Kokanee Stocking, Monitoring and Management at Clearwater Basin Lakes

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Introduction and Background

Landlocked Sockeye Salmon (*Oncorhynchus nerka*), known as 'Kokanee', are a popular sportfish in Montana and across the Western United States and Canada. Their native range includes portions of California, Washington, Oregon, Idaho, Alaska, and British Columbia, but the species has been introduced and propagated in numerous other Western states to enhance coldwater fishing opportunity (Rieman and Myers 1991).

Adult and sub-adult Kokanee primarily reside in freshwater lakes and reservoirs. Many populations are completely self-sustaining (wild), while others are maintained partially or completely through hatchery supplementation. For wild populations, successful spawning typically occurs in adjacent rivers, streams, or lake outlets, but may also occur in springs and shoals along lake shorelines (Rieman and Myers 1992).

Natural reproduction and early life history patterns are variable and somewhat plastic for Kokanee populations. However, they predominantly spawn in late fall and early winter, 1.5-2.5 years after fry emergence or stocking (Rieman & Myers 1991). Like Sockeye Salmon and other anadromous salmonids, mature adults undergo significant morphological and physiological changes prior to reproduction and die after spawning.

Kokanee are generally much smaller than anadromous (sea run) forms of Sockeye Salmon, with adults usually reaching lengths of 200 – 400 mm (8 to 16 inches) and weights of 200 – 1,100 g (0.5 – 2.5 pounds). Variation in growth may be influenced by genetic characteristics and longevity, but primarily relates to population abundance (inverse relationship) and inherent differences in lake food availability and productivity (positive relationship). In addition, the food habits (diet composition) of subadult and adult Kokanee (as well as anadromous Sockeye salmon) are significantly different than other Pacific salmon species. They primarily eat plankton, aquatic insects, and other invertebrates throughout their life span instead of transitioning to a piscivorous diet.

Figure 1. Adult Kokanee (*Oncorhynchus nerka*) from a western Montana lake.

Clearwater Basin Kokanee Fisheries

In Montana, Kokanee were initially stocked in Flathead Lake (~1914), then subsequently planted in lakes and reservoirs across the Western half of the state on both sides of the continental divide (MFWP, Historic Records). Original sources for Montana Kokanee populations included Lake Chelan and other native western Washington stocks (MFWP Historical Files). Introductions in west-central Montana began in the 1940s-1950s and included most low elevation lakes in the Clearwater River drainage (Figure 2). These populations, along with Georgetown Lake near Anaconda, represent the viable kokanee fisheries currently available to anglers in west-central Montana (FWP Region 2). Although all Clearwater Basin populations maintain some level of natural reproduction, stocking programs have continued to supplement and support these Kokanee fisheries since establishment.

Kokanee populations in Clearwater Basin lakes have historically varied in quality over time and among water bodies (MFWP, unpublished data). This variation primarily stems from changing Kokanee population densities and the underlying productivity of different lakes. 'Stunting' is a common problem in Kokanee fisheries supported by natural reproduction, as they often overpopulate and overwhelm food resources (Rieman & Myers 1992). This is particularly true in relatively unproductive, sterile lakes with readily available spawning habitat and waters with high levels of interspecies competition. In the Clearwater chain of lakes, productivity and Kokanee growth rates range from low (e.g., Alva and Inez Lakes) to relatively high (Salmon and Placid Lakes).

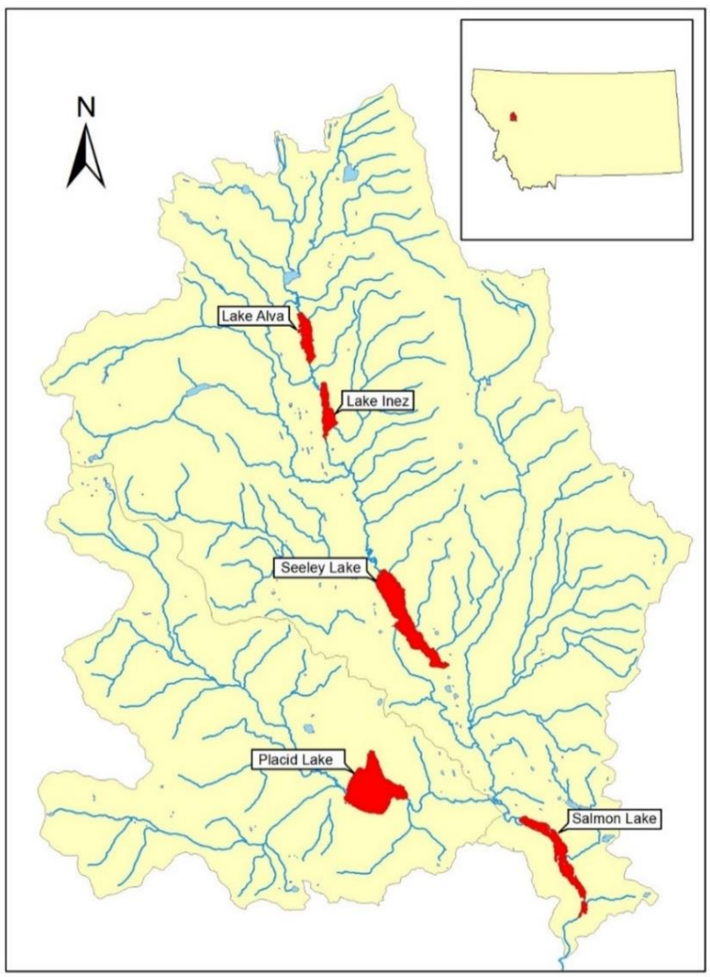

Figure 2. Clearwater Basin lakes currently supporting kokanee populations (red).

Managing kokanee densities, size structure, and growth rates is further complicated by introduction of new fish species that compete with and prey upon kokanee. Nonindigenous fish introductions have been prevalent in the Clearwater Basin's interconnected lake and river system over the past half century. Introduced fish include predator species such as Northern Pike (*Esox lucius*), Brown Trout (*Salmo trutta*), Largemouth Bass (*Micropterus salmoides*), and Smallmouth Bass (*Micropterus dolomieu*), as well as competitors including Yellow Perch (*Perca flavescens*), Pumpkinseed sunfish (*Lepomis gibbosus*), Brook Stickleback (*Culaea inconstans*), Central Mudminnow (*Umbra limi*), Brook Trout (*Salvelinus fontinalis*), and Rainbow Trout (*Oncorhynchus mykiss*). These species supplement numerous native salmonid and non-salmonid fishes that also inhabit the system, creating complex and competitive aquatic environments, with high demands for prey resources.

Angler harvest is another important factor that can influence kokanee abundance and growth rates. Fishing pressure for Kokanee varies considerably among lakes in the Clearwater Basin (MFWP Statewide Angler Pressure Estimates and Angler Surveys), but is low to moderate in all cases and does not currently appear to affect Kokanee population abundance or size structure. Recent fishing regulation changes (liberalizing harvest) at all lakes and in some spawning areas coincided with decreases in stocking rates throughout the drainage in 2013-2014 (MFWP, Unpublished Data). These changes have been continued as part of current management strategies.

Kokanee fishery management involves balancing all of these interacting facets to optimize population abundance and growth rates. Stocking rates are also a key component, particularly where natural reproduction is limited or inconsistent. Because factors influencing fishery quality and consistency vary among water bodies and through time, monitoring and management flexibility are important aspects of the overall program and emphasized in this report.

Specific objectives of this report and Kokanee management in the Clearwater Basin include:

(A) Document and monitor Kokanee size structure and relative abundance in the five Clearwater Basin lakes supporting viable populations.
(B) Identify tributary spawning locations for each lake population and monitor relative abundance and size structure of spawning adults over time.
(C) Determine and monitor the relative abundance of stocked vs wild Kokanee in each lake population and at tributary spawning locations to inform stocking rates and stocking effectiveness.
(D) Incorporate data related to A, B, & C above to increase Kokanee fishery quality and promote population stability. Specifically, manage Kokanee populations that consistently provide adults that are greater than 11 inches.

Methods

In 2009-2020, we surveyed Kokanee populations in Lake Alva, Lake Inez, Seeley Lake, Salmon Lake, and Placid Lake to evaluate the size structure, relative abundance and stocking rates for each water body. These data serve as a baseline for ongoing monitoring and the basis for recommended fishing regulation changes and adjustments to the lake stocking program.

Kokanee Stocking and Marking

Most Kokanee fisheries in western Montana are partially or completely supported by hatchery supplementation. Lake Mary Ronan provides the primary brood source for Kokanee production and stocking, although additional gametes were collected at Little Bitterroot Lake on several occasions since 2010 to enhance genetic diversity (MFWP Stocking Records). All Kokanee stocked in Clearwater Basin lakes were propagated at MFWP's Flathead Lake Salmon Hatchery until they reached 50-75 mm (2-3 inches). Fry were then transported by truck and planted annually along lake shorelines, access points, and inlet streams between April 20 and June 15 (Table 1). Stocking locations at each lake varied somewhat among years, but emphasized distribution of plants away from lake outlets and dispersal at multiple locations (where applicable) to discourage predation.

Beginning in 2010, we marked stocked kokanee in the hatchery using feed treated with oxytetracycline (OTC) for 10-day periods so that propagated fish could be distinguished from wild fish during subsequent sampling. The OTC additive lays down a permanent mark on the bone structure (e.g., vertebrae) of treated fish (see Figure 3), which appears as a fluorescent ring when bones are viewed with the aid of an ultraviolet 'black' light.

Table 1. Summary of Kokanee stocking rates in Clearwater Basin lakes, 2009-2020. Bolded values indicate lots treated (marked) with oxytetracycline (OTC).

YEAR	L. ALVA	L. INEZ	SEELEY L.	SALMON L.	PLACID L.
2009	50,000	40,000	100,000	50,000	100,000
2010	**48,000**	50,000	**60,000**	**50,000**	100,000
2011	**50,000**	**50,000**	**60,000**	**50,000**	**100,000**
2012	**50,000**	**50,000**	**60,400**	**50,500**	**100,000**
2013	**50,800**	**50,000**	**60,000**	**50,000**	**100,000**
2014	**11,000**	**11,100**	**22,700**	**16,600**	**33,200**
2015	**10,000**	**10,700**	**20,900**	**15,400**	**30,000**
2016	**10,200**	**10,200**	**20,500**	**15,000**	**30,000**
2017	**9,900**	**9,900**	**19,900**	**19,900**	**29,800**
2018	**~10,000**	**~10,000**	**~20,000**	**~30,000**	**~30,000**
2019	**10,400**	**10,400**	**19,900**	**50,000**	**30,100**
2020	10,000	10,000	10,300	**40,000**	**30,000**
2021	***10K****	***10K****	***10K****	***40K****	***30K****

* *Number of Kokanee requested from hatchery.*

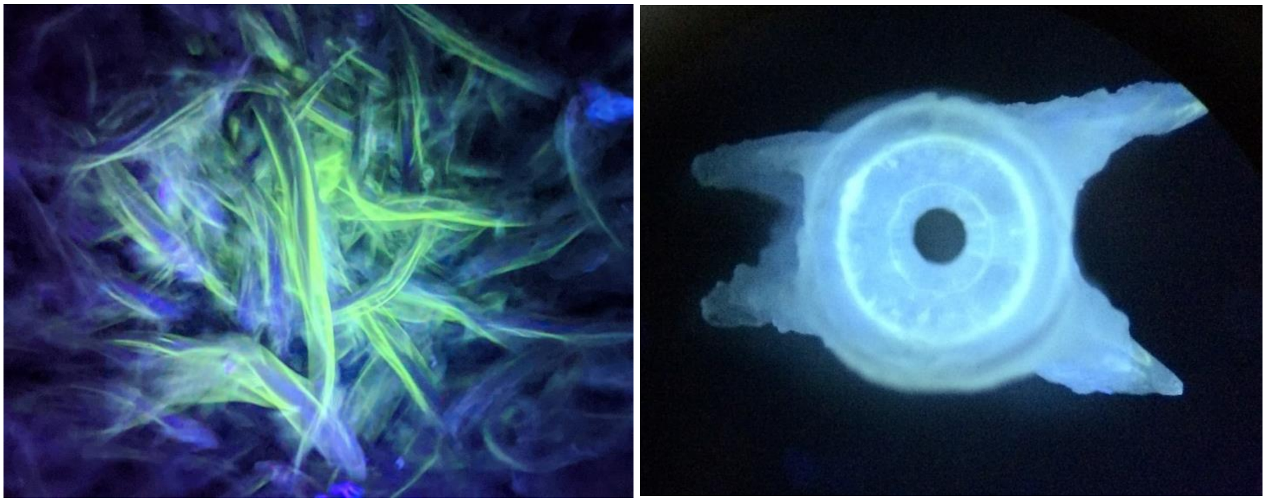

Figure 3. Marked Kokanee fluorescing under ultraviolet light in a hatchery raceway (left) and longitudinal view of a vertebra from a treated individual (right) displaying an illuminated oxytetracycline (OTC) mark.

Kokanee Sampling in Lakes

Beginning in 2012, Kokanee were collected each spring during lake-wide netting surveys at Alva, Inez, Seeley, Salmon, and Placid Lakes. Standardized sampling employed monofilament 'experimental' gill nets (125' x 6') with five panels of graduated mesh sizes (0.75 to 2 inches) placed at consistent locations along the lake shoreline (see Appendix I). Horizontal sets included both floating (~70%) and sinking (~30%) nets placed perpendicular to shore over a range of depths (6'-40').

Once baseline gill net series and methods were established (typically over 3 consecutive years), standardized 'lake-wide' netting surveys were rotated among the five lakes. When a particular lake was not scheduled for lake-wide sampling (i.e., off years in rotation) or when we did not reach our target sample size (> 50 age-2 Kokanee) during the normal netting series, we set supplemental nets that targeted Kokanee to obtain an adequate sample.

While the standardized, lake-wide gill-net series included both floating and sinking nets set at predetermined locations, we only used floating nets placed at locations with high Kokanee catch rates during supplemental 'targeted' sampling. Over time, we modified these floating nets by removing panels with larger mesh sizes (ineffective for catching Kokanee) and by fastening two nets together end-to-end. This modification maximized Kokanee capture efficiency and minimized by-catch of non-target fish species that are associated with larger mesh sizes.

In addition to 'targeted' Kokanee gill net sets, we also opportunistically extracted undigested Kokanee from Northern Pike captured in our nets (Figure 4). Kokanee are a preferred, high frequency diet item for Northern Pike on some lakes (e.g., Salmon Lake and Seeley Lake). This afforded us the opportunity to use predators as supplemental 'sampling vesicles' to further increase our Kokanee sample size. Similar to gill net sampling with graduated mesh sizes, we also obtained at least two Kokanee year classes and range of sizes in our sample from predator stomachs.

Kokanee captured in gill nets or extracted from Northern Pike stomachs were placed in coolers and processed to attain pertinent data. After measuring (TL) and weighing each fish, we extracted 10-20 mm sections of vertebrae and placed them in individually labeled envelopes. In some cases, we were forced to estimate lengths and weights of Kokanee from Northern Pike stomachs because they were partially digested.

We did not include Kokanee or utilize vertebrae from individuals that were too digested for a reasonable estimation of total length (i.e., within 5 mm TL). All vertebrae samples were frozen on the day of sampling, then later cleaned and viewed with a dissection microscope under ultraviolet light in the laboratory to determine if a OTC mark was present (indicating a fish was stocked). Vertebrae that displayed an OTC mark were noted on the datasheet, along with the strength of the mark as part of quality control measures. The OTC marking data were later used to determine the proportion of hatchery and wild fish within each Kokanee population.

Figure 4. Kokanee extracted from a Northern Pike stomach during gill net surveys at Salmon Lake.

Kokanee Sampled at Tributary Spawning Locations

Inlet and outlet streams associated with Lake Alva, Lake Inez, Seeley Lake, Salmon lake and Placid Lake were surveyed in October-November (2012-2015) to identify Kokanee staging areas and spawning locations. We also investigated lake perimeters from shore and by boat to investigate potential shoreline spawning habitat. Through comprehensive ground surveys, historical MFWP records, and anecdotal information from anglers, we established adult sampling locations associated with most lake populations (Table 2).

Kokanee spawning populations exhibited high fidelity to sites identified in our initial surveys. We observed some annual variation in timing and specific spawning locations, but primary spawning reaches sampled for each lake population were relatively consistent. Staging and spawning Kokanee were typically collected using a backpack electrofishing unit and dip net. We attempted to collect 50 fish from each tributary sampling location. However, desired sample sizes were not always attained due to variability in Kokanee abundance and logistical constraints (e.g., ice cover).

We attempted to collect a random sample of spawners, including roughly equal numbers of both sexes, at each sample site. Kokanee were measured (TL) and sections of vertebrae were extracted to later determine which individuals were stocked (displayed OTC marks) using the same laboratory procedures described above.

Table 2. River and tributary sampling locations for adult Kokanee emigrating from Clearwater Basin lakes.

Population	Sampling Period	Primary Sampling Locations	Coordinates (Lat/Long)
LAKE ALVA	10/18 - 11/13	Lake outlet (Clearwater R)	47.29921, -113.57797
	11/5 - 11/15	Richmond Cr. Mouth	47.32196, -113.58228
LAKE INEZ	10/18 – 10/29	Lake outlet (Clearwater R.)	47.26686, -113.56550
SEELEY LAKE	10/18 – 11/1	Above Lake Inlet (Clearwater R.)	47.22881, -113.53691
SALMON LAKE	10/15 – 11/5	Above Lake Inlet (Clearwater R.),	47.12011, -113.44817
	10/20 – 11/5	Owl Creek*	47.11516, -113.45315
PLACID LAKE	10/15 – 11/1	Lake Inlet (Placid Cr)	47.11976, -113.54885
	10/20 – 11/10	Lower Boles Cr.	47.11826, -113.55452
	10/15 – 11/1	Lake Outlet Arm (Above Control Structure)	47.11480, -113.50230

**Kokanee sampled in Owl Creek may originate in Salmon L. and Placid L.*

Results

Evaluation of Kokanee populations in the Clearwater Basin focused on results of spring gill-netting surveys at lakes and fall sampling of adults at spawning locations. Population characteristics, including size structure, relative abundance, and proportion of stocked fish, varied over time and among lakes. We also observed differences in growth among wild and stocked fish in some instances.

Contribution of Stocking

Oxytetracycline (OTC) marks were visible on the vertebrae of Kokanee stocked in Clearwater Basin lakes since 2010. The proportion of our total samples marked was an indication of the level of natural reproduction and the relative number of 'wild' vs stocked fish for each population. The contribution of stocked Kokanee was highly variable among lake populations (Table 3), with detection rates ranging from 0% to 95%. Substantial decreases in stocking rates beginning in 2014 (see Table 1) were also evident beginning in 2016-2017, as the proportion of marked adults generally fell as expected in those lakes with reduced stocking (all except Salmon L.).

Table 3. Contribution of stocking for Kokanee populations sampled at sites throughout the Clearwater Basin, 2012-2020.

	% OF AGE 2+ KOKANEE THAT WERE STOCKED (MARKED)								
POPULATION	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
Alva – Lake (Spring)	*-*	*-*	*57%*	*88%*	*-*	*-*	*90%*	*-*	*-*
Alva – Outlet (Fall)	*-*	*-*	*52%*	*84%*	*89%*	*95%*	*89%*	*74%*	*49%*
Inez – Lake (Spring)	*-*	*77%*	*83%*	*83%*	*-*	*50%*	*-*	*-*	*16%*
Inez – Outlet (Fall)	*-*	*-*	*-*	*-*	*-*	*85%*	*75%*	*50%*	*48%*
Seeley – Lake (Spring)	*-*	*29%*	*24%*	*21%*	*-*	*-*	*0%*	*-*	*-*
Seeley – Inlet (Fall)	*-*	*-*	*-*	*6%*	*-*	*-*	*2%*	*0%*	*0%*
Salmon – Lake (Spring)	*11%*	*11%*	*13%*	*15%*	*11%*	*2%*	*0%*	*16%*	*23%*
Placid – Lake (Spring)	*-*	*-*	*-*	*25%*	*5%*	*22%*	*12%*	*4%*	*7%*
Placid – Tribs (Fall)	*-*	*-*	*36%*	*24%*	*6%*	*8%*	*6%*	*4%*	*6%*

Size Distribution Comparisons for Wild vs. Stocked Kokanee

Marking of stocked Kokanee allowed for side-by-side comparisons of growth rates and adult size distributions for wild fish and those propagated in the hatchery beginning in 2015. We attempted to compare size distributions for adults captured in gill nets (May sampling) and for spawners sampled later in the fall (October-November) where possible. Unfortunately, greatly reduced stocking rates during this period resulted in low sample sizes for stocked Kokanee in some years and locations.

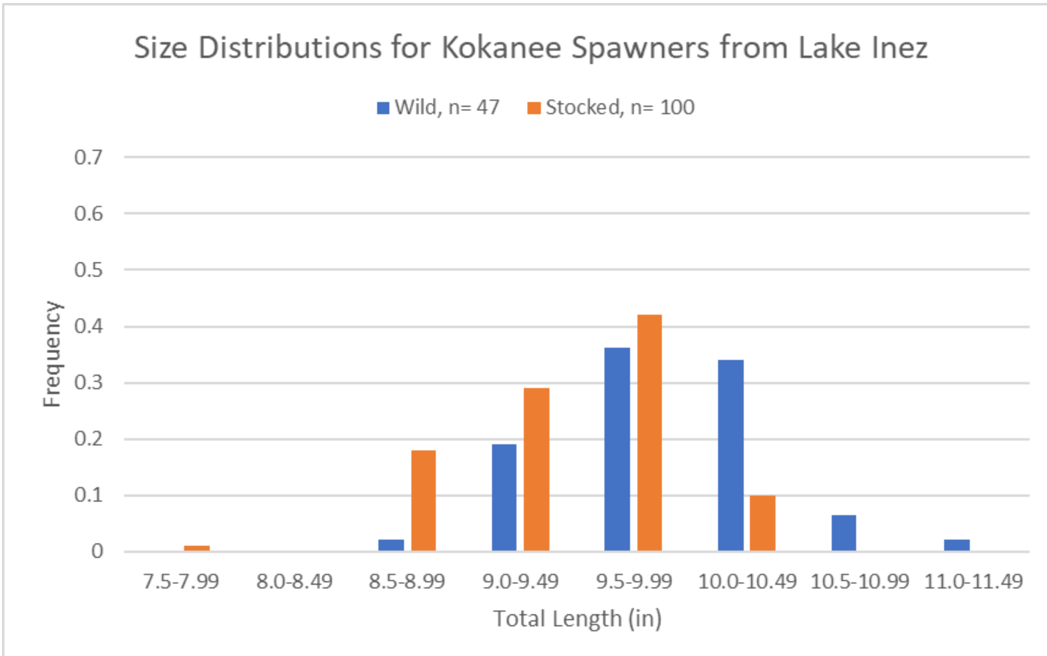

Figure 5. Comparison of cumulative size distributions for stocked and wild Kokanee spawners captured at the outlet of Lake Inez in fall, 2017-2020.

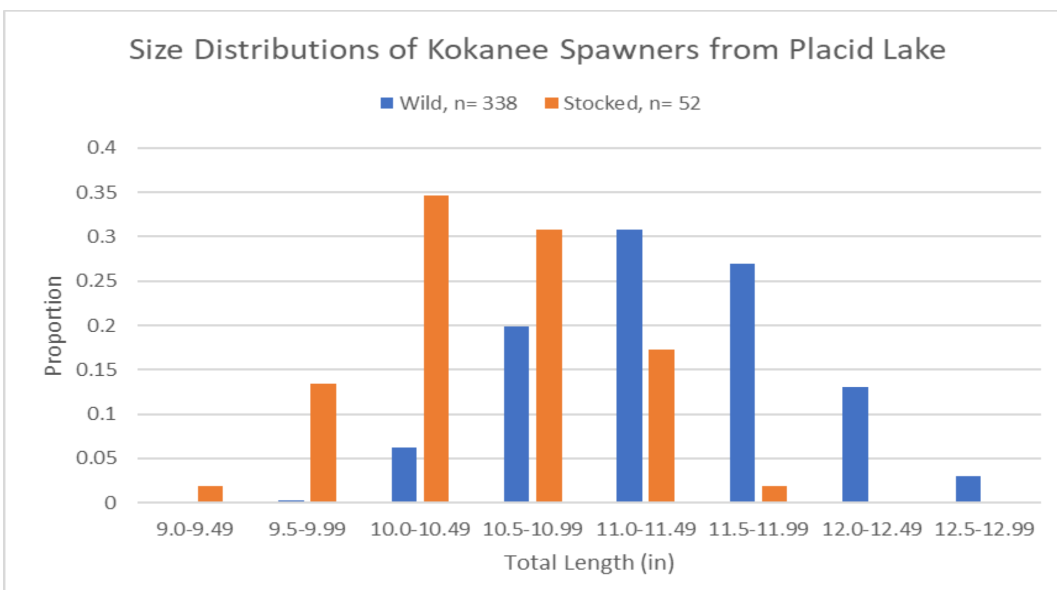

Figure 6. Comparison of cumulative size distributions for stocked and wild Kokanee spawners captured in Placid Creek, 2015-2020.

Where we were able to collect adequate and representative sample sizes, differences in growth between wild and stocked Kokanee were generally minor (e.g., Figure 5). However, significant differences in adult size distributions were noted in some lakes and typically indicated faster growth for wild fish. For instance, wild adult Kokanee were significantly larger than those stocked in Placid Lake based on the six-year sampling period in Boles Creek (Figure 6).

Lake Alva Population

Kokanee stocking rates were reduced from ~50,000 per year (2009 -2013) to ~10,000 per year (2014-2020) at Lake Alva (Table 1) in response to observed stunting and presumed overpopulation. Accordingly, the proportion of Kokanee of hatchery origin (OTC marked) began to decrease after 2017 based on adults captured at spawning areas. The proportion of fish marked was consistent among adults captured in the lake and those collected from spawning areas in years when both types of samples were collected (2014, 2015, 2018, see Table 3).

Size distributions of adult Kokanee captured in the lake each spring did not change noticeably over time (Figure 7). However, annual samples from spawning areas in fall indicated that average size, maximum size, and the cumulative size distributions of spawners may have increased after 2016 (Figure 8).

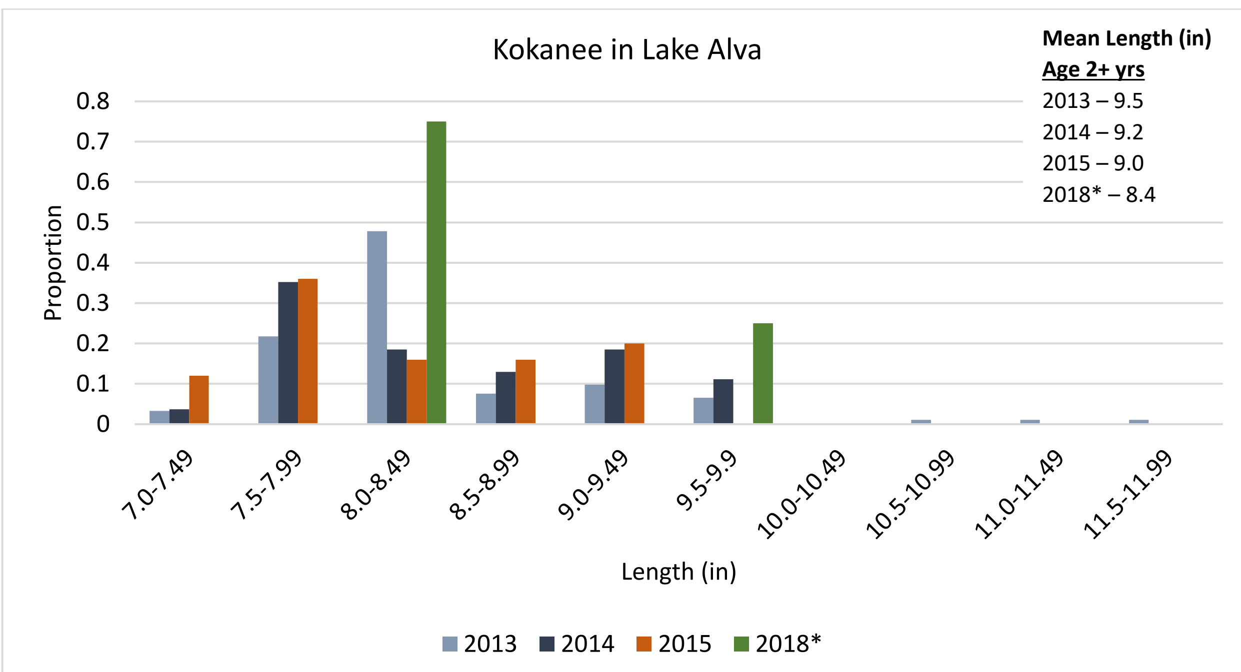

Figure 7. Length-frequency distributions for adult Kokanee gill-netted at Lake Alva in spring 2013-2018.

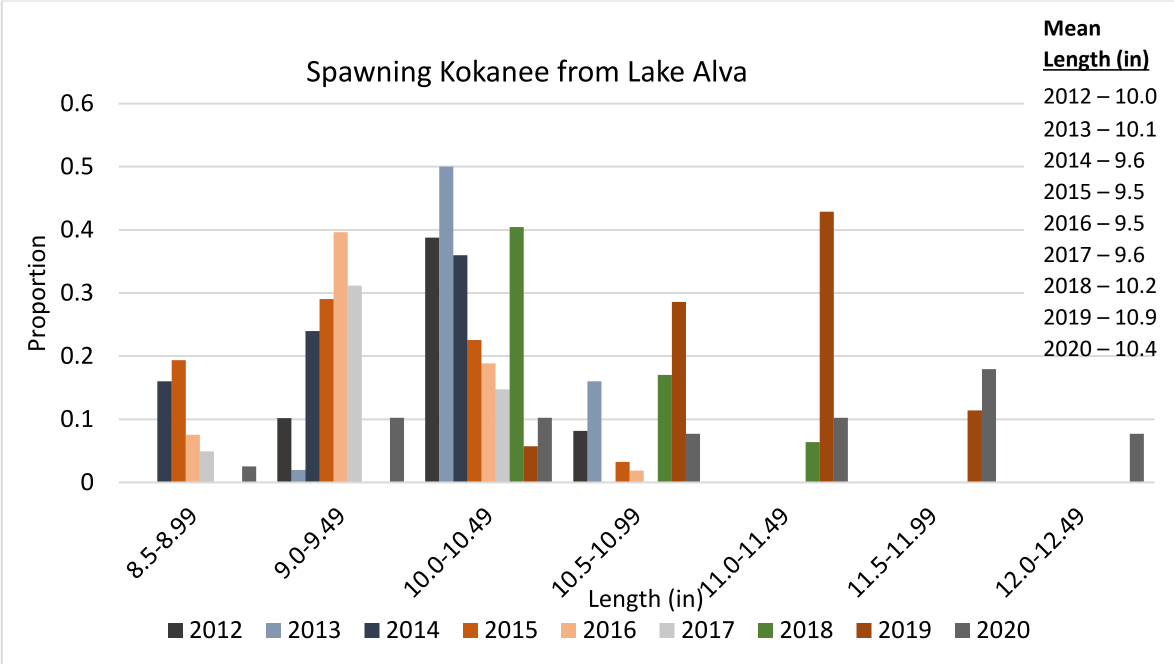

Figure 8. Length-frequency distributions for Kokanee spawners sampled at the Lake Alva outlet in 2012-2020.

Lake Inez Population

As with Lake Alva, Kokanee stocking rates were reduced from ~50,000 per year (2009-2013) to ~10,000 per year (2014-2020) at Lake Inez (see Table 1). The proportion of marked individuals in our samples reflected this reduction in stocking rate, but no significant change in the size distribution of adults was evident (Figures 9 &10) as average lengths of Kokanee adults in gill nets (range 8.4-9.4 inches mean TL) and at spawning locations (range 9.3-9.8 inches mean TL) were consistent.

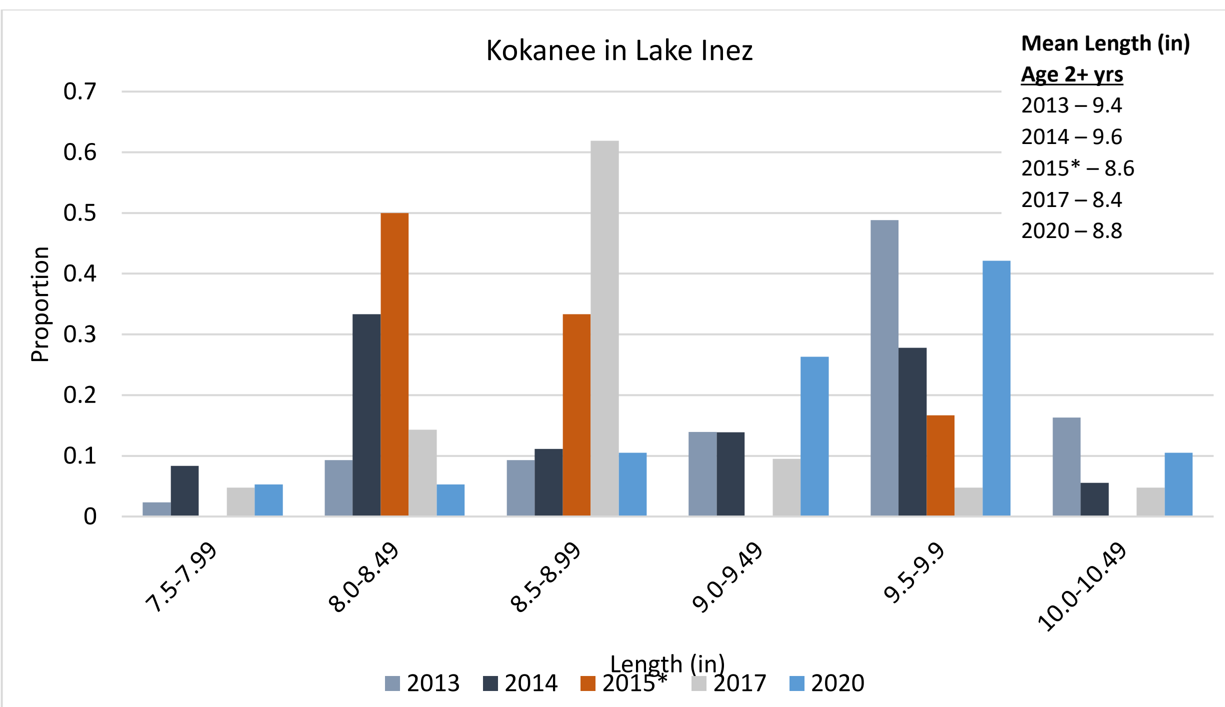

Figure 9. Length-frequency distributions for adult Kokanee gill-netted at Lake Inez in spring 2013-2020.

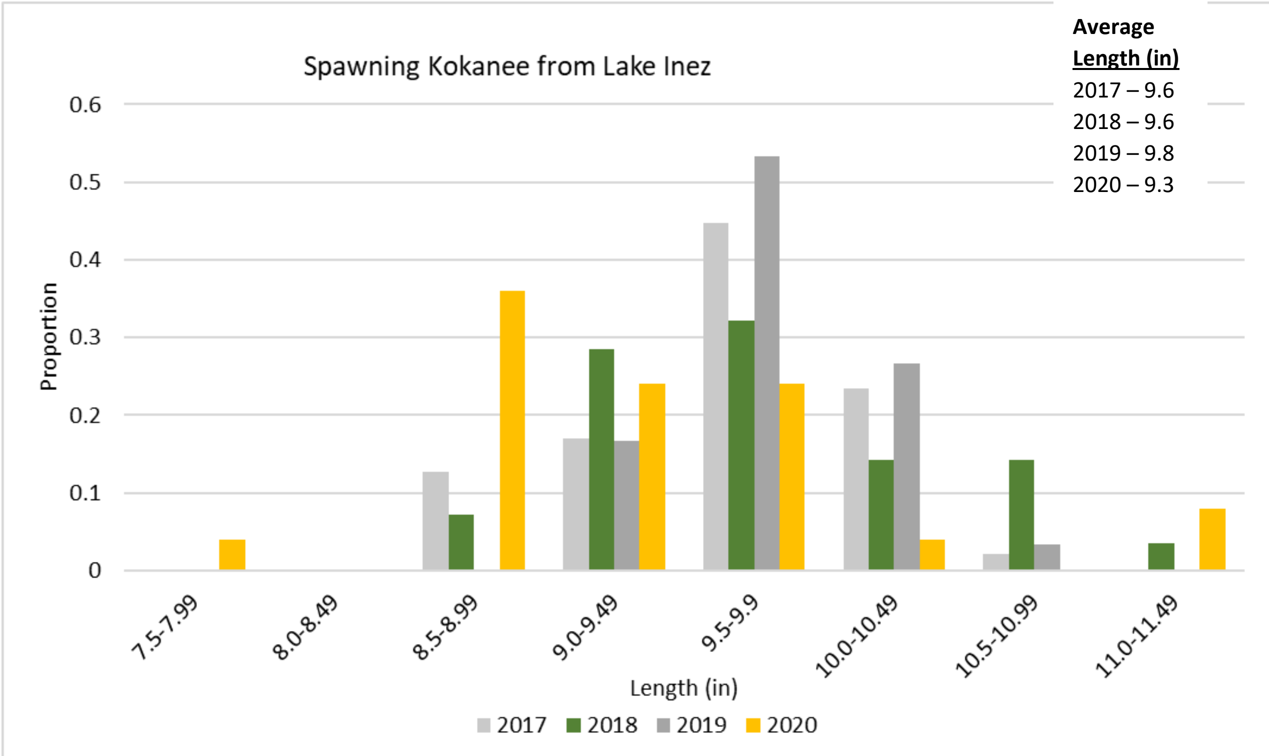

Figure 10. Length-frequency distributions for Kokanee spawners sampled at the Lake Inez outlet in 2017-2020.

Seeley Lake Population

Gill net surveys and monitoring of spawning areas indicated that natural reproduction was abundant and consistent for Kokanee occupying Seeley Lake. Consequently, Kokanee stocking has been incrementally reduced over the past decade. Kokanee plants totaled 100,000 fish per year in 2009 and prior, 60,000 per year from 2010-2013, 20,000 from 2014-2019, and were further reduced to 10,000 per year in 2020 (Table 1). Most natural reproduction appeared to occur in the Clearwater River upstream of the lake based on the abundance of spawners observed in that reach.

The proportion of OTC marked (stocked) kokanee from gill nets and spawning areas reflects the reductions in stocking rate and supports observations of abundant natural reproduction. By 2018, the incidence of stocked fish in our samples was at or near zero (Table 3).

Available gill net data (Figure 11) and spawner surveys (Figure 12) also suggest mean lengths and adult size distributions were relatively consistent in portraying a stunted Kokanee population for 2013-2020. As with Salmon Lake sampling (described below), many Kokanee specimens were collected *indirectly* from gill net sets by opportunistically extracting them from the stomachs of Northern Pike captured in the nets.

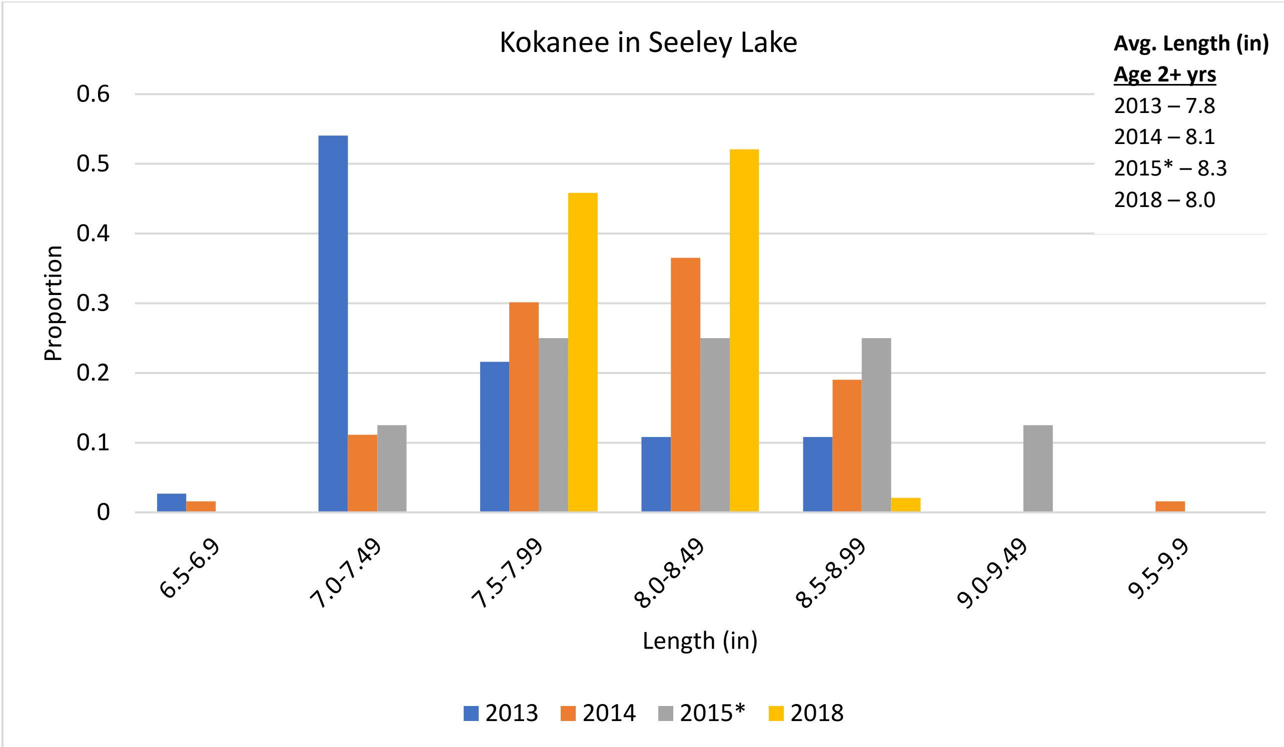

Figure 11. Length-frequency distributions for Kokanee gill-netted at Seeley Lake in spring 2013-2018.

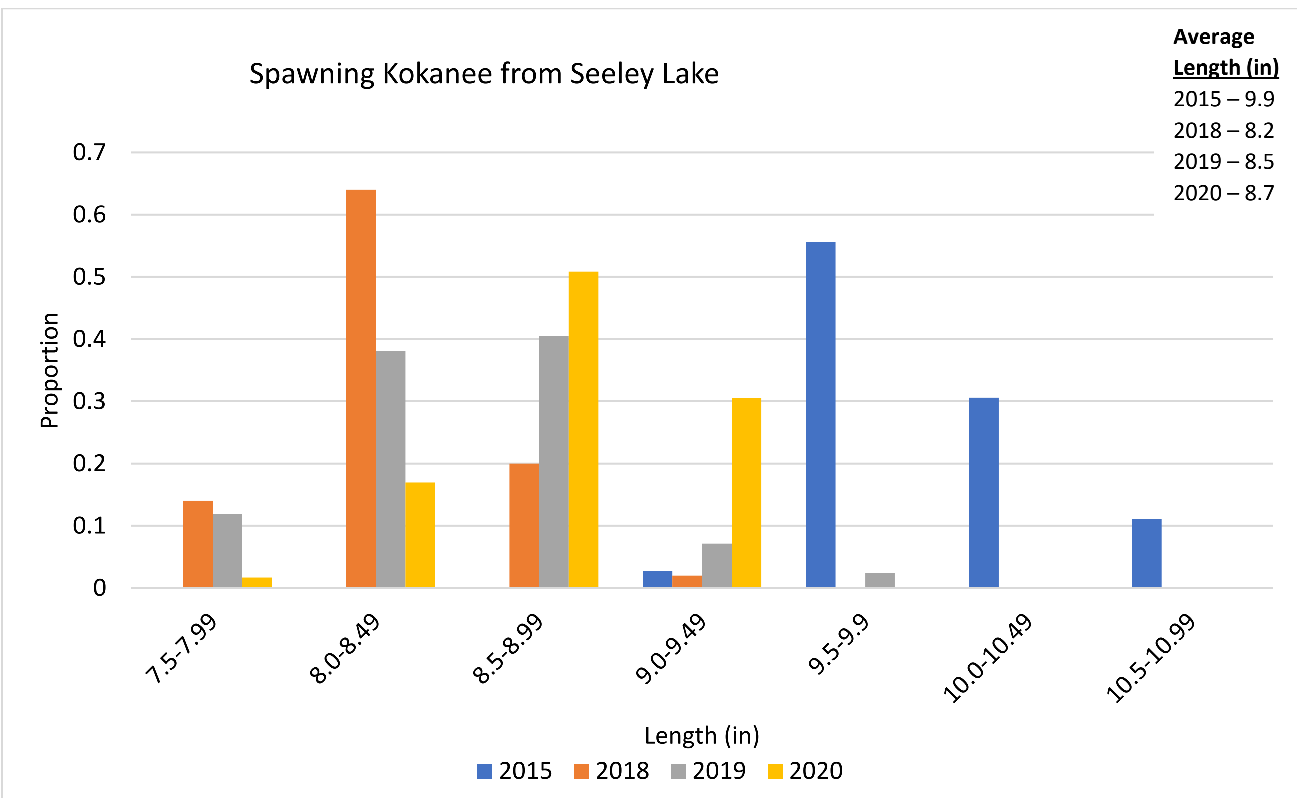

Figure 12. Length-frequency distributions for Kokanee spawners sampled at the Seeley Lake inlet in 2012-2020.

Salmon Lake Population

Kokanee stocking rates in Salmon Lake were also modified several times during the study period (Table 1). Initial annual plants of 50,000 per year (2009-2013) were reduced to 15,000-20,000 per year (2014-2017), then increased to 40,000-50,000 per year (2019-2021) as managers attempted to balance population density and stabilize growth rates based on monitoring information.

Since we were unable to identify consistent spawning reaches and adult staging areas for the entire study period, annual gill net sets (2012-2020) were the primary monitoring tool for Kokanee in Salmon Lake (Figure 13). Adult size distributions and maximum sizes were generally larger than other populations, but quite variable over the study period, indicating inconsistent population densities. The incidence of stocked (OTC marked) fish in the population remained low (11%-23%) throughout the sampling period, so we attribute population fluctuations primarily to variable reproductive success and juvenile survival. Northern Pike and other predators were certainly one factor influencing survival and growth rates, as Kokanee were common diet items in predator stomachs.

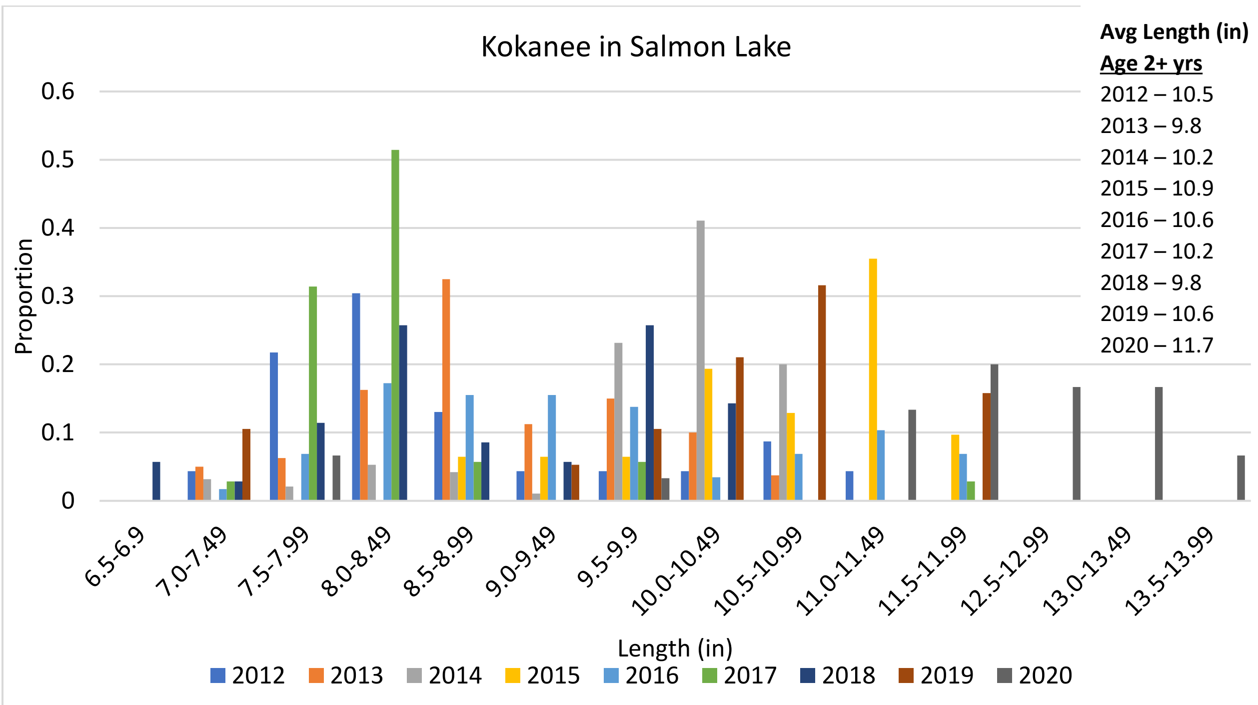

Figure 13. Length-frequency distributions for Kokanee gill-netted at Salmon Lake in spring 2012-2020.

Placid Lake Population

The Placid Lake Kokanee population has been relatively stable over the past decade, despite a 70% reduction in stocking rates since 2013 (Table 1). Stocking was reduced from 100,000 (2009-2013) to ~30,000 (2014-2020) per year when monitoring indicated abundant and consistent natural reproduction. Size distribution data from spring (Figure 14) and fall (Figure 15) sampling of adults indicate population stability and consistent fishery quality.

Furthermore, the proportion of stocked fish (OTC marked) in the population (Table 3) were directly correlated with corresponding stocking rate reductions in Table 1, as the proportion of adults marked dropped from 24%-36% to 4%-22% when stocking reductions were implemented.

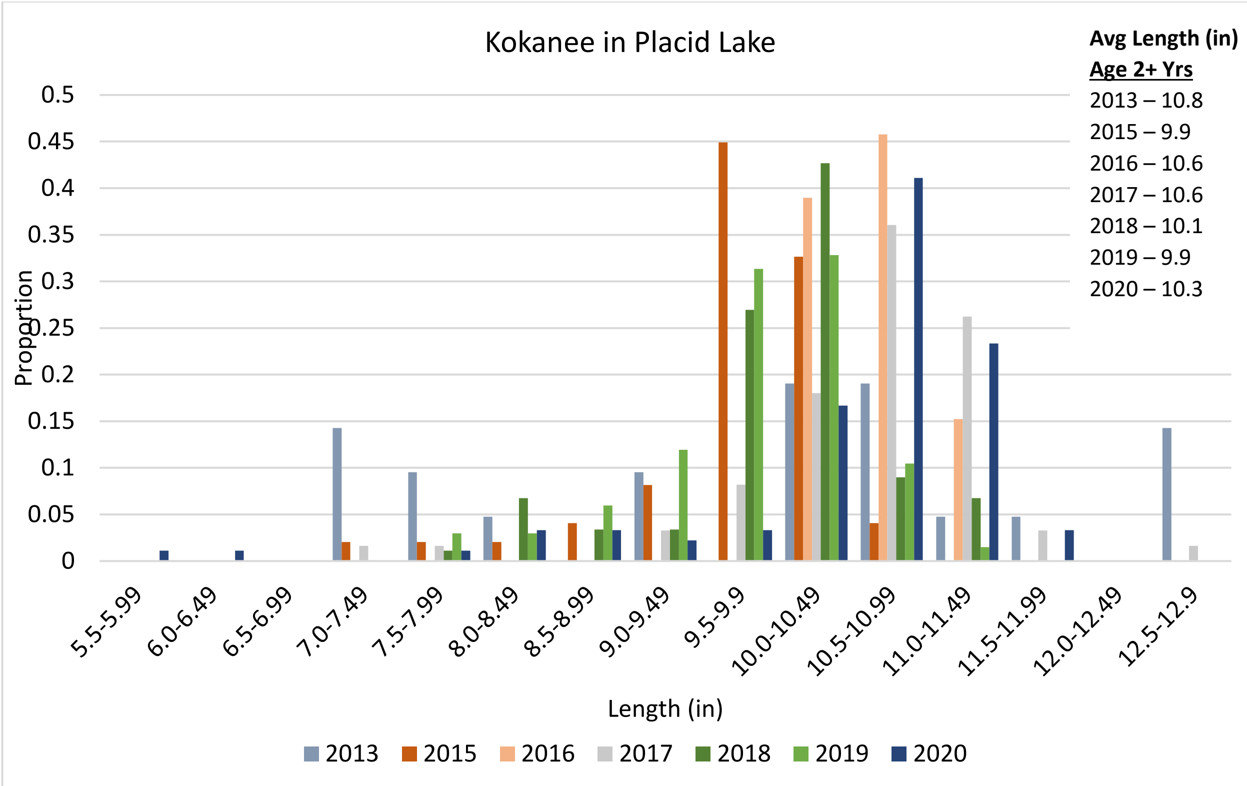

Figure 14. Length-frequency distributions for Kokanee gill-netted at Placid Lake in spring 2013-2020.

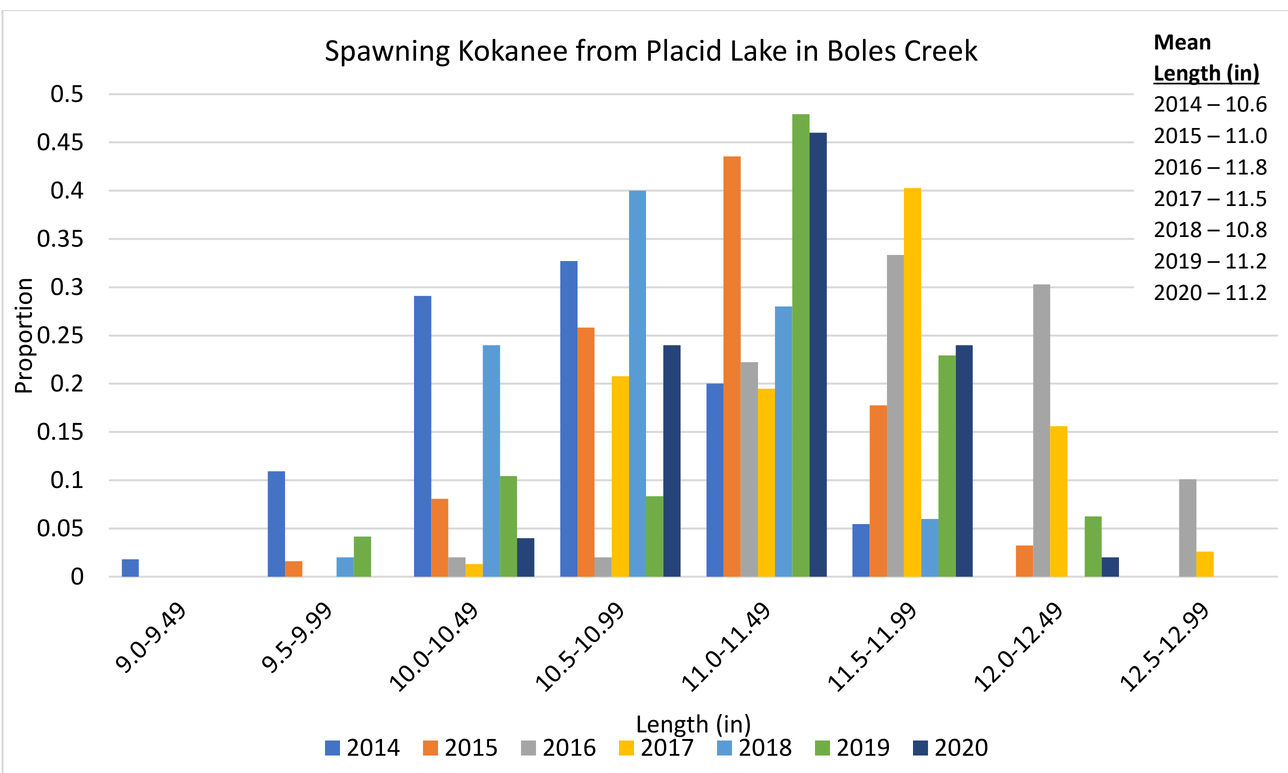

Figure 15. Length-frequency distributions for Kokanee spawners sampled at Boles Creek in 2014-2020.

Discussion and Management Recommendations

Most Kokanee populations in the Clearwater Basin are stunted, despite significant reductions in stocking rates and liberalized harvest regulations over the past decade. Management goals for all lake populations include consistent production of adults (Age 2+) with a median total length of 10 inches (254 mm) or greater by May. This objective was reliably attained for Salmon Lake and Placid Lake Kokanee populations since 2014, but growth rates and maximum size thresholds have not reached their historic potential (MFWP File Data). Adult size structure targets and fishery management objectives have generally not been achieved since 2014 for Lake Alva, Lake Inez, and Seeley Lake populations.

Suboptimal growth rates and small adult sizes are tied to a number of factors, including underlying lake productivity, high Kokanee population density and enhanced competition with a number of introduced fish species. The relative influence of these factors appears to vary significantly among populations and fluctuate over time.

We intentionally reduced Kokanee stocking rates in all study lakes in 2014 (see Table 1) and monitored population response with the aid of OTC marking on hatchery-reared individuals. Concurrent changes in fishing regulations included liberalizing harvest opportunity as daily limits were raised from 5 to 10 on all lakes and known spawning reaches on the main stem Clearwater River adjacent to Lakes Alva and Inez were opened to snagging in fall (MFWP Fishing Regulations). We observed greater angler participation (particularly in adult spawner snagging) after regulation changes were implemented and anticipated measurable increases in Kokanee growth rates and maximum size.

In Lake Alva, Kokanee densities were relatively low based on gill net catch rates and abundance in spawning congregations. Density of Northern Pike and other predators also appear to be lower than other lakes in the basin based on long term gill net data (MFWP, unpublished data). Recent sampling indicates that efforts to further reduce Kokanee populations through reduced stocking and increased harvest opportunity may be increasing size structure of adults, as significant increases were noted in the overall size distributions and maximum size of spawners in 2018-2020 (see Figure 8).

We have not observed analogous growth and adult size structure changes in Lake Inez or Seeley Lake. These Kokanee populations appear to be stable based on gill net catch rates, spawner abundance, and adult size structure monitored over time. Despite significant decreases in stocking rates, these populations likely remain stunted because of consistently high (Seeley L.) and moderate (L. Inez) levels of natural reproduction. It is unlikely that harvest rates increased significantly in response to liberalized regulations as Kokanee in these lakes are generally too small for effective angling and some spawning areas are difficult to access for snagging.

We plan to continue current management direction in Lake Alva, Lake Inez, and Seeley Lake in attempting to reduce population densities and encourage higher growth rates. Additional strategies and measures to facilitate these changes are available, but will require additional resources and effort. Possible management approaches include additional angler harvest (snagging) opportunities in spawning areas, suppression of spawning activity, or even manual removal of adults and sub-adults from the population.

Kokanee population size structure and sport fishing quality are noticeably different in Salmon Lake and Placid Lakes, relative to lakes upstream. Mean length of adults (Age 2+) has consistently reached 10-11 inches (250-280 mm) by May in both populations since 2014 (Figures 13-15). Not surprisingly, these populations support the majority of fishing pressure for anglers targeting Kokanee in the Clearwater Basin. Both populations are predominantly comprised of wild fish, but stocking may currently provide a higher contribution of adults and prove more relevant in Salmon Lake (see Table 3).

Although Salmon Lake has produced the largest Kokanee in the basin, population abundance and growth rates have been more variable over the past decade. This inconsistency is partially explained by adjustments in stocking rates, but is also surely tied to erratic reproductive success and natural recruitment as stocked (marked) fish comprise a small proportion of those sampled. Abundant predator populations (e.g., Northern Pike, Brown Trout, Northern Pikeminnow) likely contribute to Kokanee population fluctuations. However, stable Kokanee populations and similarly high predator densities in Seeley Lake suggest that other factors are driving population dynamics and fishery quality.

The Placid Lake Kokanee population is much more stable, with consistent and adequate natural reproduction. Consequently, stocking rates have been reduced to a base level and are likely only relevant in years when natural reproduction wanes significantly. Higher growth rates and population size structure are undoubtedly tied to elevated productivity and food availability relative to upper lakes. Population stability and fishery quality likely also benefit from the lack of introduced predators like Northern Pike. However, recent detection of Northern Pike in 2020 (MFWP, unpublished data) and gradually increasing populations of other predators (e.g., Brown Trout) may destabilize population dynamics and the fishery in future years.

Management strategies for Salmon Lake and Placid Lake will focus on consistency and incremental improvements in fishery quality. Supplementation is generally not relevant in Placid Lake and recent data suggest that the stocked fish present are smaller than wild individuals when they reach age 2+. Management tools include closer monitoring and management that promote recruitment stability, as well as adjustments to angling regulations and other opportunities that promote harvest. Incremental reduction in adult population density would presumably increase growth trajectories and fishery quality. Preventing the introduction and establishment of new fish species introductions (particularly Northern Pike and other predators) is also a priority for this population.

Kokanee stocking appears to be more critical in Salmon Lake, as abundance, size structure, and fishery quality are much more erratic for this population. This instability justifies closer monitoring of stocking rates, timing, and other attributes of supplementation, as well as further investigation of the wild population. Identifying key staging and spawning areas, migration timing for spawners, and possible limiting factors that contribute to recruitment instability will be the focus of our investigations. We anticipate that a better understanding of these aspects will lead to specific management recommendations to improve the quality and stability of the fishery.

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