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DEER CREEK RESERVOIR:

THE EFFECTIVENESS OF TIGER TROUT FOR CONTROLLING GOLEN SHINERS

ABSTRACT

Fingerling tiger trout (Brown Trout *Salmo trutta* X Brook Trout *Salvelinus fontinalis)* were stocked in Deer Creek Reservoir in the spring of 2014 for the purpose of controlling an overabundant Golden Shiners *Notemigonus crysoleucas* population through predation. Golden Shiners had been previously discovered in Deer Creek Reservoir in 2006 and 2010. The reservoir was renovated with rotenone in both instances. A study was initiated in 2014 to monitor the Golden Shiner population and the impacts of stocked fingerling tiger trout on these fish. Sampling was conducted using electrofishing, minnow traps, and gill nets in order to establish pre-treatment length frequency and abundance status of Golden Shiner populations before the tiger trout could grow to a predatory size. Throughout the field season, 2,648 Golden Shiners were captured with a range in length from 10 - 169 mm. Trout captured during the study included 158 Rainbow Trout, 71 Brook Trout, 13 Westslope Cutthroat Trout, and one tiger trout. Zooplankton sampling revealed a substantial decline in zooplankton length and abundance compared to previous data when Golden Shiners were not present. This decline in food resources may have been a primary reason why only one tiger trout was collected in 2014, and will likely result in future decreased growth and survival of trout dependent on this food source. Golden Shiners were present in the stomach contents of only Rainbow Trout and Brook Trout over 250 mm. The apparent lack of success in establishing a tiger trout population by stocking fingerlings suggests we should change our management strategy. Decreasing or eliminating the stocking of fingerling trout, and stocking larger trout (tiger trout, Rainbow Trout, and/or Brook Trout >250 mm) may increase their likelihood of survival, decrease the predation pressure on zooplankton, and increase pressure on the Golden Shiner population through piscivory. Additionally, minnow traps were not effective in sampling Golden Shiners, and should be discontinued. Sampling with electrofishing and gill nets should continue through the course of this study.

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INTRODUCTION

Deer Creek Reservoir (DCR) is the most remote of the Clearwater Region's lowland reservoirs, located approximately 140 km and 185 km from the region's largest population centers of Lewiston, Idaho (pop. 32,119) and Moscow, Idaho (pop. 24,080). However, it is an important part of the lowland lake program, as it provides a location for trout harvest in an area where all stream/river fishing is under restrictive harvest regulations of two trout per day. Even with its remote location, DCR accounted for an estimated 14,709 hours of angler effort in 2005 and 5,254 hours in 2012 (Hand et al. 2012). An economic survey conducted in 2011 estimated 1,175-angler trips to DCR for an estimated total economic expenditure of $75,707 (IDFG unpublished data). While other reservoirs are closer to these population centers, DCR is a popular place to fish due to its proximity to some smaller communities, easy fishing access, and good catch rates for trout. Deer Creek Reservoir is a trout-only fishery, containing Rainbow Trout *Oncorhynchus mykiss*, Westslope Cutthroat Trout O. clarkii lewisi, and Brook Trout *Salvelinus fontinalis*. There are no warm-water game species present.

In 2013, it appeared that there was an overabundance of Redside Shiners *Richardsonius balteatus* in DCR. Redside Shiners are planktivores and can have a negative impact on trout fisheries as they compete for the same food source (Larkin and Smith 1954). In an attempt to control their numbers, IDFG stocked fingerling tiger trout (Brown trout *Salmo trutta* X Brook trout *Salvelinus fontinalis)* in DCR in the spring of 2014. Tiger trout have been reported to be a more effective predator than the parent species (Scheerer et al. 1987). Hopes were that the tiger trout could effectively reduce shiner abundance and increase plankton for the other trout present.

A survey was initiated in 2014 after the tiger trout were stocked to monitor their effects on the Redside Shiner population. The tiger trout were planted as fingerlings (4-5 inches) and most likely would have little impact on the shiner population until they reached larger sizes. Therefore, even though the survey was conducted after stocking tiger trout, the survey would give a pre-treatment status on the shiner population. After the first round of surveys on DCR, closer analysis revealed that the shiner species present were Golden Shiner *Notemigonus crysoleucas*, not Redside Shiner. This misidentification was likely due to the fact that juvenile Redside Shiners and Golden Shiners are almost indistinguishable.

Deer Creek Reservoir was previously renovated with rotenone in 2006 and 2010 to remove Golden Shiners (Hand 2006; Hand et al. 2013). It is unclear how Golden Shiner got into DCR, but additional surveys found them distributed in ponds and streams throughout the general area. The decision to eradicate Golden Shiners from DCR was based on: (1) Golden Shiners are effective planktivores and would compete with trout for food resources, and (2) concern that Golden Shiner might spread downstream into Dworshak Reservoir, which supports an important kokanee fishery that has been found to generate annually over four million dollars in revenue for the surrounding communities (IDFG unpublished data).

There is a pattern of 3 - 4 years between observations of Golden Shiners in DCR. Deer Creek Reservoir was built in 2003; Golden Shiners were discovered in 2006, and reservoir renovation by rotenone treatment took place the same year. Golden Shiners were observed again in 2010 and a second renovation by rotenone treatment took place in the same year. Electrofishing surveys conducted in 2012 on DCR did not yield any shiner species (Hand et al. 2016a2); however, they were observed at small lengths and low numbers in the reservoir while performing other surveys. The Golden Shiner population in DCR may have a population growth rate which requires 3-4 years to reach a large enough population at adequate size to be detectable and identifiable in a reservoir the size of DCR.

The source of the re-appearing Golden Shiner population in DCR is unknown. However, the most likely possibility is the potential inefficiency of rotenone to completely eradicate Golden Shiners in the DCR drainage. Golden Shiners have a natural resistance to rotenone and are capable of developing a higher resistance to rotenone which would increase each time the same population is exposed (Orciari 1979). If the initial renovation was not 100% effective, any surviving Golden Shiners would have the potential of creating a rotenone-resistant population. Rotenone can be a cost-effective management tool if desired results are achieved. However, as Golden Shiners continue to repopulate in DCR, we decided that rotenone will not be used at this time. Additionally, Golden Shiners have been found in nearby drainages including Orofino Creek, Jim Ford Creek, and Schmidt Creek. This indicates that Golden Shiners are now widespread and complete eradication will be nearly impossible. Due to the fact that a management plan had already been implemented (tiger trout), and the lack of success in eradicating Golden Shiners by rotenone in previous years, a decision was made to study whether tiger trout might be effective in reducing Golden Shiners.

OBJECTIVES

1. Describe the pretreatment status of the Golden Shiner population.
2. Monitor the effects of tiger trout on size structure and abundance of Golden Shiners.
3. Monitor the effect of Golden Shiners on the zooplankton community.

STUDY AREA

Deer Creek Reservoir is located in Clearwater County, Idaho, 21 km north of the town of Pierce, Idaho (Figure 1). It is a 47.0 ha reservoir located at an elevation of 1,006 m. It has a maximum depth of 11 m, and a maximum volume of 759 acre-ft. Completed in 2003, it is the second newest reservoir in the state of Idaho. It was created by damming Deer Creek, a tributary of Reeds Creek that flows into Dworshak Reservoir. The reservoir and watershed is owned by Potlatch Corporation, which leases the reservoir property to the Idaho Department of Fish and Game. Today, the reservoir is used extensively by boaters and anglers and provides unique trout fishing opportunities.

METHODS

Limnology Sampling

Limnology sampling, consisting of dissolved oxygen and temperature profiles, were collected monthly from April - November in 2014. These samples were taken to provide information on habitat quality, the quantity of habitat available to trout, and to provide historical documentation. Dissolved oxygen (DO) and temperature profiles were taken from a boat with a YSI model 550A meter at the surface and spaced at 1 m increments down to the bottom of the lake. On sampling station was used, located at the deepest point of the reservoir. The boat was kept stationary with an anchor while measurements were taken. Temperature was recorded in ˚C, and dissolved oxygen in mg/L.

Zooplankton Sampling

Zooplankton samples were collected monthly from April - November in 2014. Zooplankton samples were collected with a Wisconsin style plankton net (80 micron mesh, 30 cm diameter mouth). The boat was anchored at the deepest location on the lake based upon bathymetric maps and depth finder readings. When anchoring the boat, the anchor was slowly dropped and slack in the anchor line was let out to let the boat drift away from the anchor location. Three vertical tows were taken from that location. Tows were started 1 m above the bottom of the lake to avoid disturbing sediment. Depth of tow was recorded on each sample jar. Samples were rinsed into sample jars and stored in 70% ethyl alcohol. A Rite-in-the-Rain label was placed inside the sample jar. Samples were labeled with date, reservoir, number of tows, depth of tow, and personnel present.

In the laboratory, zooplankton samples were diluted into a known volume container (typically 100 ml) and 5 ml aliquots were then subsampled. Subsamples were counted until 200 individuals from the most dominate family were observed. The density of zooplankton in each individual tow was then estimated by expanding the subsample estimate and dividing it by the total volume to the tow. Tow volume (T) was calculated by:

$$T = \pi r^2 \text{ x } h$$

where r = radius of the net and h = depth of tow.

Zooplankton was counted based on two categories, cladoceran (Ceriodaphnia, Diaphanosoma, and Daphnia) and copepods (Cyclopoids and Calanoids). All zooplankton within these groups were enumerated within the subsamples. In addition, the first 30 cladocerans and/or most abundant zooplanktor in the subsamples were measured under the dissecting microscope to establish a length distribution for the sample.

Fish Monitoring

Electrofishing surveys were conducted in July, August, and October 2014 to monitor the different fishes that occurred in DCR. Ten sample sites were randomly selected from shoreline GPS points developed during a vegetation survey conducted in 2012 (Figure 2; Hand et al. 2016a). These points were used as starting points for 50 m electrofishing transects. These sites were used consistently for the duration of the study. Boat mounted electrofishing was conducted using pulsed D.C. current from a Honda 5000w generator and an ETS MBS-1DP pulsator. Golden Shiner lengths were recorded into 10 mm bins and trout species were recorded to the nearest mm.

Minnow trap surveys were conducted in May, July, August, and October 2014. Fifteen sample sites were randomly selected using the method stated above for minnow trap sets (Figure 3). A depth of 1.0 m, 0.5 m, or surface level was randomly assigned to each site (

Table 1). These sites and assigned depths were used consistently for the duration of the study. Minnow traps were constructed of 6 mm galvanized, extruded steel mesh with a length of 419 mm, diameter at center of 222 mm, diameter at end of 178 mm, and a 25 mm opening. Traps were baited with 56 g of dry dog food contained in mesh bags (pantyhose). Traps were left overnight and collected in the morning. Fish collected were measured as described for electrofishing above.

Gill net surveys were conducted in October and November 2014. Gill net sites were selected by visual inspection of the reservoir shoreline due to the presence of large quantities of woody debris. Since gill nets are easily damaged by snagging woody debris, the gill nets sites were selected for areas that were least likely to cause damage to the nets. Nets used for this survey were the floating gill nets used for standard high mountain lake surveys (see High Mountain Lake section of this report for gill net specifications). The nets were set by attaching the small mesh end to the shore and setting the large mesh end towards the center of the reservoir using a rope attached to a weight. Although the nets were designed as floating gill nets, the nets were also used as sinking nets by attaching the weight directly to the large mesh end of the net. Gill nets were left overnight and collected in the morning. Golden Shiners collected were measured for total length and recorded into 10 mm length groups. Trout species collected were measured and recorded to the nearest mm. All trout were dissected to examine stomach contents for presence of Golden Shiners.

Minnow traps and gill nets were set after electrofishing when occurring on the same date to avoid bias by “herding” fish toward or away from traps and nets.

RESULTS

Limnology Sampling

Monthly dissolved oxygen (Figure 4) and temperature (

Figure 5) samples changed throughout the year with evident seasonal patterns. The changes seen throughout the year were similar to those seen in 2012, the last time limnology samples were taken at DCR (Figures 4 and 5).

Zooplankton Sampling

The zooplankton population in DCR was composed of seven different taxa in 2014: Daphnia, Cyclopoida, Ceriodaphnia, Calanoida, Chydoridae, Diaphanosoma, and Bosmina. Composition of taxa changed throughout the year with Cyclopoida being the most abundant in April, May, early July, October, and November (Figure 6). Calanoida was the most abundant taxa in late July and Bosmina was the most abundant taxa in August (Figure 6). Daphnia were not the most abundant for any sample during 2014, which is a change from 2012 (Figure 7).

Densities (number of individuals/m^3) of taxa varied throughout the 2014 field season (Figure 7). Densities of most taxa peaked in late August. However, Chydoridae and Ceriodaphnia only appeared in the November sample, while Cyclopoida peaked in April. Compared to 2012, all taxa densities were lower in 2014 with the exception of Bosmina, which was not present in 2012 (Figure 7).

The average length of Daphnia collected in 2014 varied from 0.51 - 0.65 mm with an overall average of 0.59 mm. This varied from samples taken in 2012 which ranged in length from

0.62 - 1.30 mm with an overall average of 1.00 mm (Figure 8). The percentage of samples made up of Daphnia was also much higher in 2012 than in 2014 (Figure 9). The percentage of Daphnia ≥1.00 mm in DCR varied in 2014 from 0 - 10.8 % with an average of 3.1 % and the peak in April (Figure 10). This is a substantial difference from the 2012 sampling year which showed a range of Daphnia ≥1.0 mm from 0 - 91.1 % with an average of 51.7 % and the peak in late September (Figure 10).

Fish Monitoring

Electrofishing surveys collected Golden Shiners, Rainbow Trout and Brook Trout, and tiger trout. Golden Shiners (*n* = 1,630) ranged in length from 10 - 169 mm and averaged 55 mm (Figure 11). Rainbow Trout (*n* = 18) ranged in length from 209 - 328 mm and averaged 255 mm. Brook Trout (*n* = 41) ranged in length from 181 - 285 mm and averaged 237 mm. One tiger trout was captured and was 145 mm in length.

Minnow trap surveys collected 461 Golden Shiners that ranged in length from 40 - 119 mm and averaged 65 mm (Figure 12). One Rainbow Trout was captured with a length of 274 mm. No shiners were collected from the overnight sets in October.

Gill net surveys collected Golden Shiners, Rainbow Trout, Cutthroat Trout, and Brook Trout. Golden Shiners (*n* = 557) ranged in length from 70 - 169 mm and averaged 95 mm (Figure 13). Rainbow Trout (*n* = 141) ranged in length from 203 - 322 mm and averaged 268 mm (

Figure 14). Only Rainbow Trout ≥258 mm had Golden Shiners in their stomach contents, and of the Rainbow Trout ≥258 mm, 7.1% had Golden Shiners present in their stomach contents (

Figure 14). Westslope Cutthroat Trout (*n* = 13) ranged in length from 172 - 282 mm and averaged 263 mm (Figure 15). None of the Cutthroat Trout had Golden Shiners present in their stomach contents. Brook Trout (*n* = 30) ranged in length from 174 - 365 mm and averaged 249 mm (Figure 16). Only Brook Trout ≥249 mm in length had Golden Shiners present in their stomachs. Of the Brook Trout ≥249 mm, 23.8% had Golden Shiners present in stomach contents (Figure 16).

DISCUSSION

This study was prompted by the concern that an overabundance of shiners in DCR could potentially reduce the primary food source (zooplankton) that is essential in a reservoir managed as a put and grow trout fishery. This work confirmed this concern as the zooplankton population in DCR decreased in abundance and size from 2012 to 2014. In addition, Daphnia, which is one of the preferred zooplankton for trout, showed some of the largest declines in abundance of all the zooplankton taxa.

Zooplankton communities change in composition and abundance both seasonally and annually based on environmental factors such as food sources and temperature (Wetzel 2001). However, there were no substantial differences in temperature in DCR from 2012 to 2014 (

Figure 5). There was no pattern of overall decrease in almost all taxa observed in other nearby reservoirs (Hand et al. 2016a). These data suggest that the changes in zooplankton composition and abundance from 2012 to 2014 was likely related to the increased predation pressure from overabundant Golden Shiners.

Daphnia made up on average 74% of the total stomach contents of Rainbow Trout (*n* = 9) collected from DCR in 2012 (Table 2). From this information we can assume that Daphnia are an important food source for Rainbow Trout, which make up the majority of the fish stocked in DCR (Table 3). The size-structure of a zooplankton community can give a better understanding of the food available to planktivorous fishes (Galbraith 1967; Mills and Schiavone 1982). Tabor et al. (1996) suggests that the biomass of daphnids >1.0 mm can provide a useful index for predicting Rainbow Trout growth when daphnids make up a substantial portion of the fishes diet. No biomass calculations were made in the study. However, from 2012 to 2014, on average, Daphnia abundance declined by 98% and average size declined by 41%.

He and Kitchell (1990) suggest that the addition of a predator can decrease prey abundance and change fish community structure. Mills et al. (1987) suggests that heavy predatory pressure by piscivores can regulate planktivorous fishes and produce potentially beneficial changes in zooplankton communities. It has also been demonstrated that zooplankton size can provide a useful index to monitor the predator-prey balance (Mills and Schiavone 1982; Mills et al. 1987; He and Kitchell 1990) as well as provide an index for monitoring the potential growth and survivability of Rainbow Trout (Galbraith 1967; Tabor et al 1996; Budy et al. 2005). Zooplankton monitoring should be continued on DCR for the duration of this study and possibly longer to monitor food sources, predator-prey balance, and potential growth rate for trout. This information will be helping for adjusting stocking rates to avoid poor condition of trout if food resources change.

Golden Shiner surveys were conducted in 2014 to establish a pretreatment status of the population in order to monitor changes in subsequent years. The original plan for the study was to utilize electrofishing surveys and minnow trap sets to establish abundance and length frequency of the shiner population. Gill net sets were implemented in October of 2014 for the purpose of sampling tiger trout to monitor growth and potential shift in diet towards piscivory. Electrofishing surveys collected the most Golden Shiners (*n* = 1,630) and also the largest range of shiner lengths (10 - 169 mm; Figure 17). Minnow traps collected the least Golden Shiners (*n* = 461) but had a more narrow range of lengths (40 - 119 mm) than electrofishing surveys (Figure 17).

The minnow traps were less successful in collecting Golden Shiners than expected. The traps were set near shore baited with dry dog food, which is a common method when attempting to sample littoral zone small prey fish (Jackson and Harvey 1997; Layman and Smith 2001; Danylchuk and Tonn 2003). Golden Shiners are crepuscular planktivores, which spend their time during the day near the littoral zone and leave the shoreline at dusk and dawn to feed on Daphnia which migrate towards the surface at night (Hall et al. 1979; Eggers 1982). Golden Shiners are also selective planktivores that rely on sight for feeding (Hall et al. 1979). The minnow traps set on DCR were near the shore hours after sunset when the shiners were most likely in open water feeding. Also, the traps were baited with dog food inside of mesh bags which would most likely be more of an olfactory attractant than visual. The traps were less consistent in collecting shiners than other sample methods and one survey conducted in October did not collect any fish in any of the traps. This method for minnow traps has been less effective than electrofishing surveys in DCR and should probably not be utilized in subsequent years in order to save time and resources unless a more effective method for setting minnow traps to target Golden Shiners is devised.

While no tiger trout were collected in the gill nets, it is evident that gill nets were very successful at collecting larger Golden Shiners which may be underrepresented in electrofishing and minnow trap surveys (Figure 17). In addition to sampling large shiners, the gill nets provided an opportunity to sample Rainbow Trout, Brook Trout, and Westslope Cutthroat Trout to evaluate

their diets. Golden Shiners were found in the stomach contents of Rainbow Trout and Brook Trout with lengths >258 mm and >250 mm, respectively (

Figure 14 and 16). This suggests that Rainbow Trout and Brook Trout have the potential of piscivory after reaching a length of 250 - 260 mm providing the potential for additional predatory pressure in our Golden Shiner. Beauchamp (1990) saw a similar response with Rainbow Trout in Lake Washington, Washington where once they exceeded 250 mm their diets shifted diets to more piscivory.

Larkin and Smith (1954) described the detrimental effects of an introduction of Redside Shiners into a lake through competition with small trout. Larkin et al. (1957) elaborated on this same study by highlighting the fact that once Rainbow Trout reached a certain length their growth rates were higher than before the introduction of Redside Shiners. This suggests that Rainbow Trout have the potential for faster growth rates when their diet shifts to piscivory. Golden Shiners are the only prey fish known to be available in DCR (with the exception of stocked fingerling trout) and may provide a similar potential for an increased growth rate of larger trout.

Stocking fewer but larger rainbow trout may provide multiple benefits without compromising our management goal in DCR of providing catch rates 0.5 fish/hour. Creel surveys in 2012 found that the catch rates in DCR was 4.0 fish/hour, which is eight times the management goal of 0.5 fish/hour (Hand et al. 2012). Stocking lower numbers of larger (>300 mm) Rainbow Trout would potentially reduce competition on zooplankton while at the same time introduce a fish that may be more effective at preying upon Golden Shiner.

Tiger trout were stocked into DCR as a predator to control the Golden Shiner population. However, only one was collected in 2014 during a reservoir-wide study with multiple gear types. The lack of success in sampling tiger trout in this study raises questions. Approximately 2,600 tiger trout fingerlings (~125 mm in length) were stocked in DCR in 2014, compared to about 13,500 catchable Rainbow Trout and 2,500 Brook Trout fingerlings (Table 3; Figure 18). This relative small percentage of tiger trout stocked (14%) may partially explain the lack of tiger trout collected during the study. However, 13 Westslope Cutthroat Trout were collected which have only been stocked once since the reservoir's renovation in 2010. In 2011, Westslope Cutthroat only made up 13% of the trout stocked in DCR (Table 3). Another possible explanation for the lack of tiger trout sampled in 2014 is predation by other trout species present in DCR. It has been shown that Golden Shiners are an elusive prey and can be selected against when other prey fishes are available (He and Kitchell 1990). However, based on the size that tiger trout were stocked at (~125 mm), it is unlikely heavy predation occurred from the fish that occur in this reservoir as few exceeded 300 mm. The most likely cause for the failure of the fingerling tiger trout stocking is a lack of adequate food resources. As mentioned above, over 18,000 trout were stocked into DCR in 2014 (Figure 18). This is in addition to fish that carried over from previous year's stockings. This large number of fish in the reservoir is likely resulting in very little food available for fingerling tiger trout, and is evidenced by the depressed zooplankton abundance and average length (Figure 7 and 8) seen during sampling in 2014. This lack of food resources appears to be resulting in few of these fish surviving long enough to reach piscivorous size.

The apparent lack of success in establishing a tiger trout population through the stocking of fingerlings suggests that changes to our management strategy should be implemented. The primary change should be to the size of tiger trout stocked. If fingerlings are not surviving long enough to grow to piscivorous size, we should consider stocking them at sizes where they will be large enough to prey upon Golden Shiner. Based on our findings with Rainbow Trout and Brook Trout it, tiger trout should be stocked at sizes >250 mm in the future. Planting larger catchable rainbow trout (i.e. magnum size) may also increase predation pressure on Golden Shiners.

An alternative strategy would be the addition of another predator to DCR to aid in the management of Golden Shiner populations. Deer Creek Reservoir is currently managed as a trout-only fishery which, by definition, does not allow the addition of a more traditional management predator such as Largemouth Bass *Micropterus salmoides* or Smallmouth Bass *Micropterus dolomieu*. Of these two options, Smallmouth Bass would most likely be the preferred choice as this species already inhabits Dworshak Reservoir and survives better than Largemouth Bass at colder temperatures. This would create an additional fishing opportunity on DCR; however, the predator would most likely also prey on trout species and may even select against Golden Shiners for small trout (He and Kitchell 1990). Tiger trout were chosen to manage shiners through predation without changing the trout-only management while also creating an additional fishing opportunity. While we do not recommend the additional of a bass species at this time, it may be a viable option in the future if other options are not successful.

MANAGEMENT RECOMMENDATIONS

1. Continue limnological and zooplankton sampling to monitor habitat, food source availability, and predator-prey relationships.

2. Continue fish population monitoring using electrofishing and gill netting. Discontinue minnow trap sets unless a more efficient method is devised.

3. Continue to evaluate growth, condition factor, and diets of all trout species sampled.

4. Stock tiger trout at lengths >250 mm in an effort to increase their survival and to increase predation on Golden Shiners.

5. Stock fewer but larger (>300 mm) rainbow trout in an effort to reduce competition on zooplankton and to increase the predation pressure on Golden Shiners.

Table 1. Randomly assigned depths that each minnow trap was fished at in Deer Creek Reservoir, Idaho, during 2014.

Minnow Trap Number	Depth	Minnow Trap Number	Depth
1	1.0 m	9	0.0 m
2	0.5 m	10	0.0 m
3	1.0 m	11	0.5 m
4	1.0 m	12	1.0 m
5	0.0 m	13	1.0 m
6	0.5 m	14	0.0 m
7	0.5 m	15	0.0 m
8	0.5 m		

Table 2. Stomach contents of Rainbow Trout (RBT) collected from an angling survey conducted on Deer Creek Reservoir, Idaho, during 2012.

	Taxa							
Fish Number	Daphnia	Holopedium	Eurycercus	Chaoborus	Ceratopogonidae	Cyclopoid	Other	Percent Daphnia
1	229	3	0	1	0	1	1	97.4
2	27	0	0	0	6	0	0	81.8
3	1	0	1	20	0	2	13	2.7
4	61	1	1	17	3	0	4	70.1
5	31	0	3	71	1	0	0	29.2
6	3	0	0	0	0	0	0	100
7	614	0	0	6	0	0	4	98.4
8	469	0	3	1	0	3	1	98.3
9	73	0	0	0	14	0	0	83.9
Total	1,508	4	8	116	24	6	23	73.6

Table 3. The number of fish stocked in Deer Creek Reservoir, Idaho, from 2011 to 2014.

	2011		2012		2013		2014	
Species	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Rainbow Trout	34,385	87	24,290	75	22,192	69	13,552	73
Brook Trout	0	0	8,100	25	10,000	31	2,471	13
Westslope CT	5,009	13	0	0	0	0	0	0
Tiger Trout	0	0	0	0	0	0	2,628	14
Total Fish Stocked	39,394		32,390		32,192		18,651	

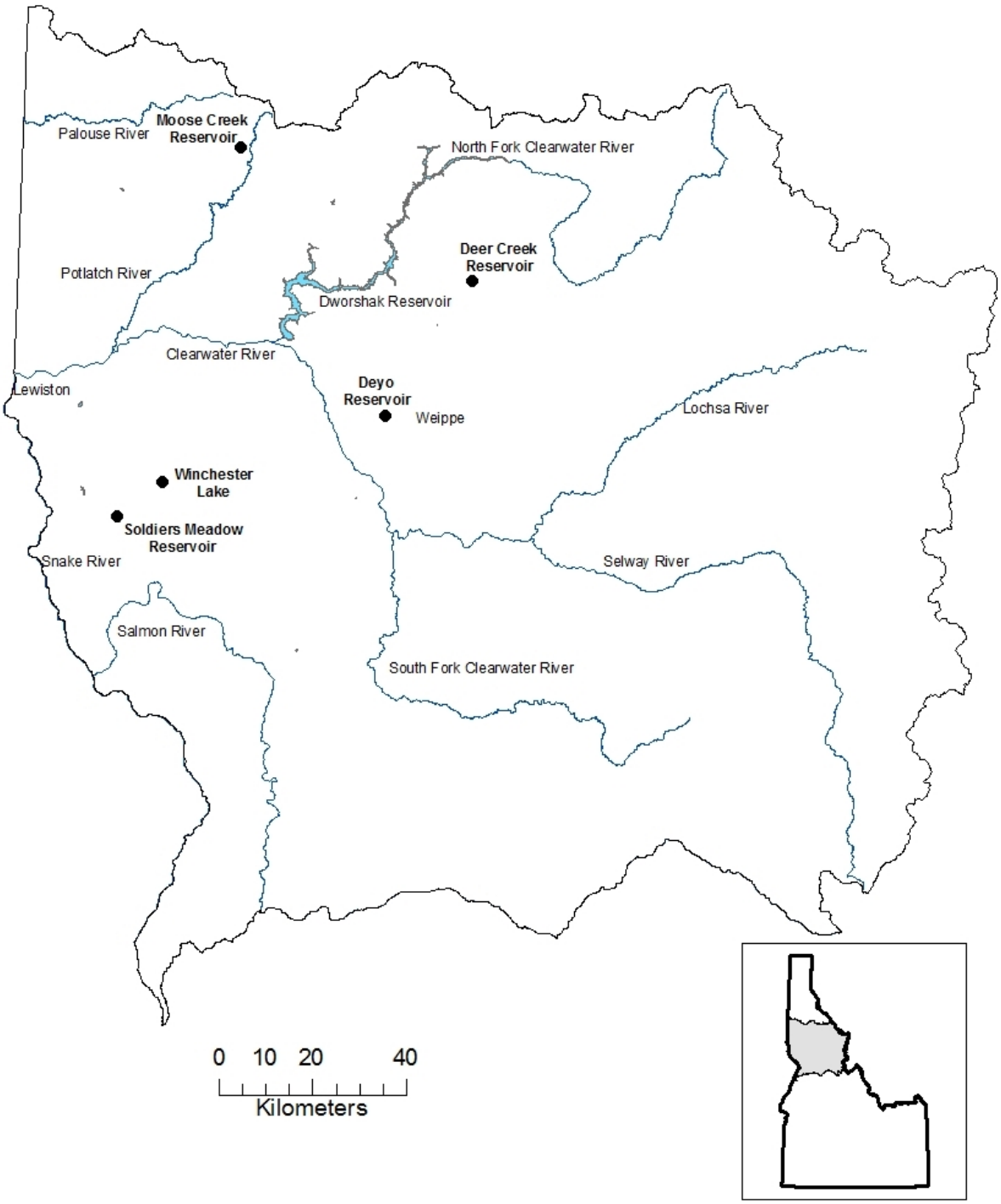

Figure 1. Map showing locations of reservoirs surveyed in the Clearwater Region, Idaho, during 2014.

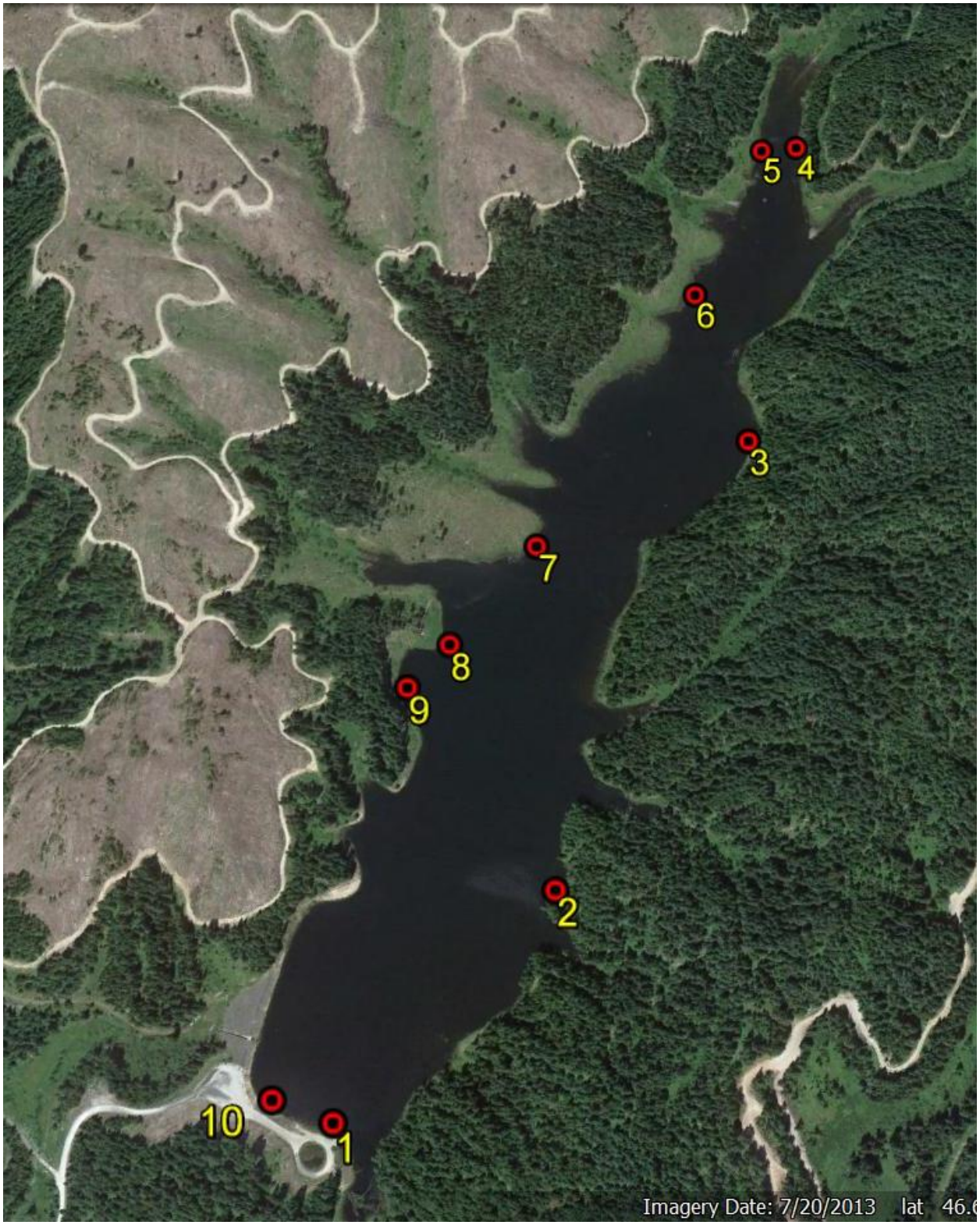

Figure 2. Randomly selected locations of starting points for 50 m electrofishing transects on Deer Creek Reservoir, Idaho, in 2014.

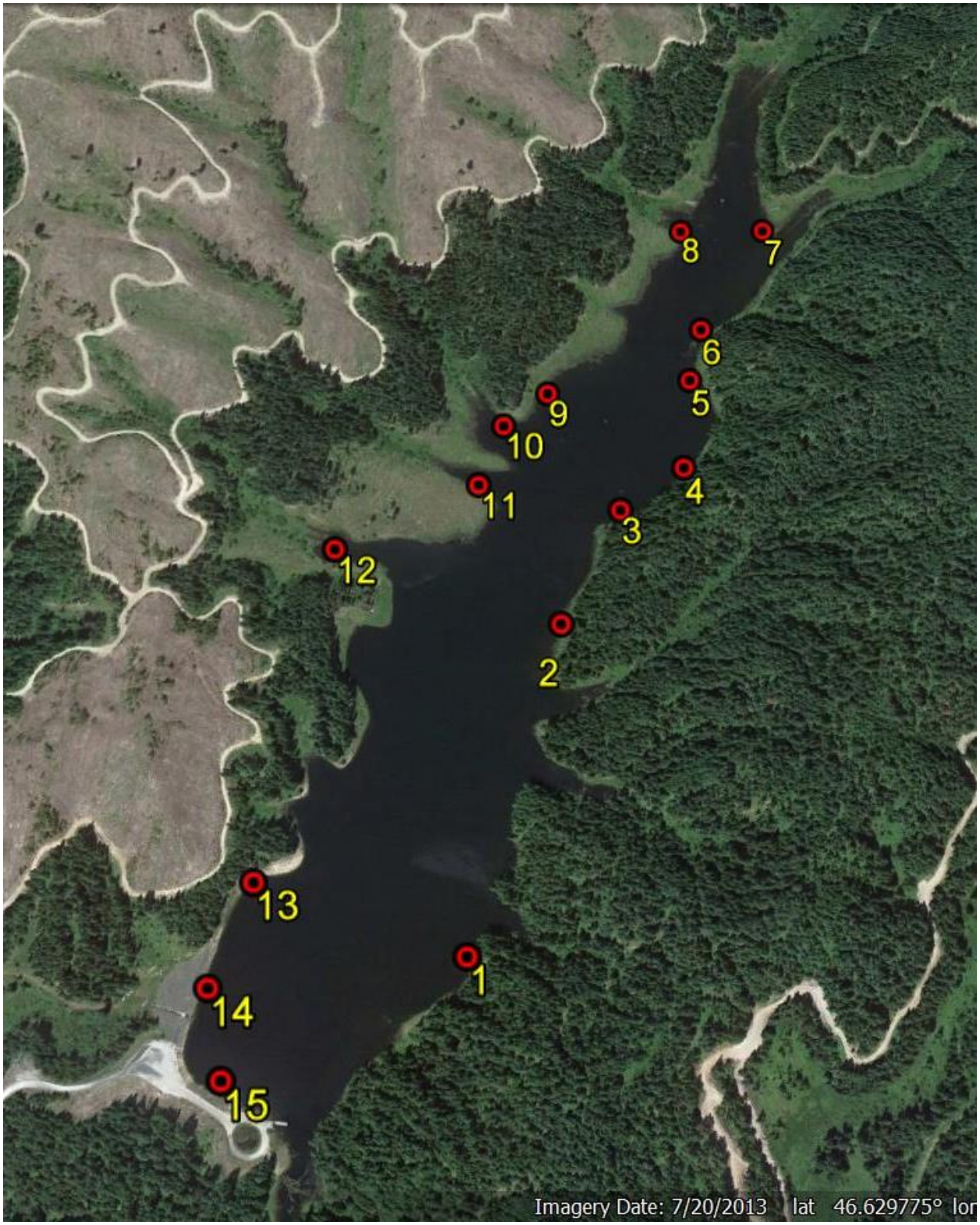

Figure 3. Locations of where minnow traps were set in Deer Creek Reservoir, Idaho, in 2014.

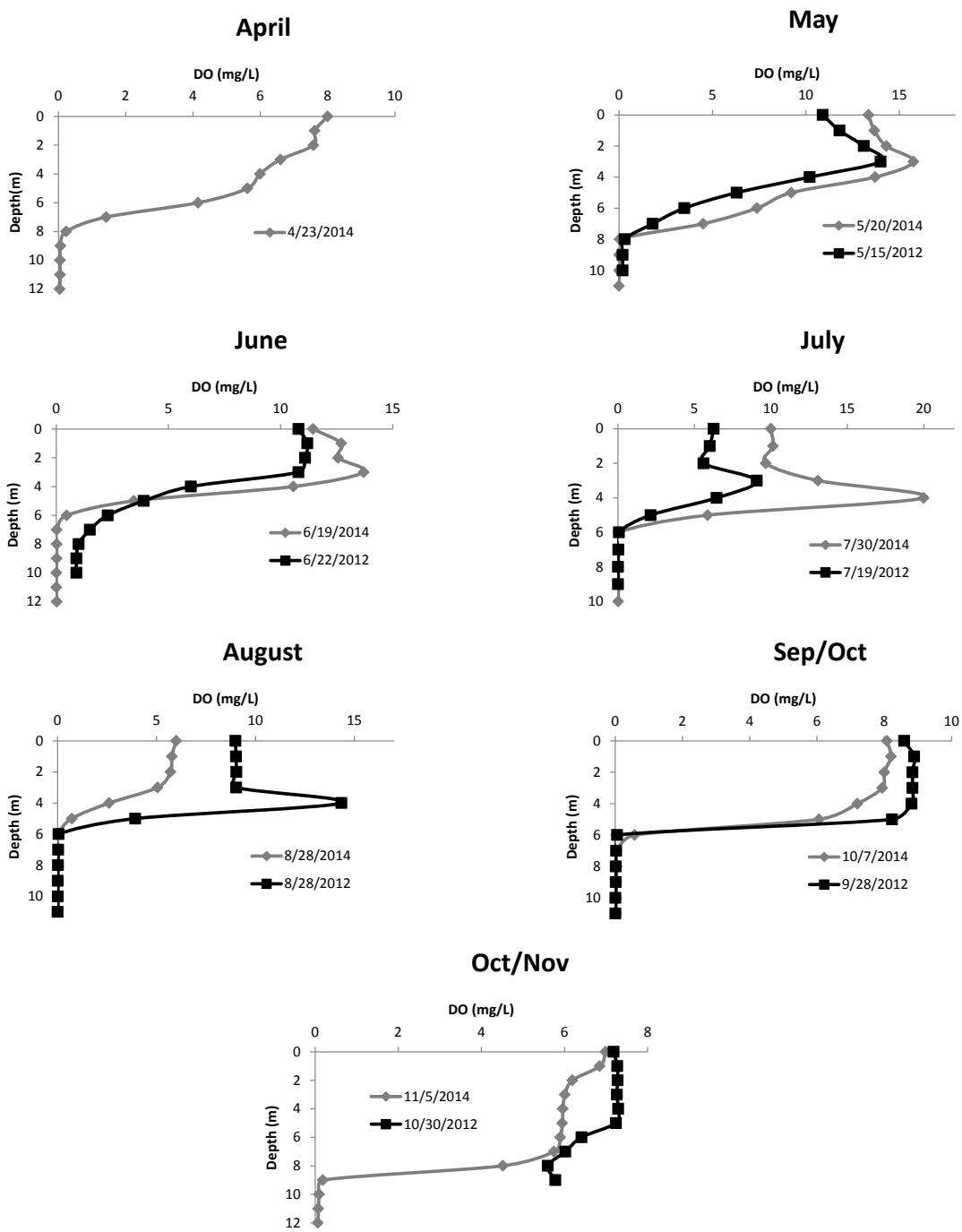

Figure 4. A comparison of dissolved oxygen profiles measured in Deer Creek Reservoir, Idaho, during 2012 and 2014.

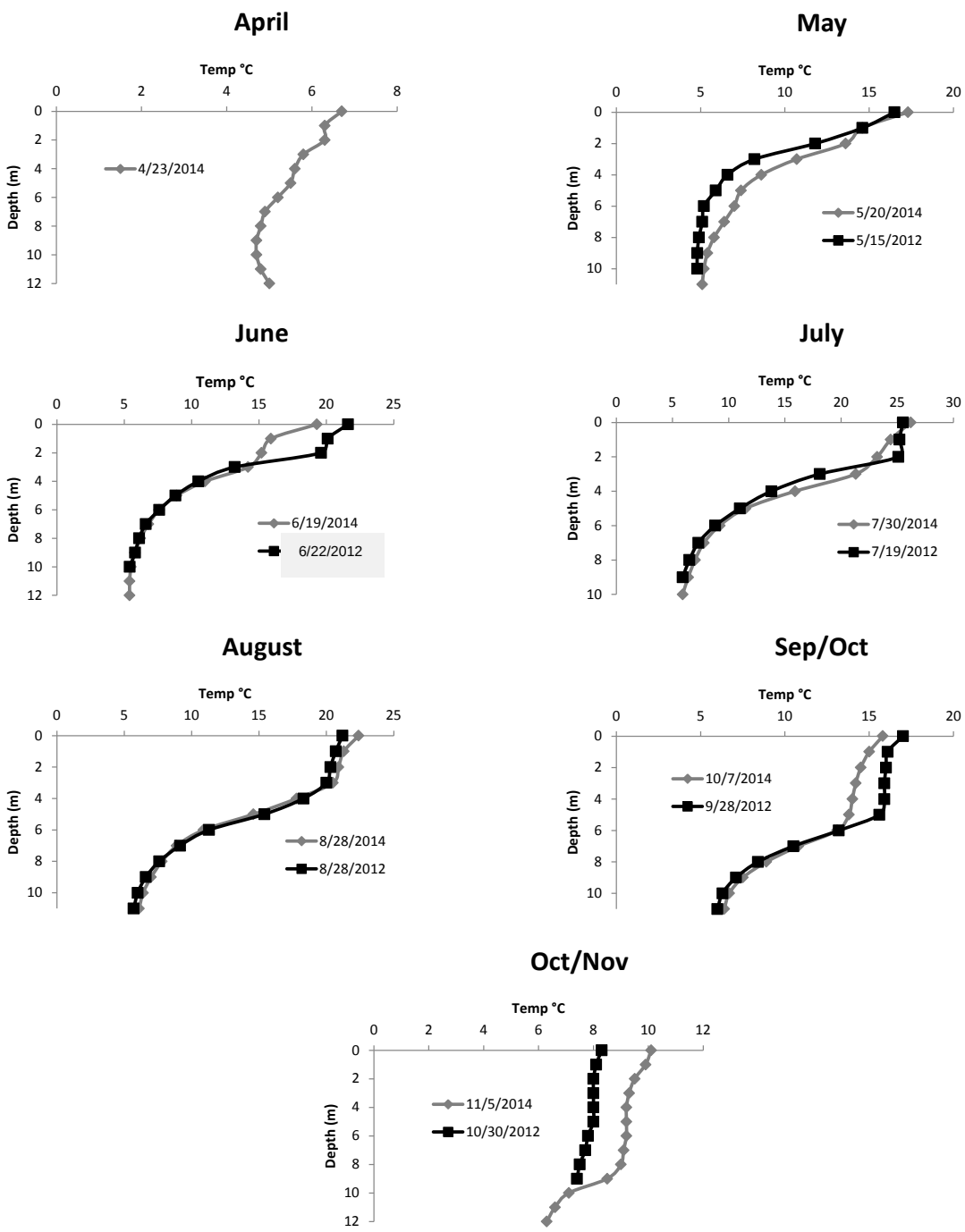

Figure 5. A comparison of temperature profiles measured in Deer Creek Reservoir, Idaho, during 2012 and 2014.

Figure 6. A comparison of zooplankton community composition in Deer Creek Reservoir, Idaho, based on monthly samples collected in 2012 and 2014.

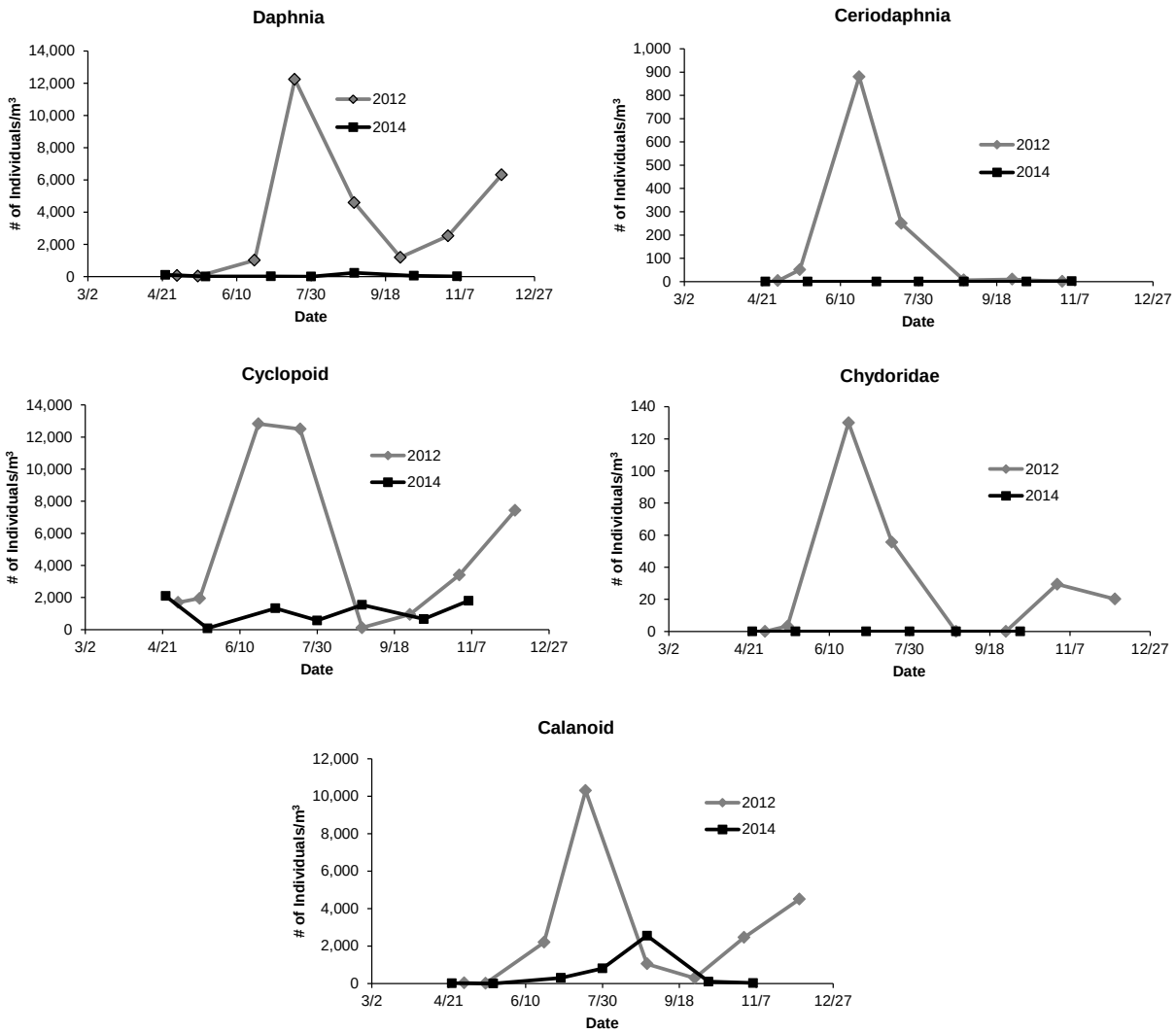

Figure 7. A comparison of zooplankton taxa densities collected from monthly sampling in Deer Creek Reservoir, Idaho, during 2012 and 2014.

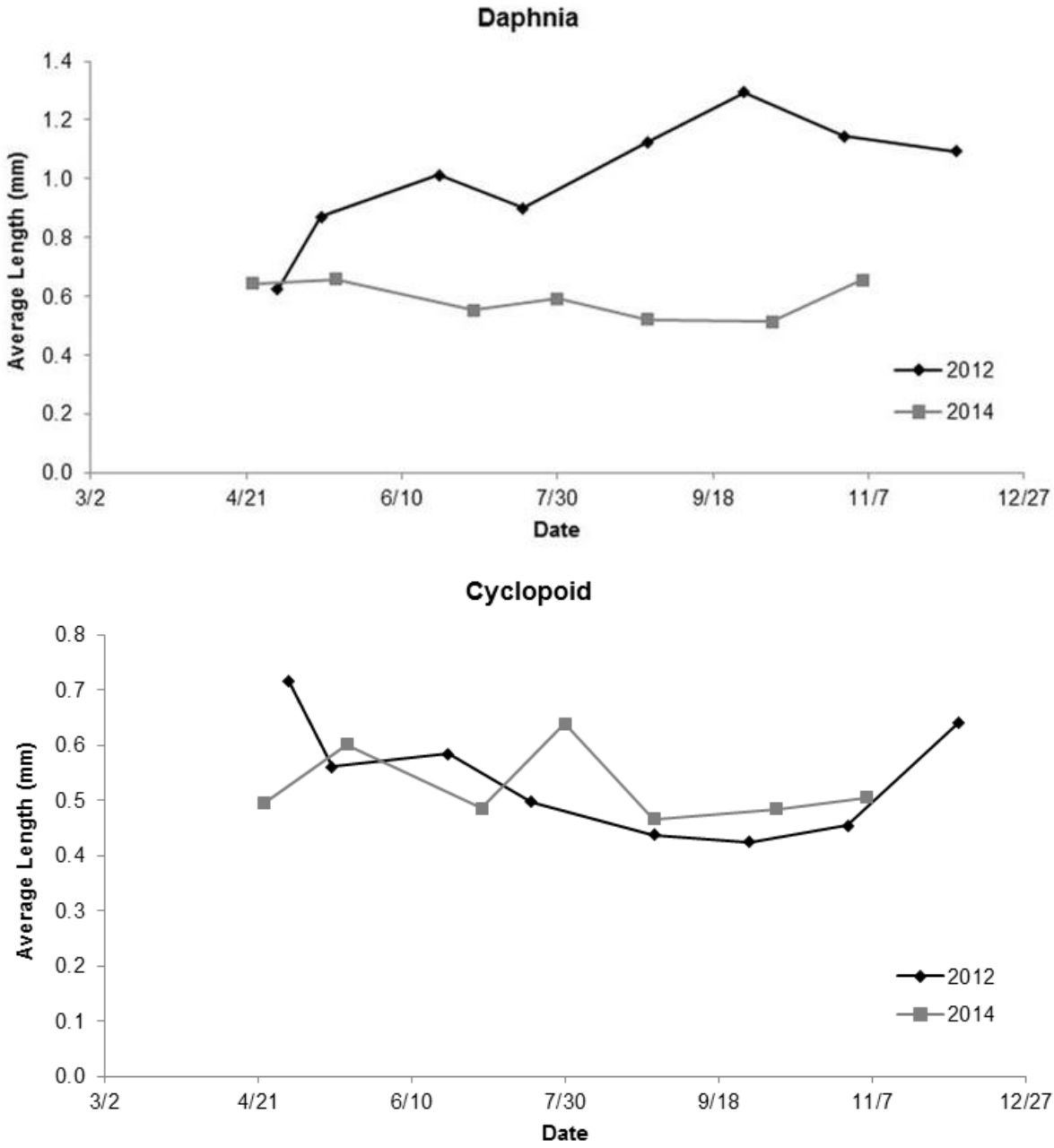

Figure 8. Mean length (mm) of Daphnia and Cyclopoida collected monthly from Deer Creek Reservoir, Idaho, during 2012 and 2014.

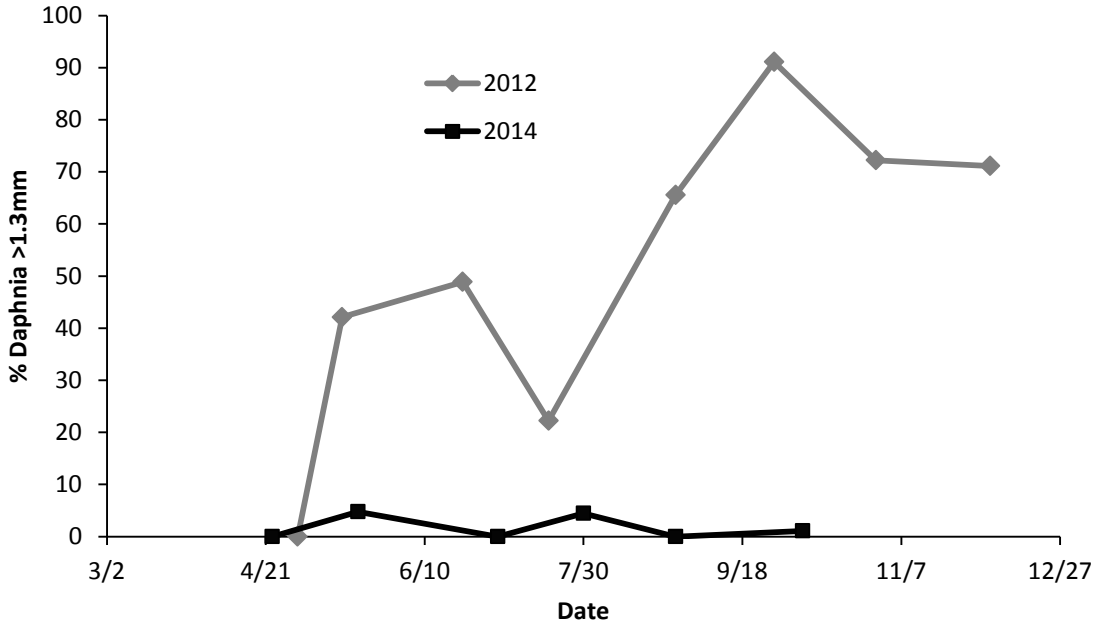

Figure 9. Percentage of Daphnia collected monthly from Deer Creek Reservoir, Idaho, in 2012 and 2014 with a length ≥ 1.0 mm.

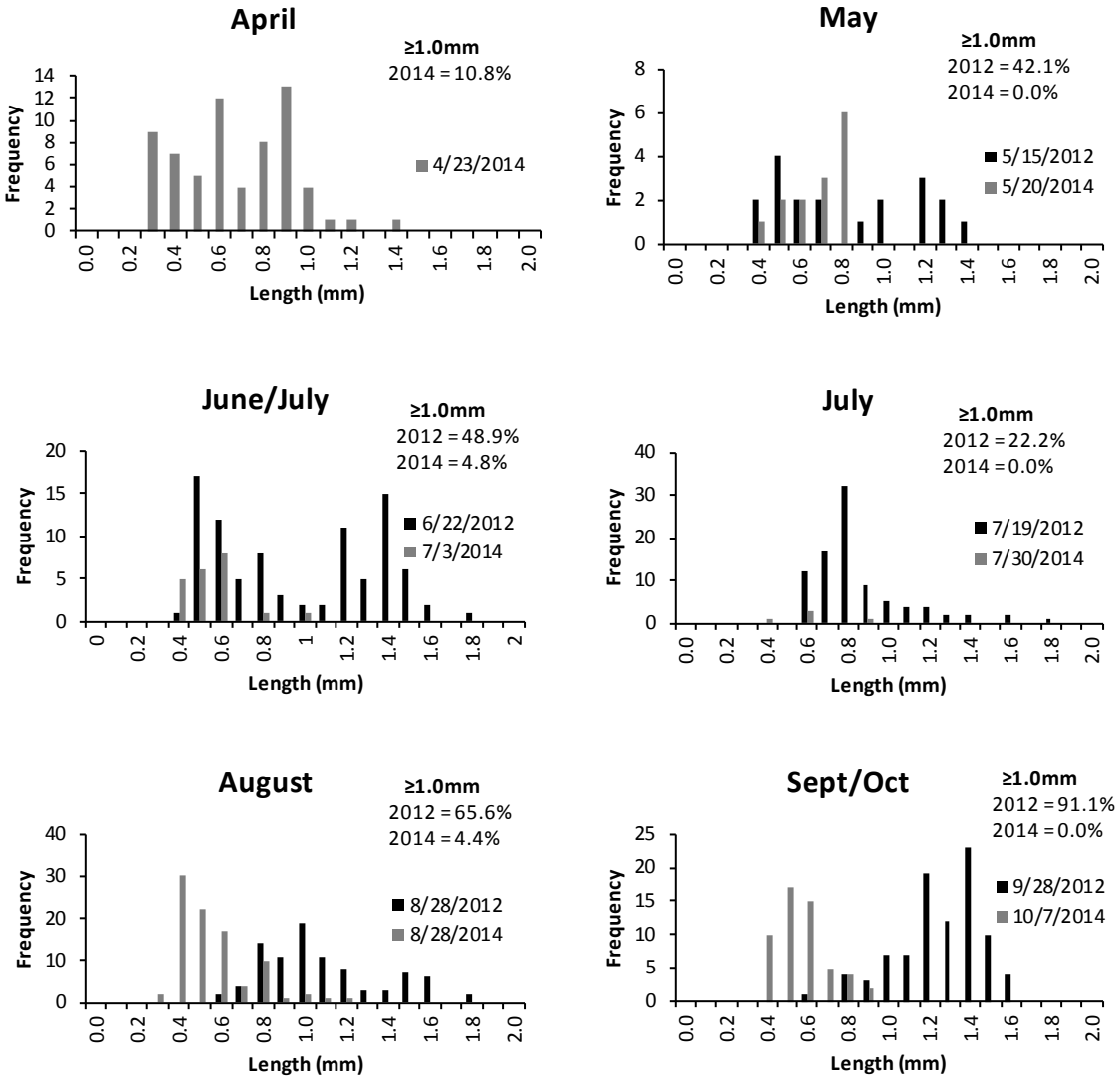

Figure 10. Length frequency distributions of Daphnia collected from zooplankton samples in Deer Creek Reservoir, Idaho, during 2012 and 2014.

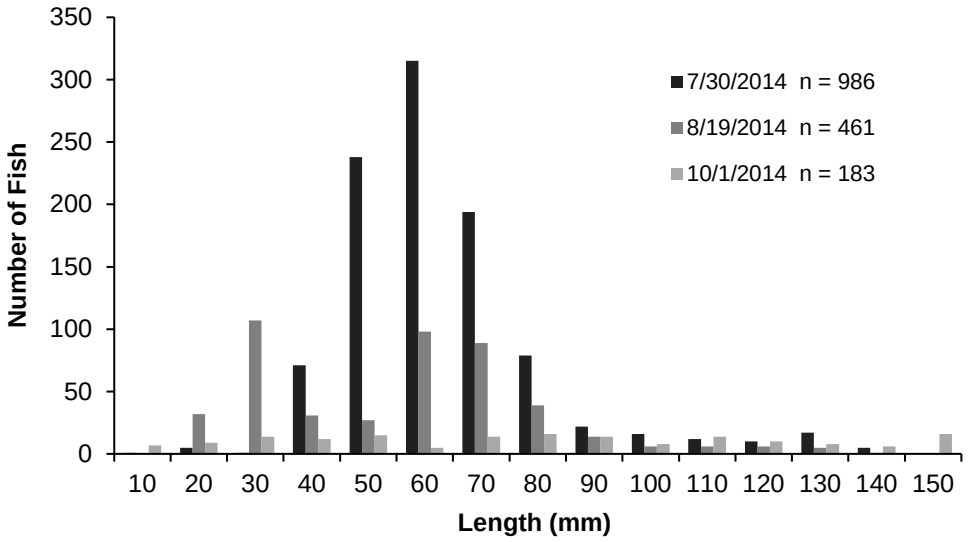

Figure 11. Length frequency distribution by sample date of Golden Shiners collected using electrofishing surveys on Deer Creek Reservoir, Idaho, during 2014.

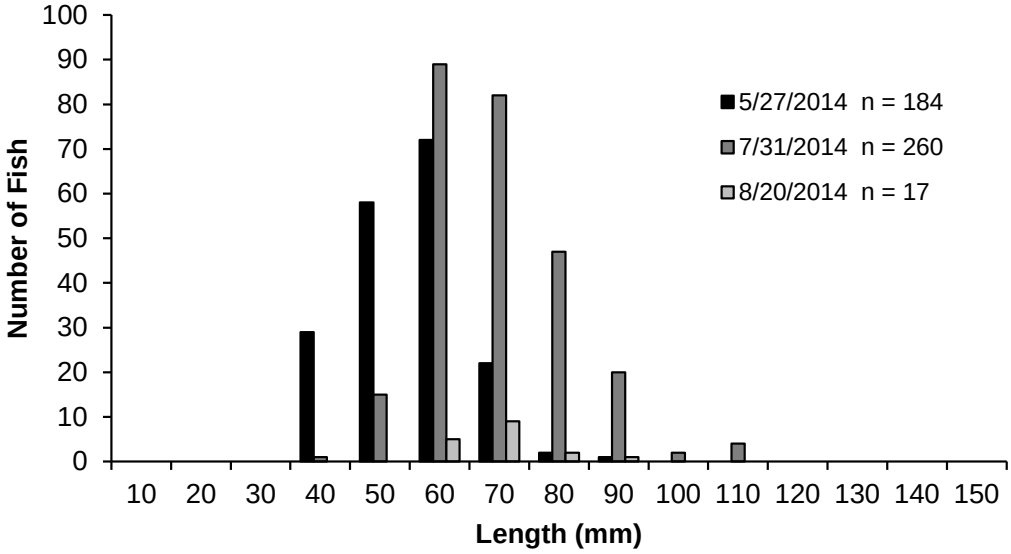

Figure 12. Length frequency distribution by sample date of Golden Shiners collected using minnow traps on Deer Creek Reservoir, Idaho, during 2014.

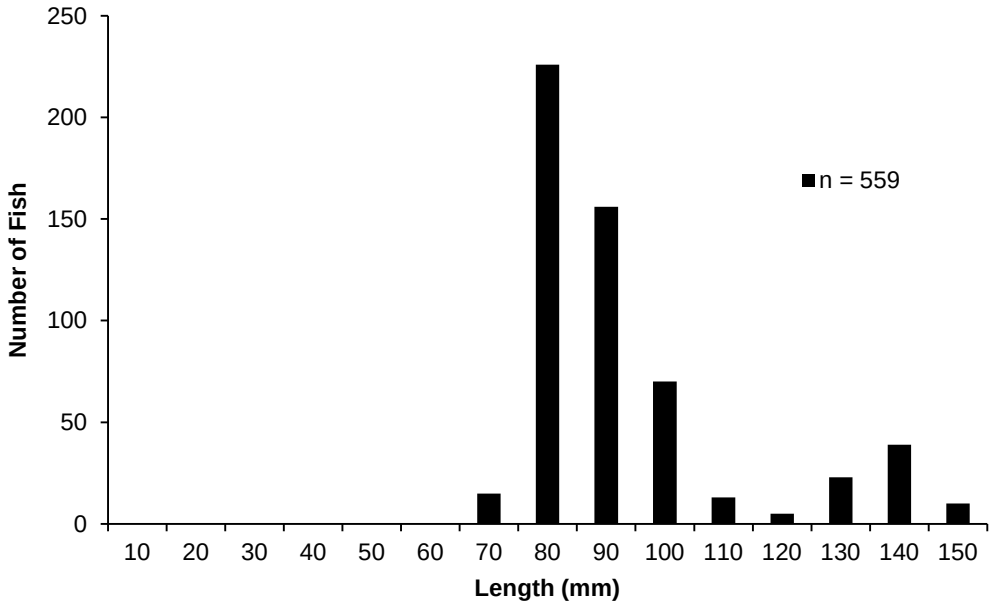

Figure 13. Length frequency distribution of Golden Shiners collected from gill net sets on Deer Creek Reservoir, Idaho, during 2014.

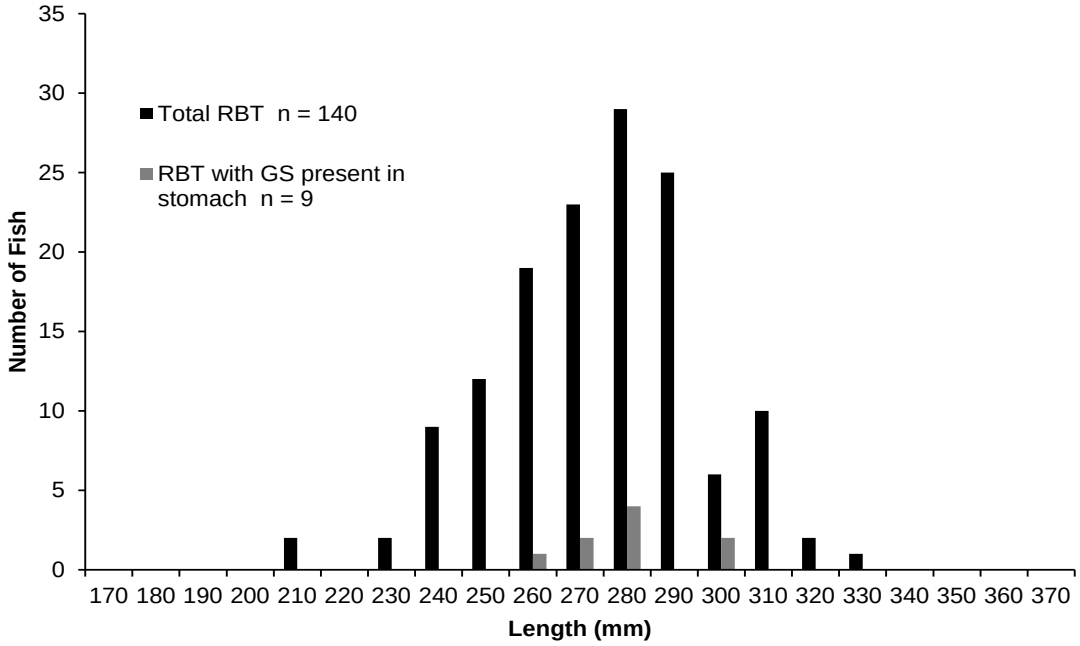

Figure 14. Length frequency distribution of all Rainbow Trout (RBT) collected through gill netting in Deer Creek Reservoir, Idaho, during 2014 in comparison to those Rainbow Trout that had Golden Shiners (GS) present in their stomach samples.

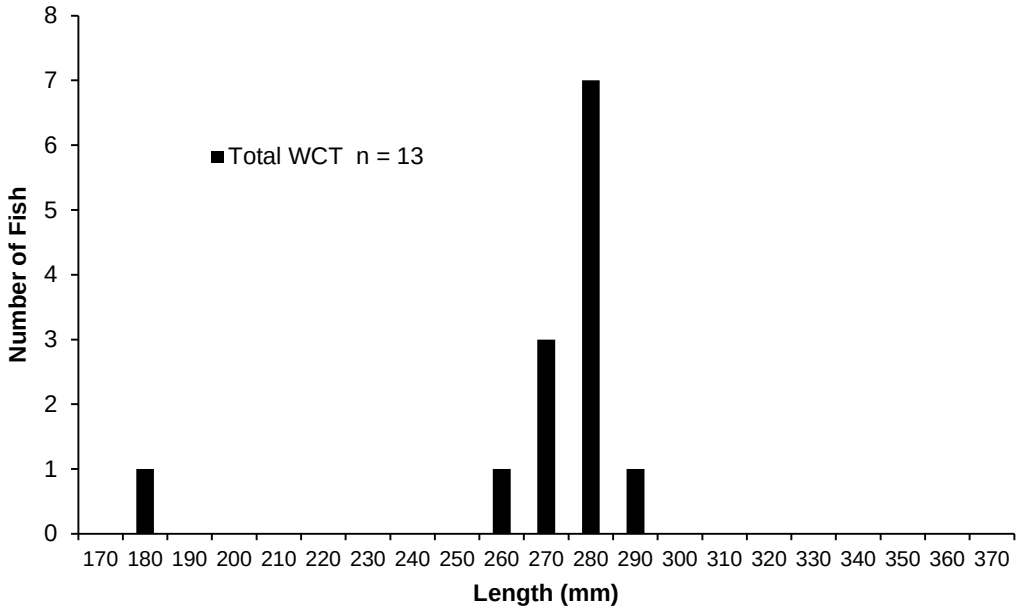

Figure 15. Length frequency distribution of Westslope Cutthroat Trout (WCT) collected from gill netting Deer Creek Reservoir, Idaho, during 2014.

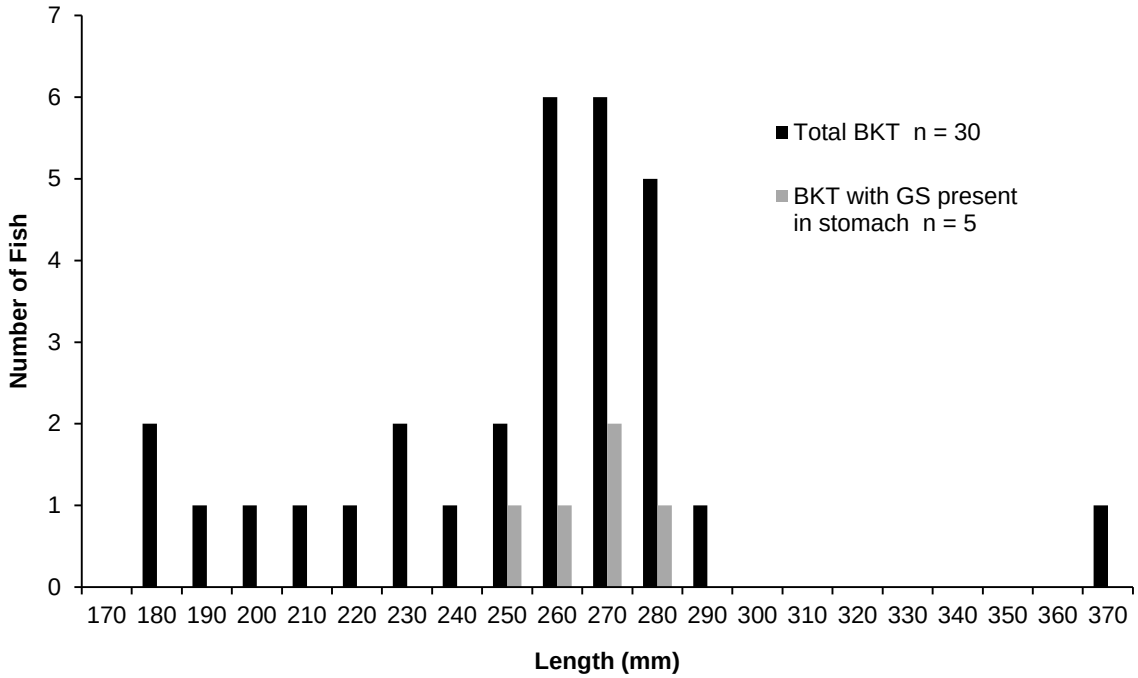

Figure 16. Length frequency distribution of all Brook Trout (BKT) collected through gill netting in Deer Creek Reservoir, Idaho, during 2014 in comparison to those Brook Trout that had Golden Shiners (GDS) present in their stomach samples.

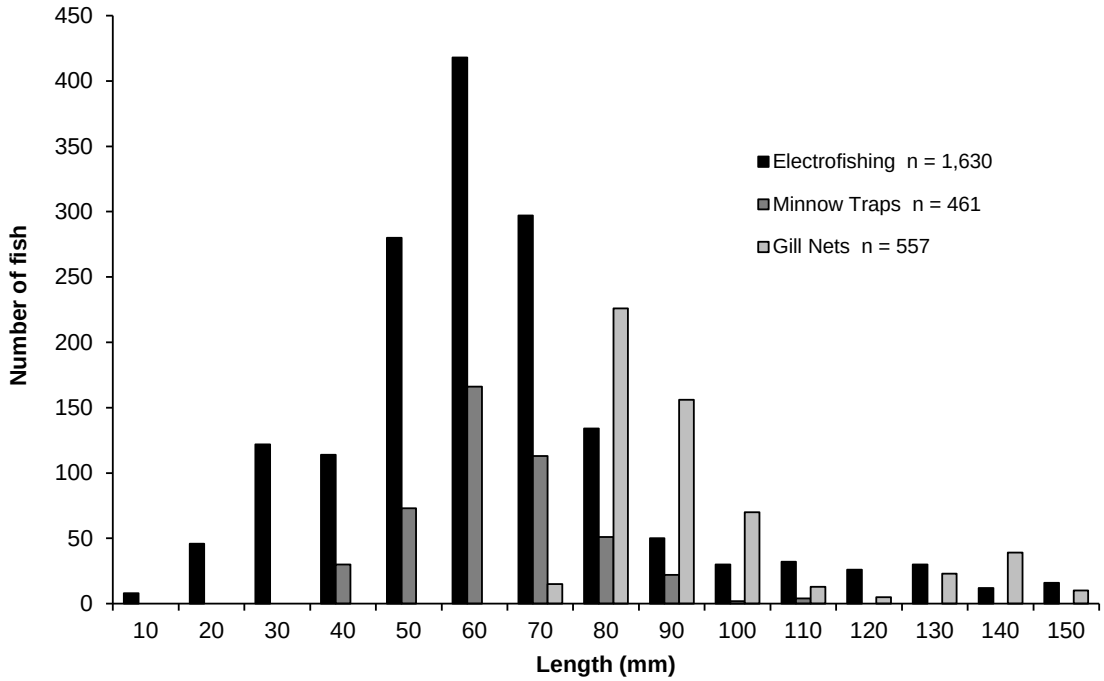

Figure 17. A comparison of length frequency distributions of Golden Shiners collected from electrofishing, minnow trapping, and gill netting on Deer Creek Reservoir, Idaho, during 2014.

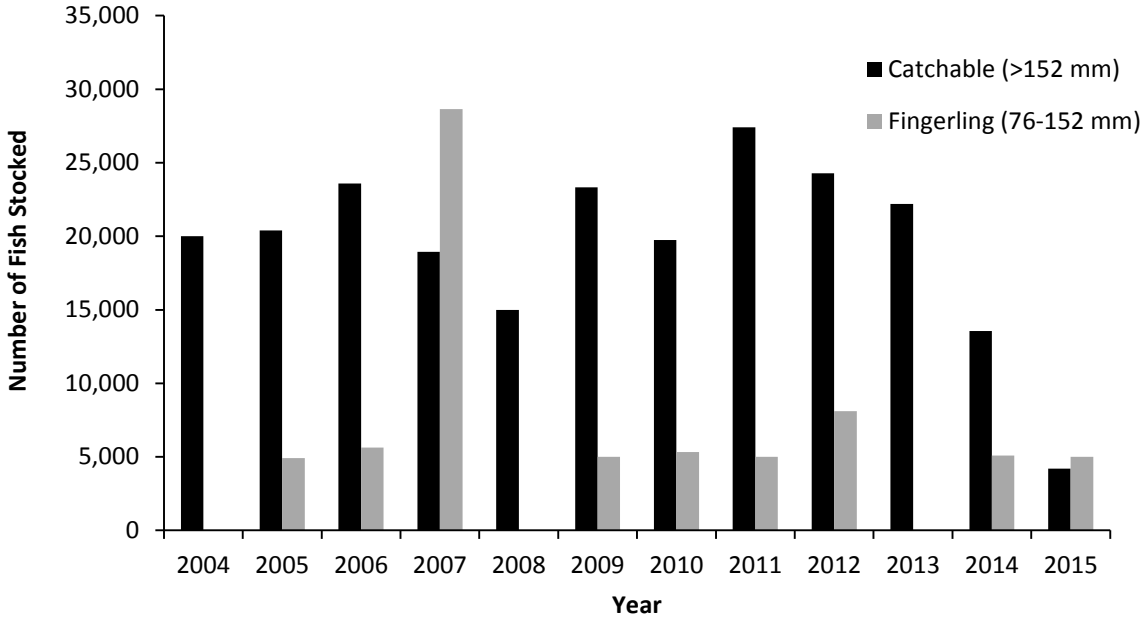

Figure 18. Number of hatchery trout (Rainbow, Westslope Cutthroat, Brook and tiger trout) stocked In Deer Creek Reservoir, by size, from 2004 - 2015.

DEYO RESERVOIR FISHERY EVALUATION

ABSTRACT

In 2014, surveys were conducted on Deyo Reservoir to track changes as the new fishery develops. The creel survey conducted in 2014 was the first ever on Deyo Reservoir, and was conducted to provide information on angler effort, catch, and harvest. Angler surveys were conducted on Deyo Reservoir from April 28 - November 12, 2014 using angler self-report cards. A total of 2,418 instantaneous angler counts were conducted by remote camera during the creel survey, resulting in an estimated total angler effort of 3,733 hours. This is a minimum effort estimate, as several camera errors occurred during the survey resulting in a loss of some pictures. Anglers caught an estimated 16,741 fish, including 12,234 hatchery Rainbow Trout, 4,196 Bluegill, and 311 Largemouth Bass. The catch rate for all fish combined was 4.5 fish/hour.

The fish community in Deyo Reservoir was a representation of what has been stocked since 2012. Largemouth Bass and Bluegill were stocked in 2012 and catchable Rainbow Trout have been stocked since 2013. This was the first fish population surveys conducted on Deyo Reservoir. Largemouth Bass collected in 2014 averaged 91 mm in length at capture, much lower than any other regional reservoir based on surveys conducted in 2012. As with the LMB population, the Bluegill population in Deyo Reservoir was dominated by small fish. With only two years of reproduction, the small average lengths for Largemouth Bass and Bluegill is to be expected. However, the lack of Largemouth Bass >300 mm collected in the population survey is concerning, and indicates that harvest may be impacting the population. Thus, we recommend stocking additional Largemouth Bass >300 mm each year over the next few years. Additionally, we recommend implementing a 406 mm minimum size limit and a two fish bag limit. These measures should help improve the Largemouth Bass population and create a desired predator prey balance.

The zooplankton survey indicated that while zooplankton were numerous, larger preferred zooplankton individuals (such as Daphnia) were in low abundance. This suggests that they are likely being cropped off. Even with high summer water temperatures, the survival of Rainbow Trout through the summer indicates that Deyo Reservoir is capable of sustaining a spring/summer put-and-take Rainbow Trout fishery. However, the lack of a quality zooplankton population indicates that we should not utilize fingerling trout, and that we should not increase stocking rates of catchable sized Rainbow Trout.

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INTRODUCTION

Idaho's Clearwater Region has a diversity of fishing opportunities. However, many of these fisheries are restrictive in nature: large rivers with anadromous fisheries, high elevation rivers and streams managed with restrictive regulations to manage wild cutthroat trout populations, and mountain lakes with difficult access. Because of these restrictive regulations and access, the region's lowland lake program has been designed and managed to provide additional fishing and harvest opportunities with easy access. Managing these reservoirs and ponds is a priority for the Clearwater Region fisheries staff.

With this in mind, the Idaho Department of Fish and Game (IDFG), in conjunction with support from local communities, constructed a 22.3 ha reservoir on Schmidt Creek near Weippe, Idaho that was completed in 2012 and first opened to the public in 2013. Named Deyo Reservoir, its purpose was to provide a new recreational fishery and an economic boost to the local economy with minimal negative biological impacts The proposed management strategy for this reservoir was a "two-story" fishery, with both cold- and warm-water species. This included stocking sterile catchable size Rainbow Trout for a "put-and-take" fishery, and Largemouth Bass *Micropterus salmoides* and Bluegill *Lepomis macrochirus* to provide a self-sustaining warmwater fishery. Largemouth Bass (n = 100) and Bluegill (n = 350) were stocked in 2012. Limnology, zooplankton, creel, and fish population surveys were conducted to provide the information needed to manage this new fishery.

OBJECTIVES

1. Survey limnology, zooplankton, and fish populations in Deyo Reservoir to track changes as the new fishery develops.

2. Evaluate angler effort and catch in Deyo Reservoir utilizing trail cameras and angler self-report cards.

STUDY AREA

Deyo Reservoir is located approximately 5 km west of Weippe, Idaho, at an elevation of 920 m (Figure 1). It is a 22.3 ha reservoir created by the damming of Schmidt Creek, a tributary to Lolo Creek, Idaho. Deyo Reservoir has a maximum depth of approximately 10 m, a mean depth of approximately 5 m, and a volume of approximately 550 acre/ft. The upper end of the reservoir has been developed into a wetland area to provide habitat for waterfowl and other wildlife. The drainage basin is composed of a mix of forest and cropland. Facilities at the reservoir include a campground with both full hookups and primitive sites, numerous fishing docks (including ADA accessible), a boat ramp, a picnic pavilion, and toilets.

METHODS

Population Surveys

Fish community surveys were performed using one hour of nighttime boat electrofishing and one overnight trap net set. Gill nets were not utilized, as previous surveys have shown they generally only catch hatchery trout. Since these trout were often stocked just before our surveys,

this provides little usable information and results in the loss of fishing opportunity for anglers due to high mortality rates.

Electrofishing was divided into 10-minute sample units, with fish collected in each sample unit processed and recorded separately. This allows for the calculation of variance estimates necessary for comparisons to other surveys and for calculating the appropriate sample size for future surveys (IDFG 2012). Species, length, and weight were recorded for each fish collected.

Boat mounted electrofishing was conducted using pulsed D.C. current from a Honda 5000w generator and an ETS MBS-1DP pulsator. Indiana style trap nets consisted of a front box maze of two six foot wide by three foot high steel frames with center braces and four 30" diameter hoops with two 8" throats, and a 50' long x 3' high leader. Mesh size was 3/4" throughout.

Status of each fish population was estimated using Proportional Size Distribution (PSD; Guy et al. 2007; Neumann et al. 2012) and relative weight (W_r; Wege and Anderson 1978; Neumann et al. 2012) techniques. Proportional Size Distribution is an updated name for the Proportional Stock Density metric developed by Anderson (1980). Proportional Size Distribution was calculated to provide information on population balance:

$$PSD = \frac{\#\ fish \geq qualitysize}{\#\ fish \geq stocksize} * 100$$

Quality size and stock size correspond to lengths considered to be the minimum size at which anglers will first catch the species (stock) and consider the fish to be of desirable size (quality). These lengths are 200 mm and 300 mm for Largemouth Bass and 80 mm and 150 mm for Bluegill (Gablehouse 1984; Neumann et al. 2012). Proportional Size Distribution values of 40 - 70 for Largemouth Bass and 20 - 40 for Bluegill and crappie are considered to be indicative of balance (Anderson 1980).

Proportional Size Distribution decision models were developed to diagnose predator-prey dynamics (Schramm and Willis 2012). The model we used plotted predator (Largemouth Bass) PSD versus prey (Bluegill) PSD. Using balanced PSD values for Largemouth Bass and Bluegill, PSD for predator and prey can each fall into three categories: low, desirable, or high. Thus, there are nine possible predator:prey PSD size structure scenarios. Explanations for each situation and recommended management actions are detailed in Schramm and Willis (2012).

Relative weight (W_r) was calculated to provide information on the condition of Largemouth Bass and Bluegill using:

$$W_r = \frac{W}{W_s} * 100$$

where W is the observed weight of the fish and W_s is the length-specific standard weight predicted by a weight-length regression. This equation is:

$$log_{10}\ Ws = a + (b * log_{10}\, total\ length)$$

where *a* is the intercept and *b* is the slope of standard weight equation developed for these fishes (Wege and Anderson 1978; Neumann et al. 2012). Relative weights were plotted using scatter plots. Trend lines within this data were used to estimate relative fitness of each species.

Age and growth information was calculated from scale samples of Largemouth Bass and Bluegill. Scales were collected from all fish sampled. Scales were removed from all fish between the dorsal fin and lateral line (Quist et al. 2012). A picture was taken of one scale from each fish using a Ken-a-Vision PupilCam camera mounted on a Fisher Scientific Micromaster compound microscope. These pictures were uploaded into FishBC software for measuring the scale radius and distance from the focus to each annuli. Back-calculation of lengths at age were determined using the Fraser-Lee equation (Quist et al. 2012):

$$L_i = c + (L_c - c)(S_i/S_c)$$

Where:

c = size of each fish at time of scale formation
S_i = the scale radius at annulus formation
S_c = the overall scale radius
L_i = the length at annulus formation
L_c = the fish length at capture

The variable "c" was determined by the Y-intercept of a regression line plotting scale radius (x-axis) versus fish length (y-axis).

Angler Surveys

Angler effort, catch, and harvest were evaluated at Deyo Reservoir from April 28 - November 13, 2014. Due to its distance from Lewiston, Deyo Reservoir was surveyed with digital trail cameras and angler report cards instead of traditional in-person interviews and angler counts. Sampling intervals were a calendar month.

Three Moultrie® MCG-12630 digital game cameras were utilized to conduct angler counts. The cameras were placed across the reservoir from the main access points and positioned to cover almost the entire reservoir (>90%), including the boat ramp and all fishing docks. The cameras were programmed to take a picture every hour to estimate use at that time. An estimated angler count was produced by counting the number of anglers in each photo. Angler survey cards and on-site return boxes were used to collect completed trip interviews (Hand et al. In Review).

Angler effort (e_i), for a fishing period (i) was estimated as:

$$e_i = I_i * T$$

where I_i is the instantaneous count of anglers multiplied by the length of the fishing period (T). Total effort (E) for a survey period is calculated by expansion:

$$E = \sum_{i=1}^{n} (\frac{e_i}{\pi_i})$$

where π_i is the total probability that fishing period (i) is included in the sample. Standard errors (SE) for effort estimates were calculated as:

$$SE(E) = \sqrt{(Var(E_1) + (Var(E_2)}$$

E_1 and E_2 represent effort from weekdays and weekends respectively. Full equations for calculating variance of angler effort are listed in Pollack et al. (1994).

Angler catch was estimated as:

$$C = E * R_1$$

The catch rate calculated from complete trips (R_1), was calculated as:

$$R_1 = \frac{\sum_{i=1}^{n} c_i}{\sum_{i=1}^{n} L_i}$$

This is the sum of the catches (c_i) divided by the sum of the trip lengths (L_i). Standard errors for effort estimates were calculated as:

$$SE(E) = \sqrt{(Var(C_1) + (Var(C_2)}$$

C_1 and C_2 represent catch from weekdays and weekends respectively. Full equations for calculating variance of angler catch are listed in Pollack et al. (1994).

Limnology

Limnology sampling, consisting of dissolved oxygen, conductivity, and temperature profiles, was conducted monthly on regional lowland reservoirs. These samples were taken to provide information on habitat quality, the quantity of habitat available to rainbow trout, and to provide historical documentation. Dissolved oxygen (DO) and temperature profiles were taken from a boat using a YSI model 550A meter at the surface and 1 m increments down to the bottom of the lake. The boat was kept stationary in the deepest part of the lake while measurements were taken. Temperature was recorded in °C, and dissolved oxygen in mg/L.

Zooplankton

Monthly zooplankton sampling was conducted on Deyo Reservoir from May - December during the 2014 field season. Samples were collected with a Wisconsin style plankton net (80 micron mesh, 30 cm diameter mouth). The boat was anchored at the deepest location based upon depth finder readings. When anchoring the boat, the anchor was slowly dropped and slack in the anchor line was let out to let the boat drift away from the anchor location. Three vertical tows were taken from that location. Tows were started 1 m above the bottom of the lake to avoid disturbing sediment. Depth of tow was recorded on each sample jar. Samples were rinsed into sample jars and stored in 70% ethyl alcohol. A Rite-in-the-Rain label was placed inside the sample jar. Samples were labeled with date, reservoir, number of tows, depth of tow, and personnel present.

In the laboratory, zooplankton samples were diluted into a known volume container (typically 100 ml) and 5 ml aliquots were then subsampled. Subsamples were counted until 200 of the most dominate family were observed. The density of zooplankton in each individual tow was then estimated expanding the subsample estimate by total volume to the tow. Tow volume (*V*) was calculated by:

$$V = \pi r^2 x\, h$$

where *r* = radius of the net and *h* = depth of tow.

Zooplankton was counted based on two categories, cladoceran (Ceriodaphnia, Diaphanosoma, and Daphnia) and copepods (Cyclopoids and Calanoids). All zooplankton within these groups were enumerated within the sample. In addition, the first 30/sample cladocerans and/or most abundant zooplanktor in the sample were measured under the dissecting microscope to establish a length distribution for the sample.

RESULTS

Population Surveys

Fish Community

A standard lake survey of Deyo Reservoir was conducted on May 29, 2014. Six 10-minute electrofishing periods were conducted on the reservoir for a total of 3,600 sec. of electrofishing effort. The electrofishing resulted in the capture of 919 fish including Bluegill (*n* = 866) and Largemouth Bass (*n* = 56). The electrofishing catch rate was 919 fish/hour (Figure 19). Catch rates for each of the six 10-minute samples ranged from 66 - 227 fish/sample). The variability from the six samples was used to estimate statistical power and sample size for future surveys (IDFG 2012). To have a 90% confidence (2-tail test) with 25% precision estimate of fish captured in an electrofishing sample of Deyo Reservoir, an estimated seven sample periods would be needed for a whole fish community survey. To have a 90% confidence with 25% precision estimate to track just Largemouth Bass or Bluegill, an estimated ten or nine sample periods would need to be conducted respectively (Table 4).

Largemouth Bass

Largemouth Bass collected ranged from 50 - 375 mm in length (Figure 20), with an average length of 91 mm. Only one of the 53 fish collected (1.9%) was over 300 mm in length. Largemouth Bass proportional size distribution (PSD) was 33. Relative weights ranged from 59 - 153, with an average of 99 (Figure 21). Relative weight was slightly lower for larger fish than for smaller fish. Scale samples were analyzed from Largemouth Bass collected in 2014 (*n* = 53). These fish ranged in age from 1 - 7 years (Table 5). Annual growth rates were 56 and 30 mm for age 1-2 fish. For fish stocked into Deyo Reservoir, annual growth rates from 2012 – 2014 (the two years since the fish have been in Deyo Reservoir) were 30 - 52 mm (Table 5).

Bluegill

Bluegill collected ranged from 12 - 127 mm in length (

Figure 22), with an average of 76 mm. Most of the fish (93%) were between 50 - 119 mm. The PSD for Bluegill was 0. Relative weights ranged from 75 - 148, with an average of 106 (Figure 6). Relative weight was similar across the range of lengths. Scale samples were analyzed from Bluegill collected in 2014 (*n* = 290). These fish ranged in age from 1 - 3 years (Table 6).

Angler Surveys

An angler survey was conducted on Deyo Reservoir from April 28 - November 12, 2014. A total of 2,418 instantaneous angler counts were conducted during the creel survey utilizing trail cameras. Total angler effort was estimated at 3,733 hours (SE ± 209). More effort occurred on

weekends (54%) than weekdays (46%). Effort consisted of 10% boat and 90% bank anglers. Seventy-one percent (2,642 hours) of the effort occurred from April through June.

Catch rate and harvest data for the 2014 creel survey on Deyo Reservoir was based on 87 completed angler report cards. The most commonly targeted fish species was hatchery Rainbow Trout (58%; Figure 8). Twenty-nine percent of respondents were not targeting a particular fish species while fishing. Warmwater species comprised 13% of the targeted fish species responses for Deyo Reservoir. Anglers caught an estimated 16,741 fish during 2014 (Table 8), resulting in a catch rate of 4.5 fish/hour (Table 9). Hatchery Rainbow Trout accounted for 73% of the fish caught during the 2014 creel survey. Catch of warmwater species included 4,196 Bluegill (25%) and 311 Largemouth Bass (2%). Anglers harvested an estimated 7,577 fish during 2014 (Table 5), 45% of the fish caught. The harvest rate for all fish combined was estimated to be 2.0 fish/hour. Harvest in 2014 consisted of 7,118 hatchery Rainbow Trout (94%), 437 Bluegill (6%), and 21 Largemouth Bass (<1%; Table 8).

A total of 12,234 hatchery Rainbow Trout were estimated to have been caught during the survey, with 7,118 harvested (Table 8). This is a catch rate of 3.1 fish/hour and a harvest rate of 1.8 fish/hour (Table 9). The majority of the fish (75.3%) were harvested from April - June (Table 8). With 22,212 hatchery Rainbow Trout stocked during the creel survey, total used was calculated to be 55% and exploitation was 32%.

Limnology

Limnology samples were collected in Deyo Reservoir monthly from April - November, 2014. Dissolved oxygen and temperature samples changed throughout the year, with seasonal patterns being quite evident. Dissolved oxygen profiles from April - October showed typical anoxic conditions were present in the hypolimnion (Figure 25). The November profile was homogenous due to fall turnover (Figure 25). Monthly temperature measurements showed very similar patterns to the DO measurements (Figure 25).

Temperatures >21°C and DO levels <5.0 mg/L can reduce the volume of water available for trout to survive in a reservoir. During 2014, water temperatures >21°C occurred from June – August, with a maximum depth >21°C of 3 m in July. Dissolved oxygen at this time was <5.0 mg/L below 3 m in depth. This resulted in a condition in which none of the water in Deyo Reservoir was conducive for Rainbow Trout survival during July. Additionally, fall turnover caused a drop in DO to <5.0 mg/L throughout the water column in November.

Zooplankton

Zooplankton samples were collected in Deyo Reservoir monthly from April - November, 2014. The zooplankton population was composed of seven taxa of zooplankton: Chydoridae, Daphnia, Cyclopoida, Ceriodaphnia, Bosmina, Calanoida, and Diaphanosoma. The composition changed substantially throughout the sampling period. Cyclopoida was the most abundant taxa in April and late May. Daphnia was the most abundant taxa in early May, June, October, and November (Figure 26). Daphnia densities ranged from 271 - 19,704/m^3 with an average of 10,196/m^3 (Figure 27), with densities peaking in August. Calanoida densities ranged from 0 - 13,729/m^3 with an average of 3,948/m^3, with densities peaking in August and December. Bosmina, Daphnia, and Calanoida all saw similar fluctuations in density, with peaks in mid-summer. Average lengths of Daphnia ranged from 0.4 - 0.7 mm (Figure 28). Length frequency distributions from each sample show that there were no Daphnia >1.3 mm in length collected during 2014 (Figure 29).

DISCUSSION

Population Surveys

Fish Community:

The fish community in Deyo Reservoir was a representation of what has been stocked since 2012. Largemouth Bass and Bluegill were stocked in 2012 and catchable Rainbow Trout have been stocked since 2013. This was the first fish population surveys conducted on Deyo Reservoir; therefore, there is no previous data to compare with the 2014 survey.

Largemouth Bass:

Largemouth Bass (LMB) collected in 2014 averaged 91 mm in length at capture, much lower than any other regional reservoir based on surveys conducted in 2012 (Hand et al. 2016a). However, this is due to Deyo Reservoir only being stocked two years ago (in 2012). Growth rates for fish aged 1 and 2 years (i.e. fish born in Deyo Reservoir) were 56 mm and 84 mm Table 5. These growth rates were below the rates seen for all regional reservoirs during 2012 surveys (Hand et al. In Review). As this data shows, the LMB population in Deyo Reservoir was dominated by small fish. This resulted in a PSD value of 33, below the balanced population range of 40 - 60 (Schramm and Willis 2012). Low PSD is often an indicator of a stunted population of LMB and/or overharvest of fish by anglers (Schramm and Willis 2012). With the reservoir being stocked in 2012, the LMB population has not had time to expand to its full potential, and is not likely to be experiencing stunting at this time.

The lack of fish >300 mm collected in the population survey is concerning, and indicates that mortality (natural and angling) is heavily impacting the population. With approximately 125 LMB >300 mm stocked in 2012, even low harvest levels would have a large impact on the population once natural mortality is taken into account. If we assumed a theoretical 40% natural mortality rate, only 45 of the fish stocked in 2012 would still be alive in 2014 based solely on natural mortality. Creel surveys of Deyo Reservoir estimated that 311 Largemouth Bass were caught, and 21 harvested in 2014. Thus, approximately 47% of those remaining fish were estimated to have been harvested in 2014 alone. Some were likely to have been harvested in 2013 as well. Compounding this further is the indication that LMB transferred from outside sources ("naïve fish") appear to be more susceptible to anglers (Butts et al. 2016). If this is occurring in Deyo Reservoir, angler harvest is likely having a larger impact than would normally occur. With no fish over age two in this population other than those originally stocked, there is no replacement occurring at this time. This is resulting in mortality having a larger impact than normal until naturally spawned fish are old enough and large enough to replace those lost.

Overall, the data for Deyo Reservoir indicates that the LMB population is being heavily impacted by natural mortality and angler harvest as fish >300 mm were rare. Therefore several management strategies should be considered. First, additional LMB >300 mm should be stocked in Deyo Reservoir. Second, restrictive regulations have proven effective in improving the size structure of LMB (Anderson 1976; Novinger 1984; Wilde 1997; Isermann and Paukert 2010). Length limits, such as a minimum length or a protective slot, should be considered. Minimum length limits are recommended for fish populations that exhibit low rates of recruitment and natural mortality, good growth rates, and high fishing mortality (Novinger 1984; Wilde 1997). They are generally used to protect the reproductive potential of fish populations, prevent overexploitation,

increase angler catch rates, and promote predation on prey species (Noble and Jones 1993; Maceina et al. 1998; Isermann and Paukert 2010).

Slot limits are recommended for populations with high recruitment and low growth rates. They are used to increase numbers of the protected size fish, promote growth of smaller fish by reducing competition (through harvest), and increase production of larger fish (Anderson 1976; Novinger 1990; Isermann and Paukert 2010). When slot limits do fail to restructure Largemouth Bass populations it is usually because anglers harvest few fish below the slot limit (Gablehouse 1987; Summers 1990; Martin 1995). This effectively results in a minimum size limit.

In this case, we are trying to build this LMB population to the point they can help control Bluegill and provide some harvest opportunity. As such, we believe the best and quickest way to reach this goal is by implementing a minimum length limit for LMB. We recommend implementing a 406 mm minimum size limit for LMB, with a two fish bag limit. This should allow LMB to reach sizes where they can effectively prey on Bluegill and allow for two or more years of spawning before they can legally be harvested. After the LMB population builds, the fishery should be evaluated to determine if different rules are necessary to maintain or reach our objectives.

Bluegill:

As with the LMB population, the Bluegill population in Deyo Reservoir was dominated by small fish. This resulted in a PSD value of zero. With only two years of reproduction, this is to be expected. It will take several more years to have a fully developed population. However, with so many smaller fish and few predators, there is concern that Bluegill could overpopulate. Annual growth rates ranged from 25 - 57 mm. These values were below the regional average of 36 - 62 mm for fish ages 1 - 3 years (Hand et al. 2016a). This is somewhat surprising as new reservoirs are generally very productive allowing for high growth rates. This below average growth rate may suggest that recruitment is high and competition is already limiting growth. If this Bluegill population becomes stunted, selective removal through electrofishing, netting, and/or small rotenone applications could be utilized. However, improving the LMB population through supplemental stocking, and reducing harvest with a minimum size limit should help control the Bluegill population.

Warmwater Fishes Predator:Prey Dynamics:

A comparison of predator and prey PSD values can provide a good assessment of population balance (Schramm and Willis 2012). In Deyo Reservoir, the 2014 sample landed in Cell 7 (

Figure 30). Fish communities fall into Cell 7 when both predator and prey PSD are low. This is usually caused by overabundant Bluegill, low predation levels by LMB, and/or overharvest of larger Bluegill. However the new and expanding populations of LMB and Bluegill are the likely explanation for this out-of-balance relationship. Care must be taken, however, as evidence suggests Bluegill recruitment is high and largemouth bass are being cropped off by anglers before they can reach spawning size. Thus, we recommend stocking additional LMB >300 mm each year over the next few years. Additionally, we recommend implementing a 406 mm minimum size limit and a two fish bag limit for LMB. These measures should help improve the Largemouth Bass population and create a desired predator:prey balance.

Angler Surveys

Based on the 2012 creel survey, most anglers either stated that they were fishing for hatchery Rainbow Trout (58%), or were not targeting any particular species (29%; Figure 24). Estimated angler catch and harvest follows a similar pattern as other Regional reservoirs, with Rainbow Trout accounting for the majority of the catch (73%) and harvest (94%) (Hand et al. 2016a). This is to be expected, as Rainbow Trout are very popular in these lowland reservoirs, and the warmwater fishery has just begun to develop. As the warmwater fishery develops, we would expect it to become a larger part of the catch and harvest.

Effort

The angler survey conducted in 2014 resulted in an estimated 3,733 hours of angler effort. This is a minimum effort estimate, as several camera errors occurred during the survey resulting in a loss of some pictures, and a small portion of the upper end of the reservoir was not covered by the cameras. This was the first angler survey conducted on Deyo Reservoir, therefore no comparisons can be made to other surveys. However, compared to angler surveys conducted at other regional reservoirs in 2012, effort at Deyo Reservoir would be the second lowest, only ahead of Tolo Lake (Figure 31). Effort was lower than expected, but this may be due to this being a new reservoir and to the quality of the fishery. It may take some time for the public to get used to going to a new, unknown location. Additionally, it will take a few years to establish a quality warmwater fishery, which will attract additional anglers in the future. However, with the excellent amenities and improving fishery, we would expect to see an increase in use over the next few years.

Catch and Harvest

Catch rates for hatchery Rainbow Trout were 3.1 fish/hour, well above the management goal of >0.5 fish/hour (IDFG 2013). Compared to the lake surveys conducted in 2012, this would have been the second highest catch rate of any regional reservoir (Hand et al. 2016a), behind only Deer Creek Reservoir (4.0 fish/hour). However, angler catch tend to be biased high with self-report cards, as unsuccessful anglers are less likely to return a card (Carline 1972, Fraidenburg and Bargmann 1982, Pollack et al. 1994). Catch rates for hatchery Rainbow Trout averaged 79% higher for self-report cards than what was estimated for creel surveys at seven regional reservoirs in 2012 where both methods were utilized (Hand et al. 2016a). This would suggest that catch rates in Deyo Reservoir during 2014 were near the management goal of >0.5 fish/hr. However, the absence of zooplankton >1.3 mm suggests that fish abundance is having an effect on this important food item. One potential solution would be to use IDFG “magnum” size catchable Rainbow Trout. These fish have been shown to return to creel at higher rates (Cassinelli 2014) than standard sized hatchery trout (Aday and Graeb 2012). This would allow us to stock fewer Rainbow Trout while maintaining similar catch rates of larger fish.

With 22,122 hatchery catchable size Rainbow Trout stocked during the time of creel survey, the angler exploitation rate (fish harvested) was estimated to be 32.0%, as determined by creel survey data. This is close to the average of 36.2% calculated for regional reservoirs in 2012 (Hand et al. 2016a), but much higher than the 17.8% calculated for Deyo Reservoir in 2013 by the “Tag You’re It” program (Meyer et al. 2009). However, it must be noted that the estimate for the “Tag You’re It” program is likely low since the reservoir did not open until June 29 that year, which is around the time of year we generally see effort begin to drop in our lowland reservoirs (Hand et al. 2016a). Angler exploitation should be evaluated again over the course of a full year to provide more comparable data.

Limnology

As we have seen in other regional reservoirs, Deyo Reservoir experiences anoxic conditions in the hypolimnion (Figure 25). The combination of an anoxic hypolimnion and warm surface waters greatly reduces the volume of the reservoir available for fish to live during the summer months, especially temperature sensitive hatchery trout (Figure 25). These conditions force the more temperature sensitive trout to live in either the warmer epilimnion with higher DO concentrations, or cooler water with less DO, both of which can cause stress. The combination of high water temperature and marginal DO concentrations compounds the stress on hatchery trout, which can result in disease and fish kills (Bjornn and Reiser 1991, Carline and Machung 2001). New reservoirs commonly have low levels of DO due to the high amount of decay that occurs. Over time, conditions should improve.

Based on the IDFG standards for temperature and DO thresholds, the volume of water available for Rainbow Trout to survive was reduced to zero in late July and early August 2014. This would indicate that there was very little, if any, chance that hatchery trout stocked in the spring would have a chance to survive through the summer and be available to the fishery in the fall. However, over 1,000 hatchery Rainbow Trout were estimated to have been caught from August - November 2014 based on the creel survey, indicating that many of these fish were able to survive the poor summer conditions. Additionally, angler exploitation tagging in 2013 showed some tags returned in September and October, after similar water conditions that summer (Hand et al. 2016b).

Zooplankton

Larger sized zooplankton species, especially Daphnia, often compose a substantial portion of the diet of lake dwelling trout species (Galbraith 1967; Hyatt 1980; Eggers 1982; Schneidervin and Hubert 1987) and juvenile warm-water species (Chipps and Graeb 2010). The zooplankton community in Deyo Reservoir was dominated by Daphnia and Cyclopoida during April - June, then by Bosmina through August, and Daphnia again in October and November. This would generally indicate the presence of a viable food source. However, Daphnia collected averaged 0.60 mm in length (Figure 28). These average lengths are substantially below the length (≥1.3 mm) preferred by *Oncorhynchus* species (Galbraith 1975; Tabor et al. 1996; Wang 1996). During 2014, no Daphnia were at or above preferred size (Figure 29). However, *Oncorhynchus* species are known to feed on zooplankton down to 1.0 mm in length. In 2014, 1.9% of the Daphnia population was ≥1.0 mm in length. Daphnia densities increased though the year, but average length declined throughout the summer.

The data suggests that while zooplankton were numerous, larger preferred zooplankton individuals (such as Daphnia) were in low abundance, indicating that they are likely being cropped off. Even with high summer water temperatures, the survival of Rainbow Trout through the summer indicates that Deyo Reservoir is capable of sustaining a spring/summer put-and-take Rainbow Trout fishery. However, the lack of a quality zooplankton population indicates that we should not utilize fingerling trout, and that we should not increase stocking rates of catchable sized Rainbow Trout. In fact, as discussed previously, it may be beneficial to reduce the number of planktivores in Deyo Reservoir. This could be accomplished by reducing stocking rates of hatchery Rainbow Trout, and/or reducing the abundance of Bluegill. However, we should conduct additional sampling in 2015 - 2016 to provide additional data to determine if Bluegill abundance is truly impacting the zooplankton population.

MANAGEMENT RECOMMENDATIONS

1. Stock an additional 150 Largemouth Bass >300 mm in 2015 and 2016 to improve predation on smaller Bluegill and maintain reproductive success as larger fish are harvested.

2. Implement 406 mm minimum size limit to reduce harvest of Largemouth Bass and help establish this new population.

3. Utilize “magnum” size hatchery Rainbow Trout to allow for reduced stocking numbers and to potentially increase angler satisfaction.

4. Continue to monitor the warmwater fish community to determine if additional measures are needed to improve the predator:prey balance.

5. Re-evaluate angler exploitation or Rainbow Trout using the “Tag You’re It” program.

Table 4. Number of Largemouth Bass and Bluegill collected through electrofishing during 10-minute electrofishing periods (samples) in Deyo Reservoir, Idaho, in 2014, and the estimated number of 10-minute electrofishing samples (n) required to generate fish species estimates with 90% confidence and 25% precision.

	Count of fish collected									
Species	EF Sample 1	EF Sample 2	EF Sample 3	EF Sample 4	EF Sample 5	EF Sample 6	Total	Mean	STDev	n
Largemouth Bass	9	15	12	7	3	7	53	8.8	4.2	10
Bluegill	56	89	159	133	209	220	866	144.3	65.0	9
Total	65	104	171	140	212	227	919	153.2	62.6	7

Table 5. Back-calculated length at annuli of Largemouth Bass collected during electrofishing surveys of Deyo Reservoir, Idaho, in 2014.

Year			Back-calculated length (mm) at each annulus						
Class	Age	n	1	2	3	4	5	6	7
2013	1	32	57						
2012	2	9	54	84					
2011	3								
2010	4								
2009	5	9	65	132	191	245	277		
2008	6	2	83	132	175	215	269	298	
2007	7	1	40	106	192	264	290	319	361
n		53	56	21	12	12	12	3	1
Length at Age			58	110	189	241	277	305	361

Table 6. Back-calculated length at annuli of Bluegill collected during electrofishing surveys of Deyo Reservoir, Idaho, in 2014.

Year			Back-calculated length (mm) at each annulus		
Class	Age	n	1	2	3
2013	1	195	64		
2012	2	86	44	83	
2011	3	9	43	80	108
n		290	290	95	9
Length at Age			57	83	108

Table 7. Summary of angler effort (hours) as determined through the use of cameras at Deyo Reservoir, Idaho, from April 28th - November 12th, 2014.

Month	Total Weekday	Total Weekend	Total Boat	Total Shore	Total Effort	Standard Error	Percent Error
April/May	518	611	83	1,046	1,129	160	14.2
June	360	801	123	1,038	1,513	79	5.2
July	202	205	26	381	398	58	14.6
August	155	280	88	347	492	69	14.1
September	163	82	40	205	154	46	30.0
Oct/Nov	62	25	24	63	48	36	75.8
Totals	1,460	2,003	383	3,080	3,733	209	5.6

Table 8. Summary of number of fish caught and harvested by anglers in Deyo Reservoir, Idaho, as determined through the use of angler report cards, from April 28 - November 12, 2014.

	Rainbow Trout		Bluegill		Largemouth Bass	
Month	Caught	Harvested	Caught	Harvested	Caught	Harvested
April/May	4,687	2,508	476	100	0	0
June	5,428	3,603	2,218	320	22	0
July	934	227	796	0	2	0
August	733	436	637	18	160	0
September	347	291	69	0	42	10
Oct/Nov	106	53	0	0	85	11
Totals	12,234	7,118	4,196	437	311	21

Table 9. Summary of angler catch rates (fish/hour) for fishes caught and harvested by anglers in Deyo Reservoir, Idaho, as determined through the use of angler report cards, from April 28 - November 12, 2014.

	Rainbow Trout		Bluegill		Largemouth Bass	
Month	Caught	Harvested	Caught	Harvested	Caught	Harvested
April/May	4.2	2.2	0.4	0.1	0.0	0.0
June	3.6	2.4	1.5	0.2	0.0	0.0
July	2.3	0.6	2.0	0.0	0.0	0.0
August	1.5	0.9	1.3	0.0	0.3	0.0
September	2.3	1.9	0.4	0.0	0.3	0.1
Oct/Nov	2.2	1.1	0.0	0.0	1.8	0.2
Totals	3.1	1.8	1.0	0.1	0.1	0.0

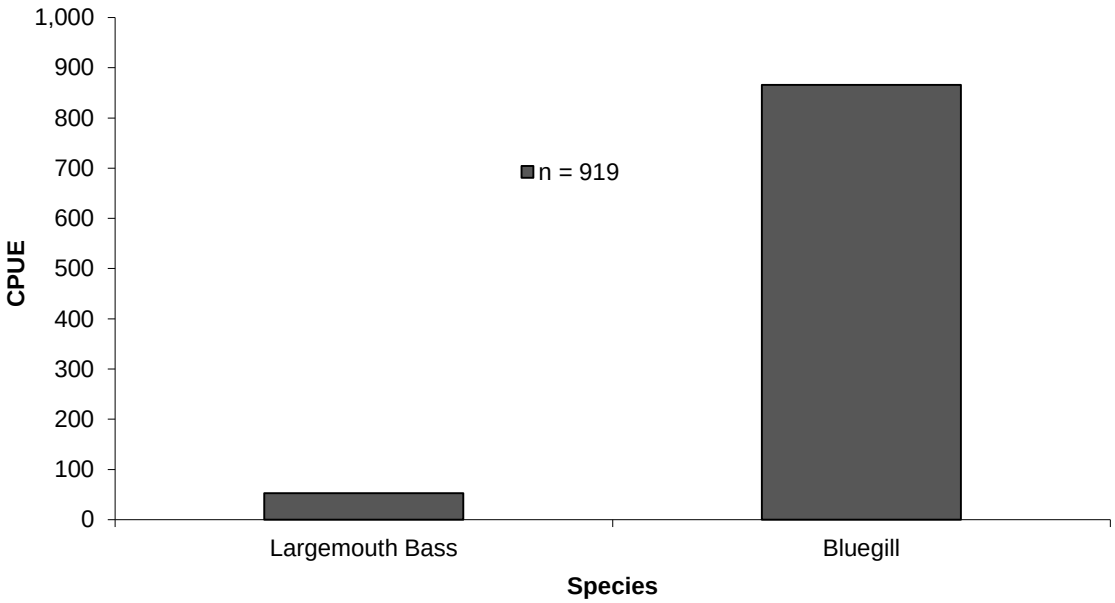

Figure 19. Catch per unit effort (CPUE; number of fish/hour) of fishes collected during electrofishing surveys of Deyo Reservoir, Idaho, in 2014.

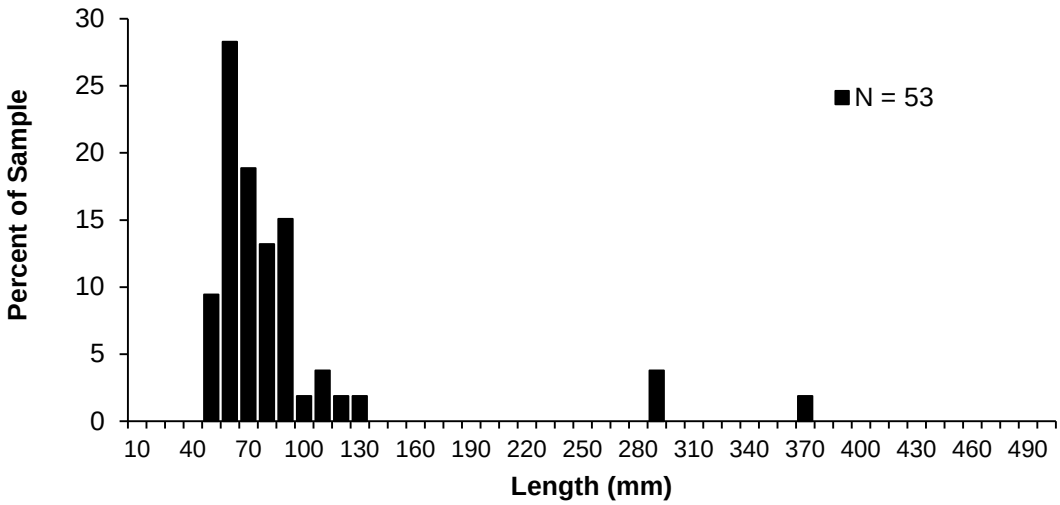

Figure 20. Length frequency distribution of Largemouth Bass collected during electrofishing surveys of Deyo Reservoir, Idaho, in 2014.

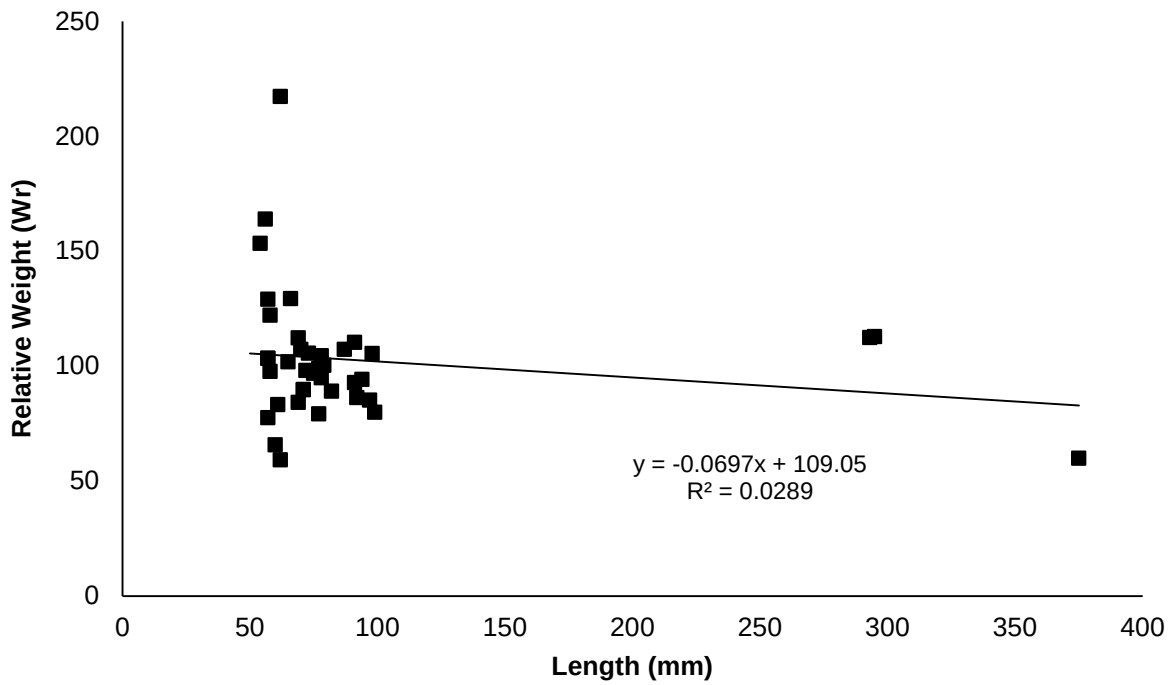

Figure 21. Relative weight (Wr) of Largemouth Bass collected during electrofishing surveys of Deyo Reservoir, Idaho, in 2014.

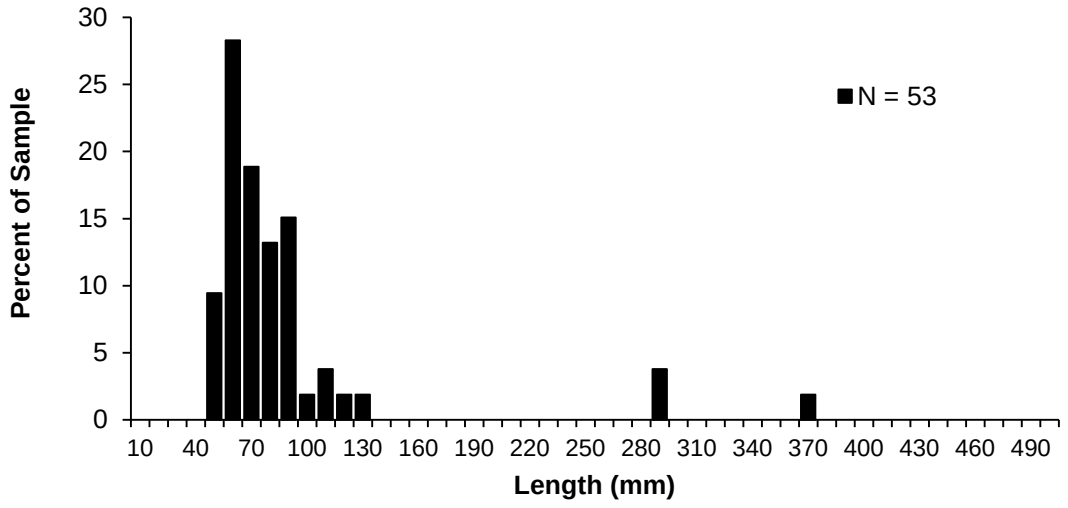

Figure 22. Length frequency distribution of Bluegill collected during electrofishing surveys of Deyo Reservoir, Idaho, in 2014.

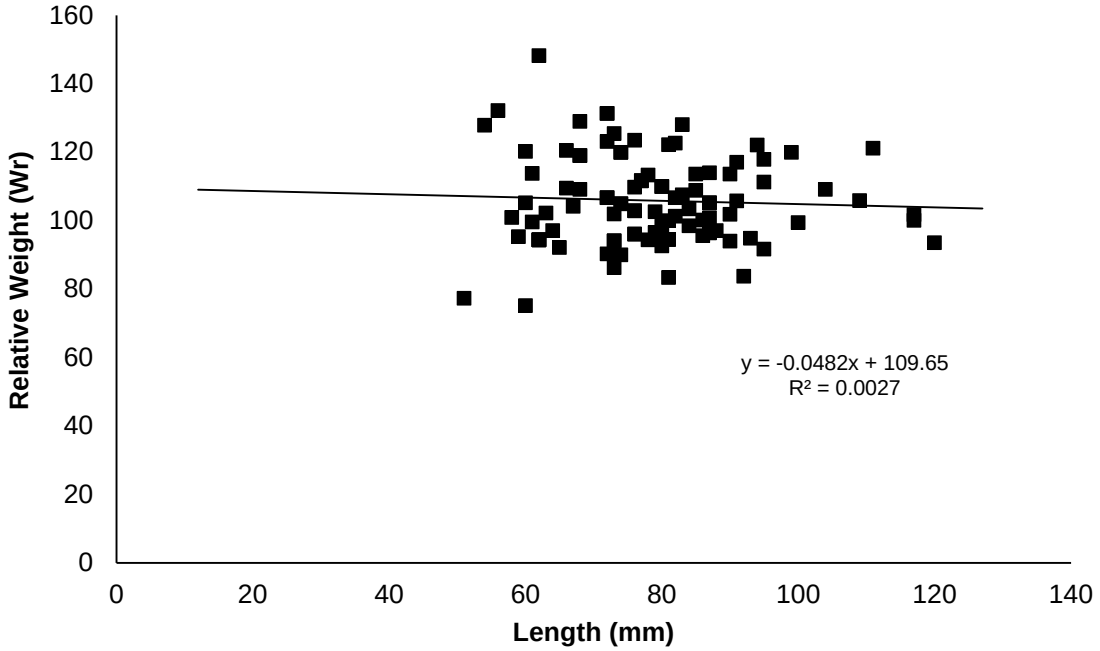

Figure 23. Relative weight (Wr) values of Bluegill collected during electrofishing surveys of Deyo Reservoir, Idaho, in 2014.

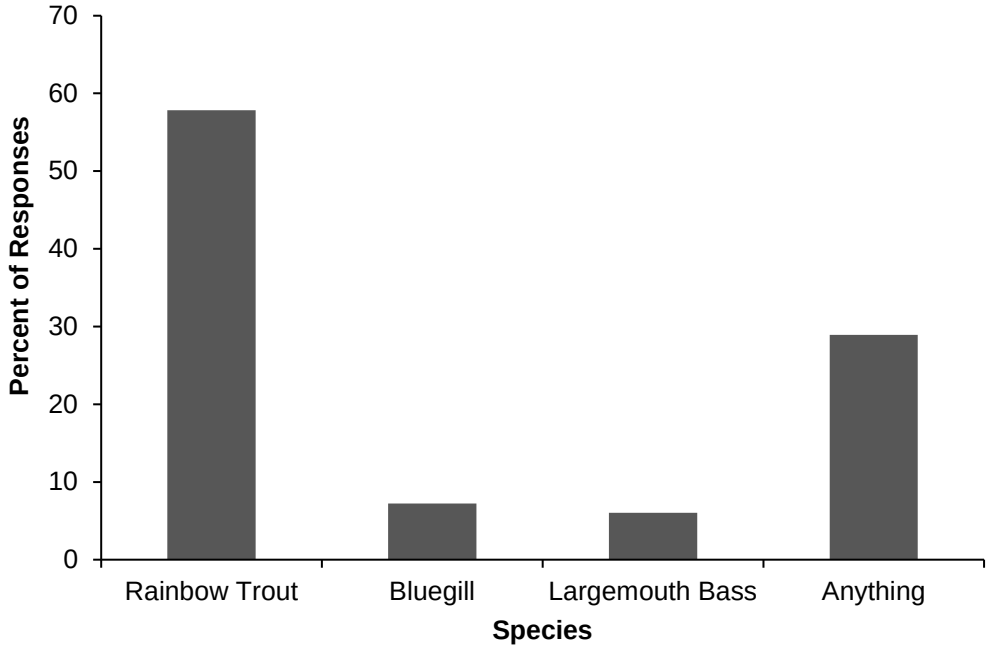

Figure 24. Summary of angler responses regarding target fish species at Deyo Reservoir, Idaho, as determined through angler report cards, from April 28 - November 12, 2014.

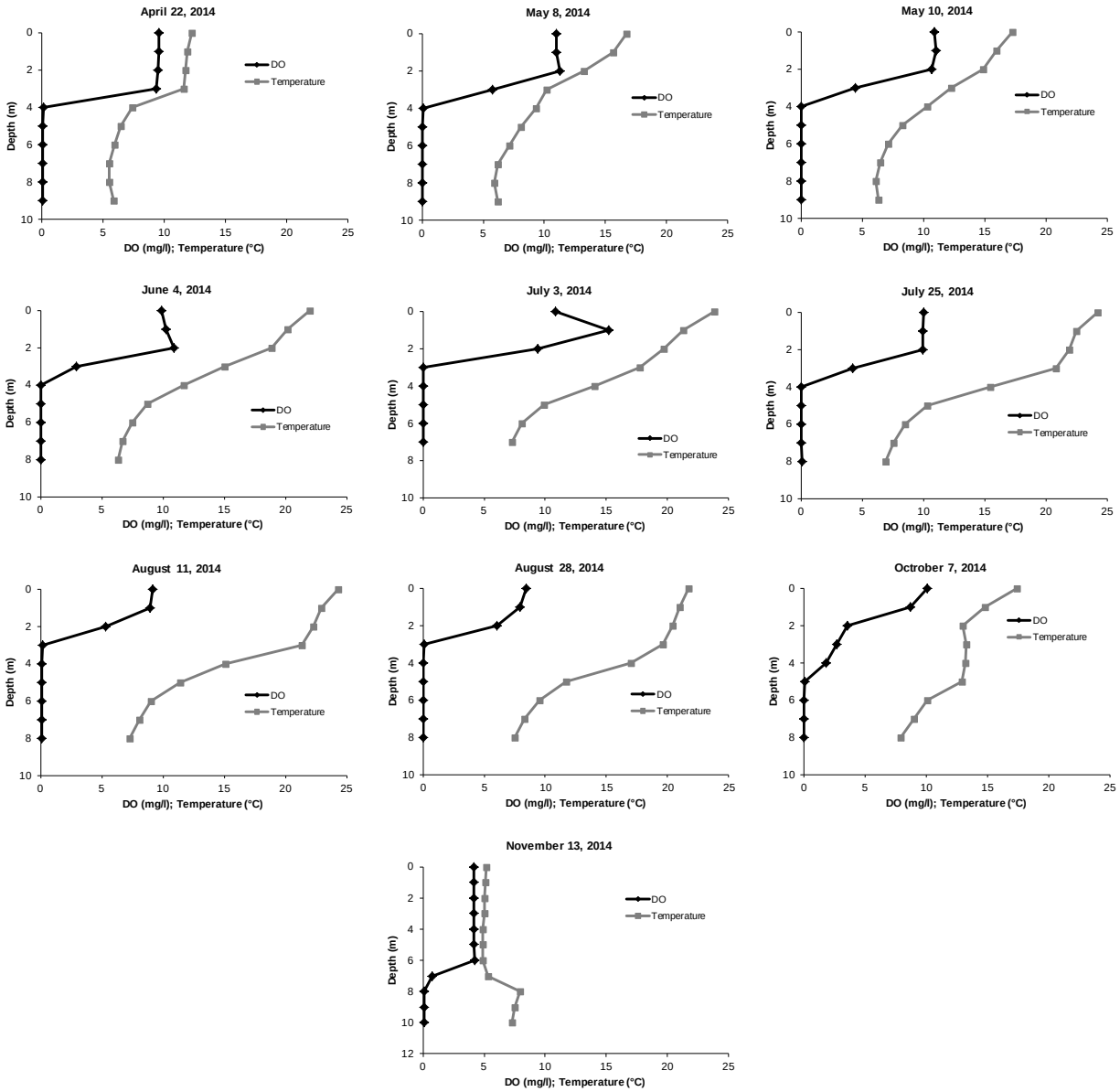

Figure 25. Dissolved oxygen (DO) and temperature profiles collected in Deyo Reservoir, Idaho, during 2014.

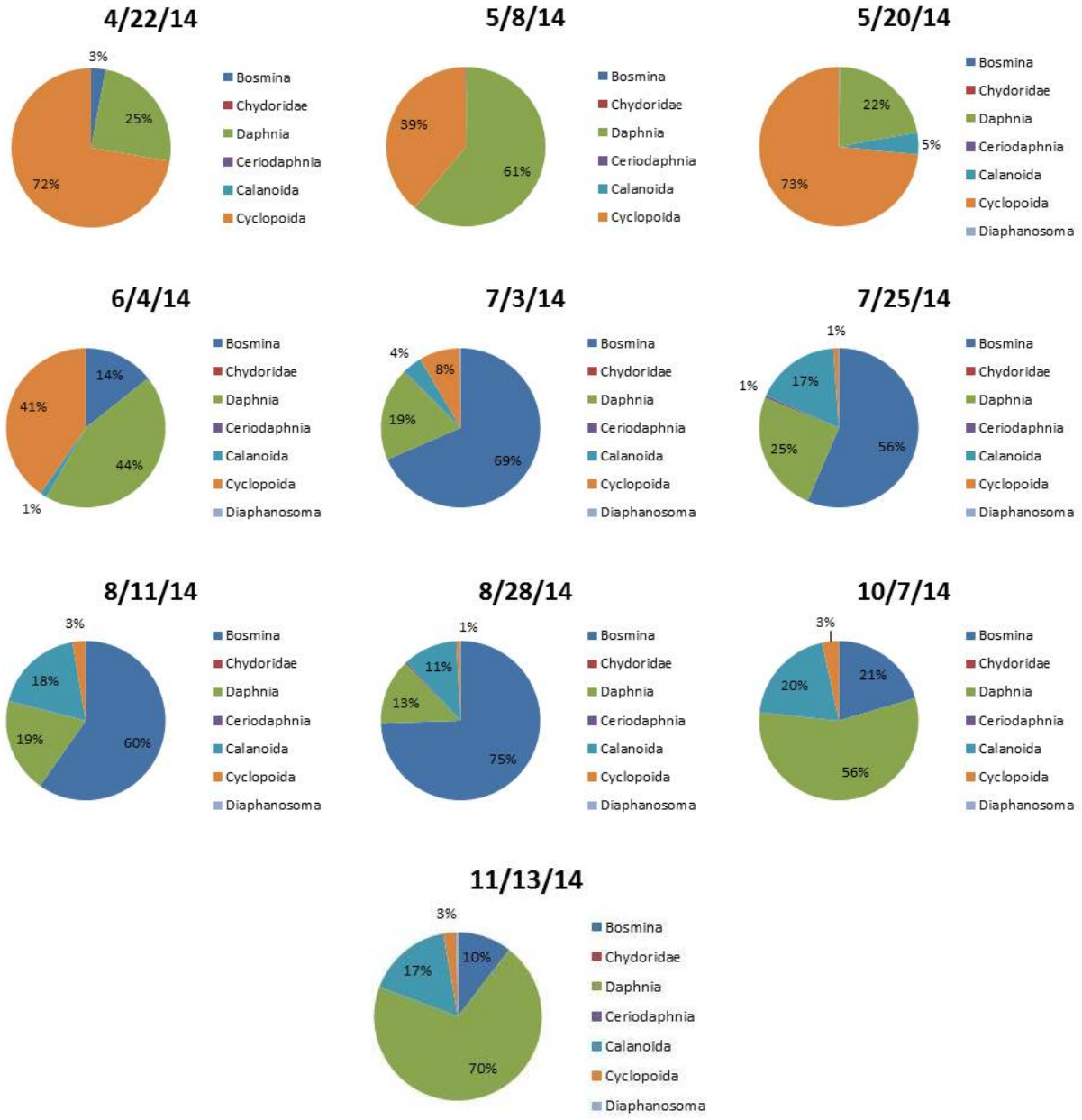

Figure 26. Zooplankton community composition based on samples collected in Deyo Reservoir, Idaho, during 2014.

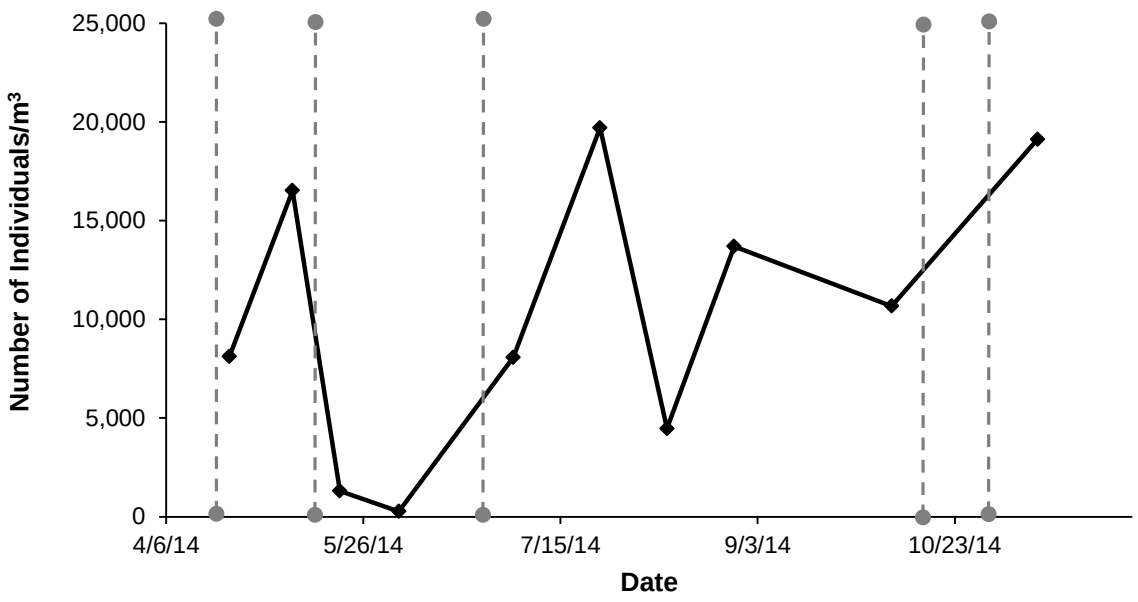

Figure 27. Densities (number of individuals/m3) of Daphnia collected in Deyo Reservoir, Idaho, in 2014. Vertical bars show the dates fish were stocked into the reservoir.

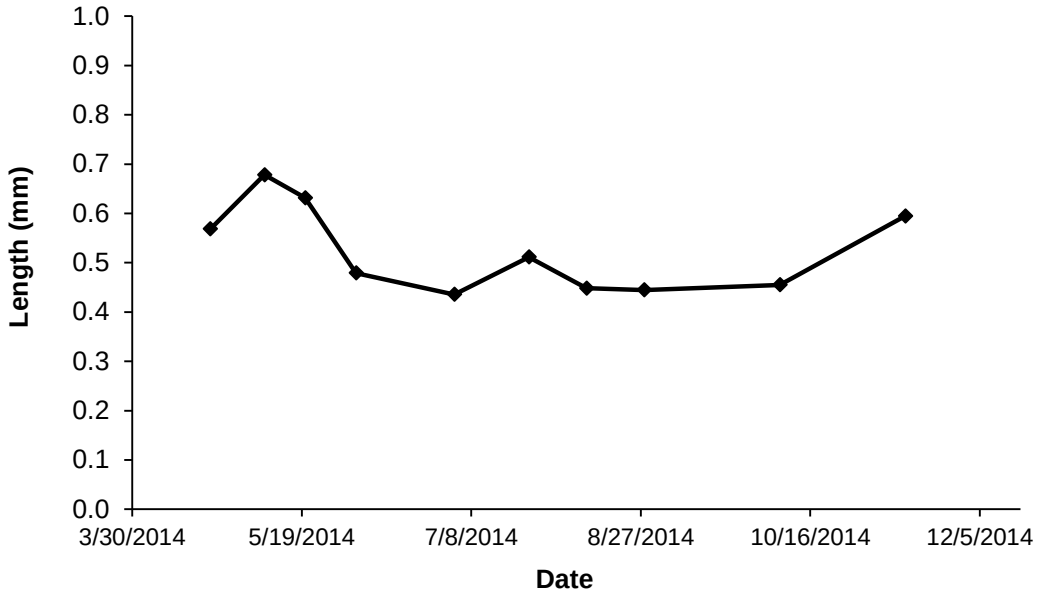

Figure 28. Average length (mm) of Daphnia collected from Deyo Reservoir, Idaho, in 2014.

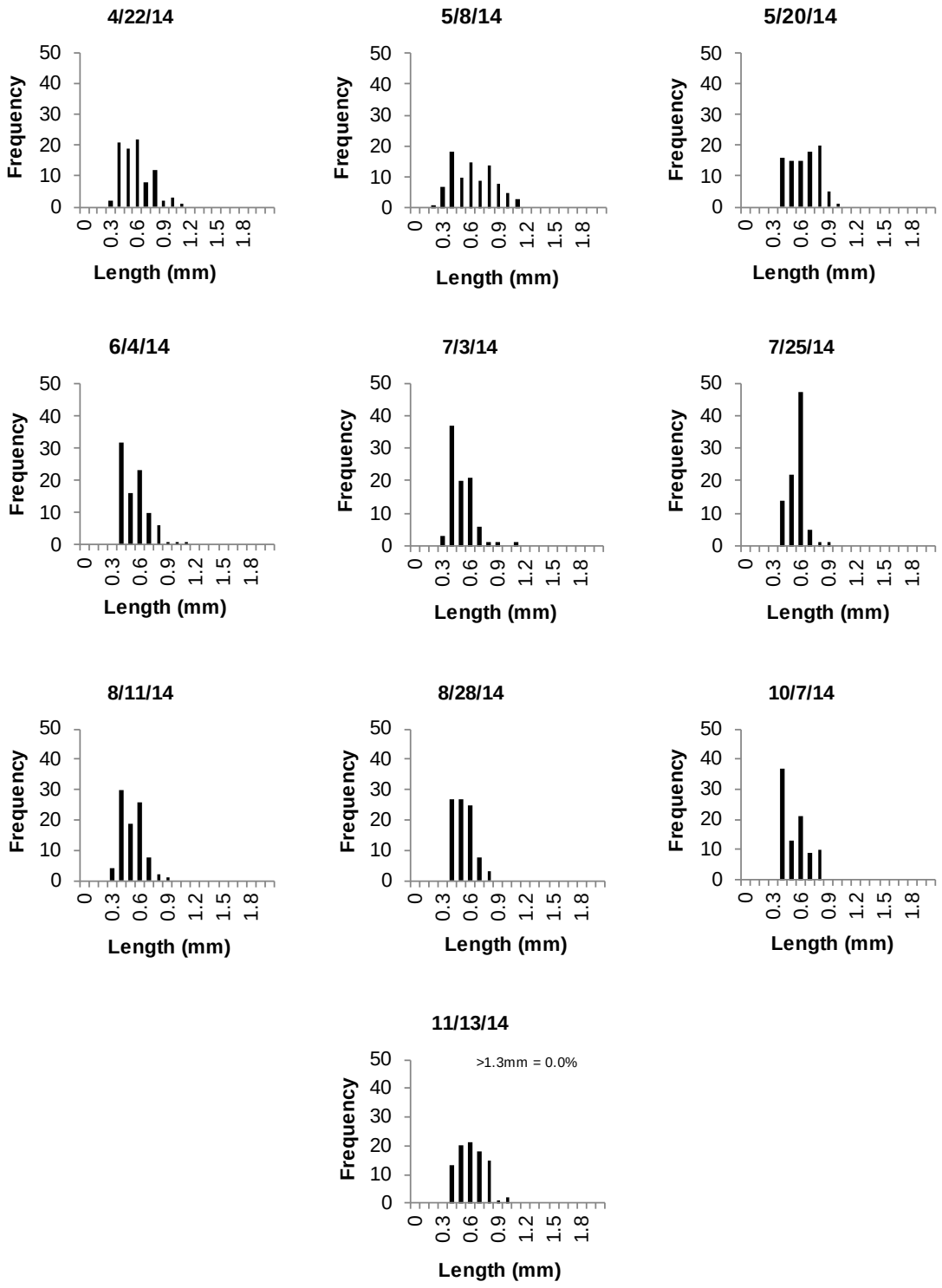

Figure 29. Length frequency distribution of Daphnia collected from Deyo Reservoir, Idaho, in 2014.

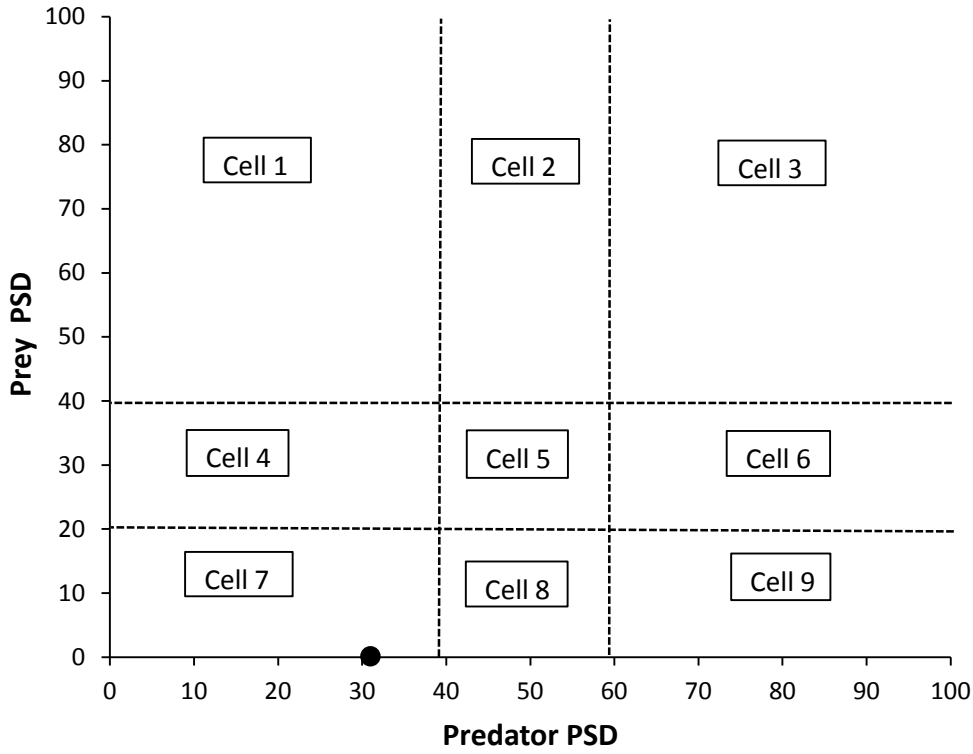

Figure 30. Comparison of predator (Largemouth Bass) and prey (Bluegill) proportional size distribution (PSD) of fish collected through electrofishing in Deyo Reservoir, Idaho, in 2014. Dashed lines define the nine predator:prey PSD size structure possibilities based on Schramm and Willis (2012).

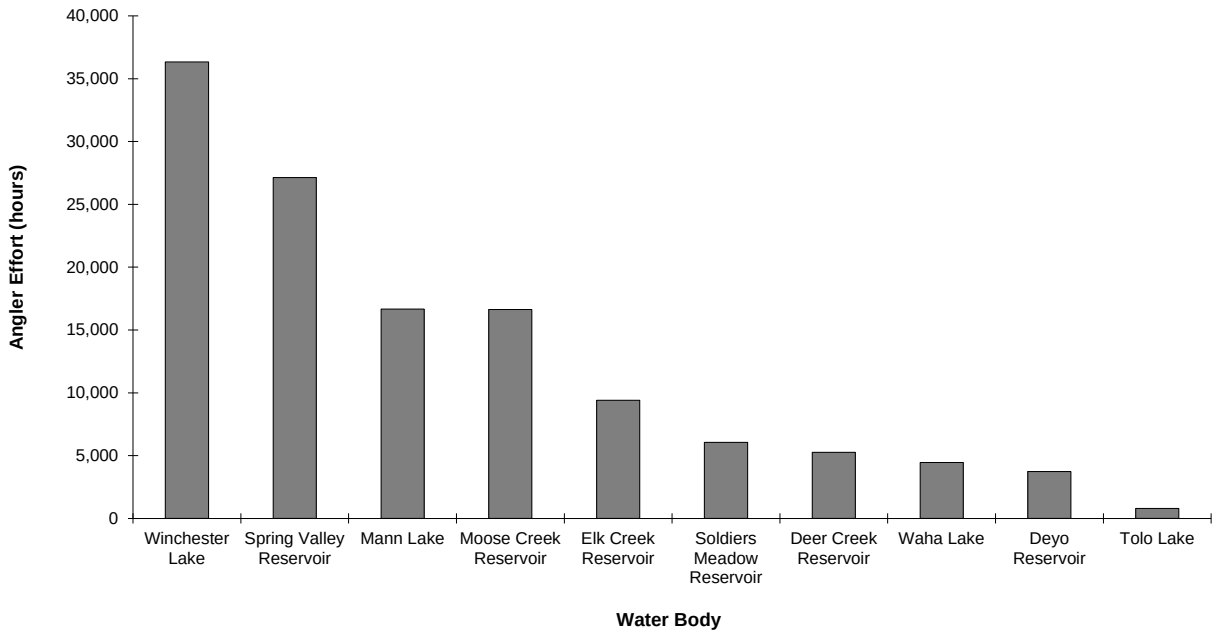

Figure 31. Estimated angler effort from creel surveys of eight lowland lakes and reservoirs in the Clearwater Region, Idaho, during 2012.

SOLDIER'S MEADOW RESERVOIR FISHERY EVALUATION

ABSTRACT

Idaho Fish and Game renovated Soldier's Meadow Reservoir (SMR) on November 7, 2013 using the piscicide rotenone. The purpose of this renovation was to remove stunted populations of Black Bullhead *Ameiurus melas*, Yellow Perch *Perca flavescens*, and Black Crappie *Pomoxis nigromaculatus,* which were illegally introduced over the last two decades. A put-grow-take kokanee *Oncorhynchus nerka* fishery and put-take Rainbow Trout *Oncorhynchus mykiss* fishery were introduced through stocking events in spring 2014. A total of 8,057 kokanee fry and 10,494 catchable size rainbow trout were stocked. A total of 42 kokanee were collected from a gill net survey in November of 2014. They averaged 172 mm in length, which was substantially higher than average lengths for fish of this age class as compared to other Idaho reservoirs. Sixty-one Rainbow Trout were also collected in the gill net survey. Zooplankton populations were monitored April - November to determine the impact of the introduced fishery. Population densities and peaks were found to be similar in number and timing to previous years for *Daphnia*, *Chydoridae*, and *Calanoid*, while densities and peaks of *Cyclopoid*, *Ceriodaphnia*, *Bosmina*, and *Diaphanosoma* were substantially different. Average lengths of *Daphnia* and *Cyclopoid* were lower in 2014 than previous years and fewer were in the preferred size classes for Rainbow Trout or adult kokanee consumption. Kokanee have been shown to more efficiently predate on smaller zooplankton than Rainbow Trout, and are likely contributing to the decline in average size and abundance of primary zooplankton species in SMR. The feasibility of the kokanee fishery will be evident in 2 - 3 years when fish are predicted to reach preferred harvest size and sexual maturity. We should continue to assess zooplankton and water quality in SMR, as well as evaluate kokanee and holdover Rainbow Trout populations in 2015 - 2016 to determine success of the introduced fishery.

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INTRODUCTION

Soldier's Meadow Reservoir (SMR) was renovated in 2013 with rotenone to remove stunted Yellow Perch *Perca flavescens*, Black Crappie *Pomoxis nigromaculatus*, and Black Bullhead *Ameiurus melas* populations (Hand et al., 2016b). Based on comments collected during public meetings and e-mail surveys, we decided to manage SMR as a put-grow-take kokanee *Oncorhynchus nerka* fishery with a minor put-take Rainbow Trout *Oncorhynchus mykiss* fishery (Hand et al. 2016b). In May 2014, 8,057 Kokanee fry (<75 mm in length) were stocked, and in May and June 2014, 10,494 Rainbow Trout of catchable size were stocked.

The objectives of this multiyear study were to evaluate Soldier's Meadow Reservoir's potential for providing a kokanee fishery, and to evaluate growth and survival of early versus late spawning kokanee strains. Specifically the objectives were as follows:

OBJECTIVES

1. Evaluate the potential of kokanee to provide a fishery in Soldier's Meadow Reservoir.

2. Evaluate growth and survival of early versus late spawning kokanee.

STUDY AREA

Soldier's Meadow Reservoir is located approximately 45 km southeast of Lewiston, Idaho, and 10 km west of Winchester, Idaho (Figure 1). It is a 47.8 ha reservoir with a mean depth of 5.6 m and a maximum depth of 14.0 m, and lies at an elevation of 1,378 m. Soldier's Meadow Reservoir was constructed for the Lewiston Orchards Irrigation District (LOID) to retain water for irrigation purposes. Its primary water supply is from Webb and Captain John creeks. Water level fluctuations up to eight meters on an annual basis are commonplace. Drawdowns usually begin by late June or early July as water is discharged for irrigation purposes. Low pool is generally reached by late fall towards the end of the irrigation season. Full pool is generally reached in May during spring runoff. Severity and timing of water level fluctuations is dependent on water yield in the LOID-managed watershed and irrigation demand. The timing of annual variations in water level can have major effects on the spawning success of warmwater species. Also, low pool levels through the winter can reduce carrying capacity of fishes. Facilities at this reservoir include primitive camping, boat ramp, and toilet. The boat ramp is only usable during higher water levels.

METHODS

Water quality and zooplankton data were collected according to the methodology detailed in the Deyo Reservoir Investigations section of this report. Fishes were sampled using two overnight gill net sets (Hand et al. 2016a). Floating experimental monofilament gill nets 36 m long and 1.8 m high were used. The nets were divided into six equal size panels with bar mesh sizes of 10 mm, 12.5 mm, 18.5 mm, 25.0 mm, 33.0 mm, and 38.0 mm. Monofilament diameter ranged from 0.15 mm - 0.20 mm. For the purpose of this evaluation, only fish species and lengths (total length, mm) were collected.

Fingerling kokanee were stocked into SMR on May 13, 2014 in order to establish a new fishery following a 2013 renovation project. Early spawners average approximately 76 mm at

stocking compared to approximately 57 mm for late spawners (Gary Burns, IDFG personal communication). These kokanee were subjected to temperature changes during rearing at Cabinet Gorge Hatchery in order to produce unique marking patterns (thermal marks) in the otolith prior to stocking (Volk et al. 1990; Hagen et al. 1995). This allows for differentiation among the early and late spawning strains stocked in 2014. However, otoliths were not collected from kokanee in 2014 due to a miscommunication. They will be collected from all kokanee in 2015 and 2016 to analyze age and growth differences between early and late spawning strains.

RESULTS

Fishery Evaluation

Two overnight gill net sets were conducted on SMR on November 7, 2014. A total of 103 fish were collected, including 61 Rainbow Trout and 42 kokanee. Kokanee collected ranged in length from 91 - 195 mm (Figure 32) and averaged 172 mm. Since these fish were stocked in spring 2014 as fingerlings, they are all age-0. This average length is substantially larger than the average lengths of age-0 kokanee sampled in other Idaho reservoirs from 2010 - 2014 (Table 10). Rainbow Trout collected ranged in length from 213 - 331 mm (Figure 33), and averaged 278 mm.

Dissolved Oxygen and Temperature

Dissolved oxygen (DO) and temperature profiles were collected monthly from April - November 2014. Dissolved oxygen and temperature profiles changed substantially over the year, with different patterns emerging seasonally. Dissolved oxygen profiles for April - May showed high surface concentrations that decreased with depth (

Figure 34). In late June – September, the hypolimnion showed anoxic conditions while November's DO profile showed homogenous concentrations at all depths, most likely due to fall turnover. Temperature profiles showed similar patterns to DO measurements (

Figure 34).

Kokanee typically prefer temperatures <21°C and are considered to have an upper temperature threshold of 24°C (Coutant 1977; Jobling 1981). Additionally, they prefer DO >6.0 ppm (Baldwin and Polacek 2002). In 2014, water temperatures >21°C and/or DO <6.0 ppm occurred April - August, resulting in 28.9 - 99.9% of the reservoir's volume providing preferable conditions for kokanee (Figure 35). However, September had 0.0% of reservoir volume >6.0 ppm. November had 100% of the reservoir volume water temperatures <21°C and DO levels >6.0 ppm (Figure 35).

Zooplankton Survey

Zooplankton samples were collected monthly from April - November 2014. The population was composed of seven taxa of zooplankton: *Chydoridae*, *Daphnia*, *Cyclopoid*a, *Ceriodaphnia*, *Bosmina*, *Calanoid*a, and *Diaphanosoma*. The composition changed from primarily *Daphnia* (55.0%) in April samples to primarily *Cyclopoid* (>58.0%) in May - June, and then back to *Daphnia* in July (45.0%). From August to November the samples primarily shifted to *Ceriodaphnia* (>34.1%) (

Figure 36).

Densities (numbers of individuals/m^3) were also highly variable. *Ceriodaphnia* and *Diaphanosoma* densities were very low in April (1/m^3), and peaked to 56,725/m^3 for *Ceriodaphnia* and to 9,987/m^3 for *Diaphanosoma* in September (Figure 37). *Daphnia*, *Cyclopoid*a, *Bosmina*, and *Chydoridae* all had low densities in spring, but peaked in the summer (Figure 37). *Calanoid*a showed an overall increase with minor peaks and declines between April and November. Densities and peak time for *Daphnia*, *Calanoid*, and *Chydoridae* in 2012 were generally similar to 2014. However, *Daphnia* and *Cyclopoid* peaked in late summer/early fall during 2013. For *Bosmina* and *Ceriodaphnia*, peak densities were 20,000 - 100,000 individuals/m^3, with peak densities being greater in 2012 than 2014. *Cyclopoid* peak density was highest in 2013. *Diaphanosoma* did not appear in samples until 2014.

Average length of *Daphnia* ranged from 0.37 - 0.91 mm in 2014 (Figure 38). Average length increased after the spring stockings, and continued to increase throughout the summer. Average *Daphnia* lengths were generally higher in 2012 (before rotenone treatment) than in 2014 (Figure 38). Length frequency distributions from each sample show that the percent of *Daphnia* >0.8 mm in length ranged from 1.1 - 73.3% of the individuals collected for April - November 2014 (Figure 39 and Figure 40). The percentage steadily increased throughout the year. Overall, the percentages >0.8 mm were lower than 2012 (Hand et al. 2016a). Samples from 2013 showed *Daphnia* >0.8 mm occurred only in the November sample (Figure 40).

Average lengths of *Cyclopoid* ranged from 0.47 - 0.79 mm in 2014 (Figure 38). Average length declined after the first spring stocking of Rainbow Trout and kokanee, but increased after the late spring/early summer stocking of Rainbow Trout. Compared to 2012, average *Cyclopoid* lengths were slightly lower during the summer months in 2014, but higher in April and October (Figure 38). Samples from 2013 had few data points over the same months. Length frequency distributions from each sample in 2014 show that few *Cyclopoids* were >0.8 mm in length (Figure 41).

DISCUSSION

When collected through gill netting in November 2013, the average kokanee total length was 172 mm. This was substantially above the average lengths of age-0 kokanee collected in numerous other Idaho and Washington reservoirs (Table 10). The kokanee captured in SMR also had a wider range of sizes of individuals caught compared to Dworshak Reservoir, probably due to the fact that both early and late spawner types were stocked into the reservoir. These two stocks hatch at different times, causing the late spawners to be slightly smaller at stocking time.

Kokanee growth also appears to be well above average for age-0 kokanee as compared to several other Idaho lakes between 1978 - 1990 and 2012 (Wilson et al. 2013; Rieman and Myers 1992). However, kokanee growth could change as annual stocking continues. Like other fish species, kokanee growth and average length at age is generally density dependent (Rieman and Myers 1992; Walters and Post 1993). As we conduct addition stocking in the next few years, density and biomass will increase. This will likely reduce average size and annual growth over what was seen this year. Future evaluations will be important to evaluate the success of these stockings and what stocking densities are needed to maintain desired growth and catch rates. In addition to fish surveys, creel surveys should be conducted to evaluate angler effort, catch rates, and satisfaction.

As the kokanee population expands through additional stockings over the next few years, food resources may become a concern. However, as *Daphnia* and *Cyclopoid* >1.0 mm make up

a substantial portion of the diet of adult kokanee (Galbraith 1967; Clarke et al. 2004), juvenile kokanee have been shown to prey on smaller species and greater variety of *Cladocerans* and *Copepods* (Brunger Lipsey and Stockwell 2001; Budy et al. 2005; Paragamian and Bowles 1995). This varied preference of zooplankton species from juvenile kokanee has been found to reduce competition/predation between zooplankton species and helps increase species richness (Donald et al. 2001). Our sampling also suggested this occurred in SMR as evident from the increase of *Diaphanosoma* sp. to observable levels (Figure 37). Juvenile kokanee predation could also account for the lower population density of smaller zooplankton, such as *Bosmina* and *Ceriodaphnia*. We will continue to monitor the zooplankton population as this fishery expands.

The small Yellow Perch and Black Crappie, and hatchery Rainbow Trout present in SMR prior to the renovation (Hand et al. 2016a) were known to target *Daphnia* and other zooplankton >1.3 mm (Schael et al. 1991). However, because kokanee are more effective planktivores and are efficient at retaining smaller zooplankton (Brunger Lipsey and Stockwell 2001), the introduction of kokanee likely played a large role in the lower average length and percent >0.8 mm of *Daphnia* observed in 2014 when compared to samples collected in 2012 (Figure 38 and Figure 40). Ultimately, future assessments are needed to evaluate how the presence of multiple year classes of kokanee (through future stocking) influences zooplankton density and size and ultimately kokanee growth. This type of information is important when assessing what future kokanee stocking densities should be if this program proves successful. Although the introduction of kokanee probably plays a role in the lower densities of larger sized zooplankton in SMR, there are other factors that likely influenced zooplankton size and abundance. Rotenone treatments, as occurred in 2013, have been found to influence zooplankton abundance (Kiser et al. 1963; Anderson 1970; Serns and Hoff 1982).

Zooplankton populations can be quite variable and have drastic fluctuations between different years as well as different months, especially after removal and introduction of new fish species (Donald et al. 2001). This is well evidenced by the differences seen in the zooplankton populations from 2012 - 2014 (pre- and post-rotenone) (Figures 37 - 40).

Future sampling over the next few years will be needed to determine whether zooplankton abundance and size is sufficient to allow kokanee to reach desired sizes (for anglers) before they reach sexual maturity (2 - 3 years old). After this time has elapsed, the success of the fishery can be evaluated and it can be determined whether adjustments need to be made or a new fishery needs to be implemented. Additionally, otoliths will be collected from kokanee over the next few years to allow for comparisons in growth and survival between early and late spawning stocks.

Preferred temperatures for kokanee are <21°C with lethal temperatures being >24°C, and preferred DO levels are >6.0 ppm (Brett 1971; Jobling 1981). Kokanee typically try to migrate to different parts of the water column to try to find more favorable conditions (Jobling 1981; Coutant 1977; Baldwin and Polacek 2002). In all months in 2014 except for September, a sufficient percentage of the reservoir volume (28.9% to 69.2%) provided areas where preferred temperatures and DO occurred to support a kokanee population. However, in September the entire reservoir had a DO concentration of <6.0 ppm signifying fall turnover (Figure 35). This is somewhat concerning, although DO concentrations were around 5.0 ppm in the top 3 m of the reservoir. Although DO concentrations around 5.0 ppm can be stressful to kokanee, this concentration is not considered to be lethal unless it persists for extended time periods of time (Brett 1971). Our gillnetting in November showed the kokanee were able to survive through this period. Because surface temperatures in July and August exceeded 21°C, it is recommended that stocking events occur before this period.

One important concern we have with the potential success of kokanee in SMR is the annual water drawdowns that occur in this reservoir due to irrigation. There is uncertainty as to whether overwinter survival will be sufficient enough to maintain a fishery. Thus, we will continue to monitor the kokanee population over the next few years. Additionally, the annual drawdown combined with the lack of a suitable stream will likely eliminate the potential for natural spawning in SMR. If this program proves to be successful, it will be fully dependent on annual stocking.

MANAGEMENT RECOMMENDATIONS

1. Continue to evaluate the water quality, zooplankton, and fishery in Soldier's Meadow Reservoir through 2016 to evaluate whether kokanee stocking can provide a consistent and meaningful fishery.

2. Collect and analyze kokanee otoliths to evaluate differences in performance of the early and late spawning kokanee stocks.

3. After multiple year classes of kokanee occur in Soldiers Meadow Reservoir, conduct a creel survey to assess whether kokanee are meeting fishery goals for anglers.

Table 10. Comparison of kokanee length at age in Idaho reservoirs.

Water Body	Survey Year	Length (mm)		
		Age-0	Age-1	Age-2
Lake Pond Orielle[a]	2010	63	148	219
Priest Lake[b]	2010	40	180	265
Cour D'Alene Lake[c]	2011	40	110	170
Deadwood Reservoir[d]	2011	<100	100-200	200-300
Payette Lake[e]	2011	45-58	105-133	
Spirit Lake[c]	2011	50	160	190
Devil's Creek Reservoir[f]	2012	@120	@280	
Dworshak Reservoir[g]	2013	84	222	270
Soldier's Meadow	2014	172		

[a]Wahl et al. (2011)
[b]Maiolie et al. (2011)
[c]Fredericks et al. (2013)
[d]Butts et al. (2013)
[e]Janssen et al. (2012)
[f]Brimmer et al. (2013)
[g]Wilson et al. (2013)

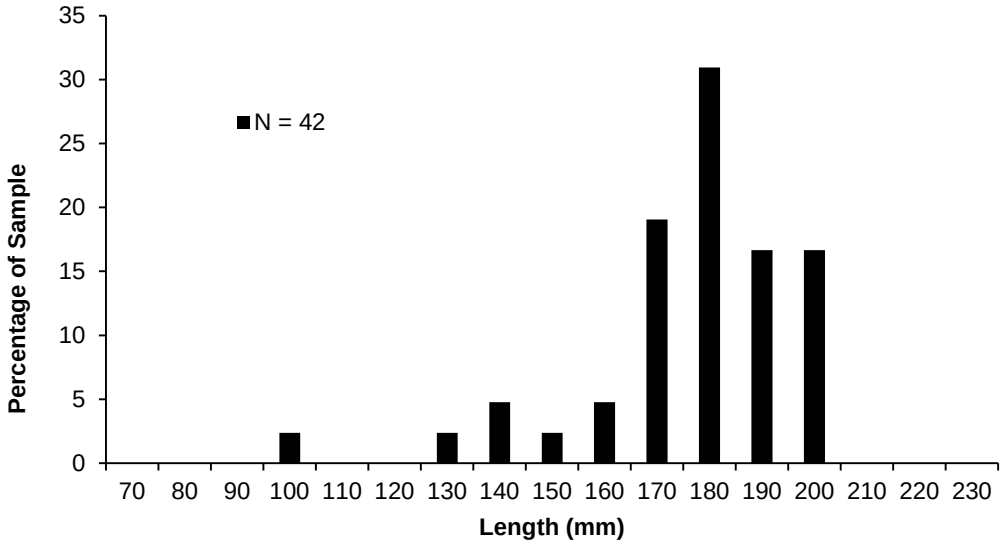

Figure 32. Length frequency distribution of kokanee gill netted in Soldier's Meadow Reservoir, Idaho, on November 7, 2014.

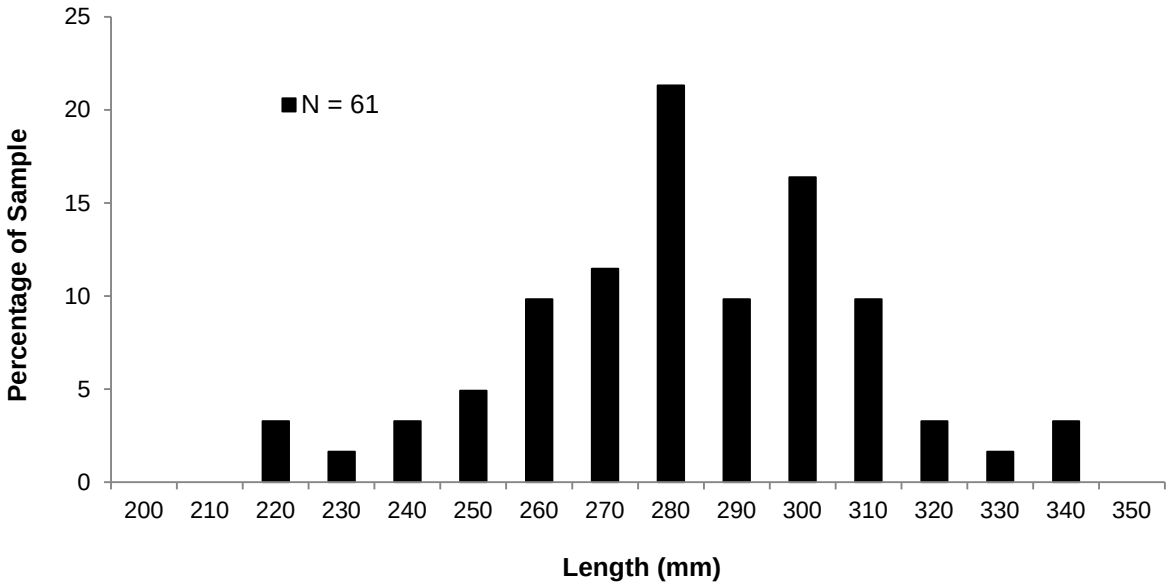

Figure 33. Length frequency distribution of Rainbow Trout gill netted in Soldier's Meadow Reservoir, Idaho, on November 7, 2014.

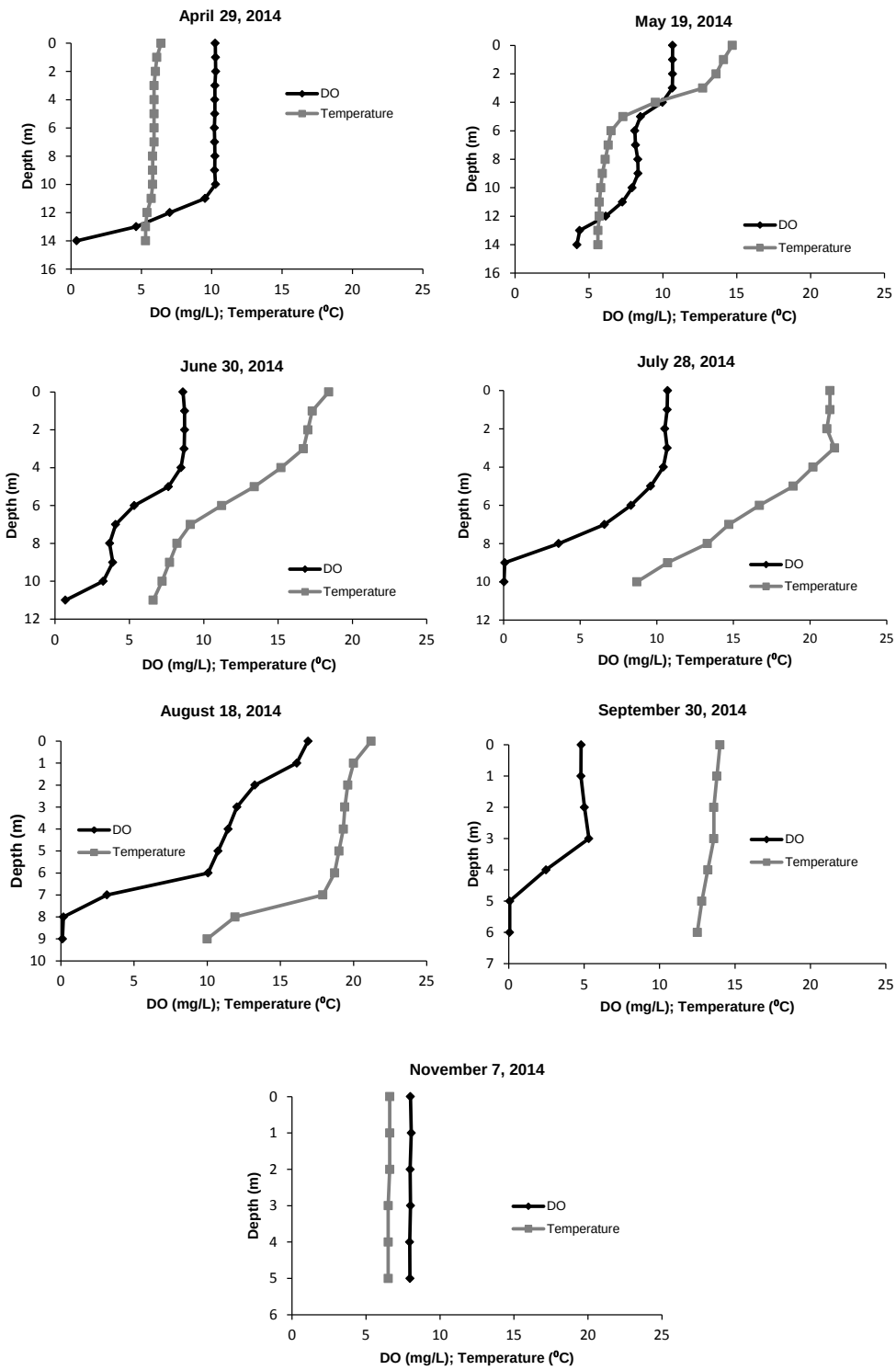

Figure 34. Dissolved oxygen (DO) and temperature profiles collected in Soldier's Meadow Reservoir, Idaho, during 2014.

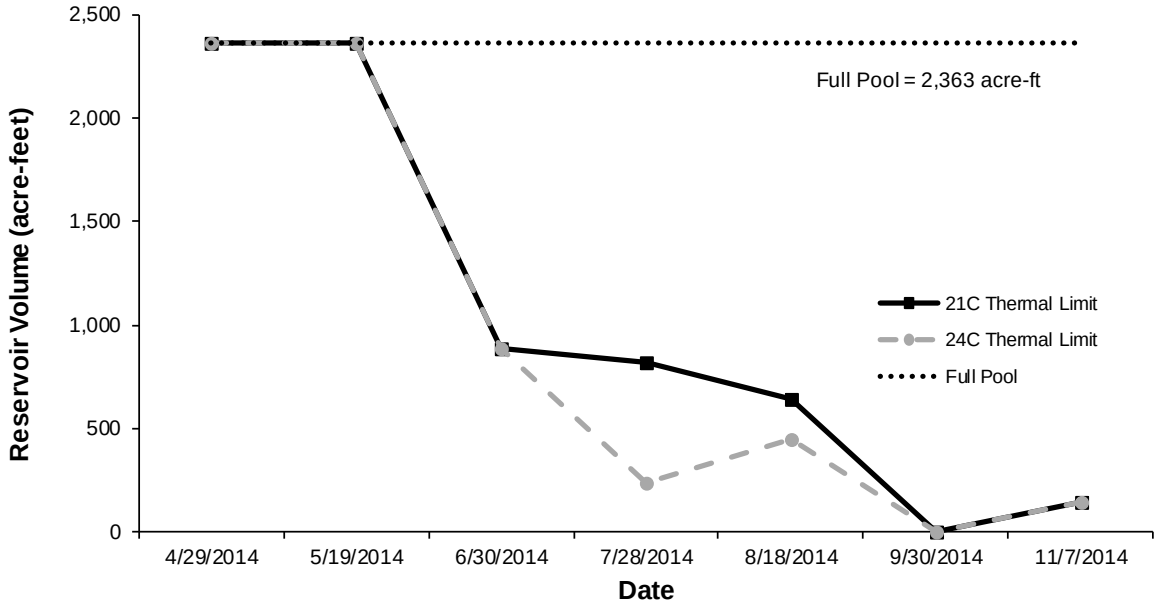

Figure 35. Estimated Kokanee habitat available in Soldier's Meadow Reservoir, Idaho, during 2014 based on upper thermal limits of 21°C and 24°C with a lower dissolved oxygen limit of 6.0 ppm.

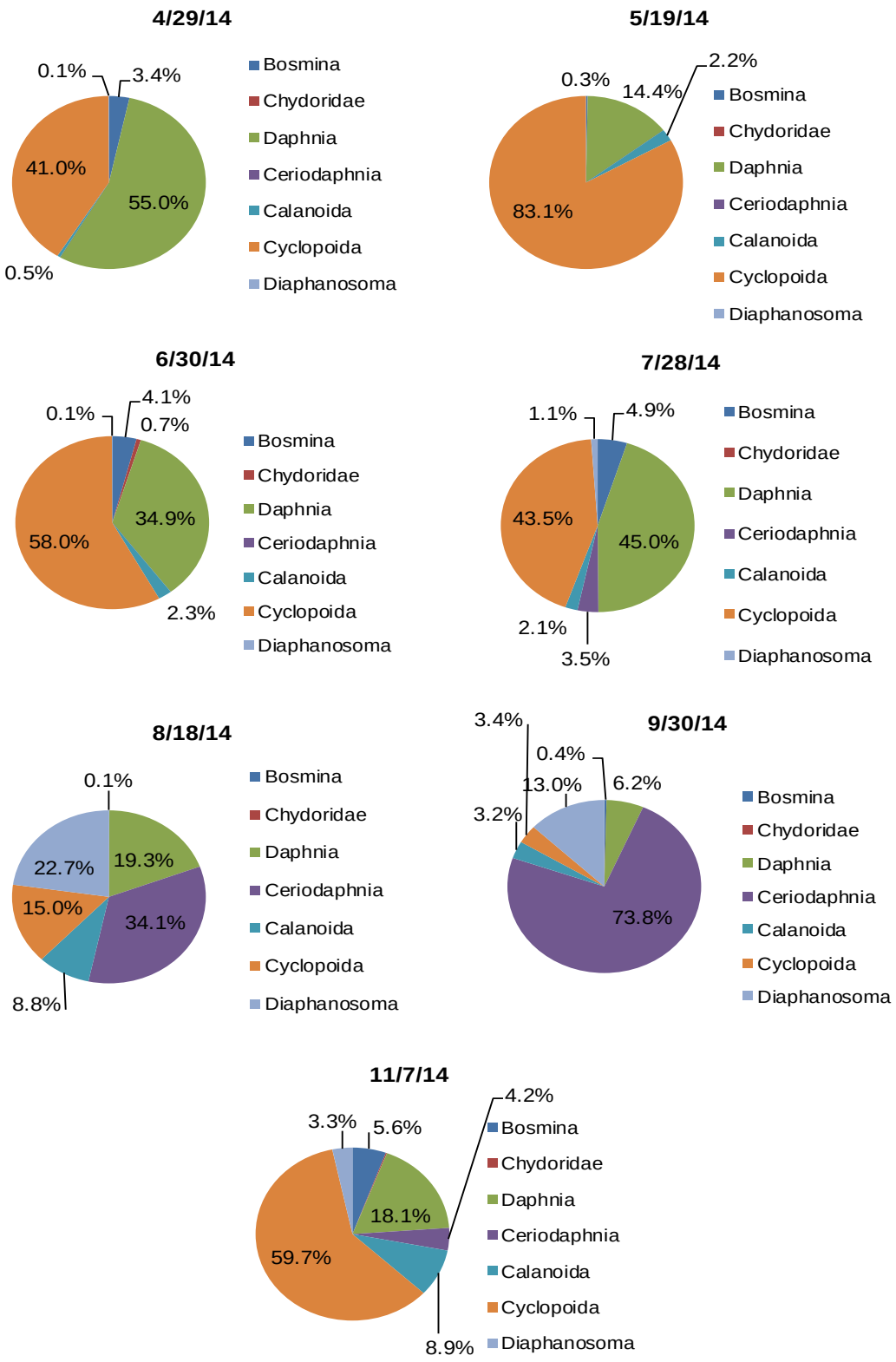

Figure 36. Zooplankton composition based on monthly samples collected in Soldier's Meadow Reservoir, Idaho, in 2014.

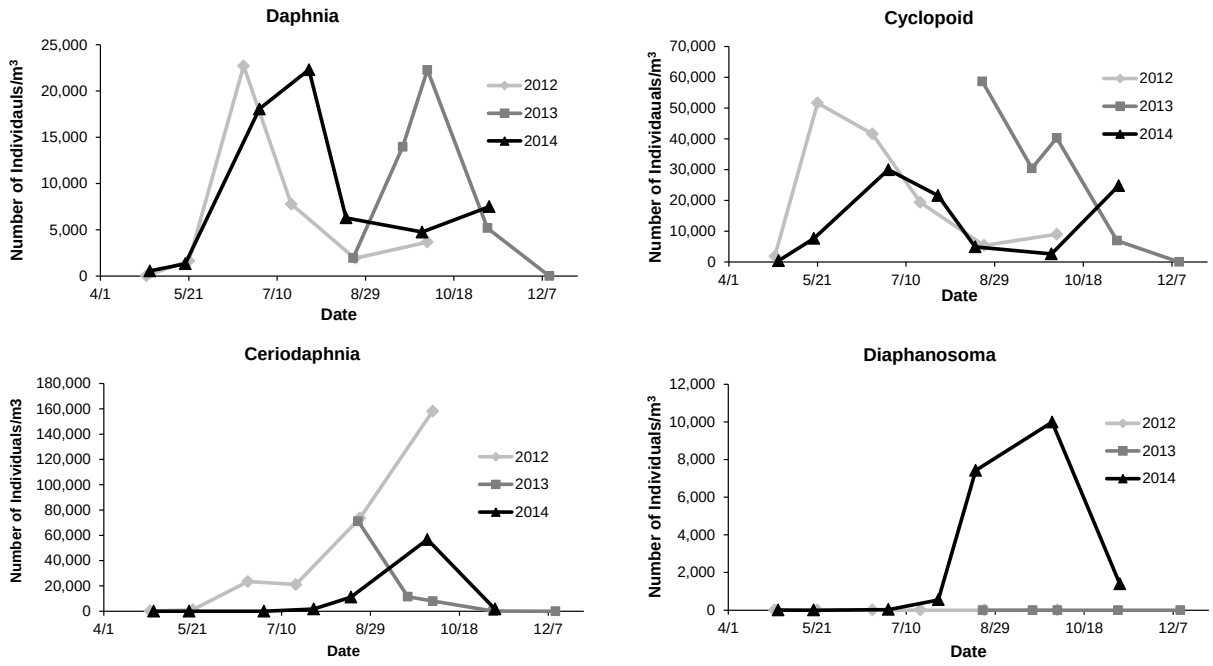

Figure 37. Zooplankton densities (number of individuals/m3) collected in Soldier's Meadow Reservoir, Idaho, in 2012 - 2014.

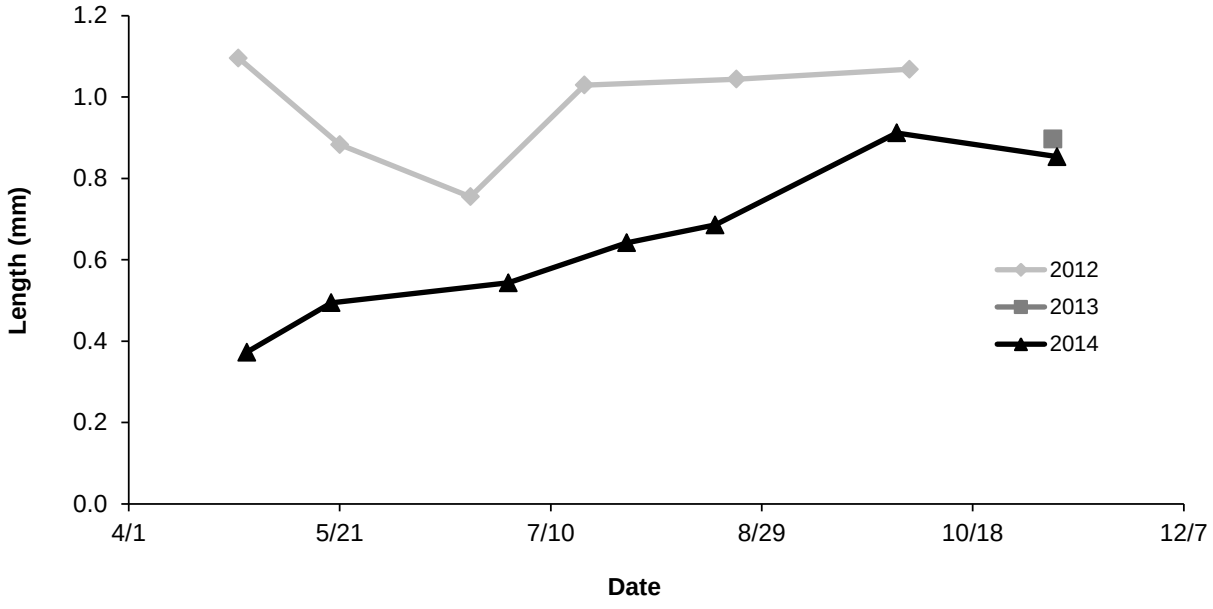

Figure 38. Average length (mm) of zooplankton collected from sampling in Soldier's Meadow Reservoir, Idaho, in 2012 - 2014.

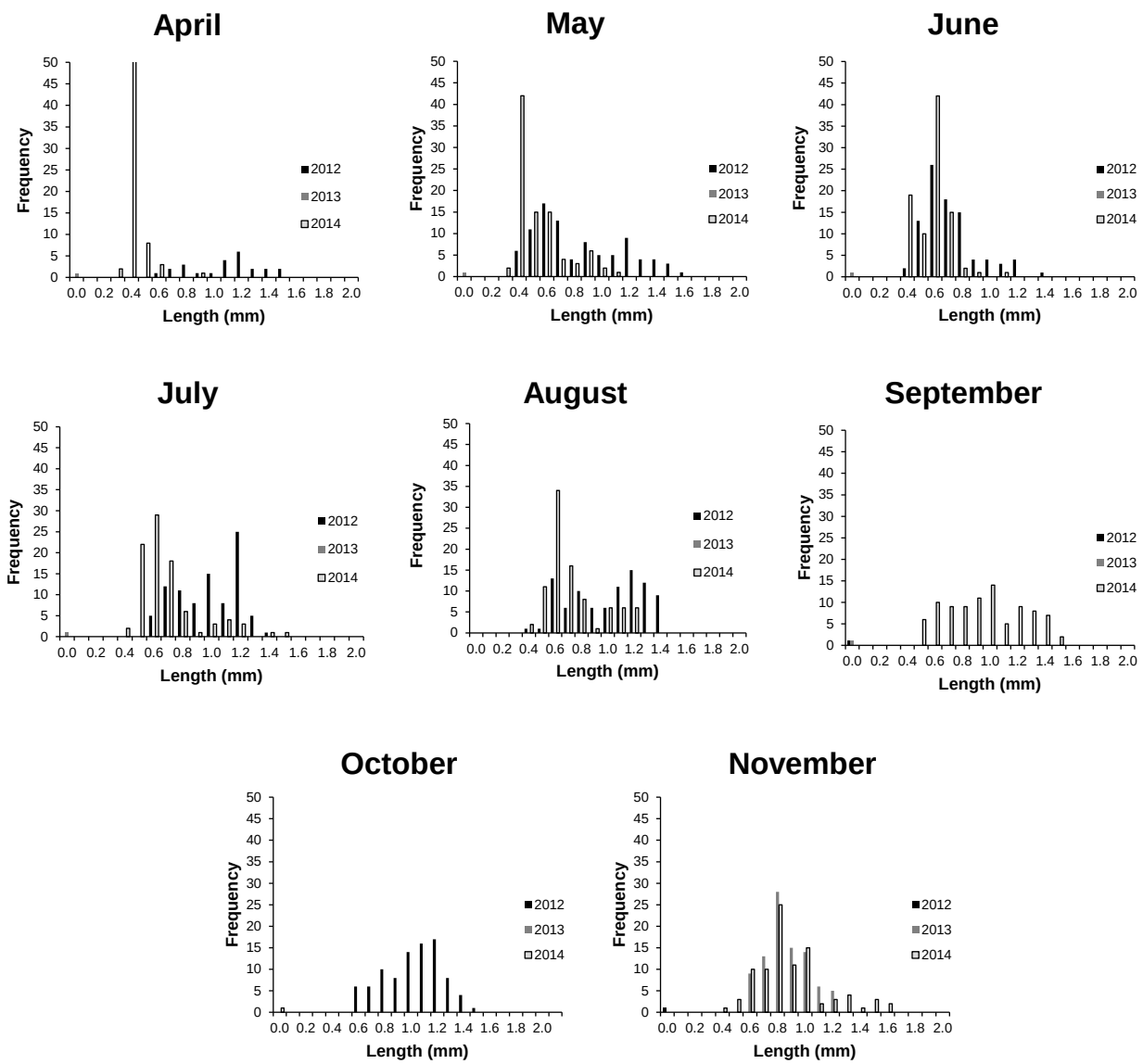

Figure 39. Length frequency distribution of Daphnia collected from Soldier's Meadow Reservoir, Idaho, in 2012 - 2014.

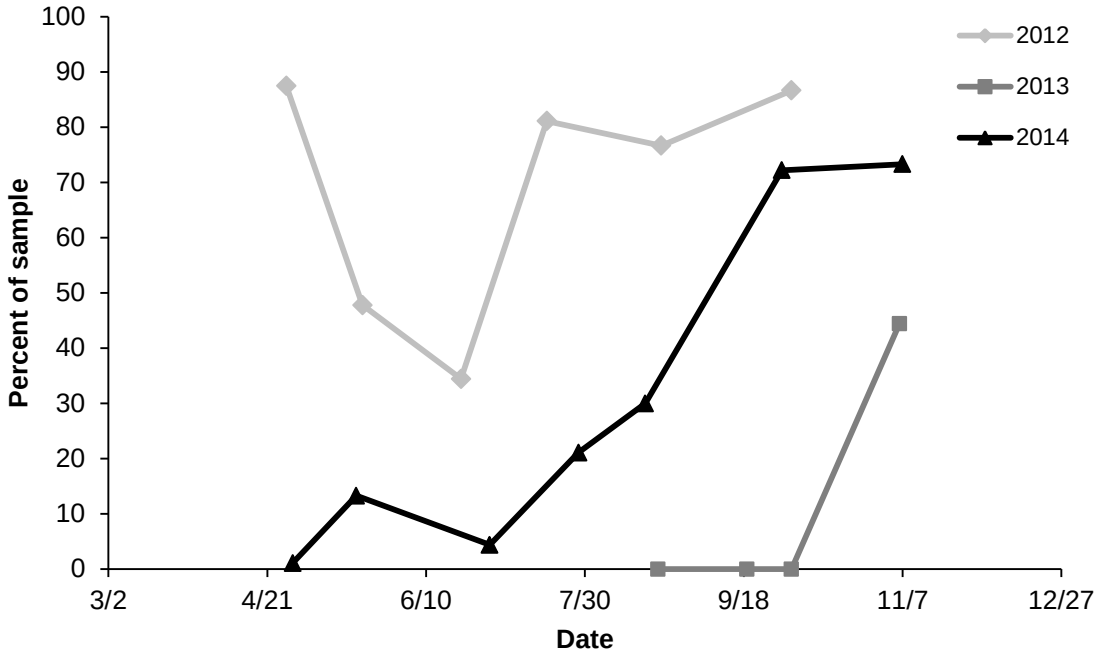

Figure 40. Percent of Daphnia >0.8 mm collected from Soldier's Meadow Reservoir 2012 - 2014.

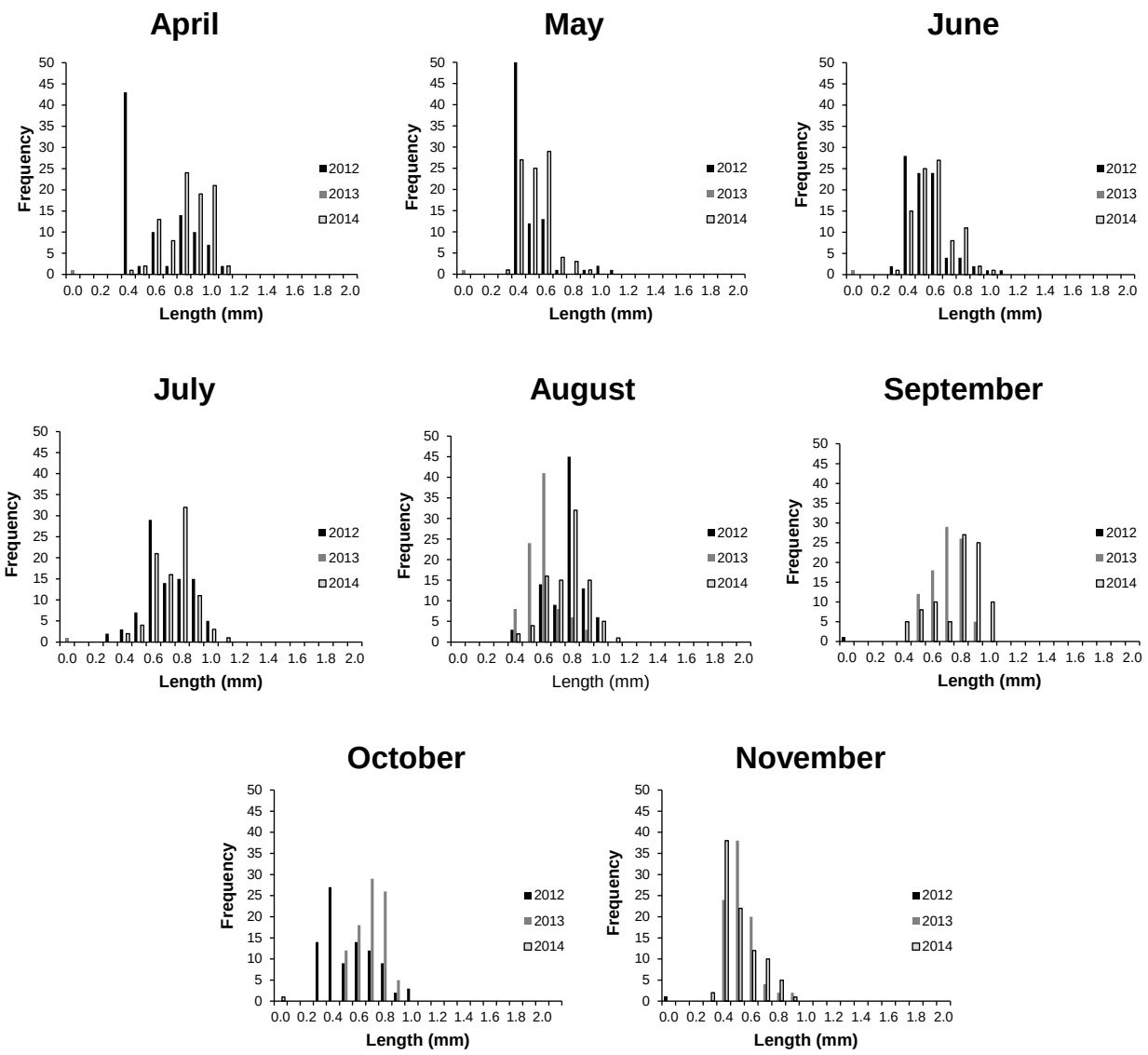

Figure 41. Length frequency distribution of Cyclopoids collected from Soldier's Meadow Reservoir, Idaho, in 2012 - 2014.

WINCHESTER LAKE FISH SURVEY

ABSTRACT

An electrofishing survey was conducted on Winchester Lake in 2014 to follow-up a survey conducted in 2012 which indicated that Largemouth Bass and Bluegill were experiencing population declines related to slow growth and overharvest. Data collected in 2014 indicated that the Largemouth Bass population has recently experienced a shift in length frequency towards larger fish. This occurred primarily in the 250 - 320 mm length range, and was confirmed by an increase seen in PSD from 2010 - 2014. Conversely, the Bluegill population has continued to decline, with average lengths and PSD values at the lowest since 1997. This indicates that natural mortality and angler harvest on this successful age class is continuing to impact the number of large Bluegill. As this large age class is removed from the population, the smaller length group of fish from 2012 is growing to fill that gap. However, the large decline in smaller fish in 2014 may indicate poor recruitment in 2013 and/or 2014. The PSD values for both Largemouth Bass and Bluegill exhibit a cyclic nature that indicates a classic “boom and bust” predator prey relationship. Due to the changes seen between the 2012 and 2014, we recommend repeating this sampling in 2016 or 2017.

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INTRODUCTION

In 2012, fish population surveys conducted on Winchester Lake indicated that length frequencies of Largemouth Bass and Bluegill were declining. Additionally, the population had few Largemouth Bass >304 mm. Data suggested that this was due to a combination of slow growth and angler harvest. Based on this information, we considered implementation of restrictive regulations such as a minimum size limit or protective slot limit to increase the size structure of Largemouth Bass. However, before making a decision to implement restrictive regulations on a family-oriented fishery, it was important to gather additional information.

OBJECTIVES

1. Assess whether sizes of Largemouth Bass and Bluegill in Winchester Lake continue to decline.

STUDY AREA

Winchester Lake is located 0.8 km south of the town of Winchester, Idaho (Figure 1). It is a 44.4 hectare reservoir that lies at an elevation of 1,189 meters. It has a maximum depth of 9.8 m and a maximum volume of 1,500 acre-ft. It was created in 1910 by the damming of the headwaters of Lapwai Creek. It served as a mill pond by several lumber companies until it was drawn down in 1967 in order to install a new spillway and boat ramp (Moeller 1985). The City of Winchester discharged its municipal wastewater into the lake until a new wastewater treatment facility was put into operation in 1972 (Moeller 1985). Today, the reservoir is characterized as highly eutrophic and prone to significant algal blooms and aquatic vegetation growth in the late summer. It is used extensively by boaters and fishermen, and is the focal point for the adjacent Winchester Lake State Park, which receives up to 37,000 visitors per year. Winchester Lake and its 3,159 ha watershed lie entirely within the Nez Perce Tribe's Reservation boundary. The watershed is used primarily for grazing, timber harvest, and recreation.

METHODS

The methodology for fish community surveys is located in the Deyo Reservoir Investigations section of this report.

RESULTS

Winchester Lake was electrofished on May 30, 2014 using five 10-minute electrofishing periods. For the purposes of this survey, only Bluegill and Largemouth Bass were collected. The electrofishing resulted in the capture of 134 Bluegill and 116 Largemouth Bass (Figure 42).

Largemouth Bass collected ranged from 78 - 497 mm in length with an average length of 257 mm (Figure 43). This was the highest average length for any sample conducted since 1997 (Figure 44). Thirteen of the 116 fish collected (11.2%) were >300 mm in length. This is close to the average of 13.1 fish >300 mm captured in the ten surveys conducted since 1997. Largemouth Bass PSD was 24 in 2014, the second consecutive increase since 2010 (Figure 45).

Bluegill collected ranged from 73 - 205 mm in length with an average of 124 mm (Figure 46). This average length was the lowest for samples collected since 1997, and supports the continued decline observed in PSD (Figure 44). In contrast to 2012, two distinct length groups were apparent in 2014 (Figure 46). The PSD of 34 in 2014 was the third straight decline since the high of 79 in 2007, and is the second lowest since 1997 when bluegill were first collected in Winchester Lake (Figure 45).

DISCUSSION

This survey was conducted as a follow-up to a survey conducted in 2012 to assess whether observed declines in Largemouth Bass and Bluegill size were continuing. Data collected in 2014 indicated that the Largemouth Bass population experienced a shift in length frequency towards larger fish compared to 2012 (Figure 43). This occurred primarily in the 250 - 320 mm length range, which is reflected in the increase in PSD since 2010 (Figure 45). This is also evidenced by the continued increase in average size since 2007 (Figure 44). In fact, the average length of 257 mm in 2014 was the highest for any sample conducted since 1997. There are still few LMB >300 mm in the population, and CPUE remains less than half of past maximums, but this trend is a positive sign for the bass fishery.

The Bluegill population has also shown changes in length frequency from 2012 to 2014. In 2012, there were two distinct length groups present, whereas in 2014 there were fewer large and small fish (Figure 46). This suggests that natural and/or fishing mortality has reduced the number of older/larger fish and recruitment has declined.

A comparison of PSD distributions for both Largemouth Bass and Bluegill can provide insight into potential population issues (Schramm and Willis 2012). In Winchester Lake, nine of the ten years of sampling since 1997 occur either in Cell 1 or Cell 4 of the predator:prey relationship chart (Figure 47). In both 2012 and 2014, this relationship was located in Cell 4. This generally indicates an absence of quality sized Largemouth Bass and a Bluegill population characterized by balanced or high PSD and few Bluegill <150 mm (Schramm and Willis 2012). With the predator PSD improving, the relationship is shifting closer to Cell 5, which is a balanced population.

It is interesting to point out the cyclic nature of both the Largemouth Bass and Bluegill populations (based on PSD values; Figure 45) that has occurred since at least 1997. These cyclic fluctuations in fish populations are generally due to a variety of factors including survival/mortality rates, variable recruitment, density dependence, predator-prey dynamics, and environmental factors such as weather (Nisbet and Gurney 1982; Sanderson et al. 1999). In Winchester Lake, these cycles are likely a combination of predator-prey dynamics, variable recruitment, and harvest. Recruitment and predator-prey dynamics are likely the biggest issues. Predator-prey PSD values exhibit classic “boom or bust” characteristics, with increases in predator PSD coupled with declines in prey PSD, and vice versa. Harvest of larger fish also continues to be an issue, especially with the slow growth of fish in regional lakes. Unless changes are made to our management of this reservoir (i.e. changes in regulations), we will likely continue to see this cycle. Normally, we would recommend implementing restrictive regulations to improve the LMB and Bluegill populations. However, due to the presence of the State Park, and popularity of the reservoir with families and children, Winchester Lake is managed as a “family friendly fishing water.” Thus, restrictive regulations are not recommended.

MANAGEMENT RECOMMENDATIONS

1. Due to repeated patterns of abundance and size of Largemouth Bass and Bluegill over time, monitoring of these fishes does not need to occur more frequently than every three or four years.

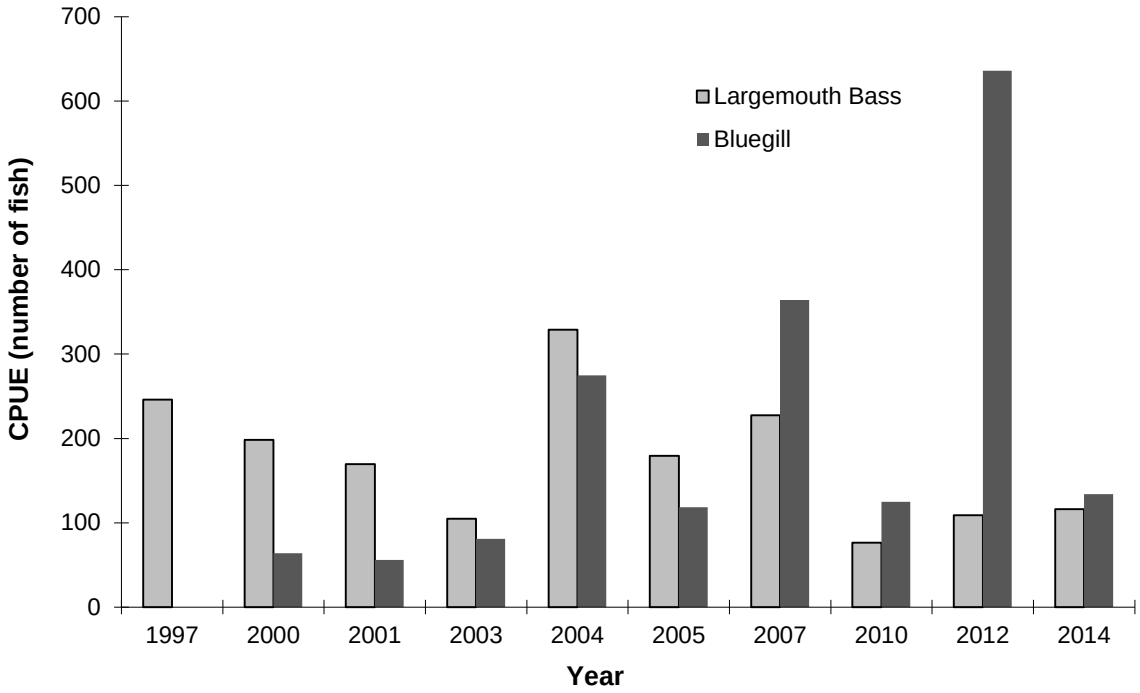

Figure 42. Mean catch per unit effort (CPUE; number of fish/hour) of Largemouth Bass and Bluegill during standard lake surveys of Winchester Lake, Idaho, from 1997 - 2014.

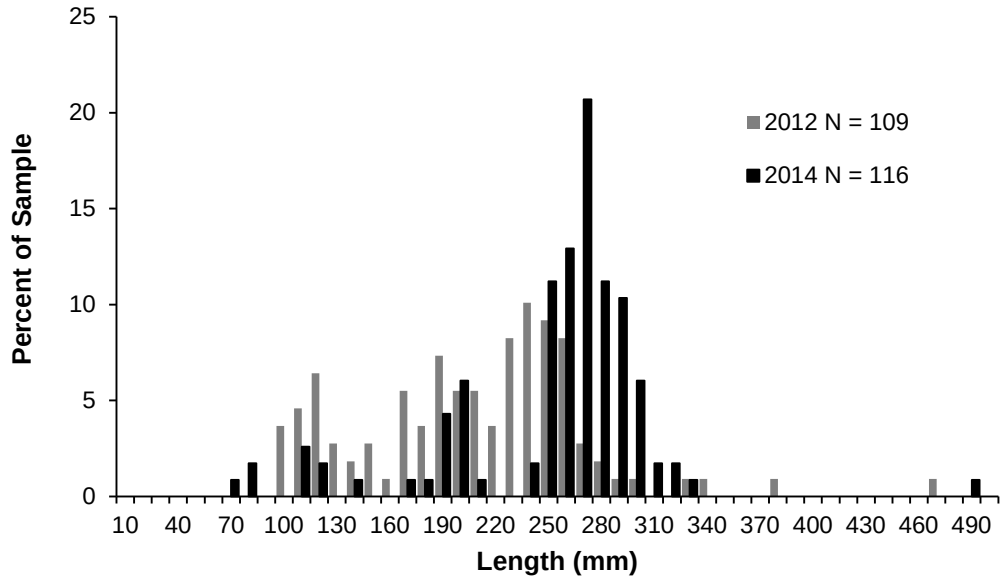

Figure 43. Length frequency distribution of Largemouth Bass collected through electrofishing in Winchester Lake, Idaho, in 2012 and 2014.

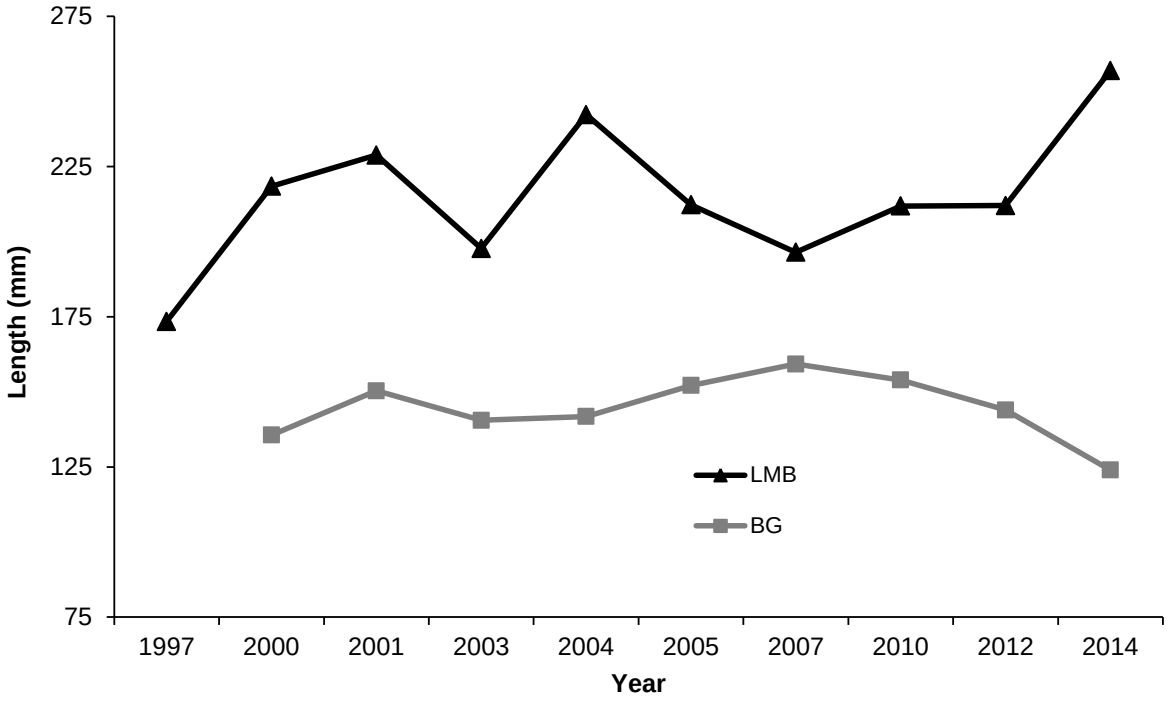

Figure 44. Average length of Largemouth Bass (LMB) and Bluegill (BG) collected by boat electrofishing from Winchester Lake, Idaho, from 1997 - 2014.

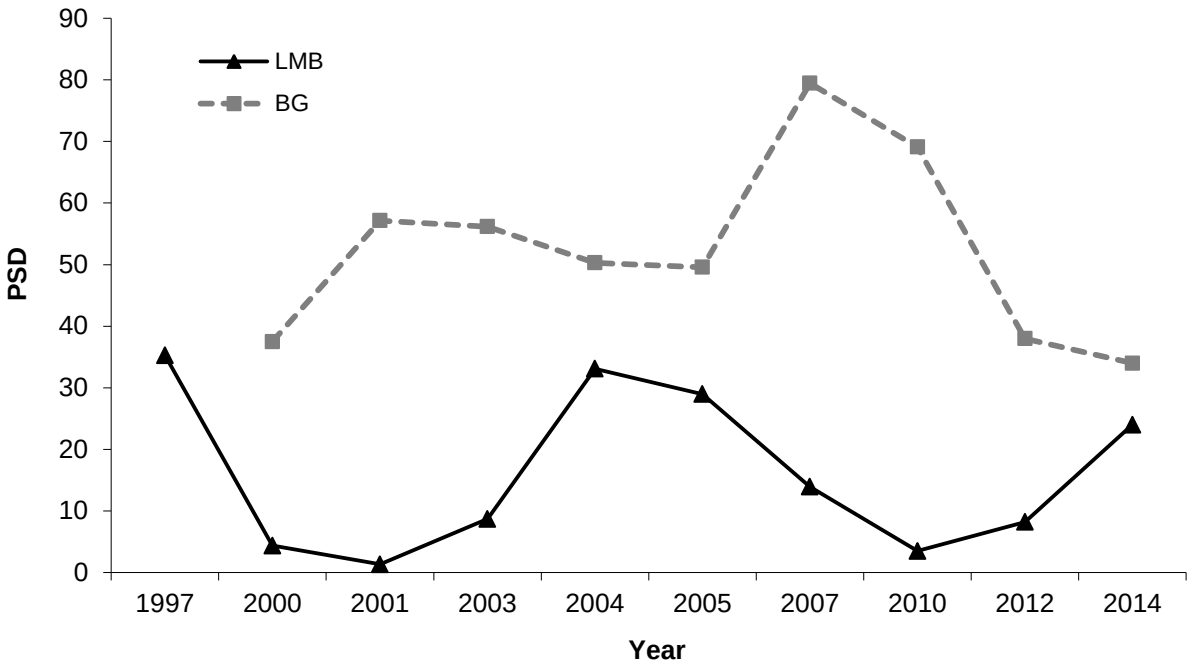

Figure 45. Proportional Size Distribution (PSD) values of Largemouth Bass (LMB) and Bluegill (BG) collected through electrofishing in Winchester Lake, Idaho, from 1997 - 2014.

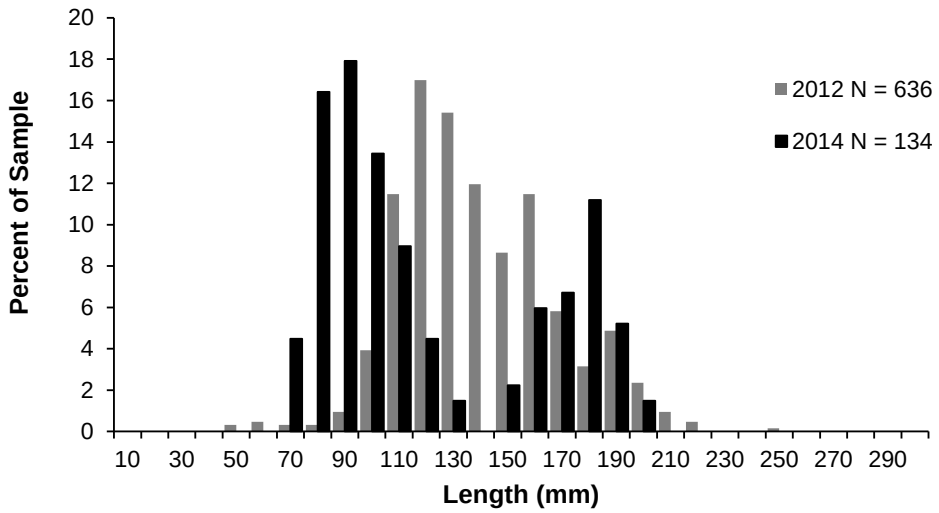

Figure 46. Length frequency distributions of Bluegill collected through electrofishing in Winchester Lake, Idaho, in 2012 and 2014.

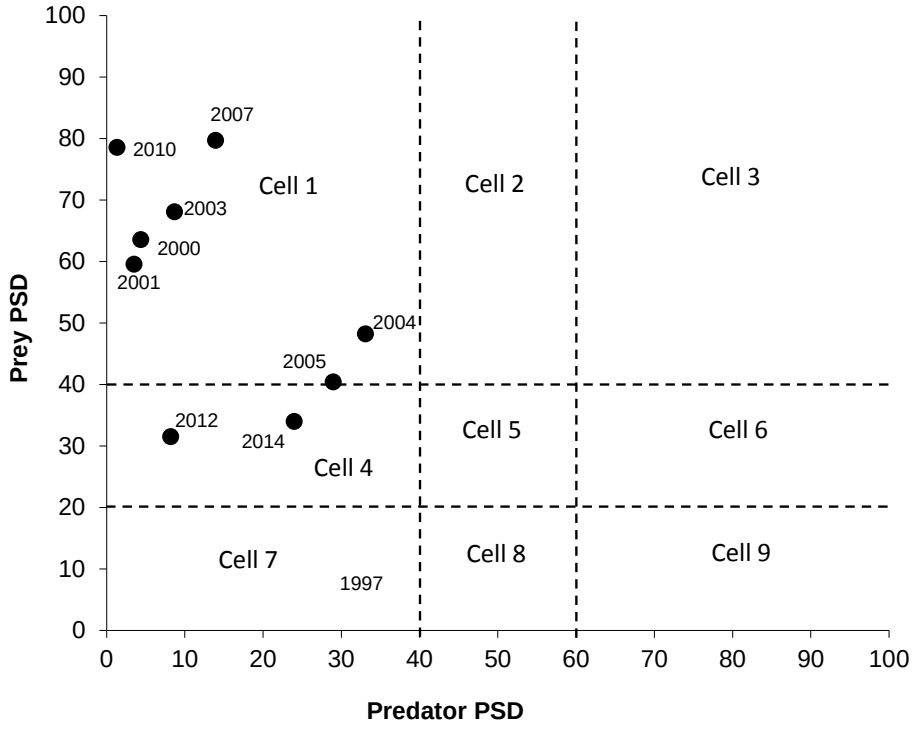

Figure 47. Comparison of predator (Largemouth Bass) and prey (Bluegill) proportional size distribution (PSD) from fish collected through electrofishing in Winchester Lake Idaho, from 2000 - 2014. Dashed lines define the nine predator:prey PSD size structure possibilities based on Schramm and Willis (2012).

SCHMIDT CREEK MONITORING

ABSTRACT

To assess whether the construction of Deyo Reservoir is negatively influencing downstream steelhead habitat, stream flow, temperature, conductivity, and DO was monitored in Schmidt Creek. Average daily water temperature across the sampling season was 12.9°C, while maximum daily water temperatures never exceeded 20°C. Average monthly DO measured on Schmidt Creek was 10.8 mg/l during the sampling season, and ranged from a low of 7.8 mg/l in September to a high of 12.1 mg/l in April. Conductivity during 2014 ranged from 63 - 139 µS/m, and stream flow ranged from a high of 1.6 cfs in April to a low of 0.1 cfs in August. Monitoring since 2011 shows that the construction of Deyo Reservoir in 2011 has little effect on environmental parameters that could influence steelhead survival in Schmidt Creek.

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INTRODUCTION

The Idaho Department of Fish and Game (IDFG), in conjunction with support from local communities, constructed a 22.3 ha reservoir on Schmidt Creek near Weippe, Idaho, in 2012. Named Deyo Reservoir, its purpose was to provide a new recreational fishery and an economic boost to the local economy (DuPont 2011).

Fish surveys in upland reaches of Schmidt Creek in close proximity to the reservoir observed Long-nose Dace, *Rhinichthys cataractae,* as the only native species in that area. Fish species distributed in lower Schmidt Creek include rainbow/steelhead trout *Oncorhynchus mykiss*, sculpin sp., and dace (DuPont 2011). Surveys conducted on Schmidt Creek by IDEQ in 2002, within 60 m of the mouth of the creek, also collected rainbow/steelhead trout. Given the presence of rainbow/steelhead trout in lower Schmidt Creek, it is important to monitor the lower reaches to ensure no detrimental effects occur downstream of the dam. An agreement was made with the U.S. Fish and Wildlife Service to monitor outflow of the Deyo Reservoir project area pre- and post-construction to ensure no deleterious effects were observed in downstream habitats below the reservoir (DuPont 2011). If deleterious effects are observed, IDFG will modify water release strategies as needed.

OBJECTIVES

1. Monitor flow, temperature, DO, and conductivity in Schmidt Creek to ensure construction of Deyo Reservoir is not having negative impacts on steelhead that occur downstream.

STUDY AREA

Deyo Reservoir is located on Schmidt Creek, a tributary to Lolo Creek, Idaho (Figure 48). Schmidt Creek contains designated critical habitat for steelhead from its mouth to 1.1 km upstream. The end of steelhead critical habitat is 2.7 km below the Deyo Reservoir Dam site. Stream flow within Schmidt Creek was considered to historically be intermittent within the reservoir project area and typically perennial in lower reaches depending on annual precipitation within the drainage area.

METHODS

Schmidt Creek was monitored in 2014 for stream temperature, dissolved oxygen, conductivity, and flow at a monitoring location approximately 50 m upstream from its confluence with Lolo Creek. Temperature was recorded hourly in °C using a HOBO™ temperature logger. Dissolved oxygen and conductivity were recorded biweekly using a YSI model 550A meter. Stream flow was recorded biweekly using an OTT MF Pro flow meter. Data was collected from April 24 - November 4, 2014.

RESULTS

Average daily water temperature at the Schmidt Creek monitoring station was 12.9°C in 2014, similar to the average of 12.9°C in 2012 and 11.3°C in 2013. Maximum daily water temperature never reached 20.0°C during 2014, peaking at 19.0°C on July 17th (Figure 49).

Minimum daily water temperatures exceeded 15˚C for 47 days in 2014, compared to 26 days in 2012 and 34 days in 2013 (Figure 50).

Average monthly DO measured on Schmidt Creek was 10.8 mg/l during the 2014 sampling season. Dissolved oxygen levels ranged from a low of 7.8 mg/l in September to a high of 12.1 mg/l in April (Figure 51). Dissolved oxygen levels were above 6.0 mg/l for the entire sample season, and were within the ranges seen in sampling conducted from 2011 - 2013 (Figure 51).

Conductivity in Schmidt Creek during 2014 ranged from 63 - 139 µS/m (Figure 52. The monthly averages were very similar to 2013, and generally followed the same pattern seen in sampling conducted since 2011 (Figure 52).

Stream flow at the Schmidt Creek monitoring station ranged from a high of 1.6 cfs in April to a low of 0.1 cfs in August (Figure 53). Flow did remain visible throughout the 2014 sample season. Flow rates in 2014 were similar to what was seen in 2013. No de-watering of the stream channel has been observed since sampling began in 2010.

DISCUSSION

Due to the construction of Deyo Reservoir during the summer of 2011, there was concern that potential changes in flow, DO, and temperature could have deleterious effects on environmental parameters measured downstream in Schmidt Creek. Flow is the most important variable for us to monitor below the reservoir. As shown in Figure 54, summer flows have not changed since monitoring began in 2011. In fact, due to natural seepage through the dam, the flow below the reservoir has changed from intermittent to perennial. Deyo Reservoir may therefore be helping to solve the major limiting factor for steelhead in Schmidt Creek (summer low flows).

Dissolved oxygen concentrations in Schmidt Creek have remained above 6 mg/L throughout the monitoring season each year since monitoring began in 2011 (Figure 51). Additionally, average and maximum water temperatures have not appeared to change from preconstruction conditions in 2010. Studies have shown Rainbow Trout/Steelhead avoid temperatures in the mid 20°C (Nielsen et al. 1994 and Matthews and Berg 1997) but temperatures at or near 20°C are not detrimental, especially for short periods of time. Maximum daily water temperatures in Schmidt Creek continue to be highly variable but still remain well below lethal limits for Rainbow Trout/Steelhead during most of the year. In 2011 and 2014, water temperatures never rose above 20°C (Figure 50). Maximum daily water temperatures peaked at 20.9°C and exceed 20°C for only seven days in 2012, and peaked at 21.2°C and exceed 20°C for only four days in 2013.

Thus, no negative response to the construction activities has been detected in Schmidt Creek. In 2015, we will continue to monitor the site with bimonthly field visits that will include DO, conductivity, and stream flow measurements. In addition, we will deploy a HOBO™ temperature logger to provide continuous temperature monitoring data.

MANAGEMENT RECOMMENDATIONS

1. Continue to monitor Schmidt Creek through 2016.

Figure 48. Map showing location of Deyo Reservoir, Idaho, and the Schmidt Creek monitoring station.

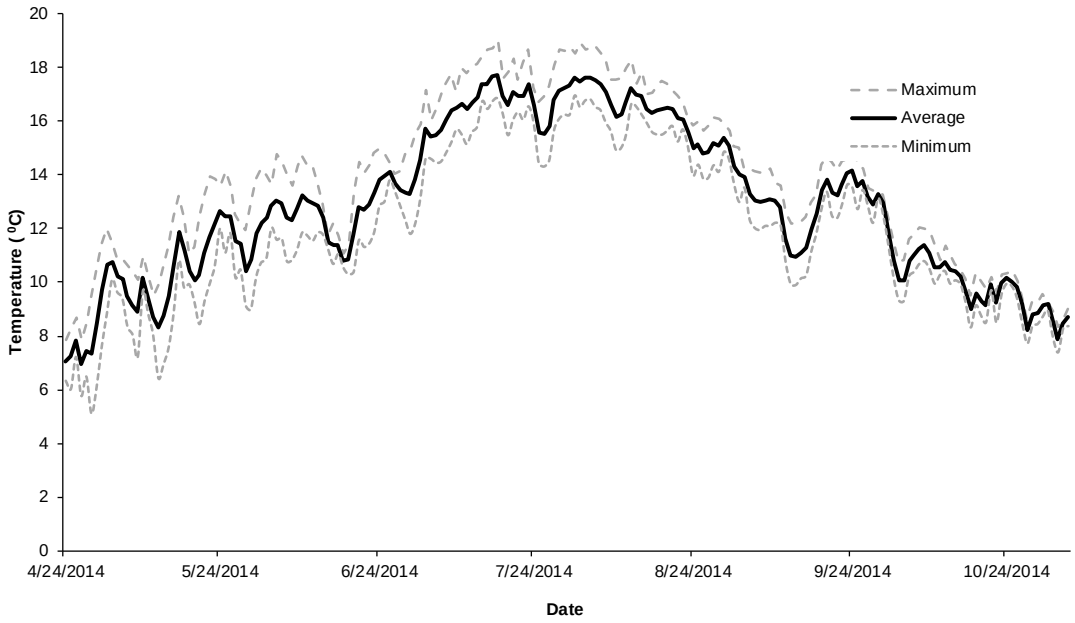

Figure 49. Mean, maximum, and minimum daily water temperatures measured at the Schmidt Creek, Idaho, monitoring station (N 46.355800°, W -116.052637°) during 2014.

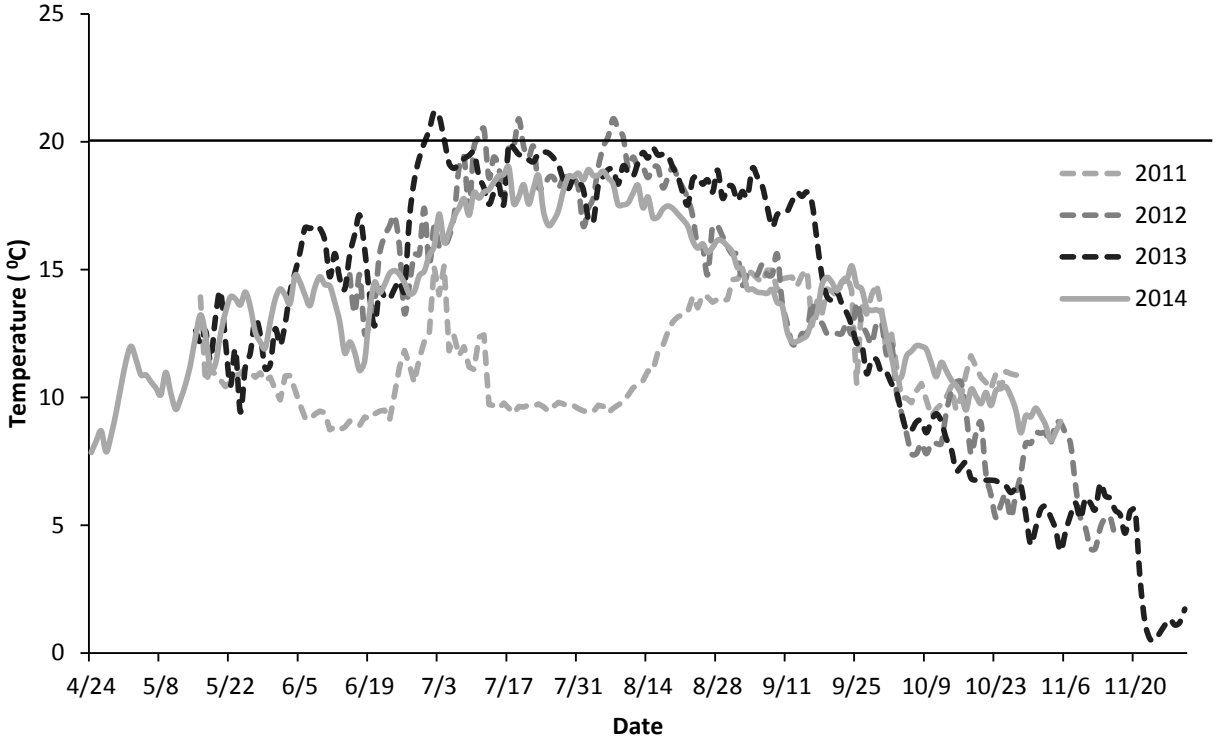

Figure 50. Daily maximum water temperatures measured at the Schmidt Creek, Idaho, monitoring station (N 46.355800°, W -116.052637°) from 2010 - 2014 (20°C thermal limit indicated by horizontal line).

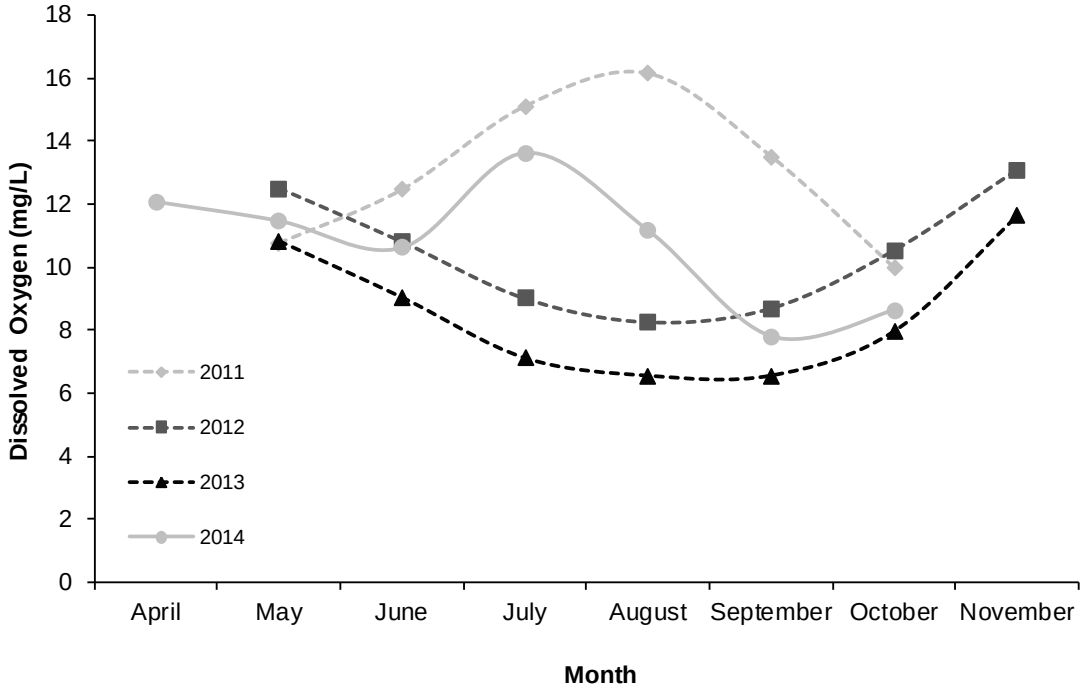

Figure 51. Average monthly dissolved oxygen levels at the Schmidt Creek, Idaho, monitoring Station (N 46.355800°, W -116.052637°) from 2011 - 2014.

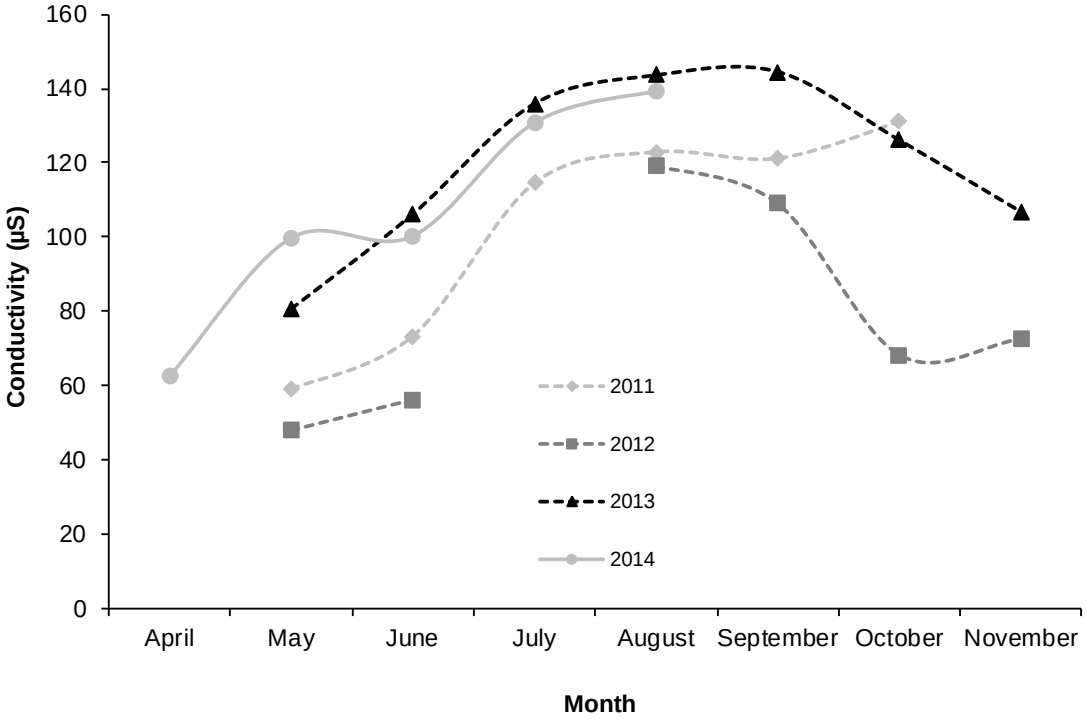

Figure 52. Average monthly conductivity readings at the Schmidt Creek, Idaho, monitoring station (N 46.355800°, W -116.052637°) from 2011 - 2014.

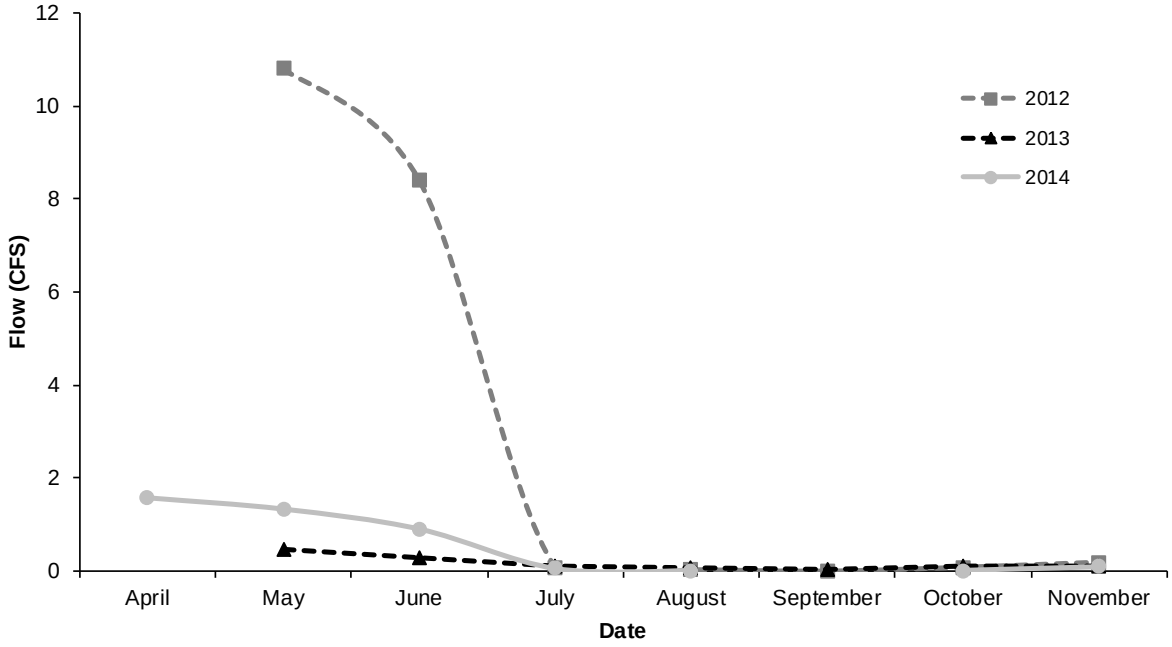

Figure 53. Average monthly flow (cfs; cubic feet per second) at the Schmidt Creek, Idaho, monitoring station (N 46.355800°, W -116.052637°) from 2012 - 2014.

BULL TROUT REDD SURVEYS

ABSTRACT

Redd count surveys were conducted on eight stream reaches within the North Fork Clearwater River subbasin in order to assess long-term population trends for mature Bull Trout *Salvelinus confluentus*. A total of 65 redds were observed, all within seven index reaches used for long-term trend monitoring. The number of redds observed in these reaches ranged from 40 in 2001 to 87 in 2005, with a mean of 64.4. He. Kendall's tau ($\tau = 0.27$) was not significant ($p = 0.24$). When analyzed independently, slopes were positive for five out of seven index reaches and only one index reach (Lake Creek) exhibited a significant negative slope ($\tau = -0.55$, $p = 0.008$). Trends in redd count data are consistent with a stable, but fluctuating population and counts continued to increase following a decline in 2011.

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INTRODUCTION

In 1998, Bull Trout *Salvelinus confluentus* were listed as threatened under the Endangered Species Act. Bull Trout in the North Fork Clearwater River subbasin are part of the Clearwater River Recovery Unit. However, the construction of Dworshak Dam, approximately two km from its confluence with the mainstem Clearwater River, has genetically isolated the North Fork Clearwater River population from the rest of the recovery unit. The criterion for Bull Trout recovery specified by the U.S. Fish and Wildlife Service (USFWS) includes achieving an adult abundance of 5,000 individuals in the North Fork Clearwater River Core Area and maintaining local populations that are stable or increasing for at least 15 years (USFWS 2002).

Redd count surveys are commonly used to monitor trends in spawning populations of Bull Trout. Since Bull Trout are fall spawners, they construct redds at an ideal time for observation, when stream flows are low and stable. Redd count surveys were continued in the North Fork Clearwater River subbasin to maintain a long-term data set in an effort to monitor trends in the spawning population of Bull Trout.

OBJECTIVES

1. Assess trends in the spawning population of Bull Trout in the North Fork Clearwater Core Area.

STUDY AREA

Bull Trout redd surveys were conducted within the North Fork Clearwater River subbasin above Dworshak Reservoir (Figure 54). The subbasin is located primarily within the Clearwater National Forest and all survey reaches are located within the forest boundaries. While forest lands are managed by the U.S. Forest Service (USFS), fish populations are managed by the Idaho Department of Fish and Game (IDFG).

As in previous years, USFS personnel surveyed reaches of Bostonian Creek, Niagara Gulch, Placer Creek, and Vanderbilt Gulch, all of which are index reaches. Index reaches of Long Creek, Lake Creek, and Goose Creek were surveyed by IDFG personnel. In addition, IDFG personnel surveyed an historical reach of Quartz Creek (Figure 54). No surveys were conducted in tributaries to the Little North Fork Clearwater River in 2014.

METHODS

Each stream was surveyed twice by USFS personnel, with the first round of surveys completed on August 28 and 29, when fish were beginning to construct redds. Redd locations were marked with a GPS and detailed descriptions were recorded to prevent double counting. The final round of surveys was completed on September 18 and 19, after spawning was complete. Personnel from IDFG conducted a single round of surveys on September 24 and 25.

Redds were identified based on the size and depth of the disturbance, size and sorting of the substrate, color of the substrate in relation to the surrounding streambed, and stream morphology. The length and width of redds were measured to the nearest 10 cm and the location was determined using a GPS. We did not try to determine whether redds were constructed by

adfluvial, fluvial, or resident fish based on redd size because there is likely some overlap in the size of redds constructed by each life history variant (Dan Kenney, USFS personal communication). The position of any live fish observed during the survey was determined using a GPS. If possible, total length (TL) was estimated by noting the position of the tip of the snout and caudal fin on the substrate and measuring the distance between these points.

To evaluate trends in the spawning population, we analyzed the number of redds counted in seven index reaches that have been surveyed fairly consistently since 2001. Since trends in red count data are not likely to be linear, and the underlying model may be difficult to determine, R 3.0.1 was used to calculate Kendall's tau, a nonparametric rank correlation technique, to determine the direction and significance of the trend (Rieman and Meyers 1997). For ease of visual interpretation, a trend line was fit to the count data using a simple linear regression. Since data from the same seven reaches were consistently used, we used total counts rather than redds/reach for simplicity. Trends were evaluated separately for each reach and as a total of all reaches. Data from 2010 and 2012 were not included in the combined analysis because IDFG did not survey one or more index reaches that year.

RESULTS

Eight transects were surveyed in 2014, in which 65 redds were observed. All 65 redds occurred in the seven index reaches. The total number of redds occurring in the index reaches has ranged from a low of 40 in 2001, to a high 87 in 2005, with a mean of 64.4 for the 14-year period. The Kendall's tau ($\tau = 0.27$) indicated a positive slope, but was not significant ($p = 0.24$). Likewise, the regression line fit to the data yielded a positive slope (Figure 55), but was not significant ($p = 0.33$).

When analyzed separately, five out of the seven reaches had a positive slope (Figure 56; Table 12). However, the slope was only significant for Bostonian Creek ($\tau = 0.45$, $p = 0.006$) and was nearly significant for Long Creek ($\tau = 0.38$, $p = 0.08$). Niagara Gulch ($\tau = -0.14$, $p = 0.51$) and Lake Creek ($\tau = -0.55$, $p = 0.008$) exhibited negative slope, but only Lake Creek was significant.

Redds ranged from 0.3 to 2.0 m^2 in size, with a mean of 1.0 m^2.

A single live fish was observed in Long Creek just below the first redd. The fish was assumed to be an adfluvial adult and estimated to be 70 cm TL.

DISCUSSION

While redd counts are commonly used to monitor trends in Bull Trout populations, there are several weaknesses in this methodology that should be considered. Al-Chokhachy et al. (2005) found that redd counts were generally comparable within, but not between, basins. They further cautioned that redd counts may not be as accurate for the resident component in systems like the North Fork Clearwater River that have both a large migratory component and a small resident component. Therefore, these surveys may only be effective at monitoring the large migratory component of this population.

Dunham et al. (2001) found that changes in the spatial distribution of spawning activity could potentially affect the accuracy of redd counts performed on limited segments of index streams. If spawning use was to shift to a section of stream outside of the survey reach in a given

year, it would give an erroneous appearance that the number of spawners had decreased. This may be the case with the historical survey reach on Isabella Creek. The upper boundary of this reach was a logjam that was believed to be a barrier to fish passage. When surveyed this year, the barrier was no longer present, possibly due to high spring flows in 2011. Since there is no longer a barrier to fish passage at this location, it is possible that spawners are using habitat that was recently opened up above it and that counts on this reach are no longer indicative of the spawning population in this stream.

Dunham et al. (2001) further found a considerable amount of variability between observers. Likewise, Muhlfeld et al. (2006) found inaccuracies amongst observers, but found that observer error was less with experienced surveyors. This could be problematic for maintaining a high level of accuracy in surveys conducted by IDFG due to the reliance on a temporary workforce. Increasing the level of training for all surveyors, in particular novice surveyors, is critical to ensuring the usefulness of the data collected.

Bull Trout redd count data for the North Fork Clearwater River subbasin suggests that the population has been stable since 2001. While both simple linear regression and Kendall's tau indicate an increasing trend, neither of these were significant. Therefore, while we cannot be certain that the population has increased since 2001, there is also no evidence that it has decreased.

Redd numbers have increased since 2001, with 2005 through 2010 comprising a period of high counts, followed by declines in 2011. This downturn may be the result of natural fluctuations in an otherwise stable spawning population. Redd count data from other Bull Trout populations in Northern Idaho and Montana have historically exhibited a considerable degree of interannual variation (Rieman and McIntyre 1996, Rieman and Meyers 1997), which suggests that fluctuations in spawning populations may be common. Counts for 2014 exhibited a continued decrease from 2011, the year for which the decrease was first observed. Future monitoring should reveal if it is a low in the natural cycle or the beginning of a downturn in the population.

RECOMMENDATIONS

1. Continue to assist the USFS with Bull Trout redd surveys in order to maintain the long-term dataset for the purpose of monitoring trends in spawner abundance.

2. Survey several additional reaches each year, preferably reaches for which there is some historical data, including one or more in the lower portion of the drainage.

3. IDFG survey crews should participate in redd count training.

Table 11. Historical data from Bull Trout redd surveys, including the number of redds counted for each stream reach, the number of surveys performed each year, and the number of redds counted in all seven index reaches for years that all seven reaches were surveyed. Index reaches are indicated by grey shading.

Stream Surveyed	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
North Fork Clearwater River	--	--	--	--	--	--	--	--	0	--	--	--	--	--	--	--	--	--	--	--	--
Black Canyon	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--
Bostonian Creek	0	0	0	0	0	4	1	1	1	18	12	15	14	26	13	15	15	11	4	9	8
Boundary Creek	--	--	--	--	--	--	--	--	--	2	3	10	--	--	--	0	--	12	--	--	--
Collins Creek	--	--	--	--	--	--	--	0	--	--	--	--	--	--	--	--	--	--	--	--	--
Goose Creek	--	--	--	--	--	--		1	0	2	1	12	8	1	0	2	0	3	--	4	8
Hidden Creek	--	--	--	--	--	--	--	--	1	0	--	--	--	--	--	--	--	--	--	--	--
Isabella Creek	--	--	--	--	--	--	--	--	1	1	0	0	--	1	1	--	--	--	--	0	--
Kelley Creek - NFK	--	--	--	--	--	--	--	14	--	--	--	--	--	--	--	6	--	--	--	--	--
Lake Creek	--	--	--	--	--	--	19	7	20	14	5	2	5	3	0	2	0	4	--	1	4
Little Moose Creek	--	--	--	--	--	--	--	0	--	--	--	--	--	--	--	--	--	--	--	--	--
Long Creek	--	--	--	--	--	--	0	0	5	0	8	10	1	6	10	11	--	4	--	3	8
Moose Creek	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	--	0	--	--	--	--
Niagra Gulch	--	--	--	--	--	--	2	5	6	10	3	4	2	2	2	4	6	2	1	5	4
Orogrande Creek	--	--	--	--	--	--	--	--	--	--	--	0	--	--	--	--	--	--	--	--	--
Osier Creek	--	--	--	--	--	--	3	0	2	0	--	--	--	--	--	--	--	--	--	--	--
Placer Creek	3	1	2	2	2	7	4	2	4	6	2	3	5	2	3	1	3	1	3	7	2
Pollock Creek	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--
Quartz Creek	--	--	--	--	--	--	--	4	0	0	0	0	--	--	8	--	--	--	--	0	0
Ruby Creek	--	--	--	--	--	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Skull Creek	--	--	--	--	--	--	--	--	0	6	5	3	--	4	9	--	--	--	--	--	--
Slate Creek	--	--	--	--	--	--	--	--	--	--	--	3	--	--	--	0	--	0	--	--	--
Swamp Creek	--	--	--	--	--	--	2	0	1	0	0	2	--	1	--	--	--	--	--	--	--
Upper NF	--	--	--	--	--	--	--	--	--	7	3	6	--	--	--	0	--	14	--	--	--
Vanderbilt Gulch	--	--	--	--	--	--		24	18	13	12	41	35	39	43	49	57	31	33	32	31
Weitas Creek	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Windy Creek	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 11 (continued).

Stream Surveyed	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Breakfast Creek																					
Floodwood Creek	--	--	--	--	--	--	--	--	4	0	0	--	--	--	--	--	--	--	--	--	--
Gover Creek	--	--	--	--	--	--	--	--	--	1	0	--	--	--	--	--	--	--	--	--	--
Stony Creek	--	--	--	--	--	--	--	--	4	0	0	--	--	--	--	--	--	--	--	--	--
Little North Fork Clearwater																					
Buck Creek	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--
Canyon Creek	--	--	--	--	--	--	--	--	--	0	--	--	--	--	--	--	--	--	--	--	--
Butte Creek	--	--	--	--	--	--	--	5	0	--	--	--	--	--	--	--	--	--	--	--	--
Rutledge Creek	--	--	--	--	--	--	--	--	--	1	1	6	0	--	--	--	--	--	--	--	--
Rocky Run Creek	--	--	--	--	--	--	--	--	5	1	3	21	13	8	--	8	10	1	14	--	--
Lund Creek	0	7	2	2	1	1	13	5	7	8	5	19	7	30	22	11	6	1	8	--	--
Little Lost Lake Creek	0	1	1	1	7	3	1	--	6	7	16	1	38	36	14	5	19	1	2	--	--
Lost Lake Creek	0	0	0	0	--	1	--	--	0	--	1	--	10	13	8	9	7	6	5	--	--
1268 Bridge to Lund Cr.	--	--	--	--	--	--	--	17	6	13	8	16	18	20	13	3	6	19	14	--	--
Lund Cr. to Lost Lake Cr.	--	--	3	1	9	8	3	12	7	7	5	8	16	21	9	11	9	11	16	--	--
Lost Lake Cr. to headwaters	0	2	0	0	--	5	1	--	5	6	5	11	13	8	20	14	7	6	31	--	--
Number of Surveys	6	6	7	7	5	9	14	18	26	29	25	23	16	18	17	18	14	17	11	9	8
Total Redds for all streams	3	11	8	6	19	31	50	97	104	129	98	193	185	221	175	151	145	127	131	61	#
Total Redds for 7 index tribs								40	54	63	43	87	70	79	71	84		56		61	#

Table 12. Results of Mann-Kendall trend tests used to analyze redd count data for seven index reaches in the North Fork Clearwater subbasin, both separately and combined. The Kendall's tau (τ) and p value (p) are given for each.

Stream	τ	p
USFS		
Bostonian Creek	0.452	0.006
Niagra Gulch	-0.144	0.508
Placer Creek	0.042	0.827
Vanderbilt Gulch	0.221	0.298
IDFG		
Goose Creek	0.224	0.291
Lake Creek	-0.551	0.008
Long Creek	0.384	0.084
Combined	0.273	0.244

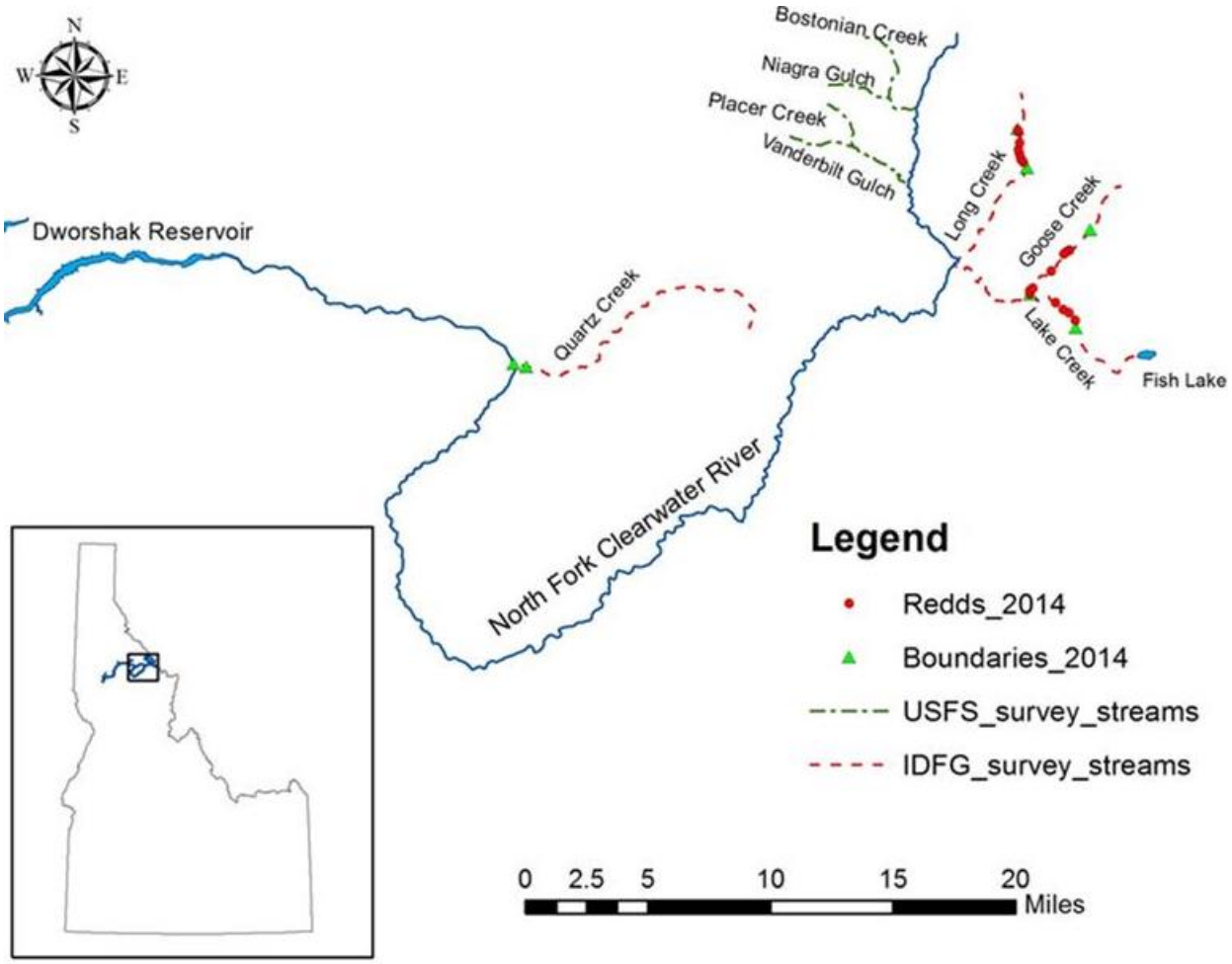

Figure 54. Locations of reaches surveyed for Bull Trout redds in 2013. Streams surveyed by IDFG personnel are indicated in red. Boundaries of the survey reaches are indicated by red diamonds and redds identified during the surveys are indicated by green diamonds. Streams surveyed by USFS personnel are indicated in green, but locations of reach boundaries and redds are not shown.

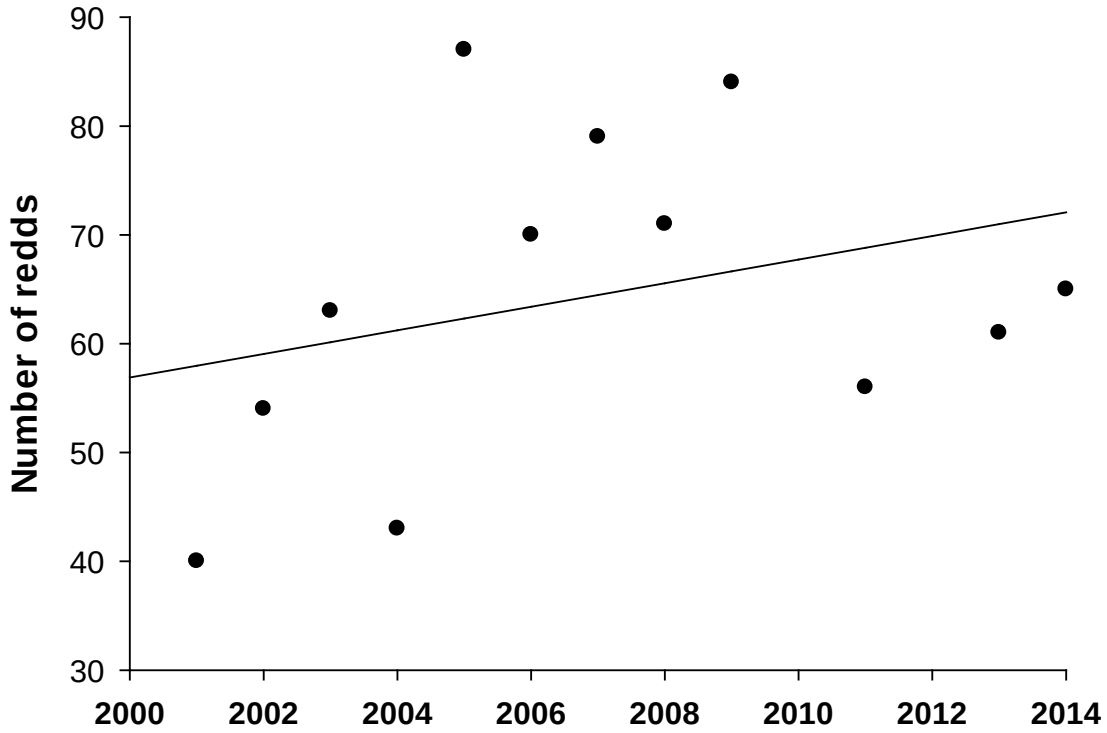

Figure 55. Combined number of Bull Trout redds counted annually in seven index reaches in the North Fork Clearwater River subbasin. The trend line was fitted using simple linear regression to assist with visualizing the long-term trend but was not significant (p = 0.33).

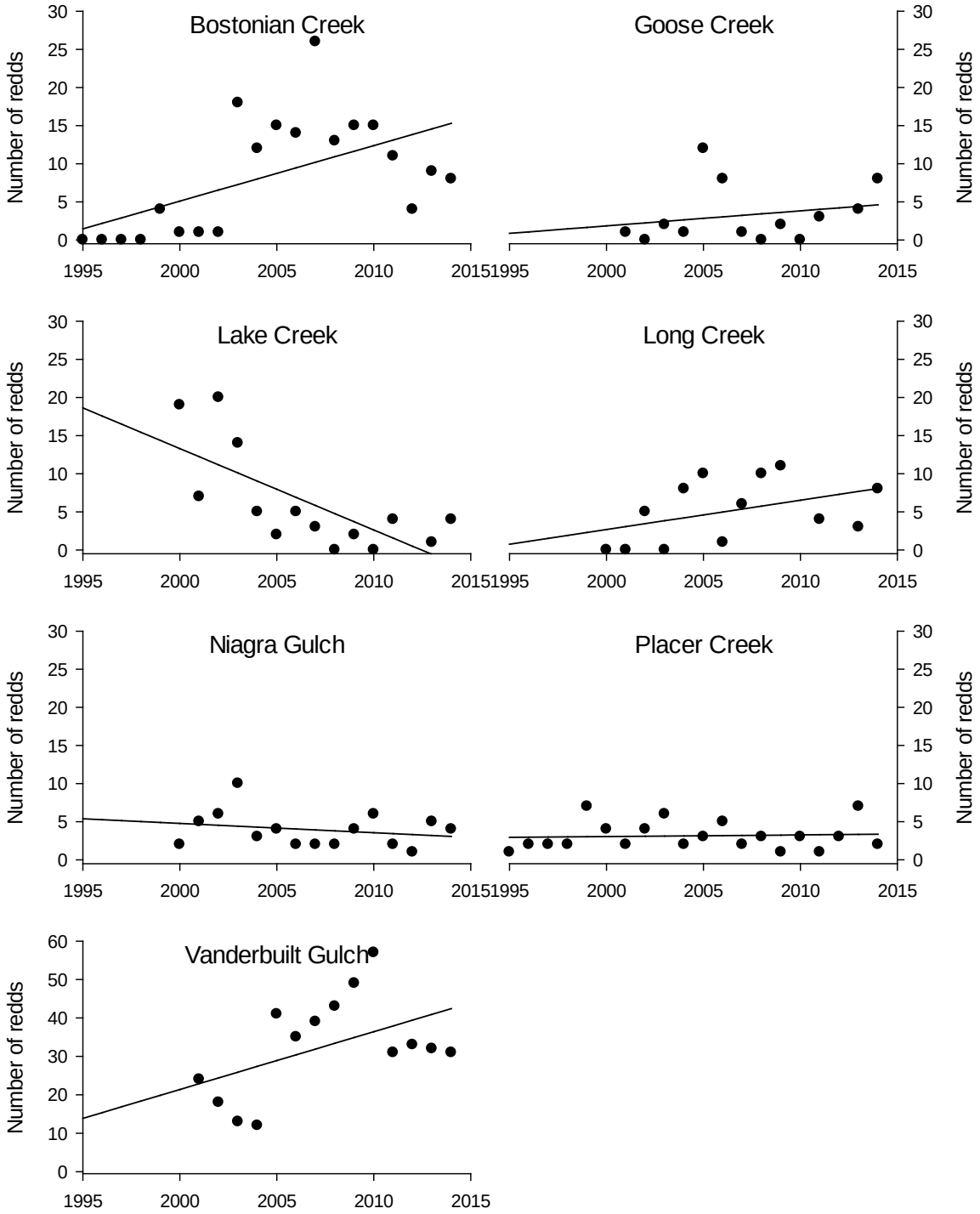

Figure 56. Combined number of Bull Trout redds counted annually in seven index reaches in the North Fork Clearwater River subbasin. The trend lines were fitted using simple linear regression.

HIGH MOUNTAIN LAKES MONITORING:
AMPHIBIAN RISK ASSESSMENT IN NORTH CENTRAL IDAHO

ABSTRACT

A 20-year study was designed in 2006 to evaluate long-term trends in amphibian populations within high mountain lakes in the Idaho Department of Fish and Game Clearwater Region and to determine the extent fish stocking was a threat to their persistence. Mountain lake surveys prior to 2006 provide baseline information on amphibian and fish abundance and distribution, and were utilized to develop an amphibian risk assessment based on the amount of fishless lakes and ponds within fifth field hydrologic unit code (HUC5) watersheds throughout the Clearwater Region.

The year 2014 was the ninth year of the long-term monitoring project. Surveys were completed on 33 lakes, including multiple amphibian surveys on a subset of 11 lakes. All 74 lakes included in this study have now been surveyed at least once. In the first round of sampling, 63 of 74 lakes (85.1%) had Columbia Spotted Frogs (CSF) present. Of these, 23 lakes had fish present and 40 did not have fish present. Additionally, 26 of 74 lakes (35.1%) had Long-toed Salamanders (LTS) present. Of these, 3 lakes had fish present and 23 did not have fish present.

Data analysis in 2014 repeated the distribution and trend models from 2013, and calculated detection probabilities on a subset of lakes that were surveyed multiple times. Detection probability for CSF in this subset appears to approach 1, and for LTS is 0.55. Habitat relationships for both LTS and CSF were generally consistent with the 2013 analysis. For CSF, the depth and proportion of fine substrates in a lake were positively correlated with both occurrence and count. Snowpack significantly correlated with CSF count, though the relationship is probably not causative. Long-Toed Salamander occurrence and count were highly affected by fish presence. This is likely attributable to the longer larval stage of LTS (relative to CSF) which increases the susceptibility to predation during this aquatic life stage. Several habitat variables also seemed to drive LTS counts, but this may model detection as much as abundance. Preliminary results show no significant trends in amphibian occurrence in the study area. We did detect a significant positive trend in counts, but these results may indicate some sampling bias and not a true population increase. Once additional rounds of surveys are completed, we can be more confident of any trends in the data.

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INTRODUCTION

Amphibian population reduction and species extinction has given urgency to amphibian conservation, inventory efforts to determine baseline data, and monitoring to determine trends in amphibian populations (Houlahan et al. 2000; Stuart et al. 2004; Beebee and Griffiths 2005; Orizaola and Brãna 2006). Potential factors in amphibian population decline are numerous and include: habitat modification/fragmentation, introduction of predators/competitors, increased UV-B radiation, changes in precipitation/snowpack, and pathogen infection (Alford and Richards 1999; Corn 2000; Pilliod and Peterson 2000; Marsh and Trenham 2001). Throughout the North Central Mountains of Idaho, direct (predation) and indirect (resource competition, habitat exclusion, and population fragmentation) impacts on amphibian populations from introductions of trout into historically fishless lakes are a cause for concern (Petranka 1983; Semlitsch 1988; Figiel and Semlitsch 1990; Bradford et al. 1993; Brönmark and Edenhamn 1994; Gulve 1994; Brãna et al. 1996; Tyler et al. 1998). Trout have been stocked into high mountain lakes to provide recreational opportunities to backcountry visitors. As much as 95% of previously and/or currently stocked high mountain lakes throughout the western United States that were once fishless, now contain fish through regular stocking efforts or self-sustaining populations from legacy stocking efforts (Bahls 1992). Murphy (2002) estimated that 96% of lakes within the Clearwater National Forest were historically fishless as the headwater area topography where lakes are located is relatively steep. According to historical stocking records, some lakes in North Central Idaho were stocked as early as the 1930s (Murphy 2002). Out of the estimated 3,000 mountain lakes in Idaho, approximately 1,355 lakes (45%) are stocked or have natural reproducing fish populations (IDFG 2012)

Mountain lake ecosystems in North Central Idaho contain amphibians such as Long-Toed Salamanders (LTS) *Ambystoma macrodactylum* and Columbia Spotted Frogs (CSF) *Rana luteiventris*, although Idaho Giant Salamanders *Dicamptodon aterrimus*, Western Toads *Bufo boreas*, and Rocky Mountain Tailed Frogs *Ascaphus montanus* may also be present. Common reptiles found at these mountain lakes may also include Common Garter Snakes *Thamnophis sirtalis* and Western Terrestrial Garter Snakes *T. elegans*, both of which were historically (before fish introductions) the main amphibian predators (Murphy 2002). The Idaho Department of Fish and Game (IDFG) Clearwater Region contains 711 mountain lakes. Approximately 400 mountain lakes were previously inventoried in the Clearwater Region through cooperation between the IDFG and United States Forest Service (USFS).

Murphy (2002) found that CSF occurrence (and breeding occurrence) in this area was not significantly different in lakes with or without fish after accounting for habitat effects (CSF were positively associated with increasing amounts of sedge meadow perimeter and silt/organic substrate). However, CSF abundance at all life stages was significantly lower in lakes with fish than without fish (Murphy 2002). Long-Toed Salamander larvae and/or breeding adult occurrence and abundance (adults are typically terrestrial except to breed) was significantly less common in lakes with fish then lakes without fish (Murphy 2002). However, where native (not stocked) Westslope Cutthroat Trout (WCT) *Oncorhynchus clarkii lewisi* existed in lakes, the impact on LTS was not as severe as compared to lakes that were historically fishless and later stocked with introduced western trout (Murphy 2002). Other studies have examined relationships between introduced trout and salamanders. Direct negative impacts by fish on amphibian populations have been mostly attributed to trout preying upon amphibians when they are at a larval stage, although trout may also cause salamanders to avoid lakes previously used as breeding sites (indirect impact) (Kats et al. 1993; Figiel and Semlitsch 1990; Bradford et al. 1993; Knapp 1996; Pilliod 1996; Graham and Powell 1999; Murphy 2002).

Introduced fish populations may also indirectly impact amphibian gene flow, recolonization, and subsequent persistence. The degree of gene flow in mountain lake amphibians likely relies on connectivity between higher and lower elevations subpopulations (with low gene flow). Gene flow may also occur between neighboring lakes that are not necessarily within the same wet stream migration corridor when overland dispersal is not drastically limited by headwater topography, precipitation, and or canopy cover (Murphy 2002). Tallmon et al. (2000) suggests that LTS within north-central Idaho are panmictic (randomly interbreeding populations) with high levels of within population variation providing evidence that populations are not evolving in complete isolation. Amphibian populations or demes in these headwater areas likely never evolved with native fish and may lack the appropriate defensive, behavioral, or chemical responses to coexist with introduced fish populations (Kats et al. 1988).

Westslope Cutthroat Trout, Rainbow Trout (RBT) *O. mykiss*, RBT x WCT hybrids, and Brook Trout (BKT) *Salvelinus fontinalis* are the most common introduced fish species in high mountain lakes in the Clearwater Region. Although, many lakes within the study area have a stocking history that may include Yellowstone Cutthroat Trout *O. bouvieri*, California Golden Trout *O. mykiss aguabonita* (last stocked in 1990 in the Clearwater Region - Steep Lakes), Arctic Grayling *Thymallus arcticus* (last stocked in 1982 in the Clearwater Region - Bald Mountain Lake), and various forms of trout hybrids. The term “introduced western trout” may be more appropriate for *Oncorhynchus* species in these lakes where natural reproduction is occurring, as the degree of hybridization is unknown in lakes where multiple species have been stocked (Behnke 1992). The Clearwater Region currently stocks 87 of its 711 high mountain lakes. Most lakes are stocked with fingerling WCT on a three-year rotation by fixed wing aircraft.

Murphy (2002) found that certain species of introduced trout tend to have a greater impact on amphibian occupancy than others. Brook Trout tend to impact CSF and especially LTS occurrence and breeding to a greater extent than the presence of either *Oncorhynchus* species. This impact is derived from differences in fish spawning times/behavior and variations in amphibian habitat usage just after ice off conditions in mountain lakes (Murphy 2002). Westslope Cutthroat Trout and RBT in these lakes spawn in spring/summer which often coincides with times that amphibian breeding occurs. As a result, both fish species are typically preoccupied with spawning in inlets or outlets while amphibians are typically breeding within the lake itself. This difference in spawning habitat use may allow amphibians to breed with fewer disturbances by WCT and RBT (Murphy 2002). In contrast, BKT spawn in the fall and are actively moving and foraging throughout the lake in spring and are more likely to prey upon any amphibian life stage and/or harass breeding adults (Murphy 2002). Furthermore, BKT tend to be more benthic oriented (where salamanders usually occur), seek out larger prey items, and attain higher densities within mountain lakes than *Oncorhynchus* species (Griffith 1974). Columbia Spotted Frogs do not tend to be impacted by BKT presence to the same magnitude as LTS because of their different habitat associations and shorter larval stage.

Long-Toed Salamanders occupy a wide range over the western United States and Canada. The majority of LTS in Idaho subalpine lakes have a two-year larval stage, making them susceptible to predation by fish for a longer period of time. Studies suggest that they are more susceptible to impacts by introduced fish than the CSF (Murphy 2002). Conclusive evidence of LTS decline is insufficient (Graham and Powell 1999). For this reason, a long-term monitoring project (20 years) was initiated in the Clearwater Region to provide knowledge of the amphibian population dynamics within the north-central mountains of Idaho. Long-term monitoring of mountain lakes will allow for amphibian population trends to be identified and will give managers the ability to determine whether sufficient fishless habitat exists to support amphibian populations into the future.

Prior to the 2006 mountain lakes field season, a long-term monitoring study design and protocol was developed for mountain lakes. The study design and protocol addressed the amphibian risk assessment that has been developed through previous studies and inventories of mountain lakes conducted within north-central Idaho (Schriever 2006).

The amphibian risk assessment is based on the amount of fishless habitat that exists within a watershed at the HUC5 level. At the individual HUC5 watershed level, it is assumed monitoring will be able to examine conditions that may dictate local response in the interactions of stocked fish and native amphibian populations to provide a more defined opportunity for prioritized management action (Murphy 2002). While there are many risk factors associated with amphibian declines, our assessment focused on considering impacts that may be associated with native and stocked fish in lakes on a HUC5 watershed basis. The amphibian risk assessment for these high mountain lake ecosystems has four categories: control or no risk, low, moderate, and elevated (Figure 1).

- *Control or no risk* – watershed has never experienced fish introductions through stocking activities.
- *Low* – At least 50% of the lakes within a watershed are fishless AND a minimum 20% of the lake surface area within the watershed is fishless.
- *Moderate* – 50% of lakes within a watershed are fishless OR 20% of surface area is fishless.
- *Elevated* – Meets neither requirement, less than 50% of the lakes within a watershed are fishless AND less than 20% of the surface area within the watershed is considered fishless.

Two watersheds (HUC5) were selected randomly from each of the amphibian risk categories (region-wide from all HUC5 watersheds that contained lakes) for sampling (Appendix A). This resulted in five HUC5 watersheds containing 33 lakes within the Nez Perce National Forest and three HUC5 watersheds containing 39 lakes within the Clearwater National Forest, for a total of 72 lakes (Appendix B). In 2013, a third randomly selected control watershed was added (in Nez Perce Forest) to increase the sample size of fishless control lakes, bringing the study's total to nine watersheds that contain 74 lakes (Appendix B). Attempts will be made to sample all lakes within a selected HUC5 watershed within the same field season. The 20-year period for the high mountain lakes long-term monitoring project will allow for each of these lakes be sampled six different times. The repetition of sampling events will allow for comparisons to be made within (for trends) and between watersheds (for comparisons among amphibian risk classes). In addition, repetition of sampling events will address the normal patterns of recruitment fluctuations often common among amphibian populations. Sampling frequency and rotation order are adjusted to accommodate weather and fire conditions.

OBJECTIVES

1. Evaluate the long-term impacts of fish on amphibian populations within the high mountain lake ecosystems in the IDFG Clearwater Region.

2. Assess whether current fish management in high mountain lakes of North Central Idaho is sufficient to provide long-term persistence of amphibian populations.

STUDY AREA

The 74 lakes selected for this study are located in the Bitterroot National Forest, Clearwater National Forest, and Nez Perce National Forest, located in north-central Idaho (Figure 57). These three national forests encompass the entirety or portions of four wilderness areas (Frank Church, Gospel Hump, Hells Canyon, and Selway Bitterroot) and one Pioneer Area (Mallard Larkins). Within the Bitterroot, Clearwater, and Nez Perce National Forests are eight, fourth field hydrologic unit code (HUC4) subbasin drainages containing 105 mountain lake management areas at the fifth field hydrologic unit code (HUC5) level. The HUC4 subbasin drainages include: the North Fork of the Clearwater River, the South Fork of the Clearwater River, the Lochsa River, the Upper and Lower Selway River, the Middle Fork and Lower Salmon rivers, and the Hells Canyon reach of the Snake River.

In 2014, IDFG personnel surveyed 33 lakes within four HUC5 watersheds: Bargamin Creek within the Nez Perce National Forest and North Fork Moose Creek, Warm Springs Creek, and Storm Creek within the Clearwater National Forest (Table 1).

Photographs, routes, and bathymetric/surrounding area maps of lakes within the HUC5 watersheds are maintained in the Clearwater Region office within the mountain lakes database. As of 2014, not all of these files are complete, and will require completion in following years of the study. Available files are located in the IDFG Clearwater Region shared drive at the address: S:\Fishery\MTN Lakes\Long Term Monitoring\Photos, Lake Maps, Routes.

METHODS

Field Sampling

Field sampling was conducted following the standard protocol used throughout the duration of this project. This protocol was updated and revised after the 2013 field season to improve the accuracy and comparability of results from year to year (Appendix C).

Laboratory Analysis

Fish scales were photographed under magnification (20-60x) and catalogued. In the future, they may be analyzed to determine age and growth rates, and compared to stocking records to determine if natural recruitment is occurring.

Zooplankton were subsampled (n >200 for each unique combination of site, survey date, and depth) and identified under magnification to the taxon levels listed in the protocol (Appendix D).

Statistical Analysis

The methods for statistical analysis conducted in 2014 are explained in detail in the 2013 annual report (Hand et al. *In press*). To supplement the 2013 description, we included Appendix E with a copy of the code for the best distribution and trend models. (Zeileis et al. 2008; Broström 2013; Bates et al. 2014; R Core Team 2014).

This year we were also able to perform two visual encounter surveys within 24 hours on three lakes (Boston Mountain Lake, Stillman Lake, and West Moose Lake #1), and three surveys

on an additional eight lakes (West Moose Lakes #2-9). We fit a zero-inflated error distribution to this subset of surveys, which match the assumptions of such a distribution better than the whole dataset.

RESULTS

Among Clearwater Region lakes >1,500 m in elevation (*n* = 703), fish-containing lakes are on average larger and deeper than fishless lakes (Hand et al. 2016b). Most lakes that have not been sampled are small and at high elevation. The lakes selected for this monitoring study (*n* = 74) closely mimic regional patterns.

In 2014, mountain lakes field personnel surveyed 33 lakes from four HUC5 watersheds. Eight of the 33 surveyed lakes contained fish; the other 25 lakes were fishless (Table 13). On the initial survey we detected Columbia Spotted Frogs in 29 lakes, Long-toed Salamanders in 17 lakes, and a Rocky Mountain Tailed Frog in one lake (Table 13).

Fish Surveys

Eight of the 33 surveyed lakes contained fish. Seven lakes had Westslope Cutthroat Trout and one (Ranger Lake) had Rainbow Trout present (Figure 58). Gill net CPUE ranged from 0.2 - 3.0 fish/hour, with an average of 0.7 fish/hour (Table 14). Angling CPUE ranged from 1 - 4 fish/hour, with an average of 3 fish/hour (Table 14). The average length of fish collected from both methods was 258 mm for Westslope Cutthroat Trout (*n* = 111) and 286 mm for Rainbow Trout (*n* = 4). Average weights were not calculated, as some equipment failures produced insufficient data. Length frequency distributions for all eight lakes are located in Figure 2.

Columbia Spotted Frog Abundance and Distribution

Columbia Spotted Frogs were detected in 29 of 33 survey lakes (87.8%) sampled in 2014 (Table 13). In the first round of sampling, 63 of 74 lakes (85.1%) had CSF present (Table 15). Of these, 23 lakes had fish present and 40 did not have fish present. Thus far, 54 lakes have been surveyed in two different years. Of these, 48 (88.9%) had CSF present. Seventeen lakes with CSF had fish present and 31 lakes had no fish (Table 16). This year 12 lakes were sampled for the third season. Nine (75%) had CSF present, and of these two had fish and seven had no fish (Table 16).

In 2013, no explanatory variables were significant in the CSF occurrence model. With the inclusion of the 2014 data, only seasonal trends (Julian Day and (Julian day)^2) became significant (P <0.001). When the binary response variable was altered to indicate counts of at least three adults, four explanatory variables became significant: Fines (P = 0.006), Depth (P = 0.034), Julian Day (P <0.001), and (Julian day)^2 (P <0.001). Fish presence did not affect CSF occurrence with either response variable (occurrence P = 0.549 and count > 2, P = 0.609).

We initially attempted to run the CSF count models through the glmer.nb function within the lme4 package, and the model would not converge. The lme4 package struggled with false errors in 2014, so we re-ran the models using the similar glmmML package. To verify the comparability of these methods, we also ran all of the other count and occupancy models through glmmML, and obtained similar results. Backwards selection immediately eliminated fish presence (P = 0.726). As in the occupancy models, the best count model contained strong seasonal trends,

Julian Day (P <0.001), (Julian day)^2 (P <0.001), and Snow (P < 0.001). The only significant habitat variables were Depth (P < 0.001) and Fines (P <0.001).

Long-toed Salamander Abundance and Distribution

Long-toed Salamanders were initially detected in 17 of 33 surveyed lakes (51.5%) sampled in 2014 (Table 13). In the first round of sampling, 26 of 74 lakes (35.1%) had LTS present (Table 15). Of these, 3 lakes had fish present and 23 did not have fish present. Thus far, 54 lakes have been surveyed twice. Of these, 27 (50.0%) had LTS present. Five lakes with LTS had fish present and 22 lakes had no fish (Table 16). This year 12 lakes were sampled for the third season. Five (41.7%) had LTS present, of which only one contained fish (Table 16).

Mirroring the 2013 analysis, the best occurrence model for 2014 included one, highly significant habitat variable: Fish (P <0.001). Julian Day (P <0.001), and (Julian day)^2 (P <0.001) were also significant. Unlike 2013, the best count model included all of the variables except Elevation: Depth, Fish, Julian Day, (Julian day)^2, Snow, and Fines (all with P <0.001). To see if a simpler model would outcompete this highly parameterized result, we ran the model without Depth (the least significant variable) and compared AIC and BIC scores. The original, complex model out-competed the simpler model in both scores.

Zero Inflated Distribution and Detection Probabilities

Eleven lakes were surveyed multiple times within 24 hours in 2014. All of these lakes contained CSF, and they were detected in every survey. These factors made fitting a zero-inflated error distribution to this subset of the data inappropriate, and justifies an assumption that CSF detection probability approaches 1.

We detected LTS in 8 of the 11 lakes and 20 of 30 surveys, and therefore met the criteria outlined in Tyre et al. (2003) for fitting a zero inflated error distribution. With so few data, however, we could not significantly determine which error distribution fit best. We used a zero-inflated Poisson distribution in this case, because that was found as the best distribution for the LTS composite counts in the whole dataset. Using the distribution's coefficient of -1.493, we derived a detection probability of 0.55 for LTS in this subset of lakes.

Long-term Trends in Presence and Abundance

The occurrence of CSF remained fairly constant across time in all lakes in the study. A logistic regression confirmed that there was still no significant long-term trend in CSF presence (P = 0.285). LTS occurrence has been more variable, though logistic regression did not yield a significant trend (P = 0.629).

Contrary to the presence models, "Year" was a highly significant variable in both the CSF (P <0.001) and the LTS (P <0.001) abundance models. They also indicate a positive trend in counts for both species over time.

DISCUSSION

Fish

The data on fish populations this year were sparse. We caught 115 fish, in contrast to 444 in 2010. This was mostly due to this year's priorities falling on HUC5s with relatively few stocked lakes. This paucity of data did not allow for much new analyses, and we prioritized other aspects of the study this year. Length frequency distributions of the lakes that we did survey appear similar to those from previous years (Figure 58). The only lake that appears to have changed over time is Lake Creek Lake South. This change could be the product of stocking efforts in the four years between surveys or that we used two gillnets in this lake in order to provide data for another study. This increased effort would increase the proportion of the population sampled, and a recent stocking event would result in more, smaller fish.

Of note was one lake: Lake Creek Lake West. The gillnet survey in 2010 resulted in a CPUE of 0.5 fish/hour for Westslope Cutthroat Trout. The VES that year also detected 71 adult CSF. In 2014, we caught no fish, nor saw any in a visual survey. We did, however, count 340 adult CSF. This may have been a product of annual variation, as amphibian counts in general were high in 2014. It may also be an amphibian population response to the extirpation of fish from this lake from an event such as winter kill. We recommend returning to this lake sooner than planned, if resources permit, to verify the presence or absence of fish.

Amphibians

Habitat Variables

Habitat relationships for both LTS and CSF were generally consistent with previous studies (Pilliod et al. 1996; Murphy 2002). Columbia Spotted Frog occurrence seemed to be driven by Fines and Depth, though this binary response should be interpreted with caution as lake depth is positively correlated with lake perimeter. The count models account for this by offsetting the lake perimeter, but this was not part of the occurrence models. Whether this relationship is biased or not, fish presence does not seem to have a significant effect on CSF occurrence within the study.

Fish do significantly affect LTS occurrence and count. This is likely attributable to the longer larval stage of LTS (relative to CSF) which increases the susceptibility to predation during this life stage. This relationship was clearest in the occurrence model, hinting that on a landscape scale, reducing the number of stocked lakes may provide more suitable salamander habitat. Especially compared to last year's analysis, the best count model for LTS ended up highly parameterized, including three significant habitat variables (Depth, Fish, and Fines). The inclusion of Depth and Fines may be the product of either or both of two processes. Depth and Fines correlate with Fish presence, and appear to determine LTS counts by colinearity. They may also affect detectability of LTS in their habitat, driving the count rather than true abundance. Using a zero-inflated model would correct for this latter process, but we do not have enough data to converge such models. The results of fitting a zero-inflated error distribution (an estimated detection rate of 0.55) suggest compensating for detectability will be needed to reach accurate esti0mates of abundance.

Temporal Variables

As was seen in 2013, Julian Day and (Julian day)^2 proved to be highly significant variables in every count and occurrence model. This strong seasonality should be taken into account in future analyses, as ignoring it can lead to erroneous interpretations. For example, this year we initially ran the occurrence trend models without these variables:

CSF/LTS occurrence ~ Year + (1/Site)

The output indicated a highly significant negative trend in occurrence for both species, with annual percentage changes of 12% for CSF and 17% for LTS. Such results were possibly driven by lakes that we sampled early or late in the 2014 season, and found no amphibians where they were detected when sampled mid-season in other years. Unlike 2013, Snow was significant in both count models. This probably has to do with a detection bias between years that we address in the long-term trend discussion.

Zero Inflated Models and Detection Rates

This year we performed multiple visual encounter surveys on a subset of lakes with the intention of addressing the question: Within our resource constraints within a given year, should we prioritize sampling more lakes or sampling lakes more often? The key to answering this question is the difference between the variation among surveys conducted within a year and between years at the same site. A lower detection probability will generally produce more variation within a year (or with a closed population), and require more replicate surveys to accurately estimate changes between years.

If CSF were the exclusive species of interest, there would be no reason to conduct multiple surveys a year at a given site. Their counts require no adjustment for detection to assume a close relationship between occurrence/count and presence/abundance.

For LTS, our estimate is very close to the P = 0.5 cutoff recommended in the literature (Tyre et al. 2003). This would also suggest allocating time to getting to more lakes, but the situation is more complex. With only 11 lakes sampled twice this season, and eight sampled three times, we do not have enough data in our detection model to be sure which side of the cutoff the true detection rate falls. This subset of lakes is also not representative of the whole study population, and all but two exist on a single ridgeline in a single basin. Literature recommends at least three closed-population replicates to estimate detection probabilities with a zero-inflated error distribution (Tyre et al. 2003). We recommend allocating resources from gillnetting to sample for amphibians three times during a visit. Fish presence appears relatively constant across the lakes (Table 3), and since we completed the first round of surveys, any lakes with fish have been gillnetted once. More amphibian surveys with a closed population would yield a more precise and representative estimate of detection probability for LTS. This estimate would help prioritize resources and greatly improve distribution and trend models.

Long Term Trends

As predicted by the power analysis conducted in 2013, we detected no significant trends in occupancy of either CSF or LTS with the addition of the 2014 data. The count models do indicate highly significant positive trends, but these results should be interpreted with caution. First and foremost, the 2014 field season contributed 20% of the surveys in the current data set used to run these models. The effect of this over-representation of a single season was amplified

by noticeably high counts in 2014. These high counts may be attributed to one or more of several processes independent of long-term trends. Amphibian populations are known to fluctuate widely from year to year (Gibbs 1993), and an estimate of linear population trends may not be generalizable to future years yet. Detection and classification also probably vary by personnel. With a different field crew almost every season, and three different biological aids this season alone, chances are high that skill and effort would vary. Bias could also stem from using different criteria to differentiate life stages, or from growth rates (therefore population structure) varying between years. The trends for CSF became less significant and had lower coefficients when we used models with a composite score of adults and subadults. The significance of Snow in the CSF count distribution model is probably also a product of the above processes, since the Snow value is the same across a given year. More explicit identification training and a larger dataset will mitigate these biases and give a clearer picture of long-term population trends.

RECOMMENDATIONS

1. Continue monitoring high mountain lakes within HUC5 watersheds in the Clearwater Region as part of the long-term amphibian risk assessment.

2. Begin conducting 2-3 Visual Encounter Surveys during one visit to each lake surveyed in a season to improve LTS detection probabilities.

3. Consider reducing gill-netting efforts and re-allocate that time and energy to conducting more amphibian surveys, as fish presence is relatively consistent, and angling CPUE is even more consistent.

4. Include seasonal variation in any future analysis used to detect trends or habitat associations.

5. Investigate the disappearance of fish from Lake Creek Lake, West

ACKNOWLEDGEMENTS

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Table 13. Clearwater Region high mountain lakes surveyed in 2014 showing fish Catch Per Unit Effort (CPUE), Columbia Spotted Frog (CSF) presence, and Long Toed Salamander (LTS) presence on initial survey.

Lake Name	Risk	HUC5	HUC4	Survey Date	Gill Net CPUE	Angling CPUE	CSF	LTS
MacArthur	Elevated	Bargamin Creek	Middle Salmon	07/09/14	0.5	---	Yes	No
Stillman	Elevated	Bargamin Creek	Middle Salmon	07/09/14	0.2	---	Yes	No
Lake Creek East	Elevated	Bargamin Creek	Middle Salmon	07/10/14	1.0	---	Yes	No
Lake Creek South	Elevated	Bargamin Creek	Middle Salmon	07/10/14	0.7	---	Yes	No
Lake Creek West	Elevated	Bargamin Creek	Middle Salmon	07/10/14	0.0	---	Yes	No
Goat	Elevated	Bargamin Creek	Middle Salmon	07/11/14	---	---	No	Yes
Bleak	Elevated	Bargamin Creek	Middle Salmon	07/14/14	---	---	Yes	Yes
Boston Mountain	Elevated	Bargamin Creek	Middle Salmon	07/15/14	0.4	4.0	Yes	No
West Moose (#1)	Low	NF Moose Creek	Lower Selway	07/23/14	---	---	Yes	Yes
West Moose (#2)	Low	NF Moose Creek	Lower Selway	07/24/14	---	---	Yes	Yes
West Moose (#3)	Low	NF Moose Creek	Lower Selway	07/25/14	---	---	Yes	Yes
West Moose (#4)	Low	NF Moose Creek	Lower Selway	07/25/14	---	---	Yes	Yes
West Moose (#5)	Low	NF Moose Creek	Lower Selway	07/26/14	---	---	Yes	Yes
West Moose (#6)	Low	NF Moose Creek	Lower Selway	07/26/14	---	---	Yes	Yes
West Moose (#7)	Low	NF Moose Creek	Lower Selway	07/27/14	---	---	Yes	Yes
West Moose (#8)	Low	NF Moose Creek	Lower Selway	07/27/14	---	---	Yes	No
West Moose (#9)	Low	NF Moose Creek	Lower Selway	07/27/14	---	---	Yes	No
Dodge	Moderate	Warm Springs Crk.	Lochsa	08/23/14	---	---	Yes	Yes
Section 28	Low	NF Moose Creek	Lower Selway	08/24/14	---	---	Yes	Yes
Fox Peak (lower)	Low	NF Moose Creek	Lower Selway	09/04/14	---	---	Yes	Yes
Fox Peak (upper)	Low	NF Moose Creek	Lower Selway	09/04/14	---	---	Yes	Yes
Isaac	Low	NF Moose Creek	Lower Selway	09/05/14	2.9	4.3	Yes	No
Isaac Creek	Low	NF Moose Creek	Lower Selway	09/05/14	---	---	Yes	No
Section 27	Low	Storm Creek	Lochsa	09/08/14	---	---	Yes	Yes
Siah	Low	Storm Creek	Lochsa	09/08/14	0.2	---	Yes	Yes
North Section 25	Low	Storm Creek	Lochsa	09/09/14	---	---	Yes	No
South Section 25	Low	Storm Creek	Lochsa	09/09/14	---	---	Yes	Yes
Old Stormy	Low	Storm Creek	Lochsa	09/09/14	---	---	Yes	No
N.E Ranger	Low	Storm Creek	Lochsa	09/10/14	---	---	Yes	Yes
Ranger	Low	Storm Creek	Lochsa	09/10/14	0.2	1.0	No	No
Storm	Low	Storm Creek	Lochsa	10/30/14	---	---	No	No
Middle Storm	Low	Storm Creek	Lochsa	10/30/14	---	---	Yes	No
North Storm	Low	Storm Creek	Lochsa	10/30/14	---	---	No	No

Table 14. Summary of catch per unit effort (CPUE) and average length, of fish captured during high mountain lake surveys in the Clearwater Region, Idaho, in 2014.

		CPUE (fish/hour)		Average Length
Lake	Species	Gill Net	Angling	(mm)
MacArthur	WCT	0.5	---	290
Stillman	WCT	0.2	---	197
Lake Creek East	WCT	1.0	---	268
Lake Creek South	WCT	0.7	---	311
Boston Mountain	WCT	0.4	4.0	239
Isaac	WCT	2.9	4.3	229
Siah	WCT	0.2	---	358
Ranger	RBT	0.2	1.0	286
Average		0.8	3.1	272

WCT=Westslope Cutthroat Trout, RBT=Rainbow Trout

Table 15. Fish and Amphibian presence in Clearwater Region high mountain lakes determined from historic surveys (pre-2006) and subsequent surveys used to assess amphibian persistence. Species listed include CSF=Columbia Spotted Frog, LTS=Long Toed Salamander, TF=Rocky Mountain Tailed Frog, IGS=Idaho Giant Salamander, WCT=Westslope Cutthroat Trout, RT=Rainbow Trout, and BT=Brook Trout.

Lake Name	Watershed/ Risk level	Historical Fish	Historical Amphibians	First Round Fish	First Round Amphibians	Second Round Fish	Second Round Amphibians	Third Round Fish	Third Round Amphibians
Bleak Creek	Bargamin/Elevated	NONE	CSF/LTS	NONE	CSF	NONE	CSF/LTS/TF	---	---
Boston Mtn.	Bargamin/Elevated	WCT	CSF/LTS	WCT	CSF	WCT	CSF	---	---
Goat Lake	Bargamin/Elevated	WCT	LTS	NONE	CSF/LTS	NONE	LTS	---	---
Lake Creek E.	Bargamin/Elevated	WCT/RT/X	CSF	WCT/RT/X	CSF/LTS	WCT	CSF	---	---
Lake Creek W.	Bargamin/Elevated	RT	CSF	RT	CSF	NONE	CSF	---	---
Lake Creek. S.	Bargamin/Elevated	WCT/RT	CSF	RT	CSF/TF	WCT	CSF	---	---
MacArther	Bargamin/Elevated	WCT/RT	CSF/LTS	WCT/RT	CSF	WCT/RT	CSF/LTS	WCT	CSF
Stillman	Bargamin/Elevated	WCT	CSF	WCT	CSF/LTS	WCT	CSF/LTS	WCT	CSF
Three Prong	Bargamin/Elevated	---	---	NONE	CSF/IGS	NONE	CSF/IGS	---	---
Big Harrington #1	Big Harr/Control	---	---	NONE	NONE	---	---	---	---
Big Harrington #6	Big Harr/Control	---	---	NONE	CSF	---	---	---	---
Bilk Mountain	Goat/Control	NONE	CSF	NONE	CSF/LTS	NONE	CSF	---	---
Goat	Goat/Control	NONE	CSF	NONE	CSF/LTS	---	---	---	---
Mud	Goat/Control	NONE	CSF/LTS	NONE	CSF/LTS	NONE	CSF	---	---
Fox Peak Lower	N.F. Moose/Low	NONE	CSF/LTS	NONE	CSF	NONE	CSF/LTS	NONE	CSF/LTS
Fox Peak Upper	N.F. Moose/Low	NONE	CSF/LTS	NONE	CSF	NONE	CSF/LTS	NONE	CSF/LTS
Isaac	N.F. Moose/Low	WCT/RT	CSF	WCT/RT	CSF	WCT	CSF	WCT	CSF
Isaac Creek	N.F. Moose/Low	---	---	NONE	CSF	NONE	CSF/LTS	NONE	CSF
Section 28	N.F. Moose/Low	NONE	CSF/LTS	NONE	CSF/LTS	NONE	CSF/LTS	---	---
West Moose #1	N.F. Moose/Low	---	---	NONE	CSF/LTS	NONE	CSF/LTS	NONE	CSF/LTS
West Moose #2	N.F. Moose/Low	---	---	NONE	CSF	NONE	CSF/LTS	---	---
West Moose #3	N.F. Moose/Low	---	---	NONE	CSF/LTS	NONE	CSF/LTS	NONE	CSF/LTS
West Moose #4	N.F. Moose/Low	---	---	NONE	CSF/LTS	NONE	CSF/LTS	NONE	CSF/LTS
West Moose #5	N.F. Moose/Low	---	---	NONE	CSF/LTS	NONE	CSF	NONE	CSF/LTS
West Moose #6	N.F. Moose/Low	---	---	NONE	CSF/LTS	NONE	CSF/LTS	NONE	CSF/LTS
West Moose #7	N.F. Moose/Low	---	---	NONE	CSF/LTS	NONE	CSF	NONE	CSF/LTS
West Moose #8	N.F. Moose/Low	---	---	NONE	CSF	NONE	LTS	NONE	CSF
West Moose #9	N.F. Moose/Low	---	---	NONE	CSF	NONE	CSF	NONE	CSF
Chimney	Old Man/Elevated	BT	NONE	BT	CSF	BT	CSF	---	---
Dishpan	Old Man/Elevated	BT	CSF	BT	CSF	BT	CSF	---	---
Elizabeth	Old Man/Elevated	BT/WCT	CSF	BT/WCT	NONE	BT/WCT	NONE	---	---
Flea	Old Man/Elevated	NONE	CSF	NONE	CSF/LTS	NONE	CSF/LTS	---	---
Florence	Old Man/Elevated	WCT	CSF/LTS	WCT	CSF/LTS	WCT	CSF	---	---
Hjort	Old Man/Elevated	BT	CSF	BT	CSF	BT/WCT	CSF	---	---
Kettle	Old Man/Elevated	RT	CSF/LTS	NONE	CSF/LTS	NONE	CSF/LTS	---	---
Lloyd	Old Man/Elevated	BT	NONE	BT	NONE	BT	NONE	---	---

Table 15 (continued).

Lake Name	Watershed/ Risk level	Historical Fish	Historical Amphibians	First Round Fish	First Round Amphibians	Second Round Fish	Second Round Amphibians	Third Round Fish	Third Round Amphibians
Lottie	Old Man/Elevated	---	---	BT	CSF	BT	CSF	---	---
Lottie Upper	Old Man/Elevated	BT	CSF	BT	CSF	BT	CSF	---	---
Maude East	Old Man/Elevated	RT	CSF	RT	CSF	WCT/X	CSF/LTS	---	---
Maude North	Old Man/Elevated	NONE	CSF/LTS	NONE	CSF/LTS	NONE	CSF	---	---
Maude West	Old Man/Elevated	RT	CSF	RT	CSF	WCT/X	CSF/LTS	---	---
Old Man	Old Man/Elevated	BT	CSF	BT	CSF	BT	CSF	---	---
Wood	Old Man/Elevated	NONE	CSF/LTS	NONE	CSF/LTS	NONE	CSF/LTS	---	---
Eagle Creek	Running/Moderate	---	---	NONE	NONE	---	---	---	---
Running	Running/Moderate	BT	CSF	BT	NONE	BT	CSF	---	---
Section 26	Running/Moderate	---	---	NONE	NONE	NONE	CSF	---	---
Section 26 #2	Running/Moderate	---	---	NONE	LTS	NONE	NONE	---	---
Dan	Storm/Low	RT	CSF	RT	CSF	RT	CSF	---	---
Dodge	Storm/Low	RT	CSF	RT	CSF	RT	CSF	---	---
Lookout	Storm/Low	RT	CSF	RT	CSF	RT	CSF	---	---
Maud	Storm/Low	NONE	CSF/LTS	NONE	CSF	---	---	---	---
Middle Storm	Storm/Low	NONE	CSF/LTS	NONE	CSF	NONE	CSF/LTS	NONE	CSF
N.E. Ranger	Storm/Low	NONE	CSF/LTS	NONE	CSF	NONE	CSF/LTS	NONE	CSF/LTS
North Sec. 25	Storm/Low	NONE	CSF/LTS	NONE	CSF	NONE	CSF/LTS	NONE	CSF
North Storm	Storm/Low	NONE	CSF	NONE	CSF	NONE	CSF/LTS	NONE	NONE
Old Stormy	Storm/Low	NONE	CSF/LTS	NONE	CSF/LTS	NONE	CSF	---	---
Ranger	Storm/Low	RT	CSF	RT	NONE	RT	CSF/LTS	RT	NONE
Section 27	Storm/Low	NONE	CSF/LTS	NONE	CSF	NONE	CSF/LTS	NONE	CSF/LTS
Siah	Storm/Low	WCT/RT	CSF	WCT/RT	CSF	WCT/RT	CSF/LTS	WCT	CSF/LTS
South Sec. 25	Storm/Low	NONE	CSF/LTS	NONE	CSF	NONE	CSF	NONE	CSF/LTS
Storm	Storm/Low	NONE	CSF/LTS	NONE	NONE	NONE	LTS	NONE	NONE
Bilk	Up.Meadow/Control	NONE	CSF	NONE	CSF/LTS	---	---	---	---
Elk	Up.Meadow/Control	---	---	NONE	CSF/LTS	---	---	---	---
Section 27	Up.Meadow/Control	---	---	NONE	CSF/LTS	---	---	---	---
Dodge	Warm Springs/Moderate	NONE	CSF/LTS	NONE	CSF	---	---	---	---
East Wind	Warm Springs/Moderate	WCT	CSF/LTS	WCT	CSF	NONE	CSF	---	---
Hungry	Warm Springs/Moderate	WCT/RT	CSF	WCT	CSF	WCT	CSF	---	---
Low. N. Wind	Warm Springs/Moderate	NONE	CSF/LTS	NONE	NONE	NONE	CSF	---	---
Middle Wind	Warm Springs/Moderate	WCT	CSF	WCT	CSF	WCT	CSF	---	---
N.W. Wind	Warm Springs/Moderate	NONE	CSF/LTS	NONE	CSF/LTS	NONE	CSF	---	---
South Wind	Warm Springs/Moderate	NONE	CSF/LTS	NONE	CSF/LTS	NONE	CSF	---	---
Up. N. Wind	Warm Springs/Moderate	NONE	LTS	NONE	CSF/LTS	NONE	CSF/LTS	---	---
West Wind	Warm Springs/Moderate	WCT	CSF	WCT	CSF	WCT	CSF/LTS	---	---
Wind Pond	Warm Springs/Moderate	NONE	CSF/LTS	NONE	CSF/LTS	NONE	CSF/LTS	---	---

CSF=Columbia Spotted Frog, LTS=Long Toed Salamander, TF=Rocky Mountain Tailed Frog, IGS=Idaho Giant Salamander, WCT=Westslope Cutthroat Trout, RT=Rainbow Trout, BT=Brook Trout.

Table 16. Summary of the number of mountain lakes surveyed in the Clearwater Region, Idaho, containing Columbia Spotted Frogs (CSF) and Long-toed Salamanders (LTS), based on fish presence. The right hand column is a total of lakes with and without fish, not a row total.

Historical

	Amphibians			
	CSF	LTS	None	Total
Fish	26	6	2	29
No Fish	25	21	0	26
Total	51	27	2	55

1st Round

	Amphibians			
	CSF	LTS	None	Total
Fish	24	3	4	28
No Fish	40	24	5	46
Total	64	27	9	74

2nd Round

	Amphibians			
	CSF	LTS	None	Total
Fish	24	7	2	26
No Fish	35	23	1	39
Total	59	30	3	65

3rd Round

	Amphibians			
	CSF	LTS	None	Total
Fish	4	1	1	5
No Fish	16	11	2	18
Total	20	12	3	23

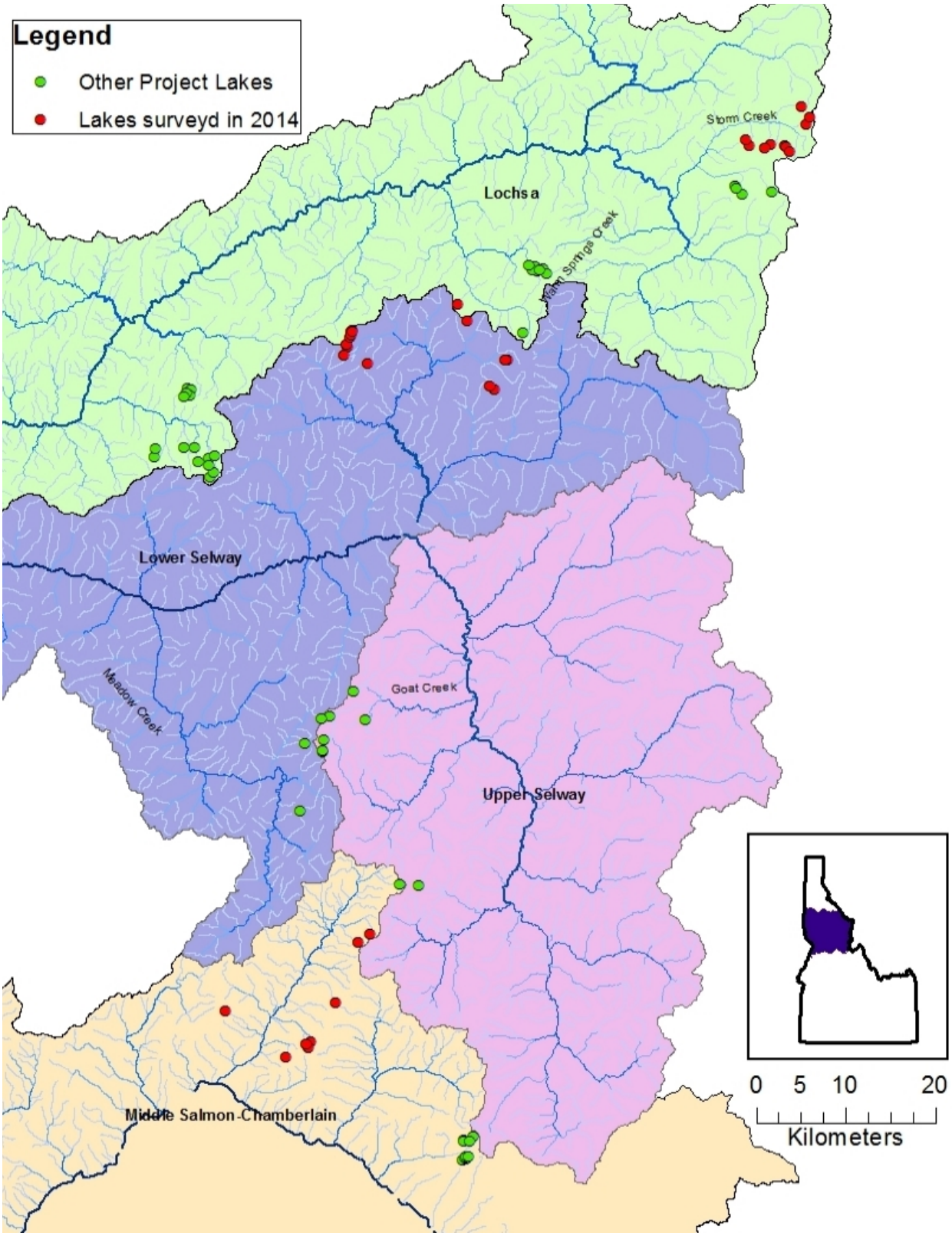

Figure 57. Map of high mountain lakes surveyed in 2014 in the Clearwater Region of Idaho.

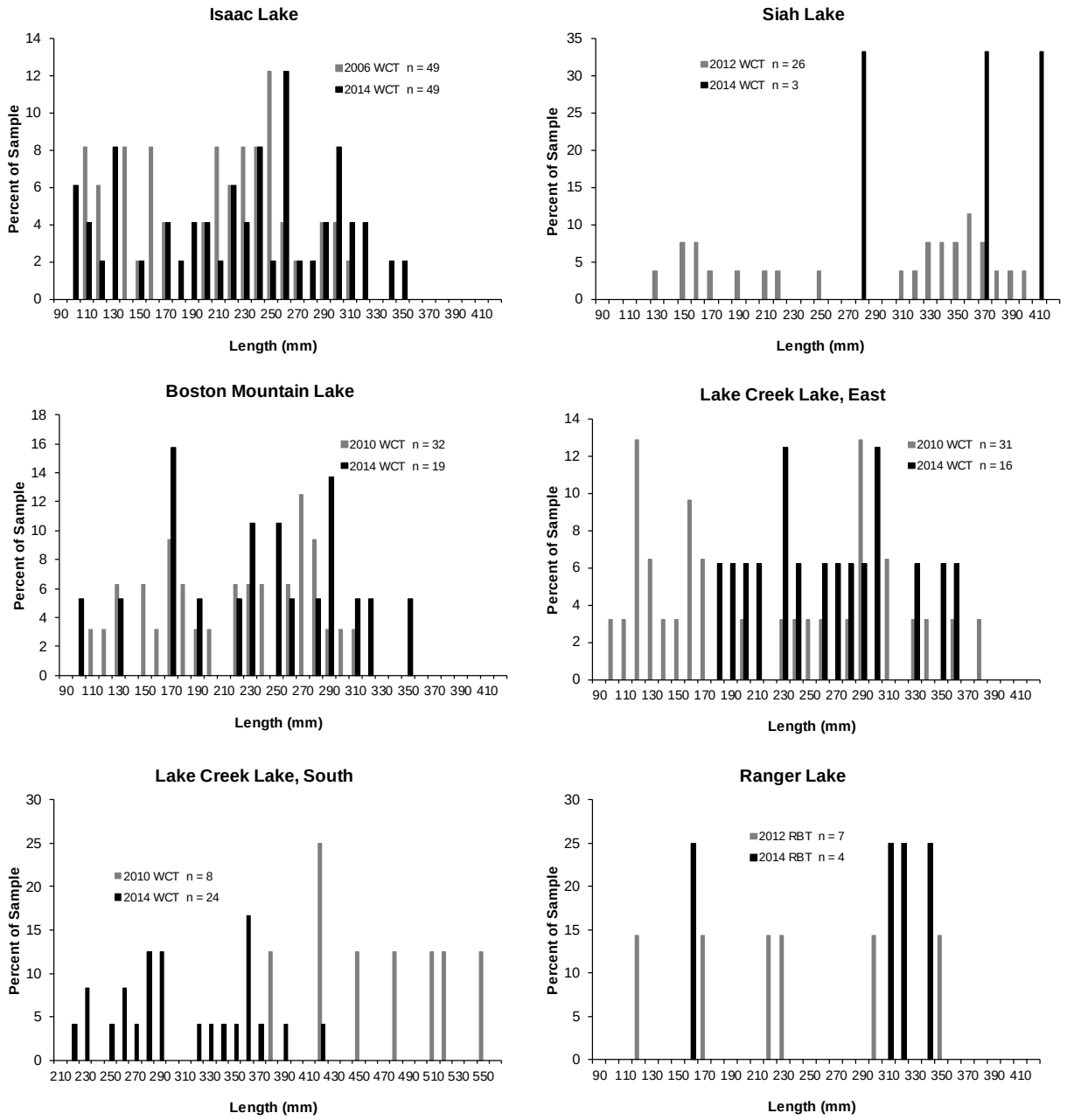

Figure 58. Length frequency distributions of Westslope Cutthroat Trout (WCT) and Rainbow Trout (RBT) caught by gillnets and angling in high mountain lakes in the Clearwater Region, Idaho, from 2006 - 2014.

APPENDICES

Appendix A. Watersheds (HUC5) selected for an amphibian risk assessment project on high mountain lakes in the Clearwater Region, Idaho.

HUC5 Watershed	National Forest	Amphibian Risk Classification	% and # of Fishless Lakes	% and # of Fishless Surface Area
Big Harrington Creek	Nez Perce	Control	100% (2 lakes)	100% (0.70 ha)
Goat Creek	Nez Perce	Control	100% (3 lakes)	100% (0.96 ha)
Upper Meadow Creek	Nez Perce	Control	100% (3 lakes)	100% (1.64 ha)
North Fork Moose Creek	Nez Perce	Low	93% (13 of 14 lakes)	53% (6.05 of 11.43 ha)
Storm Creek	Clearwater	Low	64% (9 of 14 lakes)	56% (18.56 of 33.37 ha)
Running Creek	Nez Perce	Moderate	75% (3 of 4 lakes)	9% (0.84 of 9.21 ha)
Warm Springs Creek	Clearwater	Moderate	60% (6 of 10 lakes)	12% (3.45 of 28.63)
Bargamin Creek	Nez Perce	Elevated	22% (2 of 9 lakes)	8% (1.52 of 19.52 ha)
Old Man Creek	Clearwater	Elevated	20% (3 of 15 lakes)	4% (3.14 of 75.76 ha)

Appendix B. General characteristics of lakes selected for a long-term high mountain lake amphibian monitoring project in the Clearwater Region, Idaho.

Lake Name	HUC5 Watershed	Longitude (datum WGS 84, format decimal degrees)	Latitude (datum WGS 84, format decimal degrees)	Size (ha)	Max. Depth (m)	Elevation (m)
Bilk Mountain	Goat/Control	115.0380	45.9396	0.2	<0.5	2113
Goat	Goat/Control	115.0040	45.9650	0.4	1.9	2182
Mud	Goat/Control	114.9856	45.9354	0.4	0.9	1889
Bilk	Up.Meadow/Control	115.0498	45.9370	0.9	4.0	2054
Elk	Up.Meadow/Control	115.0783	45.8430	0.7	N/A	2029
Section 27	Up.Meadow/Control	115.0732	45.9117	0.1	N/A	2100
Big Harrington #1	Harrington/Control	114.8398	45.4938	0.7	1.3	2215
Big Harrington #6	Harrington/Control	114.8246	45.5183	<0.1	0.6	2470
Fox Peak Lower	N.F. Moose/Low	114.7875	46.3000	0.5	3.7	2017
Fox Peak Upper	N.F. Moose/Low	114.7896	46.2991	0.5	3.8	2032
Isaac Creek	N.F. Moose/Low	114.8122	46.2735	0.4	0.8	1912
Isaac	N.F. Moose/Low	114.8058	46.2692	5.4	4.8	1901
Section 28	N.F. Moose/Low	114.8461	46.3386	0.5	1.3	2074
West Moose #1	N.F. Moose/Low	114.9899	46.2940	1.1	3.1	2130
West Moose #2	N.F. Moose/Low	115.0141	46.3260	0.1	<1.0	2169
West Moose #3	N.F. Moose/Low	115.0191	46.3108	0.4	<1.0	2091
West Moose #4	N.F. Moose/Low	115.0210	46.3129	0.5	<1.0	2162
West Moose #5	N.F. Moose/Low	115.0157	46.3199	0.5	1.9	2096
West Moose #6	N.F. Moose/Low	115.0142	46.3223	0.9	2.7	2110
West Moose #7	N.F. Moose/Low	115.0234	46.3029	0.5	1.7	2173
West Moose #8	N.F. Moose/Low	115.0127	46.3271	0.1	<1.0	2167
West Moose #9	N.F. Moose/Low	115.0128	46.3258	0.0	<1.0	2158
Dan	Storm/Low	114.4577	46.4766	2.2	3.3	2019
Dodge	Storm/Low	114.4487	46.4677	4.3	7.0	2118
Lookout	Storm/Low	114.4559	46.4736	0.3	0.6	2051
Maud	Storm/Low	114.4048	46.4702	9.3	6.0	1969
Middle Storm	Storm/Low	114.3552	46.5381	1.0	3.3	2081
North Sec. 25	Storm/Low	114.3858	46.5173	0.3	<1.0	2134
North Storm	Storm/Low	114.3496	46.5456	0.6	2.0	2227
N.E. Ranger	Storm/Low	114.4062	46.5186	0.3	0.3	1999
Old Stormy	Storm/Low	114.3787	46.5109	0.9	1.5	2210
Ranger	Storm/Low	114.4160	46.5149	2.7	3.7	1999
Section 27	Storm/Low	114.4383	46.5168	0.5	1.2	1999
Siah	Storm/Low	114.4437	46.5232	5.3	21	1963
South Sec. 25	Storm/Low	114.3853	46.5165	0.2	<1.0	2134
Storm	Storm/Low	114.3623	46.5562	5.4	11.0	1992

Appendix B (continued).

Lake Name	HUC5 Watershed	Longitude (datum WGS 84, format decimal degrees)	Latitude (datum WGS 84, format decimal degrees)	Size (ha)	Max. Depth (m)	Elevation (m)
Eagle Creek	Running/Moderate	114.9068	45.7695	0.0	Dry	2222
Running	Running/Moderate	115.0463	45.9151	8.4	13.3	2008
Section 26	Running/Moderate	115.0476	45.9034	0.4	2.0	2087
Section 26 #2	Running/Moderate	115.0468	45.9049	0.2	1.5	2104
Dodge	Warm Springs/Mod.	114.8593	46.3544	0.9	<1.0	1882
East Wind	Warm Springs/Mod.	114.7365	46.3918	7.5	7.6	2167
Hungry	Warm Springs/Mod.	114.7652	46.3267	10.0	12.2	2037
Low. N. Wind	Warm Springs/Mod.	114.7492	46.3933	0.2	0.1	2066
Middle Wind	Warm Springs/Mod.	114.7455	46.3889	5.8	8.2	2069
N.W. Wind	Warm Springs/Mod.	114.7568	46.3947	0.7	1.5	1945
South Wind	Warm Springs/Mod.	114.7319	46.3871	0.8	2.5	2263
Up. N. Wind	Warm Springs/Mod.	114.7477	46.394	0.6	0.5	2066
West Wind	Warm Springs/Mod.	114.7514	46.3905	2.0	7.0	2072
Wind Pond	Warm Springs/Mod.	114.7407	46.3901	0.3	2.5	2158
Bleak Creek	Bargamin/Elevated	115.0231	45.6513	0.5	4.9	2196
Boston Mtn.	Bargamin/Elevated	115.1813	45.6418	0.8	5.2	2329
Goat Lake	Bargamin/Elevated	115.0931	45.5954	0.9	3.1	2280
Lake Creek E.	Bargamin/Elevated	115.0577	45.6111	1.6	4.8	2182
Lake Creek. S.	Bargamin/Elevated	115.0622	45.6057	8.1	14.8	2231
Lake Creek W.	Bargamin/Elevated	115.0647	45.6094	3.5	5.0	2182
MacArther	Bargamin/Elevated	114.9754	45.7206	2.0	3.2	2107
Stillman	Bargamin/Elevated	114.9923	45.7126	1.2	13.3	2093
Three Prong	Bargamin/Elevated	114.9333	45.7706	1.0	2.7	2192
Chimney	Old Man/Elevated	115.2959	46.1968	2.3	6.0	1864
Dishpan	Old Man/Elevated	115.217	46.1974	2.0	2.5	1878
Elizabeth	Old Man/Elevated	115.2094	46.1989	11.9	31.9	1789
Flea	Old Man/Elevated	115.2955	46.2051	1.5	2.4	1851
Florence	Old Man/Elevated	115.2159	46.1778	12.1	7.8	1917
Hjort	Old Man/Elevated	115.2096	46.1828	0.5	3.2	1902
Kettle	Old Man/Elevated	115.2319	46.1932	5.5	15.0	2176
Lloyd	Old Man/Elevated	115.2175	46.1896	9.3	5.9	1892
Lottie	Old Man/Elevated	115.2506	46.267	3.5	3.6	1873
Lottie Upper	Old Man/Elevated	115.2446	46.2655	2.5	6.1	1888
Maude East	Old Man/Elevated	115.2467	46.2595	1.9	6.2	1938
Maude North	Old Man/Elevated	115.2511	46.2619	0.8	2.5	1884
Maude West	Old Man/Elevated	115.2549	46.2589	2.5	9.8	1853
Old Man	Old Man/Elevated	115.2382	46.2071	18.6	4.0	1695
Wood	Old Man/Elevated	115.2528	46.2076	0.8	4.5	1929

Appendix C. High mountain lake sampling protocol, updated and revised after 2013 field season.

Goal

Examine how fisheries management activities relate to persistence of native fauna at the local population and metapopulation scale within the high mountain lake ecosystems of North Central Idaho for the Idaho Fish and Game (IDFG), Clearwater Region (#2) and United States Forest Service cooperators (Nez Perce and Clearwater National Forests).

Objective

- Stratify watersheds by lake according to habitat occupied by fish, i.e. group 5th code HUC watersheds that are low, high, elevated and control into groups.
- Randomly select two to three 5th code HUCs from each amphibian risk category. Survey two watersheds every summer in a long-term monitoring program.
- Perform a statistical analysis of amphibian occurrence and relative abundance within four amphibian risk categories.
- Collect genetics samples for information to aid in a population or metapopulation viability analysis (PVA or MPVA).

Statistical Analysis

Mountain lakes that exist in watersheds (HUC5) which make up drainage systems (HUC4) lend themselves to a nested type of analysis. An analysis of variance (ANOVA) or a multiple linear regression (MLR) would work best with relative abundance measures in the nested type of analysis. Analysis of statistics will be more in depth once sessions with University of Idaho statistical counseling center (SCC) have been completed.

Sampling Protocol

1. <u>Approaching the lake</u>

   Find a location to take photographs and record appropriate metadata from a position above the lake. Use binoculars to identify if amphibians are visible in obvious locations.

2. <u>Amphibian Survey - Visual Encounter Survey (VES)</u>

   Upon arrival to the lake, the amphibian VES should be performed first (before setting gill nets) following previous mountain lake survey methodology (Crump and Scott 1994; Murphy 2002). VESs are timed perimeter searches for amphibians in which each individual amphibian and reptile encountered is recorded by species and life stage to determine presence and relative abundance. All littoral areas of lake will be sampled, as well as inlets outlets and associated wetlands (Murphy 2002). Whenever possible, each lake will be surveyed twice in a close temporal span, so a detectability estimate for each lake survey can be determined. This usually means surveying the lake twice in two days: one in the afternoon upon arrival at the lake, and once the following morning before retrieving the gill net.

   To begin a VES, select a start point along the lake shoreline. Once that point is reached, record the start time and commence a shoreline and littoral zone search for amphibians and reptiles. If multiple observers are present, you may choose to split the survey and converge

at the far shore; record each segment separately. At some lakes, steep topography or dense vegetation may limit shoreline access. In such cases, estimate the percentage of shoreline surveyed. You may choose to wade through the littoral zones of lakes to conduct the VES, but this should be done with caution as the substrate in most mountain lakes of the Clearwater Region is dominated by silt, which is very unstable and can immobilize personnel conducting searches. Dip nets will be used to sweep through vegetation in order to observe cryptic individuals or egg-masses.

Each encounter of an amphibian will be stratified by the habitat type in which the individual was encountered. Life stage of the individual will be recorded; egg-masses, larvae, juvenile, subadult, and adult. You may encounter areas in lakes where there are hundreds of Columbia spotted frog larvae. If an actual count is not feasible, approximate the number of larvae seen, and continue searching. Once the entire perimeter of the lake is searched (i.e., you have returned to the starting point or converged at the far shore), record an end time and tally each species by life stage.

During the VES, remember to look for an appropriate area to set a gill net - it should have deep water access and be relatively free of submerged woody debris and rocks. VESs are also times when there are opportunities to record (1) the presence and qualitative abundances of aquatic invertebrates, (2) details of inlets and outlets, (3) information that is to be recorded on bathymetry/surrounding area maps, (4) campsite inventories, (5) shoreline forest species composition, and (6) other animal observations (see habitat sampling section). During VES searches, the observer should record information in a small Rite-in-the-Rain notebook. After the VES, data should be transferred to the lake data sheet - this helps to keep data sheets neat and legible.

Minimizing disturbance to amphibians by gill net placement or removal is important. Thus VES sampling for amphibians should be performed after a sufficient amount of time from the disturbance of either gill net setting or removing (separated by 2-3 hours). Temporally separating gill net usage for fish and VES for amphibians is important because amphibian behavior and observability often vary with human activities/disturbances. Metadata for each survey is critical, as the behavior of amphibians and our ability to observe them is often highly variable with weather, temperature, time of day, predators, prey, etc.

A 50 to 100 meter perimeter search for terrestrial adults should also be conducted.

3. <u>Gill Netting (if lake contains fish)</u>

This is a timed gill netting effort, thus always record start and end times for calculation of catch per unit effort. The location of the gill net set should be recorded with a description and a sketch. Packable mountain lake gill nets are employed, usually during overnight sets for a duration of 12 hours (or as close to that time as possible). Gill nets are set by one person in a float tube or ultralight raft. Other personnel may assist by holding or tying off the other end and watching to ensure that the net set is perpendicular to the shoreline. The person setting the net will place the pre-stacked net (accordion style or neatly stuffed in its compression sack) on the front of the float tube and kick out toward the center of the lake while simultaneously paying out net. The smaller mesh sizes should face the shore (i.e., arranged on top of the compression sack) and the larger mesh sizes the deep water, with a float tied to the larger mesh end by a length of cord greater than the lake depth to assist retrieval. Once the net is paid out and extended to its full length the end of the gill net can be dropped to the bottom of the lake (mountain lake gill nets are sinking gill nets) and the float attached. Note

that this process is somewhat dangerous and attention must be given to ensure that feet do not become entangled while setting the net. To minimize entanglement with the gill net, the person setting the net should not wear wading boots (just neoprene booties covering their feet). If using waders, we suggest that waders be put on at the lake shoreline just before the net is set, so as to minimize chances for puncturing wader booties.

Special attention should be paid to where the gill net is to be set; a good time to scout for a suitable location is during the VES. Areas with submerged woody debris and boulders should be avoided, as the net may become snagged upon retrieval. Preferred areas should also encompass deeper areas of the lake. Gill nets are 50 meters in length and should reach the deeper parts of most mountain lakes.

All trout captured in the net are recorded by species, weighed (g) using a spring scale, and measured (mm) for total length. Collect scale samples from all fish for age and growth analysis. When used in correlation with stocking history, age information can be used to determine if natural recruitment is occurring (Murphy 2002). Fish captured in gill net will also be subject to a stomach sample analysis for evidence of amphibian predation (Murphy 2002).

After use of gill nets, crews should ensure that nets are free of debris and mud which may contain pathogens that could be transferred to other lakes. Gill nets should be dried before storage for any length of time exceeding a couple days. Repair of gill nets should be performed between trips into the field unless repair in the field is necessary.

4. Habitat Surveys (from float tube)

If the lake has not been previously sampled, develop a bathymetric map by using the portable depth sounder while in the float tube. Use a traversing pattern (multiple passes over different areas) across the lake and recording the depth at each point on a sketch of the lake area.

Once the deepest area of the lake has been found, take a deep tow (2 vertical tows) with the zooplankton net by lowering the net (with a cord the has depths measured) to ~ 0.5 meters above lake bottom and retrieving net at approximately 0.3 meters per second. Horizontal tows (2 oblique tows) can be performed from shore by throwing net toward lake center and allowing net to sink below the water surface also retrieving the net at ~ 0.3 meters per second (shallow or oblique tows should be ~ five meters in length). After each vertical tow or series of horizontal tows, transfer captured zooplankton from the net into the sieve. The squirt bottle (filled with lake water, squirted through the mesh from the outside to avoid contamination) will help to wash zooplankton off the net. Then attach an ethanol bottle to the squirt top and use it to transfer zooplankton to the sampling container. Note that the final solution should be ~70% ethanol – more concentrated solutions may burst Daphnia and other delicate zooplankton. Label sampling containers in two ways: 1) a paper label with lake name and date written in pencil placed inside of the sample, 2) use sharpie to write lake name and date on outside of sample. Beware that sharpie ink (especially ink directly on the plastic) is easily removed by ethanol, so take appropriate precautions.

In all deeper lakes, determine secchi depth. This measurement indicates lake productivity. The High Mountain Lakes project uses a small (~6 inch diameter) secchi disk. It floats (to keep its packed weight light), so add rocks to a mesh bag beneath the disk to sink it. Record the depth at which it disappears from sight.

5. Habitat Surveys (on shore)

Describe the lake and surrounding area in words (bulleted points) on the data sheet. Also draw a detailed map of the lake and surrounding area in a notebook. You may instead choose to annotate printed lake maps. Record locations of gill net sets and terrestrial amphibian searches; these should replicate previous years' sampling locations if they are known.

During or after the VES, record all campsites on surrounding area maps and record degree of human impact/size affected on the data sheet. Physical and chemical parameters, littoral zone substrate composition, and forest cover sections are fairly straightforward. Note that the handheld pH/conductivity/temp (EC) meter will need occasional calibration (see instructions with the meter) and that when a surface temperature is taken, it should be done so in a shaded area of the lake. Remember that littoral zones within these lake areas are defined by the area three meters deep or less and emergent vegetation is that vegetation growing out of lake bottom and has an above water surface portion. The data for the stream characteristics section should be collected for inlets and outlets for up to 50 meters or when a fish passage barrier has been reached. Typically, inlets in these headwater areas are small, seeps, or come from adjacent scree fields. In this case fill out as much of the stream characteristics section as is possible.

6. Angling Survey

If lake contains fish and if time permits, conduct rod and reel sampling. Record species and total length of each fish caught and fishing method (fly/spinner).

7. Fish Sampling (working up fish from gill net sample)

If any fish are alive remove those fish and attempt to revive, record a total length for these fish and release back into the lake. After removing live fish, work from one end of the net to the other removing dead fish and any small debris that will cause the net to tangle. Place dead fish in the water to prevent desiccation and to reduce the attraction of various insects (flies). Once all fish are removed from the net, record the total length (mm) and weight (g) for all dead fish. Stomach samples from at least ten fish should be analyzed for evidence of amphibian predation. Record any identifiable prey items. Scale samples should be taken from at least 20 fish that represent various size classes from the sample. Place scales in scale envelopes and record date/lake name/species/total length/weight of that fish on the outside of the scale envelope. Snap a photo of all fish captured in the gill net sample.

Dead fish can be disposed of by burying, but in many mountain lake areas the soil profiles are very shallow/rocky and digging a sufficient hole to bury fish maybe difficult. In many areas a scree (rock) field maybe associated with lake areas and fish can be disposed of by placing fish in between rocks, leaving as few fish exposed as possible (dispose of fish as far from any campsites as possible to minimize any future confrontations with possible bears in the area). While working up fish, lay the gill net in an area where it can dry. This will greatly reduce the odor from a gill net that has captured fish. Note that drying gill nets should always be attended as birds can be attracted to the fish odor on the net and birds walking in the net can become entangled. After setting or drying a net, always pre-stack the net for the next use. If the net is not completely dry and must be packed in a daypack or larger backpack, you may want to bring a small garbage bag to confine gill net inside compression sack from other personal gear.

8. Equipment Cleaning

Be sure to rinse/clean all equipment before using in next lake to avoid potential transportation of plants/animals/diseases. Waders, float tube/raft, dip nets, and other equipment that comes in contact with lake water, vegetation, or substrate should be cleaned and free of soil and debris (and dried if possible) before surveying other lakes in order keep pathogen transportation and infection to a minimum. If cleaning of equipment involves a biodegradable soap, make sure to clean equipment approximately 200 feet away from lake system and streams. A collapsible bucket may aid in such cleaning tasks. **Repair of gill nets** should be performed between trips unless repair in the field is necessary.

9. Daily Check-ins

SPOT messages (Check-in/OK) should be sent daily. USFS radio check-ins with the district's ranger station, typically 1-2x daily, should be performed according to a pre-arranged schedule. *Help will be sent in after two missed check-ins*. Note that some ranger stations are closed on weekends. Rangers should also be provided with the contact information of a person with access to SPOT messages so that, should the USFS radio malfunction, they can deduce your safety from SPOT check-ins. In case of emergency, communication via USFS radio is usually preferred to SPOT because you can describe the precise nature of the situation.

10. Upon Return to Office...

Gill nets should be dried before storage for any length of time exceeding a couple days. Repair of gill nets should be performed between trips into the field unless repair in the field is necessary. Data sheets/notebook notes should be photocopied when returning from the field. Be sure to write out any pertinent notes from the trip such as description of route taken, dangers encountered, etc. Maintenance of field and sampling equipment should also be performed promptly when returning from the field.

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