Annual Timing, Relative Numbers, and Age Frequency of Kokanee Passing Downstream through Round Butte Dam, 1995–1999

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Abstract

From December 1995 through August 1999, fish captured in the gatewells at Round Butte Dam were enumerated as an index to the numbers of kokanee and other species moving downstream out of Lake Billy Chinook. During 1999, a downstream-migrant, rotary screw trap was also fished in the tailrace below the dam. Nearly all fish captured in each location were kokanee. A few bull trout, largescale suckers, and threespine sticklebacks were also observed. The majority of the kokanee observed were yearling. The peak numbers seen from February through March each year exhibited some relationship with high flow events occurring during this time interval. Some Age 0+ kokanee were observed in April 1998, and again in June 1999. Tests showed that Age 0+ kokanee remained floating an average of 5 hours while yearling kokanee remained floating more than 10 hours after air bladder expansion caused by pressure release. Thus, numbers of Age 0+ kokanee observed in the gatewells are an underestimate. During late winter and early spring in 1999, a high kokanee population year, an estimated 135,868 yearling kokanee, or about 10% of the yearling population, exited Lake Billy Chinook through the Round Butte Dam turbines.

Introduction

Downstream fish passage from Lake Billy Chinook, the reservoir behind Round Butte Dam on the Deschutes River in Central Oregon, was terminated in 1968 (Korn et al. 1968; Ratliff and Schulz 1999). Since that time, there have only been two pathways for fish to exit the reservoir downstream: through the spillway or through the powerhouse. Because of the very constant flow of the Deschutes River at this point (River Mile 110), there have only been two events (February 1982 and February 1996) when flows were large enough that it was necessary to spill excess water at Round Butte Dam. Water has been spilled for very short durations annually to test equipment and/or to conduct experiments on surface currents.

Water for generation enters the power intake tower approximately 250 ft below the surface of Lake Billy Chinook, passes down the power tunnel to a depth of approximately 415 ft, through the turbines, and exits the powerhouse to the tailrace downstream. Along the downstream edge of the powerhouse are three rectangular wells where gates can be placed to seal the power discharge tubes if they need to be dewatered. It has been noted over the years that when kokanee *(Onchorynchus nerka)* pass downstream through the power intake tunnel, turbines, and discharge tubes, some of these fish are captured in these gatewells. Because of air bladder expansion from the pressure difference, these fish are unable to sound, and so they cannot exit the gatewells. PGE began to enumerate these fish in the fall of 1995 as an index to the timing and relative numbers of kokanee exiting Lake Billy Chinook through the powerhouse. PGE also used this location to monitor for downstream movements of other species, including bull trout (*Salvelinus confluentus*). This report summarizes these efforts to date.

With the federal and state relicensing of the Pelton Round Butte Project, reestablishment of fish passage is being considered. Because Lake Billy Chinook is a potential rearing area for sockeye salmon, the anadromous form of kokanee, information on kokanee movement may help determine when a downstream facility might pass juvenile sockeye, and if the large kokanee population might be used as the donor stock to establish the anadromous form. It is theorized that if yearling kokanee emigrate at a rate higher than their frequency of occurrence in the Lake Billy Chinook population, these fish may be actively trying to emigrate. It may be possible to use kokanee to initiate a run of anadromous sockeye if safe passage can be achieved. Information on the timing and relative numbers of kokanee moving through the powerhouse will also help determine periods of the year when it might be necessary to exclude fish from the water passing through the turbines.

Background

Sockeye and Kokanee in the Deschutes River Basin

As noted above, kokanee are the resident life history form of *O. nerka*; sockeye salmon are the anadromous life history form. Unique among Pacific salmon species, both life history types of this species require a standing water body as juvenile habitat to complete their life history. Normally, maturing adult sockeye migrate upstream during summer from the Pacific Ocean through a river and lake system to spawn in a tributary above the lake. Maturing adult kokanee ascend tributaries directly from the lake or reservoir to spawn. Adults of both forms die after spawning. Fry of both life history types emerge from the gravel in late winter or early spring and move directly downstream to the lake or reservoir. In this rearing environment, they feed primarily on zooplankton.

Sockeye rear up to several years (normally 1 year at the latitude of the Deschutes River Basin) before emigrating to the ocean in the spring. In the ocean, they rear from 1 to 3 years before they return to complete the life cycle as spawning adults. Kokanee remain in the lake or reservoir for 2 to 4 years before moving upstream to spawn and complete their life cycle.

Historically, sockeye salmon in the Deschutes River Basin spawned in Link Creek above Suttle Lake in the Metolius River subbasin (Figure 1; Nielson 1950; Fulton 1970). Construction of a small power dam at the outlet of Suttle Lake early in the century, and another dam on Lake Creek below the lake in the 1930s, eliminated the anadromous portion of this population (Nehlson 1995). The kokanee portion of this population remained in Suttle Lake, and was likely the main seed source for the kokanee population that became established in Lake Billy Chinook in the late 1960s. However, hatchery sockeye (Leavenworth stock) released from the Metolius Salmon Hatchery (Wallis 1960; Nehlsen 1995) may have contributed to this early population. In addition,

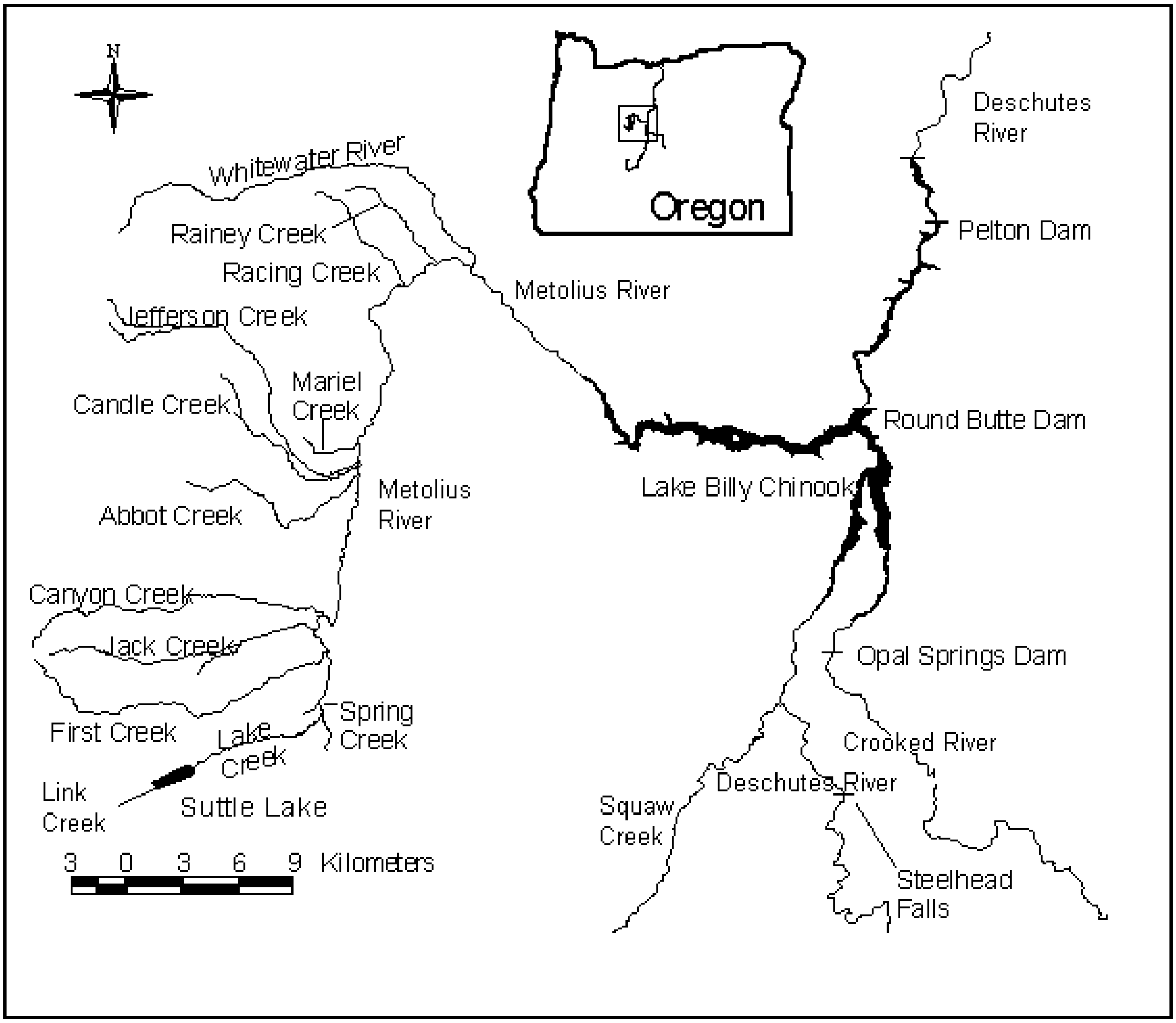

Figure 1. Map of Project area, including kokanee spawning tributaries and historic sites.

during the period 1947 to 1961, approximately 1,700,000 kokanee and sockeye fry and fingerlings from Bonneville, Leavenworth, Winthrop, Willamette, and other unknown hatcheries were stocked into lakes in the Metolius River Basin, the Metolius River, and Lake Simtustus (Wallis 1960, Fish Commission of Oregon 1967, and King 1966). The Oregon Game Commission released approximately 200,000 kokanee fingerlings into Lake Billy Chinook in 1970 and 1971. Genetic analysis using allozyme frequency indicates that the kokanee populations in Lake Billy Chinook and Suttle Lake are related but distinct (Kostow et al. 1995).

A small run of sockeye salmon has continued to ascend the lower Deschutes River since passage was terminated in 1968 (Table 1). Some of these sockeye have been shown to result from kokanee emigrating to the ocean (Zimmerman and Ratliff 1999). If safe fish passage is restored through the Pelton Round Butte Hydroelectric Project, anadromous sockeye salmon might be successful because of the large amount of lake-type rearing habitat available in present system, which includes Lake Simtustus and Lake Billy Chinook in addition to Suttle and Blue lakes (Figure 1). These habitats are now used by kokanee but would be available for sockeye with safe passage.

Table 1. Numbers of sockeye entering Pelton Fish Trap from 1972 through 1996.

Year	Sockeye count	Year	Sockeye count
1972	62	1985	28
1973	327	1986	14
1974	62	1987	4
1975	69	1988	49
1976	295	1989	37
1977	27	1990	8
1978	26	1991	60
1979	80	1992	7
1980	43	1993	1
1981	42	1994	7
1982	180	1995	7
1983	94	1996	0

A major study of the life history and limiting factors of *O. nerka* in Lake Billy Chinook began in 1996 (Chilcote 1996). One objective of this study is an estimation of the potential for sockeye smolt production from Lake Billy Chinook. An estimated 83,000 to 180,000 adult kokanee have spawned in the Metolius River Basin annually since this study began. Population estimates using hydroacoustic techniques suggest that the abundance of Age 1+ and older kokanee has varied between 200,000 and 1.5 million during summer, while the number of Age 0+ kokanee was between 600,000 and 3.5 million (Thiesfeld et al. 1999; Kern et al. 1999). If adequate seeding is available, and safe passage is achieved, an estimated 2.9 million sockeye smolts could possibly be produced in Lake Billy Chinook annually (Thiesfeld et al. 1999).

Study Area

Lake Billy Chinook

Lake Billy Chinook was created at RM 110 on the Deschutes River in 1964 by the construction of Round Butte Dam near the head of Lake Simtustus (Figure 1). In addition to extending 9 mi. up the Deschutes River canyon, the reservoir extends 7 mi. up the Crooked River canyon and 13 mi. up the Metolius River canyon. This reservoir has a maximum depth of 400 ft and a surface area of 4,000 ac (Figure 1). The Metolius River is the major kokanee-producing tributary to Lake Billy Chinook.

Round Butte Dam

Round Butte Dam is an earth-and-rock-fill structure rising 440 ft above bedrock. The crest measures 1,382 ft long by 44 ft wide, and the base is 2,500 ft thick. Three Francis-type, turbine-driven generators have a combined capacity of 300 MW. The center of the 45-ft high power tunnel intake at the base of the intake tower in the forebay is approximately 250 ft below the surface of the reservoir. The power tunnel slopes toward the powerhouse, creating 365 ft of gross head at full pool elevation (1,945 ft; Figure 2).

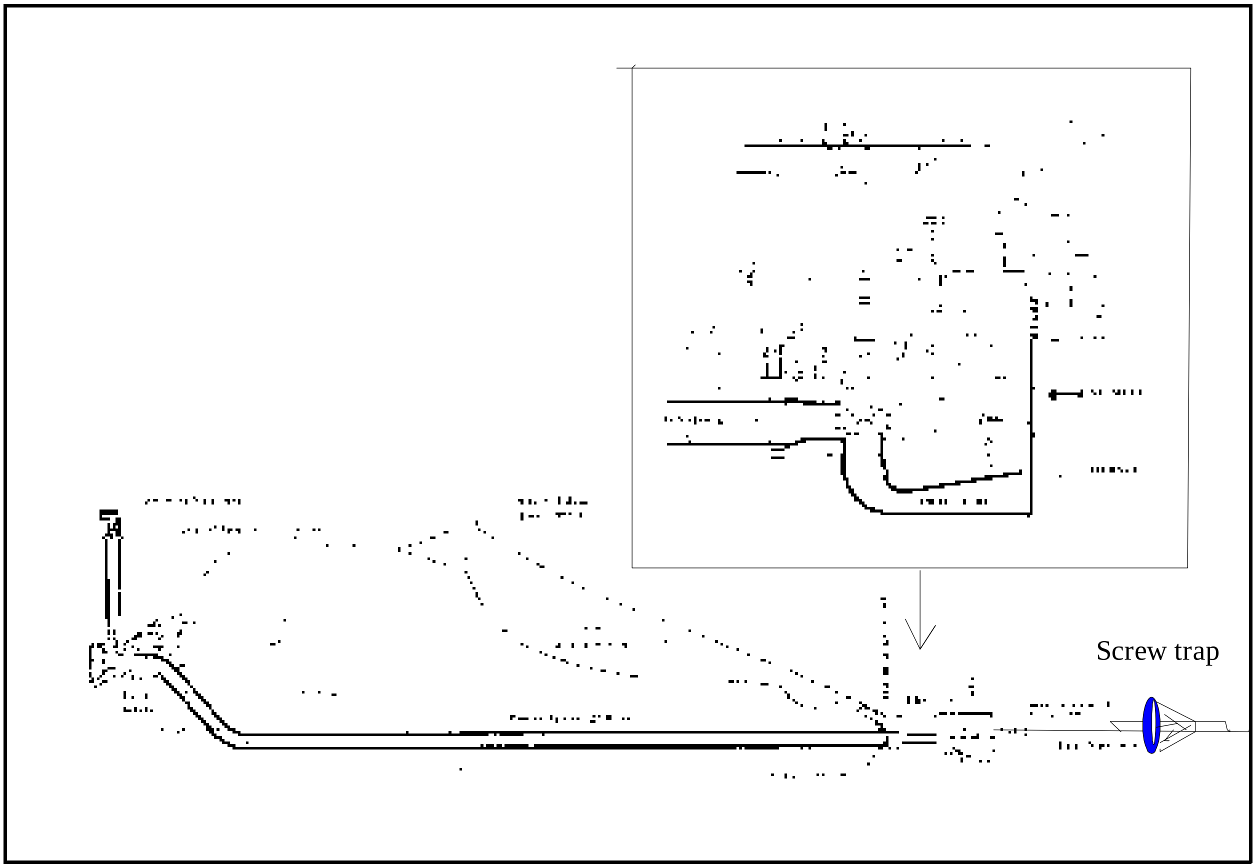

Figure 2. Round Butte power tunnel and powerhouse diagram. Water enters at approximately 250 ft below the surface of Lake Billy Chinook (left) and exits about 68 ft below the surface of Lake Simtustus (right). The screw trap was set about 400 ft downstream of the gatewells.

Impact of Depressurization on Turbine-Passed Kokanee

At the depth kokanee enter the power intake, the water pressure is approximately 109 lbs/square inch. The water then flows through a 1,435-ft long power tunnel to a depth below surface elevation of approximately 415 ft. The pressure at this depth is 180 lbs/square inch. If a kokanee passing through this system has filled its air bladder to adjust to the 415-ft depth, and the back pressure of Simtustus is at its greatest, the depressurization is 152 lbs./ square inch, or about 80%. With this quick reduction in pressure, the volume in a fish's air bladder will quadruple. This increase is sufficient to cause mortality (Bell 1973). Nevertheless, some years there is a good fishery for kokanee in Lake Simtustus, the reservoir below Round Butte Dam. Because very few of these are hatchery kokanee, and there is no documented successful spawning in tributaries to Lake Simtustus, these fish must have survived turbine passage from Lake Billy Chinook. Kokanee fry with a less developed air bladder likely survive the depressurization at a higher frequency than older fish.

Methods

Species Composition

From late fall 1995 through 1997, fish in the gatewells were enumerated by species on Monday, Wednesday, and Friday mornings when possible. In 1998, this schedule was adhered to when fish were observed on Monday. Otherwise, no further observations were conducted that week until the following Monday.

In 1999, effort intensified. To determine if other year classes of kokanee, or other species, were being missed or under-represented in the gatewell counts, an 8-ft diameter, downstream-migrant screw trap was operated and migrants counted under the same schedule as with gatewell counts. From January 14 to March 23, the screw trap was operated on the west side of the tailrace. Between March 23 and June 3, the screw trap was operated on the east side and then moved back to the west side through August. For some of this period, the screw trap was operated continuously. During this time, fish were enumerated and removed from both the gatewells and the screw trap in the morning and the evening. However, because the powerhouse generates electricity on a peaking basis, it is normally turned off for part of the night. To sample known generation periods, the standard procedure was to count and remove the kokanee from the gatewells and set the screw trap in the morning. In the evening, the kokanee were counted and removed from each trapping location. Date, time, weather conditions, location of observation (i.e., gatewell # or screw trap), and size of kokanee observed were recorded. A representative sample of the kokanee was measured on a weekly basis, and scales were taken for possible age and growth analysis.

Timing of Kokanee Movement

To determine the annual timing of kokanee movements from Lake Billy Chinook, kokanee in the gatewells were enumerated at least weekly between December 1995 and August 1999. Because the kokanee spawning period begins in September, data were organized by "kokanee year," from September 1 through August 31. Average daily generation flows were recorded to determine if certain flow levels stimulated kokanee downstream movement. Flow information was graphed on an axis secondary to numbers of kokanee observed over time for each year.

In addition to recording the numbers of kokanee found in the gatewells and screw trap, information on the relative densities of Age 0+ and Age 1+ kokanee in Lake Billy Chinook was gathered from the hydroacoustic component of the Lake Billy Chinook Kokanee Study (Thiesfeld et al. 1999). Transects taken throughout the year were regrouped into three general geographic areas: (1) near the forebay, (2) in the middle reservoir, and (3) in the upper arms. Density of kokanee near the forebay was compared to the numbers of kokanee counted in the gatewells.

During 1996 and 1997, the numbers of avian predators near the tailrace were counted and compared to the numbers of kokanee observed to determine if avian predator numbers could be used as an index to timing of kokanee movements (Schulz and Ratliff 1996 and 1997). However, little correlation was found, and this evaluation was discontinued in 1998 (Schulz and Ratliff 1998).

Relative Numbers

The number of kokanee observed in the gatewells during each kokanee year was compared between years, and also with population estimates of kokanee of each age class in Lake Billy Chinook each year. This comparison was made to determine if a similar percentage of yearling kokanee emigrated each year or if there was a density factor that caused more emigration under high population conditions. Information on the relative densities of Age 0+ and Age 1+ kokanee in Lake Billy Chinook was gathered using hydroacoustic equipment as part of the Lake Billy Chinook Kokanee Study (Thiesfeld et al. 1999).

Gatewell vs. Screw Trap Observations

During 1999, an 8-ft diameter rotary screw trap was operated in the tailrace to sample fish that had passed through the turbines at Round Butte Dam to correlate with catches in the gatewells. The powerhouse is angled slightly to the east and directs the turbine discharges to the east bank. Direct observation shows that much of the water then bounces back along the bank and into the center of the tailrace and downstream. However, a significant percentage of the discharge rolls back toward the powerhouse. This “roll-back” surface flow then moves to the west along the powerhouse and downstream along the west bank (Figure 3). To determine the relative catch frequency, the screw trap was fished along both the west bank and the east bank, and the catch from each location was compared to the catch frequency for kokanee in the gatewells.

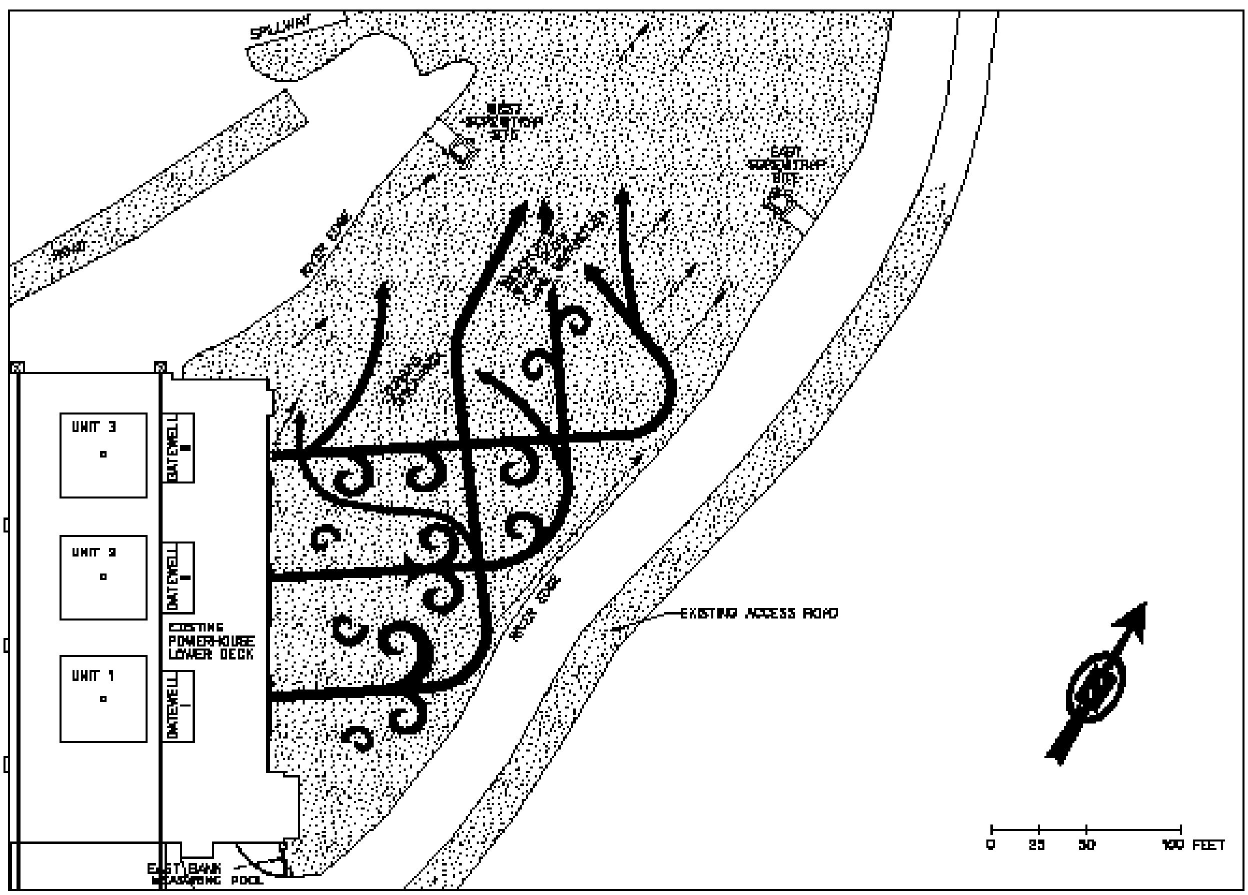

Figure 3. Schematic drawing of the tailrace illustrating the pattern of water currents in Round Butte Dam tailrace with all three turbines operating.

Relative Numbers by Age Class

Age frequency of kokanee observed in the gatewells and the screw trap indicated that relatively more Age 0+ kokanee were captured by the screw trap than the gatewells. Use of the screw trap in 1999 allowed the investigation of how long different age classes remained floating in the gatewells, and thus a determination of the relative accuracy of observation frequency of different age classes. Because the screw trap captured and retained small kokanee (<100 mm), a test was conducted to determine how long they remained afloat. To test the difference in buoyancy, and thus retention time in the gatewells for different age classes, 214 Age 0+ and yearling kokanee were captured in the screw trap, differentially fin marked, and placed in the gatewells. The numbers of fish from each age class group remaining in the gatewells were then re-observed and counted each hour during a 10-hour interval.

Age Frequency for Kokanee in the Gatewells vs. Lake Billy Chinook

Initially, kokanee were grouped into age groups by size at capture (Schulz and Ratliff 1996). Starting in 1997, the kokanee captured in the gatewells were measured, and the relative numbers and sizes of kokanee observed in the gatewells were compared to kokanee captured using an otter trawl net on Lake Billy Chinook in 1997, 1998, and 1999 to determine the length frequency by age class. Variable-mesh gill nets, designed to catch all age classes except fry, were set at Chinook Island in the Metolius Arm during March of 1998 and April of 1999. These samples were used to determine the relative age frequency of kokanee in Lake Billy Chinook for Age 1+ and older. This information was then compared to the age frequency of kokanee captured in the gatewells during the same period to determine if the frequency of yearling kokanee (i.e., kokanee at the age of sockeye smolt emigration) was higher in the gatewell counts than in Lake Billy Chinook.

Results

Species Composition

Between December 1995 and August 1999, a total of 4,364 kokanee, 4 bull trout, 1 threespine stickleback (*Gasterosteus aculeatus*), and 2 largescale suckers (*Catostomus macrocheilus*) were observed in the gatewells at the powerhouse at Round Butte Dam (Table 2). Fishing the screw trap in the tailrace during 1999 yielded a capture of 4,677 kokanee, 1 brown trout (*Salmo trutta*), and 1 bull trout, indicating that the gatewell counts were generally an accurate representation of the species composition that exit Lake Billy Chinook at depth through the power intake. Species other than kokanee only rarely exit Lake Billy Chinook through the turbines.

Table 2. Comparison of all species of fish observed in the Round Butte Dam gatewells December 1995 through August 1999.

Date	Months	Kokanee	Bull Trout	Largescale Sucker	Three Spine Stickleback
Dec 95 – Aug 96	9	566	0	2	0
Sep 96 – Aug 97	12	774	1	0	1
Sep 97 – Aug 98	12	138	1	0	0
Sep 98 – Aug 99	9	2,886	2	0	0
Total	**42**	**4,364**	**4**	**2**	**1**

Timing of Kokanee Movement

During the study, kokanee were most often observed passing downstream through Round Butte Dam during February and March (Figure 4). Counts peaked in February in both the 1995/1996 and 1996/1997 counting periods. During 1997/1998, few fish were observed. In the winter of 1998/1999, when yearling kokanee in Lake Billy Chinook were extremely abundant, yearling kokanee were observed in the tailrace starting in December and continuing through August. The peak counts were in mid-March (Figure 4). In 1999, for the first time during the study, large numbers of Age 0+ kokanee were observed moving though the dam during June and July.

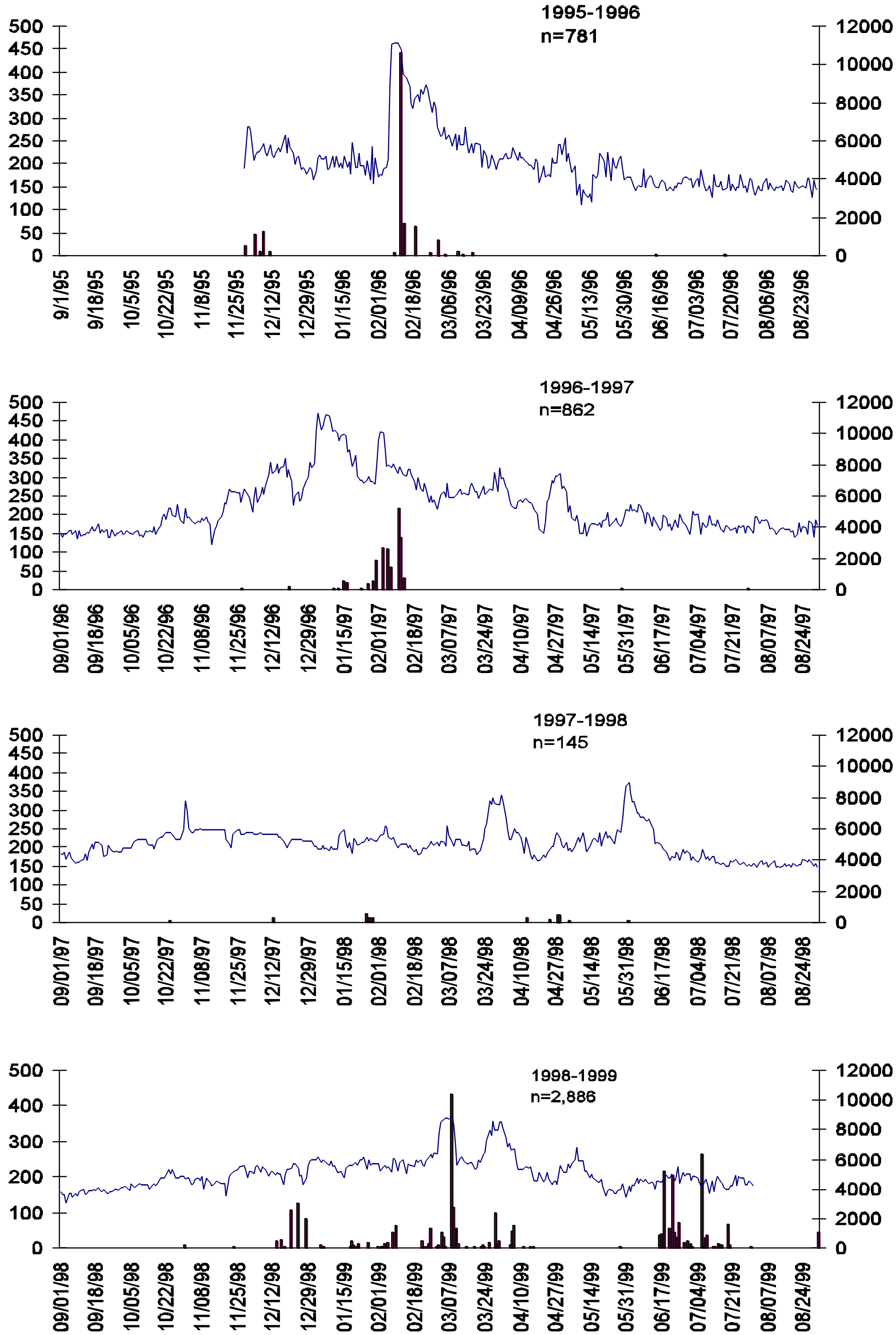

Figure 4. Numbers of kokanee observed in Round Butte Dam gatewells (left y axis) and average daily generation flows (cfs; right y axis) kokanee years 1995–1998 (kokanee year begins September 1).

Timing of Kokanee Movement verses Average Generation Flow

In February 1996, the flood of record occurred in the Metolius River. During the flood, generation flows averaged 11,079 cfs, while approximately 2,000 cfs were spilled. The first major downstream movement of kokanee during this study period coincided with this flow event (Figure 4). High flows in late December of 1996 and early January of 1997 did not appear to be related to fish movement. However, a smaller flow event in early February 1997 did coincide with kokanee movement. There was very little movement of kokanee during the winter/spring of 1997/1998 even though there were high flows in late March and again in early June. During the winter of 1998/1999, the largest peak movement did coincide with a relatively high flow in early March (Figure 4).

Timing of Kokanee Movement verses Kokanee Density in the Forebay

There appeared to be some relationship between the number of kokanee in the lower portion of the reservoir and the number of kokanee observed in the gatewells; the Kokanee Study documented kokanee concentrated in the lower portion of the reservoir during late winter each year. This occurrence coincided with the period of highest movement through the dam during years there was movement. When the density estimates from lower reservoir hydroacoustic transects in the lower reservoir were plotted against the number of kokanee observed in the gatewells during the same periods, a positive, but low, correlation ($R^2 = 0.58$) was observed (Figure 5).

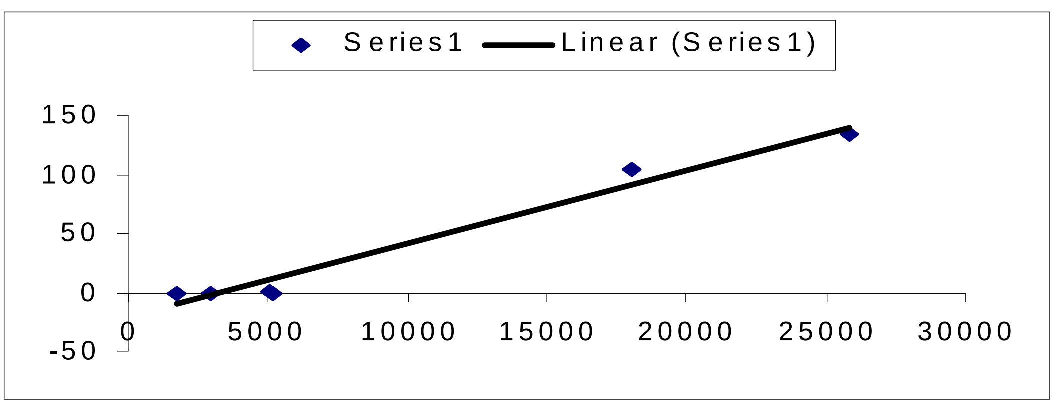

Figure 5. Correlation between density of Age 1+ and older kokanee in the lower portion of Lake Billy Chinook (x axis) and numbers of Age 1+ and older kokanee observed in the gatewells (y axis) , January–April 1999 ($R^2 = .58$).

Relative Numbers of Kokanee

Total number of Age 0+ and Age 1+ kokanee observed in the gatewells at Round Butte Dam varied from a low of 138 in 1997/1998 to a high of 2,866 in 1998/1999 (Table 3). There seemed to be some correlation between the number of yearling kokanee observed and the number of yearling and older kokanee in the reservoir upstream, as evidenced by both groups peaking during 1998/1999. The 1998 year class was very abundant, leading to an estimate of more than a million Age 1+ and older kokanee in Lake Billy Chinook in July 1999 (Kern et al. 1999).

Table 3. Numbers of kokanee observed in the gatewells at Round Butte Dam annually from December 1995 to August 1999 and the largest population estimates for Age 0+ and Age 1+ and older kokanee in Lake Billy Chinook during the same periods as determined using hydroacoustic surveys. Kokanee year begins September 1. First and last years are incomplete.

		Gatewell Observations			Peak LBC Populations		
Date	**Months**	**Yearlings**	**Age 0+**	**Total**	**Yearlings**	**Age 0+**	**Total**
Dec 95 – Aug 96	9	538	28	566	---	---	---
Sept 96 – Aug 97	12	748	9	774	303,279	937,015	1,240,294
Sept 97 – Aug 98	12	68	70	138	293,729	3,300,297	3,594,026
Sept 98 – Aug 99	10	2,594	292	2,886	1,153,135	2,711,229	3,864,364

Relative Numbers by Age Class

Tests holding yearling vs. Age 0+ kokanee that had passed through the Round Butte turbines indicated that after 10 hours, all the Age 0+ kokanee had sunk, whereas none of the yearling kokanee had sunk (Figure 6). Mean floating time for Age 0+ kokanee was approximately 5 hours. Thus, in gatewell counts in the past where some Age 0+ kokanee have been observed, this age class of kokanee was under-represented in the counts. However, numbers of Age 0+ kokanee observed have been minor during past years compared to the number observed during June and July 1999 (Table 3). During April 1998, a total of 59 Age 0+ kokanee were counted in the gatewells. Because the gatewells were checked three days per week (~every 72 hours) during the 16-day period when these fish showed active movement, there could have actually been 12.4 times as many Age 0+ fish in the gatewells than were actually observed. Thus, an estimated 730 Age 0+ kokanee entered the gatewells during April, 1998.

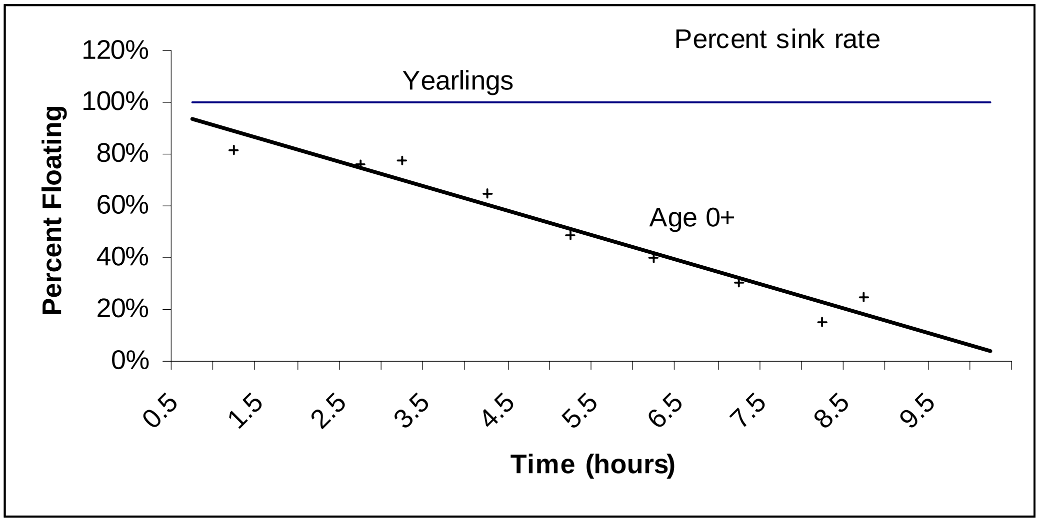

Figure 6. Average sink rate for Age 0+ and Age 1+ kokanee observed over a 10-hour period in a screw trap placed in the tailrace of Round Butte Dam, June 22, 1999.

Gatewell vs. Screw Trap Observations

The screw trap fished in the tailrace appeared to be very effective in sampling fish that had passed through the turbines at Round Butte Dam, especially when fished along the left (west) bank. It appears that the highest percentage of fish exiting the powerhouse move with the portion of the flow that rolls back to the powerhouse and then travels downstream along the west side. When the screw trap was fished along the west bank, kokanee were captured at a ratio of 2.4 to 1 over the total gatewell counts. When the screw trap was fished along the east bank, kokanee were captured at a rate of 0.5 to 1 compared to the total gatewell counts. An estimated 135,868 yearling and older kokanee exited Lake Billy Chinook through the turbines during the 1998/1999 kokanee year, based on the following four assumptions:

(1) Air bladder expansion for yearling and older kokanee due to air pressure release is sufficient that they are all vulnerable to capture by the downstream-migrant screw trap fished at and near the surface.

(2) There is no avoidance of the screw trap by these injured fish.

(3) Predation between the powerhouse and screwtrap capture locations (Figure 3) is insignificant.

(4) There is an even gradation in kokanee-capture efficiency between the east and west bank tailrace trap locations across the width of the tailrace in relation to the gatewell counts.

If the first, second, and/or third assumptions are not met, the numbers of yearling and older kokanee exiting through the turbines are underestimated. The effects of the fourth assumption being in error is unknown.

Age Frequency for Age 1 and Older Kokanee in the Gatewells vs. Lake Billy Chinook

Comparison of length frequencies for March 1998 and April 1999 for kokanee captured at Chinook Island by gill nets and kokanee observed for similar periods in the Round Butte Dam gatewells indicate a much higher concentration of Age 1+ kokanee in the gatewells. The general population in Lake Billy Chinook also had larger Age 2 and 3 kokanee that were not observed in the gatewell samples (Figure 7). (Note: Small, Age 0 kokanee fry are not captured by gill nets in late winter.)

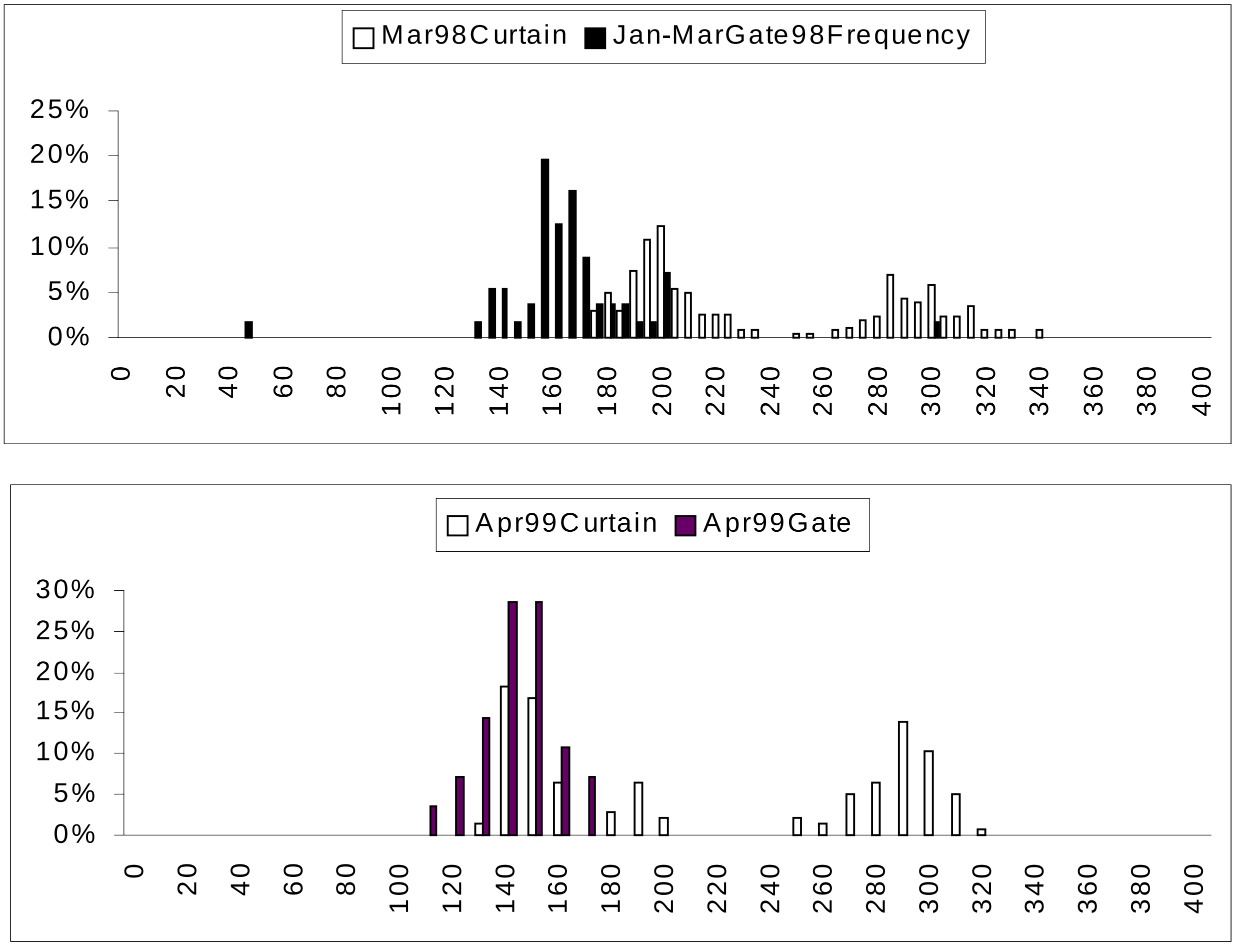

Figure 7. Length-frequency histogram (x axis is length in mm; y axis is percentage of observed) for kokanee observed in Round Butte Dam gatewells compared to those captured using gill nets at Chinook Island in March 1998 and April 1999.

Discussion

Species Composition

Nearly all of the fish captured in the gatewells during the period December 1995 through August 1999 were kokanee. Kokanee are the most numerous fish in Lake Billy Chinook by far, and nearly all the fish captured in pelagic trawl samples in this reservoir are also kokanee (Thiesfeld et al. 1999). By fishing a screw trap in the tailrace during the 1998/1999 kokanee year, we demonstrated that the gatewell counts are an accurate representation of the species exiting via the power intake. Fish species other than kokanee only rarely exit Lake Billy Chinook through the turbines. There has been some speculation that bull trout may be leaving at a higher rate than observed in the gatewells. However, the screw trap catches did not bear this out. Only 2 bull trout were captured in the screw trap during the 1998/1999 year compared to over 4,300 kokanee. This same screw trap caught large numbers of bull trout when fished in the lower Metolius River (Lewis and Madden 1999). Because only two bull trout were observed in each capture location (gatewell and screw trap) during 1999, no estimation of the total number of bull trout exiting Lake Billy Chinook through the turbines is possible; the sample size is too small.

Timing of Kokanee Movement

There appeared to be a relationship between large flows early in the year and numbers of kokanee observed in the gatewells for 1996 and 1997. During the first quarter of 1996 (January–March), the Metolius River experienced flows of over 6,500 cfs and the lower Deschutes River experienced flows of over 18,000 cfs. In February 1997, Deschutes River flows again reached over 13,000 cfs below the Project. Neither the timing or magnitude of flows have been duplicated since, nor have the observations of kokanee in the gatewells been as concentrated. During the 1997/1998 counting period, neither high flows nor large spikes in kokanee movement were observed. However, during this year, yearling and older kokanee were also not very abundant in the reservoir. During the 1998/1999 counting period, when yearling kokanee were very abundant in Lake Billy Chinook, the peak of kokanee observations in early March again coincided with a peak in generation flow.

Growth rates have been so exceptional during the first three years of the kokanee study (1995/1996–1997/1998) that Age 1+ kokanee enter the sport fishery in Lake Billy Chinook during June (Thiesfeld et al. 1999). This exceptional growth appears to be related to relatively low population densities these three years (Thiesfeld et al. 1999). It might be this relatively large size for yearlings also stimulated early migration timing in 1996 and 1997. In sockeye populations, larger members of a year class tend to migrate to sea earlier in the spring or migrate a year earlier than smaller members (Burgner 1991). In 1999, the yearling age class was much larger, growth was slower, and peak movement of yearlings from Lake Billy Chinook was also about a month later (early March).

The literature does not report a downstream migration of sockeye smolts as early as January or February. Sockeye emigrate from Lake Ozette, Washington, almost entirely during the month of May (Jacobs et al. 1996). Naturally produced sockeye smolts from the Bonneville-Priest Rapids region emigrate between March 1 and May 31, and sockeye in the Snake River region emigrate between April 1 and May 31 (Anderson et al. 1996). Sockeye smolts monitored at Rock Island Dam on the Columbia River in 1987 were seen April 1 through August, with a peak on May 22. By May 24, 90% of the sockeye smolts had passed the station (Peven et al. 1987). Kokanee in Lake Roosevelt, Washington, were found to exhibit smolting chemistry and appearance in March that increased through May and returned to that of a resident by June (Tilson et al. 1995).

Relative Numbers of Kokanee

The relative number of kokanee observed in the gatewell counts did appear to have some correlation with the number of yearlings in the reservoir upstream. The 1998 year-class was very abundant, and appeared to correlate with much larger counts of yearling kokanee during late winter 1998/1999.

When the screw trap was fished in the tailrace during the 1998/1999 counting year, it showed that Age 0+ fish have been under-represented in the gatewell counts. Some fry were caught in the screw trap starting as early as February. Because fry start entering the reservoir from the Metolius River in January, it appears that a small percentage of these fish move out with the generation water as soon as they distribute down to the forebay. However, numbers of these fish are relatively small compared to the concentrated numbers of yearlings in February–March most years. During 1999, for the first time in the study, a major movement of larger Age 0+ fingerlings was observed during June and July. It is unknown if this is related to unusual reservoir conditions (cool dry spring) or to the fact that there were large numbers of both Age 0+ and yearling kokanee in the reservoir for the first time since counts began in December 1995. Even though tests demonstrated that Age 0+ kokanee do not remain floating for extended periods in the gatewells, we are confident that large numbers as observed in June and July 1999 were not missed during previous years because of the frequency of observations.

Using the screw trap catch at two locations compared to the gatewell counts, and expanding with several assumptions (see Results, above), an estimated 135,868 yearling and older kokanee exited the reservoir during the 1998/1999 counting year. This represents approximately 10% of the July 1999 estimate of the population of yearling and older kokanee in Lake Billy Chinook (Kern et al. 1999).

Age Frequency for Kokanee in the Gatewells vs. Lake Billy Chinook

Most sockeye from other river and lake systems appear to smolt and emigrate at Age 1+ (Anderson et al. 1996, Jacobs et al. 1996, West and Mason 1987, Koenings and Burkett 1987). By comparing the length frequency of kokanee observed in the gatewell to those sampled using variable mesh gill nets in Lake Billy Chinook, we showed that the yearling age class is disproportionately represented in the fish exiting the reservoir during February and March. This would indicate that at least some of these fish are attempting to emigrate. Supporting this idea is the calculation of water velocities in front of the power intake. Because of the large opening, even at peak generation (11,500 cfs), the velocity 30 ft upstream of the trash rack is only 1.3 ft per second (Carson and Mahnken 1997).

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