LAKE SAMMAMISH WATERSHED
NATIVE LATE-RUN KOKANEE
STOCK ASSESSMENT AND MANAGEMENT PLAN

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INTRODUCTION

The Lake Washington-Sammamish Watershed is one five watersheds in Washington (Baker, Whatcom, Wenatchee, and Chelan) that support native populations of resident *Oncorhynchus nerka* or kokanee (Pfeifer 1995). There have been three distinct kokanee populations within the Lake Washington-Sammamish Watershed, including the early, middle, and late-runs (Berge and Higgins 2003). Early-run kokanee were only known to spawn in Issaquah Creek. Middle-run kokanee spawn in tributary streams to the Sammamish River, including Swamp, North, Bear, Little Bear, and Cottage Lake creeks. Late-run kokanee spawn in south Lake Sammamish tributaries, such as Lewis, Ebright, Laughing Jacobs, Vasa, Pine Lake, and East Fork Issaquah creeks.

Native kokanee within the Lake Sammamish Watershed were once very abundant. Anecdotal accounts from former Issaquah Salmon Hatchery staff and former University of Washington graduate student T.J. Berggren estimated escapement of early-run kokanee to range from 3,000-15,000. However, in the early 1980's natural resource managers became alarmed over declines in kokanee abundance from historic levels (Pfeifer 1995). Special concern was given to the early-run population in Issaquah Creek. After nearly two decades (between 1973-2002) of spawner surveys and two years (2001 & 2002) of adult trapping, early-run kokanee are now classified as extinct. Now, late-run kokanee are experiencing declines in abundance. The goal of natural resource managers is to build upon the current knowledge base of late-run kokanee populations, continue to monitor escapements in south Lake Sammamish tributaries, and ensure that this stock does not follow the same path as the early-run stock.

OBJECTIVES

The objective of this stock assessment and management plan is to provide existing information on late-run kokanee biology, ecology, stock status, factors of decline, and to document the Washington Department of Fish and Wildlife (WDFW), Region 4 Fish Program's commitment to monitoring and participating in efforts to maintain and increase populations of late-run kokanee in the Lake Sammamish Watershed. However, it is important to note that WDFW Fish Management Division's authority only extends to stock assessment, harvest, and hatchery management. Since kokanee fishing in Lake Sammamish has been closed for several years, this document will therefore focus on monitoring and hatchery supplementation commitments. Other factors causing declines in late-run kokanee populations, such as habitat degradation or poor water quality, lie within the authority of other natural resource agencies (i.e., King County DNRP and DDES, the cities of Issaquah, Bellevue, and Sammamish, DOE, etc.). Finally, this stock assessment and supplementation-oriented management plan alone will not ensure long-term viability of late-run kokanee populations in Lake Sammamish. All factors of decline must be addressed in an integrated strategy in order to significantly improve and maintain this stock's productivity, genetic diversity, and spatial distribution into the future. In the case of late-run kokanee, it is likely that achieving this outcome will require significant improvements to habitat that appears to have contributed significantly to their decline.

BIOLOGY, ECOLOGY, AND STOCK STATUS

Biology & Ecology

Kokanee are the resident form of *Oncorhynchus nerka* that spend their entire life history in freshwater environments. Typically, kokanee exhibit an adfluvial life history strategy where spawning and rearing occurs in tributary streams/rivers and lake environments, respectively (Berge and Higgins 2003; Scott and Crossman 1998). However, beach spawning occurs in some kokanee populations making this segment of the population true lake residents. While in the lake environment kokanee inhabit the pelagic zone and feed almost exclusively on zooplankton. Sexual maturity occurs at age 4 (i.e., 3+), however, some spawning adults may be age 3, 4, or 5. Spawning typically occurs during the fall months of September through November, but in Lake Sammamish kokanee spawn through January (Berge and Higgins 2003). Like other salmon, kokanee are semelparous, senescing may spawn following spawning.

Late-run kokanee native to the Lake Sammamish Watershed are genetically distinct from other kokanee stocks within and outside of the watershed (Young et al 2004). This genetic uniqueness is in spite of the fact that approximately 35 million Lake Whatcom kokanee fry were stocked into Lake Sammamish from 1976-1979 (Pfeifer 1995), which have a similar spawn timing as the late-run stock.

Lake Sammamish late-run kokanee are named for their later than normal spawn timing, which begins in October and continues into January. Although peak spawning can vary annually and between different tributaries, it generally occurs within the first two weeks of December (Berge and Higgins 2003). Late-run kokanee have been observed spawning in Lewis, Laughing Jacobs, Ebright, Pine Lake, Vasa, and East Fork Issaquah creeks. However, the core late-run kokanee spawning tributaries are Lewis, Laughing Jacobs, and Ebright creeks. Tibbets Creek, another south Lake Sammamish tributary, is believed to have limited late-run kokanee spawning, but in the past 8 years no kokanee have been documented there. Kokanee beach spawning has been observed near the mouths of Ebright and Laughing Jacobs creeks and along Sulphur Springs point on the east side of Lake Sammamish during early November and December (Berge, pers. Comm.). Although the beach spawning coincides with the late-run kokanee spawn timing, it has not yet been confirmed whether the observed beach spawning fish are part of the same population segment as late-run stream-spawning kokanee or not. Spawning adult late-run kokanee lengths average around 18 inches (453 mm) fork length and typically mature at age 4 (i.e., age 3+). Juvenile kokanee emergence and entry into Lake Sammamish is dependent upon the time of egg deposition (i.e., early or late within the spawning period) and water temperature. But, in general emergence and lake entry occurs between April and May.

Stock Status

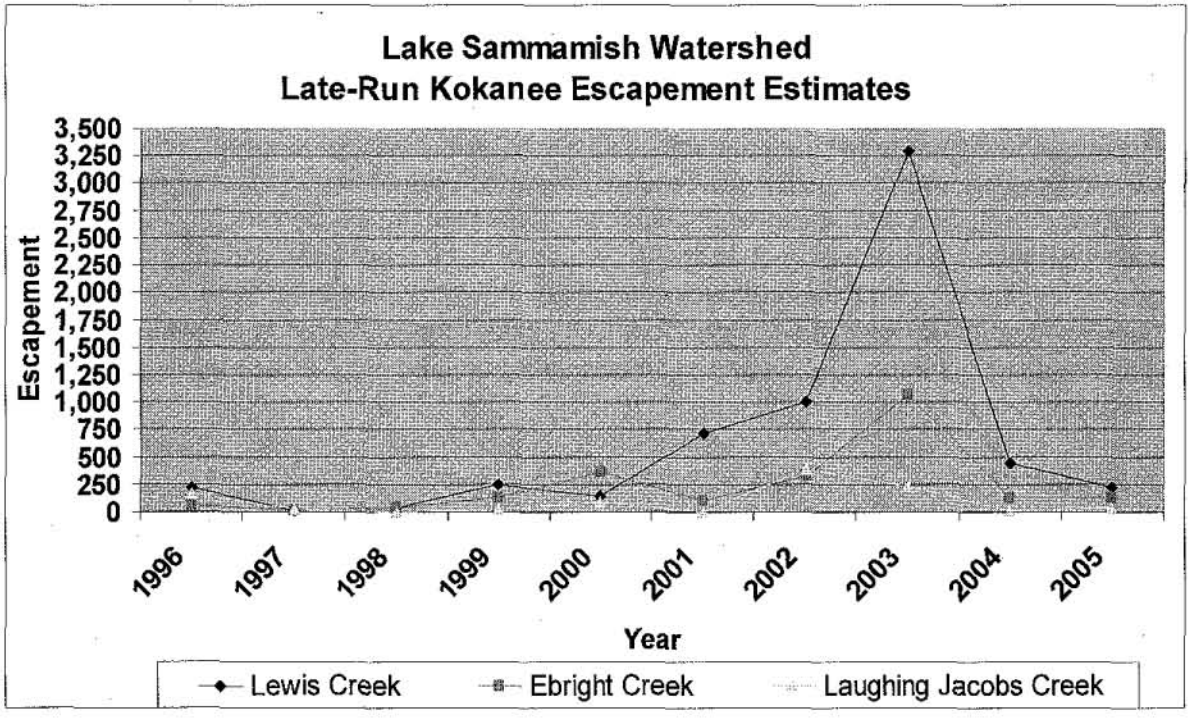
There is almost no information regarding historical abundances of late-run kokanee in the Lake Sammamish Watershed against which to compare current abundances. Most of the

historical abundance information in the literature addresses the early-run kokanee in Issaquah Creek, which ranged on the order of 3,000 to 15,000 fish (Pfeifer 1995). Current area under the curve (AUC) escapement trends of late-run kokanee within the core spawning tributaries (Lewis, Ebright, and Laughing Jacobs creeks) average 972 spawners (n=10 years) and range between 54-4,591 (Table 1 & Figure 1). These abundance trends are undoubtedly depressed from historical levels based on anecdotal information from past escapement estimates, but data is almost nonexistent. Of special concern is the occasional year class collapse or near collapse within individual tributaries. It was a series of such collapses or failures that ultimately drove the early-run stock to extinction.

Table 1. Late-run kokanee AUC escapement trends in the three core spawning tributaries in the Lake Sammamish Watershed.

	CREEK NAME/ESCAPEMENT ESTIMATES			
YEAR	**LEWIS**	**EBRIGHT**	**LAUGHING JACOBS**	**COMBINED**
1996	219	70	170	459
1997	10	15	29	54
1998	43	40	0	83
1999	247	134	27	408
2000	143	362	92	597
2001	722	110	2	834
2002	1,002	319	384	1,705
2003	3,296	1,063	232	4,591
2004	442	134	18	594
2005	217	135	44	396
AVERAGE:	**634**	**238**	**100**	**972**

Figure 1. Late-run kokanee AUC escapement trends in the three core spawning tributaries in the Lake Sammamish Watershed.



FACTORS OF DECLINE

Given that kokanee spend their entire life cycle in freshwater, ocean conditions cannot be blamed for their decline. Harvest as well is an unlikely factor due to low levels of incidental harvest of kokanee in Lake Sammamish. It is apparent, then, that conditions in freshwater habitats used by kokanee should receive primary attention in assessing factors of decline. Urban development over the past several decades has most likely contributed to declines in late-run kokanee populations within the Lake Sammamish Watershed. Specifically, urban development along the tributary streams has negatively affected the quality and quantity of spawning and early life history rearing habitat. Residential development has simplified the hydrology of tributary streams utilized by late-run kokanee. Bank stabilization and channeling has decreased stream complexity by reducing the number of pools and other beneficial habitat features. One of the consequences of decreased stream complexity is the negative impact of periodic flood events. Within the Lake Sammamish Watershed flood events primarily occur during the fall and winter months and therefore coincides with late-run kokanee staging and spawning. During these flooding events water is essentially forced through the modified stream channel, instead of dissipating into a flood plain, and has a significant scouring effect. Depending upon the magnitude of the flood event, flows may push spawning gravels out of the tributary streams, scour kokanee redds, or displace staging adults (Berge and Higgins 2003). The reduction in connectivity of the stream channel to the flood plain also deprives spawners and their progeny of shelter habitat during flood events. Annual flood events certainly could be negatively affecting kokanee year class strength. Although the relationship between flood events and late-run kokanee year class strength has not been evaluated, the late-run kokanee year class failures observed may be related to flood events.

Another habitat impact affecting late-run kokanee is the blockage of fish passage to the upper parts of the core spawning tributary streams (i.e., Lewis, Laughing Jacobs, Ebright creeks). Late-run kokanee spawning in Lewis, Laughing Jacobs, and Ebright creeks only have access to less than a mile of stream. Most notable of the three tributaries is Lewis Creek where kokanee have access to 0.75 miles of stream (longest of the three spawning tributaries) until they reach the I-90 culvert that blocks passage to approximately 2,000 square-meters of spawning habitat (SSHEAR 2000).

It is apparent that if tributary habitat improvements are not made late-run kokanee population productivity will not improve and may decrease posing the threat of local or population extinction.

MONITORING COMMITMENTS

The Region 4 Fish Program (R4FP) is committed to annually monitor late-run kokanee populations within the Lake Sammamish Watershed. Annual monitoring will allow

WDFW and other interested entities to better evaluate late-run kokanee escapement trends and make timely decisions regarding the management and/or conservation of this stock. Furthermore, if south Lake Sammamish tributaries undergo any habitat improvement or restoration projects, R4FP's annual monitoring of late-run kokanee escapement will perhaps be the best method to evaluate the success level of these projects.

It is important to note that the monitoring plan described below will utilize existing R4FP staff, principally the area inland fish biologist, to collect and report stock assessment and other pertinent information on late-run kokanee. However, work plans and staffing levels are subject to change and the amount of data collected during late-run kokanee surveys may be modified to accommodate these changes. If changes to the monitoring plan are necessary the R4FP will communicate and discuss these issues with the Lake Sammamish Watershed Kokanee Technical Committee. At a minimum, the R4FP will annually collect the data needed to estimate escapement of late-run kokanee in the core spawning tributaries. Below is a description of R4FP's late-run kokanee monitoring plan.

Spawner Surveys

The area inland fish biologist will conduct weekly live counts of late-run kokanee in Laughing Jacobs, Lewis, and Ebright creeks from October through January. These creeks represent the majority of late-run kokanee spawning activity in the Lake Sammamish Watershed. For tributary streams like Pine Lake and Vasa where late-run kokanee spawning has been documented, we will conduct spot check surveys during peak spawning. Survey dates on Pine Lake and Vasa creeks will likely occur during peak spawning event on Laughing Jacobs, Lewis, and Ebright creeks, which occur in early December. Data collected during the surveys includes counts of live and dead late-run kokanee, lengths from dead kokanee, sex identification, and otolith collection.

Hydrograph Data

Historical and current flow data will be collected from USGS gauges on Tibbets and Issaquah creeks, and King County gauges on Lewis, Ebright, and Laughing Jacobs creeks. This data will be analyzed to assess how the hydrology has changed in south Lake Sammamish tributaries and evaluate the potential affects of hydrologic change on late-run kokanee populations.

Reporting

After late-run kokanee spawning has ceased the area inland fish biologist will draft a management brief for distribution between late winter and early spring summarizing data collection efforts. Information included in management brief includes: 1.) Summary of live and dead counts from each creek surveyed, 2.) Length frequency, 3.) Age structure, 4,) Sex ratio, 5.) Escapement estimates for Laughing Jacobs, Ebright, and Lewis creek, and 6.) Escapement trends for each tributary stream. Compiling and analyzing hydrograph data will take some time to complete, so either a separate management brief will be distributed upon completion or future management briefs will report this analysis.

HATCHERY SUPPLEMENTATION COMMITMENTS

If late-run kokanee populations begin to exhibit significant declines in spawner abundance, hatchery supplementation may be necessary to restore depressed populations or prevent extinction. The role of hatchery supplementation, in general, is to circumvent high early life stage mortality rates in the wild. However, it is important to note that hatchery supplementation alone will not recover depressed fish populations. Hatchery supplementation helps maintain consistent abundances until the major factors of decline can be addressed and resolved.

In 2001, Charles Hopley drafted a hatchery supplementation plan for the now extinct Issaquah Creek early-run kokanee stock. That plan lists four supplementation options that may be initiated alone or in concert with one another. These options are appropriate as well for supplementation of the late-run kokanee stock. It is the R4FP's recommendation that the Lake Sammamish Kokanee Technical Committee adopt Charles Hopley's plan in the event hatchery supplementation is required to restore late-run kokanee populations. Below is a brief summary describing each of the four hatchery supplementation options.

Supplementation Options

Option 1-Fingerling Release: This Option will primarily circumvent limitations that occur at the time of spawning, during egg incubation, hatching, emergence and early migration. This option would be attractive if it is assumed that survival bottlenecks occur at some point from spawning to downstream migration. Conversely, it would be assumed that post-emigration factors are not the factors limiting productivity.

For the initial cycle, eggs from 5-25 females (2,000 to 10,000) will be fertilized following a prescribed mating protocol and incubated in isolation incubation buckets and vertical incubator trays, separated by family lots, until hatching. Resulting fry will be transferred to rearing vessels in individual family lots and reared according to prescribed criteria. As fry achieve adequate size they will be marked according to family and redistributed to rearing vessels of appropriate capacity to accommodate continued growth. Fingerlings will be reared to 50 fish/lbs (9g) and released into tributary streams in June after approximately 2 months of rearing. Returning adult brood stock would be recovered within tributary streams to generate the subsequent rearing cycle.

Option 2-Extended Reared Fingerling Release: This option will primarily circumvent limitations that occur between the times of spawning and initial rearing in the lacustrine environment. This option would be attractive if it is assumed that survival bottlenecks occur at some point from spawning through early rearing in the lake. Conversely, it would be assumed that the lake rearing environment is not limiting productivity between the summer of first entry to the lake and adult maturation.

For the initial cycle, eggs from 5 to 25 females (2,000 to 10,000) will be fertilized following a prescribed mating protocol and incubated in isolation incubation buckets and vertical incubator trays, separated by family lots, until hatching. Resulting fry will be transferred to rearing vessels in individual family lots and reared according to prescribed

criteria. As fry achieve adequate size they will be marked according to family and redistributed to rearing vessels of appropriate capacity to accommodate continued growth. Fingerlings will be reared to 30 fish/lbs (15g) and released into tributary streams in October after approximately 6 months of rearing. Returning adult brood stock would be recovered within tributary streams to generate the subsequent rearing cycle.

Option 3-Yearling Release: This option will primarily circumvent limitations that occur from spawning through the first year of life. This option would be attractive if it is assumed that survival bottlenecks occur during early life stages including the first year of lake residency. This alternative might also be attractive if one assumed that a relatively large size at release would provide a survival advantage. Conversely, it would be assumed that the lake rearing environment was not a factor limiting productivity for kokanee of yearling size or greater.

For the initial cycle, eggs from 5 to 25 females (2,000 to 10,000) will be fertilized following a prescribed mating protocol and incubated in isolation incubation buckets and vertical incubator trays, separated by family lots, until hatching. Resulting fry will be transferred to rearing vessels in individual family lots and reared according to prescribed criteria. As fry achieve adequate size they will be marked according to family and redistributed to rearing vessels of appropriate capacity to accommodate continued growth. Yearlings will be reared to 15 fish/lbs (30g) and released into tributary streams in May-June after approximately 14 months of rearing. Returning adult brood stock would be recovered within tributary streams to generate the subsequent rearing cycle.

Option 4-Captive Brood: This option will circumvent all life stages risks encountered in the natural environment. This option assumes that all life stages are limiting in the natural environment or that life stage limiting factors are not known. This option also assumes that life stage cumulative mortality rates will be reduced in the hatchery compared to the wild and that net reproductive efficiency will be greater in the hatchery than in the wild.

For the initial cycle, eggs from 5 to 25 females (2,000 to 10,000) will be fertilized following a prescribed mating protocol and incubated in isolation incubation buckets and vertical incubator trays, separated by family lots, until hatching. Resulting fry will be transferred to rearing vessels in individual family lots and reared according to prescribed criteria. As fry achieve adequate size they will be marked according to family and redistributed to rearing vessels of appropriate capacity to accommodate continued growth. Fingerlings will be retained and reared to adult maturation. Adults will be spawned according to prescribed mating protocols to assure maximum effective population size and to avoid sibling matings.

Supplementation Guidance

Initiating a hatchery supplementation program is a major commitment of funds and staffing. It is important that committing to a hatchery supplementation program is not the result of a rushed reaction to a single year of low late-run kokanee escapement. Since there is no quantitative data addressing minimum threshold escapement levels or

minimum viable population size for late-run kokanee, knowing when to initiate a hatchery supplementation program can be difficult. Therefore, the Lake Sammamish Watershed Kokanee Technical Committee should meet following the conclusion of spawner surveys every year to evaluate if late-run kokanee population status and recent escapement trends warrant a hatchery supplementation program. Addressing this issue early allows the technical committee to thoroughly analyze escapement data, review the specific details and learn from other salmonid stocks where a hatchery supplementation program was initiated, determine whether to supplement annually or only for future year classes that are expected to be exceptionally low in abundance, and finally reach technical agreement on whether or not to initiate such a program. Additionally, there is currently no WDFW funding dedicated or earmarked to initiate a hatchery supplementation for late-run kokanee. Therefore, reaching technical agreement early in the year provides enough time for participants to address the funding issue. It will also give R4FP staff time to address brood stock collection and culture logistics with hatchery staff.

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