Experimental Removal of Lake Trout in Swan Lake, MT: 2016 Annual Report

Prepared for the Swan Valley Bull Trout Working Group

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ACKNOWLEDGMENTS

This eight-year project would not have been possible without the collaborative working relationship of the Swan Valley Bull Trout Working Group. This group has been committed to improving conditions for Bull Trout in the Swan Valley and has shared the burden of staffing and funding a large project of this nature. Chris Guy, assistant unit leader of the Montana Cooperative Fishery Research Unit, also deserves our gratitude for the data analysis and expertise provided to the project. And finally, the authors would like to personally thank all the volunteers that have assisted with the project since 2009, as their efforts in cleaning fish have provided Flathead Valley food banks with meals for area residents.

SUMMARY

Non-native Lake Trout represent a significant threat to the Swan Lake Bull Trout population. In 2009 the Swan Valley Bull Trout Working Group initiated an eight-year experimental Lake Trout removal project. This project was a feasibility study to examine if limited gillnetting effort can reduce Lake Trout numbers and improve conditions for Bull Trout and Kokanee. The project was monitored annually using predetermined evaluation criteria to examine the efficacy of removal efforts. The methods used in this project were designed to provide consistent data for statistical analyses while maximizing Lake Trout removal and minimizing bycatch of other fish species.

After eight years of targeted gillnetting, a total of 59,752 Lake Trout were removed from Swan Lake. Incidental bycatch of other fish species was relatively low. Modeled Lake Trout exploitation rates suggest that this level of gillnetting effort can create mortality rates near 50% for age-3 and age-4 Lake Trout, as well as adult Lake Trout on known spawning areas. However, some age classes were less vulnerable to the netting and unknown spawning areas likely exist. Indices examining how this level of effort affects the Lake Trout population showed no significant trend with regard to Lake Trout abundance or relative weight, but netting on known spawning areas did appear effective in removing the larger, older individuals. During this same time period, Bull Trout and Kokanee experienced initial declines but have since stabilized. However, data suggest that further declines in Bull Trout may be possible.

This project provided information critical to making informed decisions about the future management of the Swan Lake fisheries. Improved monitoring of the Swan Lake fish community is being developed to further assist biologists with evaluating any future Lake Trout harvest scenarios. Additionally, collaborative solutions will continue to be explored for ways to protect the Bull Trout population of the Swan Valley.

BACKGROUND

The Swan Valley has historically been one of Montana's strongest Bull Trout populations. However, in 1998, anglers began to occasionally catch adult sized (20-30 inch) Lake Trout from Swan Lake and the Swan River. This caused alarm because Lake Trout are not native and are notorious for rapidly expanding and dominating fish communities in lakes with *Mysis* shrimp, particularly at the expense of Bull Trout and Kokanee Salmon (Martinez et al. 2009). In 2003, the level of concern was compounded when biologists gillnetted juvenile Lake Trout from Swan Lake during standard low-intensity sampling efforts, indicating that wild reproduction was occurring. Since 2003, Lake Trout catch by anglers as well as during Montana Fish, Wildlife & Parks (FWP) biological sampling has continued to increase, another indication that the population was expanding. Research efforts from 2006-2008 focused on Lake Trout population demographics and exploring potential techniques to reduce Lake Trout numbers while minimizing Bull Trout bycatch. Based on case histories from nearby waters, managers determined that developing long-term management actions to control this increasing Lake Trout population was necessary in order to maintain the popular Bull Trout and Kokanee fisheries.

In 2009, FWP released an environmental assessment (EA) for a three-year experimental removal of Lake Trout in Swan Lake. This removal experiment was a feasibility study to determine the effectiveness of using targeted gillnetting as a technique to reduce the number of Lake Trout and thus minimize threats to Kokanee and Bull Trout. From 2009-2011, over 20,000 Lake Trout were removed from Swan Lake. Modeled total annual mortality rates for Lake Trout year classes vulnerable to the nets (Predominantly age-3 and 4) were higher than literature suggests are sustainable (50%). FWP released another EA in May 2012 for a five-year extension of the project to further evaluate the long-term effectiveness of the current Lake Trout suppression effort relative to measurable goals and specific success criteria outlined in the original 2009 EA. The 2016 netting season represents the final year of this 8-year experiment. The results of this assessment will assist FWP and the Swan Valley Bull Trout Working Group (SVBTWG) with decisions regarding fisheries management of Swan Lake.

Previous annual reports can be found at:
http://montanatu.org/resources/swan-valley-bull-trout/

METHODS

Attempts were made to keep netting methods from 2009-2016 as consistent as possible. This consistency has allowed researchers to continue to remove Lake Trout from Swan Lake at a level that we believe should lead to long-term decline, while providing repeatable data for year-to-year comparisons and analysis.

Throughout the 8 years of netting, the project was composed of two distinct annual events. The first event (Juvenile Netting) was aimed at removing juvenile and subadult Lake Trout throughout the two deep (>60 feet) basins of Swan Lake. This removal was carried out using small-mesh (1.5 – 2.75 inch stretch) gill nets, set by professional fisheries contractors over a three-week period in late August. This netting was conducted during a time in which most adult Bull Trout were upstream in the Swan River drainage in preparation for fall spawning and also occurred during the period in which Swan Lake is thermally stratified. Netting occurred only below the thermocline (>60 feet) to reduce incidental bycatch of Bull Trout and other fish species which occupy shallower depths.

Since 2009, netting for juvenile Lake Trout has been contracted to Hickey Brothers Fisheries of Baileys Harbor, Wisconsin. Each year the boat was cleaned and disinfected following a Hazard Analysis and Critical Control Point Plan (HACCP) to minimize the risk of spreading aquatic invasive species. The boat was inspected annually by FWP personnel prior to entering Swan Lake to ensure proper cleaning procedures had been followed.

In the final year of this experiment, juvenile netting took place from August 1-26, 2016, representing the earliest start to the netting season. Prior to 2015 the contract with the Hickey Brothers always provided 30 lifts, with a lift being described as an event in which nets are set and retrieved. Insight gained over previous years revealed that the schedule of netting twice daily was exhausting crews and creating potentially dangerous working conditions. Therefore, in 2015, the schedule was adjusted to provide 22 lifts total, where every other day the nets would be set in the evening and retrieved the next morning. This strategy continued in 2016. Because the evening nets were left out for a longer duration, total soak time (net-hours) was similar amongst all years despite the reduction in lifts in 2015 and 2016 (Table 1). Although the number of net panels has varied since inception of the project, the locations of the nets have remained constant. With 2016 being the last year of the project, another change to the schedule was introduced to examine potential reasons for the declining catch rates observed from 2009-2015. Therefore in 2016 a one-week rest period was allowed between weeks of netting. This strategy was employed in an effort to determine if declining catch rates were due to depletion of the Lake Trout or displacement associated with behavioral changes.

Table 1: Dates and numbers of nets set for juvenile netting 2009-2016.

Year	Netting Dates	# Lifts	# 900' Nets	Net-hours
2009	Aug 24-Sept 11	30	248	1,946
2010	Aug 23-Sept 10	30	311	2,436
2011	Aug 22-Sept 9	30	399	3,173
2012	Aug 13-Aug 31	30	382	2,130
2013	Aug 11-Aug 30	30	347	2,059
2014	Aug 10-Aug 29	30	354	2,007
2015	Aug 10-Aug 28	22	255	1,965
2016	Aug 1-Aug 26	22	252	2,198

The second annually conducted netting event (Spawner Netting) removed adult Lake Trout during spawning and thus was targeted to directly affect further recruitment. This portion of the project was carried out largely by SVBTWG members (with contractor assistance). Large-mesh gill nets (4.5 – 5 inch stretch) were set at night and during early morning hours, along spawning areas identified through sonic telemetry conducted in 2006-2008 and again in 2014-2015. Netting for spawning Lake Trout in 2016 was conducted from October 11-28, with nets being set and lifted twice daily, Monday-Friday. While netting did not occur twice every day (Friday afternoons, Saturdays, Sundays, and Monday mornings were not fished), the schedule and subsequent effort was similar to previous years of the project.

Table 2: Dates and numbers of nets set for spawner netting 2009-2016.

Year	Netting Dates	# Lifts	# 900' Nets	Net-hours
2009	Oct 6-Nov 5	16	32	59
2010	Sept 28-Oct 29	25	101	542
2011	Oct 4-Oct 28	24	161	623
2012	Oct 8-Oct 25	24	154	450
2013	Oct 7-Oct 25	23	153	1,020
2014	Oct 6-Oct 24	25	155	1,349
2015	Oct 5-Oct 23	24	157	1,375
2016	Oct 11-Oct 28	26	151	1,345

RESULTS AND DISCUSSION

Juvenile Netting

A total of 6,443 Lake Trout ranging in total length from 6-33 inches were removed during the 2016 juvenile netting period (Figure 1). This represented a slight increase from 2015. However, the total number of Lake Trout has been relatively stable since 2012. It appears 2010 and 2012 represented strong year classes of age-3 and age-4 Lake Trout, and that the 2016 number was consistent with the preceding seven-year average (7,219 fish). The length frequency distribution of Lake Trout caught during the juvenile netting period continues to be heavily skewed toward smaller fish, a result of targeting areas containing high density juvenile Lake Trout and fishing smaller mesh nets (Figure 2). The majority of the juvenile Lake Trout catch is composed of age-3 and age-4 Lake Trout (Cox 2010). Incidental catch of other fish species during juvenile netting continues to be relatively low (Table 3).

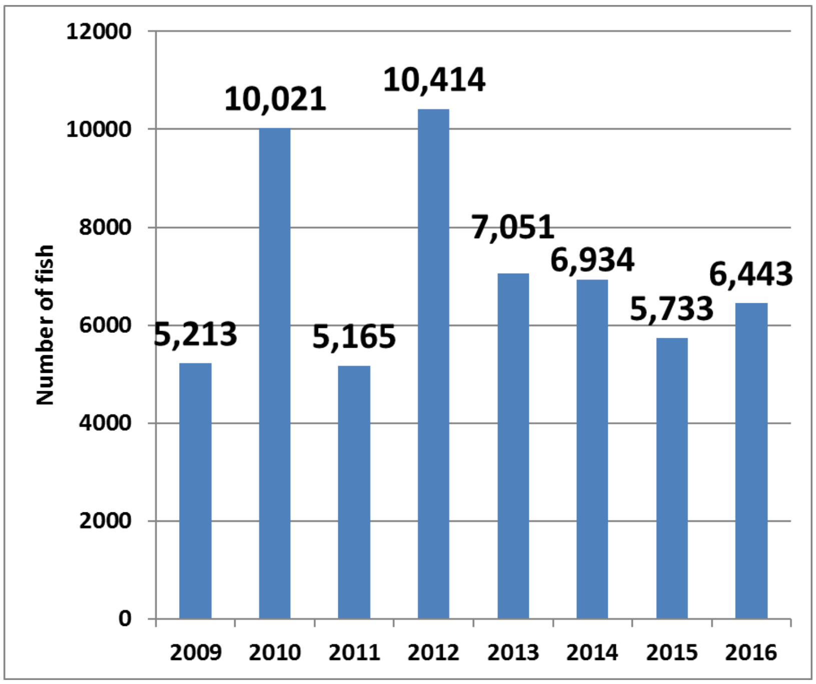

Figure 1: Total number of Lake Trout removed during juvenile netting 2009-2016.

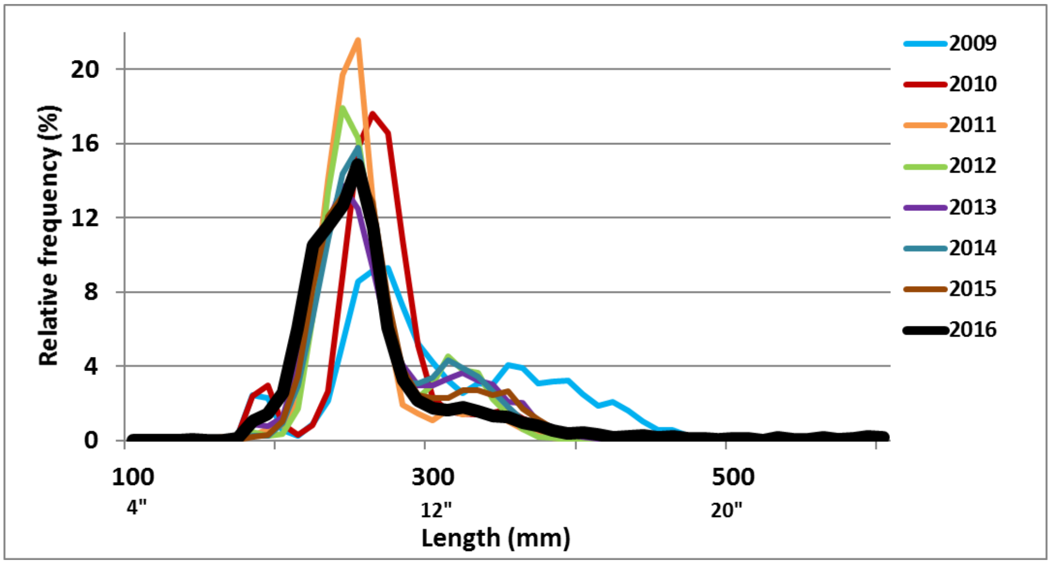

Figure 2: Relative length frequency of Lake Trout less than 600 mm (20 inches) total length caught during juvenile netting in Swan Lake 2009-2016.

Table 3: Bycatch of non-target fish species captured during juvenile and (spawner) netting events 2009-2016. Abbreviations are: BULL (Bull Trout), KOK (Kokanee), MWF (Mountain Whitefish), PWF (Pygmy Whitefish), LNSU (Longnose Sucker), NPM (Northern Pikeminnow), CSU (Largescale Sucker), RBT (Rainbow Trout), PIKE (Northern Pike). Most non-target fish were released alive.

Species	2009	2010	2011	2012	2013	2014	2015	2016
BULL	238 (26)	212 (87)	237 (104)	334 (103)	168 (135)	146 (161)	74 (174)	52(80)
KOK	205 (23)	414 (110)	159 (46)	521 (114)	388 (300)	138 (431)	166 (76)	499 (84)
MWF	107 (0)	28 (5)	31 (2)	67 (0)	104 (2)	93 (4)	15 (1)	70 (1)
PWF	139 (0)	63 (0)	9 (0)	79 (0)	27 (0)	11 (0)	28 (0)	2 (0)
LNSU	86 (50)	49 (306)	65 (145)	17 (207)	7 (157)	31 (213)	3 (234)	16 (118)
NPM	27 (36)	14 (136)	31 (131)	2 (68)	1 (132)	4 (147)	0 (141)	6 (71)
CSU	0 (58)	0 (109)	0 (111)	0 (54)	0 (96)	0 (147)	1 (134)	1 (244)
RBT	6 (3)	5 (10)	7 (11)	0 (11)	1 (11)	6 (16)	4 (19)	10 (30)
PIKE	0 (2)	0 (0)	0 (7)	0 (2)	1 (7)	0 (3)	0 (8)	0 (3)

The one-week rest period between weeks of netting did not appear to influence the number of Lake Trout caught during juvenile netting in 2016. Each year the juvenile netting period is examined by week and the rate of decline is used for population estimation (Figure 3). The rate of decline in 2016 was similar to most years of the project. This suggests that the observed decline in catch may be a result of depletion rather than displacement associated with behavioral changes. However, more research is warranted regarding these behavioral changes and potential net avoidance.

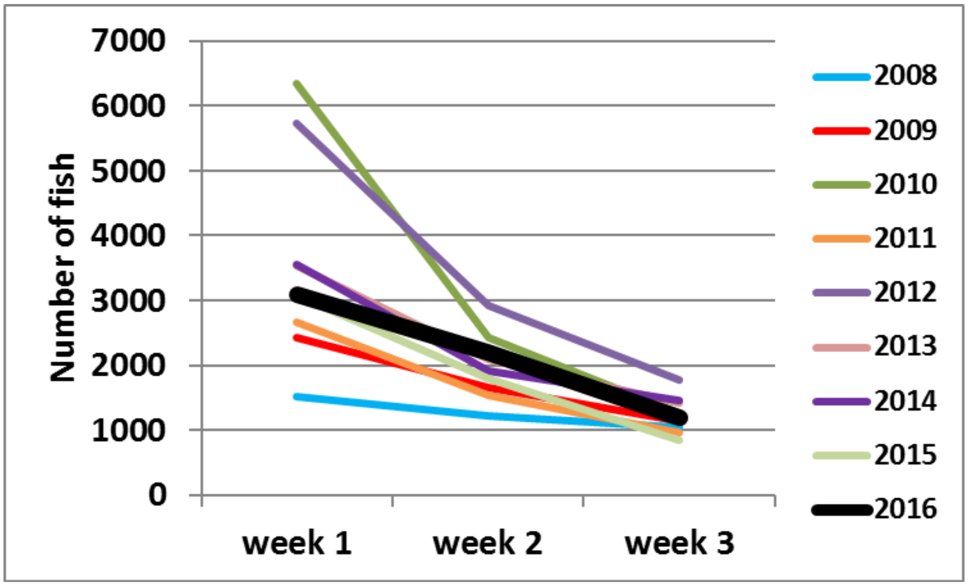

Figure 3: Lake Trout removed during each week of juvenile netting 2008-2016.

Spawner Netting

The removal of adult Lake Trout to directly reduce recruitment was an important aspect of the project. Adult Lake Trout catch in 2016 was 601 fish, which represents the third consecutive year of increased catch (Figure 4). In order to maintain netting effort on the traditional spawning area and produce consistent data, the majority of nets (99) set for adult Lake Trout were placed along the same area fished from 2009-2013 (Highway 83 road cut). The remainder of the netting effort (52 nets) was placed in areas informed by acoustic telemetry. No additional sonic tags were implanted in adult Lake Trout in 2016. Because all previously implanted tags were either recovered in previous netting events or had batteries expire, no additional telemetry was conducted in 2016. Spawning locations identified in 2014-2015 were fished as “exploratory” sites in 2016. Differing from 2014-2015, gillnetting on the traditional locations in 2016 produced higher catch rates than the exploratory sites, with 428 fish caught along the road cut and 173 fish caught along the newly identified areas.

Relative length frequency of Lake Trout captured along the Highway 83 road cut (Traditional) during spawner netting continues to be skewed to smaller individuals, suggesting that previous efforts effectively exploited larger, older fish from that area (Figure 5). Similarly, after netting over newly identified areas (Exploratory) in 2014-2016, relative length frequency in those areas also shifted toward smaller individuals. This further reinforces the notion that targeted netting can affect the age distribution of adult fish in known spawning areas (Figure 6). Bycatch of fish species other than Lake Trout during spawner netting was similar to past years (Table 3), with the exception of Bull Trout which will be described later in this document.

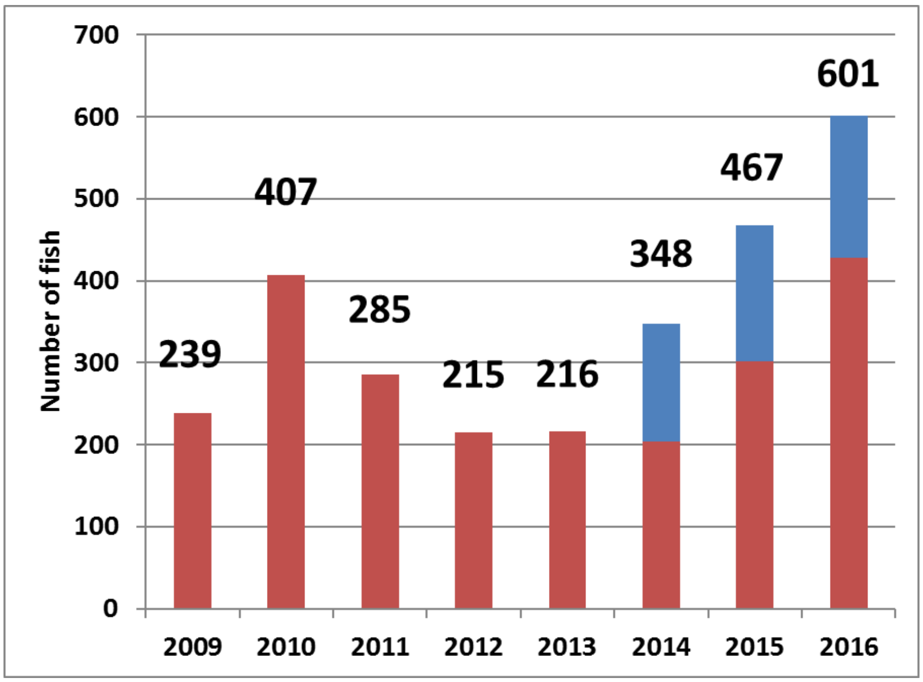

Figure 4: Total number of Lake Trout removed during spawner netting in Swan Lake 2009-2016. The red bars represent adult-sized Lake Trout removed along the "traditional" spawning area and the blue bars represent adult-sized Lake Trout removed over "exploratory" areas identified during 2014-2015 telemetry efforts. For our purposes, "adult-sized" lake trout are described as those longer than 400 mm, regardless of sexual maturity.

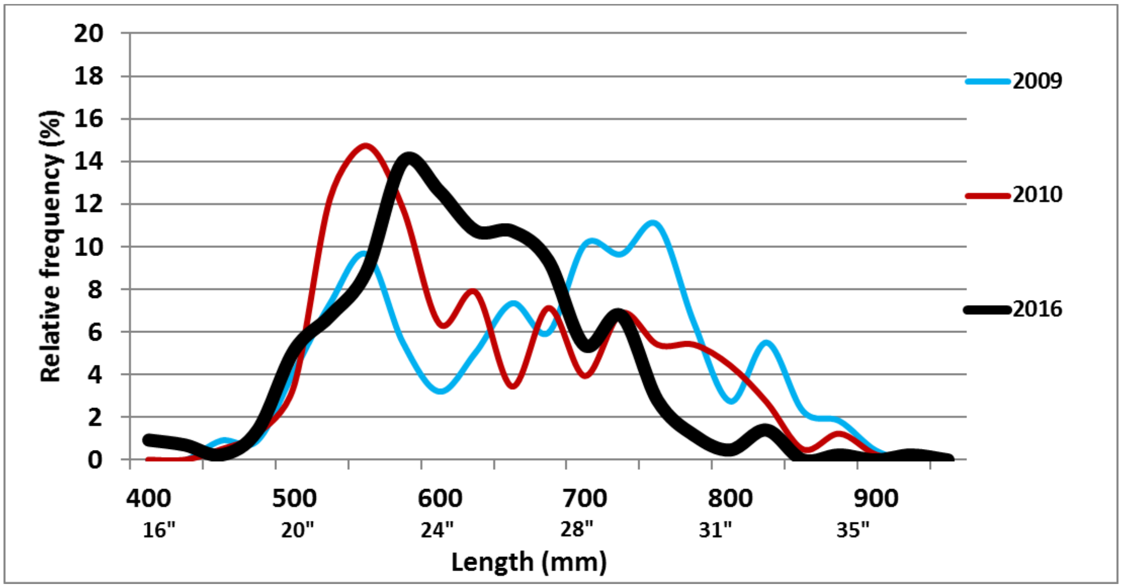

Figure 5: Relative length frequency of Lake Trout removed during spawner netting along "traditional" areas in Swan Lake 2009, 2010, and 2016.

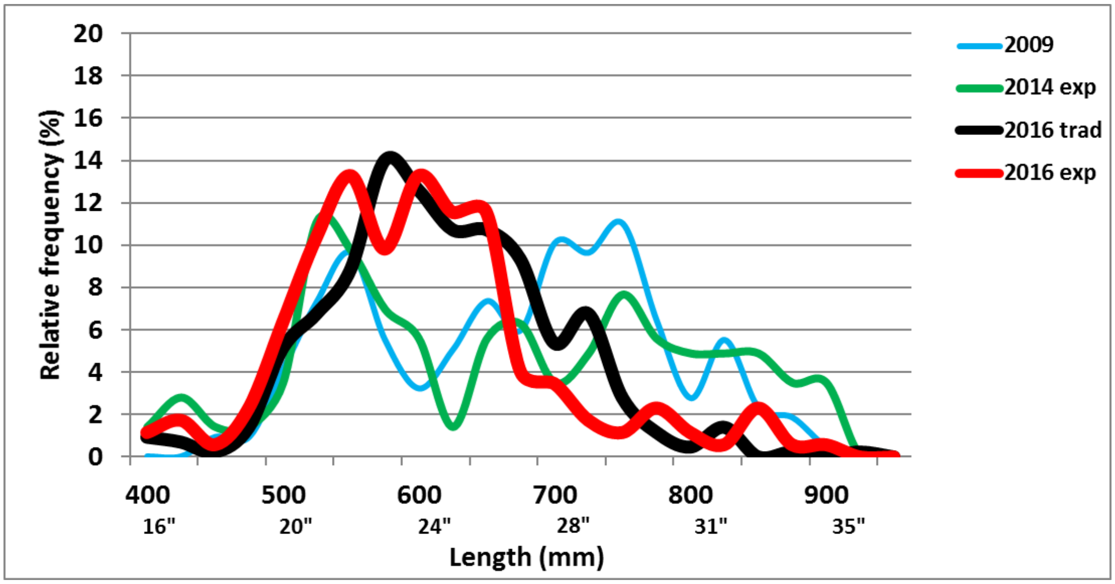

Figure 6: Relative length frequency of adult Lake Trout removed over "traditional" spawning areas in 2009 (blue) and 2016 (black), and "exploratory" spawning areas in 2014 (green) and 2016 (red).

Bycatch of Bull Trout

Throughout this program, Bull Trout bycatch has been closely monitored. A total of 132 Bull Trout were inadvertently captured as bycatch during combined project netting activities in 2016 (Figure 7). This was a reduction of the previous lowest number (248 in 2015) by almost half. The juvenile netting period resulted in only 41 Bull Trout being captured, with 11 more in the supplemental nets and 80 in the spawner netting.

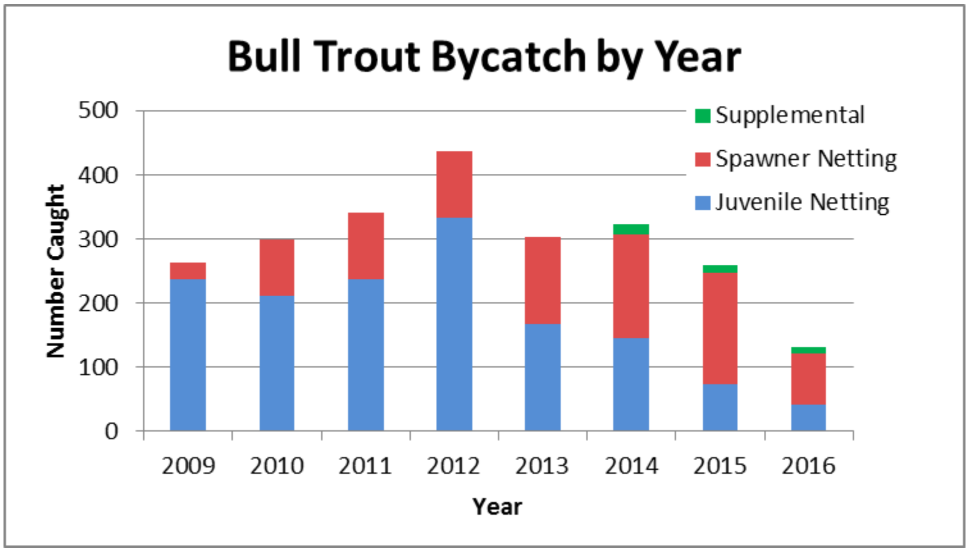

Figure 7: Bull Trout bycatch captured in juvenile and spawner netting programs on Swan Lake 2009-2016.

While it's important to note that the juvenile Lake Trout suppression netting is not designed to capture Bull Trout (mostly set in water deeper than 60 feet), there is still a high degree of randomness and high likelihood the Bull Trout bycatch indices reflect real population change. Changes in net configurations to improve standardization, beginning in 2012, included incorporating a higher density of smaller (1.5"-2.25" stretch) mesh sizes and dropping larger (2.5" plus) mesh sizes during the juvenile netting. Those changes may have enhanced Bull Trout capture rates. However, neither those changes nor other minor adjustments to locations and strategies in 2012-2016 can explain the approximate 70% decline in Bull Trout bycatch that has occurred since 2012 in the juvenile suppression netting.

Declining Bull Trout Age Cohorts

Because of this apparent declining trend in Bull Trout bycatch over the past five years, some additional analysis was performed. In order to examine age class cohorts, we assigned Bull Trout from the capture sample, by length, to age classes. Those age classes were pre-selected based on previously collected age/growth data for Swan Lake (Leathe et al. 1985). That analysis (Figure 8) shows that strong Bull Trout cohorts were produced in 2006, 2007, and 2008 when redd counts were highest (Basin-wide totals of 656, 762, and 598 redds, respectively), and increasingly diminishing returns of Bull Trout occurred to the gillnet bycatch from cohorts spawned in 2009, 2010, 2011, and 2012 (Basin-wide totals of 481, 378, 297, and 383 redds, respectively).

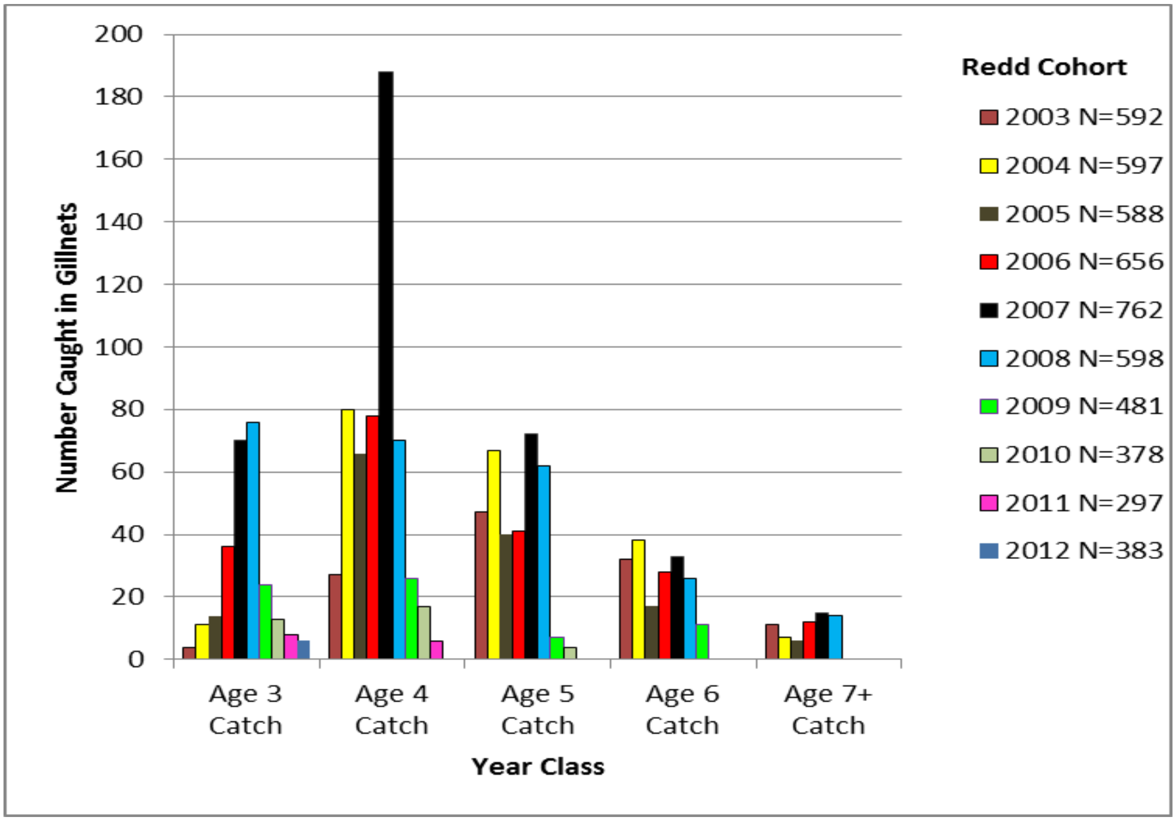

Figure 8: Bull Trout bycatch from August juvenile Lake Trout suppression netting in Swan Lake for years 2008-2016, apportioned by assigned Age Class cohort.

As an aid in interpreting Figure 8, we present the following example. The 2007 spawning cohort produced 762 redds (legend), which resulted in the strongest year class to date of Bull Trout (black bars). Bull Trout from the 2007 spawning cohort were subsequently caught in gillnet bycatch in years 2011 (Age-3) through 2015 (Age-7). Contrast that with the 2009 spawning cohort (green) where the redd count of 481 translated to a relatively weak year class in the bycatch at Ages 3-6 (with Age-7 yet to be determined in bycatch in 2017).

Age-4 Bull Trout bycatch (the first year class that typically is fully recruited to the gillnets), seems to be a relatively strong predictor of year class strength. Age-4 bycatch, representing spawning cohorts 2007-2011, declined nearly 97% in the nets from 2012 (n = 188) to 2016 (n = 6). A decline this steep is not explainable by reduction in redd counts, even though there was a roughly 60% decline in redd numbers from the 2007 recent high to the 2011 observed low. Additionally, as previously discussed in depth in our 2015 report (Rosenthal et al. 2016), the stream juvenile abundance indices, which were designed to predict potential recruitment to the lake, do not exhibit a declining trend despite the redd count reductions.

The declining gillnet bycatch indicators cause concern that juvenile and subadult Bull Trout populations in Swan Lake appear to be declining, and perhaps doing so at a much steeper rate than would be indicated by changes in the redd counts and juvenile abundance indices for those same cohorts in the stream system. Based on this observation, it is likely that disproportionately low survival of juvenile Bull Trout in Swan Lake is occurring, at least for fish emigrating to the lake from the 2009 and later spawning cohorts.

Alternatively, observed declines in Bull Trout bycatch could be due to behavioral (net avoidance) or spatiotemporal changes in the lake (e.g., water temperatures). It's also possible that other external influences have caused the Bull Trout population to change in other ways (e.g., becoming more fluvial in behavior). However, these are unsupported hypotheses. It is our belief, based on the evidence, that a direct decline in numbers of juvenile and subadult Bull Trout in Swan Lake is most likely related to competition and/or predation from Lake Trout and other predators in Swan Lake.

The decline in Bull Trout numbers in Swan Lake bycatch begins to manifest itself at the earliest ages at which these fish recruit to our gillnet methods (i.e., Ages 3-4). This factor suggests that gillnet bycatch is not likely the primary cause of the recent decline, as weak year classes are present from the very beginning (e.g., in the first year(s) they can be netted) and these weak cohorts extend across the age spectrum. In addition, our previous analysis (Rosenthal and Fredenberg 2014) found that even under worst case scenarios existing levels of gillnet bycatch could reduce Bull Trout redd counts by 130-150 annually. An impact of that magnitude would not be sufficient to result in Bull Trout recruitment failure at the level we are witnessing.

Alternative Hypotheses and Corroborating Lines of Evidence
As a cautionary note, bycatch of Bull Trout in the juvenile Lake Trout suppression netting is only one line of evidence. That evidence indicates there is declining abundance of Age-3 and older Bull Trout in Swan Lake, with the declining trend first observed in 2013 and continuing through at least 2016.

However, if the indicators we are presently seeing in the lake are real, it could translate into Bull Trout redd counts declining in 2017 or beyond, and we are concerned a cascading decline in the Swan Lake Bull Trout population could occur. Redd counts continue to be at an acceptable level and there is evidence of continuing strong recruitment from the tributaries, but if redd counts decline further the cascading effects might be severe.

As discussed in detail in the 2015 report (Rosenthal et al. 2016), we empirically derived an estimated mortality rate of 53.6% for Bull Trout caught in the bycatch and have applied that value to gillnetted Bull Trout throughout this project. Applying this formula, the estimated bycatch mortality of Bull Trout in 2016 was calculated at 71 fish (i.e., 41 juvenile + 80 spawner + 11 supplemental = 132 X .536 = 71). Because of the declining bycatch, the calculated mortality in 2016 was correspondingly much lower than in any of the past years.

For the first time since 2011, there was also a considerable decline in the Bull Trout bycatch during the October, 2016 Lake Trout spawner netting season. As this netting is less standardized and less randomized than the juvenile netting and focuses on only a small portion of the lake where Lake Trout concentrations during spawning are known to occur, we place less confidence in the spawner netting bycatch as a trend indicator. However, it is at least noteworthy that the 2016 bycatch during spawner netting (Figure 7) of 80 Bull Trout was less than half that observed in 2014 and 2015.

At least 26 Bull Trout of the total 132 captured in 2016 (a minimum of 19.7%) had been previously caught during this project and implanted with PIT Tags. This was the highest proportion of marked fish handled in the bycatch to date and another possible indicator that the Bull Trout numbers in the lake have declined. The 2016 result represented a roughly 40% increase in proportion of tagged fish over 2014 and 2015 results. We are continuing to investigate ways to use this recapture information to potentially generate Bull Trout population estimates or trend indicators.

In the 8 years since Lake Trout suppression efforts began (2009), there have been over 3,100 Bull Trout redds (i.e., spawning beds) counted in the 11 identified Swan spawning tributaries (described later in this report). Bull trout redd counts in the Swan drainage in 2016 were down slightly from 2014-2015, but largely consistent with 2010-2013 results. The 2016 spawning conditions were unusual, with a record high volume of October rainfall. It's not known how these conditions may have affected redd distribution, but the unusually high flows did have some effect on ability of observers to locate and recognize redds.

Kokanee

Nonnative Kokanee Salmon are another important fish species in Swan Lake. Kokanee provide a popular angling opportunity in Swan Lake for both ice and open-water fishermen and represent an important food resource for adult Bull Trout and Lake Trout. Case histories from surrounding area lakes have demonstrated that the combination of *Mysis*, Kokanee, Bull Trout, and Lake Trout typically results in decreased abundance of Bull Trout and elimination of Kokanee. Therefore, Kokanee represent a potentially sensitive indicator of Lake

Trout abundance, as increases in Kokanee abundance may suggest a reduction in predatory Lake Trout density.

Kokanee abundance in Swan Lake is monitored annually through redd counts along an index reach of Swan Lake shoreline. Kokanee spawner abundance had declined from 2005-2011 and then incrementally increased reaching 739 redds in 2014 (Figure 9). Kokanee were last stocked in Swan Lake in 2005, and at least some of the decline from 2005-2011 could partially be a result of the cessation of planting. The 2016 survey revealed a total of 691 redds. This represented a considerable increase from the low count in 2015 and is similar to 2012-2014. The low count in 2015 should be viewed with caution, as weather conditions during the 2015 survey made counting difficult and some redds may not have been seen. Kokanee bycatch during both netting periods can also be used to track their relative abundance and the 2016 results show an increase in the number of small Kokanee (Table 3).

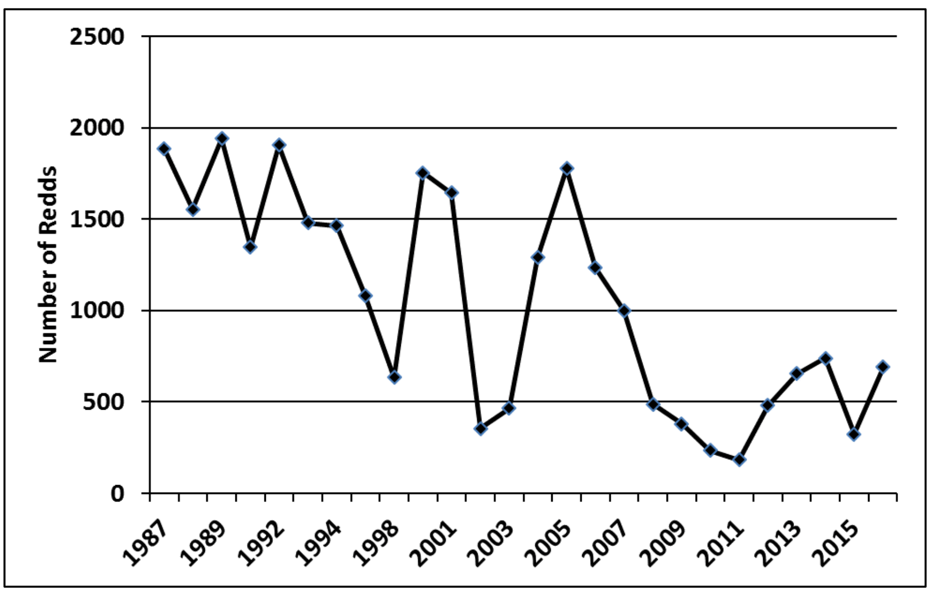

Figure 9: Kokanee redd count data from Swan Lake 1987-2016.

Length frequency analysis of Kokanee inadvertently captured during the 2016 netting reveals a complete distribution of age classes 2-3 in Swan Lake (Figure 10). Kokanee in the 2016 bycatch ranged from 5-20 inches (125-500 mm) with a strong peak of 200 mm (~8 in) probably representing age-2+ kokanee. Kokanee smaller than 7 inches (age-1+) were likely not captured as a result of the mesh sizes used for the netting. There continues to be a noticeable reduction in the age-3+ Kokanee in 2015-2016 when compared to the 2014 data (Figure 10).

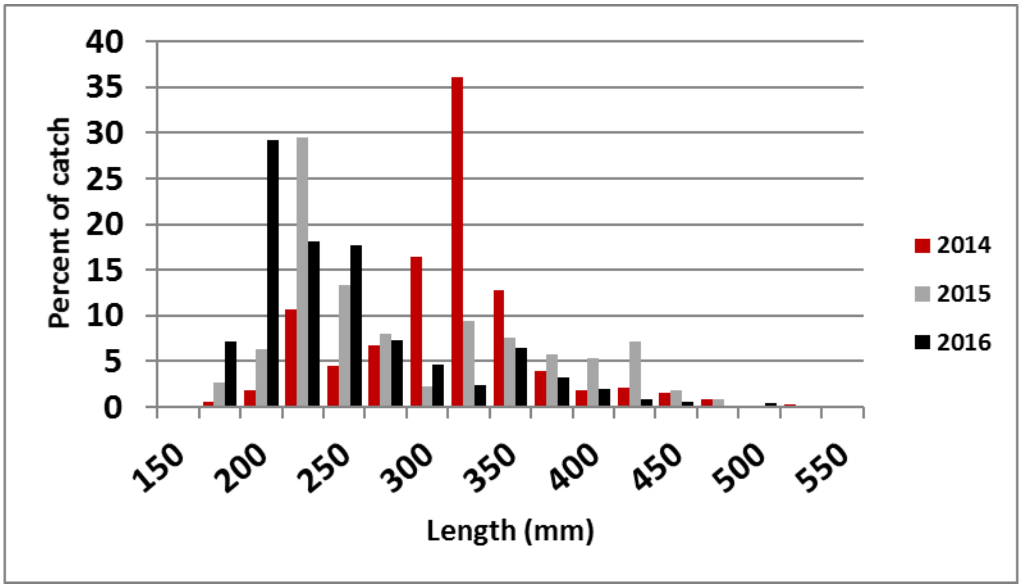

Figure 10: Length frequency of kokanee captured during both juvenile and spawner netting in 2014-2016.

EVALUATION CRITERIA

This Lake Trout removal project in Swan Lake was initiated to evaluate the efficacy of using gill nets to control the expansion of the Lake Trout population and simultaneously benefit Bull Trout and Kokanee. Criteria to evaluate this project were outlined in the original 2009 EA, and were monitored throughout the study. A previous review of these criteria with regard to the 2009-2011 efforts can be found in the 3-year Summary Report (Rosenthal et al. 2012). A comprehensive review of the criteria can be found below.

CRITERIA #1. TOTAL ANNUAL LAKE TROUT MORTALITY OF AT LEAST 50%
Netting mortality of Lake Trout during juvenile netting has been evaluated annually. In Swan Lake, conservative estimates of exploitation (mortality) of age-3 and age-4 Lake Trout have been near 50% in most years since 2009 (Figure 11). These modeled estimates are most accurate for age-3 and age-4 fish, as they are the most vulnerable to the nets being deployed and the locations being sampled. We consider these estimates as “conservative”, as they use the upper confidence interval (95%) of the Lake Trout population estimate. These estimates should be viewed with caution, as the true exploitation rate may be higher or lower and is variable by age class.

Estimates of exploitation on the spawning Lake Trout population are difficult to acquire. Based on tag recaptures from the 2014 and 2015 sonic telemetry project, we can estimate exploitation on known spawning areas. Exploitation on known spawning areas was estimated at 54% in 2014 and 42% in 2015.

When examining the Lake Trout population as a whole, it is unlikely that we are inflicting a total annual mortality in excess of 50%, as estimates show that at best we are inflicting 50% mortality on age-3 and age-4 Lake Trout and on age-7+ Lake Trout on known spawning areas. These exploitation rates do not apply to Lake Trout younger than age-3, Lake Trout age-5 to age-7, and adult Lake Trout spawning at unknown locations. It is likely that survival among the aforementioned groups of fish is high and that total annual mortality is likely less than would be expected if all age classes were vulnerable to netting.

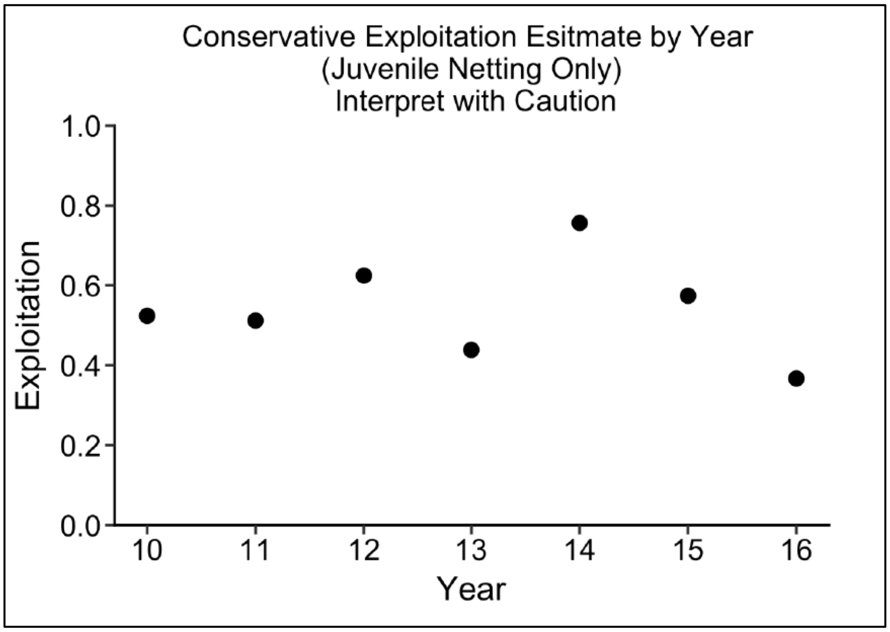

Figure 11: Modeled exploitation rates for Juvenile Lake Trout Netting in Swan Lake, 2010-2016.

CRITERIA #2. TRENDS IN LAKE TROUT DENSITY, CONDITION, AND LENGTH OF SPAWNING FISH

Lake Trout density in Swan Lake is evaluated by examining the catch per unit effort during juvenile and spawner netting events. Lake Trout catch per unit effort during juvenile netting activities has been relatively consistent since the beginning of the project (Figure 12). This lack of trend in catch per unit effort suggests that spawner netting efforts have not been sufficient to affect recruitment to a point in which the Lake Trout population is declining. Similarly, Lake Trout catch per unit effort in 4.5” and 5.0” mesh (stretch) nets set along the traditional spawning area show no significant decline (Figure 13). In fact, after an initial period of decline in 2009-2012, the Lake Trout catch per unit effort during spawner netting appears to be increasing since 2013. The lack of a significant overall trend suggests that mortality rates from juvenile netting have not been sufficient to reduce recruitment of adult Lake Trout to the spawning grounds.

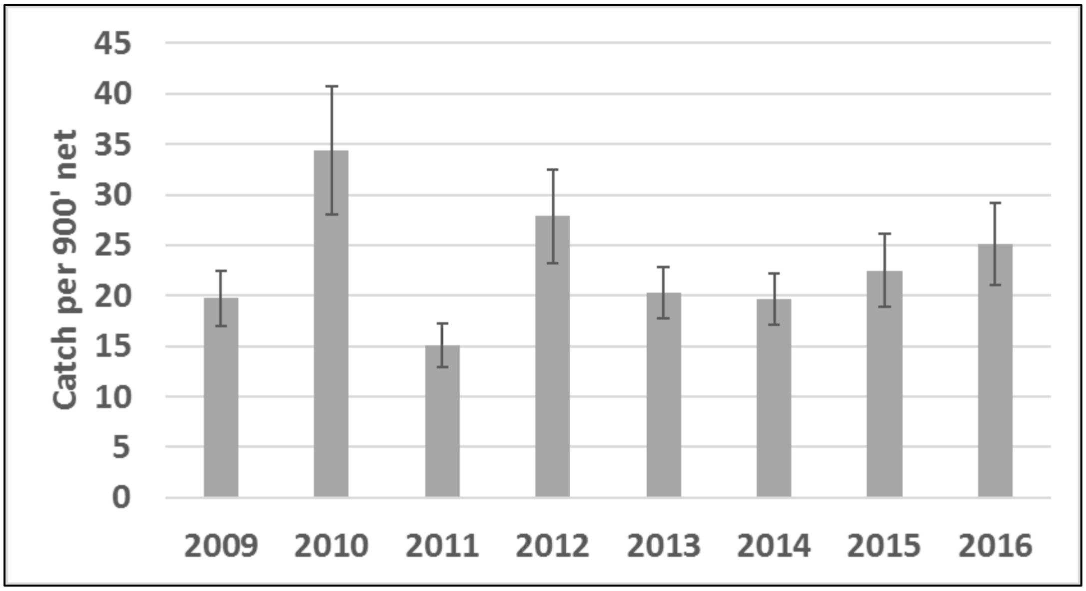

Figure 12: Lake trout catch per unit effort for mesh sizes <3"-stretch during juvenile netting 2010-2016 in Swan Lake.

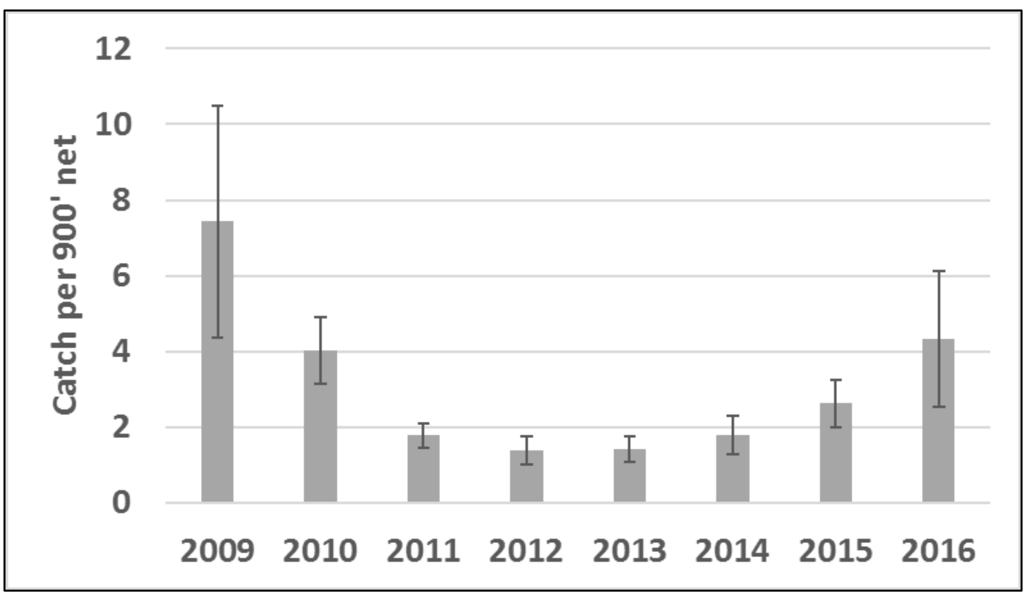

Figure 13: Lake trout catch per unit effort for nets set along "traditional" spawning areas 2009-2016 in Swan Lake.

Lake Trout condition in Swan Lake has been evaluated by examining the relative weight of Lake Trout captured in both netting events. Consistent with the work done by Cox (2010), we examined three different size classes of Lake Trout.

Immature Planktivorous Lake Trout (280-499 mm) were defined by Cox (2010) as juvenile fish that use Mysis as their primary food source. Immature Piscivorous Lake Trout (500-699 mm) were defined by Cox (2010) as fish that had yet to reach maturity but had made a diet shift to piscivory. In our current population structure, many if not most 500-699 mm fish are sexually mature in the fall. Finally, Mature Piscivorous Lake Trout (>700 mm) were described by Cox (2010) as sexually mature individuals that eat other fish almost exclusively. Relative weight data collected for all three “life history stages” over time showed no significant trend (Figure 14). This lack of trend suggests that netting has not likely affected relative weight of the Lake Trout population. Reasons for this lack of response are unclear, but may reflect a population that is still below carrying capacity. Alternatively, the lack of trend may represent a situation in which the Lake Trout population is at carrying capacity, but that gill net harvest has been insufficient to affect relative weight.

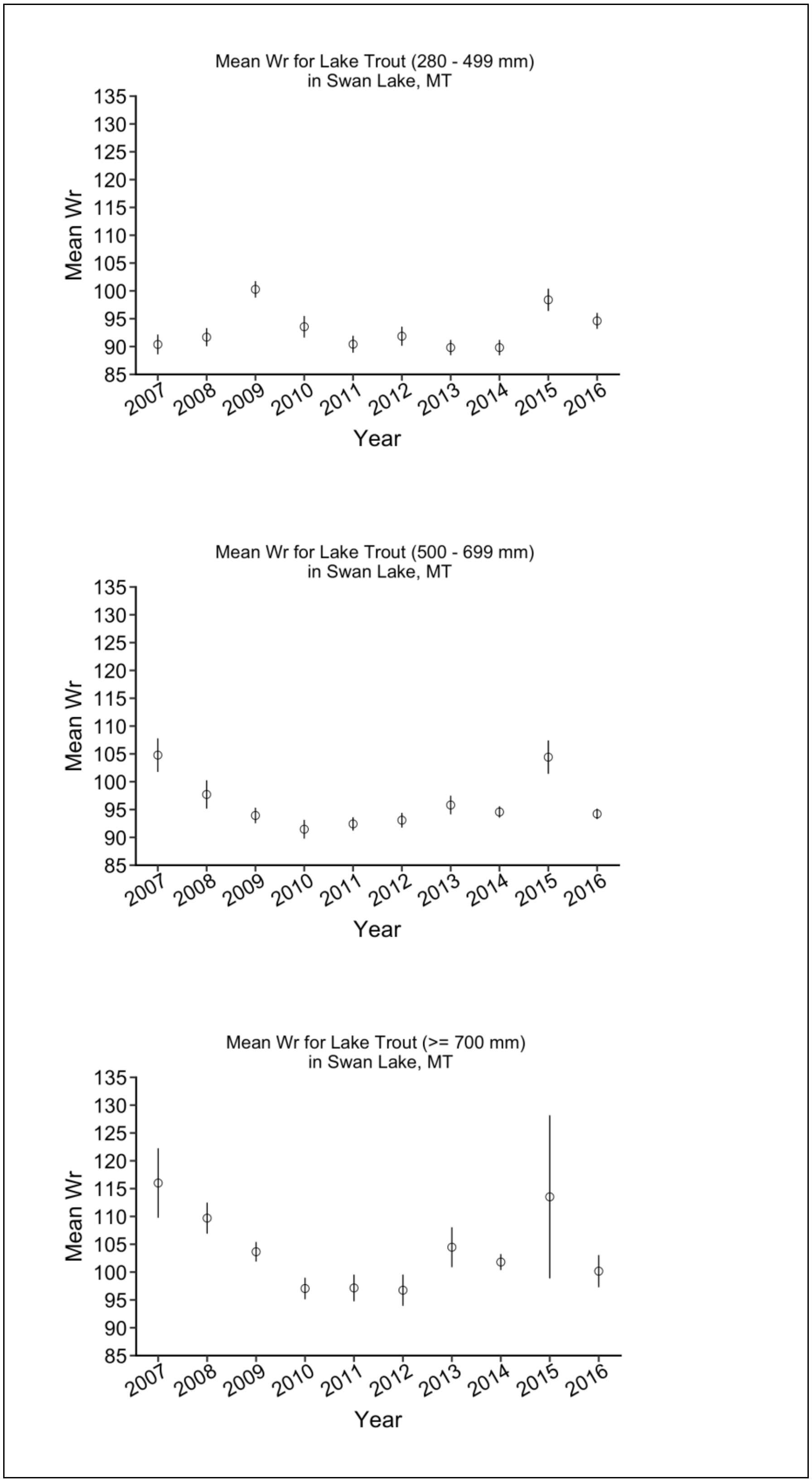

Figure 14: Lake Trout relative weight data from Swan Lake 2007-2016.

The average length of spawning Lake Trout has also been monitored throughout the project. We would expect to see the average length decline if our efforts have been effective at removing the older portion of the Lake Trout population. As described previously, the relative length frequency distribution of Lake Trout captured during suppression efforts has shifted toward smaller individuals on known spawning areas (Figures 5 and 6). This finding suggests that gillnetting has been effective at exploiting the larger, older Lake Trout on previously identified spawning areas in Swan Lake. This stresses the importance of periodic sonic telemetry, as it takes only a few successful spawners to create future cohorts of Lake Trout.

CRITERIA #3. TRENDS IN OTHER FISH POPULATIONS (BULL TROUT, KOKANEE, MYSIS)

As previously discussed, Bull Trout population trends and indicators continue to be monitored as part of the success criteria. Maintaining or increasing the population of Bull Trout is something the SVBTWG has been working toward since its creation in 2005. Adult Bull Trout numbers are monitored annually through redd counts. Bull Trout redd counts have been counted in four index tributaries (Elk, Lion, Goat, and Squeezer) since 1982 (Figure 15) and have been counted in the other eight known spawning tributaries (North and South Lost, Main and South Woodward, Soup, Cold, Piper, and Jim) for a basin-wide survey since 1995 (Figure 16). The 2016 index count of 177 redds is 49% below the 1992-2015 average of 364 redds. Similarly, the 2016 basin-wide count of 348 redds is 40% below the 1995-2015 average. Record precipitation in October of 2016 affected biologists' ability to accurately conduct the surveys and the 2016 data should be viewed with caution. However, this year's results were mostly consistent with those of the last seven years (range 312-428 basin-wide). While it appears this lower level of Bull Trout abundance has been stable since 2009, there remains concern for upcoming years, based in part on declining Bull Trout bycatch in the lake.

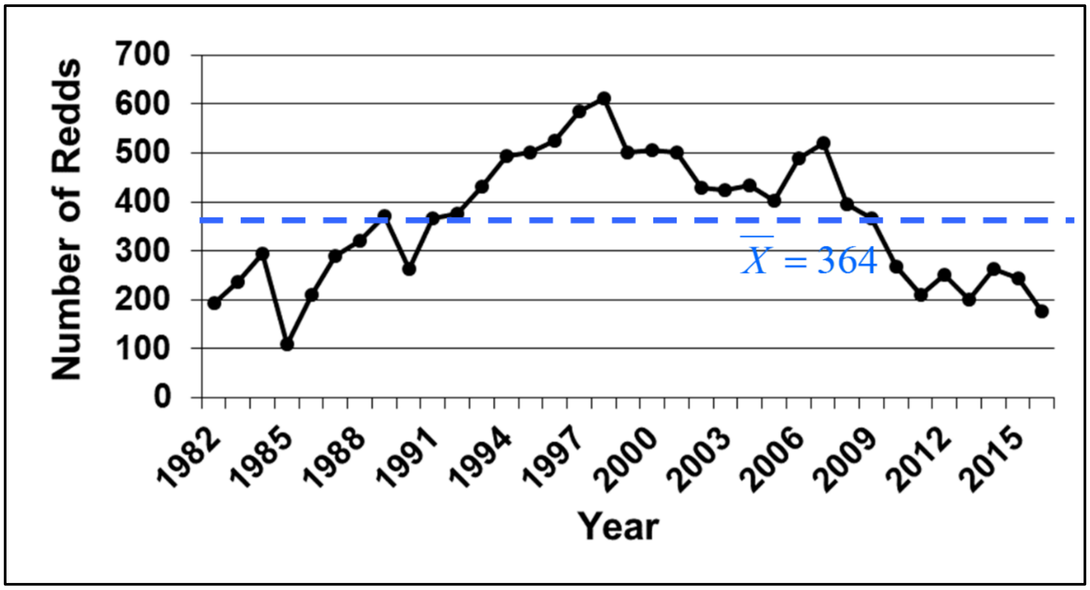

Figure 15: Bull trout redd counts in index streams of the Swan River drainage 1982-2016.

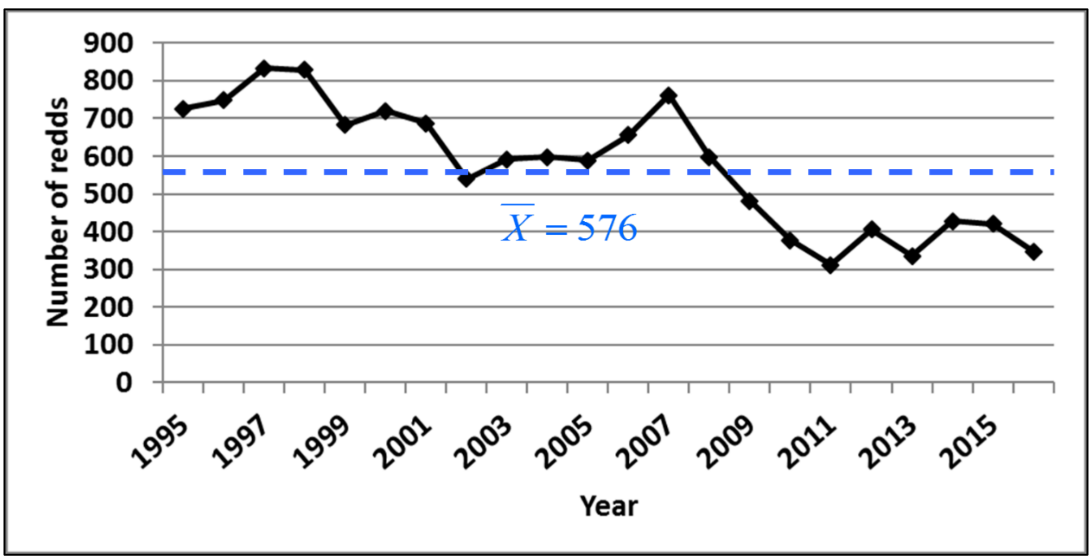

Figure 16: Basin-wide bull trout redd counts for the Swan River drainage 1995-2016.

The lag time inherent in the metrics we use to monitor Bull Trout abundance, from spawning (redd counts), to stream recruitment (juvenile abundance) to subadult (Age-4, 5) and adult (Age-6+) abundance reflected as bycatch in the lake, may provide conflicting signals. Each can only be judged on their own merits. Currently juvenile Bull Trout abundance in the upstream spawning and rearing habitat of Swan Lake remain relatively strong. However, there is also solid evidence that subadult populations in the lake have declined. The bottleneck appears to be developing at early (Age-3, 4) lake survival.

It is possible that this observed subadult bottleneck will translate into decreasing Bull Trout redd counts and contribute to some measure of declining recruitment of the Bull Trout population in Swan Lake in the next few years. To what extent cascading events can be forestalled by controlling the factors causing the decline (i.e., Lake Trout competition and/or predation) or mitigated by shifts in the Bull Trout life history parameters (i.e., toward more fluvial or resident life history forms) is largely unknown.

To more adequately predict Bull Trout trends, we recommend that the existing basin-wide redd count strategy be maintained, that juvenile recruitment indices in the spawning and rearing streams be modified and improved (as is currently in process), and that a better lake-wide population index be developed, either from a revised monitoring method or by re-interpreting existing tag and recapture information.

Kokanee Salmon and *Mysis* shrimp also continue to be monitored. As described previously in the report, Kokanee numbers have remained relatively stable during the past five years (Figures 9 and 10), after rebounding from the lowest spawning counts on record in 2011. The number of Kokanee captured as bycatch in the project has also been relatively stable with age classes 2+ and 3+ well represented. This finding is of interest, as Kokanee Salmon are often extirpated in lakes with expanding Lake Trout populations. *Mysis* shrimp densities have been monitored since 1983 by vertical plankton tows at two locations (Figure 17). While *Mysis* densities appear to be variable, the 2012 and 2016 surveys revealed low densities relative to long-term trends.

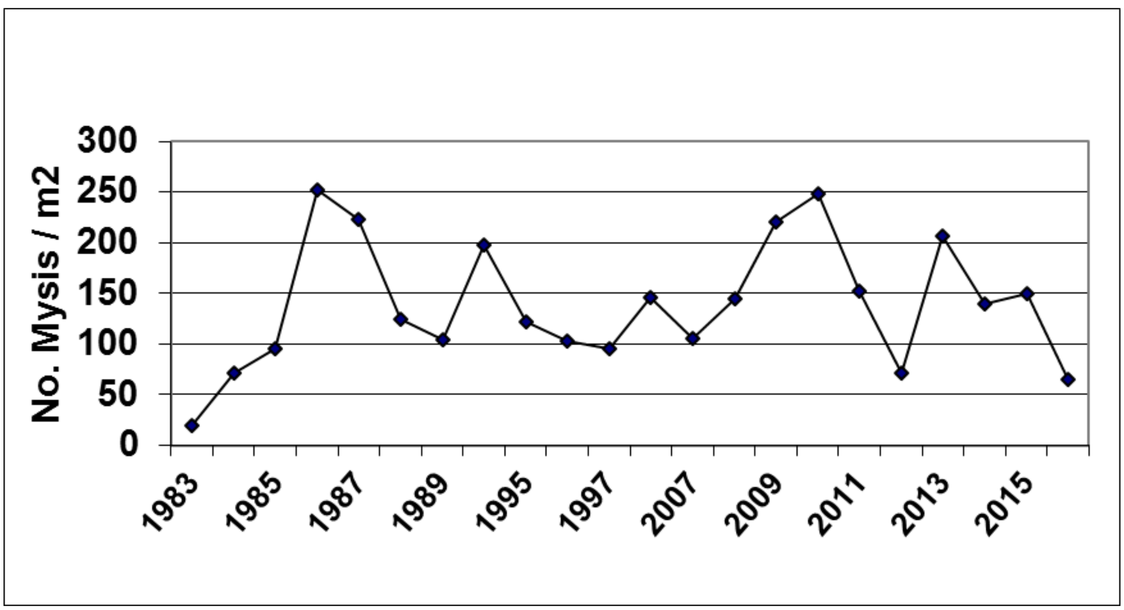

Figure 17: Mysis shrimp densities in Swan Lake 1983-2016.

2017 PLANS

The 2016 field season represented the final year of this eight-year experimental suppression project. The project was initiated to determine if limited gillnetting effort (3 weeks juvenile netting and 3 weeks spawner netting) could be an effective tool to reduce Lake Trout numbers thereby stabilizing or increasing Bull Trout and Kokanee populations. The 2009 and 2012 EA's written for this project described finite timelines. The information gained will assist biologists as options for the future management of Lake Trout in Swan Lake are considered. There are no plans for suppression netting of Lake Trout in Swan Lake in 2017. The original concerns that unchecked Lake Trout expansion could collapse other fish populations, including the Threatened Bull Trout, have not gone away.

In the meantime, routine monitoring of the aquatic organisms will continue in the Swan Lake system. The typical spring gill net survey, which examines the entire fish community of Swan Lake, occurs in late May. Annual *Mysis* sampling occurs in early June. Bull Trout will be monitored through ongoing juvenile population estimates in select spawning tributaries and basin-wide Bull Trout redd counts will be conducted in October. Kokanee will be monitored through redd counts completed in early December.

In addition to these surveys, plans are currently underway to create a new survey protocol to track Lake Trout abundance and mortality rates in Swan Lake. This survey will be designed to track trends in the Lake Trout population independent of any type of harvest scenario. This will allow biologists to better evaluate any proposed suppression alternatives.

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