B O N N E V I L L E   P O W E R   A D M I N I S T R A T I O N

Banks Lake Fishery Evaluation Project

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Bonneville Power Administration
P.O. Box 3621
Portland, OR 97208

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Banks Lake Fishery Evaluation Project Annual Report FY2006
(September 1, 2005 to August 31, 2006)

Prepared by:

Matt Polacek
Washington Department of Fish and Wildlife
Science Division
Ecological Investigations Unit
5981 Vantage Highway, Suite 100
Ellensburg, WA 98926

and

Rochelle Shipley
Washington Department of Fish and Wildlife
Fish Management Division
5981 Vantage Highway, Suite 100
Ellensburg, WA 98926

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

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Abstract

The Washington Department of Fish and Wildlife implemented the Banks Lake Fishery Evaluation Project (BLFEP) in September 2001 with funds from the Bonneville Power Administration. Fiscal Year (FY) 2001 of the BLFEP was used to gather historic information, establish methods and protocols, collect limnology data, and conduct the first seasonal fish surveys. FY 2002 through 2006 was used to continue seasonal fish and lake-wide creel surveys to establish baseline datasets. Water quality parameters were collected monthly from November to May and bi-monthly from September to October and June to August. Data have not been provided by the sub-contractor for water quality and zooplankton; however, from past years Banks Lake water temperatures began to increase in April and stratification was apparent by June at all 3 limnology collection sites. By late August, the thermocline had dropped to nearly 20 meters deep, with 16-17 °C temperatures throughout the epilimnion. Dissolved oxygen levels were generally above 10 mg/L until August when dissolved oxygen dropped near or below 5 mg/L below 20-meters deep. Secchi depths ranged from 2.5-8 meters and varied by location and date. Nearshore and offshore fish surveys were conducted in the fall (October) 2005 and summer (July) 2006 using boat electrofishing, fyke net, gill net, and hydroacoustic surveys. Yellow Perch (39%) and smallmouth bass (20%) dominated the nearshore species composition in October; however, by July yellow perch (16%) were the third most common species with smallmouth bass (40%) and sculpin (22%) being first and second highest, respectively. Yellow perch dominated the offshore catch in the fall (37 %) while lake whitefish were highest in the summer (71%) survey. Fish diet analysis indicated that juvenile fishes consumed primarily insects and zooplankton, while adult piscivores consumed cottids, yellow perch, kokanee, and rainbow trout most frequently. The highest angling pressure occurred in May 2006, when anglers were primarily targeting walleye and smallmouth bass. Boat anglers utilized Steamboat State Park more frequently than any other boat ramp on Banks Lake. Shore anglers used the rock jetty at Coulee City Park 76 % of the time, with highest use occurring from November through April. An estimated total of 19,468 (± 301 SD) smallmouth bass, 8,314 (± 124 SD) walleye, 4,065 (± 301 SD) rainbow trout, and 26,959 (± 1,241 SD) yellow perch were harvested from Banks Lake in FY 2002. Only 3 kokanee were reported in the catch during the FY 2002 creel survey. Abundance estimates from the hydroacoustic survey in July were 279,715 lake whitefish and 20,931 kokanee, with an overall abundance estimate of 409,106 limnetic fish greater than 100 mm. Entrainment studies indicated a total loss of 58,708 fish in 2005 (6.2 fish/10,000 m^3), dominated by yellow perch (80%) and sculpin (11%). When comparing spring fry, fall fingerling and yearling net pen release strategies of kokanee, 73% were of hatchery origin, 61% were from the fall fingerling release group, and of the marked fall fingerling release group, 41% were reared as yearlings in net pens. In the future, data from the seasonal surveys and creel will be used to identify potential factors that may limit the production and harvest of fishes in Banks Lake, and make recommendations to best manage the fishery.

Acknowledgements

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The Washington Department of Fish and Wildlife implemented the Banks Lake Fishery Evaluation Project (BLFEP) in September 2001 with funds from the Bonneville Power Administration. Fiscal year (FY) 2002 of the BLFEP was used to gather historic information, establish methods and protocols, collect limnological data, and conduct the first seasonal fish surveys. From FY 2003 through FY 2006 we continued seasonal fish and lake-wide creel surveys and adjusted methods and protocols as needed. The final project report will include comprehensive data reporting and analysis and provide fishery management recommendations that can be used in an effort to maximize fish production and creel harvest for the lake.

This annual report will summarize the tasks completed during FY 2006, which started on September 1, 2005 and ended August 31, 2006. The purpose of this report is to demonstrate that we completed our contractual obligations by conducting the tasks outlined in our FY 2006 Statement of Work, and report findings from data collected during the contract period. A comprehensive account of the history of Banks Lake and its fishery can be viewed at http://www.efw.bpa.gov/searchpublications/index.aspx (DOE ID #00005860-2).

1.0 Introduction

Banks Lake was considered a premier kokanee (*Oncorhynchus nerka*) fishery in the 1960's and 1970's, but by the early 1980's kokanee had disappeared from the creel. The operation of Banks Lake has changed since the height of the kokanee fishery (Stober et al. 1975, 1976, 1977, 1979, 1982). Dry Falls Dam has been altered for power production. Deep-water releases are now made compared to the earlier surface spill gate design that was in place. The feeder canal now has six reversible pump power generating units compared to four, and water elevation changes are not as severe. An increase in piscivore abundance over the past two decades with the introduction of smallmouth bass (*Micropterus dolomieu*) in 1981 and walleye (*Stizostedion vitreum*) in the 1990's (WDFW, Region 2, unpublished data) have altered historic species composition. Smallmouth bass have flourished compared to walleye with relative abundances of 25% and 3%, respectively (BLFEP, unpublished data). Some or all of these changes may act as stressors to the kokanee population, and limit this species production potential in Banks Lake.

Studies that quantify biotic and abiotic factors that can potentially limit or enhance fish populations provide fisheries managers the needed data to implement regulations that will increase the likelihood of the desired outcome (i.e. increased harvest or protective slot limits). Understanding intrinsic characteristics such as fish growth and condition, predator-prey relationships (primary production to apex piscivore), and water quality on a seasonal scale can signify deficiencies or proficiencies in a specific aquatic community. Annual creel studies can indicate rates of exploitation and provide a monitoring aspect following a regulation change.

This project continued baseline data collections to evaluate factors that may limit the recruitment of hatchery kokanee, rainbow trout (*O. mykiss)* and other gamefish to the creel. Monitoring annual predation effects, short-term acute predation during stocking events (Baldwin et al. 2003), planktivore and piscivore fish populations, prey base, exploitation, and entrainment are important steps in evaluating the ongoing kokanee recovery project for Banks Lake.

2.0 Study Area

The Bureau of Reclamation created Banks Lake in 1951 to function as an equalizing reservoir for the Columbia Basin Irrigation Project. It occupies the Upper Grand Coulee, formerly a channel of the Columbia River, located in the high scrub desert of Grant County, Washington (Figure 1). Banks Lake is contained within two earth-fill dams, the North Dam and Dry Falls Dam, or the South Dam. The North Dam, near Electric City, WA is 44 m high and 442 m long. Dry Falls Dam, close to Coulee City, is 37 m high and 2987 m long and supports a two-lane highway. Banks Lake is 43 km long, contains 1.6 billion m^3 of water and covers 10,881 ha of surface area (USBOR 1964). At an elevation of 479 m (1,570 ft) (full pool), the average depth is 14 m with a maximum depth of 26 m. Water is pumped up 85 m from a pumping plant at the left forebay of Grand Coulee Dam (Franklin Delano Roosevelt Lake -FDR) to a feeder canal 2.6 km in length, which delivers water to Banks Lake at the North Dam (USBOR 1964).

Additionally, Banks Lake is used as a pumped storage / power generating reservoir. The project includes six pump-generating units (P/G) in order to provide additional power during peak power periods, daily during the morning and evening and seasonally from October to March. The first two units were installed and operational by fall, 1974 (Stober et al. 1974). By early 1984, the other four units were fully operational (B. Mattson, personal communication). Dry Falls Dam also houses a power plant. Water for irrigation is withdrawn from the south end of Banks Lake through a turbine at Dry Falls Dam with a maximum rate of 8,000-cfs. Another 1,600-cfs is diverted to the spillway during the peak of the irrigation season (J. Moody, personal communication). The water is routed through the Main Canal 13.5 km to Billy Clapp Lake and then distributed to the Columbia Basin Irrigation Project.

Currently, water levels fluctuate minimally (1-5 ft) during the irrigation season, from late March until late October. Historically, a maximum drawdown of five to fifteen feet occurred in May, before the spring runoff increased pumping from Lake Roosevelt, achieving full elevation (1570 feet) during August. Irrigation demand, rainfall, runoff, and power demand contributed to an alteration of this elevation cycle (Stober et al. 1974).

Banks Lake consists of a myrid of fish species including gamefish such as kokanee rainbow trout, smallmouth and largemouth bass, walleye, yellow perch, lake whitefish and burbot. Banks Lake is stocked annually with kokanee and rainbow trout. More detailed stocking strategies and totals are discussed in section 4.4.

3.0 Methods

3.1 Limnology

To assess the affects of abiotic (water quality) and biotic (zooplankton prey base) conditions (water quality) on the fish community, we continued to collect baseline data on water quality and zooplankton at three fixed sites, once each month from February to May and at seven sites twice monthly from June to August. Each fixed site represented different basin morphologies of the lake. They were located in the north basin (LIM1 – 0345557, 5311151), mid reservoir west of Steamboat Rock (LIM3 – 0340127, 5305651), and the south end near Million-Dollar Mile (LIM5 – 0330396, 5288748). Four additional sites were added in June 2003 to represent two embayments, the most southern end of the lake, and the lake's maximum depth (56 m) and were located in Kruk's Bay (LIM2 – 0343817, 5307049), Devil's Punch Bowl (LIM4 – 0341957, 5302762), Devil's Lake (LIM7 – 0341897, 5306961), and southwest of Goose Island (LIM6 – 0327203, 5281572) (Figure 1). Water quality parameters included temperature (°C),

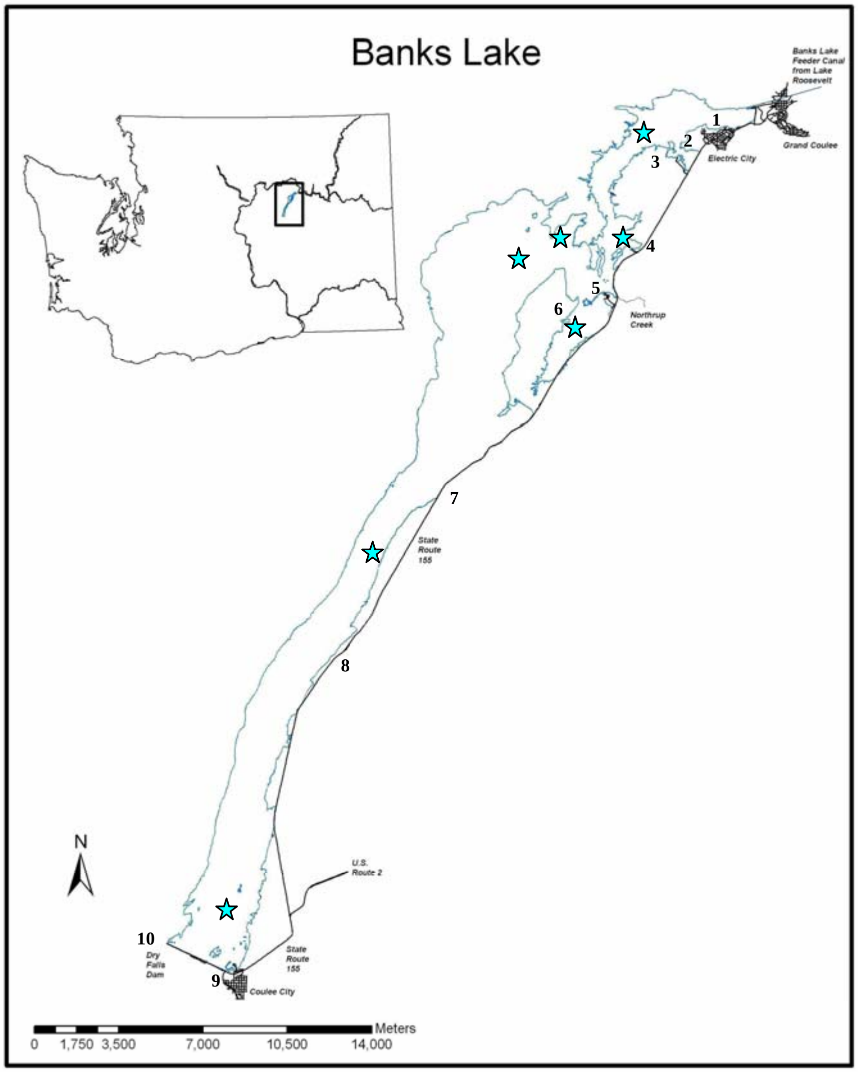

Figure 1. Map of Banks Lake showing the 7-limnology sampling sites (stars) and the 10-creel access sites (numbers) for FY06. Creel site names are as follows (north to south orientation): 1) Coulee Playland Resort, 2) Sun Banks Resort, 3) Osborne Bay Park, 4) Jones Bay, 5) Northrup, 6) Steamboat Rock State Park, 7) Paynes Gulch, 8) the Pass, 9) Coulee City Park, and 10) Dry Falls Junction.

dissolved oxygen (DO – mg/L), conductivity (mS/cm), turbidity (NTU), and pH, and were collected from the surface to the bottom at 2-m increments with a Hydrolab Inc. water quality instrument.

Zooplankton were collected with a 50 or 30 cm diameter, 153-micron mesh Wisconsin style net. Three replicate tows were taken from each site from the bottom to the surface. Zooplankton were "fixed" for 20 seconds in 95 % ethanol and then preserved in 70 % ethanol (Black and Dodson 2003). Laboratory analysis involved zooplankton identification, density and length measurements by Eastern Washington University.

3.2 Fish Surveys

We collected baseline fisheries data for littoral (nearshore) and limnetic (offshore) fish species during the fall (October 10-14) 2005, nine days in the winter 2005/06, and summer (July 17-21) 2006.

Littoral zones surveys.—To determine littoral sample sites, Arcview software was used to divide the shoreline, including islands, into 464 sites that were 400 m long each (Figure 2). Sample sites were then randomly selected using Statview. Our minimum goal was to sample 15% of the shoreline sites. We used the standard protocol from the WDFW Warm Water Fish Survey Manual (Bonar et al. 2000) to determine fish species composition, CPUE, and collection of biological data for determining growth, age, condition factor and relative weight. Specific capture methods included boat electrofishing, gill nets, and fyke nets in a 3:2:1 ratio (48 electrofishing sites, 24 gill netting sites, and 16 fyke net sites). The ratio was 3:3:1 in October to accommodate the data needs of the WDFW Fall Walleye Index Netting survey (FWIN). Gill nets were 61 m long by 1.8 m deep and consisted of 8 different stretch mesh sizes including 25, 38, 51, 64, 76, 102, 127, and 152 mm. We used 2-3 electrofishing boats to sample fish and set littoral gill and fyke nets. Each electrofishing boat set gill nets and fyke nets prior to dusk, and retrieved the nets the following morning. Electrofishing boats traveled parallel to the shoreline at night and sampled for 600 consecutive seconds. To initiate fish galvanotaxis, we produced 1-2 amps by setting the voltage to low power, the frequency to 30 Hz DC and the range to 42-48% of duty cycle. Shocked fish were collected with dip nets and placed into a live well. All fish were measured (TL, mm) and weighed (g) and diet samples were collected from a sub-sample of fish for bioenergetics modeling. Diet samples were collected using gastric lavage from live fish collected via electrofishing, and entire stomachs were dissected from dead fish. Scales and otoliths were collected for aging. Bass and walleye were inspected for anchor tags and kokanee for fin clips. Otoliths were extracted from all kokanee for thermal mark identification.

Fish condition was analyzed using mean condition factors (k) and relative weights (W_r) for fish species collected in the Fall, which provided a relationship between length and weight of an individual fish. Condition factors were calculated as,

$$= (W / TL^3)*10^4$$

where,

W = weight in grams

TL = total length in millimeters

Relative weight was calculated as,

$$= (W / W_s) * 100$$

where,

W = weight in grams)

W_s = standard weight

Standard weights are from standard $\log_{10}$ weight-length relationships for each species updated from Murphy et al. (1991), Anderson and Neumann (1996), and Blackwell et al. (2000). A W_r near or above 100 would indicate good condition when compared to the national average (75th percentile) for that species.

Hydroacoustic surveys. —We used an HTI model 241 echosounder with two 200 kHz transducers; a 15° split-beam transducer in vertical orientation and a 6° x 10° elliptical split-beam transducer in horizontal orientation. The transducers were clamped to a pole and mounted 1 m below the surface on the starboard side of 6.7 m vessel. Data were logged directly into a computer and unprocessed echoes were backed up using digital audiotapes. A pulse repetition rate of 8 pings per second was fast multiplexed between the transducers at a pulse width of 1.25 ms and a 10 kHz pulse width chirp. The horizontal transducer was offset by 7° and sampled fish targets from 1.5- to 8 m below the surface. Data within 16 m of the horizontal transducer were excluded from analysis due to the narrow beam width and potential boat avoidance by fish in the near field (Mous and Kemper 1996; Yule 2000). The vertical transducer data were analyzed from 8 m below the transducer (9 m subsurface) to within 1 m of the bottom of the reservoir. Additionally, we had to correct our fish counts within each 2 m strata for the probability of detection of fish targets based on the diameter of the sound impulse cone and the fish velocity (boat speed).

Eighteen transects were conducted in an elongated zigzag pattern across the limnetic zone of Banks Lake on July 20, 2006. The survey began one hour after sunset and each transect covered 1.4 to 3.7 km at a speed of approximately 8 km/hour, for a total survey distance of 51.4 km. A global positioning system (GPS) logged the latitude and longitude into the data files and transect distance was calculated using Terrain Navigator software version 4.05 (Maptech 1998).

A series of acoustic echoes were considered a fish if tracked for at least 3 consecutive pings, within 0.3 m/ping, a maximum velocity of 5 ms/ping, and target strengths between –55 and –28.8 dB. Target strengths were converted to fish lengths using a formula generated by Love (1971, 1977).

Density (fish/m^3) was calculated for each transect and transect densities were averaged together for a reservoir wide estimate of fish density. Mean fish density was then multiplied by reservoir volume to estimate abundance. Two standard errors were used to estimate the 95 % confidence interval of the acoustic abundance estimate. For each transect, individual tracked fish were verified as real within the post-processing software Echoscape 2.10 (HTI 2001). Raw fish counts were adjusted to the effective beam width within each 2 m depth strata by the equation:

$$F_1 = F_0 * [1-(EBW/NBW)]$$

where F_1 was the adjusted fish count, F_0 was the original fish count EBW was the effective beam width for that stratum and NBW was the nominal beam width for the transducer. Density was calculated by dividing the adjusted fish count by the total swept volume for each transect. Swept volume was calculated as the sum of the volumes for every 2 m depth strata for each transect, adjusted for bottom encroachment and multiplied by transect length. The volume of each strata was calculated by the equation:

$$Vs_1 = V_1 - V_2$$

where V_1 was the volume from the transducer to the bottom of the stratum and V_2 was the volume from the transducer to the top of the stratum and:

$$V = (½ * b * h * (l*e)$$

where e was the percent bottom encroachment (proportion of the transect where bottom depths were equal to or greater than the max depth of the stratum), l was the distance (m) of the transect, h was the distance (m) from the transducer to the end of the stratum, and b was the beam diameter calculated by:

$$b = 2 R \tan(NBW/2)$$

where R is the range (m) to the end of the stratum.

Species-specific abundance estimates were calculated by multiplying the species composition of various size classes by the acoustic abundance estimates for the corresponding sizes. We applied the length frequency from the vertical transducer to the horizontal data because fish target echoes in horizontal aspect do not relate to fish length as they do in vertical aspect (Kubecka 1994; Yule 2000). The assumption that fish species composition and size distribution was the same from 1.5- to 8 m (horizontal acoustics) and from 8- to 25 m was validated with netting data.

Limnetic gill netting surveys. --Limnetic gill net surveys were used to provide species verification, depth distributions, and length frequencies of acoustic targets larger than 200 mm. The night of the acoustic survey, and for 4 nights following the survey, a total of 50 vertical gill nets and four floating, seven sinking, and two midwater horizontal gill net were randomly placed in the limnetic zone of Banks Lake. Nets were set in the late afternoon and retrieved the following day. The vertical nets consisted of replicate samples of seven nets that are 2.6 m wide and 26.2 m deep, consisted of one mesh size throughout (25, 38, 51, 64, 76, 89, 102, 127, and 152 mm stretch). Horizontal nets were 2.6 m deep and 46 m long with eight panels (7.6 m each) and consisted of the same mesh array as the verticals.

We stratified Banks Lake into 3 horizontal strata, representing different basin morphologies. Strata 1, 2, and 3 received 42%, 43%, and 15% of the limnetic nets, respectively. We covered 25% (63 of 252) of the potential limnetic sampling sites that were deep enough (at least 12 m) to sample. Maptech software was used to spatially segregate (~500 m diameter) the limnetic sampling sites by placing a point near the center of each quadrant of each section in their respective township and range. Additional points were added along the North, South, East, and West borders of each section, as well as the center point (Figure 2). This method provided uniform coverage, representative offshore sites throughout the lake, and a GPS point to navigate to for net deployment.

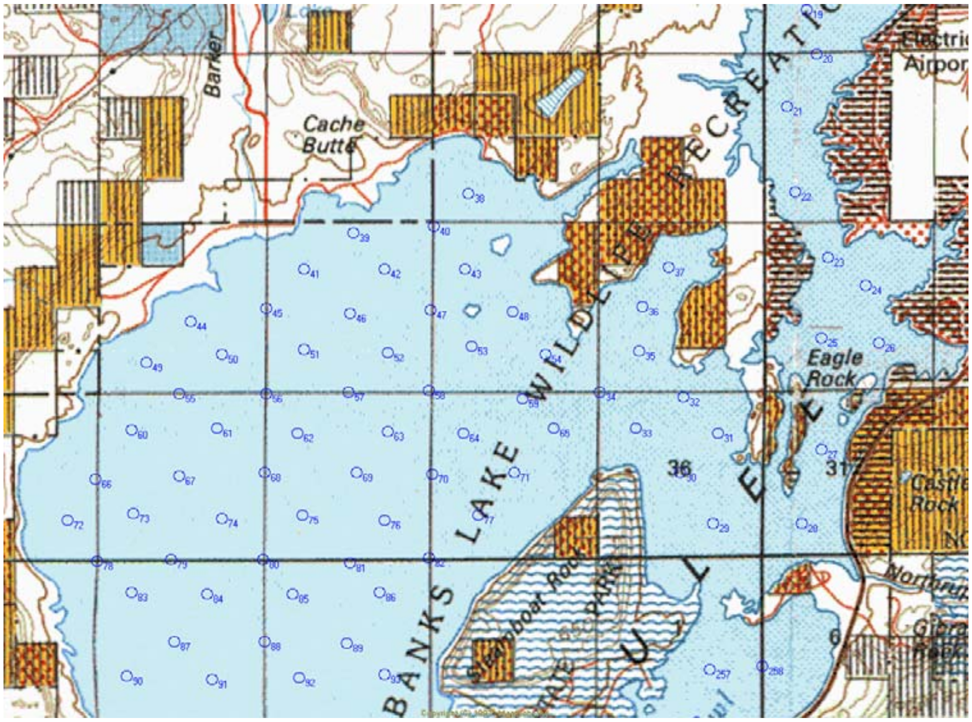

Figure 2. Partial map of Banks Lake showing the layout of limnetic sampling sites. Approximately 20% of the sites were randomly selected and surveyed with vertical and horizontal gill nets.

3.3 Fish Diet Collection and Consumption Estimates

Stomach contents were collected from fish captured during the seasonal limnetic and littoral fish surveys. Stomachs were dissected from dead fish and gastric lavage was used for live fish (Light et al. 1983). Stomach contents from a sub-sample of piscivores and planktivores (30 samples for each species) were identified to the lowest practical taxonomic level (Polacek et al. 2003). Fish prey were identified to species using diagnostic bones (Hansel et al. 1988), and zooplankton (Pennak 1989) and insects (Merritt and Cummins 1996) to practical taxonomic levels. The blotted-dry wet weight proportion of each diet taxon was determined and averaged within each species (Baldwin et al. 2003) by month.

Growth (length- and weight-at-age) was determined by scale, otolith and/or length frequency analysis depending on the species, age, and reliability of each structure. Diet proportions, prey caloric density (literature values), thermal experience (from limnology data) and growth were used in a mass balance bioenergetics model (Hanson et al. 1997) to quantify the consumption of each prey type by each predator species.

The model extrapolated between sampling dates except when fine scale diet information was available such as during stocking events. Individual predator consumption was applied to predator abundance estimates generated from mark-recapture studies (Baldwin et al. 2003; Everhart and Young 1981) and from mobile hydroacoustic estimates (Thorne 1983).

3.4 Fish Tagging, Marking and Stocking

When salmonids are artificially incubated it becomes possible to place recognizable thermal marks in their otoliths. This method is referred to as “thermal” marking and extensive reviews of the procedure can be found in Volk et al. 1999 and 2005. Briefly, shifts in water temperature experienced from the eyed stage through yolk absorption are used to induce visible bands on the microstructure of otoliths. The bands and spaces between them are organized to produce bar codes on otoliths by following a series of simple rules (Volk et al. 1994) that create relatively wide and narrow spaces between the bands. Using the methods described by Volk et al. (1994) it is possible to produce hundreds of unique thermal marks. Marks can be induced into otoliths both before and after hatching. The technique was first applied to pacific salmon in 1985 (Volk et al. 1990) and is now widely used by researchers around the Pacific Rim. In 2004 for example, over 20% of the cultured salmon released (> 1 billion) into the Pacific had been thermally marked. Marks are retrieved by collecting otoliths, creating hemi-sections and examining these under 100 to 400x with a light microscope. These are permanent marks and can be decoded at any period in the life cycle.

The WDFW Spokane Fish Hatchery thermal marked all hatchery kokanee as part of the Banks Lake kokanee program. All the cultured kokanee released directly into net pens received an additional left pelvic fin clip. Each release group received a code that reflected its rearing and release strategy (Spring fry release, fall fingerling release and spring net pen yearling release). In addition, all rainbow trout fry were otolith marked to evaluate fry versus yearling releases. For quality control, 5-20 fish from each group were sacrificed to document the thermal codes they possess. Kokanee are collected in the creel and during seasonal fish surveys so that otoliths can be collected and examined for thermal marks. In May 2006, a tagging event was conducted at the annual Big Wally’s Walleye tournament in an effort to use a mark recapture population estimate model to predict walleye abundance in Banks Lake. A total of 767 walleye were tagged dorsally using numbered Floy® anchor tags. The size of walleye caught ranged from 404 mm to 785 mm. Angling was used as the recapture method.

3.5 Creel Survey

The creel study design was based on standard protocols from Malvestuto (1983) and Pollock et al. (1994). A non-uniform probability sampling design rove/access creel survey was used to estimate total fishing pressure, catch-per-unit-effort (CPUE), harvest-per-unit-effort (HPUE), and total catch and harvest of fish from Banks Lake. Ten permanent creel survey stations were potentially surveyed from September 2005 through August 2006. These stations were established by including all major boat ramps, and were named as follows (north to south orientation): 1) Coulee Playland Resort, 2) Sun Banks Resort, 3) Osborne Bay Park, 4) Jones Bay, 5) Northrup, 6) Steamboat Rock State Park, 7) Paynes Gulch, 8) the Pass, 9) Coulee City Park, and 10) Dry Falls Junction (Figure 5). Creel survey days were randomly chosen from a set number of weekdays and weekend/holidays each month, which varied depending on season. Each survey lasted 8 hours and consisted of a rove (generally 2 hours) and two access site visits (generally 3 hours each).

Rove surveys were used to estimate the total fishing pressure, while access site visits provided information on catch and harvest rates. During the rove surveys, each station was visited to count the total number of boat trailers and shore anglers and to interview anglers for catch information. The start time of a rove survey was randomly selected (the beginning vs. end of the 8 hour creel survey). The access surveys were conducted at 2 randomly selected stations per creel day, and were designed to collect completed trip information from anglers as they left the lake. Creel clerks asked anglers for information regarding party size, recreational activity, if their trip was completed, start and end times of activity, species targeted, species-specific catch and harvest, satisfaction with the fishing experience, and city from which they live. Access site randomization was based on the proportional use of each boat ramp for that month from the previous year. The creel survey start time was randomly selected with equal probability and based on 8 hours after sunrise or 8 hours prior to sunset.

Aerial flights were conducted during one weekday and one weekend day from May to August to establish a correction factor for the total angling effort (pressure) between fishing and recreation boats. The airplane traveled north along the east shoreline and south along the west shoreline, while a creel clerk recorded the total number of boat trailers at the access creel stations and the number of fishing boats, non-fishing boats, and shore anglers on and around the lake. To eliminate duplicate counts, the creel clerk counted boats from the center of the lake to either side of the shore, dependent on the direction of travel. A creel clerk simultaneously conducted a standard creel survey from the ground.

Creel Data Analysis

Monthly estimates of catch and harvest were stratified by weekend days vs. weekdays, and boat anglers vs. shore anglers. Values were then combined to determine monthly and annual totals. The following equations were modified from Cichosz et al. (1997), McLellan (2000), Pollock et al. (1994), and Malvestuto (1983) to estimate catch/harvest rates and total harvest.

Mean number of anglers per day of fishing was estimated:

$$X_b = (A_d)(B_f)$$

Where:
X_b = the mean number of anglers per boat per day for each stratum,
A_d = mean number of anglers per boat for each stratum per month, and
B_f = mean number of boats fishing for each stratum per month.

Number of hours available for fishing (sunrise to sunset) was estimated:

$$N_s = (D_s)(H_d)$$

Where:
N_s = number of hours per weekend or weekday per month,
D_s = number of days per month (weekday or weekend), and
H_d = average number of hours per day for each stratum per month.

The number of hours sampled for each stratum per month was estimated:

$$n = \sum_{i=1}^{Ds} (H_{ci})$$

Where:
n = the total number of hours sampled for each stratum per month,
D_s = the number of days per month within each stratum per month, and
H_{ci} = mean number of hours creeled per day for each stratum per month.

The number of shore anglers per day for each stratum per month was estimated:

$$X_a = \sum_{i=1}^{Pd} S_{pi}$$

Where:
X_a = the mean number of shore anglers per day for each stratum per month from rove surveys,
P_d = the number of rove surveys conducted for each stratum per month, and
S_{pi} = the total number of shore anglers counted during rove surveys for each stratum per month.

The mean number of anglers (boat$_b$ or shore$_a$) for each stratum per month was estimated:

$$X_s = (X_{a,b})(D_s)$$

Where:
X_s = the mean number of anglers for each stratum per month,
$X_{a,b}$ = mean number of anglers for each stratum per day,
D_s = number of days per month.

The standard deviation of angler hours (boat or shore) for each stratum per month was estimated:

$$S_s = (S_d)(D_s)$$

Where:
S_s = the standard deviation of mean number of angler hours for each stratum per month,

S_d = the standard deviation of mean trip length per day for each stratum per month,
D_s = the number of days per month for each stratum per month.

The mean trip length for each stratum per month was estimated:

$$H_a = [T_h / (A_i{*}P_i)]$$

Where:
H_a = the mean trip length for each stratum per month,
T_h = the total hours spent fishing for each stratum per month,
A_i = the total number of parties interviewed for each stratum per month, and
P_i = the mean party size for each stratum per month.

Total angler pressure for each stratum per month was estimated:

$$PE_t = (N_s / n)(X_s)(H_a)$$

Where:
PE_t = the total pressure estimate for each stratum per month,
N_s = the number of hours for each stratum per month,
n = the number of hours sampled for each stratum per month,
X_s = the mean number of anglers for each stratum per month, and
H_a = the mean trip length for each stratum per month.

The species-specific pressure was calculated:

$$PE_{ss} = PE_t * \left(\sum spp_i / \sum spp_t \right)$$

Where:
PE_{ss} = the species specific pressure estimate for each stratum per month
PE_t = the total pressure estimate for each stratum per month,
spp_i = the total number of anglers who targeted a specific fish species for each stratum per month,
spp_t = the total number of anglers who targeted a specific fish species for each stratum per month

The variance of the pressure estimate for each stratum per month was calculated:

$$VPE_{ss} = (N_s / n)(S_s^2)$$

Where:
VPE_{ss} = the variance of the pressure estimate for each stratum per month,
N_s = the number of hours for each stratum per month,
n = the number of hours sampled for each stratum per month, and
S_s = the standard deviation of the mean number of angler hours for each stratum per month.

The ninety-five percent confidence intervals for each stratum per month were calculated:

$$C.I. = PE_{ss} \pm \left(\sqrt{VPE_s} * 1.96 \right)$$

Where:
C.I. = 95% confidence intervals for each stratum per month,

PE_{ss} = pressure estimate for each stratum per month, and
VPE_s = variance of the pressure estimate for each stratum per month.

Both complete and incomplete trips were used to calculate CPUE for each fish species for each stratum per month. CPUE was calculated from all caught fish, whereas HPUE was calculated only from fish that were kept by anglers.

$$CPUE = \frac{F_{c+h}}{T_h} \textit{ and } HPUE = \frac{F_h}{T_h}$$

Where:
CPUE = catch-per-unit-effort of a particular fish species for each stratum per month,
HPUE = harvest-per-unit-effort of a particular fish species for each stratum per month,
F_{c+h} = the number of fish captured (includes harvest) for each stratum per month,
F_h = the number of fish harvested per each stratum per month, and
T_h = the total hours spent fishing for each stratum per month.

Harvest of each fish species for each stratum per month was calculated:

$$H_s = (HPUE)(PE_{ss})$$

Where:
H_s = harvest of a particular species of fish for each stratum per month,
HPUE = the number of fish harvested of a particular fish species for each stratum per month, and
PE_{ss} = species-specific pressure estimate for each stratum per month.

The total economic value of the fishery was estimated:

$$EV = \frac{PE_t}{H_a} * (\$)$$

Where:
EV = the total economic value,
PE_t = the total pressure estimate for each stratum per month,
H_a = the mean angler trip length for each stratum per month, and
$= average dollar amount spent per angler trip.

Data compiled by the U.S. Fish and Wildlife Service in 1996 (USDI 2001) determined that the average inland Washington angler spent $30.00 per angling trip. This value was multiplied by the inflation rate from 1996 to 2006 (1.14) to determine the current dollar amount spent per angler trip (U.S. Department of Labor 2006).

3.6 Entrainment

To determine the loss of fish and zooplankton from Banks Lake during the irrigation season (March – November), nets were placed in the canals at the Bacon Siphons, approximately 5.6 km south of Dry Falls Dam (Figure 3). Due to safety concerns, we were unable to sample closer to the dam. The two canals were sampled during the day and night (east and west canals;

the canals were approximately 100 m from each other) from March through October 2004 and 2005. The nets were 1.5x1.5x5.5 meter trawl nets, attached to a 1.5x1.5 meter frames (Figure 4). Two of the nets consisted of 2.5 cm stretch knotted mesh and the third net 1.3 cm stretch knotless mesh. All nets had a cod end. On the east canal the net was launched and retrieved from a bridge and supported by 1,633 kg ecology blocks and 1.3 cm diameter double braided nylon rope. On the west canal the net was deployed from a highline (supported by ecology blocks) using pulleys to position the net horizontally and vertically in the canal. Nets were generally fished near the bottom of the canal; however, the mid water and surface strata were also sampled. Beginning in late June, a third net was used, and fished in the east canal simultaneously with the second net. Halogen lights, powered by a generator, were used when retrieving and inspecting the nets at night. Nets were deployed and retrieved using a truck and all-terrain vehicle (ATV).

Nets were generally fished for 3-4 hours consecutively for an 18-24 hour period. In 2005, nets were not set during the day due to low daytime catch rates in 2004. Once the nets were retrieved, fish were identified to species, measured (mm), weighed (g) and returned to the canal. All unidentified fish were saved for identification in the lab. A 30 cm diameter zooplankton net was deployed for 2 minutes during the day and night to collect entrained zooplankton and icthyoplankton. Samples were preserved using the same methods outlined in section 2.2.1 – Limnology. Plankton samples were diluted to 1% for identification and enumeration.

Water velocity measurements were taken at each outlet and near each net to calculate total discharge and the sample volume of each net. The Bureau of Reclamation supplied discharge data from Dry Falls Dam that were used to compare to flow readings at the siphons. Water elevation gauges were mounted in each canal to calculate a relationship between gauge height and total discharge.

Volumetric expansion was used to estimate the total number of fish and zooplankton that passed by the study site where,

$$E_t = \frac{Nc_t}{\left(\frac{Nv_t}{Qt_t}\right)}$$

E_t = the number of fish or zooplankton passing by the study site at time (t)
Nc_t = the number of each organisms caught in the nets at time (t)
Nv_t = the volume (m^3/sec) of water sampled by the nets at time (t)
Qt_t = the total discharge (m^3/sec) at the study site at time (t).

Total catch and flows were stratified and analyzed in one-week blocks to reduce the chance of over estimating species-specific entrainment. The canal was sampled with an electrofishing boat in 2004 after irrigation flows had ceased to determine the species and size classes of fish remaining in the canal. Electrofishing methods were consistent with those outlined in section 3.2.

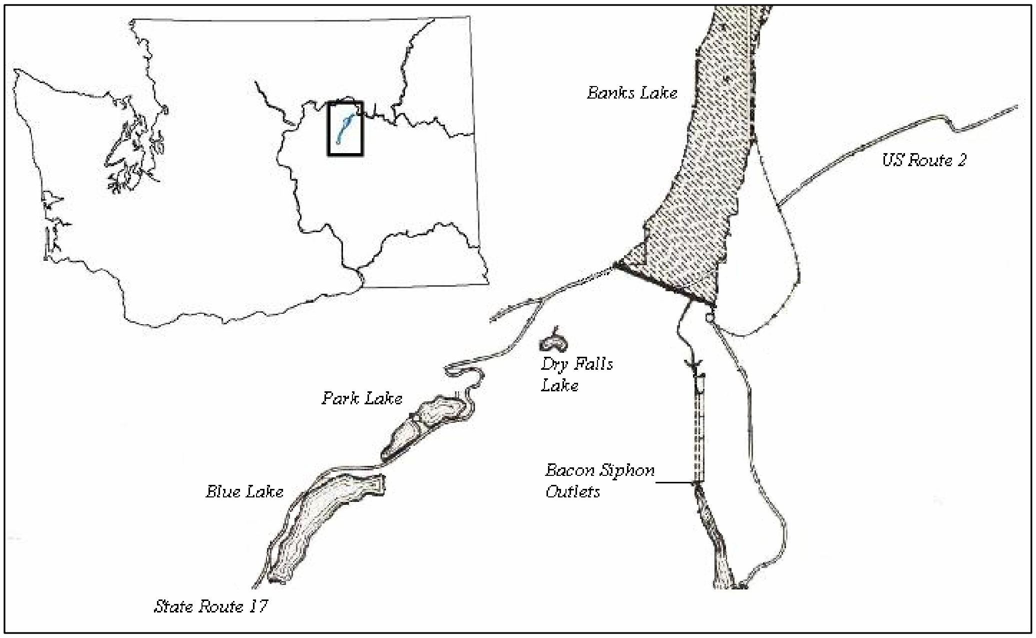

Figure 3. The location of the Bacon Siphon and outlet, site of the entrainment study for Banks Lake, WA in 2004 and 2005.

Figure 4. The trawl net (1.5 x 1.5 m opening) and rigging system used to sample fish in the west canal during the Banks Lake entrainment study 2004, 2005.

4.0 Results

4.1 Limnology

Water quality **–**waiting for data from sub-contractor
Secondary production **–**waiting for data from sub-contractor

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4.2 Fish Surveys

Sixteen fish species were collected during the seasonal fish surveys on Banks Lake (Table 1). Yellow perch were collected in a higher proportion than the other species during littoral surveys, while lake whitefish dominated the catch during limnetic surveys.

Littoral zone survey. In October (Fall survey), 48 sites were electrofished for a combined total of 28,877 seconds (8.02 hrs), 38 sites were gill netted and 16 sites were sampled with fyke nets. In all, 102 of 464 littoral sites were surveyed for 22% shoreline coverage. A total of 3,030 fish were collected during the littoral survey (Table 2) with electrofishing, gill netting, and fyke netting accounting for 1,741, 1,116, and 123 fish, respectively. Yellow perch and smallmouth bass comprised nearly 60% of the total catch (Table 2). Catch rates were 217.0 fish/hour for electrofishing, 29.3 fish/night for gill netting, and 7.7 fish/net night for fyke netting (Table 3).

In July, 48 sites were electrofished for a combined total of 28,980 seconds (8.05 hrs), 17 sites were gill netted and 16 sites were sampled with fyke nets. In all, 81 of 464 littoral sites were surveyed for 17.5% shoreline coverage. A total of 2,239 fish were collected during the littoral surveys (Table 4) with smallmouth bass and sculpin accounting for 62% of the total catch. Catch rates were 210.8 fish/hour for electrofishing, 26.4 fish/night for gill netting, and 5.8 fish/net night for fyke netting (Table 3).

Limnetic gill netting surveys. In October 2005, 64 limnetic sites were sampled with a combination of vertical and horizontal gill nets. Limnetic nets caught 433 fish during four nights. Vertical gill nets primarily caught whitefish (69.8%) and walleye (24.5%). The floating horizontal nets caught kokanee (37.5%) and whitefish (62.5%). The sinking horizontal nets accounted for 84% of the total catch, with the majority seen in yellow perch (43.1%), whitefish (22.0%), and walleye (15.7%) (Table 5). A total of 13 kokanee were captured during the limnetic survey representing 4 age classes (0-3). Total catch rates were 40.0 fish/net night for the sinking gill nets, 3.2 fish/net night for the floating gill nets and 1.06 fish/net night for vertical gill nets (Table 6).

In July 2006, 64 limnetic sites were sampled in the limnetic zone of Banks Lake. Limnetic nets caught a total of 238 fish, of which 71% were whitefish and 16% yellow perch. Kokanee comprised 4.6% of the total limnetic catch (Table 7). The sinking and mid-water horizontal nets had a catch rate of 12.9 and 11.5 fish/net night, while the floating and vertical gill nets had catch rates of 2.5 and 2.3 fish/net night, respectively (Table 6).

Table 1. The fish and zooplankton collected in Banks Lake from September 2005 to August 2006.

Fish	
Pomoxis nigromaculatus	Black Crappie
Lepomis macrochirus	Bluegill
Ictalurus spp.	Bullhead spp.
Catostomus columbianus	Bridgelip Sucker
Lota lota	Burbot
Cyprinus carpio	Carp
Cottus spp.	Sculpin
Oncorhynchus nerka	Kokanee
Micropterus salmoides	Largemouth Bass
Catostomus catostomus	Longnose Sucker
Catostomus macrocheilus	Largescale Sucker
Mylocheilus caurinus	Peamouth
Lepomis gibbosus	Pumpkinseed
Oncorhynchus mykiss	Rainbow Trout
Micropterus dolomieui	Smallmouth Bass
Tinca tinca	Tench
Stizostedion vitreum	Walleye
Coregonus clupeaformis	Lake Whitefish
Perca flavescens	Yellow Perch
Zooplankton	
Daphnia schodleri	Cladoceran
Daphnia galeata	Cladoceran
Daphnia retrocurva	Cladoceran
Bosmina longirostris	Cladoceran
Leptodiaptomus ashlandi	Copepod
Epischura nevadensis	Copepod
Diacyclops bicuspidatus thomasi	Copepod
Mesocyclops edax	Copepod
Leptodora kindti	Leptodora
Diaphanosoma	Cladoceran
Alona spp.	Cladoceran

Table 2. Number of fish collected, species composition, and the minimum and maximum lengths of fish captured in littoral gill nets, fyke nets and boat electrofishing surveys in October 2005 on Banks Lake, WA.

			Length (mm)	
Species	Number	Frequency	Minimum	Maximum
Black Crappie	41	0.014	56	397
Bluegill	3	0.001	34	59
Bullhead spp.	119	0.039	125	345
Bridgelip Sucker	0	0.000	-	-
Burbot	6	0.002	425	685
Carp	82	0.027	111	690
Cottid spp.	274	0.090	41	225
Kokanee	122	0.040	86	653
Largemouth Bass	194	0.064	40	470
Longnose Sucker	3	0.001	418	450
Largescale Sucker	4	0.001	418	520
Peamouth	3	0.001	116	358
Pumpkinseed	33	0.011	44	180
Rainbow Trout	32	0.011	115	526
Smallmouth Bass	608	0.201	44	537
Tench	3	0.001	256	333
Walleye	150	0.050	87	695
Whitefish spp.	185	0.061	190	560
Yellow Perch	1168	0.385	25	325
Total	3030	1.000	-	-

Table 3. Catch-per-unit of effort by species for all littoral gear types (boat electrofishing, fyke nets, and littoral gill nets) for October 2005 and July 2006 on Banks Lake, WA.

	Electrofishing Fish/hour		Fyke Nets Fish/net night		Littoral Gill Nets Fish/net night	
Species	Oct-05	Jul-06	Oct-05	Jul-06	Oct-05	Jul-05
Black Crappie	2.1	0.2	0.3	0.0	0.5	0.0
Bluegill	0.4	0.0	0.0	0.0	0.0	0.0
Bullhead spp.	6.5	4.7	1.8	1.2	1.0	1.1
Bridgelip Sucker	0.0	0.0	0.0	0.0	0.0	0.0
Burbot	0.0	0.1	0.0	0.0	0.2	0.0
Carp	5.4	6.0	0.1	0.0	1.0	0.0
Cottid spp.	33.9	62.0	0.1	0.0	0.0	0.0
Kokanee	2.5	0.0	0.1	0.1	2.7	0.1
Largemouth Bass	20.7	2.0	0.1	0.0	0.7	0.0
Longnose Sucker	0.0	0.1	0.0	0.0	0.1	0.0
Largescale Sucker	0.4	0.0	0.0	0.0	0.0	0.0
Peamouth	0.0	0.0	0.1	0.0	0.1	0.0
Pumpkinseed	3.4	6.6	0.1	0.1	0.1	0.1
Rainbow Trout	2.9	1.7	0.0	0.4	0.2	0.4
Smallmouth Bass	64.5	100.7	0.5	0.0	2.2	0.0
Tench	0.1	0.0	0.0	0.2	0.1	0.2
Walleye	5.4	3.9	0.0	4.3	2.8	4.1
Whitefish spp.	0.2	0.0	0.0	1.8	4.8	1.6
Yellow Perch	68.8	22.7	4.6	8.6	14.3	8.1
Total	217.0	210.8	7.7	16.6	30.7	15.6

Table 4. Number of fish collected, species composition, and the minimum and maximum lengths of fish captured in littoral gill nets, fyke nets and boat electrofishing surveys in July 2006, on Banks Lake, WA.

Species	Number	Frequency	Length (mm) Minimum	Maximum
Black Crappie	29	0.013	137	291
Bluegill	0	0.000	55	55
Bullhead spp.	53	0.024	120	355
Bridgelip Sucker	0	0.000	-	-
Burbot	2	0.001	456	456
Carp	93	0.042	269	695
Cottid spp.	484	0.216	42	143
Kokanee	0	0.000	-	-
Largemouth Bass	26	0.012	29	495
Longnose Sucker	4	0.002	431	431
Largescale Sucker	0	0.000	385	435
Peamouth	1	0.000	-	-
Pumpkinseed	69	0.031	50	178
Rainbow Trout	19	0.008	235	495
Smallmouth Bass	901	0.402	68	467
Tench	7	0.003	86	292
Walleye	111	0.050	51	501
Whitefish spp.	73	0.033	412	530
Yellow Perch	367	0.164	32	276
Total	2239	1.000	-	-

Table 5. Number of fish collected, species composition, and the minimum and maximum lengths of fish captured in limnetic gill nets in October 2005, on Banks Lake, WA.

			Length (mm)	
Species	Number	Frequency	Minimum	Maximum
Black Crappie	3	0.007	185	251
Bluegill	0	0.000	-	-
Bullhead spp.	3	0.007	240	322
Bridgelip Sucker	0	0.000	-	-
Burbot	4	0.009	493	685
Carp	10	0.023	362	587
Cottid spp.	0	0.000	-	-
Kokanee	13	0.030	-	-
Largemouth Bass	0	0.000	-	-
Longnose Sucker	1	0.002	418	418
Largescale Sucker	0	0.000	-	-
Peamouth	0	0.000	-	-
Pumpkinseed	0	0.000	-	-
Rainbow Trout	5	0.012	368	526
Smallmouth Bass	38	0.088	153	416
Tench	0	0.000	179	685
Walleye	70	0.162	190	543
Whitefish spp.	127	0.293	85	309
Yellow Perch	159	0.367	133	501
Total	433	1.000	-	-

Table 6. Catch-per-unit of effort by species for all limnetic gill nets for October 2005 and July 2006 on Banks Lake, WA.

	Floating Horizontzal Fish/net night		Sinking Horizontal Fish/net night		Vertical Fish/net night		Midwater Horizontal Fish.net night
Species	Oct-05	Jul-06	Oct-05	Jul-06	Oct-05	Jul-06	Jul-06
Black Crappie	0.00	0.00	0.33	0.00	0.00	0.00	0.00
Bluegill	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bullhead spp.	0.00	0.00	0.33	0.00	0.00	0.00	0.00
Bridgelip Sucker	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burbot	0.00	0.00	0.33	0.00	0.02	0.00	0.50
Carp	0.00	0.00	1.11	0.08	0.00	0.00	0.00
Cottid spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kokanee	1.20	0.00	0.78	0.20	0.00	0.14	0.00
Largemouth Bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Longnose Sucker	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Largescale Sucker	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peamouth	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pumpkinseed	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rainbow Trout	0.00	0.00	0.56	0.00	0.00	0.00	0.00
Smallmouth Bass	0.00	0.00	4.22	0.00	0.00	0.00	0.00
Tench	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Walleye	0.00	0.00	6.33	0.28	0.26	0.00	0.00
Whitefish spp.	2.00	0.60	8.89	1.10	0.74	12.71	11.00
Yellow Perch	0.00	1.40	17.44	0.64	0.04	0.00	0.00
Total	3.20	2.00	40.44	2.30	1.06	12.90	11.5

Table 7. Number of fish collected, species composition, and the minimum and maximum lengths of fish captured in all limnetic gill nets in July 2006, on Banks Lake, WA.

			Length (mm)	
Species	Number	Frequency	Minimum	Maximum
Black Crappie	0	0.000	-	-
Bluegill	0	0.000	-	-
Bullhead spp.	0	0.000	-	-
Bridgelip Sucker	0	0.000	-	-
Burbot	1	0.004	663	663
Carp	4	0.017	433	505
Cottid spp.	0	0.000	-	-
Kokanee	11	0.046	187	290
Largemouth Bass	0	0.000	-	-
Longnose Sucker	0	0.000	-	-
Largescale Sucker	0	0.000	-	-
Peamouth	0	0.000	-	-
Pumpkinseed	0	0.000	-	-
Rainbow Trout	0	0.000	-	-
Smallmouth Bass	0	0.000	-	-
Tench	0	0.000	-	-
Walleye	14	0.059	260	589
Whitefish spp.	169	0.710	95	727
Yellow Perch	39	0.164	211	358
Total	238	1.000	-	-

Fish Ages, Condition Indices and Diets. Otoliths and scales were collected and stomach contents were taken from fish during three sample periods as shown in Tables 8 and 9. Otoliths and scales were analyzed by WDFW to estimate fish ages. Average lengths at each age were reported for all gamefish collected in the fall from 2002 through 2005 (Table 10). Mean lengths were applied to length-weight regressions (Table 11) to determine weights and were also used to estimate mean annual growth in bioenergetics modeling.

Relative Weight (W_r) was used to compare species-specific condition to the national average (75th percentile). In Banks Lake, most gamefish were generally near or below the national average as juveniles and below as adults. Burbot, rainbow trout, smallmouth bass and, walleye were typically below the national average at most lengths, while black crappie and largemouth bass were generally above the national average (Figure 5). Condition factors (k) were also used to determine the overall state of fish populations in Banks Lake. Largemouth bass had the highest mean condition factors (1.382 ± 0.026 2 SE), followed by smallmouth bass (1.295 ± 0.011 2 SE), and black crappie (1.233 ± 0.001 2 SE), while burbot (0.591 ± 0.010 2 SE) and walleye (0.887 ± 0.010 2 SE) had the lowest mean condition factors (Table 11).

Hydroacoustic Density and Distribution. Sixteen transects were surveyed on July 20, 2006 to determine limnetic fish density and distribution. Lake-wide mean fish density was 31.7 (± 10.3; 2 SE) fish per 10,000 m^3. The mean density of fish from the vertical transducer (8 m – lake bottom) (61.5 ± 20.5; 2 SE) was significantly higher than the mean density from the horizontal transducer (2.0 ± 0.6; 2 SE) (t-test, df=15, p=0.011). Based on fish density from 8 m to the bottom, lake-wide distribution was significantly different (r^2=0.78; df=15; p=0.011), with higher densities in the middle of the lake (transects 5-8) (Figure 6). There was no significant difference when comparing distribution for fish targets detected from the surface to 8 m (r^2=0.02; df = 15; p=0.60).

Vertical distribution varied by depth, with the majority of targets deeper than 8 m, and the highest number detected between 8-16 m (Figure 7). Few fish were detected deeper than 30 m. Due to the high variance, no patterns were detected when evaluating distribution across all depth bins.

Limnetic Fish Abundance. Hydroacoustic density estimates were expanded to total lake volume resulting in a lake-wide abundance estimate of 585,544 (± 118,277; 2SE) fish with target strengths between –55 and –28 dB (~30-800 mm total length). Abundance estimates for fish less than 100 mm was not possible due to their near absence in the gill netting survey (2 lake whitefish < 100 mm), even though they comprised 30.1% of the limnetic acoustic targets. Therefore, we had to estimate species-specific abundance without the smallest size classes represented. We used two methods to estimate abundance of limnetic fish in Banks Lake. First, we applied the relative abundance from netting (Table 7) to the acoustic estimate (for fish greater than 100 mm) to approximate abundance. Using target tracking, we estimated 279,715 (± 56,501; 2 SE) lake whitefish, 74,210 (± 14,990; 2 SE) yellow perch, and 20,931 (± 4,228; 2 SE) kokanee. Second, we applied the abundance estimates for targets between 200 and 400 mm to the relative abundance of each species captured in gill nets in the same size range in an attempt to better estimate kokanee abundance. This method yielded an estimate of 19,518 (± 2,704; 2 SE) kokanee, similar to the first method (Table 12). Total catch was insufficient to estimate abundance for rainbow trout.

Table 8. Number of diet samples collected by species for the Fall 2005, Winter 2005, and Summer 2006 surveys at Banks Lake, WA.

Species	Fall 2005	Winter 2006	Summer 2006
Black Crappie	18	26	8
Burbot	2	18	2
Kokanee	6	0	10
Largemouth Bass	23	14	9
Rainbow Trout	16	13	13
Smallmouth Bass	34	4	106
Walleye	47	8	55
Whitefish spp.	16	36	41
Yellow Perch	41	29	54
Total	203	148	298

Table 9. Number of scale and otolith samples collected by species for the Fall 2005, Winter 2006, and Summer 2006 surveys at Banks Lake, WA.

	Fall 2005		Winter 2006		Summer 2006	
Species	Otolith	Scale	Otolith	Scale	Otolith	Scale
Black Crappie	26	25	2	2	9	0
Bluegill	0	0	0	0	0	0
Bullhead spp.	0	0	0	0	0	0
Bridgelip Sucker	0	0	0	0	0	0
Burbot	10	0	13	0	3	0
Carp	0	0	0	0	0	0
Cottid spp.	0	0	0	0	0	0
Kokanee	107	4	0	0	11	11
Largemouth Bass	48	59	0	2	1	0
Longnose Sucker	0	0	0	0	0	0
Largescale Sucker	0	0	0	0	0	0
Peamouth	0	0	0	0	0	0
Pumpkinseed	0	0	0	0	0	0
Rainbow Trout	25	24	0	11	19	18
Smallmouth Bass	124	162	2	2	3	2
Tench	0	0	0	0	0	0
Walleye	189	132	3	11	13	14
Whitefish spp.	94	89	0	0	2	0
Yellow Perch	107	114	0	0	0	0
Total	730	609	20	28	61	45

Table 10. Mean total length (± 2 standard errors in parentheses) of gamefish in Banks Lake, WA from 2002 through 2005. All fish were aged from scales and otoliths collected in October of each year. Species codes are as follows: BC (black crappie), BUR (burbot), KOK (kokanee), LMB (largemouth bass), RBT (rainbow trout), SMB (smallmouth bass), WE (walleye), WTF (whitefish), and YP (yellow perch).

Age	BC	BUR	KOK	LMB	RBT	SMB	WE	WTF	YP
0	81 (3)	--	128 (9)	106 (7)	128 (9)	90 (7)	203 (4)	215 (9)	94 (6)
1	157 (5)	--	330 (31)	209 (7)	353 (21)	152 (5)	323 (4)	366 (7)	158 (4)
2	233 (9)	425 (--)	415 (5)	288 (12)	427 (18)	240 (6)	429 (6)	407 (16)	222 (4)
3	336 (121)	464 (30)	414 (8)	384 (22)	488 (17)	295 (5)	482 (9)	454 (10)	278 (5)
4	313 (17)	481 (63)	450 (27)	396 (15)	507 (--)	348 (7)	514 (16)	476 (17)	300 (13)
5	316 (10)	559 (--)	--	397 (22)	492 (53)	367 (8)	564 (20)	481 (14)	311 (14)
6	--	570 (--)	--	444 (7)	--	403 (7)	580 (37)	480 (18)	318 (26)
7	329 (12)	568 (16)	--	424 (25)	--	410 (13)	602 (33)	480 (17)	--
8	--	645 (55)	--	438 (--)	--	433 (16)	606 (14)	493 (14)	--
9	--	628 (25)	--	442 (39)	--	438 (15)	720 (--)	496 (19)	--
10	--	613 (60)	--	537 (--)	--	447 (15)	--	521 (15)	--
11	--	--	--		--	435 (16)	809 (--)	503 (14)	--
12	--	--	--		--	467 (35)	770 (--)	506 (13)	--
13	--	--	--	470 (--)	--	438 (57)	781 (--)	504 (37)	--
14	--	--	--	--	--	--	--	560 (--)	--
15	--	--	--	--	--	464 (--)	--	526 (14)	--
16	--	--	--	--	--	--	--	525 (26)	--
17	--	--	--	--	--	--	--	508 (11)	--
18	--	--	--	--	--	--	--	521 (11)	--
19	--	--	--	--	--	--	--	504 (28)	--
20	--	--	--	--	--	--	--	505 (--)	--
21	--	--	--	--	--	--	--	530 (--)	--
22	--	--	--	--	--	--	--	519 (33)	--

Table 11. Equation for a line (including the r-squared value) representing the length and weight relationship for specific fish species. Mean condition factors (± 2 standard errors (SE)) were calculated for each species from the fall 2002 through 2005. Sample size is represented by n and only fish that were aged were used to calculate the parameters below.

Species	n	Length-Weight Regression	r-squared	Condition Factor (k)	Condition Factor (2 SE)
BC	153	y = 3.3497x - 5.6098	0.986	1.433	0.053
BUR	28	y = 2.7876x - 4.6469	0.912	0.591	0.028
KOK	1,078	y = 3.0760x – 5.2201	0.946	0.962	0.010
LMB	186	y = 3.1111x - 5.1142	0.990	1.387	0.046
RBT	118	y = 2.8225x - 4.5188	0.950	1.059	0.024
SMB	606	y = 3.0666x - 5.0556	0.992	1.283	0.013
WE	843	y = 3.1145x - 5.3433	0.966	0.916	0.028
WTF	431	y = 2.9944x - 4.9947	0.981	0.987	0.012
YP	451	y = 3.1901x - 5.3570	0.983	1.198	0.023

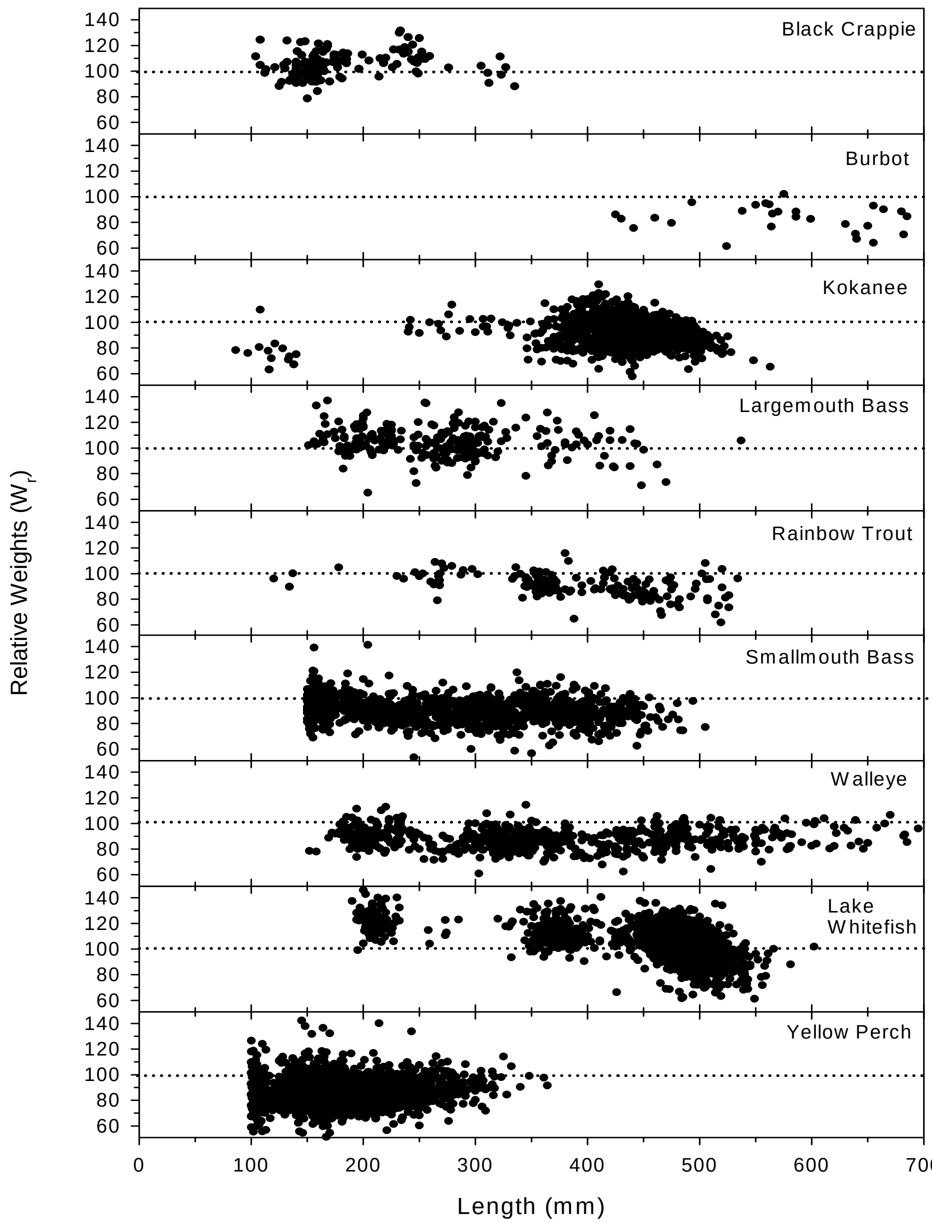

Figure 5. The relative weights for gamefish in Banks Lake, WA from the fall 2002-2005.

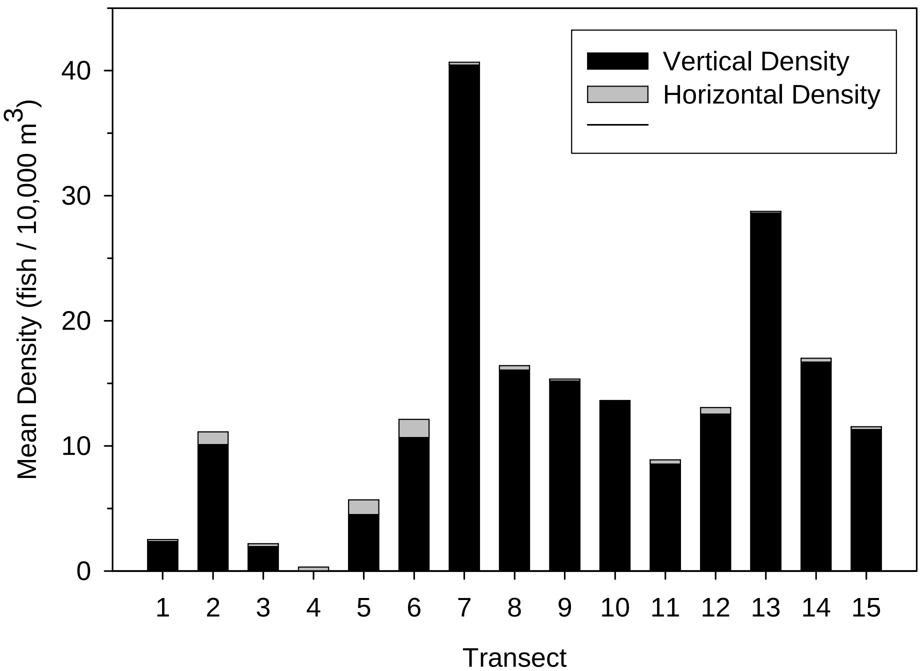

Figure 6. Density of target tracked fish from a hydroacoustic survey of Banks Lake, WA in July of 2006. The horizontal transducer observed fish between the surface and 8 m depth, whereas the vertical transducer observed fish from 8m to the bottom of the lake. Transect 1 began at the north end while transect 15 ended at the south end of the lake.

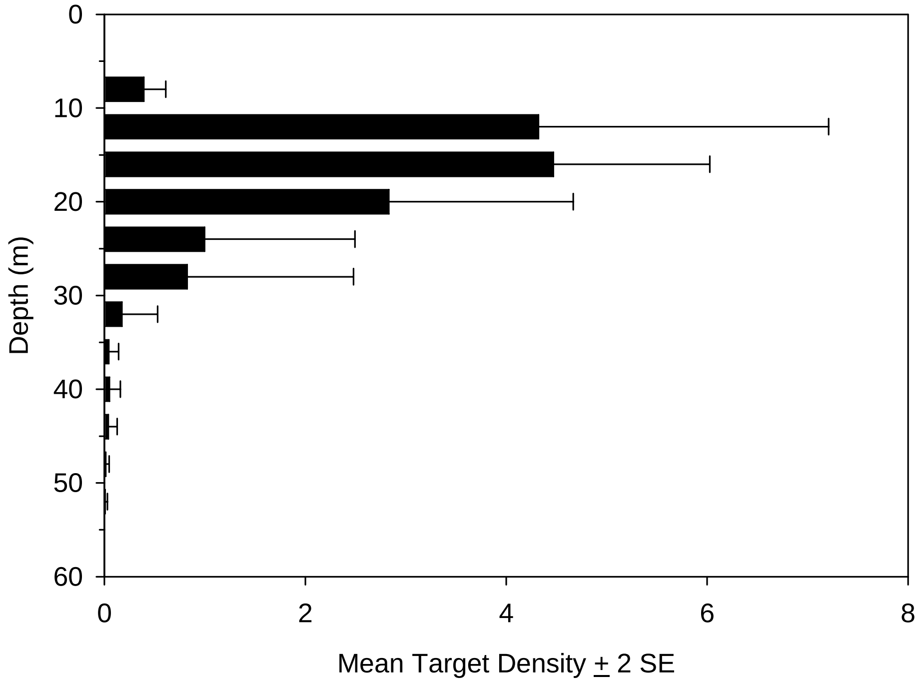

Figure 7. The vertical fish density of acoustically detected targets from the vertical transducer (from 8 m to the lake bottom) on Banks Lake, WA, July 2006.

Table 12. Abundance estimates (± 2SE) for various size classes of acoustic targets and abundance estimates of kokanee based on lengths in Banks Lake, WA, in July 2006.

	Size Class (mm)				
	30-800	30-100	100-200	200-400	400-800
% Target Frequency	100%	30.1%	39.4%	29.4%	1.0%
Abundance	585,544	176,438	230,947	172,421	5,738
2 SE	118,277	35,640	46,650	34,828	1,159
Fish / hectare	53.6	16.2	21.1	15.8	0.5

	Kokanee
Size Class (mm)	200-400
Abundance of Acoustic Targets	172,421
% of kokanee	11.1
# of kokanee captured	11
Abundance	19,158
2 SE	2,704
Fish / ha	1.8

4.3 Fish Diet Collections and Analysis

Stomach samples from Fall 2005 and summer 2006 have been analyzed (Table 13). Diet proportions will be used in bioenergetics modeling and results will be reported in the FY2007 annual report. The diets of juvenile fishes in Banks Lake contained primarily zooplankton and insects. Insects dominated the diet of rainbow trout, while whitefish consumed *Daphnia spp.* more frequently than any other prey type. The diet of adult smallmouth bass contained primarily cottids and insects. From previous years, adult walleye diets were comprised of 86%, 95%, and 100% prey fish in the spring, summer, and fall, respectively. The dominant prey fish in the diets of walleye were cottids in the summer and yellow perch in the fall (Table 14). Acute predation occurred during the kokanee-stocking events at Northrup Creek. Walleye were the primary predator with nearly 100% containing kokanee in their diets; however, both smallmouth and largemouth bass also consumed kokanee during the fall stocking event. Bioenergetics modeling will allow for the high number of kokanee in the walleye's diet in the fall, but low walleye catch rates limited our ability collect an adequate sample size of walleye diets to sample prior to and following kokanee stocking to determine acute losses due to piscivory (Baldwin et al. 2003).

4.4 Fish Tagging, Marking and Stocking

A total of 767 walleye were tagged dorsally using numbered Floy® anchor tags. The size of walleye caught ranged from 404 mm to 785 mm. Two walleye retained anchor tags from previous years tagging events. One tagged walleye was recaptured during the one day recapture event. Tagged walleye recapture proportions were reported from anglers for several months following the tagging event. This information will be used to estimate an abundance of walleye in Banks Lake and reported in the final report.

In FY2006, 1,589,120 kokanee and 240,199 rainbow trout were stocked into Banks Lake. All hatchery kokanee and summer released rainbow trout fry were otolith marked Net pen rearing accounted for 127,209 (8.0%) of the total for kokanee, and 179,386 (75%) of the total for rainbow trout stocked into the lake.

In the Fall 2005, otoliths were collected from 804 adult kokanee and these fish were also inspected for fin clips. Age-2 and age-3 kokanee comprised 46% and 53% of the sample, respectively. Kokanee from brood years 2003 (age-2) were examined for otolith marks. A total of 249 age-2 kokanee possessed otolith marks. Analysis indicated that although 53% of the hatchery kokanee released in Banks Lake were from the spring fry release group, only 33% of the 2-yr old adult hatchery kokanee sampled came from this release. In comparison, 36% and 11% of the releases in 2003 were fall fingerling and net pen yearling releases, respectively, but 47% of the sample represented the fall fingerling release, and 21% represented the net pen yearling release (Table 15). A chi-square analysis was conducted to test the null hypothesis that no difference existed between the proportion of each release group and the proportion of the recaptures. A significant difference was calculated ($\chi^2 = 51.428$; df = 2; P<0.001), thus rejecting the null hypothesis. We also used chi-square analysis with the Yates correction for continuity to compare fall fingerling to net pen yearling releases. Again, a significant difference existed between expected and observed values ($\chi^2 = 29.926$; df = 1; P<0.001), therefore, rejecting the null hypothesis.

Hatchery kokanee consisted of 73% of the sample indicating that the remaining 27% of age-2's were from wild production.

Deleted:

Table 13. Number of stomach samples analyzed by species for the Spring, Summer and Fall 2005, and Winter and Summer, 2006 surveys at Banks Lake, WA.

Species	Fall 2005	Winter 2005/06	Summer 2006	Total
Black Crappie	18	23	15	56
Burbot	1	11	2	14
Kokanee	2	0	2	4
Largemouth Bass	23	1	15	39
Rainbow Trout	15	0	9	24
Smallmouth Bass	29	2	42	73
Walleye	46	0	52	98
Whitefish	15	7	25	47
Yellow Perch	34	17	43	94
Total	183	61	205	449

Table 14. Proportion of prey items found in the diets of black crappie (BC), burbot (BUR), kokanee (KOK), largemouth bass (LMB), rainbow trout (RBT), smallmouth bass (SMB), walleye (WAL), whitefish (WTF), and yellow perch (YP), in the fall 2005 and winter and summer 2006 on Banks Lake, WA. The zooplankton prey category includes all zooplankton except *Daphnia* spp. The osteicthyes prey category includes all prey fish that were unidentifiable. No kokanee diets were collected in the winter (np).

		Predator								
	Prey Category	BC	BUR	KOK	LMB	RBT	SMB	WAL	WTF	YP
Fall 2005	Daphnia	0.207	0.000	0.000	0.000	0.485	0.000	0.000	0.919	0.113
	Zooplankton	0.027	0.146	0.000	0.000	0.067	0.000	0.000	0.078	0.032
	Insect	0.004	0.000	1.000	0.006	0.444	0.002	0.000	0.002	0.026
	Snail	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.009
	Clam	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Crayfish	0.000	0.000	0.000	0.371	0.000	0.121	0.000	0.000	0.247
	Segmented Worm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Cottidae	0.000	0.000	0.000	0.003	0.000	0.051	0.003	0.000	0.084
	Catastomidae	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Cyprinidae	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Centrarchidae	0.000	0.000	0.000	0.023	0.000	0.000	0.019	0.000	0.000
	Gadidae	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Percidae	0.528	0.854	0.000	0.494	0.000	0.076	0.148	0.000	0.316
	Salmonidae	0.234	0.000	0.000	0.100	0.000	0.750	0.827	0.000	0.166
	Ictaluridae	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
	Osteicthyes	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.006
	Other	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000
Winter 2005/06	Daphnia	0.444	0.000	nd	0.000	0.926	0.000	0.000	0.993	0.835
	Zooplankton	0.045	0.000	nd	0.000	0.074	0.000	0.000	0.007	0.159
	Insect	0.000	0.000	nd	1.000	0.000	0.000	0.000	0.000	0.006
	Snail	0.000	0.000	nd	0.000	0.000	0.000	0.000	0.000	0.000
	Clam	0.000	0.000	nd	0.000	0.000	0.000	0.000	0.000	0.000
	Crayfish	0.000	0.000	nd	0.000	0.000	0.000	0.000	0.000	0.000
	Segmented Worm	0.000	0.000	nd	0.000	0.000	0.000	0.000	0.000	0.000
	Cottidae	0.000	0.000	nd	0.000	0.000	0.000	0.000	0.000	0.000
	Catastomidae	0.000	0.000	nd	0.000	0.000	0.000	0.000	0.000	0.000
	Cyprinidae	0.000	0.000	nd	0.000	0.000	0.000	0.000	0.000	0.000
	Centrarchidae	0.000	0.000	nd	0.000	0.000	0.000	0.000	0.000	0.000
	Gadidae	0.000	0.000	nd	0.000	0.000	0.000	0.000	0.000	0.000
	Percidae	0.000	0.000	nd	0.000	0.000	1.000	0.000	0.000	0.000
	Salmonidae	0.511	1.000	nd	0.000	0.000	0.000	1.000	0.000	0.000
	Ictaluridae	0.000	0.000	nd	0.000	0.000	0.000	0.000	0.000	0.000
	Osteicthyes	0.000	0.000	nd	0.000	0.000	0.000	0.000	0.000	0.000
	Other	0.000	0.000	nd	0.000	0.000	0.000	0.000	0.000	0.000
Summer 2006	Daphnia	0.000	0.000	1.000	0.000	0.829	0.000	0.000	0.893	0.014
	Zooplankton	0.000	0.211	0.000	0.000	0.125	0.000	0.000	0.007	0.005
	Insect	0.000	0.000	0.000	0.000	0.033	0.012	0.000	0.003	0.000

Table 14 cont.

Snail	0.000	0.789	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Clam	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Crayfish	0.000	0.000	0.000	0.432	0.000	0.311	0.000	0.000	0.129
Segmented Worm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cottidae	0.000	0.000	0.000	0.001	0.000	0.210	0.041	0.097	0.014
Catastomidae	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cyprinidae	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Centrarchidae	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000
Gadidae	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Percidae	1.000	0.000	0.000	0.149	0.013	0.278	0.328	0.000	0.838
Salmonidae	0.000	0.000	0.000	0.418	0.000	0.188	0.629	0.000	0.000
Ictaluridae	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Osteicthyes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000

Table 15. The number and percent of juvenile kokanee stocked in 2003 and recaptured as adults in 2005.

Age-2 and thermal marked	Spring fry	Fall fingerlings	Net pen yearlings	Total
Number of kokanee released in 2003	627,275	419,898	127,771	1,174,944
Percent of kokanee released in 2003	0.53	0.36	0.11	1.00
Number of kokanee recaptured in 2005	81	116	52	249
Percent of kokanee recaptured in 2005	0.33	0.47	0.21	1.00

4.5 Creel Survey

Steamboat Rock State Park (31%), Northrup Launch (14%), Coulee Playland (13%), and Coulee City Park (13%) were used more frequently by boat anglers than the other creel stations from September 2005 through August 2006 (Figure 8). Shore anglers used the Coulee City Park 79% of the time, and almost never used Sun Banks Resort, Osborne Bay, Jones Bay or Steamboat Rock State Park. Annual effort (September 2005 to August 2006) was 1,881 (± 141 SD) hours for boat anglers and 1,766 (± 62 SD) for shore anglers. Weekday angling accounted for 53% of the total angling pressure. Yellow perch, smallmouth bass, walleye, and rainbow trout angling accounted for 30%, 24%, 10%, and 10% of the total pressure, respectively. Angling pressure was highest in September and lowest in December (Figure 9). During the winter months, both boat and shore anglers primarily targeted rainbow trout and yellow perch. Boat anglers shifted efforts to smallmouth bass and walleye during the spring and summer months. Boat and shore anglers continued to target rainbow trout throughout the year (Figure 10).

A total of 1,390 parties were interviewed for catch data. Boat and shore anglers caught one or more fish 66% and 8% of the time, respectively. Anglers indicated that they caught a total of 259 rainbow trout, 2,023 smallmouth bass, 317 walleye, 12,655 yellow perch, and 3 kokanee. The total CPUE was 1.91 (± 0.2.16 SD) for rainbow trout, 1.21 (± 1.35 SD) for smallmouth bass, 0.30 (± 0.48 SD) for walleye, and 3.06 (± 4.36 SD) for yellow perch (Table 16). Smallmouth bass anglers released a majority of caught fish (72%), resulting in harvest rates that were a minimum of five times less than catch rates. Rainbow, walleye, and yellow perch anglers released 33%, 47%, and 69% of the fish they caught, respectively. An estimated 4,065 (± 301 SD) rainbow trout, 19,468 (± 301 SD) smallmouth bass, 8,314 (± 124 SD) walleye, 43,719 (± 1,508 SD) yellow perch, and 1,445 (na) kokanee were harvested (Table 17), while an estimated 30,291 (± 1597 SD) rainbow trout, 64,152 (± 700 SD) smallmouth bass, 11,560 (± 131 SD) walleye, 26,959 (1,204 SD) yellow perch, and 86 (9) kokanee were caught from Banks Lake from September 2005 through August 2006 (Table 18). Anglers who targeted smallmouth bass were the most satisfied with the fishery, while kokanee anglers were the least satisfied (Table 19).

Aerial creel flights in May, June, July, and August 2003 through 2005 indicated that a combined average of 44% of the boats on Banks Lake were associated with fishing activities (Table 20). We estimated the value of the Banks Lake fishery to determine the economic benefit to the local economy. We determined that the average dollar amount spent per angler trip was $34.20, which yields a total economic value of the Banks Lake fishery from September 2005 through August 2006 of $2,208,265. This total does not include non-fishing trips and fishing trips for angling tournaments.

4.6 Entrainment

Entrainment nets were fished for 2,783 hours from March 21 through October 21, 2005. Two nets were fished in the east canal (1,949 hours) and one in the west canal (834 hours). We sampled over 3.7 million cubic meters of water during the study period, approximately 1.6% of the total combined discharge from both canals. Nets collected a total of 1,923 fish, with the highest catch during June (Figure 11). Overall fish density was 6.2 fish per 10,000 m^3. We estimated that 58,708 fish passed the sample site during the study period in 2005.

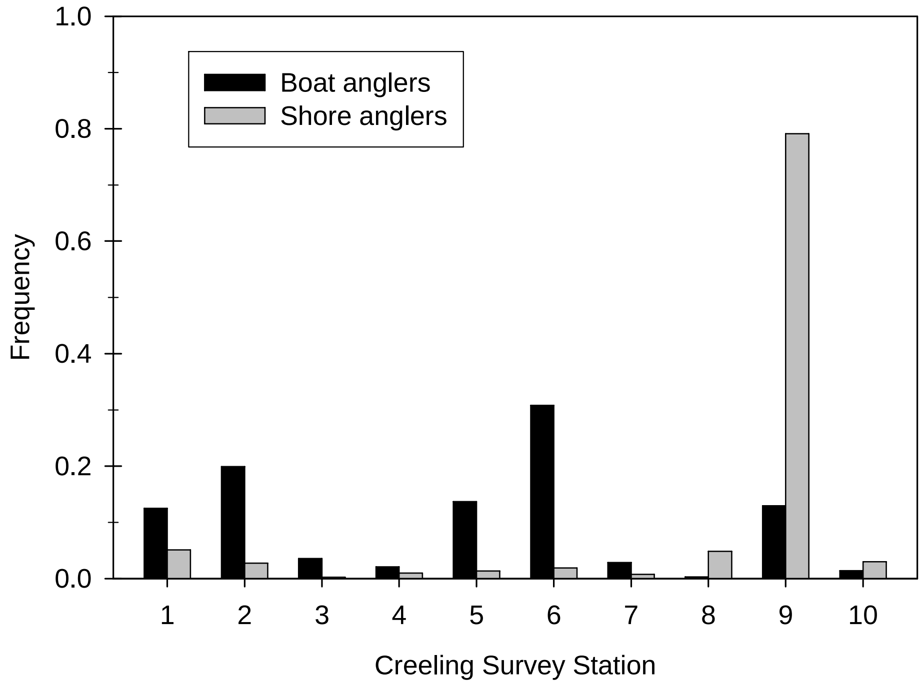

Figure 8. The frequency of site use by boat and shore anglers on Banks Lake, Washington from September 2005 through August 2006. Access site numbers correspond to site names as follows: 1) Coulee Playland, 2) Sun Banks Resort, 3) Osborn Bay, 4) Jones Bay, 5) Northrup, 6) Steamboat Rock State Park, 7) Paynes Gulch, 8) the Pass, 9) Coulee City Park, and 10) Dry Falls. *Jones Bay (4) was closed for fishing access until May 2006.

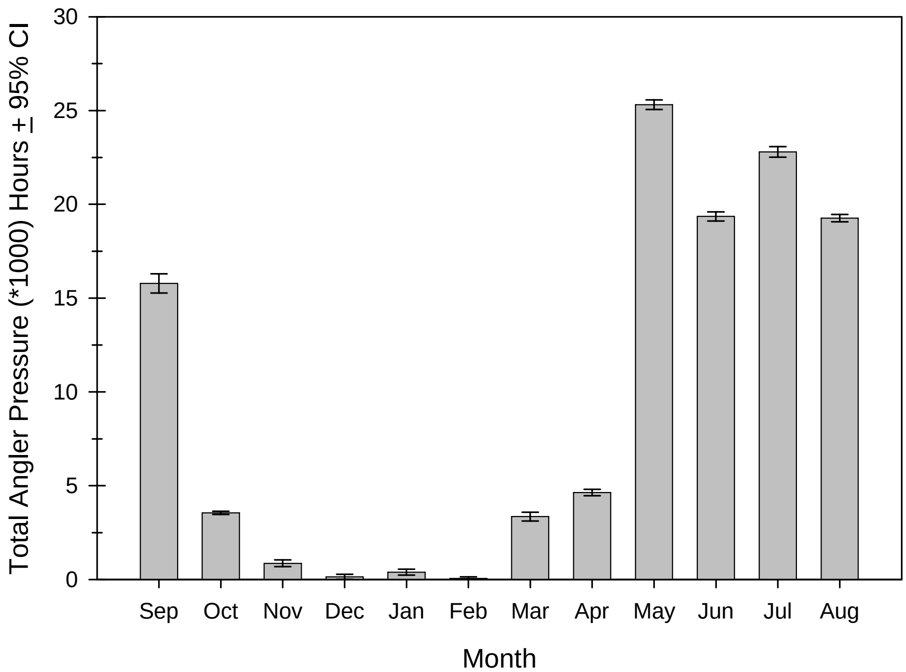

Figure 9. The monthly estimated angling pressure (± 95 confidence intervals) on Banks Lake, Washington from September 2005 through August 2006. The monthly pressure estimates include both boat and shore anglers combined.

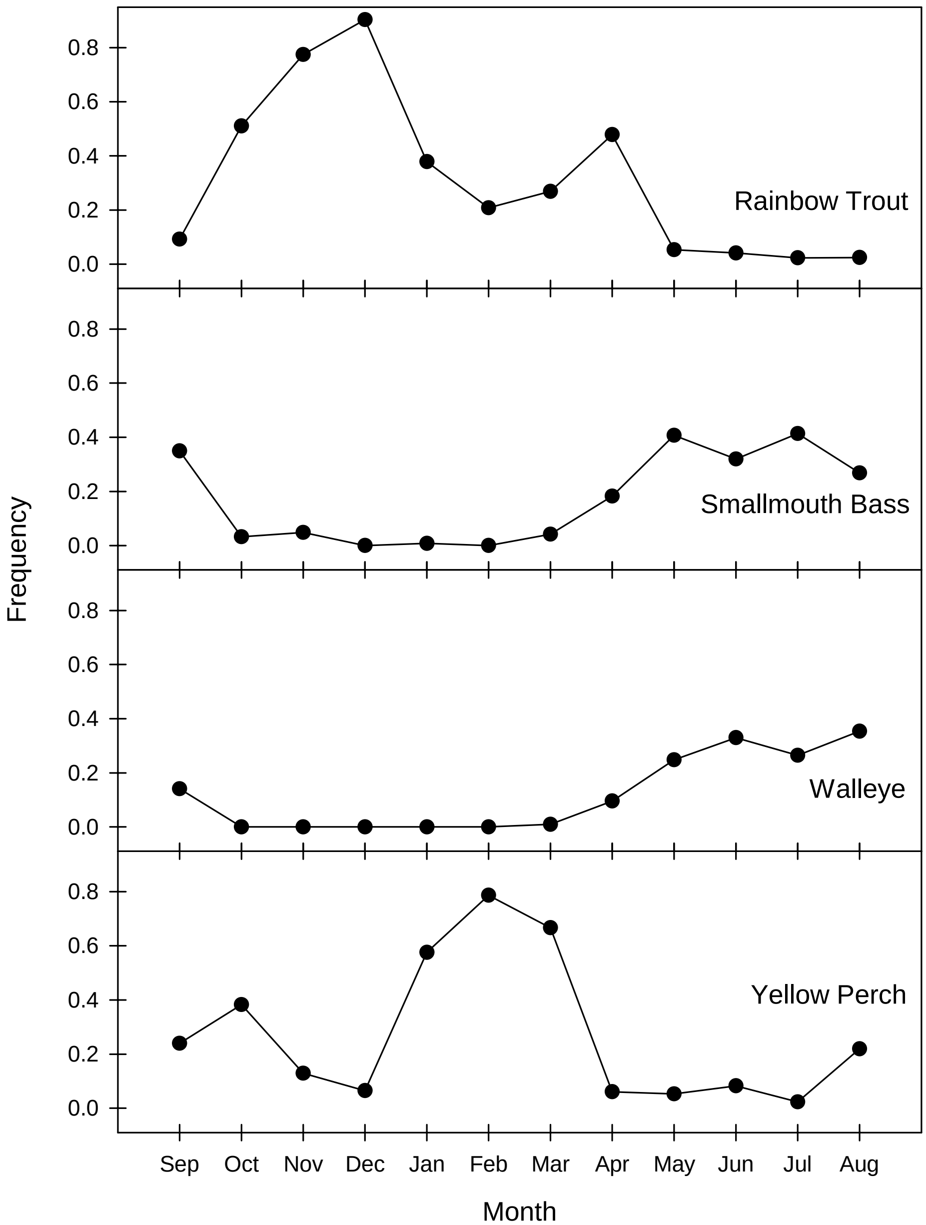

Figure 10. The relative proportion of anglers who indicated they were targeting rainbow trout, smallmouth bass, walleye, and yellow perch from September 2005 through August 2006 on Banks Lake, Washington.

Table 16. Monthly catch and release totals, catch and harvest per unit effort (± 1 standard deviation (SD)), and mean size of the most abundant fish species reported during angler interviews from September 2005 through August 2006 on Banks Lake, Washington. Harvest rates were calculated from completed trips only. Fish species codes are as follows: rainbow trout (RBT), smallmouth bass (SMB), walleye (WAL) and yellow perch (YP). All data is summarized from angler interviews.

Month	Species	Total # Caught	Total # Released	CPUE ± 1SD (fish/hr)	HPUE ± 1SD (fish/hr)	Mean Size (mm) ± 1SD
September	RBT	13	2	1.42 ± 1.15	0.63 ± 1.17	503 ± 51
	SMB	860	677	1.42 ± 1.49	0.32 ± 1.07	290 ± 53
	WAL	30	10	0.46 ± 0.81	0.25 ± 0.38	474 ± 30
	YP	1,093	447	2.85 ± 3.98	1.62 ± 2.28	257 ± 40
October	RBT	54	2	1.54 ± 1.92	0.23 ± 0.41	465 ± 97
	SMB	17	7	0.43 ± 0.50	0.18 ± 0..16	357 ± 59
	WAL	0	0	--	--	--
	YP	836	178	5.53 ± 5.43	4.28 ± 3.90	240 ± 31
November	RBT	43	14	2.10 ± 2.34	0.15 ± 0.27	500 ± 47
	SMB	50	50	2.20 ± --	1.06 ± --	--
	WAL	0	0	--	--	--
	YP	167	40	3.66 ± 3.58	2.77 ± 2.61	244 ± 34
December	RBT	10	4	2.16 ± 2.08	0.06 ± 0.16	511 ± 37
	SMB	0	0	--	--	--
	WAL	0	0	--	--	--
	YP	104	0	2.39 ± 2.24	2.39 ± 2.24	245 ± 8
January	RBT	50	9	2.84 ± 3.06	0.41 ± 2.16	522 ± 41
	SMB	0	0	--	--	--
	WAL	0	0	--	--	--
	YP	2120	59	8.96 ± 17.36	8.56 ± 17.21	244 ± 14
February	RBT	194	40	3.10 ± 4.65	1.12 ± 4.55	241 ± 14
	SMB	0	0	--	--	--
	WAL	0	0	--	--	--
	YP	4885	794	10.5 ± 10.94	8.62 ± 9.81	--
March	RBT	94	28	2.03 ± 2.08	0.27 ± 0.75	482 ± 72
	SMB	49	49	0.89 ± 0.18	0.98 ± 0.00	--
	WAL	6	0	0.24 ± 0.34	0.24 ± 0.34	534 ± 42
	YP	2689	504	5.58 ± 8.35	4.49 ± 6.69	240 ± 28
April	RBT	31	8	2.87 ± 5.82	0.12 ± 0.28	459 ± 56
	SMB	136	115	0.96 ± 1.27	0.12 ± 0.56	335 ± 30
	WAL	1	0	0.04± 0.10	0.04 ± 0.10	446 ± na
	YP	15	4	0.15 ± 0.21	0.05 ± 0.11	276 ± 31

Month	Species	Total # Caught	Total # Released	CPUE ± 1SD (fish/hr)	HPUE± 1SD (fish/hr)	Mean Size (mm) ± 1SD
May	RBT	36	36	3.53 ± --	4.00 ± --	--
	SMB	470	340	1.94 ± 2.42	0.54 ± 1.02	335 ± 30
	WAL	57	23	0.37 ± 0.41	0.22 ± 0.35	481 ± 62
	YP	106	37	1.35 ± 2.79	0.44 ± 1.07	291 ± 24
June	RBT	16	9	0.53 ± 0.52	0.09 ± 0.12	367 ± 91
	SMB	253	199	0.90 ± 1.00	0.18 ± 0.32	337 ± 42
	WAL	88	13	0.24 ± 0.28	0.22 ± 0.28	481 ± 59
	YP	164	42	0.81 ± 0.84	0.66 ± 0.90	285 ± 26
July	RBT	1	0	0.58 ± 0.42	0.05 ± 0.09	412 ± na
	SMB	216	169	0.63 ± 0.86	0.15 ± 0.26	345 ± 52
	WAL	33	11	0.24 ± 0.28	0.22 ± 0.28	478 ± 60
	YP	36	8	0.33 ± 0.39	0.25 ± 0.41	255 ± 49
August	RBT	13	0	2.47 ± 4.06	0.47 ± 1.00	345 ± 128
	SMB	310	102	1.27 ± 2.29	0.96 ± 2.30	322 ± 41
	WAL	10	0	0.42 ± 1.02	0..42 ± 1.02	488 ± 48
	YP	293	21	2.05 ± 2.76	1.79 ± 2.85	289 ± 33
Totals	RBT	542	150	1.91 ± 2.16	0.47 ± 2.78	461 ± 70
	SMB	2,369	1,708	1.21± 1.35	0.28 ± 0.64	291 ± 57
	WAL	195	47	0.30 ± 0.48	0.23 ± 0.40	483 ± 59
	YP	12,508	2,134	3.06 ± 4.36	2.48 ± 3.66	259 ± 32

Table 17. Monthly harvest estimates (± 1SD) for kokanee, rainbow trout, smallmouth bass, walleye and yellow perch from Banks Lake, Washington, September 2005 through August 2006.

Month	Kokanee	Rainbow Trout	Smallmouth Bass	Walleye	Yellow Perch
September	13 ± na	2,064 ± 29	3,453 ± 91	0	9,004 ± 86
October	0	538 ± 17	0	0	8,839 ± 402
November	0	87 ± 15	0	0	269 ± na
December	0	6 ± 8	0	0	6 ± na
January	0	103 ± 32	0	0	2,568 ± 278
February	0	31 ± 110	0	0	811 ± 223
March	0	114 ± 33	0	96 ± 13	3,076 ± 157
April	69 ± na	447 ± 16	284 ± 38	130 ± 2	0
May	0	256 ± 40	5,994 ± 83	2,493 ± 31	1,272 ± 43
June	0	77 ± 1	1,293 ± 25	2,253 ± 27	291 ± 41
July	0	0	2,200 ± 18	1,100 ± 14	719 ± 10
August	0	342 ± na	6,243 ± 46	2,242 ± 53	105 ± 1
Total	83± na	4,065 ± 301	19,468 ± 301	8,314 ± 124	26,959 ± 1,241

Table 18. Monthly catch estimates (± 1SD) for kokanee, rainbow trout, smallmouth bass, walleye and yellow perch from Banks Lake, Washington, September 2005 through August 2006.

Month	Kokanee	Rainbow Trout	Smallmouth Bass	Walleye	Yellow Perch
September	17 ± 1	2,064 ± 29	12,251 ± 99	0	14,542 ± 86
October	0	2,789 ± 289	1 ± 6	0	12,231 ± 593
November	0	2,012 ± 385	407 ± 55	0	309 ± 22
December	0	181 ± 173	0	0	6 ± na
January	0	481 ± 82	0	0	2,725 ± 291
February	0	83 ± 109	0	0	1,010 ± 245
March	0	926 ± 81	1,253 ± 66	96 ± 13	3,171 ± 176
April	69 ± 8	8,492 ± 329	3,660 ± 63	130 ± 2	0
May	0	10,587 ± 103	22,552 ± 216	5,018 ± 36	1,272 ± 43
June	0	268 ± 8	7,203 ± 90	2,524 ± 27	291 ± 41
July	0	6 ± 7	10,582 ± 81	1,548 ± 15	719 ± 10
August	0	2,394 ± na	6,243 ± 22	2,242 ± 39	105± 1
Total	86 ± 9	30,291± 1597	64,152 ± 700	11,560 ± 131	43,719 ± 1,508

Table 19. The percent of anglers who indicated that they were satisfied or dissatisfied with the fishery from September 2002 through August 2006 on Banks Lake. Data were only used if the angler specified a target fish species.

Species Targeted	% Satisfied	% Dissatisfied
ANY	97.7	2.3
Kokanee	84.6	15.4
Rainbow Trout	95.0	5.0
Smallmouth Bass	97.8	2.2
Walleye	93.2	6.8
Yellow Perch	93.4	6.6
Total	95.0	5.0

Table 20. The percent of fishing boats vs. recreational boats (water skiers, jet skiers, etc.) during high use months from May 2002 through August 2005, determined from aerial creel flights. These percentages were used as a correction factor for the number of boat trailers associated with fishing boats or other recreating boats. Most percentage values do not equate to 100% because trailer counts did not equal total active boat counts due to some boat moorage during the survey.

Flight Month	Total # of Boats Counted	Fishing Boats (%)	Recreational Boats (%)
May	95	95.6	4.3
June	403	51.9	21.0
July	442	20.4	39.5
August	519	25.3	48.3
September	97	69.8	11.0
Total	1,556	44.3	30.3

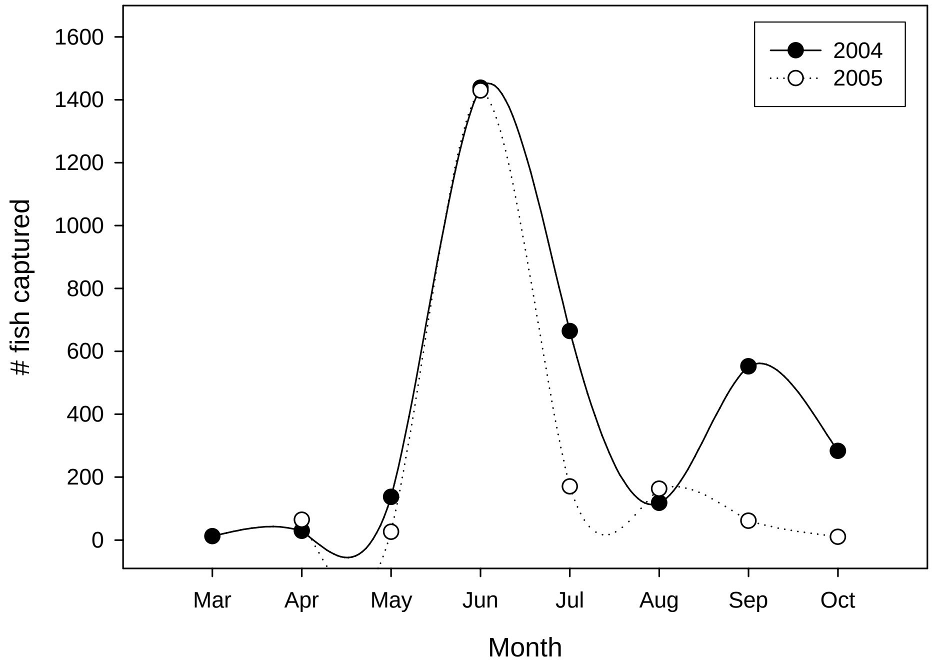

Figure 11. The monthly catch of all fish during the 2004 and 2005 entrainment studies at the Bacon Siphons, Banks Lake, Washington.

Yellow perch and cottid species combined for more than 90% of the total catch. Other fish collected included smallmouth bass (n = 86), kokanee (n = 37), walleye (n = 25), rainbow trout (n = 15), and others (Table 21). Captured fish ranged from 10-678 mm, with an overall average of 30 ± 1.3 mm (2 SE). Yellow perch and cottids ranged from 10-236 and 15-163 mm, respectively (Table 21).

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5.0 Discussion

The work elements (WE) outlined in the PISCES Statement of Work for BPA contract #24085 have been completed with the exception of WE L, which will be conducted and reported once annual diet data is synthesized for the bioenergetics model. Data have indicated that annual diet composition of planktivores and piscivores varies little among years. Therefore, we will combine seasonal diet samples into a 4-year database to provide a comprehensive analysis of the trophic dynamics of Banks Lake.

The kokanee fishery in Banks Lake has grown in popularity as the population has increased in abundance in recent years. The analysis of hatchery kokanee rearing and stocking strategies will provide the information necessary to address current temporal stocking practices. Initial results of age-2 mature kokanee indicate that spring yearling net pen releases have higher survival than spring and fall direct release groups. Fall direct releases performed better than spring direct releases. The analysis of age-3 adults collected in the fall 2006 will provide additional information as to which release group has the highest survival in Banks Lake. Currently, 4 additional year classes of kokanee possess thermal otolith marks, and these cohorts should be sampled in the fall of each year to provide a multiple year data set for analysis.

This project was funded to monitor and evaluate the success of kokanee and rainbow trout stocked into Banks Lake from the Ford State hatchery, Columbia Basin state hatchery, and the Spokane Tribal hatchery. Through this project we have collected multiple years of data to evaluate factors that could limit the production of hatchery kokanee and rainbow trout in Banks Lake. The data collected during this contract period followed a protocol outlined in the original project scope of work in 2002. Entrainment monitoring was added as an adaptive approach due to reports of large kokanee in unstocked Billy Clapp Lake; the next reservoir in the irrigation project. A barrier net placed in front of the outlet in the late 1970's was designed to prohibit adult kokanee entrainment; however, the net's mesh size allows smaller fish to pass. Our entrainment studies suggest that kokanee entrainment rates are not high enough to limit the population. Water temperature and dissolved oxygen levels are within the physiological limits for kokanee and rainbow trout, and the presence of large *Daphnia* spp. (>1.1 mm) suggest that the prey base is sufficient for planktivores. Predation on kokanee and rainbow trout has been identified as the factor limiting their survival in Banks Lake. Walleye are the primary predator, even though they are second in abundance to smallmouth bass. Bioenergetics modeling will quantify consumption rates and indicate when consumption is the highest and lowest on a temporal scale. Consumption rate extrapolations to the population level will be dependent on an abundance estimate. We have been able to calculate a population estimate for smallmouth bass, but not for walleye, due to the absence of recaptured tagged fish during the recapture surveys.

The two methods used to estimate kokanee abundance (age 1 and older) were different, but both were based upon the hydroacoustic estimate for targets over 100 mm. The first method applied species-specific relative abundance from gill netting to the hydroacoustic estimate, which yielded a kokanee abundance of 20,931 whereas the second method applied the percent of

Table 21. Catch statistics for fish collected during the entrainment study on Banks Lake, Washington from March 21 through October 21, 2005. Fish species codes are as follows: black crappie (BC), bluegill (BG), burbot (BUR), cottids (COT), kokanee (KOK), largemouth bass (LMB), rainbow trout (RBT), smallmouth bass (SMB), walleye (WAL), whitefish (WTF), yellow perch (YP), and unknown (UNK).

Species	n	%	mean TL	2 SE	Min	Max	fish/10,000 m^3
BC	5	0.3	88	41	59	169	0.02
BG	3	0.2	36	9	31	45	0.01
BUR	1	0.1	678	--	--	--	0.00
COT	212	11.0	53	4	15	163	0.68
KOK	37	1.9	54	3	30	85	0.12
LMB	2	0.1	55	56	27	83	0.01
RBT	15	0.8	113	19	83	210	0.05
SMB	86	4.5	33	3	20	84	0.28
UNK	5	0.3	--	--	--	--	0.02
WAL	25	1.3	47	7	26	86	0.08
WTF	0	0.0	--	--	--	--	0.00
YP	1,532	79.7	25	1	10	236	4.94
Total	1,923	100.0	30	1	10	678	6.20

hydroacoustic targets that were within the size class of kokanee captured in the gill nets (200-400 mm), resulting in an abundance of 19,158 individuals. There are biases associated with each method since we are assuming equal catch probability for each species and size class. These assumptions could have overestimated abundance if a specific species was more vulnerable to the gill nets. For example, if kokanee were more active than lake whitefish, but just as likely to be retained by the net once it was encountered, then kokanee abundance would be overestimated while lake whitefish abundance would be underestimated. The gill nets only captured fish greater than 100 mm (most effective > 150 mm), and larger fish have greater capture probabilities in gill nets (Hamley 1975; Rudstam et al. 1984; Henderson and Wong 1991). If species composition of the smaller fish (<150 mm) were different, then our acoustic estimates would be biased for the smaller size classes. When scenarios exist that limnetic species richness is low and there is a wide gap in species-specific size classes, the second method is useful to more accurately assign species composition to hydroacoustic targets. Because five fish species were captured in the limnetic zone and their sizes generally overlapped, we believe that the first method is the most applicable to estimate kokanee abundance in Banks Lake.

The survey of the limnetic fish populations of Banks Lake revealed low kokanee densities relative to current stocking rates. Since no small fish were collected, we assumed that the majority of acoustic targets less than 100 mm (30%) were kokanee fry stocked in the late spring (868,945) since the smallest yellow perch captured in the limnetic zone was 211 mm. Therefore, we estimated 176,249 (± 35,601; 2 SE) age-0 kokanee at the time of the limnetic survey (September), equating to a mortality rate between 76 to 84% from the time at stocking. The estimate of mortality could be conservative since we assumed all fish under 100 mm were kokanee and all kokanee were from hatchery releases. In order to better understand mortality rates, trawling surveys should be conducted in accordance with hydroacoustic surveys.

We could not determine the volume of water in the limnetic zone independently from the littoral zone. Mean density was extrapolated to lake-wide volume; therefore, we assumed that fish density in the littoral zone was equal to the limnetic zone for the species composition observed in limnetic gill nets. We recognize that species composition was different in the littoral zone and included many more species than we observed in the limnetic zone. If nearshore densities were higher than offshore densities then we underestimated lake-wide abundance for limnetic species; however, the relatively small volume of water in the littoral zone minimized the potential bias from this assumption.

The horizontal transducer could not differentiate target strength, so we could not determine the density of specific size classes for near-surface targets. We assumed that the size distribution of fish was the same from 1.5-8 m and from 8 m to the bottom. Similar mean lengths for each species and depth interval from the gill nets verified this assumption.

The location for the entrainment netting study was approximately 5.6 kilometers from the Dry Falls Dam. The distance from the dam did not allow us to evaluate the exact timing of peak entrainment and the total number of each species entrained from the lake. Fish reside in the canal and siphon between the lake and the netting site, which was verified by electrofishing after irrigation releases in 2004. No kokanee were collected in the canal during electrofishing; however, yellow perch, sucker spp., rainbow trout, sculpin, black crappie, lake whitefish, carp, burbot, largemouth bass, walleye, and smallmouth bass were collected. Specific species may be susceptible to flow and continue through the canal system whereas other species tend to reside in the canal and siphon due to the high densities of zooplankton passing through the system.

Trapping directly below the outlets with an incline plane trap would indicate entrainment timing and provide an estimation of the total number of fish lost from Banks Lake.

Detailed discussion regarding multi-year results and management recommendations will be included in the final project report.

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