# Appendix A
# Lake Roosevelt Kokanee Immigration Project

2007-08 Annual Report

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July 11, 2008

*Submitted to:*

The Washington State Department of Ecology
as part of the Columbia River Water Management Program

WDFW Contract #06-1488

## I. Summary

Due to the minor contribution of hatchery kokanee (Oncorhynchus nerka) to the Lake Roosevelt creel, the absence of documented shoreline spawning, and the open water habitat use of this species, the Washington Department of Fish and Wildlife (WDFW) concludes that the effects of an additional one-foot drawdown will not directly affect kokanee at the shoreline. Indirect effects may occur with the loss of zooplankton and fish through entrainment. Mitigation resources for fish loss should be used to identify the contribution of wild origin fish to the lake and understand immigration timing and size from fish entraining from Canadian reservoirs and entering Lake Roosevelt. Since wild origin upriver kokanee are relatively successful in Lake Roosevelt, results from this study could heavily impact the current hatchery release practices to mimic immigration timing and size, and ultimately maximize recruitment of kokanee to the creel and escapement to egg collection facilities.

## II. Introduction

Kokanee supplementation efforts have been ongoing on Lake Roosevelt since the late 1980's with little success. The artificial production program has worked closely with research biologists to design and implement studies to test alternative stocking strategies including size at release, release timing, rearing differences (net pen vs. direct releases), release locations, and different stock origin releases.

Historic and current studies have reported few hatchery origin kokanee (adipose fin clipped) in the creel (Lee, personal communication)[1] and the majority of the limited escapement to the hatchery facility and spawning tributaries were precocious yearlings or 2-year old adults (McLellan et al. 2004). Wild origin kokanee (no fin clips) have been reported in the creel. Three wild origin stocks have been identified as contributors to the Lake Roosevelt fishery, the San Poil River Stock, and two stocks from the upper Columbia River in Canadian waters (Norns Creek in the Arrow Lakes and Meadow Creek in Kootenay Lake) (Kassler and Loxterman 2006). Due to the success of the Canadian stock kokanee in Lake Roosevelt, understanding kokanee immigration is important and may alter Lake Roosevelt hatchery strategies to mimic time, size, and location of release.

[1] A weeklong winter test fishery on Lake Roosevelt from 2002 through 2005 yielded an average of only 13.6% hatchery origin (n = 17) fish caught; the remaining fish were from a wild origin (n = 125) (Spokane Tribe of Indians (STI), unpublished data). A genetic study conducted by the Lake Roosevelt Fishery Evaluation Program indicated that the majority of unmarked kokanee in Lake Roosevelt were comprised of San Poil River and upper Columbia River stocks, indicating immigration from Canada (Loxterman and Young, Washington Department of Fish and Wildlife (WDFW) unpublished data). This study indicated that the greater part of unmarked kokanee was not from wild produced hatchery origin fish and that kokanee immigration occurs from Canadian waters, probably due to entrainment from Kootenay or Arrow Lakes.

In 2004, former governor Gary Lock unveiled the Columbia River Initiative (CRI; later referred to as the Columbia River Basin Water Management Program (CRBWMP)), a plan for a new water management program for the Columbia River (WSDOE 2004). The plan was designed to issue new water rights while improving river flows for fish populations. As a result of the CRWMP, water would be withdrawn from Lake Roosevelt by an additional 0.3 m (one foot) for downstream water demands (see the Study Area section for definition of normal drawdown regimes). The effects of the proposed drawdown on the benthic and littoral aquatic community are unknown.

The effects of the drawdown on shoreline spawning adult kokanee have been a concern of biologists in the past; however, Lake Roosevelt researchers have concluded that shoreline spawning is minimal to absent, and if it exists, does not produce a significant number of recruits to the fishery (Jason McLellan and Chris Donley, WDFW Biologists and Chuck Lee, STI, personal communication)[2]. The above information leads WDFW to conclude that shoreline spawning does not exist in high enough densities to be affected by an additional one-foot drawdown on Lake Roosevelt.

However, loss of water equates to loss of freely suspended zooplankton, the primary food source for limnetic fish species such as kokanee (Baldwin et al. 2000). WDFW is concerned that the drawdown will cause loss of secondary production, and therefore fish, from the lake through entrainment.

Mitigation for the loss of fish through artificial production is an option; however, success of these programs is low, so stocking additional hatchery kokanee in Lake Roosevelt will have little to no impact on the fishery. The substantial portion of non-hatchery kokanee in the Lake Roosevelt fishery needs to be examined to determine the contribution of immigrant kokanee to the fish community.

In 2006, the WDFW received funds from the Washington Department of Ecology (WDOE) to implement a trapping study above Lake Roosevelt to evaluate the timing and size of kokanee immigrating from upstream waters (Project #06-1262-05). The contract began in May 2006; however, May through September was spent obtaining permits, logistical planning and trap removal, transport, and placement. The planning and logistical phase, which accompanies any new project, reduced our actual sampling time to 8 months in 2006, which did not represent all seasonal flows of the Upper Columbia River.

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[2] Lakewide kokanee collection efforts by Eastern Washington University (EWU) from 1999 through 2004 have yielded no spawning kokanee over shoreline habitats. Additionally, during fall walleye (*Sander vitreus*) recapture events by EWU from 1997 through 2001, no shoreline spawning kokanee were observed (Jason McLellan, personal communication). STI fall littoral gill netting and electrofishing surveys conducted for the past several years have recorded few individual adult kokanee in Lake Roosevelt (Lee et al. 2003). On Banks Lake, WA, shoreline spawning congregations of kokanee are sampled in the fall (Polacek and Shipley 2005) using the same sampling protocol used by Lake Roosevelt researchers.

The objective of the first year of this project was to monitor and evaluate the immigration of kokanee into Lake Roosevelt to determine immigration timing and size. The second year objective of this project was to continue trapping efforts to monitor downstream kokanee movement. Multi-year sampling is necessary so that results represent inter-annual differences in discharge and upstream dam operations.

## III. Study Area

Franklin D. Roosevelt Lake (Lake Roosevelt) is a Columbia River reservoir created in 1941 by the construction of Grand Coulee Dam (GCD) at river kilometer 960. The reservoir covers approximately 33,000 ha at a full pool elevation of 393 m (1,290 ft) above mean sea level and is managed as a National Recreation Area by the National Park Service. The dam was built for hydropower generation, flood control, and water storage for irrigation in the Columbia Basin Reclamation Project. The 10-year mean (1990-1999) drawdown was 12 m with a maximum drawdown of 24 m occurring in 1997 (DART 2007) and daily fluctuations in elevation are common (Figure 1). The reservoir reaches 241 km upstream from GCD, is generally 1-3 km wide, and has a maximum depth of 122 m. Water retention times are short (12-80 days) and the zooplankton community is more typical of a large river than a lake or reservoir (Black et al. 2003). Annual flows range from 60,000 to 130,000 cfs (DART 2007) depending on season and accumulative snow pack in the winter months (causing spring run-off) (Figure 2).

The study in area was located at the Little Dalles of the Columbia River approximately 12 miles south of the U.S. and Canadian border (Figure 3). The Little Dalles is a confined, narrow canyon (~100 m wide), experiencing depths greater than 50 m and discharge up to 8,500 $m^3/s$. Water levels in the Little Dalles can drop up to 8 m or greater as water elevations of Lake Roosevelt decrease in the spring for flood control (Figure 1). On February 12, 2008 we moved the traps to the log collection facility north of China Bend, approximately 2 kilometers south of the Little Dalles. This location enabled us to position the traps in the middle of the river as apposed to the shoreline in the Little Dalles. We believed that this would increase our chances of capturing kokanee, a more limnetic oriented species.

## III. Study Methods

The WDFW sampled fish entering the U.S. section of the Columbia River from Canada using an eight-foot screw trap (Figure 4) from October 24, 2006 through June 30, 2008. A second screw trap was fabricated and deployed adjacent to the original trap north of China Bend at the log collection boom. The screw traps sampled the top four feet of water (2.323 $m^2$), which represented a spatial sampling average of 1.9% of the total volume of water in the river channel. The screw traps were housed on a 32-foot pontoon barge, equipped with two 5-ton cable winches for trap fastening and maneuvering.

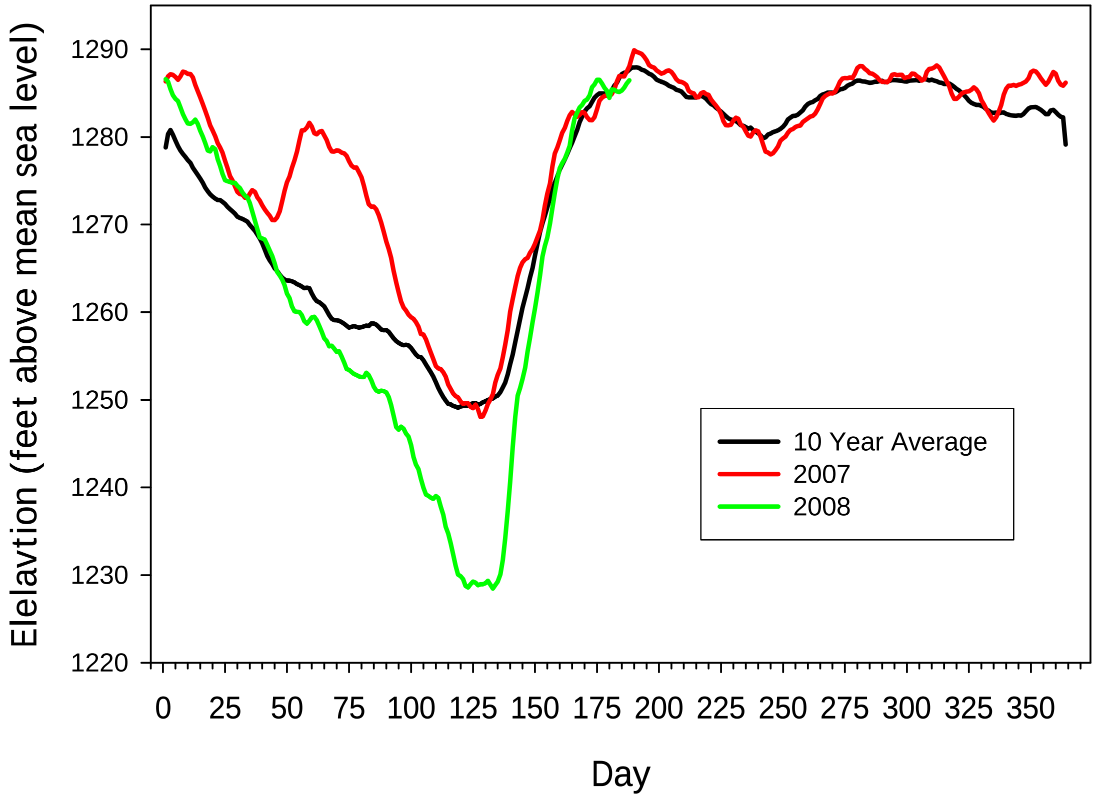


**Figure 1. The 10-year daily average for surface elevation (elevation above mean sea level), and surface elevations for 2007 and 2008 at Grand Coulee Dam on Lake Roosevelt, Washington. The elevation data were collected from the Columbia River DART web page. (http://www.cbr.washington.edu/dart/dart.html ).**

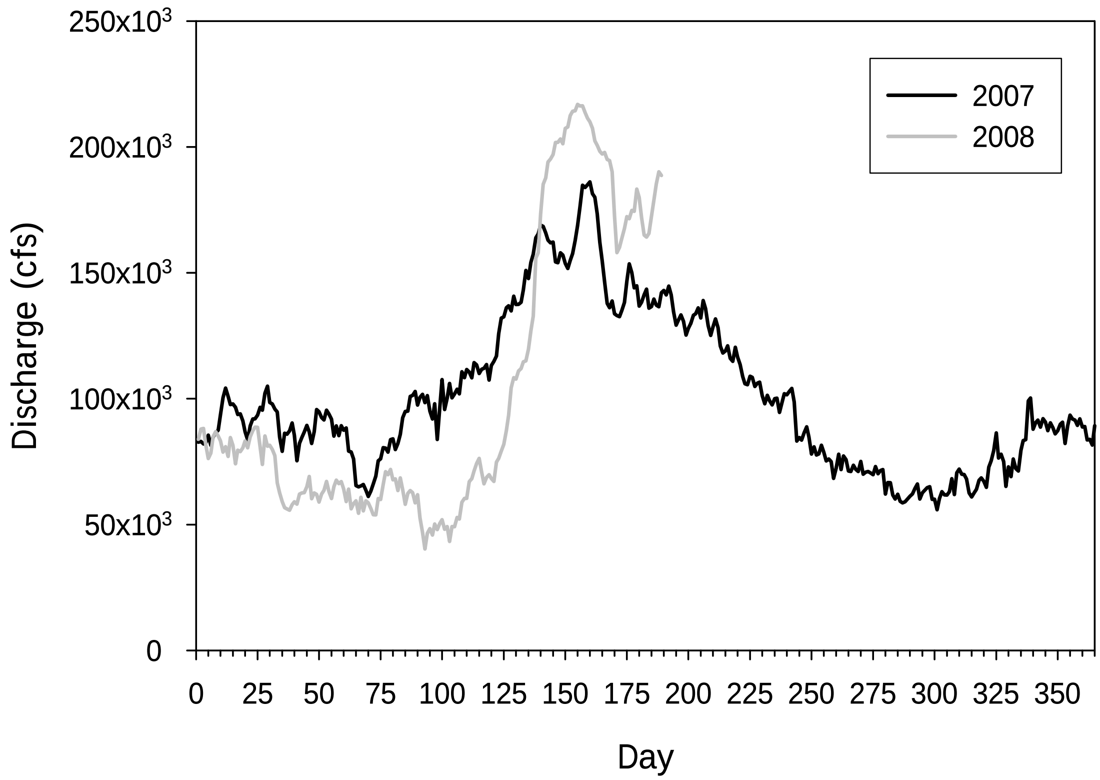


**Figure 2. The discharge (cubic feet per second) on the Columbia River at the U.S./Canadian Border for the years 2007 and 2008. The flow data were collected from the Columbia River DART web page (http://www.cbr.washington.edu/dart/dart.html) .**


**Figure 3. Map of the Columbia River Basin and the general location (indicated by the arrow) where sampling occurred. Sampling occurred in the Little Dalles from late October 2006 to late January 2008, and then north of the China Bend boat ramp from February 2008 to present.**

**Figure 4. The 2.4 m (8-foot) screw traps used to sample fish immigrating into Lake Roosevelt from Canada are located near China Bend on the Upper Columbia River above Lake Roosevelt. The traps are secured to a large metal float.**

Sampling occurred for 3-4 consecutive days each week (72-96 hours) to maximize the probability of capture dependent upon temporal fish movement. This design ensured a temporal sampling frequency of at least 43%. Capture efficiency tests were conducted at different flow regimes to determine the proportion of fish sampled by the trapping gear. Fish were marked and held in the live well, released directly in front of the trap, and/or released at a predetermined distance above the trap and recaptured at an unknown rate. These data were used to determine trap efficiency and if additional traps are needed to effectively sample the volume of water present at different time of the year.

All captured fish were identified, measured, weighed, marked to eliminate the recording of duplicate catch, and released below the trap. All unidentified fish were saved for identification in the lab. Water velocity measurements were taken twice daily with a Swoffer® 2100-14 flow meter. Flow measurements were taken directly in front of the traps in triplicate to calculate the volume of water sample by the trap.

Total catch and flows were stratified and analyzed in one-week blocks to reduce the chance of over estimating species-specific temporal entrainment movements. Total catch was corrected for effort and reported as a density (fish per 100,000 $m^3$) for comparisons with other trapping projects.

Temperatures were collected with HOBO® Water Temp Pro V2 data loggers. Data loggers were deployed at the beginning of the project to record hourly water temperatures (°C).

Volumetric expansion was used to estimate the total number of fish that passed by the study site in the top 1.2 m of water 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).

We calculated total discharge at the trapping site, where

$$Qt_t = D_t * V_t * W_t$$

$Qt_t$ = the total discharge ($m^3$/sec) at the study site at time (t)
$D_t$ = sampling depth (m) at time (t)
$V_t$ = final water velocity (m/s) at time (t)
$W_t$ = the distance (m) of the wetted river channel at time (t)

## IV. Results

The screw trap was disassembled and transported from Moses Lake, assembled in Kettle Falls, towed up the lake approximately 48 kilometers, and deployed in the Little Dalles in October 2006. The first day of trapping occurred on October 24, 2006. The trap was fastened to the bank on the east side of the river. The location provided sufficient laminar flow, in the most constrained section of the river (approximately 100 m across), and necessary shoreline access for trap checks. Kaiser Welding in Kettle Falls, Washington, fabricated a second trap in December 2007. The Spokane Tribe of Indians paid for this trap. The new trap was built to the exact specifications of the original trap and once completed it was assembled on the lake and towed to a location near China Bend. The original trap was moved from the Little Dalles downstream to the China Bend location and both traps were secured to a large floating drum in the middle of the river. This location provided a more limnetic sampling site compared to the shoreline site in the Little Dalles.

The screw traps were operated for 6,877 hours and yielded 1,266 fish from October 2006 through June 2008. Overall catch rates were 0.18 fish/hour, with the highest and lowest catch in April and February, respectively (Figure 5). The species composition was dominated by juvenile bluegill (*Lepomis macrochirus)* (n = 476; mean TL = 34.6 mm) and speckled dace (*Rhinichthys osculus*) (n = 355; mean TL = 59.2 mm). Other fish species captured in order of abundance included northern pikeminnow (*Ptychocheilus oregonensis*) (n = 161), sculpin (*Cottus* spp.) (n = 64), longnose sucker (*Catostomus catostomus*) (n = 43), rainbow trout (*Oncorhynchus mykiss*) (n = 36), kokanee (n = 33), peamouth (*Mylocheilus caurinus*) (n = 17), and others (n = 81) (Table 1).

Water velocity measurements varied by week, dependent on water elevations of Lake Roosevelt and discharge from upriver dams. Mean water velocities in the Little Dalles ranged from 0.47 m/s in mid-October 2007 to 3.55 m/s in late January 2007. Water velocities at the China Bend site ranged from 0.57 m/s in February 2008 to 2.24 m/s in late May 2008. The traps sampled a total of 80.28 x $10^6$ $m^3$ of water during the study period. Assuming that water velocities at the traps represented velocities across the river channel (channel width 100.9 m), a total of 7.84 x $10^9$ $m^3$ of water passed the study site in the top 1.2 meters (4 feet). Volumetric expansion of catch, assuming homogenous distribution, resulted in a total of 161,340 fish passing the study site from October 24, 2006 to June 30, 2008. Expanded estimates yielded 61,899 bluegill, 42,774 speckled dace, 18,393 northern pikeminnow, and 4,071 kokanee that passed by the traps in the top four feet of water from October 2006 through June 2008 (Table 2). A much higher number of fish most likely occurs because we expanded our fish densities to the top four feet of water (the depth sampled by the traps).

Water temperatures varied seasonally with a maximum temperature of 22.9 $^oC$ in September and a minimum temperature of 1.7 $^oC$ in February. Monthly average temperatures across years yielded a high of 18 (0.11 2SE) °C in August and low of 2.9 (0.05 2 SE) °C in February (Figure 6).

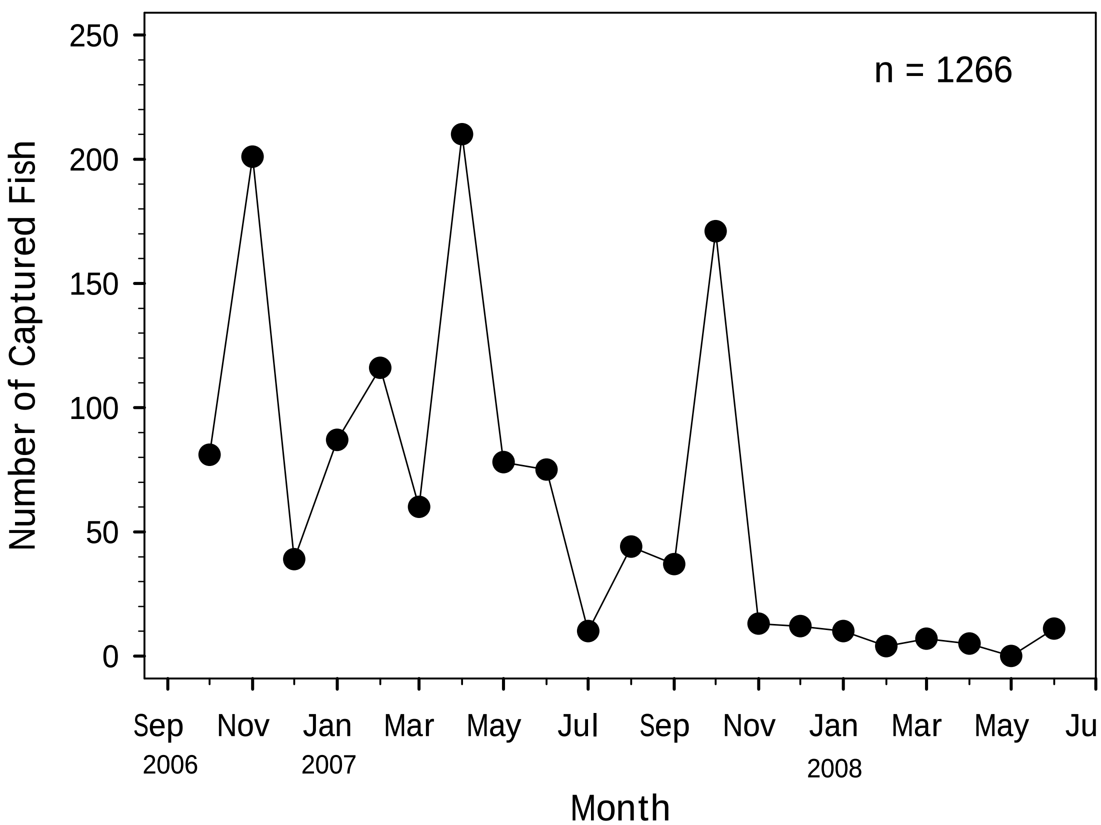


Figure 5. The monthly catch of fish in the Upper Columbia River, Washington from October 2006 through June 2008. Fish were captured in a 2.4-meter (8 foot) screw trap.

Table 1. Total catch, mean total length (mm) (± 2 standard errors (SE)), and catch per unit effort (fish/hour) for fishes captured in the 2.4 m (8 foot) screw trap at the Little Dalles, Columbia River, Washington.

| Species | n | Mean Length (mm) | 2 SE | CPUE (fish/hour) |
|---|---|---|---|---|
| Black Crappie | 1 | 161.0 | -- | 0.000 |
| Bluegill | 476 | 34.6 | 0.6 | 0.069 |
| Bridgelip sucker | 7 | 67.7 | 10.5 | 0.001 |
| Chiselmouth | 4 | 47.0 | 5.6 | 0.001 |
| Cottid | 64 | 40.4 | 3.4 | 0.009 |
| Kokanee | 33 | 168.4 | 10.6 | 0.005 |
| Largemouth bass | 2 | 96.5 | 113.0 | 0.000 |
| Longnose dace | 11 | 58.9 | 7.4 | 0.002 |
| Longnose sucker | 43 | 140.8 | 48.8 | 0.006 |
| Northern Pikeminnow | 161 | 52.1 | 2.8 | 0.023 |
| Peamouth | 17 | 39.3 | 5.0 | 0.003 |
| Rainbow Trout | 36 | 61.9 | 43.1 | 0.005 |
| Redside Shiner | 16 | 56.1 | 24.3 | 0.002 |
| Speckled dace | 355 | 59.2 | 14.0 | 0.052 |
| Smallmouth Bass | 3 | 57.7 | 14.4 | 0.000 |
| Tench | 1 | 46.0 | -- | 0.000 |
| Unknown | 23 | 39.0 | 6.6 | 0.003 |
| Unknown Sucker | 1 | 82.0 | -- | 0.000 |
| Walleye | 5 | 167.5 | 208.3 | 0.001 |
| Yellow perch | 7 | 73.8 | 38.5 | 0.001 |
| Grand Total | 1,266 | 54.0 | 2.5 | 0.183 |

Table 2. The estimated number of fish that passed by the trapping site in the top four feet of water on the Upper Columbia River north of China Bend, WA.

| Species | Number |
|---|---|
| Largemouth bass | 72 |
| Tench | 93 |
| Black Crappie | 374 |
| Walleye | 497 |
| Bridgelip sucker | 596 |
| Smallmouth Bass | 625 |
| Yellow Perch | 715 |
| Chiselmouth | 735 |
| Redside Shiner | 1,981 |
| Longnose dace | 2,252 |
| Peamouth | 2,654 |
| Unknown | 2,713 |
| Kokanee | 4,071 |
| Rainbow Trout | 4,291 |
| Longnose sucker | 8,002 |
| Sculpin | 8,604 |
| Northern Pikeminnow | 18,393 |
| Speckled dace | 42,774 |
| Bluegill | 61,899 |
| Grand Total | 161,340 |

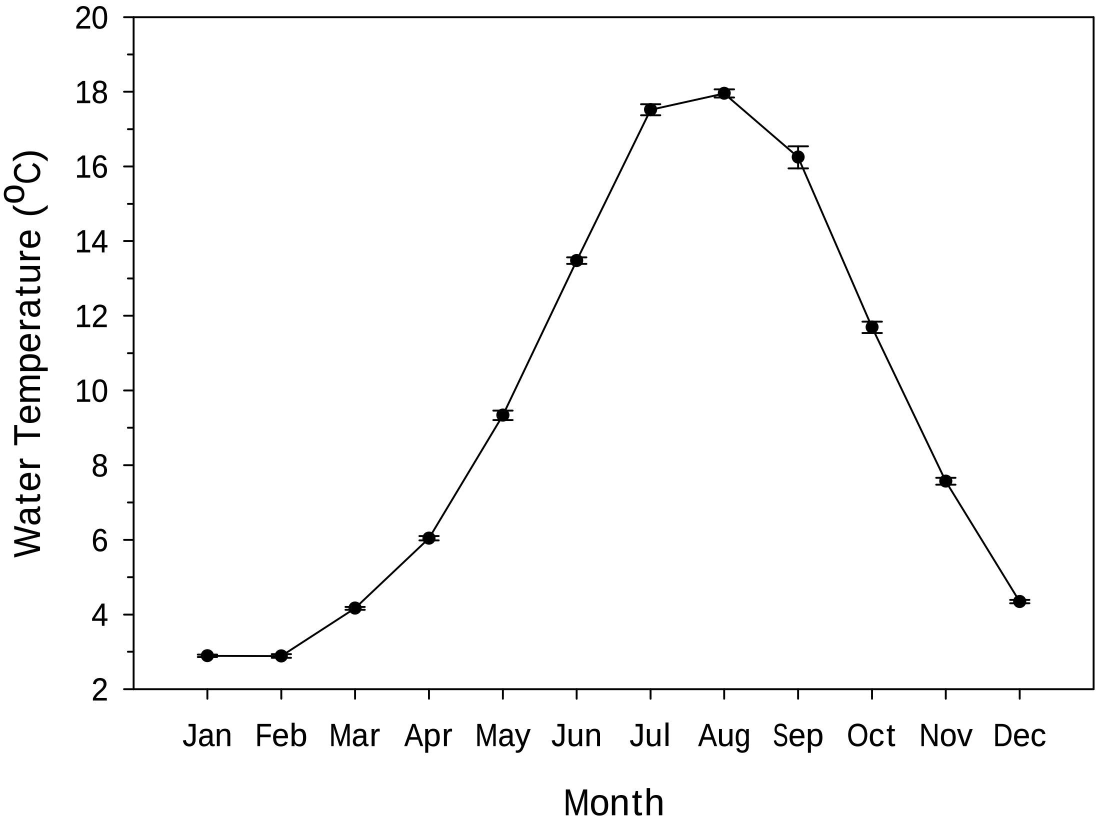


**Figure 6**. Mean monthly water temperatures with error bounds taken in the Upper Columbia River north of China Bend, WA. Temperatures were collected with HOBO® Water Temp Pro V2 dataloggers.

## V. Discussion

The primary objective of this project was to sample the kokanee that enter Lake Roosevelt from upstream reservoirs such as Kootenay and Arrow Lakes. Since a portion of wild stock kokanee were found to be from Canadian lakes (Kassler and Loxterman 2006) and are successful in Lake Roosevelt, it was of interest to local biologists and hatchery managers to understand the time and size when fish move downstream (most likely entrained from Keenleyside Dam) into the lake. We captured one wild and 32 hatchery kokanee during the study period. The hatchery fish were from of plants in Onion Creek, approximately one mile upstream from the study site. The wild kokanee was captured on February 7, 2008 and was 23 mm in length. The low capture rate of kokanee could have been attributed to several factors including: 1) kokanee densities were too low to detect by trapping, 2) kokanee did not follow the currents sampled by the trap, 3) kokanee traveled deeper than 1.2 m (the maximum sampling depth of the screw trap), and/or 4) low entrainment rates from upstream lakes/reservoirs.

Efficiency test results will be reported in future reports as sample sizes of the tests were insufficient due to relatively low catch at any one time and the difficulty of transporting the fish up the steep shoreline. The traps are now checked by boat, which will allow us to transport fish upstream for efficiency testing. If sample sizes do not increase, then we will attempt to get fish from the Sherman Creek or Colville hatcheries to use for efficiency tests.

The density and vertical distribution of kokanee entraining from upstream reservoirs are unknown. Future trapping studies will determine the feasibility and costs of using sonar to determine the vertical distribution of fishes as they pass the study site. Additionally, alternate sampling sites will also be evaluated for screw trap placement. Sampling sites must provide laminar flow, anchoring points on the shoreline (trees or large rocks) or from existing buoys, and safe access by foot or boat. Alternate sites would allow us to sample a variety of currents, where wild kokanee may be distributed. In July or August 2008 we plan to move both traps to the state route 25 bridge in Northport. This location will provide higher flows when lake levels are high and less water is released from the Lake Pend Oreille (Idaho) and the Arrow and Kootenay Lakes (Canada).

Due to the physical conditions of Lake Roosevelt with respect to lake elevations, we operated using an adaptive management approach. The original location of the trap was relatively easy to reach; however, when water elevations of Lake Roosevelt began to drop in late winter and early spring, access was more difficult, and at times required operators to use climbing gear to reach the trap. To assure safety, we continually modified our standard operating procedures to minimize the risk associated with operating the screw trap, such as the use of climbing gear, use of personal floatation devices (PFD's), and frequent "check-in" calls to the office. The current location of the traps allows access by boat. Boating procedures have been implemented to minimize risk associated with high flows and floating debris.

Data collection projects on large lotic systems that experience high discharge and high velocities can be problematic, leading to periods when sampling cannot be conducted. During this project period, we experienced various issues that made our trapping efforts difficult. On April 12, 2007 a major mechanical failure occurred, resulting in the loss of data collection. The shaft that was welded to the cone and passed through the front pillow block sheared, causing the front of the cone to drop and become pinned against the steel suspension frame. To repair the trap, we replaced the previously hollow shaft with a four-foot aluminum solid stock axle and replaced the pillow block. In order to make the necessary modifications we had to transport a welder and gear via boat from Kettle Falls to the trap because the trap was not accessible by truck.

The second major event occurred on June 13, 2007, which resulted in the entire cone suspension frame becoming severely damaged. We were unsure of the mechanism that caused the damage, but it was extensive as the steel frame was broken in some locations and considerably bent in others. At that time we did not have the funds to fix the frame, however, we fitted the barge with a winch arm capable of deploying and retrieving a trawl net deployed behind the screw trap. The trawl net had a 5x5 foot opening, was 20 feet long with a 2-foot cod end, and sampled from the surface to 5 feet deep (2.323 $m^2$). The net contained ringed baffles to help retain captured fish. The area of the frame net was identical to that of the screw trap, sampled the same amount of water (1.9 %), and therefore did not alter our sampling effort.

In the middle of May 2008 one of the traps detached from the floating drum and settled inside the log boom. At that time flows were too high to tow the trap out of the log boom. We were able to reposition the trap in its original location in the middle of June once flows decreased.

## VI. Conclusions

Due to the minor contribution of hatchery kokanee to the Lake Roosevelt creel, the absence of documented shoreline spawning, and the open water habitat use of this species, the WDFW concluded that the effects of an additional one-foot drawdown would not directly affect kokanee at the shoreline. Indirect effects may occur with the loss of zooplankton and fish through entrainment. Mitigation resources for fish loss should be used to identify the contribution of wild origin fish to the lake and understand immigration timing and size from fish entraining from Canadian reservoirs and entering Lake Roosevelt. Since wild origin upriver kokanee are successful in Lake Roosevelt, results from this study could heavily impact the current hatchery release practices to mimic immigration timing and size, and ultimately maximize recruitment of kokanee to the creel and escapement to egg collection facilities.

Hatchery origin kokanee dominated the kokanee collected during the study period. Due to mechanical failures of the trap(s), we missed a total of seven weeks of sampling over the past 20 months, mostly during the highest flows when fish movements may peak. Investigations of alternate sample sites and using sonar to determine vertical fish distribution, and adding additional traps will increase our understanding of where to place the traps and if secondary gear types should be deployed (trawl nets and/or incline plane traps).

## VII. Acknowledgements

We would like to thank the Washington State Department of Ecology for funding this project as part of the Columbia River Water Management Program (CRWMP). We greatly appreciate the help of Eric Weatherman and crew of Columbia Navigation for donating their time and equipment to help assemble and maneuver the screw traps. We thank Mitch Combs (WDFW) for logistical support, and the project technicians Aulin Smith, Kevin Vaillancourt, Josh McLellan, and Fritz Wichterman for operating the trap and collecting the data used in this report. We acknowledge Josh Harmon for his help during trap deployment and for conducting welding repair. Lastly, we thank the Bruner family for providing lodging, storage, and land access to the trapping site.

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