U.S. Fish and Wildlife Service
Columbia River Fisheries Program Office

Evaluation of Potential Differences in Catch and Length for Bull Trout Sampling Methods in the South Fork Walla Walla River

FY 2014 Annual Report

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On the cover: *CRFPO staff sampling for bull trout using electrofishing in the South Fork Walla Walla River, in the Walla Walla River drainage of Oregon.*

The correct citation for this report is:

Harris, J.E., and C. Newlon. 2014. Evaluation of Potential Differences in Catch and Length for Bull Trout Sampling Methods in the South Fork Walla Walla River, 2014 Annual Report. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA. 24 pp. www.fws.gov/columbiariver/publications.html

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2014 ANNUAL REPORT

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Final
July 7, 2014

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Introduction

Monitoring and research programs can provide important demographic information to inform species conservation (Kareiva and Marvier 2011). Objectives of such programs are often to evaluate long-term changes in population size and distribution, as well as other demographic parameters such as recruitment, growth, and mortality. The selection of sampling methods for a long-term monitoring program is a balance between costs and benefits. Optimally, sampling methods would be selected to produce precise and unbiased estimates of population changes over time, but practical aspects such as effort, financial cost, and safety, as well as impacts to the fish and habitat must also be considered (Al-Chokhachy et al. 2009). Many common fish sampling gears are size selective and understanding differences in size selectivity and catch rates between gears can help evaluate different methods for use in monitoring, stock assessment, and scientific research (Binion et al. 2009; Neal et al. 2012; Benejam et al. 2012).

Bull trout, *Salvelinus confluentus*, is a stream dwelling salmonid that has experienced population declines distribution-wide and is currently listed on the Endangered Species Act (ESA; USFWS 2012). Bull trout exhibit multiple life history strategies, including fluvial, adfluvial, anadromous, and resident; often migratory and resident life history forms are found in the same system and this variation is considered imperative for population persistence (Homel et al. 2008; Tyre et al. 2011). Migratory life history forms appear to reach larger sizes than residents (Mochnacz et al. 2013). Although always valuable, monitoring changes in both population size and fish size distribution is especially important for bull trout, since healthy populations are often composed of both smaller resident and larger migratory life history forms.

From 2002-2011, bull trout research and monitoring in the South Fork Walla Walla River (SFWWR) was conducted by Utah State University (USU). During this period, most bull trout were collected by backpack electrofishing downstream into a seine net, although catch was augmented by angling and setting fyke nets during some years (Budy et al. 2009). In 2012, the U.S. Fish and Wildlife Service took over bull trout monitoring in the SFWWR and anticipated using the electrofishing to a seine method developed by USU. However, this method was difficult and potentially unsafe to implement in swift waters for some inexperienced members of the crew, so the method was altered to make sampling easier, safer, and more efficient. The new method included backpack electrofishing without a seine, augmented by angling in pools that were too deep to be effectively shocked.

The purpose of this analysis was to evaluate if backpack electrofishing to a seine resulted in different estimates of bull trout catch or size than electrofishing augmented by angling. Since the goal of this long-term monitoring program for bull trout is to identify demographic changes in the bull trout population over time, it is important to properly interpret annual catches to differentiate changes in population abundance and size distribution from differences in gear efficiency and size selectivity (Hallett and Hall 2012).

Study Area

The South Fork Walla Walla River is a headwater stream of the Walla Walla River and is located in the Blue Mountains of northeastern Oregon (Figure 1). The Walla Walla River flows 120 km until it merges with the Columbia River. The South Fork Walla Walla River is relatively pristine and unaltered, fed by spring and snowmelt and consists of high gradient, fast flowing, cold water with complex habitat structure.

Methods

In 2002-2011, USU conducted research on the SFWWR bull trout population each summer during the period of active migration prior to spawning (Budy et al. 2009). During 2002-2003, biologists experimented with methods to collect bull trout, including backpack electrofishing to a seine, angling opportunistically from pools, and fyke-netting. From 2004-2011, 22 approximately 200-m standard reaches evenly spaced throughout the 21-km study area were sampled one time during each sampling season by backpack electrofishing to a seine, with other sites opportunistically sampled by various methods (Figure 1; Budy et al. 2009). In 2012-2013, USFWS continued monitoring the standard reaches once per summer sampling period, but changed the protocol slightly to include backpack electrofishing without a seine and angling to collect fish in deep pools that would not be successfully sampled by backpack electrofishing. Almost all collected bull trout were measured for fork length (FL in mm), total length (which was converted to FL), or both and many individuals were tagged with a PIT tag and immediately released.

The two sampling protocols were evaluated for potential differences in identified catch and size distribution using three approaches: (1) all gears were visually examined for general differences in size selectivity including data collected from all reaches and during all years; (2) potential differences in catch and size distribution obtained by USU sampling and USFWS sampling were examined including only data from the 22 standard reaches that were each sampled once during each year (i.e., only 2004-2013); (3) specific comparisons were made by sampling at one standard reach using both protocols during two years (2012 and 2013).

Differences in distributions of catch per standard reach and FL obtained by USU (2004-2011) and by USFWS (2012-2013) were evaluated using Kolmogorov-Smirnov tests, including all reaches and years. The Kolmogorov-Smirnov test is a non-parametric method to examine for differences (both central tendency and shape) between two samples of continuous data (Hollander and Wolfe 1999). To evaluate if reach or year affected mean catch or FL, Two-Way ANOVAs were completed. Post-hoc pairwise comparisons were made using Tukey's honestly significant different tests for variables found to significantly affect either catch or FL. Significance was assessed at the $\alpha=0.05$ level. Natural-logarithm transformed FL and catch were used in ANOVAs to improve normality. Although results from ANOVAs and pairwise comparisons help identify changes in time and space, the main purpose of this analysis was to evaluate whether 2012 and 2013 appeared to match any pattern of variability over years. We also evaluated catch by size group for each year using chi-square analyses. Size groups were composed of juveniles (<145 mm FL), sub-adults (145-289 mm FL), small adults (290-405 mm FL) and large adults (>405 mm FL). Because sample sizes for adult size groups were low, we combined data from all reaches to produce a total catch for each size group for each year. To evaluate for differences between specific years, we ran pairwise chi-square analyses and assessed significance at the $\alpha=0.01$ level. Again, pairwise chi-square evaluations were completed to see if distributions in 2012 and 2013 appeared different to those from other years.

Sampling to directly compare catch and FL between the two sampling protocols was conducted by USFWS in 2012 and 2013. During each year, reach 93 was sampled first by electrofishing and then later in the season, by electrofishing to a seine. Again, all captured bull trout were counted, measured, and then released. The total number caught and general sizes were compared and the length distributions produced by the two protocols were compared for

differences using a Kolmogorov-Smirnov test. Also, we used results from reach 93 in a power analysis to potentially guide future comparison efforts. Specifically, we evaluated the number of reaches required to be sampled using each method (i.e., # of paired samples) to detect a difference in catch at the α=0.05 level using a paired t-test with power of 0.8 and 0.9. Since we only had two samples from the direct comparison, we used data from all years to guide what we might expect the percent change in catch to be as a result of changing methodology to electrofishing without a seine, but we also evaluated what we might expect under more experimental conditions potentially with lower variability. The goal of this power analysis was to give us an idea of what level of sampling effort might be required to detect a difference in catch between the two methods.

Results

Electrofishing (with or without a seine) resulted in the largest distribution for bull trout size, with individuals ranging from 32 mm FL to 683 mm FL (Figure 2). Distributions from both electrofishing protocols showed a small peak in bull trout FL at 40-60 mm and a larger peak at 100-120 mm, with small proportions of fish collected in almost all FL-bins up to 580 mm FL. Median FL as collected by USU electrofishing to a seine was 123 mm and median FL as collected by USFWS was 120 mm. Fyke nets collected bull trout over much of the observed size range (118 – 594 mm FL), but did not collect smaller fish and thus the median FL was 290 mm. Angling collected larger bull trout, ranging from 225 to 589 mm FL, with an average of 425 mm FL (Figure 2).

Including all years, distributions of catch per standard reach appeared fairly similar between the two sampling protocols and a significant difference in catch between USU (2004-2011) and USFWS (2012-2013) sampling was not detected (KS=0.1045, p=0.8177; Figure 3). Median catch rate per standard reach ranged from 14 in 2004 to 27.5 in 2010. Including all years, median catch ranged from 2.5 individuals at reach eight to 57 individuals at reach 68 (Figure 4). The two-way ANOVA detected significant effects of year (DF=9, F=7.30, p<0.0001) and reach (DF=21, F=42.34, p<0.0001) on the number of bull trout caught. There was no obvious annual pattern in catch to suggest an increase or decline in this bull trout population over the study period, or to indicate a change in catch resulting from the start of USFWS sampling; however, it did appear that catch generally increased with distance upstream within the study area, although intermediate reaches 68 and 78 had the highest catches (Table 1; Figure 4).

No significant differences were detected in FL distributions between the two sampling protocols (KS=0.0476, p=0.1095) and the general pattern of sizes, including peaks, appeared similar (Figure 3). Two-way ANOVA results suggested a significant difference in bull trout length between years (DF=9, F=25.30 p<0.0001) and reaches (DF=21, F=52.69, p<0.0001). Again, there was no obvious pattern in FL differences between years. Like catch, however, there was a pattern in FL by reach. At lower reaches (8-33) median bull trout fork lengths were generally similar and higher than those at upstream reaches (56-103), with intermediate medians found at intermediate reaches in the sampling area (Table 2; Figure 5). Chi-square analyses suggested significant differences in the proportion of catch composed of each size group, by year (Chi-square=172.4, DF=27, p<0.0001). Over half of the catch in each year was composed of juveniles (Figure 6). Large and small adults combined represented less than 0.11 of the catch in any year. Again, although there were differences between years, there was no obvious pattern to suggest differences were associated with the change in protocol from electrofishing to a seine to

electrofishing with angling; 2012 most closely resembled 2005, 2010, and 2011, and 2013 most closely resembled 2004, 2007, and 2008 (Table 3; Figure 6). Juveniles were more prevalent at reaches farther upstream, as compared to downstream reaches from which only larger individuals were collected (Figure 7).

Direct comparison of the two electrofishing methods, electrofishing to a seine and electrofishing without a seine, was conducted by USFWS in 2012 and 2013 at reach 93. A larger number of bull trout were caught in 2012 as compared to 2013 (Table 4). Slightly more fish were caught using a seine in 2012, but more were caught without a seine in 2013. Sampling without a seine resulted in an average of three more individuals (SD on difference =12.73) than sampling with a seine when data from the two years were combined. Median and ranges in FL were somewhat variable by protocol and year, but likely as a result of small sample sizes (Table 4). The size distribution produced by using a seine was not significantly different to that without a seine (KS=0.1157, p=0.8854), although power was likely low and patterns were difficult to discern since sample sizes were small (Figure 8).

Similarly, when all years were examined, an average of 25.13 individuals (SD=7.28) were collected using a seine (i.e., 2004-2011), and 27 (SD=12.73) were collected without a seine (i.e., 2012-2013). First, we evaluated the number of reaches (i.e., # of paired samples) required to detect a difference (at the α=0.05 level) in catch of 2 individuals (i.e., 7% change) with a standard deviation of 7.28 (i.e., coefficient of variation of 29%) using a paired t-test, with power 0.8 and 0.9. We then examined the potential to detect differences assuming larger difference in catch (5-25%, by 5%) with lower coefficients of variation (10-30%, by 5%). Higher estimates of differences in catch by reach may be more meaningful and lower variation would be expected if each sample at a reach was completed by the same crew during the same time period in the same sampling season. Assuming a power level of 0.8, 106 paired samples would be required to detect a difference of 7% and 142 samples would be needed to detect this difference at a power level of 0.9; however, larger differences could be detected with a more reasonable level of sampling effort, if variability could be reduced (Table 5).

Discussion

Long-term datasets from monitoring programs can be highly valuable for informing conservation, as long as differences between sampling periods can be attributed to population changes, rather than differences in sampling protocols or efficiency (Hallett and Hall 2012). We could not attribute any variability or differences in size distribution or total catch to the changes in sampling protocol made by the USFWS; thus, we could tentatively suggest that results from the two methods (backpack electrofishing to a seine and electrofishing with added angling of bull trout from pools) should be comparable. Generally, the distributions of catch and length when all years were combined appeared fairly similar between the two protocols. Especially length distributions, which appeared very similar in shape overall and illustrated similar peaks. Kolmogorov-Smirnov test results must be considered approximate, since data were not truly continuous (particularly count data), but sample sizes were sufficiently large when all data were combined. Although there was annual variability in catch and size, there was no evidence that observed distributions of catch or size changed as a result of the change in sampling protocol made in 2012 and 2013. However, further consideration should be made in terms of the timing and effort put towards angling, since changes in effort could be confounded with changes in population abundance and size distribution. Angling for bull trout in the SFWWR is completed

opportunistically in pools that are too deep to be effectively sampled using electrofishing. It is not clear if angling selects for larger individuals or if larger individuals more frequently use deep pools. Angling has been found to be size-selective in some salmonid sampling programs and not in others; thus, standardizing and documenting angling effort and catch would be beneficial for long-term population assessment (DuBois and Kulinski 2004; Schwanke and Hubert 2004; Hetrick and Bromaghin 2006).

Although no differences were detected to suggest that the two sampling methods (i.e., electrofishing to a seine as compared to electrofishing with angling) varied greatly in total catch or size distribution, these analyses should be evaluated with caution considering the multiple sources of variability, most especially: annual changes in population demographics, diverse environmental conditions resulting in differential gear efficiency, and differences in experience and specific techniques of the crews conducting sampling. Such extensive variability makes it difficult to detect differences as a result of this small change in sampling protocol without a large number of samples. Directed paired sampling using both methods was completed at one reach during two years; however, a larger sample size would be more useful, especially if variability could be reduced such as by requiring that each method in the paired sample be completed by the same crew and that the timing between the two samples be considered and maintained as a constant. The interval between samples at a reach could be especially important and difficult to appropriately select; it should be large enough for fish to redistribute, but not so large that the population changes as a result of migration or that the habitat alters affecting gear efficiency. Young and Schmetterling (2004) suggested that electrofishing could increase the downstream movement for some salmonids, but this movement impacted abundance estimates only minimally and for a few days, and authors noted that impacts could vary by species and habitat. The order of sampling (i.e., which method is completed first) should be considered and randomly drawn, as order can impact capture efficiencies for some species (Poesch 2014), since disturbance from the first sampling event could impact catch in the second. Also, since total catch and size distribution varied by reach, reach selection should be considered. Higher catches were observed at upstream reaches; however, many upstream individuals were juveniles. Selection of reaches with high numbers of individuals (i.e., reaches 68 and 78), as well as reaches with high proportions of larger individuals (i.e., reaches 33, 48, and 53) may be good candidates to evaluate differences in catch and size distribution between the two sampling methods. However, it is unlikely that sampling less than five reaches using both methods would result in high enough power to detect a difference between sampling methods regardless of standardization or goals.

Annual variability in catch and size could suggest annual demographic changes in the population, but also could be caused by differences in sampling efficiency due to environmental conditions or the experience level of sampling crews. Electrofishing is widely used to collect species in wadeable streams; however, the proportion of individuals captured can be affected by sampling design and crew, species and individual attributes, and environmental factors at the site (Peterson et al. 2004; Price and Peterson 2010; Benejam et al. 2012). Data on in-stream characteristics that vary and affect capture efficiency could be incorporated into models of catch to produce more unbiased and precise estimates of population change over time.

Spatial patterns in bull trout catch and length were detected possibly suggesting that the population was not randomly distributed within the study area. In general, a larger number of juvenile fish were collected at more upstream reaches. In addition, there were specific reaches where catches were higher than would be expected given the overall spatial pattern in catch.

Sampling was conducted just before spawning initiated in the SFWWR. During this period, bull trout were actively migrating and the area was used by spawning adults (both residents and migrants) and immature residents of a variety of sizes; thus, the observed non-random spatial distribution may be related to differences in microhabitat suitability by life stage or life history type or to improve survival (Al-Chokhachy and Budy 2007; Pinto et al. 2013; Gallion et al. 2014). However, since capture efficiency for salmonids is affected by in-stream conditions and fish length (Peterson et al. 2004), apparent spatial patterns could also be impacted by differences in capture efficiency by reach. Most especially, capture efficiency appears to generally decline with increased cross-sectional area and increased velocity and turbidity (Peterson et al. 2004; Price and Peterson 2010); thus capture efficiency may be lower at downstream reaches and more limited to larger individuals. Since a spatial pattern in catch and length is observed, comparisons between years in which different reaches were sampled or some reaches were sampled multiple times could be problematic; continuing to sample at all reaches once per year would be preferable to examine long-term trends.

Although it appears that backpack electrofishing (either with or without a seine) collects a large size range of bull trout, this does not mean that the gear is not size-selective. The use and comparison of multiple gears can result in a better understanding of gear selectivity in terms of both catch and size, but cannot be used directly to evaluate gear selectivity. Including mark-recapture information can help directly estimate the proportion of fish at certain sizes that are collected by a gear (Myers and Hoenig 1997; Hetrick and Bromaghin 2006). The proportion of in-season recaptures of different size groups of tagged bull trout could be used to estimate the catchability of each size group, as long as tag loss and mortality during the season were low or estimated and enough individuals within each group could be tagged and recaptured to result in adequate precision. Indirect methods to evaluate selectivity, such as using age-structured population models with associated growth models can also be useful (Binion et al. 2009); however, these types of models may not be appropriate for ESA-listed bull trout, since ageing structures must be collected. Regardless, such size selectivity would be expected to be similar overtime, allowing for evaluation of annual changes in population demographics.

Future Sampling

We concluded that sampling 3 units (i.e., those with higher proportions of larger fish) and/or 2 units (i.e., those with higher # of individuals) using both sampling methodologies would not likely increase power enough to discern a difference between the two electrofishing methods. The current analysis suggests that any differences in catch and size distribution between the methodologies are not notably large, and that there would still be a lot of variability caused by a) bull trout actively migrating through the area and b) the first method likely impacting catch for the second method due to disturbance; both likely clouding our ability to see any difference with this sample size of reaches. Further, given the location of the suggested reaches (directly in the middle of the study area) which are large, complex, and braided, it is likely that sampling by both methods would require a considerable increase in effort, which. could possibly add an additional week of sampling, which logistically is not feasible given the timing of when flows typically drop to base flow and the arrival of spawning Chinook.

In order to avoid unnecessary harm to a listed species, adipose clipping (i.e., double marking) will be discontinued in future sampling efforts (2014 and beyond). Recent studies have shown possible harm to salmonids when removing the adipose fin (Stewart and Hale 2013).

Additionally, we currently have 10 years of tag loss data and associated rates collected by USU. Future analysis (e.g., survival) will include the calculated tag loss rate of 10% provided in previous USU reports (Budy et al. 2011). We will continue to use the same tagging protocol (i.e., PIT tag size classes for 12 and 23 mm tags, abdominal cavity) as completed by USU during the 2002-2011 sampling seasons.

Additionally, hook and line sampling will be conducted opportunistically in pool habitat where the electrofishing technique can not physically be completed. We will use experienced hook and line samplers, similar gear types (e.g., tackle), quantify sampling effort (e.g., time, # of anglers) for each reach, and report which reaches were sampled using hook and line. Bull trout captured using hook and line methods will be separated from fish caught by electrofishing, and tagging data will reflect the different capture method. Changes in population size and length frequency distribution overtime will be examined using electrofishing data, with hook and line sampling used to augment the number of larger individuals tagged for demographic analyses such as survival and growth.

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Appendix A:

Table 1: Multiple comparison p-values for differences in catch by year (upper table) and standard sampling reach (lower table). P-values significant at the 0.05 level are indicated in blue; others are indicated in green.

	2004	2005	2006	2007	2008	2009	2010	2011	2012
2005	0.9945								
2006	0.9980	>0.9999							
2007	0.4346	0.0520	0.0724						
2008	>0.9999	0.9998	0.9999	0.2502					
2009	0.0257	0.2899	0.2293	<0.0001	0.0644				
2010	0.0058	0.1088	0.0801	<0.0001	0.0169	>0.9999			
2011	0.0291	0.3121	0.2485	<0.0001	0.0717	>0.9999	>0.9999		
2012	>0.9999	0.9999	>0.9999	0.2152	>0.9999	0.0785	0.0214	0.0872	
2013	>0.9999	0.9974	0.9992	0.3748	>0.9999	0.0341	0.0080	0.0384	>0.9999

	3	8	13	18	23	28	33	38	43	48	53	56	58	63	68	73	78	83	88	93	98
8	0.6396																				
13	0.3651	0.0001																			
18	0.8051	0.0009	>0.9999																		
23	0.6376	0.0003	>0.9999	>0.9999																	
28	0.0310	<0.0001	>0.9999	0.9955	0.9996																
33	0.0000	<0.0001	0.0331	0.0037	0.0093	0.3787															
38	0.0000	<0.0001	0.2136	0.0397	0.0828	0.8477	>0.9999														
43	0.0014	<0.0001	0.9780	0.7269	0.8711	>0.9999	0.9197	0.9993													
48	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.4437	0.1003	0.0008												
53	<0.0001	<0.0001	<0.0001	0.0005	0.0015	0.1307	>0.9999	0.9999	0.6435	0.7914											
56	<0.0001	<0.0001	<0.0001	0.0004	0.0011	0.1107	>0.9999	0.9999	0.5961	0.8282	>0.9999										
58	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.3883	0.0807	0.0006	>0.9999	0.7413	0.7822									
63	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.4705	0.1107	0.0009	>0.9999	0.8131	0.8477	>0.9999								
68	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0005	<0.0001	<0.0001	0.0007	0.0004							
73	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	<0.0001	<0.0001	0.8004	0.0020	0.0026	0.8443	0.7781	0.5483						
78	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0007	<0.0001	<0.0001	0.0010	0.0006	>0.9999	0.6110					
83	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.5229	0.0004	0.0005	0.5821	0.4955	0.8199	>0.9999	0.8635				
88	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.6154	0.0007	0.0009	0.6732	0.5879	0.7442	>0.9999	0.7969	>0.9999			
93	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0380	0.0035	<0.0001	>0.9999	0.1497	0.1748	>0.9999	>0.9999	0.0232	0.9997	0.0305	0.9893	0.9958		
98	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0490	0.0048	<0.0001	>0.9999	0.1829	0.2120	>0.9999	>0.9999	0.0176	0.9993	0.0233	0.9815	0.9920	>0.9999	
103	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0007	<0.0001	<0.0001	0.9139	0.0051	0.0064	0.9392	0.9000	0.3768	>0.9999	0.4349	>0.9999	>0.9999	>0.9999	>0.9999

Table 2: Multiple comparison p-values for differences in fork length by year (upper table) and standard sampling reach (lower table). P-values significant at the 0.05 level are indicated in blue, others are indicated in green.

	2004	2005	2006	2007	2008	2009	2010	2011	2012
2005	0.0424								
2006	<0.0001	<0.0001							
2007	<0.0001	<0.0001	0.9987						
2008	0.1620	<0.0001	0.3342	0.0912					
2009	>0.9999	0.0167	<0.0001	<0.0001	0.0528				
2010	0.9992	0.1364	<0.0001	<0.0001	0.0068	0.9994			
2011	0.4054	<0.0001	0.0409	0.0072	0.9998	0.1753	0.0274		
2012	0.0043	0.9973	<0.0001	<0.0001	<0.0001	0.0012	0.0154	<0.0001	
2013	<0.0001	<0.0001	>0.9999	0.9998	0.3071	<0.0001	<0.0001	0.0408	<0.0001

	3	8	13	18	23	28	33	38	43	48	53	56	58	63	68	73	78	83	88	93	98
8	>0.9999																				
13	>0.9999	>0.9999																			
18	>0.9999	>0.9999	>0.9999																		
23	>0.9999	>0.9999	>0.9999	>0.9999																	
28	0.4915	0.2989	0.2479	0.0587	0.5611																
33	0.5943	0.3795	0.3002	0.0692	0.6615	>0.9999															
38	0.0091	0.0083	0.0005	<0.0001	0.0045	0.9853	0.7163														
43	0.0011	0.0013	<0.0001	<0.0001	0.0004	0.6703	0.1905	>0.9999													
48	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.1013	0.0018	0.9919	>0.9999												
53	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0312	0.0083											
56	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0005	<0.0001	0.9999										
58	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	>0.9999	>0.9999									
63	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	0.9995	>0.9999	>0.9999								
68	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.3657	0.9994	0.9712	0.9986							
73	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.1961	0.9832	0.8347	0.9679	>0.9999						
78	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0732	0.9355	0.5830	0.8699	>0.9999	>0.9999					
83	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.0598	0.0035	0.0201	0.1434	0.8244	0.7228				
88	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0364	0.7897	0.3659	0.6691	0.9984	>0.9999	>0.9999	0.9943			
93	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0505	0.8078	0.4276	0.7096	0.9987	>0.9999	>0.9999	0.9992	>0.9999		
98	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0088	0.4467	0.1229	0.3094	0.8971	0.9997	0.9996	>0.9999	>0.9999	>0.9999	
103	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0028	0.2936	0.0494	0.1658	0.7127	0.9972	0.9956	>0.9999	>0.9999	>0.9999	>0.9999

Table 3: Chi-square pairwise p-values for proportion of catch, by year, composed of juveniles (<145 mm FL), sub-adults (145-289 mm FL), small adults (290-405 mm FL) and large adults (>405 mm FL). P-values significant at the 0.01 level are indicated in blue, others are indicated in green.

	2004	2005	2006	2007	2008	2009	2010	2011	2012
2005	0.0631								
2006	0.5081	0.1545							
2007	0.0665	0.0017	0.0665						
2008	0.0316	0.0001	0.0264	0.9090					
2009	0.0045	0.1433	0.0523	0.0329	0.0019				
2010	<0.0001	0.0701	0.0003	<0.0001	<0.0001	0.0005			
2011	0.0000	0.0344	0.0010	<0.0001	<0.0001	0.0007	0.7230		
2012	0.0013	0.0262	0.0010	<0.0001	<0.0001	<0.0001	0.0316	0.0139	
2013	0.0417	<0.0001	0.0041	0.0577	0.1258	<0.0001	<0.0001	<0.0001	<0.0001

Table 4: Catch and size of bull trout collected during comparison sampling for the two protocols during 2012 and 2013 at reach 93.

Protocol	Date 2012	Total catch 2012	Median FL (Range) 2012	Date 2013	Total catch 2013	Median FL (Range) 2013
Electrofishing with a Seine	8/15	42	104 (42 – 418)	7/18	6	136 (92 – 179)
Electrofishing without a Seine	7/19	36	107 (74 – 251)	7/16	18	103 (40 – 330)

Table 5: Power analysis results from reach 93 to evaluate the number of paired samples needed (n) to detect a percent change in catch assuming baseline catch was 25.13 bull trout (average catch from USU sampling 2004-2011 at reach 93) at power levels of 0.8 and 0.9 and a significance level of α=0.05. All estimates of n were rounded up to the nearest whole number.

Percent Difference	Percent Coefficient of Variation	n (0.8 power)	n (0.9 power)
5	10	32	41
10	10	13	10
15	10	6	7
20	10	5	5
25	10	4	4
5	15	69	92
10	15	21	27
15	15	10	13
20	15	7	9
25	15	6	7
5	20	119	158
10	20	34	44
15	20	16	21
20	20	10	13
25	20	8	9
5	25	187	249
10	25	52	69
15	25	24	31
20	25	15	19
25	25	10	13
5	30	264	352
10	30	73	97
15	30	33	43
20	30	20	26
25	30	13	17

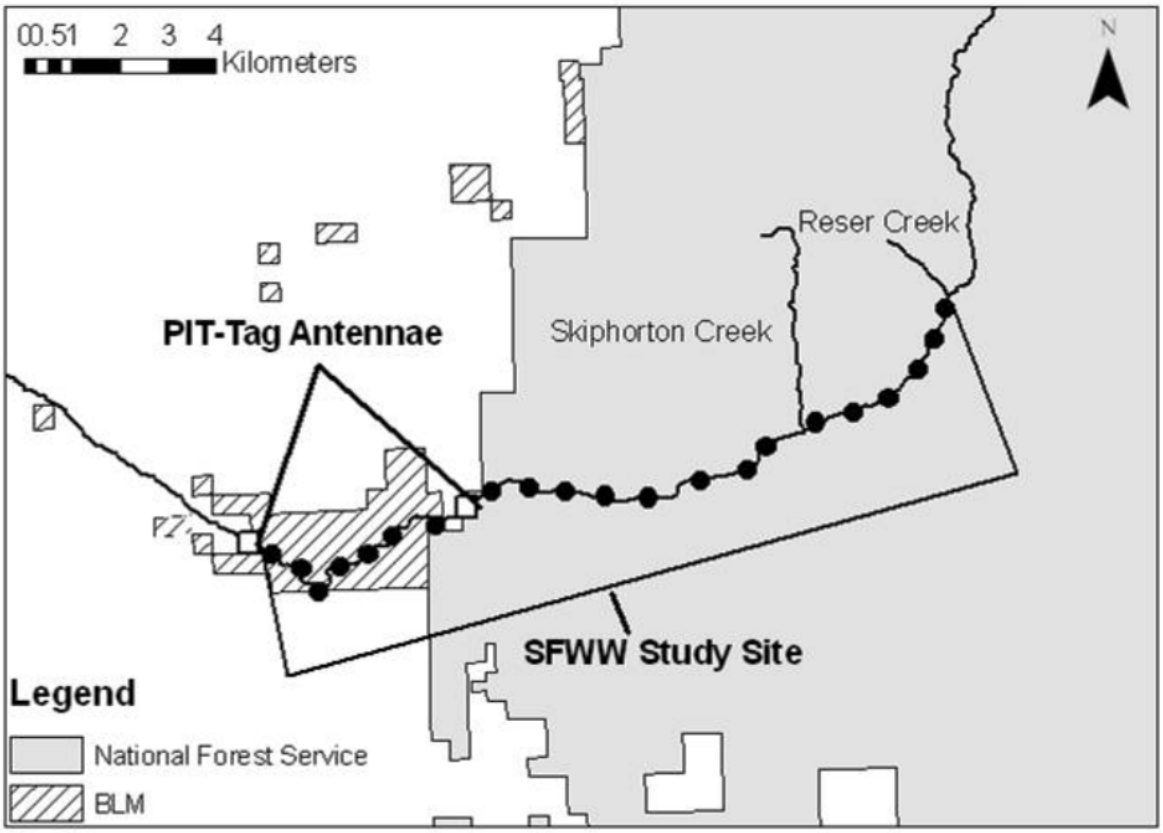

Figure 1: Map displaying the 22 study reaches (dots) within the South Fork Walla Walla River, Oregon.

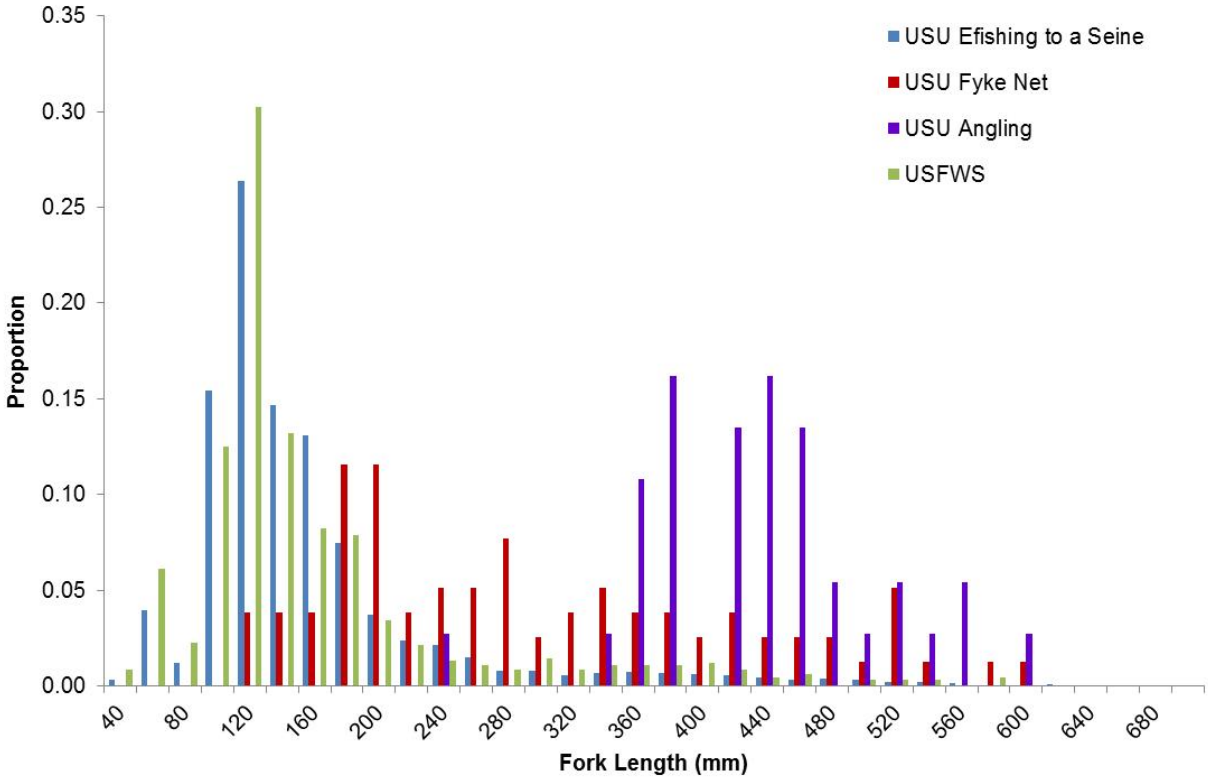

Figure 2: Proportion of bull trout catch by fork length for each sampling method. Fork length bins are 20-mm increments and data from all reaches and all years are included.

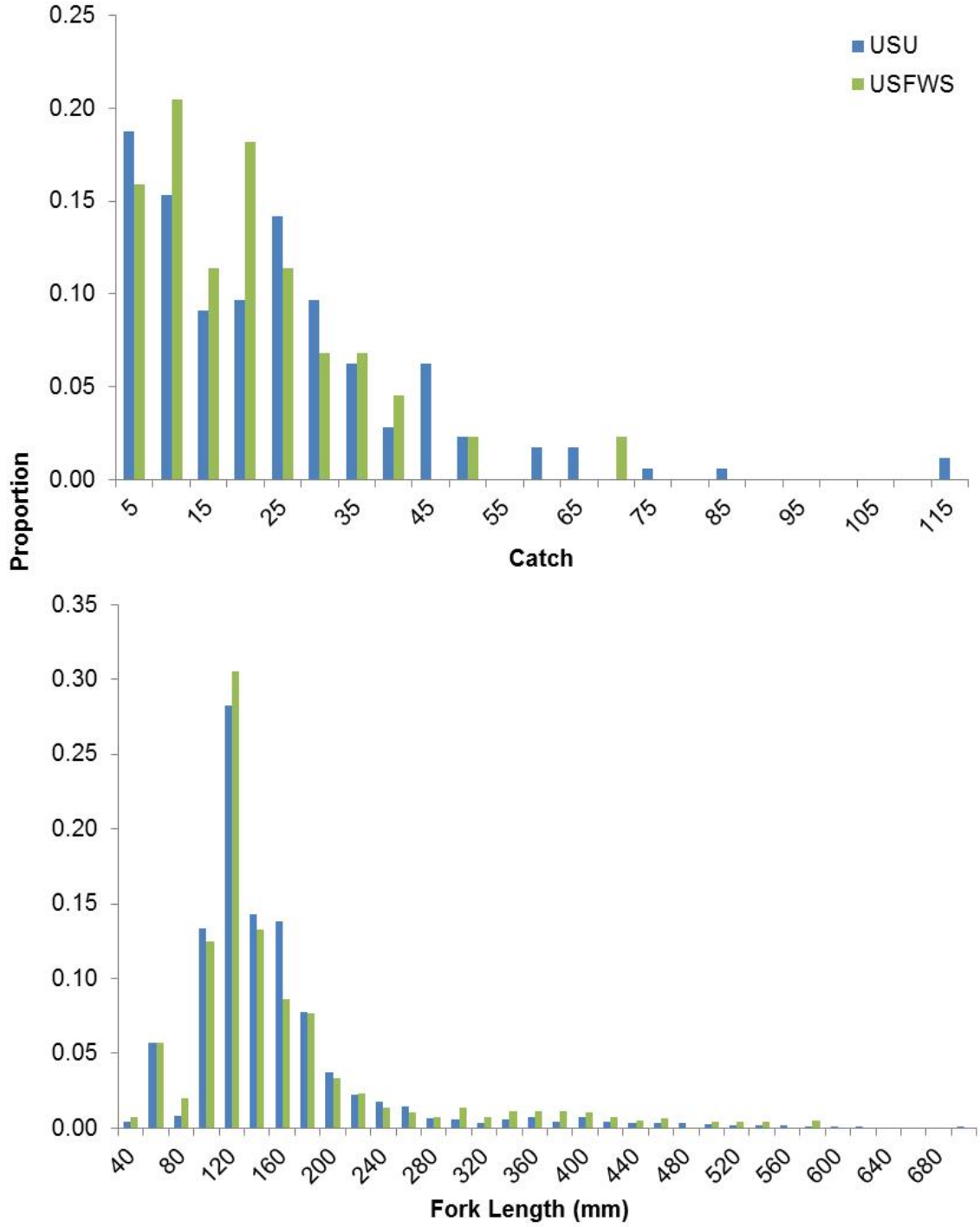

Figure 3: Observed distribution of sampled bull trout catch per standard reach (upper panel) and per fork length bin from data collections by USU (2004-2011) and USFWS (2012-2013). Fork length bins are 20-mm increments and only data from standard sampling reaches sampled once each year are included.

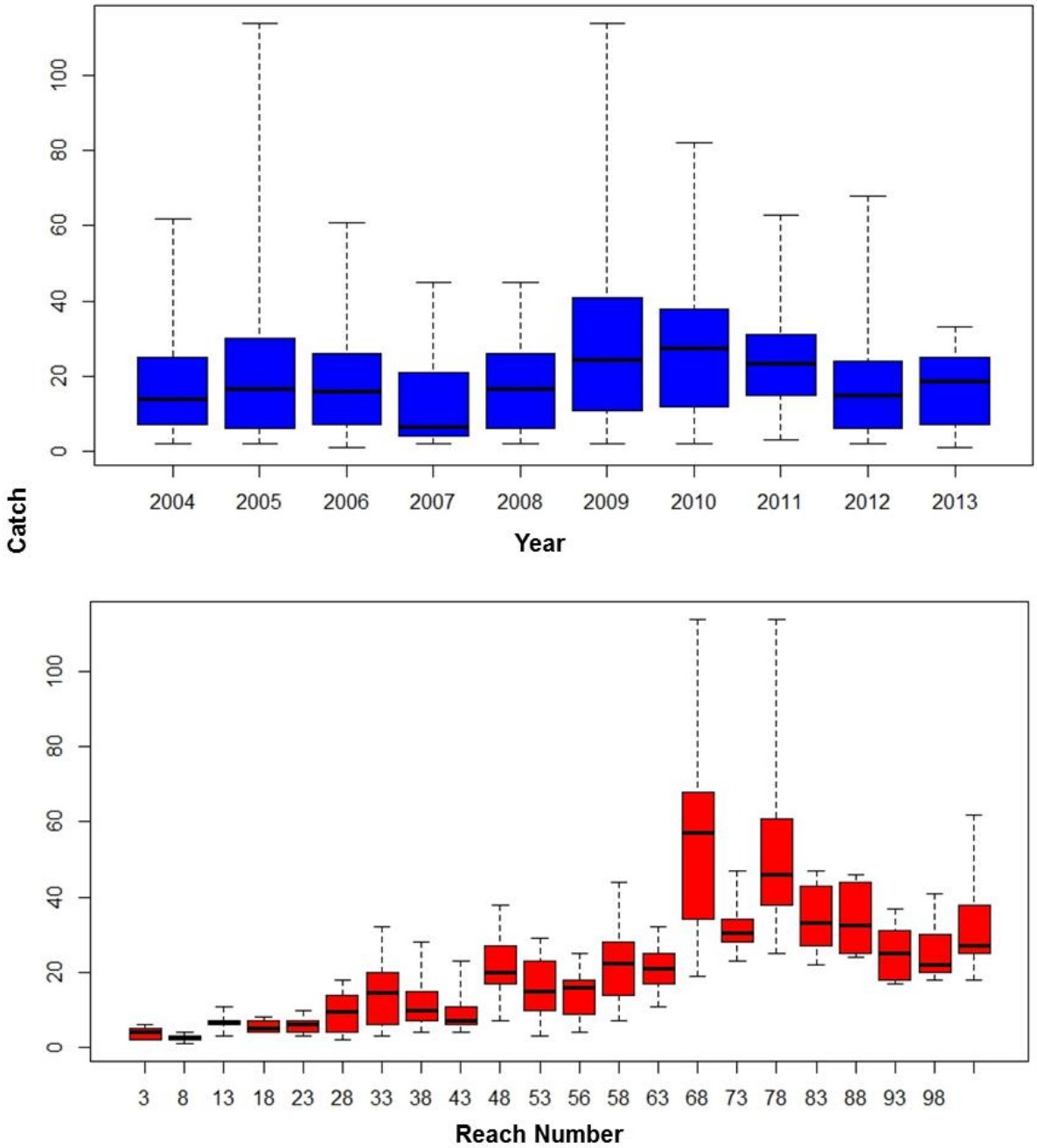

Figure 4: Boxplots of catch for each sampling year using reaches as replicates (upper panel) and catch by reach using years as replicates (lower panel).

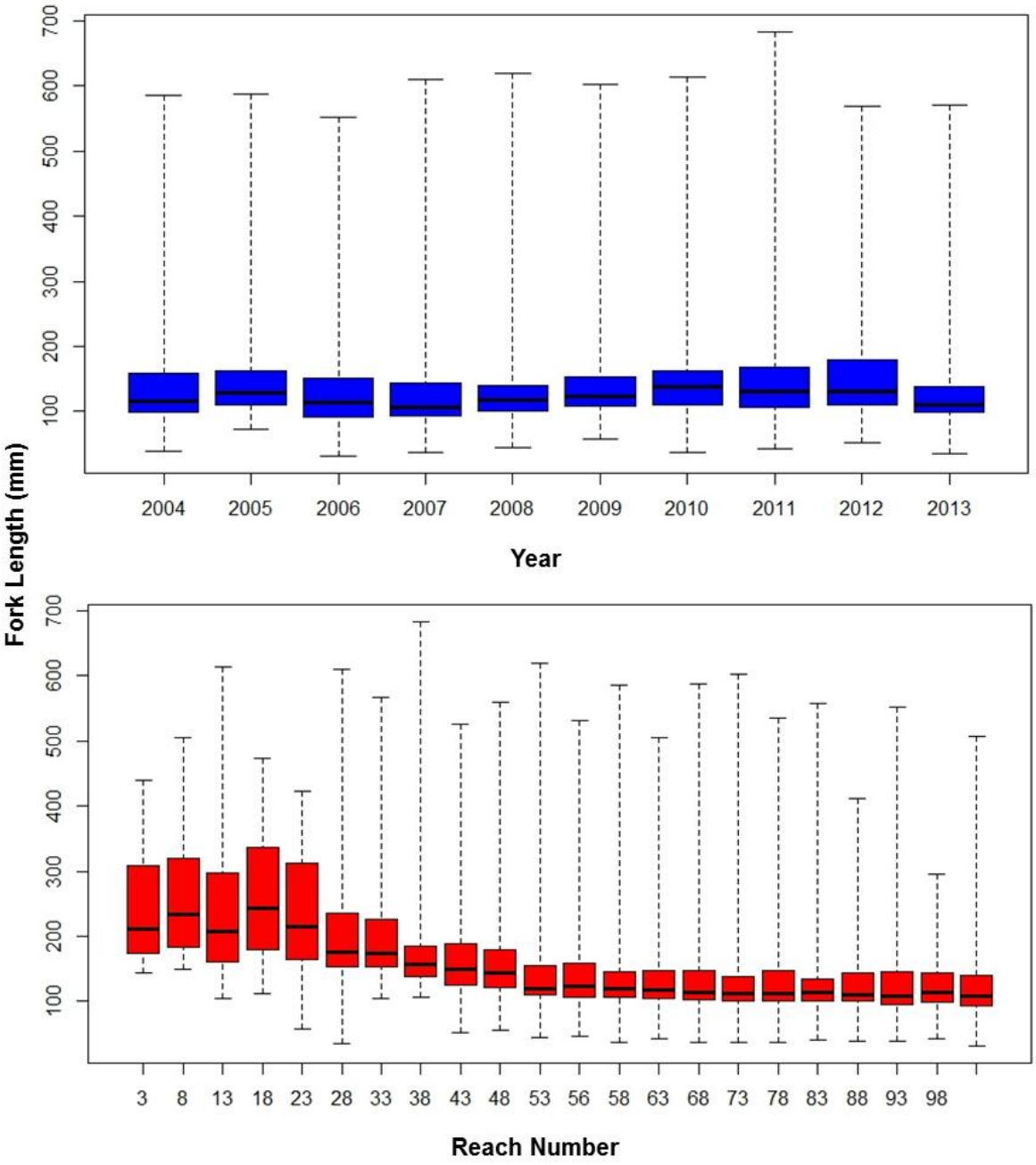

Figure 5: Boxplot of fork length by sampling year including all reaches (upper panel) and by standard sampling reach including all years (lower panel).

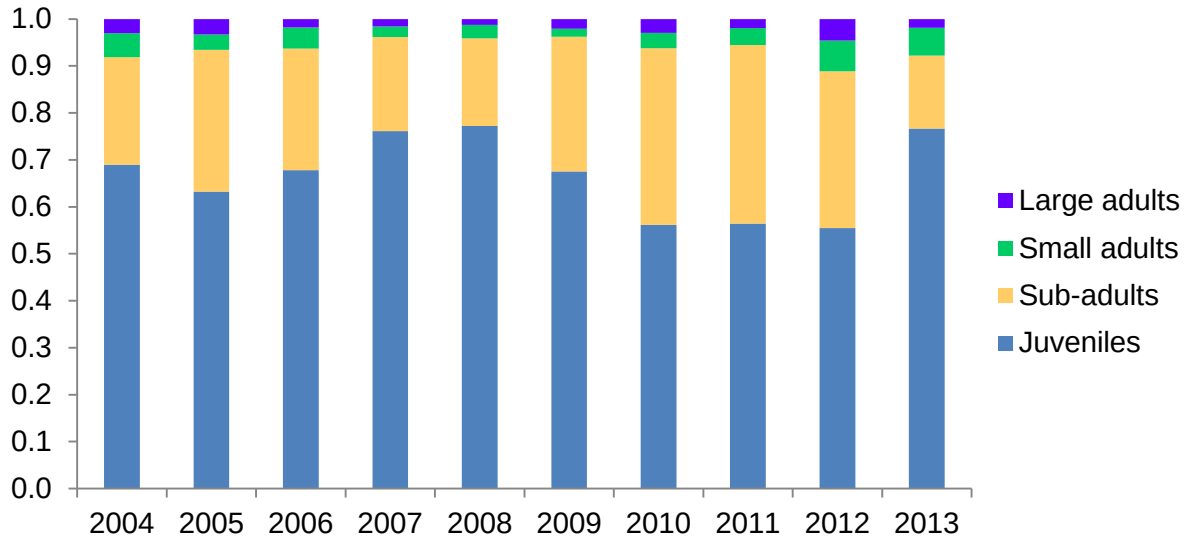

Figure 6: Proportion of the catch composed of juveniles (<145 mm FL), sub-adults (145-289 mm FL), small adults (290-405 mm FL) and large adults (>405 mm FL), by year, including all reaches combined.

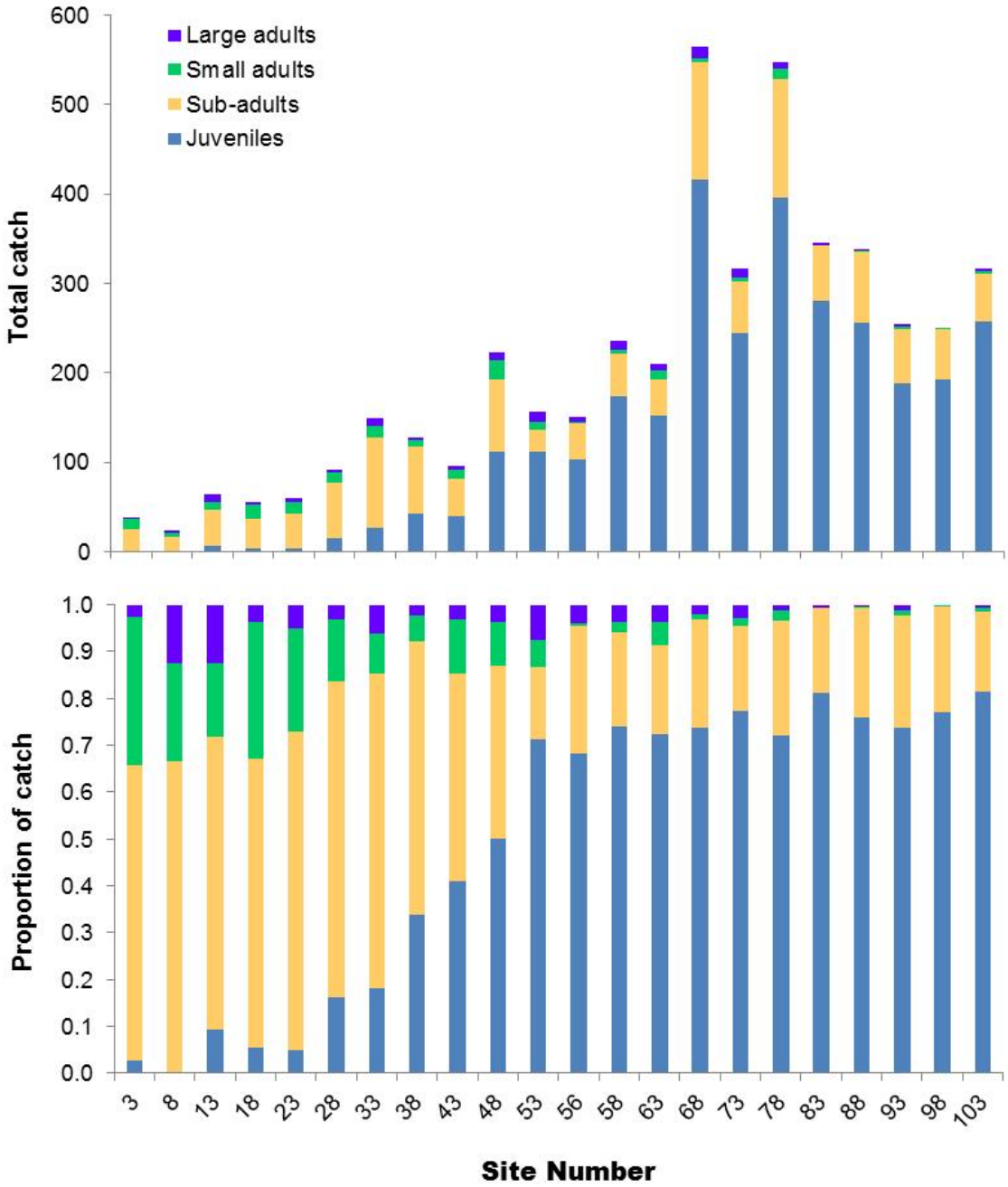

Figure 7: Total and proportion of catch for each size class by reach, including all years combined. Catch is composed of juveniles (<145 mm FL), sub-adults (145-289 mm FL), small adults (290-405 mm FL) and large adults (>405 mm FL).

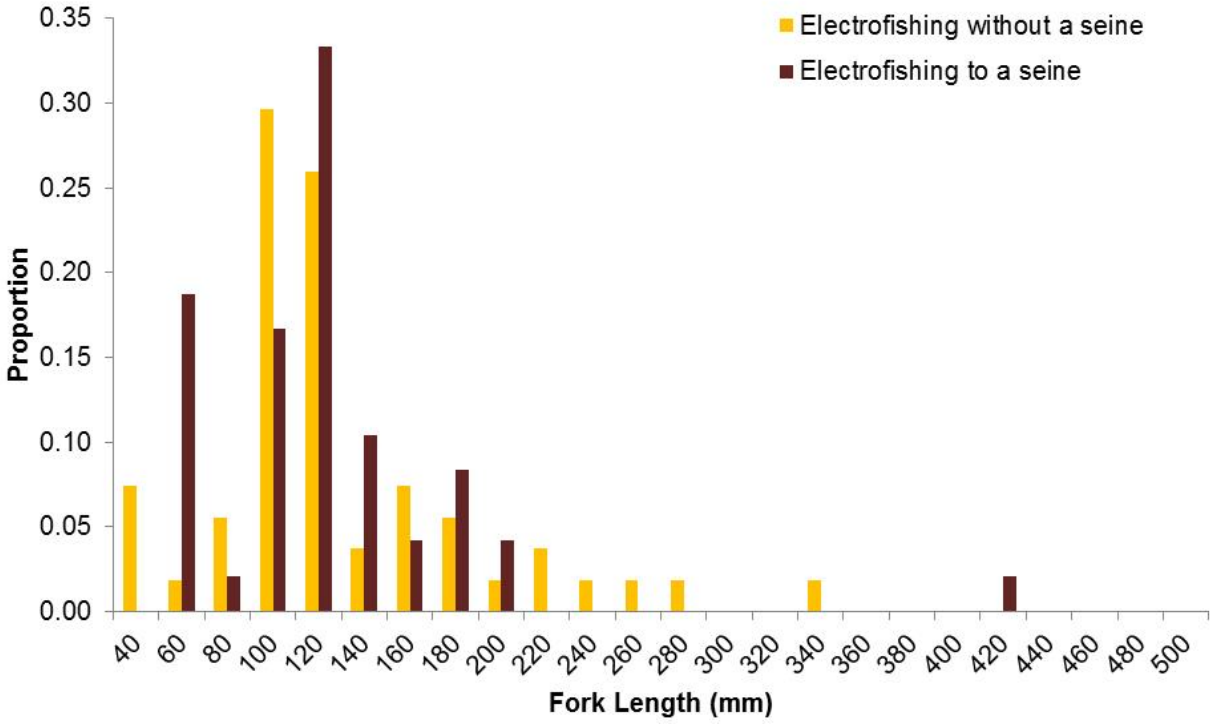

Figure 8: Proportion of bull trout catch by fork length collected from reach 93 during 2012 and 2013 (combined) to compare electrofishing with and without a seine.

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July 2014
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