of-Fit Test #2 for the fourth sampling period, as a result of low expected values.

Table 6. Numbers and ratios of tagged and untagged walleye collected in Lake Roosevelt (1998) via angling and electrofishing.

Angler	Number Tagged	Number Not Tagged	Ratio
Kern	1	14	1:14
Hullett	20	110	1:5.5
Marshall	2	29	1:14.5
Resen	1	25	1:25
Mannick	1	13	1:13
Bough	1	54	1:54
GCWT ^a	28	699	1:25
EWU Angling ^b	9	313	1:35
Total Angling	63	1,257	1:20
EWU Electrofishing	162	4,005	1:25

^aGovernor's Cup Walleye Tournament, Kettle Falls, WA, June 20th–21st, 1998.

^bIncludes angling by EWU personnel and volunteers on August 3rd, 6th, 7th, 12th and 24th, 1998 and the Spokane Arm Angling Days on April 1st, May 2nd, and May 30th, 1998.

Movements

During 1998, 382 walleye recapture events were reported with sufficient information to determine distances between previous release point and subsequent recapture location. Fifty-four recapture events were excluded from analysis, because they occurred within 7 days of the previous release (51 and 3 that were initially tagged in 1998 and 1997, respectively).

The walleye tagged in 1997 and recaptured in 1998 ($n = 145$) traveled a mean distance of 24.59 km ($SD = 43.53$) from their previous release location to their subsequent recapture location. The range of distances between previous release location and subsequent recapture location was 0 to 207.5 km. Of those 145 recaptures, 26 (17.93 %) were more than 40 km, 10 (6.90 %) were between 26 and 40 km, and 109 (75.17 %) were less than 25 km, from their respective release points. The walleye that was recaptured 207.5 km from its release location, moved upstream from the mouth of the Sanpoil River to the Washington/Canada border between August 22, 1997 and August 26, 1998.

Walleye tagged and recaptured in 1998 ($n = 182$) moved a minimum of 22.75 km ($SD = 43.57$) between their release and recapture locations. Distances between release and recapture locations ranged from 0 km to 252 km. Of those 182 recaptures, 31 (17.03 %) were more than 40 km, 12 (6.60 %) were between 26 and 40 km, and 139 (76.37 %) were less than 25 km, from their respective release points. The walleye that was recaptured 252 km from its release location, moved from the spawning ground at Little Falls (upper Spokane River Arm) to Hugh Keenleyside Dam, British Columbia between April 29th, 1998 and September 14th, 1998.

There were 73 walleye tagged during the 1998 spawning run in the Spokane Arm that were recaptured following the run. The spawners were recaptured a mean distance of 34.52 km ($SD = 55.20$) from their release location, with a range of 0 to 252 km. Walleye marked and recaptured following the spawning, were recaptured a mean distance of 20.46 km ($SD = 37.35$) from their release location. There were no walleye that had two recapture events included in the spawn versus post-spawn movement analysis.

When compared statistically, the minimum distances moved between release location and recapture location by spawning and post-spawning walleye were significantly different ($\alpha = 0.05$, $t = 1.76$, $p \leq 0.04$). Walleye marked on the spawning run

were recaptured significantly farther from their release location than those marked following the spawning run.

Age, Growth, Mortality

Walleye collected from Lake Roosevelt in 1998 ranged in age from 0 to 13 (Figure 2). The intercept of the body-scale regression line (a) was 25.03 (Figure 3). Back-calculated TL's (mm) at the formation of each annulus were estimated (Table 7). Mortality between year classes were calculated (Table 8). Mean instantaneous and mean annual mortality was estimated at 0.76 % and 46 %, respectively, using a simple catch-curve (Figure 4).

Condition

The length-weight regression equation for Lake Roosevelt walleye was $\log_{10} WT = \log_{10} TL - 5.15$ ($r^2 = 0.98$) (Figure 5). Mean K_{TL} of 4,071 walleye measured and weighed was 0.82 (SD = 0.17) (Table 9).

Figure 2. Age-frequency distribution of walleye collected in Lake Roosevelt during 1998. Ages of fish that did not have scales analyzed were estimated via an age-length key.

Figure 3. Body length-scale length regression line for Lake Roosevelt walleye collected and aged during 1998.

Table 7. Mean back-calculated total lengths ($\pm$ standard deviation) at the formation of each annulus for walleye collected in Lake Roosevelt during 1998.

Cohort	n	Mean Total Length (mm) at the Formation of Each Annulus												
		1	2	3	4	5	6	7	8	9	10	11	12	13
1997	71	155 ! 38												
1996	31	157 ! 28	274 ! 40											
1995	35	146 ! 19	261 ! 32	337 ! 30										
1994	25	144 ! 20	268 ! 35	344 ! 39	400 ! 37									
1993	24	171 ! 41	279 ! 50	353 ! 49	411 ! 50	454 ! 54								
1992	33	166 ! 22	287 ! 38	368 ! 42	428 ! 45	476 ! 47	516 ! 52							
1991	26	174 ! 27	283 ! 39	363 ! 51	427 ! 54	484 ! 48	529 ! 49	570 ! 47						
1990	26	174 ! 21	286 ! 38	360 ! 45	421 ! 48	472 ! 53	520 ! 54	560 ! 55	598 ! 51					
1989	10	174 ! 25	291 ! 37	360 ! 55	424 ! 50	481 ! 48	525 ! 50	567 ! 56	600 ! 59	632 ! 68				
1988	13	181 ! 25	273 ! 38	353 ! 44	433 ! 46	489 ! 46	547 ! 40	596 ! 40	640 ! 45	681 ! 45	715 ! 42			
1987	5	179 ! 21	291 ! 23	370 ! 40	431 ! 47	489 ! 61	534 ! 62	575 ! 62	620 ! 73	664 ! 72	702 ! 73	731 ! 67		
1986	1	201 ! N/A	307 ! N/A	378 ! N/A	434 ! N/A	498 ! N/A	540 ! N/A	589 ! N/A	660 ! N/A	709 ! N/A	751 ! N/A	780 ! N/A	808 ! N/A	
1985	2	176 ! 2	288 ! 21	356 ! 17	406 ! 22	468 ! 28	543 ! 15	616 ! 25	668 ! 25	704 ! 12	740 ! 26	770 ! 31	796 ! 31	829 ! 22
Grand Mean	320	162 ! 31	277 ! 39	355 ! 39	420 ! 47	475 ! 50	526 ! 50	572 ! 51	613 ! 55	665 ! 59	716 ! 48	746 ! 56	800 ! 23	829 ! 22
Mean Annual Growth		162	114	77	62	51	46	43	40	39	35	29	27	33

Table 8. Mean annual mortality rates for each age class of walleye collected in Lake Roosevelt during 1998. Number of fish per age class was estimated using an age-length key, developed via scale analysis.

Age	Mortality Rate (%) in ...	
	1997	1998
1 to 2	30	52
2 to 3	35	-21
3 to 4	54	32
4 to 5	47	23
5 to 6	66	28
6 to 7	87	63
7 to 8	67	23
8 to 9		70
9 to 10		63
10 to 11		73
11 to 12		67
12 to 13		-100

Table 9. Mean condition factors (K_{TL}) of walleye collected in Lake Roosevelt in 1998. Mean K_{TL} 's for each age class were calculated only from those fish that were measured and weighed.

Age	n	Mean K_{TL}	Standard Deviation	Minimum	Maximum
0	17	0.91	0.29	0.59	1.87
1	71	0.81	0.17	0.42	1.43
2	30	0.77	0.08	0.65	0.98
3	22	0.77	0.08	0.55	0.90
4	18	0.78	0.09	0.69	1.08
5	17	0.78	0.15	0.29	0.92
6	31	0.85	0.11	0.67	1.11
7	26	0.91	0.13	0.71	1.16
8	26	0.96	0.14	0.72	1.25
9	10	1.03	0.14	0.86	1.26
10	13	1.15	0.22	0.73	1.56
11	5	1.17	0.08	1.07	1.26
12	1	1.28	-	-	-
13	2	1.12	0.10	1.05	1.18
Total	4,071	0.82	0.17	0.26	3.73

Figure 4. Simple catch-curve for walleye collected in Lake Roosevelt 1998. Ages were estimated via an age-length key. The regression line was calculated for the descending limb of the curve, excluding the peak age class and the age classes with fewer than 10 individuals.

Figure 5. Length-weight regression for walleye collected in Lake Roosevelt, 1998.

Discussion

Fish Collection

The 5.6% recapture rate of walleye tagged and recaptured during the 1998 study was slightly higher than the 1.0, 3.7, 3.0 and 3.8 % reported in 1988, 1989, 1990, and 1997, respectively (Peone et al. 1990; Griffith and Scholz 1991; McLellan et al. 1998; McLellan 1998). The increased return rate may have been the result of increased angler awareness. However, the increase was most likely due to repeated sampling in the Spokane Arm during the spawning run. Return rates reported prior to 1997 were only from voluntary angler returns, unlike the 1997 and 1998 rates which included biologist recaptures. Anglers returned tags from 140 walleye marked in 1998, a return rate of 2.8 %, which was within the range reported in the previous studies. EWU biologists marked and recaptured 82 walleye within the 48 day spawning run, which resulted in a higher total recapture rate.

The mean number of days between release and recapture of walleye tagged in 1998 (43 days) was similar to those reported in 1981 and 1982 (42 and 47 days, respectively), but higher than the mean reported in 1997 (28 days) (Beckman et al 1985; McLellan et al. 1998; McLellan 1998). The sampling protocol used in 1998 did not allow for repeated sampling of the same sites within short periods of time, as in the 1997 study, probably resulting in a longer mean time between recaptures.

Abundance Estimates

Reservoir

Of the four estimates of walleye abundance for the entire reservoir, the one calculated using the CAPTURE program's M_{tb} model and the data corrected for recruitment was probably the most unbiased. The estimate provided by CAPTURE was the most accurate and unbiased, because the model accounts for unequal capture probabilities due to behavioral effects, which would have biased the other estimators (Otis et al. 1978; White et al. 1982). Both the Schnabel and Jolly-Seber models allow for

time variation in capture probabilities, however, unequal capture probabilities due to behavior would have biased their estimates either positively or negatively (Otis et al. 1978; Begon 1979; White et al. 1982; Pollock et al. 1990). Bias due to behavior during the current study was probably positive due to the low numbers of fish recaptured on more than one occasion, which indicated a possible avoidance to the collection methods. The estimate calculated with the Schnabel model (191,433) was greater than the one generated using the CAPTURE M_{tb} model (186,482), suggesting overestimation due to unequal capture probabilities, which were probably the result of capture avoidance. Since the estimates generated by the closed models (beginning) and the Jolly-Seber model (end) were for different sampling periods, the differences between the estimates could not be attributed to bias from unequal capture probabilities due to behavior. However, the fact that there were unequal probabilities of capture due to behavior, it was concluded that the Jolly-Seber estimate was biased. Pollock et al. (1990) reported that the model selection procedure of CAPTURE was subject to error, especially when capture probabilities were low. Despite the suggested problems with the model selection procedure, there were no good alternatives to the procedure and no intuitive reasons to dispute the recommended model.

The primary shortcoming of the 1998 abundance estimate was low precision, indicated by the wide confidence interval. White et al. (1982) suggested that a coefficient of variation of N should not exceed 20 % for reliable scientific studies and should be within the range of 20 to 50 % for less exacting management studies, including long term monitoring. Studies producing coefficient of variation values above 50 % can indicate only order-of-magnitude changes in population size (White et al. 1982). The walleye abundance estimate should have had a coefficient of variation (CV) of less than 20 % for use in the kokanee bioenergetics model and a CV between 20 and 50 % for the general management assessment of the population. However, the actual coefficient of variation was 98 %, indicating the estimate was not precise enough to meet any of the study objectives. The low precision of the estimate was probably the result of low capture probabilities (0.011, 0.010, 0.005, 0.001, and 0.000). According to Hightower and Gilbert (1984), capture probabilities should be 0.04 to provide acceptable estimates for general management surveys, when survival was high. Greater sampling effort, or higher

capture probabilities, would have been necessary if more precise estimates were needed or in the case of low mortality (Hightower and Gilbert 1984). Capture probabilities and precision could have been increased, by marking more fish during the study. However, EWU biologists conducted 1,090 electrofishing runs during the study period, so we believe increasing effort would be unrealistic due to time and monetary constraints. Considering the inability to realistically increase effort, we believe our estimate was the best estimate that could be calculated for the size of the Lake Roosevelt walleye population based on logistic constraints.

Further evidence that the estimated mean size of the Lake Roosevelt walleye population was accurate was the creel survey data collected by the LRMP. The creel survey data for 1997 and 1998 indicated an annual walleye harvest in the range of 87,515 to 119,346 fish (Cichosz et al. 1999; Cichosz et al. 1999b). Also, annual walleye harvest may have actually been lower than reported, because the LRMP uses total fishing pressure to estimate harvest, which could lead to an overestimation of harvest for individual species (Cichosz et al. 1997). It would be reasonable to assume that a walleye population of 186,482 fish (≥ 150 mm TL), with a spawning run of 27,345 fish, could support a sport fishery that harvests 100,000 fish a year. Spawning surveys indicated that approximately 321 million eggs were produced in the Spokane Arm and, using the most conservative survival estimates from the literature, 117,245 of those could reach sexual maturity. Our estimates of walleye abundance in the reservoir indicated the actual number of sexually mature walleye was approximately 117,245, indicating the survival of YOY walleye in Lake Roosevelt was similar to the most conservative rates reported in the literature.

Walleye density in Lake Roosevelt (5.44 fish/acre) was higher than that in John Day Reservoir, Columbia River (1.98 fish/acre; Beamesderfer and Rieman 1991). The estimated size of the population based on the Beard et al. (1997) equation fell within the 95 % C.I. for the reservoir estimate, but it was more than double the mean estimate. The differences in the estimates may have been due to the applicability of the equation for Lake Roosevelt. Beard et al.'s (1997) equation was developed on small Wisconsin lakes (all $\leq 5,100$ acres, except one 15,300 acre lake), so it may not be applicable to Lake Roosevelt, a large reservoir (82,720 acres).

Despite the high CV values for the reservoir walleye abundance estimate, we suggest that it be used in the kokanee bioenergetics model. However, due to its shortcomings recommend the bioenergetics model be calculated using three different values for the walleye abundance; 186,482 (CAPTURE mean value), 450,364 (Beard et al.'s (1997) equation), and 943,213 (CAPTURE upper 95 % C.I.). The lower 95 % C.I. should be excluded, because it was unrealistically low according to the harvest estimates.

A statistical comparison of the Schnabel estimates calculated for data not corrected for recruitment and data corrected for recruitment indicated no significant difference. The data supported the 1997 study results that suggested that recruitment of walleye to a taggable size (150 mm) was negligible prior to September 1 in Lake Roosevelt (McLellan et al. 1998; McLellan 1998).

Spawning Run

The most unbiased estimate of the size of the walleye spawning run was most likely the one generated with the Jolly-Seber model. We believe the Jolly-Seber estimate was the most accurate, because the spawning run was open and neither immigration nor emigration could be accounted for. The CAPTURE model selection procedure suggested that the sole cause of variable capture probabilities was due to time effects, which does not bias the Jolly-Seber estimator (White et al. 1982). The CV of the spawning run estimate indicated that it was not adequate for general management studies. However, the CV was close to an acceptable value, indicating a slight increase in effort could provide a reasonably precise estimate for the size of the spawning run.

Model Assumptions

The assumptions of the models were tested or relaxed, in order to provide the most unbiased estimates possible. The closure assumption was relaxed for the estimates of walleye abundance for the entire reservoir by correcting the data to account for recruitment to a taggable size, in some cases, and assuming no immigration based on past data. In the case of no additions to the population, assuming mortality and emigration rates were equal for both the marked and unmarked aspects of the population, only the

timing of the estimate was affected (White et al. 1982). The estimate was for the size of the population at the beginning of the study.

Tag loss was assumed to be negligible in all estimates. The 3.6 % tag loss rate observed during the 1998 study, was most likely the result of long-term tag loss by fish tagged in 1997, due to no evidence of short-term tag loss during the 1997 study (McLellan et al. 1998; McLellan 1998). When estimates of abundance, calculated with the Schnabel model, assuming 0 and 5 % tag loss were compared, there was no significant difference. The occurrence of tag loss would have resulted in an overestimation of walleye abundance when using the closed estimators, such as a CAPTURE model or the Schnabel model (Begon 1979); however, tag loss was not significant during this project. Arnason and Mills (1981) demonstrated that low levels of tag loss (≤ 20 %) had no effect on estimates of fish abundance calculated with the full Jolly-Seber model, except that precision may have been reduced.

CAPTURE's model selection procedure indicated unequal probabilities of capture due to time effects and behavioral effects for the whole reservoir population size estimate, which indicates the violation of the assumption equal catchability of all animals. However, CAPTURE provided the estimator M_{tb} that accounted for the differences in capture probabilities (Otis et al. 1978; White et al. 1982). The result of the comparison of angling and electrofishing recapture ratios was that there was no significant difference, indicating that both the pelagic and littoral aspects of the walleye population in Lake Roosevelt were sampled during the project. Since the recapture ratios for pelagic versus littoral sampling were not significantly different, we can conclude that the reservoir abundance estimate was truly for the entire walleye population. According to the CAPTURE tests there was no unequal probability of capture for spawning walleye, except due to time, which indicated the Jolly-Seber model (robust to changes in capture probability over time) was not biased due to heterogeneous capture probabilities.

Pollock et al.'s (1990) Jolly-Seber Goodness of Fit Test indicated that the data for the whole reservoir abundance estimate met all the assumptions of the model and that our estimate was valid. However, due to low expected values and low capture probabilities the test was not considered reliable. The Goodness-of-Fit Tests indicated the Jolly-Seber

model was valid, but little value was placed on the test results due to the low expected values.

Movements

Walleye marked and recaptured in 1998 appeared to move farther between previous release and subsequent recapture locations than walleye tagged and recaptured in 1997. The mean distance between previous release and subsequent recapture locations was 22.75 km in 1998 compared to 4.7 km in 1997. The increase in distances traveled in 1998 was probably due to marking of large numbers of walleye on the spawning run, many of which migrated long distances from the spawning area. During the 1997 study, when only 13 walleye were tagged on the spawning run, 116 (90 %) of recaptures were within 9.5 km of release, while 43 (23.09 %) fish tagged in 1998 had moved more than 25 km. Only two walleye were recaptured more than 35 km from their previous release location in 1997, and the maximum distance was 121 km. During the 1998 project, 31 walleye were recaptured more than 40 km from their previous release location, including 10 that were more than 121 km from their previous release location, with a maximum of 252 km.

Previous walleye tagging studies on Lake Roosevelt collectively indicated that walleye migrated long distances in the early spring to the only known walleye spawning area, in the upper reaches of the Spokane River Arm. Following spawning, which peaked in late April and early May, walleye rapidly dispersed throughout the reservoir, with the majority moving north, and established summer home ranges (SHR) (Nigro et al. 1982; Beckman et al. 1985; Hall et al. 1985; Peone et al. 1990; Griffith and Scholz 1991; Hildebrand et al. 1991; Hildebrand, R.L.&L. Environmental Services, personal communication, 1998; McLellan et al. 1998; McLellan 1998).

Walleye tagged on the spawning run, in 1998, traveled significantly farther than walleye tagged following the spawning run, which supported the idea that the majority of walleye movement was associated with the spawning run and that following dispersal from the spawning they establish SHR's and move little. The mean distance moved between release and recapture by walleye marked following the spawning run (20.46 km) was within the 0 to 25 km range of a SHR (Hall et al. 1985). The high proportion of

walleye recaptured within 25 km of release in 1998 (75.17 %), also supported the idea that walleye establish SHR's. Beamesderfer and Rieman (1988) indicated that walleye movements declined after June in John Day Reservoir, Columbia River.

Age, Growth, and Mortality

McLellan et al. (1998) and McLellan (1998) reported that there were fewer age classes and old walleye were less abundant in Lake Roosevelt in 1997, when compared to USFWS data from 1980 to 1983, and warned that the age structure may be an indication of an impending population collapse. However, when the 1998 age data was compared to the 1980-83 USFWS study, the same age classes were represented and there were relatively similar numbers of old walleye (Figure 6). The main reason for the absence of the older year classes and low numbers of old walleye in 1997 was probably due to the inability to effectively sample the spawning run, as suggested by McLellan et al. (1998) and McLellan (1998). The spawning run was effectively sampled in the 1998 and 1980-83 projects and they both had similar age distributions. The data collected in 1998 indicated the walleye population was stable and the concerns about the age structure that were addressed in 1997 were not warranted.

The 25.03 mm intercept of the body scale regression line was lower than the 56.7 mm intercept reported for Lake Roosevelt walleye in 1997 (McLellan et al. 1998; McLellan 1998) and the standard intercept of 55.0 mm, recommended by Carlander (1997). However, the intercept fell within the range of intercepts (6.0 to 83.0 mm) reported by Carlander (1997). The differences in the intercepts calculated for Lake Roosevelt walleye was likely due to the methods by which they were calculated. In 1997, scales were analyzed from 2,614 walleye of which the majority were young and small, possibly biasing the intercept toward values for small fish (McLellan et al. 1998; McLellan 1998). The intercept was calculated in 1998, using relatively equal numbers of samples from every length class, by using scale lengths from no more than five individuals per 1 cm length class. The 1998 intercept value was the probably the most accurate due to equal weighting of the scale length and body length relationship for all sizes of fish.

Figure 6. Comparison of age-frequency distributions of walleye collected on Lake Roosevelt in 1980-83, 1997, and 1998, by USFWS and EWU, respectively.

Growth of Lake Roosevelt walleye, estimated by back-calculation, was average when compared to the mean total lengths at the formation of each annulus of walleye from 16 lakes and rivers in the United States and Canada (Peone et al. 1990) (Table 10). Back-calculated total lengths at the formation of each annulus for walleye with scales analyzed in 1998 were roughly the same as those reported for 1997, except that first year growth had decreased by 10 mm and growth had decreased after age 6, in 1998 (Table 7).

The mean annual mortality rate of Lake Roosevelt walleye calculated in 1998 was similar to the estimated mean annual mortality in 1997 and was average when compared to other walleye producing waters (Table 11). Mean annual mortality rates between age classes of walleye collected in Lake Roosevelt in 1998 were different than those in 1997 (Table 8). There were some negative values for mortality rates in 1998 (Table 8), indicating we did not meet the assumptions of equal selectivity to sampling, equal numbers born in each cohort, or equal mortality between each age class for each cohort.

Condition

Mean K_{TL} (0.82) in 1998 was similar to the mean for Lake Roosevelt walleye reported in 1997 (0.81) (McLellan et al. 1998, McLellan 1998), indicating stable growth.

The length-weight regression equation, calculated in 1998, was similar to the equations calculated for Lake Roosevelt walleye in 1997 and 1980-83.

Conclusions

We believe that the Lake Roosevelt walleye population consisted of approximately 186,000 individuals, as of the spring of 1998 and that approximately 27,000 members of the population spawned in the Spokane River Arm. The estimates provided had low precision due to low capture probabilities, however they appeared to be reasonable when compared to creel harvest estimates. We believe we have provided the most accurate and reasonable estimates that could be provided without a large increase in effort and money or developing new sampling techniques that are more effective.

Table 10. Comparison of mean back-calculated total lengths (mm) at annulus formation between an average from 16 lakes and rivers in the United States and British Columbia and Lake Roosevelt, Washington.

Location	n	Mean Total Length (mm) at Annulus Formation													Reference
		1	2	3	4	5	6	7	8	9	10	11	12	13	
Average		177	280	368	431	483	530	554	548	675	675	728			Peone et al. (1990)
L. Roosevelt, 1980-83	3248	189	307	385	450	515	569	629	668	702	742	740	761	780	Beckman et al. (1985)
L. Roosevelt, 1988	369	204	273	348	410	470	532	590	635	688	689				Peone et al. (1990)
L. Roosevelt, 1989	467	210	282	351	418	493	571	603							Peone et al. (1990)
L. Roosevelt, 1990	311	184	295	380	439	511	597	651	698	734					Griffith and Scholz (1990)
L. Roosevelt, 1997	2,614	173	279	363	425	478	535	618	662						McLellan et al. (1997)
L. Roosevelt, 1998	320	162	277	355	420	475	526	572	613	665	716	746	800	829	Present study

Table 11. Comparison of mean annual mortality rates (%) between Lake Roosevelt and other walleye producing waters.

Location	Mean Annual Mortality (%)	Source
20 NW Wisconsin Lakes	47	Klingbiel (1986) ^a
32 N. Cent. Wisconsin Lakes	48	Klingbiel (1986) ^a
Leech Lake, MN	37	Schupp (1972) ^a
Boyd Lake, CO	48	Weber (1976) ^a
Lake of Woods, MN, 1980-84	65	Payer et al. (1987) ^a
W. Blue Lake, Ontario	80	Kelso and Ward (1977) ^a
Manistee Lake, MI (ages 3 to 7)	56	Laarman (1981) ^a
Lake Oneida, NY, 1960-74	34	Forney (1977) ^a
Lake Roosevelt, 1980-83	52	Beckman et al. (1985)
Lake Roosevelt, 1997	48	McLellan et al. (1998)
Lake Roosevelt, 1998	46	Present study

^a Cited in Carlander (1997).

For the most part, walleye moved little, except when migrating to and dispersing from the spawning area. Dispersal data indicated some walleye make long distance post spawning movements throughout the reservoir before establishing a SHR.

Walleye age, growth, mortality, and condition data indicated that the walleye population was average when compared to other walleye producing waters and relatively stable when compared to previous Lake Roosevelt studies.

Our data indicated there is no need for changes in the management of the Lake Roosevelt walleye population at this time.

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Appendices

Appendix A.

Table A1. Recaptures of Lake Roosevelt walleye during 1998. Multiple recaptures are in bold. Section numbers correspond to Figure 1.

Tag #/color	Original Capture Data					Recapture Data				
	Date	Section	TL (mm)	WT (g)	Crew	Date	Section	TL (mm)	WT (g)	Crew
OR 46005	5/8/98	H	444	850	STOI	6/2/98	S 1	511		ANG
OR 46110	8/20/97	H	240	143	STOI	7/27/98	S 1	NL		ANG
OR 46110	8/20/97	H	240	143	STOI	5/23/98	H	283	196	EWU
OR 46129	8/21/97	2	233	101	EWU	6/27/98	H	343		ANG
OR 46140	8/22/97	SP	257	148	STOI	7/27/98	S 1	NL		ANG
OR 46203	8/7/97	6	208	75	EWU	8/13/98	5	305		ANG
OR 46212	8/9/97	8	394	610	STOI	6/20/98	8	417		KFWT98
OR 46220	8/10/97	7	297	213	STOI	6/13/98	7	NL	681	ANG
OR 46223	8/10/97	7	289	181	STOI	7/8/98	7	346	400	STOI
OR 46308	6/26/97	8	351	308	STOI	6/20/98	10	381		ANG
OR 46310	8/26/97	8	315	260	STOI	6/20/98	9	403		KFWT98
OR 46325	6/26/97	8	513	1120	STOI	6/22/98	8	533		ANG
OR 46377	8/7/97	6	219	84	STOI	9/2/98	6	357	371	EWU
OR 46703	8/22/97	SP	282	178	STOI	4/4/98	S 1	332	620	SRAD1
OR 46706	8/22/97	SP	362	410	EWU	8/26/98	BC	432		ANG
OR 46786	7/21/98	S 2	237	125	STOI	9/1/98	S 1	NL		ANG
OR 46916	8/6/97	S 2	234	90	STOI	9/12/98	6	394		ANG
OR 46928	8/6/97	S 2	258	144	STOI	8/15/98	S 1	381	681	ANG
OR 48002	5/30/98	S 2	334	500	EWU	7/16/98	S 1	NL		ANG
OR 48015	5/30/98	S 1	382	300	EWU	6/15/98	S 1	330		ANG
OR 48021	5/30/98	S 1	382	200	EWU	7/16/98	S 1	NL		ANG
OR 48186	7/9/98	4	219	84	EWU	8/12/98	4	251	116	EWU
OR 48199	7/13/98	S 2	213	78	EWU	Unknown	Spokane Arm	NL		ANG
OR 48244	7/16/98	4	213	74	EWU	8/12/98	S 1	236		EWU
OR 48383	7/7/98	K	382	514	EWU	8/6/98	K	381		ANG
OR 48407	6/30/98	SP	393	540	EWU	8/26/98	SP	440	773	EWU
OR 48452	6/30/98	SP	207	75	EWU	7/22/98	SP	220	75	EWU
OR 48459	6/30/98	SP	196	65	EWU	7/22/98	SP	225	85	EWU
OR 48521	6/21/98	9	377		KFWT98	9/2/98	BC	NL		ANG
OR 48560	6/25/98	H	226	99	EWU	7/20/98	H	253	142	EWU
OR 48577	6/30/98	SP	318	250	EWU	7/1/98	SP	316	248	EWU
OR 48654	6/20/98	9	389		KFWT98	6/27/98	9	394	636	ANG
OR 48669	6/20/98	9	370		KFWT98	9/13/98	7	394		ANG
OR 48879	7/27/98	7	307	240	EWU	Aug-98	K	356		ANG
OR 49611	7/20/98	H	247		EWU	8/5/98	H	251	131	EWU
OR 49726	7/16/98	4	312	225	EWU	8/2/98	S 1	NL		ANG
OR 49811	7/8/98	6	344	335	EWU	8/7/98	5	356		ANG
OR 49853	7/13/98	S 2	220	88	EWU	Unknown	Spokane Arm	NL		ANG
OR 49859	7/13/98	S 2	222	93	EWU	8/3/98	S 2	224	92	EWU
OR 49984	7/13/98	S 3	325	286	EWU	8/28/98	S 2	356		ANG
OR 49987	7/13/98	S 3	208	74	EWU	8/6/98	S 3	226	161	EWU
OR 49993	7/15/98	S 2	362	389	EWU	8/1/98	S 1	381		ANG
OR 49996	7/15/98	S 2	318	254	EWU	8/3/98	S 3	325		ANG
OR 49999	7/15/98	S 2	226	89	EWU	9/14/98	S 1	254		ANG
OR 51026	7/8/98	7	291	290	STOI	7/27/98	7	307	224	EWU
OR 51110	4/4/98	S 1	308	500	SRWA1	6/14/98	Spokane Arm	318		ANG
OR 51110	4/4/98	S 1	308	500	SRAD1	5/18/98	S 3	313	350	STOI
OR 51111	4/4/98	S 2	453	1150	SRAD1	5/19/98	S 2	451	625	EWU
OR 51111	4/4/98	S 2	453	1150	SRAD1	4/29/98	S 3	454	672	EWU
OR 51120	4/4/98	S 1	324	600	SRWA1	6/25/98	S 1	330	114	ANG
OR 51135	5/2/98	S 2	384	750	EWU	6/2/98	S 1	356		ANG

OR 51190	5/5/98	SP	300	250	STOI	7/1/98	SP	308	244	EWU
OR 51199	5/5/98	SP	216	150	STOI	7/22/98	SP	265	146	EWU
OR 51207	5/13/98	S 2	361	430	STOI	5/19/98	S 2	354	377	EWU
OR 51207	5/13/98	S 2	361	430	STOI	7/21/98	S 2	370	550	STOI
OR 51210	5/13/98	S 2	190	50	STOI	6/17/98	S 2	203	62	EWU
OR 51214	5/13/98	S 1	314	280	STOI	7/15/98	S 1	330	255	EWU
OR 51215	5/13/98	S 1	300	250	STOI	9/8/98	S 1	NL		ANG
OR 51227	5/13/98	S 1	370	450	STOI	6/4/98	S 1	375		ANG
OR 51227	5/13/98	S 1	370	450	STOI	9/8/98	S 1	NL		ANG
OR 51229	5/13/98	S 1	344	400	STOI	5/19/98	S 2	345	310	EWU
OR 51231	5/13/98	S 1	321	320	STOI	9/8/98	S 1	NL		ANG
OR 51242	5/14/98	6	361	400	STOI	7/10/98	6	381	681	ANG
OR 51259	5/15/98	7	338	410	STOI	7/8/98	7	345	460	STOI
OR 51276	5/18/98	S 3	313	390	STOI	7/21/98	S 3	344	500	STOI
OR 51294	5/19/98	H	529	1750	STOI	7/31/98	6	440	800	WDFW
OR 51297	5/19/98	H	300	350	STOI	6/6/98	H	279	492	ANG
OR 51299	5/19/98	H	288	260	STOI	6/14/98	H	368	227	ANG
OR 51302	5/19/98	H	552	1500	STOI	9/7/98	S 1	584	2043	ANG
OR 51307	5/19/98	H	330	400	STOI	5/25/98	H	NL		ANG
OR 51308	5/19/98	H	315	350	STOI	7/10/98	H	350	510	STOI
OR 51312	5/19/98	H	305	312	STOI	6/14/98	H	368	227	ANG
OR 51335	7/9/98	5	348	370	STOI	Unknown	6	305	341	ANG
OR 51348	7/9/98	5	222	130	STOI	7/29/98	5	237		EWU
OR 51552	7/22/98	H	295		STOI	8/12/98	H	326	317	EWU
OR 51557	7/22/98	H	325		STOI	8/14/98	S 1	330	454	ANG
OR 52005	6/24/98	H	322	252	EWU	6/28/98	H	356		ANG
OR 52011	6/24/98	H	392	504	EWU	6/25/98	H	395	497	EWU
OR 52016	6/24/98	H	330	261	EWU	6/25/98	H	336	252	EWU
OR 52023	6/24/98	H	347	339	EWU	6/28/98	H	356		ANG
OR 52026	6/24/98	H	399	466	EWU	9/7/98	BC	NL		ANG
OR 52027	6/24/98	H	330	286	EWU	7/20/98	H	350	334	EWU
OR 52028	6/24/98	H	399	488	EWU	6/28/98	H	356		ANG
OR 52040	6/24/98	H	401	467	EWU	6/28/98	H	356		ANG
OR 52068	6/24/98	H	229	113	EWU	7/20/98	H	252	134	EWU
OR 52080	6/24/98	H	231	107	EWU	6/25/98	H	233	87	EWU
OR 52108	6/24/98	H	170	40	EWU	7/20/98	H	195	60	EWU
OR 52118	6/24/98	H	194	60	EWU	7/20/98	H	218	85	EWU
OR 52136	6/24/98	H	194	81	EWU	8/5/98	H	232	102	EWU
OR 52148	6/24/98	H	186	46	EWU	7/20/98	H	200	55	EWU
OR 52163	6/24/98	H	162	35	EWU	7/20/98	H	183	47	EWU
OR 52182	6/24/98	4	198	67	EWU	7/16/98	4	221	90	EWU
OR 52184	6/24/98	4	407	511	EWU	7/30/98	4	NL		ANG
OR 52362	8/3/98	S 2	259	123	EWU	Unknown	Spokane Arm	NL		ANG
OR 52586	6/21/98	9	365		EWU	7/27/98	7	377	394	EWU
OR 52690	6/21/98	8	380		KFWT98	6/27/98	9	394	636	ANG
OR 52707	6/3/98	8	337	305	EWU	7/7/98	8	345	410	STOI
OR 52725	6/3/98	7	398	590	EWU	7/27/98	S 1	NL		ANG
OR 52727	6/3/98	7	376	478	EWU	7/7/98	7	381		ANG
OR 52741	6/6/98	5	341	297	EWU	7/27/98	S 1	NL		ANG
OR 52745	6/6/98	5	400	490	EWU	6/20/98	9	396		KFWT98
OR 52763	6/6/98	6	377	515	EWU	7/29/98	6	418	616	EWU
OR 52780	6/12/98	S 3	391	493	EWU	7/27/98	S 1	NL		ANG
OR 52865	6/17/98	S 2	231	109	EWU	7/16/98	S 2	256	142	EWU
OR 52898	6/17/98	S 2	190	51	EWU	7/16/98	S 2	224	84	EWU
OR 52904	5/19/98	S 1	285	166	EWU	6/2/98	S 1	NL		ANG
OR 52948	5/20/98	S 3	364	338	EWU	8/6/98	S 3	396	471	EWU
OR 52950	5/20/98	S 3	395	472	EWU	6/17/98	S 2	406		ANG
OR 52987	6/20/98	10	360		KFWT98	9/3/98	10	394		ANG

OR 53015	6/21/98	9	378		KFWT98	8/29/98	NP	NL	863	ANG
OR 53043	8/6/98	S 3	325	272	EWU	9/14/98	S 1	279		ANG
OR 53248	7/29/98	7	245	133	EWU	9/25/98	10	305		ANG
OR 53252	7/29/98	6	235	105	EWU	9/1/98	6	255	159	CCT
OR 53277	8/5/97	6	223	92	EWU	7/29/98	6	321		EWU
OR 53294	7/29/98	8	362		EWU	8/13/98	5	305	341	ANG
OR 53354	7/29/98	6	230	101	EWU	10/8/98	6	285	130	STOI
OR 53769	6/21/98	8	406		KFWT98	8/5/98	BC	406 FL		ANG
OR 53782	6/21/98	8	448		KFWT98	6/21/98	8	452		KFWT98
OR 53792	6/21/98	8	666		KFWT98	7/16/98	5	406	454	ANG
OR 54012	5/22/98	S 3	287	212	EWU	7/16/98	S 1	NL		ANG
OR 54012	5/22/98	S 3	287	212	EWU	6/6/98	S 2	305		ANG
OR 54024	5/22/98	S 3	347	292	EWU	6/6/98	Spokane Arm	356		ANG
OR 54034	5/22/98	S 3	318	247	EWU	8/3/98	S 2	305		ANG
OR 54034	5/22/98	S 3	318	247	EWU	Unknown	Unknown	305		ANG
OR 54037	5/23/98	H	340	393	EWU	6/24/98	H	348	356	EWU
OR 54038	5/23/98	H	278	194	EWU	7/16/98	S 1	NL		ANG
OR 54045	5/23/98	H	391	527	EWU	6/24/98	H	405	571	EWU
OR 54051	5/15/98	S 3	521	1034	EWU	7/16/98	S 1	514		ANG
OR 54063	5/15/98	S 3	334	301	EWU	6/12/98	S 3	406	681	ANG
OR 54074	5/15/98	S 3	428	619	EWU	5/16/98	S 3	422	648	EWU
OR 54084	5/15/98	S 3	412	589	EWU	6/20/98	9	408		KFWT98
OR 54089	5/15/98	S 3	364	444	EWU	6/6/98	Spokane Arm	356		ANG
OR 54099	5/15/98	S 3	345	324	EWU	5/16/98	S 3	341	317	EWU
OR 54117	6/21/98	9	359		KFWT98	7/13/98	S 3	336	286	EWU
OR 54185	6/21/98	9	440		KFWT98	7/25/98	8	445		ANG
OR 54237	6/21/98	8	368		KFWT98	7/25/98	8	394		ANG
OR 54259	6/24/98	H	311	212	EWU	6/28/98	H	356		ANG
OR 54268	6/24/98	H	194	51	EWU	6/25/98	H	193	61	EWU
OR 54282	6/24/98	H	232	102	EWU	7/22/98	H	285		STOI
OR 54311	6/18/98	S 1	384	432	EWU	9/8/98	S 1	NL		ANG
OR 54356	6/20/98	8	359	392	KFWT98	8/25/98	BC	394 FL		ANG
OR 54393	6/20/98	8	399		KFWT98	7/11/98	10	400	454	ANG
OR 54425	5/15/98	S 3	448	770	EWU	5/16/98	S 3	455	741	EWU
OR 54427	5/15/98	S 3	478	935	EWU	5/20/98	S 3	478		EWU
OR 54452	5/23/98	H	172	60	EWU	7/20/98	H	243	109	EWU
OR 54453	5/23/98	H	200	62	EWU	10/29/98	H	331		EWU
OR 54456	5/23/98	H	213	79	EWU	6/24/98	H	227	92	EWU
OR 54467	6/2/98	9	421	511	EWU	6/20/98	9	417		KFWT98
OR 54470	6/2/98	8	377	321	EWU	6/20/98	8	378		KFWT98
OR 54477	6/3/98	8	467		EWU	9/16/98	BC	NL		ANG
OR 54493	6/3/98	8	396	579	EWU	6/21/98	9	396		KFWT98
OR 54516	5/22/98	S 3	487	851	EWU	9/5/98	S 1	489		ANG
OR 54521	5/22/98	S 3	360	327	EWU	6/14/98	Spokane Arm	356		ANG
OR 54525	5/22/98	S 3	376	420	EWU	6/7/98	S 3	394	341	ANG
OR 54526	5/22/98	S 3	360	336	EWU	6/14/98	Spokane Arm	356		ANG
OR 54541	5/22/98	S 3	335	317	EWU	6/11/98	S 2	330		ANG
OR 54555	5/16/98	S 3	455	820	EWU	5/22/98	S 3	454	737	EWU
OR 54556	5/16/98	S 3	330	278	EWU	6/18/98	S 2	330		ANG
OR 54559	5/16/98	S 3	299	249	EWU	6/2/98	S 3	279		ANG
OR 54573	5/16/98	S 3	485	932	EWU	6/14/98	Spokane Arm	470		ANG
OR 54576	5/16/98	S 3	298	232	EWU	5/20/98	S 3	298		EWU
OR 54585	5/19/98	S 2	307	199	EWU	6/17/98	S 2	314	241	EWU
OR 54616	5/16/98	S 3	478	857	EWU	6/14/98	Spokane Arm	470		ANG
OR 54616	5/16/98	S 3	478	857	EWU	5/22/98	S 3	477	797	EWU
OR 54622	5/16/98	S 3	500	841	EWU	7/16/98	S 1	NL		ANG
OR 54626	5/16/98	S 3	395	488	EWU	5/16/98	S 3	392	488	EWU
OR 54640	5/16/98	S 3	423	556	EWU	7/16/98	S 1	NL		ANG

OR 54641	5/16/98	S 3	480	1018	EWU	6/25/98	Unkown	NL		ANG
OR 54647	5/16/98	S 3	408	481	EWU	7/13/98	S 3	409	496	EWU
OR 54660	5/16/98	S 3	401		EWU	7/9/98	2	400		ANG
OR 54665	5/16/98	S 3	362	347	EWU	6/20/98	S 1	381		ANG
OR 55002	4/29/97	S 3	492	1000	EWU	4/22/98	S 3	526	1358	EWU
OR 55002	4/29/97	S 3	492	1000	EWU	5/16/98	S 3	519	1359	EWU
OR 55016	5/13/97	S 3	422	650	EWU	Aug-97	7	NL		ANG
OR 55023	5/13/97	S 3	395	500	EWU	5/20/98	S 3	411	541	EWU
OR 55032	5/13/97	S 3	508	1050	EWU	3/20/98	S 2	521		ANG
OR 55115	8/25/97	H	361	388	EWU	7/16/98	S 1	NL		ANG
OR 55135	8/25/97	H	306	250	EWU	7/7/98	H	381		ANG
OR 55150	10/17/97	S 3	384	424	EWU	6/4/98	S 2	356		ANG
OR 55162	8/25/97	H	274	182	EWU	6/15/98	S 1	330		ANG
OR 55253	8/21/97	7	296	211	EWU	Aug-98	K	356		ANG
OR 55288	8/21/97	6	310	289	EWU	5/14/98	6	325	330	STOI
OR 55295	8/21/97	6	310	338	EWU	7/1/98	6	330		ANG
OR 55296	8/21/97	6	218	83	EWU	7/8/98	6	238	94	EWU
OR 55321	8/19/97	S 3	350	338	EWU	3/12/98	S 1	400		ANG
OR 55322	8/19/97	S 3	343	303	EWU	7/20/98	S 3	393	630	STOI
OR 55347	8/19/97	S 3	399	498	EWU	5/20/98	S 3	403		EWU
OR 55349	8/19/97	S 3	318	266	EWU	7/16/98	S 1	NL		ANG
OR 55409	8/5/97	8	366	380	EWU	6/20/98	8	360		KFWT98
OR 55437	8/5/97	8	312	227	EWU	6/3/98	8	362	382	EWU
OR 55487	8/4/97	8	561	1694	EWU	5/13/98	S 2	578	1750	STOI
OR 55504	6/21/97	8	387		KFWT97	6/20/98	8	430		KFWT98
OR 55517	6/22/97	8	421		KFWT97	6/20/98	9	432		KFWT98
OR 55519	6/22/97	8	357		EWU	4/25/98	S 3	514	1410	EWU
OR 55630	6/22/97	8	364		KFWT97	6/23/98	Unknown	NL		ANG
OR 55633	7/29/97	S 1	207	70	EWU	6/5/98	Spokane Arm	356		ANG
OR 55645	7/30/97	S 2	360	455	EWU	6/11/98	S 2	394		ANG
OR 55656	9/4/97	S 2	345	331	EWU	6/2/98	S 2	381		ANG
OR 55657	9/4/97	S 2	345	331	EWU	7/8/98	K	318		ANG
OR 55683	9/4/97	S 2	275	159	EWU	5/13/98	S 2	285	230	STOI
OR 55704	9/8/97	S 2	174	45	EWU	7/11/98	S 1	229		ANG
OR 55734	9/9/97	7	309	239	EWU	7/8/98	7	316	260	STOI
OR 55740	9/9/97	7	399	575	EWU	7/8/98	7	410	800	STOI
OR 55751	9/5/97	H	314	240	EWU	6/9/98	H	330		ANG
OR 55755	9/5/97	H	307	251	EWU	7/10/98	H	351	500	STOI
OR 55758	9/5/97	H	308	221	EWU	9/21/97	H	356		ANG
OR 55769	9/5/97	H	254	122	EWU	8/22/98	10	337	318	ANG
OR 55789	9/8/97	S 3	429	610	EWU	7/21/98	S 3	440	800	STOI
OR 55790	9/8/97	S 3	417	553	EWU	6/7/98	S 2	394		ANG
OR 55837	6/18/97	H	541	1590	EWU	6/24/97	H	546		ANG
OR 55870	8/20/97	8	358	427	EWU	8/21/98	8	394		ANG
OR 55873	8/20/97	8	448	707	EWU	6/3/98	8	465	805	EWU
OR 55884	8/20/97	8	275	164	EWU	6/27/98	8	305		ANG
OR 55888	8/20/97	8	272	168	EWU	7/28/98	8	330	331	EWU
OR 55890	8/20/97	8	337	340	EWU	6/3/98	8	362	364	EWU
OR 55895	8/20/97	8	389	494	EWU	6/20/98	9	422		KFWT98
OR 55896	8/20/97	8	347	357	EWU	5/16/98	8	277	560	STOI
OR 55898	8/20/97	8	506	1205	EWU	3/30/98	S 2	521		ANG
OR 55924	5/31/97	S 2	446	890	SRWA97	6/14/98	Spokane Arm	457		ANG
OR 55927	5/31/97	S 2	421	690	SRAD97	4/22/98	S 3	444	623	EWU
OR 55947	5/31/97	S 2	462	1000	SRAD97	4/29/98	S 3	480	971	EWU
OR 55988	5/31/97	S 2	473	880	SRAD97	4/18/98	S 3	481	804	EWU
OR 56002	4/4/98	S 2	365	350	EWU	6/24/98	S 2	368		ANG
OR 56007	4/4/98	S 2	466	777	EWU	5/2/98	S 2	467	712	SRAD2
OR 56013	4/4/98	S 2	452	672	EWU	5/16/98	S 3	448	754	EWU

OR 56041	4/15/98	S 3	578	1915	EWU	7/16/98	S 1	NL		ANG
OR 56046	4/15/98	S 3	478	847	EWU	4/25/98	S 3	483	790	EWU
OR 56056	4/17/98	S 3	484	589	EWU	4/29/98	S 3	487	959	EWU
OR 56057	4/17/98	S 3	470	776	EWU	5/13/98	S 3	468	688	EWU
OR 56084	4/17/98	S 3	557	1562	EWU	4/25/98	S 3	556	1524	EWU
OR 56091	4/17/98	S 3	489	908	EWU	4/25/98	S 3	585	884	EWU
OR 56101	4/22/98	S 3	523	1160	EWU	5/15/98	S 3	515	1070	EWU
OR 56103	4/22/98	S 3	513	1167	EWU	7/27/98	S 1	NL		ANG
OR 56108	4/22/98	S 3	503	1173	EWU	5/16/98	S 3	499	1096	EWU
OR 56113	4/22/98	S 3	520	1136	EWU	4/25/98	S 3	519	1136	EWU
OR 56114	4/22/98	S 3	545	1246	EWU	4/29/98	S 3	545	1238	EWU
OR 56119	4/22/98	S 3	402	495	EWU	7/27/98	S 1	NL		ANG
OR 56121	4/22/98	S 3	395	454	EWU	6/6/98	Spokane Arm	380		ANG
OR 56124	4/22/98	S 3	419	539	EWU	5/22/98	S 3	411	529	EWU
OR 56125	4/22/98	S 3	419	538	EWU	6/2/98	S 1	514		ANG
OR 56148	4/22/98	S 3	499	1038	EWU	6/2/98	S 3	457		ANG
OR 56150	4/22/98	S 3	526	1029	EWU	4/25/98	S 3	526	1041	EWU
OR 56163	4/21/98	S 3	612	2055	EWU	6/17/98	S 1	610	2270	ANG
OR 56164	4/21/98	S 3	374	418	EWU	6/6/98	Spokane Arm	356		ANG
OR 56165	4/21/98	S 3	396	479	EWU	7/27/98	S 1	NL		ANG
OR 56180	4/22/98	S 3	463	836	EWU	5/2/98	S 2	460	560	SRAD2
OR 56188	4/22/98	S 3	506	1125	EWU	4/25/98	S 3	507	1089	EWU
OR 56199	4/22/98	S 3	402	495	EWU	7/27/98	S 1	NL		ANG
OR 56202	4/22/98	S 3	475	791	EWU	6/14/98	Spokane Arm	457		ANG
OR 56267	4/22/98	S 3	393	441	EWU	6/6/98	Spokane Arm	381		ANG
OR 56267	4/22/98	S 3	393	441	EWU	5/13/98	S 3	390	420	EWU
OR 56268	4/22/98	S 3	437	679	EWU	4/29/98	S 3	438	648	EWU
OR 56286	4/25/98	S 3	358	351	EWU	6/9/98	S 2	330		ANG
OR 56346	5/13/98	S 3	459	813	EWU	6/21/98	4	457		ANG
OR 56350	5/13/98	S 3	448	794	EWU	5/16/98	S 3	455	805	EWU
OR 56355	5/2/98	S 3	406	520	SRWA2	6/17/98	S 2	406		ANG
OR 56373	5/2/98	S 3	396	436	EWU	6/7/98	S 3	394	341	ANG
OR 56376	5/2/98	S 3	420	570	EWU	5/20/98	S 3	421	582	EWU
OR 56378	5/2/98	S 3	474	837	EWU	5/15/98	S 3	447	782	EWU
OR 56384	5/2/98	S 3	397	438	EWU	6/22/98	S 2	NL		ANG
OR 56392	5/2/98	S 3	392	445	EWU	7/27/98	S 1	NL		ANG
OR 56412	5/13/98	S 3	384	430	EWU	5/15/98	S 3	386	450	EWU
OR 56437	5/13/98	S 3	427	612	EWU	5/15/98	S 3	425	635	EWU
OR 56438	5/13/98	S 3	510	958	EWU	6/14/98	Spokane Arm	495		ANG
OR 56453	5/20/98	S 3	368	410	EWU	7/16/98	S 1	NL		ANG
OR 56482	5/20/98	S 3	388		EWU	6/21/98	S 1	356		ANG
OR 56492	5/20/98	S 3	310		EWU	7/13/98	S 3	331	259	EWU
OR 56657	4/25/98	S 3	434	588	EWU	5/30/98	S 2	428	521	SRAD3
OR 56663	4/25/98	S 3	369	355	EWU	8/7/98	BC	368 FL		ANG
OR 56664	4/25/98	S 3	387	471	EWU	5/2/98	S 3	385	455	SRAD2
OR 56675	4/25/98	S 3	490	826	EWU	7/25/98	3	514	1022	ANG
OR 56685	4/25/98	S 3	490	905	EWU	4/29/98	S 3	487	893	EWU
OR 56687	4/25/98	S 3	467	969	EWU	5/15/98	S 3	457	801	EWU
OR 56700	4/25/98	S 3	487	785	EWU	5/16/98	S 3	480	775	EWU
OR 56701	4/17/98	S 3	532	1217	EWU	4/21/98	S 3	532	1215	EWU
OR 56718	4/17/98	S 3	359	345	EWU	5/16/98	S 3	358	354	EWU
OR 56720	4/17/98	S 3	444	685	EWU	5/18/98	S 3	435	950	STOI
OR 56728	4/18/98	S 3	457	639	EWU	10/11/98	Lake Roosevelt	438		ANG
OR 56736	4/18/98	S 3	401	485	EWU	10/21/98	8	427	739	EWU
OR 56752	4/15/98	S 3	470	746	EWU	7/16/98	S 1	NL		ANG
OR 56760	4/15/98	S 3	518	1168	EWU	5/18/98	S 3	384	640	STOI
OR 56762	4/15/98	S 3	488	898	EWU	4/21/98	S 3	487	724	EWU
OR 56765	4/15/98	S 3	506	1111	EWU	8/8/98	S 2	530		ANG

OR 56773	4/15/98	S 3	510	1077	EWU	4/17/98	S 3	503	1069	EWU
OR 56775	4/15/98	S 3	445	683	EWU	5/16/98	S 3	440	667	EWU
OR 56776	4/15/98	S 3	521	1320	EWU	7/16/98	S 1	NL		ANG
OR 56782	4/15/98	S 3	408	547	EWU	6/6/98	Spokane Arm	404		ANG
OR 56782	4/15/98	S 3	408	547	EWU	4/25/98	S 3	407	523	EWU
OR 56789	4/15/98	S 3	470	825	EWU	4/29/98	S 3	470	775	EWU
OR 56791	4/17/98	S 3	427	654	EWU	4/29/98	S 3	422	620	EWU
OR 56792	4/17/98	S 3	662	2634	EWU	5/20/98	S 3	657	2615	EWU
OR 56797	4/17/98	S 3	403	488	EWU	5/16/98	S 3	396	480	EWU
OR 56798	4/17/98	S 3	500	1024	EWU	7/16/98	S 1	NL		ANG
OR 56840	4/29/98	S 3	502	986	EWU	7/25/98	8	514		ANG
OR 56870	12/2/97	8	482	928	EWU	6/11/98	9	464		ANG
OR 56945	10/28/97	8	355	401	EWU	6/20/98	9	358		KFWT98
OR 56957	10/1/97	8	442	804	EWU	6/21/98	9	464		KFWT98
OR 56960	10/1/97	8	412	571	EWU	Unknown	Unknown	403		ANG
OR 56992	10/22/97	8	524	1158	EWU	6/2/98	S 1	578		ANG
OR 56998	10/24/97	H	321	274	EWU	6/14/98	H	368	227	ANG
OR 57044	6/21/97	8	383		KFWT97	6/21/98	8	413		KFWT98
OR 57078	6/22/97	8	504		KFWT97	6/27/98	S 1	508		ANG
OR 57087	6/21/97	9	371		KFWT97	6/20/98	8	391		KFWT98
OR 57108	11/11/97	S 3	447	740	EWU	4/29/98	S 3	449	719	EWU
OR 57110	11/11/97	S 3	418	629	EWU	4/15/98	S 3	416	599	EWU
OR 57112	11/11/97	S 3	422	561	EWU	4/17/98	S 3	429	564	EWU
OR 57112	11/11/97	S 3	422	561	EWU	4/22/98	S 3	426	553	EWU
OR 57119	11/4/97	8	480	841	EWU	6/21/98	9	489		KFWT98
OR 57154	10/10/97	8	389	545	EWU	6/20/98	8	399		KFWT98
OR 57170	10/15/97	8	504	1153	EWU	7/25/98	S 1	660	2043	ANG
OR 57207	4/21/98	S 3	387	461	EWU	6/13/98	S 1	384		ANG
OR 57210	4/21/98	S 3	416	543	EWU	7/16/98	S 1	NL		ANG
OR 57231	4/21/98	S 3	738	4850	EWU	4/29/98	S 3	736	4950	EWU
OR 57237	4/21/98	S 3	432	464	EWU	7/16/98	S 1	394		ANG
OR 57239	4/21/98	S 3	469	649	EWU	6/21/98	5	457		ANG
OR 57243	4/21/98	S 3	453	655	EWU	4/25/98	S 3	455	725	EWU
OR 57246	4/21/98	S 3	567	1446	EWU	4/22/98	S 3	559	1720	EWU
OR 57248	4/21/98	S 3	488	713	EWU	5/2/98	S 3	482	883	SRAD2
OR 57277	4/21/98	S 3	335	222	EWU	7/4/98	S 1	368		ANG
OR 57283	4/21/98	S 3	544	1205	EWU	5/15/98	S 3	542	1387	EWU
OR 57284	4/21/98	S 3	368	275	EWU	6/12/98	S 3	366	376	EWU
OR 57312	8/21/97	6	319	285	EWU	7/16/98	S 1	NL		ANG
OR 57348	8/22/97	4	284	191	EWU	7/16/98	S 1	330		ANG
OR 57348	8/22/97	4	284	191	EWU	6/18/98	S 1	330	277	EWU
OR 57370	8/19/97	S 3	332	299	EWU	1/28/98	S 2	356	369	ANG
OR 57379	8/19/97	S 3	264	165	EWU	7/13/98	S 3	315	268	EWU
OR 57381	8/19/97	S 3	250	135	EWU	2/25/98	S 1	292	227	ANG
OR 57389	8/20/97	8	377	402	EWU	4/15/98	9	368		ANG
OR 57390	8/20/97	9	363	349	EWU	8/26/98	BC	432		ANG
OR 57396	8/20/97	8	360	365	EWU	6/20/98	8	383		KFWT98
OR 57505	8/22/97	4	240	132	EWU	7/30/98	4	NL		ANG
OR 57512	8/22/97	4	240	120	EWU	8/2/98	S 1	NL		ANG
OR 57513	8/22/97	4	258	143	EWU	9/1/98	S 1	NL		ANG
OR 57518	8/22/97	4	235	118	EWU	7/16/98	S 1	NL		ANG
OR 57529	8/22/97	S 1	275	166	EWU	7/16/98	S 1	NL		ANG
OR 57534	8/22/97	S 1	255	130	EWU	7/16/98	S 1	305		ANG
OR 57535	8/22/97	S 1	256	135	EWU	7/14/98	S 2	318	284	ANG
OR 57541	8/22/97	S 2	275	127	EWU	4/4/98	S 1	318	223	SRAD1
OR 57551	8/22/97	S 2	287	197	EWU	6/17/98	S 2	325	232	EWU
OR 57551	8/22/97	S 2	287	197	EWU	5/13/98	S 2	322	300	STOI
OR 57554	8/22/97	S 2	339	325	EWU	5/24/98	S 2	381		ANG

OR 57557	8/22/97	S 2	277	160	EWU	3/28/98	S 2	298		ANG
OR 57565	8/22/97	S 2	273	153	EWU	7/16/98	S 1	NL		ANG
OR 57569	8/22/97	S 2	269	150	EWU	8/8/98	S 1	291		ANG
OR 57572	8/25/97	H	305	290	EWU	6/24/98	H	345	397	EWU
OR 57586	8/25/97	H	305		EWU	6/28/98	H	356	341	ANG
OR 57629	8/4/97	9	503	1220	EWU	2/10/98	7	NL	1361	ANG
OR 57647	8/4/97	9	260	143	EWU	6/19/98	9	368		ANG
OR 57670	7/14/97	8	331	319	EWU	6/27/98	10	NL		ANG
OR 57670	7/14/97	8	331	319	EWU	8/8/98	10	384	499	ANG
OR 57710	7/28/97	5	212	69	EWU	6/24/98	4	NL		ANG
OR 57716	7/28/97	5	213	59	EWU	6/18/98	4	305		ANG
OR 57777	7/28/97	6	272	175	EWU	8/5/98	6	368		ANG
OR 57799	7/28/97	6	222	65	EWU	6/5/98	6	NL		ANG
OR 57840	8/5/97	6	289	176	EWU	5/14/98	6	333	360	STOI
OR 57840	8/5/97	6	289	176	EWU	7/9/98	6	343	420	STOI
OR 57848	8/5/97	6	280	173	EWU	8/20/98	10	356		ANG
OR 57870	8/6/97	H	236	126	EWU	6/24/98	H	313	256	EWU
OR 57883	8/6/98	1	226	82	EWU	10/21/98	4	343		ANG
OR 57916	8/5/97	6	229	103	EWU	5/14/98	6	298	260	STOI
OR 57933	8/5/97	5	281		EWU	7/17/98	6	NL		ANG
OR 57953	6/21/97	8	400		KFWT97	5/15/98	S 3	439	702	EWU
OR 57959	6/21/97	8	396		KFWT97	6/20/98	8	418		KFWT98
OR 58021	7/30/97	S 2	238	125	EWU	7/29/98	S 2	318		ANG
OR 58034	7/30/97	S 2	235	100	EWU	6/27/98	S 2	330		ANG
OR 58040	7/31/97	S 2	220	75	EWU	Unknown	Spokane Arm	NL		ANG
OR 58051	6/22/97	9	374		KFWT97	6/20/98	8	405		KFWT98
OR 58109	6/22/97	9	359		KFWT98	8/15/98	4	381		ANG
OR 58138	6/22/97	9	400		KFWT97	4/22/98	S 3	403	575	EWU
OR 58152	6/22/97	9	371		KFWT97	6/20/98	10	412		KFWT98
OR 58316	9/10/97	8	284	190	EWU	7/7/98	9	308	209	EWU
OR 58349	9/11/97	SP	308	232	EWU	6/30/98	SP	347	350	EWU
OR 58372	7/8/97	H	331	322	EWU	7/30/98	4	505		ANG
OR 58434	9/5/97	H	345	340	EWU	7/16/98	S 1	NL		ANG
OR 58435	9/5/97	H	369	494	EWU	5/25/98	H	NL		ANG
OR 58444	9/5/97	H	297	217	EWU	6/24/98	H	332	300	EWU
OR 58492	9/4/97	S 1	296	189	EWU	6/14/98	S 1	305		ANG
OR 58501	4/25/98	S 3	389	476	EWU	6/21/98	8	384		KFWT98
OR 58534	4/29/98	S 3	525	1110	EWU	Jun-98	S 3	537	1447	ANG
OR 58546	4/29/98	S 3	470	701	EWU	5/22/98	S 3	464	729	EWU
OR 58551	4/25/98	S 3	347	306	EWU	5/16/98	S 3	340	324	EWU
OR 58551	4/25/98	S 3	347	306	EWU	5/20/98	S 3	341		EWU
OR 58552	4/25/98	S 3	512	1507	EWU	4/25/98	S 3	519	1358	EWU
OR 58563	4/25/98	S 3	622	2138	EWU	4/25/98	S 3	622	2144	EWU
OR 58568	4/25/98	S 3	555	1230	EWU	5/15/98	S 3	371	434	EWU
OR 58577	4/25/98	S 3	527	1269	EWU	6/3/98	S 1	546		ANG
OR 58578	4/25/98	S 3	516	1219	EWU	5/15/98	S 3	514	1125	EWU
OR 58596	4/25/98	S 3	283	193	EWU	6/17/98	S 2	406		ANG
OR 58599	4/25/98	S 3	387	425	EWU	7/16/98	S 1	381		ANG
OR 58599	4/25/98	S 3	387	425	EWU	4/29/98	S 3	386	418	EWU
OR 58600	4/25/98	S 3	384	442	EWU	6/6/98	Spokane Arm	356		ANG
OR 58707	4/18/98	S 3	491	422	EWU	6/21/98	8	384		KFWT98
OR 58710	4/18/98	S 3	423	572	EWU	6/30/98	BC	NL		ANG
OR 58720	4/18/98	S 3	472	678	EWU	4/25/98	S 3	472	697	EWU
OR 58725	4/18/98	S 3	453	744	EWU	4/25/98	S 3	446	787	EWU
OR 58728	4/18/98	S 3	587	2301	EWU	4/21/98	S 3	595	2199	EWU
OR 58741	4/18/98	S 3	344	266	EWU	5/20/98	S 3	342		EWU
OR 58745	4/21/98	S 3	480	851	EWU	6/12/98	S 3	483	1135	ANG
OR 58752	4/21/98	S 3	521	1229	EWU	5/15/98	S 3	519	1111	EWU

OR 58754	4/21/98	S 3	572	1807	EWU	6/11/98	S 1	584	2242	ANG
OR 58760	4/21/98	S 3	386	473	EWU	6/18/98	S 1	NL		ANG
OR 58769	4/21/98	S 3	407	497	EWU	5/15/98	S 3	407	540	EWU
OR 58774	4/21/98	S 3	457	755	EWU	4/22/98	S 3	459	753	EWU
OR 58775	4/21/98	S 3	496	936	EWU	5/20/98	S 3	491	1111	EWU
OR 58780	4/21/98	S 3	561	1409	EWU	4/25/98	S 3	560	1364	EWU
OR 58782	4/21/98	S 3	417	571	EWU	7/16/98	S 1	NL		ANG
OR 58782	4/21/98	S 3	417	571	EWU	5/22/98	S 3	416	529	EWU
OR 58785	4/21/98	S 3	457	701	EWU	5/20/98	S 3	450	703	EWU
OR 58798	4/21/98	S 3	447	676	EWU	4/25/98	S 3	447	680	EWU
OR 58810	9/26/97	S 3	378	402	EWU	6/8/98	S 2	330		ANG
OR 58850	9/23/97	H	275	185	EWU	6/27/98	H	343		ANG
OR 58857	10/3/97	2	351	327	EWU	7/13/98	S 3	374	426	EWU
OR 58873	10/3/97	S 3	376	412	EWU	8/2/98	S 1	400		ANG
OR 59075	7/14/97	3	330	350	EWU	6/21/98	8	369		KFWT98
OR 59111	4/4/98	S 2	391	487	EWU	6/15/98	Spokane Arm	NL		ANG
OR 59112	4/4/98	S 2	463	784	EWU	4/22/98	S 3	462	737	EWU
OR 59125	4/4/98	S 2	436	704	EWU	5/22/98	S 3	434	702	EWU
OR 59134	4/4/98	S 1	363	368	EWU	5/16/98	S 3	355	353	EWU
OR 59137	4/4/98	S 1	298	175	EWU	6/12/98	S 1	305		ANG
OR 59154	9/18/97	S 3	310	222	EWU	Aug-98	K	356		ANG
OR 59169	9/18/97	2	389	482	EWU	5/20/98	S 3	394	466	EWU
OR 59191	9/18/97	S 3	278	153	EWU	8/29/98	BC	NL		ANG
OR 59201	4/29/98	S 3	367	426	EWU	9/14/98	BC	NL	1419	ANG
OR 59203	4/29/98	S 3	507	950	EWU	10/11/98	NP	NL		ANG
OR 59220	4/29/98	S 3	389	437	EWU	7/16/98	S 1	NL		ANG
OR 59252	4/29/98	S 3	600	2361	EWU	4/29/98	S 3	600	2264	EWU
OR 59273	4/29/98	S 3	390	472	EWU	6/21/98	4	400		ANG
OR 59276	4/29/98	S 3	401	485	EWU	7/16/98	S 1	NL		ANG
OR 59311	4/25/98	S 3	679	2463	EWU	4/29/98	S 3	676	3300	EWU
OR 59320	4/25/98	S 3	480	889	EWU	7/11/98	S 2	508		ANG
OR 59321	4/25/98	S 3	522	1280	EWU	5/16/98	S 3	518	1306	EWU
OR 59344	4/29/98	S 3	432	597	EWU	7/22/98	SP	352	389	EWU
OR 59359	6/21/97	8	409		KFWT97	4/18/98	S 3	439	633	EWU
OR 59368	6/21/97	8	411		KFWT97	7/16/98	S 1	NL		ANG
OR 59371	6/21/97	8	533		KFWT97	6/25/98	S 1	597	2497	ANG
OR 59583	5/31/98	S 1	323	245	EWU	7/16/98	S 1	NL		ANG
OR 59644	6/22/97	8	527		KFWT97	6/6/98	S 2	533		ANG
OR 59644	6/22/97	8	527		KFWT97	4/17/98	S 3	545	1286	EWU
OR 59644	6/22/97	8	527		KFWT97	4/22/98	S 3	544	1291	EWU
OR 59652	6/22/97	8	368		KFWT97	6/20/98	8	406		KFWT98
OR 59653	6/22/97	8	362		KFWT97	Aug-97	7	NL		ANG
OR 59656	6/22/97	8	400		KFWT97	6/21/98	8	425		KFWT98
OR 59684	6/22/97	8	393		KFWT97	6/12/98	8	419		ANG
OR 59691	6/22/97	8	393		KFWT97	6/3/98	8	436	896	EWU
OR 59693	7/28/97	5	220	88	EWU	6/5/98	6	NL		ANG
OR 59704	7/31/97	S 1	218	80	EWU	5/16/98	S 3	274	173	EWU
OR 59704	7/31/97	S 1	218	80	EWU	6/12/98	S 3	280	153	EWU
OR 59717	7/31/97	S 3	232	140	EWU	7/13/98	S 3	322	322	EWU
OR 59746	7/31/97	S 3	304	288	EWU	7/13/98	S 3	355	394	EWU
OR 59779	8/4/97	8	286	182	EWU	8/29/98	8	403	568	ANG
OR 59795	8/4/97	8	406	514	EWU	6/20/98	8	432		KFWT98
OR 59843	8/5/97	5	296		EWU	6/28/98	8	330		ANG
OR 59857	9/11/97	SP	287	213	EWU	5/2/98	S 2	NL		SRAD2
OR 59879	9/12/97	2	395	491	EWU	6/6/98	Spokane Arm	356		ANG
OR 59891	9/18/97	S 3	369	477	EWU	6/12/98	S 3	410	511	EWU
OR 59894	9/18/97	S 3	281	193	EWU	6/6/98	Spokane Arm	304		ANG
OR 59912	7/8/97	4	206	40	EWU	7/16/98	S 1	NL		ANG

Appendix B.

Table B1. Raw numbers used for calculation of entire reservoir walleye abundance estimates without the recruitment adjustment.

Pass	Number Captured	Number Marked	Recaptures Marked in Pass...				Total Recaptures
			1	2	3	4	
1	2,153	2,027	-	-	-	-	-
2	1,944	1,805	15	-	-	-	15
3	998	943	7	15	-	-	22
4	230	229	1	2	4	-	7
5	77	77	0	1	0	0	1
Total	5,402	5,080	23	18	4	0	45

Table B2. Raw numbers used for calculation of entire reservoir walleye abundance estimates with the recruitment adjustment.

Pass	Number Captured	Number Marked	Recaptures Marked in Pass...				Total Recaptures
			1	2	3	4	
1	2,150	2,027	-	-	-	-	-
2	1,902	1,769	15	-	-	-	15
3	977	930	7	15	-	-	22
4	225	224	1	2	4	-	7
5	63	63	0	1	0	0	1
Total	5,317	5,013	23	18	4	0	45

Table B3. Raw numbers used for calculation of the size of the walleye spawning run in the Spokane River Arm.

Pass	Number Captured	Number Marked	Recaptures Marked in Pass...					Total Recaptures
			1	2	3	4	5	
1	29	29	-	-	-	-	-	-
2	215	215	0	-	-	-	-	0
3	536	536	1	11	-	-	-	12
4	263	263	0	3	9	-	-	12
5	296	296	1	4	13	1	-	19
6	196	179	1	4	5	2	4	16
Total	1,535	1,518	3	22	27	3	4	59

Appendix C.

Table C1. Age-length key for walleye collected from Lake Roosevelt by EWU during 1998.

Length Group (cm)	n	Number of Walleye of Age...													
		0	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0														
2	0														
3	0														
4	0														
5	1	1													
6	0														
7	0														
8	2	2													
9	1	1													
10	6	5	1												
11	19	11	8												
12	28		28												
13	33	13	20												
14	37	7	30												
15	30	12	18												
16	51	31	20												
17	83		83												
18	119		119												
19	187		187												
20	207		166	41											
21	207		207												
22	189		189												
23	169		101	68											
24	134		134												
25	190		114	76											
26	79		47	32											
27	62		62												
28	66		13	53											
29	100		40	40	20										
30	112			45	67										
31	138			55	55	28									
32	116			70	46										
33	111			67	44										
34	115			46	69										
35	125			50	75										
36	163			33	130										
37	145			58	58		29								
38	134			27	27	54	27								
39	160				160										
40	179					107	72								
41	127				51	76									
42	129				52	52		26							
43	110				44	44	22								
44	103				21	82									
45	109					65	44								
46	111					44	67								
47	136					27	54	54							
48	104					42	42	21							
49	117						70	47							

50	101							40	40	20									
51	75								60		15								
52	72								14	29	29								
53	53								21	21		11							
54	39								23	8	8								
55	29								6	12	6	6							
56	28							6	11	6	6								
57	15								9	3	3								
58	15							6		9									
59	14							3	3	3	3	3							
60	13								5	5	3								
61	7										7								
62	8								2	2	5								
63	7								3	3	1								
64	10									6	4								
65	8								2	2	3	2							
66	4								1	1		2							
67	5									1	4								
68	2									1	1								
69	4											1	2				1		
70	1																1		
71	3										1		2						
72	1												1						
73	5										1	2	2						
74	3											3							
75	2										1		1						
76	1											1							
77	1												1						
78	0																		
79	0																		
80	1												1						
81	0																		
82	2												1				1		
83	1																		1
84	1															1			
85	1																		1
5076		83	1587	759	919	621	481	348	130	100	30	11	3	1	2				

Appendix D.

Table D1. Relative abundance (R.A.; %) and catch-per-unit-effort (CPUE; fish/hr) of fish collected via boat electrofishing from Lake Roosevelt between April 1st and December 10th, 1998. Total effort was 313.66 hours.

Family	Species	n	R.A. (%)	CPUE (fish/hr)	Size Range (mm)
Salmonidae	Chinook	14	0.1	< 0.1	69 - 522
	Kokanee	3,551	23.9	11.3	75 - 569
	Rainbow Trout	677	4.6	2.2	52 - 560
	Cutthroat Trout	1	< 0.1	< 0.1	321
	Brown Trout	98	0.7	0.3	149 - 698
	Brook Trout	123	0.8	0.4	85 - 422
	Mountain Whitefish	68	0.5	0.2	59 - 545
	Lake Whitefish	30	0.2	0.1	362 - 595
Cyprinidae	Northern Pikeminnow	202	1.4	0.6	17 - 590
	Peamouth	25	0.2	0.1	72 - 232
	Redside Shiner	4	< 0.1	< 0.1	69 - 120
	Longnose Dace	12	0.1	< 0.1	60-80
	Carp	299	2.0	1.0	45 - 848
	Tench	27	0.2	0.1	125 - 541
Catostomidae	Largescale Sucker	3,267	22.0	10.4	56 - 654
	Bridgelip Sucker	35	0.2	0.1	130 - 436
	Longnose Sucker	215	1.4	0.7	45 - 515
	Hybrid Sucker	10	0.1	< 0.1	467 - 594
Ictaluridae	Brown Bullhead	5	< 0.1	< 0.1	36 - 215
	Yellow Bullhead	1	< 0.1	< 0.1	172
Gadidae	Burbot	132	0.9	0.4	381 - 716
Centrarchidae	Largemouth Bass	173	1.2	0.6	41 - 463
	Smallmouth Bass	1,172	7.9	3.7	47 - 450
	Pumpkinseed	12	0.1	< 0.1	75 - 115
	Black Crappie	50	0.3	0.2	30 - 367
Percidae	Yellow Perch	433	2.9	1.4	42 - 266
	Walleye	4,169	28.1	13.3	46 - 851
Cottidae	Piute Sculpin	44	0.3	0.1	46 - 142
	Torrent Sculpin	6	< 0.1	< 0.1	52 - 110
	Mottled Sculpin	2	< 0.1	< 0.1	85 - 92
Total		14,857		47.37	